Frieda River Limited

Sepik Development Project

Environmental Impact Statement

Appendix 13 – Social Impact Assessment

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coffey
A TETRA TECH COMPANY

Frieda River Limited

Sepik Development Project

Social Impact Assessment

1 November 2018

FRIEDA RIVER

Results emerge
when local knowledge
intersects with
global expertise

Sepik Development Project

Prepared for
Frieda River Limited

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Executive Summary

The Sepik Development Project (the Project) is located within the Sepik River catchment in the Sandaun Province and western area of the East Sepik Province of Papua New Guinea, and consists of four interdependent projects:

- Frieda River Copper-Gold Project (FRCGP).
- Frieda River Hydroelectric Project (FRHEP).
- Sepik Infrastructure Project (SIP).
- Sepik Power Grid Project (SPGP).

Following a seven-year implementation period, the FRCGP has an estimated mine life of 33 years while the FRHEP will have an operating life in excess of 100 years. The total initial direct capital investment for the Sepik Development Project is expected to be US$6.9 billion (PGK21.7 billion[1] in October 2018) in real terms (ACIL Allen, 2018).

SIA objectives and method

This Social Impact Assessment (SIA) has been prepared as part of the Environmental Impact Statement (EIS) for the development of the Project. It assesses potential positive Project effects and negative socioe-conomic impacts of the Project, and outlines strategies designed to enhance net-socioe-conomic opportunity created by the Project.

The objectives of the SIA are to:

- Describe the socio-economic characteristics of the region including the existing land and natural resource use of the Project area.
- Identify the socio-economic factors that may pose constraints to achieving Project objectives and/or which may otherwise require management.
- Identify the potential socio-economic impacts associated with the Project and develop approaches to managing these impacts.
- Identify the potential positive socio-economic opportunities to benefit from the Project, and develop strategies for maximising those benefits, primarily for Project-affected stakeholders.
- Provide an assessment of residual socio-economic impact following the application of mitigation measures.

Completion of the SIA has aligned with international guidelines through a five-stage process:

1. Scoping, baseline studies and identification of social values.
2. Identification of positive Project effects.
3. Impact identification.
4. Impact assessment (through a risk-based approach).
5. Application of mitigation measures and residual impact assessment.

This process is described in detail in the following sections.

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[1] US dollars are converted to Kina at an assumed exchange rate of US$1.00 = 3.15 Kina.

Scoping, baseline studies and identification of social values

The social context has been established through completion of a series of in-depth studies over the past 20 years, as well as ongoing regular engagement and dialogue with communities potentially affected by the Project. Initial scoping of Project effects involved the review of current infrastructure plans, previously completed socio-economic assessments, technical reports and stakeholder engagement records. Baseline information was acquired through field surveys, use of previously collected primary data where appropriate, and the review of broader secondary source documentation where available.

Baseline field studies were completed in 2010, 2011, 2015, 2016 and 2017. The scope of these studies included:

- Socio-economic surveys (census, household and village) (2010, 2015 and 2017).
- Archaeology and cultural heritage survey (2016).
- Community health survey (2010 and 2011).
- Consultation on social values (by way of workshop with village leaders) (2015).

Social values

Social values are qualities of the social environment that are conducive to individual well-being now and into the future, and for which community stakeholders have a high regard. Each social value is characterised by a range of indicators, and is associated with stakeholders who have an interest in the value within the social catchment. Fundamental to the assessment of social risks has been the identification of social values held by potentially affected communities and the analysis of all elements of the Project to identify potential risks to such values. Social values were identified through the analysis of baseline information and workshops with community leaders. This process resulted in the articulation of six social values (SV), under the categories of: Livelihoods; Culture; and Personal and Community Well-being, shown in Table ES1.

Table ES1 Project area social values

Category 1-Livelihoods		**Category 2-Culture**		**Category 3-Personal and community well-being**	
SV1	**SV2**	**SV3**	**SV4**	**SV5**	**SV6**
The capacity to support subsistence livelihoods	Opportunities for participation in the cash economy	An enduring ability to sustain individual and group cultural identity and traditions including connection to ancestors	An enduring ability to maintain customary rights to land access and resource use	An environment amenable to personal and family health, education, safety and security	The availability of services supportive of personal health, education, safety and security

It is important to note that social values can change and sometimes do so rapidly, as key stakeholders in the Project have themselves initiated quite radical change (and continue at present to experience the consequences of such change) in relatively recent times. Consequently, caution is warranted in assigning significance to expressions of those values centred on culture and traditional leadership which may well evolve in different ways during the life of the Project.

Positive Project effects

The degree of community confidence to embrace uncertainty in pursuit of social development influences how Project-induced change is perceived and impacts are experienced. In this respect an equally important step in SIA is the identification of positive Project effects that will likely enhance social values, as these can offset negative impacts, or improve the status of the social value. Communities potentially impacted by the Project currently have minimal access to cash economy work and business opportunities, health and education services, and community and regional infrastructure. Positive Project effects that have the capacity to enhance social values were identified by drawing on the experience of similar projects in PNG, the characteristics of the proposed Project, and the aspirations of community members and other stakeholders.

These positive Project effects include:

- Opportunities for employment (and receipt of associated income) and skills acquisition, both for males and females.
- Opportunities for the development of local economies, including trading businesses and potentially cash-cropping due to improved access to input supplies and product markets.
- Landowner receipt of statutory payments including royalties and compensation that may be applied to consumption or investment.
- Access to improved village-level infrastructure and service delivery in health and education.
- For resettled communities, access to improved village-level infrastructure including new housing, and water and sanitation facilities.
- Access to regional infrastructure, including new and improved road transport links to Sandaun service centres, and telecommunications facilities.
- Opportunities to establish community programs to improve family and gender relations, and increase support for other vulnerable groups such as youth and the disabled.

The Project will generate substantial financial benefits for government and landowners. Economic modelling undertaken by ACIL Allen indicates that tax, royalty and production levy revenue to PNG governments and landowners over the first 40 years of the Project are expected to total PGK29.0 billion in real terms (ACIL Allen, 2018). Real national gross domestic product (GDP) is estimated to increase by a cumulative value of PGK90.3 billion (US$28.7 billion) over the first 40 years of the Project (ACIL Allen, 2018).

While these benefits are significant, the ongoing mining and electricity generation operations and their associated infrastructure provides significant potential to influence economic performance throughout the economy as a result of flow-on effects to other industry sectors. Economic spending by Project participants, employees, government and landowner beneficiaries will lead to ‘multiplier effects’ as the economic activities associated with the Project flow through the broader economy. Investment in productive physical assets (e.g., infrastructure for power generation, roads and airports) and in social assets (e.g., improved education and health services) can also benefit the economy by enhancing the productivity of economic factors (ACIL Allen, 2018).

Impact identification

The following aspects of the Project were identified as having the potential to cause a direct negative effect on communities:

- Physical disturbance, resulting in loss of land used for subsistence livelihoods, and the generation of sediment that will report to the downstream environment.
- Physical displacement as certain villages will require resettlement.
- Road access and communications infrastructure which will bring improved access to markets, education and health services and knowledge, but also provides potential for higher exposure to communicable disease and socially disruptive and illegal activities.
- Traffic, which can have implications for human safety and wellbeing, including the generation of noise, light and dust emissions.
- Employment, business development and procurement which will provide income, training and development for local people, but which can also result in a shortage of labour to assist with rural livelihoods, dietary change and associated health effects, and accelerated change in traditional leadership and lifestyle practices.
- Presence of the Project workforce where interactions with local communities can lead to a range of issues, such as exposure to communicable diseases, and behaviour at odds with accepted local social norms. In addition, the influx of foreign workers, who may come from a range of different cultural backgrounds, can be a source of animosity within the workforce and between the workforce and local communities.
- Discharges, emissions and waste disposal from Project activities which can result in the pollution of land and water resources, impaired community amenity and health concerns and heightened levels of anxiety regarding the environmental integrity of waterways downstream of the mine.
- Accidental spills and leaks which have the potential to pollute land and water resources and expose people to hazardous materials.

The Project also has the potential to cause indirect positive and negative effects and impacts on communities. The following are the primary indirect drivers of social change induced by the Project:

- In-migration, which may ultimately benefit local trade, employment, infrastructure and services, but also has the potential to cause a range of negative economic, health and social consequences. These negative consequences may include pressure on land and resources, price inflation due to increased income, reduced business and employment opportunities for local communities, damage to cultural heritage, a loss of customary rights, disruption to social relations, deterioration of community safety and security, higher exposure to communicable diseases and a reduced availability of health and education services due to increased demand.
- Distribution of monetary wealth that will provide financial benefits at a local, provincial and national level, but can also place strain on social relations within and between communities, lead to changes to traditional lifestyles and systems of governance, and the abuse of alcohol and drugs that has the potential to lead to increased public and domestic violence.

Risk significance assessment

Identified risks were then analysed to determine whether they might occur in each social catchment. A matrix approach was used to evaluate the potential significance of the risk to social values, assessing the likelihood of the potential risk occurring and the consequential effect if it was to occur. The establishment of likelihood and consequence levels for each identified risk was undertaken in a workshop comprising persons familiar with the social impact assessment of mining in PNG, direct experience in engaging with residents of the Project area and an appreciation of community attitudes, development needs and aspirations. Technical studies were undertaken for archaeology and cultural heritage and health, with the findings considered in the development of the SIA.

Mitigation measures and residual risk assessment

For those risks which were assessed as having a ranking of very high, high or medium significance, measures were identified to avoid or limit the likelihood or consequences of their occurrence.

The residual significance assessment presented in the SIA is based on the assumed effective implementation of identified mitigation measures. The significance of many impacts can be reduced to negligible or minor levels with the effective implementation of tailored mitigation measures. However, some will remain high, primarily due to the acceleration of social change which a Project of this nature will inevitably have upon the socio-economic characteristics of communities in the social catchments. Primary residual risks to social values associated with the Project for each social catchment are discussed below.

The Health Impact Assessment considered the potential exposure to communities from metals in the environment, including an assessment of predicted changes due to mine discharges. The study determined there would be no adverse health impacts from the Project, as consumption of water and fish and wildlife from the potentially impacted areas is predicted to remain safe.

Social Catchment 1A: Mine area

Within Social Catchment 1A the highest level of impact will occur in the Telefol villages of Wabia and Ok Isai which will, because of the FRHEP, be required to relocate to an area mutually agreed through the resettlement planning process. Resettlement site planning will ensure that the resettled villages do not experience impaired amenity associated with Project construction and operation, while having access to an improved level of infrastructure. As both villages have strong cultural links to the Telefomin and Eliptaman areas approximately 30 km to the south, it could be expected that there will be some level of pressure to host Telefol in-migrants seeking access to benefits from the Project.

Resettlement of Paupe to the upper Kaugumi Creek catchment will mitigate the potential for direct physical impact due to proximity to the access road and FRHEP construction activity, and minimal loss of customary land will support the restoration of subsistence livelihood activity with an appropriate level of transitional assistance. It is expected that a substantial level of in-migration may occur in the relocated Paupe village, with people likely to come from nearby Sepik villages who have used Paupe as a staging post when seeking exploration program employment in the past. Such in-migration will likely place pressure on the availability of subsistence resources currently relied upon to support livelihoods.

Within the Miyan social sub-catchment, Wameimin 2 will be resettled so that the future population near the Nena deposit does not overly constrain the potential development of that deposit. The FRHEP and mine infrastructure footprint in the Nena Valley will remove a significant amount of land which has been available to Miyan for hunting purposes. Amaromin may experience some effects of in-migration, due to its proximity to Hotmin and the May River, which is accessible by canoe from the Sepik River. Population movement toward Wameimin 2 from Wameimin 1, and potentially from Amaromin and Sokamin, may also occur. Population influx will create pressure on aquatic and terrestrial resources close to settlements to support livelihoods based on subsistence production. The

Project will seek to collaborate with landowners and government to manage effects associated with in-migration in Catchment 1A through implementation of the Project-Induced In-Migration Management Strategy (PIIMMS).

While cultural identity is currently robust across all villages, villagers display a pragmatic attitude to the potential for Project-related interference with archaeological and cultural heritage sites and acceleration of cultural change. Due to the scale of the Project and its potential transformative social effects, it is highly likely that the Project will significantly impact cultural identity and tradition within the social catchment area. The intensity and duration of the Project, which will influence changes in lifestyle across generations and bring a deeper immersion in the mainstream economy, may inhibit a return to traditional practices following mine closure, assuming there remains a desire to do so. The Project has limited capacity to manage processes of social change, particularly when such change is sought by communities themselves, but will seek to ensure that the cultural identity of the groups is duly recognised and respected through a workforce induction which includes cultural awareness briefings and through stakeholder engagement mechanisms which promote culture. The Project will seek to support a community leadership initiative to assist village leaders in managing the expectations of community members regarding village justice systems, traditional leadership and authority structures in interactions with villagers. Despite these factors, the likely proximity to resettlement villages and scale of the Project, and the transformative effects which are likely to result, mean that villages will experience a recognisable degree of change to cultural identity and traditional leadership.

All Social Catchment 1A villages are in the Zone 1 employment and business development, supply and procurement category. Participation in the mine and contractor workforces (following required training and skills acquisition) will constitute a major avenue for livelihood in the future, as will participation in commercial business, supply or procurement opportunities associated with the Project that would otherwise likely be non-existent in the absence of the Project.

Social Catchment 1B: Frieda River infrastructure and road corridor

Social Catchment 1B encompasses part of the proposed road corridor extending from Hotmin to Green River, approximately 110 km. Subsistence practices play a significant role in the livelihoods of households within the catchment. Opportunities for formal employment and participation in the cash economy are limited. The new road will allow for public transport, commercial ventures and improved access to markets. Until cash incomes improve significantly, there will be a continuing dependence on subsistence livelihoods in the social catchment. Improved access to the catchment may stimulate further logging or industrial-scale agriculture such as oil palm plantations, with associated impacts. While there will be potential for in-migration along the road corridor, effects are more likely to be felt in areas closer to population centres, such as at Green River or Hotmin, or areas where alluvial gold is worked. Development enabled by improved access (employment, production for sale, cash crop production and business opportunities) is expected to lead to improved household income levels. Improved access may also facilitate the establishment of commercial trade stores, and more reliable access to government services because of lower service costs.

There may be some loss of amenity experienced by villages near the road during construction and operations due to dust and noise, though this is expected to be minor. Safety risks resulting from the interaction of residents and traffic (some significant) are almost certain as villagers use the road as a pedestrian walkway. The risk of this will be managed through implementation of traffic management and safety plans, drawing on the experience of other major infrastructure and resource projects in PNG.

Social Catchment 1C: Existing infrastructure and road corridor, Green River to Vanimo

The existing infrastructure and road corridor social catchment consists of Green River and villages located in proximity to the existing public road between Vanimo and Green River including Aminii, Kwomtari, Itomi, Kilifas, Sumunini and Imbrinis. Land use in the catchment is currently dominated by logging and oil palm plantations. The infrastructure corridor will be subject to more frequent vehicle movements during construction and operation of the FRCGP and FRHEP, and there will also be several construction camps (estimated at up to 200-person capacity) established to support construction activity in various locations.

The viability of subsistence livelihoods in the catchment has already been adversely affected by the impacts of logging and oil palm plantation establishment. While the construction of the road, pipeline and transmission line may impose some impairment to the existing environment (e.g., water course impacts and land clearing for quarries), this is expected to be relatively limited and short-term. The implementation of a robust construction environmental management plan will reduce the duration and severity of this impact.

The upgraded road should result in lower vehicle operating costs and a higher level of reliability than the existing road. In turn, this should promote the entrance of more transport service providers, with competition leading to lower costs for local users, and support an expansion in the marketing of subsistence surplus in both Green River and Vanimo (and possibly the FRCGP) as a viable income-generating activity. In general, upgraded road access should support improved levels of service delivery for government-provided services in health, education and policing. Improved access and the proposed provision of electricity will stimulate in-migration into the road corridor villages and particularly to the Green River area. Amenity in villages in proximity to the upgraded road has the potential to be degraded through ongoing traffic-generated noise and dust, as well as elevating the risk to pedestrians using the road as a walkway. The risk of this will be managed through implementation of traffic management and safety plans, drawing on the experience of other major infrastructure and resource projects in PNG.

Social Catchment 1D: Vanimo Ocean Port

The Vanimo Ocean Port catchment includes Vanimo and the adjacent villages of Wesdeco and Cis Point. Vanimo Port is currently used for commercial activities, such as log and timber exports. The port will be upgraded as part of the SIP to include up to three new berths and facilities to support the FRCGP and other port users. The filtrate from the concentrate filter plant will be treated and then disposed to the harbour, and there will potentially be several emissions from the FRCGP facilities, including diesel power plant exhaust, dust and noise.

Livelihoods for residents of Cis Point and Wesdeco are primarily based on paid employment in the Vanimo area, with fishing, reef gleaning and minor agriculture (kitchen gardens) being subsidiary activities that support viable livelihoods. Impacts from the construction and operations of the Vanimo Ocean Port will largely be confined to the area immediately surrounding the port development site which is contained within the existing port boundary. There will be some alteration of the nearshore marine environment through a small area of reclamation required, as well as noise, traffic and amenity impacts from construction due to pile driving, new berth construction activity and the installation of the concentrate pipeline. These risks will be managed through a construction environmental management plan, which includes a traffic management plan to limit the disruption of traffic in Vanimo.

Construction of the port facilities will present opportunities for employment and skill development for Vanimo residents and landowners of the port area. There will also be a limited number of employment opportunities during port operations. However, there is expected to be a higher level of commercial activity supporting the FRCGP (and other industry sectors that may expand with access to improved infrastructure), with concomitant increase in employment levels above those currently available. In-migration to Vanimo is highly likely and is expected to be generally positive in its effects, which will include increased commercial opportunities for the provision of goods and services.

Social Catchment 2: Sepik River corridor

Project activities, particularly throughout the early years of construction, have the potential to disrupt livelihoods within Social Catchment 2. The residents of the Sepik River corridor are highly dependent on the river for subsistence, income, recreation and cultural activity. The Sepik River is also used as a primary water source for many of the villages with access to its banks. As such, communities throughout the Sepik River corridor have significant interest in the health and water quality of the river, which is vital to their well-being. One concern is around fishing and crocodile farming activities which typically occur in off-river waterbodies, and which modelling predicts will not be impacted by the Project. There are also concerns around use of the river for transport of materials and hazardous goods such as fuel and chemicals, the structural integrity and safety of the integrated storage facility (ISF), and the potential for increased sediment loads and introduction of contaminants, all of which may induce a heightened level of anxiety among residents of the area.

Downstream water quality modelling predicted that water quality in the Sepik River would meet health-based WHO drinking water guidelines (2011) except for iron and lead concentrations which are already elevated under existing conditions. The concentrations of dissolved metals and metalloids in water in the Sepik River are also expected to be within the range of background concentrations, with the exception of aluminium concentrations, which are not anticipated to result in acute and chronic toxicity based on US Environmental Protection Agency calculated site-specific aluminium criteria (US EPA, 2017 a and b), and copper concentrations, of which labile concentrations are indicated to approach the ANZECC/ARMCANZ (2000) guideline for copper, and which will be further reduced by adsorption to suspended particulate matter. As such, there are not expected to be any adverse impacts to people from drinking water or consuming fish or other wildlife from waterways in the Sepik River as a result of the Project. However, perceptions within the population may be different, and the management of perceptions will require the effective provision of information on monitoring results.

The ISF will be used as a critical piece of sediment management infrastructure allowing much of the upstream sediment to settle prior to discharge, which will be controlled to ensure compliance with the applicable mixing zone boundary upstream of Paupe (the point at which determined water quality criteria must be met). As a result, modelling predicts that that Project related suspended sediment concentrations in the Sepik River will remain comparable to existing conditions.

A key consideration in the design of the ISF embankment is to ensure that the main containment dam will be constructed to endure a probable maximum flood and earthquake scenarios. The following measures will be implemented for the unlikely event of a dam break:

- Early warning surveillance monitoring of ISF embankment.
- Alert and communication system and procedures for potentially affected communities.
- Evacuation plan for the site and potentially affected communities.
- Emergency support plan for essential services to affected communities.

The Project is committed to ongoing regular engagement in villages downstream of the mine and ISF to address concerns about the environmental integrity of the waterways on an ongoing basis.

Social Catchment 3

Based on the Project location and activities and the findings of the EIS investigations, it is expected that only social values centred on livelihoods and community well-being will be impacted within Social Catchment 3.

FRL will seek to recruit the majority of its workforce from PNG with a preference to employ from Sandaun and East Sepik provinces. During the construction and operational phases the Project will generate approximately 4,200 and 2,430 full time equivalent positions respectively per year, of which a majority (estimated at 90%) will be occupied by PNG nationals. This will have the effect of generating substantial indirect employment across PNG as increased incomes lead to increased demand for other goods and services.

The preferential employment system aims to maximise local employment; however, candidates must possess the relevant skills and experience to fulfil the requirements of each role. FRL will implement a substantial training and development program to support local and regional employees to attain required skill levels to meet the required educational criteria for employment opportunities. Access to this program will be based on a combination of the requisite of literacy and numeracy skills and aptitude-based selection. Improved national human capital from training and work opportunities in the Sandaun and East Sepik provinces has the potential to result in reduced dependence on foreign workers and provide improved quality of life and life choices for those trained and experienced individuals.

The Project's host provincial governments will benefit from new revenue streams including:

- **Mineral royalties.** Negotiated by the National Government with host provincial governments, landowners and, in some cases, the relevant Local Level Governments (LLGs) and other affected communities, as determined through the government led benefit distribution process.
- **Dividends on Project equity.** It is estimated that between 5% and 10% of the State's 30% entitlement will be allocated between the Sandaun and East Sepik provinces.

The projected cumulative changes in local provincial and regional real GDP and real income as a result of the Project from 2020 to 2060 (ACIL Allen, 2018) are shown in Table ES2 .

Table ES2 Estimated changes in real GDP and real income

Region	Real GDP (Kina billion, 2018 terms, 2020 to 2060)	Real income (Kina billion, 2018 terms, 2020 to 2060)
Sandaun and East Sepik	83.1	40.9
Rest of Momase region	6.8	16.5
Rest of PNG	2.2	21.9
Total PNG	**90.3**	**79.3**

The increase in national wealth due to the Project has the potential to positively affect aspects such as health and education levels, should such wealth be used to support infrastructure and service provision in host provinces.

Social considerations for mine closure

Once the mine decommissioning and closure process is put in place, income streams for the social catchments will sharply decrease as levels of employment for the Project (which are dominated by the

FRCGP) are significantly reduced. This will particularly be the case for Social Catchments 1A and 1B which are located closest to the mine and which will have a high number of villagers employed by the Project, as well as receiving other financial benefits. The direct benefits of the FRCGP (employment, incomes, skill development, royalty flows, supply contracts, etc.) will cease at mine closure; some other benefits of the Project may continue, such as a small number of jobs with the FRHEP. FRL will develop targeted closure programs that address identified support for post-closure community livelihoods. This, in conjunction with effective planning and implementation of sustainable local and regional economic development programs throughout the life of the Project, will provide Project-affected communities with the means for successful transition to other monetary or agriculture-based livelihoods at mine closure. The desire to balance the short-term and long-term benefits of the Project to local villagers will be a key social challenge for FRL. While FRL will encourage people to ensure that a portion of Project benefits are invested in ways which will provide for their needs after the mine closes, it cannot dictate how this is done nor force people to do it. Likewise, while FRL can provide guidance and encouragement for FRCGP benefit streams to be invested in ways which do not rely on the Project in the long term (and, therefore, increase the potential for them to remain viable after mine closure), it has no means to regulate this. Business development support during life of mine will focus on building local companies which also have capability to engage in non-mining related enterprises.

The development of individual capability for employment, through training, is an aspect that FRL can directly influence during the life of the Project and which can have sustainable long-term benefits. The proposed 30-plus-year operating life of the FRCGP (with credible potential for this to significantly extend) provides sufficient time for FRL to put in place comprehensive training programs for the local workforce that will provide employees with skills that (1) will provide them employment during the Project, and (2) allow them the option to transfer those skills to work on mining (or other) projects elsewhere after the mine closes, should they choose to do so. The closure of the Project will result in the transition of ownership and management of public infrastructure agreed to be retained after closure from FRL to another entity, most likely the local level government(s). Developing the capacity and funding of the local level government(s) to manage such infrastructure after closure will be factored into closure planning. Preparation for such a transition will commence from the start of the Project, with a general understanding by stakeholders on governance and maintenance required for sustainability developed over time.

Impact management framework

Guidance to the management of Project impacts will be provided by an integrated environmental and socio-economic management framework pursuant to PanAust’s Sustainability Policy. Critical to successful management will be a high level of mutual trust with communities developed through effective community engagement. FRL has a structured approach to stakeholder engagement to ensure:

- On-going informed consultation and participation through the Project development phase and into future construction and operations phases.
- The active management of expectations and the identification of existing and emergent social risks.
- A consistent approach to build relationships with stakeholders based on transparency, integrity and trust.
- Support for a formal grievance management process that is responsive and transparent.

As Project environmental impacts are inherently linked to social well-being, the management of social impacts fundamentally requires the sound management of environmental impacts. To this end, Environmental Management and Monitoring Plans (EMMPs) for each major component of the Project has been developed in parallel with the EIS. The EMMPs reflect the commitments contained in the EIS and describes issue-specific sub-plans that support the implementation of those commitments. The widely-held concern for the environmental integrity of the waterways downstream of the FRCGP and ISF will be managed by an on-going program of engagement and consultation with communities on a regular basis, focussed on disclosing the results of environmental monitoring, as well as measures available to capture Project-derived opportunities for employment and community development. Complementing the EMMPs will be six Social Management Plans which together act to both manage socio-economic impacts and support the capture of socio-economic opportunity made available by the development of the Project. These plans are the:

- Cultural Heritage Management Plan.
- Community Development Plan.
- Business Development, Supply and Procurement Plan.
- Human Resources and Localisation Plan.
- Project-Induced In-Migration Management Strategy.
- Resettlement Action Plan.

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Appendices

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1 Introduction

Coffey has prepared this social impact assessment (SIA) on behalf of Frieda River Limited (FRL) to support the Environmental Impact Statement (EIS) as the statutory basis for the environmental assessment of the Sepik Development Project.

1.1 Project overview

FRL is assessing the feasibility of developing the nation-building Sepik Development Project in northern Papua New Guinea (PNG). The Sepik Development Project is primarily located within the Sepik River catchment and will comprise development of the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) copper-gold deposits in the Sandaun Province and supporting infrastructure and facilities in the Sandaun and East Sepik provinces. The Sepik Development Project consists of four interdependent projects:

- Frieda River Copper-Gold Project (FRCGP).
- Sepik Infrastructure Project (SIP).
- Frieda River Hydroelectric Project (FRHEP).
- Sepik Power Grid Project (SPGP).

This SIA has been prepared for all four elements of the Sepik Development Project: the FRCGP, SIP, FRHEP and SPGP (the Project).

The following sections describe the four interdependent projects that make up the Sepik Development Project.

1.1.1 Frieda River Copper-Gold Project (FRCGP)

The FRCGP is held by the Frieda River Joint Venture, an unincorporated joint venture between Frieda River Limited (FRL), a wholly owned subsidiary of PanAust Limited (PanAust), and Highlands Frieda Limited (HFL), a wholly-owned subsidiary of Highlands Pacific Limited. FRL manages the Project and holds an 80% interest; HFL holds the remaining 20% interest. The Independent State of PNG has a right, prior to the grant of a Special Mining Lease or Mining Lease to purchase up to 30% equity in the FRCGP. The FRCGP is located in the northern foothills of the Central Range of the New Guinea Highlands in Sandaun Province. It lies in a remote area approximately 200 kilometres (km) from the northern coast and 50 km from the Sepik River. The FRCGP area is characterised by steep terrain, very high rainfall, low population density and a near-absence of infrastructure such as road, power and communication networks (Figure 1.1).

The greenfield FRCGP is based on the HITEK porphyry copper-gold deposits which contain an estimated total combined Measured, Indicated and Inferred Mineral Resource (JORC classifications) of 2,640 million tonnes (Mt) at an average grade of 0.45% copper and 0.24 grams per tonne gold. Copper mineralisation was first identified at Frieda River in 1966/67 and the long history of exploration and study activities undertaken by several companies has generated a considerable body of information.

The FRCGP comprises a large-scale conventional open-pit mine operation feeding ore to a conventional comminution and flotation process plant producing a copper-gold concentrate for export to custom smelters. Mining inventory comprises 1,500 Mt of mill feed. The average annual copper-gold concentrate production will be 735,000 wet metric tonnes (wmt) and the average annual metal in concentrate production will be 175,000 tonnes (t) copper and 235,000 ounces (oz) gold. The FRCGP will have a mine life of approximately 33 years preceded by a seven-year implementation period. The large HITEK Mineral Resource together with additional known deposits, such as the Nena deposit, and exploration targets provide the potential for mine life extension. Figure 1.2 shows the general FRCGP layout around the open-pit and supporting infrastructure.

1.1.2 Sepik Infrastructure Project (SIP)

The mine will be accessed by the infrastructure corridor, which consists of an existing road from Vanimo to Green River Station and a new road through to Hotmin and to the site. In this SIA, all references to Green River relate to the place (i.e., Green River Station), rather than the river, unless otherwise noted. The Frieda River Port will also provide riverine access to the site, predominantly prior to construction of the road (Figure 1.3).

This infrastructure corridor forms part of the SIP, which consists of an upgrade to the existing Green River airstrip and regional road servicing the FRCGP located in both the Sandaun Province and the East Sepik Province. It also includes an upgrade to the port located at Vanimo. There is an opportunity to connect the regional road through to Telefomin, however this not required for development of the FRCGP and therefore is not included in the EIS nor SIA.

The majority of the workforce will access the site from the existing airstrip at Green River which will be linked to the mine site by road (Figure 1.3).

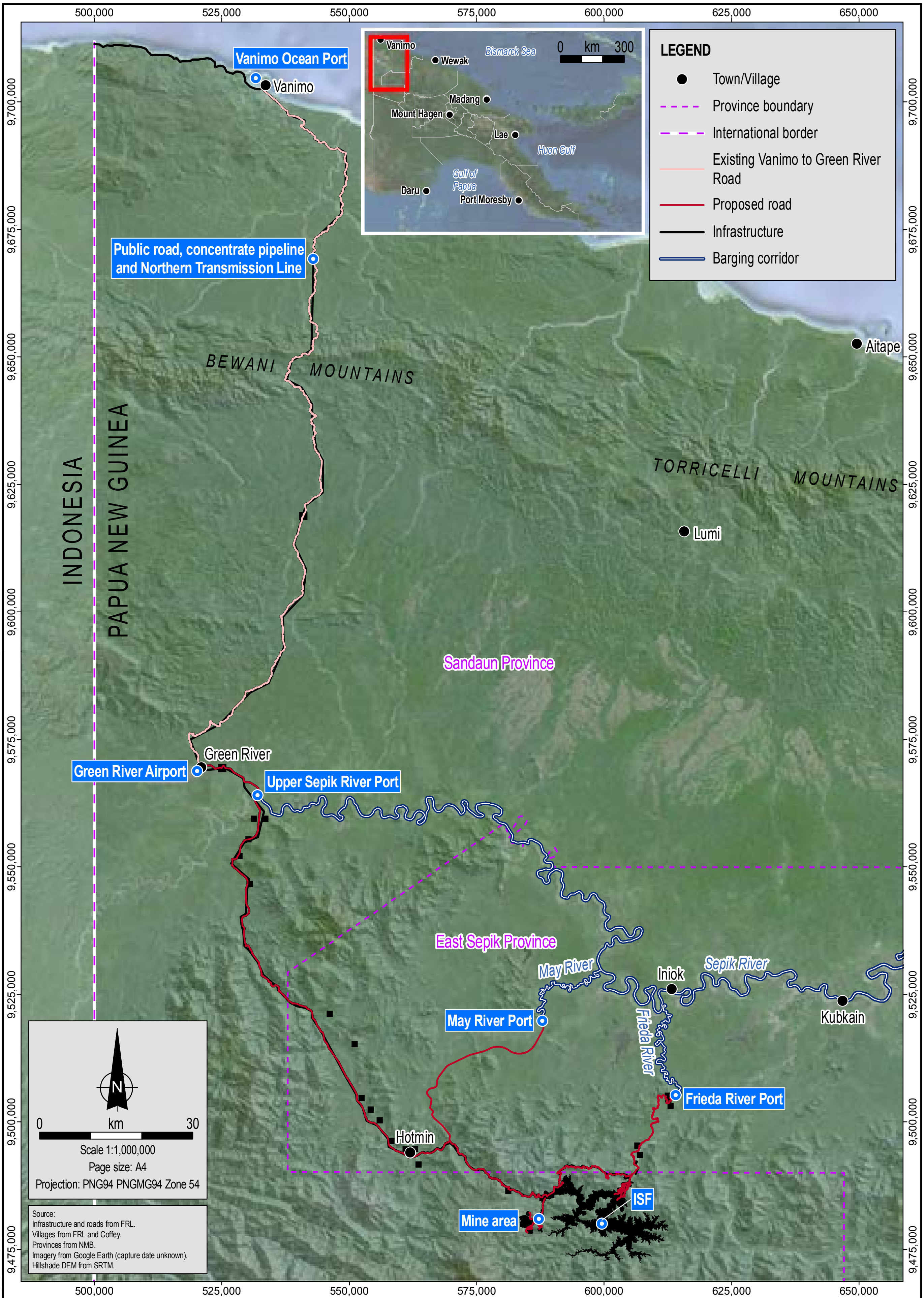
The copper-gold concentrate will be transported from the process plant via a 325 km-long concentrate pipeline located within the infrastructure corridor to a concentrate drying, storage and export facility located at the Vanimo Ocean Port (Figure 1.1).

1.1.3 Frieda River Hydroelectric Project (FRHEP)

The FRHEP reservoir will be located within the Frieda, Nena and Niar river valleys downstream of the mine site. A 600 MW hydroelectric facility will use water from the FRHEP reservoir to generate low-cost power to the FRCGP and supply excess power to other consumers via the SPGP's Northern Transmission Line (Figure 1.2). The hydroelectric power generation facility will have an annual maximum energy generation of 2,800 gigawatt hours per year (GWh/year) (up to 470 MW). The mine's power demand will reach up to 280 MW by Year 8 which provides an opportunity for the export of excess power to other customers.

The FRHEP final embankment will be approximately 190 m (238 m Reduced Level (RL)) in height, utilising 30 million cubic metres (Mm^3) of fill material and creating a total storage capacity in the ISF of 9.6 billion cubic meters (Bm^3), which translates to 4.6 billion tonnes (Bt) of maximum waste rock and tailings storage capacity. The operating water level will be 226 m RL.

The FRHEP will provide storage for both tailings and waste rock. Over the life of the mine approximately 1,450 Mt of waste rock will be extracted. To limit the potential for this material to generate acid and metalliferous drainage, best practice waste management will include subaqueous deposition of the mine waste rock and tailings in the FRHEP.



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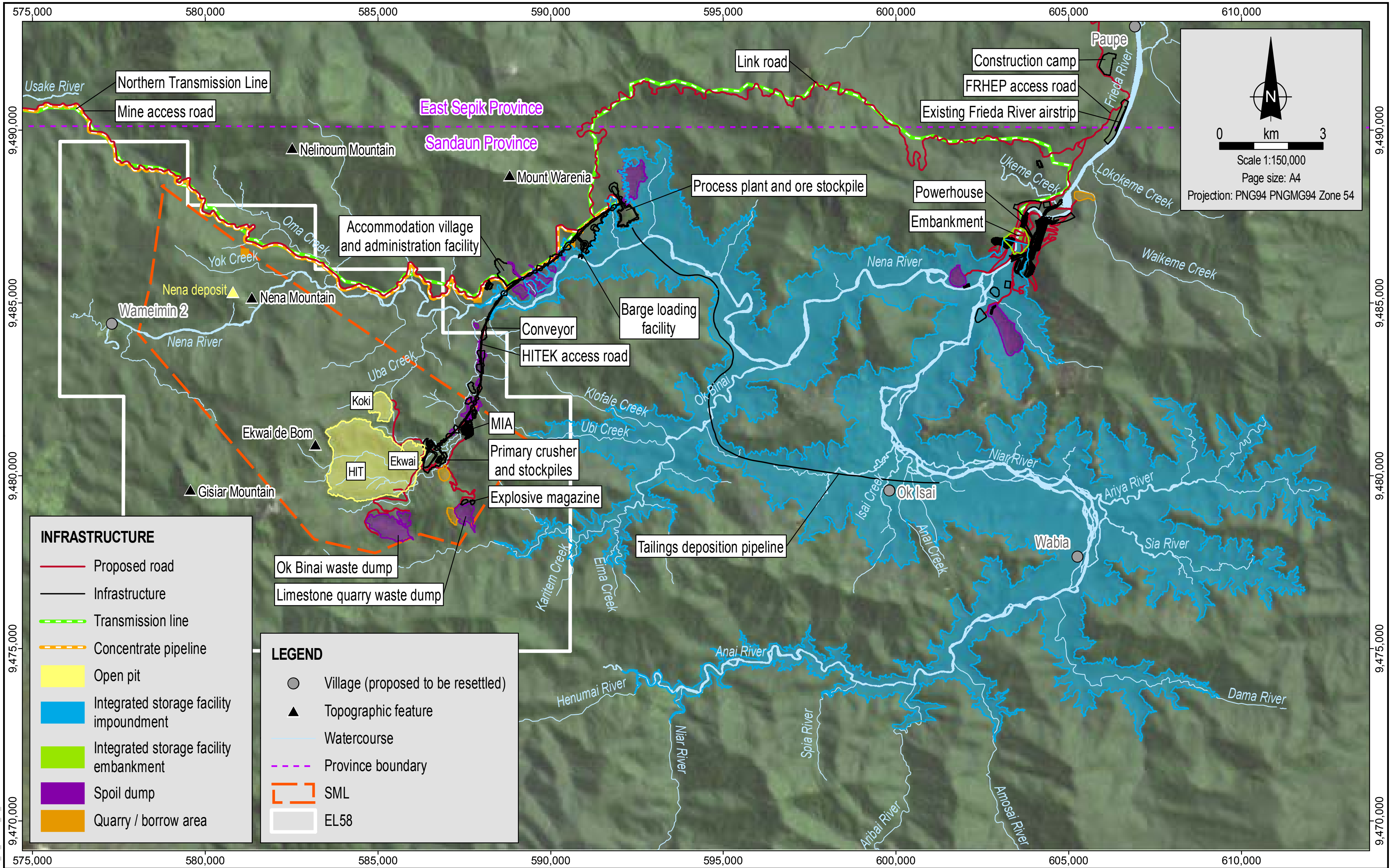
coffey A TETRA TECH COMPANY	Date: 07.09.2018 Project: 754-ENAUABTF11575B File Name: 11575_15_F01.01_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Project overview	Figure No: 1.1



MXD Reference: 11575B_15_GIS002_v0_2

Source:
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown).
Hillshade DEM from SRTM.

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Project: 754-ENAUABTF11575A
File Name: 11575_15_F01.02_GIS

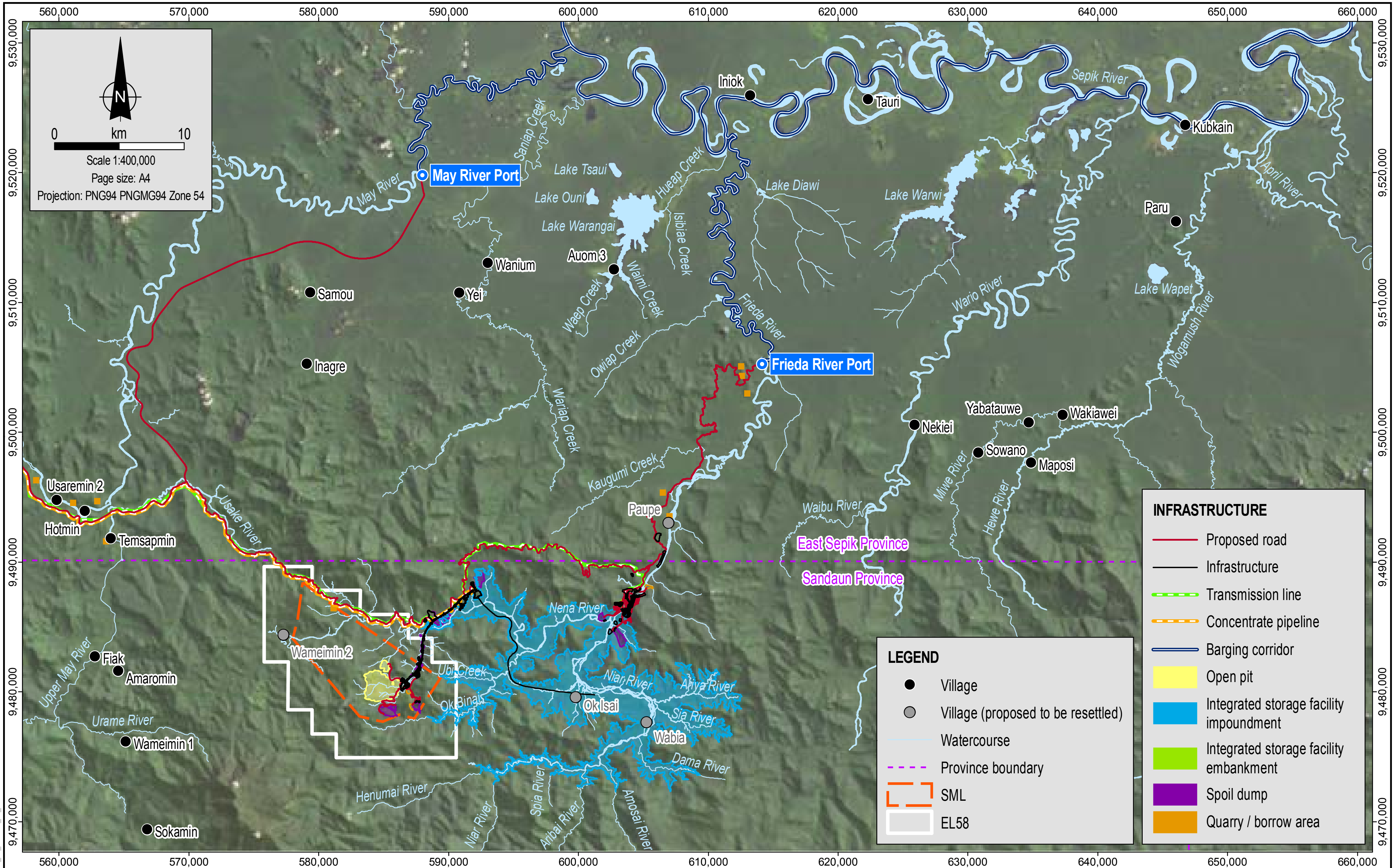
Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Mine and ISF area

Figure No: 1.2



Source:
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown).
Hillshade DEM from SRTM.

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Date:	07.09.2018
Project:	754-ENAUABTF11575B
File Name:	11575_15_F01.03_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Mine and FRHEP area, and downstream corridor

Figure No: 1.3

1.1.4 The Sepik Power Grid Project (SPGP)

The SPGP is a potential future opportunity that provides a connection between the FRHEP and potential customers in the northwest of PNG. The excess power from the FRHEP provides an opportunity to supply high voltage power to industries such as agriculture, fisheries, food and timber processing, mining and manufacturing. It will also allow for rural electrification along transmission line routes, through the installation of a 19.1 kV single wire earth return line, and potentially for power export to population centres in neighbouring Indonesia.

1.1.5 Key Project characteristics

Table 1.1 provides a description of the key characteristics of the Project.

Table 1.1 Key characteristics of the Sepik Development Project

Item	Key Characteristics
Frieda River Copper-Gold Project	
Mining method	Large-scale open-pit.
Mining	Approximately 1,500 Mt of mill feed and 1,450 Mt of waste rock to be mined from the open-pit over the life of the mine. Life of mine strip ratio of 1:1 (waste rock:ore).
Open-pit dimensions (ultimate pit)	The Horse-Ivaal-Trukai (HIT) open-pit will be 2.6-km-long and 2.4-km-wide, the Ekwai open-pit will be 0.8-km-long and 0.6-km-wide and the Koki open-pit will be 0.7-km-long and 0.9-km-wide. The Ekwai open-pit void will be used as an intermediate ore stockpile and contact water sump.
Mine life	Approximately 33 years (with an additional 7-year implementation period).
Mining rate	Average mining rate of 45 Mt/year of mill feed and 42 Mt/year of waste rock and peak total material movements of 135 Mt/year. The total material mined over the life of mine will be 2,950 Mt comprising 1,500 Mt of mill feed (0.45% copper and 0.24 g/t gold) and 1,450 Mt of waste rock.
Processing method	Primary crushing, grinding and flotation circuit. Initially 1 x 28 MW SAG and 2 x 22 MW ball mills expanding to 2 x 28 MW SAG and 4 x 22 MW ball mills in Year 8.
Mill throughput	Nominal volumetric ore processing rates are: • Years 1 to 7: up to 49 Mt/year (6,000 t/h). • Year 8 to LOM: up to 65 Mt/year (8,000 t/h).
Concentrate and metal production	Concentrate and metal production will include: • Average copper-gold concentrate production of 735,000 wmt per year with a peak of 1.1 million wet metric tonnes per year at 9.5% moisture. • Average copper production 175,000 t per year (peak of 290,000 t per year). • Average gold production 230,000 oz per year (peak of 370,000 oz per year).

Item	Key Characteristics
Tailings and waste rock storage	A spoil dump will be developed in the headwaters of the Ok Binai. This spoil dump will store non-acid forming (NAF) waste rock from Year -1 and organic pre-strip material over the 33-year mine life. All waste rock (other than that reporting to the Ok Binai waste dump) including PAF waste rock will be placed within the ISF by barge. At the barge loading station the waste rock will be stockpiled, reclaimed and loaded into 5,000 t barges. The barges will transport and deposit the waste rock for subaqueous storage in the ISF. Thickened tailings will be pumped via a dedicated pipeline from the process plant for subaqueous storage in the ISF.
Power requirement and distribution	Power demand for the mine: • Approximately 180 MW (1,400 gigawatt hours per year (GWh/year)) energy demand increasing to 280 MW (2,200 GWh/year) in Year 8. Power demand offsite: • Vanimo Ocean Port concentrate and logistics facilities – 4 MW (23 GWh/year). • Two concentrate booster pump stations – 7 MW (42 GWh/year) each. Power supply to the process plant will be provided by a 22-km, 132 kV transmission line from the hydroelectric powerhouse. Power supply to the offsite facilities will be provided by the Northern Transmission Line as part of the SPGP.
Raw water requirement and supply	Raw water will be sourced from the FRHEP at a rate of up to approximately 3,800 cubic metres per hour (m^3/h) for ore processing and general non-potable consumption. Potable water will be sourced by treating water from the Nena River upstream of the ISF and pumped to the site accommodation village.
Mine infrastructure area	The mine infrastructure area (MIA) will be located close to the HITEK open-pit. The MIA will consist of the following major facilities: • Workshops. • Warehouse. • Muster, training and dining areas. • Bulk fuel storage.
Overland logistics	Overland logistics includes: • 39 km mine access road from Hotmin to the mine (unsealed 7.5 m-wide dual-lane). • 33 km unsealed 7.5 m-wide dual-lane Link Road from the powerhouse to the mine. • A buried 325-km-long pipeline providing transport of concentrate to the Vanimo Ocean Port. • Equipment and goods will be transported via road along the main access route during operations.

Item	Key Characteristics
	• Coaches will be used to transport personnel between points of hire along the public road and from the Green River Airport to the mine.
Ocean/riverine logistics	During construction, freight will be imported via existing ports at Wewak, Lae and Madang and barged upstream along the Sepik River to the Frieda or May river ports until upgrade of both the Vanimo Ocean Port and the Vanimo to Green River Road has been completed. Freight will then be trucked from Vanimo to Green River and barged from the Upper Sepik River Port downstream along the Sepik River. Once the main access route from Green River to the mine is complete all freight will be trucked to site. During operations, freight will be imported via the upgraded Vanimo Ocean Port and trucked to site. Barge freighting may occasionally be required. Bulk ocean carriers for concentrate export, multipurpose feeder vessels for containerised cargoes and parcel tankers for diesel will be utilised. Riverine transport will be used during operations on an as required basis.
Employment (staff and on-site contractors)	**Construction:** Peak construction workforce of approximately 2,800 personnel. **Operations:** Average of approximately 2,000 personnel.
Accommodation	**Construction:** The main construction camp will be located in the Nena River valley approximately 5 km from the process plant and will accommodate up to 3,550 personnel. **Operations:** A site accommodation village at the mine site will house approximately 2,780 personnel with a further 100 personnel to be accommodated at Vanimo for office, logistics and port operations.
Frieda River Hydroelectric Project	
Power supply	Hydroelectric power generation will be produced using Francis turbines with an installed hydroelectric power capacity of up to approximately 600 MW. The hydroelectric power generation facility will have an annual maximum energy generation of 2,800 gigawatt hours per year (GWh/year) (up to 470 MW). The mine's power demand will reach up to 280 MW by Year 8 which provides an opportunity for the export of excess power to other customers. The powerhouse will be approximately 190 m x 34 m in size and will be located at the toe of the embankment. The powerhouse complex will include: • Tunnel exit portal and penstocks. • Main turbine hall housing the generating equipment. • Erection bay and workshop area for assembling the power generation equipment and undertaking maintenance. • Local control room and office facilities. • Electrical equipment rooms. • Step-up transformers and adjacent substation building. • A tailrace discharging to the Frieda River. • A penstock pipeline to connect the tunnel to the powerhouse.

Item	Key Characteristics
Design	The FRHEP will include an engineered ISF for the storage of construction spoil, mine waste rock and tailings, and sediment control. The embankment will be located in the Frieda River Valley and has been designed as an engineered rock-fill embankment with a central asphalt core. Design characteristics include: • Embankment height of 190 m (at 238 m RL) using 30 million cubic meters (Mm^3) of fill material. • Crest elevation of 238 m RL and maximum operating water level of 226 m RL. • Total water storage capacity of 9.6 billion cubic metres (Bm^3). • Maximum waste rock and tailings storage capacity of 3.3 Bm^3 (approximately 4.6 Bt). • Designed to store and release water from a Probable Maximum Flood event (30,000 m^3/s). • Designed to withstand maximum credible earthquake peak ground acceleration of 1.09 grams (g). • Catchment area of 1,033 km^2. • Operating life of greater than 100 years.
Construction facilities	The FRHEP will require the development of the following site-based facilities to allow construction of the embankment, spillway and powerhouse: • Quarry. • Coffer dams. • Diversion tunnels. • Concrete batch plant. • Maintenance workshop. • Geotechnical laboratory. The FRHEP will be constructed in a single stage over a 5-year construction duration.
Overland logistics	40 km unsealed 7.5-m-wide dual-lane FRHEP access road from the Frieda River Port to the powerhouse.
Ocean/riverine logistics	The Sepik and Frieda rivers will support transport of construction materials for the FRHEP. The rivers will also provide a contingency in the event of loss of access along the infrastructure corridor.
Employment (staff and on-site contractors)	• **Construction:** Peak construction workforce of up to approximately 2,300 personnel. • **Operations:** Approximately 100 personnel.
Accommodation	• **Construction:** The FRHEP construction camp near the powerhouse will house up to 3,270 personnel. • **Operations:** An accommodation village near the powerhouse will house up to 420 personnel, which includes sufficient beds for shutdown periods.

Item	Key Characteristics
Sepik Infrastructure Project	
Vanimo to Green River Road and Hotmin Road (public)	The existing road from Vanimo to Green River will be upgraded, and a new public road constructed from Green River to Hotmin. The road will be 7.5-m-wide with a gravel pavement surface, built to allow for 12-tonne axle loading. Some road sections may be sealed during the operations phase. The road will allow for public transport, commercial ventures and access to new markets.
Sepik River bridge	A new bridge will be built on the Hotmin Road at the Sepik River, consisting of: • Steel box girder superstructure. • Dual-lane deck with 8.0 m width between kerbs. • Total bridge length of 350 m. A cross-river ferry service will be required during construction of the bridge.
Green River Airport	The existing airstrip at Green River, located 150 km from the mine area, will be upgraded for commercial use. The airstrip will be made suitable for up to Lockheed C-130 sized aircraft. The new facilities will include a terminal with the capacity for 80 passengers, baggage handling facilities, immigration and customs, freight handling and storage facilities.
Vanimo Ocean Port	Construction of two new berths at the Vanimo Ocean Port to provide import and export facilities for the Project and other users.
Employment (staff and on-site contractors)	**Construction**: Peak construction workforce of up to approximately 900 personnel.
Sepik Power Grid Project	
Northern Transmission Line	A 370-km-long 275 kV transmission line from the FRHEP to the Indonesian border via Vanimo. The Northern Transmission Line will provide power to the FRCGP facilities based at Green River and Vanimo. Excess power may be made available for a power distributor to sell to regional users within PNG and for export to Indonesia. The Northern Transmission Line will be located within the infrastructure corridor and will follow the existing Vanimo-Jayapura Highway from Vanimo to the Indonesian border.
Substations	Three substations will be located along the Northern Transmission Line at the FRCGP site accommodation village, near Green River and at Vanimo.
Distribution Line	A 19.1 kV single wire earth return will be installed along the Northern Transmission Line to allow a power distributor to sell excess power to communities along the infrastructure corridor.
Employment (staff and on-site contractors)	**Construction**: Peak construction workforce of approximately 300 personnel.

1.1.6 Development schedule

The indicative schedule for the EIS and associated government approvals and construction and commissioning of the Project is shown in Figure 1.4.

Key milestones in the Project schedule are:

- Submission of the Environmental Inception Report, Notice of Intent and Environment Permit application to Conservation and Environment Protection Authority (CEPA) on 20 December 2017.
- Completion of the 2018 Feasibility Study in Q4 2018.
- Registration of the revised Special Mining Lease (SML) and associated tenement applications by the Minerals Resources Authority (MRA) in Q4 2018.
- Submission of the EIS and acceptance of the EIS by CEPA in Q4 2018.
- Receipt of EIS approval in principle.
- Receipt of environment permit.
- Grant of SML and other associated tenements.
- Commencement of critical detailed design in Year -8.
- Final Investment Decision for the Project in Year -7.
- Commencement of preconstruction enabling works in Year -7.
- Commencement of construction at end of Year -7.
- Commissioning and commencement of mining in Year -1.
- Production and export of first concentrate in Year 1.

1.1.7 Workforce and recruitment

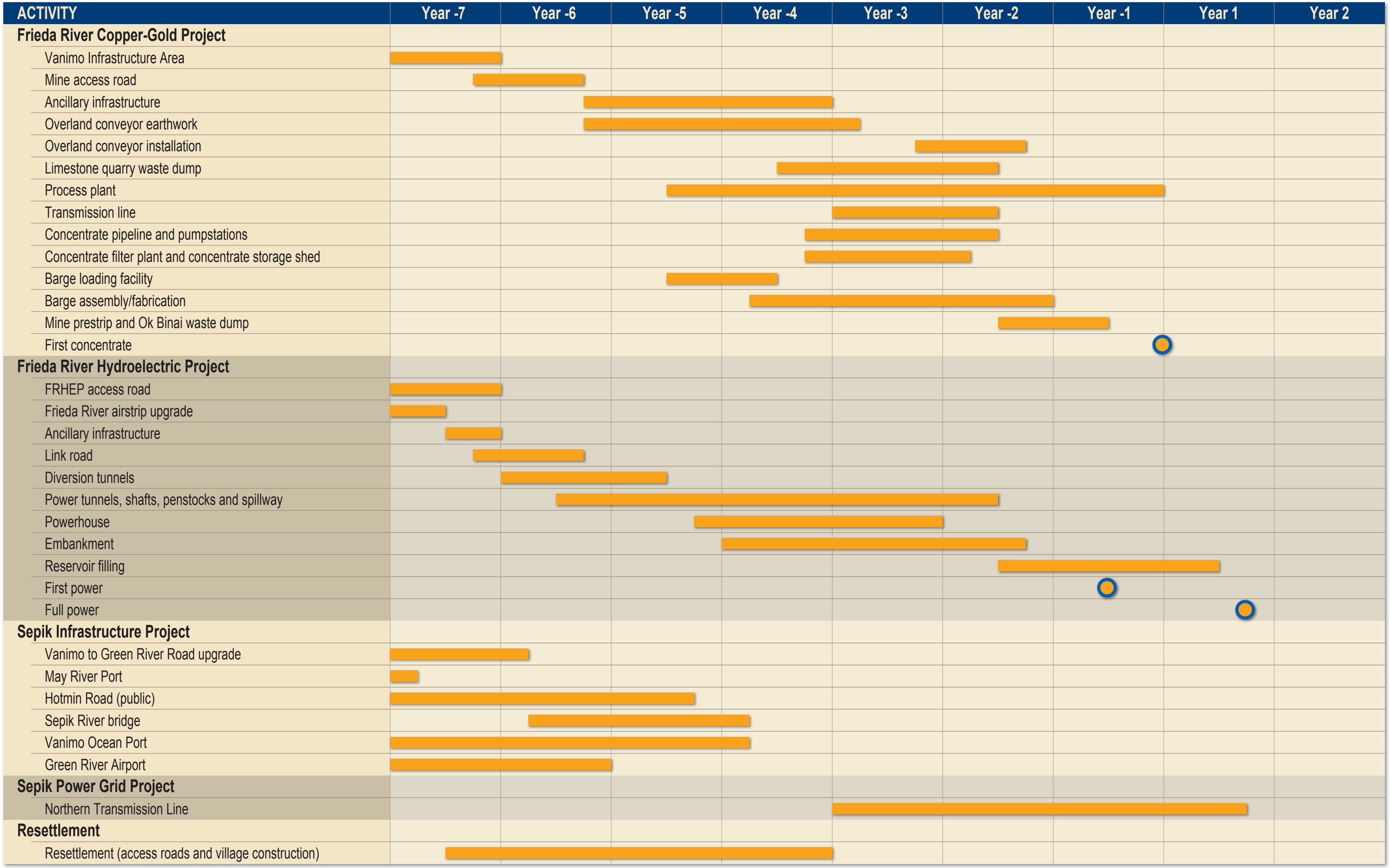
The Project is expected to have a long operational life of 33 years for the FRCGP and approximately 100 years for the FRHEP, preceded by a seven-year implementation period. Additional known resources together with exploration potential may provide an opportunity to further extend the mine life. A long-life Project provides time for local communities to build intergenerational capacity to benefit from employment during the operations phase. Workers sourced from local communities can be supported to assist with transition through the skills pipeline from unskilled, to semi-skilled and skilled roles. This approach will enable the Project to localise key roles over the life of the FRCGP and FRHEP.

Approach to recruitment

Recruitment will prioritise sourcing labour within PNG to the extent possible, in compliance with PNG employment regulations, with expatriates only employed where required skills and experience are not available within PNG.

FRL has designated six recruitment zones for employment (see Figure 1.5 for the four zones for PNG). The zones, in decreasing order of employment preference, are:

- Zone 1: PNG national. Landowning communities of the SML, Mining Lease (ML) and the Leases for Mining Purposes (LMP) made up of the villages Wabia, Ok Isai, Paupe, Wameimin 2, Wameimin 1, Sokamin and Amaromin.



Milestone
Task

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Date: 26.09.2018
Project: 754-ENAUABTF11575B
File Name: 11575_15_F01.04_GRA

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Sepik Development Project indicative development schedule

Figure No: 1.4

AI Reference: 11575_15_GRA001.ai_6

- Zone 2: PNG national. Any community within the Telefomin LLG and the western part of the Tunap Hunstein LLG, along the infrastructure corridor, and along the Sepik River downstream of the Frieda River.
- Zone 3: PNG national. Sandaun and East Sepik provinces.
- Zone 4: PNG national. Any other provinces within PNG.
- Zone 5: Australia.
- Zone 6: Asia.

The FRCGP will be a fly-in fly-out (FIFO) and drive-in drive-out (DIDO) operation with approximately seven flights using Twin Otter aircraft to regional airstrips and fourteen 50 seater flights to commercial airport hubs each week. Buses will be used to transport personnel between points of hire along the public road and from the Green River Airport to the mine and FRHEP sites.

Workforce

During the seven-year implementation period, workforce numbers onsite will peak at approximately 5,200, including approximately 2,300 contractors for the FRHEP. The main construction camp will be located in the Nena River valley approximately 5 km from the process plant.

Two shifts of 12 hours each will be in operation and employees will typically work a six week on (42 days) and two week off (14 days) roster. Operations staff for FRL and contractors is estimated at approximately 2,500 personnel including hydroelectric power facility operation, which will be approximately 100 personnel.

Table 1.2 shows the proportion of roles with associated rosters.

Table 1.2 Proportion of roles and rosters

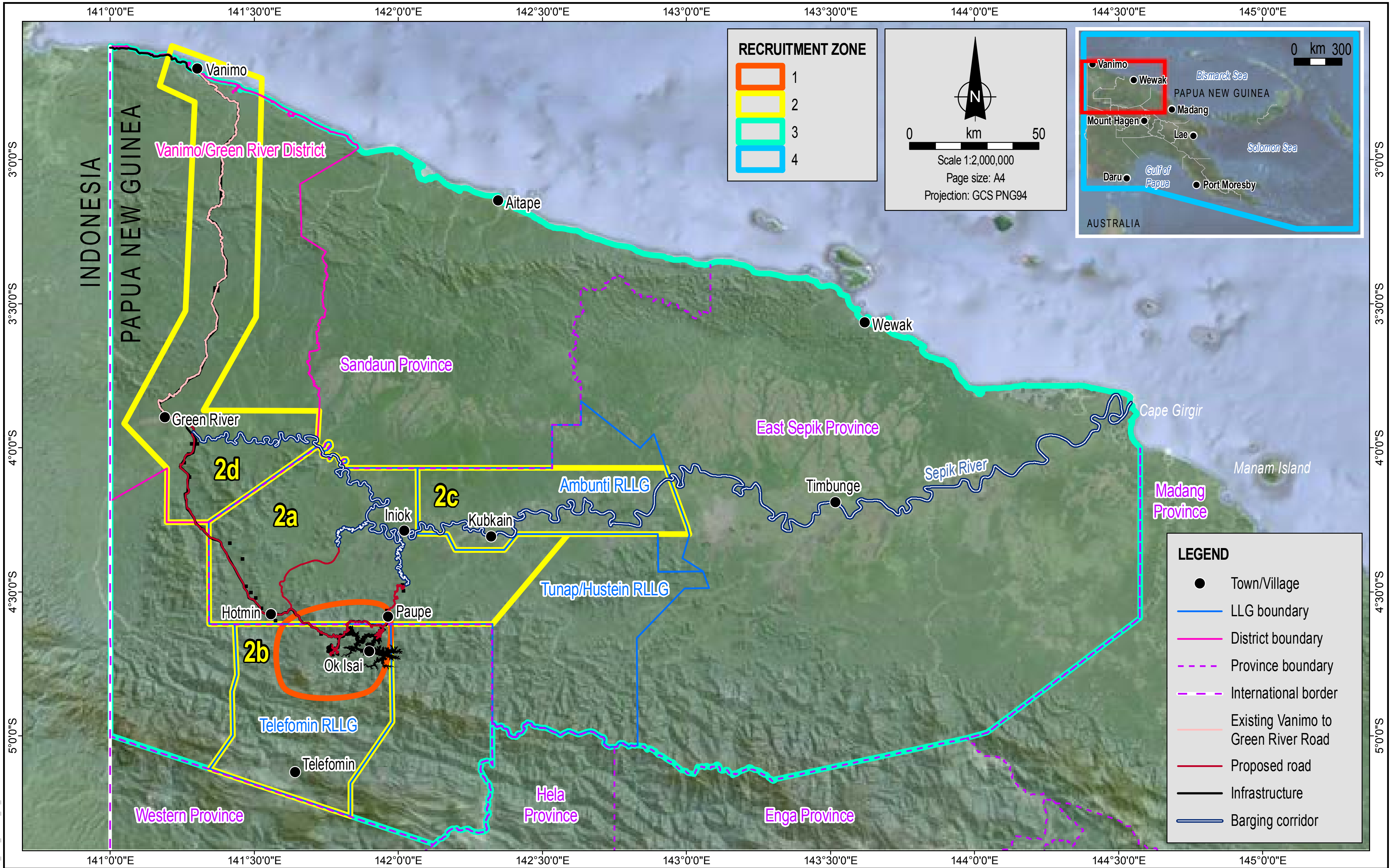
Role	Proportion (%)	Roster (days on/days off)	Hours per shift
Manager	5	9/5	12
Day worker	40	18/10	12
Continuous shift worker	40	21/10 or 11	12
Southeast Asian expatriates	10	42/14	12
Vanimo / Port Moresby / Brisbane (off site workers)	5	5/2	9

The following shift arrangements will be established to facilitate the FRCGP's 24-hour operation:

- All site work will be based on a nominal 6.00 a.m. to 6.00 p.m. shift.
- Mine and concentrate export facility: a 12-hour day and night shift commencing at 6.00 a.m. and 6.00 p.m., respectively.

1.1.8 Life of mine and Project investment

Following a seven-year implementation period, the mine life for the FRCGP is expected to be approximately 33 years. The FRHEP is expected to have an operating life in excess of 100 years.



Source:
Recruitment zones, infrastructure and roads from FRL.
Villages from FRL and Coffey.
Provinces from NMB.
Imagery from Google Earth (capture date unknown).
Hillshade DEM from SRTM.

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Date: 29.08.2018
Project: 754-ENAUABTF11575B
File Name: 11575_15_F01.05_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Sepik Development Project recruitment zones

Figure No: 1.5

MXD Reference: 11575B_REV_GIS005_v0_4

The total initial capital investment for the Sepik Development Project will be up to US$6.9 billion (PGK21.7 billion[2] in October 2018) in real terms (ACIL Allen, 2018).

1.2 Project history

Copper mineralisation was first discovered in the Frieda River area in 1966/67 and potential commercial mineralisation identified in the early 1970s. Since that time, the area has been subject to exploration and study activities undertaken by several companies.

Baseline environmental and social investigations for the FRCGP began in 1979 via a joint taskforce consisting of Frieda Copper Pty Ltd and the PNG Government. The scope of work included investigating the Horse-Ivaal porphyry copper-gold deposit as well as the nearby Nena epithermal copper-gold deposit. Various activities and investigations continued intermittently through the 1980s and into the 1990s. By mid-1993, the Nena deposit had become the focus of development activities and was subjected to renewed environmental investigations by Highlands Gold Properties Proprietary Limited (subsequently renamed Highlands Pacific Limited). The evaluation studies completed up to 1997 did not define an economically viable project.

Xstrata Frieda River Limited (XFRL, subsequently renamed Frieda River Limited) acquired the tenements in October 2006 following a period of relative inactivity in the late-1990s and early-2000s, and initiated a scoping study defining an execution model for the FRCGP that could be taken into pre-feasibility study. As part of that process a number of environmental and social programs were re-established. These programs were supplemented by the extensive investigations undertaken in support of an EIS that was completed in December 2011. The EIS was not submitted to the regulatory authorities as the owners decided not to proceed with the FRCGP at that time.

In 2013 the owner of Xstrata Frieda River Limited, Xstrata PLC, merged with Glencore International PLC to form Glencore Xstrata plc (subsequently renamed Glencore plc). On 1 November 2013, PanAust announced it had entered into a share sale and purchase agreement with a subsidiary of Glencore Xstrata plc to acquire Glencore's interest in the FRCGP. On 25 August 2014, PanAust confirmed the purchase of the FRCGP from Glencore had been completed. Xstrata Frieda River Limited was renamed Frieda River Limited.

FRL completed a feasibility study in May 2016 that re-assessed the FRCGP scale, scope and implementation arrangements. This included assessing mine waste storage options, refining the mineral resource estimate, and reducing the implementation risk by having a staged mine waste management plan.

This study built on the body of knowledge since 2007 and refined the work of previous studies including comprehensive environmental, socio-economic and cultural heritage baseline data.

In 2016, Coffey prepared an EIS for the FRCGP which was submitted to CEPA in December 2016. There are three key changes to the proposed Project since the submission of the 2016 EIS: the inclusion of the FRHEP; inclusion of an infrastructure corridor to Vanimo together with an upgrade of the Vanimo Port as part of the SIP; and an extension of the mine life from 17 years to approximately 33 years. The scale and nature of these changes mean that a new EIS and SIA is required.

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[2] US dollars are converted to Kina at an assumed exchange rate of US$1.00 = 3.15 Kina.

The long history of study activities has generated a considerable body of information and a large number of reports that address both the environmental and social aspects of the Project area. Many of the social studies undertaken by the previous owner remain relevant to the current proposed Project and have informed this SIA, together with additional studies undertaken by FRL between 2015 and 2017.

Table 1.3 provides a chronology of previous developments in the Project area.

Table 1.3 Previous developments

Date	Development
1966-67	Australian Bureau of Mineral Resources first identified copper mineralisation in the Frieda River area.
1968	Mount Isa Mines' exploration arm, Carpentaria Exploration, was granted an Exploration Licence (Authority to Prospect No. 58).
1968-72	Porphyry-style mineralisation was identified at the Koki and Horse deposits.
1974-87	Exploration was managed by Sumitomo Metal Mining Co. Ltd and Mount Isa Mines Ltd.
1975	Nena deposit was discovered, with the first mineral resource estimated in 1982.
1979	OMRD Frieda Co Ltd, CRA Exploration Pty Ltd and Norddeutsche Affinerie entered the Project.
1987	Mount Isa Mines transferred Project interest to wholly owned subsidiary Highlands Gold Properties Pty Ltd; Mount Isa Mines sells Highlands Gold in 1990.
1993	CRA Exploration Pty Ltd and Norddeutsche Affinerie sold Project interest to Highlands Gold Ltd.
1993-96	Highlands Gold Ltd completed exploration and a pre-feasibility study on the Nena, Horse/Ivaal and Koki resources.
1997	Highlands Gold Ltd was purchased by Placer Dome and 85% equity in Frieda River Project transferred to a new entity, Highlands Pacific Ltd. The remaining Project interest is held by Japanese consortium OMRD Frieda Co.
1998	Cyprus-Amax Minerals entered into a joint venture agreement with Highlands Pacific Ltd and OMRD Frieda Co Ltd. Cyprus-Amax exit Project in 1999.
2002	Highlands Pacific Ltd entered into joint venture agreement with Noranda Pacific and OMRD Frieda Co Ltd.
2005	Noranda Pacific Ltd merged with Falconbridge and Xstrata entered the Project through acquisition of Falconbridge in 2006.
2007	Xstrata Frieda River Ltd (Xstrata Copper) exercised management option and enters a joint venture with Highlands Pacific and OMRD Frieda Co. Ltd. to complete a scoping study.
2008-10	Xstrata Copper completed an extended scoping study and pre-feasibility study and commenced studies to support an EIS. OMRD exits the Project in 2009.
2010-11	Xstrata Copper conducted a Feasibility Study.
2011	Xstrata completed an EIS but did not submit it to the regulatory authorities as the FRCGP was not considered financially feasible.
2013	Xstrata PLC merges with Glencore International PLC forming Glencore Xstrata PLC.
2014	PanAust Limited (PanAust) acquires Glencore Xstrata PLC's interest in the Frieda River Project. Frieda River Limited formed.
2015	Guangdong Rising H.K. (Holding) Limited acquired 100% ownership of PanAust.

Date	Development
2015-16	Frieda River Limited prepared an SML application and Proposals for Development (including a Feasibility Study) to satisfy a condition of EL58. These were submitted to and accepted by MRA in June 2016. Frieda River Limited completed a scoping study, prefeasibility study and studies to support the EIS which was submitted to CEPA in December 2016.
2017	Key Project changes since submission of EIS to CEPA in December 2016 lead to requirement for new EIS and SIA.

1.3 Social impact assessment study scope

1.3.1 Preliminary scoping assessment

On 20 December 2017, a Notification of Preparatory Work, environment permit application and environment inception report (EIR) were submitted to CEPA for the current Project concept. The EIR was approved by CEPA on 14 February 2018.

This SIA addresses the issues set out in the EIR[3] and substantially complies with the Department of Environment and Conservation's (DEC, now CEPA) information guideline for conduct of environmental impact assessment and preparation of environmental impact statement (DEC, 2004). The guideline requires the EIS to assess potential environmental and social impacts of the Project and to describe how the proponent intends to avoid, manage or mitigate those impacts. This SIA also addresses CEPA feedback on the EIR regarding the scope of investigations to be covered in the EIS.

The PNG Guideline for preparation of an EIR stipulates that socio-economic impacts be differentiated into two distinct groups (Group A and Group B) to make clear which impacts will occur as either a direct or indirect result of the Project. As described in DEC (2004):

> *Group (A) impacts are those that can be identified and addressed by the DEC approval process. They arise directly from adverse impacts upon the biophysical environment as caused by the development.*
>
> *Group (B) impacts are secondary [indirect] effects that are reasonably expected to manifest themselves [which can be attributed to the Project] and are normally best handled by the responsible National, Provincial or Local Level Government agencies.*

The social aspect of the EIR was informed by various social and land investigation studies conducted by FRL, XFRL and other previous proponents. The results of the EIR formed part of the scoping phase of the SIA, as it:

- Identified the potential environmental and social issues associated with developing the Project.
- Described the scope of the EIS (and, as part of it, the SIA) to address those issues.
- Initiated the formal process of stakeholder consultation.
- Enabled CEPA to review the proposed EIS scope and provide input.

Table 1.4 outlines the main potential socio-economic impacts that were identified in the EIR.

[3] With one exception: the alluvial and small-scale mining study. Community surveys sought information on levels of household income, primarily derived from employment by FRL and alluvial gold mining for mine area villages. Due to uncertainty surrounding income levels stated by respondents, FRL has commissioned a more detailed longer-term alluvial and small-scale mining study to inform the negotiation of compensation agreements. The results of this study are not yet available.

Table 1.4 Potential socio-economic impacts identified in the EIR

Potential impact
Group A Potential Impacts (Direct)
Physical and economic displacement of villages due to the development of the FRHEP.
Loss of land due to the establishment of Project components and consequent impacts on livelihoods due to loss of resources such as alluvial gold areas, gardens and hunting and gathering areas.
Health impacts on residents in downstream villages, associated with the uptake of contaminant metals from discharged surface water and fugitive sediment associated with the Project.
Reduced amenity from reduction in air quality, increased noise and visual impact and associated consequences on quality of life for affected people.
Loss of or damage to archaeological or cultural sites and practices.
Increased direct employment and training opportunities for employees, landowners and other affected communities.
Improved road access for villages between the mine site and Vanimo.
Increased incomes from employment and other benefit streams.
Generation of new business opportunities to directly service the Project, with consequent increased local incomes.
Effects on the general quality of life of local villagers and those living downstream from the FRCGP, with particular focus on their livelihoods, subsistence resource use, river use, income derivation, and local culture and customs.
Group B Potential Impacts (Indirect)
Increased government revenue from taxes, fees and other payments.
Increased in-migration and associated potential impacts on social cohesion, safety and security, health, land use, services, infrastructure and accommodation.
Increased law and order issues resulting from migration, increased mobility and altered social structures and relationships.
Increased incidence and spread of communicable diseases including HIV/AIDS.
Regional and local electrification arising from FRHEP commercial power distribution and sale.
Large scale renewable power generation from the FRHEP.
Ongoing generation of human, as well as financial, capital, which may underpin further economic and social development in PNG.
Continuity within the PNG mining sector and with it the maintenance of expertise, on which PNG’s future mining industry depends.
Indirect stimulation of PNG’s economic sectors that drive local, provincial and national economic growth.
Improved national balance of trade, infrastructure development and commercial, employment and educational opportunities.

1.3.2 Purpose and objectives

The purpose of the SIA is to assist decision-makers and Project stakeholders to determine whether the changes that the Project will bring to the socio-economic environment are able to be managed in the event of the Project proceeding.

The objectives of the SIA are to:

- Describe the socio-economic characteristics of the region including the existing land and natural resource use of the Project area.
- Identify the socio-economic factors that may pose constraints in terms of the siting of Project facilities and/or which may otherwise require particular management.
- Identify the potential negative socio-economic impacts associated with the Project and develop methods for managing the risks associated with these.
- Identify the potential positive socio-economic benefits resulting from the Project and develop strategies for maximising those benefits, primarily for Project-affected stakeholders.
- Provide an assessment of residual socio-economic impact following the application of mitigation and management measures.

1.3.3 Study area

The geographic areas and their constituent communities subject to potential influence from the Project have been broadly defined through consideration of:

- Community location, including watershed boundaries and proximity to the Project's footprint and likely lease boundaries.
- Type of Project activity that may potentially occur in proximity to communities.
- Language group or cultural affinity of the villages, including landownership of project SML and LMP areas, i.e., communities of interest.

Taking such factors into account the following SIA catchment areas were defined:

- **Social Catchment 1A: Mine area.** Comprising landowner communities from the Miyan, Telefol and Paiyamo language groups comprising seven villages located close to mine site infrastructure or activities.
- **Social Catchment 1B: New infrastructure and road corridor, Hotmin to Green River.** Comprising landowner communities from the Miyan, Bo, Abau and Iwam language groups located in proximity to the new infrastructure and road corridor between Hotmin, May River Port and Green River.
- **Social Catchment 1C: Existing infrastructure and road corridor, Green River to Vanimo.** Comprising landowner communities from the Kwomtari and Fas language groups located along the existing infrastructure and road corridor between Green River and Vanimo.
- **Social Catchment 1D: Vanimo Ocean Port.** Comprising landowner communities from the Vanimo language group located within proximity to the Vanimo Ocean Port.
- **Social Catchment 2: Sepik River corridor.** Extending from the proposed Sepik River bridge crossing to the mouth of the Sepik River (and including the proposed May River Port and Auom 3), comprising communities from several language groups along the upper, middle and lower section of the river.
- **Social Catchment 3: Sandaun and East Sepik provinces.** Acknowledging that the location of the Project's infrastructure and activities extends across two provinces (Sandaun and East Sepik) and will have an effect on each of those host provinces and on the nation.

Figures 1.6, 1.7 and 1.8 show the social catchment areas in relation to the Project.

1.4 Report structure

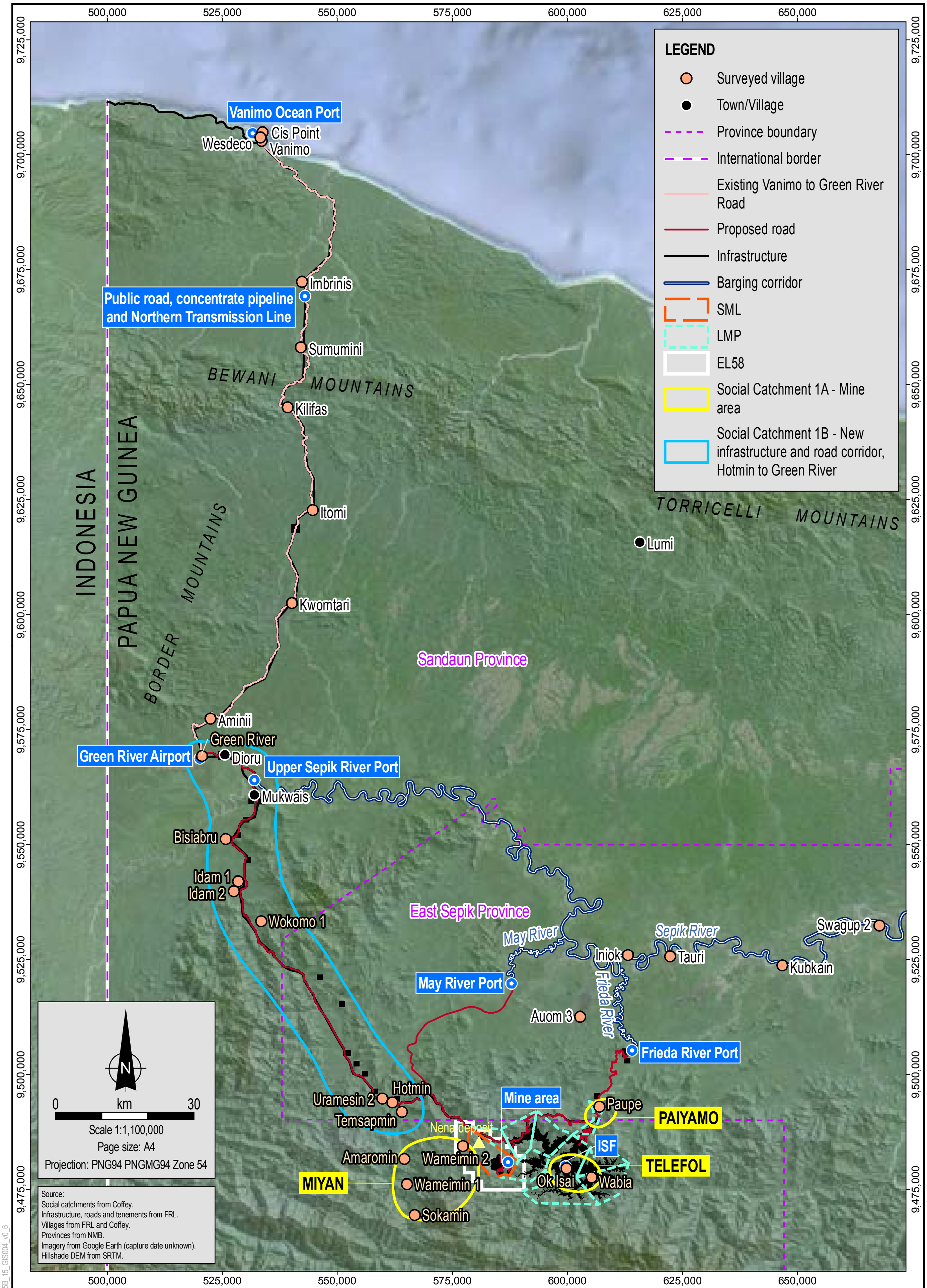
The SIA is presented in ten chapters and an Executive Summary:

- **Executive Summary.** Provides a summary of the key findings of the SIA.
- **Chapter 1 (this chapter).** Introduces the Project and describes the SIA study scope.
- **Chapter 2.** Describes the statutory and policy context for the SIA.
- **Chapter 3.** Outlines the method used to undertake the impact assessment and compile this SIA report.
- **Chapter 4.** Provides an overview of the approach to sourcing information relevant to the indicators of the social values and presents a summary of the status of social values by catchment area.
- **Chapter 5.** Provides an analysis Project induced causes of social change and associated impacts upon social values. This section also provides and an assessment of positive Project effects opportunity associated with the Project.
- **Chapter 6**. This section presents the mitigation measures committed to by FRL and discusses Project impacts to social values prior to mitigation measures and residual impacts for each of the social catchments. Social considerations for mine closure are also discussed.
- **Chapter 7.** Details the management framework that will be adopted by the Project to manage impacts to social values.
- **Chapter 8.** Describes the study team responsible for undertaking the SIA and associated supporting studies.
- **Chapter 9.** Includes the glossary and abbreviations.
- **Chapter 10.** Lists references used in this report.

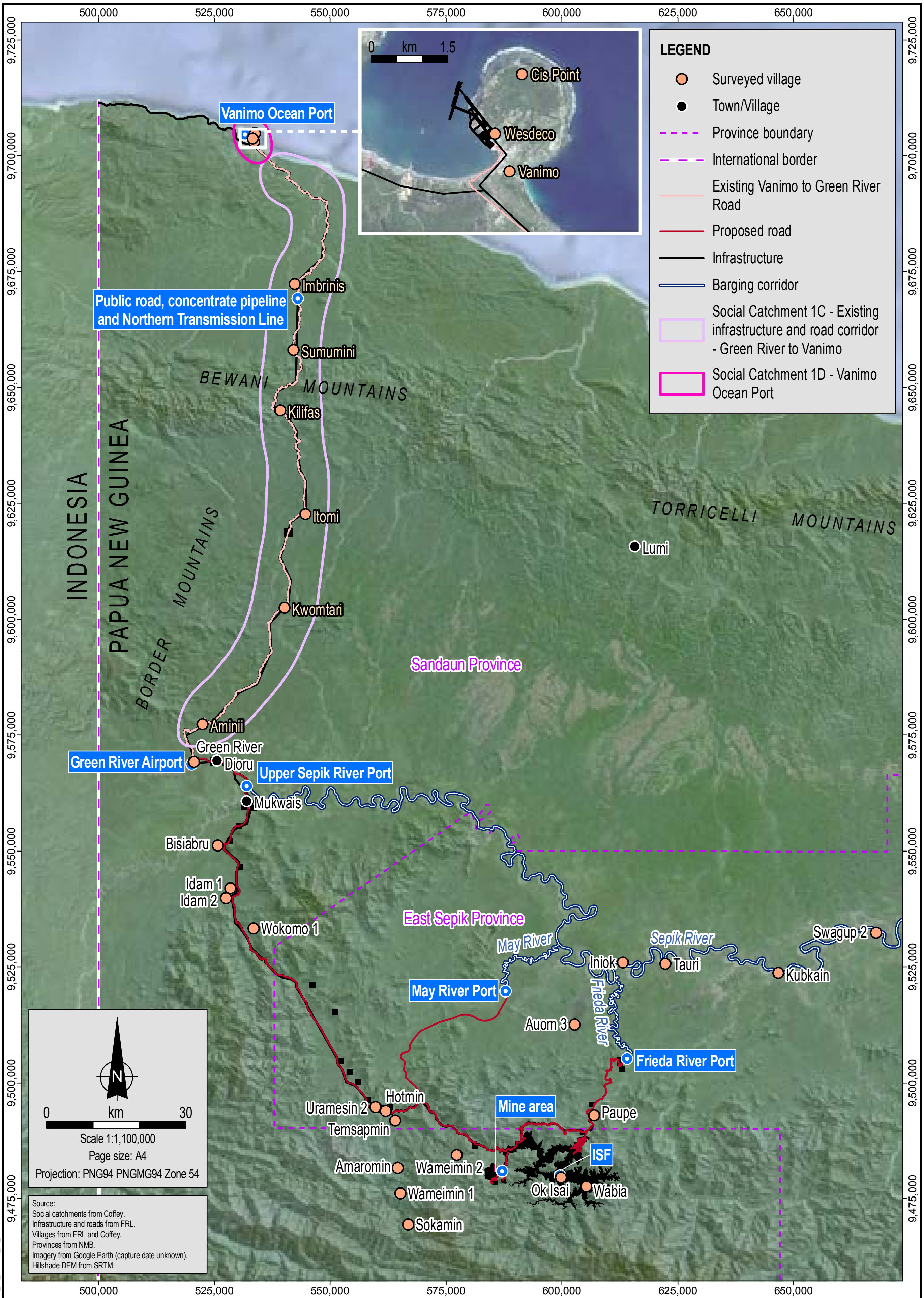
The supporting studies to the SIA and other appendices are set out in Table 1.5.

Table 1.5 Frieda River Project SIA appendices

Appendix number	Appendix title	Author
1	Study area social profiles	Coffey, 2018. Melbourne.
2	Cultural Heritage Baseline and Impact Assessment	EcoLogical Australia. 2018. Melbourne.
3	Baseline health, diet and nutrition survey	Bentley, Keith. 2018. Centre for Environmental Health. Canberra.
4	Health impact assessment	Dempsey, Jack. 2018. Dempsey Toxicology and Risk Assessment. Canberra.
5	Impact assessment table	Coffey, 2018. Melbourne.



coffey A TETRA TECH COMPANY	Date: 04.10.2018 Project: 754-ENAUABTF11575B File Name: 11575_15_F01.06_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Social Impact Assessment catchments 1A and 1B	Figure No: 1.6



MXD Reference: 11575B_15_GIS005_v0_4

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A TETRA TECH COMPANY

Date: 03.10.2018
Project: 754-ENAUABTF11575B
File Name: 11575_15_F01.07_GIS

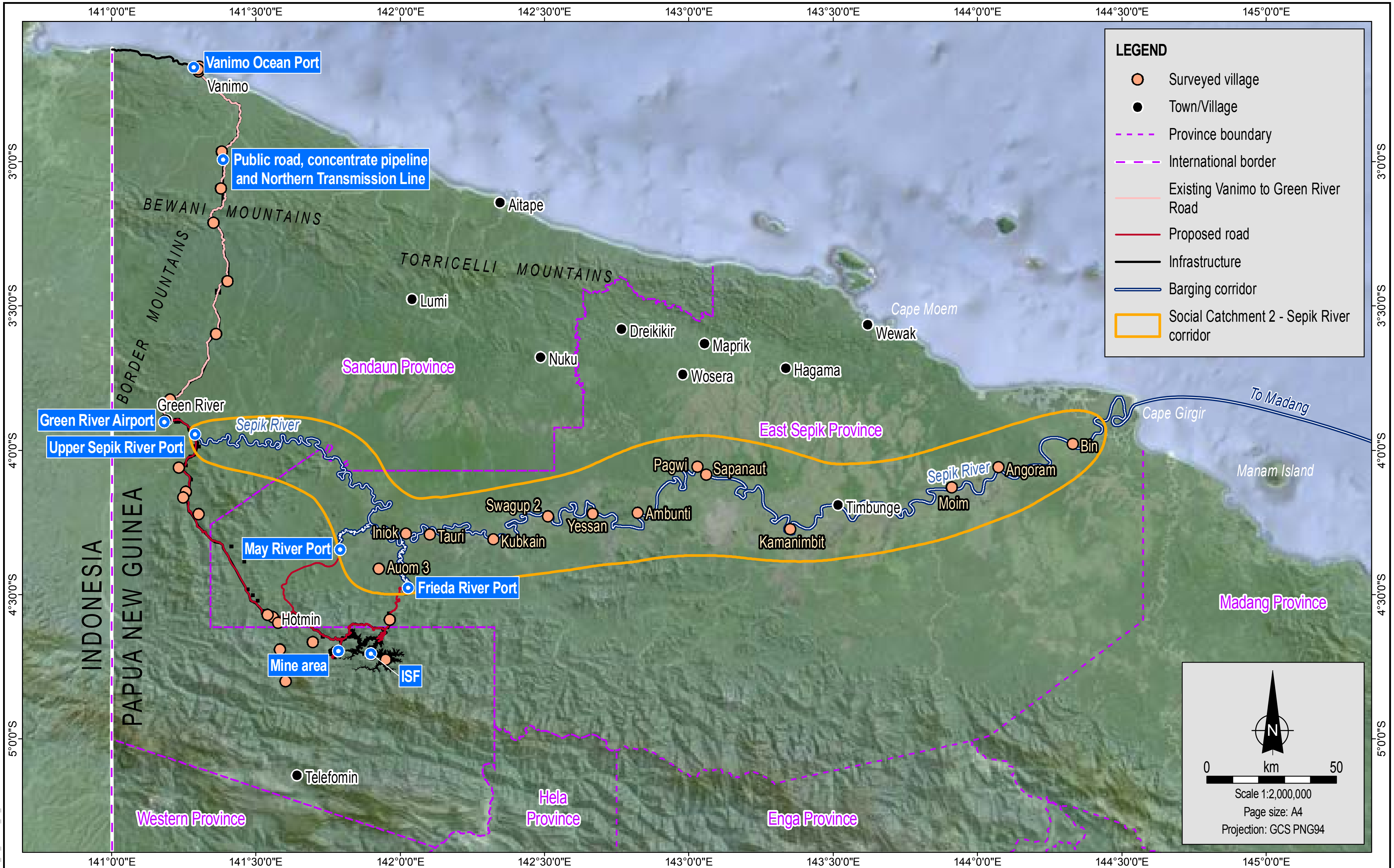
Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Social Impact Assessment catchments 1C and 1D

Figure No: 1.7



Source:
Social catchments from Coffey.
Infrastructure and roads from FRL. Villages from FRL and Coffey.
Provinces from NMB.
Imagery from Google Earth (capture date unknown).
Hillshade DEM from SRTM.

coffey
A TETRA TECH COMPANY

Date: 03.10.2018
Project: 754-ENAUABTF11575B
File Name: 11575_15_F01.08_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Social Impact Assessment catchments 2 and 3

Figure No: 1.8

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2 Statutory and policy context

The SIA has been prepared with consideration of the following legislation, regulations, policies, guidelines, international standards and PanAust Group policies and standards.

2.1 PNG Constitution, legislation and policy

The PNG Constitution 1975 is the charter for all legislation since the country obtained independent governance. The Preamble to the Constitution includes the National Goals and Directive Principles that outline the aspirations and principles for the development of the nation. The constitution is supported by a legislative and policy framework that seeks to ensure that proposed developments assess, reduce and manage residual environmental and social impacts such that they are as low as practicable. In particular, the environmental and socio-economic considerations relevant to the Project are governed by the *Environment Act 2000* (the Environment Act), which provides for, and gives effect to, particular national goals and principles of the constitution.

The Independent State of PNG promotes the development of its mineral resources through various policies which encourage investment and manage impacts of mineral extraction. It is a priority of the government that the people of PNG benefit from the development of their resources. The PNG Constitution includes national goals and directives that outline the aspirations and principles for the development of the nation. The fourth of these national goals and directives states:

> *We declare our Fourth Goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all, and be replenished for the benefit of future generations.*

The development of the Project in a manner that is environmentally aware, technologically achievable, economically viable and socially responsible is consistent with this goal.

2.1.1 Environment Act 2000

The EIS (including the SIA) for the Project will be assessed under the Environment Act, which is administered by CEPA.

The act gives effect to the PNG National Goals and Directive Principles and aims to protect and manage PNG's natural resources by setting environmental objectives and by establishing processes which aid the observance of those objectives (Section 6).

The importance attached to social and environmental values in PNG is highlighted in Section 5 of the Environment Act, which states that (Independent State of Papua New Guinea, 2000):

> *All persons exercising powers and functions under this act shall recognise and provide for the following matters of national importance:*

- *The preservation of Papua New Guinea traditional social structures.*
- *The maintenance of sources of clean water and subsistence food sources to enable those Papua New Guineans who depend upon them to maintain their traditional lifestyles.*
- *The protection of areas of significant biological diversity and the habitats of rare, unique or endangered species.*

- *The recognition of the role of land-owners in decision-making about the development of the resources on their land.*
- *Responsible and sustainable economic development.*

Section 51 of the act requires that the likely social impacts of a proposed activity are described in the EIS in accordance with the issues identified in the EIR. Two Department of Environment and Conservation (DEC, now CEPA) guidelines apply:

- Guideline for Conduct of Environmental Impact Assessment and Preparation of Environmental Impact Statement (DEC, 2004).
- Social Impact Assessment Guideline (working draft) (DEC, undated).

These guidelines align with international practices incorporating scoping, assessment, management and monitoring phases.

The Social Impact Assessment Guideline (DEC, undated) requires that a social impact statement form part of the EIS and include, but not be limited to, demographic information, information on existing infrastructure, public health issues and social services availability, and the economic status of the Project area. These information requirements have been addressed in the social baseline prepared for the SIA.

2.1.2 Other legislation

Other national legislation that is applicable to the preparation of the SIA is listed in Table 2.1.

Table 2.1 Other legislation relevant to SIA

<table>
<tr><th>PNG legislation</th><th>Relevance to SIA</th></tr>
<tr><td>Mining Act 1992</td><td>The Mining Act does not refer to social impact assessment, but stipulates that in assessing the application for a mining lease, the Mining Advisory Council shall consider whether the proposals submitted by the applicant provide adequately for the protection of the environment, as per the requirements of the Department responsible for environmental matters (Independent State of Papua New Guinea, 1992, p.20). Social aspects are incorporated in the definition of the environment.</td></tr>
<tr><td>Land Act 1996</td><td rowspan="5">The Land Act is the principal legislation regulating matters relating to State-owned land and land held under customary tenure in PNG, including acquisition of land (both voluntary and compulsory). The Land Act prohibits customary landowners from transferring (i.e., selling) customary land, except to other citizens and in accordance with custom. It does not prohibit the acquisition of customary land by the State.
The State can use the compulsory acquisition process under the Land Act only when the land is required for a ‘public purpose’ (as defined in the Land Act). The defined public purposes include for the purposes of or connected with the generation or supply of electricity, a road and a port or harbour. The State is required to compensate landowners for any compulsory acquisition of land.</td></tr>
<tr><td>Land Titles Compensation Act 1962</td></tr>
<tr><td>Land Groups Incorporation Act 1974</td></tr>
<tr><td>Land Disputes Settlement Act 1975</td></tr>
<tr><td>Land Registration Act 1981</td></tr>
</table>

PNG legislation	Relevance to SIA
	Land legislation provides avenues for customary landowners to participate in economic development on their customary land and addresses matters such as titles, registrations and settlement of disputes. At the time of writing, land legislation was under reform.
Fisheries Management Act 1998	Recognises and protects customary fishing rights.
National Cultural Property (Preservation) Act 1965	Provides for the preservation and protection of objects of cultural or historical importance to PNG.

2.1.3 Policy requirements

PNG policy requirements of particular relevance to the SIA relate to compensation agreements and the Memorandum of Agreement (MOA) that describes the provisions for, among other matters, benefits sharing and community infrastructure. These two agreements are negotiated with landowners in order to enable mining developments to occur in PNG.

The *Mining Act 1992* (the Mining Act) specifies the reasons landholders are entitled to compensation as being for:

- Deprivation of the possession or use of the natural surface of the land.
- Damage to the natural surface of the land.
- Severance of land or any part thereof from other land held by the landholder.
- Loss or restriction of a right of way easement or other right.
- Loss of, or damage to, improvements.
- Loss of earnings in the case of land under cultivation.
- Disruption of agricultural activities on the land.
- Social disruption.

The compensation agreement requires the proponent to negotiate faithfully with landowners of the tenement areas to establish a compensation regime for the deprivation, loss and or damage to land, and social disruption.

The MOA is determined by the process of a development forum, provided by the Mining Act, and convened by the Minister before the grant of any SML. The development forum considers the views of the people that the Minister believes will be affected by the grant of such leases. The Minister invites the people he thinks will fairly represent the views of the:

- Applicant for the SML (in this case FRL).
- Landholders of the land over which the application for the SML and other tenements is made.
- National government.
- Provincial government in whose province the land that is the subject of the application(s) is situated (in this case, Sandaun and East Sepik provinces).

The resultant MOA contains standard clauses covering, among other concerns, environment, local business development and training and localisation. The MOA sets out provisions for:

- Obligations and responsibilities between the proponent, national and provincial government(s) and landowners.
- Funding and implementation of community infrastructure.

- Distribution of financial benefits.
- Stakeholder engagement.

All MOAs are expected to contain standard clauses for:

- Environmental protection.
- Local business development (for which a plan must be developed, identifying how the proponent will maximise local business development opportunity for landowners and affected communities).
- National employment, training and localisation (for which a plan must be developed, identifying how the proponent will maximise national and local employment and training).
- Landowner and Local Level Government benefits.

MOAs also contain a number of formal legal clauses consistent with most agreements (e.g., legal context, Force Majeure, dispute resolution).

2.2 PNG development goals and planning guidelines

PNG has adopted an ambitious set of development goals where achievement of objectives is guided by a hierarchy of strategic and medium-term development plans and planning guidelines. These require proponents to support the implementation of sustainable development plans at the provincial, district and local level in the areas impacted by its infrastructure and activities. The key planning instruments are summarised in the following sections.

2.2.1 Vision 2050

In 2009 the PNG government, through the National Strategic Plan Taskforce (NSPT), released Vision 2050. This document describes the country’s long-term strategy and reflects the aspirations of Papua New Guineans, with the goal that PNG will be ranked in the top 50 countries in the United Nations Human Development Index by 2050 (NSPT, 2009). For context, in 2016 PNG was rated 154 out of 188 countries in this index (UNDP, 2016). To achieve this goal, the NSPT listed seven strategic areas or ‘Key Pillars’ and eight ‘critical enablers’ to support the achievement of Vision 2050.

The Key Pillars include:

- Human capital development, gender, youth and people empowerment.
- Wealth creation, Natural Resources and Growth Nodes.
- Institutional development and service delivery.
- Security and international relations.
- Environmental sustainability and climate change.
- Spiritual, cultural and community development.
- Strategic planning, integration and control.

The Critical Enablers include:

- Effective Leadership and Good Governance.
- Healthy, Educated and Skilled Citizens.
- Enabling Legislation and Policies.
- Enabling Basic Infrastructure.
- Financial Capacity.
- Effective Service Delivery.

- Enabling Citizen Values and Participation.
- Performance and Accountability.

Institutional barriers to the achievement of Vision 2050 outcomes are seen to include: a high-level of corruption in the public and private sectors; a lack of good governance and political instability; law and order problems; and deteriorating infrastructure including roads, airports and sea ports in many parts of PNG. Particular challenges include: engaging young people in the development process (with more than three million young people under 18 years of age); low levels of literacy (with more than a third of the population, most of whom live in rural areas, unable to read and write); and the extremely high need for infrastructure improvement in rural areas (Ambang, 2012).

2.2.2 Papua New Guinea Development Strategic Plan

In 2010, in order to provide direction in policy making to achieve the goals of Vision 2050, the PNG Department of National Planning and Monitoring released the Papua New Guinea Development Strategic Plan (PNGDSP) 2010 to 2030 (DNPM, 2010). The PNGDSP advances strategies for the provision of infrastructure and services and sectoral development strategies in key economic sectors; a key feature is the proposal for ‘economic corridors’ located ‘in the poorest regions of PNG’ (though with strong economic potential) ‘with the aim of extending the benefits of development to the most disadvantaged regions’ (with half of the Development Budget earmarked for corridor development in future years). An economic corridor is defined in the PNGDSP as ‘a region in which the Government provides a well-planned zoning system, a comprehensive and effective network of transport and utilities, and quality education and health services’.

Of relevance to the Project is the identification of a north-south Border Corridor along the PNG-Indonesia border encompassing Sandaun, Southern Highlands and Western provinces. Within this area it is envisaged that service delivery would be improved by providing basic social, transport, electricity and communications infrastructure, thereby encouraging private sector investment.

2.2.3 National Strategy for Responsible Sustainable Development for Papua New Guinea

The National Strategy for Responsible Sustainable Development for Papua New Guinea (StaRS) was released in January 2014 as a response to the Government’s desire to ensure that economic development was based on a sustainable development paradigm, with responsible stewardship of PNG’s environment and natural resources. The PNGDSP was seen to be ‘not strategic enough since it does not prescribe a road map that builds on PNG’s unique natural and cultural resources’. The aim of StaRS is to support ‘inclusive green economic growth’ where ‘a green economy is one that is low carbon, resource efficient and socially inclusive’. A ‘Green Growth Framework’ within the strategy proposes measures to facilitate ‘businesses to fully integrate sustainability and equity concerns’ into their operations, and the development of policies to support and incentivise investment in ‘green energy’.

The inclusion within the Project of the FRHEP, with the capacity to export hydro power surplus to FRCGP requirements to other centres in PNG, will contribute broader sustainable development objectives.

2.2.4 Medium-Term Development Plan 3

The Medium-Term Development Plan 3, 2018 to 2022 (DNPM, 2018), is a five-year plan describing the priorities and actions of the Government, continuing from the Medium-Term Development Plan 1 and 2. This plan provides the road map for a sustainable future towards Vision 2050 and supports the guiding principles of sustainable development established in the National Strategy for Responsible Sustainable Development for PNG (DNPM, 2014). It is designed to provide strategic direction to Government investment decisions and the main indicators and targets needed to meet development objectives. Six strategic assets for investment are identified in the plan, of which one is Minerals and Petroleum Resources.

The Medium-Term Development Plan 3 acknowledges the important role the minerals sector has had in PNG's economy and its future importance in PNG's development.

Development of the Project is consistent with the Medium-Term Development Plan 3 and the stated targets to increase mineral exports and the number of mines in operation in PNG, while minimising the adverse impacts on the environment. The Project is specifically included as a key strategy for increasing exports through the development of new mines, and the Plan notes that the Governmetn will support the development of two new mining projects, one of which is the FRCGP (DNPM, 2018).

2.2.5 District Development Plans

District Development Authorities, which merged with District Administrations in 2014, are required to each prepare a District Development Plan which sets out their development priorities. The District Development Program Plans align with PNG Vision 2050 and outline 14 strategic objectives for the district over the next 20 years. These relate to:

- Improving access to goods, services and development through upgrades to transport infrastructure.
- Improving and maintaining quality health services.
- Improving children's education.
- Providing agriculture, livestock, inland fisheries and forestry extension services.
- Minimising the threat of lawlessness.
- Strengthening Christian and cultural values.
- Empowering people to better utilise existing natural resources and encourage economic growth.
- Encouraging people to participate in effective government and administrative structures.
- Assisting in the creation of improved financial capability.
- Running an effective human resources management program.
- Mobilising traditional land for production.
- Improving awareness of health, environmental and gender equality issues.
- Encouraging potential cultural and tourism opportunities.
- Providing effective disaster response services.

While the District Development Program Plans set out budget estimates for each of the key proposed initiatives, the capacity for the Provincial Government to fund the implementation of the plan is unclear.

2.3 Relevant international standards and corporate policy and standards

This section outlines the relevant international and national standards and guidelines, together with the PanAust Group policy and standards that the SIA has been developed to align with.

2.3.1 International standards and guidelines

Key international standards and guidelines of relevance to the Project and this SIA include the Equator Principles, International Finance Corporation (IFC) performance standards, and the International Association for Impact Assessment (IAIA) principles and guidance on social impact assessment.

Equator Principles

Projects in the developing world are frequently assessed within the context of the Equator Principles (EPFI, 2006), which were developed in 2003 as an international banking industry framework to determine the environmental and social risks of Project financing, and are commonly referred to as 'World Bank guidelines'. The ten Equator Principles aid financial institutions in assessing the environmental and social impacts, along with the management of impacts and risks associated with Projects that they fund.

International Performance Standards

The IFC of the World Bank Group has developed eight performance standards on environmental and social sustainability (IFC, 2012). If a Project generally follows the IFC performance standards, then financial institutions can consider funding of the Project to be generally consistent with the Equator Principles.

FRL has used the requirements of the performance standards to guide Project planning. In particular, Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts, Performance Standard 5: Land Acquisition and Involuntary Resettlement, and Performance Standard 7: Indigenous Peoples are particularly relevant to the development of the SIA. The SIA has also considered matters relevant to social assessment outlined within the other five performance standards.

In addition to the performance standards, the IFC has developed several environmental, health and safety guidelines that are to be used by Project proponents as a technical reference to support the implementation of the IFC performance standards. This includes the IFC Good Practice Note: Addressing the Social Dimensions of Private Sector Projects (IFC, 2003). Consideration has been given to these guidelines in the development of this SIA, where appropriate.

International principles and guidelines

The IAIA's International Principles of Social Impact Assessment (IAIA, 2003) provide core values and principles for developing an SIA. They incorporate:

- A definition of SIA.

- Standards for SIA practice in an international context for development corporations and international banking financiers.
- An articulation of best practice in SIA as a model to aspire to.
- A scope for the social component of impact assessments.

IAIA suggests the following social impacts may require consideration as a part of an SIA:

- People's way of life (how they live, work, play and interact with others).
- Their culture.
- Their community.
- Their political systems.
- Their environment.
- Their health and wellbeing.
- Their personal and property rights.
- Their fears and aspirations.

In addition, the IAIA Social Impact Assessment: Guidance for assessing and managing the social impacts of Projects (Vanclay et al., 2015) provides information on good practice SIA and SIA management processes.

The SIA has been developed to align with both documents.

Australian Minerals Industry Framework for Sustainable Development

The Minerals Council of Australia's (MCA) Enduring Value incorporates global industrial sustainability initiatives and provides guidance on the International Council on Mining and Metals (ICMM) Sustainable Development Framework. PanAust is an associate member of the MCA and a signatory to its 'Enduring Value – The Australian Minerals Industry Framework for Sustainable Development' (MCA, 2005). The framework commits companies to upholding fundamental human rights and respecting cultures, customs and values in their dealings with people affected by their activities. As an associate member of the MCA, PanAust is committed to applying operational standards globally that are consistent with Australian operational standards, while accommodating variations as a result of cultural, geographical or environmental circumstances in the countries in which it operates.

2.3.2 Corporate policy and standards

PanAust has a corporate policy and standards related to environmentally and socially responsible project development. These encourage culturally appropriate communication and respect for communities within which the proponent operates.

PanAust's Vision and Values, and Sustainability Policy outline the company's commitment to preserving and enhancing the environmental, social, technical and financial elements of the business.

PanAust Vision and Values

PanAust's vision is to be a growth-oriented mining company determined to excel. It states it will outperform its competitors through:

- Growth by discovery, acquisition, development and operations that consistently meet performance targets.
- Optimising returns on capital.
- Adherence to core values.

PanAust's values include:

- High performance outcomes in all business activities.
- Respect for people.
- Integrity in all of its dealings with employees, communities, government, suppliers and shareholders.
- Excellence in communications with all stakeholders but especially with its employees.
- Recruitment of high-calibre people, recognising the key to its success will be leaders who earn the authority of their position by gaining the respect of their team.
- Alignment of employees to Company objectives through good leadership and systems that drive the right behaviour.

In addition to its vision and values, PanAust operates under a code of conduct known as ‘The PanAust Way’ (PanAust, 2017). The code builds on PanAust’s values and provides a guide for how employees behave, make decisions, and interact with colleagues and external stakeholders.

PanAust has a set of operational safety standards and a set of ‘cardinal rules’, which outline behaviours relating to health and safety for achieving a ‘zero harm’ workplace.

PanAust Sustainability Policy

PanAust is part of an industry that has an important role to play in improving the standard of living of current and future generations through meeting the global demand for copper and precious metals in a responsible way. The PanAust Sustainability Policy (Figure 2.1) describes the company’s aims to ensure the businesses’ activities are financially profitable, technically appropriate, environmentally sound and socially responsible. When legally permitted and consented to by host governments, PanAust supports making the material terms of its contracts publically available (in line with Extractive Industries Transparency Initiative (EITI) requirements).

PanAust Sustainability Management Standards

The Sustainability Management Standards provide a basis from which to drive continuous improvement towards leading industry practice in sustainability and to establish performance requirements and auditable criteria which can be measured. Fourteen Sustainability Management Standards relating to leadership, risk management, health and safety, training, environment, stakeholder engagement and community have been developed by PanAust to ensure consistent sustainability-related outcomes across the business.

SUSTAINABILITY POLICY

PanAust is part of an industry that has an important role to play in improving the standard of living of current and future generations through meeting the global demand for copper and precious metals in a responsible way. PanAust recognises that sustainable business development is essential for our ongoing success. We strive to ensure that our activities are financially profitable, technically appropriate, environmentally sound and socially responsible. As a minimum, we will meet applicable legal requirements in our host countries, the PanAust Sustainability Standards and other Company commitments such as the Mineral Council of Australia's Enduring Value Framework, the International Council on Mining and Metals Sustainable Development Framework, the Voluntary Principles on Security and Human Rights and consistency with the Universal Declaration of Human Rights.

Consistent with our Vision and Values PanAust is committed to:

- Preventing workplace injuries and ill health (zero harm objective).
- Recognising and respecting the culture, heritage values and environment in which we operate of local communities and indigenous peoples.
- Preventing or minimising pollution by promoting efficient use of natural resources; reusing and recycling waste; minimising release of contaminated emissions to air, land and water; and progressively rehabilitating land.
- Providing a positive and lasting impact on our local communities by improving their socio-economic wellbeing through employment and training opportunities, and supporting local business development and health initiatives that will benefit the community beyond the life of mine.
- Applying ethical business practices and corporate governance standards as an integral part of our business planning and decision making.

We seek to continually improve our sustainability management and performance by:

- Applying systematic approaches to identifying, understanding, prioritising and managing material sustainability risks and opportunities associated with our activities throughout the entire project lifecycle, including closure.
- Setting and reviewing performance improvement objectives and targets and measuring and reporting performance against these targets.
- Promoting a proactive and positive safety culture of awareness and understanding of sustainability issues based on personal accountability for self and others.
- Continuously building core competences across the company to manage and mitigate material sustainability risks and opportunities for the business.
- Engaging in fair, honest and transparent dealings with key stakeholders, in particular our employees, local communities, governments, shareholders, business partners and customers through open two way communication to understand and consider each others' needs and concerns.
- Verifying our progress through internal and external auditing.
- Including sustainability performance in appraisal of staff and contractors.
- Providing oversight of sustainability processes and issues through our Executive Governance Committee.
- Reporting publically on our sustainability performance.

Adrian Bell
General Manager HR and Risk Management

Dr Fred Hess
Managing Director

29.06.2016

This policy will be communicated to all people working for and on behalf of PanAust Limited and its subsidiaries (collectively, the "PanAust Group") and will be made available to all stakeholders through PanAust's website. This policy will be periodically reviewed to ensure it remains relevant and appropriate to PanAust's business.

Source: PanAust Sustainability Policy, 2016.

Other standards and procedures relevant to PanAust's operations include:

- Enterprise Risk Management Procedure – for assessment and management of risks. This document supports PanAust's Risk Management Policy.
- Incident Procedure Classification, Notification, Investigation and Reporting – to outline terminology used in classification of incidents and to detail the minimum requirements for internal investigation and reporting.
- Contractor Safety Management Standard – to evaluate and manage contractors and subcontractors in accordance with PanAust's safety policies, standards and procedures.

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3 Method

This chapter describes the SIA method which was developed in consideration of CEPA's Draft Social Impact Assessment Guideline (DEC, undated), the International Principles for Social Impact Assessment (IAIA, 2003; Vanclay et al., 2015), the International Finance Corporation's (IFC) Good Practice Note, Addressing the Social Dimensions of Private Sector Projects (IFC, 2003) and the IFC Performance Standards on Social and Environmental Sustainability (IFC, 2012). Chapter 2 provides further detail about these guidelines and standards.

The International Principles for Social Impact Assessment (IAIA, 2003) defines SIA as being 'the processes of analysing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, Projects) and any social change processes invoked by those interventions'. It considers that 'good practice SIA' involves four phases (Vanclay et al., 2015):

1) Understanding issues.

2) Predicting, analysing and assessing likely impact pathways.

3) Developing and implementing management strategies.

4) Designing and implementing monitoring programs.

These phases are embodied in the five-stage process used to undertake this SIA, listed below with the corresponding IAIA stage shown in brackets following:

- Scoping, baseline studies and identification of social values (1).
- Impact identification (2).
- Positive Project effects (2).
- Impact assessment (2).
- Mitigation measures and residual impact assessment (3).

Monitoring and reviewing the effectiveness of mitigation measures (4) is an on-going process implemented by the project developer post submission and approval of the EIS, in the project implementation phase.

This process is described in detail in the following sections.

3.1 Scoping, baseline studies and identification of social values

3.1.1 Scoping

Table 1.4 outlines the main potential socio-economic issues and opportunities that were identified in the EIR in accordance with CEPA's 'Guideline for Preparation of Environmental Inception Report' (DEC, 2004). The identification of these issues drew on the knowledge of specialist consultants and community affairs personnel considering the potential impacts of a mine development at Frieda River. This initial understanding of potential issues and impacts to social values was refined continually throughout the SIA process.

3.1.2 Baseline studies

The purpose of the baseline assessment was to define a meaningful unit of analysis to characterise which groups of people, in which locations, will potentially be subject to particular types of impact. In this SIA these areas of influence have been termed ‘social catchments’[4], and have been broadly defined through consideration of: community location (including watershed boundaries, and proximity to the Project’s footprint and likely lease boundaries); the type of Project activity that may occur in proximity to villages in the catchment; and language group or cultural affinity of the villages in the catchment.

Baseline information was generated through the collection of primary data by way of field surveys, review of relevant studies previously completed for the Project as well as review of broader secondary source documentation.

The following baseline field studies completed in 2010, 2011, 2015, 2016 and 2017 inform this SIA:

- Socio-economic survey (census, household and village) (2010, 2015 and 2017).
- Archaeology and cultural heritage (2016).
- Community health (2010 and 2011).
- Social values (by way of workshop with village leaders) (2015).

Section 4.1.4 describes the timing and extent of these field studies.

3.1.3 Identification of social values

Social values are qualities of the social environment that are conducive to individual well-being now and into the future, and for which community stakeholders have a high regard. Each social value is characterised by a range of indicators, and is associated with stakeholders who have an interest in the value within the social catchment.

The identification of social values held by stakeholders is central to the SIA process. These values are developed by assessing stakeholder interests in relation to social conditions and their indicators. This allows consideration of the local aspirations for transformation of the existing environment to better support sustainable livelihoods, and avoids a singular focus on preservation of the existing environment which, in the PNG context, is rarely encountered as an aspiration. It also establishes a basis for dialogue with and between stakeholders with differing interests and strategies for achieving a sustaining social environment. It facilitates an integrative approach to impact assessment where potentially multiple impact pathways combine to affect a single value, in either a positive or negative sense.

In general, the broad nature of social values held by people in rural areas of PNG is reasonably well understood; however, these need to be characterised for each of the social catchments. This characterisation was done as part of the community consultation process. This included discussions with FRL community affairs staff that had long experience with Project area villages, consultation with PNG resource sector community affairs practitioners, and focus group discussions with mine area social catchment village leaders, all of which took place between 2014 and 2017.

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[4] Hugo, G. Smailes, P. Macgregor, C. Fenton, M. and Brunckhorst, D. Defining Social Catchments in Non-metropolitan Australia, Bureau of Rural Science, Australia, 2001.

However, it is important to note that social values can change and sometimes do so rapidly, as key local stakeholders in the Project have themselves initiated quite radical change (and continue at present to experience the consequences of such change) in relatively recent times (see in particular Jorgensen (1990) and Hyndman (1995)). The Mountain Ok speakers (the Min and, to a large degree, the Miyan) had evolved a complex understanding of their origins based upon an interlocking series of creation sagas focused on a legendary ancestor, Afek. Their social organisation and values were grounded in these sagas. In simplified terms, the Min and Miyan had values focused on:

- A series of ancestral stories based on Afek and her deeds.
- A bilateral descent system.
- No clans as such but rather groups tied together by their common residence.
- A complex male initiation system.
- Leadership based on progress through that initiation system.
- Access to land through both male and female lines.
- Village and satellite garden residences.

Toward the end of the colonial period, and stimulated by Baptist mission influence, there was a significant social change as Afek's stories were supplanted by Bible stories, and men's houses were torn down and initiation schedules abandoned. One consequence of this was that traditional leadership systems were also overthrown. While this helps to explain why the influence of both local Baptist pastors and local government councillors is greater than usually evident in the region, neither group has the legitimacy-granted-by-tradition which empowered the pre-existing set of social values. There is some indication that in the broader region to the south of the Project area, social values are themselves still in a re-formative stage following the earlier abandonment of Afek stories. Consequently, caution is warranted in assigning too much weight to expressions of those values centred on culture and traditional leadership which may well evolve in different ways during the life of the Project.

3.2 Impact identification

Impact identification involved a close examination of:

- The Project description (location of Project elements for the FRCGP, FRHEP, SPGP and SIP).
- Proposed approaches to construction (which typically involves an intense period of activity using large numbers of workers living in camps close to work sites).
- Operations (which involves a smaller number of workers focussed on the mine, mine infrastructure area and other Project components, and regular logistics activities to import project supplies and export product).

The construction and operational experience of projects in similar environments has been considered, as well as the findings of specialist studies that have been undertaken for this Project EIS, such as cultural heritage, water and air quality assessments, terrestrial and aquatic ecology assessments, human health and ecological impact assessments, and transport and logistics studies. The experience of other mining developments, both in PNG and globally, highlights the importance of considering downstream effects due to Project-related discharges to waterways during construction and operations. The general absence of compensation to downstream communities due to the lack of direct ground disturbance impact, combined with a heightened level of anxiety concerning the integrity of the aquatic environment which is highly important for subsistence livelihoods, elevates the issue to a high level of concern.

An understanding of community aspirations and attitudes to development in general, and the proposed Project in particular, is also an essential input into the identification of potential impacts. The degree of community confidence to embrace and manage risk in the quest for development has a bearing on the experience of impact. In this respect an equally important step at this stage is the identification of potential opportunities for the enhancement of social values, as these can offset impacts on the values, or improve the status of the value above its current state. As stated by Gardner (1996a) the low level of access to services for the population in the Project area, and the awareness of services available in other areas of the country, means that ‘people have a keen sense of deprivation relative to other areas of the country’. As well, the long period of mineral exploration at Frieda River has already induced significant impact on the cultures of the area. Knowledge of aspirations and attitudes was gained by direct consultation by means of household surveys, women’s focus group discussions, and village leader workshops on social values in 2015. Information on attitudes to development was also available from consultation that occurred in 2010, enabling an assessment of change that may have occurred over the intervening period.

3.3 Positive Project effects

The degree of community confidence to embrace uncertainty in order to advance social development influences how Project induced change is perceived and impacts experienced. In this respect an equally important step is the identification of positive Project effects that will likely enhance social values, as these can offset impacts, improve the status of the social value, or even create new social values.

As the Project is a development project, rather than a stand-alone mining project, the identified Project impacts often have associated opportunities and positive socio-economic development effects. For example, the negative impacts of the public road development, such as reduced amenity, have been considered as well as the positive effects such as the opportunity for public transport and commercial ventures along a route that currently has no transport infrastructure in a remote part of PNG. Positive project effects that will likely enhance existing or create new social values were identified by drawing on the experience of similar projects, the characteristics of the proposed Project, and the aspirations of community members and other stakeholders. The identified positive Project effects have not been further assessed using the matrix method described in Section 3.4, as enabling action, such as the continued maintenance of a public road, are often not within the control of the Project proponent. However, opportunities associated with positive effects are discussed in detail in Chapter 5.

3.4 Impact assessment

A risk assessment approach was used to evaluate the significance of potential impacts on social values, by consideration of the likelihood of the potential impact occurring and the consequential effect if it was to occur (Table 3.1 and Table 3.2). Criteria used for the definition of likelihood and consequence levels, shown in Table 3.3 and Table 3.4, were established in consideration of Australian/New Zealand ISO 31000:2009 Risk management – Guidelines (AS/NZS, 2009). The establishment of likelihood and consequence levels for impacts was undertaken in a workshop comprising persons familiar with the social impact assessment of mining in PNG, with direct experience in engaging with residents of the Project area and with an appreciation of community attitudes, development needs and aspirations.

Technical studies were undertaken for cultural heritage and archaeology (Appendix 2) and health (Appendix 4). Results of the cultural heritage and archaeology and health impact assessments have been incorporated into this SIA.

Table 3.1 Impact significance assessment matrix

Consequence	Likelihood				
	Almost Certain	**Likely**	**Possible**	**Unlikely**	**Rare**
Critical	Very High	Very High	High	High	Medium
Major	Very High	High	High	Medium	Medium
Moderate	High	Medium	Medium	Medium	Low
Minor	Medium	Medium	Low	Low	Very Low
Negligible	Medium	Low	Low	Very Low	Very Low

Table 3.2 Significance category definitions

Significance category	Definition
Very high	Likely for irreversible and widespread impairment of a social value to occur, having major consequences for well-being of the majority of community. Extensive support and capacity-building is required to manage change.
High	Possibility for substantial impairment of a social value for a large number of persons with limited capacity to adapt to change. Considerable support and capacity-building required to manage change.
Medium	Possibility for impairment of a social value to some extent with an effect on the well-being of a limited number of persons who will require support to manage change.
Low	Possibility for impairment of a social value that may have minimal effect on individual and community well-being. Support may be required only for vulnerable members of the community.
Very low	Unlikely to be an impairment of a social value and requires no support for individual or community management of change.

Table 3.3 Likelihood criteria

Likelihood level	Definition
Almost certain	Common, often occurs in similar environments or expected to occur in most circumstances.
Likely	Has occurred in recent history; likely to have occurred in similar environments, or will probably occur in most circumstances.
Possible	Has occurred in the past, but not common. The event could occur.
Unlikely	Not likely or uncommon; event is not expected, and is seen as unusual.
Rare	Practically impossible; the event is unlikely to have occurred elsewhere, and will only occur under exceptional circumstances.

Table 3.4 Consequence criteria

Consequence level	Definition
Critical	The impact will affect the value and substantially deteriorate the people's wellbeing. Significant support and capacity building will be required to manage the adverse impacts, and compensation and resettlement may be required for unavoidable impacts. Long-term health effect; wide-spread (regional); fatality(ies); serious injury/ illness requiring extensive medical treatment.
Major	The impact will affect the value and noticeably deteriorate the people's wellbeing. Considerable support and capacity building will be required to manage the adverse impacts, and compensation and resettlement may be required for unavoidable impacts. Medium to long-term health effects; extends beyond the geographic area of a community; serious injury/ illness requiring moderate level of medical treatment.
Moderate	The impact will affect the value and slightly deteriorate the people's wellbeing. Some support and capacity building will be required to manage the adverse impacts. Medium-term health effect; restricted to geographic area of a community; injury/ illness requiring moderate level of medical treatment.
Minor	The impact may affect the value and slightly deteriorate the people's wellbeing. Limited support and capacity building may be required to manage the adverse impacts. Short-term health effect; restricted to a community; injury/ illness requiring minor medical treatment.
Negligible	The impact is unlikely to affect the value and there is no noticeable change to the people's wellbeing. No support or capacity building will be required to manage the adverse impacts.

3.5 Mitigation measures and residual impact assessment

For those risks assessed as having a ranking of very high, high or medium significance, mitigation measures were identified which served to avoid or limit the likelihood or consequences of their occurrence. These measures, described in Section 6.1, were identified in collaboration with FRL and with reference to:

- Current practices and FRL-supported community programs in the Project area.
- Experience from other mining projects in PNG.
- Government and other group (generally faith-based organisations) community support activities and plans.
- Input provided by community and other stakeholders engaged throughout the EIS process.

The residual risk assessment presented in this SIA is based on the assumed effective implementation of identified mitigation measures, with justification provided to demonstrate how the mitigation measures act to reduce the significance of the risk.

4 Social values baseline summary

The approach to understand the social baseline conditions, landowner and community concerns and the status of social values has been comprehensive and robust involving several community surveys and a social values workshop with mine area landowners in August 2015.

The detailed baseline assessment of social values for the social catchments is presented in Appendix 1. Indicators or elements that form the basis of the social values are shown in Table 4.1. This section provides an overview of the approach to sourcing information relevant to these indicators and also provides a summary of the social setting for the Project, including the status of social values by social catchment.

As described in Section 3.1.3, the social values are regarded as qualities of the social environment that are conducive to individual well-being now and into the future, and for which community stakeholders have a high regard. They are potentially impacted by the causes of social and physical change associated with the Project described in Chapter 5.

4.1 Sources of baseline information

This section discusses the sources of baseline information used to derive the status of the social values for the Project area.

4.1.1 Primary sources

As the remoteness of the Project area limits the availability of reliable secondary information directly relevant to villages in the social catchments, primary data collection was necessary and undertaken by means of household, village and specialist surveys, including cultural heritage (Appendix 2) and health (Appendix 4) and key informant interviews and focus groups in 2009, 2010, 2011, 2015, 2016 and 2017. Resettlement, in-migration and land use change studies were also undertaken in 2018 and the results of these studies have been incorporated into this SIA where applicable. Table 4.2 indicates the coverage of villages in the social catchments during the various survey campaigns. Further information on the types of surveys undertaken is provided in Appendix 1.

Villages in the mine area (Social Catchment 1A), which are the areas in closest proximity to the FRCGP mine and FRHEP activities, have received the most intense coverage through the primary data collection surveys as shown in Table 4.2.

To accommodate key Project changes, in November 2017 primary socio-economic data was collected at villages along the infrastructure and road corridor between the mine area and Vanimo (Social Catchments 1B and 1C), and within the Vanimo Ocean Port (Social Catchment 1D) as shown in Table 4.2.

In addition to survey work shown in Table 4.2, the following information-gathering activities were also undertaken in November 2017:

- Opportunistic interviews with key informants along the infrastructure corridor between Green River and Vanimo (inclusive). Interviews were undertaken with people associated with health centres, schools, churches, logging camps, the Provincial Government and Catholic Mission.
- Points of interest surveys to record key features and points of interest along the infrastructure corridor between Green River and Vanimo (inclusive), e.g., logging camps, schools, churches and hospitals.

- Fish market surveys in Vanimo to gain an understanding of the types and sizes of fish caught and what locations they were caught.

Villages along the Sepik River corridor (Social Catchment 2) were surveyed during 2011 and engaged through a Sepik River awareness campaign undertaken by FRL during 2011, 2015 and 2016. During these consultation sessions, information on the FRCGP was delivered, and issues and concerns of villagers were identified and discussed.

Given the focus of Social Catchment 3 (Sandaun and East Sepik provinces) is regional in nature, information on these areas was largely obtained through a review of secondary sources, such as government documents and research publications. Consultation was done and feedback obtained at quarterly Joint Provincial Consultative Committee (JPCC) meetings held with key staff of both provincial governments.

4.1.2 Stakeholder consultation

Additional qualitative information drawn upon to characterise social values was obtained through an extensive program of stakeholder consultation, including on-going community engagement by FRL community affairs officers, focus group and individual semi-structured interviews during village and household survey campaigns, and regular quarterly consultation with Provincial administrations through meetings of the JPCC held alternately in Wewak and Vanimo. This approach enabled the capturing of issues and concerns of all community stakeholders including women and those who are vulnerable.

Workshops on social values were held with male and female leaders from each village for the mine area at the Frieda Camp between 1 and 3 October 2015. The workshops focused on understanding village leader views on the potential for the Project to impact on key social values. These workshops were particularly important in confirming that the social values identified through the analysis of data collected during the socio-economic surveys were an accurate interpretation of what people valued and how impacts to such values could be managed. The workshops provided local leaders with an opportunity to engage in detailed dialogue as to what their communities wished to protect and what they aspired to achieve if the Project proceeded to development.

Table 4.3 provides details of when these workshops were held and the number of participants.

Table 4.1 Social values and associated elements/indicators

SV1 The capacity to support subsistence livelihoods	**SV2 Opportunities for participation in the cash economy**	**SV3 An enduring ability to sustain cultural identity and traditions including connection to ancestors**	**SV4 An enduring ability to maintain customary rights to land access and resource use**	**SV5 An environment amenable to personal and family health, education, safety and security**	**SV6 The availability of services supportive of personal health, education, safety and security**
Elements/Indicators					
Natural capital		***Cultural knowledge***		***Built environment***	
• Access to productive garden land. • Access to productive forest harvest and hunting areas. • Access to aquatic resources (fish, crocodiles etc.). • Access to water (drinking, washing, cooking). • Household dependency on imported food. • Population density. • Carrying capacity of land and water resources.	• Access to productive cropping land. • Access to aquatic resources (fish, crocodiles etc.). • Quality of aquatic environment. • Access to other resources (e.g., alluvial gold, logging). • Level of income derived from commercial activity (e.g., alluvial mining, small business, sale of subsistence surplus, cash cropping and animal husbandry).	• Tangible cultural heritage site integrity and management. • Maintenance of intangible cultural heritage. • Maintenance of traditional material culture practices. • Degree of exposure to external cultural change agents.	• Level of definition of customary ownership and use rights.	• House size and quality. • Access to service infrastructure (water, power, sanitation, telecommunications). • Community amenity (through noise, light, dust etc.). • Access to retail outlets and services. • Isolation in relation to road, river or air transport infrastructure.	• Availability and quality of public infrastructure (clinic, school, community hall, sporting facilities). • Availability of infrastructure supporting law and order.

SV1 The capacity to support subsistence livelihoods	**SV2 Opportunities for participation in the cash economy**	**SV3 An enduring ability to sustain cultural identity and traditions including connection to ancestors**	**SV4 An enduring ability to maintain customary rights to land access and resource use**	**SV5 An environment amenable to personal and family health, education, safety and security**	**SV6 The availability of services supportive of personal health, education, safety and security**
Labour		***Integrity of cultural domain***		***Human capital***	
• Labour availability for the maintenance of subsistence activity. • Level of traditional ecological knowledge.	• Labour skill levels. • Labour availability for the maintenance of enterprise activity. • Level of formal employment.	• Level of intermarriage. • Number of in-migrants settled in community. • Level of access and engagement with regional and urban communities. • Strength of religious observance. • Strength of customary leadership.	• Number of in-migrants settled in community. • Level of land alienation and degree of irreversible landscape alteration. • Active customary owner custodianship of land and water. • Strength of customary leadership.	• Health status (status of maternal and child health). • Incidence of disease (malaria, tuberculosis, STIs, diabetes, obesity etc.). • Education level. • Prevalence of literacy and numeracy ability. • Faith adherence.	• Availability of programs and personnel supporting law and order, • Availability of public servants across all service areas.
Market access		***Respect for cultural norms and practice***		***Relationships/social capital***	
• Access to points where subsistence exchange, trade or bartering occurs.	• Availability of economic support services (communications, banking, marketing, advisory). • Market access infrastructure. • Availability of savings, wealth creation and investment opportunities (through royalty and compensation benefit streams). • Availability of economic enhancement programs (financial literacy, cash crop extension etc.).	• Adherence to traditional societal norms and cultural practices (noting the dynamic nature of traditional norms and cultural practices). • Maintenance of traditional social structures.	• Customary owner and leader engagement and input to site location decisions.	• Harmonious relationships and management of conflict. • Level of social capital (nature and extent of social relations). • Level of inter and intra-clan and family disputation. • Adherence to customary and formal law and behavioural norms.	• Level of community support given to public servants. • Level of conflict over or with public servants.

SV1 The capacity to support subsistence livelihoods	**SV2 Opportunities for participation in the cash economy**	**SV3 An enduring ability to sustain cultural identity and traditions including connection to ancestors**	**SV4 An enduring ability to maintain customary rights to land access and resource use**	**SV5 An environment amenable to personal and family health, education, safety and security**	**SV6 The availability of services supportive of personal health, education, safety and security**
				Capability-building services	
					• Access to functional health and education service delivery. • Access to formal institutions and services to aid in the management of conflict (law enforcement, justice adjudication).

Table 4.2 Survey coverage of villages included in the social profile

Village	2009 to 2011 Socio-economic survey (census, household and village)	2015 Socio-economic survey (census, household and village)	2010 Health baseline survey	2010 Cultural heritage	2016 Cultural heritage (targeted sites)	2015 Village leaders social values workshops	2015 and 2016 Sepik River Awareness	2017 Socio-economic survey (household and village surveys)	2017 Focus group / key informant interview
Social Catchment 1A - Mine area									
Sokamin	✓	✓				✓			
Wameimin 1	✓	✓	✓	✓		✓			
Wameimin 2	✓	✓	✓	✓	✓	✓		Village survey only	✓
Amaromin	✓	✓	✓	✓	✓	✓			

Village	2009 to 2011 Socio-economic survey (census, household and village)	2015 Socio-economic survey (census, household and village)	2010 Health baseline survey	2010 Cultural heritage	2016 Cultural heritage (targeted sites)	2015 Village leaders social values workshops	2015 and 2016 Sepik River Awareness	2017 Socio-economic survey (household and village surveys)	2017 Focus group / key informant interview
Ok Isai	✓	✓	✓	✓	✓	✓		Village survey only	✓
Wabia	✓	✓	✓	✓	✓	✓		Village survey only	
Paupe	✓	✓	✓	✓	✓	✓		Village survey only	
Social Catchment 1B – New infrastructure and road corridor, Hotmin to Green River*									
Uramesin 2								Village survey only	
Temsapin								Village survey only	
Hotmin								✓	✓
Idam 1*								✓	✓
Idam 2								✓	
Wokomo 2								✓	
Bisiabru								Village survey only	✓
Social Catchment 1C – Existing infrastructure and road corridor, Green River to Vanimo									
Green River									✓
Aminii								Village survey only	
Kwomtari								Village survey only	
Itomi								Village survey only	

Village	2009 to 2011 Socio-economic survey (census, household and village)	2015 Socio-economic survey (census, household and village)	2010 Health baseline survey	2010 Cultural heritage	2016 Cultural heritage (targeted sites)	2015 Village leaders social values workshops	2015 and 2016 Sepik River Awareness	2017 Socio-economic survey (household and village surveys)	2017 Focus group / key informant interview
Kilifas								Village survey only	
Sumumini								Village survey only	
Imbrinis								Village survey only	
Social Catchment 1D – Vanimo Ocean Port									
Wesdeco								Village survey only	
Cis Point								Village survey only	
Social Catchment 2 – Sepik River corridor									
Auom 3	✓	✓	✓	✓					
Iniok	✓	✓	✓	✓					
Kubkain	✓	✓	✓	✓			✓		
Social Catchment 2 – Sepik River corridor									
Tauri				✓			✓		
Swagup	Village survey only						✓		
Yessan							✓		
Ambunti	Village survey only						✓		
Pagwi	Village survey only	Village and limited household survey					✓		

Village	2009 to 2011 Socio-economic survey (census, household and village)	2015 Socio-economic survey (census, household and village)	2010 Health baseline survey	2010 Cultural heritage	2016 Cultural heritage (targeted sites)	2015 Village leaders social values workshops	2015 and 2016 Sepik River Awareness	2017 Socio-economic survey (household and village surveys)	2017 Focus group / key informant interview
Sapanaut			✓				✓		
Moim	Village survey only						✓		
Kamanimbit	Village survey only						✓		
Angoram	Village survey only						✓		
Bin	Village survey only						✓		

*The survey team planned to undertake village, household and resource use surveys at Dioru on 7 November 2017. Due to logistical complications and high rainfall the village could not be accessed by road and consequently Dioru was not surveyed.

Table 4.3 Social values workshop details

Workshop	Date	Village	Number of attendees	Female participants
1. (Paiyamo)	1/10/2015	Paupe	5	1
2. (Telefol)	2/10/2015	Wabia	5	2
		Ok Isai	5	1
3. (Miyan)	3/10/2015	Amaromin	3	1
		Wameimin 1	2	-
		Wameimin 2	3	1
		Sokamin	2	-
Total			25	6 (24%)

In addition, FRL delivered FRCGP awareness sessions to communities along the Sepik River. The awareness program was undertaken in July and August 2015 and again in August and September 2016 and covered approximately 50 villages located from near where the Frieda River meets the Sepik River, through to the mouth of the Sepik River at Kopar, including the western delta in the Murik Lakes. Sepik River Awareness and Pre-EIS submission awareness sessions are also planned for all Project areas in August and September 2018, including the Kubkain road corridor which was previously part of the Project design.

In 2017, Project awareness sessions focused on the revised Project design and were delivered in the FRCGP mine area, new and existing infrastructure corridors and Vanimo Ocean Port social catchments. During these awareness sessions information on the Project design was delivered, and issues and concerns of villagers were identified and discussed. In addition to Project awareness sessions, FRL has regular engagement visits to villages within the FRCGP mine and FRHEP area social catchment, and communities within the revised Project design social catchments will continue to be engaged during the EIS process in 2018 and 2019.

4.1.3 Secondary sources

Secondary sources of information on the social catchments and values included Provincial and District development plans; survey data available from the PNG National Statistical Office including data from the 2000 and 2011 Census and the 2009 National Household Income and Expenditure Survey; reports and publications of national, provincial and local government departments such as the Department of Health, the Department of Education, the Department of Foreign Affairs and Trade, and Vanimo Local Level Government; university research publications; reports from development agencies such as the United Nations Children's Fund, Australian Aid, World Bank and Asian Development Bank; non-government organisations such as the Save the Children Fund Australia and the World Wildlife Fund; the PNG Tourism Promotion Authority and various other business publications.

4.1.4 Historical studies

As the Project has been subject to a large number of studies since the identification of mineralisation in the area in the 1960s, there is a range of historical information available from reports by previous proponents. Historical studies used to inform the compilation of social profiles and completing the impact assessment are referenced throughout and include socio-economic and cultural studies undertaken in the 1995 to 1996 period, including:

- Gardner, D. (1996a) Nena Project Socio-economic Impact Assessment-Cultural Impacts.
- Subada Consulting (1996) Community Directory Nena Project Area.

4.1.5 PNG experience

Information and data to enable a reliable assessment of the status of social values is available from a number of sources, including the existing literature on the impacts of mine development and operations in PNG. This literature was reviewed to identify common issues and lessons learned from large-scale mining projects now closed or currently operating including Misima, Panguna, Porgera, Lihir and Ok Tedi. The review identified ten recurring themes:

- Access to and use of **customary land.**
- Transparent and equitable distribution and use of **benefits.**
- The importance of effective **consultation and informed consent.**
- The effects of **inward migration.**
- Managing tensions between **local autonomy and state authority.**
- Minimising **environmental impacts.**
- The challenge of the **health paradox** (i.e., reducing disease incidence while at the same time introducing new diseases linked to lifestyle behaviours).
- The pressure for developers to provide **infrastructure.**
- **Building capacity** for future generations.
- Planning for the effects of **closure.**

4.2 Summary of social setting

The following sections summarise the socio-economic environment of the Project area and the status of social values for each social catchment. A detailed description of the elements and indicators for each social value by social catchment is provided in the study area social profiles (Appendix 1).

4.2.1 Social Catchment 1A: FRCGP mine and FRHEP area

Social catchment 1A comprises three social sub-catchments and communities. The Miyan, Telefol and Paiyamo communities are located in the FRCGP mine and FRHEP area and contain the villages of Sokamin, Wameimin 1, Amaromin, Wameimin 2, Ok Isai, Wabia and Paupe, as shown in Figure 1.6. These villages reside within 15 to 20 km of the proposed open-pit, infrastructure footprint or downstream of the ISF embankment. Members of landowning clans for the FRCGP and FRHEP largely reside in these villages, and will be impacted by the loss of land and for Ok Isai and Wabia, and significant restriction on resource use in their customary land.

The terrain within this social catchment area is rugged and mountainous. Villages are remote and accessibility is mostly via walking tracks with some villages including Amaromin, Ok Isai and Wabia also having adjacent access to canoe transport. From Sokamin, access to the nearest administrative centre (Mianmin) is via a two-day walk to the south; from Amaromin, following a walk to Fiak there is canoe travel available to Hotmin and the Sepik River. From Wameimin 2, residents walk to the headwaters of the Usake River from where canoe travel downstream to Hotmin and the Sepik River is available.

The location of each social sub-catchment in relation to government administrative boundaries (LLG, District and Province) is shown in Table 4.4.

Table 4.4 Mine area government administrative boundaries

Social sub-catchment	LLG	District	Province
Miyan	Telefomin Rural	Telefomin	Sandaun
Telefol	Telefomin Rural	Telefomin	Sandaun
Paiyamo	Tunap/Hunstein	Ambunti-Dreikikir	East Sepik

The Miyan social sub-catchment comprises four villages. Villages of Sokamin, Wameimin 1 and Amaromin are located approximately 20 km west to southwest from of the mine area, and situated within catchments of the Upper May River. Wameimin 2 is located approximately 7 km northwest of the proposed open-pit on the Upper Nena River and approximately 11 km upstream from of the western extent of the ISF reservoir. Wameimin 2 is also located approximately 3 km west-southwest of the Nena mineral deposit, which has the potential to be developed in future.

The Telefol social sub-catchment comprises two villages, Ok Isai and Wabia. These villages are located approximately 15 to 20 km due east of the proposed FRCGP open-pit, within the footprint of the ISF reservoir, and within catchments of the Niar River.

The Paiyamo social sub-catchment consists of one village, Paupe. Paupe is located 2.5 km north of the Frieda River airstrip, approximately 25 km from the HITEK deposits, 7 km downstream of the ISF embankment and 12 km downstream of the confluence of the Nena River and Ok Binai.

The total population of the social catchment at the end of 2017 (the most recent data collected from FRL) was approximately 2,000 persons, with an annual growth of around 60 persons per year. Population characteristics of the mine area are shown in Table 4.5.

The age profile of the population in the Mine and FRHEP areas was skewed toward younger age groups, however the number of older persons in the older age cohorts (as shown in Table 4.6) is comparable to the national average of 5.1% of the population aged 60 years and over (NSO, 2015a).

The gender ratios (number of men per 100 women) for the villages are shown in Table 4.7. The most obvious feature of this data is the higher gender ratio for the Miyan and Paiyamo villages in comparison to the Telefol villages. The basis for this difference is not known. The gender ratio for the Telefomin Rural District at the time of the 2011 census was 104 (NSO, 2014).

In relation to the status of social values centred on livelihoods (Social Values 1 and 2), Gardner (1996a) asserted that ‘the communities in the mine area retain a viable subsistence base and functioning social systems’. Twenty years on it is apparent through the investigations undertaken for the SIA that this statement remains valid for all mine area social sub-catchments, notwithstanding that the Telefol villages have established livelihoods based primarily on income derived from alluvial gold mining. The Miyan subsistence base appears to be robust, with limited participation in the cash economy through small scale alluvial gold production (particularly at Wameimin 2) and the supply of labour and services to FRL on an intermittent basis. The Paiyamo also take advantage of opportunities for income generation through the provision of transport and labour as they become available, and by supplying fish and other garden produce to upstream villages.

Table 4.5 Social Catchment 1A population data

Village	Population				Number of households				Annual growth rate (%)				Household occupancy (persons per household)		
	1996*	2009†	2014§	2017**	1996*	2009†	2014§	2017**	1996 to 2009	2009 to 2014	2014 to 2017	Telefomin Rural District 2000§§ to 2011 Census††	2009/2010 Momase rural††	2014	2017
Amaromin	n.a.	116	143	137	n.a.	25	29	27	n.a.	4.3	-1.4	2.4	6.7	4.9	5.1
Sokamin	201	256	332	360	25	39	55	57	1.9	5.3	2.7	2.4	6.7	6.0	6.3
Wameimin2	77	151	163	196	14	26	32	33	5.3	1.5	6.3	2.4	6.7	5.1	5.9
Wameimin1	81	144	171	188	16	23	27	32	4.5	3.5	3.2	2.4	6.7	6.3	5.9
Miyan sub-total	359	667	809	881	n.a.	113	143	149	4.9	3.9	2.9	2.4	6.7	5.5	5.9
Ok Isai	175	348	413	465	21	38	46	60	5.4	3.5	4.0	2.4	6.7	9.0	7.8
Wabia	177	319	369	393	17	45	61	63	4.6	3.0	2.1	2.4	6.7	6.0	6.2
Telefol sub-total	352	667	782	858	38	83	107	123	5.0	3.2	3.1	2.4	6.7	7.5	7.0
Paupe	105	163	222	262	18	22	28	38	3.4	6.4	5.7	2.4	6.7	7.9	6.9
Total	816	1,497	1,813	2,001	n.a.	218	278	310	-	-	-	-	-	-	-

n.a.: not available

* 1996 Subada Consulting survey

† Coffey 2009 survey

§ 2014 FRL census

** 2017 FRL census.

†† NSO, 2014

§§ NSO, 2000.

Table 4.6 Population age distribution in villages within the Mine and FRHEP area

Village	Total Population	Number and percentage of population under 15	Number and percentage of population over 60
Amaromin	137	57 – 41.9%	6 – 4.4%
Sokamin	360	146 – 41.6%	9 – 2.6%
Wameimin 1	188	79 – 42.0%	10 – 5.3%
Wameimin 2	196	73 – 38.4%	10 – 5.3%
Ok Isai	465	189 – 41.9%	18 – 4.0%
Wabia	393	146 – 38.0%	18 – 4.7%
Paupe	262	107 – 44.8%	12 – 5.0%
Total	**2,001**	**797 – 39.8%**	**83 – 4.1%**

Source: Data from December 2017 FRL census.

Table 4.7 Village gender ratios (number of men per 100 women)

Village	Gender ratio (2014)	Gender ratio (2017)
Miyan social sub-catchment		
Amaromin	119	121
Sokamin	110	112
Wameimin 1	118	109
Wameimin 2	120	120
Telefol social sub-catchment		
Ok Isai	92	97
Wabia	100	92
Paiyamo social sub-catchment		
Paupe	116	101

Source: 2014 and 2017 FRL census.

With respect to the status of social values centred on culture (Social Values 3 and 4; refer to discussion in Section 3.1.3 about the dynamic nature of social values), cultural knowledge among the current generation of adults is strong, though accompanied by an acknowledgement that elements of culture have been evolving since initial contact with the Australian colonial administration, and that they will continue to evolve, possibly at an accelerated rate, should the Project proceed to development. There is a common sentiment expressed that it is the responsibility of parents to ensure that important elements of tradition and ancestral connection are passed on to the next generation. Land custodianship in the FRCGP area, in accordance with customary precepts for access and resource use, is complex considering the past settlement history (Jorgensen, 2007). While there is an agreement between Miyan and Telefol in regard to the sharing of royalties, there is recognition that, in the event of the Project proceeding, there will inevitably be pressure for in-migration from outsiders and distant 'clan' relatives that will require State and company support to manage.

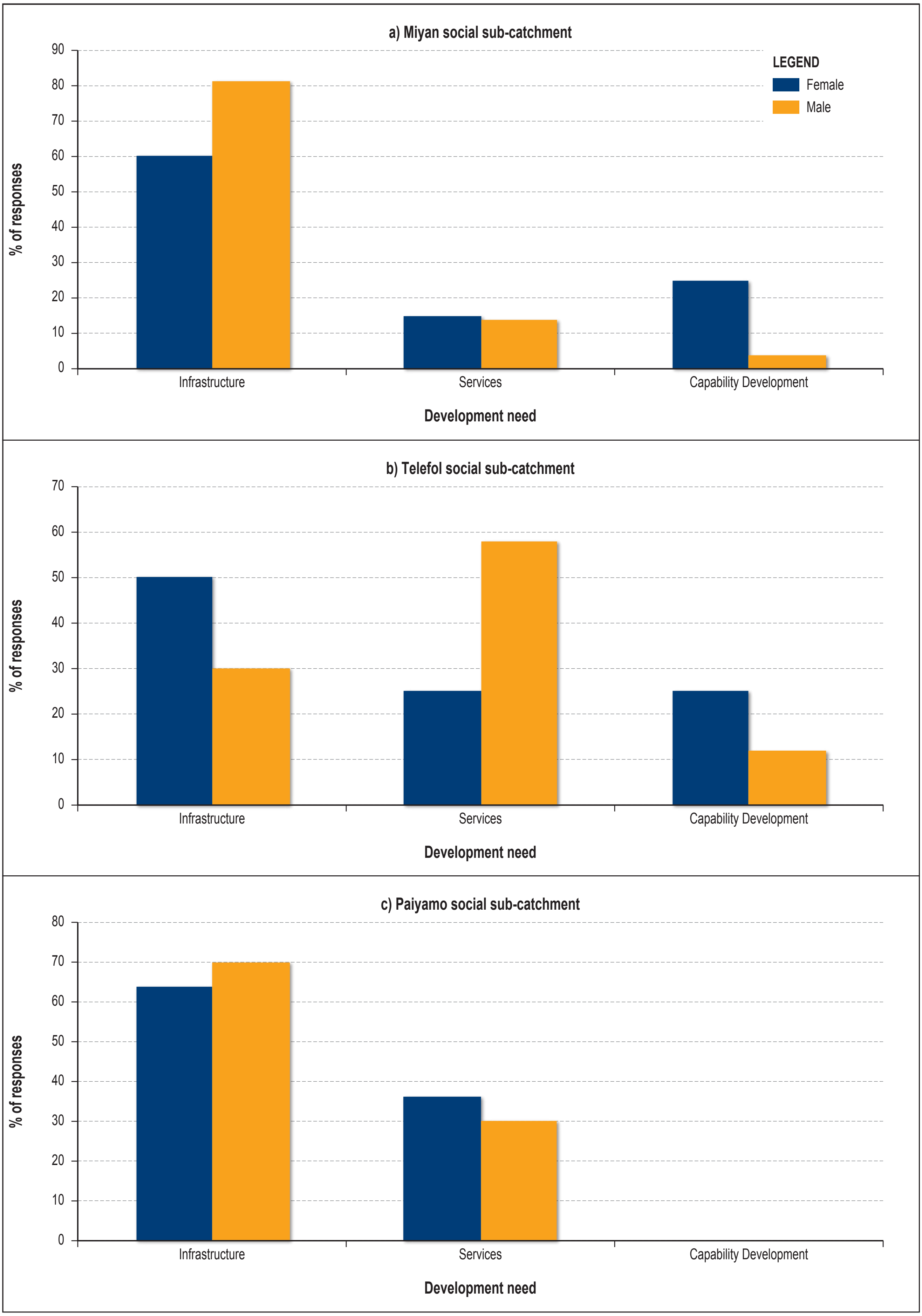
Personal and community well-being (Social Values 5 and 6) are highly important values, with the current physical and social environment of all mine area social catchment communities being conducive to health, safety and security, primarily due to remoteness (and consequent minimal contact with outside persons or the use of alcohol and drugs), continued access to good quality gardening land, forests and rivers, and health services supported by FRL. Limited public infrastructure and services are viewed as a detriment to community life that is only likely to be rectified in the event of the Project proceeding. Villages required to resettle (Ok Isai and Wabia in the FRHEP reservoir area, Paupe due to its proximity to the FRHEP and Project roads, and Wameimin 2 due to its proximity to the Nena Deposit) will be subject to a Resettlement Action Plan that will address standard of living needs and have commitments aimed at restoration of livelihoods and maintenance of social values.

Figure 4.1 summarises development needs for social sub-catchments within the mine area catchment expressed by males and females during consultation for the SIA. While expressed development needs are reasonably similar across social sub-catchments, women appear to have a higher focus on capability development (training), particularly in the Miyan social sub-catchment. All mine area villages are in the Project's Employment Zone 1, and will therefore be a priority source of employees for the construction and operations stages of the Project.

Tables 4.8, 4.9 and 4.10 summarise positive and negative concerns expressed during the 2015 surveys by males and females, should the mining development proceed. Of note, women expressed concerns with the potential for an increase in sexually transmitted diseases, domestic violence and family breakdown, whereas these concerns were rarely mentioned by men. Men generally raised the potential for environmental damage more than women.

Table 4.8 Miyan social sub-catchment - top female and male responses to awareness on potential mine impacts

Top five negative responses – female (%)	Top five negative responses – male (%)
• Substance abuse (17). • Family breakdown (17). • STIs (17). • In-migration (17). • Violence against women (11).	• In-migration (32). • Substance abuse (21). • General law and order (16). • Family breakdown (11). • Increase in disease incidence (11).
Top five positive responses – female (%)	**Top five positive responses – male (%)**
• Better economic infrastructure (33). • Business opportunities (17). • Employment and income (11). • Better social infrastructure (11). • Employment and training opportunities (5).	• Better economic infrastructure (37). • Better social infrastructure (19). • Employment and income (15). • Royalty receipt (11). • Better social services (11).



coffey A TETRA TECH COMPANY	Date: 26.09.2018 Project: 754-ENAUABTF11575B File Name: 11575_15_F04.01_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Expressed development needs of social sub-catchments within mine area catchment	Figure No: 4.1

AI Reference: 11575_15_GRA003.ai_2

Table 4.9 Telefol social sub-catchment - top female and male responses to awareness on potential mine impacts

Top five negative responses – female (%)	Top five negative responses – male (%)
• General law and order (18). • Substance abuse (18). • Family breakdown (18). • STIs (18). • In-migration (18).	• Environmental damage (24). • General law and order (12). • Substance abuse (12). • Family breakdown (12). • In-migration (12).
Top five positive responses – female (%)	**All positive responses – male (%)**
• Better social services (36). • Better economic infrastructure (25). • Employment and incomes (12). • Business opportunities (12). • Development support programs (12).	• Better economic infrastructure (56). • Better social services (19). • Employment and incomes (12). • Business opportunities (12).

Table 4.10 Paiyamo social sub-catchment - top female and male responses to awareness on potential mine impacts

Top five negative responses – female (%)	All negative responses – male (%)
• Environmental damage (30). • Violence against women (13). • Substance abuse (13). • In-migration (13). • Labour shortage (7).	• Environmental damage (89). • In-migration (7). • Family breakdown (4).
All positive responses – female (%)	**Top five positive responses – male (%)**
• Better economic infrastructure (60). • Employment and incomes (40).	• Employment and incomes (29). • Better social infrastructure (21). • Better economic infrastructure (14). • Business opportunities (14). • Better social services (14).

4.2.2 Social Catchment 1B: New infrastructure and road corridor, Hotmin to Green River

The new infrastructure and road corridor (Social Catchment 1B) encompasses approximately 110 km of the proposed main access route to the mine area and runs from Hotmin north-northwest to Green River. At this point it meets the existing infrastructure and road corridor (Social Catchment 1C). Eight representative villages in Social Catchment 1B were subject to a limited survey by Coffey in 2017, and this survey data forms the basis of much of the information on this catchment. These villages include Hotmin, Idam 1, Idam 2, Bisiabru, Wokomo 2, Uramesin 2 and Temsapin (Figure 1.6). Hotmin, Uramesin 2 and Temsapin are located in the Tunap/Hunstein Rural LLG of the Ambunti/Dreikikir District of East Sepik Province. Wokomo 2, Idam 1, Idam 2, Bisiabru and Green River are located in the Green River Rural LLG of the Vanimo/Green River District of Sandaun Province.

The corridor tracks in a northwesterly direction from Hotmin following the valley of the Right May River in the East Sepik Province for approximately 40 km through customary land belonging to the Miyan and Bo language groups. From this point, the corridor crosses the West Mountain Range into Sandaun Province and tracks generally in a northerly direction through the Idam River valley back swamps and flood plains to Green River, crossing the Sepik River near Simaiye village. The major portion of this customary land belongs to the Abau language group. The Abau language is spoken by more than 7,000 people in Sandaun Province, in the area to the immediate east and west of Green River, as well as the villages along the Sepik River and its tributaries, starting at the border with Indonesian Papua through to the border with East Sepik Province.

The total population for villages surveyed within this social catchment was approximately 2,100 people. Most of the inhabitants recorded (62%) reside in Idam 1 with 794 inhabitants, followed by Idam 2 with 518 inhabitants. Wokomo 2 contained the smallest population, with 65 inhabitants.

Regarding the status of social values centred on livelihoods (Social Values 1 and 2), most of the villages are remote making subsistence practices play a significant role in the livelihoods of households within the catchment. There is enough access to resources currently to provide for a subsistence lifestyle throughout the catchment with a variety of produce grown and animals hunted. Opportunity for participation in the cash economy is limited, with Hotmin hosting a reasonably vibrant local market, possibly due to the higher level of population and the availability of cash through some employment at the Frieda base and the mining of alluvial gold on the Left May River. There appears to be almost no routine participation in the cash economy in villages such as Idam 1, Idam 2 and Wokomo 2. Opportunities for formal employment in that area are limited, with few households generating income from such means. Increasing opportunities for participation in the cash economy through market access via the development of local road infrastructure is seen as an important benefit of the Project among the villages.

Regarding the status of social values centred on livelihoods (Social Values 3 and 4), there is a strong connection to the land and the traditional ways of life within the catchment. Due to their isolation, low population density and the absence of demand for access to their land for industrial agriculture (notwithstanding the now-proposed Idam-Siawi agroforestry project, which was not widely understood at the time of the surveys), communities within the catchment have been able to maintain their customary rights to land access and resource use and maintain or discard their cultural identity and traditions according to their own terms. Elements of tradition continue to be passed down through generations and practised, while being overlaid with Christian religious observance. Opportunities to improve living standards through increased wealth and basic services from the proposed infrastructure and road development are acknowledged throughout the catchment. However, there is a concern among some that an increase in wealth and outside influences in the community has the potential to negatively impact on traditional cultural practices and family values. The development of a road may affect land access and resource use around proposed infrastructure locations and effective negotiations with landowners will need to take place to allow access to customary lands. Access to lands and resource use in the new infrastructure and road corridor may become an issue should in-migration occur or external service industries seek to establish themselves in the area.

With respect to personal and community wellbeing (Social Values 5 and 6) the communities within the catchment generally experience a safe and secure social environment, in large part due to the remoteness of the villages. The current physical and social environment of the catchment is moderately supportive of health, safety and security, though highly dependent on favourable seasons to ensure that resource harvest is sufficient for family food requirements. The remoteness of the villages generally ensures family safety and security, but is an obstacle when accessing health facilities. There is little public infrastructure and the services available to support personal health, safety and security are limited. Where infrastructure such as an aid post exists, the general state is characterised by an absence of staff and medical supplies. These factors combine to indicate a moderate level of vulnerability regarding personal and community wellbeing and is an area where communities have strongly held views on the need for improvement.

Within the catchment there is a strong desire for development and a pledge to provide labour and land to those delivering services, whether government or the private sector. Figure 4.2 and Table 4.11 detail the expressed development needs within the catchment. The villages surveyed saw potential benefits of the Project as being improved access to economic infrastructure and business opportunities, while the potential negative impacts identified included environmental damage and the potential for a deterioration in law and order (Table 4.12).

Table 4.11 Social Catchment 1B priority development needs

Infrastructure	Services	Capability development
• School • Aid post • Road • Water supply • Market • Air strip	• Education • Health	• Literacy • Skills development

Table 4.12 Social Catchment 1B top female and male responses from villages on potential impacts associated with the Project

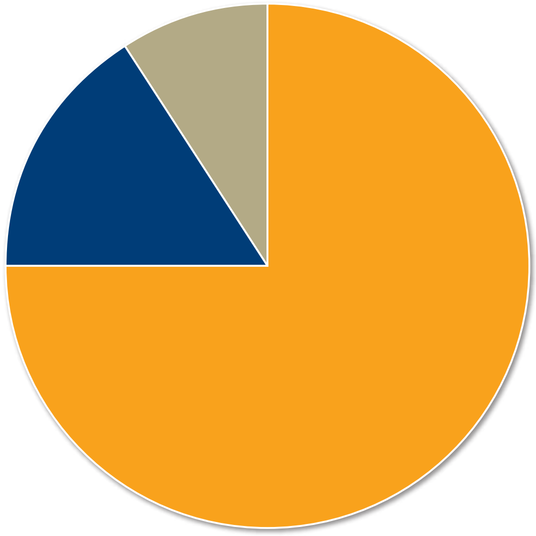
Top 5 negative - female	Top 5 negative - male
• Pollution/environmental damage • Loss of land • Foreign influence	• Foreign influence • Pollution/environmental damage • Crime/violence • Family breakdown • Substance abuse
Top 5 positive - female	**Top 5 positive - male**
• Increased economic activity/market • Road • Electricity	• Electricity • Road • Increase livelihood/living standard • Water supply

4.2.3 Social Catchment 1C: Existing infrastructure and road corridor, Green River to Vanimo

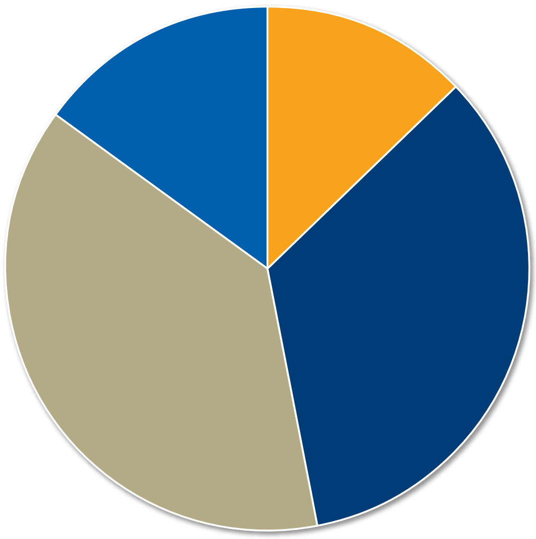
Social catchment 1C comprises seven representative villages situated along the existing public road, encompassing part of the main access road (approximately 190 km) extending from Green River to Vanimo on the northwest coast of the Sandaun Province.

These villages include Aminii, Kwomtari, Itomi, Kilifas, Sumumini, Imbrinis and Green River (Figure 1.7). Aminii and Green River are located in the Green River Rural LLG, Kwomtari and Itomi are located in the Amanab Rural LLG, Kilifas is located in the Walsa Rural LLG and Sumumini and Imbrinis are located in the Bewani/Wutung Onei Rural LLG. All seven villages are within the Vanimo/Green River District of Sandaun Province.

Catchment 1B - expressed development needs (% of responses)



Catchment 1B - expressed infrastructure development needs (% of responses)



coffey A TETRA TECH COMPANY	Date: 26.09.2018 Project: 754-ENAUABTF11575B File Name: 11575_15_F04.02_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Expressed development needs within Social Catchment 1B	Figure No: 4.2

AI Reference: 11575_15_GRA004.ai_4

The population of Vanimo/Green River District grew by an average annual rate of 2.9% between 2000 and 2011, from 50,751 to 69,052 (NSO, 2000 and NSO, 2014). The highest rate of population growth was in the Bewani/Wutung Onei Rural LLG, the closest LLG to the town of Vanimo. At the village level, both Itomi and Imbrinis had substantially higher than average growth rates, 13.5% and 8.2% respectively. This is possibly attributable to in-migration associated with logging activities in the region.

Key population characteristics for Social Catchment 1C are detailed in Table 4.13.

Table 4.13 Social Catchment 1C population data

Village	Population	Households	Household occupancy	Male	Female	Gender Ratio*
Aminii	292	39	7.5	150	142	106
Kwomtari	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Itomi	525	77	6.8	287	238	121
Kilifas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sumumini	1,010	168	6.0	556	454	122
Imbrinis	939	141	6.7	516	423	122

Source: NSO, 2014

Table 4.14 details the age demographics in the catchment. Between 44% and 46% of the population are between 20 to 49 years of age.

Table 4.14 Social Catchment 1C estimated age demographics

Villages	Percentage of population under 15	Percentage of population over 60
Aminii	46%*	3%*
Kwomtari, Itomi	44%†	4%†
Kilifas	45%§	2%§
Sumumini, Imbrinis	45%**	3%**

* Based on Green River Rural LLG data
† Based on Amanab Rural LLG data
§ Based on Walsa Rural LLG data
** Based on Bewani/Wutung Onei Rural LLG data
Source: NSO, 2014

Heading north from Green River, Catchment 1C travels on the edge of western hills to Kwomtari, from where it crosses alluvial plains and back swamps to Kilifas. The land traversed generally belongs to clans from the Kwomtari language group. From Kilifas, the corridor crosses the Bewani Range to Sumumini, and then proceeds across alluvial plains and hilly terrain to Imbrinis and on to the Nemayer River from where it tracks northwest to Vanimo. The majority of this section (Kilifas to Imbrinis) belongs to clans from the Fas language group.

Villages in the south of Social Catchment 1C are largely isolated with few settlements spread out along the existing road corridor. Further north in the catchment, commercial operations including logging and oil palm plantations increasingly dominate the landscape. A major logging camp known as Maka is located between Itomi and Kilifas from where logging operations are run and supplies are stored. A limited number of roadside stalls can be found within the catchment, particularly further north towards Vanimo, which largely serve vehicles associated with logging operations travelling along the road.

The total population for most of the villages recorded within this social catchment was approximately 2,700 people. Most of the inhabitants recorded reside in Sumumini (1,010), followed by Imbrinis (939), Kwomtari (597) and Kilifas (521) (NSO, 2014).

In relation to the status of social values centred on livelihoods (Social Values 1 and 2), opportunities to support a subsistence livelihood within the catchment are strong given favourable seasonal conditions, low population and abundance of land. However, some areas are vulnerable to unfavourable climatic conditions such as flooding and pressure from commercial agricultural operations such as logging and oil palm plantations. There are greater opportunities for participation in the cash economy within Social Catchment 1C compared to Social Catchment 1B due to the logging operations and proximity to the provincial capital Vanimo. However, opportunities are limited and incomes relatively low compared to other areas of PNG. The positive socio-economic development outcomes of large-scale logging are limited at best, and often outweighed by negative effects (Forest Trends, 2006).

In relation to the status of social values centred on maintaining cultural identity and traditions and the ability to maintain customary rights to land access and resource use (Social Values 3 and 4), there is a strong connection to the traditional ways of life within the regions south of the Bewani Range. This is a result of the isolation, low population density and the absence of demand for access to land for industrial agriculture in these areas within the catchment. This has allowed communities to maintain their cultural identity and traditions. Elements of tradition continue to be passed down through generations and practised, while being overlaid with Christian religious observance. South of the Bewani Range, pressures on land access and resources is relatively low compared to areas north of the Bewani Range.

As the corridor moves further north away from the Bewani Range towards Vanimo, traditional ways of living are being met by industrialised practices, which is modifying day to day ways of living from traditional customs to a combination of traditional and non-traditional practices. Logging practices have increased over the past 10 years putting pressure on the local populations' access to land and natural resources. Through logging and oil palm, large areas of land have also been placed under Special Agricultural Business Leases resulting in a serious erosion in customary tenure security (COI, 2013; Winn, 2012).

The current physical and social environment of Social Catchment 1C is moderately supportive of personal and community health, safety and security (Social Values 5 and 6). The villages generally live a traditional subsistence lifestyle which is dependent on favourable environmental conditions. However, the subsistence based lifestyle is becoming supplemented more and more by opportunities to enter the cash economy particularly in the villages closer to Vanimo and near the logging camps. Increased exposure to the cash economy in some circumstances has seen a rise in substance abuse and law and order issues. Villages in the more remote locations generally experience a safe environment however face difficulty when access to services is needed. The existing infrastructure and road corridor social catchment communities have limited public infrastructure and, in general, do not have access to services supportive of personal health, safety and security. Where infrastructure exists (such as aid posts), the general state is characterised by an absence of staff and medical supplies. These factors combine to indicate a moderate level of vulnerability in relation to personal and community wellbeing. Overall however, due to linkage to Vanimo by road, Social Catchment 1C has greater access to essential services than the other catchments.

The development priorities of the communities visited within the catchment predominantly related to basic infrastructure and services including water and electricity supply and education and health services (Table 4.15).

When asked to identify potential social impacts from the Project, a number of villages surveyed were not able to specify any (Coffey, 2017). The most common positive impacts reported were the potential for improved road and market access to sell produce. Other responses included the potential for improved access to Vanimo, health services, improvements to law and order and human resources. No negative impacts were identified.

Table 4.15 Social Catchment 1C priority development needs

Infrastructure	Services	Capability development
• Water supply • School • Electricity • Aid Post • Sports and community facilities • Transport infrastructure	• Education • Health • Mobile phone coverage	• Literacy • Skills development

4.2.4 Social Catchment 1D: Vanimo Ocean Port

Social catchment 1D comprises the capital of Sandaun Province, Vanimo, and two representative villages of Wesdeco and Cis Point (Figure 1.7). This catchment is an extension of the existing public road from Green River to Vanimo.

Vanimo Town is located on the north coast of Sandaun Province encompassing the Vanimo Peninsula, approximately 30 km east of the Indonesian border. Cis Point is a peri-urban village located approximately 1 km from Vanimo town centre. Wesdeco is a village located less than 0.5 km north and east of the existing Port of Vanimo. The inclusion of the villages in the catchment is due to their proximity to the existing port which is proposed to be upgraded as a part of the Sepik Infrastructure Project. The Wesdeco village was established in early 1979 by the West Sepik Development Corporation Pty Ltd (Boyce, 1992). The 'Cis' in Cis Point stands for Corrective Institutions Service, the operators of a correctional service facility in proximity to the village.

Vanimo, Wesdeco and Cis Point fall within the government administrative boundaries of Vanimo Urban LLG. Wesdeco and the existing Port of Vanimo are located in ward three (Wesdeco) and Cis Point is situated in ward two (Dali/Makepa).

Population data for social catchment 1D is based on the 2011 national census (NSO, 2014) and the 2000 national census (NSO, 2000), shown in Table 4.16. The total population of Vanimo Town was approximately 13,970 in 2014 (NSO), and 144 for Cis Point and 507 for Wesdeco (NSO, 2011).

Table 4.16 Population and household characteristics of Social Catchment 1D

Town/Village	Population	Households	Male	Female
Vanimo Town*	13,970	2,370	7,404	6,566
Cis Point†	144	11	108	36
Wesdeco†	507	82	274	233

* NSO, 2014

† NSO, 2000

The age distribution within the Vanimo Urban LLG is shown in Table 4.17. The age profile is skewed to the younger age groups for both male and females. Approximately 1.4% of the Vanimo Urban LLG are in the 65 plus age group which aligns with the national trend where approximately 2.6% of the population are aged 65 and over (NSO, 2015a).

Table 4.17 Total population by Vanimo Urban Local Level Government, age and sex

Age (years)	Number and percentage of population	Males	Females	Gender ratio*
0-4	1,801 - 13%	915	886	103
5-9	1,779 - 13%	930	849	110
10-14	1,610 - 12%	829	781	106
15-24	1,666 - 12%	916	750	122
20-24	1,419 - 10%	792	627	126
25-29	1,256 - 9%	623	633	98
30-34	944 - 7%	469	475	99
35-39	894 - 6%	472	422	112
40-44	711 - 5%	356	355	100
45-49	652 - 5%	349	303	115
50-54	478 - 3%	295	183	161
55-59	304 - 2%	199	105	190
60-64	193 - 1%	111	82	135
65-69	117 - 1%	62	55	113
70-74	45 - <1%	23	22	105
75-79	23 - <1%	15	8	188
80-84	11 - <1%	4	7	57
85-89	3 - <1%	1	2	50

NSO, 2014

* Number of males per 100 females

Regarding the status of livelihood values (Social Values 1 and 2), due to Wesdeco and Cis Point's geographic location, fishing is the key subsistence activity practiced within the settlements. Subsistence practices in terms of mixed staple gardens are limited due to Vanimo's urban and industrial setting. The town of Vanimo is the economic and political hub of Sandaun Province with a range of shops, markets and logging operations which provides greater accessibility into the cash economy in comparison to the other social catchments. There are opportunities for participation in the cash economy through activities such as selling fish and other fresh food. For instance, some families earn a small income from the sale of surplus garden produce or fish at markets in Vanimo. Commercial activities, such as timber and palm oil operations, take place close to Vanimo, which also hosts headquarters of, and major service providers to these enterprises.

Residents of Vanimo and surrounding settlements largely belong to the Vanimo language group, also referred to as Dumo, Duso, Manimo and Wanimo (Clifton, 2013). This language group is made up of two dialects, Vanimo and Waromo (Clifton, 2013). With respect to the status of social values centred on culture (Social Values 3 and 4), communities in the Vanimo Ocean Port social catchment have retained customary rights to use land and access its resources through activities such as fishing, harvesting seafood and maintaining gardens. However, these rights and access to land are under pressure in Vanimo and surrounding areas due to the increasing development of the town, migration to settlements surrounding Vanimo from rural areas and commercial agricultural operations in proximity to Vanimo. The population of Vanimo includes residents born in the town with ancestral links to the area as well as migrants from other rural areas of PNG and international residents (Vanimo Urban LLG, 2014). This is also the case for both Wesdeco and Cis Point. Rural urban migration to

Vanimo, and the settlements of Vanimo, is on the increase with migrants attracted by opportunities to generate an income through participation in the cash economy.

The current physical and social environment of the Vanimo Ocean Port social catchment is moderately supportive of personal and community health, safety and security (Social Values 5 and 6). The Vanimo township and settlements within Vanimo support a range of infrastructure and services including a hospital, police station, primary and secondary schools, recreational areas, banks, supermarkets and an airport. Much of this infrastructure is in a need of an upgrade and/or characterised by a lack of staff and equipment which limits the extent to which it can adequately service the community.

A prominent concern from local communities is the increase in law and order issues within the catchment. Comments made by the local community and officials revealed concerns, particularly in relation to health, education and law and order. Social issues that stem from the presence of HIV/AIDS, youth violence and the increase in teenage pregnancies are prominent concerns among the communities interviewed. Community leaders and governmental officials also reported concerns with the consumption of addictive substances including alcohol (which may be store bought or locally-produced) and betel nut. Law and order issues are also understood to be on the rise in the catchment (Vanimo Urban LLG, 2014). These factors combine to indicate a high level of vulnerability.

Residents in the settlements of Cis Point and Wesdeco were asked about what they saw as the priority development needs for their communities. Both communities identified the need for an improved water supply, proper sanitation, school facilities and electricity (Coffey, 2017). In Wesdeco settlement, survey respondents also identified the need for sealed roads, improved law and order and market facilities.

In relation to the perceived impacts of the Project within Cis Point and Wesdeco, in particular relating to the upgrade and expansion of Vanimo Port, the community generally welcomed the development but indicated that they would have terms and conditions that they would endeavour to impose on the development. It was identified that the Vanimo Ocean Port could provide a boost to the fishermen through the establishment of permanent market facilities at the port, which they welcomed. They also felt that the Project would generate economic benefits. A common concern was the potential for pollution of the marine environment. In Wesdeco, expressed potential benefits include the opportunities the Project could provide for people to access markets and businesses. It was also expected that the Project could lead to improving access to health and education facilities. Key disadvantages identified related to the potential for an increase in law and order issues, an increased incidence of disease including sexually transmitted diseases, and increases in foreign influence, prostitution and substance abuse.

4.2.5 Social Catchment 2: Sepik River corridor

Social Catchment 2 extends from the proposed Sepik River bridge crossing to the mouth of the Sepik River (and including the proposed May River Port and Auom 3 at the southern end of Lake Warangai), comprising communities from several language groups along the upper, middle and lower sections of the river.

The Sepik River corridor is located within the East Sepik Province extending from the confluence of the Frieda River to the Sepik River mouth at Cape Girgir. Most village households were located on the river bank. These communities may experience effects from barging or be a source of labour for Project construction and operations (Figure 1.8).

Communities surveyed along the Sepik River corridor ranged in an estimated population from 229 at Pagwi to 1,884 in the largest community at Angoram. Data from the 2011 census indicate a reasonably balanced gender ratio in most communities, except for Yessan and Kubkain where 42% and 43% of the population was male, respectively (NSO, 2014). Table 4.18 provides the population and gender ratio at each location.

Table 4.18 Population of selected communities along Sepik River corridor

Community	Population estimate	Gender ratio (Number of males per 100 females)
Iniok	499	90
Auom 3	118	79
Tauri	664	92
Kubkain	324	76
Swagup	552	104
Yessan	721	73
Ambunti	547	94
Pagwi	229	99
Sapanaut	438	96
Moim	1,012	110
Kamanimbit	560	98
Angoram	1,884	102
Bin	1,008	93

Regarding the status of social values, socio-economic surveys were completed in 15 representative communities: Bin, Angoram, Moim, Kamanimbit, Sapanaut, Pagwi, Ambunti, Swagup, Kubkain, Tauri, Auom 3, Iniok, Hauna, Senapiena and Biaga. Auom 3 was selected as it is reliant on Lake Warangai as a source of drinking water and fish and this lake is hydraulically connected to the Frieda and Sepik rivers via several channels. The other 14 sites were selected on the basis of both geographical spacing and coverage of customary landowning groups, and are considered to be representative of the general population along the relevant sections of the Sepik River.

In addition, a program of Sepik River engagement sessions for the FRCGP was completed across 41 villages along the Sepik River between July and August 2015 (estimated 7,000 attendees) and across approximately 50 villages between August and early September 2016 (estimated 8,000 attendees). These awareness sessions were delivered from near where the Frieda River meets the Sepik River at Iniok village, through to the mouth of the Sepik River at Kopar village, and ended in the western delta in the Murik Lakes. A notable difference between the awareness sessions completed in 2015 and those in 2016 was that in 2016 the residents were far more informed regarding the FRCGP. The questions and concerns raised contained a greater level of detail regarding specific elements of the FRCGP and potential impacts. They also covered a greater range of subjects and issues than in 2015.

Issues raised by attendees were recorded and categorised into three main themes as presented in Table 4.19. Many of issues raised and questions posed were similar across communities and primarily relate to the importance of the Sepik River to the wellbeing of these communities. Engagement with Sepik River villages is ongoing in 2018.

Table 4.19 Main issues raised during the 2015 and 2016 Sepik Awareness patrols

Issue	Description
Environmental issues	Environmental queries and issues raised included: • Highlighted the importance of Sepik River to all aspects of life and concerns that its ongoing water quality is maintained. • Concerns of mine waste including riverine tailings disposal and ISF overflow, reaching the Sepik River and how this may impact on environmental and human health. • Concerns as to the structural integrity of the ISF dam wall and the ability to construct a wall capable of withstanding flood events, unstable ground and earthquakes. • The types of chemicals to be used to extract gold and copper; and whether these chemicals will affect water quality and the environment. • Concerns that siltation from the Project will cause a rise in the river bed (already attributed to logging activity by locals). • The potential to construct a road to transport concentrate to a sea port and avoid the river transport route. • Fear around disturbance and depletion of local fish and crocodile stocks, especially through barging. • Concerns relating to increased flooding in low lying river side areas if a raising of the river bed occurs (e.g., the scenario at Ok Tedi). • Requests for further information on the ISF at PanAust's other mine in Laos. • Whether the Project can guarantee that wastes will not leak through the groundwater or through the walls of the ISF dam.
River use issues	Queries and concerns relating to the use of the Sepik River queries included: • The desire for the mine and use of the Sepik River not to disrupt subsistence livelihoods. • The effects of barges upon fish including the noise generated by barges scaring fish away and changing the physical attributes of the river and subsequently affecting availability of fish. • The edibility of fish exposed to mine related wastes. • Concerns relating to disturbance from increased noise and light. • Concerns relating to increased wave action leading to land slips from river banks and its potential to disrupt daily use of the river for transport and inundating houses during periods of high flow. • Concerns relating to accidental discharge of oil or other pollutants into Sepik River by river craft.
Benefits	Queries and concerns relating to the potential benefits and job opportunities included: • Discussion of potential benefits and job opportunities. • Compensation arrangements for impacts. • Concern that communities will bear most of the impacts but be given few of the benefits. • Concern that the Sepik River will not be adequately represented at the Development Forum.

Issue	Description
	• Distrust of all political levels of leadership (provincial to local level government) to deliver allocated benefits to the village or ward levels (misuse and corruption). • Concern that no level of benefits will offset feared environmental impacts ('net worse off').

With respect to the status of social values centred on livelihood (Social Values 1 and 2) the subsistence base of villages in Social Catchment 2 is robust given favourable seasonal conditions, but vulnerable to climatic extremes such as flooding or the drought conditions being experienced at the time of the survey in late 2015. The flooding and presence of swamps mean cash-cropping opportunities are negligible. Market access and the availability of aquatic resources, for which there is demand, afford Sepik villages a modest level of opportunity to participate in the cash economy. However, environmental change occurring currently, such as sedimentation due to alteration to catchment cover from logging and the reduction of aquatic vegetation and crocodile habitat in off-water river bodies due to the introduction of exotic fish species and overpopulation in areas, was increasingly being noticed. Opportunities for migration and labour market participation within East Sepik and other areas of PNG have historically been important for income generation, however the low education levels provide limited opportunities for employment.

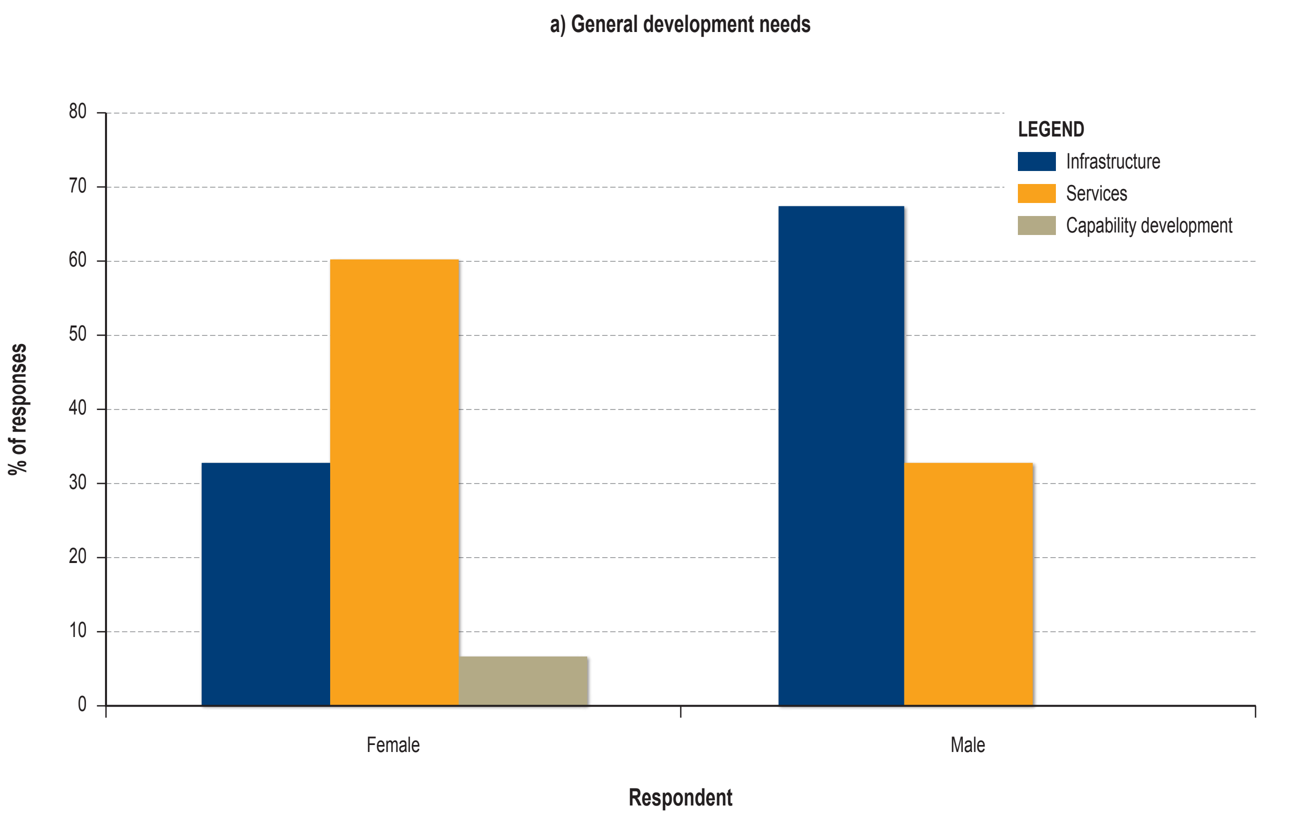
Christian religious beliefs and observance have become a significant part of village culture along the Sepik River corridor where communities also maintain a strong cultural connection with the river. Cultural values and customary practices (Social Values 3 and 4) continue to be an important part of daily life along the Sepik River corridor, and are used in marketing ecotourism ventures in the area. Most cultural sites have not been subject to disturbance from development activity; however, traditions are not as readily passed down to younger generations. Customary rights to land and water resources are currently intact and robust.

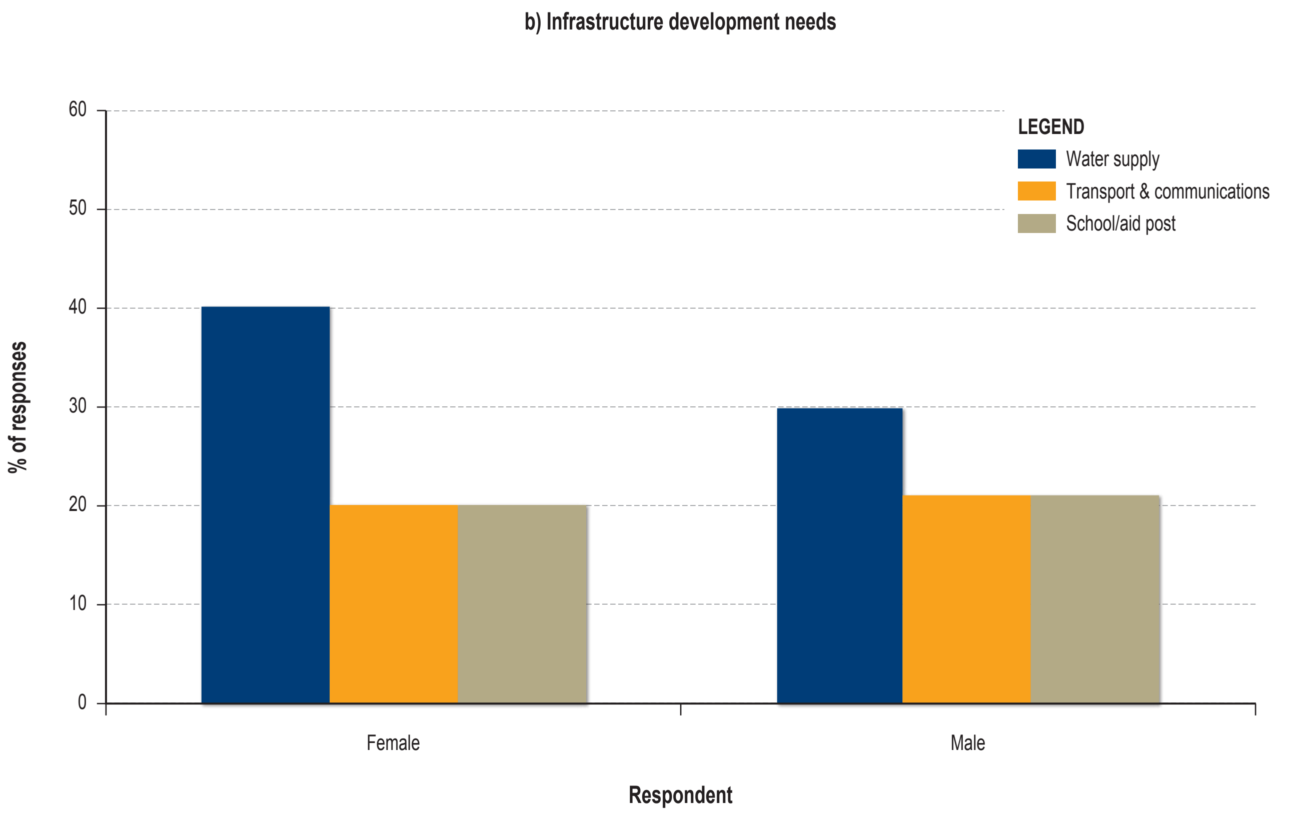
In relation to personal and community well-being (Social Values 5 and 6), services (policing, education and health) along the Sepik River are limited at best, and non-existent in the more remote areas, especially in off-water river bodies. Villages are reliant on their own initiatives and strategies to support fundamental needs of families. Combined with social dysfunction due to alcohol and drug use (and consequent domestic violence) family health, safety and security have a high level of vulnerability.

The communities within the catchment visited by Coffey identified a variety of development priorities. These included improvements to infrastructure, in particular water infrastructure as well as transport, communications, education and health services (Figure 4.3).

4.2.6 Social Catchment 3: Sandaun and East Sepik Provinces

Social Catchment 3 comprises the balance of the provincial areas not included in any of the other social catchments.





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Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Sepik River port village responses to query on development needs

Figure No: 4.3

AI Reference: 11575_15_GRA005.ai_2

Sandaun Province encompasses 36,000 km^2 in the northwest of mainland PNG, along the northern section of the Indonesia and PNG border, and shares provincial borders with Manus, East Sepik, Southern Highlands and Western provinces. The terrain comprises coastal environments in the northern region, the Sepik River basin in the centre and mountainous regions in the south. It also shares a common international border with the Indonesian province of Irian Jaya and a road links the provincial capital Vanimo to Jayapura (Hanson et al., 2001).

The total population of the Sandaun Province in 2011 was 248,411 (NSO,2014). Aitape-Lumi District is the most populated in the province.

East Sepik Province occupies 43,700 km^2 in the northwest of mainland PNG, and shares a border with the Manus Province and Bismarck Sea in the north, Madang Province in the east, Sandaun Province in the west and Enga and Southern Highlands provinces in the south. Wewak is the provincial capital, located on the coast of the province. The terrain includes a scattering of islands occurring off shore and mountain ranges along the coast, including the Torericelli and Prince Alexander ranges. The remainder of the province's geography is dominated by the Sepik River.

In 2011, the population of East Sepik Province was 450,530 and is considered to contain the most heavily populated areas of the Sepik region (NSO, 2014).

Regarding the status of social values, Sandaun Province is one of the most remote provinces of PNG. Due to the difficult terrain and lack of access routes (i.e., roads and rivers) there are few income-generating opportunities in rural areas, however many young people generally stay in their community (AusAid, 2004). East Sepik Province covers a vast area with many villages isolated due to challenging terrain and flooding along lower reaches of river plains. The lack of income generating opportunities in rural areas has led to out-migration from rural to urban areas across East Sepik Province (East Sepik Province, 2010). Those on the Wewak coast and fringing mountains earn low incomes from minor sales of fresh food, cocoa, fish and betel nut (Hanson et al., 2001).

The subsistence base of Social Catchment 3 is robust given favourable seasonal conditions. Land potential in some areas of Sandaun Province is greater than East Sepik Province but both are vulnerable to climatic extremes such as flooding and drought conditions. Market access, invariably constrained by remoteness and lack of infrastructure, and vulnerability to highly variable commodity prices for cash crops (such as vanilla and cocoa), mean there is limited opportunity for communities in Sandaun and East Sepik provinces to participate in the cash economy. Opportunities for migration and participation in the labour market in other areas of PNG have historically been important for income generation in these provinces. There are large fresh food and fish markets at Pagwi, Angoram, Maprik and Wewak. Two tuna canneries in Wewak (owned by South Seas Tuna Corporation and Frabelle) are the biggest employers in the area (Mercy Works, 2014). Alluvial gold provides moderate incomes for communities around Maprik as well as other select areas within the two provinces.

The physical and social environment of Sepik River communities appears to be under considerable stress, particularly in recent years of drought. Combined with social dysfunction due to alcohol and drug use (and consequent domestic violence) family health, safety and security would have a high level of vulnerability. Services (policing, education and health) are limited at best, and non-existent in the more remote areas. Villages are reliant on their own initiatives and strategies to support fundamental needs of families. There is one hospital in the East Sepik area, located at Wewak, however due to funding issues from mid-September 2015 this hospital only treats emergency cases (Save the Children, 2015). There is also only one hospital within Sandaun Province, located at Vanimo which is better funded and well-staffed.

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5 Project impact and opportunity

This chapter describes the ways in which social values may be altered because of the construction, operation and decommissioning of the Project which may drive social change. Project-induced drivers of social change and associated positive and negative effects upon social values were identified through the examination of each element of the proposed Project to build an understanding of the type of activity and its spatial and temporal relationship to study area communities with reference to outcomes which have eventuated from similar projects in PNG. This process informed identification of the range of potential direct and indirect impacts and how they may have an effect on social values (i.e., the impact pathway).

5.1 Impact drivers

The following aspects of the Project were identified as having the potential to cause a direct effect on communities:

- Physical disturbance.
- Physical displacement (including resettlement).
- Access and communications infrastructure.
- Traffic.
- Employment and commercial participation.
- Project workforce.
- Discharges, emissions and waste disposal.
- Accidental spills and leaks.

The Project also has the potential to impose indirect positive and negative effects on communities. The following are the primary indirect causes of social change induced by the Project:

- In-migration.
- Distribution of monetary wealth.

Each of these drivers of social change is described below, including definition of the potential positive and negative effects and/or impacts on social values, and a description of the impact pathway. Only potentially adverse impacts have been described where there are no positive effects associated with a driver of societal change.

5.1.1 Physical disturbance

Land and water and the ecosystems which they support will be physically disturbed because of the development of the Project. The total area of direct Project disturbance (i.e., requiring vegetation clearance or land subject to ISF inundation) is estimated to be 16,000 ha. This comprises:

- The FRCGP (1,145 ha) including the HITEK open-pit (520 ha), processing plant and ore stockpile (35 ha), mine infrastructure area (15 ha), spoil dumps (235 ha), quarries (40 ha), construction camp and site accommodation village (25 ha), haul roads and access roads (220 ha) and conveyor (55 ha).
- The FRHEP (12,725 ha) including the ISF (embankment, spillway and reservoir) (12,495 ha), Frieda River airstrip (20 ha, predominantly existing disturbance), FRHEP access road (80 ha), laydown areas (45 ha) and spoil dumps (85 ha).

- The SIP (505 ha) including the Green River Airport upgrade (20 ha, existing disturbance), Vanimo to Green River Road (225 ha, existing disturbance), Hotmin Road (public) (225 ha) and Vanimo Ocean Port upgrade (35 ha, existing disturbance).
- The SPGP (1,770 ha) including the Northern Transmission Line corridor.

The land supporting the FRCGP mine infrastructure including ancillary infrastructure (accommodation camps and administration building) will be rehabilitated following the cessation of mining activity, subject to final closure plans. In addition to lands directly disturbed by the footprint of Project components, all land within the SML, LMPs and other leases associated with infrastructure which supports the mine (e.g., Mining Easements), will not be available for use by local communities for the life of the respective leases.

All mines constructed and operated in mountainous, high-rainfall environments such as at Frieda River generate fugitive sediment, particularly during the construction phase. The volume of sediment generated during operation and reporting to the downstream environment is typically much lower than during construction. Because the ISF is located downstream of the major areas of earthworks for the FRCGP such as the open-pit, processing plant and spoil dumps it will act as the critical piece of sediment management infrastructure for the mine site, allowing much sediment to settle-out prior to discharge over the spillway, through a decant or via a hydroelectric intake tunnel. This will contribute to the limiting of associated impacts on the downstream environment. Mining operations will have an impact on sediment concentrations within the Ubai and Ok Binai catchments, and to a lesser extent in the Ubai Creek and Nena River catchments. The most significant impact will be in the Ok Binai because of ongoing sediment losses from the Ok Binai waste dumps. The impacts downstream of the ISF will be more limited, with the annual median concentration of total suspended solids (TSS) in the Frieda River downstream of the ISF initially being higher than under existing conditions, but once the ISF is impounded in Year -2, TSS concentrations are predicted to reduce to background concentrations. Changes in suspended sediment concentration downstream of the lower Frieda-Sepik River confluence in the Sepik River because of the Project are predicted to be negligible.

While uncommon in such a high rainfall environment, disturbance to land can also include fire such as the extensive fires following drought across much of PNG in 1997. In addition to Project activities that have the potential to cause fire, Project-induced population increase and associated clearing of lands for gardens also creates increased risk of unintentional disturbance to lands because of fire.

The existing Vanimo Port will be upgraded to provide import and export facilities for FRCGP construction and operations. This port development may also stimulate growth in the volume and diversity of the Sepik region's exports to Asia. The upgrade will include two new berths to support the Project and other port users, and will have the potential to affect the Dakriro Bay marine environment. The port will have a footprint of approximately 15 ha onshore and will require reclamation of approximately 3.4 ha of the bay adjacent to the port. Potential disturbance to the onshore and marine environment may result from earthworks, disturbance to marine habitats through land reclamation and ship movements, and generation of contaminated runoff during operations. In parallel with FRL's development planning, PNG Ports Corporation is also currently undertaking a feasibility study into the potential upgrade of the port. FRL is working with PNG Ports Corporation to identify and optimise efficiencies between the upgrade planning.

People's wellbeing will be most affected where disturbance occurs on lands that are used for subsistence living, or in areas of land rich in cultural heritage. Project activities and infrastructure may impede access to land and water-related resources through the placement of facilities such as the ISF, open-pits, processing plant, NAF dumps, and other physical barriers such as accommodation villages and fences. People who rely on these resources for their livelihoods may be affected as the utility or productivity of land or water bodies are reduced.

Potential impacts on social values caused by physical disturbance are provided in Table 5.1.

Table 5.1 Potential impacts caused by physical disturbance

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Reduced availability of foods hunted, caught or gathered by local people.	The Project will be developed on lands which are currently used to support subsistence livelihoods. The loss of such lands may affect the availability of foods which are gathered, hunted or caught by local people.
Reduced availability of aquatic resources.	Flows in the Frieda River will be regulated by operation of the hydroelectric power facility from Year -2 of the FRCGP. While average flows are not anticipated to change, high flows will be reduced and low flows will be increased substantially from these natural flow conditions. Impact on aquatic resource use downstream is unlikely to be affected due to changes in flows in the Frieda River. Aquatic resource use in the Frieda River is likely to be affected during construction prior to reservoir of the ISF for a period of 2 years (Year -4 to Year -2) as a result of TSS concentrations elevated above background concentrations. Flows during this period will not be affected substantially by Project activities. Once the ISF is impounded in Year -2, TSS concentrations reduce to comparable background concentrations and impacts on aquatic resources in the Frieda River are not expected.
Reduced availability of marine resources.	Construction of the Vanimo Ocean Port will require the disturbance of Dakriro Bay which supports subsistence marine resource use activities. There is the potential for such disturbance to result in temporary or prolonged reduction in the availability of marine resources utilised for subsistence purposes.
Reduced availability of lands used by local people for the growing of foods.	The Project will be developed on lands which may otherwise be used to support the growing of food. Food grown in gardens forms an integral part of subsistence diets and a reduction in the availability of suitable lands may influence the ability to maintain subsistence livelihoods.
Reduced availability of building materials, medicines and other resources.	The Project will be developed on lands which are currently used to support subsistence livelihoods. The loss of such lands may affect the availability of building materials, medicines and other resources used by local people to support subsistence livelihoods.
Reduction in availability of clean water supply due to water source damage, increased sedimentation or destruction during Project construction.	Earthworks associated with the construction of Project infrastructure and the extraction of water used during construction may interfere with existing water supplies relied upon to support subsistence livelihoods.
SV2 Opportunities for participation in the cash economy	
Reduced availability of lands used to grow cash crops.	The Project will promote changes to existing land uses and alienate land. Changed land use may impact the ability of the land to support cropping, and alienated land will no longer be available to local people to grow crops that may be sold for a commercial return.

Impact	Impact pathway
Reduced income for tourism operators due to construction of Vanimo Ocean Port.	The Vanimo Ocean Port footprint will impact the visual amenity of Dakriro Bay, which may reduce the tourism appeal of the region. This could result in a decline in tourism, which would reduce the amount of income generated by tourism operators.
Reduced income from alluvial gold due to sterilisation from inundation.	The FRHEP is likely to sterilise the majority of alluvial gold areas currently accessed by near-mine communities. This would significantly reduce income and cash availability.
Reduced access during construction to outside markets due to FRHEP construction.	The FRHEP construction may limit access for certain near-Project communities to outside markets, including transport of goods back for local retailing.
SV3 Enduring ability to sustain cultural identity and traditions	
Erosion of cultural understandings and sense of place.	The development of lands for Project purposes has the potential to disrupt or destroy items or sites of cultural significance. The loss of physical sites/items connected to important stories and cultural understandings may contribute to an erosion of cultural knowledge and sense of place.
SV4 An enduring ability to maintain customary rights to land access and resource use	
Loss of customary rights to access and use lands.	The granting of the SML and associated leases provides FRL exclusive use of such lands for Project purposes. For the duration of the lease, land within the SML will not be accessible and there may be restrictions around land use in accordance with customary rights. Land within the ISF reservoir will be lost permanently. While such loss is subject to full and fair compensation, some landowners may feel that such customary rights cannot be compensated through monetary means.
Distress caused by physical changes to lands.	The Project will result in changes to existing land uses and major alteration of the appearance of the landscape. Landowners may be concerned and become distressed as to the degree of change to the land by development of the Project.
Modification of landscape	Complete modification to landscape, through the FRHEP inundation or pit excavation may lead to ambiguity around land boundaries as previous boundary features and markers no longer exist.
SV5 An environment amenable to personal and family health, education, safety and security	
Positive effects discussed below.	
SV6 The availability of services supportive of personal health, education, safety and security	
Positive effects discussed below.	

While the physical disturbance caused by the Project will have the negative impacts described above, physical disturbance will also indirectly create positive impacts, notably establishment of the main access road and power transmission line which open up opportunities for business, employment and greater development opportunities. As discussed in Section 5.2, the most common positive impacts of the Project identified by communities include the improved road (and access to markets, economic activity, health and social services) and electricity. In Social Catchment 1C, no negative impacts were identified.

The positive aspects of Project physical disturbance are also directly linked to PNG development goals and guidelines. In particular, the PNGDSP which sets out to provide direction in policy making to achieve the goals of Vision 2050 (refer to discussion in Section 2.2).

While the Project is underpinned by the development of the FRCGP, which is a national priority of the PNG Government, one of the central themes of the PNGDSP is for the PNG economy to advance beyond the mining and petroleum sectors. There is a focus on creating the enabling environment for investment and economic participation through the construction, operation and renovation of physical structures that provide a platform for most other economic activities. This includes telecommunications, electricity, water and waste services, roads and public works programs, ports and airports, shipping and aviation services (Kaiku, 2016). The Project provides such an enabling environment for the investment and economic participation envisaged by the PNGDSP.

The PNGDSP has identified ten regions across PNG as economic corridors that will be transformed to provide access to transport, utilities, education and health services. This includes future electricity super-corridors that connect areas where electricity can be generated at low cost (such as by the FRHEP) to a national grid.

The Northern Transmission Line aligns with the Border Corridor economic region, designated in the PNGDSP, for the Western, Southern Highlands and Sandaun provinces. It is envisaged that the FRHEP and SPGP will supply power to northwest PNG and enable a reliable, long-term supply of energy long after the FRCGP has closed. It will assist in the PNGDSP's target of 70% of households having access to electricity by 2030 and will also supply other industries such as agriculture, fisheries, food and timber processing, mining and manufacturing. There is also opportunity to establish a new industry from the export of excess power to neighbouring Indonesia.

The SIP includes a 286-km-long extension and upgrade of the existing road from Vanimo to Green River. The public road extension will continue to Hotmin and then extend via a 39-km-long private road to the mine and FRHEP area. A potential connecting road between Hotmin and Telefomin is also proposed; however, this extension is not required for development of the FRCGP and therefore is not included in this EIS. The extension and upgrade of the existing roads will contribute to meeting the strategic plan's target of tripling the PNG road network by 2030.

5.1.2 Physical displacement

The Project will avoid and limit resettlement as much as possible but will require some resettlement for its development. Up to four villages (Table 5.2) comprising a total of 194 households will be required to relocate. Impacts on these villages will be typical of those associated with resettlement exercises and will require attention to the following elements:

- Direct support for re-establishment of housing.
- Direct support during the physical transition phase.
- Compensation for gardens and other physical assets lost or impacted by the project.
- Infrastructure and service re-establishment.
- Support for livelihood restoration.
- Re-establishment or compensation for businesses.

Table 5.2 Villages subject to potential resettlement

Village	Households (2017)	Families / persons (2017)	Reason for resettlement
Frieda River Hydroelectric Project			
Wabia	66	83 / 393	Inundation following establishment and operation of the FRHEP means that the village cannot remain in its present location under the current FRHEP design.
Ok Isai	57	93 / 465	Inundation following establishment and operation of the FRHEP means that the village cannot remain in its present location under the current FRHEP design.
Paupe	38	51 / 262	Multiple construction phase impacts due to proximity to the FRHEP (Paupe is approximately 5 km downstream of the ISF embankment) and FRHEP access road, potentially reducing amenity to an unacceptable level. Adverse impacts are likely to include: air and noise nuisance during construction and operation of the FRHEP access road; significantly reduced flows in the Frieda River during filling of the FRHEP; loss of Frieda River for aquatic resource use during seven year implementation period due to fugitive sediment; and proximity to large construction camp.
Mine area			
Wameimin 2	33	36 / 196	Proximity to Nena deposit (approximately 3 km east-northeast) presents risks for the potential future development of the Nena deposit as a brownfield expansion to the FRCGP. The proximity of Wameimin 2 to the access road route also increases the risk of attraction for in-migration to the village, before and during FRCGP development, with consequent population growth and therefore increased resettlement costs should “brownfield” resettlement be required in future. In the event the Nena deposit was developed, Wameimin 2 would likely be affected by air, noise and vibration impacts during construction and operations, significantly reducing amenity in the village.

Potential impacts on social values caused by physical displacement are provided in Table 5.3.

Table 5.3 Potential impacts caused by physical displacement

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Reduced availability of subsistence produce during re-establishment of subsistence gardens.	Affected households will have access to subsistence gardens both during the period of physical displacement and post-displacement phase, however there may be a period where gardens are less productive as they are re-established.
Reduced access to food via hunting and foraging activities.	The proposed relocation sites will allow households to continue to hunt and forage but at a reduced level which will limit the extent to which affected households will be able to continue existing hunting and foraging activities.

Impact	Impact pathway
SV2 Opportunities for participation in the cash economy	
Limited river trade due to restricted river usage and access.	Paupe village will experience temporary impacts in terms of river access and trade during construction. Wameimin 2 current river usage will not be significantly impacted. Ok Isai and Wabia will require alternative means for transport and trade once the construction of the FRHEP commences.
Temporary interruptions or reductions in business opportunities.	Small scale trade will be interrupted during the construction phase of the Project. Site-specific opportunities (e.g., guest accommodation), such as at Ok Isai and Wabia will be diminished due to changed access to alluvial gold workings.
Reduced access to alluvial gold workings.	The relocation sites may have reduced access to alluvial gold workings. This will reduce income and cash availability (which is currently used purchase store-bought food).
Reduced access to cash cropping opportunities.	New village locations will have access to the road corridor to Vanimo, however this is not expected to stimulate any cash crop agricultural production due to land availability constraints and inability to compete with mine-derived employment income.
SV3 Enduring ability to sustain cultural identity and traditions	
Erosion of cultural identity and traditional leadership.	Resettled communities will experience impacts on cultural understandings, sense of place and traditional leadership due to loss of land, homes and assets.
Erosion of cultural identity from changes in economic status.	A deeper immersion in the mainstream economy is likely to influence perspectives on identity and sense of place, especially for the next generation of clan members. This will likely include a loss of language and culture.
SV4 An enduring ability to maintain customary rights to land access and resource use	
Loss of customary rights and access to land.	Resettled communities will lose access to traditional lands. While such loss is subject to full and fair compensation, some landowners may feel that such customary rights cannot be compensated through monetary means.
SV5 An environment amenable to personal and family health, education, safety and security	
Potential exposure to increased mine-related contaminant metals.	The Project has minor potential to expose people at the resettled Paupe location to increased mine-related contaminant metals in the event they continue to use the Frieda River for fishing and swimming.
Loss of shelter and other assets.	Physical relocation of people to another location will involve loss of their original homes and shelter and other assets.
SV6 The availability of services supportive of personal health, education, safety and security	
Positive effects discussed below.	

Arguably the single biggest social impact of the Project will arise from the resettlement of the four villages, which also includes the following positive effects compared to present conditions:

- Higher standard of housing and infrastructure.
- Improved facilities including water supply and health care clinics.
- Improved health outcomes resulting from the improved standard of housing, water supply and access to health care.

- Improved access through construction of all-weather roads, enhancing trade opportunities.
- Restoration programming will include a range of rural extension programs aimed at maximising the value of economic opportunities for affected communities including:
  - Enhanced techniques for subsistence agriculture.
  - Identifying cash cropping opportunities for local and regional markets.
  - Financial literacy and long-term investment planning (compensation and royalty management).
  - Small, medium and larger scale business development mentoring.
- The scope of business opportunities will be enhanced as relocated communities will be prioritised for employment and for opportunities to engage with the mine's supply chain.
- The Project will design literacy and vocational training programs that increase the capacity of the local communities to take up opportunities with the Project.

5.1.3 Access and communications infrastructure

The Project will include the construction of a public road between Hotmin and Vanimo, along with an access road to the mine and FRHEP. The distance by road between the Vanimo Ocean Port and the mine area is approximately 325 km. A 65 km section of access road will be constructed from the end of the public road in Hotmin, through the mine and FRHEP area, to the Frieda River Port, and a 20 km access road will be constructed from the mine access road to the May River Port. Once the main access route is constructed, materials and equipment will be loaded onto trucks at Vanimo and travel directly along the public and mine access roads to site.

The road between Hotmin and Vanimo (286 km) will be a gazetted public road. A private road will extend from Hotmin to the mine (39 km) within a mining easement. The road section within the mining easement will be a controlled access road rather than a public road, with public travel only available under strict conditions.

The existing Vanimo Port will be upgraded to provide import and export facilities for construction and operations of the elements of the Project as described in Section 5.1.1.

Site-wide communications, information technology, fire services and security links will be via a fibre optic network linking all facilities. A fibre optic cable will be run with overhead lines and underground 33 kV power reticulation to each facility. Similarly, a fibre optic cable will run along the concentrate pipeline enabling communications between the process plant, booster pump stations and the concentrate filter plant at the Vanimo Ocean Port. A satellite link will be installed in the mine area for communications during construction and will be retained during operations as a back-up to the fibre optic network. There is potential for access to communications infrastructure by local communities.

Road and communications infrastructure will improve access to, and knowledge of, markets, education and health services along with increased opportunity for community engagement and participation in society (Section 5.2). However, improved accessibility also provides potential for higher exposure to communicable diseases, in-migration and socially disruptive and illegal activities.

Potential impacts on social values caused by road access are provided in Table 5.4.

Table 5.4 Potential impacts caused by access and communications infrastructure

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Reduction in the availability of marine resources due to Vanimo Ocean Port construction and operation.	Construction and operation of the Vanimo Ocean Port will require the disturbance of Dakriro Bay which supports subsistence marine resource use activities. There is the potential for such disturbance to result in temporary reduction in the availability of marine resources utilised for subsistence purposes.
Reduced ability to lead subsistence livelihoods due to the introduction of weeds and plant pathogens.	The construction of the road movement may facilitate the spread of weeds and plant pathogens through the incidental movement of contaminated soil and plant materials. The introduction of new weeds and plant pathogens, or the spread of existing ones, may result in reduced crop yields.
Reduction in availability of clean water supply due to water source damage or destruction during road construction.	Communities in proximity to the road corridor have limited access to reliable water sources. Earthworks associated with road construction, and the extraction of construction water, may interfere with existing supplies which may impose significant hardship depending on seasonal conditions.
Increased access to subsistence resources by outsiders because of road construction.	Construction of the road will provide outsiders with increased access to lands and waters which may be exploited for subsistence resources such as foods, building materials and traditional medicines.
SV2 Opportunities for participation in the cash economy	
Local people unable to access business opportunities due to increased competition.	Development of the road and other transportation infrastructure will facilitate access to the Project area. People are likely to attempt to locate themselves as close as possible to Project infrastructure and activities to take advantage of commercial opportunities directly provided or indirectly stimulated by the Project. Residents of communities proximal to the FRCGP and FRHEP (except for Ok Isai and Wabia) have had very limited exposure to business dealings and subsequently may not be able to compete with outsiders who have superior commercial acumen.
SV3 Enduring ability to sustain cultural identity and traditions	
Disturbance and possible destruction to culturally significant sites and sense of place due to road construction providing greater access.	Construction of the road will improve access to sites of cultural significance resulting in possible disruption or destruction to items or sites of cultural significance. The loss of physical sites/items connected to important stories and cultural understandings may contribute to an erosion of cultural knowledge and sense of place.
Erosion of cultural identity and traditions due to greater exposure to alternate ideas and practices.	Improved access and communications infrastructure will facilitate increased interaction with other communities and exposure to alternative ways of living. Over time this can have the effect of altering people's views, perspectives and values and promote subsequent changes in the practice of traditions and ultimately the cultural identity of the community.
SV4 An enduring ability to maintain customary rights to land access and resource use	
Access to customary lands impacted by the road corridor.	The main access road corridor will run through lands occupied by customary landowners. Construction of the road may facilitate the influx and settlement of migrants who are non-landowners, which may impair the customary rights of landowners.

Impact	Impact pathway
SV5 An environment amenable to personal and family health, education, safety and security	
Reduced amenity associated with an increase in noise, dust and light emissions due to construction and operation of the road and Vanimo Ocean Port.	Construction of the road and Vanimo Ocean Port will involve land clearing and major earthworks. Throughout the construction period nearby communities may experience reduced amenity due to the noise, dust and light emissions associated with road and port construction.
Decrease in security for women and children and increase in inter-personal violence.	Improved access to townships and markets may increase the general availability of alcohol and illicit drugs in communities decreasing the level of security for women and children
Higher exposure to communicable diseases.	Improved access to townships and markets will result in the residents of villages along the road having higher rates of inter-personal interaction. This can lead to greater exposure to sexually transmitted and communicable diseases.
SV6 The availability of services supportive of personal health, education, safety and security	
Positive impacts discussed below.	

In addition to the impacts identified in Table 5.4, there are a number of positive effects that will result from increased access and communications. The development of the Project will significantly improve the potential for long-term development, both within the Project area and in PNG more broadly, because it will build roads to previously isolated locations that had no prospect of economic development. The Project will improve access to external markets and reduce the cost of transporting local products to market. The Project will also enhance the economic potential of Green River (consistent with the Sandaun Provincial Government plan for Green River as a ‘Level 2’ growth centre for the province) through the upgrade of the airstrip and road link to Vanimo. Similarly, Vanimo’s presently limited economic potential will be improved significantly, consistent with the Sandaun Provincial Government plan for Vanimo as a ‘Level 1’ growth centre for the province.

Other specific positive effects of the Project associated with access and communications include:

- Improved access to health and infrastructure services arising from the road development. Establishment of communications infrastructure may improve access to medical information and assistance including emergency assistance.
- Improved access to educational facilities which will also reduce travel time to schools and enhance access in general. Increased ease of access to secondary and vocational schools may lead to the achievement of higher levels of education which may increase outward migration.
- Greater access to business and to markets for sale of produce and cash crops which will provide an opportunity for the sale of surplus goods that could lead to commercial-scale growing and sale of produce and cash crops, providing an ongoing source of income to rural families, particularly women. Such access will also likely promote the establishment of small-scale family enterprises selling garden produce and other products such as small goods and mobile phone charge cards to the workers and other people who use the access road.
- Increased availability of subsistence foods and other resources supplied from outside areas due to road access.
- Improved communications have the potential to lead to improved financial and marketing services which can lead to wealth creation and savings (refer to Section 5.2).

- Improved levels of education and availability of cash may result in a resurgence in cultural and social values, as has been observed at Lihir and Misima.
- Road construction may lead to clear identification of land boundaries which secures tenure and resolves previous land disputes.

5.1.4 Traffic

The Project will generate vehicular, water-based and air traffic throughout construction and operations.

A 325 km infrastructure corridor will be developed between the FRCGP and Vanimo Ocean Port. This will include:

- 286 km public road from Vanimo to Hotmin.
- 39 km access road from Hotmin to the mine.
- A buried 325 km pipeline to transport concentrate slurry from the mine site to Vanimo Ocean Port.
- The Northern Transmission Line from the FRHEP to Vanimo Ocean Port which will provide power to the FRCGP facilities, with excess power made available to communities along the infrastructure corridor, other regional users and for export.

During road construction

Project equipment and consumables will be transported via ocean freighter to existing ports at Wewak, Lae and Madang and barged upstream along the Sepik River to the Frieda or May River ports until upgrades to both the Vanimo Ocean Port and the Vanimo to Green River Road have been completed (which is expected to take about one year).

During mine construction

Once built and operational (Year -4 of seven year implementation period), the public road from Vanimo to Hotmin will be used to support construction of the FRCGP and FRHEP. An estimated five truck movements (prime movers with 12 m trailers) and eight buses per day are expected to travel between the Vanimo Ocean Port and the mine and FRHEP area during the mine construction period. In addition, the Project will generate light vehicle movements along the road for the transport of materials and people throughout the construction period.

Mine and FRHEP construction will generate an estimated one barge movement (round trip) per day from the Lae, Madang and Upper Sepik River ports along the Sepik, May and Frieda rivers to the river ports over the seven year Project construction period. From the Frieda River Port, freight will be transported to the mine and FRHEP via the FRHEP access road using heavy vehicles with an estimated five vehicle movements per day. A temporary access road will be constructed from the May River Port to a point on the mine access road approximately six kilometres east of Hotmin to mobilise equipment for construction of the resettlement villages.

Air travel will initially use the existing Frieda River airstrip which will be upgraded to support personnel movements until the Green River Airport upgrade is completed, which will then be the main airport used for transport of personnel during construction. For the transport of construction personnel, it is estimated that three flights will fly in and out of the Frieda River airstrip per week at peak usage.

Buses and light vehicles will transport personnel between airstrips and accommodation villages. During construction, it is estimated that there will be a requirement for approximately eight bus movements (round trips) per day between the Green River Airport and the mine site.

During operation

Equipment and supplies will be transported via road during operations. Buses will be used to transport personnel between points of hire along the public road and from the Green River Airport to the mine. Riverine transport using barges is likely to be used for transport of Zone 2 workers (e.g., workers from Iniok).

The Green River airstrip is located 150 km from the FRCGP site and is currently a well-formed unsealed airstrip. It will be upgraded to cater for larger aircraft (up to Lockheed C-130 aircraft) to service the Project during operations and made available for commercial use. It is intended to be upgraded to the standard required to accept and process international flights, which would include appropriate stationing of immigration, customs and quarantine officers as required.

From the Green River Airport it is estimated that there will be an average of seven flights using Twin Otter aircraft each week to regional airstrips and fourteen 50 seater flights to commercial airport hubs each week. The Frieda River airstrip will be used during operations to transport local workers and short-roster management personnel, as well as for emergency purposes

During operations it is estimated that the number of bus movements per day between the Green River Airport and the mine site will reduce to three.

Increased road, water and air traffic can have implications for human safety and wellbeing. Traffic generates noise, dust, light and air emissions and heightens the risk of accidents. The risk of accidents is more likely due to people's unfamiliarity with road traffic given the isolation of the Project area, particularly in the mine and FRHEP areas. Most traffic and barge movements will be generated during the construction phase of the Project and will reduce during operation with corresponding decreases in potential health, nuisance and safety issues. Ocean and river port construction and barge and watercraft movements also have the potential to impact on fishing activities (e.g., deployment of fishing nets, and barge vessel wash has the potential to increase erosion of riverbanks adjacent to villages). Crocodile farming is not expected to be impacted by barge and watercraft movements as breeding activity and local community harvesting of crocodile eggs, juveniles and adults occurs in off-river waterbodies rather than main river channels (i.e., the Frieda and Sepik rivers; EIS Appendix 8) which will not be impacted by the Project, except for potential short-term and highly localised turbidity impacts associated with road and pipeline construction.

Potential impacts on social values caused by traffic are provided in Table 5.5.

Table 5.5 Potential impacts caused by traffic

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Limited disruption to subsistence livelihoods due to barge movements.	Barge movements on relatively narrow reaches of the May and Frieda rivers and during times of high flood on the Sepik River have potential to disrupt livelihood activities (such as setting fishing nets, sago making and safe canoe transport) through either direct impact or by the effects of vessel wash created by the tug and barge.

Impact	Impact pathway
SV2 Opportunities for participation in the cash economy	
Interference with fishing activity leading to a decrease in income generated from this industry.	Construction of port infrastructure in Dakriro Bay, Frieda River and May River, and the use of the Sepik, May and Frieda rivers to deliver construction material and Dakriro Bay to export concentrate, may interfere with existing fishing activity, through either direct impact or by forcing fishing activity to relocate to more distant areas.
SV 5 An environment amenable to personal and family health, education, safety and security	
Increase in accident injury and trauma because of local population interactions with Project vehicles.	The interaction of local populations with Project vehicular movements poses a safety risk, heightened by the volume of traffic during construction and the unfamiliarity of residents with road transport. This may lead to injury and trauma resulting from accidents.
Increase in accident injury and trauma as a result of local population interactions with Project vessels.	The interaction of local populations with Project vessel movements primarily along the Frieda, May and Sepik rivers, and to a lesser extent in Dakriro Bay, poses a safety risk both in terms of being directly hit by a vessel or through the associated wave action. The stability of small canoes relied upon by local communities for transport and subsistence activities may be affected by wave and wash action created by Project vessels.
Impaired community amenity and health concerns because of air emissions (e.g., dust, vehicle emissions) noise and light generated from movement of Project vehicles, machinery and vessels.	The movements of construction vehicles and machinery along the public road and barge vessels in Dakriro Bay during construction and operations, and barge transport along river access corridors during construction, may impair community amenity and generate concerns over health effects from the generation of dust, vibration, noise and light.
SV6 The availability of services supportive of personal health, education, safety and security	
Positive impacts discussed below.	

While increased traffic brings with it the impacts discussed in Table 5.5, increased traffic also provides opportunities for business development and access to markets for sale of produce and cash crops. For example, increased traffic will also likely promote the establishment of small-scale family enterprises selling garden produce and other products such as small goods and mobile phone charge cards to the workers and other people who use the public road. Opportunities related to the Project are discussed further in Section 5.2.

5.1.5 Employment and commercial participation

Employment

Development of the Project will generate significant employment opportunities in a remote part of PNG that has little formal employment. The estimated workforce numbers onsite during the seven-year implementation period will peak at approximately 5,200 personnel, including approximately 2,300 contractors for the FRHEP. In the operations phase, it is estimated that the Project will require an average of approximately 2,500 personnel. Most of these workers will be PNG nationals with some expatriate employees, contractors and support staff.

To maximise the opportunity for local people to gain employment, FRL has designated six recruitment zones (Figure 1.5), each including several locations, with decreasing preference for employment and business development, supply and procurement including:

- Zone 1: PNG national. Landowning communities of the SML, ML and the LMP including Wabia, Ok Isai, Paupe, Wameimin 2, Wameimin 1, Sokamin and Amaromin Villages.
- Zone 2: PNG national. Any community within the Telefomin LLG and the western part of the Tunap Hunstein LLG, along the infrastructure corridor, and along the Sepik River downstream of the Frieda River .
- Zone 3: PNG national. Sandaun and East Sepik provinces.
- Zone 4: PNG national. Any other provinces within PNG .
- Zone 5: Australia.
- Zone 6: Asia.

While a preferential recruitment system will be implemented, candidates must possess the relevant skills and experience to be able to fulfil the requirements of each position, or demonstrate aptitude in the absence of formal education. If suitably qualified and experienced candidates cannot be sourced from Zone 1, candidates will be sourced from Zone 2, 3 or 4 in that order, on a preferential basis. Best efforts will be made to identify suitable candidates locally, provincially or nationally before considering the need to source expatriates from Zones 5 and 6. By operating on a FIFO basis, the Project will maximise the distribution of wage income benefits across Zones 1 to 3 encompassing Sandaun and East Sepik provinces, and avoid the potential impacts of developing a large enclave development for residential workers. The improved transport connections to Vanimo will facilitate access to training and commercial opportunities for landowner groups without the need to develop a purpose-built ‘company town’, and support the development of Green River as a growth centre under the provincial development plan.

The same system of preference will apply towards commercial opportunities related to the Project. These may include business contracts, supply of goods and services or procurement of local goods.

The prospect of employment and commercial opportunities associated with the Project will raise expectations of local people. These prospects may also attract people to the Project area, depending on the location of Project activity (Section 5.1.9), however there will be no direct employment engagement at Project sites for non-landowners as part of a suite of measures to manage in-migration.

Training will be required for the local workforce, although some local residents may have previously worked at other resource projects (such as Ok Tedi and Porgera), and already have experience and skills acquired through relevant training. PanAust has demonstrated a strong commitment to local training and skill development at its operations in Laos, and will implement similar capability development programs to ensure commitments to local employment and workforce progression are met.

Commercial participation

Economic activity associated with construction and operation (through local contracts for the procurement of materials, goods and services) will also lead indirectly to the creation of employment opportunities in the local economy. This will increase the capacity of people employed by the Project to purchase goods, health and education services and luxury items. Flow-on effects from the injection of wealth into this economy will allow new businesses to establish and existing businesses to expand operations. There will also be a significant growth of new businesses directly associated with Project related contracts.

The total initial capital investment for the Sepik Development Project will be up to US$6.9 billion (PGK21.7 billion[5] in October 2018) in real terms (ACIL Allen, 2018). Recurrent operating expenditure for the FRCGP and the FRHEP, including a significant level of local spending on support services, is estimated to average US$685 million (PGK2.1 billion) per year (ACIL Allen, 2018).

The purchase of such materials and services from within PNG will result in a higher level of activity in the local and national economy. This growth will lead to the creation of additional employment opportunities and stimulate further growth and development of the economy. It is estimated that for the Sandaun and East Sepik provinces over the period to 2060, the Project will result in an increase of PGK81.3 billion in regional real gross domestic product (GDP) and an increase in regional real income of PGK40.9 billion (ACIL Allen, 2018).

Employment, business development and procurement can also result in negative impacts including a shortage of labour to assist with rural livelihoods, dietary change and associated health effects, and accelerated change in traditional leadership and lifestyle practices.

Potential impacts on social values caused by employment and commercial participation are provided in Table 5.6.

Table 5.6 Potential impacts caused by employment and commercial participation

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Reduction in the consumption of food from gardens due to absence of male labour to establish new garden areas.	The lack of male labour to undertake traditional heavy forest clearing, due to Project employment, may lead to new gardens not being established and a loss of traditional food production skills, encouraging a shift to store purchased food. This may also occur in food systems dependent on sago where males traditionally fell the trees and transport logs to the village for sago production by women.
Reduction in the consumption of food from gardens due to a reduction in female labour available.	A reduction in female labour to undertake regular garden maintenance and harvest, due to employment, may lead to a loss of traditional food production and preparation skills, particularly in the production of sago. This may encourage a shift to store purchased food.
Reduction in the consumption of fish due to a reduction in fishing effort.	A reduction in labour to undertake subsistence fishing due to Project employment may lead to a reduction in the amount of fish available for consumption and lead to an increased dependence on store bought food.
Increased cost of food sold in markets resulting in a greater reliance upon subsistence resources for people not receiving Project income.	An increase in incomes and associated purchasing power may lead to an escalation in prices of food sold at local markets. People who do not have access to higher incomes may subsequently struggle to afford the purchase of food at higher prices thereby inducing a higher reliance upon subsistence resources.

[5] US dollars are converted to Kina at an assumed exchange rate of US$1.00 = 3.15 Kina.

Impact	Impact pathway
SV2 Opportunities for participation in the cash economy	
Loss of employment in the transition from construction to operation leading to alienation and social unrest.	Following construction (where there is a higher demand for unskilled labour) there will be a significant reduction in local employment due to lack of appropriate skills. This may lead to alienation and social unrest due to the reduction in income experienced, and the possible perception of outsiders benefiting from on-going employment (perceived to be at the expense of residents).
SV3 Enduring ability to sustain cultural identity and traditions	
Erosion of traditional cultural practice because of formal employment and earning of formal incomes.	The availability of regular high levels of income will create opportunities for more individual lifestyles (in some cases supported by travel) than were previously unattainable, potentially resulting in the erosion of traditional practices.
Loss of traditional practices due to long-term involvement with and dependency on the Project.	The intensity and duration of a long-lived project such as a major mine, which transforms lifestyles across generations, may result in the loss of traditional practices and cultural identity. Following mine closure there may no longer be an understanding or awareness of traditional practices and they may be forever lost.
SV4 An enduring ability to maintain customary rights to land access and resource use	
Formal employment contributing to the erosion of traditional leadership leading to an inability to resolve land access and resource use issues.	Leadership, based on traditional knowledge and experience, will be eroded as non-traditional forms of knowledge and skill related to the Project employment become more central to social life. Processes of social change are likely to be greatly accelerated because of the greater exposure to alternative ways of living and the injection of monetary wealth into communities which previously led predominantly subsistence lifestyles.
Increased cash from formal employment and commercial participation utilised in legal land or tenure disputes.	Increased levels of disposable income may be used to raise disputes over land rights in the hope of securing more benefits for individuals or sub-groups. This has been observed at other mines in PNG (e.g., Misima and Porgera).
SV5 An environment amenable to personal and family health, education, safety and security	
Increase in the prevalence of communicable disease because of an increase in disease exposure.	Local workers in accommodation camps in contact with workers from other areas of PNG and the world may experience higher levels of morbidity due to an increase in disease exposure. Due to the nature of communicable diseases, this effect may also be transferred to the families of employees in host community villages.
Increase in inter and intra-family disputes around control of and benefits from commercial opportunities.	Increased commercial opportunities and financial benefits may lead to an increase in disputes both within and between families around control of the new resources and opportunities, as observed at other mines in PNG (e.g., Lihir).
Increased prevalence of lifestyle disease associated with dietary change (blood pressure, diabetes, obesity etc).	Local workers in accommodation camps will be exposed to dietary changes that may result in weight increases. Higher income levels may result in an increase in worker family diets based on store bought food that could also result in weight increase.
Decreased attendance at school due to children taking on additional household duties as	The Project will result in an increased level of formal employment and workers will be recruited from local communities where possible. This will change the distribution of labour within the household where parents of children are employed. Children may be required to stay at home and

Impact	Impact pathway
parents gain formal employment and/or due to increased income.	help with domestic duties in the absence of one or both parents. Further, it has also been observed at other mines in PNG (e.g., Lihir) that if children are receiving increased income from the Project they may be less likely to attend school.
Increased disposable income may be spent on alcohol, drugs and women which can lead to increased family issues and polygamy.	The Project will result in increased levels of disposable income which may be spent on alcohol and drugs which can cause and worsen family issues. Increased disposable income may also be spent on prostitution and/or additional wives which causes disruption to family structures.
SV6 The availability of services supportive of personal health, education, safety and security	
Positive effects discussed below.	

Increased employment and commercial participation brings many positive benefits and opportunities (discussed further in Section 5.2). The positive effects of the Project related to increased employment and commercial participation include:

- The Project will increase employment opportunities through the direct creation of formal employment. In addition to direct Project employment, a range of other employment opportunities will be generated by local businesses that could commercially benefit from increased circulation of cash in the economy. These jobs provide additional employment opportunities, particularly for women, which lead to increased generation of income.
- The Project will directly inject wealth into the local, regional and national economy through Project business development, supply and procurement. Business development opportunities linked to the Project will be available for local landowners through to regional businesses. The procurement of goods and services required by the Project will also provide opportunities for businesses (including landowner companies) within PNG to establish and grow, particularly given the long life of the FRCGP and FRHEP. This growth will lead to the creation of employment opportunities and stimulate further growth and development of the economy.
- The creation of employment opportunities will result in higher household incomes. With increased disposable income, households are likely to purchase goods, services and products which make life more comfortable or appealing. Increased household incomes will also provide people the opportunity to make improvements to housing such as replacing semi-permanent elements (e.g., thatched roofing) with more permanent materials (e.g., iron roofs).
- The Project is likely to have a positive effect on skills attainment. Workplace training will be required for all locally recruited workers, including short-term casual labourer positions. This training will increase skill levels and the employability of those trained. Additional education and training may also be provided for longer-term employees such as engineers and technical staff, security officers, cooks and office support staff. Women may receive training and employment in areas such as food processing, camp management, health and hygiene and as office support staff. Such training will increase the skills and ongoing employability of women who otherwise might struggle to attain formal employment.
- The availability of regular high levels of income will create opportunities for more individual lifestyles (in some cases supported by travel) that were previously unattainable.
- FIFO workers employed by the Project joined with effective Zone 2 and 3 employment rates will provide regional stimulation to the economy in Sepik provincial and other centres.

- Increased cash from formal employment and commercial participation can be used to secure non-disputed land through formal registration, ensuring land tenure for future generations.
- Increased incomes can be used to fund better personal health through the purchase of store-bought food and access to medical care.
- Higher levels of income will allow for purchase of store-bought food which has the potential to increase levels of nutrition, particularly in relation to protein intake.
- The availability of regular high levels of income will create more educational opportunities for children (if the choices are made wisely).

5.1.6 Project workforce

The Project will require the presence of a large construction and operations workforce in the Project area, which is currently sparsely populated. The management of workforce accommodation camps will be a key factor influencing the manner in which the Project workforce interacts with the host community.

In construction it is proposed that the FRCGP site accommodation camp will be located in the Nena River valley and accommodate up to 3,550 personnel during construction, and approximately 2,780 personnel during operations. The FRHEP accommodation village near the powerhouse will accommodate up to 3,270 personnel during construction, and up to 420 personnel during operations. In addition, there will be accommodation for 100 personnel at the Vanimo Ocean Port for office, logistics and port operations.

Notwithstanding accommodation in construction camps, there will be some level of worker interaction with communities close to Project activities. Such interactions can lead to a range of issues, such as exposure to infectious diseases, and behaviour at odds with accepted local social norms. In addition, a high level of non-local workers can be a source of animosity between the workforce and local communities, particularly if local communities perceive that they are missing out on employment opportunities, regardless of the reasons. Such animosity can result in tension, conflict and, ultimately, violence if not managed appropriately.

A positive impact of the workforce presence will be increased income for local people, particularly women who sell goods (such as locally-grown food) and services (such as accommodation servicing) to sustain the workforce (Section 5.2). This will be particularly relevant to villages along the infrastructure corridor between Hotmin and Green River (Social Catchment 1B) proximal to road construction, and villages within a daily commuting distance to Project accommodation facilities.

Potential impacts on social values caused by the Project workforce are provided in Table 5.7.

Table 5.7 Potential impacts caused by the Project workforce

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Positive effects discussed below.	
SV2 Opportunities for participation in the cash economy	
Positive impacts discussed below.	

Impact	Impact pathway
SV3 Enduring ability to sustain cultural identity and traditions	
Damage or destruction to cultural heritage.	Undisciplined activity of the Project workforce may result in items and areas of cultural significance being damaged or destroyed. Some members of the workforce will have only a limited appreciation of locally important cultural heritage and either inadvertently or maliciously cause damage.
Introduction of new ideas may undermine traditional culture and authority.	Increased interaction with national and foreign workforce introduces new ideas that may undermine traditional culture and authority.
SV4 An enduring ability to maintain customary rights to land access and resource use	
None identified.	
SV5 An environment amenable to personal and family health, education, safety and security	
Tension between Project workforce and communities due to grievances or inappropriate workforce behaviour.	It is likely that some construction camp facilities will be in proximity to villages, particularly along the infrastructure corridor. Tension between construction camp and community residents may result if there are residents who are aggrieved at not securing employment, or if workforce behaviour does not meet community expectations.
Higher exposure to sexually transmitted and communicable diseases.	Presence of the Project may result in members of the host community being more exposed to communicable diseases. This may occur through local people employed by the Project being exposed to diseases because of mixing with the broader workforce and subsequently introducing these into the village.
Tensions and hostility between Project security personnel and local residents.	To secure Project sites and protect equipment and infrastructure, security personnel will be hired. Tensions and hostility may arise in the undertaking of security services.
SV6 The availability of services supportive of personal health, education, safety and security	
Positive impacts discussed below.	

In addition to the potential Project impacts discussed above, there will be positive effects arising from the Project workforce, including:

- The presence of the Project workforce will increase and/or create demand for fresh food that may be partially met by increased local area production, resulting in increased household income, and income for women who undertake the majority of gardening activity.
- The operation of accommodation camps will offer opportunities for camp service employment. Should camps be in proximity to villages, these employment opportunities may be accessible to village women, thereby facilitating discretionary spending, often targeted at the needs of children.
- FIFO workers employed by the Project joined with effective Zone 2 and 3 employment rates will provide regional stimulation to the economy in Sepik provincial and other centres.
- Additional services may be available as a result of the Project in order to meet the health, education, safety and security needs of an increased workforce.

5.1.7 Discharges, emissions and waste disposal

Project activities will result in the discharge of water, the generation of dust, and the emission of air pollutants, noise and light to the surrounding environment. People who live near or downstream of Project construction and operations may be affected by changes to quality and quantity of land and water resources on which they depend. With Paupe being resettled away from the Frieda River, likely to a location on Kaugumi Creek, residents will have access to a piped water supply and will not be dependent on water from the Frieda River, though may still access and use the river for recreation or fishing.. Perceptions held by downstream villagers about water quality will also require active management.

Controlled discharges of water to surface water or land will occur during construction and operations and will include:

- Discharge of water from the FRHEP to the Frieda River downstream of the ISF.
- Discharge of water associated with copper concentrate dewatering at the Vanimo Ocean Port.
- Discharge of treated wastewater from Project camps.

These and other Project discharge streams are discussed below.

Open-pit water will be treated prior to discharge into the ISF catchment, and water released from the FRHEP will meet IFC standards, with the exception of iron which is naturally elevated in the receiving Frieda River. Water quality will be assessed at a series of monitoring points downstream of the ISF to ensure it meets agreed human health and ecological criteria. Monitoring point AP7 is located downstream of the FRHEP discharge point and upstream of Paupe, and will be the primary monitoring point to ensure that water flowing down the Frieda River past Paupe meets PNG water quality standards. FRL will also establish values for triggering further investigation at this point, based on ANZECC/ARMCANZ (2000) ecosystem protection trigger values, advancement in the derivation of site-specific criteria and background concentrations. Water discharged from the copper concentrate handling process at the Vanimo Ocean Port and at Project camps will also be treated and tested to ensure it meets PNG water quality standards at the compliance points. Water quality modelling undertaken by SRK (2018) predicted that downstream water quality in the Frieda and Sepik rivers will meet PNG Schedule 1 criteria during mine life and post mine closure. Health-based WHO drinking water guidelines (2011) will be met in the Frieda River at AP7, with the exception of iron which is naturally elevated at that location. Dissolved concentrations of aluminium, chromium and copper in the Frieda River are predicted to exceed the ANZECC/ARMCANZ (2000) guidelines for the protection of aquatic ecosystems and background concentrations, however these concentrations are not expected to impact on aquatic resource availability. Health-based WHO drinking water guidelines (2011) are predicted to be met in the Sepik River. While concentrations of cadmium and zinc are also expected to marginally exceed the ANZEC/ARMCANZ (2000) guidelines, the concentrations of these parameters are within the natural variability of the background concentrations within the Frieda River.

Access to the Special Mining Lease tenement areas will be managed until relinquishment, after which there will be no restriction. Upon mine closure, water in the open-pit lake will likely be of poor quality and will continue to be treated prior to discharge until agreed post-closure water quality criteria are met. It has been assumed that water will need to be treated for approximately 50 years post-closure at this stage. Surface water diversion drains around the open-pit will be maintained while there is active water treatment.

Air emissions will be produced during the construction and operation of the open-pits, airstrips, ports and roads including disturbance to earthworks from wind erosion (likely to be minor due to the high rainfall), blasting, products of combustion from diesel powered construction equipment (e.g., trucks, excavators, bulldozers), generators and incinerators and hydrogen sulphide and odour from the sewage treatment plant and Environmental Waste Management Facility. There is also the potential for fugitive concentrate emissions during shiploading activities at the Vanimo Ocean Port. The greatest potential for air quality impacts will be from dust associated with:

- Construction of the infrastructure corridor, which will occur in close proximity to 13 villages comprising Aminii, Vanimo, Dioru, Sumumini, Imbrinis, Kilifas, Green River, Wokomo 2, Itomi, Kwomtari, Hotmin, Bisiabru and Usaremin 2 (all located within 800 m of the proposed road/pipeline alignment).
- Construction of the Vanimo Ocean Port, which will occur in proximity to Vanimo and Wesdeco.

The FRCGP and FRHEP are remote from nearby villages (pending resettlement of Ok Isai, Wabia, Paupe and Wameimin 2 prior to construction) and therefore air quality impacts will not be an issue for these villages.

Noise emissions and vibration will be produced during the construction and operation of the FRCGP, FRHEP, airstrips, ports and infrastructure corridor including from Project machinery, earthworks and blasting. Construction of the infrastructure corridor may cause short-term noise and vibration impacts at 13 villages (Hotmin, Wokomo 2, Idam 1, Idam 2, Dioru, Green River, Aminii, Kwomtari, Itomi, Kilifas, Sumumini, Imbrinis and Vanimo), which are located within 415 m of construction activities. Residents at these villages are not expected to be impacted by road traffic noise during operations. There is potential that adverse noise impacts may be generated by construction and operation at sensitive receptors nearby the Green River Airport. Potential noise impacts from the Vanimo Ocean Port construction and operation have been assessed, however will not differ considerably from the existing noise environment in Vanimo. Community consultation and noise mitigation are addressed in the respective EMMPs for the construction and operation of the Green River Airport and Vanimo Ocean Port.

Levels of artificial lighting will increase around Project sites and activities, including the Vanimo Ocean Port. During construction and operation, the mine and all mine related infrastructure will generate artificial light as will all Project related vehicular, air and water-based traffic. This will include barges travelling along the Sepik, May and Frieda rivers during the night. Such lighting may influence visual amenity and cause annoyance to local communities.

The Project has the potential to generate a variety of wastes through the construction and operation of infrastructure. Wastes generated through the construction and operation of the Project will be managed in accordance with waste management procedures that aim to avoid generating waste and/or to reduce waste, and then, to recycle and reuse waste material in preference to disposal. Sewage generated at accommodation villages and work sites will be appropriately treated prior to disposal. An engineered environmental facility including a landfill will be constructed in a central location within the mine area to manage the waste streams produced by the Project including solid waste, oil, hazardous waste and tyre disposal.

Increases in population because of in-migration within the Project area and surrounds, as well as an increase in purchased food, may increase the amount of waste generated. Few, if any, formal sanitation or other waste disposal facilities exist in local communities. Areas around the accommodation villages and communities located near Project infrastructure may experience increased littering and contamination of water supplies because of inappropriate waste disposal, with corresponding effects to people’s wellbeing and health.

Potential impacts on social values caused by discharges, emissions and waste disposal are provided in Table 5.8.

Table 5.8 Potential impacts caused by discharges, emissions and waste disposal

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Pollution of land and water resources because of Project discharges, emissions and waste disposal.	Discharges/emissions that exceed water quality criteria guidelines or environment permit conditions, or inappropriate waste disposal, may lead to pollution of land and water resources, resulting in impacts to food sources such as gardens or aquatic resources.
SV2 Opportunities for participation in the cash economy	
None identified.	
SV3 Enduring ability to sustain cultural identity and traditions	
None identified.	
SV4 An enduring ability to maintain customary rights to land access and resource use	
None identified.	
SV5 An environment amenable to personal and family health, education, safety and security	
Impaired community amenity and health concerns because of air emissions (e.g., dust, vehicle emissions) noise, vibration and light generated from movement of Project vehicles, machinery and vessels.	The movements of construction vehicles and machinery along the main access road, cargo vessels at the Vanimo Ocean Port during construction and operations, and barge transport along river access corridors during construction may impair community amenity and generate concerns over health effects from the generation of dust, vibration, noise and light.
Heightened levels of anxiety due to concerns about the Project's effect on the environmental integrity of waterways.	Downstream communities hold concerns about the environmental integrity of the waterways including the structural integrity and safety of the ISF, and the presence of contaminants in upstream discharges to rivers. If this anxiety is not assuaged on an on-going basis it may result in disruptive action in relation to perceived impacts not being addressed.
Increased animal pest-related diseases due to Project-related creation of suitable habitat or food source.	Project activities, particularly accommodation village operations and the associated disposal of wastes, have the potential to create favourable conditions for pest animals such as mice and rats, by providing food and habitat. These animals could promote the spread diseases within the camp and to nearby villages.
SV6 The availability of services supportive of personal health, education, safety and security	
None identified.	

5.1.8 Accidental spills and leaks

Accidents or equipment failures may cause spills and leaks of hazardous materials. A range of hazardous materials will be transported along the Sepik, May and Frieda rivers by barge and stored at the river ports during the Project construction period. Hazardous materials including fuel, oil, solvents and other chemicals, will also be transported by vehicle along the main access road. Copper concentrate will be filtered and stored at the Vanimo Ocean Port. These materials are potentially hazardous to ecological and social receptors if an accidental spill or leak were to occur. The operational standards required and implemented by FRL mean that the risk of such an event occurring is low; these are described in the relevant EMMPs. In the unlikely event of a spill or leak occurring it will most likely be relatively small and will be contained within the immediate area by physical barriers such as bunds. Major spills could occur although this is a very low probability.

Structural failure of the ISF, and any associated discharge of contaminated water or tailings and waste rock, would have serious long-term downstream effects on the Frieda and Sepik rivers, and the communities which rely on riverine resources, and is of significant concern to the residents of those communities. There have been instances, within PNG and elsewhere, of tailings storage facilities failing, and there is an associated level of public awareness about the consequential environmental effects. There is also heightened sensitivity in PNG to the downstream impacts of riverine tailings and waste rock discharge due to the observed effects at Panguna, Porgera and Ok Tedi mines in particular. While a ‘dam break’ analysis, simulating a very low probability failure event, was undertaken to inform the design of the ISF and to ensure that appropriate factors of safety have been incorporated into the design, the analysis illustrates the catastrophic consequence in the unlikely event of a dam wall failure (EIS Appendix 2). Hence, community anxiety of such an event occurring is an important social impact associated with Project development, even if such anxiety is expected to decrease over time.

Potential impacts on social values caused by accidental spills and leaks are provided in Table 5.9.

Table 5.9 Potential impacts caused by accidental spills and leaks

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Pollution of land and water resources because of Project accidental spills or leaks.	Project activities could degrade lands or the quality of water in rivers and Dakriro Bay through accidental spills of hazardous materials such as fuel, oil, copper concentrate, solvents or other chemicals. Contamination from such materials could affect the availability of resources relied on to support subsistence livelihoods.
SV2 Opportunities for participation in the cash economy	
None identified.	
SV3 Enduring ability to sustain cultural identity and traditions	
None identified.	
SV4 An enduring ability to maintain customary rights to land access and resource use	
None identified.	
SV5 An environment amenable to personal and family health, education, safety and security	
Increased exposure to spills of hazardous materials from Project installations such as concentrate and fuel pipelines/storage containers along with incidents on public or Project roads.	The Project will involve the transport, storage and handling of hazardous materials such as fuel, oil, fluids, solvents and other chemicals required for construction and operation. These activities bring an increased risk of an accidental spill of hazardous materials during transport, storage and use. People living and working near Project areas and along transport corridors could be exposed to hazardous materials if they are released or spilt, causing potential negative health impacts.
Heightened levels of anxiety due to concerns as to Project effect on beneficial environmental values of waterways.	Downstream communities hold concerns as to the environmental integrity of the waterways including the structural integrity and safety of the ISF, and the presence of contaminants in upstream discharges to rivers. If this anxiety is not assuaged on an on-going basis it may result in disruptive action in relation to perceived impacts not being addressed.

Impact	Impact pathway
SV6 The availability of services supportive of personal health, education, safety and security	
None identified.	

5.1.9 In-migration

In-migration is a term used to describe the movement of people into an area in anticipation of economic opportunities and improved services, which are stimulated by the development of a project. Such opportunities include employment, trade and other commercial opportunities arising from wealth generation in an area. In-migration is a phenomenon in PNG which occurs due to personal motivation to access economic opportunity, and has been documented at other mining projects. The potential impacts that result from in-migration are indirect rather than directly attributable to the Project.

To inform the potential for the Project to induce in-migration, FRL undertook a study (Jackson, 2018) that concluded that significant in-migration will most certainly occur if the FRCGP was to advance to development. The likely primary sources of in-migrants are Telefol people, the Sepik (particularly the Middle Sepik/Wosera-Gawi but also potentially from the East Sepik), and Min people, who had moved to Tabubil due to the Ok Tedi mine, returning to the Project area. These conclusions are supported by the genealogical and other social linkages held by the Miyan, Telefol and Paiyamo villages in Social Catchment 1A. The potential for in-migration from the East Sepik area is slightly attenuated due to the main Project area access being via a road to Vanimo; however, the Sepik corridor area is still a potentially significant source for in-migration.

Development of the FRHEP will result in resettlement of Ok Isai, Wabia, and Paupe villages. Wameimin 2 will need to be resettled if the Nena deposit is developed at some stage in the future due to construction and operations phase impacts, as the village is located approximately 3 km from the resource. To avoid having to relocate a significantly higher future population in this village (due to in-migration), it has been proposed to undertake resettlement at the commencement of the Project. Paupe will need to be resettled due to multiple prolonged construction phase impacts arising from proximity to the FRHEP (the embankment of which is approximately 5 km upstream of the village) and the Frieda River Port access road, potentially reducing amenity to an unacceptable level. Negotiations are currently underway over the selection of new sites to relocate the four villages.

The infrastructure corridor between the FRCGP/FRHEP and Vanimo creates a dominant pathway for potential migrants to the FRGCP and FRHEP area, using the public road with a significant secondary pathway being via the Sepik River (Jackson, 2018). The Sepik-Frieda waterway route remains important in terms of migration as experience at Frieda River and elsewhere in PNG shows that migrants do not need road links to move. The FRCGP and FRHEP will still have an attraction for potential migrants from along the length of the Sepik River, as the river is navigable to the point where the current public road is projected to cross it.

Additionally, a proposed future road link to Telefomin – while outside the scope of the EIS and SIA – has the potential to increase the likelihood of movement by Miyan and Telefol people towards the FRCGP and FRHEP. From the point of view of sustainable regional development, the revised infrastructure corridor greatly enhances the probability that the Project will create benefits that are sustainable over a wide region that is currently very poorly developed (Jackson, 2018). Migration can occur in the absence of roads, but economic development cannot. The implications of the infrastructure corridor between the mine and FRHEP area and Vanimo overall are extremely positive for regional development, linking large parts of Sandaun Province (south of the Sepik River) by road to the coast for the first time (Jackson, 2018).

The road between Hotmin and Vanimo passes through or near villages whose total population according to the 2011 PNG Census was around 13,600. In the same year Vanimo had a population of around 14,000 while the whole Sandaun Province had 248,000. The FRCGP and FRHEP will be much more accessible to potential migrants along the infrastructure corridor between the FRCGP and Vanimo. Access controls to be installed between Hotmin and the mine area, and the hydroelectric power facility and Frieda River Port, will act as a major control on unauthorised movement into these Project areas; however, the junction of the private and public road at Hotmin has the potential to become a focal point for a wide range of economic activity and population movement, due to the tendency for migrants to attempt to get as close to the source of potential economic opportunity as possible (Jackson, 2018).

The Frieda River will remain accessible to boat traffic and access to the FRHEP area via the river will still be relatively easy. As such, Sepik River people with access to canoes will continue to come up the Frieda River all the way to the Frieda River airstrip as they do now and have done for many years.

One attractive location for potential migrants identified in earlier studies was the alienated land on which the present Project airstrip stands, as alienated land is much easier to settle or squat on than village land. With the revised Project design this attraction remains because while the Frieda River airstrip will be retained and used by the Project, Paupe is scheduled to be resettled and this will provide additional space along the river banks for migrant settlement. When Paupe is resettled, it will be important that the land it currently occupies is secured by the Project to limit the attraction for in-migration to this point. This is because Paupe and land surrounding the Frieda River airstrip are still hotspots through which migrants from the middle and lower Sepik region might be expected to pass or occupy.

Ok Isai and Wabia villages are to be resettled, and flooding of their land in the Niar and Ok Binai valleys by the FRHEP will sterilise alluvial gold deposits which have been a major incentive for in-migration to the area in the past. Wameimin 2 will also be resettled due to its proximity to the Nena deposit and associated construction and operation impacts should this deposit be developed. However, the relocation of these villages will not diminish their attraction for other Telefol people to move to the new village sites.

Land along the length of the Vanimo to Hotmin public road is, to some degree, vulnerable to in-migration, particularly from the point at which the private road extends from Hotmin to the FRCGP. In cultural terms, however, this is not ideal because it is in Miyanten territory. While the Miyanten may not be especially concerned about migrants arriving from the south, as they have reached an amicable agreement with the Telefol people over general Project land ownership and benefit-sharing matters, it would strain that emerging relationship which is crucial to the management of the Project overall if large numbers of Telefol people or other Min moved into and settled at this site. Also, while many Telefol people and other Min might opt to move towards the resettled villages of Ok Isai and Wabia or to walk from Telefomin town into the Elip Valley to gain access to the FRCGP, as incomes increase and public motor vehicle services emerge, more and more people are likely to converge on this Hotmin junction point.

The development of the Project will significantly improve the potential for long-term development at several points within the overall Project area because it will build roads to previously isolated places which had no prospect of economic development. All previous attempts at economic development in the Telefomin District, for example, were stymied by the cost of transporting local products to market. The only significant ‘export product’ from the area in the past has been migrant labour. The Project will improve Telefomin District’s access to external markets via Vanimo. The Project will also enhance the economic potential of Green River through the upgrade of the airstrip, in addition to linking it by road to Vanimo. Green River has the existing advantage of ready access by river to the populations of the Sepik River, which will support its role as a future transport hub. Similarly, Vanimo's presently limited economic potential will be significantly improved. In these locations some additional migration will occur as a consequence and, in all three places, such inward migration will by viewed by most existing residents and by their local governments as a positive development and a sign of progress.

The level of in-migration likely to be generated by the Project is difficult to accurately predict. Jackson (2018) states that significant in-migration will most certainly occur, however does not attempt to estimate the extent of in-migration in terms of the number of people likely to attempt to settle in any location. The point is made that factors other than simply the number of in-migrants have a bearing in terms of subsequent impact upon the host community. For example, whilst the number of external traders that establish themselves in villages close to the Project may be numerically small, the impact they can have in terms of facilitating the flow of wealth out of local villages (and the tensions this can invoke in local communities) may be significant. It is likely that there will be an initial surge of people into the Project area. Arguably, the rate of in-migration may diminish after construction is completed and after arrangements relating to the distribution of Project benefits are finalised, however that is uncertain and it may remain at high levels well into operations.

The relatively rapid movement of people into an area will likely cause changes in host communities. While in-migration may ultimately benefit local trade, employment, infrastructure and services, there can also be negative economic, health and social consequences for host communities, particularly in the short term.

Potential impacts on social values caused by in-migration are provided in Table 5.10.

Table 5.10 Potential impacts caused by in-migration

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Reduced ability to lead subsistence livelihoods due to reduced garden productivity.	Population growth due to in-migration may place pressure on land surrounding settlements which is used to support gardens leading to reduced fallow periods further leading decline in garden productivity.
Reduced ability to support subsistence livelihoods due to reduced availability of terrestrial and aquatic resources.	Population growth due to in-migration may result in higher demand and subsequent scarcity of terrestrial and aquatic resources such as animals hunted for food, fish, building materials and medicines which are utilised to support subsistence livelihoods.
Increased cost of food sold in markets resulting in less opportunity for people to purchase food, and insufficient dietary intake.	Pressure on land and resources because of in-migration and an increase in earning capacity leading to a localised rise in the costs of market bought food, may lead to food shortages and decreases in store food affordability, particularly for people not receiving Project income.
SV2 Opportunities for participation in the cash economy	
Reduction in the availability of business opportunities for communities within the Project area due to in-migration.	The availability of business opportunities, due to higher levels of disposable income, may attract experienced business operators from outside the local area to establish operations, thereby inhibiting local enterprise development.
Reduced opportunity to gain formal employment.	The influx of people with higher levels of education and work experience may result in reduced opportunities for residents of local villages to access formal employment opportunities created by the Project.
Reduction in the per capita amount of royalties and	The in-migration of people into villages where they assert a genealogical connection may result in more people placing pressure on landowners for

Impact	Impact pathway
compensation attained due to in-migrants claiming a share.	a share of royalty and compensation payments made to landowners; this reduces the per capita amount of income received.
SV3 Enduring ability to sustain cultural identity and traditions	
Inability to maintain customary rights and practices because of in-migration creating pressure on land and resources.	Increased population occurring relatively quickly may create pressure on land and resources close to settlements leading to an inability to maintain customary rights and practices which rely on such land and resources.
Damage or destruction to cultural heritage.	Population growth due to in-migration may result in the clearing of areas for settlements and resultant damage or destruction of items or areas of cultural significance.
Erosion of traditional practices and authority due to new ways or challenges by in-migrants.	Increased numbers of in-migrants may disrupt and erode traditional practices and authority due to the in-migrants bringing new ideas and challenging local systems of authority.
SV4 An enduring ability to maintain customary rights to land access and resource use	
Loss of customary rights and access to lands.	A motivating factor for some in-migrants is to assert rights to land and residency to claim a share of royalties and compensation. This may result in-migrants settling on the land and opting not to move, despite encouragement from landowners to do so.
Inhibited access to lands and resources due to in-migration.	The settlement of in-migrants and use of resources may reduce residents' access to customary land and resources.
Heightened incidence of land and resource disputes triggered by in-migrant ties and interference.	The settlement of in-migrants and use of resources may trigger disputes over land and resources.
SV5 An environment amenable to personal and family health, education, safety and security	
Disruption to social relations and community wellbeing due to population influx.	The effects of population influx on access to land and resources may induce tensions in social relations within communities.
Deterioration of community safety and security.	Population growth due to in-migration may result in increased infringement of law and order and a reduced level of safety and security in local communities, particularly for women and children.
Higher exposure to communicable diseases.	Population growth due to in-migration may result in members of the host community being more exposed to communicable diseases.
Higher exposure to sexually transmitted diseases.	Population growth due to in-migration may result in members of the host community being more exposed to sexually transmitted diseases.
Social disruption caused by tensions between in-migrants and locals.	The influx of in-migrants may cause social disruption due to tensions between in-migrants and locals over employment and commercial participation.
SV6 The availability of services supportive of personal health, education, safety and security	
Reduced availability of health services.	In-migration will increase the demand for health and emergency services in affected areas. Such services are already limited and lack capacity. Increased demand may reduce the availability of health and emergency services for residents.
Reduced availability of education services.	In-migration will increase the demand for education services in affected areas. As the capacity of existing schools is limited, increased demand may reduce the educational services for residents.

Impact	Impact pathway
Reduced effectiveness of law and order and judiciary services.	In-migration and population growth results in an increase burden on and reduced effectiveness of essential police, village court and other law and order and judiciary services.

In-migration will have positive effects in addition to the impacts outlined above. The development of the Project will significantly improve the potential for long-term development at several points within the overall Project area because it will build roads to previously isolate places which had no prospect of economic development. In particular, the Telefomin District, Vanimo and Green River will experience in-migration which will be viewed by most existing residents and their local governments as a positive development.

In addition, in-migration will increase the number of people to which local people can sell goods in the Project area, which will increase incomes. People migrating to the area will also set up business enterprises to support Project construction and operations which will likely employ local people from the Project area, thereby increasing incomes.

5.1.10 Distribution of monetary wealth

The Project will generate substantial landowner incomes, some of which may be saved; however, a significant portion of income is expected to be spent and contribute to the incomes of a variety of entities throughout PNG. The resultant impacts are indirect rather than directly attributable to the Project, as the management of such wealth is determined by parties external to FRL, and as such are outside the control of FRL.

The Project will financially benefit the regional economy through the procurement of goods and services, payment of wages and the distribution of project benefits. This wealth will diffuse into other sectors of the economy, thereby increasing market activity at the regional scale. The Project will also result in local entities being able to generate additional income through service delivery and the associated the creation of direct and indirect employment opportunities. The term ‘Project financial benefits’ refers to income which will accrue to the PNG Government and applicable landowners because of this Project. The major items of income will be:

- Taxation:
  - Company tax payable by the Project owners.
  - Personal income tax from employees.
- Development levies.
- Royalties.
- Compensation payments
- Equity participation (leading to dividends).

Financial benefits will include increased revenue to the PNG Government, the provincial governments, local-level governments and landowners, extending to the completion of the Project operations phase.

The quantum of Project financial benefits will be influenced by the extent to which the PNG Government takes up its option to acquire a participating interest in the Project. Economic modelling undertaken by ACIL Allen (2018) indicates that if the full participating interest (30%) was acquired, potential returns to the PNG Government is estimated to total PGK17.2 billion (post-tax, ungeared) or PGK12.1 billion on a post-tax, geared basis after financing (ACIL Allen, 2018).

While these benefits are significant, the ongoing mining and electricity generation operations and their associated infrastructure provides significant potential to influence economic performance throughout the economy as a result of flow-on effects to other industry sectors. Economic spending by Project participants, employees, government and landowner beneficiaries will lead to 'multiplier effects' as the economic activities associated with the Project flow through the broader economy. Investment in productive physical assets (e.g., infrastructure for power generation, roads and airports) and in social assets (e.g., improved education and health services) can also benefit the economy by enhancing the productivity of economic factors (ACIL Allen, 2018).

The PNG Government-led benefit sharing agreement negotiation process will determine how the equity, royalties and development levy benefits are allocated among landowners and various levels of government. Project area landowners will receive benefits depending on the activities carried out on their land. The quantum of benefits flowing to beneficiaries will vary, with the owners of lands over which the SML is granted likely to receive the highest level of financial benefit and those along the infrastructure corridor receiving substantially lesser amounts.There is the potential for negative impacts associated with Project benefits. The process of determining rightful beneficiaries can place strain on social relations within and between communities. The distribution of cash to beneficiaries, many of whom have not previously had access to cash incomes, can promote changes to traditional lifestyles and systems of governance. Cash incomes can also lead to increased gambling activities and the consumption of alcohol and drugs that has the potential to lead to increased public and domestic violence.

Potential impacts on social values caused by the distribution of monetary wealth are provided in Table 5.12.

Table 5.12 Potential impacts caused by Project induced distribution of monetary wealth

Impact	Impact pathway
SV1 The capacity to support subsistence livelihoods	
Reduction in the availability of terrestrial fauna for subsistence purposes due to overharvesting enabled by more effective techniques.	The ongoing regular availability of increased levels of cash will allow people to purchase items such as guns and traps which will enhance the effectiveness of hunting practices. This could lead to unsustainable harvesting and scarcity of bush meat in the longer term. This could be exacerbated by an increase in population because of in-migration (Section 5.1.9).
SV2 Opportunities for participation in the cash economy	
Macro-economic effects constraining the opportunity to access the cash economy.	The Project will make a substantial contribution to the GDP of PNG which could indirectly influence inflation and the real exchange rate of the Kina. An appreciation of the Kina due to export earnings can affect the financial viability of other export industries such as agriculture, forestry and manufacturing which may find it more difficult to complete on the international market. This impact can have long term effects in terms of national economic diversity and thereby constrain opportunities to access the cash economy.
Increased opportunity to participate in the broader cash economy due to the indirect stimulation of economic activity.	The Project will generate indirect employment and business opportunities through the accrual of wealth into the local economy and stimulation of increased economic activity. This will occur through the procurement of goods and services, payment of wages and the delivery of government programs funded through taxes, royalties and equity dividends.

Impact	Impact pathway
SV3 Enduring ability to sustain cultural identity and traditions	
Erosion of cultural identity and traditions because of the transition to a cash based economy.	The generation of cash incomes will directly change traditional behaviour and practices. The ability to use cash to purchase food changes the focus of traditional subsistence lifestyles. Knowledge, customs and beliefs, which are framed around a subsistence style of living lose their relevance and meaning as people come to rely more on cash as the primary means of supporting livelihoods. This can also disrupt traditional power relations as authority shifts to those able to generate the greatest economic wealth, potentially eroding the influence of elders and other traditional village leaders. Knowledge of traditional languages, medicines and ways of interpreting and utilising the environment may diminish. Together these changes will affect household management.
SV4 An enduring ability to maintain customary rights to land access and resource use	
None identified.	
SV5 An environment amenable to personal and family health, education, safety and security	
Disputes amongst landowners over the distribution of monetary benefits.	The distribution of Project benefits will be negotiated through the development forum process. Experience from other projects within PNG indicates this process will expose and exacerbate existing uncertainties and disagreements about land ownership. Negotiations could lead to disagreements among customary landowners. The finalisation of the benefit sharing agreement can lead to lasting stress for customary landowners and within communities.
Reduction in school attendance as higher income levels result in less emphasis given to formal education.	Households will generally have increased capacity to meet education costs, although education may be given less of a priority because of increased household incomes. In some instances, large-scale resource development projects may have a negative effect on the uptake of education. The ability to generate wealth in ways which do not require educational attainment, such as through royalty and equity payments and wages, may result in a decrease in school attendance and educational attainment.
Increase in STI and HIV infections arising from high-risk behaviour associated with higher levels of disposable income.	Changes in lifestyle and behaviour, particularly for young adult males removed from social structures with high levels of disposable income, may lead to sexual behaviour which increases risk of infection.
Decrease in security for women and children and increase in inter-personal violence, prostitution, bride prices etc.	Weakened traditional authority, combined with high levels of disposable income and the presence of outsiders, may increase the general availability of alcohol and drugs in communities creating an adverse security environment for women and children. Increased availability of money may also foster social dysfunction through stimulating practices such as the purchase of additional wives and prostitution.
SV6 The availability of services supportive of personal health, education, safety and security	
Positive impacts discussed below.	

Increased incomes and Project-related benefits will have a number of positive effects:

- Enhanced incomes can be utilised to purchase existing subsistence resources at increased levels or new resources previously unavailable locally, and can also be utilised to purchase subsistence services leading to an improvement in subsistence livelihoods.

- Increased monetary wealth can lead to excess funds being directed to savings and wealth creation through non-mine dependent investment (e.g., cash cropping, property and managed funds) as well as through directly investing in Project-related commercial opportunities (e.g., contracts, supply and procurement).
- The distribution of Project-direct monetary payments (royalties, compensation and resettlement payments) benefit the nuclear family level and empower female heads of family.
- Additional monetary wealth can stimulate the traditional wealth exchange and display culture such as feasting and public ceremonies.
- Development of the Project could provide a catalyst for investment in infrastructure. The governments of the Sandaun and East Sepik provinces are likely to receive infrastructure grants from the PNG Government as part of the distribution of Project benefits. Such grants could provide a means to improve or develop new infrastructure such as roads, airstrips and other facilities.
- The Project's contribution to national, provincial and local-level government income may improve the availability and standard of education facilities. Improvements to educational facilities, such as school buildings, sanitation facilities, teacher housing and the provision of power may also help to increase teacher recruitment and retention.
- The Project will likely indirectly contribute to improving the availability of health infrastructure and services. Taxes and royalties contributed by the Project could assist the national, provincial and local-level governments in providing health services to local communities once Project benefits have been realised. Increased household incomes will also assist people to afford health care, and road improvements will provide easier access clinics, hospitals and specialist services in other villages and towns.

5.2 Opportunity capture

Sandaun Province and the western districts of East Sepik Province are amongst the least developed in PNG. Broad-scale development initiatives (such as the West Sepik Provincial Development Project (World Bank ,1984)) have been implemented in the past, though have met with limited success (World Bank, 1994) due to the complexity of implementation in remote areas lacking basic social and physical infrastructure. Where infrastructure was provided it had little impact on agricultural production due to deterioration and a lack of commitment to maintenance.

In addition to the FRCGP, new and upgraded road infrastructure and the provision of access to power for communities along the road corridor has the potential to generate a broad range of positive social effects and opportunities across communities in the western half of Sandaun Province that currently have minimal access to the cash economy, work and business opportunities, health and education services, and community and regional infrastructure. As well, the distribution of high voltage power to Vanimo, the Indonesian border area at Wutung, and potentially in the longer term the Aitape and Wewak areas, should act to stimulate private sector development in these areas. The low voltage single wire earth return power line along the infrastructure corridor as part of the SPGP provides the potential for a third-party provider to connect communities along the infrastructure corridor to a long-term, reliable and sustainable power supply. The supply of electricity to these communities has the potential to significantly improve education, health, trade, village amenity and community infrastructure, as well as creating opportunities for a higher level of women's participation in economic activities. While the earlier provision of infrastructure to communities between Vanimo and Green River was not maintained (either by government or private users such as logging companies), the Project will maintain the public and private road links to the FRGCP for at least the life of the mine

(33 years), supporting the longer-term development of agricultural industry and government delivery of social services such as health and education.

The employment preference policies of the FRCGP should result in a significant number of highly paid positions accruing to both Sandaun and East Sepik residents during the life of the mine. A conservative estimate of wage income across both provinces is in the order of PGK112M per year. While this will drive business development to service private consumption, it should also provide equity for investment in new enterprises and contribute to taxation revenues in both provinces. This, together with royalty payments, should enhance the capacity of the provincial governments to fund service delivery and the maintenance of public infrastructure over the long life of the FRCGP.

Indicative opportunities include:

- Opportunities for employment (and receipt of associated income) and skills acquisition, both for males and females.
- Opportunities for the development of local economies including trading businesses and potentially cash-cropping due to improved access to input and product markets.
- Landowner receipt of statutory payments including royalties and compensation that may be applied to consumption or investment.
- Access to improved village-level infrastructure and service delivery in health and education.
- For resettled communities, access to improved village-level infrastructure including new houses and water and sanitation facilities.
- Access to regional infrastructure including improved road transport links to Sandaun service centres and telecommunications facilities.
- Opportunities to establish community programs to improve family and gender relations, and increase support for other vulnerable groups such as youth and the disabled.

The Project will generate several benefit streams that are likely to result in greater provincial and national wealth, particularly from royalties and taxes. The notable aspects of these benefit streams include:

- Direct FRCGP initial capital investment in PNG of more than US$2.8 billion (PGK8.8 billion) in real terms.
- FRCGP recurrent operating expenditure averaging US$655 million (PGK2.1 billion) per year including significant local spending on support services.
- Gold, copper and silver production valued at an average US$1.5 billion (PGK4.8 billion) per year.
- Direct FRHEP capital investment in PNG of more than US$3.2 billion (PGK10.1 billion) in real terms.
- FRHEP recurrent operating expenditure averaging US$30 million (PGK94.5 million) per year including significant local spending on support services.
- Project construction workforce peaking at approximately 4,200 full-time equivalent workers, and an operating workforce of approximately 2,430, with the majority (90%) being PNG nationals.
- Tax, royalty and production levy revenue to PNG governments and landowners from the operation of the FRCGP in the order of PGK24.4 billion in real terms over the life of the Project (an average of PGK610 million per year for 40 years from 2021).

- Tax (company tax and PAYE tax) payments to PNG governments and landowners from the operation of the FRHEP in the order of PGK4.9 billion in real terms over the life of the Project (an average of PGK121 million per year for 40 years from 2021).

Government and the Project proponent must work together with communities to develop practical, affordable and achievable plans for development to ensure that these opportunities present realistic, enduring and intergenerational benefits, particularly for mine area communities. At a local scale, the receipt of Project income may be used to improve health and education levels within communities, and to develop business enterprises such as supply companies and trade stores.

FRL's focus will be on providing foundational and discretionary community development support across priority villages to catalyse development across the two core themes of 'skilful' and 'healthy'. It is proposed that priority projects under these two themes will be developed and funded in consultation and partnership with host communities and government, with broad parameters agreed through the Development Forum, and focused on Social Catchment 1A communities as these will be the communities most affected by the Project (see Section 6.2.1 for further discussion). FRL proposes to discuss with government the potential for access to the Tax Credit Scheme (TCS) for priority provincial infrastructure projects in Sandaun and East Sepik Provinces, as well as the potential for government infrastructure grants for the Telefomin area and the infrastructure corridor between the FRCGP mine area and Vanimo,.

FRL has developed a draft Business Development and Supply and Procurement Plan, required as part of its submission to apply for a SML. Key initiatives under this plan are the establishment of the Business Development Office that will include business development staff dedicated to providing assistance to independent businesses owned by clans, sub-clans, family groups and individuals (from communities within the SML and other lease areas) to undertake minor contracts for the provision of services. Many of these contracts will be suitable for youth groups, women's groups, church groups and others. It is also proposed to work across the infrastructure corridor between the FRCGP and Vanimo to identify opportunities for the supply of fresh produce to the Project, to be developed across at least the first 10 years of Project development covering construction and early years of operations.

FRL will also assist in the formation and operation of a company to represent the landowners of the SML in larger contracts with the Project where appropriate. Subject to capacity, FRL will source goods and services based on an order of preference, from suppliers that are:

- Owned by recognised landowners from the Frieda River area.
- Based in Sandaun Province.
- Based in East Sepik Province.
- Based elsewhere in PNG.
- Based overseas.

All tendering for the provision of goods and services to the Project will be on a strictly commercial and competitive basis with a focus on price, quality and schedule.

A significant opportunity associated with the Project, for both local and provincial residents, is participation in employment. FRL has developed a training and development strategy to support workforce development and ensure that unskilled local and provincial residents are able to participate to the maximum extent possible. This strategy will be implemented by a dedicated Training Section within the Human Resources Department, supported by embedded skills training specialists in operating departments. Training will occur at a primary training centre at the FRCGP site and within operational workplaces. A secondary training centre will operate in Vanimo for the provision of apprentice/trade training and specialist development training which is best delivered away from the workplace. In addition to standard operator and trades training, FRL will implement a ‘workforce culture program’ prior to start-up and in the early stages of operations. This program will be important in establishing a consistent employee culture within the Project workforce as some employees will be recruited from communities across PNG (and elsewhere) with different cultures, languages and values. A proposed community development fund will incorporate an initiative designed to build the literacy and numeracy skills of the mine area social catchment residents to access work opportunities. The proposed Project approach therefore reflects a partnership between the Community Affairs and Human Resources departments, to enable local communities to optimise opportunities presented by access to work.

Project employment and training will provide long-lasting benefits for communities. People employed and trained by the Project will learn valuable skills that they would likely otherwise not have access to, particularly in Social Catchment 1A, 1B, 1C and 1D. This will provide people with the ability and confidence to seek employment elsewhere in the mining and resources industry in PNG and internationally, should they choose to do so. A good precendent exists at the former Misima mine where, 13 years after mine closure, charter flights fly people from Misima to work at the Porgera, Lihir and Ok Tedi mines. The seven-year construction and 33-year operating life of the FRCGP will provide the potential to train many people over the life of the mine.

Increased access to infrastructure and transport links will present a significant opportunity for communities within the Project area. The proposed public road will provide communities with increased access to markets, enabling opportunities for the sale of surplus goods that could lead to commercial-scale growing and sale of produce and cash crops, thereby providing an ongoing source of income to rural families, particularly women. Such access will likely promote the establishment of small-scale family enterprises selling garden produce and other products such as small goods and mobile phone charge cards to the workers and other people who use the public road.

Access to health and educational facilities will be improved because of the development of road and communications infrastructure. This could include medical clinics, hospitals, specialist services and schools, the quality of which will be significantly improved by a long-term, reliable and sustainable source of power. The development of communications infrastructure will likely improve access to medical and educational information and assistance, as well as facilitate more efficient commerce. Development of the Vanimo Ocean Port and the SPGP will likely stimulate trade between PNG and Indonesia and generate employment opportunities.

6 Impact assessment

This chapter presents the assessment of potential socio-economic impacts of the Project which encompasses:

- Proposed socio-economic impact mitigation measures.
- An assessment of residual significance of impacts in each social catchment following the assumed effective implementation of the mitigation measures.
- A discussion of social considerations for mine closure.

6.1 Mitigation measures

A set of over-arching mitigation measures have strongly influenced the design and proposed operating philosophy of the Project. Mitigation measures have been identified through consideration of the experience of similar mines in PNG, PanAust's operations in Laos, and the Project Environmental Management and Monitoring Plans (EMMPs). Mitigation measures will be further refined in the development of the Project EMMPs and social management plans under the Social Performance Policy (Chapter 7).

Table 6.1 describes the mitigation measures that FRL has committed to address impacts to social values from Project activities. Stakeholder access to the Grievance Management Procedure (SEM057) is a mitigation measure applying to all identified impacts.

Table 6.1 Mitigation measures

Mitigation number	Mitigation title	Mitigation measure
SV1 – The Capacity to support subsistence livelihoods		
SEM001	Vegetation clearance mitigation measures	Implement vegetation clearance management and monitoring measures in the Project Biodiversity Management Sub-plans.
SEM002	Terrestrial fauna mitigation measures	Implement terrestrial fauna management and monitoring measures in the Project Biodiversity Management Sub-plans including the avoidance of areas with high biodiversity values and the management of disturbance to fauna, where possible.
SEM003	Water management and monitoring	Implement water management and monitoring measures outlined in the Project EMMPs including diverting clean water away from disturbed areas, not washing machinery near watercourses, meeting discharge requirements described in environment permit conditions and documenting and investigating complaints about water quality.
SEM004	Resettlement Action Plan	Develop and implement Resettlement Action Plans in collaboration with residents of villages to be resettled. Ensure that livelihood restoration measures are coordinated with other social management measures (e.g., in-migration management, recruitment strategy, lease boundary monitoring, provision of regional infrastructure and services) and are monitored for effectiveness.
SEM005	Weed management plans	Implement weed, plant pathogen and pest management controls within the Project EMMPs.
SEM006	Pre-construction surveys	During road pre-construction surveys, identify construction water source locations that avoid impacting local community water supplies. If impact is unavoidable, implement measures to provide an alternate water supply.

Mitigation number	Mitigation title	Mitigation measure
SEM007	Information on construction impacts	Provide briefings to local communities on when and where construction will occur, what potential construction impacts may occur, and the means of communicating with contractors and the Project around issues, including the use of the Project Grievance Management Procedure.
SEM008	Fish and crocodile stocks	Monitor fish and crocodile stocks and local harvest at select locations prior to construction, at regular intervals during construction, and six months post construction. Develop an operational response in the event that surveys indicate impairment of local harvest due to the Project.
SEM009	Engagement process	Ensure the Project has an active engagement process in villages downstream of the mine area to address concerns about the environmental integrity of the waterways on an ongoing basis.
SEM010	Erosion and sediment control	Implement and maintain erosion and sediment controls as per the Project EMMPs.
SV2 – Opportunities for participation in the cash economy		
SEM011	Compensation – cash economy	Ensure that fair and equitable compensation is provided to parties affected by Project related impacts on subsistence resource use or existing income generating resources or activities.
SEM012	Wealth capture and creation	Design, encourage and implement mechanisms (such as bank accounts) to capture a reasonable portion of direct monetary payments (royalties, compensation, resettlement) and encourage these funds to be re-invested for further wealth creation including inter-generational.
SEM013	Wealth distribution	In partnership with stakeholders, design, encourage and implement wealth distribution systems across the range of benefit streams including royalties, compensation, representative company (RepCo) dividends and equity participation, which ensure that monetary payments are made equitably and transparently to the nuclear family level.
SEM015	Business development, supply and procurement support	Implement the Business Development, Supply and Procurement Plan aligned with the designated preferential zones.
SEM016	Employment and commercial opportunity awareness	Notify communities about proposed employment and commercial participation (business development, supply, procurement) policies and systems, including the designated preferential zones, and ensure that stakeholders have clear and regularly updated information on how to access employment and procurement opportunities.
SEM017	Pre-employment training	Implement pre-employment training for Zone 1 and Zone 2 landowners as far in advance of construction as possible.
SEM018	Contractor development plans	Contractor scope of works and contract conditions will include the development of plans and protocols to comply with Project employment, training and procurement policies. Contractor plans to be assessed and approved by FRL prior to contract award and be subject to regular performance reporting and audit.
SEM019	Income management training	Deliver income management training and advice to local employees and households to assist local people to manage the transition to higher incomes.

Mitigation number	Mitigation title	Mitigation measure
SEM020	Women's participation	Implement measures, based on an assessment of demonstrated need and local preference, to support the participation of women in training, employment and business development activities associated with the Project.
SEM021	Livelihood surveys	Undertake a baseline assessment of settlement and livelihoods along road corridors prior to construction. Assess change post-construction as part of Social Management Plan monitoring.
SEM022	Transition to closure support	Manage transition from operation to closure through the progressive development and implementation of a closure plan that addresses key livelihood issues such as employment and service provision.
SEM023	Conflict management	Work with the PNG Government to assist in managing conflict associated with distribution of benefits.
SEM024	Benefit distribution agreements	Establish benefit distribution agreements that encourage the adoption of a benefit stream sustainable wealth strategy which: • Includes measures to provide for future generations. • Favours long-term investment over immediate consumption. • Supports vulnerable group members. Includes on-going feedback to landowning clan members.
SEM025	Local procurement	Encourage the development of local procurement as per the Business Development, Supply and Procurementt Plan.
SEM026	Local enterprises	Encourage the development of non-mining related local enterprises, such as cash cropping, within Zones 1 and 2.
SEM027	Regional development cooperation	Encourage coordination with the two Sepik provinces and other major impact project developers in the area of agriculture and industry, so that the Project supply and procurement systems, and potential community investment programs, support the broader regional development aspirations and plans.
SEM028	Employment maximisation	Promote employment from Zone 1, Zone 2 and Zone 3 to ensure that wages and benefits accrue to the Sepik regional and urban centres.
SV3 – An enduring ability to sustain cultural identity and traditions including connection to ancestors		
SEM029	CHMP	Implement Cultural Heritage Management Sub-plan and associated Chance Finds Protocol.
SEM030	Cultural heritage induction	Include cultural heritage awareness briefings in workforce inductions, including briefing on individual obligations to protect cultural heritage in accordance with PNG law.
SEM031	Informing cultural heritage custodians	Disseminate information derived from chance finds acquired during the Project to the custodians of cultural heritage and/or the public and National Museum and Gallery, where relevant.
SEM032	Support for cultural research programs	Support research programs which document cultural aspects of communities including traditional subsistence practices (e.g., hunting and gardening), language, capturing 'stories' and other cultural aspects.

Mitigation number	Mitigation title	Mitigation measure
SEM033	Pre-construction surveys	Conduct engagement with local communities regarding: • The content of the Project EMMPs. • The development of culturally appropriate methods for the practical management of cultural heritage values that are to be protected from impacts. The development of appropriate management measures in relation to their oral tradition sites. Culturally appropriate responses to the management of sites and places that will be unavoidably impacted by Project activities may include avoidance, exhumation/relocation of the value and traditional ceremonies (that should precede the commencement of Project activities in that location).
SEM034	Information on construction impacts	Implement site specific management measures as specified in the Project Cultural Heritage Management Sub-plans.
SV4 – An enduring ability to maintain customary rights to land access and resource use		
SEM035	Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Develop and implement the Project-Induced In-Migration Management Strategy in collaboration with landowners and provincial and local governments. Ensure that integration with other measures contributing to the management of population movements (e.g., recruitment strategy, contractor compliance with policy, provision of regional infrastructure and services) is coordinated and effective.
SEM036	Land dispute resolution	Collaborate with the PNG Government and support government led processes to resolve land disputes if they arise
SEM037	Membership qualification criteria (MQC)	Implement the MQC to codify social and cultural criteria by which each of the three Zone 1 groupings (Telefol, Miyan and Paiyamo) identify membership and from this establish and maintain a database at the nuclear family and individual levels.
SEM038	Land access	Conduct new post-permitting land access in a manner that promotes transparency and the fair treatment of customary landowners in PNG and follows established protocols for landowner identification.
SEM061	In-migration management	Support government initiatives that aim to discourage settlement within road and transmission line easements.
SV5 – An environment amenable to personal and family health, education, safety and security		
SEM039	Capacity building programs	Through a community capacity development program, collaborate with stakeholders and engage vulnerable groups in capacity building programs to develop youth leadership initiatives that support the active role of future generations.
SEM040	Air, noise, vibration management measures	Implement air, noise and vibration management controls in the Project EMMPs.
SEM041	Project emergency response measures	Establish Project Emergency Response and Fire Sub-plans including provisions for community awareness and coordination with District and Provincial authorities.
SEM042	Workforce code of conduct	Develop and implement (commencing with workforce induction training) a workforce code of conduct to guide workplace behaviour and respectful interaction with host communities. As a minimum, this code of conduct will cover: ethics; health; environment; safety; alcohol and drug use; workforce diversity; harassment; and cultural and social sensitivities of workers and communities.

Mitigation number	Mitigation title	Mitigation measure
SEM043	Vehicle awareness training	Develop and implement measures including driver education, community risk awareness, operational road traffic management protocols and appropriate physical safety measures (including vehicle-pedestrian separation) where required.
SEM044	Vessel management protocols	Develop and implement measures which include vessel crew education, community risk awareness, operational vessel management protocols, and appropriate physical safety measures (such as visual and audible warnings) where required for construction and operations.
MM144	EMMP measures	Conduct awareness training of the alert and communications system procedures to potentially affected communities, FRHEP employees and contractors in the unlikely event of an ISF emergency.
SEM046	Workforce health screening	Implement workforce health screening during the recruitment process; on-going workforce health education and awareness programs; and comprehensive employee health service provision in compliance with legislative requirements and company workplace health and safety policies.
SEM047	Workforce accommodation	Construct and operate workforce accommodation and messing facilities in accordance with recognised standards for hygiene and safety[6].
SEM048	Health awareness education	Educate workers on disease prevention and health promotion, and encourage workers to share their learnings with the community.
SEM049	Workforce induction	Implement a Project-wide induction process that covers, as a minimum: ethics; health; environment; safety; alcohol and drug use; workforce diversity; harassment; and cultural and social sensitivities of workers and communities.
SEM050	Security personnel training	Conduct background checks on security personnel and train them in the Voluntary Principles on Security and Human Rights.
SEM051	Infectious disease control	Implement infectious disease management programs for workers, incorporating worker education, to reduce potential for disease occurrence.
MM050	Hazardous materials	Store, handle and transport hazardous substances in accordance with Australian Standards AS1940:2017 and AS3780:2008, and the PNG Environmental Code of Practice for Vehicle/Machinery Workshops and Petroleum Storage/Resale/Usage Sites.
SV6 – The availability of services supportive of personal health, education, safety and security		
SEM054	Health and education programs	In partnership with government and non-government health service providers implement health and education programs, and infrastructure development and delivery of health treatment and prevention services in communities surrounding Project facilities.
SEM056	Community and government justice	Through the Project's community investment programs, actively support and promote initiatives aimed at law and order, community and government justice administration and conflict management initiatives.
SEM057	Grievance Management Procedure	Provide access to an effective and transparent Grievance Management Procedure for communities, employees and contractors.

[6] IFC/EBRD (2009) Workers Accommodation: Processes and Standards, A Guidance Note by the International Finance Corporation and the European Bank for Reconstruction and Development, London

Mitigation number	Mitigation title	Mitigation measure
SEM058	Early conceptual closure planning	Conduct conceptual closure planning as part of Project design to enable design consideration of post-closure sustainability of infrastructure and assets.
SEM059	District and Local Level Government	Actively support the five year rolling District and Local Level Government plans within the Zone 1 and 2 host districts.
SEM060	Provincial government coordination	Actively support the Sandaun Provincial Government's 'Growth Centre' strategy, and other provincial and regional development plans.

6.2 Assessment of residual impact significance in each social catchment

This section discusses the residual significance of impacts to social values based on the impacts described in Chapter 5 for each social catchment, following the assumed effective implementation of mitigation and management measures. As presented in Appendix 5, those impacts which were assessed as having pre-mitigated significance ratings of medium or higher have been assessed in terms of how they may be experienced in each respective social catchment.

A health impact assessment (Appendix 4) was completed for the Project, the purpose of which was to examine the potential exposure of Project community villages to the essential micronutrient metals copper, selenium and zinc, and the contaminant metals arsenic, cadmium, mercury and lead associated with the development of the Project. Potential exposure pathways modelled included drinking water, food, village soils, sediments and surface/recreational water through the ingestion and dermal absorption routes. The air exposure pathway was not modelled as this pathway has been demonstrated to represent an insignificant percentage of the total aggregated exposures in previous PNG studies. However, the modelling results do indicate that during construction fugitive dust management measures may need to be implemented when works are being performed within 800 m of populated areas.

The health impact assessment adopted a standard deterministic health risk assessment method comparing modelled exposure with international standards and guidelines. The assessment included the use of Site-specific Project data including:

- Social baseline surveys undertaken for the Project between 2009 and 2015 (Coffey 2009, 2010, 2011, 2015 and 2017).
- Baseline Health, Diet and Nutrition Survey (Appendix 3).
- Water Quality and Aquatic Ecology Baseline (EIS Appendix 7).
- Sediment Transport Assessment (EIS Appendix 5).
- Site-wide Water Balance (EIS Appendix 6a) and Load Balance (EIS Appendix 6b).
- Bioaccumulation and Biomagnification Assessment for the ISF (EIS Appendix 7b).
- Surrogate data from previous studies of PNG Western Province communities with similar environmental health circumstances as the Project community villages (Bentley 2007a, b).

The health impact assessment considered the potential exposure to communities from metals in the environment, including an assessment of predicted changes due to mine discharges. The dominant exposure pathways to metals in the environment were determined to be food and drinking water pathways. As a conservative approach, the health impact assessment modelled a worst-case scenario in which communities access drinking water from waterways impacted by predicted maximum total metal concentrations, such as the Frieda River. Baseline studies found that villagers access their drinking water from a range of sources including creeks, off-river water bodies, natural springs and water tanks and therefore do not source all their drinking water from the Frieda River, hence the health impact assessment conservatively overestimates the exposure from this source. Even with this worst-case scenario, the health impact assessment determined there would be no adverse impacts from this activity. This includes consumption of fish and wildlife from the potentially impacted areas which are predicted to remain safe to eat. Other Project-related impacts are discussed in further detail for each of the social catchments below.

Air quality modelling (EIS Appendix 11) indicated that the highest potential for air quality impacts (amenity) will be from dust associated with:

- Construction of the infrastructure corridor, which will occur in close proximity to 13 villages comprising Aminii, Vanimo, Dioru, Sumumini, Imbrinis, Kilifas, Green River, Wokomo 2, Itomi, Kwomtari, Hotmin, Bisiabru and Usaremin 2 (all located within 800 m of the proposed road/pipeline alignment).
- Construction of the Vanimo Ocean Port, which will occur in proximity to Vanimo and Wesdeco.

The FRCGP and FRHEP are remote from nearby villages (pending resettlement of Ok Isai, Wabia, Paupe and Wameimin 2 prior to construction) and therefore air quality impacts will not be an issue for these villages.

The following sections provide a summary of the socio-economic impacts to social values in terms of how they may be experienced in each respective social catchment.

6.2.1 Social Catchment 1A: Mine area

The following sections describe the Project activity and associated residual impact assessment for Social Catchment 1A.

Miyan social sub-catchment

Wameimin 2 is the village in closest proximity to the mine area and related activities, located approximately 8 km northwest of the mine area, and 3 km west-southwest of the Nena deposit. There is no ground disturbance expected upstream of Wameimin 2, and no construction camps in its vicinity. Wameimin 2 will be resettled so that the future population near the Nena deposit will not overly constrain the development of that deposit (where the decision to develop or not will be made at some stage in the future), nor be physically impacted should the deposit be developed. The ISF and mine area will remove access to approximately 13,500 ha of forested land, a significant amount of which was available to Miyan for hunting purposes. The other Miyan villages are located to the west-southwest of Wameimin 2 at distances of 13 to 20 km from the mine area. As such, they will experience no direct physical impact.

In-migration is not expected to be prevalent within the Miyan social sub-catchment. Amaromin may experience some effects of in-migration due to its proximity to the May River which is accessible by canoe from the Sepik River.

Livelihoods - The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

It is possible that the capacity of the Miyan people to support subsistence livelihoods will be impacted by the in-migration of people into the social sub-catchment, principally to Amaromin due to its proximity to Fiak, its status as a landowning village, and eligibility to receive Project-related financial benefits. Internal population movement toward a relocated Wameimin 2 may result from Wameimin 1 (who have expressed a desire to co-locate with Wameimin 2 to access better services and resolve a land dispute), and potentially from Amaromin and Sokamin. The consequence of population influx on the capacity to support subsistence livelihoods within the Miyan social sub-catchment is moderate, as it will create pressure on land and resources close to settlements which could lead to a decline in garden productivity (if fallow periods are shortened) and less land being available for garden production. It will also increase the pressure on hunted animals and aquatic fauna such as fish, though Miyan people during consultation indicated significant undisturbed areas would remain for hunting. The Project will seek to collaborate with landowners and government to manage effects associated with in-migration through implementation of the PIIMMS. The residual significance of the impact is assessed as medium.

The capacity of the Miyan people to support subsistence livelihoods will also be impacted by physical disturbance from Project activities such as vegetation clearance and inundation of the ISF area which will reduce the land available for hunting. The Project will implement comprehensive water monitoring, pre-construction surveys, vegetation clearance planning, and erosion and sediment control to reduce the risk of impacts from physical disturbance to subsistence lifestyles. The residual significance of the impact is assessed as very high due to the large area of land that will be lost for resource use as a result of the Project.

While the Project will facilitate access to the cash economy through direct employment, receipt of Project related financial benefits along with stimulation of the local economy, there is likely to be a reduction in the number of people from Miyan villages able to access formal employment when the Project transitions from construction to operations, as there will be less demand for unskilled labour, and this will affect their ability to participate in the cash economy. There are currently only a small number of people in the Miyan social sub-catchment who possess the skills and experience required to access operational employment, however this will be mitigated by developing and implementing a training and employment plan to up-skill local people. The consequence of not gaining employment which was expected will be moderate, as it may lead to alienation and social unrest due to not obtaining expected or hoped-for income, compounded by the observance of outsiders perceived to be benefiting from employment. The Project will implement training and capacity building initiatives for Project employees to facilitate transition from wage employment. The residual significance of the impact is assessed as medium.

Culture- An enduring ability to sustain cultural identity and traditions (Social Value 3) and maintain customary rights to land access and resource use (Social Value 4)

While cultural identity is currently robust with little significant external engagement other than church activity and schooling due to remoteness, villagers display a pragmatic attitude to the potential for Project related interference to archaeological and cultural heritage sites and acceleration of cultural change. Nonetheless, due to the scale of the Project and its potential transformative social effects, it is likely that the Project will impact cultural identity and tradition within the Miyan social sub-catchment. The intensity and duration of the Project, which facilitates changes of lifestyle across generations, may inhibit a return to traditional practices following mine closure, assuming there remains a desire to do so. The Project has limited capacity to manage processes of social change, particularly when such change is sought by communities themselves. The Project will seek to ensure that the cultural identity of the Miyan is duly recognised and respected through a workforce induction which includes cultural awareness briefings. The support of programs to sustain culture, including traditional subsistence practices (e.g., hunting and gardening), language protection and promotion, and the documentation of 'stories' and other features of culture will also be considered. Following the application of management measures the residual significance of the impact is assessed as being medium.

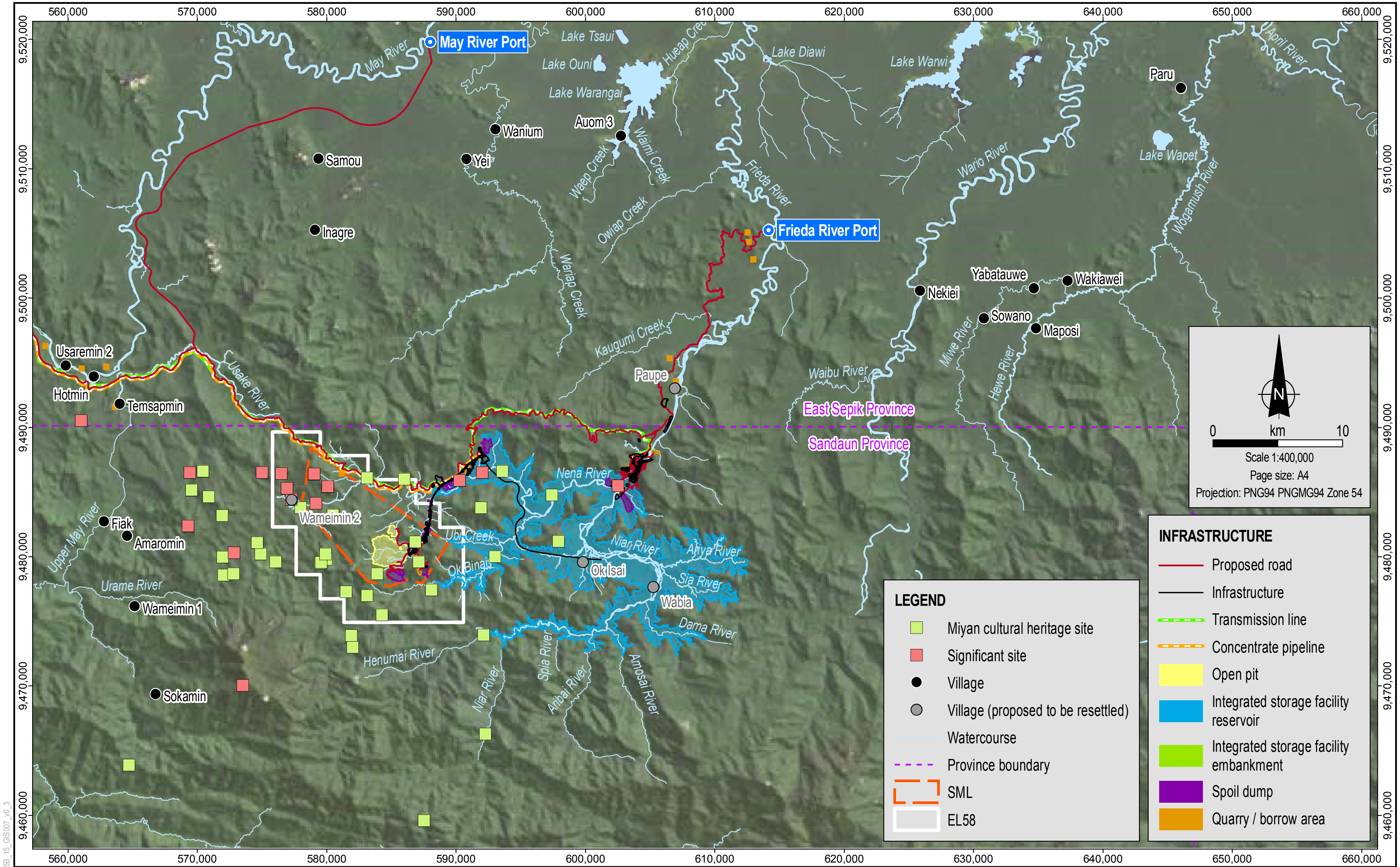
It is certain that the Project will indirectly influence the status of traditional leadership due to increased exposure to non-traditional forms of knowledge and lifestyles. Ensuing social change has the potential to alter current traditional leadership structures which can have adverse effects on community governance. Evidence from other mines in PNG indicates there is the potential for disagreements that may act to polarise groups in the community making it difficult to achieve consensus on the management of issues that affect the broader community (Jackson, 2012). The Project will seek to support a community leadership initiative to assist village leaders in managing the expectations of community members regarding village justice systems, traditional leadership and authority structures in interactions with villagers. With the application of such measures, adverse effects on the exercise of traditional leadership will have minor consequences and the residual impact is assessed as medium.

It is possible the rights of the Miyan to land and resource use may be placed under pressure because of in-migration to Amaromin and possibly the relocated Wameimin 2 villages, as well as by disruption to traditional leadership. In collaboration with government and landowners, the PIIMMS will be implemented to manage the impacts of population influx on Miyan social sub-catchment community. This will include measures to support landowner communities to maintain customary rights to land access and resource use. Nevertheless, an increase in population will have a moderate impact on Miyan social sub-catchment communities' ability to maintain customary rights and practices and the residual significance of the impact is assessed as medium.

Project disturbance will impact on Miyan cultural heritage sites and will need to be managed to ensure that significant cultural heritage sites are avoided or the disturbance of them is appropriately compensated. The Project Cultural Heritage Baseline and Impact Assessment study (Appendix 2) identified a total of 66 cultural heritage sites within the Miyan social sub-catchment (Figure 6.1), many of which combine to form composite site typologies at a single location. A Cultural Heritage Management Plan will be implemented during the construction phase to protect cultural heritage sites or ensure appropriate compensation. Therefore, it is unlikely that the Miyan people's ability to sustain their cultural identity will be impacted by Project disturbance to cultural heritage sites. The consequence of damaging or destroying a cultural heritage site is moderate, as the loss of physical sites connected to important stories may contribute to an erosion of cultural knowledge and sense of place. The residual significance of the impact is assessed as medium.

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

It is possible that the in-migration of people to the Miyan social sub-catchment will induce social tensions as conflicts develop because of increased social interaction, as has happened with other mining projects in PNG. The safety and security of residents may therefore be compromised. To manage this impact the Project will partner with government and non-government health service



Source:
Cultural heritage sites from ALA.
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown). Hillshade DEM from SRTM.

coffey
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File Name:	11575_15_F06.01_GIS

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Sepik Development Project

FRIEDA RIVER

Location of Miyan cultural heritage sites identified in Social Catchment 1A

Figure No: 6.1

providers to implement community health education and awareness programs, and support the legitimacy of community and government justice administration and conflict management initiatives, to sustain a stable and safe environment, particularly for women, children and those who are vulnerable. An increase in population may have a moderate consequence on the safety and security of residents in Miyan social sub-catchment villages. The residual significance of the impact is assessed as medium.

The entitlement to Project financial benefits is likely to impact on the stability of villages in the Miyan social sub-catchment as the negotiation of the distribution of rightful benefits potentially invokes division, inequality and conflict within and between communities. The Project proposes to address this situation through the provision of pre-employment training in literacy and numeracy for residents as far in advance of construction as possible and the implementation of measures to support the participation of women in training, employment and business development activities associated with the Project. FRL will also look to support benefit distribution agreements which encourage the adoption of a benefit stream sustainable wealth strategy which includes measures to provide for future generations, favours long-term investment over immediate consumption and supports vulnerable group members. The PIIMMS will include a leadership support initiative to assist clan leaders in managing expectations and the response to demands for access to Project benefit streams from their broader social networks. Following the application of such measures, issues associated with entitlement to benefits will have a minor consequence. The residual significance of the impact is assessed as medium.

It is possible that community members interacting with Project workers from other areas of PNG and beyond will experience higher levels of morbidity (potentially including STI and HIV infections) which will subsequently be spread to other members of the community. In response to this potential impact the Project will develop and implement community health education and awareness programs, and support the delivery of disease treatment and prevention services by third parties. Implementation of these measures will reduce the likelihood from likely to possible. The residual significance of the impact is assessed as medium.

Increased disposable income and the presence of outsiders can increase the general availability of drugs and alcohol and can lead to men taking more wives and prostitution. This can lead to decreased security for women and children and an increase in inter-personal violence. There may also be violence and other forms of inappropriate behaviour by Project workers or security personnel. In response, the Project will support community capacity to develop and sustain an environment conducive to the physical, spiritual and emotional well-being of its members, in particular women, children and those who are vulnerable, to reduce the impact to the social value. It is possible that the impact will occur in Miyan social sub-catchment villages, and the consequence of decreased security and increased violence is moderate. The residual significance of the impact is assessed as medium.

There are likely to be high levels of expectation in landowner communities such as the Miyan that Project development will lead to much improved service provision, particularly in health and education. Any delay or non-provision of these services will lead to community disappointment and tension, notwithstanding any poor performance by government or other service providers. The Project proposes to work in partnership with government and non-government health service providers to implement community health, education and awareness programs, and support the improvement of infrastructure. Following the application of such measures the issues associated with unrealised service delivery expectations will have a moderate consequence. The residual significance of the impact is assessed as medium.

Telefol social sub-catchment

The Telefol social sub-catchment, comprising Ok Isai and Wabia villages, is in the Niar River catchment. Because of the ISF, both villages will be required to relocate to an area mutually agreed through the resettlement planning process. This location is yet to be determined. While this process has commenced, the identification of location options for new villages is currently under discussion with both village communities. Options are expected to include sites on recognised Telefol land not requiring land acquisition, as well as a potential site on customary land of other landowning groups that will require Government acquisition to ensure security of tenure.

What is clear is that the reservoir will alienate most Telefol land and watercourses currently used for subsistence food production, alluvial gold mining, and transport access, with resettlement requiring a substantial program of livelihood restoration initiatives. Telefol are in the Zone 1 employment category, and participation in the mine and contractor workforces (following required training and skills acquisition) will constitute a major avenue for livelihoods in the future.

Flexibility in resettlement site planning should ensure that the resettled villages do not experience impaired amenity through noise, vibration or air emissions associated with Project construction and operation, while having access to an improved level of infrastructure such as road access, water supply and sanitation facilities. Alluvial gold mining areas in the upper reaches of the Niar River and Ok Binai are still expected be available to Telefol to support livelihood activity, assuming the Telefol choose to access these areas via land due to lack of access via the ISF.

It is expected that there will be some level of pressure to host Telefol in-migrants seeking access to benefits from the Project because both villages have strong cultural links to the Telefomin and Eliptaman areas, approximately 30 km to the south, and Ok Isai has experienced outside settlers in the past seeking employment or access to alluvial gold areas.

Livelihoods- The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

The Telefol will experience significant disruption to current subsistence livelihood activity (gardening, hunting and fishing) though it is acknowledged that there is a current high level of reliance on imported food due to the cash economy associated with alluvial gold mining. The restoration of subsistence livelihood activity, should it be desired, will be dependent on the suitability of new village sites and access to land with adequate land use capability at those sites. The importance placed on future subsistence livelihood activity (Social Value 1) will be dependent on the dominant form of livelihood activity pursued, which is likely to be mine wage employment for those capable. This indicates that close attention will need to be given to vulnerable villagers in the resettlement locations who will likely not be able to secure this employment and who may not receive income through royalty payments. Telefol land will remain available south of the ISF, though this may be harder to access for vulnerable households should the resettlement sites be located remote from that land. The likelihood of these impacts occurring is almost certain with moderate consequences indicating a high level of significance.

The ability to engage in alluvial gold production will likely be highly constrained should sites be distant from resettled villages and access across the ISF will be restricted for reasons of personal safety. The returns to labour from alluvial mining will also be compared to incomes able to be derived from mine wage employment, which will influence the level of engagement in this activity after construction of the mine begins. While the impact is almost certain, the consequences will be moderate due to the alternative income sources available, and compensation that will be paid for the alienation of the resource, indicating a high level of impact. There will be some potential for community resentment towards the Project due to the expected significant employment loss between construction and operational phases of the Project. While new village locations will have access to the road corridor to Vanimo, this is not expected to stimulate any cash crop agricultural production due to land availability and suitability constraints, and the inability to compete with mine-derived employment income.

There will be potential for positive impact from opportunities to derive income through business development and operation in the mine supply chain, as well as potential for investment of royalty flows in commercial activities elsewhere (such as in Vanimo).

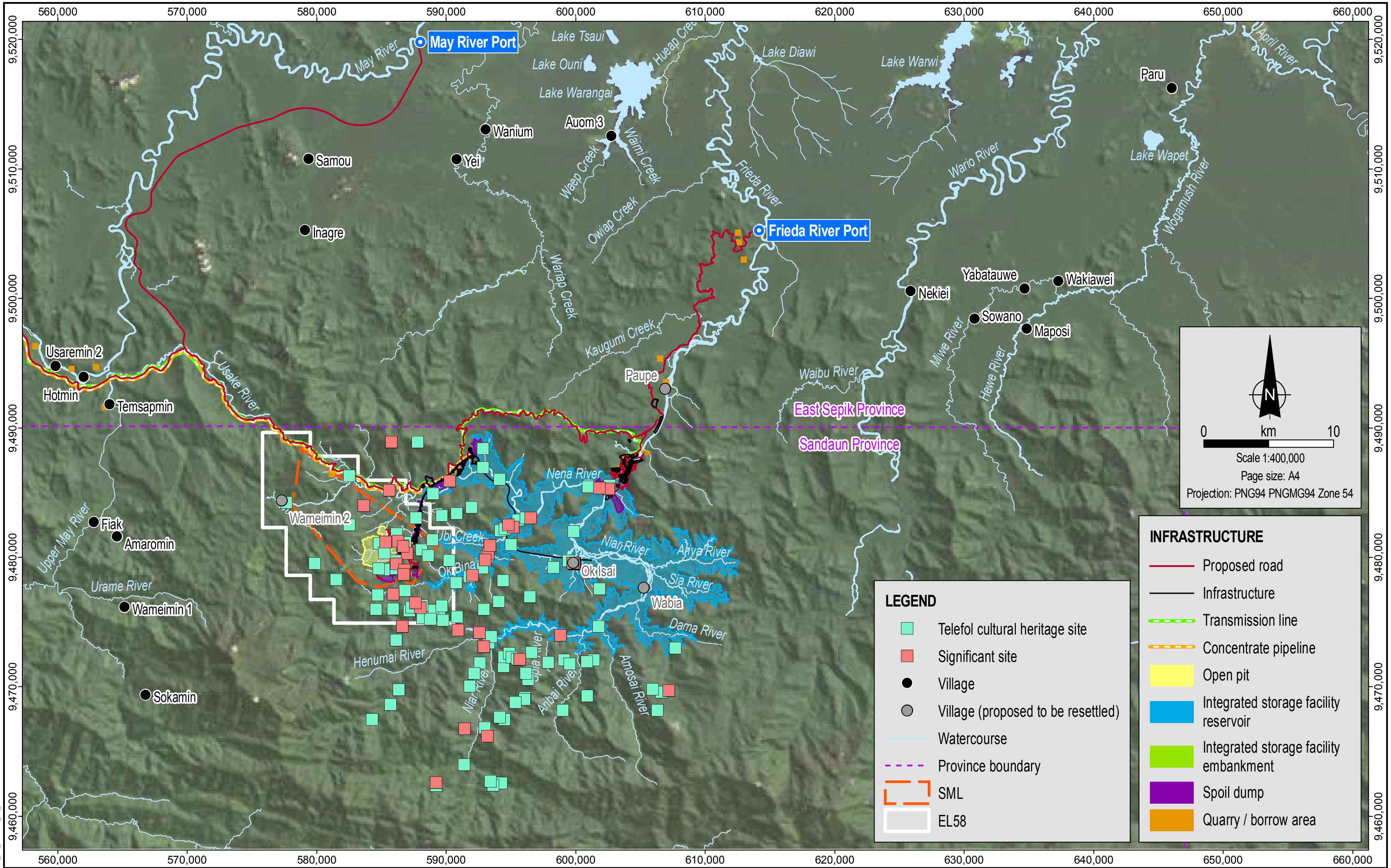
Culture- An enduring ability to sustain cultural identity and traditions (Social Value 3) and maintain customary rights to land access and resource use (Social Value 4)

It is possible that the Project will impact on cultural identity and traditional leadership within the Telefol social sub-catchment as the Telefol villages will need to be resettled, entailing land loss and significant changes to livelihood activity. There is a high level of cultural self-confidence amongst the Telefol, a reflection of which is seen in the pursuit of their rights to land in the Project area over more than 30 years. This, combined with an active alluvial gold industry and the relocation of villages to their current sites in the early 1990s to be closer to mine exploration and development activity, indicates that the Telefol have pursued economic opportunity and managed associated cultural change. As such cultural and traditional leadership may well evolve in different ways during the life of the Project.

However, a deeper immersion in the mainstream economy is likely to influence perspectives on identity, especially for the next generation of clan members. The Project will work with communities to develop and implement programs to respect and sustain language and culture. Despite these factors, the likely proximity of the Project to resettlement villages, the scale of the Project and the transformative effects which are likely to result, mean that there will be ongoing effects on cultural identity and sense of place through the life of the Project.

It is possible that social organisation and customary rights to land and resource use may be affected by in-migration (both to resettled villages, and to Telefol land not subject to inundation, though this is considered less likely). The Project, in collaboration with government and landowners, will seek to limit the movement of people on to customary lands through the development and implementation of an PIIMMS. The plan will include measures to protect customary rights to land such as lease boundary monitoring, and partnerships with respective landowners to police the incursion of migrants on to customary lands. An increase in population may affect Telefol social sub-catchment communities' use of land and associated resources in the immediate vicinity of the Project.

Project disturbance will impact on cultural heritage within the Telefol social sub-catchment, and will need to be managed to ensure that significant cultural heritage sites disturbed are appropriately compensated. The Project Cultural Heritage Baseline and Impact Assessment study (Appendix 2) identified a total of 142 cultural heritage sites within the Telefol social sub-catchment (Figure 6.2), with typical sites including spiritual (*masalai*), oral tradition and settlement sites. A Cultural Heritage Management Plan will be implemented during the construction phase to protect cultural heritage sites and ensure appropriate management, and compensation for sites that cannot be avoided. Therefore, it is not expected that the Telefol people's ability to sustain their cultural identity will be impacted by Project disturbance to cultural heritage sites. The loss of physical sites connected to important stories, through damage or destruction, may contribute to an erosion of cultural knowledge and sense of place. The residual significance of the impact is assessed as medium.



MXD Reference: 11575B_15_GIS008_v0_3

Source:
Cultural heritage sites from ALA.
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown). Hillshade DEM from SRTM.

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Location of Telefol cultural heritage sites identified in Social Catchment 1A

Figure No: 6.2

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

The potential for impairment of community well-being is highly dependent on the effectiveness of the resettlement planning and implementation process, and the success of the livelihood restoration support initiatives. This process aims to be highly participative and, to gain villager agreement on the resettlement site, will address security of tenure, and initiatives for the replacement of housing, infrastructure, service provision and livelihood restoration. While it is not expected that the resettlement villages will be subject to any environmental impacts from mine construction and operations, they will be provided with road access that will link to the public road from Hotmin to Vanimo. The maintenance of social cohesion (both within and across language groups) following resettlement will be important, as in times of community stress historical animosities have a tendency to surface and disrupt relations – notwithstanding the recent surfacing of apparent divisions between Ok Isai and Wabia which require further investigation to understand. Supported community development programs will focus on leadership, problem solving and conflict resolution, and will be implemented in partnership with non-government organisations, such as the Baptist Church, trusted by Telefol. The Project will provide support for community and government justice administration and seek to partner with government and non-government development agencies to sustain stable and safe living environments, particularly for women, children and those who are vulnerable.

Personal and community well-being will be influenced by the interactions which Telefol villagers have with neighbouring communities (potentially including in-migrants) and the Project workforce. There is the possibility for such interaction to result in an increase in the availability and consumption of alcohol (or drugs) or higher risk sexual behaviour which can result in social unrest and law and order issues along with negative health outcomes. The Project will support village justice systems and develop and implement a workforce code of conduct and induction process to guide workplace behaviour and respectful interaction with host communities. However there remains a possibility of such impacts occurring, the consequences of which are moderate. The residual significance of the impact is assessed as medium.

Disparities in income due to non-uniform participation in Project opportunities and the receipt of Project benefit entitlements may invoke division, inequality and conflict within and between communities, and potentially result in the use of force to resolve issues, which would impact on community safety within the resettled communities of Ok Isai and Wabia. The Project proposes to address this situation through the provision of pre-employment training in literacy and numeracy for residents as far in advance of construction as possible and the implementation of measures to support the participation of women in training, employment and business development activities associated with the Project.

Plans for service provision (including the sustainable financing of such service provision) will be developed in collaboration with the local level and provincial government during the resettlement planning process and considered for inclusion in agreements negotiated during the Development Forum process.

Paiyamo social sub-catchment

The Paiyamo social sub-catchment area is centred on Paupe village. Paupe is the closest village downstream of the ISF embankment (approximately 5 km), about 2 km downstream from the existing Frieda River airstrip. Paupe is also adjacent to the planned FRHEP access road. Hence, Paupe in its current location will be impacted by construction traffic for the duration of the construction period, and will host a construction camp close to the existing airport site. Construction activity associated with the mine and FRHEP upstream from Paupe will, at times, increase the turbidity and sediment load of the Frieda River, while road construction activity has the potential to interfere with natural springs that communities rely on for water.

In consultation undertaken as part of the SIA, residents from Paupe expressed a high level of concern for the aquatic environment, and expressed anxiety concerning the potential for river pollution should the structural integrity of the ISF embankment be compromised, or due to spillage of chemicals or fuels which are not contained during construction and operations, and which subsequently enter the Frieda River system. Due to these concerns, and the intense construction activity in proximity to the village, it was agreed that the village would be relocated, likely to a site in the upper Kaugumi Creek catchment.

Substantial potential in-migration pressure is still expected to occur in the relocated Paupe village due to its direct access to the Sepik River and Frieda River airstrip.

Livelihoods- The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

It is certain that resources currently available to the Paupe residents to support livelihoods (including forest in the Nena River valley and aquatic resources in the Frieda River) will be impacted directly by the construction and operation of the Project (FRHEP access road and embankment construction, road operations, airstrip construction and operations, and water quality impairment) and that this could reduce their capacity to support subsistence livelihoods. Fair and equitable compensation will be provided regarding Project-related impacts on subsistence resource use and an agricultural livelihood security program will be implemented if required. Following application of mitigation measures, and due to large areas of land available for subsistence purposes that will not be impacted, particularly in the Kaugumi Creek catchment near the proposed resettlement location, the consequence of losing available hunting land is moderate and the residual significance has been assessed as medium.

When flows from the ISF reservoir are regulated through the hydroelectric power facility for power generation, flows in the Frieda River will be highly modified compared to baseline flows. While average flow in the Frieda River will remain largely unchanged throughout the mine life, there will be much less variability in flow, though low flows will be much higher and high flows will be much lower compared to baseline flows. Residual impacts on freshwater ecology (and available freshwater resources) in the upper Frieda River during operations are assessed as minor. Impacts on aquatic ecology of the lower Frieda River during operations are assessed as negligible.

Aquatic resource use in the Frieda River is likely to be affected during construction prior to reservoir of the ISF for a period of 2 years (Year -4 to Year -2) as a result of TSS concentrations elevated above background concentrations. Flows during this period will not be affected substantially by Project activities.

Once the ISF is impounded in Year -2, TSS concentrations are predicted to reduce to comparable background concentrations and impacts on aquatic resources in the Frieda River are not expected. The villagers of Paupe have a moderate livelihood dependence on the Frieda River and are likely to still use it for resources following resettlement. Therefore, to assist in mitigation of potential impacts on subsistence production from aquatic resource use, fish stocks and local harvests will be monitored at select locations prior to construction, at regular intervals during construction, and six months post construction. An operational response will be developed if surveys indicate Project impairment of local harvest outside the predictions of the EIS and the Project's environment permit. Therefore, there is expected to be a medium level of impact on subsistence resource production during construction. During operations, impacts in the Frieda River on aquatic resources are not expected.

It is expected that a moderate to high level of in-migration may occur at the relocated Paupe village, with people likely to arrive from Auom 3 and Iniok and from nearby Sepik villagers who have used Paupe as a staging post when seeking exploration program employment in the past. Residents from further down on the Sepik River may also seek to relocate to Paupe in search of work, based on a perception that closeness to the Project may provide a higher likelihood of recruitment and access to other forms of economic opportunity. Such in-migration will likely place pressure on the availability of subsistence resources currently relied upon to support livelihoods. The Project will seek to collaborate with landowners and government to manage effects associated with in-migration through implementation of the PIIMMS, as well as restricting Project employees from engaging in hunting or forest harvest activities while on Project sites. The consequences for the availability of subsistence resources will be moderate and the residual significance of the impact is assessed as medium.

It is likely that the availability of business opportunities will attract experienced business operators from outside the Paiyamo social sub-catchment to establish operations in the area, either with the permission of landowners or in some form of partnership with them. The influx of entrepreneurs may serve to inhibit the ability of residents to capture available business opportunities and limit the development of local enterprises, assuming that they desire to engage in business when there is likely to be significant wage employment opportunities. The Project will establish a Business Development Office and commence the development and implementation of priority business development and support programs for landowners well in advance of Project construction. This will serve to reduce the likelihood of local vendors being outcompeted by outside interests from almost certain to likely. The residual significance of the impact is assessed as medium.

Culture- An enduring ability to sustain cultural identity and traditions (Social Value 3) and maintain customary rights to land access and resource use (Social Value 4)

As with all mine area villages, Paupe value their distinct culture but acknowledge the inevitability of on-going change that may accelerate with the advent of mine development. As a small group, leadership is generally cohesive though there is a high level of concern for the consequences of uncontrolled in-migration and an expressed need for law and order assistance to address management of the issue.

As per the Miyan and Telefol social sub-catchments, it is likely that Project development (and the related increased level of monetary wealth) will impact on cultural identity and traditional practices within Paupe. The Project will seek to support local cultures through the avoidance and protection of sites of cultural significance and look to implement programs to respect and sustain culture, including traditional subsistence practices (e.g., hunting and gardening), language protection and promotion, and documenting 'stories' and other aspects of culture, as identified by community representatives. However, a substantial degree of cultural change could be expected over the medium term.

It is likely that in-migration to Paupe will affect people's ability to maintain customary rights and practices relating to access to land and resources use. The Project will seek to minimise the movement of people on to customary lands through the development and implementation of an PIIMMS in collaboration with landowners and government. The plan will include measures to preserve the capacity of affected communities to maintain customary rights to land access and resource use, and to exclude migrants from the vacated former village site. In-migration will have moderate consequences on Paupe’s ability to maintain customary rights and practices and the residual significance of the impact is assessed as medium.

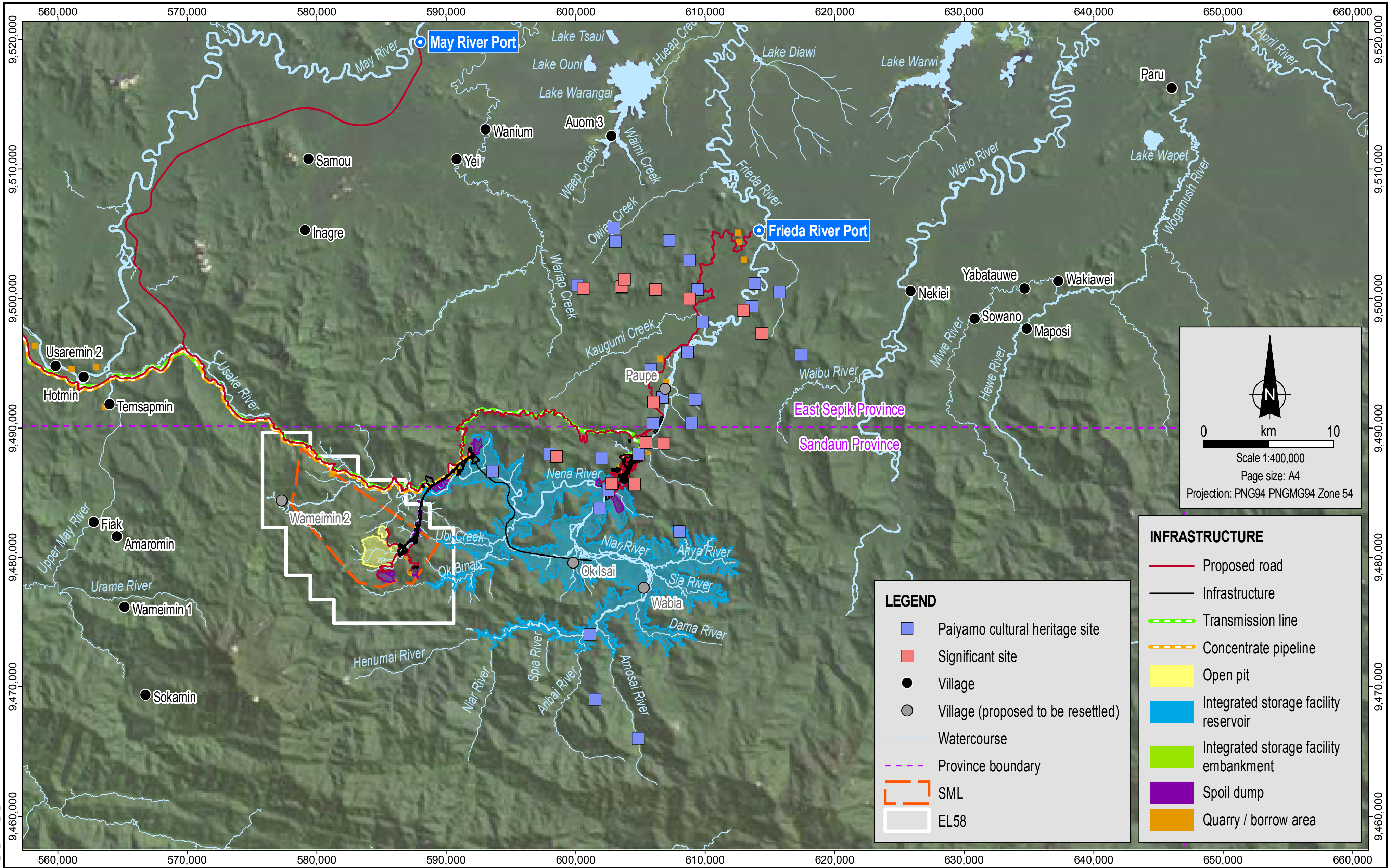
Project land disturbance will almost certainly impact on cultural heritage sites, and will need to be managed to ensure that significant cultural heritage sites are avoided, or the disturbance of them is appropriately compensated. The Project Cultural Heritage Baseline and Impact Assessment study (Appendix 2) identified a total of 43 cultural heritage sites within the Paiyamo social sub-catchment (Figure 6.3). For the Paiyamo, the most significant sites, and the ones that they do not wish to see disturbed, are indicated to be landforms associated with various *masalai* spirits (who regulate the Paiyamo world-order), ossuaries containing the bones of ancestors, and mountains that house the spirits of the dead. Therefore, higher priority will be given to the management of these site types. Cultural heritage pre-construction surveys will be undertaken to identify cultural heritage sites within vicinity of the FRHEP access road alignment and embankment location, and a Cultural Heritage Management Plan will be implemented during the construction phase to protect cultural heritage sites or ensure appropriate compensation. Therefore, it is not expected that the Paiyamo people’s ability to sustain their cultural identity will be impacted by Project disturbance to cultural heritage sites. The effects of damaging or destroying a cultural heritage site are material, as the loss of physical sites connected to important stories may contribute to an erosion of cultural knowledge and sense of place. The residual significance of the impact is assessed as medium.

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

The Project will expose people at the resettled Paupe location to increased mine-related contaminant metals should they continue to use the Frieda River for fishing and swimming, which would be expected. However, the HIA indicates that this will not pose a human health risk.

As with other mine area villages, personal and community well-being will be influenced by interactions with the Project workforce, the manner in which high levels of personal income are used and the behaviour that accompanies that use. To manage these impacts, the Project will develop and implement (commencing with workforce induction training) a workforce code of conduct to guide workplace behaviour and respectful interaction with host communities. It will also partner with government and non-government health service providers to implement community health education and awareness programs, and support the legitimacy of community and government justice administration and conflict management initiatives. Following the implementation of such measures the residual significance of the impact is assessed as medium.

Disparities in income due to non-uniform participation in Project opportunities and the receipt of Project benefit entitlements may invoke division, inequality and conflict within and between communities, and potentially result in the use of force to resolve issues, which would impact on community safety within Paupe. The Project proposes to address this situation through the provision of pre-employment training in literacy and numeracy for residents as far in advance of construction as possible and the implementation of measures to support the participation of women in training, employment and business development activities associated with the Project. In addition, the Project seeks to partner with government and non-government development agencies in supporting community capacity and well-being, for women, children and those who are vulnerable. These measures will reduce the consequence to community health and safety to minor. The residual significance of the impact is assessed as medium.



Source:
Cultural heritage sites from ALA.
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Villages, topographic features, watercourses and water bodies from FRL and Coffey.
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Landsat satellite imagery from FRL (capture date unknown). Hillshade DEM from SRTM.

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Sepik Development Project

FRIEDA RIVER

Location of Paiyamo cultural heritage sites identified in Social Catchment 1A

Figure No: 6.3

MXD Reference: 11575B_15_GIS009_v0_3

People within Paupe have significant concerns regarding Project effects on the environment and particularly on water quality. These concerns are almost certain to persist despite EIS technical studies indicating that water will remain safe to drink and fish will remain safe to eat. Communities will be briefed on the predicted Project impacts on the downstream environment; however, due to their location with respect to the mine area it is still possible that there will be community anxiety regarding the environmental integrity of waterways, including the structural integrity and safety of the ISF and the potential for increased sediment loads and introduction of contaminants. While relocation to the upper Kaugumi Creek catchment may help to address concerns relating to the structural integrity of the ISF, the Project is committed to maintaining an active presence in Paupe to address concerns about the environmental integrity of the waterways. While the heightened level of community anxiety is likely to dissipate over time, it may nevertheless remain at a low level during operations and post-closure.

The interaction of local populations with vehicles driving along the FRHEP and mine access roads may pose a safety risk for people who reside in Paupe, notwithstanding the location of the resettled village. People crossing and walking along roads will be vulnerable, and it is possible that accidents may occur considering the volume of traffic during construction coupled with the unfamiliarity of residents with road transport. The Project will develop and implement driver education, community risk awareness, operational protocols, and appropriate physical safety measures (including vehicle-pedestrian separation and visual/audible warnings) where required to reduce the likelihood of occurrence. Vehicle collisions with pedestrians have the potential to cause serious injury and fatalities. Therefore, the consequence of an increase in accident trauma is critical and the residual significance of the impact is assessed as high, indicating the requirement for on-going attention to traffic safety awareness during operations.

Overview – Social Catchment 1A

Of the three social sub-catchments which constitute Social Catchment 1A: Mine Area, the assessment has identified that the Telefol social sub-catchment will experience the highest level of impact (due to inundation of the Ok Isai and Wabia villages by the FRHEP and their necessary relocation), followed by the Paiyamo social sub-catchment due to the proximity of construction activity and the need for resettlement.

Across all three social sub-catchments the primary causes of social change attributable to the Project relate to the disturbance of resources used to support subsistence livelihoods, the social effects associated with access to cash incomes and the transition to a cash based economy, the re-establishment of livelihoods following resettlement, and impacts caused by in-migration. Across Social Catchment 1A, the greatest loss of resources used for subsistence purposes will occur in the Telefol social sub-catchment due to land inundation, and the Paiyamo social sub-catchment, particularly with respect to potential effects on water quality throughout construction due to its location downstream from the mine area, noting that the findings of the health impact assessment (Appendix 4) predicts that the Project will not increase the risk of impacts to human health.

The Paiyamo social sub-catchment is also predicted to encounter substantial in-migratory pressure due to Paupe's location close to Project infrastructure and physical accessibility. In addition to these factors Paupe residents may also experience impacts associated with Project traffic and transport activity should they engage in activity in proximity to the FRHEP and mine access roads and Frieda River Port. The combination of impacts predicted to occur across all Social Catchment 1A communities, and particularly in the Telefol and Paiyamo social sub-catchments due to village resettlement, will place significant pressures on social values which will require the effective implementation of proposed mitigation measures, along with external support and partnerships, to ensure effective management.

6.2.2 Social Catchment 1B: New infrastructure and road corridor, Hotmin to Green River

The following sections describe the key impacts identified for the new infrastructure and road corridor social sub-catchments and the assessment of residual impact significance.

Social Catchment 1B encompasses part of the proposed public road corridor extending from Hotmin to Green River, approximately 90 km. From Hotmin the corridor tracks in a northwesterly direction following the valley of the Right May River in the East Sepik Province for approximately 40 km through customary land belonging to clans from the Miyan and Bo language groups.

Subsistence practices play a significant role in the livelihoods of households within the catchment. There is currently sufficient access to resources to provide for a subsistence lifestyle throughout the catchment with a variety of produce grown and animals hunted. Opportunities for formal employment and participation in the cash economy are limited; however, Hotmin, and to a lesser extent Temsapin and Uramesin 2, have access to markets for the sale of surplus subsistence production.

Culture in the catchment has been undergoing a process of slow change since initial contact in the 1940s by the Australian colonial administration (Gardner 1996b). Culture is very much underpinned by traditional rights to land access and resource use and there has been no large-scale land alienation for uses such as cash cropping or logging, or use of waterways for commercial purposes.

The communities within Catchment 1B generally experience a safe and secure social environment, largely due to the remoteness of the villages. The current physical and social environment ensures family safety and security, however it is an obstacle when accessing health facilities. Communities in general do not receive regular services supportive of personal health, safety and security due to the limited public infrastructure.

The new road from Green River to Hotmin will be at least 7.5 m wide with a gravel pavement surface, built to allow for 12-tonne axle loading. The road will allow for public transport, commercial ventures and access to new markets. A new bridge will be built on the Hotmin Road at the Sepik River where there will be a cross-river ferry service during bridge construction.

Livelihoods- The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

There will be a continuing dependence on subsistence livelihoods in the social catchment until cash incomes improve significantly. Securing work in infrastructure or mine construction may limit labour participation in subsistence production, though this is likely to be in place for a limited period due to the relatively short-term nature of construction activity. Improved access may also support labour migration to urban centres as it may make more frequent return journeys feasible.

In general, full access to subsistence resources will be maintained along the road corridor as the alienated land will be a very small percentage of that available. There may be minor environmental impairment due to construction impacts (e.g., temporarily elevated sediment loads in streams), and the potential for modified hydrology where the road corridor traverses back swamp areas. These impacts are predictable and there are standard construction design and environmental management measures that will be employed.

Improved access to the catchment via the public road may stimulate further logging or industrial-scale agriculture, such as oil palm plantations, which will remove land from subsistence production while generating some employment. It is noted that logging operations are already occurring on the south side of the Sepik River, and that the Idam-Siawi Integrated Agro-forestry Development Project is under development (a proposed extensive Forest Management Area to the west of the road alignment, between Idam, Green River and the Indonesian border). Should these projects proceed, effective impact management will require collaboration between parties to the developments and effective regulation by government agencies. The cumulative socio-economic impacts of the Project and the Idam-Siawi Agroforestry Development Project are further described in Chapter 10 of the EIS.

While there will be potential for in-migration along the road corridor, effects are more likely to be felt in areas closer to population centres, such as at Green River (where development as a Level 2 Growth Centre is Sandaun Provincial Government policy) or Hotmin. This may create opportunities for the sale of surplus subsistence crops in these locations. Public road access to larger population centres may also provide an opportunity for the planting of cash crops or the commercial exploitation of fish or other aquatic products. The level of alluvial gold production may also increase if the road supports easier access to inputs such as fuel and rations for labour.

Culture- An enduring ability to sustain cultural identity and traditions (Social Value 3) and maintain customary rights to land access and resource use (Social Value 4)

Development of the public road will provide improved connection to population centres that may stimulate population movement and interactions with different cultural groups. Eventually this may lead to longer-term relationships (including marriage) that will act to alter cultural identity. While this may be considered an impact, it is also an outcome of national development that is likely to continue. The presence of the Project in Sandaun Province may act to accelerate this form of change that has been limited to date due to remoteness and lack of access infrastructure. While these changes are likely, the consequences are expected to be moderate resulting in a medium impact significance. Communities in the catchment will also have access to support from the Project for community development initiatives, some of which may aim to celebrate cultural identity and traditions.

In-migration along the road corridor may result in some land appropriation in selected areas (principally near population centres or known alluvial gold areas) which may act to erode customary rights in those areas. The consequences of this action may be moderate and confined to those areas. The PIIMMS will have measures to limit in-migration and manage consequences, including supporting the development of regional service centres, and supporting the capacity of local level governments to establish by-laws to regulate the use of customary land. This could be expected to result in a residual significance of medium.

With improved access, there could be increased pressure for the acquisition of land for plantation production (like Idam-Siawi Integrated Agro-forestry Development Project) which may restrict access to land if it has been alienated through lease arrangement. The consequences would at least be moderate, but would depend on the purpose for which the land was sought. Observations of the fate of other logged land in the province may influence landowners to lean toward protection of their land, however if the need for cash was not satisfied the incentive to lease may be dominant. The securing of mine employment by landowners along the road corridor may potentially act to mitigate the pressure to lease, however the residual significance of the impact remains medium.

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

Development enabled by improved road access and reticulated power (employment, production for sale, cash crop production) is expected to lead to improved household income levels, a portion of which may be allocated to the improvement of housing (such as corrugated iron roofing and water tanks). Improved access and power may also facilitate the establishment of commercial trade stores, and more reliable access to government services because of lower service costs.

There may be some loss of amenity experienced by villages near the road during construction and operations due to dust and noise, though this is expected to be moderate. Safety risks resulting from the interaction of residents and traffic are certain (as villagers will use the road as a pedestrian walkway) with the potential for loss of life in a serious vehicle-pedestrian incident, resulting in a risk significance of high. This risk is capable of being managed through implementation of traffic management and safety plans, drawing on the experience of other major infrastructure and resource projects in PNG, however even with effective plan implementation the residual significance of the impact remains high due to the potential for fatalities.

The presence of a construction workforce for the infrastructure corridor may possibly lead to potential health and security risks, which, in the absence of effective management, would be of medium significance. There are a range of management measures which will be included in a construction social management plan, including careful camp location (sufficiently distant from a village to minimise impact but not exclude villager employment), and camp and employment codes of practice to manage employee behaviour. These reduce the likelihood to possible with a resulting medium level of residual impact significance. Depending on camp location, there may also be opportunities for local food supply to camps, though this would be short-term in duration and of limited scale due to the rate of construction and the regular relocation of work camps along the infrastructure corridor.

Improved access may also support the more effective provision and maintenance of public infrastructure, as well as improve the attendance and retention of service provider staff (such as teachers, aid post orderlies and police officers).

6.2.3 Social Catchment 1C: Existing infrastructure corridor, Green River to Vanimo

The infrastructure and road corridor social catchment consists of Green River and villages located in proximity to the existing public road between Vanimo and Green River (including Aminii, Kwomtari, Itomi, Kilifas, Sumunini and Imbrinis). Land use in the northern portion of the catchment is currently dominated by logging and oil palm plantations, which use and maintain the existing road. Villages in the south of the catchment are largely isolated and are located along the existing road corridor at intervals of approximately 10 to 20 km. In the past there have been attempts to establish commercial agricultural production (such as rubber) however those projects are now largely dormant.

Opportunities to support a subsistence lifestyle are strong given favourable seasonal conditions, however some areas are vulnerable to unfavourable environmental conditions such as flooding and pressure from the impacts of logging and oil palm operations. Proximity to Vanimo and employment with logging and oil palm operations provide greater opportunities for participation in the cash economy than within Catchment 1B, however opportunities are still limited. Increased exposure to the cash economy in some circumstances has seen a rise in substance abuse and law and order issues.

There is limited public infrastructure and access to services supportive of personal health, safety and security.

The infrastructure corridor will be subject to more frequent vehicle movements during construction and operation of the FRCGP and FRHEP. On completion of construction, the infrastructure corridor (40 m in width) will include the upgraded road (a 7.5-m wide all-weather gravelled road), a buried concentrate transport pipeline and the SPGP transmission lines. There will be five major river crossings required along the regional road. This includes one crossing over the Sepik River and four major bridges longer than 100 m in length across other regional rivers. In addition, 16 minor bridges will be required to cross small creeks. Construction activity will likely include in-river work such as the: driving of piles and construction of bridge abutments; clearing of vegetation in the corridor and pipe laydown areas; quarrying and transport of road making material; road construction including the placement, shaping and compaction of pavement material; pipeline trench excavation, pipe transport, welding, testing, lowering and trench backfilling. There will be a number of construction camps (estimated at up to 200-person capacity) established to support this activity.

The existing airstrip at Green River will be upgraded to an international standard that will cater for larger aircraft (up to Lockheed C-130) and made open for commercial domestic use. New facilities will include a terminal, baggage and freight handling facilities and storage.

While Green River is designated a Level-2 Growth Centre under the Sandaun Province Growth Centre Strategy (Vanimo being Level 1), the existence of an approved and funded investment plan has not been determined. It could be expected that the provincial government will take the opportunity to leverage off Project investment in infrastructure to progress the development of Green River.

The following summary sets out the key Project-induced causes of social change and the associated impacts on social values within Social Catchment 1C.

Livelihoods- The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

The viability of subsistence livelihoods in the catchment has already been adversely affected by the impacts of logging and oil palm plantation establishment. While the construction of the road, pipeline and transmission line may impose some impairment to the existing environment (e.g., water course impacts and land clearing for quarries), this is expected to be relatively limited and short-term, having a low significance, and amenable to control using standard construction environmental management techniques.

It is possible that the improved access provided by the road upgrade may enhance the viability of existing broad scale land use (oil palm) and former land uses (such as rubber near Green River) leading to the conversion of more land to cash cropping. In-migration may also increase population density in key areas, such as Green River (a Level 2 Growth Centre in the Sandaun Province Growth Centre Strategy, and the availability of employment through commercial development may further draw some residents away from subsistence production towards dependence on store-bought foods. The upgraded road should result in lower vehicle operating costs and a higher level of reliability than the existing road to Green River. In turn, this should promote the entrance of more transport service providers with competition leading to lower costs for local users. This should facilitate an expansion in the marketing of subsistence surplus in both Green River and Vanimo (and possibly the mine area) as a viable income-generating activity. The ease of access to Vanimo and the mine area should also support job opportunities for residents of the corridor.

While improved access should enable more economic activity in the catchment, limited access to investment funds by locals may still inhibit local-led development creating opportunities for external investment, particularly in trading ventures that repatriate profits out of the local area.

Culture - An enduring ability to sustain cultural identity and traditions (Social Value 3) and maintain customary rights to land access and resource use (Social Value 4)

The population within the catchment has been subject to significant lifestyle change over the past decades including change due to the presence of large-scale logging operations with follow-up planting of oil palm plantations. This has exposed the population to outside cultural influences to a significantly greater extent than what has occurred in Social Catchment 1B.

While it is possible for disturbance of cultural heritage through the establishment of quarries to source road construction material, the implementation of a cultural heritage management plan requiring pre-clearance surveys should make disturbance unlikely, however with a significance level unchanged at medium as the consequences of disturbance will still be moderate. The potential for disturbance to cultural heritage sites is significantly lower when compared to Social Catchment 1B as the road will largely be upgraded along the existing alignment.

Improved access will stimulate in-migration, particularly to the Green River area. This in-migration is envisaged and supported by the government, as Green River is designated a Level-2 Growth Centre under the Sandaun Province Growth Centre Strategy (Vanimo being Level 1). This could lead to additional land requirements at the station, however this would be subject to negotiation with customary owners who are generally supportive of development in the area to restore and upgrade infrastructure and to provide commercial business opportunities. While it is possible that this development could impair customary rights to land, the residual impact significance is low.

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

Amenity in villages in proximity to the upgraded road has the potential to be degraded through increased traffic-generated noise and dust, as well as elevating the risk to pedestrians using the road as a walkway. The likelihood off accident trauma is possible and the consequences are critical (as there is the potential for life-threatening injuries), resulting in a high significance. However, there are well-proven measures to reduce the risk likelihood including the incorporation of safety features in road and bridge design (such as routing the alignment around rather than through villages, installing pedestrian walkways separated from the road carriageway, and pavement sealing where the road goes through a village to reduce the possibility of dust nuisance), and incorporating traffic management measures for Project vehicles such as restricting travel at night and limiting vehicle speeds (which will be monitored through the use of GPS tracking). Accident trauma following the application of management measures will be unlikely, with the consequence remaining at critical due to the possibility of serious injury, resulting in a residual impact significance of the impact of high.

In general, upgraded road access should support improved levels of service delivery for government-provided services in health, education and policing, though in-migration to Green River may require the expansion of these services and their enabling infrastructure to cope with a higher level of demand. The Project will work with the Sandaun Provincial Government to assess needs and consider the need for support through the community development program.

As with Catchment 1B, the presence of a construction workforce may lead to potential health and security risks, which in the absence of effective management would be of medium significance. Similar management measures to Catchment 1B would be included in a construction social management plan, including careful camp location, and camp and employment codes of practice to manage employee behaviour. These can lower the likelihood to possible with a resulting medium level of risk significance. Depending on camp location, there may also be opportunities for local food supply to camps, though this would be short-term and of limited scale due to the rate of construction and the regular relocation of work camps along the road corridor.

6.2.4 Social Catchment 1D: Vanimo Ocean Port

The Vanimo Ocean Port catchment includes Vanimo and the adjacent settlements of Wesdeco and Cis Point. The Port of Vanimo is currently used for commercial activities, primarily round log and sawn timber export. The port will be upgraded as part of the SIP to include two new berths to support the FRCGP and other port users. Once complete, the port will also include warehouse facilities, FRCGP facilities (concentrate filter plant, container laydown, fuel storage and administration buildings), facilities for existing operators and support equipment such as mobile cranes, forklifts and other port-related equipment. The treated filtrate from the concentrate filter plant will be released to Dakriro Bay, and there will potentially be emissions from the FRCGP facilities including diesel power plant exhaust during construction, dust and noise.

Livelihoods for residents of Cis Point and Wesdeco are primarily based on paid employment in the Vanimo area, with fishing, reef gleaning and minor agriculture (kitchen gardens) being subsidiary activities that support viable livelihoods. While Vanimo is primarily a government and private sector service centre with a reasonably well-developed store precinct and cross border trade with Jayapura in Indonesian Papua, tourism based on surfing, and the associated provision of accommodation for this purpose at Lido, is a niche industry activity for which Vanimo is becoming increasingly well-known. Vanimo also hosts a timber processing sector and is the base for a detachment of the PNG Defence Force responsible for border patrolling.

Commercial fishing in the Vanimo area is limited due to natural constraints such as the lack of reef areas and adverse sea conditions. Fish for sale in the small harbour side market are generally caught in areas further east, closer to Aitape. Pressure on customary land has increased over the years with in-migration and development, however the Provincial Government, through the Provincial Physical Planning Board, has developed a draft Vanimo City Urban Development Plan (the first in PNG) that sets out proposed town boundary extensions required by 2066, together with structure and zoning plans, to support the orderly development of the town. The potential for growth in Vanimo is moderate, and will be strengthened with the development of the Vanimo Ocean Port to support the FRCGP, the provision of power through the SPGP that may stimulate industrial growth in the Vanimo-Jayapura border corridor, and infrastructure improvements such as the Asian Development Bank-financed airport runway extension to support higher passenger capacity jet aircraft operations.

Livelihoods- The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

Impacts on resource use from the construction and operations of the Vanimo Ocean Port will largely be confined to the area immediately surrounding the port development site which is contained within the existing port boundary (Figure 6.4). There will be some alteration of the nearshore marine environment arising from a small area required for reclamation, as well as noise impacts from construction due to pile driving and new berth construction activity. Construction will also impair the amenity of the town area through increased vehicular traffic and the installation of the concentrate pipeline, which is expected to be installed under the western end of the airport by horizontal directional drilling. These impacts will be managed through a construction environmental management plan (which includes a traffic management plan). However, the residual risk significance will remain at medium. During operations excess filtrate water from the concentrate thickener will be reused for washdown with the excess being mechanically treated to remove solids prior to discharge to the marine environment. Hydrodynamic modelling indicates that PNG ambient marine water quality guidelines will be met (under conservative conditions) at about 10 m from the discharge location.

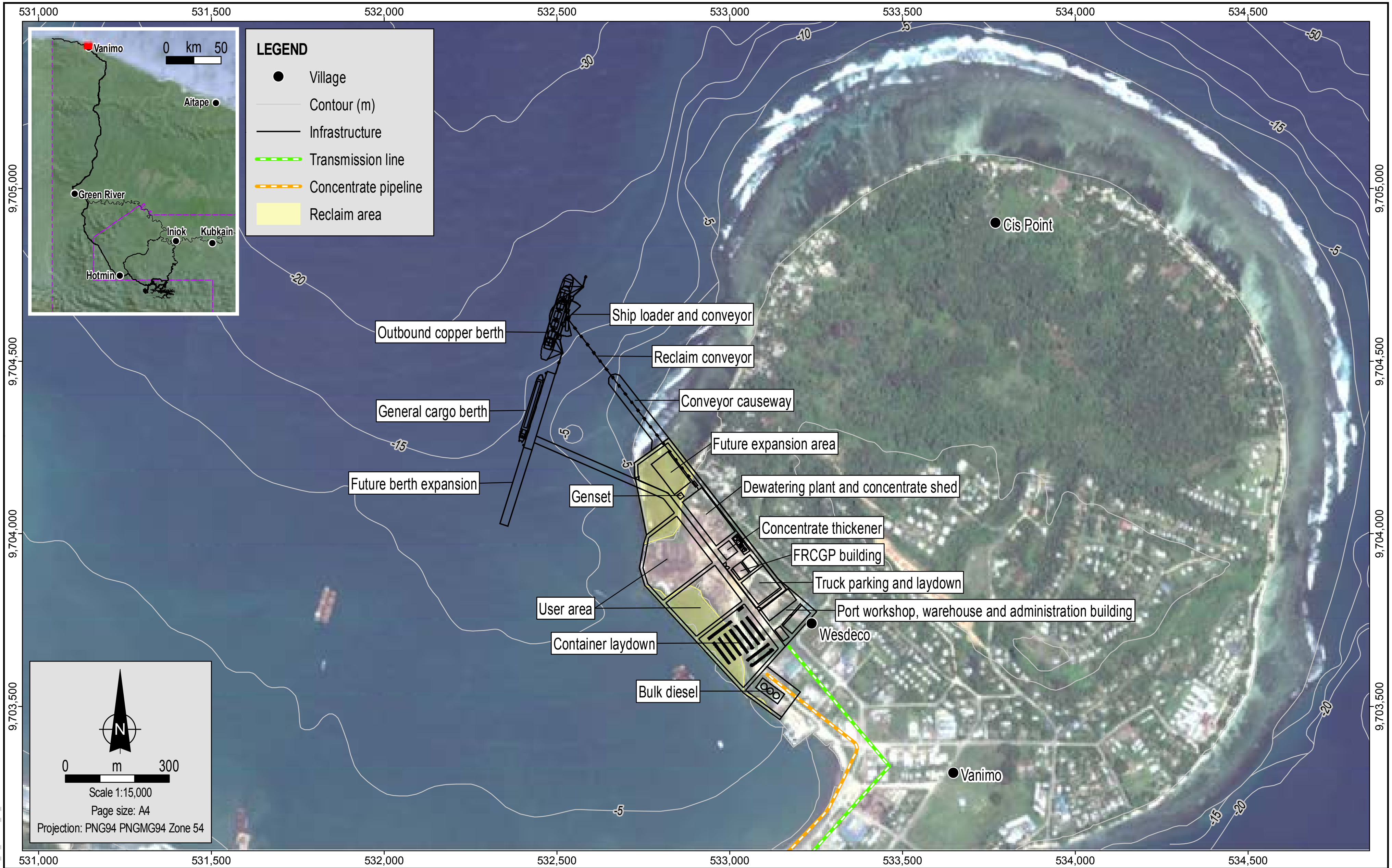
Construction of the port facilities will present opportunities for employment and skill development for Vanimo residents and landowners of the port area. There will also be a limited number of employment opportunities during port operations. However, there is expected to be a higher level of commercial activity supporting the FRCGP (and other industry sectors that may expand with access to improved infrastructure), with concomitant increase in employment levels above those currently available. In-migration to Vanimo is highly likely and is expected to be generally positive in its effects, which will focus on commercial opportunities for the provision of goods and services. This in-migration is envisaged and supported by the government, as Vanimo is designated a Level 1 Growth Centre under the Sandaun Province Growth Centre Strategy.

Culture- An enduring ability to sustain cultural identity and traditions (Social Value 3) and maintain customary rights to land access and resource use (Social Value 4)

Vanimo has developed as a culturally-mixed urban centre over many years. While there is still recognition of the original customary owners, the social fabric of the town is firmly characterised as modern, culturally-diverse Papua New Guinean, with an observable Indonesian influence. The development of a 50-year town plan provides a degree of certainty for customary owners to deal with town expansion land requirements, and to manage the potential for in-migrants to occupy land without authorisation. Furthermore, the Port of Vanimo is located with an area zoned as a future international port. Close consultation with customary owners of land near the proposed Vanimo Ocean Port area about port development plans, and potential opportunities for benefit, will be undertaken to avoid misunderstandings and consequent grievances.

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

As indicated earlier, the construction of the Vanimo Ocean Port and operation of the concentrate export facility has a likely potential to impair the amenity of adjacent settlements (Wesdeco and Cis Point) through the imposition of noise, light and vehicular traffic at nuisance levels, fugitive dust and altering the character of the existing surrounding environment and visual outlook from one of peri-urban village to one of industrial precinct (Plate 6.1). The consequences of this change will be moderate, with a risk significance of medium. Mitigation measures will need to receive careful consideration at the design phase (sound attenuation at the source, low-impact lighting, dust filters on concentrate storage shed exhausts etc.), and include close consultation at that stage with the communities so that what is possible (and what is not), and what the outcomes are likely to be, is well-understood. The outcome of the successful implementation of mitigation measures may reduce the consequences to minor, with the resultant impact significance remaining at medium.



MXD Reference: 11575B_15_GIS010_v0_3

Source:
Transmission line and concentrate pipeline from FRL.
Port layout and reclaim areas from GHD.
Villages from FRL and Coffey.
Contours from BMT WBM.
Imagery from Google Earth (DigitalGlobe captured 14 December 2014).

coffey
A TETRA TECH COMPANY

Date: 23.08.2018
Project: 754-ENAUABTF11575B
File Name: 11575_15_F06.04_GIS

Frieda River Limited
Sepik Development Project

FRIEDA RIVER

Vanimo Ocean Port

Figure No: 6.4

Plate 6.1
Visual photomontage of Vanimo Port

6.2.5 Social Catchment 2: Sepik River corridor

The Sepik River corridor social catchment includes villages between Auom 3 and the Sepik River mouth. Prior to the public road being constructed, the Sepik and Frieda rivers will be used during construction to barge equipment and materials to the river ports. This may include transport of large heavy loads to the mine. Barge movements along the Sepik and Frieda rivers will be approximately one every 24 hours. The public road, once constructed, will be to the primary route for the transport of equipment and goods during construction and operations. The Frieda River Port and Sepik and Frieda rivers will also be used during operations to transport freight to the FRCGP and FRHEP in the event that access along the road route is restricted.

The Frieda River Port will be established near the confluence of Owiap Creek and the Frieda River, approximately mid-way between Iniok and Paupe and 10 km east of Auom 3. It will comprise an unloading facility and material laydown area, office facilities, security facility with associated truck and barge movements.

Following is a summary of the key Project-induced causes of social change and the associated impacts on social values within Social Catchment 2.

Livelihoods- The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

Between the Frieda River Port and the Sepik River mouth, riverside communities will experience barge movements during construction of the FRHEP and FRCGP until the upgrade of the Vanimo to Green River Road is complete. Occasional barge movements may also be experienced during operations in the event that road access is restricted.

The residents of the Sepik River corridor are highly dependent on the river for subsistence, income, recreation and cultural activity. Communities along the Sepik River reported fishing on a nearly daily basis and consuming fish almost daily.

Some villages in Catchment 2 may experience highly localised and short term disruption to fishing associated with barge movements during construction. Fishing activity in the Frieda River has the potential to be disturbed during construction (in advance of the public road being constructed) by barge movements as fish nets may not be able to be set when barges are passing through, or they could be damaged or destroyed by passing barges if not removed beforehand. Barge movements along the Sepik River are unlikely to impact fishing as fishing is predominantly undertaken in off-river water bodies and not in the Sepik River main channel.

There are large numbers of both freshwater and saltwater crocodiles within the Sepik River corridor, particularly from Kubkain to the mouth, and the crocodile industry is important for Sepik River communities (Appendix 1). The numbers of wild crocodiles are not expected to be impacted by the Project, and crocodile farming is also not expected to be impacted as breeding activities and harvesting of crocodile eggs, juveniles and adults typically occurs in off-river waterbodies, which modelling predicts will not be impacted by the Project (EIS Appendix 5).

There was previously a crocodile farm at Auom 3 which is no longer operating, presumably due to it being financially unviable. Crocodile farms within villages along the Sepik River, if present during construction of the FRHEP and FRCGP, are unlikely to be impacted by barge vessel wash due the slow speed of Project barges and the small wave produced, similar to existing logging barges that transit on the river. Barge movements along the Sepik River will be limited to three years during construction and are unlikely to affect crops and sago production along the river banks.

Sepik River corridor villages have expressed a high level of concern for the aquatic environment as they have a close affinity with the health of the river, which is vital to their well-being. Communities have expressed concern over the potential for river pollution should the structural integrity of the ISF embankment be compromised, or should there be spillage of chemicals or fuels which are not contained during construction and operations, and which subsequently enter the river systems.

The Project will implement barge vessel operation management measures to ensure safe handling and transport of equipment and materials during construction. Water monitoring will be conducted at various locations along the barging transport corridor, as outlined in the Project EMMPs, including the regular testing of discharges associated with the Project and implementation of remedial actions if required. As the aquatic ecology of the Sepik River will not be impacted, village reliance on resource use along the river for livelihood purposes will not be impaired.

To monitor impacts on subsistence production from barge movements, fish stocks and local harvest will be monitored at select locations prior to construction, at regular intervals during construction, and six months post construction. An operational response will be developed in the event that surveys indicate Project impairment of local harvest outside the predictions of the EIS and determined compensation agreements. The consequences of barge movements impacting livelihood activity along the Sepik River are moderate, as the village of Iniok has a very high level of dependence on aquatic resources (in particular sago and fish) for subsistence. The residual significance of the impact is assessed as low.

Culture- An enduring ability to sustain cultural identity and traditions (Social Value 3) and maintain customary rights to land access and resource use (Social Value 4)

Barge movements along the Frieda and Sepik rivers may temporarily interfere with traditional uses of the rivers during the seven year implementation period. This is not expected to have any impact on Social Values 3 or 4.

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

Communities throughout the Sepik River corridor have a close affinity with the health of the Sepik River, which is vital to their well-being. The river is used as a primary water source by many of the villages along its length despite the fact that women surveyed (at Iniok) recognised consumption of water from the Sepik River as being a significant source of sickness and infection in their children.

Construction of the Frieda River Port and barge movements along the Sepik and Frieda rivers have the potential to create a minor disturbance to amenity of households in villages or hamlets located in close proximity to the proposed port and/or along the banks of these rivers, such as at Iniok.

There is a risk that the wash effect of barges travelling along the Sepik River could lead to minor flooding in houses built in proximity to the banks. During periods of flooding, the water level along the river rises close to the underside of the flooring of houses. During such periods the wash caused by Project vessels could result in instances where lower-level houses become inundated. This would reduce the amenity of housing and potentially affect the health and well-being of residents. This issue will be monitored by FRL and preventative actions taken if found to occur.

As outlined above, use of the Sepik and Frieda rivers for transport of material and hazardous goods such as fuel and chemicals, as well as concerns regarding the structural integrity and safety of the ISF embankment, the potential for increased sediment loads and the potential for the introduction of contaminants, may induce a heightened level of anxiety among residents in the catchment due to the high level of concern for water quality and environmental damage. This anxiety has been expressed during community engagement undertaken to date.

Downstream water quality modelling predicted that water quality in the Sepik River would meet health-based WHO drinking water guidelines (2011), with the exception of total concentrations of lead which are already elevated under existing conditions. The concentrations of dissolved metals and metalloids in water in the Sepik River are also expected to be within the range of background concentrations, with two exceptions. The first exception is aluminium concentrations, which are not anticipated to result in acute and chronic toxicity to aquatic life based on US Environmental Protection Agency calculated site-specific aluminium criteria (US EPA, 2017 a and b). The second exception is copper concentrations, of which labile concentrations are indicated to approach the ANZECC/ARMCANZ (2000) ecosystem protection guideline for copper, and will be further reduced by adsorption to suspended particulate matter. As such, there are predicted to be no adverse impacts to people from drinking water or consuming fish or other wildlife from waterways in the Sepik River as a result of the Project. Modelling also predicts that Project-related suspended sediment concentrations in the Sepik River will remain comparable to existing conditions. However, perceptions within the population may be different, and the management of perceptions will require the effective provision of information on monitoring results.

The ISF will be used as a critical piece of sediment management infrastructure allowing much of the upstream sediment to settle prior to discharge, which will be controlled to ensure compliance with the applicable mixing zone boundary upstream of Paupe (the point at which determined water quality criteria must be met). Modelling also predicts that Project related suspended sediment concentrations in the Sepik River will remain comparable to existing conditions.

The Project is committed to ongoing regular engagement in villages downstream of the mine area and ISF to address concerns about the environmental integrity of the waterways on an ongoing basis. A key consideration in the design of the ISF embankment is to ensure that the main containment dam will be constructed to endure a probable maximum flood and earthquake scenario. The following measures will be implemented for the extremely unlikely event of a dam break:

- Early warning surveillance monitoring of ISF embankment.
- Alert and communication system and procedures for potentially affected communities.
- Evacuation plan for the site and potentially affected communities.
- Emergency support plan for essential services to affected communities.

It could still be expected that community anxiety about water quality and personal safety will remain heightened in the early years of the project (though declining over time), which would have an effect on community and personal well-being. The residual significance of the impact is assessed as low.

6.2.6 Social Catchment 3: Sandaun and East Sepik Provinces

The location of all components of the Project and a majority of the Project's designated points of hire are within Sandaun and East Sepik provinces.

In relation to the status of social values centred on livelihood, the subsistence base of the social catchment is robust given favourable seasonal conditions. However, there is limited opportunity for communities in Sandaun and East Sepik provinces to participate in the cash economy. Historically, opportunities for migration to participate in the labour market in other areas of PNG have been important for income generation in these provinces. With regard to personal and community well-being, services (policing, education and health) in these provinces are limited at best, and non-existent in the more remote areas.

Based on the Project location and activities it is expected that only social values centred on livelihoods and personal and community well-being will be impacted. A description of the general drivers of societal change that have the potential to impact these social values in Social Catchment 3 is provided below.

Livelihoods- The capacity to support subsistence livelihoods (Social Value 1) and the opportunity to participate in the cash economy (Social Value 2)

FRL will seek to recruit the majority of its workforce from PNG with a preference to employ from Sandaun and East Sepik provinces. During the operational phase the Project will generate approximately 2,430 full time equivalent positions per year, of which a majority (estimated at 90%) will be occupied by PNG nationals. This will have the effect of generating substantial indirect employment across PNG as increased incomes lead to increased demand for other goods and services. The projected cumulative changes in local provincial and regional real gross domestic product and real income as a result of the Project from 2020 to 2060 (ACIL Allen, 2018) are shown in Table 6.2.

Table 6.2 Projected cumulative change in local, provincial and regional real GDP and real income as a result of the project, relative to the reference case (in 2018 terms)

Region	Real GDP (Kina billion, 2018 terms, 2020 to 2060)	Real income (Kina billion, 2018 terms, 2020 to 2060)
Sandaun and East Sepik	83.1	40.9
Rest of Momase region	6.8	16.5
Rest of PNG	2.2	21.9
Total PNG	**90.3**	**79.3**

A preferential employment system will be implemented to maximise local employment. However, candidates will be required to possess the relevant skills and experience to fulfil the requirements of each role. It is likely that many job aspirants throughout the Sandaun and East Sepik provinces will be unable to access employment opportunities due to not meeting required educational criteria which could be a source of frustration and disappointment, inducing a level of resentment toward FRL and/or major contractors servicing the Project. FRL will implement a comprehensive skills development program to support local and regional employee’s transition through to higher skill level positions. Access to this program will be dependent on candidates meeting the requisite literacy and numeracy skills and successfully completing an aptitude-based selection process. Improved national human capital from training and work opportunities in the Sandaun and East Sepik provinces has the potential to result in reduced dependence on foreign workers and provide improved quality of life and life choices for those trained and experienced individuals. This will also increase the pool of trained and experienced workers with skills able to be applied to other resource Projects, or transferred to other industries.

Personal and community well-being- An amenable environment (Social Value 5) and the availability of services supportive of personal health, education, safety and security (Social Value 6)

The Project's host provincial governments will experience increased provincial revenue streams including:

- **Mineral royalties.** Negotiated by the National Government with host provincial governments, landowners and, in some cases, the relevant LLGs and other affected communities, as determined through the government led Development Forum process.
- **Dividends on Project equity.** The State has the right to acquire up to 30% equity in the Project. This will be negotiated and formalised through a State Equity Acquisition Agreement.

Similarly, provincial constituents will experience increased income through wages directly from the Project and indirectly through associated 'spin-off' business opportunities. Effective revenue management at all levels will be required if the well-being of provincial residents is to improve. The Project will also support the objectives of the Extractive Industries Transparency Initiative regarding accountability and transparency.

The TCS was implemented in PNG in 1992 and is widely considered one of the most effective development funding schemes in PNG. Through the TCS, certain agreed development projects funded by resources companies earn a tax credit (with approval by provincial and national governments). Filer (2007) noted that the TCS had an added advantage for resource developers, enabling them to finance development projects for stakeholders who were in greatest need (irrespective of the project's impacts) and/or who posed a threat to the developer's harmonious operation. While the TCS is currently suspended during the PNG Government's review of its operation, given the level of underdevelopment in the Project's areas of influence, particularly Sandaun Province, the Project will endeavour to utilise the TCS to fund social and infrastructure development projects on the assumption that it is continued in some form. Additionally, the TCS may be focused at specific target areas such as women's empowerment.

6.3 Social considerations for Project closure

The approach to Project closure is based on a recognition that the direct benefits of the FRCGP (employment, incomes, skill development, royalty flows, supply contracts, etc.) will cease at mine closure; some other benefits of the Project may continue, such as a small number of jobs with the FRHEP. However, with effective planning and implementation of sustainable local and regional economic development programs throughout the life of the Project, in conjunction with targeted closure programs that equip the community for post-closure living, Project-affected communities in particular should have the means for successful transition to other monetary or agriculture-based livelihoods. The desire to balance the short-term and long-term benefits of the Project to local villagers will be a key social challenge for FRL.

Conceptual FRCGP and FRHEP closure plans have been prepared for the Project (EIS Appendix 3). These consider both environmental and social aspects of closure with this SIA used to inform the social aspects. The FRCGP is currently expected to close after 33 years, though further exploration in the area may result in mine life extension. The FRHEP is expected to have an operational life of at least 100 years and will provide a long-term supply of hydropower well after the FRCGP closes. With respect to the future safety of harvesting and consuming fish from the ISF, the bioaccumulation assessment (Appendix 7B), which evaluated metal concentrations of aluminum, cadmium, and copper within fish in the ISF, found that they would generally be well below safe maximum thresholds established by Food Standards Australia New Zealand (FSANZ) and other agencies during both active operations and post closure. Other metals were predicted to also be well below food safety standards in fish that people consume, due to their similar uptake and the low bioaccumulation rate in fish. Accordingly, restrictions on the harvesting and consumption of fish from the ISF post mine closure will not be required.

6.3.1 Likely effects

Mine closure will result in a sharp contraction of local economies and a decrease in population which can significantly affect social stability. Reduced economic activity will not only affect individual wealth but also the availability of social services, schools, labour markets, employment, land valuation and other impacts. Payment of taxes and royalties will cease upon mine completion, which will reduce government revenue (and subsequent expenditure).

Once a decision to close the FRCGP is taken and the decommissioning and closure process is put in place, income streams derived from the Project will fall (and eventually cease) as mine production and associated employment levels reduce. This will affect Social Catchments 1A and 1B in particular, as they are located closest to the mine area and are likely to have a high percentage of villagers employed by the Project, as well as being in receipt of other financial flows (such as royalties and compensation payments) which will cease. Revenue flows to the Sandaun and East Sepik provincial governments will also be reduced as business activity dependent on the expenditure of wages paid to workers resident in the provinces decreases.

The reduction in mine employment in the lead-up to closure will pose a social risk during the closure process. To address this risk in advance of closure, FRL will develop a supplement to the Human Resources Plan at least five years prior to closure that includes retention strategies for personnel required for closure and rehabilitation activities, and will investigate employment transition strategies (including training) for locally employed staff. Employee retrenchment will be in accordance with applicable legislation and the PNG mine closure policy and guidelines (MRA and DMPGM, 2015).

6.3.2 Management

Socio-economic mitigations implemented through the life of mine will aim to address the potential for over-reliance on the operation and plan for development programs which are self-financing following closure. While FRL can encourage people to take measures to ensure that some benefits of the Project are invested in ways which may provide for their needs after the mine closes, it cannot dictate how this is done nor force people to do it. Likewise, while FRL can provide guidance and encouragement for the use of FRCGP benefit streams to be invested in ways which do not rely on the Project in the long-term (and, therefore, increase the potential for them to remain viable after mine closure), it has no means to control this.

Human capital development through training is an aspect that FRL can directly influence during the life of the Project which can have sustainable long-term benefits. The proposed 30-plus year operating life of the FRCGP allows sufficient time for FRL to establish comprehensive training programs for the local workforce that will provide employees with skills that (1) will provide them employment during the Project, and (2) allow them the option to transfer those skills to work on mining (or other) projects elsewhere after the FRCGP closes, should they choose to do so. The experience of former employees of the Panguna and Misima mines is relevant, as comprehensive training programs during the life of those mines allowed highly skilled workers to gain employment at other PNG mines and elsewhere after both of those mines closed (Jackson, 2012).

The closure of the Project will result in the transition of ownership and management of public infrastructure agreed to be retained after closure from FRL to another entity, most likely the local level government(s). Developing the capacity and funding of the local level government(s) to manage such infrastructure after closure will be factored into closure planning. Preparation for such a transition will commence from the start of the Project, with a general understanding by stakeholders on governance and maintenance required for sustainability developed over time.An SIA will be conducted at least five years prior to FRCGP closure as a component of closure planning. The SIA will provide a pre-closure baseline that can be used to develop social completion criteria with appropriate local performance indicators, related to aspects such as health, education, household incomes and social harmony, that can inform the management of closure impacts.

6.3.3 Standards

Minimum standards for socio-economic planning for closure will consider:

- Direct and indirect impacts on landowners and socio-economic dependency on nearby communities.
- Transfer plans for fixed assets, which have been identified as providing potential end use benefits, including municipal, financial and governance planning.
- Institutional planning for community development programs addressing social disadvantage such as health, education and micro-financing services. This will include management plans and resourcing for sustained delivery of services and phasing out of reliance on mine funding. The aim of these operational development plans should be to make the mine no longer necessary for the future successful operation of the programs.
- Development of programs to address artisanal mining and other community activities on and around the mine lease which could impact on mine closure sustainability.

6.3.4 Consultation for closure

FRL recognises that effective consultation and engagement is essential for successful closure. FRL will highlight closure issues such as management options for the open-pit lake, end land use and ongoing use of facilities and infrastructure when undertaking discussions with relevant parties, in particular, the provincial government and local stakeholders. This will allow for interests and concerns to be raised and addressed during mine planning and provide sufficient time for local stakeholders to plan for mine closure.

Consultation will occur with relevant government agencies, local landowners and communities, and other stakeholders to ascertain what buildings, structures, equipment and facilities may be of ongoing benefit and could therefore be sold or left behind under agreed terms. The stakeholder consultation will take place as outlined in Chapter 5 of the EIS, but is likely to be refined during operations. Any such agreement will only be considered by FRL where public safety and environmental health is not compromised and the recipient has the financial, technical and other resources necessary to adequately manage, operate and maintain the infrastructure, both in the short and long-term.

7 Impact management framework

The primary mechanism guiding the management of Project impacts will be an integrated environmental and socio-economic management framework developed under the governance of PanAust's Sustainability Policy. This policy is supported by established Sustainability Management Standards (PanAust, 2013) that incorporate good industry environmental management practice and integrate the management of health, safety, environment and social aspects. The Sustainability Management Standards describe the processes that FRL will implement to demonstrate compliance with applicable sustainable development legislation and guidelines through an effective management system. The key elements of this framework are presented in Figure 7.1.

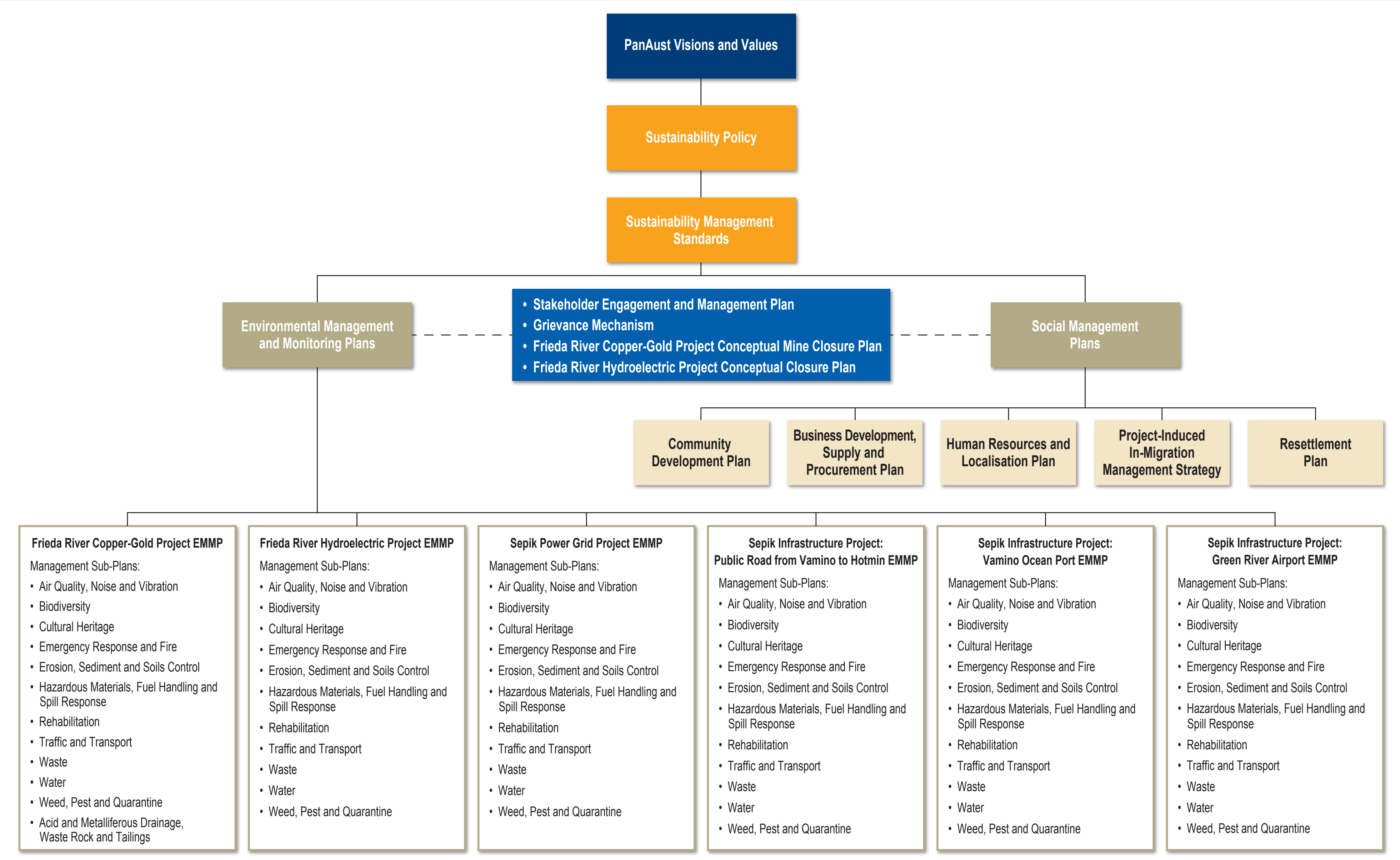
A critical element of the management of social impacts on local communities is the existence of on-going consultation to build a high level of trust and a mutually beneficial relationship between the Project and the communities. FRL has a structured approach to stakeholder engagement to ensure:

- On-going informed consultation and participation through the Project development phase and into future construction and operations phases.
- The active management of expectations and the identification of existing and emergent social risks.
- A consistent approach to build relationships with stakeholders based on transparency, integrity and trust.
- Support for a formal grievance management process that is responsive and transparent.
- Ongoing monitoring of social impacts and socio-economic change (including demographic change).

The framework includes the Stakeholder Engagement and Management Plan (SEMP) and the Grievance Mechanism which are essential for maintaining a constructive dialogue with potentially affected individuals and communities. The inclusion of the Conceptual Mine Closure Plan within the framework also provides a reference for the management plans to promote capacity development aimed at mitigating the impacts of eventual mine closure.

A majority of the people potentially impacted by Project development lead a largely subsistence based lifestyle and maintain a strong and intricate connection to the biophysical environment in which they live. The environmental impacts associated with the Project are inherently linked to social well-being. Subsequently, the management of social impacts fundamentally involves the management of environmental impacts. To this end, six environmental management and monitoring plans (EMMPs) specific to the Project sub-projects (FRCGP, FHREP, SPGP, SIP (Road), SIP (Green River Airport) and SIP (Vanimo Ocean Port)) have been developed in parallel with the EIS. These EMMPs reflect the commitments contained in the EIS and describe issue-specific sub-plans (for the management of biodiversity, water, waste, hazardous materials and fuel handling, spill response, emergency response and fire, noise and vibration, air quality, traffic and transport, erosion and sediment, cultural heritage and rehabilitation) that support the implementation of those commitments.

During consultations for the SIA, and in the Sepik River Awareness undertaken by FRL, it was apparent there was a widely held concern for the environmental integrity of the waterways downstream from the mine area and ISF which were perceived to be at risk from the Project. These perceptions are likely to remain, and will need to be managed by an on-going program of engagement and consultation with communities on a regular basis, focussed on the results of environmental monitoring and measures to capture Project-derived opportunities for employment and community development.



coffey
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Date: 26.09.2018
Project: 754-ENAUABTF11575B
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Frieda River Limited
Sepik Development Project

FRIEDA RIVER

Environmental and social management framework

Figure No: 7.1

AI Reference: 11575_15_GRA006.ai_4

Complementing the EMMPs will be six management plans which together act to both manage socio-economic impacts and support the capture of socio-economic opportunity made available by the development of the Project. These plans are the:

- Cultural Heritage Management Plan.
- Community Development Plan.
- Business Development, Supply and Procurement Plan.
- Human Resources and Localisation Plan.
- PIIMMS.
- Resettlement Plan.

Respect for culture and the management of cultural heritage impacts will be integral to the upholding of social values. Archaeological studies and surveys have been undertaken across potential areas of disturbance by the Project (Appendix 2). These have involved close consultation with landowners in regard to the identification and assessment of the importance of sites and the manner of their treatment should disturbance be unavoidable. The results of these studies and surveys will inform the development of the Project's Cultural Heritage Management Plan, and the need and desire for cultural support through community capacity development.

The Community Development Plan will be framed by the Community Development Strategy which will provide strategic direction for the identification, prioritisation and execution of community development projects over the first five years of the Project, commencing with the granting of the SML. The Community Development Strategy will identify scalable community development commitments, supporting upfront foundational projects for long term growth.

The Community Development Plan focuses on providing foundational and discretionary community development support across priority villages to catalyse development across the two core themes of 'Skilful' and 'Healthy'. Priority projects have been identified in collaboration with communities and governments and address areas of need aligned with community values. Under the theme of 'Skilful', Community Development Plan initiatives include supporting educational outcomes through the provision of new elementary classrooms and upgrades to existing primary schools, along with scholarships and the delivery of literacy and numeracy improvement programs. Entrepreneurship, livelihoods and leadership initiatives include business development assistance, the assessment of fresh produce supply to the Project and women in leadership and small business capacity building program. Under the theme of 'Healthy', Community Development Plan initiatives include the provision of aid posts/clinics in each mine area village and health support services (for communities between the mine area and Vanimo); along with family and financial literacy support and environmental health programs including waste management, participatory environmental monitoring and river research partnerships. Proposed infrastructure support includes the provision of village water supply and sanitation infrastructure, recreational facilities, telecommunications access and upgrade road and air infrastructure. As revenue streams flow to landowners, communities and governments, discretionary community development support may be amended, consistent with the intent of building sustainability and reducing dependency on the Project. Monitoring and evaluation reporting mechanisms are inherent in the Community Development Plan design with an emphasis on reporting outcomes rather than expenditure.

FRL will also develop and implement a Business Development, Supply and Procurement Plan. Key initiatives under this plan are the establishment of the Business Development Office that will include a business development officer dedicated to providing assistance to independent businesses that clans, sub-clans, family groups and individuals own (from communities within the SML, FRHEP and other lease areas) to undertake minor contracts for the provision of services (with many of these contracts being suitable for youth groups, women's groups, church groups and others). It is also proposed to work across infrastructure corridor between the mine area and Vanimo to identify additional business development opportunities such as the supply of fresh produce to the Project.

Sourcing goods and services will be based on an order of preference, from suppliers that are:

- Owned by recognised landowners from the Frieda River area.
- Based in Sandaun Province.
- Based in East Sepik Province.
- Based elsewhere in PNG.
- Based overseas.

Tendering for the provision of goods and services to the Project will be on a strictly commercial and competitive basis with a focus on price, quality and schedule.

The most significant direct opportunity associated with the Project, for both local and provincial residents, is participation in employment. FRL will develop a Human Resources and Localisation Plan (including a specific Employment and Training Plan) to support local employment and ensure that unskilled local and provincial residents are able to participate to the maximum extent possible. This strategy will be implemented by a dedicated Training Section within the Human Resources Department supported by embedded skills training specialists in operating departments. Training will occur at a primary training centre at the mine site and within operational workplaces. A secondary training centre will operate off-site in Vanimo for the provision of apprentice/trade training and specialist development training which is best delivered away from the workplace. In addition to standard operator and trades training, FRL will also implement a ‘workforce culture program’ prior to start-up and in the early stages of operations. This program will be important in establishing a consistent employee culture within the Project workforce as some employees will be recruited from communities across PNG with different cultures, languages and values.

A primary cause of social change induced by Project development will be in-migration. As discussed in Chapter 5, to further inform the potential for the Project to manage in-migration a range of initiatives will be implemented including:

- Close collaboration with communities in the development and implementation of initiatives.
- Linkages to plans for workforce recruitment locations.
- Support for the establishment of Ward Reporters in each village and the use of the National Identity system as available.
- Clearly defined relationships and responsibilities for the Police and Project security personnel guided by a charter to ensure respect for human rights.
- Active management and monitoring of all Project lease areas (SML and associated LMPs) to ensure that no residential structures are built on them, and do not become an in-migration access route.
- Robust contractor management to ensure that local employment preference is followed in practice.
- Linkage to plans for regional growth centres where the provision of improved infrastructure and services may act as an incentive to remain rather than migrate closer to the mine.

Integral to the PIIMMS is the establishment of an on-going monitoring program to detect early indicators of population change and inform strategy effectiveness and necessary corrective actions.

Land access negotiations and resettlement will be approached using a comprehensive process of stakeholder engagement, planning, implementation, and monitoring and evaluation. Engagement with

Project stakeholders will include community information and awareness sessions, consultation and negotiations with households and host communities that will be affected by resettlement. FRL will develop and use a Resettlement Policy Framework (RPF) to serve as the guidance document for land access and involuntary resettlement activities, and provide an overarching policy framework under which the following components will be developed and agreed:

- Compensation Agreements – These will be negotiated with customary land owners/clans in accordance with the *Mining Act 1992*. Compensation agreements cover elements relating to land, crops and trees and environmental compensation (impacted water for example).
- Household Resettlement Agreements – These will cover items such as replacement housing, livelihoods and transitional support, and support for vulnerable persons. The agreement terms will be developed and negotiated through a company convened Resettlement Planning Committee (RPC). The RPC will be comprised of representatives from the affected communities. The Frieda River Project RPC will be a sub-committee or working group of the Community Leaders Forum (CLF), an established forum with representatives from the Telefol, Miyan and Paiyamo villages. The structure and terms of the resettlement agreement will be developed at the RPC and signed at the household level following extensive village level awareness about the resettlement and agreement process. Where host communities are affected by resettlement, then agreements defining community support measures will also be concluded with them.

Collectively, the EMMPs and Social Management Plans will seek to ensure that Project induced impacts upon communities are effectively managed. The array of impacts identified by the SIA indicates that, despite three decades of exploration and development planning, there will still be pressures on social values and community well-being which will require external support and partnerships to manage.

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8 Study team

This chapter outlines the SIA study team. FRL appointed Coffey to prepare the SIA, which draws on the work of five specialist consultant studies.

8.1 Coffey

Study director

Pat Vidler

Pat Vidler is a Senior Associate with over 25 years' experience working with remote and regional communities in the fields of social impact assessment, community development and community and stakeholder engagement. Pat's experience spans consultancy, industry, aid organisations and government. It includes undertaking and managing social impact assessments, the provision of rural enterprise advice; the development and implementation of community development strategies and resettlement action plans; the mentoring of community engagement staff; and the facilitation of cross-sector partnership agreements.

Study lead

Tasha Latham

Tasha Latham is a Senior Associate with over 10 years' experience in environmental and social impact assessment, planning, policy and management in the public and private sectors. Tasha has managed social specialists and conducted social impact assessments across a range of sectors. This experience extends across the mining, oil and gas and infrastructure sectors within several different jurisdictions in Australia and internationally.

Technical writers

Amy Hallion

Amy Hallion is a Senior Consultant with eight years' experience in social perceptions analysis, environmental risk assessment and development of environmental management plans. Amy has been involved in the preparation of social impact assessments for several mining and oil and gas projects in PNG. Her involvement has ranged from data analysis and review to preparation of baseline and impact assessments. Amy was part of the field baseline data collection team for the Project in 2015.

Greg Heath

Greg Heath is a Senior Consultant with eight years' experience in environmental and social impact assessment, field survey and specialist study management, data analysis and environmental management. Greg's experience extends across the mining, oil and gas sectors within Australia and internationally, and he has predominantly worked on PNG projects for the last eight years. Greg was part of the field baseline data collection team for the Project in 2015 and 2017.

Anna Yates

Anna is an associate environmental and social consultant with over 10 years of experience in environmental and public health consulting. Anna has managed social specialists and been involved with multiple environmental and social impact assessments for the mining sector in PNG as well as other jurisdictions in the Asia Pacific region.

Mark Pendlebury

Mark is a Senior Consultant with two years' experience in environmental and social impact assessment, and five years' experience in environmental management systems and environmental data analysis. Mark has been involved in the preparation of environmental and social impact assessment reports across several mining projects, both national and international. He has predominantly been responsible for data review and analysis and co-authoring baseline and impact assessments reports.

Isabelle Kielbaska

Isabelle is an environmental consultant with one year of experience in environmental and social impact assessment and environmental data analysis across several mining projects. Additionally, Isabelle has analysed assessment strategies for Victorian based projects. She has largely been responsible for writing baseline reports and data review and analysis.

8.2 Specialist consultants

Health, diet and nutrition

Dr Keith Bentley (Centre for Environmental Health)

Dr Keith Bentley undertook baseline health, diet and nutrition studies for the Project which broadly examined the socio-economic circumstances, public and environmental health, diet and nutritional status, and clinical health of sentinel communities within the Project area. The results of this study have been used to inform this SIA. Keith is the Director of, and principal technical consultant for, the Centre for Environmental Health Pty Ltd (CEH). A major focus of CEH since 1999 has been the conduct of deterministic community health risk assessments for contaminant metals in areas surrounding mining operations. Keith has a broad-based knowledge of environmental health, specialising in the toxicology of metals and health risk assessment for the mining and minerals industries for both occupational and community exposures.

Health impact assessment

Jack Dempsey (Dempsey Toxicology and Risk Assessment)

Jack Dempsey, Director of Dempsey Toxicology and Risk Assessment, undertook a desktop Health Impact Assessment for the Project which outlines potential exposure pathways and risks to Project communities from essential and contaminant metals. The results of this study have been used to inform this SIA. Jack is an expert in human health risk assessment with extensive experience across Australia and PNG, including a review of a health risk assessment for communities impacted by mine-related contamination of an entire river system in PNG for the PNG Department of Environment and Conservation. Jack has a Bachelor of Science (Honours) and over 25 years post graduate experience undertaking research at Flinders University South Australia (Flinders Medical Centre) and CSIRO Human Nutrition, focused on mutagenesis and carcinogenesis.

Archaeology and cultural heritage

Dr Mike Green (Andrew Long and Associates)

Mike has over 30 years of professional and academic experience in archaeology, biological anthropology and Indigenous cultural heritage management across Australia, PNG and New Zealand. He is a nationally recognised expert in the field investigation, laboratory analysis, curation and repatriation of Indigenous ancestral remains. From 2004 to 2010 he was Head of the Indigenous Cultures Department at Museum Victoria, where he developed co-operative partnerships with external bodies including universities, community organisations (particularly Indigenous communities) and Government, and positioned the museum in leadership roles in state, national and international programs relating to research and collections and the repatriation of Aboriginal ancestral remains. He has a Bachelor of Arts (Honours) degree (1983) and a PhD (1990), both from the Australian National University.

Joe Crouch (Andrew Long and Associates)

Joe is a consulting archaeologist with over 20 years of professional and academic experience working in the fields of archaeology and cultural heritage, particularly in PNG over the last 10 years. He has a Bachelor of Arts (Honours) degree (2000) in Australian Indigenous Archaeology from the University of Melbourne and is undertaking a PhD (2016) in Australian Indigenous Archaeology at Monash University. Joe has been involved in numerous cultural heritage and archaeology investigations and research programs for projects across a range of sectors including several mining projects.

Dr John Muke (Social Research Institute Ltd)

John is the Managing Director at the Social Research Institute and has over 35 years of professional and academic experience in working in the fields of cultural heritage, archaeology and anthropology in PNG. John has a Doctorate of Philosophy from the University of Cambridge and a Bachelor of Arts from the University of Cambridge, and has been involved in numerous cultural heritage and archaeology investigations, projects and programs across a range of sectors including several projects in the mining industry. John has also authored over 40 publications and reports on cultural heritage, archaeology and anthropology in PNG.

John Sepe (Social Research Institute)

John Sepe is a Senior Cultural Heritage Specialist at the Social Research institute and has over 10 years professional and academic experience working in the fields of cultural heritage, archaeology and anthropology in PNG. John has a Bachelor of Arts majoring in Archaeology, and has been involved in numerous cultural heritage and archaeology investigations for projects in the mining and oil and gas sectors.

Yawan Alo (Social Research Institute)

Yawan Alo is Specialist Anthropologist at the Social Research Institute and has over 10 years professional and academic experience working in the fields of cultural heritage, archaeology and anthropology in PNG. Yawan has a Bachelor of Arts (Honours) in Anthropology, and has been involved in numerous cultural heritage and archaeology investigations for projects in the mining and oil and gas sectors.

Dr Tim Denham (Australia National University)

Tim Denham has a PhD in Archaeology and Palaeoanthropology from the Australian National University, a MSc in Geography from Pennsylvania State University and a BA (Honours) in Geography, University of Cambridge. His archaeological research has focussed on the long-term history of plant exploitation and early agriculture in the highland interior of PNG. His research has resulted in three contributions of demonstrated international significance. During 2006-2007, he successfully led the nomination by the PNG Government of the Kuk Early Agricultural Site for UNESCO World Heritage Listing.

Dr Garrick Hitchcock (Arafura Consulting)

Garrick is the Director of Arafura Consulting and a highly experienced anthropologist and heritage manager with extensive work experience across Australia and PNG. Garrick has a Doctorate in Anthropology and a Bachelor of Arts (Honours). He is a Fellow of the Anthropological Society of Australia, Member of the Australian Archaeological Association, and Member of the Australian Institute of Aboriginal and Torres Strait Islander Studies.

In-migration

Dr Richard Jackson

Dr Richard Jackson is a geographer with significant experience researching and assessing the social impacts of mining in Papua New Guinea, South-East Asia and Africa. He is a private consultant who has previously held professorial chairs at the University of Papua New Guinea and the James Cook University of North Queensland. He is currently an Honorary Industry Fellow at the Centre for Social Responsibility in Mining at the University of Queensland Sustainable Minerals Institute

Land use change

Dr Alex Lechner (University of Nottingham, Malaysia)

Dr Alex Lechner is a Landscape Ecologist with experience in applying spatially explicit modelling to conservation biology and natural resource management. He currently works as an Assistant Professor at the School of Environmental and Geographical Sciences at the University of Nottingham Malaysia Campus and is an adjunct research fellow at the University of Queensland. He has held a variety of different roles at the Regional Water and Land Resources program, Center for Social Responsibility in Mining and Centre for Mined Land Rehabilitation at the University of Queensland, Centre for Environment at the University of Tasmania, and the Mathematics and Geospatial department at RMIT University. Alex has completed a BSc majoring in Ecology at the University of Queensland, and a MAppSci specialising in Geospatial Science and a PhD in Landscape Ecology at RMIT University.

Dr John Hunter (University of Nottingham, Malaysia)

Dr John T. Hunter has over 26 years' experience managing an environmental consultancy and 24 years' experience with GIS. He is a landscape ecologist who is one of the most experienced field botanists within NSW. John has conducted extensive mapping programs across most regions of NSW. He has conducted vegetation mapping over most of regions of NSW and has placed over 25,000 floristic survey sites. John is also leading expert in plant identification and systematics. John has completed a Bachelor of Science, Honours and Doctorate at the University of New England,

9 Glossary, abbreviations and acronyms

9.1 Units of measure and symbols

%	percentage (proportion out of one hundred)
Bm^3	billion cubic meters
Bt	billion tonnes
g	gram
GWh/year	gigawatt hours per year
ha	hectare
km	kilometre
Km^2	square kilometre
kV	kilovolt
m	metre
m^3/h	cubic metres per hour
m^3/s	cubic metre per second
Mm^3	million cubic metres
Mt	million tonnes
Mt/year	million tonnes per year
MW	megawatt
oz	ounces
PGK	Papua New Guinea kina
RL	reduced level
t	tonne
t/h	tonnes per hour
wmt	wet metric tonnes

9.2 Glossary

Betel nut	The Areca nut is the seed of the Areca palm (*Areca catechu*). It is commonly referred to as ‘betel nut’ as it is often chewed wrapped in betel leaves. Chewing betel nut or ‘buai’ is tradition in PNG.
Catchment	Grouping of impacted villages into study areas defined through a consideration of community location, type of Project activity that may potentially occur in proximity to villages in the catchment, and language group or cultural affinity of the villages.
Formal employment	Formal, paid employment where employee has a regular income (can be full or part-time or casual).
Sub-catchment	Grouping of villages within a catchment. Primarily used in the mine area catchment to group villages of the same language group/landowner rights.

9.3 Abbreviations and acronyms

AIDS	Acquired immune deficiency syndrome
CEPA	Conservation and Environment Protection Authority (formerly, DEC)
CLF	Community Leaders Forum
DEC	Department of Environment and Conservation (now, CEPA)
DIDO	Drive in drive out
EIR	Environment inception report
EIS	Environmental impact statement
EITI	Extractive Industries Transparency Initiative
EL	Exploration License
EMMP	Environmental Management and Monitoring Plan
FIFO	Fly-in fly-out
FRCGP	Frieda River Copper-Gold Project
FRHEP	Frieda River Hydroelectric Project
FRL	Frieda River Limited
FSANZ	Food Standards Australia New Zealand
GDP	Gross Domestic Product
HFL	Highlands Frieda Limited
HIA	Human Impact Assessment
HITEK	Horse-Ivaal-Trukai, Ekwai and Koki
HIV	Human immunodeficiency virus
IAIA	International Association for Impact Assessment
ICMM	International Council on Mining and Metals
IFC	International Finance Corporation
ISF	Integrated storage facility
JORC	Joint Ore Reserves Committee
JPCC	Joint Provincial Consultative Committee
LLG	Local Level Government
LMP	Lease for Mining Purpose
MCA	Minerals Council of Australia
MIA	Mine infrastructure area
ML	Mining Lease
MOA	Memorandum of Agreement
MQC	Membership qualification criteria
MRA	Minerals Resources Authority
NAF	Non-acid forming
NSO	National Statistical Office

NSPT	National Strategic Plan Taskforce
PAF	Potentially acid forming
PIIMMS	Project-Induced In-Migration Management Strategy
PNG	Independent State of Papua New Guinea
PNGDSP	Papua New Guinea Development Strategic Plan
RPC	Resettlement Planning Committee
RPF	Resettlement Policy Framework
SEMP	Stakeholder Engagement and Management Plan
SIA	Social Impact Assessment
SIP	Sepik Infrastructure Project
SML	Special Mining Lease
SPGP	Sepik Power Grid Project
StaRS	National Strategy for Responsible Sustainable Development for Papua New Guinea
STI	Sexually transmitted infection
SV	Social value
TCS	Tax credit scheme
TSS	Total suspended sediment
XFRL	Xstrata Frieda River Limited

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Appendix 1

Study area social profiles baseline

Frieda River Limited

Sepik Development Project

Study area social profiles

September 2018

SDP-6-G-00-01-T-003-025

When you
think with a
global mind
problems
get smaller

Sepik Development Project - Study area social profiles

Prepared for
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September 2018

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Quality information

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v2 draft	1	PDF	Mick Hawkins	9/05/2018
V3 final	1	PDF	Mick Hawkins	14/09/2018

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1. Introduction

Coffey has characterised social profiles within the Sepik Development Project (the Project) study area on behalf of Frieda River Limited (FRL) to support the Social Impact Assessment (SIA) and the Environmental Impact Statement (EIS) as the statutory basis for the environmental assessment of the Project.

1.1. Project overview

Frieda River Limited is assessing the feasibility of developing the nation-building Project in northern Papua New Guinea (PNG). The Project is primarily located within the Sepik River catchment and will comprise development of the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) copper-gold deposits in the Sandaun Province and supporting infrastructure and facilities in the Sandaun and East Sepik provinces. The Project consists of four interdependent projects:

- Frieda River Copper-Gold Project (FRCGP).
- Frieda River Hydroelectric Project (FRHEP).
- Sepik Power Grid Project (SPGP).
- Sepik Infrastructure Project (SIP).

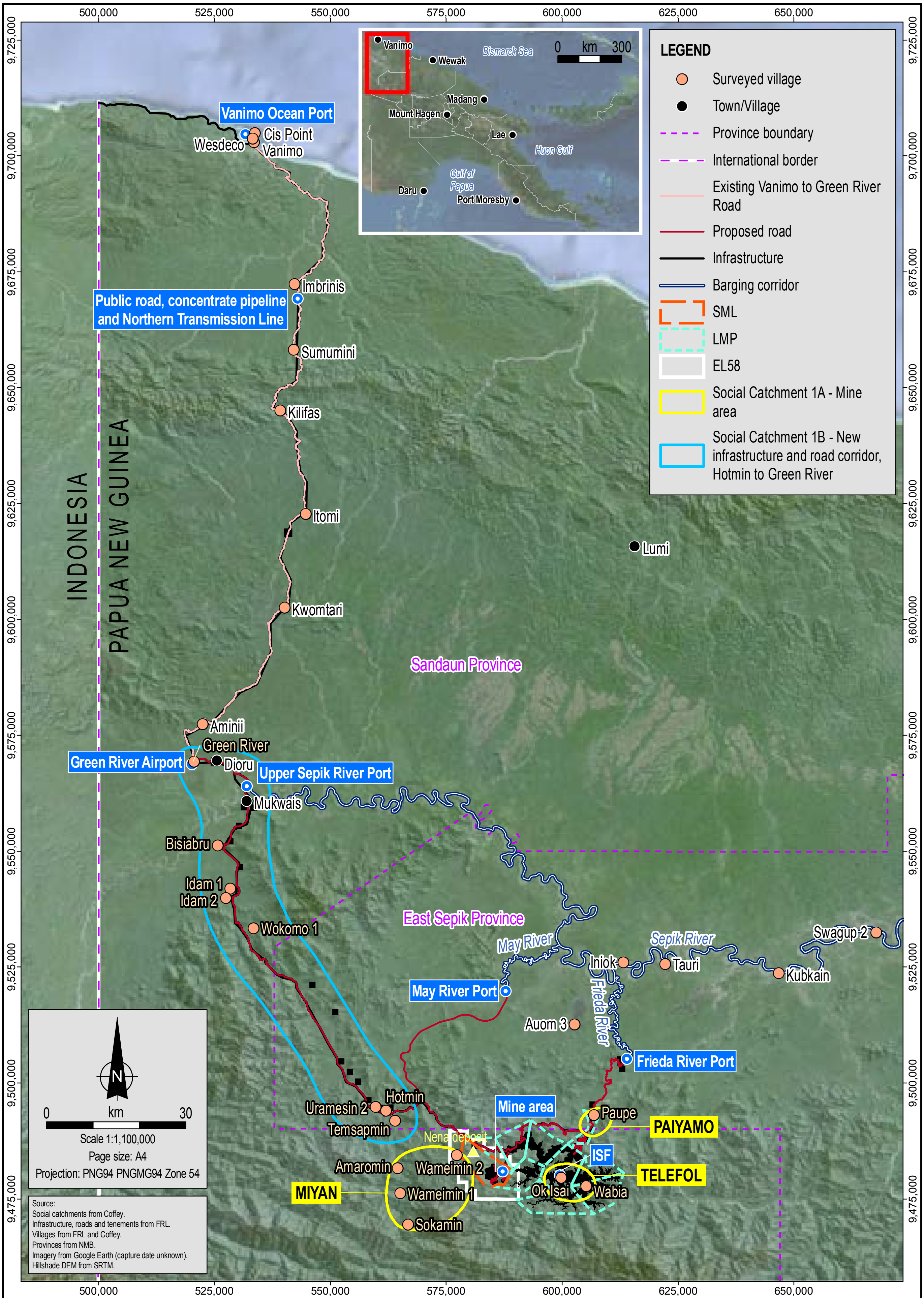
Study area social profiles are relevant to all four elements of the Project — the FRCGP, SIP, FRHEP and SPGP.

1.2. Social values and study area

The purpose of the social profiles is to describe the baseline characteristics of communities potentially affected by the Project. This serves to build an appreciation of the social values that may be affected by the Project.

A social value is regarded as a quality of the Project area that is conducive to individual well-being now and into the future and for which community stakeholders have a high regard. It is not normally amenable to a single measure or indicator. The profiles were developed for social catchment areas that were defined through consideration of location (including watershed boundaries, landowner status and proximity to the FRCGP and FRHEP), the type of Project activity that may potentially occur in proximity to villages in the social catchment, and language group or cultural affinity of the villages in the social catchment. The social catchments are:

- Social Catchment 1A: Mine and integrated storage facility area (Figure 1).
- Social Catchment 1B: New infrastructure and road corridor, Hotmin to Green River (Figure 1).
- Social Catchment 1C: Existing infrastructure and road corridor, Green River to Vanimo (Figure 2).
- Social Catchment 1D: Vanimo Ocean Port (Figure 2).
- Social Catchment 2: Sepik River corridor (Figure 3).
- Social Catchment 3: Sandaun and East Sepik Provinces (Figure 3).



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Date:
23.08.2018
Project:
754-ENAUABTF11575B
File Name:
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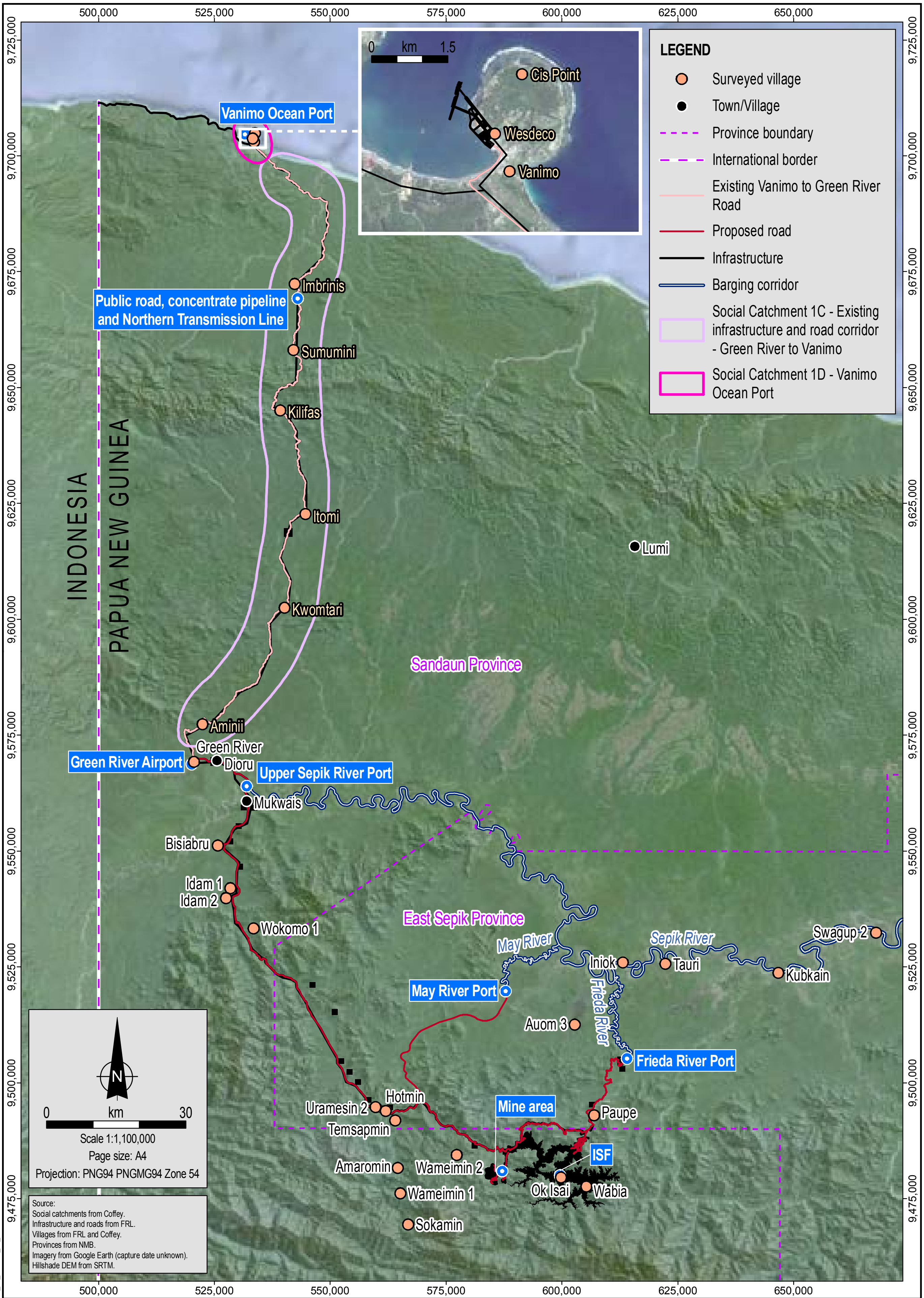
Frieda River Limited

Sepik Development Project

FRIEDA RIVER

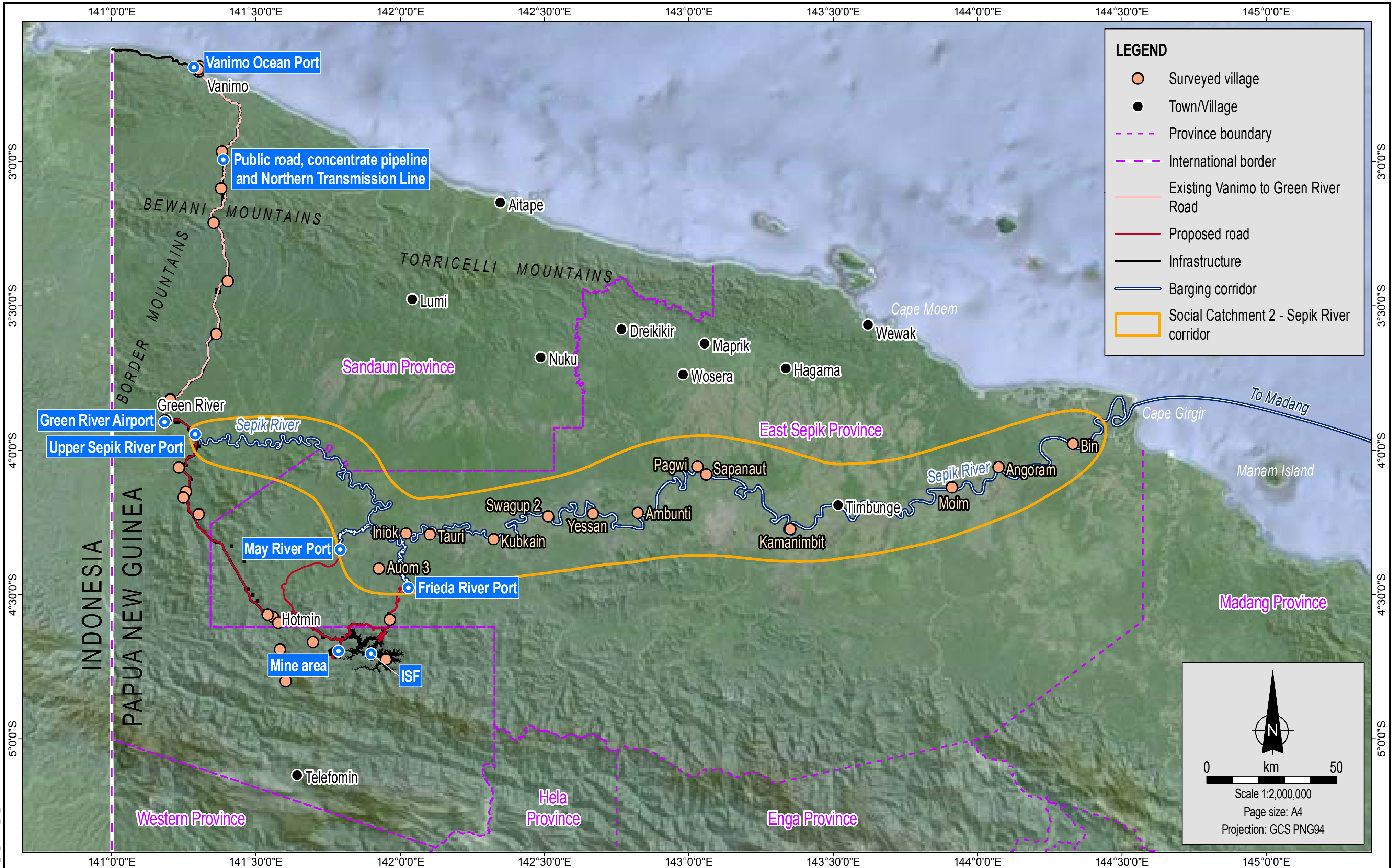
Social Impact Assessment catchments 1A and 1B

Figure No:
1



MXD Reference: 11575B_16_GIS002_v0_8

coffey A TETRA TECH COMPANY	Date: 04.10.2018 Project: 754-ENAUABTF11575B File Name: 11575_16_App1_F002_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Social Impact Assessment catchments 1C and 1D	Figure No: 2



Source:
Social catchments from Coffey.
Infrastructure and roads from FRL. Villages from FRL and Coffey.
Provinces from NMB.
Imagery from Google Earth (capture date unknown).
Hillshade DEM from SRTM.

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Frieda River Limited
Sepik Development Project

FRIEDA RIVER

Social Impact Assessment catchments 2 and 3

Figure No: 3

MXD Reference: 11575B_16_GIS003_v0_8

1.3. Baseline studies

There have been extensive baseline studies dating back to 1995 examining the social conditions of communities in the social catchment areas. Relevant information has been drawn upon in preparation of the social profiles including:

- Review of socio-economic and cultural studies undertaken in the 1995 to 1996 period on behalf of the Project. These included:
  - Gardner, D. (1996a) Nena Project Socio-economic Impact Assessment-Cultural Impacts.
  - Subada Consulting (1996) Community Directory Nena Project Area.
- Analysis of population census, household surveys and village surveys undertaken by Coffey in 2009 to 2011 (on behalf of Xstrata Frieda River Limited (XFRL), and 2015 and 2017 on behalf of FRL.
- Review of village health baseline surveys (CEH 2018) undertaken by the Centre for Environmental Health on behalf of XFRL in 2010/11. These surveys remain the most recent and comprehensive assessment of population health in this area of the East Sepik Province.
- Review of cultural heritage studies and archaeological surveys undertaken in 2010 and 2015 by Monash University and Andrew Long and Associates (ALA). Review of ALA reports from 2016 and 2018 on behalf of FRL.
- Discussions with village women’s focus groups in the mine and integrated storage facility (ISF) area (mine area) and Sepik River corridor social catchments, and social value workshops with village leaders from the mine area social catchment.
- Review of secondary information derived from reports and plans sourced from national, provincial and district level government agencies (such as the National Strategy for Responsible Sustainable Development, PNG Vision 2050, East Sepik Provincial Development Plan 2011-2015 and West Sepik (Sandaun) Provincial Integrated Development Plan, 2014-2018).

Table 1 indicates the coverage of villages in the social catchments during the various survey campaigns. Villages in the mine area, infrastructure and road corridors and Vanimo Ocean Port social catchments have been the focus of primary data collection through field surveys, due to their proximity to Project activities. Villages along the Sepik River corridor (Social Catchment 2) were surveyed during 2011 and further engaged by way of the Sepik River awareness campaigns undertaken by FRL throughout July and August in 2015 and September and October in 2016. Select villages in the mine area (Social Catchment 1), along the infrastructure corridor (Social Catchment 1B and 1C) and the Vanimo Ocean Port (Social Catchment 1D) were surveyed during 2017. As part of the surveys, a Project awareness campaign was carried out. In these consultation sessions, information on the Project was delivered to communities in a format which was readily able to be understood, and issues and concerns of villagers were identified and discussed.

Table 1 Survey coverage of villages included in the social profile

Village	2009 to 2011 Socio-economic survey (census, household and village)	2015 Socio-economic survey (census, household and village)	2010 Health base-line survey	2010 Cultural heritage	2016 Cultural heritage (targeted sites)	2015 Village leaders social values work-shops	2017 Socio-economic survey (household and village surveys)	2017 Focus groups / key informant interviews
Social Catchment 1A - Mine area								
Sokamin	✓	✓				✓		
Wameimin 1	✓	✓	✓	✓		✓		
Wameimin 2	✓	✓	✓	✓	✓	✓	Village survey only	✓
Amaromin	✓	✓	✓	✓	✓	✓		
Ok Isai	✓	✓	✓	✓	✓	✓	Village survey only	✓
Wabia	✓	✓	✓	✓	✓	✓	Village survey only	
Paupe	✓	✓	✓	✓	✓	✓	Village survey only	
Social Catchment 1B – New infrastructure and road corridor, Hotmin to Green River*								
Uramesin 2							Village survey only	
Temsapin							Village survey only	
Hotmin							✓	✓
Idam 1*							✓	✓
Idam 2							✓	
Wokomo 1							✓	
Bisiabru							Village survey only	✓
Green River								✓
Social Catchment 1C – Existing infrastructure and road corridor, Green River to Vanimo								
Amini							Village survey only	
Kwomtari							Village survey only	
Itomi							Village survey only	
Kilifas							Village survey only	✓

Village	2009 to 2011 Socio-economic survey (census, household and village)	2015 Socio-economic survey (census, household and village)	2010 Health base-line survey	2010 Cultural heritage	2016 Cultural heritage (targeted sites)	2015 Village leaders social values work-shops	2017 Socio-economic survey (household and village surveys)	2017 Focus groups / key informant interviews
Sumumini							Village survey only	
Imbrinis							Village survey only	
Social Catchment 1D – Vanimo Ocean Port								
Wesdeco							Village survey only	
CISPoint							Village survey only	
Social Catchment 2 – Sepik River corridor								
Auom 3	✓	✓	✓	✓				
Iniok	✓	✓	✓	✓				
Kubkain	✓	✓	✓	✓				
Tauri				✓				
Swagup	Village survey only							
Yessan								
Ambunti	Village survey only							
Pagwi	Village survey only	Village and limited household survey						
Sapanaut			✓					
Moim	Village survey only							
Kamanimbit	Village survey only							
Angoram	Village survey only							
Bin	Village survey only							

*The survey team planned to undertake village, household and resource use surveys at Dioru on 7 November 2017. However, due to logistical constraints and high rainfall the village could not be accessed by road and consequently was not surveyed.

In addition to the above survey coverage, the following survey work was also undertaken in November 2017:

- Opportunistic interviews with key informants along the infrastructure corridor between Green River and Vanimo (inclusive). Interviews were undertaken with people associated with health centres, schools, churches, logging camps and the Provincial Government.
- Points of interest surveys to record key features and points of interest along the infrastructure corridor between Green River and Vanimo (inclusive), e.g., logging camps, schools, churches and hospitals.
- Fish market surveys in Vanimo undertaken on 14 and 15 November to gain a preliminary understanding of the types and sizes of fish caught and what locations they were caught.

In 2015 and 2016 FRL delivered FRCGP and FRHEP awareness sessions to communities in the mine area social catchment and along the Sepik River corridor relating to the previous FRCGP and FRHEP design. In 2017, Project awareness sessions focused on the current Project design and were delivered in the mine area, new and existing infrastructure corridor and Vanimo Ocean Port social catchments. During these awareness sessions information on the revised Project design was delivered, and issues and concerns of villagers were identified and discussed. In addition to Project awareness sessions, FRL has regular engagement visits to villages within the mine area social catchment, and other villages within the social catchments. This engagement work will continue during the EIS process in 2018.

Given the focus of Social Catchment 3 (Sandaun and East Sepik provinces) is regional in nature, information was largely obtained through review of secondary sources including government planning documents, such as the East Sepik Provincial Integrated Development Plan 2011-2015, West Sepik (Sandaun) Provincial Integrated Development Plan 2014-2018 and Sandaun Provincial Government Education Plan 2007-2014, along with research published by academic institutions and non-government organisations.

2. Social Catchment 1A: Mine area

2.1. Overview

There are three social sub-catchments of villages within the mine area social catchment which are either within or in proximity (15 to 20 kilometres (km)) to the proposed FRCGP mining operation, or immediately downstream of the FRHEP ISF (Figure 1). The social sub-catchments, Miyan, Telefol and Paiyamo, align with and are named after the principal language spoken in the villages, and include the recognised owners of lands covered by the proposed Special Mining Lease (SML) and Leases for Mining Purposes (LMP) associated with mine infrastructure. The villages that make up each social sub-catchment are listed in Table 2.

Table 2 Mine area social sub catchments

Social Sub-catchment	Village
Miyan	Amaromin
	Sokamin
	Wameimin 1
	Wameimin 2
Telefol	Ok Isai
	Wabia
Paiyamo	Paupe

The cultures of the groups have been described broadly by Gardner (1996a). Gardner characterises the area as being the domain of a number of cultural groups with a high level of interaction with each other as well as with the proponent at that time. An important feature of these cultural groups was linkages and relationships with communities that are peripheral to the mine area social catchment, with which there are cultural obligations and significant interactions. Physically the area is comprised of a series of distinct topographical types: mountains, foot hills, inter-fluvial plains and swampy alluvial flats, each supporting distinctive patterns of subsistence use. A further important physical characteristic is that the groups are located within river catchment areas that have the potential to be impacted by FRCGP and FRHEP construction and operations.

2.1.1. Location

Villages within Social Catchment 1A are characterised by remoteness, being located a considerable distance from any township and not able to be accessed by road. In addition, there is substantial geographic separation between villages and the proposed mine area and associated infrastructure (see Figure 1) and some of the villages within this Catchment such as Amaromin, Sokamin and Wameimin 1. Other villages within the Catchment including Ok Isai, Wabia and Paupe are located in close proximity to the proposed mine and associated infrastructure or within the FRHEP inundation area (see Figure 1). Wameimin 2 is located west of the SML boundary (see Figure 1) in close proximity to the Nena copper-gold deposit. The location of each social sub-catchment in relation to government administrative boundaries (Local Level Government (LLG), District and Province) is shown in Table 3.

Table 3 Mine area social catchment government administrative boundaries

Social sub-catchment	LLG	District	Province
Miyan	Telefomin Rural	Telefomin	Sandaun
Telefol	Telefomin Rural	Telefomin	Sandaun
Paiyamo	Tunap/Hunstein	Ambunti-Dreikikir	East Sepik

The Miyan social sub-catchment is located to the west of the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) deposits. Three villages (Sokamin, Wameimin 1 and Amaromin) are approximately 20 km west to southwest from the mine area, and situated within catchments of the Upper May River. A fourth village (Wameimin 2), is located approximately 10 km northwest of the HITEK deposit on the upper Nena River, approximately 6 km upstream from the western extent of the FRHEP inundation area and 3 km from the Nena deposit. The village of Fiak, located approximately 2 km west of Amaromin, is not considered to be within the Miyan social sub catchment due to residents generally not being recognised as landowners of the area within the proposed SML and LMP boundaries.

The terrain within the social sub-catchment area is rugged and mountainous, with access via walking tracks only. From Sokamin, access to the nearest administrative centre (Mianmin) is via a two-day walk to the south; from Amaromin, following a walk to Fiak there is canoe travel available to Hotmin and the Sepik River. From Wameimin 2, residents walk to the headwaters of the Usake River from where canoe travel downstream to Hotmin and the Sepik River is available.

The Telefol social sub-catchment is located to the east of the HITEK deposits. It consists of two villages (Ok Isai and Wabia) that are approximately 15 and 20 km respectively in a direct line from the proposed open pit, and within the footprint of the FRHEP inundation area, and situated within catchments of the Niar River. The terrain within this social sub-catchment area is rugged and mountainous, though both villages have airstrips suitable for light aircraft up to Twin Otter size and are accessible via canoe from the Frieda and Sepik rivers.

The Paiyamo social sub-catchment consists of one village (Paupe) located on the banks of the Frieda River, 2.5 km north of the Frieda River airstrip and approximately 25 km from the HITEK deposit and 12 km downstream of the confluence of the Nena and Ok Binai rivers. While it has a relatively small population, Paupe is located approximately 7 km north from the proposed embankment of the FRHEP. The FRHEP access road associated with the FRHEP ISF will traverse through the village. The village was previously used as an entry point for villagers from the Wario River area to the east who were seeking employment with the Project.

2.1.2. Population

The total population of the mine area social catchment at the end of 2017 (the most recent data collected by FRL) was estimated to be approximately 2,000 persons, with annual growth adding around 60 persons per year to the population. Key population and household characteristics of the three social sub-catchments are shown in Table 4 and Table 5 respectively.

Table 4 Social Catchment 1A population characteristics

Village	Population				Annual growth rate			
	1996*	2009†	2014§	2017#	1996 to 2009	2009 to 2014	2014 to 2017	Telefomin Rural District 2000** to 2011 census††
Sokamin	201	256	332	360	1.9%	5.3%	2.7%	2.4
Amaromin	n.a.	116	143	137	n.a.	4.3%	-1.4%	2.4
Wameimin 2	77	151	163	196	5.3%	1.5%	6.3%	2.4
Wameimin 1	81	144	171	188	4.5%	3.5%	3.2%	2.4
Miyan sub-total	359	667	809	881	4.9%	3.9%	2.9%	2.4
Wabia	177	319	369	393	4.6%	3.0%	2.1%	2.4
Ok Isai	175	348	413	465	5.4%	3.5%	4.0%	2.4
Telefol sub-total	352	667	782	858	5.0%	3.2%	3.1%	2.4
Paupe	105	163	222	262	3.4%	6.4%	5.7%	2.4
TOTAL	**816**	**1,497**	**1,813**	**2,001**	**-**	**-**	**-**	**-**

n.a.: not available.
*1996 Subada Consulting survey.
†Coffey 2009 survey.
§2009 XFRL census.
#2017 FRL census.
** NSO, 2000.
††NSO, 2014.

Table 5 Social Catchment 1A household characteristics

Village	Number of households				Household occupancy (persons per household)		
	1996*	2009†	2014§	2017§§	2009/2010 Momase rural††	2014	2017
Sokamin	25	39	55	57	6.7	6.0	6.3
Amaromin	n.a.	25	29	27	6.7	4.9	5.1
Wameimin 2	14	26	32	33	6.7	5.1	5.9
Wameimin 1	16	23	27	32	6.7	6.3	5.9
Miyan sub-total	n.a.	113	143	149	6.7	5.5	5.9
Wabia	17	45	61	63	6.7	6.0	6.2
Ok Isai	21	38	46	60	6.7	9.0	7.8

Village	Number of households				Household occupancy (persons per household)		
	1996*	2009†	2014§	2017§§	2009/2010 Momase rural††	2014	2017
Telefol sub-total	38	83	107	123	6.7	7.5	7.0
Paupe	18	22	28	38	6.7	7.9	6.9
TOTAL	**n.a.**	**218**	**278**	**310**	**-**	**-**	**-**

n.a.: not available.

The rate of population growth for the last three years has increased in all villages except Amaromin. Semi-regular proponent-supplied medical services provided from the early 1990s may have supported a higher level of general population health, in turn influencing population growth between 1996 and 2009.

The age profile of the population is skewed toward the younger age groups, however there are a reasonable number of persons in the older age bracket as shown in Table 6. This is compared to the national average of 2.6% of the population aged 65 years and over (NSO, 2015a).

Table 6 Population age distribution in mine area social catchment villages

Village	Total Population	Male	Female	Number and percentage of population under 15	Number and percentage of population over 60
Sokamin	360	190	170	146 – 41.6%	9 – 2.6%
Wameimin 1	188	98	90	79 – 42.0%	10 – 5.3%
Wameimin 2	196	107	89	73 – 38.4%	10 – 5.3%
Amaromin	137	75	62	57 – 41.9%	6 – 4.4%
Ok Isai	465	230	236	189 – 41.9%	18 – 4.0%
Wabia	393	188	205	146 – 38.0%	18 – 4.7%
Paupe	262	132	130	107 – 44.8%	12 – 5.0%
Total	**2,001**	**1,020**	**982**	**797 – 39.8%**	**83 – 4.1%**

Source: Data from December 2017 FRL census.

Observations on population change during the three-year period from 2014 to 2017 compared to the prior five years include:

- Wameimin 2 and Paupe have the highest rates of population growth among the mine area social catchment villages.
- Wameimin 1, Sokamin, Ok Isai and Wabia showed a slower rate of population growth; Amaromin showed a decrease in population growth.
- The greatest increase in the rate of annual population growth was at Wameimin 2 (1.5% to 6.3%).
- The greatest decrease in the rate of annual population growth was at Amaromin (4.3% to -1.4%).

Observations on household occupancy (persons per household) during the three-year period from 2014 to 2017 (Table 5) include:

- An increase in household occupancy was observed at Amaromin, Wameimin 2, Wabia and Sokamin.
- A decrease in household occupancy was observed at Paupe, Wameimin 1 and Ok Isai.

The gender ratios (number of males per 100 females) for the villages are shown in Table 7. The most obvious feature of this data is the higher gender ratio for the Miyan villages in comparison to the Telefol villages. The basis of this difference is not known. The gender ratio for the Telefomin Rural District at the time of the 2011 Census was 104 (NSO, 2014).

Table 7 Village gender ratios (number of males per 100 females)

Village	Gender ratio (2014)	Gender-ratio (2017)
Miyan social sub-catchment		
Amaromin	119	121
Sokamin	110	112
Wameimin 1	118	109
Wameimn 2	120	120
Telefol social sub-catchment		
Ok Isai	92	97
Wabia	100	92
Paiyamo social sub-catchment		
Paupe	116	101

Source: Data from 2014 and 2017 FRL census.

2.2. Livelihoods (social values 1 and 2)

Information on subsistence livelihood activity has been drawn from Bonnell and Robinson (1995), the CEH health baseline survey (CEH, 2018), and the household surveys undertaken by Coffey in 2015 which replicated the nutritional elements of the 2010 health baseline survey (CEH, 2018). This has been supplemented from the 2017 village surveys where available. Information on cash economy activity has been derived from the 2015 household and village surveys.

2.2.1. Natural capital / subsistence activity

Apart from Amaromin, villages in the Miyan social sub-catchment are in mountainous areas where the subsistence system is based on taro. It is acknowledged that there are continual changes in subsistence systems throughout PNG due to land pressure or factors such as the adoption of a more sedentary lifestyle close to infrastructure (e.g., airstrips and schools) (Bonnell and Robinson, 1995). Bonnell and Robinson (1995) state that the ‘sweet potato with its enormous number of cultivars will continue to expand and perhaps overtake taro as the staple of the mountain areas'. They also noted increased plantings of the less-favoured (but very robust) cassava.

Within the subsistence system 'cutting of the heavy bush is done by the men, but all other operations are carried out by men, women and children working together', with women and children doing most of the weeding (Bonnell and Robinson, 1995). Food preference indicated by a typical garden in mountainous areas in 1995 was taro, sweet potato and taro kongkong. Bananas, sago and breadfruit were enjoyable supplements but not eaten daily. Pawpaws were also grown in taro gardens or close to village houses, and there were inter-plantings of pitpit, pumpkin, cucumbers, cabbages, tomatoes, beans, onions, peanuts and greens. Food surveys in 2015 indicated that food preferences were basically unchanged. Labour requirements for gardens following initial clearing were not high but did need to be continuous.

Amaromin is situated at the head of the river plains (Plate 1), and the subsistence system incorporates elements from the Iwam people to the north. Typically, land preference for gardens is given to areas less likely to flood, but people have both hillside and river flat garden-sites. Labour is carried out by all family members, with vines and undergrowth cleared by women followed by the cutting of bigger trees by the men. Some burning of the trees is carried out, with cucumbers, pumpkins, melons, tomato, ginger and tobacco grown in the ashes. There are specialist areas (e.g., for corn and sweet potato) established in the gardens, which at the time was a practice not observed in the mountains. Bonnell and Robinson (1995) state that the impression is of 'mountain horticulture translated to hotter and flatter hills areas', with a much 'greater importance of sago in their diet'.

The Telefol social sub-catchment villages of Ok Isai and Wabia settled on the upper reaches of the Niar River relatively recently, with Wabia relocating to its present site in 1993. The subsistence system is similar to Amaromin, being in the foothills at the head of river plains. In 1996 they had not adopted sago to the degree of the Miyan villages at lower elevations; however, fishing and sago production were obviously of increasing importance (Plate 2). At Ok Isai there was a preference for establishing gardens on lower and flatter river areas that are more fertile. Taro is the main crop (Plate 3), with multiple cultivars planted and garden rotations approximately every 10 to 15 years.

In the Sepik and Frieda River areas, Bonnell and Robinson (1995) state that 'gardens truly are supplements to sago and fish rather than a major food source'. Nevertheless, gardens are established on riverbank levees, with the second food crop preference being bananas (Plate 4) and the third being taro. At Paupe, Bonnell and Robinson (1995) observed riverside gardens with a great number of species with strong evidence of innovation in agricultural practice. While the staple for Paupe villagers was sago, garden produce provided an important part of the diet.

Health baseline surveys carried out by CEH in 2010 (CEH, 2018) examined food security and the frequency of food consumption. These surveys were again undertaken by Coffey in April 2015 to examine whether there were any significant changes in diets over the interim period. In the absence of trade stores in some of these remote communities, these food consumption surveys are also an indirect indicator of the functioning of the subsistence system as it is the primary means of survival. The comparison between surveys is shown in Table 8. There has been no significant change in the types of food grown and consumed, however there are indications that the diversity of foods

Photo credit: Coffey

Plate 1
Aerial view of Amaromin village

Photo credit: Coffey

Plate 2
Woman cutting sago


Photo credit: Coffey

Plate 3
Taro garden


Photo credit: Coffey

Plate 4
Banana tree at Ok Isai

consumed has increased, possibly indicating greater availability of cash facilitating travel to neighbouring communities and the consumption of store bought foods.

Table 8 Food consumption changes between 2010 and 2015

Community	Foods consumed by a higher percentage of surveyed households in 2015 compared to 2010	Foods consumed by a lower percentage of surveyed households in 2015 compared to 2010	Food consumption diversity*
Amaromin	Sago, rice, fresh fish, green vegetables, tin fish, tin meat, vegetable oil	Sweet potato	Increase from 7 to 18 food types
Wameimin 1	Sweet potato, cooking banana, sago, fresh fish, yellow vegetables, tin meat, vegetable oil	Cassava	Increase from 11 to 22 food types
Wameimin 2	Cassava, cooking banana, fresh fish, pork, other meat, vegetable oil	Green vegetables	Increase from 11 to 14 food types
Wabia	Cassava, taro, cooking banana, sago rice fresh fish, yellow vegetables, fresh fruit, tin fish, tin meat, milk, sugar, bread, vegetable oil	Sweet potato	Increase from 18 to 25 food types
Ok Isai	Sweet potato, taro, cooking banana, sago, fresh fish, tin meat	Rice, flour, tin fish, sugar, bread, vegetable oil	Increase from 18 to 20 food types

*The increase or decrease in the number of types of foods consumed in 2015 compared to those consumed in 2010

Responses to a question in relation to food insufficiency are shown in Table 9. While there are food shortages from time to time due to weather, pests or crop diseases, it seems clear that these are not sufficiently serious to impose any long-term impacts on the health status of the population. The 2010 health baseline survey (CEH, 2018) indicated above average nutritional health with little wasting, stunting or underweight incidences in children under 5 years of age and little child malnourishment in the first five years of life.

Table 9 Food insufficiency responses for 2010 and 2015

Village	Percentage of surveyed households reporting previous 24-hour food insufficiency in 2010	Percentage of surveyed households reporting previous 24-hour food insufficiency in 2015	Comments on 2015 shortages
Sokamin	Not surveyed	Nil	Mainly taro and sweet potato, recent planting of gardens.
Amaromin	8%	8%	Mainly taro, recent planting of gardens.
Wameimin 1	Nil	Nil	Mainly sweet potato, recent planting of gardens.
Wameimin 2	Nil	Nil	Mainly cassava and taro, recent planting of gardens and destruction by pigs.
Wabia	Nil	Nil	Mainly taro, recent planting of gardens and destruction by pigs.

Village	Percentage of surveyed households reporting previous 24-hour food insufficiency in 2010	Percentage of surveyed households reporting previous 24-hour food insufficiency in 2015	Comments on 2015 shortages
Ok Isai	6%	Nil	Mainly taro and banana, recent planting of gardens and pest attack on taro.
Paupe	15%	25%	Mainly garden food and fish, significant destruction by pigs and limited fish catch.

Source: CEH, 2018 and Coffey household survey 2015.

Domestic water supplies, used for drinking, cooking and washing, are mainly sourced from unprotected surface water sources including rivers, creeks, springs and streams, with communal or household water tanks present in some villages (although water availability through this method was seasonal). An assessment of domestic water sources conducted by CEH in 2010 (CEH, 2018), indicated that domestic water sources in the mine area social catchment were of good quality but some water sources (particularly tanks) appeared likely subject to faecal contamination. Some villages had received support in the past for the provision of basic reticulated systems, and in some places water tanks had been installed. CEH noted that, in practice, without attention to maintenance, tanks posed a risk of becoming microbiological traps and the source of childhood diarrhoea, a major cause of morbidity in infants. In 2009 at Amaromin and Wameimin 1, the water supply was from a local mountain spring, gravity fed to the village through a polyethylene pipe providing a rudimentary reticulated water system. In 2015 the Amaromin system was in a state of disrepair, while the Wameimin 1 system was operational but often unserviceable due to sedimentation following heavy rain. There was no treatment of domestic water supplies except at Wabia which was recorded during the 2017 surveys.

During the 2015 surveys, a water sample was collected from a water tank in Paupe and analysed for contaminants. The contaminant values were below the PNG Drinking Water Standards and the World Health Organisation (WHO) drinking water guideline values.

The use of household pit latrines varied between villages with untreated human wastes being sometimes discharged to the surrounding environment; solid waste disposal was at best disorganised. At Amaromin, only a small proportion of the households had pit toilets (possibly due to an elevated groundwater level), with most human waste being disposed to the nearby river. Data from the 2009 household surveys indicated that waste disposal methods differed between households within a village and individuals in Amaromin, Sokamin, and Wameimin 1 reported using their own, rather than a communal, designated rubbish dump. Domestic water and sanitation practices are outlined in Table 10.

Table 10 Domestic water and sanitation

Community	Domestic water source	Sanitation	Rubbish disposal
Sokamin	Creek, tank	Private and communal pit toilets	Bush, bury, designated rubbish dump
Wameimin 1	River, reticulated water from mountain spring (in 2015	Private pit toilets	Bush, designated rubbish dump

Community	Domestic water source	Sanitation	Rubbish disposal
	often unserviceable after heavy rain), tank		
Wameimin 2	River, tank, spring	Communal pit toilets (one per two houses), opening dumping	Bush, river, burning, communal facilities
Amaromin	River, reticulated water from mountain spring (in a state of disrepair in 2017)	Pit, river	Bush, bury, river, designated rubbish dump
Ok Isai	River, spring, tanks	Private pit toilets, open dumping	Bury, designated rubbish dump, burning
Wabia	River, spring, reticulation from tanks	Private pit toilets, bush	River (biodegradables), designated rubbish dump, bush
Paupe	River, tanks, springs	Private pit toilets, river, bush	Designated rubbish dumps

Source: Coffey household survey 2009 and 2015; Coffey village survey 2017

2.2.2. Cash economy activity

The mine area social catchments are characterised by remoteness and the general absence of a market economy, however data on household income and expenditure derived from the 2015 household survey gives some insight into the sources, levels and uses for cash in the area and its surrounds. Principal income sources include government work or work on exploration activities for FRL, as well as working for alluvial gold in the streams draining from the area. Work with FRL is intermittent and only available for large numbers when there is significant site activity occurring. During the 2015 and 2017 household survey period there was a geotechnical drilling program underway that engaged a substantial number of employees from the surrounding communities.

Income from working for alluvial gold is regular in the Telefol villages (Wabia and Ok Isai) but intermittent in the other mine area social catchment villages with production levels dependent on the means used (e.g., dredge operation or manual sluicing). Income and expenditure estimates have been derived from the responses to the 2015 household survey questions.

Income

The relative contribution to total income provided by respective sources of income for each social sub-catchment area is shown in Figure 4. In particular, Figure 4 presents household income sources, average annual house income (excluding income from alluvial gold mining) and average annual household income from non-mechanised alluvial god mining across the three social sub-catchments. For the Miyan villages, alluvial gold mining and FRL employment were the most important sources of income as the isolation precludes almost any other cash generating activity. For Paupe, its location enables a range of income-generating activities to be undertaken including canoe transport to and from the Sepik River, trading in produce such as vegetables and fish with neighbouring Telefol villages that have a higher disposable income from alluvial gold mining, and the gathering and marketing of eaglewood. The 2017 village survey indicated that there are currently seven trading stores in Paupe but these are poorly stocked and three are were not trading at the time of the survey.

FRL employment was the primary source of income and closely associated with the supply of labour for the nearby Frieda River airstrip.

For the Telefol villages, producing and selling gold from alluvial mining generated income for a high proportion (up to 90%) of households within Ok Isai and Wabia. The 2015 household surveys indicated that this income generation also stimulated the operation of trade stores in the village (five in Ok Isai and two in Wabia). However, when the 2017 village survey was conducted the five trade stores in Ok Isai were not trading and had average levels of stock. Wabia village have increased the number of trade stores within the village to five but most were both poorly stocked and not trading at the time of the 2017 survey. Employment with FRL was the least important source of income generation, essentially due to the higher returns to labour available through alluvial mining.

Methods of small scale mining included the use of dredges, panning, locally-made sluice boxes, diving for gold with goggles and manually searching for gold under rocks or in small areas of accumulated sand or gravel. It was estimated that there are up to 27 dredges operated by residents of Ok Isai and Wabia employing approximately 128 dredge workers, with up to 600 persons regularly engaging in alluvial mining activity in Social Catchment 1A. Incomes earned through the operation of dredges is highly variable as they are affected by factors such prevailing environmental conditions, locational variability and the availability of tools, fuel and labour. They are also owned by a minority of households, and averaging their income across households will give a distorted appreciation of household income. Consequently, an estimate of income generated through alluvial mining by dredging has not been included in the average income calculations for respective villages; however, it is recognised that this form of alluvial mining is an important source of income generation in Catchment 1A.

Income from all sources (excluding income from alluvial gold mining) in Catchment 1A is shown in Figure 4. Miyan villages exhibited the lowest income, commensurate with their higher level of isolation. Paupe have historical relationships and river access to Telefol villages with whom they trade vegetables and fish, resulting in a higher level of average household income than Miyan villages.

Household income from gold, with the exception of gold won by dredging, is shown in Figure 4 for each social sub-catchment. The dominance of alluvial mining income in Wabia and Ok Isai is evident, though gold is still an important source of income for Miyan villages.

Income estimates by village for the Miyan social sub-catchment area is shown in Figure 5.

For Miyan households, average annual income from all sources other than gold is reasonably uniform, between PGK4,000 to PGK5,000 per annum.

Income estimates by village for the Telefol social sub-catchment area are shown in Figure 6.

For Telefol households in Ok Isai and Wabia, income earned from working alluvial gold manually was substantially higher than any other source of income. Anecdotal evidence suggests it plausible to produce between one and two grams of gold per day which equates to income of PGK70 to PGK100 per day. Working gold 24 days per month would subsequently generate between PGK20,000 to PGK40,000 per year. Working alluvial gold was recorded as being the primary economic activity amongst Telefol households.

Income estimates for the Paiyamo households are shown in Figure 7. Income from gold represents approximately 27% of total household income, reflecting the higher level of income generating opportunities available to Paiyamo households in comparison to Miyan households (with the exception of Wameimin 2). These opportunities include the provision of transport services and the harvest and sale of eaglewood.

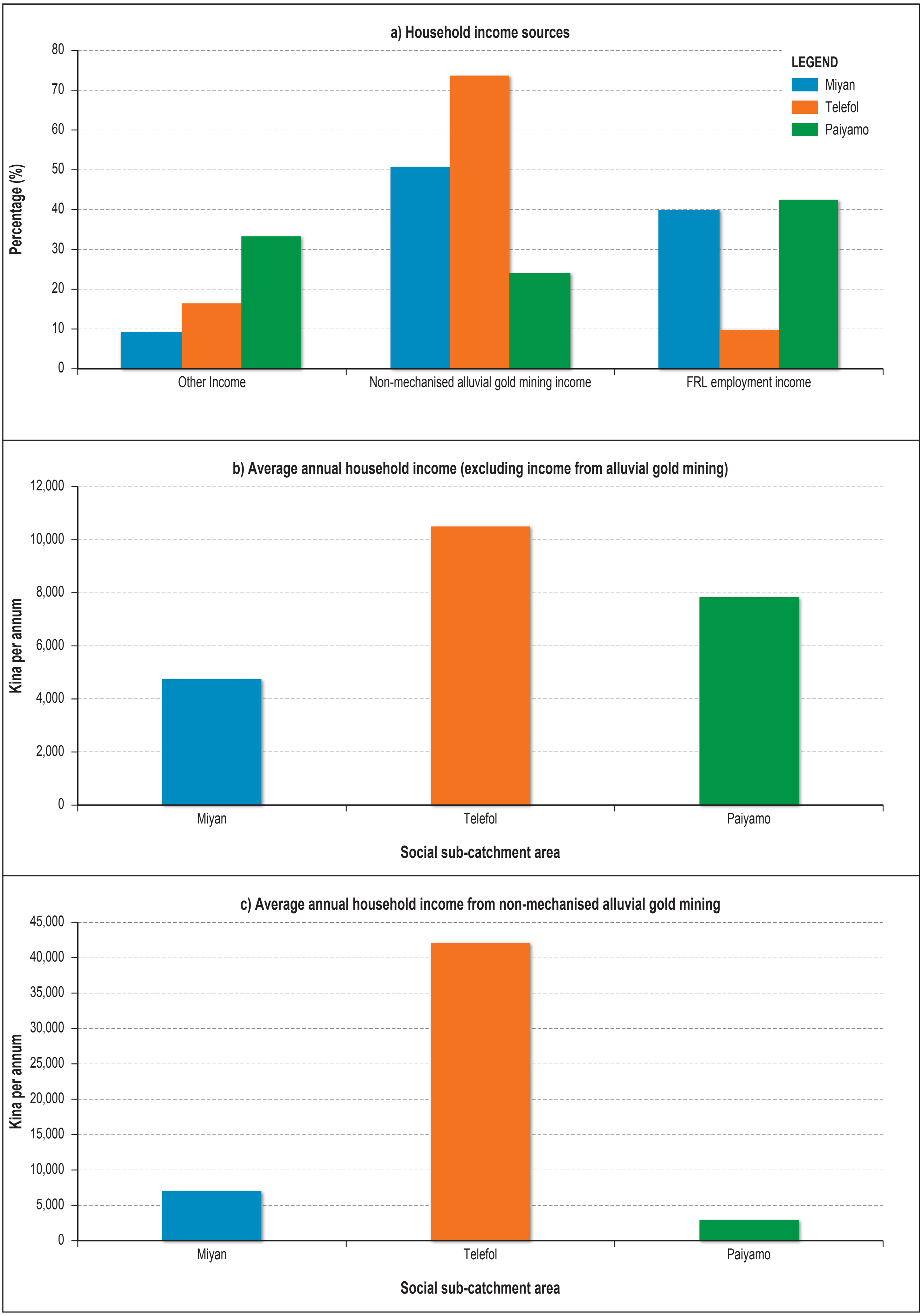
Gini coefficients for income inequality were estimated for the seven mine area villages to gain an appreciation of the distribution of income across households. The Telefol villages (Ok Isai and Wabia) were treated separately from the other five mine area villages as they have significant differences, i.e., they are located very close to the alluvial gold areas and are the biggest miners of alluvial gold. Household income estimates were obtained through a survey of twenty-five percent of households in the mine area villages in 2015. The results are shown in Table 11 and Figure 8, indicating significant levels of household income disparity across the five mine area villages and the Telefol villages (where there is a high level of access to alluvial gold workings).

Table 11 Gini coefficients for income equalities for mine area villages (Sokamin, Wameimin 1, Wameimin 2, Amaromin), Ok Isai and Wabia

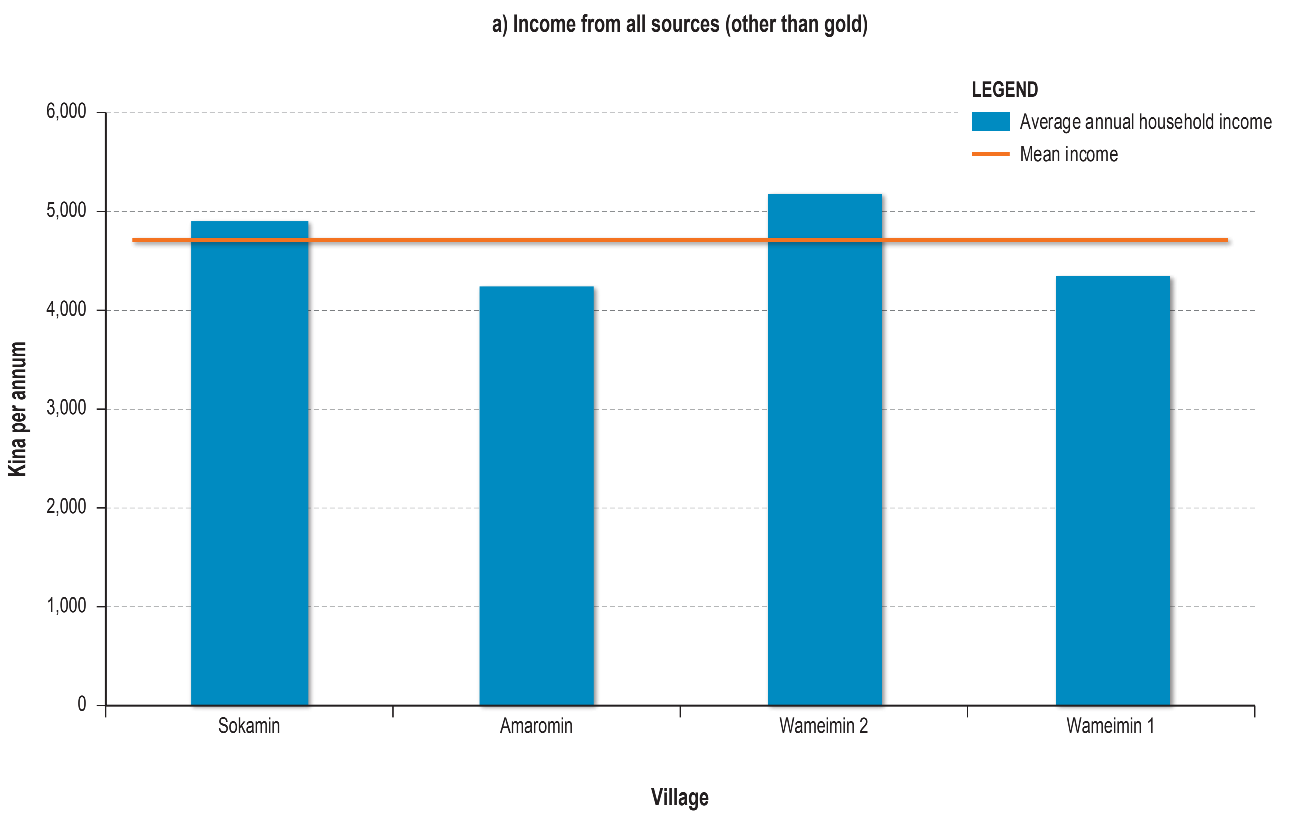
Community	Gini coefficient	Income received by bottom 40% of households	Income received by top 20% of households
Mine area villages	0.62	2%	68%
Ok Isai and Wabia	0.52	6%	56%

Women’s income-generating activity

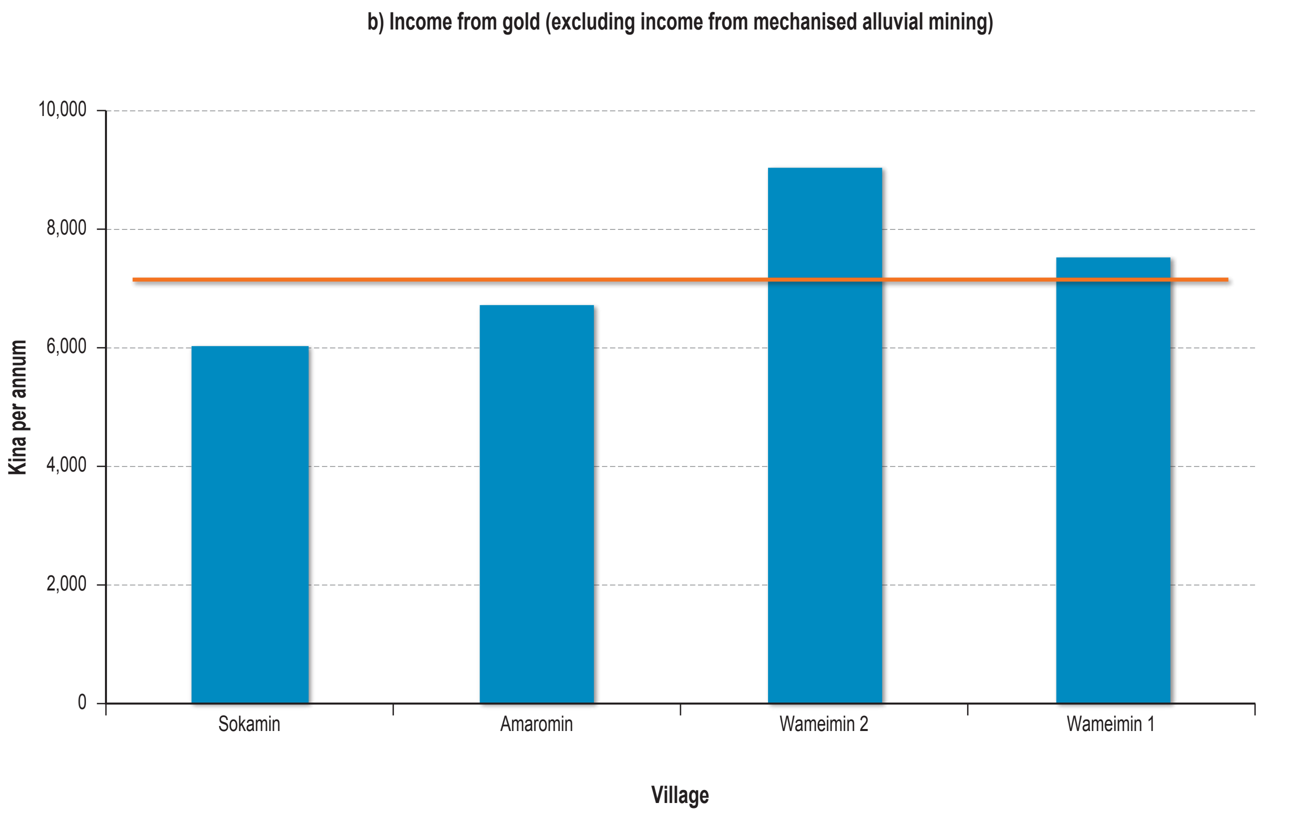
Traditionally, the sexual division of labour and wealth has meant women’s roles were anchored to ‘domestic’ contexts, with men monopolising income and employment. The distribution of wealth has, and continues to be, directed and controlled by males. Over many years of operation of the Frieda base camp and exploration activity, there has been a fluctuating level of purchase of village-grown produce for the mess. It is understood that the previous Project owner, XFRL, provided seed for villagers to establish gardens with desired produce not normally grown. While this practice has not been implemented by FRL to any great extent, through discussions and comment received during surveys it is apparent that this activity provided an important and highly-valued source of income for women in the villages who were not able or unwilling to undertake formal employment. Invariably they lamented the cessation of the practice, and were hopeful that it would be re-implemented at some time, particularly should development proceed. It is apparent that a program such as this could have the potential to provide an effective means of targeting important benefits to women and should be explored further.



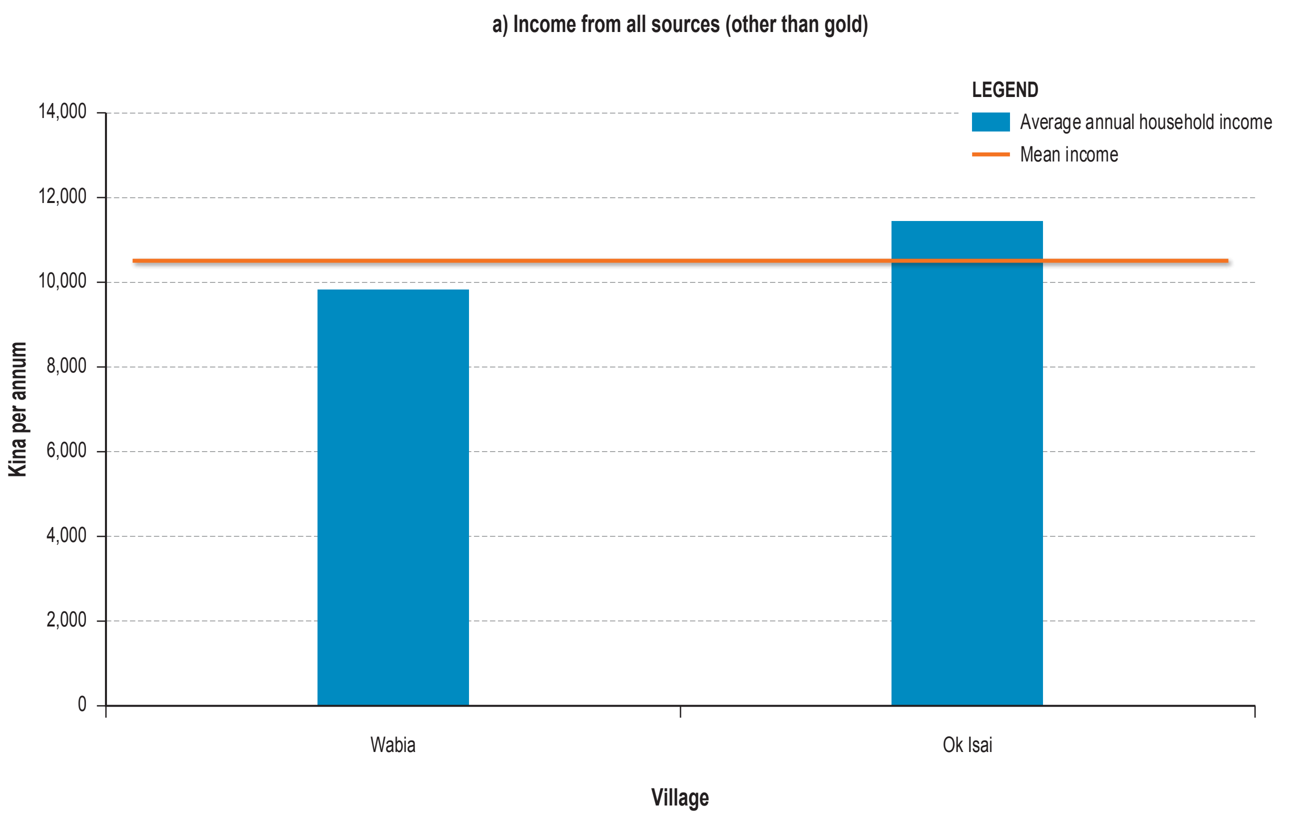
coffey A TETRA TECH COMPANY	Date: 09.02.2018 Project: 754-ENAUABTF11575B File Name: 11575_16_App1_F004_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Mine area average household income	Figure No: 4

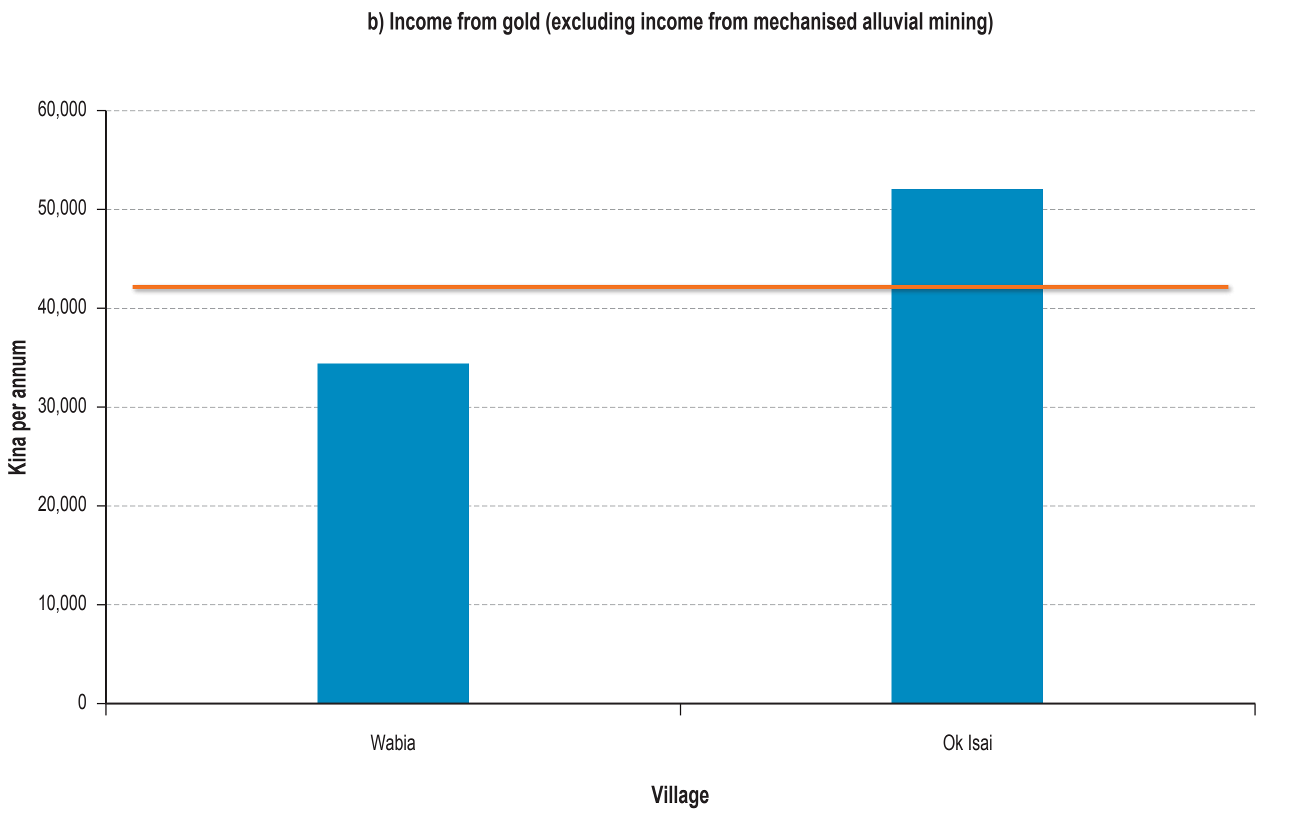


a) Income from all sources (other than gold)
LEGEND
Average annual household income
Mean income
Kina per annum
6,000
5,000
4,000
3,000
2,000
1,000
0
Sokamin
Amaromin
Wameimin 2
Wameimin 1
Village



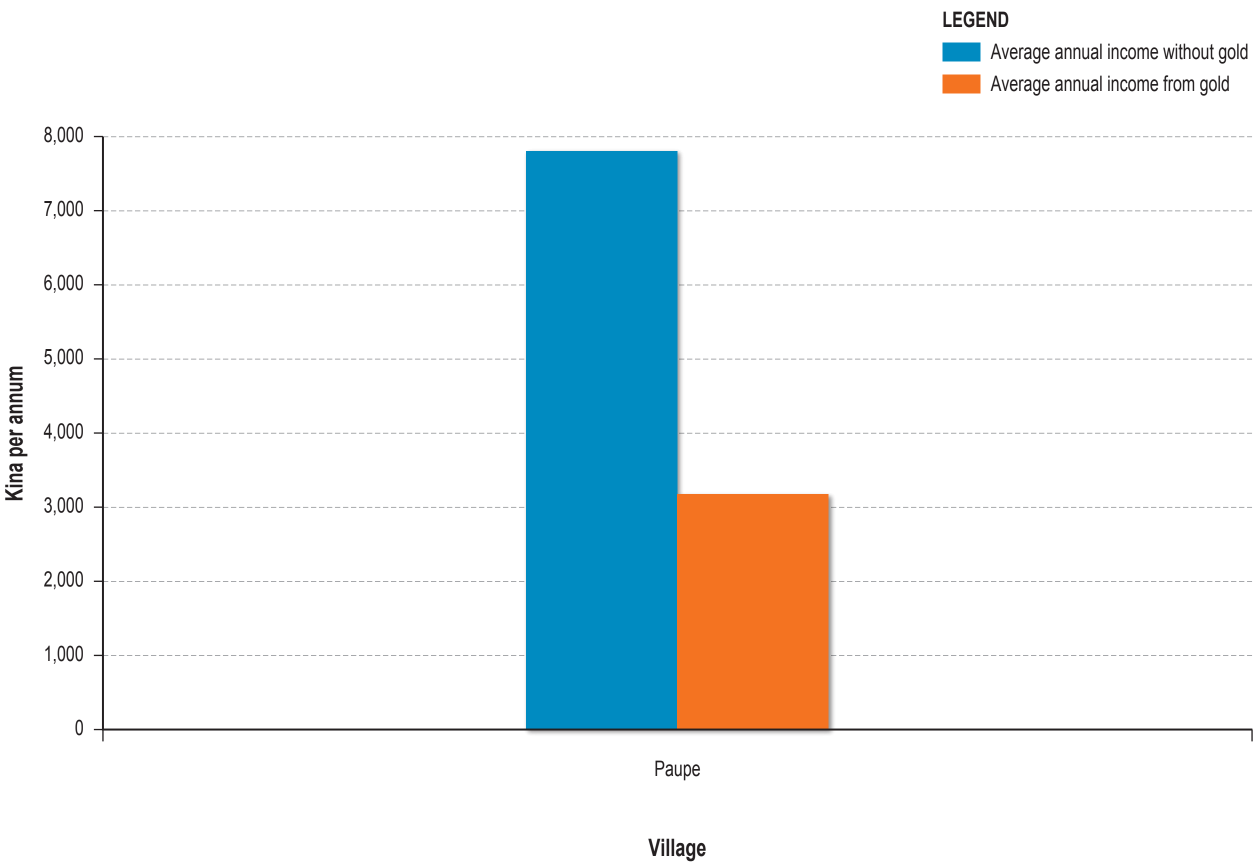
b) Income from gold (excluding income from mechanised alluvial mining)
Kina per annum
10,000
8,000
6,000
4,000
2,000
0
Sokamin
Amaromin
Wameimin 2
Wameimin 1
Village





coffey A TETRA TECH COMPANY	Date: 09.02.2018 Project: 754-ENAUABTF11575B File Name: 11575_16_App1_F006_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Telefol social sub-catchment household income by village	Figure No: 6

AI Reference: 11575_16A1_GRA006.ai_6



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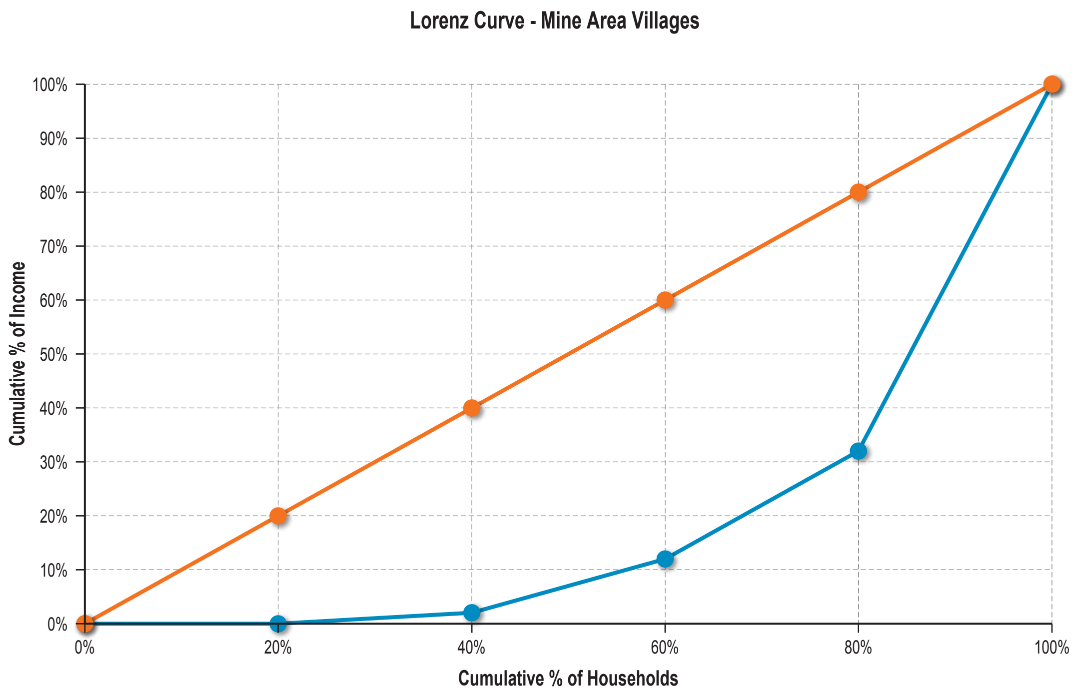
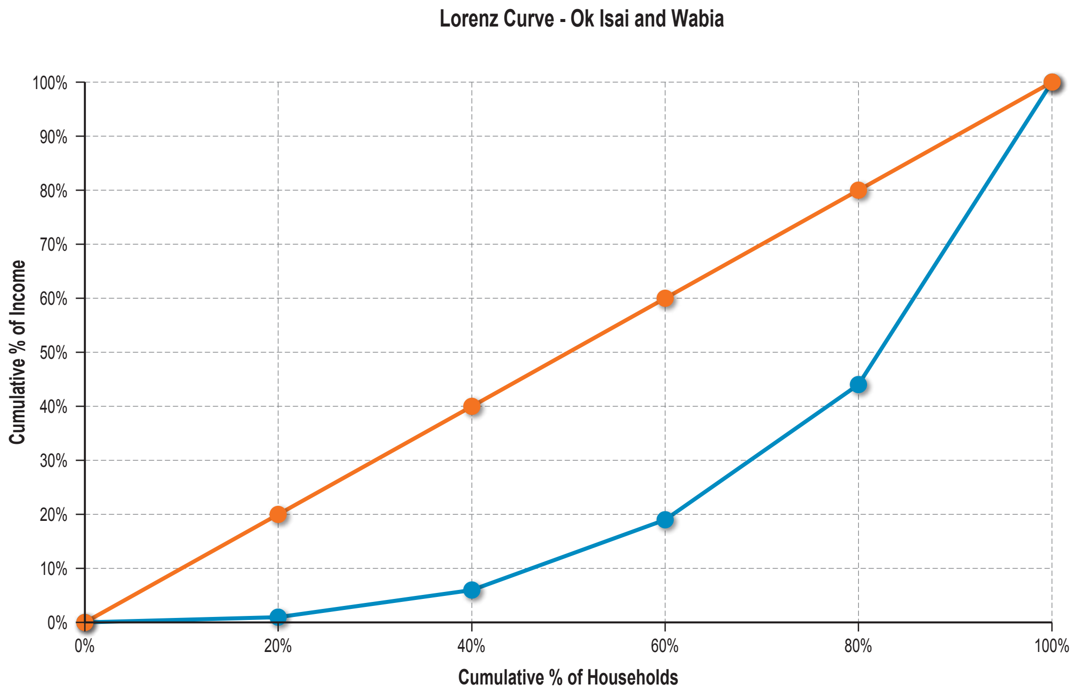
Date: 09.02.2018	Frieda River Limited	FRIEDA RIVER	Paiyamo social sub-catchment household income from all sources	Figure No: 7
Project: 754-ENAUABTF11575B				
File Name: 11575_16_App1_F007_GRA	Sepik Development Project			


Lorenz Curve - Mine Area Villages
Cumulative % of Income
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
20%
40%
60%
80%
100%
Cumulative % of Households


Lorenz Curve - Ok Isai and Wabia
Cumulative % of Income
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
20%
40%
60%
80%
100%
Cumulative % of Households

Expenditure

Estimates of expenditure were made by asking survey respondents to recall purchases made in the past fortnight, and to indicate the type and purchase price of major durable items purchased over the past year. As education costs are incurred by many households with children who attend school outside the village, respondents were also asked to indicate annual payments for schooling (fees, transport and boarding costs).

The summary figures shown in Figure 9 indicate the significant dependence on store goods in the Telefol villages (where households devote more time to working alluvial gold) as well as the highest level of expenditure on transport in these villages (where residents with cash avail themselves of air travel provided by the Missionary Aviation Fellowship as both villages have operational airstrips). Store goods are increasing in significance for the Paiyamo social sub-catchment, possibly due to the higher levels of income from FRL employment and lesser effort expended on planting and protecting gardens.

A proportion of the expenditure on education payments for all villages is the cost to send children away to attend high school (and often primary school). The higher level of expenditure in Telefol villages (Figure 9) on education may indicate the use of more expensive air transport to convey students to school. Expenditure on durable items (Figure 9) highlights the importance that villagers attach to household lighting through the purchase of solar battery and light packs (Table 12).

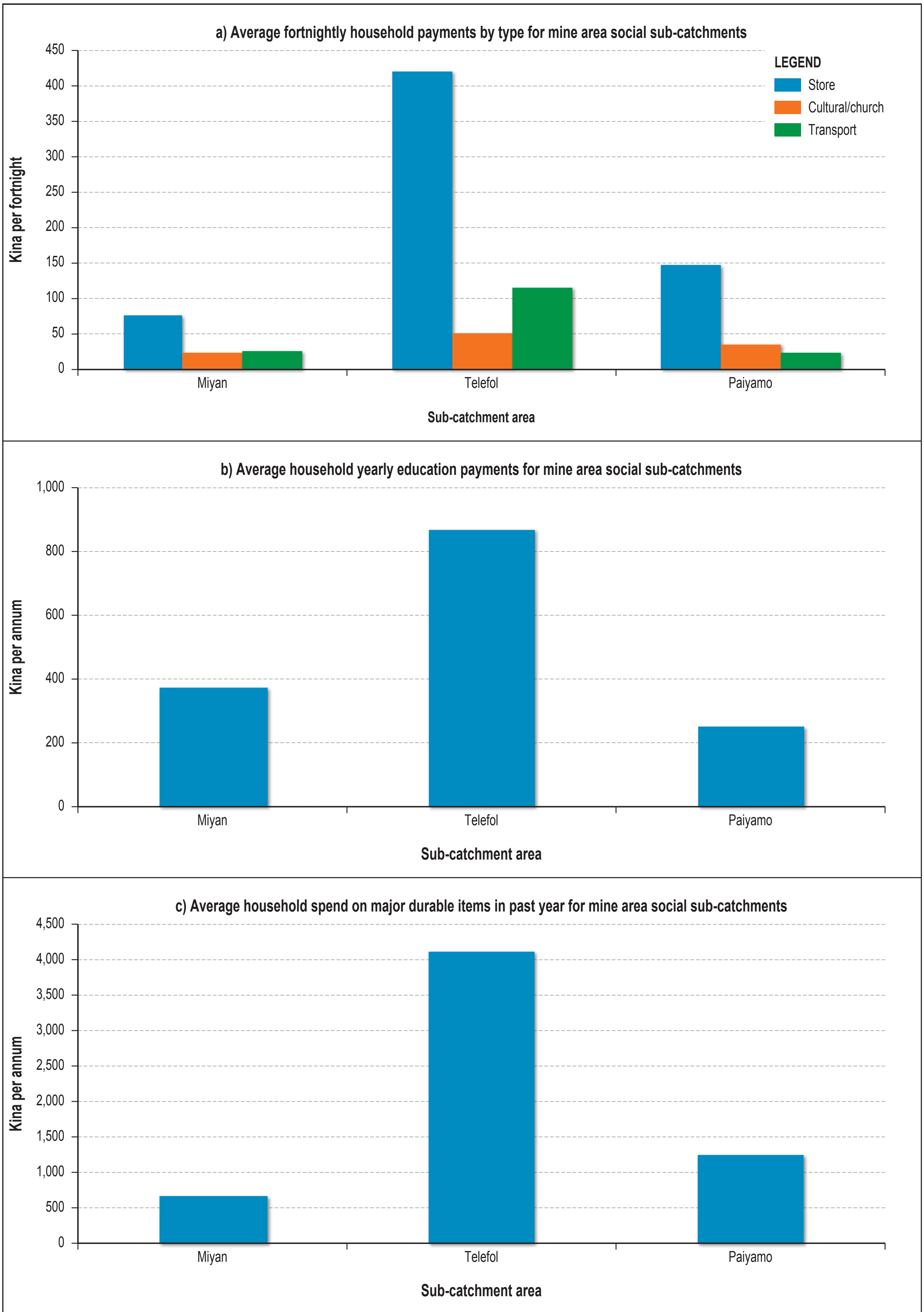
Table 12 Type and number of durable items purchased in the previous 12 months

Village	Type of goods				
	Solar lights	Generator	Gold dredge	Outboard motor	Building material
Sokamin	5				
Amaromin			1		
Wameimin 2	4				
Wameimin 1	5	1			
Wabia		1	1	1	1
Ok Isai	2	1	1	3	
Paupe	3			1	
Total	19	3	3	5	1

Source: Coffey household survey 2015.

Labour

Labour availability for subsistence gardening would appear to be adequate at present given that other demands for labour (principally work with FRL) are intermittent. Most of the local labour engaged by FRL could be classed as unskilled, though in some areas there is a reasonable amount of skills acquisition occurring on the job (e.g., drilling assistants, kitchen hands, helicopter loadmasters and aircraft refuelers and small equipment operators). Telefol villagers recorded the highest levels of



coffey A TETRA TECH COMPANY	Date: 13.09.2018 Project: 754-ENAUABTF11575B File Name: 11575_16_App1_F009_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Average household expenditure for mine area social sub-catchments	Figure No: 9

AI Reference: 11575_16A1_GRA008.ai_7

secondary and tertiary educational attainment (see Section 2.4.2). They were also the villages which engaged outside labour to work on gold dredges. It is estimated that approximately 100 (80%) of dredge workers come from outside the area.

Exploration employment has been and continues to be the major source of formal employment for mine area social catchment residents. Only the Provincial Government (in health and education service provision) and, to a lesser extent, missions have provided any other formal employment.

Very few people in the mine area social catchment are qualified in trades although those employed in exploration work have been provided with on-the-job training to increase their skill level and undertake semi-skilled work. There are a number trained as carpenters, mechanical assistants on drilling rigs, and supervisors.

Market access

With the exception of airstrips at Wabia, Ok Isai and Paupe (Frieda River airstrip), there is minimal to no access to economic support services in any of the mine area social catchment villages. There is no phone communication (with the exception of Wabia and Ok Isai that gained access to the Digicel mobile network in 2017) or road travel, with canoe travel being expensive due to the significant distance to marketing centres and the associated fuel cost for this. The nearest market centres are in Telefomin or Ambunti. Access to these markets takes several days travel by foot or canoe.

2.2.3. Status of social values

Comments made by those who participated in the social values workshop held in October 2015 and during the 2017 village surveys regarding potential impacts to livelihoods (social values 1 and 2) as a result of the Project are shown in Table 13. A noticeable difference between 2015 and 2017 surveys were mine area social catchment village concerns relating to resettlement, due to the fact that in 2015 there was not planned to be any villages resettled, while the current Project proposes the resettlement of four villages (Paupe, Ok Isai, Wabia and Wameimin 2).

Table 13 Village leader comments in relation to livelihoods social values 1 and 2

Miyan villages
• Impact on the Nena River valley area is recognised, though the group acknowledged that they had access to other areas for hunting and fishing. • Some concern for animals being scared away by noise / light etc. from operations. • Appreciation of the importance of business in a mining economy. • Recognise that there will be no impact from the mine on water used by Miyan villagers. • Minimal concern with direct physical impact and see potential for improvement through implementation of infrastructure improvements in village. • Natural resources are adequate, provided in-migration is limited. • Opportunities for cash income for village women who do not work in mine due to family responsibilities is very important. • No overt desire to retain a traditional lifestyle. • Currently there is limited use of money in daily life, though acknowledge that this will change with Project development. • General concern in regards to employment opportunities and issues between outsiders (immigrants) and locals.

Telefol villages
• General concern with respect to re-establishing housing and livelihoods in resettlement villages, while acknowledging that Project need for power through a hydro dam was unavoidable. • Negotiation of compensation for the sterilisation of alluvial gold areas would be a significant issue to resolve. • Income derived from previously supplying vegetables to FRL (mainly by women) was seen as very important. • Support required for business development and improving adult literacy.
Paiyamo (Paupe) village
• Access to land resources post commencement of mining are okay as alternative land areas are available. • Expressed the need to be resettled in an area with flat ground and adequate natural resources to support housing construction and livelihoods. • There would be a high level of ability to retain a full subsistence lifestyle if desired, but felt that most people would combine this with paid work. • Confirmed that the Nena and Frieda rivers were important for access to river fauna, hence high consequence for impacts. • Can undertake hunting in the Kaugumi catchment, therefore did not feel any significant impact from loss of Nena catchment for hunting. • Indicated that smaller streams were important for drinking, and these may be vulnerable to construction impacts. • Currently limited cash economy (selling produce to Telefol, some alluvial mining, FRL work and limited eaglewood harvest and sale). Distance from markets limits ability to exploit natural resources further, as well as lack of support services. Access to canoe transport from time to time. • There is only a limited skills base for employment. • Emphasised that the Frieda River is very important to livelihoods (washing, fish, turtles, eels, washing sago; only used for drinking when no other ready sources are available).

Source: Coffey, social values workshop notes, September 2015 and 2017.

Summary statements of the status of social values 1 and 2 are:

SV1 - The capacity to support subsistence livelihoods

Gardner (1996a) asserted that ‘the communities in the mine area retain a viable subsistence base and functioning social systems’. Twenty years on it is apparent through the investigations made that this statement remains valid for all mine area social sub-catchments, notwithstanding that the Telefol villages have established livelihoods based primarily on income derived from alluvial gold mining. The Miyan and Paiyamo subsistence bases appear to be robust, with the Paiyamo exploiting opportunities for income generation through the provision of transport and labour as they become available.

SV2 - Opportunities for participation in the cash economy

Opportunities for participation in the cash economy are limited to alluvial gold production and the supply of labour and services to FRL on an intermittent basis. The availability of better infrastructure (principally roads) would improve accessibility, however the area would remain relatively isolated which may reinforce a dependence upon the Project to provide economic opportunity.

2.3. Culture (social values 3 and 4)

The Miyan and Telefol live on the northern extremity of land occupied by the Mountain Ok, or Min, cultures. Traditionally, their lifestyle was characterised by frequent settlement shifts, long fallow one crop gardens dominated by taro, and a dependence upon hunting rather than domestically produced protein. Gardner (1996a) asserts that this lifestyle, coupled with large land areas and significant adverse health effects experienced in settlements at lower elevations, meant that ‘personnel, rather than land, were the crucial resource, and that competition for people, rather than for land, was a key element of social ‘progress''. In pre-contact times the northern expansion of the Mountain Ok was a response to expansionary pressures in the central valleys around Ifitaman, and resulted in the displacement of groups like the Owininga and upper Sepik peoples from the valleys (such as the Usage River valley) currently occupied. In colonial times the expansion of the Miyan people northward can also be attributed to the pressure that was also placed on them by the Telefolmin. Hence, life was characterised by continual raiding.

Gardner (1996b) also states that ‘an important feature of Mountain Ok cultures is the stress on kinship and co-residence, rather than descent as such, as paired principles of social organisation’. Miyan and Telefol culture was characterised by a preference for local endogamy (marriage with a person of one’s own social group, regardless of the descent identity of that person), and an open and inclusive mode of social existence, where in the past virtually any outsider (including, providing there was no prior enmity, those of other language groups) could find a welcome in a community. He posits that this characteristic, in the event of mine development, may mean a ‘painful transition from an open, inclusive mode of social existence to one that makes the closure and exclusivity of groups necessary’.

In this vein, Gardner (1996b) also states that traditionally the Paiyamo were also very open and generous to friends and relatives from other places and would let them come to live on Paiyamo land.

The Telefol settlement of Ok Isai was founded in the early 1980s following a move by its residents from a village further up the Niar River valley. The people are historically linked to villages near Telefomin itself. Wabia was settled around ten years later, and has strong links to villages near Eliptamen. These links to related areas will be very important in negotiations over the sharing of benefits (including employment and the delivery of improved community services) flowing from Project development.

The Miyan live principally in the Upper May River and Upper August River valleys of the Telefomin District, traditionally in dispersed settlements that would shift when life in the current one was judged uncongenial or threatening. Once highly mobile, the last 30 to 40 years has seen a process of settling of the previously nomadic population (‘sedentarisation’) and concentration of population into defined villages. The Miyan claim ownership or rights to use most of the SML area and a large portion of the Nena River valley area. Notwithstanding that the boundaries are contested by the Telefol and Paiyamo groups, there are generally cordial relations between the groups which are reflected in on-going negotiations with FRL in relation to issues concerning Project development.

The Paiyamo are the least populous cultural group in the mine area social catchment (largely residing in one village, Paupe) and are more closely related to groups of the Wario River system to the east and Duranmin, where there are genealogical connections, to the south. Paiyamo also have close relations with the residents of Auom (sharing resources between Lake Warangai and the Frieda River) and Iniok. Historically the Paiyamo were significantly impacted by the Telefol annexation of the upper Frieda River, and ‘have managed to maintain their population in recent decades by persuading outsiders to join them through offers of marriage and / or access to resources’ (Gardner, 1996a).

Land ownership

The issue of land ownership (and the associated delineation of land boundaries) of the land required for the FRCGP and FRHEP has been the subject of numerous investigations over the period of exploration and development studies. As boundaries tended to move over time depending on the relative strengths of competing groups, the issue of historical ownership of the Frieda River mineral deposits has been subject to on-going contestation between the Miyan and Telefol groups. While there have been a number of past agreements, an Agreement under the Land Dispute Settlement Act 1975 was signed on 12 January 2015 between the Telefol and Miyan landowning groups establishing criteria for membership of the landowning groups and the sharing of royalties for the HITEK and Nena mineral deposits.

While this aspect of land ownership is codified, the management of landowner group land not affected by the Project is subject to customary practice, influenced by the ‘openness’ of the Miyan, Telefol and Paiyamo communities as mentioned previously. There has been on-going acceptance of outsiders settling on customary land, but also instances of evictions of outside settlers when intractable disputes have arisen, for instance in Wabia. There has also been concern expressed by all groups regarding the potential for in migration should the Project proceed, and an acknowledgement that customary landowner power to control this has limitations and will require the involvement of state law enforcement agencies to be effective.

Cultural change

Among the drivers of the inexorable process of cultural change evident in the Miyan, Telefol and Paiyamo communities today are education (in particular the adoption of English language), contemporary governance and the influence of religion. As further discussed in Section 2.4.2, access to education in Catchment 1A is constrained by remoteness and a lack of educational services. Household surveys undertaken in 2009 recorded respondents (self-declared) ability to speak English. Results for Catchment 1A villages are presented in Table 14. With the exception of Sokamin, the Miyan villages recorded substantially lower rates of proficiency speaking English than the Telefol villages and Paupe. These results correlate with the levels of educational attainment as further discussed in Section 2.4.2. Contemporary governance and religious adherence is discussed in sections 2.3.1 and 2.3.2 respectively.

Table 14 Ability to speak English in mine area social catchment villages

Village	English (%)
Sokamin	18
Amaromin	2
Wameimin 1	6
Wameimin 2	6
Ok Isai	13

Village	English (%)
Wabia	34
Paupe	20

Source: Coffey household survey 2009.

2.3.1. Governance

Governance refers to the administrative and political framework, along with community decision making and law and order practices.

Telefomin District (Sandaun Province) is divided administratively and politically into four local level governments (LLGs) and 82 ward areas. These are: Telefomin Rural LLG, Yapsie LLG (on the west), Oksapmin LLG (in the east) and the Namea LLG (on the north). The Miyan and Telefol social sub-catchments are part of the Telefomin Rural LLG area while the Paiyamo (Paupe) are part of the Tunap/Hunstein LLG in East Sepik Province. The political leadership at the district level comprises of the elected member of the National Parliament, the presidents of the four LLGs and the ward members of the 82 wards in the district. During community surveys, awareness of the identity of ward councillors amongst communities in the mine and infrastructure area was variable and tended to depend on whether the ward councillor was resident in village or not (and even that did not guarantee that the rest of the residents knew who the elected person at the time was). Representation and contribution to decision-making from ward to LLG or district level was perceived to be low in all cases, matched with a lack of capacity to engage in planning processes or implement planning decisions. The Telefomin district development program plan (2014-2018) (Sandaun, 2014) chapter on existing development conditions (Chapter 7) outlines a system of formal governance characterised by a chronic lack of capable staff compounded by severe under-resourcing, and operating in a remote area with significant logistical constraints. This is not uncommon of district level governments in PNG.

During the 2009 surveys, governance, and law and order practices and capabilities varied from community to community, however overall there was very little formal law and order capability in the mine area social catchment. Generally, village councillors, community leaders and, in some cases, church leaders provided authority and helped to resolve conflict and manage intra-community relations. The Telefomin district development program (Sandaun, 2014) indicates that ‘Ward members in Telefomin are now conducting duties normally administered from sub district office by field officers like conflict resolution, ensuring public safety, mediating and settling disputes, maintaining order and other court related matters at the Ward level. Since there is no Police presence, Village Court Magistrates and Peace Officers to deal with those issues at respective ward level. The district is currently manned with only three regular policemen physically on the ground and they are not able to attend to all that is happening in the district’. The program also states that:

> *Land issues and disputes are also increasing in the district and there are no Land Mediators to deal with those issues as such it then gets into the hands of the Ward members who sometimes can’t handle alone and that at times get out of hand and trouble do flare out causing tribal clashes among tribes.*
>
> *Village Courts Services are not functioning and the poor Ward Members are trying all their best to uphold Law and Order in the communities that they live in. They report those problems that*

are beyond their control to the skeletal policemen in Telefomin or in Oksapmin and wait longer to get policemen to attend to those reported issues. Yapsie and Namea LLGs are without the regular policeman or even there are no Village Peace Officers.

Court Circuits are not happening at the district as there are no court houses or even no magisterial visits to the district. It is very expensive to fly those found to have committed offenses to stand trials and prosecutions in to Vanimo.

Ambunti is the location of the nearest court, lock up and police station for Paupe. Table 15 indicates governance infrastructure and law and order services and facilities at each community.

Table 15 Governance, law and order summary by village

Community	Governance	Infrastructure	Formal police	Auxiliary police
Sokamin	Village councillor; village council	None	None	1
Wameimin 1	Village councillor	None	None	None
Wameimin 2	Village councillor; committee of elders	None	None	None
Amaromin	Village councillor; village committee of elders	None	None	1
Ok Isai	Village councillor; village magistrate	None	None	2
Wabia	Village councillor; village magistrate	None	None	None
Paupe	Village councillor; sub-group leader	None	None	None

Source: Coffey household survey 2010.

Despite the absence of the formal apparatus for law and order, residents of Sokamin, Wameimin 1 and Wameimin 2 reported that criminality was generally low, with the only crimes committed in the 12 months prior to the 2010 survey being family fighting and domestic violence. Alcohol was considered a considerable contributor to the incidence of crime (from domestic violence and physical abuse through to public nuisance) across almost all communities in the mine area social catchment, despite village laws existing in most places banning the consumption of some or all types of alcohol. Amaromin, Wameimin 1 and Wameimin 2 reported only occasional issues as a result of alcohol consumption, with no incidence of drug use or gambling. The social values workshop in 2015 confirmed that what was recorded in the 2010 surveys is still representative of law and order issues within these communities.

2.3.2. Religious adherence

As reported by Gardner (Gardner et al., 1996), while all cultural groups in the mine area social catchment have changed with the coming of Christianity,

…old knowledge has not completely gone and people still think about the way they used to do things. People are especially concerned about the success of their gardens and the health of their children and sometimes the old ways are thought to be powerful in these important matters. All groups retain fundamental ideas about how the world can be affected by spirits and by human beings who have the knowledge.

A number of comments by village leaders relevant to these observations are listed in Section 2.3.4. Gardner et al. (1996) also states that:

> *…a significant aspect of the unity of the northern Mountain Ok populations and a conscious dimension of their identity is their commitment to Baptist doctrines.*

The Baptist Church (initially through the Australian Baptist Missionary Society, now through the Baptist Union of PNG) has been present in the Telefomin area for over 50 years and has had a significant influence on events in the area, delivering many services, such as maternal and child health, that have improved livelihoods. The Baptist Church presence also provides an important network of links between dispersed congregations through regular meetings of pastors and women's groups.

Table 16 indicates the status of mainstream Christian faith adherence in the mine area social catchment villages. All pastors were local men, except for the pastor at Wameimin 1 who was from Yawe, outside of the village. All villages indicated strong attendance at church services except for Paupe, where attendance was said to be weak. Churches in PNG are often providers of basic social services and this is the case in the mine area social catchment, where Sokamin and Wabia have church agency schools, and all villages apart from Sokamin receive assistance from health patrols supported by churches. Wabia appeared to be in receipt of the most substantial development assistance from a church agency, with the Baptist Union of PNG providing assistance with the production of sawn timber for the development of a primary school. Amaromin and Paupe appear to be villages where there is a low level of church influence.

Table 16 Mainstream faith indicators

Village	Religion	Dedicated church building?	Resident pastor?	Frequency of service	Attendance at services
Sokamin	Baptist	✓	✓	Weekly	Strong
Amaromin	Baptist	x	x	Nil	Nil
Wameimin 1	Baptist	✓	✓	Weekly	Strong
Wameimin 2	Baptist	✓	✓	Weekly	Strong
Ok Isai	Baptist, New Guinea Revival	✓	✓	Weekly	Strong
Wabia	Baptist	✓	✓	Weekly	Strong
Paupe	Baptist	✓	✓	Weekly	Weak

Source: Coffey survey 2015 and Coffey village survey 2017.

2.3.3. Archaeology and cultural heritage

Project development studies included a detailed assessment of archaeology and cultural heritage by Denham and Hitchcock (2015) followed by a targeted cultural heritage survey completed by ALA in 2010 (2018). Table 17 indicates the number of sites recorded for the mine area social catchment.

Table 17 Number of archaeological and cultural heritage sites recorded during the field investigations, by language group

Language Group	Number of sites
Miyan	66
Telefol	142
Paiyamo	43
Total	251

Source: ALA, 2018

For the Paiyamo the most significant sites, and the ones that they do not wish to see disturbed, are indicated to be landforms associated with various masalai spirits (who regulate the Paiyamo world order), ossuaries containing the bones of ancestors, and mountains that house the spirits of the dead. Certain episodes associated with the period of ‘marking the landscape’ have particular relevance to Miyanmin cultural heritage with reference made to ancestors named ‘Wanyea’ and ‘Oiyap’. In regard to the Miyan the assessment reported an overwhelming impression from people living at Wameimin 2 (and by default Wameimin 1) ‘that even though places are of varying significance, nearly all of them could be disturbed or destroyed during development if need be, although of course through consultation, negotiation and compensation’ (Denham and Hitchcock, 2015). The Telefol had the greatest number and density of cultural sites compared to any other group, with sites of greatest significance being ossuaries and some masalai places. A complicating factor in the consideration of Telefol claims to sites, as noted for land claims per se, is that the groups now resident at Ok Isai and Wabia incorporate refugees and captives from groups who formerly inhabited the area.

The potential for disturbance to sites (including the long-term potential for loss of cultural knowledge) is acknowledged and invariably approached with pragmatism, as indicated by the comments recorded in the following section.

2.3.4. Status of social values

Comments made on potential impacts to cultural social values as a result of the Project by leaders from social sub-catchment area villages during the social values workshop held in September 2015 are shown in Table 18.

Table 18 Village leader comments in relation to cultural social values 3 and 4

Miyan villages
• Pressure being exerted by extended clan relatives calling on / imposing obligations for the sharing of benefits. • Individual / immediate family is now a more dominant feature of village life. • Feel that some aspects of culture will be carried forward (e.g., bilas, traditional celebrations). • Acknowledgement that loss / change of culture occurs across the nation, and felt that there is a significant role for parents to address this (if they so desired). • Land boundaries from before exist, but they are always contested to a greater or lesser degree (even following land dispute settlement), but do not see land disagreements impeding Project development. • Noted the influence of adherence to Christian religion in altering traditions. • Expressed some degree of scepticism on the accuracy of anthropological reports in relation to stories and determining land boundaries.

Telefol villages
• Pressure being experienced from outside clan relatives in respect of benefit sharing, and there is also some concern with the criteria for benefit distribution (e.g., who is inside the first 'banis'). • See the need for government to address regional benefits. • Felt that plenty of culture was currently retained though some aspects were diminishing, with retention seen as a responsibility of parents. • Some aspects of traditional culture (such as the use of magic in relation to healing) are not practiced, though adults are aware of this and are generally comfortable with its passing, seeing no compulsion to retain. • Feel that culture is intrinsic to people and that identity will remain, even when there is large scale Project disturbance. • Aspects of traditional culture have changed over the exploration period (e.g., such as fear of some sites) as people have worked over the area with no perceived adverse effects. • Some aspects of culture will transform with the increasing importance of cash, and some aspects of traditional rights (e.g., around land ownership) will be strengthened by their inclusion in legal settlements. • Felt that the issue of in-migration was important, but second-generation (youth) appreciation of what leaders are agreeing to is uncertain, and there is a need for more consideration of this issue. • Sepik in-migrants are currently a problem.
Paiyamo (Paupe) village
• Felt that custom is strong currently, and Paiyamo value their distinct culture from that of their neighbours. • There is acknowledgement of the inevitability of future change (mixing of cultures and the disappearance of aspects such as dancing). *Tok Ples* is now not known by teenagers who can hear but not respond, and the custom of the *haus boi* is gone. All appears to be accepted as a consequence of exposure to outsiders. • While fundamental elements of culture remain and are practised (e.g., *sik mun* for women) the priority on the retention of culture appears to be low, and seen as a responsibility of adults to pass on to younger family members. There even appears to be some level of bewilderment as to why there was any particular focus on culture. • Pressure is currently being experienced from distant clans in relation to the distribution of Project benefits, and there is concern with the potential for in-migration.

Source: Coffey, social values workshop notes, September 2015.

Summary statements of the status of social values 3 and 4 are:

SV3 - An enduring ability to sustain cultural identity and traditions including connection to ancestors

Cultural knowledge among the current generation of adults is strong, though accompanied by an acknowledgement that elements of culture have been evolving since initial contact with the Australian colonial administration, and that they will continue to evolve, possibly at a higher rate, should the Project proceed. There is a common sentiment expressed that it is the responsibility of parents to ensure that important elements of tradition and ancestral connection are passed on to the next generation.

SV4 - An enduring ability to maintain customary rights to land access and resource use

Land custodianship in accordance with customary precepts for access and resource use is currently reasonably strong, partly supported by the isolation and difficulty of access and travel within the area. There is recognition that, in the event of the Project proceeding, there will inevitably be pressure for in-migration from outsiders and distant clan relatives that will require State and company support to manage.

2.4. Personal and community well-being (social values 5 and 6)

Hanson et al. (2001) describe people living in Sandaun Province as 'strongly disadvantaged relative to people in other districts of PNG' and that people living in Telefomin District:

> *…are extremely disadvantaged relative to people in other districts of PNG. There is no agricultural pressure, land potential is low, access to services is very poor and cash incomes are very low. Child malnutrition is of concern.*

The Telefomin district development program plan (Sandaun, 2014) gives some insight into the delivery of services aimed at ensuring the well-being of residents in the district. It describes the provision of basic health care services as a 'mammoth task' due to the dependence on expensive air transport, and indicates that:

> *…outreach maternal and child health programs are being scaled down to one or two rounds for major health centres…*

It also indicates that education services are:

> *…no different, school materials had to be stranded either in Vanimo or at Telefomin District HQ, as there are no regular flights into the district and even out to the remote parts of the districts for the teachers and materials to be delivered. Most schools in the remote areas of the district are not fully staffed with teachers, as accessibility and other hardships that the teachers are going through makes it difficult for them to live and work there.*

A World Bank report into health equity (Irava et al., 2015) highlights some of the challenges to addressing these problems, when it said that:

> *PNG faces a critical shortage of health workers. PNG currently has 6 health workers per 10,000 people, well below the 23 that WHO recommends are needed to achieve the MDGs2. In addition to the low numbers of health workers, the current workforce has been found to be inadequately trained, aging and demotivated by poor working conditions, including pay and infrastructure. Staffing shortages, poor conditions, and insufficiently trained staff are felt most acutely in the poorer/ rural areas…*
>
> *Initiatives geared toward the most vulnerable that are not increasing utilization, that is, mobile clinics or patrol visits need to be reviewed and amended. Though increased resources were allocated to these initiatives, the on-time receipt of funding by the front-line services remains an issue. The cost and distribution of medicine needs to be improved and monitored.*

In this situation, the well-being of residents rests in the hands of the communities themselves, and it is unsurprising that they rely on the development and service programs of churches where they are available, and in the case of the mine area social catchment, on support that can be provided by FRL.

2.4.1. Built environment (housing, infrastructure, amenity)

While all villages in the mine area social catchment are well-established, a number had been relocated in the relatively recent past (20 to 30 years) from former areas. This has been on the advice of government representatives citing improved accessibility for both services being provided to villages and for villagers to access services located elsewhere. Other reasons cited for resettlement included:

- Increasing mobility by moving closer to the river.
- Moving closer to the FRCGP and its facilities such as the Frieda River airstrip.
- Finding a more spacious location or consolidating smaller hamlets into one village.
- Inhospitable conditions (e.g., poor health sometimes thought to be the result of bad spirits in a location).
- At the direction of a pastor or other person of influence.

Village amenity is generally thought of in terms of proximity to potable water sources, river transport, and hunting and gardening areas. The built environment in all mine area social catchment villages is typical of remote PNG villages. Houses are generally constructed by the owner and residents working collectively using bush material; though in Ok Isai and Wabia (where there is substantial income from alluvial mining) persons with carpentry skills are sometimes engaged to build elevated houses of sawn timber framing on steel posts. Roofs in this case are invariably made of corrugated iron, but wall cladding may be of natural material, sawn planks or profiled steel sheets (Plate 5). The path to upgrading housing when funds are available usually involves adding a corrugated iron roof which then allows the collection of rain water (sometimes in a large polyethylene 'Tuffa' tank, but often in a range of smaller receptacles such as 200 litre drums or large cooking pots). There is evidence of this process of upgrading in all mine area social catchment villages except for Paupe. Surveys in 2017 found corrugated iron roofing present on 46 of the 61 houses surveyed in Ok Isai and 28 out of 68 of the houses surveyed in Wabia, 16 of the 33 houses surveyed in Wameimin 2 and 13 of the 44 houses surveyed in Paupe. The coverage of Miyan houses is impressive given the remoteness of villages and the requirement to carry all material by hand over steep mountain tracks, as well as the costs incurred to transport the material initially to pick-up points. Other improvements to housing include the addition of windows with insect screening, as well as the use of battery powered solar lights which appear to be a priority purchase for households. Sanitation is mainly by means of pit toilets, though use of bush areas does occur. In general, villages are very clean and devoid of litter, probably due to the low consumption of store-bought packaged food. The status of water supply and sanitation is described in Section 2.2.1.

The provision of other public infrastructure is extremely limited, and where it is in place it is difficult to sustain. Villages surveyed in 2017 indicated that the movement of people and goods was mainly by canoe (in some villages, motorised canoes), walking and aircraft. Wabia and Ok Isai both have airstrips (Plate 6) which are maintained, however a piped water supply at Amaromin (initially installed by a previous project developer) has been in disrepair for what appears to be a lengthy period.

Two villages (Sokamin and Wabia) indicated the presence of a community meeting hall, and sporting facilities (such as playing fields and volleyball courts) were rare and generally not maintained to a good standard even where available. The 2017 surveys observed Ok Isai to have a community meeting hall powered by a combination of solar and generator power and a recreational playing field, and a volleyball court at Wameimin 2. In Sokamin and Wameimin 1 there are topographical constraints to the establishment of dedicated areas for playing fields (limited level areas of ground), though all villages have helicopter landing areas established by FRL. Only Ok Isai and Wabia villages have mobile phone network, however all have access to radio communication with the Frieda River airstrip or church headquarters. Wabia, Ok Isai and Paupe villages have access to motorised canoe transport but no built landing facilities (Plate 7 and Plate 8).

The status of health and education infrastructure is described in Section 2.4.4.

2.4.2. Human capital (education and health status)

Education

Table 19 shows that the Telefol villagers have attained the highest levels of secondary and tertiary education in the social catchment (8.4% and 10% for Ok Isai and Wabia respectively).

Table 19 Highest education level attainment by village

Village	None (%)	Elementary (%)	Primary (%)	Secondary (%)	Tertiary/ vocational (%)	Unknown (%)
Sokamin	42.6	10.9	42.2	3.5	0.4	0.4
Wameimin 1	44.4	15.3	21.5	1.4	0	17.4
Wameimin 2	45.7	11.9	23.2	4.6	0	14.6
Amaromin	51.7	2.6	19.8	1.7	0	24.1
Ok Isai	37.9	1.7	27.6	7.8	0.6	24.4
Wabia	41.7	5.3	24.1	9.7	0.3	18.8
Paupe	65	12.9	17.8	1.2	0	3.1

Source: Coffey household survey 2015.

During the 2009 village surveys, women’s groups from all villages highlighted the need for education and training opportunities for adults as well as children, suggesting adult, specifically women’s, literacy classes and sewing lessons as useful contributions. In 1995 and 1996 representatives from the then-project proponent provided the women of Paupe with sewing machines, materials and training. In October 2009, XFRL had funded a women’s literacy program in Amaromin. Similarly, the women of Ok Isai and Wameimin 2 reported that a women’s literacy program was operating within their village, with one course having been completed and more to be run in the future. The 2017 village surveys indicated that educational development needs continue to be a priority, particularly for the village of Wameimin 2.

Photo credit: Coffey

Plate 5
Houses at Ok Isai showing use of different construction materials

Photo credit: Coffey

Plate 6
Airstrip at Ok Isai


Photo credit: Coffey

Plate 7
Canoes at Ok Isai


Photo credit: Coffey

Plate 8
Canoes tied up at Wabia

Health

The health status of families is a priority issue for residents of the mine area social catchment villages. Table 20 shows the reported medical conditions recorded during the 2010 health baseline survey (CEH, 2018), indicating the significant morbidity due to malaria and intestinal parasites. During the 2015 community surveys informants indicated that fevers due to malaria and upper respiratory tract infections and diarrhoea were the most prominent morbidity factors. The Telefomin district development program plan (Sandaun, 2014) indicates that in addition to upper respiratory tract infections and malaria, skin disease was also an important source of morbidity, however this was not obvious during the 2015 community surveys. Table 21 presents a summary of the 2010 CEH survey (CEH, 2018) and a comparison with the observations relevant to health made during the 2015 and 2017 surveys. Note that the 2015 and 2017 household surveys focused on collecting socioeconomic data at a village and household level and did not involve a health baseline survey, therefore comparisons against some 2010 health baseline survey results is not possible.

Table 20 Percentage of people surveyed in 2009 that reported medical conditions in the previous 12 months

Village area and number surveyed	Asthma (%)	Pneumonia (%)	Hypertension (%)	Intestinal Parasites (%)	Malaria (%)	Dengue-like Fever (%)
Mine area social catchment villages (480)	3.1	1.3	4.4	39.0	77.0	-

Note: The description 'dengue-like fever' is based on the observed symptoms. In many instances, the individual had suffered from viral infections.
Source: CEH, 2018.

Table 21 2010 Health survey results and 2015 and 2017 health observations

2010 Health survey results*	2015 Village survey observations	2017 Village survey observations
Environmental health		
• Reasonably typical for remote low-altitude rural and remote communities in PNG. • For most village households, the results confirm that overcrowding and ventilation were not of health concern. • The majority of village households generally had at least one mosquito net, but insufficient bed nets for all of the family. This is particularly notable at Auom 3 (89%), Wabia (81%) and Iniok (58%). The general practice at these communities appeared to be to reserve the mosquito nets for babies and infants. At all of the villages, none of the bed nets were treated with pesticides, since purchase. • The availability of screens and use of mosquito nets, considering the observed high malaria incidence does not appear to be effective as a means of vector control. • Overall smoking rate (49%) was markedly higher than that reported both nationally (37%), as measured in the Mt Obree area of	• No significant observable changes. • Kapa roofs: Telefol (64%), Miyan (31%), Paiyamo (5%). • Paupe in most obvious need for improvement in housing. • Piped water supply at Amaromin in disrepair; pit toilets at Wameimin 2 of a higher standard than elsewhere; no overall improvement in water supply; villages clean.	• No significant observable changes. • Iron roofing present on 16 out of 33 houses surveyed in Wameimin 2; 13 out of 45 in Paupe; 28 out of 68 in Wabia and 46 out of 61 in Ok Isai. • Water sourced from tanks, rivers or lakes are said to be in good or satisfactory condition. Treatment of water only occurs in Wabia. • The village surveys generally indicated the need for an upgrade to service facilities and

2010 Health survey results*	2015 Village survey observations	2017 Village survey observations
Central Province (30%) and in a recent study of inland villages in Madang Province (37%). • Both the socio-economic and health surveys found that alcohol consumption was largely restricted to adolescent and adult males in all of the communities with the exception of Ok Isai where a significant number of females reportedly consume alcohol.		equipment provided by the Aid Posts.
Nutrition		

• Nutritional surveys identified significant differences in the range of food consumed and consumption frequencies between the more isolated inland villages and those along the Frieda and Sepik rivers.
• Degree of isolation, local environmental conditions and household access to a cash income stream were the main determinants for food diversity and food consumption frequency.
• Food insufficiency was invariably either a short-term issue, relating to insufficient taro or other crops planted, unexpected visitors, or was a consequence of large family size (Paupe and Iniok).
• 24-hour food recall and food frequency survey indicated:
  ▪ Tubers supplemented by banana, provided the main carbohydrate source at Amaromin, Ok Isai, Wabia and the Wamiemin 1 and 2 villages.
  ▪ Consumption of rice dominated at the more affluent communities of Ok Isai and Wabia.
  ▪ More than 50% of the households at Paupe had consumed fresh fish on the previous day.
  ▪ Tinned fish and tinned meat have almost entirely replaced fresh fish at Ok Isai (90% of households).
  ▪ The diet at Ok Isai, while still including the traditional consumption of tubers and green vegetables, is largely dominated by store-purchased foods. A similar situation is apparent at Wabia.
• Consumption of store foods by household in the other mine area villages, was very low.
	• Store food for mine area social catchment villages (Wabia, Ok Isai, Paupe) appear to be around 25 to 50% higher than at Pagwi, with price of some items (e.g., cooking oil) up to 100% higher.
	• No discernible change in food insufficiency.
	•
	•
	• 2010 Tinned fish and tinned meat have almost entirely replaced fresh fish at Ok Isai (90% of households)
	• 2015 A higher consumption of fresh fish (50% of households).
	• 2010 Ok Isai diet largely dominated by store-purchased foods
	• 2015 Ok Isai modest decrease in dependency on store foods; Wabia, significant increase in store foods consumed; Paupe and Auom 3 show some intrusion of store foods, with a significant increase in consumption of rice at Paupe.
		• No nutrition data collected in 2017.

Anthropometric measurements		
• Indicated above average nutritional health with little wasting, stunting or underweight in children under five years of age. Little child malnourishment in the first five years of life. Mildly overweight children in all of the age groups are of some significance, but not of health concern.	• Little observable evidence of obesity, even in camp mess.	• No anthropometric measurements made in 2017.

2010 Health survey results*	2015 Village survey observations	2017 Village survey observations
• Comparison of the mean adult values for weight and height suggest that male weights were markedly higher in those communities that are transitional towards urban PNG lifestyles. The villagers at Iniok, Ok Isai and Wabia, by example, were generally more affluent and had better food diversity and food quality. • Small survey of XFRL employees (35) at the Frieda River airstrip indicated that on average, employees were approximately 10 kilograms heavier than their village lifestyle counterparts. • Measurement of blood pressure, indicated that there were few hypertensive individuals, as to be expected in a group with very low levels of adult obesity. • Spleen enlargement was typical of communities living in hyperendemic malaria areas of rural and remote PNG. • Prevalence of eye infections was similar to the results reported for a number of other inland village groups, but markedly higher than that observed along the Ramu River system in Madang province. • The prevalence of skin infections varied between villages and on a whole-of-population basis, was somewhat higher than that reported in other recent PNG studies.		
Clinical measurements		
• The medical examinations clinically identified four unreported cases of tuberculosis at Wabia (2) and Amaromin (2) confirming that there are pockets of uncontrolled tuberculosis in these communities. Since the examinations involved only 19% and 26.7% of the respective total populations at Wabia and Amaroumin, the prevalence is significant. • None of the villages appeared to have an awareness of family planning. Girls marry at very young ages, multiple births are routine and although unconfirmed, there would appear to be unusually high maternal and 0 to 12 months infant mortality. • Blood pressure results were almost universally in the normal to low range, with little difference between the males and females of all age groups. • Only two cases of liver enlargement and no cases of kidney enlargement in any of the villagers examined. • Splenomegaly (spleen enlargement) result (overall 38%; Miyan 18%; Paiyamo 46%; Telefol 47%) very similar to that reported in Madang Province (41%) for mid-altitude rural villagers.	• No clinical measurements made in 2015.	• No clinical measurements made in 2017.

2010 Health survey results*	2015 Village survey observations	2017 Village survey observations
• Prevalence of eye infections were somewhat comparable with those reported for rural and remote villages in the remote Fly River region. • Prevalence of skin infections was scabies 0.2%, scalp infections 1.1% sores and tropical ulcers 21.2%, ringworm 18.4% and other skin infections 43.2%. These results were similar to those reported for Western Province lowland communities.		
Immunisation rates		
• Villages had widely variable immunisation coverage rates. • On a whole-of-population basis, immunisation coverage was markedly below the average in PNG.	• Immunisation rates were consistent with the PNG average which ranged from 63% to 84% dependant on the specific vaccine.	• Immunisation rates not recorded in 2017.
General state of health		
• A comparison between villages, identified Amaroumin (56%), Auom 3 (65%), and Paupe (72%), as reporting the lowest health satisfaction ratings. • Over the previous 12 months the participants from all communities had sought little treatment for medical complaints, other than malaria (77%) and internal parasites (39%).	• No observations recorded in 2015.	• Young children in Wameimin 2 and Wabia do not receive regular immunisations. Paupe and Ok Isai do. • Main type of illness for Ok Isai, Wabia and Paupe is diarrhoea, malaria and fever. • Main type of illness for Wameimin 2 is skin infections, malaria and upper respiratory infections.
• Self-reported medical complaints indicate a high prevalence of fever associated with malaria and upper respiratory tract infections.		

* Focussing on PNG Department of Health priority health indicators.

Children’s health

A snapshot of the status of select indicators of children’s health in the Sandaun and East Sepik Provinces, compared to the national level, is shown in Table 22. While remote, Sandaun and East Sepik provinces compare favourably when compared to the national level on a number of indicators. In 2013, Sandaun Province experienced an outbreak of measles (in the Vanimo / Green River District) for the first time in five years.

Table 22 Children’s health indicators

Indicator	Sandaun	East Sepik	National
Percentage of children under five weighed at clinics who are less than 80% weight for age	31%	27%	25%
Percentage of live births in facilities that weigh less than 2,500 grams	16%	16%	9%

Indicator	Sandaun	East Sepik	National
Incidence of diarrhoeal disease in children younger than five years (cases per 1,000 children)	232	132	244
Outreach clinics held for every 1,000 children younger than five years	25	11	34
Percentage measles vaccine coverage for children younger than one year	67%	32%	49%
Percentage 3rd dose pentavalent coverage for children younger than one year	38%	27%	46%

Source: Department of Health, 2013

The nutritional status of children under five years of age is commonly assessed using three indices: weight-for-height (wasting) which reflects acute growth disturbances, height-for-age (stunting) which reflects long-term growth faltering and weight-for-age (underweight) which is a composite indicator of both long- and short-term effects. According to a recent research working paper by the World Bank (Hou, 2015):

> *Maternal and child undernutrition is a pervasive and detrimental condition in PNG. Despite rapid economic growth during the past decade, the stunting rate for children under 5, one of the primary indicators for child undernutrition, was estimated at 46 percent in PNG in 2010, stagnant from 44 percent in 2005.*

The data from the 2010 health baseline survey (CEH, 2018) was reviewed to assess the significance of this issue in the mine area social catchment villages. Table 23 presents survey data as the percentage of children under 71 months of age, falling below two or three standard deviations reference population median value for each of the three indices weight-for-age, height-for-age and weight-for-height. Whilst accepting the normal caveats associated with such a small sample, it can be seen that there is little child malnourishment in the first five years of life in mine area social catchment villages. The survey results also indicated that there were a number of mildly overweight children in all of the age groups which were of some significance, but not of health concern.

Table 23 Anthropometric data of children 12 to 71 months of age (all values %)

Age (months)	Number	Weight-for-age		Height-for-age		Weight-for-height	
		Underweight		Stunting		Wasting	Overweight
		< -3 sd	< -2 sd	< -3 sd	< -2 sd	< -2 sd	< +2 sd
12 – 23	17	0	0	0	5.9	0	5.9
24 – 35	31	0	0	0	3.2	0	6.5
36 – 47	49	0	0	0	2.0	0	2.0
48 – 59	38	0	0	0	2.6	0	5.3
60 – 71	34	0	5.9	0	3.0	3.0	3.0

sd = standard deviation.

The results compare favourably with the World Bank anthropometric database for lowland and highland fringe communities in PNG, which although using different criteria nationally, identified a prevalence of stunting in these geographic groups of 35% to 59% (CEH, 2018). The results for wasting in the mine area social catchment population is also at the lower end of the values recorded in the World Bank survey of 0 to 14.8% and similar to the prevalence observed in Madang and Morobe provinces in 2007 (0% and 2% respectively). The weight-for-age measure for mine area social catchment villages also compares favourably to the 2012 provincial figure of 31% for children under five.

Immunisation of children is supported by FRL in the mine area social catchment villages. The status of child immunisation in November 2015 survey is shown in Table 24. All children born in 2015 had commenced their immunisation, and the immunisation rate for children 1 to 5 was 73%.

Table 24 Status of child immunisation as at November 2015

Village (No children surveyed)	Immunisation status			
	Infant (0 to 12 months) Started (%)	Child (1 to 5 years)		
		Complete (%)	Incomplete or behind schedule (%)	No record (%)
Wameimin 2 (28)	100	70	22	9
Wameimin 1 (47)	100	62	38	0
Amaromin (18)	100	100	0	0
Ok Isai (83)	100	59	19	22
Wabia (73)	100	57	22	21
Paupe (47)	100	68	16	16
Mean coverage	-	73%	-	-

Women's health

The women's focus groups conducted in each village as part of the 2010 socio-economic survey conducted by Coffey sought information specifically about women's health.

In the mine area social catchment, most villages did not have access to any government maternal health services and women delivered their children without medical assistance, relying on FRL's healthcare personnel in the case of serious complications. A number of villages reported, through the village survey, to have a village birth attendant present in the village. Some villages reportedly had access to maternal health services outside of the village, but few women utilised these services due to the distance to access the service and the inconvenience of travel when pregnant. Village surveys undertaken by Coffey in 2015 confirmed the 2010 survey results relating to maternal health.

CEH (2018) noted that although unquantified, it appeared that a combination of poor hygiene, multiple births in very young women and the lack of pre- and post-natal support was a major contributor to the high-level of mortality (and evident morbidity) in females aged 15 to 45 years.

Women were largely aware of family planning methods; however, accurate knowledge about family planning and access to contraceptives was variable. The contraceptive pill and injections were reportedly more readily available than condoms. Agreement for the use of contraception was reportedly determined by husbands, many of whom felt that their wife's use of contraception would reflect negatively on their status by resulting in less children (a status of virility), and implying that their wife may be promiscuous.

Traditional birth control methods were said to be used in only a small number of villages surveyed for the socio-economic study; methods included the ingestion of various herbs and betel nut, and the traditional practice of placing herbs in the mouth of a turtle and releasing it into a stream to prevent pregnancy.

Women's groups from most villages reported that abstinence from sex after childbirth was practiced as a means to allow the mother to recuperate and to prevent another immediate pregnancy. The period of abstinence varied dramatically from village to village with a period of four to six months the most commonly stated duration. In nearly all cases, the abstinence period was at the discretion of husbands, and the women reported that they were often harassed (sometimes physically assaulted) if they tried to withhold sex.

Women in most villages generally maintained the traditional practice of keeping themselves segregated from the rest of the village during menstruation, sometimes by removing themselves altogether for the duration of menstruation, others by segregating themselves only from their husbands by sleeping in the same house but separate beds.

Human immunodeficiency virus status

During the 2015 surveys communities were not directly asked whether they had human immunodeficiency virus (HIV) as many wouldn't know their HIV status if they hadn't been tested, and due to confidentiality. However, when communities were asked about their general concerns a number of people mentioned a possible increase in HIV.

Following the first diagnosis HIV infection in PNG in 1987, and the scale-up of sentinel antenatal HIV surveillance sites in PNG, more precise estimates of national prevalence became available in late 2010 suggesting for the first time that the national HIV epidemic was concentrated in certain populations rather than generalised, with an estimated national adult HIV prevalence of less than 1%

(0.9%) (Kelly, 2012). However, PNG still has the highest rate of HIV and acquired immunodeficiency syndrome (AIDS) in the Pacific.

The Telefomin district development program plan (Sandaun, 2014) states that:

> *…a recent survey conducted by the District Administration Team with the assistance from the Village people who participated in the data collection established that most wards have limited knowledge on HIV/AIDS.*

Only people who have access to travel to a town had access to HIV and AIDS information which was felt to contribute to an increase in cases of sexually transmitted infections and HIV and AIDS. However, the incidence of HIV and AIDS in the Telefomin district was unknown due to a lack of information and a lack of testing. There were reported cases from Telefomin district that were detected in Vanimo or Tabubil which indicated the presence of HIV in district communities. The district administration is endeavouring to develop a HIV and AIDS response however specific actions are not clear.

In the East Sepik, remote areas of the Wosera-Gaui District and Ambunti-Dreikikir District (including Paupe) were included in a 2005 social mapping project (NHASP, 2005) as a precursor to strategic planning aimed at developing prevention and care strategies. The social mapping concluded that communities in very remote areas, such as Paupe, that at that stage had limited exposure to visitors (mainly in connection with alluvial gold mining) said that ‘they did not know much since it is a new disease’. Among measures for managing the disease some suggested ‘control of people bringing foreigners into the communities’.

2.4.3. Social capital (law and order, family relationships, support networks)

Social capital refers to the ‘nature and extent of social relations in communities…and its consequences for human welfare’ (Jones and Woolcock, 2007), and is comprised of six dimensions: Groups and networks, trust and solidarity, collective action and cooperation, social cohesion and inclusion, information and communication, and empowerment and political action. These dimensions must be seen in the context of the mine area social catchment villages being very remote with limited means of communication, but having ‘significant interactions with culturally related groups outside it’ (Gardner, 1996a). In the absence of an in-depth assessment of social capital, consideration of the status of law and order, incidence of domestic violence and the existence and functioning of groups and networks provides some insight into the status of social capital within the mine area social catchment villages.

As indicated in Section 2.3.1, there is no on-site presence of the formal law and order and dispute resolution institutions; however, the need for this presence is generally limited at present due to minimal law and order issues being reported. Surveys by Coffey in 2010 concluded that domestic violence (generally seen as being caused by a failure of wives to fulfil their marital duties) was pervasive across all communities surveyed, as acknowledged by both male and female participants. This may have over-stated the issue in the mine area social catchment villages due to the nature of the survey questions, but as stated by Chandler (2014):

The women of PNG endure some of the most extreme levels of violence in the world. They continue to be attacked with impunity despite their government's promises of justice. The situation has been described as a humanitarian disaster yet still does not receive the broader public attention it deserves, inside or outside PNG. It is also a significant obstacle to PNG's development and prosperity.

Chandler (2014) comments that while there is a cultural dimension to this violence with 'wife beating' condoned by a large proportion of the PNG population, older women 'recall the threat of domestic violence going back for generations, but they add the caveat that in the past this was contained by kastom (traditional culture)'. Women also comment on the profound change 'in terms of their safety in wider society'. In this regard, the mine area social catchment villages may be on the cusp of change should the Project proceed.

The majority of mine area social catchment village internal social groupings revolve around church-oriented women's, men's and youth groups, with participation reportedly being around 40 to 50%. Activities include religious fellowship, tok pisin classes, sewing and sport. External links are limited by isolation; however, some villages (e.g., Wabia) exhibit strong relationships with church development agencies which support local development activities. Other links to local political members do not appear to be particularly strong or productive at present, but will assume greater prominence if the Project proceeds.

2.4.4. Access to functioning services

Public facilities, such as health centres and schools, require skilled staff to be present, receiving their wages, and equipped with adequate resources such as equipment, drugs, and educational material to enable service delivery to be effective. Rural aid posts, nominally staffed by community health workers with two years training, are designed to cover a population group of about 1,000 people each, and comprise more than 70% of all health facilities in PNG. They are the level of health facility nominally available in the mine area social catchment villages, and deliver basic health care including mother and child care, and community-based health promotion. A significant number have closed due to shortages in funding, staff, and other resources, and in Sandaun and East Sepik around 76% and 55% of aid posts respectively were open in 2012. Where there are no aid posts, village health volunteers, village birth attendants and Marasin Meri (medicine women) are meant to provide basic first aid and health education in villages and homes. The following sections outline the status of health and education facilities at the time of the 2015 community surveys.

Health

Table 25 lists the status of health facilities in the mine area social catchment villages. Four out of seven villages have limited infrastructure: one (Wabia) has a Community Health Worker (CHW) on duty; and one (Sokamin) has limited services delivered by Village Health Volunteers. All villages express the need for improved health services as a priority and anticipate improvements will be made should the Project proceed to construction. At present, there is a high level of dependency on FRL to assist with basic services such as child immunisations, and to provide air transport to the district hospital in Telefomin in cases of emergency. Villages surveyed in 2017 indicated that there needs to be further improvements to health services.

Table 25 Village health infrastructure and service status

Community	Current status	Comments
Sokamin	Community have built a bush material hut to use as an aid post, though it is not gazetted by government.	• Village Health Volunteers, trained by Telefomin District Health, provide basic services. • Medical supply is from Telefomin or through FRL collection from the Wewak Medical Store in East Sepik Province. • Other medical services provided by FRL on scheduled clinics. • The 2017 village survey indicates the Aid Post is in poor condition.
Amaromin	No facility and nearest aid post is at Fiak (two hours' walk)	• No health worker at Fiak for the past six years. • In May 2015, a CHW was posted and FRL provided transport assistance, moving the CHW and family from Eliptamin to Fiak.
Wameimin 1	No facility.	• Medical services provided by FRL on scheduled clinics.
Wameimin 2	Government gazetted aid post.	• A permanent building in the village, though devoid of any equipment or medicine. • No health worker, services provided by FRL on scheduled clinics. • No electricity or refrigerator, aid post considered to be in poor condition.
Ok Isai	Government gazetted aid post.	• No infrastructure in place, the aid post needs a generator and a new water tank. • There was a community health worker in the village in 2017 however there is a general shortage of staff and staff training programs. • Medical services provided by FRL on scheduled clinics. •
Wabia	Aid post and CHW present	• FRL continues to provide ad hoc support to the CHW and family with food rations and transport assistance at the end of the year and beginning of the year. • The Aid Post is run down with no storage areas for medicines.
Paupe	Government gazetted aid post.	• Permanent building renovated by FRL. • In 2017 the village had a trained CHW and a village midwife. • Aid post had a stock of in-date drugs but no electricity or refrigerator to preserve medicine that need to be kept cool. • Services provided by FRL on scheduled clinics. • It was stated the government does not effectively support the facility.

Source: FRL Community Affairs Department.

Table 26 lists the status of education facilities in the mine area social catchment villages.

Table 26 Education facilities

Community	Current school status	Comments
Amaromin	No facility, children walk to Fiak Community School.	• Lowest number of students attending school from this community. • Community have indicated that an Elementary Teacher was assigned to teach Elementary class in the village (yet to be confirmed by Telefomin District Education Department).
Sokamin	Elementary school with local teachers, stationed in the community.	• Nearest primary school is Mianmin, a two-day walk. • Teacher access to pay is difficult, a three-day walk to Telefomin District. • In Mianmin parents have built a house and gardens to provide food for the students.
Wameimin 1	• Elementary school with semi- permanent classroom built using Community Project Fund. • Local teachers stationed in the community.	• Teacher access to pay is difficult, a four-day walk to Telefomin District. • Nearest primary school is Fiak. Takes at least one day to walk. • Primary students currently attending school at Fiak where parents have built a house and gardens to provide food for the students.
Wameimin 2	• Elementary school with semi- permanent classroom built using Community Project Fund. • Local teachers stationed in the community.	• Two teachers present in the village in 2017. • Teacher access to pay is difficult, a five-day walk to Telefomin District. • The school has no electricity or sanitation facilities • Upgrades needed to for classrooms and educational facilities,
Ok Isai	Primary school with three teachers, school operational.	• Two local teachers (local graduate teacher) and one assistant teacher. • Seven classrooms accompanied by seven teachers on site where five were considered satisfactory. • The graduate teacher is a product of the FRL Education Assistance Programs – both Fee Assistance Scheme (FAS) and Travel subsidy. • There is a shortage of adequately trained teachers and teacher training programs. • The school has no electricity or sanitation facilities.
Wabia	Elementary school, one teacher.	• The school was opened in 2012 but closed due to teacher being ill. • Primary school development being supported by Baptist Union of PNG. • The 2017 survey found the school had reopened and is being operated by the Baptist Union in PNG with four classrooms, two of which are considered in adequate condition.

Community	Current school status	Comments
		• It was stated that there is a shortage of teachers in Wabia and improvements needed to improve teacher literacy.
Paupe	Elementary school.	• School operated in 2012 and 2013 with two female teachers from Wewak supported by the FRL transport assistance program. • Four teachers present in Paupe in 2017 and one vacant teacher position. Two teachers were adequately trained and two were not. • New teachers housing to accommodate teachers were identified as a priority. • Eight classrooms, four considered to be in good condition and four considered to be in poor condition. • School has running water and adequate sanitation facilities. • Community support for the teachers was poor, as was support from District Education with a shortage of teaching and learning materials.

Source: FRL Community Affairs Department.

Telefomin district has two high schools; Telefomin High School which is a government agency school and the Oksapmin High School, which is a Church Agency School. The Telefomin district development program plan (Sandaun, 2014) has identified a need to upgrade one of these schools into a secondary school so that it eases the burden on parents of the expense of sending out their children to other secondary schools in the province. The plan also identified a need for improving the Technical and Vocational Education and Training (TVET) available at Telefomin for those children who do not progress into the academic pathway and who desire to pursue the Skills Development Pathway such as offered by TVET Centres. It proposes to do this by upgrading the current Telefomin Vocational Centre into a TVET Centre to deliver trade skills training.

Commercial

The availability of commercial services has been an ongoing problem for the Telefomin district. The South Pacific Bank has opened a Rural Bank Agency at the District Headquarters in Telefomin which has greatly assisted public servants who previously had to travel to Tabubil or Vanimo to access banking services, however the other LLGs within the district are still without a banking service. None of the communities in this social catchment had access to banking services, including phone banking.

2.4.5. Status of social values

Comments made on the potential impacts to personal and community well-being social values as a result of the Project by leaders from social sub-catchment area villages during the social values workshop held in September 2015 are shown in Table 27.

Table 27 Village leader comments in relation to personal and community well-being social values 5 and 6

Miyan villages
• General sentiment that improved health has led to population growth. • A recognition that the Project will bring negative as well as positive changes, and that there is a need to acknowledge and discuss these changes in order to effect service improvements. • A general concern with the potential for in-migration to Sokamin and Amaromin, see the need for FRL and government to collaborate in order to manage. • Desire for services to be closer to villages (e.g., schools). See the need for a police presence. Need collaboration at all levels to secure services. • Have noted aspects of cooperation at village level already declining. • Concern expressed for potential negative impact on health due to population pressure and more frequent travel to other centres. • Noted that FRL support for health improvement (e.g., immunisations) has been very important. • High level of concern for health at Amaromin (e.g., tuberculosis). • See cooperation with churches as important for managing social problems, and the need for early awareness raising and education for young people in regard to mine effects. • Some general uncertainty around population growth. • See benefits and potential for negative impact from improved mobile phone communication. • Improvements to transport options including road access, mobile network coverage, health services, schools and educational services and a higher presence of law and order facilities within service centres.
Telefol villages
• Felt that improved health services and a better diet through consumption of store goods had contributed to a population increase. • There is current in-migration that is worsening and contributing to community dysfunction. See the need for implementation of a by-law, joint action by FRL and the government, and the establishment of a service centre closer to the Sepik River to manage in-migration. • Concern that Project development may precipitate land disputes and income disparity (haves and have-nots) within community. • Feel that values could be enhanced through opportunities to improve basic conditions. • See some challenges to maintenance of harmonious relationships due to an increase in individualism. There is a need for leadership and assistance with capability-building, but acknowledge changes are occurring now. • If community governance is strong, values will be strengthened, see a strong church role/influence. • While LLG infrastructure is in place, feel it needs strengthening. There is a need for more effective delivery of government services. No district development plan is seen as an issue. There is a ward development plan, and there is a felt need for a sub-health centre to be established. • Health services are relatively strong, but education delivery is weak, has influenced decision to seek support from the Baptist Church. • Women see a high potential for conflict in the community, while men believe it can be managed. • Concerns for biodiversity were expressed. • Development needs in Ok Isai include improvement in sports facilities, water supplies, aid post upgrades, education facilities including provision of new staff housing and classrooms and increased funding for Frieda River Women's Association. • General concern to issues arising in regards to potentially introducing alcohol into the village and movement of outsiders into the village.
Paiyamo (Paupe) village
• Access to quality drinking water appears as to be a priority issue, as does improvements to school and health services. • Housing and the built environment does not appear to be a particular priority. • Indications that respectful relationships exist between community members. • High concern for the potential for in-migration and see the need for assistance with law and order issues (management by implementation of by-laws enforced by a police presence). • Specific mention made of the need for better communication facilities.

Miyan villages
• Appears to be a high concern for personal and community well-being, linked to the need for planning to address potential adverse Project impacts. • Provision of educational facilities. • Provision of health services to support drug procurement. • Transportation concerns continue to be a need, especially road access to the Aid Post.

Source: Coffey, social values workshop notes, September 2015.

Summary statements of the status of social values 5 and 6 are:

SV5 - An environment amenable to personal and family health, safety and security

The current physical and social environment of mine area social catchment communities is supportive of health, safety and security, primarily due to remoteness (and consequent minimal contact with outside persons and influences such as alcohol and drugs), continued access to good quality gardening land, forests and rivers, and health services supported by FRL. Villages required to resettle (Ok Isai and Wabia in the FRHEP impoundment area, and Paupe and Wameimin 2 due to proximity to infrastructure) will be subject to a Resettlement Action Plan that will address standard of living needs and have commitments aimed at restoration of livelihoods and maintenance of social values.

SV6 - The availability of services supportive of personal health, safety and security

Mine area social catchment communities have limited public infrastructure and, in general, are not in receipt of services supportive of personal health, safety and security. This is an area where communities have strongly held views on the need for improvement which they believe will only occur should the Project proceed.

2.5. Consultation outcomes

Extensive consultation as part of an EIS process occurred in 2009, 2010, 2015, 2016 and 2017. For the 2015 community surveys, responses to questions on village development needs were subject to a thematic analysis in accordance with the themes listed in Table 28.

Table 28 Village development needs themes

Infrastructure	Services	Capability development
• Housing • School • Aid Post • Road • Airstrip • Water supply • Power • Market	• Education • Health • Police • Agriculture	• Literacy • Skills development

Infrastructure	Services	Capability development
• Transport facilities		

Potential concerns and positive perspectives in relation to mining development were analysed to highlight the most frequently ranked concerns across social sub-catchment areas.

2.5.1. Development needs

Figure 10 summarises expressed development needs by males and females for social sub catchment areas. While expressed development needs are reasonably similar across social sub catchments, women appear to have a higher focus on capability development (training), particularly in the Miyan social sub-catchment.

2.5.2. Concern with impacts of mining

Table 29, Table 30 and Table 31 summarise the top five positive and negative concerns, for males and females, should mining development proceed. Of note, women expressed concerns with the potential for an increase in sexually transmitted diseases, domestic violence and family breakdown, whereas these concerns are rarely mentioned by men. Men raised the potential for environmental damage significantly more than women.

Table 29 Miyan social sub-catchments - top five female and male responses to awareness on potential mining impacts

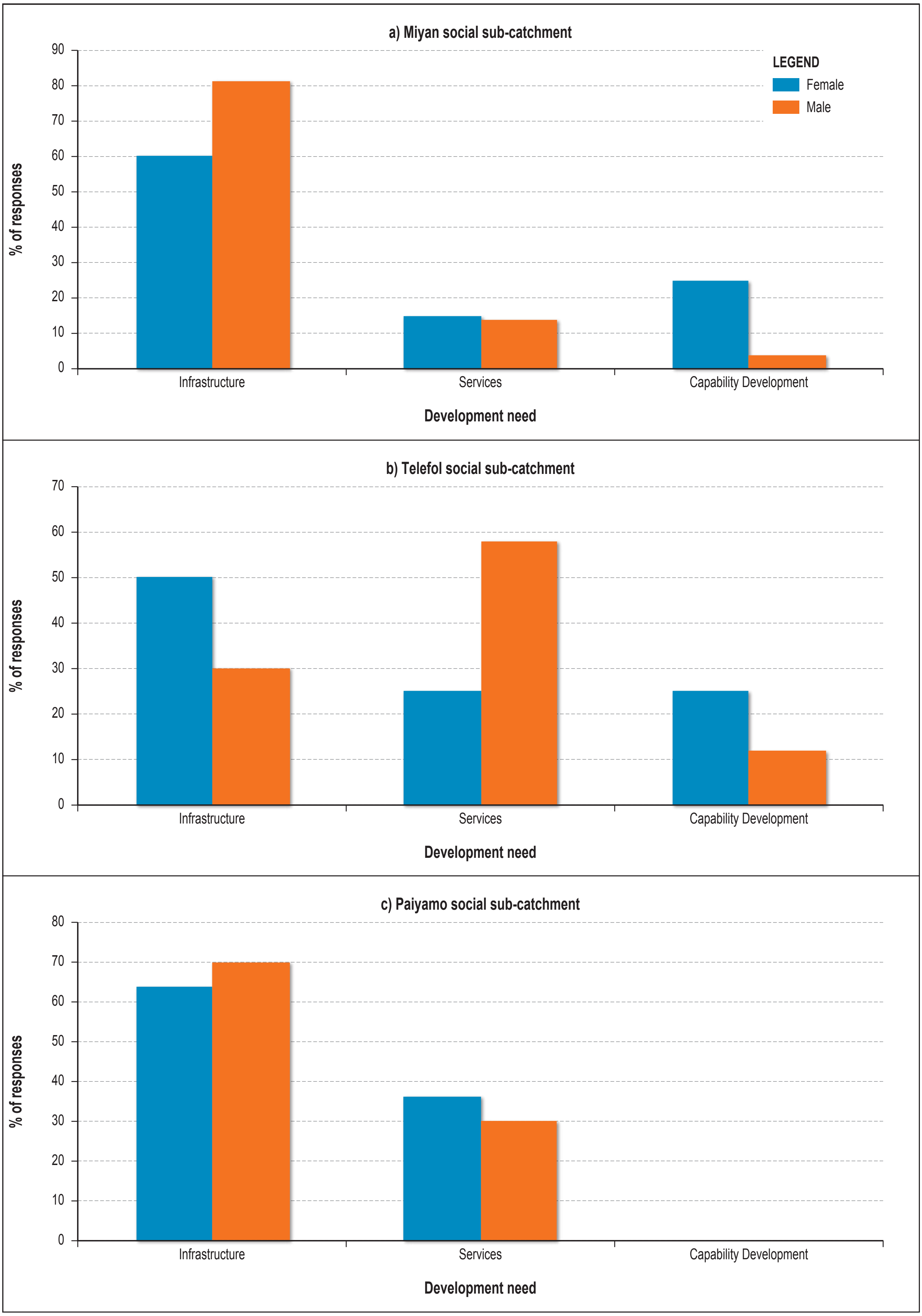
Top 5 negative – female (%)	Top 5 negative – male (%)
• Substance abuse (17) • Family breakdown (17) • STIs (17) • In-migration (17) • Violence against women (11)	• In-migration (32) • Substance abuse (21) • General law and order (16) • Family breakdown (11) • Increase in disease incidence (11)
Top 5 positive – female (%)	**Top 5 positive – male (%)**
• Better economic infrastructure (33) • Business opportunities (17) • Employment and income (11) • Better social infrastructure (11) • Employment and training opportunities (5)	• Better economic infrastructure (37) • Better social infrastructure (19) • Employment and income (15) • Royalty receipt ((11) • Better social services (11)

Table 30 Telefol social sub-catchments - top five female and male responses to awareness on potential mining impacts

Top 5 negative – female (%)	Top 5 negative – male (%)
• General law and order (18) • Substance abuse (18) • Family breakdown (18) • STIs (18) • In-migration (18)	• Environmental damage (24) • General law and order (12) • Substance abuse (12) • Family breakdown (12) • In-migration (12)
Top 5 positive – female (%)	**Top 5 positive – male (%)**
• Better social services (36) • Better economic infrastructure (25) • Employment and incomes (12) • Business opportunities (12) • Development support programs (12)	• Better economic infrastructure (56) • Better social services (19) • Employment and incomes (12) • Business opportunities (12)

Table 31 Paiyamo social sub-catchment - top five female and male responses to awareness on potential mining impacts

Top 5 negative – female (%)	Top 5 negative – male (%)
• Environmental damage (30) • Violence against women (13) • Substance abuse (13) • In-migration (13) • Labour shortage (7)	• Environmental damage (89) • In-migration (7) • Family breakdown (4)
Top 5 positive – female (%)	**Top 5 positive – male (%)**
• Better economic infrastructure (60) • Employment and incomes (40)	• Employment and incomes (29) • Better social infrastructure (21) • Better economic infrastructure (14) • Business opportunities (14) • Better social services (14)



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Expressed development needs of mine area social sub-catchments

Figure No: 10

AI Reference: 11575_16A1_GRA009.ai 7

3. Social Catchments 1B: New Infrastructure and Road Corridor – Hotmin to Green River

3.1. Overview

Social profile information for Social Catchment 1B, which comprises the new infrastructure and road corridor between Hotmin and Green River, has been derived from a range of sources. This includes household surveys (conducted in Hotmin, Idam 1, Idam 2 and Wokomo), village surveys (conducted in Uramesin 2, Temsapin, Hotmin, Idam 1, Idam 2, Wokomo 1 and Bisiabru), key informant interviews (conducted in Green River) and a land and water resource use survey (Idam 1), all conducted in 2017 by Coffey. While the survey team planned to undertake village, household and resource use surveys at Dioru in November 2017, due to logistical complications and high rainfall the village could not be accessed by road and consequently Dioru was not surveyed. Information has also been derived from the PNG census and a range of other secondary sources.

These four villages selected for household surveys were chosen as they were known to be relatively large villages and likely to be representative of other villages between Hotmin and Green River. Hotmin was also selected as it was previously surveyed in 2011, therefore allowing for comparisons to be made between the two sets of data. The household surveys carried out covered approximately 10% of households across the four selected villages.

3.1.1. Location

Catchment 1B encompasses part of the proposed main access route to the mine area and extends from Hotmin to Green River, a distance of approximately 90 km (see Figure 1). From Hotmin the corridor tracks in a northwesterly direction following the valley of the Right May River in the East Sepik Province for approximately 40 km through customary land belonging to the Miyan and Bo language groups.

From there the corridor crosses the West Mountain range into Sandaun Province and tracks generally in a northerly direction through the Idam River valley back swamps and flood plains to Green River, crossing the Sepik River in the vicinity of Mukwais village. The major portion of this customary land belongs to the Abau language group. The Abau language is spoken by more than 7,000 people in Sandaun Province, in the area to the immediate east and west of Green River, as well as the villages along the Sepik River and its tributaries, starting at the border with Indonesian Papua all the way down to the border with the East Sepik. In the language the name Abau means infertile land, which is any area of open grassy land without trees that cannot be used for food gardens. The Green River airstrip was built on such land, and the local people continued to refer to the area as Abau, and consequently the Green River area with its airstrip became known as Abau. The name eventually transferred to the people group and the language (Lock, 2011).

3.1.2. Population

Population data has been assembled from a number of sources, including the 2011 national census (NSO, 2014) and household and village surveys conducted by Coffey in 2017.

Population characteristics and age demographics within the catchment are detailed in Table 32 and Table 33 respectively. Idam 1 supports the most inhabitants (794) followed by Idam 2 and Hotmin. The smallest village based on the number of inhabitants is Wokomo 1 followed by Tempsapin. For the majority of the villages within the catchment, the female to male ratio is balanced. However, for the larger villages, Idam 1 and Idam 2, there are more males than females.

In the absence of village level data for age demographics within the catchment, LLG data for Tunap/Hustein Rural and Green River Rural from the 2011 census has been used to estimate the age characteristics of the population within the catchment (see Table 33).

Table 32 Population characteristics of Social Catchment 1B villages

Village	Population	Households	Household occupancy	Male	Female	Gender Ratio*
Hotmin	367	80	4.6	193	160	121
Idam 1	794	148	5.4	457	336	136
Idam 2	518	115	4.5	316	259	122
Bisiabru	255	50	5.1	n.a.	n.a.	n.a.
Wokomo 1	65	10	6.5	20	45	44
Uramesin 2	194	38	5.1	n.a.	n.a.	n.a.
Tempsapin	112	22	5.1	n.a.	n.a.	n.a.

n.a.: not available. Population data was not available for Green River.
Source: 2017 Coffey village and household survey
* Number of males per 100 females

Table 33 Estimated age demographics within Social Catchment 1B

Villages	0 – 9 years old	10 – 19 years old	20 – 49 years old	50 + years old
Hotmin, Uramesin 2, Temsapin*	29%	22%	42%	7%
Wokomo 1, Idam 2, Idam 1, Bisiabru, Green River†	34%	25%	35%	6%

* Villages within Tunap/Hustein Rural LLG
† Villages within Green River Rural LLG

3.2. Livelihoods (social values 1 and 2)

Food consumption and food security surveys were conducted in 35 households across Hotmin, Idam 1, Idam 2 and Wokomo 1 (Coffey, 2017). The survey responses provide an insight into the functioning of the subsistence system. Water supply data was collected on a village by village basis for each of the seven villages surveyed within the catchment.

3.2.1. Natural capital/subsistence activity

Villages within the catchment live primarily subsistence based lives by developing mixed staple gardens including crops of banana, sweet potato and taro. Sago is the most important food in the catchment, some of which is managed in naturally occurring stands, with other staples being banana, Chinese taro, coconut and taro (*Colocasia*). Hunting and fishing are also important activities for protein food sources (Hide et al., 2002).

Household diets generally consist of a variety of plant based products, such as taro, sago and banana, aibika, kumu and other vegetables (Table 34). Protein food sources predominantly included fish and to a lesser extent bush meat and chicken.

Table 34 Food consumption in Social Catchment 1B

Village	Most frequently consumed foods
Hotmin	Taro, banana, sago, fish (in any form), aibika/kumu and other greens.
Wokomo 1	Banana, sago, aibika/kumu and other greens
Idam 2	Sago, aibika/kuma and other greens,
Idam 1	Banana, sago, aibika/kumu and other greens

Source: Coffey household surveys 2017

Throughout the corridor there is low intensity land use with garden fallow periods typically in the order of 15 years or longer. In Hotmin, garden site selection is based on soil fertility and drainage criteria, with a preference for flat areas, however the risk of flooding means a variety of flat and hillside gardens are developed (Bonnell and Robinson, 1995). Garden development and maintenance is carried out by all family members, with the women clearing the undergrowth, men removing larger trees and all family members participating in planting (Bonnell and Robinson, 1995).

The main sources of carbohydrate in Hotmin are taro, sago and banana, with at least two thirds of households surveyed consuming these products within the last 24 hours (Coffey, 2017). A comparison between the survey data of household food consumption in Hotmin in 2011 and 2017 indicate:

- There is an increasing importance of cassava, banana, sago and rice.
- There is a decreased consumption of fresh fish, taro and sweet potato.

Apart from rice consumption in Hotmin, the penetration and consumption of store bought foods appears minimal within the catchment.

The most commonly consumed carbohydrate rich foods in Idam 1 were sago and banana with at least 70% of households surveyed consuming them in the past 24 hours. Coconut was also widely consumed. Vegetables including aibika and kumu were regularly consumed within the village. Fresh fish was the main source of protein, however the frequency of consumption varied, with six households consuming fish weekly while at least four households only ate it occasionally (Coffey, 2017).

Households in Idam 2 were primarily dependant on sago as their staple carbohydrate food source; approximately two thirds of households surveyed had consumed it within the past 24 hours. Other commonly consumed foods included banana, coconut and vegetables such as aibika and kumu. Protein rich foods varied in frequency of consumption and type, with fish being consumed by only a couple of households on a weekly basis. Other sources of protein included bush meat and chicken, however these were only occasionally consumed.

Only three (of ten) households in Wokomo 1 were surveyed. Of these households, the predominant foods consumed were similar to that in other villages, i.e., sago, coconut and banana. Store purchased items were infrequently consumed and protein rich foods were not a regular part of their diet.

Of the 35 households surveyed within the catchment, four households (one within Hotmin, two within Idam 2 and one in Wokomo 1) reported that there were shortages of some food supplies, including taro, banana and sweet potato (Table 35).

Table 35 Food insufficiency responses in Social Catchment 1B

Village	Number of surveyed households	Number of surveyed households reporting previous 24-hour food insufficiency	Comments on shortages
Hotmin	12	1	A few survey respondents suggested that garden food (i.e., taro and banana) were in short supply.
Wokomo 1	3	1	-
Idam 2	9	2	Households experiencing food shortages pointed to banana, sago, aibika, tulip, taro and sweet potato as being in short supply.
Idam 1	11	0	-

Source: Coffey household survey 2017

All of the villages surveyed within the catchment (Hotmin, Idam 1, Idam 2 and Wokomo 1, Uramesin 2, Temsapin and Bisiabru) obtain their drinking water from natural untreated sources either from a river or natural spring. None of the villages have water tanks so water supply is totally reliant on these natural sources year round. Water quality and reliability is generally considered satisfactory or better, except within Bisiabru, where quality and reliability is considered poor, and within Idam 1 where reliability is deemed poor (Coffey, 2017).

3.2.2. Cash economy activity

Villages within the catchment are characterised by their remote location and low level cash economy activity. The data derived from the household surveys provides an insight into the sources, levels and uses for cash in the area and its surrounds, while village surveys and key informant surveys conducted within the catchment have provided an understanding of the existing market infrastructure and development priorities to improve participation in the cash economy.

Of the four villages within the catchment where a household survey was conducted, Hotmin (the closest major village to the FRCGP area on the new infrastructure and road corridor) exhibited the greatest level of participation in the cash economy, as indicated by the levels of household income and expenditure. The low levels of participation in the cash economy of Idam 1, Idam 2 and Wokomo 1 is largely due to the absence of local markets and lack of access to markets in the southern villages due to their remote location and high transport costs.

An increase in participation in the cash economy was a key issue among villages where there was strong sentiment for the need for improved local roads to allow market access.

Income

Estimates of income were made by asking household survey respondents to recall income received in the past fortnight. Information on the sources of income over the past year was also gathered during the 2017 household surveys.

Four of the villages surveyed in the catchment have markets (Hotmin, Uramesin 2, Temsapin and Green River) and transport (generally by means of motor canoes) is expensive due to fuel costs, severely constraining participation.

Thirty-one of the 35 households surveyed reported earning an income over the past year and 17 households reported earning an income within the two-week period leading up to the survey. The average fortnightly household income was PGK569 across the 35 households. If the results from Hotmin are removed due to the potential for them to skew results for the remainder of the catchment, the average fortnightly household income was PGK238 across 23 households.

Hotmin households were the greatest income earners in the catchment, with some of the key characteristics of income including:

- Most households (>70%) derive some income from selling garden produce, fish or betel nut.
- There is no cash cropping, but minor harvest of eaglewood.
- Around 35% of households derive income from alluvial gold. Some households (approximately 30%) derive income from work with FRL or the Government. A small number of households produce handicrafts.
- Without gold, the fortnightly household income is in the order of PGK412, equating to an annual average income of PGK10,790.
- Household income from gold may be in the order of PGK800 per fortnight (or PGK20,000 per annum) which is significant. However, a more detailed assessment would need to be done to have a higher level of confidence in the estimate. A substantial alluvial mining settlement comprising over 30 structures has recently been observed north of Hotmin on the Right May River.

In Idam 1 (a typical remote village, aligned to services from Green River), there was a limited response to a substantial number of survey questions. This may be due to a lack of understanding of the survey questions, an unwillingness to share this information and/or people feeling embarrassed to reveal this information. Some of the key findings of the household survey were:

- Fortnightly income is in the order of PGK30 per household (approximately PGK780 per annum).
- In the order of 30% of households derive this income from sales of vegetable, fish, betel nut and handicrafts. There is no indications of gold or cash crops, and very limited project (FRL or logging) work or work for the government.
- Expenditure information is limited, with the majority appearing to be for clothing and consumables such as nails for housing and torch batteries (Coffey, 2017).

Formal employment within the catchment was minimal and only accounted for income in seven households over the past year. This employment was either through FRL (at Hotmin only), the government or logging work. The average fortnightly income from this formal employment was between PGK200 to PGK300 over a two-week period for the households engaged in the work.

Key household income information within the catchment is represented in Figure 11 (excluding alluvial gold) and Figure 12 (including alluvial gold).

Expenditure

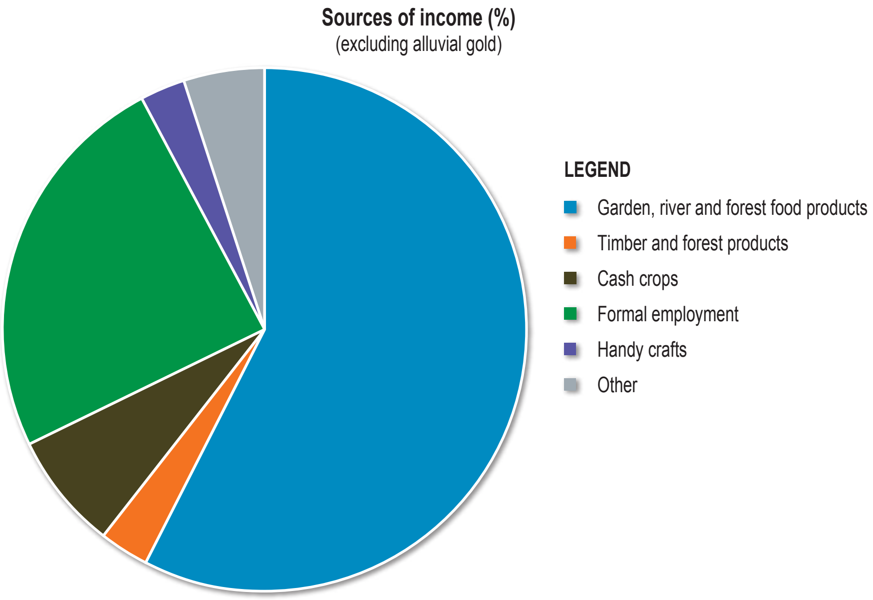
Estimates of expenditure were made by asking survey respondents to recall purchases made in the past fortnight, and to indicate the type and purchase price of major durable items purchased over the past year. Survey respondents were also asked to indicate the school/education fees incurred over the past year, including transport and boarding costs.

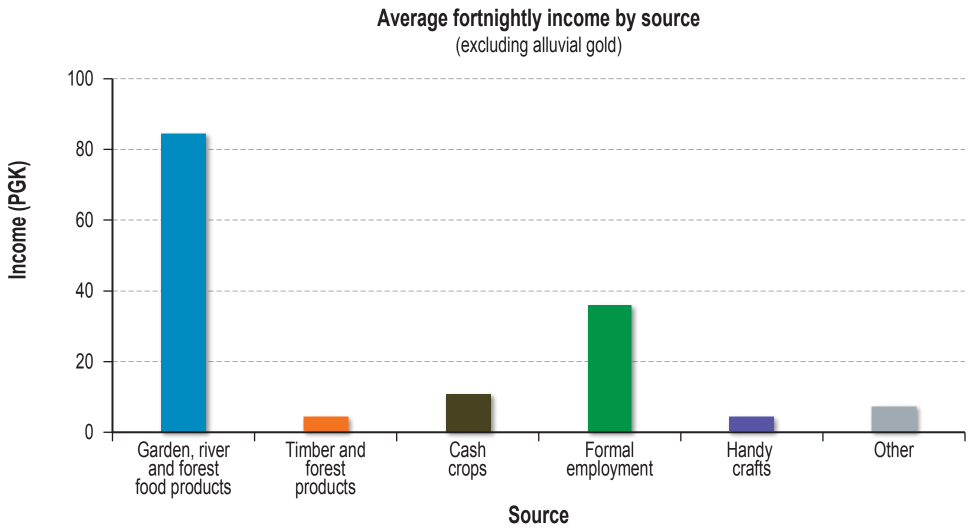
Household expenditure on goods and services is higher in Hotmin than in Idam 1, Idam 2 and Wokomo 1. The average household expenditure from stores and markets in the fortnight prior to the 2017 Coffey survey in Hotmin was PGK157 compared to PGK42 for households in Idam 1, Idam 2 and Wokomo 1. The average expenditure figure of PGK157 for Hotmin does not include PGK5,000 that was reportedly spent on fuel by one household, which was treated as an anomaly.

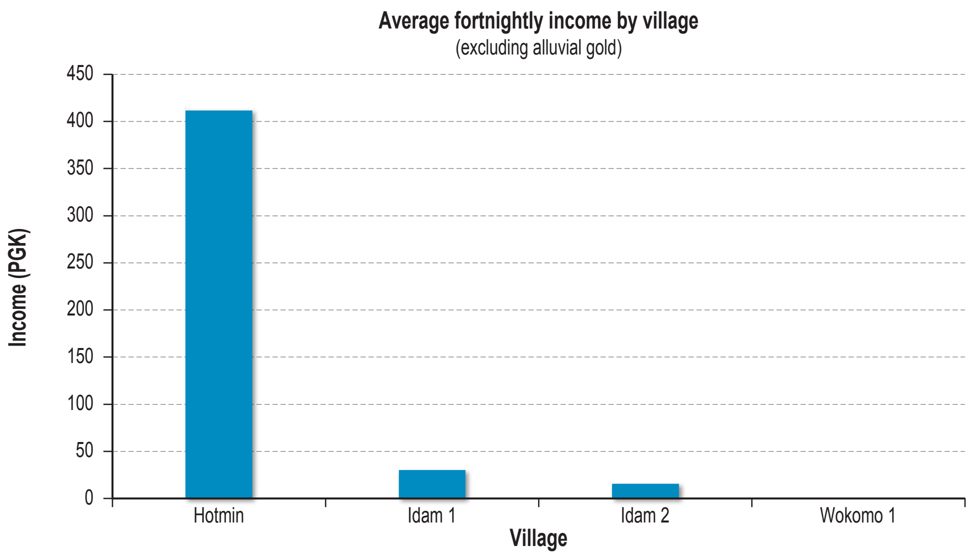
The average fortnightly household expenditure from stores and markets across the catchment was PGK124. Table 36 details the average fortnightly expenditure across the surveyed households in the catchment.

Indicative annual household expenditure in Hotmin is in the order of PGK2,000/year for food and consumables, PGK2,814 for education expenses and PGK5,000 for transport costs. There appears to be minimal expenditure on health or other costs, such as Church donations. Typical durable goods purchased by surveyed households in the past year include a gold dredge, an outboard motor and solar lights (Coffey, 2017).

Household education expenditure is greatest in Hotmin (which reflects the significantly greater income in the village, particularly from alluvial gold). In Idam 1, Idam 2 and Wokomo 1 annual household education expenses are almost non-existent at PGK5.







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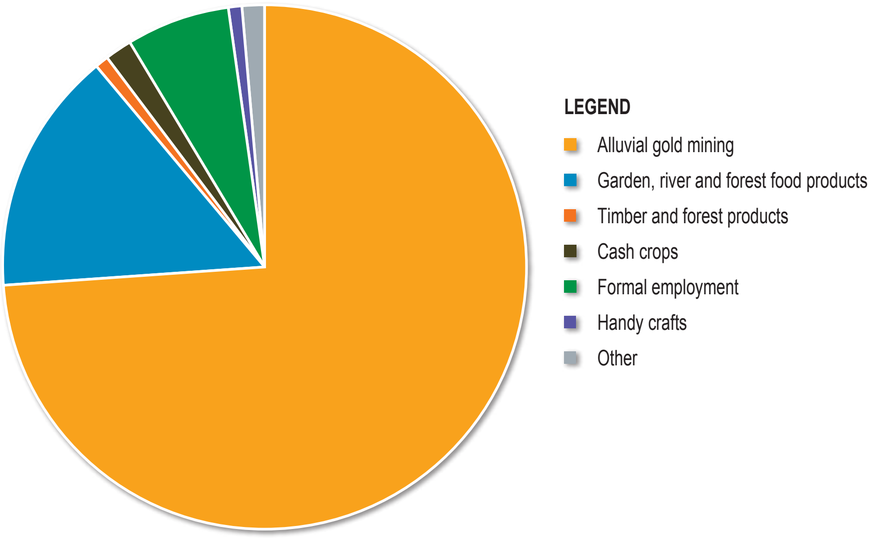
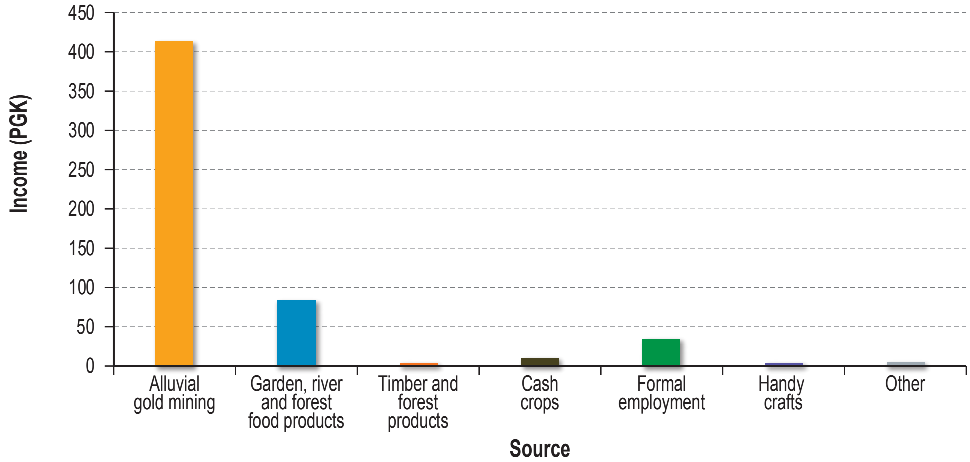
Sources of income (%)
(including alluvial gold)



Average fortnightly income by source
(including alluvial gold)



Average fortnightly income by village
(including alluvial gold)

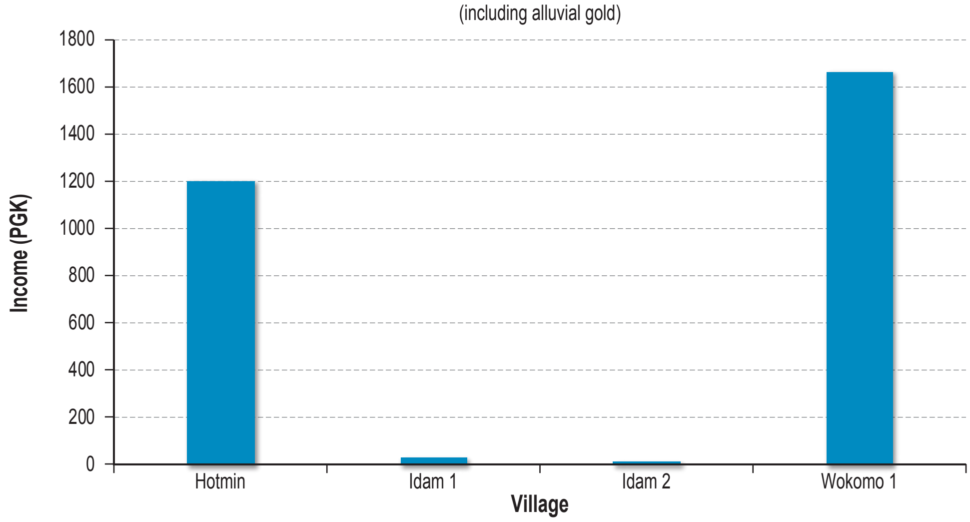


Table 36 Average fortnightly household expenditure in Social Catchment 1B villages

Expense category	Average fortnightly expenditure (PGK)	Comments
Purchase from store or market	124#	Most common store bought purchase was food followed by clothing or shoes.
Transport	Airfare: 91 Canoe travel: 22 PMV: 0 Other: 54	Hotmin had the highest transport cost due to airfares out of those villages that reported on transport expenditure. Idam 1 village had the lowest transport cost which likely reflects its closer proximity to Green River than the other villages surveyed enabling a cheaper trip to Vanimo.
Church and cultural	Cash: 1 In-kind: 1 Giving for repaying loans: see comments Other: 1	The offerings given to repay loans were mostly in the form of garden produce.

Excludes the PGK5,000 that was reportedly spent on fuel by one household in Hotmin which was treated as an anomaly.
Source: Coffey household surveys 2017

3.2.3. Status of social values

SV1 – The capacity to support subsistence livelihoods

Subsistence practices play a significant role in the livelihoods of households within the catchment. There is enough access to resources currently to provide for a subsistence lifestyle throughout the catchment with a variety of produce grown and animals hunted.

SV2 – Opportunities for participation in the cash economy

The opportunity for participation in the cash economy is skewed, with Hotmin experiencing the greatest level of participation due to access to markets along with Temsapin and Uramesin 2. There appears almost no routine participation in the cash economy in villages such as Idam 1, Idam 2 and Wokomo 1. Opportunities for formal employment is limited, with few households generating income from such means. Increasing opportunities for participation in the cash economy through market access via the development of local road infrastructure is seen as an important benefit of the project among the villages. This would allow villages to buy and sell local garden, forest and fish products.

3.3. Culture (social values 3 and 4)

Culture in the catchment has been undergoing a process of slow change since initial contact by the Australian administration. Drivers of this change have been the imposition of a foreign system of law and order, labour out-migration to other areas of PNG, marriage outside of traditional norms and the inroads made by Christian missions. As with all Papua New Guineans, culture is underpinned by traditional rights to land access and resource use. In social catchments 1B there has been no large-scale land alienation for uses such as cash cropping or logging, and waterways and lakes are subject to minimal outside use for shipping purposes. Population densities are low and there is minimal pressure on resource use, though there are ongoing disputes over land boundaries, a perennial feature of traditional PNG society.

3.3.1. Governance

The new infrastructure and road corridor is located within two provinces, East Sepik Province and Sandaun Province. The government administrative boundaries within which the catchment falls are detailed in Table 37.

Table 37 Government boundaries within Social Catchment 1B

Village	LLG	District	Province
Hotmin	Tunap/Hustein Rural	Ambunti/Drekikir	East Sepik
Uramesin 2	Tunap/Hustein Rural	Ambunti/Drekikir	East Sepik
Temsapin	Tunap/Hustein Rural	Ambunti/Drekikir	East Sepik
Wokomo 1	Green River Rural	Vanimo/Green River	Sandaun
Idam 2	Green River Rural	Vanimo/Green River	Sandaun
Idam 1	Green River Rural	Vanimo/Green River	Sandaun
Bisiabru	Green River Rural	Vanimo/Green River	Sandaun
Green River	Green River Rural	Vanimo/Green River	Sandaun

Source: NSO 2011 census

There are 38 wards within Tunap/Hunstein LLG and 30 wards within the Green River Rural LLG.

3.3.2. Religious and traditional practice adherence

Communities within the catchment continue to practice traditional cultural activities while also adopting non-traditional practices into their society. For example, methods of birthing are generally a combination of traditional and non-traditional practices. Three of the five villages surveyed in the catchment (Bisiabru, Idam 1 and Temsapin) that provided responses to questions relating to birthing practices indicated that they use both traditional village birth attendants and either trained village birth attendants or qualified medical officers (Coffey, 2017). The other two villages, Uramesin 2 and Idam 2, indicated that traditional village birth attendants were not used.

All of the villages surveyed within the catchment, except Idam 1, have a dedicated church.

Language

There are three traditional langauge groups associated with social catchment 1B, Miyan, Abau and Amto. The traditional languages are still used in the communities, but there is a slow shift among young people who are more comfortable speaking Tok Pisin. Tok Pisin is widely used in all villages within the catchment and understood by children and adults of all ages. As Lock 2011 notes, there is still a strong appreciation of their traditional language and culture, however there is no shame associated with having poor language skills in Abau.

Religion

All villages surveyed within the catchment, except Idam 1, have a functioning church building with resident pastors. Weekly church attendance is strong throughout the surveyed villages except within Bisiabru where attendance was reported as weak.

Most of the villages receive support from the church through church funded community development programs such as canoe and house building and infrastructure building (see Table 38). The church in Idam 2 (Plate 9) has contributed to educational and health development activities in the community.

Table 38 Mainstream faith indicators in Social Catchment 1B villages

Village	Religion	Dedicated church building?	Resident pastor?	Frequency of service	Attendance at services	Church support for community development?
Hotmin	Other	Yes	Yes	Weekly	Most people	No
Uramesin 2	Other	Yes	Yes	Weekly	Many people	Yes – Church members help individuals with canoe/house building etc.
Temsapin	Other	Yes	Yes	Weekly	Many people	Yes - Prayer healing for the sick
Wokomo 1	Other	Yes	Yes	Weekly	Most people	No
Idam 2	Catholic	Yes	Yes	Weekly	Many people	Education and health and pastoral services
Idam 1	Other	No	Yes	Weekly	Many people	Yes – carry posts to build house for new church building
Bisiabru	Other	Yes	Yes	Weekly	Few people	Yes – built elementary school (CBC)

Source: Coffey village surveys 2017.

3.3.3. Archaeology and cultural heritage

A study in 2018 by Andrew Long and Associates (Appendix 12) investigated whether any known cultural heritage sites exist within the new and existing infrastructure and road corridors (social catchments 1B and 1C). The study reviewed files from the PNG National Museum and Art Gallery (NMAG), a repository of all registered cultural heritage sites in PNG. One NMAG registered site was found to exist within the Hotmin road (public) corridor (applying a 50 m buffer) in social catchment 1B, a cave/rockshelter site (site code RAK) located near Green River Patrol Station which was first identified in 1964 (ALA, 2018). There are a further six registered NMAG sites within 1.5 km of the Hotmin road (public) corridor that fall within social catchment 1B (Table 39 and Figure 13).

Table 39 NMAG registered cultural heritage sites within 1.5 km of the Hotmin road (public) corridor

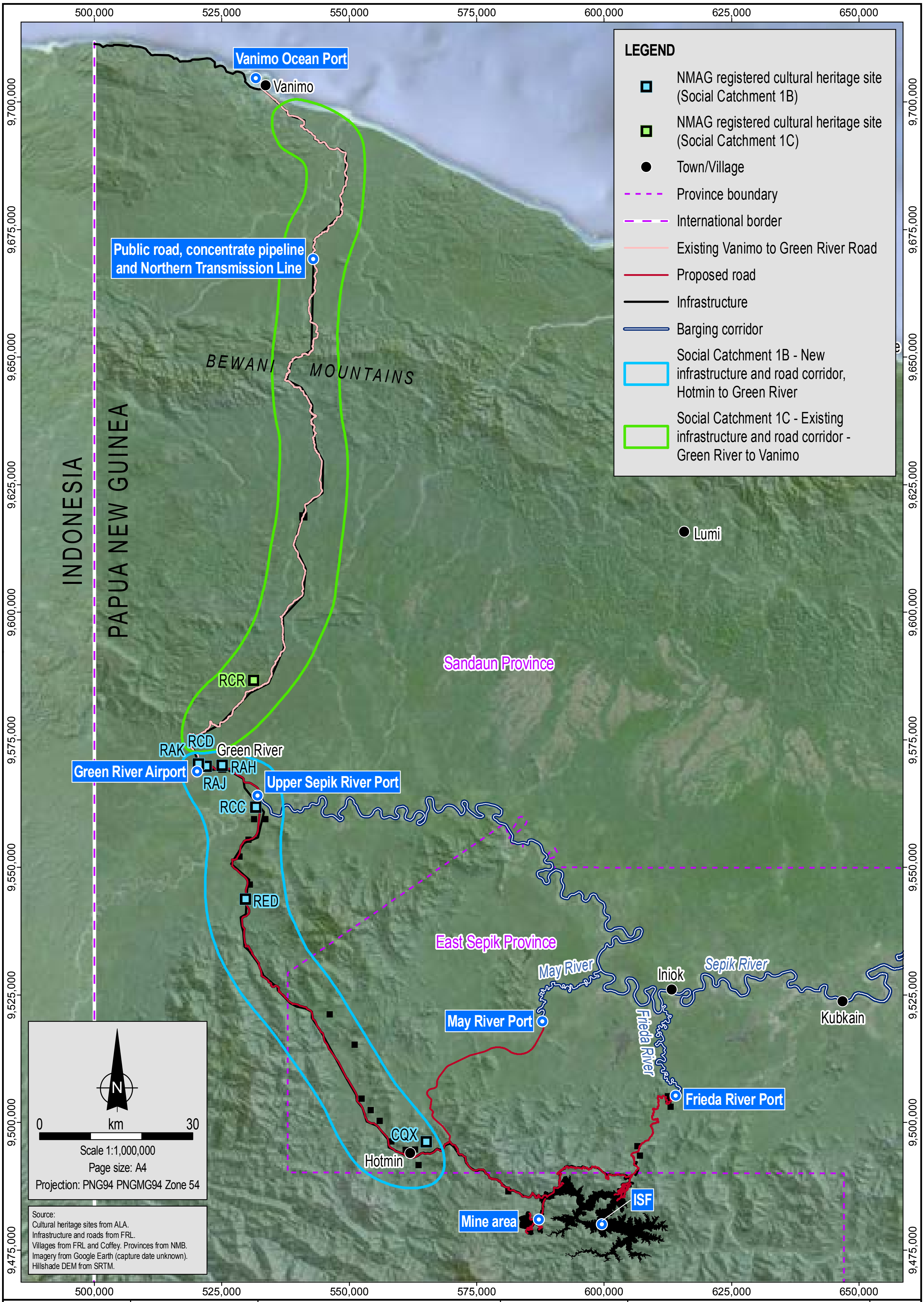
National Site File code	Site name	Site type
RAK	Panganggan Cave	Cave/Rockshelter
CQX	Kwemi Village	Archaeological
RED	Bipan Village	Archaeological
RCC	Mukwasi Village	Archaeological
RAH	Dieru Settlement	Archaeological
RAJ	Green River Gravel Rise	Archaeological
RCD	Unknown	Archaeological

3.3.4. Status of social values

There is a strong connection to the land and the traditional ways of life within the catchment. Opportunities to improve living standards through increased wealth and basic services from the proposed infrastructure and road development are acknowledged throughout the catchment. However, there is a concern among some that an increase in wealth and outside influences in the community has the potential to negatively impact on traditional cultural practices and family values.

SV3 – An enduring ability to sustain cultural identity and traditions including connection to ancestors

Due to their isolation, low population density and the absence of demand for access to their land for industrial agriculture, communities within the catchment have been able to maintain or discard their cultural identity and traditions according to their own terms. Elements of tradition continue to be passed down through generations and practised, while being overlaid with Christian religious activities.



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NMAG registered cultural heritage sites within 1.5km of social catchments 1B and 1C

Figure No: 13

SV4 – An enduring ability to maintain customary rights to land access and resource use

Due to their isolation, low population density and the absence of demand for access to their land for industrial agriculture, communities within the catchment have been able to maintain their customary rights to land access and resource use. The development of a road may affect land access and resource use around proposed infrastructure locations and effective negotiations with landowners will need to take place to allow access to customary lands. Access to lands and resource use in the new infrastructure and road corridor may become an issue should in-migration occur or external service industries seek to establish themselves in the area.

3.4. Personal and community well-being (social values 5 and 6)

Inhabitants of the Sandaun Province and East Sepik Province are among some of the most disadvantaged in PNG with poor access to services (Hansen et al., 2001).

The catchment includes remote and isolated areas of the Sandaun and East Sepik provinces (and, by comparison, PNG more broadly). Housing is very basic with the majority constructed with bush materials with no piped water or sewage systems. There are little to no government services or public infrastructure and community halls and recreational facilities are rare and generally not maintained to a good standard when available. In general, health and education infrastructure is degraded to non-existent, and education and health status is poor. There is no transport related infrastructure in the region and access to functional services such as markets, health and education facilities involves long canoe rides or walking for most villages, often in excess of several days.

The communities within the catchment generally experience a safe and secure social environment, in large part due to the remoteness of the villages.

3.4.1. Built environment (housing, infrastructure, amenity)

Housing

The built environment throughout the catchment is basic and minimal (Plate 10). Typically, housing structures are made entirely from bush materials. Only a small fraction of houses are semi-improved with iron roofing or improved (i.e., made from sawn timber framing and iron roofing) (see Table 40).

Table 40 Housing structures in Social Catchment 1B villages

Village	Number of houses	Number of improved houses (Roofing iron and sawn timber framing)	Number of semi-improved houses (Roofing iron and bush timber framing)	Number of traditional houses (All bush material)
Usaremin 2	38	4	34	0
Bisiabru	50	0	50	0
Hotmin	44	6	38	0
Temsapin	22	1	21	0
Idam 1	148	0	148	0
Idam 2	115	No data	No data	No data
Wokomo 1	10	No data	No data	No data

Source: Coffey village surveys 2017.

Infrastructure

Water supply infrastructure does not exist within the villages. All water is sourced from rivers, lakes or natural springs and is untreated prior to consumption. Sanitation facilities throughout the villages primarily consists of latrines, however between 25% and 55% of households in Idam 1, Idam 2 and Wokomo 1 lack any such infrastructure and use the bush.

Waste disposal in most households is either done through depositing waste into pits or in open settings, while burning and other methods are used by approximately 20% of households.

Amenity

Community amenities are limited within the catchment (Table 41). Of the seven villages surveyed, two have community halls, four have sporting facilities (either a volleyball court, basketball court or playing field), four had trade stores and three had a village market (Coffey, 2017). Neither Temsapin nor Wokomo 1 have any recreational facilities.

Table 41 Amenities within villages surveyed within Social Catchment 1B

Village	Community hall	Volleyball court	Basketball court	Playing field	Trade stores	Village market	Mobile market visits village
Usaremin 2	No	Yes	No	No	Yes	Yes	Yes
Bisiabru	Yes	Yes	No	Yes	No	No	No
Hotmin	Yes	No	No	No	Yes	Yes	No
Temsapin	No	No	No	No	Yes	Yes	Yes
Idam 1	No	Yes	Yes	Yes	No	No data	No data

Village	Community hall	Volleyball court	Basketball court	Playing field	Trade stores	Village market	Mobile market visits village
Idam 2	No	Yes	Yes	Yes	Yes	No	No
Wokomo 1	No	No	No	No	No	No	No

Source: Coffey village survey 2017.

3.4.2. Human capital (education and health status)

Education status

Overall, education levels within the catchment are low. The 2017 household surveys interviewed 163 people residing in Hotmin, Idam 1, Idam 2 and Wokomo 1. Hotmin had the highest percentage of people having attended / attending secondary level education (25% of people survey), while Wokomo had the lowest percentage of formally educated people, with 74% of people surveyed having no formal education (Table 42). Most people surveyed received education up to an elementary grade signalling an overall lack of higher formal education.

To provide a broader context, the level of education within the Ambunti/Drekikier and Vanimo/Green River districts were analysed from the 2011 census data. Education within Ambunti/Drekikier District is lower across all levels compared to Vanimo/Green River District. When compared to the rural population of PNG, the population of Ambunti/Drekikier has slightly lower levels of education attainment, apart from grades 1 to 6. Current education attendance within the surveyed villages is discussed within Section 3.4.4.

Literacy levels within the catchment are low with respondents to household surveys revealing that 86% were illiterate.

Table 42 Highest education levels attained

Village	None	School grades 1 - 5	School grades 6 - 12	Bible studies	Tertiary/trade certificate	Unknown
Usaremin 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Bisiabru	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Hotmin	26%	30%	24%	5%	0%	15%
Temsapin	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Idam 1	43%	38%	16%	2%	2%	0%
Idam 2	25%	55%	13%	0	0%	7%
Wokomo 1	74%	21%	0%	0%	5%	0%

n.a.: not available.
Source: Coffey household and village survey 2017.

An educational and religious program, the Abau Project, in the Yabru village in Sandaun, was established in 1990 to raise the level of literacy within the Abau people, particularly among children and women. The program has contributed to the training of more than 100 local teachers and the production of reading materials in Abau as well as the establishment of schools for children in all 25 Abau speaking villages. The program started out as a one-year curriculum which has since grown to a three-year program and has succeeded in an enrolment of approximately 2,000 children through the Abau schools. Annual testing of children is conducted, with more than 80% of students being assessed as adequate to good readers. The main training centre also has adult courses in mathematics, calculator use, simple bookkeeping, manual typewriter skills, and courses by correspondence on family life, religion, arts and music (Lock, 2011).

Health status

The improvement of health services is a key development priority identified by the leaders of communities within the catchment. Current health services within the catchment are minimal, with inadequate equipment and resources. The lack of health services and means of transport further limit access to adequate health services for the local population.

The level of reported childhood immunisations in the four villages where household surveys were conducted varies (Table 43). Forty percent of the 20 children (aged between 0 and 5 years) had reportedly received the full triple antigen vaccination (for diphtheria, tetanus and pertussis), while 35% had received partial vaccination and 25% had not received any stages of the vaccination (which is usually administered at 2, 4 and 6 months of age).

Just under 75% of children in the four villages surveyed at the household level had received a measles vaccination. Hotmin and Idam 1 only had one child each that was not vaccinated for measles, while Idam 2 and Wokomo 1 had two children each that were not vaccinated. During the village surveys with community leaders, four of the seven villages surveyed indicated that young children were receiving regular immunisations.

Health care services (including an ante-natal clinic and tetanus vaccination) were available to mothers during pregnancy in Hotmin, Idam 1 and Idam 2. Mothers in Wokomo 1 did not attend an ante-natal clinic or receive tetanus vaccinations during their pregnancy.

Table 43 Child health indicators in surveyed households

Village	No. of children (5 years and younger)	No. of mothers attended ante-natal clinic during pregnancy	No. of mothers vaccinated for tetanus during pregnancy	No. of children received Triple antigen vaccination	No. of children received Measles vaccination	No. of children that sleep under a bed net
Hotmin	9	8	8	3 (fully) 5 (partial)	8	9 (always)
Idam 1	5	3	4	4 (fully)	4	5 (always)
Idam 2	3	3	3	1 (fully), 1 (partially)	1	1 (always), 1 (sometimes), 1 (not at all)

Village	No. of children (5 years and younger)	No. of mothers attended ante-natal clinic during pregnancy	No. of mothers vaccinated for tetanus during pregnancy	No. of children received Triple antigen vaccination	No. of children received Measles vaccination	No. of children that sleep under a bed net
Wokomo 1	3	0	0	1 (partially)	1	1 (always) 2 (not at all)

Source: Coffey household surveys 2017.

The characteristics of illness experienced within Social Catchment 1B are reflective of those experienced across Sandaun and East Sepik provinces. The common illnesses experienced within the seven surveyed villages include malaria, diarrhoea, upper respiratory tract infections, fever and skin and eye infections (Table 44).

Within the month leading up to the Coffey household survey the most commonly reported illness in Hotmin, Idam 1, Idam 2 and Wokomo 1 was malaria. The highest occurrence of malaria was within Idam 1, with 45% of households reporting someone had developed malaria in the past month (Table 45).

Table 44 Main types of illnesses reported by villages surveyed in Social Catchment 1B

Village	Diarrhoea	Malaria	Fever - other	Upper respiratory tract infection	Skin infections	Eye infections	Other
Uramesin 2	No	Yes	Yes	No	Yes	No	Yes
Temsapin	Yes	Yes	Yes	No	Yes	No	No
Hotmin	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Idam 1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Idam 2	Yes	Yes	Yes	Yes	Yes	Yes	No
Wokomo 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Bisiabru	Yes	Yes	Yes	Yes	Yes	Yes	Yes

n.a.: not available.
Source: Coffey village survey 2017.

Table 45 Percentage of households reporting illnesses within the past month

Village	Number of households surveyed	Reporting illness (%)	Malaria (%)	Flu/Cold (%)	Headache (%)	Injury (%)	Other
Hotmin	13	38	15	8	0	0	15
Idam 1	11	64	45	9	0	0	9
Idam 2	11	73	27		9	9	27
Wokomo 1	6	100	33	17	17	0	33

Source: Coffey household survey 2017.

3.4.3. Social capital (law and order, family relationships, support networks)

Law and order issues were not considered to be a significant problem in any village within the catchment. However, concerns were raised that the new infrastructure and road corridor will create issues related to land access due to in-migration that will need to be managed.

3.4.4. Access to functional services

Health

The availability of health services in the catchment is limited and the condition of existing health service facilities such as aid posts is poor (Coffey, 2017). The infrastructure and supplies provided at existing health service centres and aid posts are severely lacking, with basic needs such as sanitation, separate water supplies, electricity as well basic medical supplies in short supply. Respondents to key informant interviews in Green River (Coffey, 2017) also noted that access to existing services is an issue for people in the catchment, with people in need of medical support required to travel large distances resulting in high financial expenses or long travel times. The lack of health workers to staff existing health services was also noted by key informant interview respondents as an issue (Coffey, 2017)

The status of the existing health services within the catchment is summarised in Table 46.

Table 46 Village health infrastructure and service status

Village	Current status	Comments
Uramesin 2	No aid post	
Temsapin	No aid post	
Hotmin	No aid post	Nearest aid post 6 hours away in Fiak. Nearest hospital 120 hours away.
Idam 1	No aid post	Nearest aid post less than 1 hour away in Idam 2. Nearest hospital 48 hours away.
Idam 2	Aid post present. Community health worker present. Midwife present. Staff are trained. Needs repair.	Nearest hospital 48 hours away. No refrigerator, medical instruments, sterilising equipment, bandages, electricity, separate water supply, adequate sanitation system, transport to undertake patient visits In-date drugs present.
Wokomo 1	No aid post	Nearest aid post 24 hours away.
Bisiabru	No aid post	Nearest aid post 3 hours away in Green River. Nearest hospital 10 hours away.
Green River	Aid post present.	No refrigerator or water tanks.

Source: Coffey village survey 2017.

Idam 2 and Green River were the only villages identified as having aid posts. The facility in Idam 2 is in poor condition and needs upgrading. It services nearby villages which do not have an aid post.

Green River's aid post has no electricity for lighting or for a freezer to store medication, no water tank(s) to provide potable and reliable water, and road infrastructure to facilitate reliable access.

Education

Five of the seven villages surveyed within the catchment have schools of varying condition, resources and attendance (Table 47). Hotmin has an elementary school run by the government which has a total of four classrooms reportedly in a good to satisfactory condition. A maximum of 75 students attend the school, however attendance is not regular. Temsapin also has a government run elementary school. It has four classrooms (two of which are in poor condition). Attendance at this school was not known.

Idam 1 and Idam 2 have the largest schools in the villages surveyed within the catchment (Plate 11). The elementary school in Idam 1 has eight classrooms teaching E1, E2A, E2B. The primary school in Idam 2 consists of 11 classrooms teaching prep and grades 1 and 3 to 8 (Plate 12). Both schools are run by the Catholic Church. Attendance at the Idam 1 school is strong, with most of the 86 students attending regularly. Enrolment at the Idam 2 school is high (280 students), however student attendance is not regular. Bisiabru has a school consisting of 2 classrooms attended by 27 students on a regular basis. No high schools, tertiary institutions or vocational training centres are present in Social Catchment 1B.

Photo credit: Coffey

Plate 9
Church in Idam 2

Photo credit: Coffey

Plate 10
Typical house in Uramesin 2

Photo credit: Coffey

Plate 11
School in Idam 2

Photo credit: Coffey

Plate 12
School classroom in Idam

Table 47 Schools at villages surveyed in Social Catchment 1B

Village	Number of classrooms	Condition of classrooms	Enrolment	Grades taught	Attendance	Responsible authority	Operational
Uramesin 2	0	NA	5 students (3 boys, 2 girls)	Elementary	NA	NA	NA
Temsapin	4	Good (2), Poor (2)	No data	Data not available	Most on a regular basis	Government	Yes
Hotmin	4	Good (2), Satisfactory (2)	75 students (35 boys, 30 girls)	Elementary	Very few on a regular basis	Government	Yes
Idam 1	8	Good (4), Poor (4)	86 students (49 boys, 37 girls)	E1, E2A, E2B	Most on a regular basis	Catholic church	Yes
Idam 2	10	Good (5), Satisfactory (2), Poor (4)	280 students (50 boys, 40 girls, 190 unknown)	Prep, 1, 3 - 8	Not many on a regular basis	Catholic church	Yes
Wokomo 1	0	NA	NA	NA	NA	NA	NA
Bisiabru	2	Poor (2)	27 students (14 boys, 13 girls)	Prep	Most on a regular basis	Christian Brothers Church	Yes

NA: not applicable
Source: Coffey village and household surveys 2017

3.4.5. Status of social values

SV5 - An environment amenable to personal and family health, safety and security

The current physical and social environment of the catchment is moderately supportive of health, safety and security, though highly dependent on favourable seasons to ensure that resource harvest is sufficient for family food requirements. Remoteness generally ensures family safety and security, but is an obstacle when accessing health facilities. These factors combine to indicate a moderate level of vulnerability.

SV6 - The availability of services supportive of personal health, safety and security

Social Catchment 1B communities have limited public infrastructure and, in general, do not receive regular services supportive of personal health, safety and security. Where infrastructure such as an aid post exists, the general state is characterised by an absence of staff and medical supplies. This is an area where communities have strongly held views on the need for improvement.

3.5. Consultation outcomes

As a part of the 2017 surveys, focus discussions were held with communities within social catchment 1B to gain a general understanding of their development needs, views on the Project and their understanding of potential social impacts should the Project eventuate.

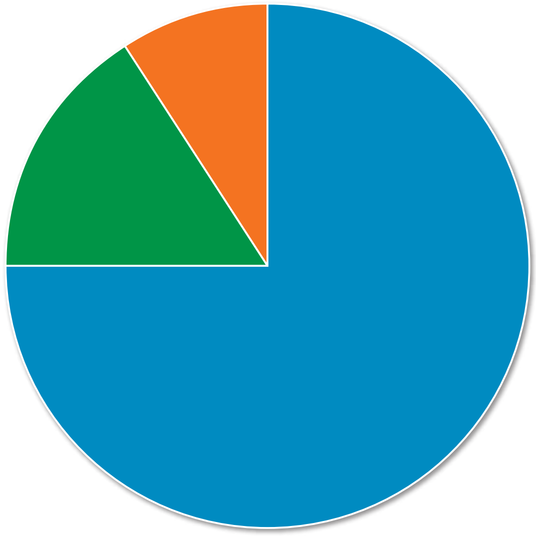
An assessment of responses to development needs and general concerns in villages from Hotmin to Green River indicates that:

- There is some scepticism on whether the mine will start up.
- In Hotmin there is a level of underlying grievance over what they see as a lack of assistance from FRL.
- There is a strong desire for development and a pledge to provide labour and land to those delivering services, whether government or the private sector.
- There is a general feeling of being abandoned while other areas of PNG are moving forward.
- Along the corridor, there is almost no government presence, and no available funding.

3.5.1. Development needs

Respondents of the 2017 household and village surveys were asked to identify the development priorities for their village. These priorities are detailed in Table 48 and Figure 14.

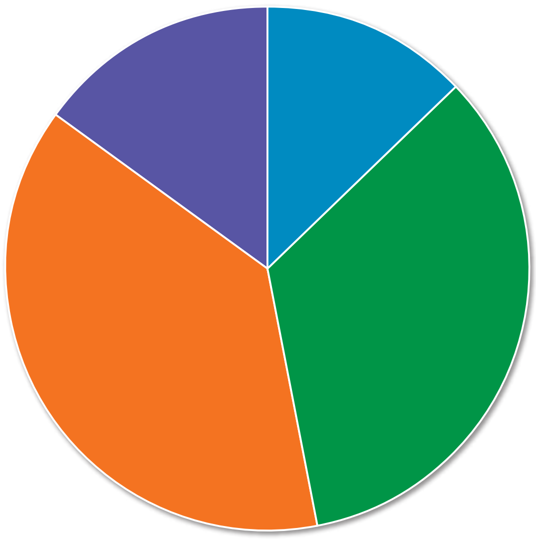
Catchment 1B - expressed development needs (% of responses)



LEGEND

- Infrastructure
- Services
- Capability development

Catchment 1B - expressed infrastructure development needs (% of responses)



LEGEND

- Water supply
- Transport and communications
- School / aidpost
- Other infrastructure needs

Table 48 Priority development needs

Infrastructure	Services	Capability development
School Aid Post Road Water supply Market Air strip	Education Health	Literacy Skills development

Source: Coffey village and household surveys 2017.

There was general uniformity among males and females on the development needs throughout the catchment. Key identified needs were for improved education, health and market infrastructure and access, all of which are seen as significant barriers to improving their livelihoods.

3.5.2. Concerns with impacts of Project

The responses to questions on potential Project impacts are shown in Table 49. Survey respondents saw potential benefits as improved access to economic infrastructure and business opportunities. Potential negative impacts identified included environmental damage and the potential for a deterioration in law and order. There was a high level of uncertainty expressed in relation to potential impacts or benefits (approximately 50%), with some raising concern about landowners within the catchment not being eligible for SML landowner benefits.

Table 49 Top five female and male responses from villages on potential impacts associated with the Project

Top 5 negative - female	Top 5 negative - male
Pollution/environmental damage Loss of land Foreign influence	Foreign influence Pollution/environmental damage Crime/violence Family breakdown Substance abuse
Top 5 positive - female	**Top 5 positive - male**
Increased economic activity/market Road Electricity	Electricity Road Increase livelihood/living standard Water supply

Source: Coffey village and household surveys 2017.

Key informant interview respondents in Green River identified the following key areas of concern:

- Potential to impact on traditional hunting grounds.
- Environmental damage.
- Disruption to customary use of land.

- Potential to create conflicts over land ownership.

Key informant interview respondents also identified that the Project had the potential to bring several benefits such as improved access to health and education services, improved standard of living, better communication infrastructure and improved facilities at health services.

4. Social Catchment 1C: Existing Infrastructure and Road Corridor – Green River to Vanimo

4.1. Overview

The existing infrastructure and road corridor social catchment consists of villages located in proximity to the existing public road between Vanimo and Green River.

The six villages surveyed within the Social Catchment 1C, Amini, Kwomtari, Itomi, Kilifas, Sumumini and Imbrinis, were selected as they are considered to be representative of villages within the catchment in terms of size and location.

4.1.1. Location

Heading north from Green River, Catchment 1C encompasses the existing road corridor of the Vanimo to Green River road on the edge of western hills to Kwomtari, from where it crosses alluvial plains and back swamps to Kilifas. The land traversed generally belongs to clans from the Kwomtari language group. From Kilifas, the corridor crosses the Bewani Range to Sumimini, and then proceeds across alluvial plains and hilly terrain to Imbrinis and on to the Nemayer River from where it tracks northwest to Vanimo. Most of this section (Kilifas to Imbrinis) belongs to clans from the Fas language group.

Villages in the south of Social Catchment 1C are largely isolated with few settlements spread out along the existing road corridor (see Figure 2). As you move further north in the catchment, commercial operations including logging and palm oil plantations increasingly dominate the landscape. A logging camp is located between Itomi and Kilifas where logging operations are run from and supplies are stored. Roadside stalls can be found within the catchment, particularly as you move further north towards Vanimo, which largely serve vehicles associated with logging operations travelling along the road. Villages within this social catchment sit within four LLG areas as detailed in Table 50.

Table 50 Social Catchment 1C government administrative boundaries

Village	Local Level Government (LLG)	District	Province
Amini	Green River Rural	Vanimo/Green River	Sandaun
Kwomtari	Amanab Rural	Vanimo/Green River	Sandaun
Itomi	Amanab Rural	Vanimo/Green River	Sandaun
Kilifas	Walsa Rural	Vanimo/Green River	Sandaun
Sumunini	Bewani/Wutung Onei Rural	Vanimo/Green River	Sandaun
Imbrinis	Bewani/Wutung Onei Rural	Vanimo/Green River	Sandaun
Green River	Green River Rural	Vanimo/Green River	Sandaun

4.1.2. Population

The total population of the Vanimo-Green River District in 2011 was 69,052 (NSO, 2014). This grew from 50,751 in 2000 (NSO, 2000), at an average annual growth rate of 2.9%, compared to the Sandaun Province growth rate of 2.6%.

Key characteristics of the population within the four LLG areas (Green River Rural, Amanab Rural, Walsa Rural and Bewani/Wutung Onei Rural) within the social catchment are shown Table 51, Table 52 and Table 53.

Table 51 Average Annual Population Growth Rates within Social Catchment 1C

	2011 Population	2000 Population	Average Annual Population Growth Rate	
			2000 to 2011	Sandaun Province Annual Growth
District				
Vanimo-Green River District	69,052	50,571	2.9%	2.6%
LLGs				
Amanab Rural	11,869	9,579	2.0%	2.6%
Bewani-Wutung	20,813	14,514	3.3%	2.6%
Walsa Rural	8,134	5,994	2.8%	2.6%
Green River	14,266	10,886	2.5%	2.6%
Village				
Amini	292	199	3.5%	2.6%
Itomi	525	131	13.5%	2.6%
Imbrinis	939	394	8.2%	2.6%

Source: NSO, 2000; NSO, 2011.

During the 11-year period from 2000 to 2011 when census data was collected, some key changes in population can be observed within the LLGs of Social Catchment 1C:

- Bewani/Wutung Onei Rural, the LLG area located closest to Vanimo, has experienced the highest rate of population growth within the catchment (annual average growth rate of 3.3%, compared to 2.6% for Sandaun Province).
- Average annual population growth rates in more remote areas (Amanab Rural and Green River) are less than the Provincial average

Within this same 11-year period, average annual population growth rates in Itomi (13.5%) and Imbrinis (8.2%) were substantially higher than the provincial growth rate (2.6%), possibly due to in-migration associated with logging activity in the area.

The gender ratios for the villages surveyed indicate that there is a greater number of males to females in each village.

Table 52 Social Catchment 1C Local Level Government population characteristics

	2000					2011				
Local Level Government	**Male**	**Female**	**Total**	**Households**	**Household occupancy (persons per household)**	**Male**	**Female**	**Total**	**Households**	**Household occupancy (persons per household)**
Green River Rural	5,664	5,222	10,886	1,718	6.3	7,276	6,990	14,266	2,241	6.4
Amanab Rural	5,058	4,521	9,579	1,850	5.2	6,291	5,578	11,869	2,236	5.3
Walsa Rural	3,168	2,826	5,994	1,080	5.6	4,311	3,823	8,134	1,410	5.8
Bewani/Wutung Onei Rural	7,615	6,899	14,514	2,323	6.2	10,823	9,900	20,813	3,352	6.2

Source: NSO, 2000; NSO, 2011.

Table 53 Social Catchment 1C surveyed villages' population characteristics

	2000					2011				
Village	**Male**	**Female**	**Total**	**Households**	**Household occupancy (persons per household)**	**Male**	**Female**	**Total**	**Households**	**Household occupancy (persons per household)**
Amini	92	107	199	34	5.9	150	142	292	39	7.5
Kwomtari	54	32	86	16	5.4	n.a.	n.a.	n.a.	n.a.	n.a.
Itomi	65	66	131	22	6.0	287	238	525	77	6.8
Kilifas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sumunini	n.a.	n.a.	n.a.	n.a.	n.a.	556	454	1,010	168	6.0
Imbrinis	198	196	394	48	8.2	516	423	939	141	6.7

n.a.: not available
Source: NSO, 2000; NSO, 2011.

4.2. Livelihoods (social values 1 and 2)

Information on subsistence livelihood activity has been drawn from a range of secondary sources including studies by Hanson et al. (2001), Ausaid (2004), and the Sandaun Education Plan 2007 – 2014 (Sandaun Provincial Government, undated) and survey data from the Coffey 2017 village surveys. Information on how villages within the catchment participate in the cash economy has been derived from the Coffey 2017 village surveys.

4.2.1. Natural capital / subsistence activity

People in Sandaun Province have a strong connection to the land and most of the rural population live a subsistence based life through gardening, hunting and fishing (Ausaid, 2004).

The primary food source in the catchment is sago, complemented by important crops of banana and taro. Game and fish are important sources of protein within the catchment. Fishing is mainly carried out for subsistence purposes within the Vanimo/Green River District, including the Sepik River and the coast in the north of the district. In some parts of the district, particularly areas that have been subject to logging activity, animals and birds have migrated to hinterland areas making them more scarce for hunters (AusAid, 2004).

Land potential in the Vanimo/Green River District varies. Within the Bewani Range foothills and Border Mountains land potential is high to very high, however, is limited in areas due to the steep slopes. The land potential within the Bewani plains, Neymayer flood plains and Vanimo coastal plains is low to moderate due to poor soils and frequent flooding, while the Bewani Range has a low potential due to the steep terrain (Hanson et. al, 2001).

Villages within the catchment source water from a variety of sources including rivers, springs, bores and tanks. Half of the villages surveyed in 2017 described the condition of their water as poor, while the other half described it as satisfactory to good (Coffey, 2017). Year-round water supply reliability was also deemed as poor within half of the six villages surveyed, while the remaining villages deemed it to be satisfactory to good (Table 54).

Table 54 Water supply within the surveyed villages of Social Catchment 1C

Village	Source	Condition	Reliability
Amini	Spring	Good	Satisfactory
Kwomtari	Bore	Poor	Poor
Itomi	River	Poor	Poor
Kilifas	Spring	Satisfactory	Good
Sumumini	Tank	Satisfactory	Satisfactory
Imbrinis	River	Poor	Poor

Source: Coffey, 2017

4.2.2. Cash economy activity

Rural people in the Sandaun Province are among the poorest in PNG (Hanson et al., 2001). Across the Province, income is estimated at less than PGK20 per person per year. The Vanimo/Green River District has more of a developed economy than other districts in the province (Sandaun Provincial Government, 2013). This is due to the forestry operations near Vanimo and Aitape which provide employment opportunities and royalties. People around Vanimo also earn low incomes from the sale of surplus garden produce and betel nut at markets in Vanimo. Income is also generated through roadside stalls which sell goods to vehicles travelling between logging operations and the existing Vanimo Port.

Cash income is gained through work in forestry as well as oil palm plantation work in some areas. Rubber was a cash crop previously cultivated in the area north of Green River, though field observations indicate that this has been substantially neglected in recent years.

Trade stores were observed in four of the villages surveyed in Social Catchment 1C (Amini, Sumumini, Kilifas and Itomi). Villages in the northern section of the catchment such as Imbrinis have access to roadside markets, and food/trade stores and fuel stations in Vanimo.

A review of census data from 2000 to 2011 indicates that there has been a slight shift in people earning a wage from employment within the catchment (excluding income generated from gardening and fishing). In 2011, 13.5% of the male population over 10 years received a wage from employment, an increase from 8% in 2000. This was true of only 4% of females (increase from 2% in 2000). In 2011, subsistence employment (gardening/fishing for own use, helping in family business without pay and housework) was undertaken by 49% of males and 65% of females (NSO, 2014).

4.2.3. Status of social values

SV1 – The capacity to support subsistence livelihoods

Opportunities to support a subsistence livelihood within Social Catchment 1C are strong given favourable seasonal conditions, however, some areas are vulnerable to unfavourable climatic conditions such as flooding and pressure from commercial agricultural operations such as logging and oil palm plantations.

SV2 – Opportunities for participation in the cash economy

There are greater opportunities for participation in the cash economy within Social Catchment 1C compared to Social Catchment 1B due to the logging operations (Plate 13) and proximity to the provincial capital Vanimo. However, opportunities are limited and incomes relatively low compared to other areas of PNG.

Photo credit: Coffey

Plate 13
Logging activities in Itomi

4.3. Culture (social values 3 and 4)

Information on cultural values within Social Catchment 1C has been derived from Coffey's 2017 village surveys and secondary sources including the Sandaun Provincial Integrated Development Plan 2014-2018 and the Kwomtari Phonology and Grammar Essentials 2008 (SIL, 2008).

4.3.1. Governance

The Vanimo/Green River District is made up of 100 wards and covers an area of approximately 10,295 km².

Public infrastructure is minimal within the catchment and as is common throughout the province, the majority of LLGs lack adequate facilities and systems to effectively govern.

4.3.2. Religious adherence and traditional practice adherence

The Sandaun Province is the most linguistically diverse region in Papua New Guinea (SIL-PNG, 2008) with approximately 80 different ethnic and cultural groups.

The Vanimo/Green River District contains 670 clan groups and 29 language groups (Sandaun Provincial Government, 2013).

There are four language groups within Social Catchment 1C:

- **Fas:** Kilifas, Sumumini, Imbrinis villages.
- **Kwomtari:** Kwomtari village.
- **Nai:** Amini village.
- **Baibai:** Itomi village.

The Kwomtari language is spoken in the plains south of the Bewani Mountains. The Kwomtari are traditionally hunter gatherers, who subsequently introduced gardening practices. Most families live a subsistence life, based on garden produce and forest products. Hunting is predominantly undertaken by men using traditional practices such as bows and arrows to catch bush meat such as pig, cassowary and smaller animals, for example possums (SIL-PNG, 2008).

Clans are a significant part of the social structure of the Kwomtari, with recognised leaders within each clan. Leadership is passed down to the eldest male within the clan. Arranged marriages are common practice and are used to strengthen relationships between clans. Marriages are arranged by male relatives of both parties (SIL-PNG, 2008).

The Kwomtari are animistic. Their fear of spirits influences the way they live their lives including their daily actions and interactions with people. As spirits are believed to have the capacity to do good or harm, efforts are made to avoid offending individuals (who may engage a scorer who can be paid to influence spirits) or spirits (SIL-PNG, 2008).

Sickness and death are commonly linked to attacks from spirits and the use of magic to remedy an illness is commonplace. Ceremonial dances (*singsings*) are performed to appease spirits when someone is very ill and used as an enjoyable social activity, perhaps as a way to pass on cultural tradition (SIL-PNG, 2008). Development has not impacted the traditional way of life of the Kwomatri as it has in other parts of PNG (SIL-PNG, 2008). The Kwomtari people think highly of their language and it is the predominant language spoken in almost all social situations, except when speaking to outsiders. Most women who marry into the language group learn to speak Kwomtari.

All villages surveyed by Coffey in 2017 have a functioning church building and all pastors are residents of the community (Table 55). Church attendance varies among the villages from minimal attendance to most people attending. Three of the villages, Amini, Kwomtari and Imbrinis, reported receiving church support for community development. For example, the church contributed to the development of the Amini Primary School in this village.

Table 55 Mainstream faith indicators in Social Catchment 1C villages

Village	Religion(s)	Dedicated church building?	Resident pastor?	Frequency of service	Attendance at services
Amini	Pentecostal and other	Yes	Yes	Weekly	Few people
Kwomtari	Other	Yes	Yes	Weekly	Most people
Itomi	Other	Yes	Yes	Weekly	Few people
Kilifas	Other	Yes	Yes	Weekly	Many people
Sumumini	Seventh Day Adventist and Pentecostal	Yes	Yes	Weekly	Few people
Imbrinis	Catholic	Yes	Yes	Weekly	Few people

Source: Coffey village survey, 2017.

4.3.3. Archaeology and cultural heritage

A review of NMAG site files, as part of a cultural heritage and archaeological study in 2018 (Appendix 12) found that there is one registered cultural heritage site within 1.5 km of the Vanimo to Green River Road within the catchment (Table 56 and see Figure 13).

Table 56 NMAG registered cultural heritage sites within 1.5 km of the Vanimo to Green River Road

National Site File code	Site name	Site Type
RCR	Biaka Village	Archaeological

Source: ALA, 2018.

4.3.4. Land ownership

Customary rights to land resources and land access are under pressure and have the potential to be alienated within the catchment from commercial logging operations (AusAid, 2004). These logging operations have increased in the past five to 10 years, as reported by Lechner et al (2018). As outlined in Section 4.2.1, logging activity has reportedly resulted in animals and birds dispersing to hinterland areas in some parts of the catchment (AusAid, 2004). The potential income streams to be generated from activities such as logging has also resulted in people forming sub-clans to claim ownership of resource rich land (Sandaun Provincial Government, 2013). While villages such as Amini identified that the proposed upgrade to the existing public road as a result of the Project was welcome (Coffey, 2017), there is recognition that this may also lead to increased in-migration and associated pressure on customary rights to land resources.

4.3.5. Status of social values

There is a strong connection to the land and the traditional ways of life within the southern section of the catchment. As the corridor moves further north towards Vanimo, traditional ways of living are being met by industrialised practices such as logging and cash cropping. As these activities increase in and around Vanimo, the urban hub of the Sandaun Province, changes to traditional ways of living is occurring.

SV3 – An enduring ability to sustain cultural identity and traditions including connection to ancestors

Due to their isolation, low population density and the absence of demand for access to their land for industrial agriculture, communities south of the Bewani Range catchment have been able to maintain their cultural identity and traditions. Elements of tradition continue to be passed down through generations and practised, while being overlaid with Christian religious activities. Areas close to Vanimo are more susceptible to experiencing cultural change due to the influence of non-traditional practices in and around the urban setting.

SV4 – An enduring ability to maintain customary rights to land access and resource use

South of the Bewani Range, pressures on land access and resource use is relatively low compared to north of the Bewani Range. North of the Bewani range, logging practices have increased over the past 10 years putting pressure on the local populations’ access to land and natural resources.

4.4. Personal and community well-being (social values 5 and 6)

Housing is basic in Social Catchment 1C and most houses have no piped water or sewage systems. There are little to no government services or public infrastructure and facilities are generally not maintained to a high standard when available. In general, health and education infrastructure is degraded to non-existent and the status of education and health are poor.

4.4.1. Built environment (housing, infrastructure, amenity)

Housing

The most common housing construction materials within the catchment are a mix of bush materials and iron roofing, with over 75% of houses being constructed this way (see Figure 15). Traditional houses (houses constructed entirely of bush materials) are less common for most villages apart from Sumumini village, where nearly 50% of houses are constructed entirely of bush materials. The only villages to support modern or improved housing were identified at Imbrinis village and Kilifas village. A quarter of houses in Imbrinis village and almost half the houses in Kilifas are constructed of modern building materials such as sawn timber and iron roofs (Coffey, 2017).

Infrastructure

Villages within the catchment rely primarily on rivers, springs and bore water for their domestic water. Water tanks are common in just under 50% of houses in Sumumini, however far less common in all the other villages surveyed in the catchment (less than 5% of houses).

Sanitation infrastructure varied within the villages surveyed. In Amini and Sumumini all houses had access to latrines. In Kwomtari, Imbrinis, Itomi and Kilifas most households (90% or more) used the bush for their sanitation requirements.

Waste disposal methods include use of a pit (Amini and Sumumini) and open dumping (Imbrinis, Itomi and Kilifas).

Amenity

Public and community services and facilities are limited within the communities visited during the surveys (see Table 57). Some villages have recreational facilities within the catchment including playing fields (Amini, Kwomtain, Itomi, Imbrinis) and volleyball courts (Amini, Itomi, Sumumini). Sumumini is the only village with a local village market and only two of the six villages (Amini and Kilifas) have a mobile market visiting the village.

Table 57 Public and community services and facilities

Village	Community hall	Volleyball court	Basketball court	Playing field	Trade stores	Village market	Mobile market visits village
Amini	No	Yes	No	Yes	Yes	No	Yes
Kwomtari	No	No	No	Yes	No data	No	No
Itomi	No	Yes	Yes	Yes	Yes	No	No
Kilifas	No	No	No	No	Yes	No	Yes
Sumumini	No	Yes	No	No	Yes	Yes	No

Village	Community hall	Volleyball court	Basketball court	Playing field	Trade stores	Village market	Mobile market visits village
Imbrinis	No	No	No data	Yes	No data	No	No

Source: Coffey 2017

4.4.2. Human capital (education and health status)

Education

The literacy rate within the Vanimo/Green River District is 65% which is similar to the literacy rate across the province (62%), and the national rate of 67% (NSO, 2011). The literacy rates within the LLGs located within Social Catchment 1C are provided in Table 58. The highest literacy rate is found within Bewani/Wutung Onei Rural (75%). This LLG is in the northern section of the catchment and includes the surveyed villages, Imbrinis and Sumumini.

Table 58 Literacy levels within Social Catchment 1C LLGs

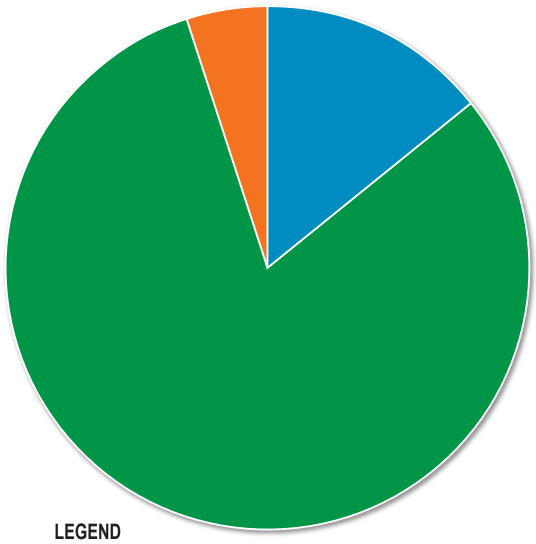
LLG within Social Catchment 1C	Rate of literacy
Amanab Rural	52%
Bewani/Wutung Onei Rural	75%
Green River Rural	56%
Walsa Rural	51%

Source: NSO census, 2011

Key characteristics of education attainment and attendance levels within the LLGs that sit within catchment 1C are summarised below: (NSO, 2014):

- Approximately 50% of the population across the four LLGs have never attended school.
- As shown in Table 59, Walsa Rural LLG has the highest percentage of people with no qualification (59%) across the four LLGs while Bewani/Wutung Onei Rural has the lowest (28%).The percentage of the population who have completed school education to grade 5 is fairly consistent across the four LLGs (on average 16%).
- Bewani/Wutung Onei Rural LLG has the highest level of secondary educational attainment (52% of the population) across the four LLGs in the catchment.
- Across the four LLGs a small percentage of the population (5% and less) has a tertiary qualification.

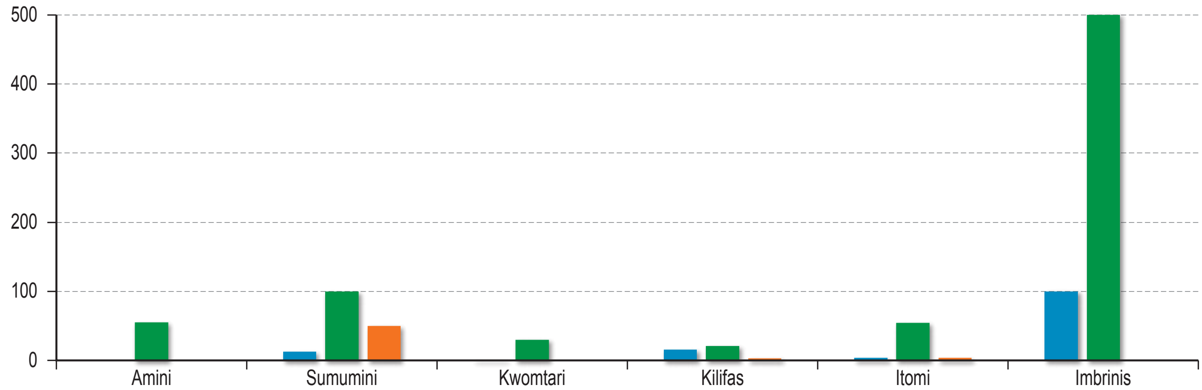
Housing construction materials of surveyed villages in Social Catchment 1C



LEGEND

- % Improved houses (Roofing iron and sawn timber framing)
- % Semi-improved houses (Roofing iron and bush timber framing)
- % Traditional houses (All bush material)

Housing structures of surveyed villages in Social Catchment 1C



LEGEND

- Improved houses (Roofing iron and sawn timber framing)
- Semi-improved houses (Roofing iron and bush timber framing)
- Traditional houses (All bush material)

Table 59 Highest level of education attainment in Social Catchment 1C

LLG	No qualification			School education Grade 1 -5			School education Grade 6 - 12			Further education qualification				
	Male	Female	Total / % of the population	Male	Female	Total / % of the population	Male	Female	Total / % of the population	Health College	Vocational College	Teachers College	Other	Total / % of the population
Amanab Rural	1,240	1,802	3,042 (52%)	619	412	1,031 (17%)	916	569	1,485 (25%)	19	42	53	206	320 (5%)
Bewani/Wutung Onei Rural	1,103	1,707	2,810 (28%)	803	788	1,641 (16%)	2,702	2,333	5,215 (52%)	25	27	116	239	407 (4%)
Walsa Rural	1,007	1,393	2,400 (59%)	416	273	689 (17%)	579	252	832 (21%)	10	7	20	69	106 (2.4%)
Green River Rural	1,480	2,172	3,652 (56%)	505	444	949 (14%)	1,001	613	1614 (25%)	14	23	49	61	147 (2.1)

Source: NSO, 2011
Note: the sum of all corresponding percentages does not equal 100% due to decimal rounding.

Health

Access to adequate health services is a major obstacle to improving the health of people in Sandaun Province, including in Catchment 1C. There is a high reliance on non-state provided services, such as services provided by the church.

While health statistics specific to Social Catchment 1C could not be obtained, some of the key health issues within Sandaun Province are relevant to this catchment:

- Malaria and pneumonia are the two most common illnesses people are admitted to health care facilities for.
- Other common illnesses include other respiratory illnesses, diarrhoea and anaemia.
- The rates admissions to health care facilities for malaria, malnutrition and other respiratory illnesses are high compared to many other parts of PNG.
- The rates of admission to health care facilities for anaemia and pneumonia are high compared to average admissions in PNG.

4.4.3. Social Capital (law and order, social and support networks)

Law and Order

Formal law and order services and facilities within the catchment are limited. There is no police presence and the nearest police station and corrections facilities are located in Vanimo (Sandaun Strategic Development Plan, 2008).

Respondents to the Coffey village survey in Imbrinis and Itomi (2017) indicated that ward development committees manage law and order issues within the villages. Respondents in Kwomtari identified that they had their own way of settling internal disputes which often involves sharing food to quell any misunderstandings. The need for increased security and police patrols was identified in Sumumini and Amini.

Family relationships and support networks

Alcohol consumption was observed in several villages surveyed in the catchment (Coffey, 2017) and survey respondents reported experiencing law and order problems such as lawless youth. As outlined above, the need for increased security and police presence was identified.

When faced with such issues, community members generally turn to local leaders and ward development committees to help them. There are also several support networks and community based organisation that exist in the catchment. Those within the Vanimo/Green River District are shown in Table 60.

Table 60 Social groups and organisations in Vanimo/Green River

Group	Vanimo/Green River
Church-based organisations	30
Women’s groups	34
Youth groups	27

Group	Vanimo/Green River
Sports associations	14
NGOs	10

Source: Ausaid, 2004.

The women's groups' main activities involve spiritual development, sewing and cooking (Ausaid, 2004). Youth groups usually work closely with the church in spiritual development and community work. The sports associations generally arrange sports such as soccer, basketball and volleyball between communities.

4.4.4. Access to functional services

Health

There are two hospitals in the province, the closest to Social Catchment 1C being Vanimo General Hospital. Access is restricted however, due to poor transport infrastructure and the long distances required to reach it (up to 6 hours from Amini).

Access to health services is an issue for several villages within the catchment, particularly in the more remote villages of Amini, Kwomtari and Itomi. Neither Amini nor Itomi have an operational aid post, and the closest health care centres are 4 to 5 hours away. In Kwomtari, the aid post is constructed out of bush materials and there were no supplies of in date medication and sterilising equipment. In the villages visited in the northern section of Social Catchment 1C (Kilifas, Sumumini and Imbrinis), in-date medication, sterilising equipment and adequate sanitation systems were present at two of the three posts, however, the condition of the facilities within the villages were basic and in need of repair. Table 61 summarises the status of the aid posts within the villages surveyed in the catchment.

Data collected from the village surveys (Coffey, 2017) show that health care services provided to villages in Social Catchment 1C include:

- Child immunisations.
- Assistance during birth by qualified medical officer.
- Assistance from trained village birth attendant.
- Assistance from traditional village birth attendant.
- Medical patrols.

However, not all of these services are available to all of the villages. Only two of the villages, Imbrinis and Sumumini, reported receiving birthing assistance from a trained medical officer, while four villages, Imbrinis, Sumumini, Kilifas and Itomi, reported receiving birthing support from a traditional village birthing assistant.

Table 61 Village health infrastructure and service status

Village	Current status	Comments
Amini	No aid post. No community health worker. No Midwife.	Nearest health care centre is in Green River (4 hrs away). Nearest hospital is in Vanimo (6 hrs away).
Kwomtari	Aid post made of bush materials present. Health care worker present. No Midwife. Staff are trained.	Next closest aid post is in Bewani (2hrs away). Nearest hospital is in Vanimo (3 hrs away). There are limited necessary supplies. For example, no stocks of in date drugs or sterilising equipment. Lacks sanitation system and refrigerator. Instruments are available. Has separate source of water and internal plumbing. Has transportation to undertake patient visits.
Itomi	No aid post present.	Nearest health care centre is in Maka (5 hrs away). Nearest hospital is in Vanimo (4hr away).
Kilifas	Aid post present (Plate 14). Health care worker present. No Midwife. Staff are trained. Needs maintenance.	Nearest hospital is in Vanimo (3 hrs away). No refrigerator, no instruments, no sterilising, no separate water or plumbing. In date drugs and bandages are present. Generator or solar powered electricity present. Adequate sanitation system is present. No transport.
Sumumini	Aid post present. Health care worker present. No Midwife. Staff are trained. In need of new construction/maintenance.	Nearest hospital is in Vanimo (3hrs away). No refrigerator present, no in date drugs stocked, no sterilising equipment. Instruments and bandages are present. No generator or solar powered electricity. Has separate source of water and internal plumbing. No adequate sanitation system present. Has transportation to undertake patient visits.
Imbrinis	Aid post present. Health care worker present. No Midwife. Staff are trained. Needs maintenance including to two staff houses.	Nearest hospital is in Vanimo (1hr away). No refrigerator, instruments, separate source of water and internal plumbing, or transportation to undertake client visits. In date drugs, sterilising equipment, bandages generator or solar powered electricity and adequate sanitation system are present.

Source: Coffey village surveys (2017).

Education

Within the catchment each of the villages surveyed reported having a school (Coffey, 2017) (Plate 15). The Christian Brethren Church, the Catholic Church and the Government each manage two schools. The conditions of the schools vary from good to poor (see Table 62).

Table 62 Schools at villages surveyed in the Social Catchment 1C

Village	Classroom conditions	Water and sanitation facilities	Attendance	Teachers	Teacher vacancies
Amini	4 (good), 2 (satisfactory)	No	Not many on a regular basis	6	0
Sumumini	3 (good), 3 (satisfactory),	No	Most on a regular basis	6	0
Kwomtari	2 (good), 2 (poor)	Yes	Very few on a regular basis	1	1
Kilifas	6 (good), 6 (satisfactory), 6 (poor)	Yes	Very few on a regular basis	4	2
Itomi	4 (good), 4 (poor)	Yes	Not many on a regular basis	3	6
Imbrinis	8 (good), 8 (poor)	Yes	Most on a regular basis	7	3

Source: Coffey village survey, 2017

The issues identified during the village surveys regarding access to education varied along the catchment. The more remote villages in the south of the corridor, Amini and Sumumini, generally identified lack of staff housing and water and electricity supply as the main priorities. Further north in the catchment, the main issues relate to a lack of interest in education among the community and the attraction of paid work which was enticing people to join the market economy in lieu of going to school.

4.4.5. Status of social values

SV5 - An environment amenable to personal and family health, safety and security

The current physical and social environment of the existing infrastructure and road corridor and social catchment communities is moderately supportive of health, safety and security. The villages generally live a traditional subsistence lifestyle which is dependent on favourable environmental conditions. However, the subsistence based lifestyle is becoming supplemented more and more by opportunities to enter the cash economy particularly in the villages closer to Vanimo and near the logging camps. Increased exposure to the cash economy in some circumstances has seen a rise in substance abuse and law and order issues. Villages in the more remote locations generally experience a safe environment however face difficulty when access to services is needed. These factors combine to indicate a moderate level of vulnerability.

SV6 - The availability of services supportive of personal health, safety and security

The existing infrastructure and road corridor social catchment communities have limited public infrastructure and, in general, do not have access to services supportive of personal health, safety and security. Where infrastructure such as aid posts exist, the general state is characterised by an absence of staff and medical supplies.

Photo credit: Coffey

Plate 14
Aid post in Kilifas

Photo credit: Coffey

Plate 15
Kilifas Primary School building

4.5. Consultation outcomes

As a part of the 2017 surveys, focus discussions were held with communities within Social Catchment 1C to gain a general understanding of their development needs, views on the Project and their understanding of potential social impacts associated with the Project.

4.5.1. Development needs

The 2017 village surveys within the catchment identified the development priorities of the communities visited. These priorities are detailed in Table 63.

Table 63 Priority development needs

Infrastructure	Services	Capability development
Water supply School Electricity Aid Post Sports and community facilities Transport infrastructure	Education Health Mobile phone coverage	Literacy Skills development

4.5.2. Concerns with impacts of the Project

When asked to identify potential social impacts from the Project, a number of villages surveyed were not able to specify any (Coffey, 2017). The most common positive impacts reported were the potential for improved road and market access to sell produce. Other responses included the potential for improved access to Vanimo, health services, improvements to law and order and human resources. No negative impacts were identified.

5. Social Catchment 1D: Vanimo Ocean Port

5.1. Overview

Social Catchment 1D comprises the capital of Sandaun Province, Vanimo and the settlements of Wesdeco and Cis Point (see Figure 2). Wesdeco settlement was established in early 1979 under West Sepik Development Corporation Pty Ltd (Boyce, 1992). The ‘Cis’ in Cis Point stands for Corrective Institutions Service, a correctional service which operates in proximity to the settlement. Both settlements are located in close proximity to the town of Vanimo.

The catchment is located within a flat to gently undulating coastal environment dominated by floodplains and swamps (Hanson et al., 2001). The inclusion of the settlements in the catchment is due to their proximity to the existing Port of Vanimo which is proposed to be upgraded as a part of the Sepik Infrastructure Project. Social profile information for the catchment was obtained from social survey work completed by Coffey in November to December 2017. This included village, key informant, marine resource use, fish market and points of interest surveys. Information has also been obtained from secondary sources including the Vanimo-Urban Local Level Government Activity and Project Plan 2014 – 2018 and Papua New Guinea rural development handbook (Hanson et al., (2001).

5.1.1. Location

Vanimo is a township located on the north coast of Sandaun Province, approximately 30 km east of the Indonesian border. Wesdeco is a settlement within the Vanimo Urban Local Level Government (LLG) area and is located less than 0.5 km due east of the existing Port of Vanimo. Cis Point is a peri-urban settlement located approximately 1 km from Vanimo town centre within the Vanimo Urban LLG administrative boundary.

Vanimo Urban LLG falls within the Vanimo Green River District. The Vanimo Urban LLG is made up of seven wards. Wesdeco and the existing Port of Vanimo are located in ward three (Wesdeco) and Cis Point is situated in ward two (Dali/Makepa). The supporting infrastructure for the concentrate pipeline, collectively known as the concentrate export facility, is located next to Wesdeco settlement in ward three. The last 6 km of the proposed concentrate pipeline falls within wards three, four (Dasi/Konkong), five (Transmitre/Sawmil), six (Salame/Waraston) and seven (Wusipi/Pasi) (Vanimo Urban LLG, 2014).

This social catchment is an extension of Social Catchment 1C existing infrastructure and road corridor.

5.1.2. Population

Population data has been compiled from the 2011 national census (NSO, 2014) and the 2000 national census (NSO, 2000). Census data has provided information on population and household numbers down to the settlement level within this social catchment (Table 64).

Table 64 Population and household characteristics of Social Catchment 1D

Settlement	Population	Households	Male	Female
Vanimo Town*	13,970	2,370	7,404	6,566
Cis Point†	144	11	108	36
Wesdeco†	507	82	274	233

*NSO, 2014
†NSO, 2000

The age distribution within the Vanimo Urban LLG is shown in Table 65 (NSO, 2014). The age profile is skewed to the younger age groups for both male and females. This can be compared to the 65 plus age group which makes up approximately 1.4% of the population of Vanimo Urban LLG. This aligns with trends nationally where approximately 2.6% of the population are aged 65 years and over (NSO, 2015a).

Table 65 Total Population by Vanimo Urban Local Level Government, Age and Sex

Age (years)	Number and percentage of population	Males	Females	Gender Ratio*
0-4	1,801 (13%)	915	886	103
5-9	1,779 (13%)	930	849	110
10-14	1,610 (12%)	829	781	106
15-24	1,666 (12%)	916	750	122
20-24	1,419 (10%)	792	627	126
25-29	1,256 (9%)	623	633	98
30-34	944 (7%)	469	475	99
35-39	894 (6%)	472	422	112
40-44	711 (5%)	356	355	100
45-49	652 (5%)	349	303	115
50-54	478 (3%)	295	183	161
55-59	304 (2%)	199	105	190
60-64	193 (1%)	111	82	135
65-69	117 (1%)	62	55	113
70-74	45 (<1%)	23	22	105
75-79	23 (<1%)	15	8	188
80-84	11 (<1%)	4	7	57
85-89	3 (<1%)	1	2	50

NSO, 2014
* Number of males per 100 females

5.2. Livelihoods (social values 1 and 2)

Due to their geographic location, fishing is the key subsistence activity practiced for the settlements of Wedesco and Cis Point. The town of Vanimo is the economic hub of Sandaun Province with a range of shops, markets and logging operations (Plate 16 and Plate 17). Due to this, it provides greater accessibility into the cash economy in comparison to the other social catchments. The settlements of Wesdeco and Cis Point are closely situated to the Port of Vanimo which is primarily utilised by commercial activities, such as timber and palm oil operations (Plate 17 and Plate 18).

5.2.1. Natural capital/subsistence activity

People situated on the coastal plains around Vanimo cultivate low intensity mixed staple gardens where the main crops include sago and coconut (Hanson et al., 2001). Small kitchen gardens are also grown in Cis Point.

The following summary outlines the importance of fishing to coastal communities in PNG.

> *Fish is a major source of animal dietary protein in Papua New Guinea (PNG). Annual per capita fish consumption is 13 kilograms (kg), but reaches 53.3 kg (Bell et al. 2009) in coastal communities. Significant loss of coastal fisheries is evident along PNG's coastline. Marine resources in provinces that have depended heavily on them to sustain livelihoods have come under increasing stress because of fish catches that exceed sustainable levels, destructive fishing methods, and use of outboard engine-powered crafts to access distant or protected fishing grounds. Agroforestry projects are active in many of the 14 Maritime Provinces. Over the past 20 years, many of these projects have contributed to marine resource degradation. Siltation from seasonal heavy rainfall has likewise contributed to degrading marine resources, particularly when it follows extended droughts*
>
> *PNG's relatively porous international boundaries with Australia and Indonesia have also facilitated unsustainable rates of capture of threatened species such as dugongs and turtles.* (Asian Development Bank, 2014a; 29)

Fishing within the study area is conducted for subsistence (for direct consumption), local (for market) and commercial purposes.

Within and in close proximity to Vanimo, harvesting of marine resources by coastal settlements is quite important, with informants indicating that seafood is consumed daily (2-3 fresh fish, or 1-2 cans of fish) and harvesting by households living adjacent to the reefs occurring at least several times per week (Coffey, 2017). Subsistence (or artisanal) fishing is conducted using spears, line and net fishing (see Appendix 12). Spearfishing is most common when ocean conditions are more favourable with better visibility and smaller waves during the dry season (June and July). Fishing activities are common at night, as it is reportedly more advantageous to catch fish while they sleep using flashlights and spears while fishing during the day is practised with less success. Line and net fishing also occurs along the beaches when boats are not available. Deeper reef areas offshore from the entrance of Vanimo Harbour are fished via line and net fishing methods. From June to September, there are greater numbers of pelagic species such as tuna, and local fishermen troll for them with feathered lures on monofilament lines. As is typical for other PNG coastal settlements, men fish predominantly for finfish while both women and men harvest invertebrates such as octopus. A wide variety of fishing gear is utilised. The main fishing locations identified by locals are around Vanimo Bay as shown in

Figure 16. The type of fish and seafood reportedly caught and consumed in Wesdeco and Cis Point is shown in Table 66.

Table 66 Type of fish and seafood caught and consumed in Wesdeco and Cis Point

Type of fish or seafood	Size of fish or seafood harvested
Bundle fresh fish	Medium to large
Finfish	Small to large
Beche de mar	Large
Tuna	unknown
Reef fish	unknown
Octopus	Medium to large

Source: Coffey marine resource use survey, 2017

People reported typically harvesting invertebrates daily, which may indicate a scarcity of this form of seafood, possibly due to unsustainable harvesting due to increased population pressure. According to locals interviewed in Cis Point, the types and numbers of fish caught have remained the same over the last five years; conversely, locals from Wesdeco reported a reduction in fish caught over the last five years despite the settlement being adjacent to Cis Point settlement.

The Vanimo fish market is a small informal facility with no services (e.g., power, refrigeration or running water) located on the beach near the banana boat landing close to the area of retail shops (see Plate 20). When Coffey conducted a survey at the market in 2017, the majority of vendors were women from outside of Vanimo, selling fish caught generally to the east of Vanimo toward Warapu. The informal market operates whenever a vendor has fish to sell, so can operate up to seven days per week. Responses to the fish market survey (Coffey, 2017) indicate that there may be a higher level of selling on 3 to 4 days per week. Vendors indicated that they felt the quantity of fish able to be caught and sold was similar to five years ago. The purchase price of fish is in the order of PGK6 to PGK8 per kilo for single fish, or K10 per kilo for a bundle of smaller fish. While provincial fisheries staff indicated that fishing was more of a recreational activity by local residents, responses to Coffey's marine resource use surveys showed that it is also important for subsistence (Coffey, 2017). An ice-making machine was purchased by the fisheries department to sell ice to vendors and assist them in keeping fish cold at the market but was under-utilised by local residents, ostensibly due to the cost of the ice.

Provincial fisheries staff indicated that commercial fishing was not a significant industry in the Vanimo area for a range of reasons (Coffey, 2017). This includes a lack of islands and reef areas within a reasonable distance, concerns around safety when fishing in open waters, and a general lack of interest by local residents. Overseas fishing vessels operate offshore approximately 30 km north of Vanimo. Fish are caught primarily via seiners (a method of fishing that employs a fishing net called a seine). The Global Fishing Watch lists vessels from PNG, the Philippines and China who operate in the region. Their catch consists of fish species including the skipjack, yellowfin, bigeye tuna, small pacific mackerel, frigate tuna, mackerel tuna, sharks and rays.

Source:
Fishing points from Coffey 2017 marine resource use survey.
Infrastructure and roads from FRL.
Villages from FRL and Coffey.
Imagery from Google Earth (DigitalGlobe captured 14 December 2014).

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Date: 13.09.2018
Project: 754-ENAUABTF11575A
File Name: 11575_16_App1_F016_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Fishing locations in Catchment 1D in proximity to Vanimo

Figure No: 16

Excess fish from artisanal fishing are sold at the local fish market. Fish sold are not sourced from Vanimo Harbour. Some of the species of fish, including the freshwater fish (*Tilapia,* fresh or smoked),are brought in by plane from elsewhere (Appendix 12).

Marine fish for sale at the Vanimo fish market included (Plate 18 - Plate 22):

- Long-tom (Belonidae).
- Small garfish.
- Flying fish.
- Estuary cod (*Epinephelus coioides*).
- Scarlet sea perch (*Lutjanus malabaricus*).
- Squirrelfishes (Holocentridae).
- Long nose fish.
- Reef fish.
- Red emperor.
- Crayfish.

The Vanimo Urban LLG is relatively developed with several stores and markets for buying food including supermarkets (including SVS and VSL), trade stores and fish and other fresh produce markets (Vanimo Urban LLG, 2014). The strong presence of food in stores and markets within the town indicates that they are a key source of food for residents.

Domestic water supplies in Cis Point and Wesdeco are obtained from a dug well or tank (Coffey, 2017). The water sources at Cis Point were reportedly in a good condition whereas domestic water in Wesdeco was reportedly of poor quality. It was reported that Cis Point's water supply is from a tank and is treated twice per year whereas Wesdeco's water supply is sourced from water tanks or dug wells and received no water treatment. People who reside in the Vanimo Urban LLG have access to rain water tanks but the water supply is not reticulated. Other sources of water include local creeks and rivers (Vanimo Urban LLG, 2014).

5.2.2. Cash economy activity

As outlined in Section 3, the rural population of Sandaun Province are considered to be some of the poorest in PNG (Hanson et al., 2001). While communities in the Vanimo Ocean Port social catchment have good access to a cash economy and opportunities to earn an income, levels of income are low compared to other parts of PNG (Hanson et al., 2001). Some people earn a small income from sales of fresh food such as surplus garden produce, fish, seafood, and betel nut. This is sold locally at makeshift market places operating in Vanimo town centre, Cis Point settlement and Wesdeco settlement. The market operating close to Wesdeco settlement is situated approximately 0.5 km from the existing Vanimo Port. These markets consist of open stalls selling commodities including fish, seafood, betel nut, cigarettes and ice blocks (Coffey, 2017).

Some income is derived from wage employment and royalties provided by forestry operations near Vanimo and Aitape. There are also a small number of people who import and sell their goods from Jayapura in Irian Jaya (Hanson et al., 2001), approximately 100 km to the west of Vanimo.

Photo credit: Coffey

Plate 16
Logging ships in Vanimo Bay

Photo credit: Coffey

Plate 17
Logging operations along Vanimo foreshore

Photo credit: Coffey

Plate 18
Fish sold at Vanimo Fish Market

Photo credit: Coffey

Plate 19
Vanimo Fish Market

Photo credit: BMT 2017

Plate 20
Scarlet sea perch (*Lutjanus malabaricus*) and Estuary cod (*Epinephelus coioides*) at Vanimo fish marke

Photo credit: BMT 2017

Plate 21
Long tom at Vanimo fish marke

Photo credit: BMT 2017

Plate 22
Squirrelfishes (Holocentridae
at Vanimo fish marke

Large scale agricultural production is limited within the boundaries of the Vanimo Urban LLG due to current laws and regulations which limit their activity in urban areas and the absence of fertile soil within these areas (Bourke et al., 2001). Prior to the Newcastle disease outbreak in 2012 which decimated the industry there were successful poultry and piggery projects throughout the Vanimo Urban LLG (Vanimo Urban LLG, 2014). As outlined in Figure 17, in 2010 and 2011, ward 4 generated an annual income of PGK50,000 from the sale of chickens. Efforts have since been made to revive the industry following the outbreak of Newcastle disease in 2012.

Commercial agricultural operations in Bewani Wutng Onei Rural LLG (adjacent to Vanimo Urban LLG) include oil palm plantations, rubber farming and cocoa farming (Sandaun Provincial Government, 2013).

Tourism is a small scale industry in Vanimo and the surrounding settlements. While surf beaches attract surfboard riders nationally and internationally, Vanimo is relatively isolated and difficult to access (Plate 23). Beaches toward Wutang west of Vanimo attract surfers during September through to January. Lido settlement situated 8 km west from Vanimo also attracts surfers where there are a small number of facilities such as a guesthouse and surfboard and bicycle hire facilities. Small scale guesthouses and services for tourists provide income to the small businesses that run these services (Papua New Guinea Tourism Promotion Authority, 2018).

Another source of income within the Vanimo Urban LLG is that generated from Public Motor Vehicles (PMVs). The monthly income generated from PMVs ranges from 3,000 to PGK10,800 within the Vanimo Urban LLG. There are many informal fuel businesses operating on the sides of the road throughout the town (Vanimo Urban LLG, 2014).

5.2.3. Status of social values

SV1 – The capacity to support subsistence livelihoods

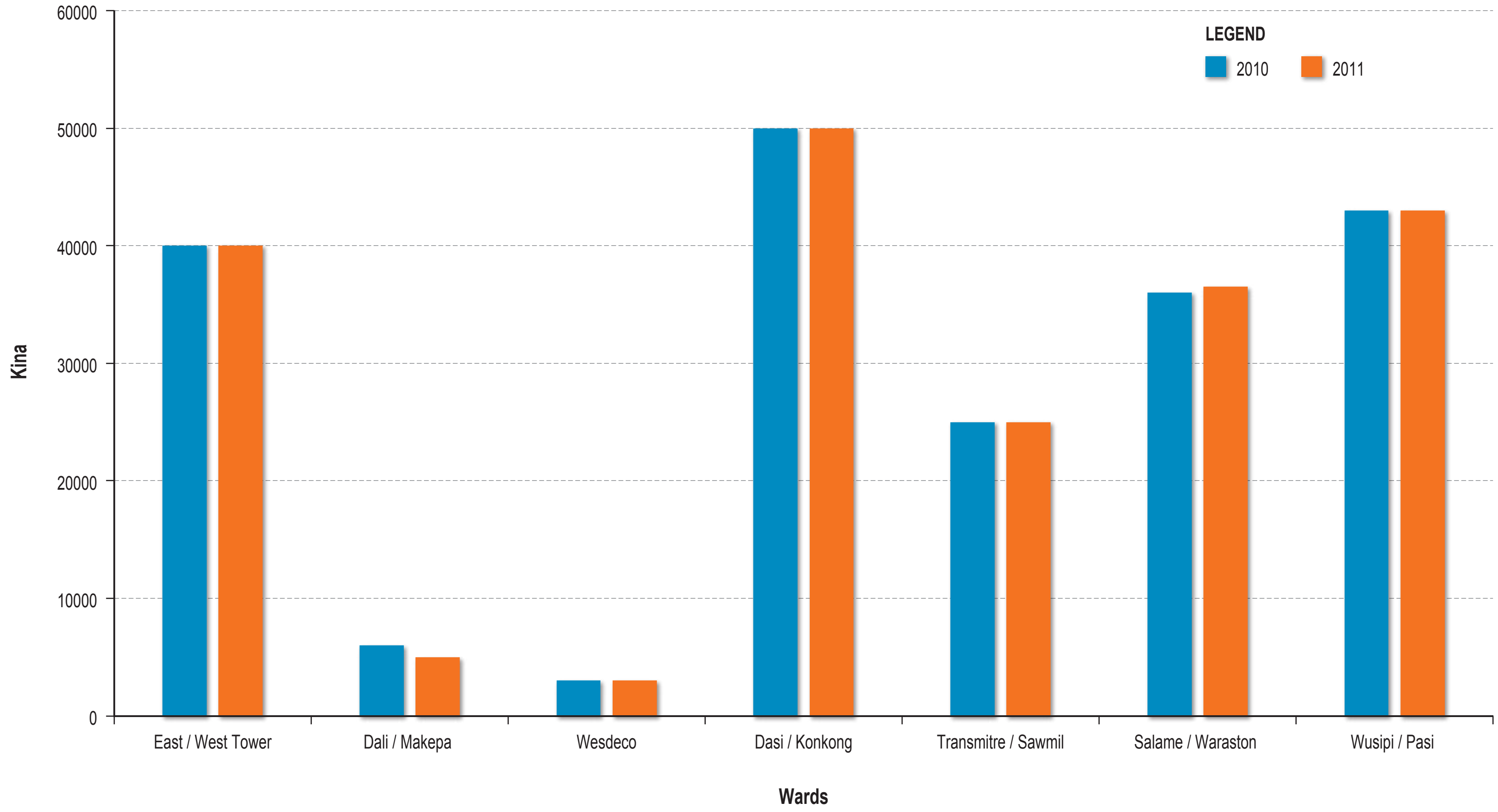
Subsistence practices in terms of mixed staple gardens are limited due to Vanimo’s urban and industrial setting. However, fishing plays a significant role in supporting a subsistence livelihood within Wesdeco settlement and Cis Point settlement.

SV2 – Opportunities for participation in the cash economy

There are opportunities for participation in the cash economy within the catchment through activities such as selling fish and other fresh food. For instance, some families earn a small income from the sale of surplus garden produce or fish at markets in Vanimo.

5.3. Culture (social values 3 and 4)

Residents of Vanimo and surrounding settlements belong to the Vanimo language group, also referred to as Dumo, Duso, Manimo and Wanimo (Clifton, 2013). This language group is made up of two dialects, Vanimo and Waromo (Clifton, 2013).



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File Name: 11575_16_App1_F017_GRA

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Income generated in the chicken industry during 2010 and 2011 in the Vanimo Urban LLG

Figure No: 17

Photo credit: Coffey

Plate 23
Surfing spot close to Lido villag

The population of Vanimo includes residents born in the town with ancestral links to the area as well as migrants from other rural areas of PNG and international residents (Vanimo Urban LLG, 2014). Rural urban migration to Vanimo, and in particular the settlements of Vanimo, is on the increase with migrants attracted to opportunities to generate an income and participate in the cash economy. International residents often come to work in one of the internationally owned commercial enterprises operating in the town.

5.3.1. Governance

Vanimo, Cis Point and Wesdeco are located within the Vanimo-Green River District. Vanimo township is the capital of the District and is made up of five LLGs. Cis Point and Wesdeco are part of one LLG area, Vanimo Urban LLG, which shares an administrative boundary with Bewani Wutng Onei Rural LLG. The Vanimo Urban LLG is broken into seven different wards covering 780 km^2.

The majority of wards within Vanimo Urban LLG lack adequate government facilities and systems such as ward centres, village court systems and ward development committees (Vanimo Urban LLG, 2014).

Local government centres are understaffed resulting in a lack of committee meetings to effectively govern (Vanimo Urban LLG, 2014). The performance of public servants is also hindered by a lack of accommodation and low salaries.

Public infrastructure in Vanimo includes provincial government buildings, a court house, police station and army barracks (Coffey, 2017) (Plate 24 and Plate 25). A corrections facility is also located within close proximity to Cis Point. However, the Vanimo Urban LLG does not have a village court system in place to conduct hearings and lacks appropriate personnel to conduct mediations and counselling and oversee court cases (Vanimo Urban LLG, 2014). While there is a police presence in Vanimo they are under resourced, particularly given the increasing law and order problems in the town and surrounding areas (Vanimo LLG, 2014).

5.3.2. Religious and traditional practice adherence

Across the Vanimo Urban LLG there are churches of a number of denominations such as Catholic, Lutheran, United, Revival and Baptist.

The main religion in Wesdeco is Catholic followed by Lutheran and Seventh Day Adventist (Coffey, 2017). The settlement has a dedicated church building with church services held weekly (Plate 26). Church attendance is strong and the church has provided support to community development through the construction of an elementary school. The church pastor is not local to the settlement and travels from Monobe. Residents of Cis Point are understood to adhere to a range of faiths (including Catholic and Revival) and to attend church services in Vanimo.

Communities in Wesdeco and Cis Point indicated that customary practices associated with fishing continue to be part of daily life (Coffey, 2017). Fishing is generally undertaken by men and trapping techniques include the use of gill nets, circle nets, handlines, trolling gear and spear guns.

Photo credit: Coffey

Plate 24
Sandaun Province Government Headquarters in Vanimo

Photo credit: Coffey

Plate 25
Indonesian Consulate in Vanimo

Photo credit: Coffey

Plate 26
Catholic Church in Vanimo

Catching seafood such as molluscs is another customary practice that continues in communities within the catchment, particularly by women. Traditionally, women of the Vanimo (or Dumo) language group would participate in an activity known as ‘coral gleaning’ where they would harvest small reef fish and invertebrates (Si and Lahe-Deklin, 2015). These coral gardens consisted of patches of fringing reefs or rock walls in shallow lagoons. With the assistance of their children, women would use juice from pieces of crushed poisonous vine *(Derris trifoliata)* at low tide to stun small fish and invertebrates that made their way into these shallow lagoons (Si and Lahe-Deklin, 2015). Residents of Cis Point are also understood to engage in customary practices associated with food production in kitchen gardens.

5.3.3. Archaeology and cultural heritage

Cultural heritage specialists, ALA, reviewed the registered cultural heritage site files at the NMAG in 2018. No registered cultural heritage sites were identified within Social Catchment 1D. As mentioned in Section 4.3.3, three registered sites occur within 1.5km of the existing infrastructure corridor running from Vanimo to Green River.

5.3.4. Status of social values

SV3 – An enduring ability to sustain cultural identity and traditions including connection to ancestors

The catchment’s ability to sustain its cultural identitiy and traditions is being challenged by a range of factors including population pressures, commercial activities and the relatively porous boundaries of the region with Australia and Indonesia. Vanimo is the economic hub of the Sandaun Province and while traditional ways of living persist in some form, the region is exposed to culturally diverse practices and people, decreasing the catchment’s ability to maintain it cultural traditions.

SV4 – An enduring ability to maintain customary rights to land access and resource use

Communities in the Vanimo Ocean Port social catchment have retained customary rights to use land and access its resources through activities such as fishing, catching seafood and maintaining gardens. These rights and access to land are under pressure in Vanimo and surrounding areas due to the increasing development of the town, migration to settlements surrounding Vanimo from rural areas and commercial agricultural operations in proximity to Vanimo.

5.4. Personal and community well-being (social values 5 and 6)

The Vanimo LLG area currently supports a range of public services and infrastructure. The majority of these services and infrastructure lack in proper establishment and management and are affected by a lack of staff and equipment. A prominent concern from local communities is the increase in law and order issues within the catchment.

5.4.1. Built environment (housing, infrastructure, amenity)

As the capital of Sandaun Province, the town of Vanimo has a range of infrastructure and services including an airport, port, a general hospital, elementary, primary and high schools, a technical college, several churches, banks, postal services, Provincial government buildings, embassies, trade stores, supermarkets and recreational areas.

The existing Port of Vanimo is predominately used to export logs from nearby logging operations such as Jumbo Treck, Amanab 56, Border International and Vanimo Forest Products (Coffey, 2017). Plate 27 shows Vanimo Forest Products activity close to the Port of Vanimo along the foreshore of Vanimo Bay (Plate 28). The export of timer constitutes the bulk of goods handled at the port with bulk fuel and break bulk cargo also imported and exported from the port (PNG Ports Corporation, 2010). Anecdotal information suggests that the port is also used to export palm oil as well as by passenger ships. In the late 1990s approximately 250 passengers would pass through Vanimo each month. A service between Wewak and Vanimo had operated approximately 40 times a year (Boyce, 1992). The port can accommodate vessels to a maximum size of 150 m.

Vanimo Urban LLG is linked by roads to Bewani-Onei-Wutung LLG. The Coastal Sepik Highway previously linked Aitape to Vanimo and Butum at the PNG/Indonesia border. This link has been severed due to the road becoming impassable due to a lack of maintenance. Sea transport is the main mode of transport connecting people from Vanimo to Aitape (Kama, 2017). All of the roads in the district remain in poor condition.

In Cis Point, housing is typically built out of sawn timber framing with corrugated iron roofs. This differs to Wesdeco, where the majority of houses were made from bush materials with iron roofing.

The majority of houses in both Cis Point and Wesdeco had a latrine. Waste disposal methods in Cis Point mainly included use of a pit (60% of houses), burning (30% of houses) and other practices (10%). This differs slightly to Wesdeco, where the majority of households dispose of waste through open dumping (60%), use of a pit (30%), burning (10%) and use of other methods (10%).

Community and recreational sporting facilities are rather limited in the catchment. Cis Point has a volleyball court and one other playing field available to locals. Wesdeco has one playing field and Vanimo has one recreational area (Plate 29).

Mobile phone systems were installed in Vanimo in 2006 yet respondents to social surveys (Coffey, 2017) had mixed views on the level of mobile phone coverage within the catchment. While residents of Cis Point indicated that mobile phone coverage is average in their settlement, in Wesdeco residents said that it was good (Coffey, 2017). Given that these settlements are located in close proximity to each other, this difference is likely due to differing perceptions in the two settlements on the level of coverage provided. The main communication providers include Digicel, B mobile and Telikom. These companies provide communication services including radio, television, internet and phone coverage.

Photo credit: Coffey

Plate 27
Vanimo Forestry Logging company near Port of Vanimo

Photo credit: Coffey

Plate 28
Existing Port of Vanimo

Photo credit: Coffey

Plate 29
Recreational field in animo

5.4.2. Human capital (education and health status)

Education

According to the 2011 census, 78% of the Vanimo Urban LLG population 10 years and over are literate in one language while the remaining 22% are illiterate.

The provision of educational services in Vanimo Urban LLG remains poor. This is reportedly due to shortages in teachers and inadequate infrastructure and facilities such as toilets and staffing accommodation (Coffey, 2017).

All seven wards within the Vanimo Urban LLG have elementary and primary schools. The only secondary school in Vanimo Urban LLG is situated in Ward seven. Anecdotal information suggests that schools in wards two and three have the lowest attendance levels (Vanimo LLG, 2014). A review of census data (NSO, 2011) indicates that school attendance levels are the highest in elementary and primary school compared to high school. The highest grade level achieved within Vanimo LLG was Grade 10 as detailed in Table 67.

Table 67 School attendance/non-attendance by age profile in the Vanimo Urban LLG

Age (years)	Attended school	Never attended	Highest Grade level
5-9	583	1,100	Grade 1
10-14	1,183	286	Grade 3
15-19	235	31	Grade 8
20-24	72	42	Grade 10
25-29	43	185	Grade 10

NSO 2011 data

According to settlement survey data, the highest grade level attained by settlements of Wesdeco and Cis Point were to elementary levels (2017).

Health status

The main illness identified as affecting both Cis Point and Wesdeco is malaria, which appears to be hyperendemic in all of the communities within this catchment (Coffey, 2017). Other illnesses such as fever and skin infections are also prevalent in Wesdeco. Children are receiving regular immunisations but it is unknown how regular or when the last medical patrol visited the settlement.

Provision of sufficient health services and medical supplies are a development priority for settlements residing within the Vanimo Urban LLG (Vanimo LLG, 2014).

The key health issues and concerns within the catchment reported by community leaders and governmental officials (Coffey, 2017) included:

- AIDS and STI disease transmissions.
- Increase in teenage pregnancies.
- Access to a clean water supply.

- Consumption of addictive substances: alcohol and betel nut.
- Inhalation of addictive substances: tobacco and marijuana.

As in many other parts of PNG, medical services in the catchment often lack in facilities and labour to ensure the population receives adequate treatment for prevalent illnesses (Ausaid, 2004).

In Sandaun Province, more than half of the children are classified as malnourished and it is the leading cause of child deaths (Bourke et al., 2001). Data compiled by Vanimo General Hospital for 1991-1997 indicates that the average number of malnourished children in Vanimo Green River District categorised as having energy malnutrition was 3,691 while 272 were categorised as having severe protein malnutrition (Bourke et al., 2001).

5.4.3. Social capital (law and order, family relationships, support networks)

Vanimo supports infrastructure to implement law and order such as Provincial government buildings, a police station, a court house and corrections service near Cis Point. However, the various institutions such as Ward Centres, Village Court Systems and Ward Development Committees, councils and dispute hearings are under-funded and under resourced to manage the increasing law and order issues reportedly being experienced within Vanimo (Vanimo LLG, 2014). These issues include unsettled youth, rising drug and alcohol abuse, gambling and stealing.

In terms of functioning groups and networks, the church provides support to community development through the construction of schools.

Participation of women

Responses to key informant interviews indicate that women are ill represented in decision making in Cis Point settlement (Coffey, 2017). Decisions are mainly made by men and there is no active network or organisation for women to actively participate. Women find business endeavours are hard to establish as it was reported that women do not receive loans from banks easily.

Women within the catchment help to provide for their families by harvesting seafood such as molluscs, whereas fish are caught by men. Most fish vendors at the Vanimo fish market are typically women (Plate 30).

Anecdotal information collected through Coffey’s 2017 surveys indicates that domestic violence is prevalent in households and single mothers have reportedly been forced into the sex industry in order to support their children (Coffey, 2017).

5.4.4. Access to functional services

Both Cis Point and Wesdeco rely on the Vanimo town centre for retail, wholesale, health, schooling and market services. Residents in Cis Point travel to Vanimo by PMV. The cost of the trip is approximately 10 Kina. Residents of Wesdeco access Vanimo on foot.

Education

Vanimo offers elementary, primary and high school education (see Plate 31). The town also contains a technical college. Schools are run by the government, church or private organisations.

There are elementary schools in Wesdeco and Cis Point. Details of each of these schools is provided in Table 68. Cis Point's elementary school has eight teachers with an enrolment of 47 students. Wesdeco's elementary school has three teachers with an enrolment of around 157 students.

Table 68 Schools at settlements surveyed in catchment 1D

Settlement	Number of class-rooms	Condition of class-rooms	Enrolment	Grades taught	Attendance	Responsible authority	Operational
Wesdeco	3	Poor	154 (76 boys and 78 girls)	Grade 1	Most children in settlement	Catholic Church	Yes
Cis Point	2	Satisfactor y	47 (28 boys and 19 girls)	Grades Prep, 1, 2	Most children in settlement	Other	Yes

Source: Coffey village survey (2017)

Schools in Cis Point and Wesdeco communities labour under similar barriers to effective education as many other schools in the region: they lack housing for teachers, proper classroom facilities, and a water supply (Coffey, 2017).

All the wards within the Vanimo Urban LLG support elementary and primary schools but secondary schools are only present in ward seven. Overall, there are 10 elementary schools, three primary schools, two secondary schools and four private schools. There are no tertiary institutions or vocational training centres present in Social Catchment 1D.

Health

Vanimo General Hospital is located a short walking distance from Cis Point and Wesdeco (Plate 32). In addition to the hospital, Dapu Urban Clinic in Vanimo is staffed by three health workers and serves an estimated population of 10,000 people. Both the hospital and clinic are understaffed, have inadequate health facilities and shortages in medical equipment (Vanimo Urban LLG, 2014). There are no village aid posts in Cis Point or Wesdeco.

In 2012, the hospital received an upgrade through the Incentive Fund grant of K7.8m. The new facilities include (Coffey International Development, 2014):

- A new administration block.
- Dental and radiology clinics.
- Twelve 2-bedroomed staff units.
- A 36-roomed dormitory for single nurses.
- A social services building.
- A Family Support Centre providing medical assistance, counselling and family planning.

Photo credit: Coffey

Plate 30
Women fish vendors at animo Fish Market

Photo credit: Coffey

Plate 31
Vanimo Primary School

Photo credit: Coffey

Plate 32
Vanimo General Hospital

As a result of the upgrade, patient numbers rose from 255 to 325 immediately after completion of the upgrade; ante-natal visits rose from 625 in 2012 to 2,717 in 2013 and HIV counselling rose from 114 in 2012 to 553 in 2013 (Coffey International Development, 2014).

5.4.5. Status of social values

Social surveys conducted in 2017 reveal comments made by leaders and officials on social values that reflect community and personal well-being.

SV5 - An environment amenable to personal and family health, safety and security

The current physical and social environment of the Vanimo Ocean Port social catchment is moderately supportive of health, safety and security.

Comments made by the local community and officials revealed concerns, particularly in relation to health, education and law and order. Social issues that stem from the spread of HIV/AIDS, youth violence and the increase in teenage pregnancies are prominent concerns among the communities interviewed. Law and order issues are also understood to be on the rise in the catchment (Vanimo LLG, 2014). These factors combine to indicate a high level of vulnerability.

SV6 - The availability of services supportive of personal health, safety and security

The Vanimo township and settlements within Vanimo support a range of infrastructure and services including a hospital, police station, primary and secondary schools, recreational areas, banks, supermarkets and an airport.

Much of this infrastructure is in a need of an upgrade and / or characterised by a lack of staff and equipment which limits the extent it can adequately service the community.

5.5. Consultation outcomes

As part of the 2017 surveys, representatives and public officials within Social Catchment 1D were asked about their development needs, their views on the Project and their understanding of potential social impacts associated with the Project.

5.5.1. Development needs

The settlements of Cis Point and Wesdeco were asked about what they saw as the priority development needs for their settlements. Both Cis Point and Wesdeco identified the need for an improved water supply, sanitary facilities, school facilities and electricity (Coffey, 2017). In Wesdeco settlement, survey respondents also identified the need for sealed roads, improved law and order and market facilities.

5.5.2. Concerns about Project impacts

When asked what they saw as the key benefits of the Project, particularly relating to the upgrade and expansion of the Port of Vanimo, respondents of the 2017 village survey in Cis Point generally welcomed development but indicated that they would have terms and conditions on which this would depend. They identified that the Vanimo Ocean Port could provide a boost to the fisherman and result in the establishment of permanent market facilities at the port, which they welcomed. They also felt that the Project would generate economic benefits. They were concerned about potential pollution of the marine environment.

In Wesdeco, respondents to the village survey saw potential benefits in the opportunities it could provide for people to access markets and businesses. They also indicated that it could assist in improving access to health and education facilities. Key disadvantages identified related to the potential for an increase in law and order issues, spread of disease including sexually transmitted diseases such as HIV/AIDS, increase in foreign influence, prostitution and substance abuse.

6. Social Catchment 2: Sepik River Corridor

6.1. Overview

The Sepik River corridor social catchment extends from the proposed Sepik River bridge crossing to the mouth of the Sepik River (and including the proposed May River Port and Auom 3 at the southern end of Lake Warangai), comprising communities from several language groups along the upper, middle and lower section of the river.. (Figure 3). The Sepik River will be used as a barging corridor to support the construction of the FRHEP and will provide an alternative means of access during operations if required.

The communities of Bin, Angoram, Moim, Kamanimbit, Sapanaut, Pagwi, Ambunti, Yessan, Swagup, Kubkain, Tauri, Auom 3 and Iniok were selected on the basis of both geographical spacing and coverage of customary groups. These communities are considered to be representative of the general population along the sections of the Sepik River that will be used for barging during construction. Auom 3 was selected as it is reliant on Lake Warangai as a source of drinking water and fish and this lake is hydraulically connected to the Frieda and Sepik rivers via several channels. Yessan and Sapanuat were only surveyed as part of the baseline health survey and were included instead of Kubkain, Pagwi, Moim and Kamanimbit because these latter villages were inaccessible due to flooding. As a result, information presented in this baseline characterisation includes a full suite of socio-economic and health information for at least five locations and additional data for other locations visited by each team where possible.

6.1.1. Location

The Sepik River corridor is located within the East Sepik Province extending from the confluence of the Frieda River to the mouth of the river at Cape Girgir.

In most of the communities visited along the Sepik River, residents' houses are located along the river bank with no obvious community centre. Swagup was an exception where houses lined the edge of the swamp and were clearly established around the centrepiece of the village, i.e., the haus tambaran (ancestral worship house). It was common for villages to be split across both sides of the river, requiring canoes to shuttle residents from one side to the other.

6.1.2. Population

Surveyed communities along the Sepik River ranged in estimated population from around 200 at Pagwi to approximately 1,884 at the largest community, Angoram. Data from the 2011 census conducted by the PNG National Statistical Office (NSO) indicate a reasonably balanced gender ratio in most communities, with the exception of Kubkain and Yessan where there were 76 and 73 males per 100 females, respectively (NSO, 2014). Table 69 provides the population and gender ratio at each location.

Table 69 Population of selected communities along Sepik River corridor

Community	Population estimate	Gender ratio (Number of males per 100 females)
Iniok	499	90
Auom 3	118	79
Tauri	664	92
Kubkain	324	76
Swagup	552	104
Yessan	721	73
Ambunti	547	94
Pagwi	229	99
Sapanaut	438	96
Moim	1,012	110
Kamanimbit	560	98
Angoram	1,884	102
Bin	1,008	93

Source: NSO, 2014.

6.2. Livelihoods (social values 1 and 2)

Information on agricultural subsistence livelihood activity has been drawn from surveys including a health baseline survey conducted in 2010 (CEH, 2018) and household, village and women’s surveys conducted by Coffey in 2010. This has been supported with information from secondary sources and the Sepik River Awareness campaigns undertaken in 2011, 2015 and 2016.

6.2.1. Natural capital/subsistence activity

Villages along the Sepik River are highly dependent on the river for subsistence (Coffey, 2010). Gardner et al. (1996) described that, on the Sepik River plains, few gardens were made and inhabitants relied more on fishing and sago supplemented by hunting in the wet season. Staple crops were considered to be sago (the most important food crop), taro, yam and banana (Hanson et al., 2001; Australian National University (ANU), 1999). Generally small gardens were made on levee banks parallel to rivers, with gardening activity restricted to the dry season (ANU, 1999). The household and village survey in 2010 observed numerous flooded gardens, during the wet season, however the regular deposition of silt was considered to be important for maintaining soil fertility (ANU, 1999). In most communities, residents claimed an abundance of river food to feed residents all year round, however sago and garden vegetables were only available seasonally. Exceptions were noted at Ambunti and Moim where survey participants indicated there was not always enough for everyone to eat.

Fishing and hunting are important livelihood activities in all of the communities surveyed. Fishing for household consumption was undertaken daily and mainly by women, except in Bin where both men and women participated in fishing. Fishing lines, nets and traps were used in all locations. Hunting occurred less frequently and was undertaken solely by men (except in Bin) with target species including aquatic resources (turtles and crocodiles). The terrestrial biodiversity survey (EIS Appendix 8A) found that the crocodile industry is dependent upon wild production for the harvests and habitats that support breeding are critical. Breeding activity and local community harvesting of crocodile eggs, juveniles and adults occurs in off-river waterbodies rather than main river channels. Terrestrial resources such as snakes, pigs, cassowaries, birds and possums are also hunted (Coffey, 2010).

Villagers of Auom 3 are also highly dependent on fishing for household consumption and for their livelihood (Coffey, 2015); all households surveyed reported the consumption of fish on the previous day of the survey. Approximately 44% of households consumed green leafy vegetables on the previous day of the survey. Sago is the principal source of carbohydrate, however significant proportions of households also consumed rice (25%) and banana (38%) on the day prior to the survey (Coffey, 2015).

The proportion of households reporting food insufficiency in 2015 was higher than the proportion in 2009 (CEH, 2018; see Table 21 in section 2.2.1 and Table 35 in Section 3.2.1) and there has been an increase in the diversity of foods consumed. While there has been no diminution in access to resource areas to support the village, residents of Auom 3 indicated that fishing yields in Lake Warangai were declining, although they still identified that selling fish in markets at Vanimo or Pagwi was a prime source of income.

In all the communities along the Sepik River included in the survey, the river was used as a:

- Primary source of drinking water and for washing, cleaning and cooking.
- Primary source of staple food items including fish and sago, in addition to other river food species (such as turtles and eels) and a variety of aquatic plants.

Household sanitation primarily utilised pit-latrines. Sometimes one latrine was available per household, but in other cases one latrine was shared amongst several households (up to seven households noted at Pagwi). In some cases, sanitary waste was often discharged to the river and/or surrounding environment. Pit latrines in some communities were located below the high-water mark and were prone to leaking waste into the river. Septic toilets were located in Angoram in government offices and guest lodgings and in Ambunti in some private homes and guest lodgings.

Solid waste disposal was primarily into the Sepik River, with some also burnt in home cooking fires and/or buried in either private or communal dumps. Designated village rubbish dumps were located at Moim, Bin and Iniok.

Some villages had communal rainwater tanks that provided water during the wet season. At Ambunti, rainwater tanks from a nearby mountain spring supplied a reticulated water system that was reportedly built in the 1970s but which had fallen into disrepair following a dispute over the land on which it was built. At the time of the survey, the system remained in place and provided some water to residents living north of the village away from the Sepik River, but supply was considered inadequate and often of poor quality. At Iniok, water supplies for some households were supplemented by roof catchments discharging into 200 litre drums.

Auom 3 residents predominantly reported sourcing drinking water from Lake Warangi, which was not treated prior to drinking and considered of poor quality (Coffey, 2015). Once collected, the water was stored in a tank. They also collected water from a nearby spring that was reported to have satisfactory reliability and quality.

Domestic water sources and sanitation and waste disposal practices at the communities are outlined in Table 70.

Table 70 Domestic water sources and sanitation and waste disposal practices

Community	Domestic water source	Sanitation	Rubbish disposal
Iniok	River; tank	Private pit toilets; river	Bush; burn; designated rubbish dump; river
Swagup	Sepik River and communal rainwater tank (seasonal)	Private pit toilets	Bury; burn; Sepik River
Yessan	Sepik River	Pit toilets	Bury; open rubbish dump
Ambunti	Sepik River; reticulated water from mountain spring; rainwater tanks (seasonal)	Private pit and flush toilets	Sepik River
Pagwi	Sepik River	Communal pit toilets (one per up to seven households)	Sepik River; burn
Sapanaut	Sepik River	Pit toilets	Open rubbish dump
Moim	Sepik River	Private pit toilets	Bury in designated open rubbish dump; Sepik River
Kamanimbit	Sepik River	Private pit toilets	Sepik River; burn; bury
Angoram	Sepik River	Private pit and flush toilets	Bury; burn; Sepik River
Bin	Sepik River; communal rainwater wells	Communal pit toilets	Bury in designated open rubbish dump
Auom 3	Lake Warangai, tank, spring	Private pit toilets	Bury in designated open rubbish dump, pit, burn

Source: Coffey household and village survey 2010.

6.2.2. Cash economy activity

There is limited formal sector employment along the Sepik, although the CEH baseline health survey conducted in 2010 found that 55% and 50% of households surveyed in Ambunti (20 households) and Angoram (20 households), respectively, earned a salary (CEH, 2018). In all the communities included in the survey, harvest of aquatic resources provided the primary source of income (e.g., sale of fish, crocodiles, shellfish, hard shell turtles) (Plate 33 - Plate 35).

Photo credit: Coffey

Plate 33
Baskets used to catch small fis

Photo credit: Coffey

Plate 34
Resident of Kamanimbit with freshwater turtle

Photo credit: Coffey

Plate 35
Saltwater crocodile skull at Kamanimbit

The limited number who participated in formal employment worked mainly in:

- Education.
- Trades.
- Law enforcement.
- Health.
- Government administration.
- Transportation.

While the formal labour market in the Sepik is limited, there is large informal sector of labour activity engaged in harvesting and selling aquatic and terrestrial resources and producing craft for the tourism market. In addition, the Sepik has traditionally been a significant source of labour for work on smallholder settlements and plantations in other areas of PNG.

Other income was derived from:

- Sale of crocodile meat, skins and eggs at all communities included in the surveys, but primarily at Ambunti, Swagup, Kubkain, Kamanimbit, Sapanaut and Yessan (Plate 36).
- Sale of fresh and smoked fish, particularly at Swagup, Pagwi and Kamanimbit. Smoked fish was reportedly sold locally, and exported to Maprik and Wewak.
- Sale of arts and crafts, particularly at Swagup, Ambunti, Bin, Yessan and Kubkain. CEH (2018) found that art and crafts buyers from other provinces, elsewhere in PNG and Australia visited Swagup ‘regularly’ to purchase handicrafts (Plate 37).
- Sale of garden produce in most communities.
- Lodging, reported at Swagup, Pagwi and Ambunti.
- Tourism, reported at Swagup and Ambunti.
- Sale of cocoa at Ambunti and Pagwi.
- Transport at Pagwi, Swagup.
- Sale of timber at Ambunti, Bin and Yessan.
- Minor employment at rubber farms and the factory near Angoram.
- Hiring of canoes for transport of cargo from Iniok (a major source of income for Sepik Iwam people for more than 20 years).

Betel nut was identified as a significant cash crop in the Ambunti and Angoram districts with cocoa and tobacco having minor cash cropping activities (ANU, 1999).

The crocodile industry is an important industry to communities in the middle Sepik region. Historically, wild populations of crocodiles in PNG were subjected to unrestricted harvesting for skins, and as a consequence were seriously depleted in many areas in the late 1950s and 1960s. Crocodiles are managed at sustainable levels for the benefit of customary landowners. Under the *Crocodile Trade (Protection) Act 1974* crocodiles can be legally harvested by landowners for personal use (food and ritual), but commercial sale and export of hides is restricted to a specific size range. Egg collection is organised by agents acting on behalf of large farms, and is undertaken with traditional landowners. Egg collectors receive cash payments for crocodile eggs. In a similar fashion there is also trade in live juvenile crocodiles to be raised in farms (SWMI, 2009).

Photo credit: Coffey

Plate 36
Live small crocodile to be farmed or sold directly in Iniok

Photo credit: Coffey

Plate 37
Baskets being made to sell

The sale of crocodiles and their products was, in many cases, found to be the most important and often primary, income source in particular at Kubkain, Swagup, Ambunti, Kamanimbit, Sapanaut and Yessan. Crocodile farms located at Ambunti, Kamanimbit, Kubkain and Swagup reported sustainably harvesting the crocodiles. The women described sale of goods from the farms, particularly eggs to Mainland Holdings Ltd, as important income streams for the community.

Some households from Angoram and Ambunti were involved in small-scale gold mining, an activity largely involving young males in the community who travel as a group into the upper reaches of the Sepik and Frieda rivers to recover gold directly or work for some of the gold dredge owners.

A small number of community members from Ambunti and Kubkain were employed in some capacity by FRL.

Sago was widely harvested and processed for later sale in Maprik, Wewak, Lae and Madang. It was a major source of income at Bin (Plate 38). Similarly, the sale of cocoa was economically important at Yessan.

In Auom 3, income from work with FRL was the dominant form of income, with smaller amounts being derived from alluvial mining upstream in the Telefol and Miyan social sub-catchments. While income from alluvial mining was relatively small (9%), it was an important source of income for residents of this village (on average approximately PGK900 per year; Coffey, 2015).

Other sources of income reported for Auom 3 residents were catching and marketing dried fish and crocodile products, including skins and eggs. At the time of the 2010 community surveys it was reported that a crocodile farm was established at Auom 3, however it was not operational in 2015. The nearest markets are at Vanimo and Pagwi, each at least two days travel from the area.

Trade stores operated in all communities, selling noodles and rice, tinned meat and fish, kerosene, matches, soap, salt, cigarettes and other basic goods. Daily or weekly markets were conducted in most communities with the exception of Kubkain, Swagup and Kamanimbit (Plate 39). Angoram's daily market was described as being of critical importance to the community because of the limited land available to residents to build gardens (Plate 40). Iniok held a village market day each Saturday.

In Iniok there were two trade stores and in Auom 3 one person selling a limited range of goods from a house. No other forms of service provision were observed in the villages (Coffey, 2015).

None of the communities along the Sepik River corridor surveyed reported having local access to banking services except at Ambunti via the Sepik Savings and Loans Society. At the same time, none of the communities reported having any savings to deposit in a bank. CEH (2018) reported a money-lending business operating at Angoram.

Household expenses (classified as much as possible from most to least expensive for households) were reported as:

- School fees.
- Food.
- Motorised canoe transport and canoe repairs.
- Fuel.

Photo credit: Coffey

Plate 38
Canoe filled with sago for sale on the Sepik River

Photo credit: Coffey

Plate 39
Raft of canoes used by traders to transport goods to market on the Sepik River

Photo credit: Coffey

Plate 40
Small trade stand in Angoram

- Medical costs.
- Clothes.
- Bride prices.

6.2.3. Status of social values

SV1 – The capacity to support subsistence livelihoods

The subsistence base of villages in Catchment 2 is robust given favourable seasonal conditions, but vulnerable to climatic extremes such as flooding and drought conditions (as were being experienced in late 2015). Environmental change occurring currently, such as sedimentation due to alteration to catchment cover and the reduction of aquatic vegetation and crocodile habitat in off-water river bodies due to the introduction of exotic fish species, was increasingly being noticed.

SV2 – Opportunities for participation in the cash economy

Market access and the availability of aquatic resources for which there is a demand, afford Sepik villages a modest level of opportunity to participate in the cash economy. Opportunities for migration and labour market participation within East Sepik and other areas of PNG have historically been important for income generation.

6.3. Culture (social values 3 and 4)

Due to the Project’s unlikely potential impact on cultural heritage within the Sepik River corridor (i.e., predominantly river barging during construction), a separate targeted survey of cultural sites was not conducted in the catchment. A preliminary survey of cultural sites was undertaken within the FRCGP area and at the location of the then proposed Sepik River port (ALA, 2018 - Appendix 12), as part of the socio-economic characterisation studies. This included consultations about and observations of sites belonging to the Sepik River Iwam who live largely along the Sepik River between the Wario Sepik junction and Iniok (Iniok-Nenuwe), upstream of the junction of the Frieda and Sepik rivers. Indications of the values associated with cultural heritage held by residents of the remaining representative villages along Sepik River corridor can be gleaned from these surveys and the responses provided by participants in the household and village surveys conducted in the corridor.

The preliminary survey identified a total of 26 sites belonging to the Sepik River Iwam; the most significant sites were places associated with original/semi-mythical ancestors and associated masalai and former locations of haus tambaran (spirit house).

Local languages vary along the river, with an estimated 10 different languages spoken in the villages involved in the survey. In most cases, the majority of the population was also reported to speak Tok Pisin. Villages classified themselves into the following language groups:

- **Sepik River Iwam**. Iniok.
- **Wogamusin, Guvlu and Gubrukomnau.** Kubkain.
- **Galadup.** Swagup.
- **Yessan-Mayo.** Yessan.

- **Kara, Manung, May River and Mamara**. Ambunti.
- **Iatmu.** Pagwi, Moim, Angoram.
- **Kanda.** Kamanimbit, Angoram and Bin.
- **Ama.** Angoram.
- **May River Iwam.** Auom 3.

No language group was recorded at Sapanaut.

The Iwam language group is described by Gardner et al. (1996):

> *The Iwam lead a life that is crucially dependent on the rivers around which they dwell. Fish and sago are their principal foods, supplemented by breadfruit and other tree-crops, a modest amount of garden produce and the game they find in the extensive bush to which they also have access. Like other Sepik peoples the Iwam are deeply committed to life on the river. Their villages suffer seasonal and often lengthy inundation by rivers, an event which frequently devastates the Iwam's riverside gardens.*

Bonnel and Robinson (1995) comment that the Iwam plant sago for their sons and daughters and harvest sago planted by their fathers. An individual will own blocks of 'wild sago' stands as well as some areas containing cultivated sago planted by himself or his forebears.

The Sepik has always been a source of a large proportion of PNG's migrant labour force, and this is reflected in the history of the Iwam. Iwam men were going to work on plantations in New Britain and other parts of PNG before their villages were officially contacted by administration patrols. In 1963 Government officers reported that 40% of adult Iwam males were working on contracts outside the area.

6.3.1. Governance

A district court, servicing all villages along both the lower and middle Sepik River, is located at Ambunti. All matters relating to 'justice' generally occurred at the police station. A small police station and rural lock up capable of holding alleged offenders for short durations are located at Angoram.

The middle Sepik is home to three government stations (Ambunti, Angoram and Pagwi), with Pagwi the headquarters of the Wosera-Gawi District. Ambunti was the most developed of the communities included in the survey, containing more infrastructure and services than other villages in the survey area.

Ambunti (located approximately 200 km west of the mouth of the Sepik River) was originally a government station, established as part of the government administration plan for PNG to develop stations at strategic locations along the coast and inland. The stations were staffed by government officers who were responsible for interaction between the government and local residents and to expand administrative control throughout the country (NAA, 2011).

Pagwi Station (situated 170 km west of the mouth of the Sepik River) was reportedly developed shortly after World War I as a mission station by the Catholic Church and has remained at its present location ever since. The station is probably the best access point to the middle Sepik, with a road connection to Wewak.

Along the Sepik River corridor, formal police (police who are trained and paid by the government) were stationed only at Ambunti and Pagwi. Auxiliary police (volunteers who did not possess uniforms or weapons) assisted with law enforcement in all communities in the Sepik River corridor. In a number of villages, concerns were raised about the conduct of some auxiliary police and, in some cases, their alleged involvement in criminal activities.

Governance structure and law and order services and facilities recorded at each surveyed community are presented in Table 71.

Table 71 Governance, law and order services and facilities

Community*	Governance	Infrastructure	Formal police	Auxiliary police
Iniok	Village councillor	None	0	0
Kubkain	Village magistrate; village development committee; community leaders	None	0	1
Swagup	Community leaders	None	0	4
Ambunti	Ward committee; land mediators	Police station; rural lock up	2	35
Pagwi	Village magistrate/land mediator; village council; customary leaders/clan leaders; formal and auxiliary police; church leaders	Police station	3	6
Moim	Village court; customs mediator; village magistrate; land mediators	Auxiliary police base; rural lock-up; court house	0	22 - 46
Kamanimbit	Village magistrate; village council; church leaders; land mediator	None	0	20
Angoram	Court magistrate	District court; police station; lock-up	0	20
Bin	Village magistrate; village councillor; customary leader; auxiliary police; church leaders	Three court houses	0	28

* Information on governance, law and order services and facilities is not available for Auom 3
Source: Coffey household and village survey 2010.

6.3.2. Religious and traditional practice adherence

All communities expressed a deep spiritual connection with the Sepik River and explained that it contained many sacred sites (both within the river and along the river's edge). Most communities were reluctant to describe the nature of the sites; however, at Angoram community members noted that the sites related to initiation and spiritual beings.

Sepik people reportedly believed that the Sepik River gave life to all other rivers around the world and was the river where human life on earth evolved. Community leaders at Moim and Angoram explained that Sepik River people believed that both good and bad spirits resided in the river; the good spirits provided assistance to Sepik people and protected their land and gardens and the bad spirits brought sickness and death. They explained that Sepik River people were able to call upon the water spirits (which often took the form of crocodiles) when they required assistance with tasks such as fishing or even fighting.

At Angoram, the crocodile was central to many of these beliefs. Angoram residents described how they could call upon the river animals, such as the crocodile, to protect them from danger or bring danger to rivals. They described how they could summon danger to be brought upon the Project if they thought that their river or way of life might be threatened by the Project.

Most of the surveyed communities (exceptions being at Moim, Pagwi and Iniok) indicated that cultural and customary practices continued to be an important part of daily life. They noted that many traditions had been passed through generations. These ranged from simple everyday activities such as making sago, sing-sings with neighbouring villages, wood carving (Plate 41 and Plate 42), entertaining tourists with traditional dances and songs, and fishing using traditional trapping techniques, to some more ritualistic and spiritual customs such as:

- Limiting access to the spirit house and close surroundings of the spirit house to men and boys only.
- Initiating young boys by residing in the spirit house for an extended period of time or, in some cases, by whipping their backs to cause scars that resemble those on the back of a crocodile. At Kamanimbit, residents believed that to heal these wounds, Sepik River water should be poured on the cuts.
- Dressing traditionally to celebrate special events.
- Observing menstruation ceremony, where for the duration of a woman's menstruation they must be segregated from the rest of the community. It was believed that the blood from the woman was impure and reduced the effectiveness of men to hunt and the quality of fishing grounds (most women reported this custom to be practised only irregularly).
- Teaching boys how to construct canoes.
- Conducting traditional funerals.
- Worshiping animals in the river. In Kamanimbit, residents believed that crocodiles could be called upon by throwing a type of ginger into the river. Making offerings of ginger to the river was also thought to bring rain and return lost people to the village.
- Offering bride price and conducting traditional wedding ceremonies.
- Initiation ceremonies of young men.

The women described customs banning menstruating and pregnant women from washing in the Sepik River, and giving offerings to the river to raise water levels; however, they explained that many of these customs were no longer practiced.

In Moim, community members described many spiritual sites along the river but told how they largely now only held significance for older members of the community. An exception was noted at Swagup, where community leaders described how children were prohibited from visiting some spiritual sites up to the present day. In Iniok, community members described that they no longer had sites of cultural significance in the village area and they had not had such places since the introduction of Christianity by missionaries.

At Pagwi, community leaders felt that very few traditional practices took place in the village due to the multi-racial nature of the population, although Christian religious beliefs and activities were a prominent part of the local culture.

A number of Christian denominations were active in the Sepik River corridor study area and many activities and celebrations were related to the Christian calendar. Catholic, Seventh Day Adventist and Revival churches were the most prominent (Table 72). At Swagup, only one member of the community was reportedly a member of a religious faith (the Catholic Church). The majority of the Swagup population had more traditional spiritual beliefs reportedly associated with their 'insect cult'.

Table 72 Dominant religion by village

Community	Religions
Iniok	Assemblies of God, New Guinea Revival
Swagup	Traditional beliefs, Catholic
Ambunti	Catholic, Assemblies of God, South Sea Evangelical Church, Seventh Day Adventist
Pagwi	Catholic
Moim	Catholic, Church of Latter Day Saints
Kamanimbit	Catholic, Seven Day Adventist, Revival International
Angoram	Predominantly Catholic but many religions present
Bin	Catholic, Christian Revival Church
Auom 3	Sepik Christian Mission, New Guinea Revival

Source: Coffey household and village survey 2010.

6.3.3. Archaeology and cultural heritage

Project development studies included a detailed preliminary assessment of archaeology and cultural heritage by Denham and Hitchcock (2015) and a targeted cultural heritage survey by ALA (2018). Table 73 indicates the number of sites recorded in the Sepik River corridor area belonging to the Sepik Iwam and May River Iwam people.

Table 73 Number of archaeological and cultural heritage sites recorded during the field investigations, by language group

Language Group	Number of sites
Sepik River Iwam	30
May River Iwam	5
Total	35

Source: Denham and Hitchcock, 2015 and ALA, 2018.

For the Sepik River Iwam, a total of thirty sites were recorded including former haus tambaran (spirit house) sites, tumbuna sites (ancestral places, which are generally tambu, or restricted); and ol ples (more recent former settlements). The most significant sites for the Sepik River Iwam are places associated with original/semi-mythical ancestors and associated masalai and former locations of haus tambaran. Ideally these types of site should be avoided, but there is provision with the local customs – as elsewhere in PNG – to perform ceremonies that enable masalai to be relocated.

For the May River Iwam, a total of five sites were recorded including the site of the former haus tambaran, an artefact collection and a number of spirit places in or near Lake Warangai. Local people were emphatic that all these sites were masalai places and places of ritual/spiritual importance, and therefore must be protected and avoided during construction.

A survey near Mount Wariwari conducted in 2016 by ALA identified four masalai (spirit) places. Two of these sites where located within the Sepik and Wario rivers respectively. Community interviews established that ceremonies would need to be held in order to relocate the masalais.

Denham and Hitcock (2015) identified a total of 10 sites within Kubkain village comprising: a haus tambaran (spirit house); an archaeological site (a cave reported to contain pottery); an ancestral village (former settlement); two masalai (spirit) places; and six story sites, five of which are associated with the arrival of the Yenoyan clan into the area. The community has preferences on areas to be protected (including a number of small hills to the south of Kubkain village).

6.3.4. Status of social values

SV3 – An enduring ability to sustain cultural identity and traditions including connection to ancestors

Christian religious beliefs and activities have become a significant part of village culture along the Sepik River Corridor where communities also maintain a strong cultural connection with the river. Cultural and customary practices continue to be an important part of daily life along the Sepik River Corridor, however traditions are not as readily passed down to younger generations. Most cultural sites have not been subject to disturbance from development activity as such activity along the Sepik River Corridor is limited.

SV4 – An enduring ability to maintain customary rights to land access and resource use

While customary rights to land and water resources are currently intact, in some areas land may be under pressure to be alienated for commercial agricultural activity, such as oil palm. Previous proposals for the potential use of the Sepik River for industrial scale transport during construction and operation has induced widespread concern for environmental integrity and associated impacts on resource use, indicating a moderate level of vulnerability.

6.4. Personal and community well-being (social values 5 and 6)

According to the PNG Rural Development Handbook (Hansen et al., 2001), inhabitants of the Sepik Valley are amongst the most disadvantaged in PNG with poor access to services. Communities upstream of Ambunti and along the river in Angoram District are classified as moderately or seriously disadvantaged relative to people in other parts of PNG. This was supported by the findings of Coffey's household and village surveys (2010) which identified a continued lack of functioning services within many of the villages. The situation had not improved at the time of the 2015 surveys.

6.4.1. Built environment (housing, infrastructure, amenity)

Houses are predominately constructed from bush materials (Plate 43). In Iniok and Auom 3 for instance, housing was found to be almost universally built of traditional materials, with minimal housing improvements such as the addition of a corrugated iron roof and water tank. Those closer to the riverbank or on swamp land are on stilts, with house floors approximately two metres above ground level. Some housing and infrastructure at the larger communities of Ambunti, Angoram and Pagwi were constructed from processed materials such as concrete, sawn timber and iron.

There was no transportation and communications infrastructure in many of the villages in the Sepik River corridor and where it does exist, it is in a poor state of repair. Road infrastructure links Pagwi and Timbunge to the provincial capital, Wewak. The 170 km journey can take up to five hours to drive. In a traffic survey completed for the Project in 2015 it was noted that the road from Pagwi to Wewak was generally in good condition however some respondents commented that it deteriorates rapidly during rainy periods and requires substantial maintenance. The majority of road users were pedestrians, followed by private buses. Road use was busiest between 6 a.m. and 12 p.m. The main reasons for travel on the road in the fortnight prior to the survey were to go to market, school, visit relatives or for medical reasons.

Airstrips exist at Ambunti and Angoram. The Angoram strip is in disrepair and had not been used for approximately 20 years. The airstrip at Ambunti is a grass strip running perpendicular to the Sepik River.

The Sepik River provided the most accessible and effective transport corridor for residents living along its banks and in close proximity. All communities had access to paddle and motor canoes and canoe traffic past communities was observed as being of high volume.

Iniok, by virtue of its size, has 15 motorised canoes in the village, while Auom 3 has three. It was reported that six canoes were available for regular transport (two in Auom 3 and four in Iniok) and that the villages were not serviced by motorised canoes from other villages.

Most communities found it difficult to quantify, even approximately, the river traffic that passed their village each day and simply described it as 'many'. The community leaders at Angoram estimated anywhere between 100 and 300 vessels may pass on any one day. This river traffic consists predominantly of canoes, with the passing of occasional logging barges (Plate 44 and Plate 45). All communities also reported the occasional barge passing their villages and the general perception was that they were on route to the Project. A barge loading facility is located at Iniok and is used by FRL (Plate 46). The facility is reportedly visited by a supply barge (mainly carrying diesel) approximately three-to-four-times a year.

A number of residents in the Sepik River corridor owned mobile phones, however where there is coverage mobile service was intermittent at best and non-existent in a number of places. The service in Ambunti was reasonably reliable. There had previously been a mobile phone tower close to Iniok,

Plate 41
Traditional wood carving from Bin

Photo credit: Coffey

Plate 42
Wood carving

Photo credit: Coffey

Photo credit: Coffey

Plate 43
House made of bush materials in Iniok

Photo credit: Coffey

Plate 44
Traders on the Sepik River

Photo credit: Coffey

Plate 45
Canoes in Swagup

Photo credit: Coffey

Plate 46
Barge loading and fuel storage facilities at Iniok

but it had been disabled by disgruntled community residents who felt that use of mobile phones was aiding extra-marital relationships in the community. None of the communities visited had landlines or public telephones. UHF radios were available and functioning in some communities (often located at the police station or church), however, there were no forms of communications noted at Moim, Kamanimbit or Bin.

Neither Auom 3 nor Iniok village has community hall or an aid post, and the nearest health centres are at Mowi and Hauna which are two to seven hours away by non-motorised canoe.

Access to transportation and communications infrastructure within the catchment is outlined in Table 74.

Table 74 Transportation and communication infrastructure

Community	Road infrastructure	Airstrip	Nearest airstrip	Riverside infrastructure	Tele-communications
Iniok	None	None	Ambunti; 90 km; 12 hours (hrs) by motor canoe	Barge loading facility (Plate 48) used for the unloading and storage of fuel and other cargo.	1 x UHF radio
Kubkain	None	None	Hauna; 14 km; 30 minutes by motor canoe	None	1 x UHF radio
Swagup	None	None	Ambunti; 34 km; 2 hrs by motor canoe	None	Intermittent mobile phone service (B-Mobile)
Ambunti	Road connection to Pagwi, 29 km away.	Tuesdays and Thursdays, operated by MAF	-	Disused jetty	Mobile phone service (PNG Telecom); 3 x UHF radios (at the hospital, police station, church)
Pagwi	Sealed road connection to Wewak, 170 km away	None	Ambunti; 29 km	Concrete landing served as boat ramp	Intermittent mobile phone service; 2 x UHF radios (at the police station and church)
Moim	None	None	Wewak; 70 km	Number of small timber jetties	None
Kamanimbit	None	None	Timbunge; 20 km; 30 minutes by motor canoe	None	None
Angoram	Partially sealed road connection to Timbunge 64 km, and Wewak, 100 km away	Disused	Timbunge; 63 km	None	Intermittent mobile phone service (B-Mobile); 2 x UHF radios (at the church and health centre)

Community	Road infrastructure	Airstrip	Nearest airstrip	Riverside infrastructure	Tele-communications
Bin	None	None	Timbunge; 93 km	None	None
Auom 3	None	None	Ambunti	None	None

Source: Coffey household and village survey 2010 and 2015.

6.4.2. Human capital (education and health status)

Education

With the exception of Iniok and Auom 3, education levels were not formally recorded in communities along the Sepik River corridor as part of the household and village survey. Table 75 presents the highest education levels attained by villagers in Iniok and Auom 3.

Table 75 Highest education levels attained by village

Village	None (%)	Elementary (%)	Primary (%)	Secondary (%)	Tertiary/ vocational (%)	Unknown (%)
Iniok	54.1	11.7	8.7	0.9	0	24.5
Auom 3	51.7	27.5	14.8	1.3	0	4.7

Source: Coffey census, village and household surveys 2010.

An assessment of access to education services and facilities within the catchment was conducted and the findings are presented in Section 6.4.4.

A limited number of people surveyed were proficient in speaking English (often limited to a small number of community leaders and in some cases students). The exception was at Pagwi and Kubkain, where community leaders estimated that 80% and 50% of the residents, respectively, spoke some English. This is likely the result of long-term church and mission presence, and road access to the north coast providing access to the provincial capital, Wewak.

Health

Although the Sepik River is central to the villages' existence, the river is also used for human waste and rubbish disposal. It was recognised among communities that not all people residing along the river had the knowledge or desire to properly care for it.

Immunisation coverage rates were found to be variable but generally below those reported nationally in PNG. Extensive flooding in the area at the time of the baseline health survey meant that the immunisation rates for Sapanaut, Swagup and Yessan could not be reliably confirmed.

Examinations indicated that there were few hypertensive individuals in the communities' surveyed and minimal adult obesity. Similarly, very low prevalence of clinical conditions associated with the liver, kidney and lymph nodes was identified. Spleen enlargement rates were exceptionally low, and considered to be atypical of communities living in hyperendemic malaria areas of PNG. CEH (2018) was unable to determine a reason for this.

The prevalence of cataracts was three times that observed in the mine area (Social Catchment 1A), but not considered to be exceptional for rural and remote PNG. The prevalence of pterygium was unusually high and significantly greater than that observed in the mine area communities. CEH (2018) noted that this prevalence was significantly higher than that previously reported in PNG.

A significantly lower prevalence of skin infections was observed on a whole among the Sepik River population than observed in the mine area for all classes of fungal infections. Sores and tropical ulcers were identified at about 25% of the levels reported in the mine area. Tropical ulcers were evenly distributed between all age groups in contrast with the mine area communities where sores were predominantly present in school-age children and adolescents. Ringworm was observed mainly in infants and children.

Overcrowding and ventilation were not of health concern for any of the households surveyed (CEH, 2018). The medical conditions reported in the 12 months previous to the baseline health survey included:

- Hypertension – 3.3%.
- Asthma – 5.1%.
- Dengue-like fever – 17.1%.
- Pneumonia – 22.5%.
- Intestinal parasites – 59.5%.
- Malaria – 65.2%.

At Iniok, women described the general health of both women and children in the village as fair. This was supported by the household survey results showing that 76.5% indicated fair health (17.6% considered their health to be poor and 5.9% considered their health to be good). The most common illnesses in children were reportedly diarrhoea, malaria, fever and colds. The women recognised that consumption of water from the Sepik River was the main source of sickness and infection in the children. Community leaders and the women's representatives felt that health services were a development priority for Iniok, as was an improved water supply to avoid illness caused by drinking water directly from the river. Health care personnel in Iniok consisted of two village health volunteers, a male and a female, one of whom was also a trained birth attendant.

Auom 3 residents indicated a low level of satisfaction with health (65%) and nominated fevers from malaria, upper respiratory tract infections and diarrhoea as being the principal causes of morbidity. The village has no aid post.

In all communities, women reported having some sort of access to maternal health services. Where clinics were not held in the village they were visited by other villages nearby:

- Kubkain quarterly clinics were held out of Maposi.
- Swagup clinics were visited by Ambunti staff.
- Pagwi clinics were conducted by Burui health clinic.
- Moim clinics were visited by staff from Angoram.
- Bin was visited by staff from Marienberg.

- Kamanimbit clinic was visited by staff from Timbunge.

Iniok reportedly had access to maternal health services outside of the village at Hauna and Mowi, but few women utilised these services due to the distance and the inconvenience of travel when pregnant. Angoram District Hospital provided basic maternal health check-ups but as the hospital was often without electricity and running water most women reportedly saw little benefit in delivering their babies at the hospital, preferring to stay at home.

Women from all the communities surveyed were aware of, and said they had access to, contraception methods for family planning. However, few used contraception often stating that their husbands would not agree to it. Traditional methods were said to be used in some places (sometimes involving ovulation calculations, sometimes herbal mixtures), but traditional means were thought to be used less and less. Swagup was an exception, where women explained that traditional family planning methods were still very much practiced but could not be described because it was reportedly the role of husbands to prepare the preventative remedies. Practices and periods of abstinence after the birth of children varied and were often at the discretion of husbands.

Malaria was hyperendemic in all of the surveyed communities. As outlined in Table 76, the majority of households had access to at least one mosquito net, but insufficient nets were available for all family members. This was particularly notable at Bin and Sapanaut where only 35% and 10%, respectively, had nets for all family members. General practice at these communities appeared to be to reserve the mosquito nets for babies and infants.

Table 76 Vector borne disease control

Community	Protection measures		Mosquito bed nets	
	Screens (%)	Cleaning around house (%)	At least one (%)	For all family (%)
Iniok	83	67	83	42
Swagup	5	50	100	65
Yessan	0	35	100	60
Ambunti	45	100	100	70
Sapanaut	0	20	80	10
Angoram	20	95	100	50
Bin	15	65	100	35
Auom 3	100	67	100	11

Source: CEH, 2018.

Both the Coffey (2010) household, village and women's survey and baseline health survey (CEH, 2018) questioned participants on the use of alcohol and other stimulants. Overall consumption of tobacco was similar among males (mean 50.8% of the population) and females (mean 44.9% of the population). The overall smoking rate (47%) was similar to that observed in the FRCGP area (49%), but higher than the national average (37%) (CEH, 2018).

The level of consumption of betel nut was similar in males and females in the study area except at Ambunti (males 44%, females 32%) and Iniok (males 55%, females 39%), where consumption levels were slightly higher among men.

Along the Sepik River corridor, alcohol was consumed by both males and females. With the exception of Bin, more than 40% of males in Sepik River corridor communities consumed alcohol. More than 25% of females in Ambunti, Angoram and Sapanaut consumed alcohol. Alcohol consumption amongst males (8%) and females (0%) at Bin was inexplicably low. Female consumption of alcohol at Swagup and Yessan was also low (<5%).

Food and nutrition

Nutritional surveys identified that the principal diet of communities consisted of sago and fresh or smoked fish, supplemented by bananas, green vegetables and coconuts. The exception was at Angoram where some store foods were included in the diet. Generally, gardens in the Sepik River Corridor were reported to only be productive in the relatively short dry season (June to September) (Plate 47).

Anthropometric data indicated a profile of above-average nutritional health with few showing signs of wasting, stunting or being underweight in all age brackets – infants under five years of age, children, adolescents and adults. The number of overweight female adolescents and adults (measured through BMI and waist measurements) was high in Sepik River corridor villages compared to the other social catchments (Table 77).

Table 77 Nutritional status of adults in Sepik River corridor

Village	Weight (mean +/- sd) kg		Height (mean +/- sd) cm		Calculated BMI	
	Males	Females	Males	Females	Males	Females
Ambunti	67.5 +/- 6.7	63.4 +/- 10.8	165.8 +/- 5.8	157.5 +/- 4.4	24.6	25.6
Angoram	67.2 +/- 6.7	53.7 +/- 9.4	160.9 +/-8.6	150.9 +/- 6.9	26	23.6
Bin	65.0 +/- 10.9	58.0 +/- 5.9	156.3 +/- 5.5	147.0 +/- 5.8	26.7	26.8
Iniok	70.2 +/- 9.2	54.6 +/- 5.8	165 +/- 6	154+/- 4	25	23
Sapanaut	66.8 +/- 6.9	58.5 +/- 9.0	162.2 +/- 7.3	152.2 +/- 5.9	25.4	25.3
Swagup	66.8 +/- 6.1	55.4 +/- 8.1	162.3 +/- 3.8	148.8 +/- 6.0	25.4	25
Yessan	62.8 +/- 4.8	52.5 +/- 8.0	159.1 +/- 4.5	150.2 +/- 5.2	24.8	23.3
Auom 3	60.2 +/- 3.6	50.2 +/- 7.2	163 +/- 0.05	151 +/- 0.05	23	22

Source: CEH, 2018.

In a number of communities, residents claimed an abundance of river food to feed all residents all year round, but not so for sago and garden vegetables, which were only available seasonally.

Photo credit: Coffey

Plate 47
Kau kau grown in gardens

Exceptions were noted at Ambunti, Moim, Auom 3 and Iniokwhere survey participants indicated there was not always enough for everyone to eat. For instance, in Auom 3 and Iniok food insufficiency in the previous 24 hours was reported by 30% and 35% of households respectively.

6.4.3. Social capital (law and order, family relationships, support networks)

The severity of law and order issues experienced in communities differed markedly across the Sepik River corridor. In Kubkain, for example, criminality was considered to be low, with few incidents occurring and usually in relation to a minor physical assault often resulting from drunkenness. In Angoram, community leaders felt that crime had been largely absent 15 years ago but was, at the time of the survey, of considerable concern and included occurrences of rape, murder and assault.

Community leaders felt that increased in-migration to and transience through Angoram had contributed to a dramatic increase in crime.

Domestic violence was common across all communities surveyed, acknowledged by both male and female participants. The perceived severity of domestic violence varied from men to women. Domestic violence was described as often sparked by a wife's refusal to partake in sex (often also resulting in marital rape), disagreements over additional wives and sometimes over money. Some women believed they deserved domestic violence in order to 'learn a lesson'. In Angoram, women reported some incidents of domestic violence as fatal. In most communities surveyed, women had avenues to report incidences of domestic violence, and in some cases, to be compensated, but in other cases there was reluctance to use those avenues for fear of exacerbating the situation.

Alcohol was considered a significant contributor to the incidence of crime across all communities, despite village laws existing in most places banning the consumption of some or all types of alcohol. Homebrew was most often consumed across the Sepik River corridor and often perceived as causing the majority of social problems (from domestic violence and physical abuse through to public nuisance). In Angoram, the consumption of homebrew and the actions of those under the influence of alcohol had created a general feeling of fear among the community with many members concerned about their personal safety. In some cases, the feeling of fear had led to the carrying of weapons including bush knives, slingshots and sometimes homemade guns in order for people to protect themselves.

Drugs and gambling were reported to occur in all communities except Swagup (although the women reported marijuana use as an emerging issue). In Ambunti and Pagwi, men, women and children participated in gambling, and in some cases resulted in school absenteeism and theft to support gambling habits. In Kamanimbit, residents believed gambling (or specifically unpaid debts from gambling) was the cause of some inter-village disharmony, sometimes resulting in physical assault. In Kubkain community leaders and women's representatives felt that marijuana use was becoming a problem among the men in the village, and was purchased from river traders who themselves smoked the drug (Coffey, 2010).

Prostitution was not widely reported, although at Bin and Ambunti it was explained that some women turn to prostitution to fund gambling habits. Community leaders at Kubkain and the women's group at Pagwi reported that prostitutes were transported and their services traded along the river.

River traders were mentioned at numerous communities with regard to their participation in unlawful activities through provision of contraband such as alcohol, drugs and prostitutes, and the traders themselves abusing drugs and alcohol, damaging property and causing fights within communities during their stay or transit.

Participation of women

At Pagwi, women's representatives explained that gender-specific customs involving women and the Sepik River were dying out. All of the communities included in the women's survey (Coffey, 2010) described the role of women as being to:

- Care for husband and children.
- Tend to gardens.
- Raise livestock (chicken, pigs and crocodiles).
- Make sago.
- Fish (for food and sale at markets).
- Make arts and crafts for sale (in some communities).

In Moim, Angoram, Swagup, Ambunti and Kamanimbit, the women explained that they played an active role in the decision-making involving their families. They all claimed to have access to their own (small amount of) money, usually as the result of their contributions to income generation by fishing and/or gardening, that they could choose to spend (or save) how they wished.

The women in Ambunti explained that they played a larger role in the economic stability of the family (through their ability to earn income) and that they therefore had a right to contribute to decision making in the family. In the satellite villages of Ambunti, the women were thought to contribute less to the decision-making commensurate with their economic contribution.

In Bin, the participation of women in family decision-making was said to be dependent on the level of respect a husband had for his wife. They claimed not to have access to their own money, nor any savings.

In Pagwi, the women described how their opinions were not considered in the home and they were unable to contribute to decision making, even regarding their children, due to the male-dominated culture. However, because they were nearly entirely responsible for income generation for their families through the sale of fish at the markets, they were able to have a small amount of money to spend or save as they wished.

In most communities, women and youths had access to social and sporting organisations, often run by church groups. At Ambunti, numerous women were involved in the Ambunti District Council of Women, which was affiliated with the East Sepik Council of Women.

6.4.4. Access to functional services

Education

All of the communities surveyed, except Sapanaut, had elementary classes, but secondary school classes were only available at Angoram, Ambunti and Wewak. The expense of school fees was considered prohibitive for some families in accessing education services.

Table 78 outlines community access to education services and facilities.

Table 78 Education services and facilities

Community	Infrastructure	No. students	Staff	Nearest service	Distance
Iniok	Elementary school (P to E2)	-	None	Community school at Auom 2	17 km. Have infrastructure and materials but at the time of the survey no teacher, school had not been operating since late 2009
Kubkain	Elementary school (P to E2)	24	One teacher	High school (Gr 9, 10) at Ambunti; senior high school (Gr 11, 12) at Wewak	56 km and 166 km, respectively
	Community school (Gr 4, 6, 7)	100	Two teachers		
Swagup	Elementary school (P to E2)	23	One teacher	High school (Gr 9, 10) at Ambunti; senior high school (Gr 11, 12) at Wewak	34 km and 144 km, respectively
	Community school (Gr 3 to 8)	60	One teacher		
	Women's training programs run by the Seventh Day Adventist Church (domestic science and health education)	Unknown	Unknown		
Yessan	Elementary school (P to E2)	Unknown	One teacher	High school (Gr 9, 10) at Ambunti; senior high school (Gr 11, 12) at Wewak	2 hrs by motor canoe
Ambunti	2 x elementary schools (P to E2)	200	Six teachers	-	-
	2 x community school (Gr 3 to 8)	500	Seven teachers		

Community	Infrastructure	No. students	Staff	Nearest service	Distance
	High school (Gr 9 to 10)	400	Nine teachers		
	Vocational college	43	Unknown		
Pagwi	Catholic mission school (Gr 1 to 8)	150	Five teachers	-	-
Sapanaut	None	-	-	Pagwi	5 km
Moim	Elementary school	Not operating in 2010	Not operating in 2010	High school at Angoram; senior high school (Gr 11, 12) at Wewak	20 km and 71 km, respectively
	Community school (Gr 3 to 5, 7)	>100	Five teachers		
Kamanimbit	Elementary school (Gr 2)	50	One teacher	High school (Gr 9, 10) at Angoram; senior high school (Gr 11, 12) at Wewak	85 km and 84 km, respectively
	Community school (Gr 3 to 8)	250	One teacher, two teacher's aides		
Angoram	3 x elementary schools (P to E2)	270	Nine teachers	-	-
	Community school (Gr 3 to 8)	620	16 teachers		
	High school (Gr 9 to 10)	360	Eight teachers		
	Vocational training centre	None	Five teachers		
Bin	Elementary school (P to E2)	140	Two teachers	High school (Gr 9, 10) at Angoram; senior high school (Gr 11, 12) at Wewak	31 km and 91 km, respectively
	Community school (Gr 3, 4, 6, 7)	150	Four teachers		
Auom 3	Elementary school (P to E2)	34	Two teachers	Primary School in Mowi or Iniok	13 km, 6 hours by paddle canoe

P = Prep; E2 = Elementary Grade 2; Gr = Grade.
Source: Coffey household and village survey 2010.

A common concern held by most communities was that there were insufficient or inadequate staff and/or materials and infrastructure to operate regular and effective classes and provide students with a reasonable level of education. This was evident in communities such as Moim which reported having an elementary school but could not offer grades Prep to Elementary 2 during 2010 due to a lack of teachers. Similarly, it was reported that in 2009, Moim had a Grade 8 class of 16 students but a Grade 9 class could not be provided so 10 of those students were undertaking Grade 9 classes at Angoram. Angoram had reportedly offered boarding facilities for students from around the district in the past, but the boarding services were not operating at the time of the survey, meaning that students from elsewhere could only attend if there were family or friends in Angoram prepared to host them.

At Bin, the village had a Grade 8 class of 17 students in 2009 but was unable to provide continuing education for those students in 2010. The women representatives estimated that 10 of those students would have continued their education if they had the opportunity.

The primary school in Iniok (attended during the week by children from Auom 3) is in a poor state of repair, and the community has not been able to organise the installation of water tanks. The school labours under similar barriers to effective education as many of the other schools in the region: limited equipment and consumables such as paper and pens, inadequate teaching resources, poorly motivated and remunerated teachers, and a lack of institutional support. Further education beyond the elementary grades required village children to board away from home, or to paddle significant distances, both of which act to de-motivate students and lead to a low participation rate in schooling.

Attracting and retaining teachers to the more remote villages in the study area was described as challenging, particularly where communities found it difficult to provide adequate housing and/or where teachers were unable (through remoteness and lack of facilities) to receive their salaries from the government (it was often described that teachers would travel to the provincial centre at the end of the school year to receive their wages).

At some places along the Sepik River, flooding causes the temporary but seasonal closure of schools constructed in flood-prone areas. At Ambunti, community leaders described law and order issues pertaining to damage of school property and the threatening of teachers causing them to leave as barriers to education.

Health

The health infrastructure at communities in the study area was, at best, degraded and at worst non-existent. Health service delivery was intermittent, with health patrols and extension programs conducted infrequently in most places and reportedly conditional on the availability of qualified and motivated staff from the district health centres.

The Angoram District Hospital is located some kilometres from Angoram centre itself (and therefore problematic for access for most residents) and is only operational for outpatients. At the time of the survey the hospital had both solar and gas for electricity and water from rain water tanks. It stocked medicines and basic supplies (such as bandages) but was unable to sterilise equipment and many facilities were in need of maintenance (CEH, 2018). The household and village survey found that the hospital often had to operate without electricity, making it impossible to store immunisation and other medicines requiring refrigeration.

There were two health centres at Ambunti, one operated by the government and one by the Seventh Day Adventist Mission. The government health centre was being upgraded at the time of the survey and provided a limited range of facilities.

At Kamanimbit and Angoram, a health extension program conducted by the Department of Health in early 2010 focussed on awareness of HIV/AIDS and other sexually transmitted diseases. A cholera awareness program had also been delivered at some communities in 2009.

Community access to health services and facilities are provided in Table 79.

Table 79 Health services and facilities

Community	Infrastructure	Nearest service	Distance	Staff
Iniok	None	Hauna aid post Mowi aid post	21 km 9 km; 3 hrs by motor canoe	Two health volunteers; one trained as birth attendant
Kubkain	Aid post (dysfunctional)	Ambunti hospital	56 km; 7 hrs by canoe and foot	Four health volunteers also trained as birth attendants
Swagup	None	Ambunti hospital	34 km; 2 to 4 hrs by motor canoe	One health volunteer; one trained birth attendant
Yessan	None	Ambunti hospital	20 km; 2 hrs by motor canoe	Unknown
Ambunti	Government district health centre; Seventh Day Adventist health centre	-	-	Two nurses at government centre; one at mission centre; one health extension officer, several health volunteers and trained birth attendants
Pagwi	None	Burui health centre	5 km; 1.5 hrs by foot; 15 minutes by car	One nurse
Sapanaut	None	Burui health centre	2 hrs by road	Unknown
Moim	Aid post	Angoram district hospital	20 km	Three health volunteers
Kamanimbit	None	Timbunge health centre	20 km; 30 minutes by motor canoe	One health volunteer
Angoram	District hospital	-	-	One doctor; two nurses
Bin	None	Marienberg	15 km; two hours by motor canoe	One health volunteer also trained birth attendant

Community	Infrastructure	Nearest service	Distance	Staff
Auom 3	None	Mowi aid post	2 hours by motor canoe	Unknown

Source: Coffey household and village survey 2010.

Public services and facilities

None of the communities surveyed in the Sepik River corridor had access to mains electricity, though some communities were able to run public (communal) generators when availability of fuel permitted.

Aside from Ambunti, residents did not have access to banking or postal services; the nearest banking and postal services were located at Maprik or Wewak. Residents of Ambunti reported that basic banking services were provided by Sepik Savings and Loans Society but that few residents were interested in banking due to their lack of cash flow. Ambunti also reported having post office infrastructure that was not operational.

Angoram's public infrastructure was previously substantial with the presence of a main road, airstrip and power generation and distribution. At the time of Coffey's survey in 2010, infrastructure was in poor condition with reportedly no mains power generation at Angoram for at least 15 years. It is expected that this has not changed in the years since.

Community access to public services and facilities is outlined in Table 80.

Table 80 Public and community services and facilities

Community	Recreation	Religious	Post	Banking	Electricity
Iniok	None	Revival church	None	None	None
Swagup	Soccer field; basketball court; volleyball court	None	None	None	None
Ambunti	4 x soccer fields; volleyball court	Southern Seas Evangelical Church; Catholic Church, Seventh Day Adventist Church and Assemblies of God	Have post office infrastructure but not operational	Sepik Savings and Loans Society	Generator
Pagwi	None	Catholic church	None	None	Generator
Moim	Volleyball court; soccer field; basketball court	Catholic church; Church of Latter Day Saints	None	None	Generator
Kamanimbit	Volleyball court; soccer field	Catholic church; Church of Latter Day Saints; Revival International church	None	None	None

Community	Recreation	Religious	Post	Banking	Electricity
Angoram	2 x soccer fields; kickboxing ring	Catholic Church; Sepik River Church; Pentecostal Church; Nazareth Church; Four Square Church; Seventh Day Adventist Church; Protestant Church; Baptist Revival Church; PNG Revival Church	None	None	Infrastructure for mains electricity in disrepair Generator
Bin	Soccer field; volleyball court; basketball court	Catholic Church; Revival Church; Four Square Church	None	None	Generator
Auom 3	None	Revival Church; Sepik Christian Ministry Church	None	None	None

Source: Coffey household and village survey 2010

6.4.5. Status of social values

SV5 – An environment amenable to personal and family health, safety and security

The physical and social environment of Sepik River communities appears to be under considerable stress, with hyperendemic malaria and water-borne disease being pervasive and the availability of food being highly dependent on seasonal conditions. Combined with social dysfunction due to alcohol and drug use (and consequent domestic violence) family health, safety and security would have a high level of vulnerability.

SV6 – The availability of services supportive of personal health, safety and security

Services (policing, education and health) are limited at best, and non-existent in the more remote areas. Villages are reliant on their own initiatives and strategies to support fundamental needs of families.

6.5. Consultation outcomes

6.5.1. Overview

Consultation with Sepik River communities as part of the EIS process was undertaken in 2010, and via three Sepik Awareness Programs conducted in 2011, 2015 and 2016. The most recent Sepik River Awareness campaign was completed in September 2016 by FRL community affairs officers.

The 2016 Sepik Awareness Program was estimated to have been delivered to more than 7,000 people throughout approximately 50 to 60 key villages, smaller villages and nearby hamlets that were engaged during the 2015 Sepik River Patrol. The aim of the exercise was to give communities an update on Project progress (SML application, feasibility study and Project design), cover environmental and social impacts in advance of the submission of the EIS and to give villagers a chance to air issues, concerns, ask questions and receive answers.

Issues raised were categorised in terms of concerns with current use of the river, concerns for the future of the Sepik River, and expressed development priorities. These are shown in Table 81.

Table 81 Concerns of the Sepik River

Major concerns	Lesser concerns
Concerns with current use of Sepik River	
• Wave impact at high tides. • River bank damage. • Boat collisions and capsize, especially for women and children. • Declining fishing productivity.	• Damage to fishing nets. • Law and order, including prostitution occurring on the moored craft of river traders. • Disposal of waste. • Drinking polluted water. • Logging effects.
Concerns for future of the Sepik River	
• Floods. • Pollution and its impact on livelihoods, particularly those dependent on sago and fish. • Sedimentation. • Higher tides flooding gardens.	• Transport. • Possible dredging to facilitate barge transport. • Lakes decreasing in size. • Disruption to fish breeding season. • Illness due to pollution. • The movement of many people along the river disrupting social structure of communities.
Expressed development priorities	
• Improved education. • Better health services. • Better law and order. • Stabilised river banks.	• Power. • Piped water supply. • Better roads. • Improved communication. • Control of agricultural pests.

Source: FRL, 2015.

6.5.2. Concerns with impacts of mining

In all the communities along the Sepik River corridor, the river is honoured as their source of life. The greatest concern in the Sepik River corridor was maintaining the water quality of the river and managing the potential impacts the Project may have on it. Key issues raised during the 2016 Sepik Awareness Program included:

- Concern that extensive damage to the Sepik River could be caused from waste or water from the integrated storage facility and due to barging along the river, and that this damage would significantly impact or even destroy their livelihood (which is based almost wholly on the river).
- The perception that people along the Sepik River will not benefit in any real way from the Project's development.
- That if environmental damage occurs people will not get compensated or assisted by either the company or government (or even if that compensation was to occur, it will not replace or commensurate for the environmental, livelihoods and even social and cultural loss that has occurred).
- Concern about the Project permitting process and the government's role in this.

7. Social Catchment 3: Sandaun and East Sepik Provinces

7.1. Overview

Information presented in the baseline characterisation for Sandaun and East Sepik provinces was obtained primarily from a range of secondary sources. Provincial information was also gathered from a joint provincial development workshop held in October 2009 and from interviews conducted with representatives of the provincial government administrations in March 2010. The semi-structured interviews sought information about:

- Level of services and/or infrastructure pertaining to each area of interest.
- State of development or growth plans for each service and/or infrastructure.
- Capacity to accommodate increased demand.
- Capacity to plan for increased demand.

7.1.1. Sandaun Province

Location

Sandaun Province is located in the northwest of mainland PNG, along the northern section of the border between Indonesia (Irian Jaya Province) and PNG. It shares provincial borders with Manus, East Sepik, Southern Highlands and Western provinces. The province encompasses an area of 36,000 km^2 and is the third largest province in PNG in terms of land size. The northern region of the province is comprised of a coastal environment, the Sepik basin comprises the centre of the province and mountainous regions are in the south. A road links the provincial capital Vanimo to Jayapura in Indonesia (Hanson et al., 2001).

Population

According to NSO (2014), the total population of the Sandaun Province in 2011 was 248,411, of which 127,771 (51.4%) were men and 120,640 (48.6%) women (equates to a gender ratio of 107 males per 100 females, divided between 44,934 households). The census also reported a population density of 7 persons per square kilometre (NSO, 2014), which is due to approximately half of the province being unoccupied (Hanson et al., 2001). Aitape-Lumi District is the most populated in the province.

Between 2000 and 2011, Sandaun Province experienced an annual population growth rate of 1.8% (compared with 2.0% between 1980 and 1990 and 2.8% between 1990 and 2000).

The median age in 2011 was 19.1 (compared with 21.4 in PNG). In 2011, 41.1% of the population was under the age of 15 and 2.3% were 65 and over, resulting in a high dependency ratio of 76.8 (NSO, 2015a).

Governance

Sandaun Province has four districts, 17 local governments, 418 wards and 852 villages. The four districts are Aitape-Lumi, Nuku, Telefomin and Vanimo-Green River (CIA, 2011).

The provinces are responsible for planning for and implementing governance processes and systems and public services such as law and order, health and education.

Development planning for the provinces is undertaken using a bottom-up approach of ward planning, which includes consultation and ward-level needs assessments. Ward planning informs LLG planning and includes the screening and prioritisation of ward proposals for development; this in turn informs district planning (in which LLG plans are summarised and a development framework established in line with the National Government’s Medium Term Development Plan 2 (MTDP2 2016 to 2017) (PNGMNPM, 2015) and the National Medium Term Development Goals (MTDG)).

Each province is required to prepare five-year provincial development plans under the *Organic Law on Provincial and Local-level Governments 1995*. Provincial plans are compiled as a summary of the rolling five-year district development plans and outline the district and provincial development goals and priority projects. The West Sepik (Sandaun) Provincial Integrated Development Plan 2014-2018 was prepared in 2013 and is the first development plan of the Sandaun Province to align with PNG Vision 2050, which is PNG’s national strategic plan.

The provincial government budgets for the administration and provision of services to its constituents are allocated annually by calendar year. In 2013, the estimated recurrent budget for Sandaun Province was approximately PGK82 million, up from PGK54 million in 2011. The province received PGK2.7 million in development grants, under the Direct Support Improvement Program (DSIP) and Public Investment Program (PIP), up from PGK2 million in 2011 (Department of Treasury, 2013). It is estimated that a budget of PGK79,619 million will be required to implement the strategies outlined in the Sandaun Province Integrated Development Plan.

At a national level, PNG has also established a Border Development Authority (BDA) through the Border Development Authority Act 2008. The purpose of this authority is to ‘manage and fund developmental activities in the Border Provinces of Papua New Guinea’. There does not appear to be any significant development initiatives being sponsored by the Authority, other than the Asian Development Bank (ADB) financed Pilot Border Trade and Investment Development Project. The BDA was the executing agency for this project which, according to the Project Completion Report, sought to ‘enhance economic cooperation between PNG, Indonesia and the broader Asia region’ through addressing ‘the infrastructure bottleneck along the northern transport corridor which serves to connect WSP of PNG and Papua Province of Indonesia’. Concurrently, the Department of Commerce and Industry (DCI) served as the implementing agency for preparing investment policy legislation and a telecommunications strategy (ADB, 2016).

7.1.2. East Sepik Province

Location

The East Sepik Province occupies 43,700 km^2 in the northwest of PNG. Wewak is the provincial capital, located on the coast of the province. There is a scattering of islands off shore. Coastal ranges, including the Torricelli and Prince Alexander ranges, dominate the landscape just inland of the coast. The remainder of the province's geography is dominated by the Sepik River, which is one of the largest rivers in the world in terms of water flow.

The province is bordered to the north by the Bismark Sea and Manus Province, to the east by Madang Province, to the west by Sandaun Province and to the south by Enga and Southern Highlands provinces.

Most of the East Sepik's population depends on the Sepik River, which runs 1,126 km from its source in the central mountains to the sea. The Sepik River is known for flooding and the river level can alter by as much as 5 metres in the course of the year as it rises and falls. The southern areas of the province are dominated by the Hunstein Range and other mountain ranges, which form a central cordillera and feed the Sepik River (Hanson et al., 2001).

Most of the population of the East Sepik Province live near the Sepik Highway which extends from Wewak to Maprik. Traffic from the Sandaun Province also connects to the Sepik Highway. The road is in poor condition due to a lack of maintenance (East Sepik Provincial Government, 2011). Roads that lead inland from the Sepik Highway connect people to the coast from the villages of Pagwi and Angoram.

Population

In 2011, East Sepik's population was 450,530 with a near even gender ratio (101 males to 100 females), and an average household size of 5.2 people, (NSO, 2014). The province contains the most heavily populated areas of the Sepik region. The population of the provincial capital, Wewak was 24,471 in 2011 (NSO, 2014).

In the years 2000 to 2011, East Sepik Province experienced an annual population growth of 2.1%, compared with annual population growth in PNG of 2.8% (NSO, 2015a).

Some out-migration occurs from this province, largely from the Sepik Valley around Ambunti. Large migrant communities from the East Sepik region are found in Rabaul, Madang, Lae and the West New Britain oil palm settlements (Hanson et al., 2001).

The median age in 2011 was 19.2 (compared with 21.4 in PNG). In 2011, 40.8% of the population was under the age of 15 and 3.1% were 65 and over, resulting in a dependency ratio of 78.1 (NSO, 2015b).

Governance

East Sepik Province has six districts and 26 LLGs. The districts are Ambunti-Drekikir, Angoram, Maprik, Wewak, Wosera-Gawi and Yangoru-Saussia (NSO, 2014). Part of the FRHEP, including the Frieda River Port, is located within Ambunti-Drekikir District, which has four local level government areas each containing a number of wards: Ambunti Rural (30 wards), Drekikir Rural (32 wards), Gawanga Rural (20 wards) and Tunap/Hunstein (38 wards). Within each ward are one or more census units.

Law and order and development planning occur in East Sepik in the same way described for Sandaun Province.

Limited information is available on law and order in the East Sepik. In rural areas, tension between ethnic, communal or sub-group occasionally leads to outbreaks of fighting. This may involve the use of firearms, rioting and looting. Private security firms play a major role in providing safety and security in the region. Criminal activity along the Sepik River has been reported as being prevalent, including attacks and robberies of people travelling on canoes along the river (Mauludu, 2017). Domestic violence is likely to be common in the province, although no statistics are available (DFAT, 2009).

The East Sepik Provincial Integrated Development Plan 2011-2015 was the first development plan of the East Sepik Province to align with PNG Vision 2050.

In 2013, the estimated recurrent budget for East Sepik Province was approximately PGK101 million (Department of Treasury, 2013). The Province received approximately PGK3.8 million in development grants, under the DSIP and PIP, up from PGK3.2 million in 2011 (Department of Treasury, 2013). It is estimated that a budget of PGK315,787 million will be required to implement the strategies outlined in the East Sepik Integrated Development Plan (East Sepik Province, 2010).

7.2. Livelihoods (social values 1 and 2)

Sandaun Province is one of the most remote provinces of PNG. Due to the rugged terrain and lack of access routes (i.e., roads and rivers) there are few income generating opportunities in rural areas but many young people stay in their community (AusAid, 2004). East Sepik Province covers a vast area with many isolated areas due to challenging terrain and flooding along lower reaches of river plains. The lack of income generating opportunities in rural areas has led to out-migration from rural to urban areas across the province (East Sepik Province, 2010).

7.2.1. Sandaun Province

Natural capital / subsistence activity

Only 8% of the population of Sandaun Province lived in urban areas in 2011. The remaining 92% of the population lived in rural settings and were reliant on subsistence farming (NSO, 2011).

People in Sandaun Province have a strong connection to the land. As income opportunities or participation in the cash economy are limited, access to land is an essential requirement for their subsistence livelihoods.

Subsistence agriculture consists primarily of sago with low intensity mixed staple gardens in Vanimo Green River, Aitape-Lumi and Nuku districts. In Telefomin district, subsistence agriculture comprises mainly low intensity taro with some low intensity sweet potato. Coconut and banana are important on the coastal plains. The Sepik River acts as a lifeline for much of the Sandaun Province, providing water, fish and a mode of transport (Hanson et al., 2001).

Unlike its neighbour, East Sepik Province, Sandaun Province has significant areas of high or very high land potential, particularly across the northern half of the province. Land potential in Telefomin District is less, rated at moderate and low, because of the steep slopes of the southern mountains, high rainfall and frequent cloud cover. The Sepik Valley has low potential because of the poor soils caused by high rainfall and inundation (Hanson et al., 2001).

Sandaun Province experiences no agriculture pressure on land and some potential for agricultural development – especially in the Torricelli foothills where the land potential is high and where markets exist and are reasonably accessible in Wewak.

Cash economy

Rural people in the Sandaun Province are amongst the poorest in PNG. Across the province, income is estimated at less than PGK20 per person per year.

People around Vanimo earn low incomes from the sale of fresh food and betel nut. In the Torricelli foothills income is from minor sales of cocoa and robusta coffee. Smallholder cocoa production is increasing around Lumi, but market access is limited by poor road conditions and occasional periods of criminal activity along the Sepik Highway. Forestry operations have provided some employment opportunities and royalties for Sandaun people (Hanson et al., 2001).

The provincial capital, Vanimo (population 13,970), has an economy based around the timber industry. The logging company, Vanimo Forest Products, a Malaysian owned company, is the major employer.

Telefomin is close to the Ok Tedi Mine from which some landowners receive royalties, while in other areas mineral exploration provides a source of employment. Artisanal gold mining is also undertaken in a number of areas.

From 2000 to 2011 there was a slight increase in people earning a wage from employment (not including gardening and fishing for money). In 2011, 13.5% of the male population over 10 years received a wage from employment, an increase from 8% in 2000. This was true of only 4% of females (increase from 2% in 2000). Subsistence employment (gardening/fishing for own use, helping in family business without pay and housework) was undertaken by 49% of males and 65% of females (NSO, 2011).

Income-generating employment in urban areas of the province was primarily in a wage job for both males and females. In 2000, people in rural areas classified their income-generating employment as gardening and fishing, however in 2011 the census recorded more males in wage jobs than gardening and fishing for money (NSO, 2011). Gardening and fishing for personal use was still the primary activity for non-income activities.

Selling betel nut was the highest-ranking income generating activity in 2011 with 54% of households claiming to sell betel nut followed by 52% of households selling food crops or cooked food (NSO, 2011).

7.2.2. East Sepik Province

Natural capital / subsistence activity

People in the East Sepik Province have a strong connection to the land. Traditionally customary owners never considered their land as property, but as a domain for survival of land group members, past, present and future. The land is considered a source of social, spiritual, ecological and subsistence values.

People use the land to grow crops such as taro, yam, sago, and banana. As with Sandaun, the Sepik River acts as a lifeline for a large part of East Sepik Province providing water, fish and a mode of transport (Hanson et al., 2001).

In East Sepik Province, low intensity subsistence agriculture dominates the land use, primarily for yam, taro and banana. Sago is important across much of the province. The land potential for agriculture across the province is generally low, except for in the north around Dreikikir and Maprik where it is very high. The Sepik Valley has low potential because of the frequent flooding of the Sepik River and resultant nutrient poor soils (Hanson et al., 2001).

Cash economy activity

As a large portion of the population lives in rural settings (approximately 90%), most people live a subsistence lifestyle with limited sales of surplus agricultural production or cash crops.

People around Dreikikir, Maprik and Yangoru earn moderate incomes from the sale of cocoa, coffee and fresh food. Those in the Sepik Valley earn low incomes from minor sales of fresh food, cocoa, fish and betel nut (Hanson et al., 2001). People in the northern fall of the Central Range and in remote areas of the Sepik Valley have very low incomes. The growth of cocoa by small scale farmers to earn cash is increasing in the province, particularly west of Maprik where most villages have at least one cocoa fermentary. However, the marketing of cocoa is constrained by poor road maintenance. There are large fresh food and fish markets at Pagwi, Angoram, Maprik and Wewak. Two tuna canneries in Wewak (owned by South Seas Tuna Corporation and Frabelle) are the biggest employers in the area (Mercy Works, 2014). In 2010, the number of people employed by industry in East Sepik was 4,000 (compared with 82,500 nationwide) (East Sepik Provincial Government, 2010). Despite a large migrant population outside the province, little money is remitted back to rural villages (Hanson et al., 2001). The Sepik River is also recognised as an eco-tourism destination. The tourism sector has been identified as an economic development area in the East Sepik Provincial Integrated Development Plan (2011-2015) (East Sepik Provincial Government, 2010).

7.2.3. Status of social values

SV1 – The capacity to support subsistence livelihoods

The subsistence base of Catchment 3 is robust given favourable seasonal conditions. Land potential in some areas of Sandaun Province is greater than East Sepik Province but both are vulnerable to climatic extremes such as flooding and drought conditions (as were experienced in late 2015).

SV2 – Opportunities for participation in the cash economy

Market access and the availability of cash crops, for which there is a demand, mean there is limited opportunity for communities in Sandaun and East Sepik provinces to participate in the cash economy. Opportunities for migration and participation in the labour market in other areas of PNG have historically been important for income generation in these provinces.

7.3. Culture (social values 3 and 4)

Culture and religious traditions have not been detailed at a provincial level as this is more appropriately covered at a village level in Social Catchments 1A, 1B, 1C and 2.

7.4. Personal and community well-being (social values 5 and 6)

Sandaun Province contains some of the country's most challenging terrain and as such is one of the most remote and underdeveloped in PNG. Across both provinces there is a lack of functional health services and/or medicine and access to education services is limited.

7.4.1. Sandaun Province

Built environment (housing, infrastructure, amenity)

The lack of economic activity in the Sandaun Province has, over many years, resulted in widespread rural poverty, poor infrastructure and poor social services in most of the province.

Almost 80% of the province is estimated to have poor access to government service centres (Sandaun Provincial Government, 2013). Only the coastal areas and inland hills of Sandaun Province have a relatively good network of roads. Poor roads are a major constraint to development in other areas of the province. There are often limited funds for maintenance and some roads become impassable after extended periods of wet weather. Some roads in the province are constructed and maintained by logging companies such as the provincial road between Green River and Vanimo (Sandaun Provincial Government, 2013). Roads such as these deteriorate once logging activities finish. Most of the inland districts can only be accessed by light aircraft or vessels reaching the Upper Sepik River. The majority of residents of Sandaun Province are very remote and require more than one day's travel to reach basic services.

Reliable communications infrastructure in Sandaun is variable. In 2006, mobile phone systems were installed in Aitape and Vanimo. The services are very limited in range of access and the high costs of the service also restrict usage. Many districts are restricted to an unreliable two-way radio system operated by the health centres and churches (Sandaun Provincial Government, 2013).

Water supply and sanitation infrastructure is limited and only available in urban areas. Most people do not have access to piped water and must rely on surface and groundwater supplies for their water for all uses. Access to potable water is limited (Hanson et al., 2001).

Over 90% of people within Sandaun Province are estimated to live in houses made of bush materials with one space for sleeping, cooking and eating (Sandaun Provincial Government, 2013).

Human capital (education and health status)

Education

An education survey and literacy assessment conducted in 2011 found the literacy rate in Sandaun Province in 2000 was 52.9% compared with 62% recorded in the 2011 census (ASPBAE, 2011; NSO, 2011). The literacy rate of males was 68% compared with 55% for females (NSO, 2011).

Forty-three per cent of males over the age of five had never been to school (down from 53% in 2000), compared with 48% females (up from 41% in 2000). Only 1% of males (down from 1.5% in 2000) and 0.5% females had completed Grade 12 (NSO, 2000; NSO, 2011).

Almost 9% of males and 5% of females claimed to have a qualification with this defined as a degree, diploma, certificate or professional title acquired after successful completion of a course lasting three months or longer (NSO, 2011).

Health

Malaria is endemic along the coastal section of Sandaun Province. It poses a particular threat to children under the age of five years.

The infant mortality rate (per 1,000 live births) in 2000 in Sandaun Province was 105 (compared with 57 in PNG) (NSO, 2000). Child malnutrition rates within the province are among the highest in the country (Hanson et al., 2001).

Social

Alcohol and marijuana are predominantly consumed by young men and in some areas young men have established networks to distribute marijuana (AusAid, 2004). Other common problems experienced by Sandaun communities relate to domestic violence, violence in relation to land disputes and alcohol consumption, adultery, men having several wives, people having multiple sex partners and prostitution. Communities commonly rely on village leaders to resolve law and order issues (AusAid, 2004).

In most communities there are church groups, women's groups and youth groups and these are most often engaged in activities which aim to strengthen spiritual development in young people (AusAid, 2004).

Access to functional services

Sandaun Province is one of the most under resourced provinces in PNG for health infrastructure. The majority of health services within the province are isolated and contain inadequate medical supplies or have insufficient and unqualified medical staff (Sandaun Provincial Government, 2013).

There are 2.4 doctors, 59 nurses and 323 hospital beds per 100,000 population (Dugue and Izard, 2004). Most communities in the Sandaun Province have an aid post, although some have been closed for years or lack medicine. Functioning aid posts are staffed by one medical orderly and provide basic medical care. According to the National Inventory of Health Facilities, in 2000 there were approximately 151 aid posts in the Sandaun Province, of which 30 were closed (PNGHD, 2008).

In 2000, Sandaun Province had 10 health centres and 19 health sub-centres. There was also one urban clinic and one provincial hospital, both in Vanimo (PNGHD, 2008). More serious health cases are usually referred to the provincial hospital in Vanimo. Some health centres also run patrols travelling to rural communities to provide infant health clinics and immunisations. In several communities the aid post orderlies and health clinics provide basic information on HIV/AIDS (PNGHD, 2008). Most health centres are run by the government, while health sub-centres are generally run by missions, such as the Catholic Church, Christian Brethren Churches and Baptist Church (AusAid, 2004).

In the districts of Telefomin and Nuku, there were approximately:

- Twenty-seven community schools run by the government.
- Thirty-two elementary schools run by the government.
- Six primary schools, of which four are run by the government and two by missions.
- One secondary school run by the government.
- Two vocational centres run by the government.

In the district Vanimo-Green River there were approximately:

- Ninety-five elementary schools, of which 49 are run by the government and 46 by the church.
- Fifty-six primary schools, of which 21 are run by the government and 35 by the church.
- Three secondary schools, of which one is run by the government and two by the church.
- Three vocational centres, of which one is run by the government and two by the church.

Information was not available for the Aitape-Lumi district.

7.4.2. East Sepik Province

Built environment (housing, infrastructure, amenity)

Access to infrastructure and services in East Sepik Province ranges from good in the northwest, moderate in the centre and east, to very poor in the south and southwest. With the exception of people living close to Wewak and between Dreikikir and Yangoru, most of the population of East Sepik is required to travel four to eight hours to access services (Hanson et al., 2001).

Road infrastructure is limited. The Sepik Highway runs from Wewak to Maprik but is in poor condition due to lack of ongoing maintenance. The sealed roads in urban areas are largely poorly maintained and few sealed roads exist outside urban areas and the Sepik Highway. Travel by boat along the Sepik River system is a popular means of travel (East Sepik Province, 2011). The river plays a vital part in transporting agricultural goods and fish to market (Hanson et al., 2001; Coffey, 2015).

Communications infrastructure in East Sepik is limited. Most districts have access to very high frequency (VHF) radio however in most cases this is rundown or only in fair condition. Mobile phone, land lines and internet services remain limited to the majority of the population outside of major towns (East Sepik Province, 2011).

The electricity supply in urban areas is unreliable. Voltage variations and surges are commonplace and power cuts are frequent, particularly during periods of heavy rain. There is no mains power available to the rural population. Generators are used as an alternative source of power, but are not affordable for the majority of the population, who go without electricity or may have a shared generator for the village.

Most of the rural population of East Sepik Province situated in proximity to the Sepik River rely heavily on the river and its tributaries as their water supply for drinking, cooking and washing. There are no sewerage systems in rural areas and the river is often used for disposal of human waste and rubbish, contaminating the water source. Water in the urban areas is safe for washing and cooking. However, drinking water quality is not always reliable, especially if the water is from back up tanks or rainwater storage (Hanson et al., 2001).

Human capital (education and health status)

Education

Relative to world standards, school retention rates in the East Sepik Province are low. In 1999, the education system was only able to offer a post primary education for about one in six children and less than 2% of students enrolling in Grade 1 reached Grade 12 (WEF, 2000).

The proportion of the regional population going on to tertiary study was low when compared to the PNG national average. There are no universities in the province (WEF, 2000).

The literacy rate in East Sepik Province in 2011 was 64.7%, up from 52.7% in 2000, (compared with the PNG average rate in 2000 of 67%). About 41% of the province's population had completed Grade 1, 2 or 3, 26% had completed Grades 4 to 6 and just 20% had completed from Grade 7 up.

Health

The reliance on the Sepik River as a water supply for washing, drinking, cooking and for the disposal of human waste and garbage makes the province particularly susceptible to the spread of water borne diseases (Hanson et al., 2001).

A cholera outbreak occurred along the Sepik River in September 2009. Cholera spread due to a lack of health and sanitation infrastructure in the area, with disposal of human waste and rubbish to the river contaminating drinking water sources (Relief Web, 2009).

In 2009, the most common causes of hospitalisation within East Sepik Province included malaria, tuberculosis, pneumonia, malnutrition, accidents, domestic violence, unintentional injuries, pregnancy complications and childbirth (East Sepik Province, 2011).

In 2008, Save the Children's East Sepik Women and Children's Health Project was implemented to treat common diseases in the area. Malaria was the main illness treated by this project; almost half of those treated for malaria were children under five years old. Malaria is especially prevalent along the Sepik River, its tributaries and associated swamps (Save the Children, 2009).

Malnutrition problems are evident in the region, associated with inadequate intake of energy and protein. Children are particularly vulnerable and child malnutrition in the region is of concern, particularly in certain villages during times of drought (Save the Children, 2009).

The infant mortality rate in 2000 in East Sepik was 79 (per 1,000 live births) (compared with 57 in PNG, and the child mortality rate was 36 (per 1,000 live births) compared with 75 in PNG (NSO, 2000).

In 2004, the total number of confirmed cases of HIV/AIDS within East Sepik Province was 66, of these 34 were women, 27 were men and 5 did not have a record of gender. This is a relatively low level compared with other provinces, however the disease still poses a significant risk to the community. The province's link with Jayapura (Indonesia) through the vanilla trade, and urban and village environments that provide trading and entertainment, are all considered to be high risk areas for the transfer of HIV/AIDS. Communities within the province have a basic knowledge of the severity of HIV/AIDS and how it is transmitted however further awareness and initiatives are required to create a greater understanding of the disease amongst the community (AusAid, 2005).

Social

Alcohol is consumed by both men and women of different ages across communities in East Sepik Province and the East Sepik police commander has identified alcohol consumption as a major issue for the province (Sirias, 2016). Alcohol consumption is associated with high risk activities such as fighting, men pursuing women for sex, prostitution, rape and theft, particularly in urban and district centres. Marijuana use is common but not as widespread as alcohol consumption (AusAid, 2005).

Increase in cash income in rural communities has contributed to an increase in sexual activity and women selling sex in all districts across the province. It has also been reported that schoolgirls and mothers sell sex in exchange for vanilla beans (AusAid, 2005).

Information on women's groups in the districts of East Sepik is limited. Where there is record of women's groups they are mainly engaged in community services and credit schemes. Youth groups are also present across the province and are mainly engaged in community services and spiritual activities (AusAid, 2005).

Access to functional services

Access to health facilities in East Sepik Province is limited and, like Sandaun Province, it is one of the most under-resourced provinces in PNG. For each 100,000 people there are only 1.8 doctors, 64 nurses and 261 hospital beds. There is one hospital in the East Sepik area, located at Wewak. Most people must travel for four to eight hours to a reach services (Dugue and Izard, 2004). In 2006, only 51% of aid posts were considered open in the East Sepik Province (PNGHD, 2008).

Access to education is limited within East Sepik Province. Many students from rural areas are required to travel large distances or live away from home in order to attend school. According to AusAid (2005), within East Sepik Province there are approximately:

- Twenty-eight community schools.
- Two hundred and eleven elementary schools, of which 65 are run by the government.
- Two hundred primary schools, of which 74 are run by the government.
- Twelve secondary schools, of which seven are run by the government.
- Nine vocational centres, of which three are run by the government.

7.4.3. Status of social values

SV5 – An environment amenable to personal and family health, safety and security

The physical and social environment of Sepik River communities appears to be under considerable stress, particularly in recent years of drought. Combined with social dysfunction due to alcohol and drug use (and consequent domestic violence) family health, safety and security would have a high level of vulnerability.

SV6 – The availability of services supportive of personal health, safety and security

Services (policing, education and health) are limited at best, and non-existent in the more remote areas. Villages are reliant on their own initiatives and strategies to support fundamental needs of families.

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Appendix 2

Archaeology and Cultural Heritage Assessment

SEPIK DEVELOPMENT PROJECT

Cultural Heritage
Baseline and Impact Assessment

Report to Coffey and Frieda River Limited

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31 July 2018

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EXECUTIVE SUMMARY

1 Introduction

Frieda River Limited (FRL) is assessing the feasibility of developing the Sepik Development Project (the Project) in northern PNG.

The Sepik Development Project consists of four interdependent projects:

- Frieda River Copper-Gold Project (FRCGP). Includes the open pit, processing facility, site accommodation camp and mine access roads.
- Frieda River Hydroelectric Project (FRHEP). Hydroelectric power generation capable of producing up to 400 MW once the impoundment has filled.
- Sepik Infrastructure Project (SIP). Including the Vanimo Ocean Port (an upgrade to the existing Port of Vanimo), Green River Airport and a public road from Vanimo to Hotmin.
- Sepik Power Grid Project (SPGP). A 370 km 275 kV Northern Transmission Line from the FRHEP to the Indonesian border, via Vanimo.

This cultural heritage study forms part of an Environmental Impact Statement (EIS) that is being prepared for the Project.

Study Objectives

The objectives of the Project EIS cultural heritage study are to:

- Identify, describe and map any cultural heritage values that may exist in relation to areas where ground disturbing impacts arising from Project activities are proposed.
- Identify potential impacts to the identified cultural heritage values arising from Project activities.
- Recommend measures that might be adopted to mitigate and manage these impacts.
- Determine the residual impacts expected following implementation of proposed management measures.

The Project EIS cultural heritage baseline and impact assessment comprised:

- A Baseline Assessment describing the existing cultural heritage environment in the study area.
- An Impact Assessment detailing the potential, actual and perceived impacts of the Project, recommended management measures to address the identified impacts, and an assessment of the residual impacts assuming implementation of the recommended measures.

Study Area

The Project EIS cultural heritage study area was defined on the basis of three discrete elements encompassing the following Project components:

- **Mine:** all components mapped according to the proposed disturbance footprint buffered by an additional 50m, 100m or 200m as required; mine access roads (50m buffer).
- **FRHEP:** all components mapped according to the proposed disturbance footprint buffered by an additional 100m for the FRHEP embankment and impoundment and 50m for associated linear alignments.
- **Infrastructure Corridor**: including the SIP, the SPGP and the concentrate pipeline component of the FRCGP; all components mapped according to the proposed disturbance footprint buffered by an additional 100m or 30m as required.

2 Baseline Assessment

Cultural Groups

The cultural and linguistic context of the cultural heritage study area is extraordinarily complex, including complicated inter-group kinship relationships extending throughout and beyond the immediate area. Cultural groups display a high degree of variation in terms of language, demography, subsistence, group structure, land tenure, marriage practices and settlement patterns.

Twelve language groups and 21 communities are associated with the Project EIS cultural heritage study area:

Language Group	Community
Miyan	Wameimin 2 Temsapmin Hotmin Uramusin
Telefol	Ok Isai Wabia
Paiyamo	Paupe
Amto	Wokomo 1
Abau	Idam 1
	Idam 2
	Bisiabru
	Dioru
	Green River
Anggor	Aminii
Kwomtari	Kwomtari
Baibai	Itomi
Momu	Kilifas
	Sumumini
Pagi	Imbrinis
Vanimo	Vanimo
Wutung	Wutung

NMAG National Site File (NSF)

Reviews of the National Site File (NSF) were completed prior to the commencement of preliminary EIS archaeological and cultural heritage fieldwork in 2010, and subsequently in 2011 to determine if any registered cultural heritage sites were located within the general vicinity of the FRCGP. In response to changes in the project layout that have come into effect since 2011, a third review of the NSF was conducted in January 2018. This identified 25 registered sites situated within 10km of the cultural heritage study areas.

Previous Studies

Relevant prior studies were reviewed during the preparation of the baseline assessment. Ultimately, the primary resource that informs understandings of cultural heritage sites in the mine and FRHEP study areas is Denham and Hitchcock (2011) report, which also incorporated and cross-referenced the limited cultural site information generated through the mid-1990s consulting period.

Project EIS Cultural Heritage Fieldwork and Assessments

A targeted cultural heritage field program was undertaken in June 2016, with the primary objective of:

- Completing a detailed recording and ground-truthing of 20 sites recorded by Denham and Hitchcock in 2010-2011 from interviews with landowners and located using topographic maps or helicopter fly-overs. The selected sites are situated within or in close proximity to areas likely to be directly impacted by the construction of the proposed mine and adjacent facilities, based on the current Project layout.
- Undertaking surveys and meetings with community members regarding the previously proposed Sepik River port. This proposed location was an addition to the Project layout assessed during cultural heritage fieldwork in 2010-11, and therefore no previous surveys had been completed in this area. The Sepik River port is no longer proposed as part of the design for the Project.

Baseline Summary

The baseline assessment identified 60 cultural heritage sites which, based on the locational data currently available, are identified as being located within the mine, FRHEP and infrastructure corridor study areas. The table below differentiates sites located within proposed construction or impact footprints from those identified within study area buffers.

Site Code	Site Name	Site Type	Project (Worksite)	Project (Buffer)
D001	Kemeti	Story/Former Settlement	FRHEP (ISF)	
D002/D044	Siarema/Timarimbip	Story/Former Settlement	FRHEP (ISF)	
D007	Memusu	Economic	FRHEP (Frieda River Diversion	
D013	Kaluasikeme/Kowruasekeme	Story	FRHEP (ISF)	
D014	Serekeme	Story	FRHEP (ISF)	
D018	Soko somoyo	Archaeological	FRHEP (ISF)	
D024	Piapaupi/Piapauke	Burial		FRCGP (road)
D041	Awayuabip	Story/Former Settlement/Burials	FRHEP (ISF)	
D045	Ifublitomkuwandim	Story	FRHEP (ISF)	
D061	Emoriabip	Former Settlement	FRHEP (ISF)	
D075	Emeiblu	Story/Former Settlement	FRHEP (ISF)	
D097/H139	Ifumbri/Tuym Amemdim	Story	FRHEP (ISF)	
H037	Mowaitem	Story	FRCGP (quarry)	
H038	Ekwaitem	Story		FRCGP (road)
H042/H162	Ekwai Imaal/Ekwai Cave	Story/Archaeological	FRCGP (crusher and stockpiles)	
H045	Mowai Imaal	Story/Archaeological	FRCGP (mine)	
H070	Wepwao	Story	FRHEP (ISF)	
H079	Uyuvi or Amorai	Story	FRHEP (ISF)	
H098	Amulaifife	Former Settlement	FRHEP (ISF)	
H099	Yongfale Dang	Former Settlement/Burial	FRHEP (ISF)	
H116	Frieda-Nena Junction	Masalai	FRHEP (ISF)	
H126	Bengemdebom	Burial	FRHEP (ISF)	
H127	Ok Binai-Misitem Junction	Burial	FRHEP (ISF)	
H128	Ok Binai-Dinomtem Junction	Burial	FRHEP (ISF)	
H129	Ok Milia (Nena)-Ubai	Burial	FRHEP (ISF)	
H131	Alivaifif	Burial	FRHEP (ISF)	
H132	Ok Isai Kongamemtem	Story	FRHEP (ISF)	
H133	Aune	Burial	FRHEP (ISF)	
H134	Frieda-Nena Junction	Story	FRHEP (ISF)	
H135	Warenia	Story/Former Settlement	FRHEP (ISF)	
H136	Mebluavip	Former Settlement	FRHEP (ISF)	
H137	Binaifip	Story	FRHEP (ISF)	
H138	Solavufip	Former Settlement/Burial	FRHEP (ISF)	
H141	Cave	Burial	FRHEP (ISF)	
H143	Ubai Bagan	Economic		FRCGP (road)
H150	Imma Imaal	Archaeological	FRHEP (ISF)	
H151	Nokomen Am	Story	FRHEP (ISF)	
H152	Unamemtem	Story	FRHEP (ISF)	

Site Code	Site Name	Site Type	Project (Worksite)	Project (Buffer)
H153	Kongamemtem	Story	FRHEP (ISF)	
H154	Yongfareavip	Former Settlement	FRHEP (ISF)	
H155	Atalavip	Former Settlement	FRHEP (ISF)	
H156	Uyubi Bengemdebom	Story	FRHEP (ISF)	
H158	Ekwaiamemtem	Story	FRCGP (crusher and stockpiles)	
H161	Cave at Henumai-Frieda Junction	Story	FRHEP (ISF)	
H163	Cave at Ima-Bina Junction	Story	FRHEP (ISF)	
H166	Uviaiamemtem	Story	FRHEP (ISF)	
H167	Foliaivip	Former Settlement	FRHEP (ISF)	
H168	Ok Binai-Apoiya Junction	Burial	FRHEP (ISF)	
H169	Nena River-Sumomelia Junction	Burial	FRHEP (ISF)	
H171/H172	Ok Esai Collection 1/Ok Esai Collection 2	Archaeological	FRHEP (ISF)	
H176	Ok Esai Grave 1	Burial	FRHEP (ISF)	
H177	Ok Esai Grave 2	Burial	FRHEP (ISF)	
H178	Ok Esai Grave 3	Burial	FRHEP (ISF)	
H179	Ok Esai Grave 4	Burial	FRHEP (ISF)	
H180	Ok Esai Grave 5	Burial	FRHEP (ISF)	
H181	Ok Esai Grave 6	Burial	FRHEP (ISF)	
H182	Ok Esai Grave 7	Burial	FRHEP (ISF)	
CRD	Frieda Airstrip	Archaeological	SIP (Frieda River airstrip)	
RAK	Panganggan Cave	Cave/Rockshelter	SPGP (transmission line)	
J10	Ok Amurai	Unknown	FRHEP (ISF)	

The baseline assessment identified uncertainties regarding the accuracy of locational data recorded during the 2010-2011 cultural heritage field program for sites identified solely based on a review of topographic maps during local community interviews. As a means of recognising these uncertainties and dealing with them in the context of the baseline (and subsequent impact) assessment, a secondary component of the baseline assessment identified cultural heritage sites with 'Map' source locational data only which situates them within 1.5km of the overall Project cultural heritage study area.

Seventy-five cultural heritage sites with 'Map' sourced locations only are situated within 1.5km of the current Project EIS cultural heritage study area.

3 Impact Assessment

Potential Impacts to Cultural Heritage

Potential impacts to cultural heritage include:

- Direct disturbance of cultural heritage sites due to on-ground works including vegetation clearance, topsoil stripping, subsoil excavation, quarrying, and the creation of borrow pits and spoil dumps.
- Direct and indirect disturbance due to impoundment of the integrated storage facility (part of the FRHEP), which will result in flooding, disturbance to materials and loss of access cultural heritage places.

- Direct disturbance due to the movement of Project employees and contractors and their vehicles (e.g. erosion, unauthorised removal of artefacts).
- Indirect disturbance due to associated population growth that increases the movement of people and vehicle traffic.
- Physical modifications to the land resulting in the destruction of some sites and their loss from living memory and, hence, from oral tradition.
- Disturbance to ecosystems through environmental impacts on landform and soils, water resources and hydrology, and biodiversity, which have the potential to affect the immediate utility and long-term viability of cultural heritage sites that are identified based on these extant systems (e.g. *ples tambu* or *masalai* story sites associated with water).
- Restricted physical access of communities to cultural heritage sites on account of Project activities and operational requirements. This includes the likely resettlement of Ok Isai and Wabia villages, which are located within the area to be inundated by the ISF.
- Loss of connection between people and their places of cultural value through the destruction or damage of a site.
- Loss of information which could otherwise be gained by conducting research today.
- Loss of the archaeological resource for future research using methods and addressing questions not available today.
- Permanent loss of the physical record.

Cultural Heritage Site Significance Assessments

The significance of the impact on each of the 58 cultural heritage sites included in the formal impact assessment was determined based on the cultural heritage significance of each site and the magnitude of the impact. The overall significance rating determined for each cultural heritage site was derived as a cumulative score across four cultural heritage values (historical, scientific, social and spiritual). The assessment of each value was based on information gathered during the 2010-2011 and 2016 field programs, which in all cases included community interviews and, in some cases, direct field inspection.

Forty-eight cultural heritage sites (83%) were assessed as being of low cultural heritage significance, nine (15%) were assessed as being of medium cultural heritage significance, and one (2%) was assessed as being of high cultural heritage significance.

Management Measures

The following mitigation measures were developed to manage impacts to cultural heritage values.

- Avoidance (where practicable) of cultural heritage sites.
- Development and implementation of a Cultural Heritage Management Plan (CHMP) which includes:
  - Ongoing local community consultation.
  - Pre-construction surveys of all previously undisturbed areas that will be directly disturbed by on-ground works, including suitably buffered infrastructure/impact area footprints and alignments.
  - Development and implementation of a Chance Finds Protocol defining a process for the reporting, investigation and management of chance cultural heritage finds during all Project-related activities.
  - Salvage and recording of a representative proportion of archaeological sites that cannot be avoided by Project-related impacts. Salvage can include archaeological survey, surface collection and preservation of artefacts, and controlled archaeological subsurface excavation.

A series of site-specific management recommendations are also included.

Residual Impact Assessment

Prior to the implementation of the proposed management measures, only two cultural heritage sites included in the impact assessment would have experienced impacts with significance ratings less than Moderate. However, subject to the appropriate implementation of these measures, impact magnitudes should be reduced by at least one rating level, and in many instances by two rating levels. The net result is that only one recorded cultural heritage site will experience an impact rated as greater than Moderate, and 54 sites (90%) will experience impacts rates as either Negligible or Minor.

'Map' Sourced Cultural Heritage Sites

The baseline assessment identified 75 cultural heritage sites with potentially inaccurate locational data which situated them within 1.5km of the overall Project EIS cultural heritage study area. These sites should be further investigated by a qualified cultural heritage specialist and their locations confirmed as being situated either inside or outside the proposed Project impact footprint. If any sites are confirmed as being situated within the proposed Project impact footprint, then appropriate impact management or mitigation measures should be developed for each site, consistent with the range of measures outlined in this report regarding the needs of each site type.

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ABBREVIATIONS

ALA	Andrew Long & Associates
AMSL	Above Mean Sea Level
BP	Before Present (years)
CEPA	Conservation Environment Protection Authority
CHMP	Cultural Heritage Management Plan
DWT	Deadweight tonnage
E	East
EIS	Environmental Impact Statement
EL	Exploration licence
ENE	East-north-east
ESE	East-south-east
FRCGP	Frieda River Copper-Gold Project
FRHEP	Frieda River Hydroelectric Project
FRL	Frieda River Limited
FRL CA	Frida River Limited Community Affairs
GWh	Gigawatt hour
h	Hour
ha	Hectares
HITEK	Horse, Ivaal, Trukai, Ekwai and Koki open pits
IFC	International Finance Corporation
IFO	Intermediate fuel oil
ISF	Integrated Storage Facility
km	Kilometres
m	Metres
MIA	Mine Infrastructure Area
ML	Mega litre
Mt	Mega tonne
N	North
NAF	Non-acid forming
NCC	National Cultural Commission
NMAG	National Museum and Art Gallery of Papua New Guinea
NE	North-east
NNE	North-north-east
NNW	North-north-west

NSF	National Site File, NMAG
NW	North-west
PAF	Potentially acid-forming
PNG	Papua New Guinea
RL	Relative level
S	South
SE	South-east
SIP	Sepik Infrastructure Project
SPGP	Sepik Power Grid Project
SRI	Social Research Institute
SSE	South-south-east
SSW	South-south-west
SW	South-west
t	Tonne
W	West
wmt	wet metric tonne
WNW	West-north-west
WSW	West-south-west

1 INTRODUCTION

1.1 Project Description

Frieda River Limited (FRL) is assessing the feasibility of developing the Sepik Development Project in northern PNG. The Project will be developed by FRL (a wholly owned subsidiary of PanAust Limited) on behalf of the joint venture between FRL (80%) and Highlands Frieda Limited (HFL) (a wholly owned subsidiary of Highlands Pacific Limited (HPL)) (20%).

The Sepik Development Project consists of four interdependent projects:

- Frieda River Copper-Gold Project (FRCGP)
- Frieda River Hydroelectric Project (FRHEP)
- Sepik Power Grid Project (SPGP).
- Sepik Infrastructure Project (SIP).

FRL will own and operate the FRCGP, while it is anticipated that third-party entities will own and operate the remaining elements.

The Sepik Development Project is primarily located within the Sepik River catchment and comprises development of a copper-gold deposit in Sandaun Province and supporting infrastructure and facilities in the Sandaun and East Sepik provinces (Figure 1 and Figure 2).

1.1.1 Frieda River Copper-Gold Project

The greenfield FRCGP is based on the Horse, Ivaal, Trukai, Ekwai and Koki (HITEK) porphyry copper-gold deposits which contain an estimated total combined Measured, Indicated and Inferred Mineral Resource (JORC classifications) of approximately 2.7 billion tonnes at an average grade of 0.44% copper and 0.23 grams per tonne gold. Copper mineralisation was first identified at Frieda River in 1966/67 and the long history of exploration and study activities undertaken by several companies has generated a considerable body of information.

Figure 3 shows the general FRCGP layout around the open-pits including the HITEK deposits and supporting infrastructure. Mined ore will be processed at a process plant located approximately 8 km northeast of the open-pits to produce a copper-gold concentrate.

The FRCGP comprises a large-scale conventional open-pit mine operation feeding ore to a conventional comminution and flotation process plant producing a copper-gold concentrate for export to custom smelters.

Mining inventory comprises approximately 1,500 Mt of mill feed. The average annual copper-gold concentrate production will be 740,000 wet tonnes and the average annual metal in concentrate production will be 175,000 tonnes (t) copper and 235,000 ounces (oz) gold. The FRCGP will have mine life of approximately 33 years preceded by a six-year implementation period.

A concentrate pipeline that follows the infrastructure corridor will transport the copper-gold concentrate produced at the process plant to a concentrate dewatering, storage and export facility located at the Vanimo Ocean Port.

The FRCGP's power demand will be approximately 155 MW increasing up to 235 MW by Year 11. Offsite power demands for the Vanimo Ocean Port facilities and two concentrate booster pump stations will require approximately 10 MW and 2.0 MW respectively.

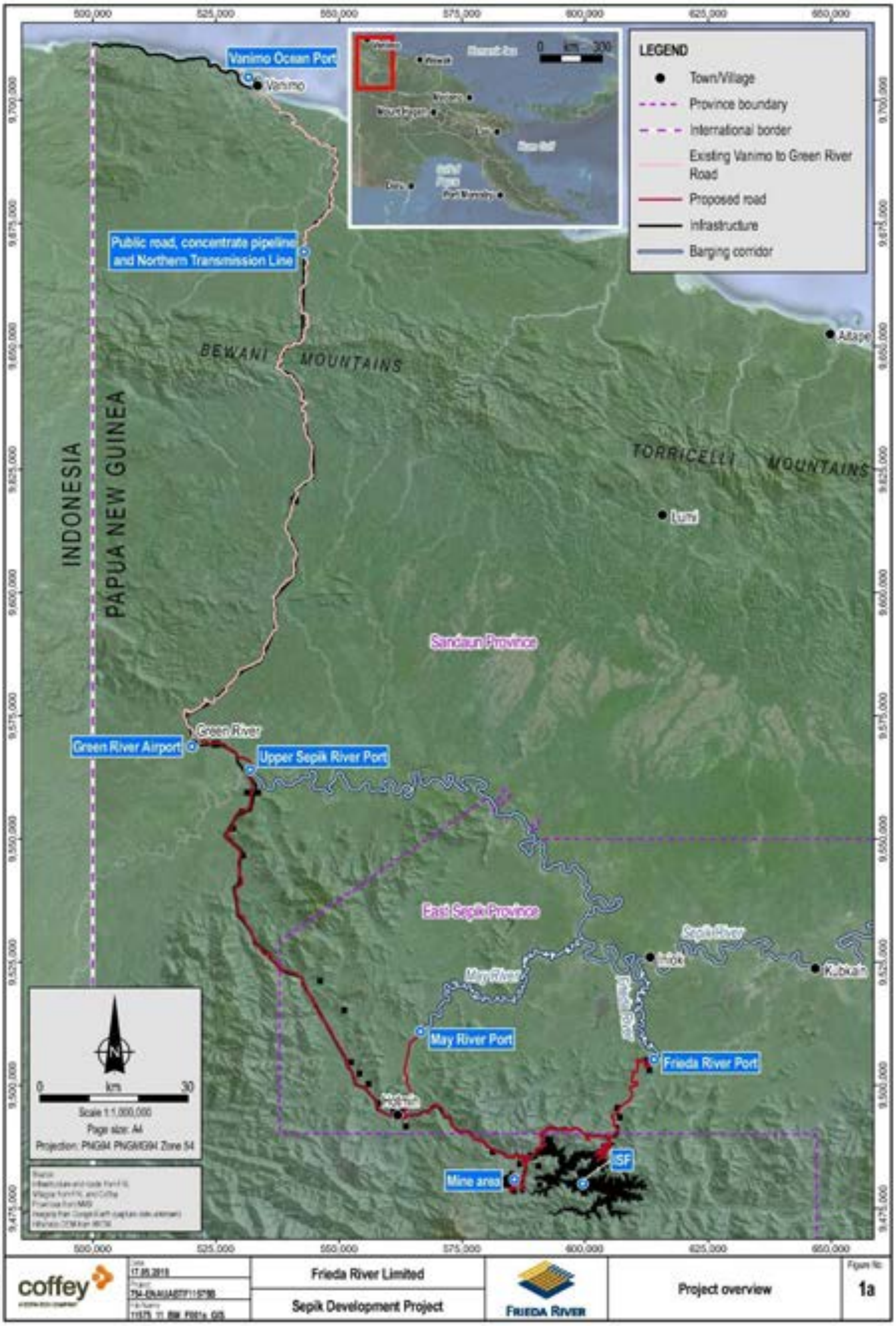


Figure 1: Project overview

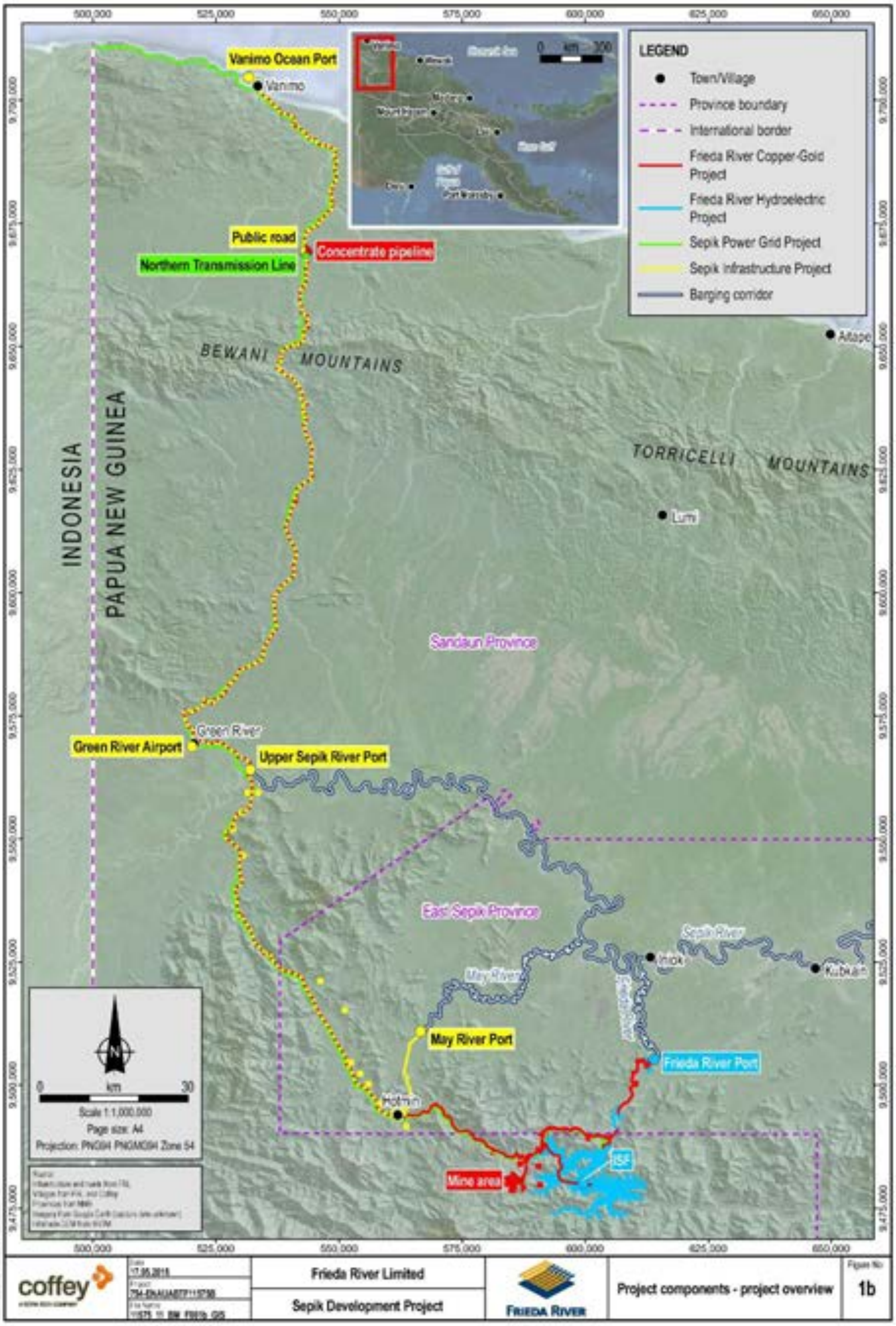


Figure 2: Project components – project overview

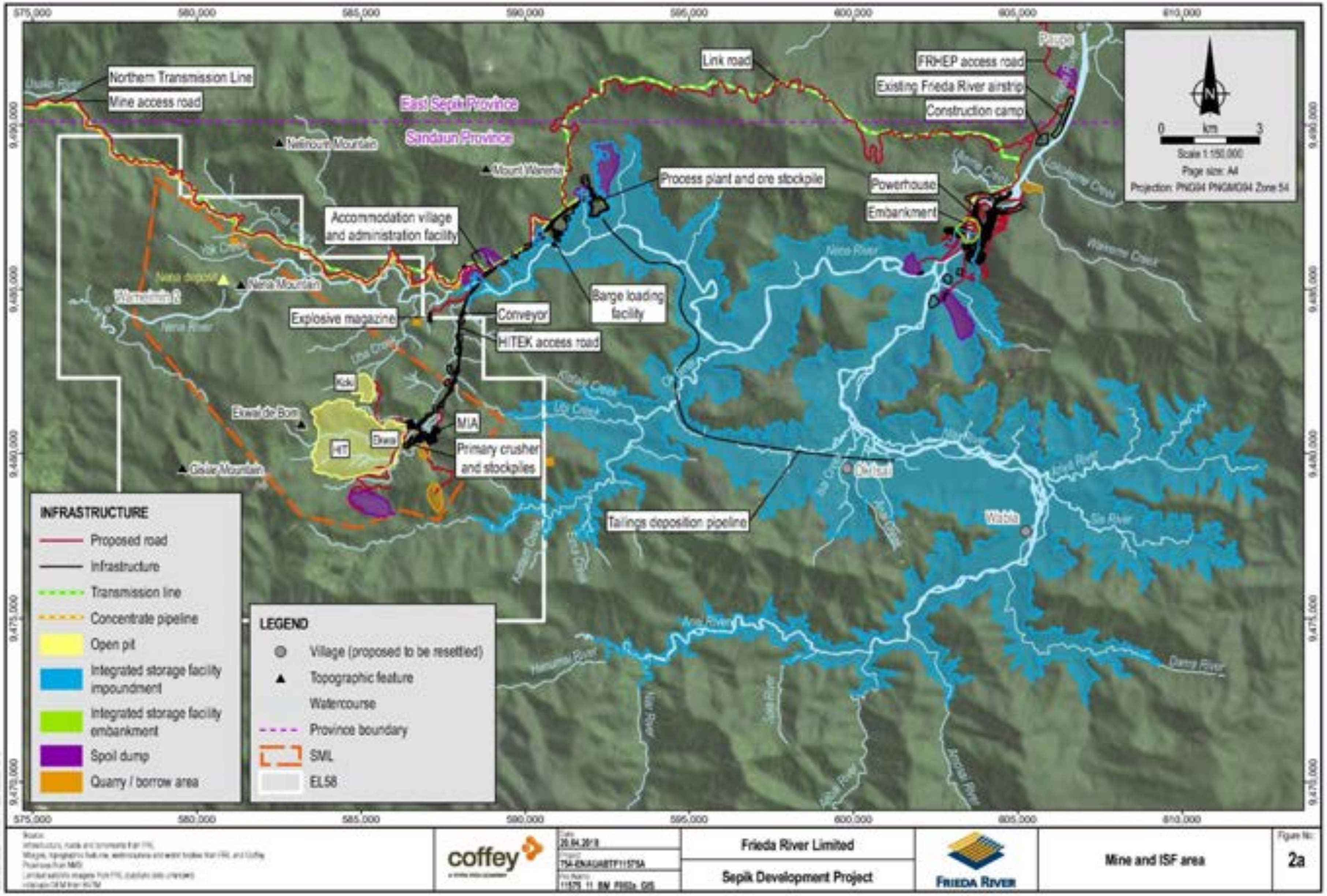


Figure 3: Mine and FRHEP area

1.1.2 Frieda River Hydroelectric Project

The Frieda River Hydroelectric Project (FRHEP) includes an Integrated Storage Facility (ISF) and a hydroelectric power facility. The ISF is located in the Frieda River Valley downstream of the FRCGP mine site will store water for power generation and provide subaqueous storage of mine waste, including tailings and waste rock.

The hydroelectric power facility will provide power to the FRCGP from Year 1, which will be transmitted via a 22-km transmission line.

The FRHEP will be capable of producing 600 MW (8 x 68 MW and 2 x 19 MW turbines) with a firm generating capacity of 400 MW. At least one turbine at a time will be offline for periods of planned maintenance and one on standby for back up.

From approximately Year 4, the excess power will be available for export.

The ISF final embankment will be approximately 187 m (235 m RL) in height, utilising 26 million cubic metres (Mm^3) of fill material and creating a total storage capacity of 10.8 billion cubic metres (Bm^3). The ISF will provide waste rock and tailings storage capacity of 3.5 Bm^3 (approximately 4.9 billion tonnes (Bt)). The operating water level will be approximately 225 m RL.

1.1.3 Sepik Infrastructure Project

The mine and ISF area will be accessed by a 325-km-long infrastructure corridor, which includes an existing road from Vanimo, on the north coast of mainland PNG, to Green River and a new road through to Hotmin and to the site. The road will be a public road from Vanimo to Hotmin and a private mine road from Hotmin to the site.

The existing airstrip at Green River is located 150 km from the FRCGP site. It will be upgraded to an international airport that will cater for larger aircraft (up to Lockheed C-130) and made open for commercial domestic use.

A 325-km-long infrastructure corridor will be developed between the mine site and the Vanimo Ocean Port, located on the north coast of mainland Papua New Guinea. Diesel trucks will transport fuel to the site using the road corridor.

The existing Port of Vanimo will be upgraded to support the FRCGP and other port users.

1.1.4 Sepik Power Grid Project

The SPGP consists of a new 370 km 275 kV Northern Transmission Line from the FRHEP to the Port of Vanimo with a 70 km connection to Jayapura in Indonesian border, via Vanimo. The transmission line will provide power for the offsite FRCGP facilities. The Northern Transmission Line will be located within the infrastructure corridor.

The excess power from the FRHEP also provides an opportunity to supply power to communities along the infrastructure corridor and to industries such as agriculture, fisheries, food and timber processing, mining and manufacturing.

1.1.5 Key Characteristics

Table 1 to Table 4 provide a summary of the key characteristics of the Sepik Development Project. Some of these aspects are in the process of being refined and may change, particularly in relation to the workforce and accommodation facilities.

Table 1: Key characteristics of the Frieda River Copper-Gold Project

Item	Description
Mining method	Large-scale conventional open-pit.
Mining	Approximately 1,493 Mt of mill feed and 1,558 Mt of waste rock to be mined from the open-pit over the life of the mine (approximately 33 years with an additional 6-year implementation period). Life of mine strip ratio of 1.1:1 (waste:ore).
Open-pit dimensions (final shell)	The Horse-Ivaal-Trukai (HIT) open-pit will be 2.6 km long and 2.4 km wide, the Ekwai open-pit will be 0.8 km long and 0.6 km wide and the Koki open-pit will be 0.7 km long and 0.9 km wide. The Ekwai open-pit void will be used as an intermediate ore stockpile.
Mining rate	Average production of 44 Mt/year of mill feed and 47 Mt/year of waste and peak total material movements of 135 Mt/year. The total material mined over the life of mine will be 3,051 Mt comprising 1,493 Mt of mill feed (0.46% copper and 0.24 g/t gold) and 1,558 Mt of waste rock.
Processing method	Conventional crushing, grinding and flotation circuit. Initially 1 x 28 MW SAG and 2 x 22 MW ball mills expanding to 2 x 28 MW SAG and 4 x 22 MW in Year 8.
Mill capacity	Nominal volumetric processing rate limits are: • Years 1 to 8: 49 Mt/year (peak 49Mt/year). • Year 8 to LOM: 65 Mt/year (peak 65Mt/year).
Concentrate and metal production	Concentrate and metal production will include: • Copper-gold concentrate production of 672,000 wet metric tonnes (wmt) per year with a peak of 1.1 Mwmt per year at 9.5% moisture. • Average copper metal production 175,000 t per year (peak of 293,000 t per year). • Average gold metal production 227,000 ounces (oz) per year (peak of 368,000 oz per year).
Tailings and waste rock storage	An Ok Binai waste dump will be developed in the headwaters of the Ok Binai. This spoil dump will store NAF waste rock from Year -1 and organic pre-strip material over the 33-year mine life. All waste rock (other than that reporting to the Ok Binai waste dump) including potentially acid forming (PAF) waste will be barge placed within the ISF. At the barge loading station the waste rock will be stockpiled, reclaimed and loaded into 5,000 t barges. The barges will transport and deposit the waste rock for subaqueous storage in the ISF. Thickened tailings will be pumped via a dedicated pipeline from the process plant for subaqueous storage in the ISF.
Power requirement and distribution	Power demand for the mine: • Approximately 155 MW (1,200 gigawatt hours per year (GWh/year)) energy demand increasing to 235 MW (1,800 GWh/year) in Year 11. Power demand offsite: • Vanimo Ocean Port concentrate and logistics facilities – 10 MW (75 GWh/year). • Two concentrate booster pump stations – 2.0 MW (15 GWh/year) each. Power supply will be via a 22-km, 132 kV transmission line from the hydroelectric powerhouse to the process plant. Power supply to the offsite facilities will be provided by the Northern Transmission Line as part of the SPGP.
Raw water requirement and supply	Raw water will be sourced from the ISF at a rate of approximately 3,800 cubic metres per hour (m^3/h) for ore processing and general non-potable consumption.

Item	Description
	Potable water will be sourced from the Nena River upstream of the ISF and pumped to the site accommodation village.
Mine infrastructure area	The mine infrastructure area (MIA) will be located close to the HITEK open-pits. The MIA will consist of the following major facilities: • Workshops. • Warehouse. • Muster, training and dining areas. • Fuel storage.
Overland logistics	Overland logistics includes: • 39 km mine access road from Hotmin to the mine (unsealed 7.5-m-wide dual lane). • 33 km unsealed 7.5-m-wide dual-lane Link Road from the powerhouse to the mine. • A buried 325-km-long pipeline providing transport of concentrate to the Vanimo Ocean Port. • Equipment and goods will be transported via road along the main access route during operations. • Coaches will be used to transport personnel between points of hire along the public road and from the Green River Airport to the mine.
Ocean/riverine logistics	During construction, freight will be imported via existing ports at Wewak, Lae and Madang and barged upstream along the Sepik River to the Frieda or May River ports until upgrade of the Vanimo to Green River Road has been completed. Freight will then be trucked from Vanimo to Green River and barged from the Upper Sepik River Port downstream along the Sepik River. Once the main access road from Green River to the mine is complete all freight will be trucked to site. During operations, freight will be imported via the upgraded Vanimo Ocean Port and trucked to site. Bulk carriers for concentrate export, multipurpose feeder vessels for containerised cargoes and parcel tankers for diesel will be utilised. Riverine transport is not expected to be used during operations.
Accommodation	**Construction**: The main construction camp will be located in the Nena River valley approximately 5 km from the process plant and will accommodate up to 3,500 contractors. **Operations**: A site accommodation village at the mine site will house 1,500 personnel with a further 100 personnel to be accommodated at Vanimo for office, logistics and port operations.

Table 2: Key characteristics of the Frieda River Hydroelectric Project

Item	Description
Power supply	Hydroelectric power generation will be produced using 8 x 68 MW and 2 x 19 MW Francis turbines. The installed hydroelectric power capacity will be approximately 600 MW with a firm generating capacity of 400 MW. At least one turbine at a time will be offline for periods of planned maintenance and one on standby for back up. From approximately Year 4, the excess power will be available for export. The powerhouse will be approximately 190 m x 34 m in size and will be located at the toe of the dam. A penstock pipeline will connect the tunnel to the powerhouse. The powerhouse complex will include: • Tunnel exit portal and penstock. • Main turbine hall housing the generating equipment. • Erection bay and workshop area for assembling the equipment and undertaking future maintenance to the equipment. • Local control room and office facilities. • Electrical equipment rooms.

Item	Description
	• An area to locate the step-up transformers and adjacent substation building. • A tailrace discharging into the Frieda River.
Design	The FRHEP will include an engineered ISF for the storage of water, construction spoil, mine waste rock and tailings, and sediment control. Embankment located in the Frieda River Valley and designed as an engineered rock-fill embankment with a central asphalt core. Design characteristics include: • Embankment height of 187 m (235 m RL) using 26 million cubic meters (Mm^3) of fill material. • Crest elevation of 235 m RL and maximum operating water level of 225 m RL. • Total storage capacity of 10.8 billion cubic metres (Bm^3). • Maximum waste rock and tailings storage capacity of 3.5 Bm^3 (approximately 4.9 billion tonnes (Bt)). • Designed to store and release water from a Probable Maximum Flood event (26,000 m^3/s). • Designed to withstand maximum credible earthquake peak ground acceleration of 1.09 g. • Catchment area of 1,036 km^2. • Operating life of greater than 100 years.
Construction facilities	The FRHEP will require the development of the following site-based facilities to allow construction of the embankment, spillway and powerhouse: • Quarry. • Coffer dams. • Diversion tunnels. • Concrete batch plant. • Maintenance workshop. • Geotechnical laboratory. The FRHEP will be constructed in a single stage over a 4 to 5 year construction duration.
Overland logistics	40 km unsealed 7.5-m-wide dual-lane FRHEP access road from the Frieda River Port to the powerhouse.
Ocean/riverine logistics	The Sepik and Frieda rivers will be required to support transport of construction materials for the FRHEP. The rivers will also provide a contingency in the event of loss of access along the infrastructure corridor.

Table 3: Key characteristics of the Sepik Infrastructure Project

Item	Description
Vanimo to Green River Road and Hotmin Road (public)	The existing road from Vanimo to Green River will be upgraded, and a new road constructed from Green River to Hotmin. The road will be at least 7.5-m-wide with a gravel pavement surface, built to allow for 12-tonne axle loading. The remaining road sections may be sealed during the operations phase. The road will allow for public transport, commercial ventures and access to new markets.
Sepik River bridge	A new public bridge will be built on the Hotmin Road (public) at the Sepik River. A cross-river ferry service will be required during construction of the bridge. The proposed Sepik River bridge consists of: • Steel box girder superstructure. • Dual lane deck with 8.0 m width between kerbs. • Total bridge length of 350 m.
Green River Airport	• The existing airstrip at Green River, located 150 km from the mine area, will be upgraded for commercial use.

	• The airport will be made suitable for up to Lockheed C-130 sized aircraft. • The new facilities will include a terminal with the capacity for 80 passengers, baggage handling facilities, immigration and customs, freight handling and storage facilities.
Vanimo Ocean Port	Construction of two new berths at the Vanimo Ocean Port to provide import and export facilities for the Project and other users.

Table 4: Key characteristics of the Sepik Power Grid Project

Item	Description
Northern Transmission Line	A 370-km-long 275 kV transmission line from the FRHEP to the Indonesian border via Vanimo. The Northern Transmission Line will provide power to the FRCGP facilities based at Green River and Vanimo. Excess power will be made available for a power distributor to sell to regional users within PNG and for export to Indonesia. The Northern Transmission Line will be located within the infrastructure corridor and will follow the existing Vanimo-Jayapura Highway from Vanimo to the Indonesian border.
Substation	Three substations will be located along the Northern Transmission Line at the FRCGP site accommodation village, near Green River and at Vanimo.

1.1.6 Project Area

Project-related activities will occur in four geographically distinct areas:

- Mine area – includes the open-pit, process plant, mine access roads, site accommodation village and other ancillary infrastructure.
- FRHEP area – includes the ISF, power generation facilities, Frieda River Port, FRHEP access road, and quarries to support construction of the FRHEP. Note that Figure 3 refers to the 'ISF area' as this figure does not include all features of the FRHEP such as the Frieda River Port.
- Infrastructure corridor – includes the access road from Vanimo to the mine site, concentrate pipeline, Green River Airport, Northern Transmission Line and other ancillary infrastructure.
- Vanimo Ocean Port – includes the export facilities at Vanimo where concentrate will be discharged from the pipeline, dewatered, stored and loaded to ocean-going vessels for shipment to overseas markets. An industrial area will be located in Vanimo for support facilities.

1.1.7 Disturbance Area

In total, the Project disturbance area will alienate approximately 16,000 ha as detailed in Table 5.

Table 5: Indicative areas of disturbance associated with the Project

Facility	Area (ha)
Frieda River Copper-Gold Project	
HITEK open-pit	520
Process plant and ore stockpile	35
Mine infrastructure area	15
Spoil dumps	205
Construction camp and site accommodation village	25
Haul roads and access roads (includes existing exploration access road)	220

Conveyor	55
Quarries	40
Frieda River Hydroelectric Project	
ISF – impoundment	12,400
ISF – embankment	35
ISF – spillway	60
Frieda air strip (predominantly existing disturbance)	20
FRHEP access road	80
Laydown areas	45
Spoil dumps	105
Sepik Infrastructure Project	
Green River Airport (existing disturbance)	20
Vanimo to Green River Road (existing disturbance)	225
Hotmin Road (public)	225
Vanimo Ocean Port (includes existing land disturbance)	35
Sepik Power Grid Project	
Northern Transmission Line	1,770
Total*	**16,000**

* Total disturbed area has removed areas where infrastructure footprints overlap. Therefore, these areas represent the total area of disturbance and not the actual size of each project component.

1.2 Regulatory and Industry Frameworks

The cultural heritage assessment framework applicable to the Project includes:

- PNG regulatory requirements and legislative context.
- International principles, standards and guidelines.

1.2.1 Papua New Guinea Legislation

Papua New Guinea (PNG) national legislation and regulations relevant to the protection of cultural heritage generally and with regard to the specific range of cultural heritage site types likely to be encountered within the Project Environmental Impact Statement (EIS) study area are listed below.

Cultural property in PNG is protected under the *National Cultural Property (Preservation) Act 1965* (NCPP Act). The principal government institutions responsible for enforcing the NCPP Act are the National Museum and Art Gallery of Papua New Guinea (NMAG) and the National Cultural Commission (NCC), each of which is established under its own enabling legislation. In practice, the NMAG performs a number of the statutory functions of the NCC, including:

- Maintenance of a national cultural heritage site register.
- Issue of artefact export permits.
- Statutory body to which cultural heritage sites are reported.

With regard to this study, PNG legislation requires that:

- Cultural property not be wilfully destroyed, damaged or defaced.
- The discovery of cultural property is reported to the NMAG/NCC.

1.2.1.1 *National Cultural Property (Preservation) Act 1965* and *National Cultural Property (Preservation) Regulations 1965*

The *National Cultural Property (Preservation) Act 1965* and *National Cultural Property (Preservation) Regulations 1965* protect moveable and immoveable cultural property, including both manufactured and natural objects that are connected with past and present traditional cultural practices. The NCPP Act specifies offences and penalties that apply to the wilful destruction, damage or defacement of national cultural property, and requires anyone who discovers the following to report the discovery to the regulatory authority:

- Cave or other place in which ancient remains, human or other, are to be found; or
- Carving, painting or other representation on rock or in a cave; or
- Deposit of ancient pottery or historical remains; or
- Place used in former times as a ceremonial or burying ground.

1.2.1.2 *National Cultural Commission Act 1994*

The NCC is established under the provisions of its enabling legislation, the *National Cultural Commission Act 1994* (NCC Act). The National Cultural Commission is responsible for:

- Preserving, protecting, developing, promoting and (for approved aspects) marketing the traditional and contemporary cultures of PNG.
- Establishing three National Cultural Institutions (the Institute of PNG Studies, the National Film Institute and the National Performing Arts Troupe).

However, beyond these general functions, the NCC Act does not provide any specific role in the protection of cultural heritage sites known or likely to be found in the study area.

1.2.1.3 *National Museum and Art Gallery Act 1992*

The *National Museum and Art Gallery Act 1992* (NMAG Act) establishes the National Museum and Art Gallery of Papua New Guinea (NMAG) as the principal government institution responsible for preserving PNG's cultural heritage. Section 4(1) of the NMAG Act lists the functions of the NMAG, which include:

- Protect and conserve the cultural and natural heritage of Papua New Guinea as required by the *Environmental Planning Act 1978*, *National Cultural Property (Preservation) Act 1965* and the *Conservation Areas Act 1978*;
- Administer the *National Cultural Property (Preservation) Act 1965* and *War Surplus Materials Act 1952* and any other Act that applies to the functions of the Museum;
- Research and document the prehistory of Papua New Guinea by archaeological surveys and excavations and manage the national archaeological collections;
- Monitor archaeological research in Papua New Guinea and issue archaeological permits for the short-term loan of archaeological material for study overseas;
- Maintain the national register of traditional and archaeological sites, locate and record prehistoric sites and monuments, and carry out the salvage of archaeological excavations as required by the *National Cultural Property (Preservation) Act 1965* and the *Environmental Planning Act 1978*;
- Identify, document and monitor the conditions of objects of national cultural significance, recommend their proclamation as national cultural property, and keep a register of national cultural property;
- Monitor the collection and export of artefacts, issuing permits and perform other duties as required by the *National Cultural Property (Preservation) Act 1965*;

- Monitor and affiliate researchers from other institutions carrying out research in the areas of the Museum's functions.

1.2.1.4 *War Surplus Material Act 1952*

This Act provides for the protection of material derived from World War II, along with the protection of historical period (contact period) properties in the context of buildings, structures, monuments, burial places and shipwrecks, and other relevant materials of historical significance to PNG.

1.2.1.5 *Cemeteries Act 1955*

The *Cemeteries Act 1955* allows for burials on private grounds to be considered cemeteries for the purposes of the Act. Section 29 of the Act allows for the exhumation of burials under certain conditions, if authorised by the Minister, a Provincial Administrator (under delegated authority from the Minister) or a coroner (subject to any law relating to coroners).

This act is therefore relevant to the Project in that the potential exhumation of traditional burials as a Project-related impact management measure requires a specific authority.

1.2.1.6 Compensation

Where destruction of cultural heritage sites occurs either by accident or following consultation with landowners, the PNG Valuer-General's *Compensation Schedule for Trees and Plants, All Regions* (Department of Lands 2008; see also PNG Chamber of Mines and Petroleum 2008) provides guidelines for appropriate compensation rates for 'ceremonial grounds', 'sacred sites' and 'grave sites'. These guidelines also note that:

> Where there is disagreement over the authenticity, importance, or extent of any sacred site the matter should be referred to the Valuer-General, who may in turn refer the matter to an appropriately qualified person or organisation for adjudication (Department of Lands 2008: 8).

1.2.2 International Policies, Standards and Guidelines

International policies, standards and guidelines specific to cultural heritage include the Burra Charter, the International Council on Mining and Minerals Principles (ICMM Principles) and the International Finance Corporation Performance Standard 8. These are discussed briefly below.

1.2.2.1 The Burra Charter

The Australia International Council on Monuments and Sites (ICOMOS) is a non-government, not-for-profit organisation of cultural heritage professionals which was formed as a national chapter of ICOMOS International in 1976. One of the key goals of Australia ICOMOS is to promote an understanding of the cultural significance of places and raise conservation standards through education and communications.

The Australia ICOMOS Charter for Places of Cultural Significance 2013, generally referred to as the Burra Charter, is widely recognised as a benchmark standard for cultural heritage management in Australia. In general, it defines the basic principles and procedures to be followed in the conservation of heritage places (Australia ICOMOS 2013). The Charter emphasises that the policy for managing a place must be based on an understanding of its cultural significance, which it defines as the:

> …aesthetic, historic, scientific, social or spiritual value for past, present or future generations. Cultural significance is embodied in the *place* itself, its *fabric*, *setting*, *use*, *associations*, *meanings*, records, *related places* and *related objects*. Places may have a range of values for different individuals or groups (Australia ICOMOS 2013: Article 1.2).

These criteria were incorporated into the EIS cultural heritage impact assessment methodology, specifically with regard to the determination of the significance of relevant cultural heritage values.

The Burra Charter criteria were used in the absence of any criteria previously developed for use in a PNG context.

1.2.2.2 International Council on Mining and Minerals (ICMM)

The ICMM is a global body which was established in 2001 as a catalyst to improve sustainable development in the mining industry. Continued improvement is a key goal. Member companies make public commitments to improve their sustainability performance and report against progress.

FRL supports the implementation of the ICMM Principles. The approach taken in the collection of cultural heritage data and implementation of the consultation program was guided by the relevant principles, which are:

- To uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
- To implement effective and transparent engagement and communication with our stakeholders.

1.2.2.3 International Finance Corporation (IFC) Performance Standard 8

The objectives of IFC Performance Standard (PS) 8 (Cultural Heritage) are to protect cultural heritage from the adverse impacts of Project activities, support its preservation, and promote the equitable sharing of benefits from the use of cultural heritage, regardless of whether it has been legally protected or previously disturbed. Performance Standard 8 provides specific guidance on several aspects that were taken into consideration during the field surveys, the preparation of the impact assessment reported in this study, and the development of recommended management measures, including:

- Protection of cultural heritage in Project design and execution
- Chance finds procedures
- Consultation
- Community access
- Removal of replicable cultural heritage
- Removal of non-replicable cultural heritage

1.3 Study Objectives

The objectives of the Project EIS cultural heritage study were to:

- Identify, describe and map any cultural heritage values that may exist in relation to areas where ground disturbing impacts arising from Project activities are proposed.
- Identify potential impacts to the identified cultural heritage values arising from Project activities.
- Recommend measures that might be adopted to mitigate and manage these impacts.
- Determine the residual impacts expected following implementation of proposed management measures.

The Project EIS cultural heritage baseline and impact assessment comprises:

- A Baseline Assessment describing the existing cultural heritage environment in the study area (see Section 1.5 for study area definition).
- An Impact Assessment detailing the potential, actual and perceived impacts of the Project, recommended management measures to address the identified impacts, and an assessment of the residual impacts assuming implementation of the recommended measures.

1.4 Study Methods

1.4.1 Baseline Assessment

The Baseline Assessment comprised:

1. Review of existing information, including:
    - Meetings in 2010-2011 with personnel from the PNG National Museum and Art Gallery (NMAG), regarding the potential for Project-related impacts to portions of the FRCGP and FRHEP based on the project layout in use at that time.
    - Review of the NMAG National Site File (NSF) (all study areas) (Section 2.3).
    - Review of previous studies (Section 2.4).
2. Field investigations in 2010-2011 and 2016 in and near the FRCGP and FRHEP, based on project layouts in use at those times.

Tasks common to all field investigations included the identification and recording of the current condition and state of preservation of cultural heritage sites. Field investigations were carried out for:

- Previously unknown cultural heritage sites identified through community interviews and targeted field surveys of areas that could be impacted by the development of Project infrastructure.
- Cultural heritage sites previously recorded through interviews only, which also aimed to verify their locations within the Project study area.

The sequence and details of each component of the general field methodology are described below. Two rounds of cultural heritage fieldwork were specifically commissioned by FRL in support of the FRCGP, the first in 2010-2011 (Denham and Hitchcock 2011) and the second in 2016 and presented for the first time in this study. Instances where the field methodologies differed between these two field programs are detailed below.

1.4.1.1 Pre-awareness Discussions

Frieda River Limited's Community Affairs department conducted pre-survey village awareness briefings with nominated communities to bring the fieldwork to their attention, to gain their endorsement to enter their lands and document the information gathered, and to identify individuals who would be willing to assist the field program by participating in interviews and acting as guides during the subsequent field surveys.

1.4.1.2 Community Consultation

Interviews were held with representatives nominated by each cultural group regarding known cultural heritage sites potentially located within or near proposed Project infrastructure. The villages consulted depended upon the specific requirements of each fieldwork phase.

A critical element in the consultation process was to ensure that all community representatives understood that the field program was not intended to contribute to or influence issues around land ownership. Care was taken to emphasise that the fieldwork was designed to identify cultural heritage values associated with the study area, which would then enable FRL to progress infrastructure development in ways that avoided or minimised the impact of their activities on cultural heritage to the greatest extent practicable.

<u>2010-2011 Field Program</u>

The intention of the 2010-2011 field program was to visit as many communities as possible likely to have cultural sites within the FRCGP study area as defined at that time. Some of these communities were located outside of the 2010-2011 study area, but formerly they may have lived in or used the landscapes within it. The aim was to obtain a balanced coverage of communities both within and near the 2010-2011 study area.

Where possible, messages were relayed to local communities via the existing high-frequency (HF) radio system prior to departure from Base Camp, thereby alerting people of the impending visit and to ensure that the appropriate individuals were available for consultation. Additionally, workers at Base Camp who were going on break were told to inform their communities of the upcoming cultural heritage field program. Upon arrival in a community, the team held a *tok save* (information session) meeting to outline the purpose of the visit and the nature of the work. An FRL Community Affairs (CA) officer was always present to ensure that the appropriate individuals were available for consultation from each community, and to assist with the smooth running of fieldwork. Local people assisted with translation from *tok ples* (local language) to *Tok Pisin*, as well as translation into English; FRL CA staff also assisted with translation from *Tok Pisin* to English.

Most sites were plotted on 1:100,000 topographic maps by local people, and informant testimony and field observations were recorded during the interviews.

<u>2016 Field Program</u>

The consultation protocol for each village visited during the 2016 field program was to:

- First, provide a general introduction regarding the purpose of the cultural heritage survey and its methods.

Second, to invite individuals to participate either singly or as a group in a more focused interview (All community interviews were conducted with the assistance of FRL CA staff. Interviews commenced with a brief description of the materials that would be used to record relevant cultural heritage information, which included standard 1: 100,000 topographic maps. The maps included basic location information such as village names, but they did not include any information depicting FRCGP infrastructure or operational layouts. The purpose of this was to enable frank and open discussion about the locations of cultural heritage sites within the area of interest without the potentially biasing influence of prior knowledge of preferred FRCGP infrastructure locations.

- Plate 1). Alternatively, individuals already nominated by their community as suitable representatives were identified and invited to participate in an interview.

Men and women were always invited to attend and participate in the introductory briefing sessions and to participate in key informant interviews and subsequent fieldwork.

All community interviews were conducted with the assistance of FRL CA staff. Interviews commenced with a brief description of the materials that would be used to record relevant cultural heritage information, which included standard 1: 100,000 topographic maps. The maps included basic location information such as village names, but they did not include any information depicting FRCGP infrastructure or operational layouts. The purpose of this was to enable frank and open discussion about the locations of cultural heritage sites within the area of interest without the potentially biasing influence of prior knowledge of preferred FRCGP infrastructure locations.

Plate 1: Community cultural heritage interview in progress at Kubkain village (26 June 2016)

To enable the interview participants to orientate themselves with regard to the maps, time was allocated for the identification of key geographic landmarks such as watercourses, mountains and valleys. Once these landmarks were identified and their locations understood, it became easier for interview participants to then indicate the approximate locations of known cultural heritage sites in relation to these mapped landmarks.

During the 2016 field program, informant responses during community interviews were recorded using a standardised report template (Appendix 1).

At the completion of each community interview the results were reviewed by the study team and arrangements made with relevant informants for a field inspection of selected sites. Field inspections also included onsite consultation with local community representatives regarding the presence or absence of oral tradition sites within each component of the 2016 field program study area. Community representatives were asked to state:

- Whether the specific area of interest contained any oral tradition sites.
- Whether they had any concerns that proposed works within the 2016 field program study area might negatively impact on any cultural heritage values that may be associated with these locations.

All responses from the community representatives present during these onsite consultations were noted.

1.4.1.3 Pedestrian Field Survey and Cultural Heritage Site Recording

The final step in the fieldwork methodology for all stages of fieldwork was to undertake pedestrian surveys of sites selected as an outcome of the community interviews. Decisions as to which sites would be included in pedestrian surveys were based on considerations regarding accessibility, time constraints, and the potential for FRCGP activities to impact these locations.

<u>2010-2011 Field Program</u>

All sites were given a temporary site number – beginning with a D if recorded by Denham's team and an H if recorded by Hitchcock's team. If a site was recorded by multiple groups, it was usually given a separate site code because:

- In the field it was not always possible to know if it was the same site or a site with a similar name (often places, things and people have multiple names that are used in different social settings); and

- This would enable mapping of sites by major groups and sub-groups (if necessary).

Several places were named but not explicitly documented as sites.

The survey methods varied greatly between communities, although all were community-led. The cultural survey at each community focused on sites of ongoing cultural significance, although occasionally people presented materials from archaeological sites, or described sites of archaeological significance that they had come across.

2016 Field Program

During the 2016 cultural heritage field program, all cultural heritage sites were individually recorded using a standard site recording form (Appendix 2), which included all the information required by the NMAG National Site File form as well as additional information on environment and content. Field notes and a field diary were recorded separately. Site recording included information regarding site size and contents, the environmental context, a general description of the site, oral traditions, and preliminary observations regarding potential management recommendations.

All new cultural heritage sites were assigned a consecutively numbered temporary field code beginning with SAS. All cultural heritage sites were photographed, and their locations recorded using a Garmin GPSmap 62s or a Garmin eTrex Vista HCx handheld GPS device standardised to the WGS84 datum and UTM Zone 55S projection. Whenever possible formal cultural heritage survey tracks were also recorded using the handheld Garmins. All pedestrian site visits were conducted with the direct assistance of FRL CA staff, and were accompanied at all times by relevant landowners.

1.4.1.4 Archaeological Fieldwork Permits

It is common practice in PNG that the NMAG issues permits for archaeological investigations. The 2010-11 field program was completed under the provisions of NMAG Archaeological Research Permit No. 170, issued on 8 January 2010 by Herman Mandui. The 2016 field program was completed under the provisions of two NMAG permits issued by Alois Kuaso on 24 May 2016:

- Cultural Heritage Mapping Permit No. 004 (Appendix 3)
- Archaeological Survey Permit No. 202 (Appendix 4)

All field methods and site recording protocols employed during the survey meet the requirements of the Prehistory Department, National Museum and Art Gallery of PNG.

No archaeological excavation program was undertaken during the 2010-2011 or 2016 field programs.

1.4.2 Impact Assessment

1.4.2.1 Impact Assessment Framework

The impact assessment framework used in this study incorporates the following sequential elements:

1. Identification of the cultural heritage sites to be included in the assessment. For this study, these include all cultural heritage sites known to be located within the Project EIS cultural heritage study area (defined in Section 1.5) at the conclusion of the baseline assessment.
2. Assessment of the cultural heritage significance of each site using established, internationally recognised criteria specifically developed to identify the values of a cultural heritage site, as well as the opinions of the local communities.
3. Assessment of the magnitude of the impact from proposed Project activities on cultural heritage sites, based on an assessment of the severity, geographical extent and duration of the impact.
4. Determination of the significance of a potential Project impact on identified cultural heritage sites, based on the consideration of the site's cultural heritage significance and the magnitude of the impact it is likely to experience.

5. Identification of avoidance and management measures that, if implemented, should either avoid Project impacts to cultural heritage sites altogether or reduce the significance of these impacts.
6. Determination of residual Project-related impacts to cultural heritage sites by assessing the significance of a potential impact after the implementation of recommended avoidance and management measures.

1.4.2.2 Cultural Heritage Significance

The assessment of cultural heritage significance is a fundamental component of cultural heritage management. Such assessments can assist in determining which items, sites, places, landscapes and even environments are of sufficient cultural importance that they require preservation, and if this is not possible, they can inform the development of appropriate management measures to mitigate impacts. Significance assessment establishes the assessment criteria and significance ratings to be applied to each cultural heritage site, both tangible and intangible.

A statement regarding the significance of each cultural heritage site is an essential step in the process of developing appropriate cultural heritage management recommendations. Although it may seem self-evident, it is important to state that while all known cultural heritage sites have at least some level of 'cultural heritage significance', the preservation of all cultural heritage may not be possible. In this context, *management* is not necessarily synonymous with *preservation*, and may involve disturbance or destruction, or partial disturbance through controlled above-ground, ground surface and subsurface salvage investigations where archaeological material is present.

A process for establishing cultural significance is provided in the *Australia ICOMOS Charter for Places of Cultural Significance 2013*, otherwise known as 'The Burra Charter' (Australia ICOMOS 2013; Marquis-Kyle & Walker 2004). Article 1.2 of the Burra Charter states that:

- *Cultural significance* means aesthetic, historic, scientific, social or spiritual value for past, present or future generations.
- Cultural significance is embodied in the *place* itself, its *fabric*, *setting*, *use*, *associations*, *meanings*, *records*, *related places* and *related objects*.
- Places may demonstrate a range of these significance criteria for different individuals or groups.

An accompanying Practice Note defines these criteria (ICOMOS 2013: 3-4), as follows.

Aesthetic: Refers to the sensory and perceptual experience of a place—that is, how we respond to visual and non-visual aspects such as sounds, smells and other factors having a strong impact on human thoughts, feelings and attitudes (Kerr 1990:10). Aesthetic qualities may include the concept of beauty and formal aesthetic ideals. Expressions of aesthetics are culturally influenced. Despite the poorly defined nature of aesthetic significance, it remains one of the most important criteria for official registration of heritage sites in many parts of the world (e.g. Schapper 1993).

Historic: Intended to encompass all aspects of history—for example, the history of aesthetics, art and architecture, science, spirituality and society. It therefore often underlies other values. A place may have historic value because it has influenced, or has been influenced by, an historic event, phase, movement or activity, person or group of people. It may be the site of an important event. For any place the significance will be greater where the evidence of the association or event survives at the place, or where the setting is substantially intact, than where it has been changed or evidence does not survive. However, some events or associations may be so important that the place retains significance regardless of such change or absence of evidence.

Scientific: Refers to the information content of a place, or its ability to reveal something about the past through the use of scientific techniques such as archaeology. The relative scientific value of a place is likely to depend on the importance of the information or data involved, on its rarity, quality or representativeness, and its potential to contribute further important information about the place itself or a type or class of place or to address important research questions. To establish potential, it may be necessary to carry out some form of testing or sampling. For example, in the case of an archaeological site, this could be established by a test excavation.

Social: Refers to the associations that a place has for a particular community or cultural group and the social or cultural meanings that it holds for them. Places of social significance are usually important in maintaining a community's integrity and *sense of place*; that is, a sense of belonging to a particular area as a distinctive cultural group (Hall and McArthur 1993:8). For many peoples, indigenous archaeological sites (e.g. burials) and European-Indigenous contact sites (e.g. missions, plantations) have strong social significance. Archaeological sites with materials deemed to be markers of the prior presence of the cultural groups may also assume a strong social significance during land ownership disputes.

Spiritual: Refers to the intangible values and meanings embodied in or evoked by a place which give it importance in the spiritual identity, or the traditional knowledge, art and practices of a cultural group. Spiritual value may also be reflected in the intensity of aesthetic and emotional responses or community associations, and be expressed through cultural practices and related places. The qualities of the place may inspire a strong and/or spontaneous emotional or metaphysical response in people, expanding their understanding of their place, purpose and obligations in the world, particularly in relation to the spiritual realm.

For the purposes of this study, the cultural heritage significance of each site was assessed using four of these five criteria: the historic, scientific, social and spiritual values of each cultural heritage site were individually assessed and rated as being either low, medium or high according to the criteria set out in Table 6, which incorporates specific criteria outlined in the Practice Note produced by ICOMOS (2013: 3-4). An assessment of aesthetic value was not included in the current significance assessment given its somewhat subjective nature and the lack of established criteria that could be applied to an independent assessment of this criterion with regard to cultural heritage sites in PNG.

Table 6: Cultural heritage criteria and ratings (based on ICOMOS 2013)

Cultural Heritage Criterion	Examples	Rating
Historic	The place may be associated with an important event or theme in history, or a particular person or cultural group important to the history of the local area, state or nation	Historical value was rated as follows: • Low (1) for sites which are not associated with any known historical event, person or theme. • Medium (2) for sites which are associated with a moderately significant historical event, person or theme at either the local and/or provincial and/or national level. • High (3) for sites which are associated with a highly significant historical event, person or theme at either the local and/or provincial and/or national level.
Scientific	Through the use of scientific techniques such as archaeology, the place has the potential to reveal new information or understandings about people, places, processes or practices	Ratings for scientific value take into account • Site contents (e.g., size and patterning of site where 0 = no materials remaining, 1 = small number of artefacts with limited diversity (0-10 artefacts), 2 = larger number but limited range of artefacts, 3 = large and diverse range of artefacts). • Site condition (0 = destroyed, 1 = deteriorated, 2 = fair to good, 3 = excellent). • Site representativeness (1 = common, 2 = occasional, 3 = rare). The rating for overall significance is calculated based on the cumulative score for site contents, site condition and site representativeness where: • Low (1) (cumulative score 1-3).

Cultural Heritage Criterion	Examples	Rating
		• Medium (2) (cumulative score 4-6). • High (3) (cumulative score 7 or greater).
Social	The place may be an important local marker or symbol or contribute to the identity of a particular cultural group	Social value was rated as follows: • Low (1) for sites which do not appear to have any clear social connection at either the local and/or provincial and/or national level. • Medium (2) for sites which have a moderately significant social connection for a cultural group at either the local and/or provincial and/or national level. • High (3) for sites which have a highly significant social connection for a cultural group at either the local and/or provincial and/or national level.
Spiritual	The place may contribute to the spiritual identity or belief system of a cultural group and/or may be important to maintaining the spiritual health and wellbeing of a culture or group.	Spiritual value was rated as follows: • Low (1) for sites which do not appear to have any clear spiritual connection with a cultural group at either the local and/or provincial and/or national level. • Medium (2) for sites which have a moderately significant spiritual connection for a cultural group at either the local and/or provincial and/or national level. • High (3) for sites which have a highly significant spiritual connection for a cultural group at either the local and/or provincial and/or national level.

Numeric values were assigned to objective criteria differentiating low (1), medium (2) and high (3) scientific value. These criteria included the contents of the site, the condition of preservation of the site, and the representativeness of the site in terms of the wider (regional) cultural heritage site inventory.

Criteria differentiating low, medium and high historic, social and spiritual value were based on professional experience and information obtained during community consultation. Each criterion was assigned a numerical rating (low (1), medium (2) or high (3)).

Equal weight was given to all four criteria when determining the overall significance of each cultural heritage site. The potential to variably weight the degree of contribution of each criterion was initially considered but not pursued owing to the somewhat subjective nature of the factors used to determine historic, social and spiritual sensitivity.

The overall significance rating determined for each cultural heritage site was derived as a cumulative score across the four cultural heritage criteria, according to the following classification system:

- ≤ 6 – Low significance
- 7-9 – Medium significance
- ≥ 10 – High significance

1.4.2.3 Impact Magnitude

The magnitude of an impact on a cultural heritage site is an assessment of: 1) the geographical extent of the impact; 2) the duration of the impact; and 3) the severity of the impact. The magnitude of the impact is determined before and after the application of management measures.

Impact magnitude criteria have been specifically developed for extractive industry cultural heritage impact assessments by Andrew Long and Associates Pty Ltd. These criteria are presented in Table 7.

Given that the impact magnitude criteria identified above may not all apply equally in terms of their severity in any given instance, an overall impact magnitude rating was calculated based on the cumulative score for each criterion, as follows:

- Low (cumulative score ≤ 3)
- Medium (cumulative score between 4 and 6)
- High (cumulative score ≥ 7)

Table 7: Impact magnitude criteria

Consequence Category	Nil	Low (Rating 1)	Medium (Rating 2)	High (Rating 3)
Severity	No impact	Loss of up to one third of site contents. Site condition rating decreases by one rating point. Site representativeness rating unchanged. Minor impact to the site's scientific value. Minor community reaction; attracts stakeholder concern at a local level.	Loss of up to two thirds of site contents. Site condition rating changes by two rating points. Site representativeness rating decreases. Moderate impact to the site's scientific value. Substantial community reaction; results in stakeholder concern at local and provincial levels.	Loss of greater than two thirds of site contents. Site condition rating changes by three rating points. Site representativeness rating decreases. Major impact to the site's scientific value. Major community reaction; results in stakeholder concern at a national or international level (i.e., media, shareholder, government, international non-government organisation concern).
Extent	No impact	Impact damages less than one third of site. No loss of access to site.	Impact damages up to two thirds of site and/or access to site restricted.	Impact damages greater than two thirds of site and/or permanent loss of access to site.
Duration	No impact	Temporary or short-term impact or loss of access to site limited to Project construction phase.	Medium-term impact or loss of access to site that will alleviate within life of Project.	Long-term (extends beyond the life of the Project) or permanent impact.

1.4.2.4 Assessing Impact Significance

The matrix used to assess the significance of a Project-related impact on a cultural heritage site is presented in Table 8. The significance of an impact is determined by assessing the significance of a cultural heritage site in relation to the overall magnitude of the expected impact on it.

Table 8: Impact significance assessment matrix

		Cultural Heritage Significance		
		High	Medium	Low
Impact Magnitude	High	Extreme	Major	Moderate
	Medium	Major	Moderate	Minor
	Low	Moderate	Minor	Negligible

Characteristics for each impact significance rating are presented Table 9.

Table 9: Impact significance rating characteristics

Impact Significance	Characteristics
Extreme	• Likely to result in major widespread community and stakeholder concern at the local, provincial and/or national/international level. • Affects the majority of the people in the area of influence. • The effect is very intense with people experiencing a rapid rate of change. The effect is immediate and/or endures for, and beyond, the duration of the activity or Project phase. • The effect significantly disrupts a cultural group's spiritual connection to land and in turn their spiritual identity and/or spiritual health and wellbeing. • Archaeological site conditions are destroyed such that potential understandings about people, places, processes or practices associated with the Project area are irrevocably lost.
Major	• Likely to result in a strong community and stakeholder reaction at the local, provincial and/or national level. • Affects a large number of people in the area of influence. • The effect is intense with people experiencing a relatively rapid rate of change. • The effect starts in a short time and/or endures for, and potentially beyond, the duration of the activity or Project phase. • The effect disrupts a cultural group's spiritual connection to land and in turn their spiritual identity and/or spiritual health and wellbeing. • The effect disrupts a cultural group's social connection to land which contributes to their cultural identity. • Archaeological site condition is damaged such that the ability to derive potential understandings about people, places, processes or practices associated with the Project area is reduced.
Moderate	• Could attract community and stakeholder concern being voiced at the local and provincial level. • Affects a moderate number of people in the area of influence. • The effect is moderate with people experiencing a moderate rate of change. • The effect is gradual and/or endures for the duration of the activity or Project phase. • The impact affects a cultural group's spiritual connection to land and in turn their spiritual identity. • The impact affects a cultural group's social connection to land which contributes to their cultural identity. • Archaeological site condition is damaged such that the ability to derive potential understandings about people, places, processes or practices associated with the Project area is somewhat reduced.
Minor	• May result in community and stakeholder concern being voiced in a localised area. • Affects a small number of people in the area of influence. • The effect is not very intense with people experiencing a slow rate of change. • The effect is delayed, medium-term and/or confined to the duration of the activity or Project phase. • A cultural group's spiritual or social connection to the land, and therefore spiritual or cultural identity, is largely undisturbed or maintained. • Archaeological site condition is largely undisturbed resulting in little effect on the ability to derive understandings about people, places, processes or practices.
Negligible	• Unlikely to create any concern in the community and among Project stakeholders. • Affects a very small number of people in the area of influence. • The effect is not intense with people experiencing a very slow rate of change. • The effect is immediate or delayed, short-term and/or confined to the duration of the activity or Project phase. • A cultural group's spiritual or social connection to the land is preserved resulting in little effect or maintenance of their spiritual or cultural identity. • Archaeological site condition is preserved resulting in little effect on the ability to derive understandings about people, places, processes or practices.

1.5 EIS Cultural Heritage Study Area

The Sepik Development Project EIS cultural heritage study area was defined based on three discrete elements encompassing the following Project components. The individual components are described in Section 1.1 above.

- **Mine study area** (all components mapped according to the proposed disturbance footprint buffered by an additional 50m, 100m or 200m as specified below; Figure 4), including:
    - HITEK open pits (100m buffer)
    - Mine Infrastructure Area (MIA), including primary crushing plant (ore and waste) and stockpiles (100m buffer)
    - Organic waste spoil dump (100m buffer)
    - Process Plant and ore stockpile (100m buffer)
    - Other infrastructure (e.g. construction camp and site accommodation village, administration and maintenance facilities) (100m buffer)
    - Quarries and spoil dumps (100m buffer)
    - Mine access roads (50m buffer)
    - Frieda River Port (200m buffer)
    - Barge loading facility (100m buffer)
- **FRHEP study area** (all components mapped according to the proposed disturbance footprint buffered by an additional 100m for the ISF embankment and impoundment and 50m for associated linear alignments; Figure 5), including:
    - ISF embankment (100m buffer)
    - ISF impoundment (100m buffer)
    - Hydroelectric powerhouse (100m buffer)
    - Tailings deposition pipeline (50m buffer)
    - Access Roads (50m buffer)
    - Quarries (200m buffer)
    - Frieda River Airport (100m buffer)
- **Infrastructure Corridor study area** (including the SIP, the SPGP and the concentrate pipeline component of the FRCGP; all components mapped according to the proposed disturbance footprint buffered by an additional 100m or 30m as specified below; Figure 6), including:
    - Mine access road from the site accommodation village to Hotmin (50m buffer)
    - Public road from Hotmin to Vanimo (50m buffer)
    - May River Port (200m buffer)
    - Green River Airport (200m buffer)
    - Vanimo Ocean Port (100m buffer)
    - Concentrate pipeline from mine process plant to Vanimo Ocean Port (50m buffer)
    - Northern Transmission Line from the hydroelectric powerhouse to its termination west of Vanimo at the Indonesian border (50m buffer)
    - Quarries (200m buffer)

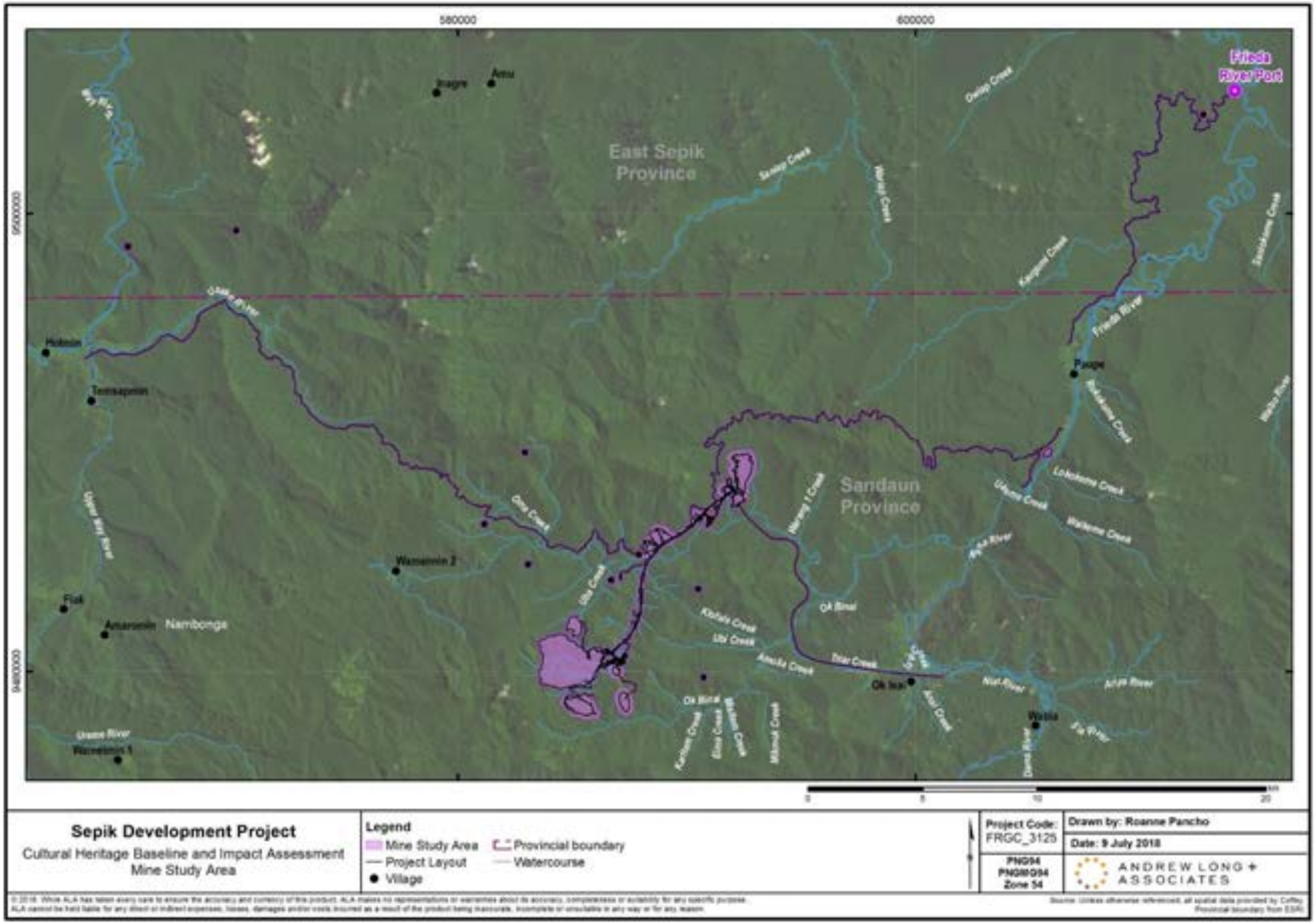


Figure 4: Mine study area

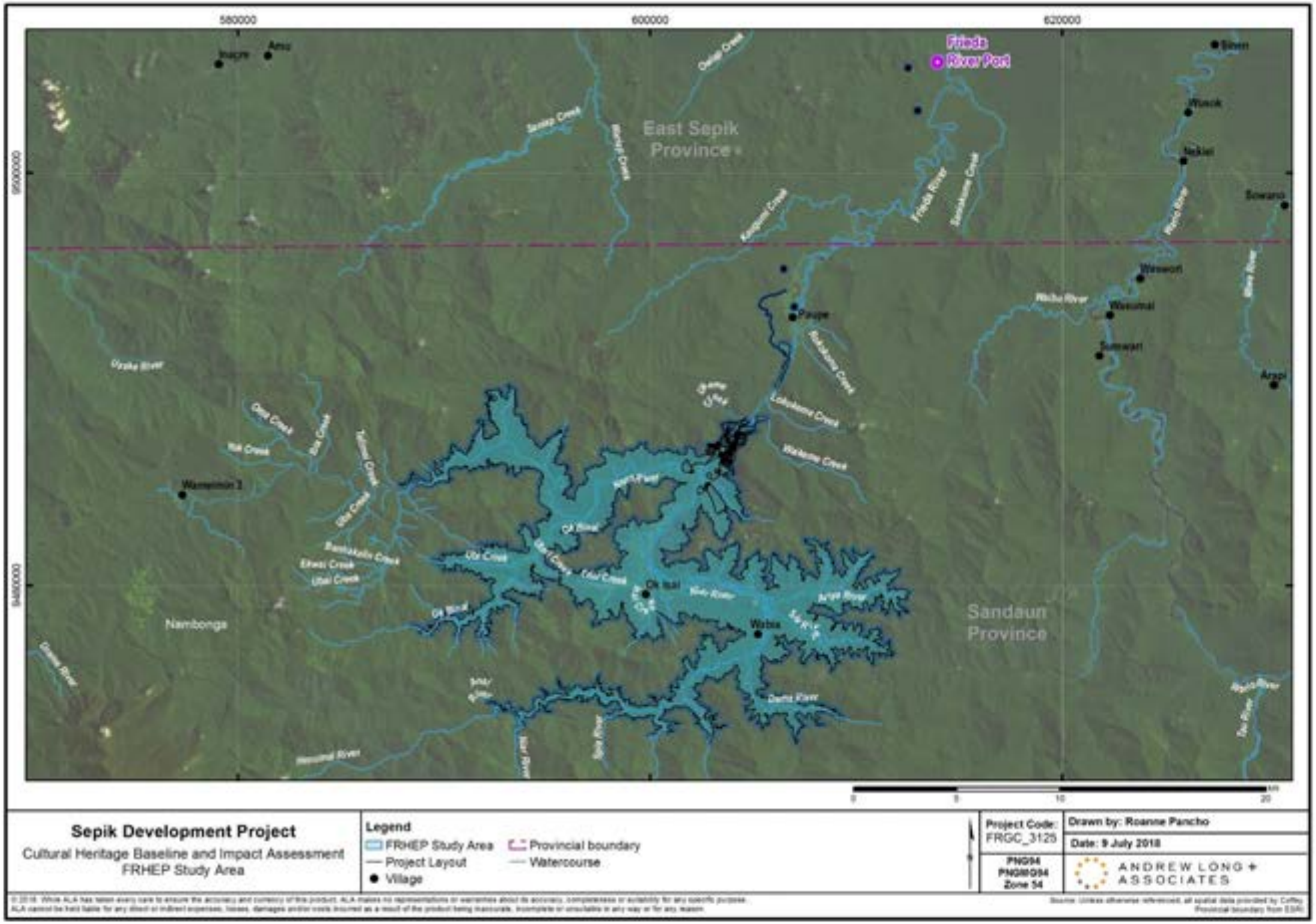


Figure 5: FRHEP study area

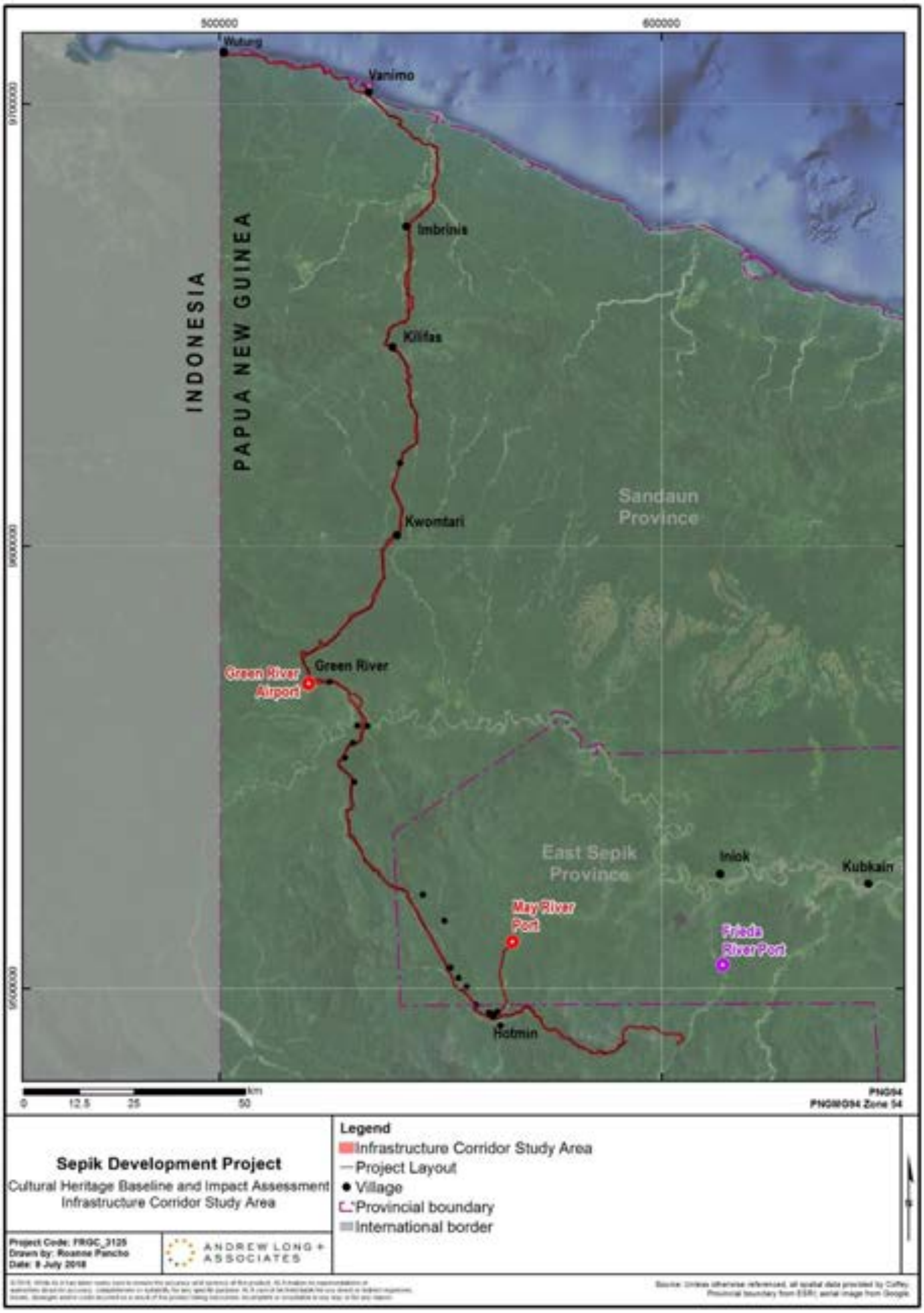


Figure 6: Infrastructure corridor study area

2 BASELINE ASSESSMENT

2.1 Cultural Groups

2.1.1 Mine and FRHEP Study Areas

The cultural and linguistic context of the mine and FRHEP study areas is extraordinarily complex, including complicated inter-group kinship relationships extending throughout and beyond the immediate area (Gardner et al. 1996: 4–5; Fingleton 2010b; Denham and Hitchcock 2011: 26). Cultural groups display a high degree of variation in terms of language, demography, subsistence, group structure, land tenure, marriage practices and settlement patterns (Gardner et al. 1996: 5). This situation is highlighted by Fingleton (2010b: iv):

> Both geographically and culturally, the project area lies in a 'transition zone', between the larger populations inhabiting the high peaks of the New Guinea cordillera to the south and the extensive plains of the Sepik basin to the north…. Over the centuries, the project area has seen dramatic shifts of population, as Mountain Ok groups from the south expanded into the area, wiping out previous occupants. The invaders raided and killed, capturing women and children who were adopted and incorporated into their communities, as they progressively settled the area. Groups were hungry not for land but for people. Their incorporation of captives has led over time to the extraordinary complexity of the groups presently living in the project area.

Gardner (1996: 22) terms this practice of pre-contact raiding 'demographic warfare' and Gardner et al. (1996: 11) note that 'the consanguineal links established by this pattern of raiding are of considerable social significance.' According to Fingleton (2010b: 1) the 'Frieda project area was previously occupied by as many as 20 different cultural groups, but by the mid-1900s most of these had either been extinguished, or been dispersed and absorbed into neighbouring groups' – primarily due to the northward migration of Ok-speaking peoples.

Fingleton (2010b) reported that there are six cultural groups encompassing an area which includes the mine and FRHEP study areas: Miyan, Telefol, Paiyamo, Owininga, Iwam and Wario. Anthropological investigations in the mid-1990s also identified six cultural groups, but they did not include the Wario, and instead broke the Iwam into two separate groups: Sepik River Iwam and Tunap (May River) Iwam (Gardner 1996: 16; Gardner et al. 1996: 4–5). Although Denham and Hitchcock (2011) did not specifically include the Wario group as part of their 2010–2011 cultural heritage fieldwork, they did recommend future reconnaissance cultural heritage surveys be conducted with 'some additional communities of the neighbouring Leonard Schultze (Wario) and Wogamush River systems' (Denham and Hitchcock 2011: 107).

Gardner et al. (1996:4) suggested that populations relevant to the Project, which include six language groups, fall into three broad geographical categories:

a. The mountain people (Miyan and Telefol)
b. The riverine populations (Tunap Iwam (May River Iwam) and Sepik River Iwam)
c. People of the transition zone characterised by foothills and plains (Owininga and Paiyamo)

These geographical categories were in turn related to subsistence practices. For example, higher topographic areas in the south are more generally characterised by horticulture and hunting, while the foothills/plains areas are characterised by hunting and sago exploitation, and the riverine areas are characterised by sago exploitation and fishing (Gardner 1996: 17).

A further three language groups (Saniyo-Hiyowe, Wogamusin and Yahe) were identified by Denham and Hitchcock (2011: 53) during cultural heritage fieldwork in 2010-2011 as being relevant to the project layout in use at that time. However, although Denham and Hitchcock (2011) noted that the community at Paru identify themselves, as well as the community at Pei, as Yahe-speakers, Laycock

(1973) classifies the language as Pei of the Walio language family (see Section 2.1.5 below for further details).

On this basis, nine language groups were previously identified as being relevant to the general location of the mine and FRHEP study areas. However, revisions to the project layout since 2011 mean that the Sepik River Iwam, May River Iwam, Owininga, Saniyo-Hiyowe, Walio, Wagamusin, Yahe and Pei communities will no longer be impacted by the Project. For this reason, these eight language groups were not considered further in this study.

The three language groups associated with the mine and FRHEP study areas are listed in Table 10, which is adapted from Gardner et al. (1996:4) and supporting linguistic research by Dye et al. (1968), Laycock (1973) and Wurm et al. (1996).

Table 10: Languages associated with the mine and FRHEP study areas

Phylum	Stock	Family	Language
Trans-New Guinea	Central and SE New Guinea Highlands	Ok	Telefol Miyan
Sepik-Ramu	Leonard Schultze	Leonard Schultze	Paiyamo

The mine and FRHEP study areas are linguistically rich. They are located within the most linguistically diverse region anywhere in the world, where the densest concentration of language families occurs: the Sandaun and East Sepik provinces of northern New Guinea (Pawley 2007: 46). The three languages correspond to two language families (Ok and Leonard Schultze) and two language phyla (Central and SE New Guinea Highlands, and Leonard Schultze) (Table 10). All three languages are Papuan languages – languages indigenous to New Guinea and nearby island groups that are neither Austronesian nor Australian.

The Trans New Guinea language phylum is essentially montane. It extends across the central cordillera of the mainland, but in some cases (e.g. Telefol and Miyan) it also includes foothill and lowland areas. The Trans New Guinea phylum includes approximately 300 languages and around half of the Papuan-speaking population (Foley 2000: 363).

The high cultural and linguistic diversity evident across the northwest mainland of Papua New Guinea has been linked in part with the long-term history of major geomorphological changes in the region (Swadling et al. 1989; Swadling 1997; Swadling and Hide 2005; Pawley 2007; Swadling 2010; see also Chappell 2005). The existence of a brackish and shallow inland sea across the modern joint floodplains of the Sepik and Ramu rivers – attaining its largest extent 6,500 to 7,500 years ago (Swadling 2010: 142–145) – would have allowed 'an almost direct exchange of ideas and products between the people inhabiting its shoreline and the highlands' (Swadling 1997: 1–3; Swadling et al. 1989: 109). This is further discussed below in Section 2.4.1, including associated archaeological evidence and their implications for the regional archaeological record.

Table 11 lists the three language groups and six communities associated with the mine and FRHEP study areas. The locations of these communities are shown in Figure 7.

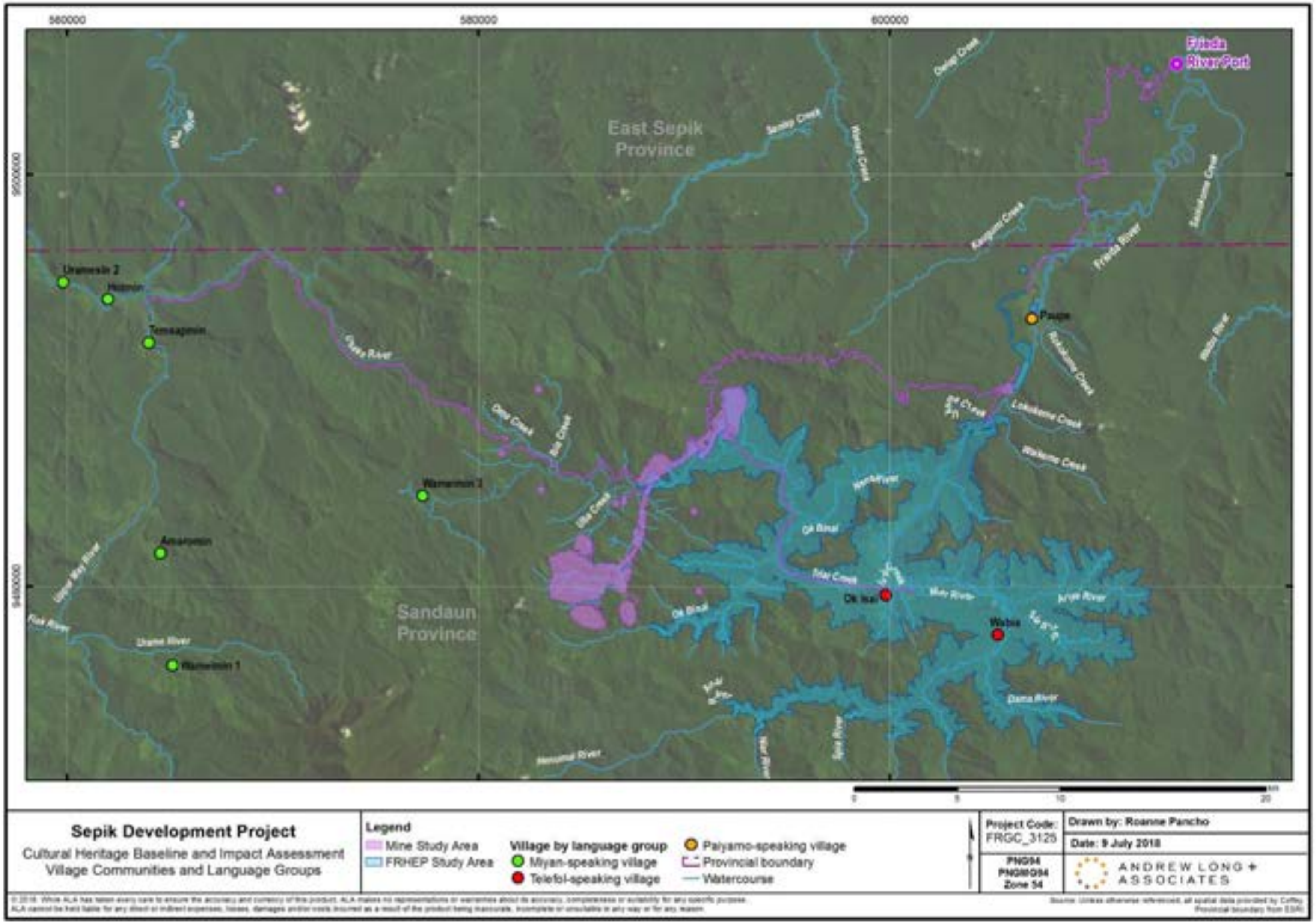


Figure 7: Village communities and language groups associated with the mine and FRHEP study areas

Table 11: Language groups and communities associated with the mine and FRHEP study areas

Language Group	Community
Telefol	Ok Isai Wabia
Miyan	Wameimin 2
Paiyamo	Paupe

Previous research into the cultural heritage and social structures of these language groups has identified a rich cultural repertoire including tangible and intangible heritage components associated with a range of cultural heritage site types. These include isolated burials, ossuaries, campsites associated with hunting and resource extraction, former villages, origin sites and various other story sites, a wide variety of ceremonial/sacred/spirit places (often linked to geographical features such as confluences, pools, hills/mountains, caves etc.) and archaeological sites (including caves and rockshelters) exhibiting a range of material culture (e.g. rock-art, hearth features, stone artefacts such as axes, sago pounders, mortars). These cultural heritage site types are detailed in Section 2.2.

A key dimension of cultural heritage in relation to the mine and FRHEP study areas concerns the journeys of ancestral figures recorded in the oral histories of these various groups. These journeys interlink the cultural landscape and associate historical (and/or semi-mythical) events with various kinds of locations (e.g. past settlements, geographical features, spirit places, and so on). Anthropologist Dan Jorgensen (1996: 24) notes the kind of complications that can arise in attempting to reconstruct history across the general Project area through documentation of such oral accounts: in addition to addressing variations within and between villages, he notes that 'complication arises from a kind of telescoping in which events from a number of different periods are all attributed to the actions of a single well-known ancestor'. Songs recounting such journeys are regarded locally as quintessential elements of intangible cultural heritage. As will be highlighted, these variously intermeshed cultural and ancestral landscapes contain examples of cultural heritage that cannot necessarily be neatly classified. For example, in a Telefol context, Jorgensen (1996:41) describes how bones of ancestors traditionally kept in spirit houses (but often subsequently buried or discarded with the advent of Christianity) can become evidence bolstering land and/or resource ownership claims, presenting a complicated mix of mortuary, ceremonial, spiritual and political practices.

Furthermore, the history of mineral exploration and mining development prospects in the general Project area has itself sometimes become incorporated into group ontology. For example, Jorgensen (1996: 43) explains how Telefol have traditionally regarded stone tools as having 'powerful symbolic valances' with subterranean sources and links to the dead; this has intersected with the advent of mining in the region (beginning in the 1960s) such that 'geologically anomalous locations' already traditionally regarded as sacred sites (*amemtem*) are now also associated with valuable minerals. In this way, economic geology has become incorporated into Telefol oral traditions (see Jorgensen 1996: 43–49 for details).

The following sections provide outlines of cultural characteristics pertinent to the cultural heritage of each of the three language groups. It should be noted, however, that previous studies have focused on some groups more than others; more information is available for Mountain Ok groups (Telefol and Miyan) while Gardner (1996: 8) reported that the Paiyamo speaking groups were lacking 'detailed investigations necessary to describe all dimensions of social life relevant to resource ownership'.

2.1.1.1 Miyan

Linguistically, Miyan (or Miyanmin) is a montane language, part of the Ok language family and the Trans New Guinea language phylum (Healy 1964). Mountain Ok and Min are terms sometimes used interchangeably to refer to a group of cultures; however, Min is broader than Mountain Ok which refers more specifically to cultural groups of the Ok language family (Gardner et al. 1996: 5).

The 2010–2011 cultural heritage field program identified three communities of Miyan associated with the FRCGP based on the project layout in use at that time (Denham and Hitchcock 2011: 52, 57): Wameimin 1, Wameimin 2 and Amaromin, represented by three clans (Wamei, Henamo and Spia Sorolnomoy) (Table 12). However, during cultural heritage interviews conducted at Wameimin 2 in June 2016, three residents who had formerly identified as Wamei instead identified their affiliation as Outomin.

Table 12: Miyan communities and groups associated with the Project during the 2010-2011 field program

Community	Group name (Alternate)
Wameimin 1	Wamei
Wameimin 2	Wamei
Amaromin	Henamo Spia Sorolnomoy (Solmoy)

Miyan occupy a vast area between the Donner and Thurnwald ranges in the south to the May Hills and the West range in the north (Morren 1986: 60). Miyan are organised in terms of cognatic stocks (or parish groups) named *miit* which are highly variable in size (40–300 members), expansive in terms of territory, and further subdivided into *molub* – 'principal land-holding and resource allocating groups' which are usually patrilineages (Morren 1996: 289,292). Two *miit* commonly operate together as a cooperative partnership which can blur 'differentiations affecting land use and marriage' (Morren 1996: 289). Co-residence is a key aspect of *miit* membership and community identity, resulting in fluid settlement histories (Denham and Hitchcock 2011: 53–54; Morren 1996: 291).

Traditionally Miyan settlements were dispersed hamlets situated on ridges, spurs or riverbanks, consisting of square houses built on posts and characterised by bark floors and walls, central hearths and thatched roofs. Each *miit* also had a large dance house (*itam*), a men's cult house (*kwoisam*) that housed ritual objects including ancestral bones, and a male initiation dormitory (*yominam*) (Morren 1996: 290). Modern settlements retain *itam* however the male initiation cycle (including *yominam*) has been abandoned, and Morren (1996: 294) suggests this has been a key factor in the disruption of traditional knowledge (e.g. cultural heritage) transmission.

In terms of subsistence economy, Miyan are 'shifting cultivators and hunters' with taro (*Colocasia esculentum*) as a staple supplemented by squash, banana, greens, and more recently, Western vegetables (e.g. papaya) along with a range of wild plant foods (e.g. nuts, fruits, fungi). Miyan hunt wild pigs, wallabies, rats and cassowary, and exploit smaller terrestrial fauna such as lizards, frogs and insects (Morren 1996: 299).

Morren (1996: 298) documented the Miyan 'sacred landscape' – e.g. 'sites associated with demonic forces, entrances to or contact points with the land of the dead, historic sites, and works and artefacts associated with legendary/ancestral figures'. Related to this are traditional Miyan ritual types including initiation (12 named rituals), spirit intervention (e.g. contact to establish cause of death at a funeral ceremony) and demon control (e.g. curing rituals) (for details see Morren 1986: 201–235). Correspondences between this 'sacred landscape' and recorded cultural heritage sites are discussed in Section 2.4.4.3 and cross-referenced in Appendix 5.

In terms of origins, Miyan believe they were founded by Afok (literally 'old woman' or ancestress) and associate her and her sisters' travels with many aspects of their culture: e.g. the distribution of groups, plants and animals and the creation of geographical features, cultivars, villages, the land of the dead, and much more (Morren 1996: 263–265, 299). Morren (1996: 264) speculates the time of Afok to be c. 3,000 before present (BP).

Traditionally Miyan believed dead people became spirits (*bekel*), moved to the land of the dead where they conducted normal activities (e.g. hunting) and could influence the living (usually benignly). Besides *bekel*, Miyan also traditionally recognised a range of supernatural beings and malevolent bush spirits associated with natural features (e.g. caves, watercourses) (Morren 1996: 297–298).

Morren (1996: 264–289) highlights three key periods in relation to the history of Miyan population distribution:

1. A long and indefinite period of 'marking the landscape' following the founding of Miyan by Afok.
2. A period of Miyan population expansion and intergroup violence c. 300 years ago associated with the Ifitaman valley (regional geographic centre) (see Craig 1969).
3. A modern period following establishment of a government post at Telefomin, and the construction of airstrips and development of mining activities.

Certain episodes associated with the period of 'marking the landscape' have particular relevance to Miyan cultural heritage sites recorded in 2010 and documented by Denham and Hitchcock (2011), particularly regarding ancestors named Wanyea and Oiyap. Denham and Hitchcock (2011: 54) note the complex interwoven nature between itineraries of 'real' figures (e.g. Oiyap) and 'fictive' or semi-mythical figures (e.g. Dimoson) 'with the latter acting as a foundation for the former'. This dynamic is discussed in Section 2.4.4.3 in relation to cultural heritage site survey findings.

The period of population expansion beginning c. 300 years ago resulted in (amongst other things) a hostile and changing frontier across the Project area, involving groups such as the Telefol and Ontou (Morren 1996: 274). Administration patrols aimed at pacification began in the early 1950s from a station established at Telefomin, and this marks the 'modern period' (Morren 1996: 281).

2.1.1.2 Telefol

Telefol, like Miyan, are mountain people, and linguistically Telefol is of the Mountain Ok language family and Trans New Guinea language phylum (Healy 1964). In addition to Nenataman (the Telefol name for the upper Frieda River system), Telefol also occupy three valley systems further to the south: Mantaman, Eliptaman and Ifitaman (Jorgensen 1996: 12). The communities of Ok Isai and Wabia in the mine and FRHEP study areas are thus the most northern extent of the Telefol. Preliminary EIS cultural heritage fieldwork was conducted at Wabia (15–17 March 2010) and at Ok Isai (17–19 March and 25–27 April 2010), and five sub-groups were identified by informants (Denham and Hitchcock 2011: 72) (Table 13). However, Denham and Hitchcock (2011: 72) noted that traditional Telefol social divisions (*miit*) were related to local territorial groups rather than being clan-like, and these sub-groups or 'clans' (i.e. Table 13) are suggested to be recently established as a strategic response to potential Project benefits (Jorgensen 1996: 71–73; 2007: 63–65).

Telefol expansion into Nenataman from the south into an ecologically different context while maintaining a hostile frontier has meant some changes to cultural characteristics such as land rights, settlement structure, subsistence practices, and so on, which are reported by Jorgensen (1996: 39):

> Because Nenataman [upper Frieda River system] was on the frontier of Telefol expansion, settlements tended to be more fluid and dynamic than in the home valleys of Ifitaman and Eliptaman. As Telefol raiding progressively displaced more and more of the aboriginal Nenataman population, village and gardening sites tended to shift accordingly. The general tendency of movement has been from south(west) to north(east), following the Henumai and Frieda (Ok Naa) downstream and across into the Binai, Melia, and Nogobai drainages. Themselves faced with the risk of raids, the colonists tended to cluster their gardens relatively close together for mutual protection, with the result that named areas of second growth (*mum*) tended to form distinct

islands in the forest landscape. These are perhaps the most impressive of the marks people have made on the landscape, including tracts such as Sibiatefapmun, Womikimun and Mimokmun.

Ecologically, Nenataman is a low-lying area with an extensive cover of primary forest, in contrast with upland valleys of Eliptaman and Ifitaman. Game – particularly cassowary and wild pigs – is far more abundant here, and the low-lying elevation and high rainfall are particularly conducive to sago, which is absent from the higher valleys. Accordingly, hunting and sago-making play a far more significant role in Nenataman than elsewhere; lower portions of the valley also afford opportunities for fishing and crocodile hunting unavailable elsewhere. The attraction of the area for Telefomin has thus been mainly in terms of its wild resources, and local people have become accustomed to hosting visitors in search of forest products absent from their home valleys.

Sago is perhaps the most distinctive resource available in Nenataman, and its use and ownership are governed by rules which have no counterpart among Telefomin living elsewhere. Most sago grows in swampy stands which were established by original inhabitants or by pioneering ancestors in the last century. Sago is used in a number of ways, but is most important as an adjunct to hunting and, in the past, to warfare. Groups of hunters or warriors would plant sago, *marita* and arrow cane (*biil*) at bivouac sites far from home in order to provision future expeditions with food and weapons, and in this way a network of sago stands was established.

Table 13: Telefol sub-group affiliations with the mine and FRHEP study areas

Community	Sub-group name
Ok Isai	Atemkialik Kialik Ontou
Wabia	Sivio Iligim Kialik

Telefol land tenure can be discussed in terms of gardening land, and land for hunting and collecting. Jorgensen (1996:36–42) makes the point that while hunting and collecting rights are relatively diffuse, gardening land 'is governed by a more restrictive set of conventions organized around the principles of first clearance, bilateral inheritance or permissive usufruct' and as 'Telefol agriculture puts a premium on cultivation in different altitudinal zones, most people have claims in several locations.'

The history of named locations of secondary forest (characterised by the plantings and/or former garden sites of ancestors) manifest as important elements of Telefol land ownership claims and cultural heritage sensitivities. Jorgensen (1996: 41) also notes that certain material culture items or relics (*men amem*) can lend further support to such land claims; e.g. the bones of the ancestor associated with the event or place in question, and warfare items, including those related to warfare rituals (bones, weapons, shields, booty). However, widespread conversion to Christianity since the late 1970s has often resulted in the burial of ancestors' bones which previously had been kept in *haus tambarans* (*yolam*).

As previously mentioned, Telefol cultural heritage intersects with mining developments and there is the belief that 'Telefol ancestors 'seeded' the landscape with stone adze blades which later became mine sites (Ok Tedi, Porgera, Nena)' (Jorgensen 1996: 46). For example, small women's adzes named *bangeli* in Telefol language, used in the clearing of garden undergrowth and quarried at a mountain called Tom-dubom in the Saniap headwaters, are now associated with mineral wealth ('gold') at Nena (Jorgensen 1996: 43). Associated Telefol oral history varies, with one version suggesting it was Kayalikmin ancestors in particular that first expanded into Nena 'smelling out' the *bangeli* (Jorgensen

1996: 46). The Telefol 'Land of the Dead' in some oral history is a place of mineral wealth (Jorgensen 1996: 49).

Song has an important place in terms of Telefol cultural heritage, as highlighted by Jorgensen (1996: 42):

> Perhaps most important in local eyes, certain kinds of knowledge are regarded as persuasive. Secrecy is an important ingredient of traditional Telefol culture, and those who speak of spirits or ancestors do so with most authority when they know the secret name of people and places in a tale. Finally, genealogical knowledge is augmented by detailed accounts of particular incidents, the most notable of which are commemorated in song (*aseng*, *fuup*). These songs are compact and consist of only a handful of lines, but knowledge of them and of the events and circumstances they refer to effectively vouchsafes the truth of a narrator's tale: on numerous occasions during the course of my work recollections were confirmed, challenged, amended or rejected on the strength of a song one of the audience began singing. Such songs were invariably convincing to the assembled audience, and I must confess that I found them persuasive as well. The dictum then might be: to know who knows, find out who knows the songs.

An incident known as 'the Binaiavip raid' represents a key historical episode in Telefol–Miyan relations and thus a brief description is necessary (summarised from Jorgensen 1996: 32–34):

> In the late 1920s a Telefol party from a settlement named Binaiavip encountered a Miyan man and two boys in the Usake drainage area. They killed the man and abducted the boys (named Mimabesep and Wengkemap). Miyan staged a retaliatory raid on Binaiavip, killing a number of people, retrieving Wengkemap and abducting several women and children. Binaiavip survivors sent to Eliptaman and Ifitaman for help and a large war party journeyed to Wabia, joined the Nenataman warriors, and made their way across the Melia (by building a bridge), Nogobai and then Usake to a Miyan settlement named Yettemdal-Daunavip, composed of two hamlets (one on either side of the Usake River). The Telefol raiding party killed everyone at one hamlet with the exception of a single man who escaped; at the other hamlet they killed one man and took his daughter (named Betabison) and two boys. On the return journey Betabison escaped and the two boys were then killed in anger.

The post-Binaiavip period saw Miyan withdraw from the Usake and Telefol abandon the settlement of Binaiavip. Telefol warfare shifted more towards their northern and eastern frontiers with the Paiyamo and upper Wario (Jorgensen 1996: 34). Binaiavip was recorded as a cultural site during the 2010–2011 cultural heritage field program.

Gardner et al. (1996: 2) summarise the complex Miyan–Telefol sociodemographic relationship with the upper Frieda River system (or Nenataman) and former Ontou landowners as follows:

> The Ontou people that used to own it [Nenataman] were driven out and some became Miyanten and some became Telefolmin, so that there are now Ontou descendants in both groups (some of whom still remember the Ontou language). Now there is a dispute between the Miyanten and the Telefolmin about who are the true owners of the Nena area.

In terms of the Ontoumin as a landowning group, Fingleton (2010b: 11) reports the situation as follows:

> In the case of the Ontoumin, its status as the "aboriginal landowners" of the Frieda project area has encouraged people to attempt to identify themselves as Ontoumin. The small lineage which has made the strongest claim to this status is, in fact, descended from one Ontoumin individual, Oblum, who was captured and adopted as an infant, and initiated as a Telefol. As an adult, he returned to make war on his people, and is said to have begun the new village of Unamo… As a separate landowning group, however, the Ontoumin no longer exists. Its descendants, too, have been incorporated, in this case into the Ok Isai community.

Jorgensen (1996: 50–51) generated a table of 'Telefomin Sacred Sites (*Amemtem*) in Nentamen' which was cross referenced with recorded cultural heritage sites by Denham and Hitchcock (2011: Appendix

B). Significantly, most of these *amemtem* (12 of the 15 sites) are caves. These findings are presented in Sections 2.4.3 and 2.4.4.4.

2.1.1.3 Paiyamo

Paiyamo is one of the smallest language groups in Papua New Guinea (Fingleton 2010: 51–53; Gardner et al. 1996: 56). In the mid-1990s, Gardner (1996:56) reported only 85 Paiyamo speakers at Paupe village. The 2010–2011 cultural heritage field program identified four (potentially five) *sane* (clan-like groups; see Gardner 1996: 70) of Paiyamo at Paupe, and a population of 163 Paiyamo speakers (Denham and Hitchcock 2011: 45). These *sane* are presented in Table 14 and match (more-or-less) the four *sane* identified by Fingleton (2010a:52 cf. Fingleton 2010b:5).

Paiyamo *sane* sub-groupings are also referred to as 'house-groups' and traditionally each of these occupied a single communal longhouse (Gardner 1996: 58). In terms of group structure, Denham and Hitchcock (2011: 45) note the following:

> Each group has a distinct spatial expression, probably reflecting that residence is a major determinant of grouping (rather than rigid descent). Major groupings are expressed as being oriented in an approximate north to south alignment down the Frieda River, although, in practice the spatial distribution is more variable… Informants stated that prior to pacification Paiyamo communities lived dispersed across the landscape; only Inago lived at Paupe. Impressionistically, and based on the nature of cultural sites (namely, spiritual and settlement connections to landscape), Paiyamo attachment to place seems stronger north of the junction of the Nena and Frieda Rivers.

Table 14: *Sane* (clan-like groups) and sub-groups identifying as Paiyamo at Paupe village in 2010

Main *sane* name	Sub-groupings
Merepare	Imaka, Kuay-are, Simwe, Imarou
Inago/Inako	Patriyali, Oloku
Suna	Pimogu, Ouwasu
Aiyamo/Aiyawo	Inaylu
Nesiya	None

The following descriptive summary of Paiyamo cultural characteristics is drawn from Gardner (1996:56–59) and Jorgensen (1995, 1996) unless otherwise referenced.

Paiyamo *sane* are named, totemic, patrilineal (although in practice men may change their residence and affiliation) and endogamous social groups. Paiyamo *sane*, and their culture and society more generally, share some similarities with Mountain Ok *miit* ('clans' – see Sections 2.1.1.1 and 2.1.1.2), and others with Owininga and Iwam groups. For example, as is typical of Mountain Ok groups, the Paiyamo traditionally practiced (cult) rituals oriented to warfare and gardening, and their origin narrative features a creator-heroine; their technology also shares similarities. Much less is known about Paiyamo *sane* totemic affiliation compared to the Owininga context.

The Paiyamo are more closely related to groups to the east (along the Wario or Leonard Schultze River system) and to the south (around Duranmin) than to other groups within the mine and FRHEP study areas; they were important trade intermediaries between Iwam and upper Wario groups (see also Conrad and Lewis 1988; Tomlinson 1968). Oral history indicates Paiyamo were subjected to intense raiding from Telefol groups from the south and Sepik River Iwam groups from the north.

The Paiyamo subsistence system is traditionally associated with exploitation of transitional zone (foothills/plains) resources: in addition to hunting and fishing, taro and bananas are grown in hillside gardens, while breadfruit groves and sago stands are exploited at the riverine end of the spectrum. Bonnell and Robinson (1995: 4, 12) note that Paupe village exhibits the most development of the 'riverside garden', and that while sago is today the Paiyamo staple, their acceptance of sweet potato is a significant recent change in terms of traditional subsistence. Paiyamo settlements traditionally consisted of communal longhouses; however, this has been abandoned since European contact.

Merepare are identified as one of the original inhabitants of the mine and FRHEP study areas, formerly known as Melipale or Milifale (Paiyamo language) or Blifalemin (Telefol language) (Jorgensen 1996: 71; Fingleton 2010a: 35; Denham and Hitchcock 2011: 50). While Telefol incursions pushed Merepare north down the Frieda River, they maintained social links with Paiyamo groups to the south and associate with places south of Kemeti (Denham and Hitchcock 2011: 50; Fingleton 2010a: 52). According to Fingleton (2010a: 53), Paiyamo territory formerly 'ran south of a boundary running from a ridge west of the Amosai River down the Frieda River towards its junction with the Nena River, across country to the Nena River above that junction, then up the Nena River to where the Siarime Creek joins it from the north.'

Of particular significance, four mountains are understood to represent Paiyamo *sane* origin places, each featuring a respective ancestral ossuary; dead ancestors are believed to live inside these mountains and have an active influence across *sane* territory (e.g. control game movements). However, cultural heritage fieldwork conducted with the Paiyamo in 2010 could not completely confirm this scenario nor identify each location (Denham and Hitchcock 2011: 48–49).

2.1.2 Infrastructure Corridor Study Area

The Infrastructure Corridor study area includes land and village communities associated with the Miyan cultural group within East Sepik Province. However, as the corridor moves northwest and then north from Hotmin to Vanimo via Green River it crosses back into Sandaun Province, one of the most linguistically diverse regions on the planet. The Vanimo/Green River District alone contains 670 clan groups and 29 language groups (Sandaun Provincial Government, 2013).

Honeyman (2016) includes a representation of the general location of language groups in northwest PNG (reproduced as Figure 8 below). His language layout accords well with an earlier representation presented by Steer (2005; reproduced as Figure 9 below). These maps have been checked against the standard language map for Sanduan Province published by the Summer Institute of Linguistics (SIL 2015a), and where any discordance is noted the maps produced by Honeyman (2016) and Steer (2005) have been given preference.

The 11 languages associated with the Infrastructure Corridor study area are listed in Table 15. Table 16 lists the 18 communities associated with the Infrastructure Corridor study area, grouped by language. The locations of these communities are shown in Figure 9.

2.1.2.1 Miyan and Telefol

As noted in Section 2.1.1, the Trans New Guinea language phylum is essentially montane. It extends across the central cordillera of the mainland, but in some cases (e.g. Miyan and Telefol) it also includes foothill and lowland areas. The Trans New Guinea phylum includes approximately 300 languages and around half of the Papuan-speaking population (Foley 2000: 363). The portion of the Infrastructure Corridor study area between its commencement near the mine and FRHEP study areas and Uramesin 2 Village in the northwest crosses land associated mostly with the Miyan cultural group, although it also includes land which falls within a frontier zone between the Miyan and the Telefol.

Figure 8: Sandaun Province languages mapped by Honeyman (2016)

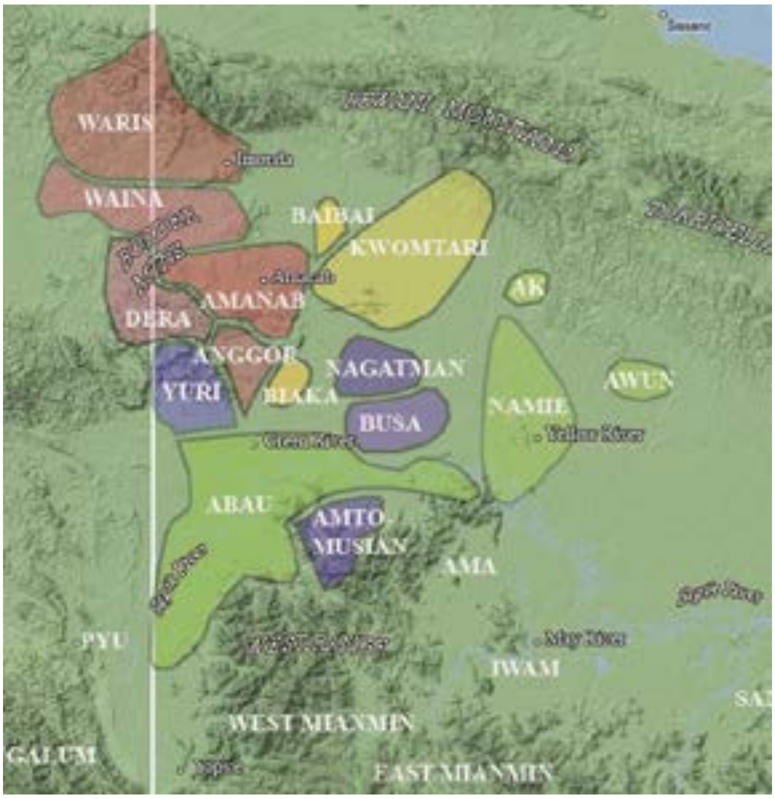


Figure 9: Sandaun Province languages mapped by Steer (2005)

Table 15: Languages associated with the Infrastructure Corridor study area

Phylum	Stock	Family	Language
Trans New Guinea	Central and SE New Guinea Highlands	Ok	Miyan Telefol
	Border	Bewani	Pagi
Amto-Musan (isolate)	---	---	Amto
Sepik-Ramu	Upper Sepik		Abau
Senagi (isolate)	---	---	Anggor
Kwomtari	Kwomtari	Kwomtari	Kwomtari
	---	Momu (Fas)	Momu (Fas)
			Baibai
Skou	---	Vanimo	Vanimo
			Wutung

Table 16: Language groups and village communities associated with the Infrastructure Corridor study area

Language Group	Community
Miyan	Wameimin 2 Temsapmin Hotmin Uramesin 2
Amto	Wokomo 1
Abau	Idam 1
	Idam 2
	Bisiabru
	Dioru
	Green River
Anggor	Aminii
Kwomtari	Kwomtari
Baibai	Itomi
Momu	Kilifas
	Sumumini
Pagi	Imbrinis
Vanimo	Vanimo
Wutung	Wutung

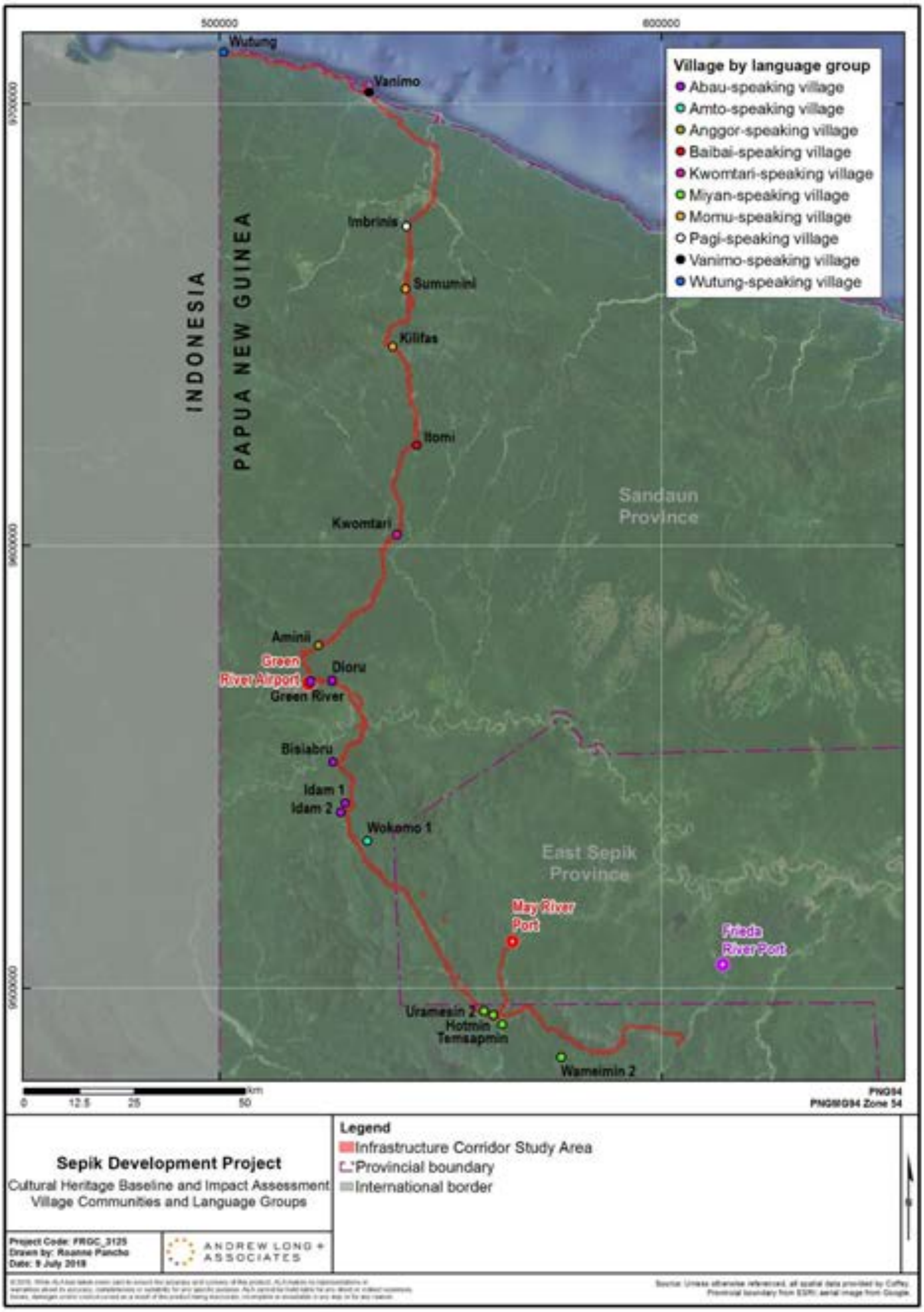


Figure 10: Village communities and language groups associated with the infrastructure corridor study area

2.1.2.2 Amto

Amto (also known as Ki, Siwai, Siawi or Siafli) is spoken in the Rocky Peak District of the West Range in Sandaun Province. Along with Musan (a neighbouring language), Steer (2005: 11) classifies Amto as belonging to a phylum-level isolate (Amto-Musan), while Usher[1] includes Amto and Musan within the Samaia subdivision of the Arai-Samaia language family. For the purposes of the present study, Amto has been classified following Steer (2005) within the Amto-Musan phylum-level isolate. The Infrastructure Corridor study area passes near Wokomo 1 Village, which is situated within the Amto portion of the Amto-Musan isolate.

Apart from a paper by Craig (1980a) published online by the Upper Sepik-Central New Guinea Project[2], which describes several Amto legends, very little information is currently available regarding the cultural heritage of these communities.

2.1.2.3 Abau

Abau is spoken in the Amanab subdistrict of Sandaun Province. The language extends along both sides of the Sepik River from near the junction of the Sepik and Yellow rivers in the east to just west of the Papuan border, and from the lower Green River in the north to the floodplains of the August River in the south (Steer 2005: 24). The language has sometimes been referred to as 'Green River'. Abau is generally included in the Upper Sepik stock of the Sepik-Ramu phylum (Stock 2005: 24), although Lock (2011) notes that while Foley (2005) and Ross (2005) regard Abau as a member of the Sepik family that is related to other languages of the upper and middle Sepik river valley and the Sepik hill country, it is not related the languages of the Lower Sepik or Ramu families. Abau is spoken in the following villages which are situated near the Infrastructure Corridor study area: Idam 1, Idam 2, Bisiabru, Dioru and Green River.

Apart from a paper by Craig (1980b)[3] which describes several traditional Abau legends, and a paper by Fyfe and Bolton (2010) which analyses associations between string bag variability, language and geographical distance in the upper Sepik basin and the Border Mountains, very little information is currently available regarding the cultural heritage of these communities.

2.1.2.4 Anggor

Anggor (also known as Senagi or Watapor) is spoken in the Amanab District of the Border Mountains, Sandaun Province (Steer 2005: 18). Although previous studies placed Anggor in the Senagi language family within the Trans New Guinea phylum based on a relationship with the Dera language (also in the Senagi family), Steer argues that the previous evidence is insufficient, and that in fact there are aspects of the two languages that suggest that they should be excluded from the Trans New Guinea phylum. On this basis, the Anggor language has been classified in the present study as a member of an isolate shared with Dera (Steer 2005: 23).

Anggor is spoken by the community living at Aminii Village, which is situated near the Infrastructure Corridor study area, approximately 8km north of Green River. It should be noted that the Infrastructure Corridor study area then crosses lands which border the Amanab language group before crossing into Kwomtari country.

No further information is currently available regarding the cultural heritage of the Anggor cultural

[1] https://en.wikipedia.org/wiki/Arai%E2%80%93Samaia_languages – accessed 22 April 2018

[2] http://uscngp.com/papers/ - accessed 22 April 2018

[3] ibid

group.

2.1.2.5 Kwomtari, Baibai and Momu

The Kwomtari and Baibai languages are spoken by communities living north of the Sepik River in the upper Sepik basin (Steer 2005: 15). Baibai adjoins Kwomtari in the territory between the Bapi and Wuro Rivers. Momu (also known as Fas), is spoken by villages situated at the eastern end of the Bewani Ranges, on its northern and southern slopes (Honeyman 2016). Kwomtari, Momu and Baibai are generally grouped within the Kwomtari language phylum (Baron 2007, Honeyman 2017, SIL 2015a). However, Hammarström (2012) presents a contrary view which separates Kwomtari from Momu-Baibai without any higher-level grouping. While Honeyman (2016) appears to retain the notion of a Kwomtari phylum, he does note that there is very little in common between Kwomtari and Momu (Honeyman 2016: 9).

Although Momu is generally referred to in the literature as Fas (Loving and Bass 1964, Laycock 1975a, Baron 2007), the autonym provided by residents in the area during field visits as recently as 2012 was Momu (Honeyman 2016: 3), and for this reason the language will be referred to as Momu throughout the present study.

The Infrastructure Corridor study area passes close to Kwomtari Village (Kwomtari language group), Itomi Village (Baibai language group), and Kilifas and Sumumini villages (Momu language group).

Unless otherwise referenced, the following description of the Momu cultural group is derived from Thomas Honeyman's 2016 PhD thesis.[4] It probably also applies to the Kwomtari and Baibai cultural groups.

The environment in which Momu is spoken varies from fertile delta plain soils to steep mountains rising to 1,400m above sea level. Rivers and streams serve as the main corridors upon which Momu speakers have traditionally travelled from village to village.

People live a mostly subsistence lifestyle, engaging in swidden agriculture to grow a variety of vegetables, although vanilla and cocoa are also grown as a commercial crop. Sago is the primary staple across the region, but people also eat aibika, taro, *tulip* and bananas. Coconuts are grown and consumed by lowland villages. Game meat is plentiful; although pigs and cassowaries are sometimes raised in the village, they are usually caught as wild using a bow and arrow. Smaller game includes tree kangaroos, possums, bandicoots and cuscus. Villagers also keep chickens, cats and dogs.

Honeyman noted that in 2005, there were just three patrilineal clans in Mori village (the Momu-speaking community which was the primary focus of his linguistic research): Makumene, Safnamui, and Farsisu (Honeyman 2016: 11). The last two were also present in other Momu speaking villages, along with other clans that were not present at Mori. Makumene is a continuation of a clan and identity that pre-dates Momu speakers in Mori. In later visits, Honeyman noted that Makumene had split into several smaller sub-branches (apparently due to receipt of logging royalties), and that Safnamui and Farsisu clan members had to return to the village of their (grand)parents if they wished to claim a stake in royalty payments.

Momu-speaking communities were traditionally exogamous. Marriage outside the village often brings individuals or families from non-Momu speaking coastal groups. Honeyman noted that inter-marriage between villages is more common than marriage within villages (Honeyman 2016: 12), and that traditionally a system of sister exchange was practiced that is still sometimes expected.

[4] https://openresearch-repository.anu.edu.au/bitstream/1885/132961/2/Honeyman%20Thesis%202017.pdf – accessed on 21 April 2018

Traditionally, families were divided into men's and women's houses. Separate housing for unmarried young men is still common. The houses are raised on stilts, but in peaceful times these stilts are not as high. The roofs are constructed from dried sago leaves. The walls were traditionally made from bark, but contemporary housing is more commonly constructed with sago palm stems. Floors are constructed with the bark of the Toddy palm.

Sorcery is still practised (or at least feared as practised) by older men, involving disembodied travel or invisible arrows quietly assassinating targets. Targets usually die within three days of being attacked. Other forms such as "smoke bombs" were used for killing large numbers of people. Deaths not directly attributed to a murder or clear accident are assumed to have been the act of a sorcerer. Many traditions such as not stepping over another person, or the necessary destruction or hiding of bodily waste, appear to be practices brought from the coast.

Haus Tambaran (men's ceremonial house) are no longer practiced in Mori (Honeyman 2016: 13). Traditionally there were ceremonies for initiation of young men, hunting and war parties (before and after), all of which were focused on a *haus tambaran*.

2.1.2.6 Pagi

One other Trans New Guinea phylum language, Pagi, is spoken by communities (including Imbrinis Village) living near the Infrastructure Corridor study area north of the Bewani Mountains (Brown 1981). According to Brown (1981: 194), Pagi and a neighbouring language, Kilmeri, belong to the Bewani language family within the Border Stock of the Trans New Guinea Phylum. Preliminary linguistic reconstructions and information on migrations indicate that the ancestors of the Pagi language speakers moved down from the Bewani Mountains via the Poal River (Brown 1981: 195). The community at Imbrinis Village speak a Pagi dialect which Brown identifies as 'Eastern' (Brown 1981: 199).

No further information is currently available regarding the cultural heritage of the Pagi cultural group.

2.1.2.7 Vanimo and Wutung

Vanimo and Wutung are languages spoken by communities living along the northwest coast of PNG between Leitre in the southeast and Wutung near the border with Indonesian Papua in the northwest. The two languages are grouped within the Vanimo language family of the Skou (or Sko) language phylum (Laycock 1981). Vanimo was traditionally spoken by the communities living at what is now the provincial capital at Vanimo, and the site of the proposed Vanimo Ocean Port component of the Infrastructure Corridor study area. The proposed transmission line component of the Infrastructure Corridor study area then continues west from Vanimo to the Indonesian Papua border, passing Wutung Village which is located less than 1km from the border.

The following account of traditional cultural life as practised by the Dumo (the traditional residents of Vanimo) is derived from a Wikipedia entry.[5] It has been reproduced here in its entirety as it provides a personal account that has probably been prepared by a Dumo person, although the author is anonymous.

> Agriculture
>
> Sago is the main staple food, where the clan owns individual palms. Within the clan trees are allocated to individual families, if it was planted by an ancestor. Sago takes an average of 40 years to grow so a man plants the sago for his grandchildren. A man's status is measured by the number of plants he plants for his descendants. Food gardens are a joint responsibility where men clear

5 https://en.wikipedia.org/wiki/Vanimo_language - accessed 22 April 2018

the larger trees, and women clear the undergrowth. Although decision making was supposedly made by the men, the women had covert decision-making power behind the scenes over many gardening decisions. Most of the planting is mostly done by the women, who collect seeds from other women, although men too can collect and plant a garden. Traditionally pigs were raised by the women although traditionally owned by the men.

Economy

The Dumo culture has its own currency called the *Deh* and *Hu-o*. The *Deh* has the form of green jade beads stored on a string, in which they have a base 8 counting system for payments. One could give one *Deh* to someone who provides a fish or sago meal. If my brother gives a lot of fish, and I get a basket of sago too, I would recompense with 8 *Deh*. There is a lot of superstition about how the *Deh* came about. For example, there is a legend that *Deh* fell as seeds from a tree that fell into Lake Sentani, in West Papua, and changed into Jade Beads. There are also other legends about how they came about. The most recent findings is that they were made in Asia, somewhere in Borneo, Brunei, Pakistan, or India. They are not just normal beads, local people are very discriminating as to which are the genuine article. Different types of *Deh* have different prices – so that green ones have a value of about 5 Kina, the blue have greater value. The light blue are very rare, dark blue is the most expensive. Brown, white, and transparent, varieties have intermediate value. The dark blue *Deh* has a value of about 20 Kina.

Ho-u is made of the same Green Jade, some are white or brown, or clear glass. It currently has a value of about 500K for one. Each *Hu-o* is circular with a diameter of about 4 inches (5-6 centimetres) and they are about ½ an inch thick, with a central hole about 3-4 centimetres in diameter.

Hu-o are used usually for brideprice and death ceremonies. For example, when some member of a clan dies. A woman and her male sons are the property of her brothers and the clan. At her death the *Hu-o* goes to her immediate clan brother, and 24 *Deh* are paid to other male clan members. To attend a celebratory feast, a woman must pay 24 *Deh* plus a minimum of 100 Kina, to the brothers and other male Clan members who have organized the feast.

The *Deh* and *Hu-o* are believed to have come from somewhere in the west. They came with migration. Women wear a belt with beads set in a distinctive pattern that tells members where they come from, for example a Papua New Guinea woman may wear beads that inform others that she came from Skuo, just across the West Papuan Border. The *Deh* of poorer quality are used for decoration, where the pattern of decoration tells others which clan you are from.

Social structure

The female members of the clan are highly valued members of the community, who must marry exogamously into other clans in order to bring more *Deh* into the clan. One man who had many sisters is considered to be a lucky man. There are four payments for each couple, the first is for engagement price which varies in value. A second payment is the bride price, that contains several payments; paying first for her head (to signify the work she does carrying a bilum, here called the *"limbum"*) and breasts and her navel (or *"wuto"*, to signify extension of her husband's clan through her children that she carries in the womb). The third payment is when she dies which is the payment for the eyes or "*hlou*" payment, for when she closes her eyes for the last time. The final payment is for each male child she produces, which is called the "*wahun*", literally meaning *"a human seedling"*. The male child is owned by her clan even though they belong to her husband's clan. A payment must be made to her clan for each of them when they die. Female children belong to her husband's clan, and bride price is paid to her husband's clan.

Political structure

Dumo society had a chieftain (*"Wateh"*) structure, associated with "big men" and "warriors". Warriors often acquire and obtain larger holdings. Decisions are traditionally made by the men in the "men's houses" or "*haus tambaran*" (spirit houses) which were the biggest built structures of the clan. Women lived in a "family house" with their children. Many of the tambaran houses were destroyed during the days of the German administration. The German administration also established a *"luluai"* and *"tultul"* system which has now been restructured as a ward system of local government.

<u>Spiritual life</u>

The Dumo people believed traditionally in two worlds, one is the world of the living, the second is the world of the dead. The living have a duty to maintain peace with the spirits of the ancestors who have departed. If they performed acts that were not acceptable to the living it would also be unacceptable to the dead. The living would know through dreams or visions that the dead were unhappy. In such cases sickness of children was seen as the spirits were unhappy. The long illnesses and death of a child was often seen as a result of parental stubbornness, and the spirits as a result would need to be appeased. The Dumo believed that the spirits of the ancestors did not depart but remained in close proximity helping and keeping an eye upon the living. Dreams play a significant role in the Dumo culture in foretelling events that are about to happen or in providing a message from the spirits of the dead to the living prescribing specific actions. Some people were believed to be more accurate dreamers than others, and they are able to confront others with a pointed message that is necessary to restore the victim of others to health. Today about 80% of the coastal people of the Dumo culture would be Catholic. The first missionaries arrived in Vanimo district in 1939. Since 1939 each village has a community cemetery, wheres previously they would be interred near the family houses. Previously the number of Catholics was almost 100% but the number has declined due to the arrival of American Pentecostal and evangelical missionaries.

2.2 Cultural Heritage Site Types

Cultural heritage is often considered in terms of both the tangible and intangible ways that people create, express and preserve that heritage. As would be expected, tangible and intangible heritage varies from culture to culture. For the purposes of this assessment, tangible and intangible are defined as follows:

- Tangible heritage includes moveable or immovable objects, property, sites, structures or groups of structures, which have archaeological, paleontological, historical, cultural, artistic values, or religious values.
- Tangible heritage also includes unique natural features or tangible objects that embody cultural values, such as lakes, ponds, outcrops, rocks and waterfalls.
- Intangible forms of culture heritage include (but are not limited to) knowledge, innovations, religious ceremonies, values, beliefs, and the continuing practice of traditional lifestyles.

Previous studies investigating the potential for extractive industry projects to impact on cultural heritage in PNG typically distinguish between two classes of tangible cultural heritage: oral tradition sites and archaeological sites.

2.2.1 Oral Tradition Sites

Oral tradition sites are places of intrinsic contemporary cultural significance or are associated with specific forms of contemporary cultural knowledge (this aspect being tangible). They are identified primarily on the basis that people alive today possess knowledge of these places (including their location, the stories behind them and the reasons why they are considered to be of cultural importance), and that the places exist as physical entities in the landscape.

While some of these places may contain physical (i.e. tangible) evidence of the human behaviours that relate to them, it is not an essential requirement in order for the place to be identified as a cultural heritage site – the fact that people have an extant oral tradition that identifies the place as being associated with a cultural activity or belief (i.e. intangible heritage) is sufficient. In PNG, these may include (but are not limited to) the following:

- Places associated with ceremonial or ritual activities.
- Places where spirits dwell, both ancestral (*tumbuna*) and spirit (*masalai*).
- Hunting camps, former settlements and clan origin places.
- Burials and cemeteries.
- Sites associated with warfare.
- Places where people lived or undertook important social or economic activities.

2.2.2 Archaeological Sites

An archaeological site is a place (or group of physical sites) in which evidence of prehistoric, historic or contemporary human activity is preserved, and which has been, or may be, investigated using the discipline of archaeology. Archaeological sites may range from those with few or no remains visible above ground, to buildings and other structures still in use. In PNG, many archaeological sites typically include a range of manufactured materials such as pottery and stone or wooden artefacts, or evidence for human intervention in the landscape (e.g. fortifications, drainage ditches or mounded gardens). Archaeological site types in PNG include (but are not limited to):

- Artefact scatters.
- Occupation sites, including open settlement sites and caves or rockshelters.
- Economic sites, including stone quarries, former gardens and sago processing sites.
- Ossuary sites and marked graves and cemeteries.

Some archaeological sites still have significance for local people. For example, a rockshelter or cave used as an ossuary will usually have continuing cultural significance to members of the clans which used them, or in rare cases continue to visit them. Simultaneously, these sites are of archaeological interest in terms of understanding traditional mortuary practices, as well as contemporary conceptions of those places and practices.

In other instances, ancient archaeological sites may be encountered that have no contemporary cultural significance for local people, i.e. a cave or open site that bears evidence of past human occupation but which has no associated contemporary oral tradition. Following discovery, the site may acquire a new cultural significance to local communities because it now needs a place within their worldview (Hitchcock 2012). For example, a site with evidence of thousands of years of human occupation may become a source of pride for local people.

2.2.3 EIS Study Site Types and Categories

For the purposes of this study, the terms 'cultural heritage' and 'cultural heritage sites' will be used to collectively refer to both oral tradition sites and archaeological sites. However, the criteria outlined above differentiating these two site classes should be borne in mind with regard to the following review of previous studies, and the methodologies used to investigate these site classes.

While a distinction between archaeological and oral tradition sites is generally recognised in relevant previous studies, the specific site types they identify are not consistently defined or applied. For example, whereas one study simply identifies 'sacred' sites, another differentiates five site types that might all conceivably be included under the general heading of 'sacred', i.e. spirit, story, origin, skull house and spirits of the dead. Similarly, one study includes all archaeological sites within a single 'archaeological' site type, whereas another differentiates between three archaeological site subcategories (caves and rockshelters, transit camps, and material culture sites).

In order to maintain a degree of consistency throughout the review process, the following cultural heritage site types are used throughout this study. These have been derived based on the results of relevant previous work, and have been deliberately constructed to be as inclusive as possible in order to facilitate cross-referencing between these different studies and the outcomes of this study. The results of the previous studies are reinterpreted and presented using these site types.

Oral Tradition Sites

- Burials, Cemeteries, Ossuaries (includes Denham and Hitchcock (2011) site types 7 [ossuary cave] and 8 [open burial site]).
- Temporary Camp Sites (associated with an oral or historical tradition).
- Former Villages and Cave/Rockshelter Occupation Sites (includes Denham and Hitchcock (2011) site types 5 [old settlement site] and 6 [*haus tambaran* site]).
- Story Sites (includes Denham and Hitchcock (2011) site types 1 [*masalai* place], 2 [story/*tumbuna* site], 3 [origin story site], 9 [spirits of the dead site], 10 [ritual/ceremonial site] and 11 ['bloodshed' site or fight ground]).
- Subsistence/Trade Sites (includes Denham and Hitchcock (2011) site type 4 [economic site], but only if clearly associated with
    - a relevant oral tradition or historical association;
    - the procurement of natural resources used in the manufacture of material culture items (e.g. clay for making pots or stone for making artefacts); or
    - the pursuit of cultural activities (e.g. bird feathers featuring in dances or other ceremonies).

Archaeological Sites

- *Archaeological:* any place (or group of physical sites) in which evidence of prehistoric, historic or contemporary human activity is preserved, and which has been, or may be, investigated using the discipline of archaeology; no distinction is made between site types (although the specific nature of each site will be elaborated in individual site descriptions).

2.3 NMAG National Site File

One of the statutory functions of the PNG National Museum and Art Gallery (NMAG) is to maintain a catalogue known as the National Site File (NSF), which lists all registered cultural heritage sites recorded across PNG.

The National Site File (NSF) was reviewed prior to the commencement of preliminary EIS archaeological and cultural heritage fieldwork supporting an earlier design of the FRCGP in 2010, and again in 2011 (Denham and Hitchcock 2011), to determine if any registered cultural heritage sites were located within the general vicinity of the previous project layout. This review identified 19 sites. Field notes and cultural heritage site record forms for sites that were directly inspected during the 2010-2011 fieldwork program were subsequently forwarded to the NMAG for inclusion on the NSF.

In response to changes in the project layout that have come into effect since 2011, a third review of the NSF was conducted by Dr John Muke (Social Research Institute, Port Moresby) on behalf of the Project in January 2018. The review extracted basic site location data and descriptive information on 103 registered NSF sites located in East Sepik and Sandaun Provinces, including the 19 sites identified during the earlier reviews in 2010 and 2011 by Denham and Hitchcock (2011).

Twenty-five NSF-registered cultural heritage sites are located within 10km of the mine, FRHEP and Infrastructure Corridor study areas. Summary information regarding these sites is presented in Table 17, and their locations are mapped in relation to the study areas in Figure 11.

2.4 Previous Studies

Previous studies with relevance to cultural heritage of the Project study area are discussed in subsequent sections in terms of the following categories:

1. Archaeological and geomorphological studies commencing in the 1980s.
2. Previous linguistic, anthropological and ethnographic research characterising the Project area cultural groups.
3. Consulting reports generated in the mid-1990s for Highlands Gold Limited (HGL) and the Frieda Mine Landowners' Association (FMLA) (e.g. Gardner et al. 1996; Gardner 1996; Jorgensen 1996; Morren 1996; Bonnell and Robinson 1995).
4. The Frieda River Project preliminary archaeological and cultural heritage impact assessment (Denham and Hitchcock 2011) reporting fieldwork conducted in 2010 and 2011, along with Fingleton's (2010) land investigation for the Frieda River Project.

Ultimately, the primary previous study resource that informs understandings of cultural heritage sites in the mine and FRHEP study areas is Denham and Hitchcock's (2011) report, which also incorporated and cross-referenced the limited cultural site information generated through the mid-1990s consulting period.

Various government reports, including patrol reports (e.g. Tomlinson 1968), also provide some information about cultural groups in the study area. These were reviewed by Denham and Hitchcock (2011: 31–32) who noted: 'These reports are useful historic documents for noting (often with low resolution) the location of old settlements and general activities of the region's inhabitants. However, they do not refer specifically to other types of archaeological or cultural sites'. Government reports are not discussed separately here but where relevant are identified in relation to other previous study reviews.

2.4.1 Chronology of Occupation on the Vanimo Coast

Archaeological excavations at cave sites at Taora, Watinglo, and Lachitu on the Vanimo coast between Vanimo and the border with Indonesian Papua (Gorecki et al. 19091; O'Connor et al. 2011) contain evidence for occupation dating as far back as 33,000 years BP, and continuous sequences from about 14,000–5,000 years ago, followed by a chronological gap and reoccupation at around 2000 BP. It is possible that this gap can be attributed to resettlement along lagoons associated with the Sepik Inland Sea, and that the areas of primary occupation along PNG's northwest coastline and hinterland during much of the mid-Holocene are now buried under metres of erosional deposits.

2.4.2 Sepik Inland Sea

Fieldwork led by Pamela Swadling (along with Nick Araho, John Chappell and Baiva Ivuyo), conducted in 1986 and 1987, aimed to test and model the hypothesis that an inland sea was formed during the Pleistocene in the Sepik-Ramu area and then infilled during the Holocene (Swadling et al. 1988, 1989). Research included collection and dating of shell and organic samples.

Table 17: Cultural heritage sites within 10km of the mine, FRHEP and infrastructure corridor study areas registered on the NMAG National Site File as at January 2018

NSF Site Code	Site Name	Site Type	Site Description
CFH	Paupe Village	Rock Shelter	A cave located approximately 750m west of the southerly tip of Frieda River Airstrip. The cave is approximately 13m in width and 10m deep from overhang to rear wall and is recorded as containing substantial ashy deposits and a soot stained roof, suggestive of intensive use in the past through to the present. Wilde (1978: 4) reports several old hearths and a broken stone axe fragment, suggesting its archaeological potential. Prior to pacification under Australian administration, the site was used by Paupe people to conceal themselves from Unamo-Wabia (Telefol) raiders (site originally reported by Wilde 1978: 4; also see Swadling 1983: 72). The site was revisited by Swadling, Araho and Ivuyo in 1989 and various stone materials were collected from the surface and during an excavation (not published).
CGL	Buremai Village	Archaeological	Stone sago cutter collected at Buremai Village, May River, East Sepik Province.
CHC	Biaka Village	Archaeological	Stone adze collected from Biaka village, Yellow River, East Sepik Province.
CHF	Bifrou Village	Archaeological	Stone Axe collection from Bipro Village, Green River, Amanab Sub-District, West Sepik Province.
CLA	Hotmin Village	Archaeological	Engraved human foot print in stone, Hotmin Village, May River, East Sepik Province.
CQX	Kwemi Village	Archaeological	Stone sources near Kwemi, May River, East Sepik Province.
CRD	Frieda Airstrip	Archaeological	Refers to a *Tridacna* (genus of giant clam) hinge shell adze blade found by 'Frank Martin's workers when draining Frieda River Airstrip. Found at a depth of 10ft when the drain was dug'. Swadling *et al.* (1988: 19) state that the artefact is 5000 years old. More precise information indicates that it was from a giant clam shell (*Tridacna gigas*) and radiocarbon dated to 4980±90 BP (ANU 6170; Swadling *et al*. 1989: 109).
RAH	Dieru Settlement	Archaeological	Hill top, Dieru-deserted hamlet. Flint and chert chips, 3 cores 4 flakes.
RAJ	Green River Gravel Rise	Archaeological	Gravel rise, standing above the flat levels of the surrounding plains. Surface collections of chert and flint flakes. Preservation good.
RAK	Panganggan Cave	Cave/Rockshelter	Described as Panganggan - deep cave.
RAQ		Cave/Rockshelter	Rock shelter, west of Wutung Patrol Station, beach area but interior (Japanese bones?).
RCC	Mukwasi Village	Archaeological	Mukwasi village, Sepik River near Green River Patrol Post.
RCD	---	Archaeological	Green River Patrol Post, West Sepik Province.
RCE	Mahane Village	Archaeological	Mahani Village on Sepik River, West Sepik Province. Sago pounders and stone adzes.
RCR	Biaka Village	Archaeological	Biaka Village South of Ananab. Sago pounder called YAKAU and other artefacts.
RCT	Bifrou Village	Archaeological	Stone Axes from Bifrou, Green River area, Amanab Sub-District, West Sepik Province.
RCY	Yuri Village	Archaeological	Yuri Village, Bewani Area, Ananab Sub-District. Ritual stone objects.
RDO		Subsistence/Trade	A 'firestone' (pyrite, struck to spark a fire) source, which together with two other sources (sites RDN and RDM outside of the Project vicinity), supplied the Eliptamas Kasel and Telefol (source: Craig 1967).
RDP	Anataman- Upper Frieda	Archaeological	A bird's head made of clay found at Anataman (Nenataman) that was discovered by Telefol villagers while clearing ground for a new village.

NSF Site Code	Site Name	Site Type	Site Description
RDR	Inika De Bom	Cave/Rock Shelter	A significant rock site occurs on the eastern face of Inikia De Bom. It consists of limey sandstone, located approximately 12km west-north-west of Frieda Base Camp (Report by Kevin Wilde, Camp Manager, Frieda River 1976-1978)
RDS	Fogorobe Tem Ancestral Spirit Site	Story	The site is named 'Fogorobe Tém' and is listed as an 'ancestral spirit site' (following Wilde 1978: 3; also Swadling 1983: 70). This site is located a few hundred metres upstream of the OK MLIA (Nena River) Gorge, and is reported to be a rock-shelter under an overhang. The writers' informants stated that it 'houses' a malevolent spirit known as Fogorobe who can inflict people with sickness, and in extreme cases even death. The site is '*tambu*' (prohibited) and is reportedly still used for magico-spiritual ceremonies, the details of which have not been fully investigated.
RDT	Wabia Gorge	Cave/Rock Shelter	The site is said to be located in limestone near Wabia Village, possible ancestral or archaeological significance reported but not visited.
RDW	Tan De Bom Quarry	Archaeological	A stone quarry on the side of the so-named mountain 'Tan de Bom'. The quarry is reported as having been used by the ancestors to source stone for the manufacture of stone axe and adze heads (Wilde 1978: 3; Swadling 1983: 70).
RED	Bipan Village	Archaeological	Hafted stone sago adzes from Bipan village, Amanab Area, West Sepik Province.
RGC	Wai'ou	Ossuary	Situated approximately 15 minutes walk west along the beach from Wutung Village. The site lies approximately 50m from the concrete plinth marking the border between Papua New Guinea and Irian Jaya. Nearest village: Wutung, Vanimo West Coast CD, Vanimo District, West Sepik (Sandaun) Province. A large limestone rockshelter on the beachfront, containing the cranial and postcranial remains of at least 25 individuals; 20 crania are in good condition.

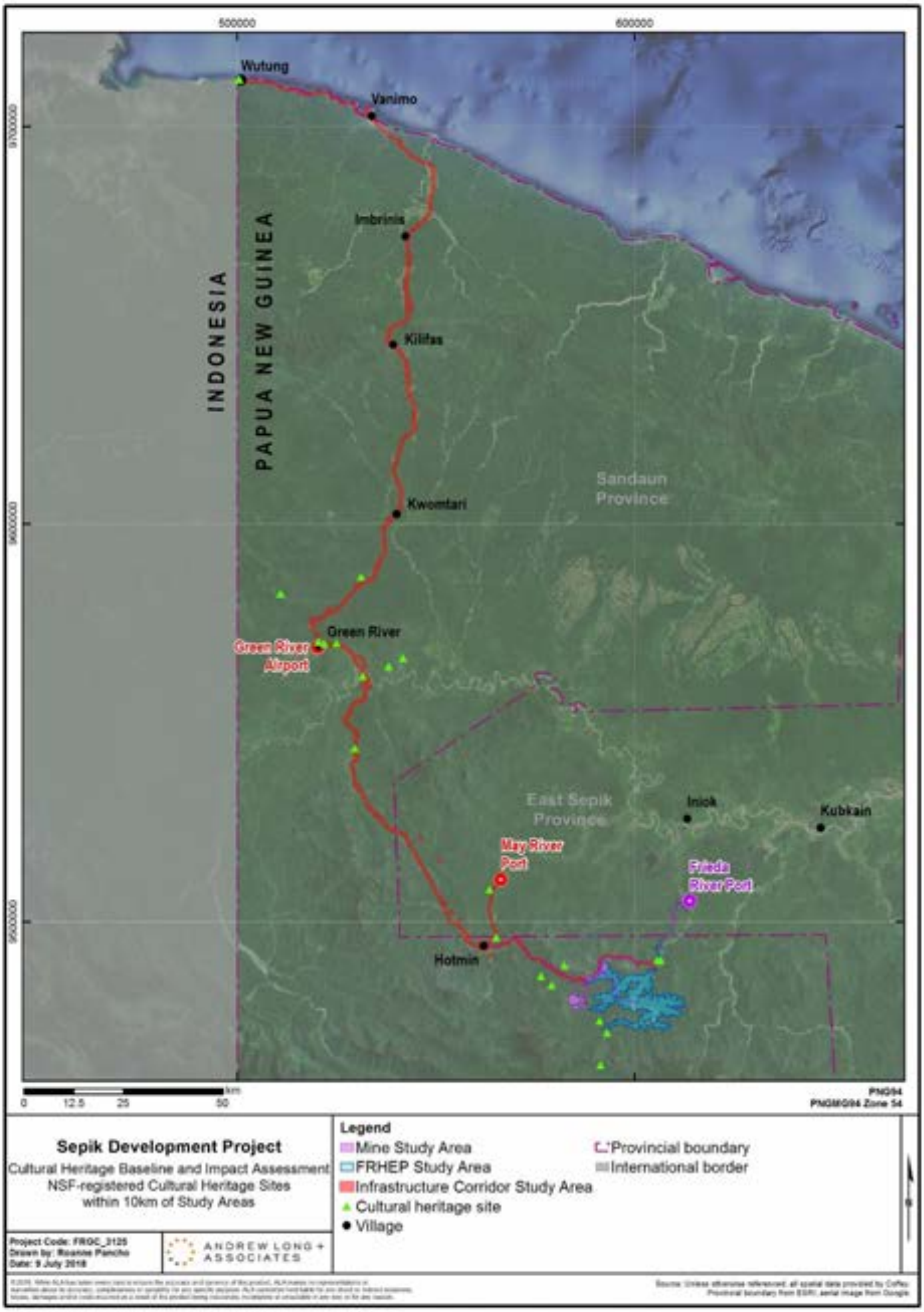


Figure 11: NSF-registered cultural heritage sites within 10km of the mine, FRHEP and infrastructure corridor study areas

The existence of a brackish and shallow inland sea across the modern joint floodplains of the Sepik and Ramu rivers was confirmed (Swadling et al. 1989; see also Golitiko et al. (2016) for more recent evidence derived from archaeological and palaeoenvironmental studies). Subsequent modelling and interpretation suggests the inland sea would have been at its largest extent 6500–7500 years ago, facilitating interactions between inhabitants of the sea shoreline and the highlands (Swadling 1997, 2010; Swadling and Hide 2005; see also Chappell 2005). Low salinity at the western margin of the inland sea (near the Ambunti area) associated with Sepik discharge would have discouraged mangrove development and made conditions favourable for agriculture (Swadling 1997: 4–5). Swadling (1997:6) cites the recovery of a 'prehistoric tanged stone spade' in a lagoon west of Ambunti (NSF code CLU) as supporting the early practice of agriculture in the area.

Swadling (1997: 8; 2010) suggests that key changes beginning c. 4,000 BP in the area would have included:

- Infilling of the inland sea
- Floodplain formation
- Progradation of the Sepik delta
- Backswamp development across formerly well drained areas

This suite of geomorphological changes is linked to the development of trade spheres – e.g. the 'middle Sepik trade sphere' which extended from the north coast, over the coastal mountains to the middle Sepik, and then further south linking to the central highlands – and ultimately to the current language distribution in the Sepik-Ramu region (Swadling 2010). For example, Swadling (1997: 8) suggests there was a large-scale migration (dispersal) c. 3,500 BP towards the coast from the vicinity of the Ambunti region, and in terms of the 'middle Sepik trade sphere' (Swadling 2010: 146):

> The descendants of the Sepik groups would have found that they were cut off from supplies of exotic north coast trade goods [e.g. shell valuables] when trade items could not be obtained via the Sepik River. This would have encouraged them to move away from the developing floodplain and back swamps and to try to re-establish their coastal links via the coastal mountains to the north.

In terms of implications for the regional archaeological record, and particularly in relation to the Project study area, Swadling et al. (1989: 108–109) noted the following:

> Archaeology itself will be hampered in the inland sea basin by cover of younger alluvial and swamp sediments, and the best prospects for finding late Quaternary sites are likely to be near coastal and inland hills… There is evidence for contact between coastal peoples and the Sepik interior at the time of the inland sea. A large (27cm) adze of giant clam shell (*Tridacna gigas*), dated to 4,980 ± 90 BP (ANU 6170), was recovered from 3m depth below alluvium during construction of the Frieda airstrip, 300km upstream of the Sepik mouth (illustrated in Swadling et al. 1988: 20)…The potential for contact between coastal and highland peoples would have been greater during the existence of the inland sea. Finally, patterns of language diversity…are likely to reflect changing environmental opportunities associated with shrinking and disappearance of the inland sea.

The *Tridacna gigas* adze, registered on the NMAG's NSF as site CRD, is therefore an important example of non-lithic technology, and its recovery from such a depth (3m below the alluvial sediment layer) will have implications for the development of the Project's chance finds protocols.

Fieldwork conducted in 1989 also involved excavation (and surface collection) at a Paiyamo cave and story site located within the Project study area (NSF code CFH and recorded during cultural heritage fieldwork in 2010 as site D019 – see Sections 2.3 and 2.4.4.3); however, these results remain unpublished.

2.4.3 Previous Academic Studies

Academic studies with relevance to the cultural heritage of the mine, FRHEP and infrastructure corridor study areas are anthropological, ethnographic and linguistic; no specific archaeological studies are available. As noted by Denham and Hitchcock (2011: 25):

> Cultural practices of the named groups whose territory extends, or formerly extended, into the Study Area are relatively well-documented in academic texts, e.g., Telefol (Craig and Hyndman 1990), Miyanmin (Morren 1986), Iwam (Yoshida 1987) and Saniyo-Hiyowe (Townsend 1969, 1974, 1978, 1995). However, with the exception of Townsend's work, none of these academic texts (as opposed to the consultancy reports) explicitly studied members of these groups who lived within the Study Area.

In particular, four anthropologists (or ethnographers) variously involved in academic studies of language groups within the Project study area – George Morren (e.g. 1986), Dan Jorgensen (e.g. 2007), Don Gardner (e.g. 1983) and Rune Paulsen (e.g. 2003) – represent the consulting team primarily responsible for the mid-1990s consulting reports (reviewed below in Section 2.4.3):

- **George Morren** conducted his PhD research with the Miyan (in 1968–1969) with a focus on the relationship between hunting and settlement patterning, and made several subsequent visits conducting fieldwork with the Miyan (in 1981, 1989, 1990, 1992 and 1993) (see Morren 1996). His book entitled *The Miyanmin: Human ecology of a Papua New Guinea society* (1986) provides a detailed window into Miyan culture relating to groups studied in the Uk and Hak valleys to the south of the Project study areas.
- **Don Gardner** likewise conducted PhD research with the Miyan (1975–1977) focusing on cult rituals and social organisation (adjacent to the Project study areas), with subsequent fieldwork in 1986–1987 and 1994–1995.
- **Dan Jorgensen** conducted PhD research with the Telefol, commencing in 1974 and based at the village of Derolengum situated to the south of the Project study areas. His work focused on Telefol religion and particularly the secret rites and myths of the men's cult.
- **Rune Paulsen** (a Norwegian anthropologist) conducted a two-year study with the May River Iwam (in the middle May) in the early 1990s with a focus on social organisation and particularly food taboos. As the May River Iwam are no longer relevant to the current Project layout, Paulsen's work will only be mentioned in passing and will not be reviewed in any detail.

Findings from these previous academic studies relevant to this report are incorporated into cultural descriptions of language groups presented in Section 2.1; elements pertinent to cultural heritage sites are further highlighted below.

2.4.4 Mid-1990s Consulting Reports for HGL and FMLA

The series of consulting reports were prepared for Highlands Gold Limited (HGL) and the Frieda Mine Landowners' Association (FMLA) in relation to the cultural context and related socio-economic impacts of the 'Nena Project' (e.g. Bonnell and Robinson 1995; Gardner 1996a, 1996b; Gardner et al. 1996; Jorgensen 1996; Morren 1995; Paulsen 1995). The anthropological team consisted of Jorgensen (Paiyamo and Telefol), Morren (Miyan), Rune Paulsen (May River and Sepik River Iwam) and Gardner (Sepik River Iwam, Owininga and overall coordination). Gardner (1996b: 10) noted:

> It is not easy to imagine an impact area more complex than that around Nena, where the range of physical, ecological and cultural variability is tremendous. Yet the complexity of the cultural context is not just a function of variation; one of the area's striking aspects is the degree of interaction between the various cultural groups within it.

Together these reports represent the most relevant body of background information specific to the mine and FRHEP study areas (prior to the commencement of the Project EIS). However, the findings are relatively limited in terms of cultural heritage site information, especially regarding the development of an accurate spatial data set. Furthermore, the archaeological dimension of cultural heritage appears not to have received direct attention during this period, except in terms of the intrinsic overlap between archaeological and oral traditions sites.

Appendix 6 combines the cultural site information gathered during the mid-1990s fieldwork. The sites are limited to the two Mountain Ok groups (Miyan and Telefol) and relate to the following three sources:

- In a Miyan context, Morren (1996: 260) attempted 'to gather place names that serve as markers for a wide array of events and circumstances… [including] river and mountain names as well as the names of villages and settlement areas (past and present), sacred sites, and locals of historic events'. These place names and locations were provided to Denham and Hitchcock (2011: Appendix A).
- Jorgensen (1996:50–51) reported details of fifteen 'Telefomin Sacred Sites (*Amemtem*)' in the Project study areas, and also directly related cultural information to Denham and Hitchcock (2011: 31) regarding 17 cultural sites (in some cases associated with particular *amemtem*).
- Gardner located and reported twelve Telefol cultural sites during 1995 fieldwork that are listed by Denham and Hitchcock (2011: 29). They are likely to be the result of a helicopter survey.

Whenever possible, Denham and Hitchcock (2011: Appendix B) cross-referenced these lists of cultural sites with the cultural heritage site catalogue they recorded during their 2010–2011 field program.

2.4.5 Frieda River Project Preliminary Archaeological and Cultural Heritage Impact Assessment 2010–2011 (Denham and Hitchcock 2011)

This study was the first formal cultural heritage baseline and impact assessment associated with an earlier iteration of the FRCGP, then referred to as the Frieda River Project, and was coordinated by Monash University. The fieldwork was conducted by Dr Tim Denham (Monash University), Dr Garrick Hitchcock (Arafura Consulting), Dr John Muke (Social Research Institute) and Mr Paul Kop (PNG NMAG). Mr Solomon Hopkos, a former district mine liaison officer (East Sepik Province) also participated in the fieldwork. The original report for this study (Denham and Hitchcock 2011) was completed in 2011. Although the report was subsequently updated in October 2015 based on a revised project layout, these revisions were completed by Hitchcock, who noted that no substantive changes were made to the report regarding its findings and recommendations. Given that the substantive report was produced in 2011, this date has been used when referencing the report in the present study.

Denham and Hitchcock's (2011) cultural heritage assessment was conducted at a similar time to Fingleton's (2010a) Frieda River Project Land Investigation Report. Denham and Hitchcock (2011: 26) highlighted the relationship between land ownership and cultural heritage as follows:

> Perhaps of greatest immediate significance for characterizing the cultural resources within the [mine and FRHEP] Study Area is an understanding of the history of land ownership (Fingleton 2010). Land ownership is not a static concept. Prior to European pacification land ownership was fluid and as a consequence there are anticipated to be a whole range of overlapping claims by different groups to land and associated sites, whether historical or spiritual, across the whole region. It is likely that the distribution of sites will reflect to a relatively high degree the history of movement of different people in the past. However, the correspondence will not be exact, for a multitude of reasons including:
>
> - The distribution of cultural sites for a given group will reflect recent and more ancient connections to the land; namely, each group's site distributions can be anticipated to be an historical palimpsest and these will overlap.
> - Multiple groups may share the same 'origin' story, whether in 'mythical' terms or in terms of where they actually trace their genealogical routes; resultant dispersals across the landscape may have occurred in different directions.

- Group membership among Telefol, Miyan, Paiyamo and other groups is not strictly based on descent; rather non-agnates are readily incorporated into groups for which membership is primarily based on residence. Consequently, people moved between different communities in the past – whether voluntarily or forcibly (as refugees or 'captives') - and, people who may now live in the same community may trace their own origins across the landscape (and identify culturally significant places across the landscape) in markedly different ways.

2.4.5.1 Scope and objectives

The field team attempted to visit as many communities as possible that were likely to have cultural heritage sites located within the study area that could be directly or indirectly impacted by the FRCGP (according to the project layout in use at that time) (Denham and Hitchcock 2011: 11,36). In total, 17 communities and nine language groups were consulted (Table 18). This involved a total of 93 reported informants whose names and details are tabulated in Appendix 7. The complete field team conducted the majority of the study in 2010 with Garrick Hitchcock then making a subsequent field visit in 2011 to consult with Wogamusin, Saniyo-Hiyowe and Yahe communities.

The objectives of the 2010–2011 cultural heritage study were to (Denham and Hitchcock 2011: 11):

- Provide a preliminary characterisation of the relevant archaeological and cultural heritage (oral tradition sites) within the study area (as defined at that time), including identification of areas of archaeological and cultural significance.
- Assist in the identification of potential project impacts on archaeology and cultural heritage and recommend mitigation and community development strategies.
- Provide a framework that can assist in the development of an Archaeology and Cultural Heritage Management Plan for the FRCGP.

2.4.5.2 Methodology and Cultural Heritage Site Types

Pre-Fieldwork Investigations

In terms of pre-fieldwork investigations, Denham and Hitchcock (2011: 11) reviewed previous archaeological, anthropological and geographical records pertinent to the cultural heritage study area as defined at that time. This included a review of the NSF held at the NMAG prior to each phase of fieldwork (1–5 February 2010 and 4 May 2011) (see Section 2.3) along with relevant government records (e.g. patrol reports) held at various locations in Canberra (22 February – 5 March 2010). Scholars known to have worked in the vicinity of the study area (e.g. Pamela Swadling, Barry Craig, Dan Jorgensen and Don Gardner) were also directly consulted.

Fieldwork Methodology

All cultural heritage site survey methods employed were community-led, with a focus on sites of ongoing cultural significance (Denham and Hitchcock 2011:38–39). These included:

- **Topographic maps** (1:100,000 scale) were used during interviews with informants to locate sites (the vast majority of sites were located using this method).
- **Helicopter** surveys were conducted with informants (especially for sites with high local significance) to obtain a GPS reading above the site.
- **Canoe** surveys were conducted to record sites located near rivers (sometimes approximately in relation to landmarks visibly from the riverbank).
- **Pedestrian** surveys (i.e. ground truth surveys): 'A few significant cultural sites were visited, recorded and accurately located using a GPS' (Denham and Hitchcock 2011: 39).

Thus, in terms of spatial data, Denham and Hitchcock (2011: 40) reported 'highly variable degrees of accuracy associated with the location of sites.'

At some communities, collections of artefacts were presented to the field team and documented (i.e. measured, photographed and given a site code) but not collected.

Table 18: Language group communities and field team consultation dates for the 2010–2011 cultural heritage fieldwork (Denham and Hitchcock 2011: vii)

Community	Language Group	Team	Dates
Paupe	Paiyamo	Denham, Muke & Hopkos	8–10 March 2010
Wameimin 2	Miyan	Denham, Muke & Hopkos	11–14 March 2010
Amaromin	Miyan	Denham & Muke	15–16 March 2010
Wameimin 1	Miyan	Denham & Muke	16–17 March 2010
Iniok	Sepik River Iwam	Hitchcock & Kop	8–9,11 March 2010
Auom	May River Iwam	Hitchcock & Kop	9–10 March 2010
Tauri	Sepik River Iwam	Hitchcock & Kop	10 March 2010
Inagri (Inagre)	Owininga	Hitchcock & Kop	12 March 2010
Wabia	Telefol	Hitchcock & Kop	15–17 March 2010
Ok Isai	Telefol	Hitchcock & Kop Hitchcock	17–19 March 2010 25–27 April 2010
Yabatauwe	Saniyo-Hiyowe	Hitchcock	7 April 2011
Sowano (Suwano)	Saniyo-Hiyowe	Hitchcock	8 April 2011
Nekiei (Nikiei)	Saniyo-Hiyowe	Hitchcock	9 April 2011
Kubkain	Wogamusin	Hitchcock	10 April 2011
Paru	Yahe	Hitchcock	11 April 2011
Wakiawei (Wakiawe)	Saniyo-Hiyowe	Hitchcock	12 April 2011
Maposi	Saniyo-Hiyowe	Hitchcock	13 April 2011

Cultural heritage site codes employed during fieldwork involved sequential numbering attached to a prefix letter representing the initial of the respective team leader recording the site (i.e. D for Denham and Muke or H for Hitchcock and Kop). In some instances, cultural heritage sites were identified by more than one group and given separate site codes:

> '…it was not always possible to know if it was the same site or a site with a similar name (often places, things and people have multiple names that are used in different social settings) … [and] this would enable mapping of sites by major groups and sub-groups (if necessary)' (Denham and Hitchcock 2011: 38).

No formal archaeological surveys were conducted; i.e., no survey tracks, survey coverage, ground surface visibility ranges, and so on, are available.

Cultural Heritage Site Classes and Types

Denham and Hitchcock (2011: 33) considered cultural heritage sites in terms of two classes (not necessarily mutually exclusive):

- Sites of contemporary **cultural** significance or knowledge.
- Sites of **archaeological** significance beyond oral memory.

The focus was recording cultural sites identified through interviews with local informants at communities; cultural sites were regarded as representing the major management issue, and systematic archaeological site surveys were beyond the study scope (Denham and Hitchcock 2011: 34).

Thirteen site types were identified by Denham and Hitchcock (2011: 42–43):

- *Masalai place:* place that is the residence of, or associated with a *masalai*, or spirit.
- *Story/tumbuna site:* a place that has a significant story, whether spiritual, mythological or historical.
- *Origin story site:* a place associated with the origin of a particular group or thing, whether animal, plant or inanimate element (e.g. rock, stone, mountain, waterfall, etc.).
- *Economic site:* a place acknowledged as significant for gardening, harvesting sago, hunting, making traditional tools, sourcing clay, obtaining pyrite (for fire-making), for obtaining stone (to make artefacts), or otherwise.
- *Old settlement site:* the location of former villages, which may contain burials (post-missionary period).
- *Haus tambaran site:* the location of a former spirit house.
- *Ossuary cave:* a cave used for the interment of secondary burials and accompanying rituals.
- *Open burial site:* a place used for various forms of open burial whether former excarnation platform or fenced enclosure, Christian burial, or other form of interment.
- *Spirits of the dead site:* a place where the spirits of the dead reside.
- *Ritual/ceremonial site:* a place at which significant rituals or ceremonies of various forms occurred.
- *'Bloodshed' site or fight ground:* the location of raids or battles.
- *Archaeological site:* includes a variety of places – especially caves and rock shelters – that are potentially to have been used by people in the past.
- *Find location*: place where cultural artefacts have been collected from communities or found.

Many of the cultural heritage sites were recorded as having a multiple typology (e.g. spirit/story/ossuary or story/village/burial).

The following sections present summaries and selected findings of the 2010–2011 cultural heritage fieldwork for the Miyan, Telefol and Paiyamo cultural groups (Denham and Hitchcock 2011: 44–91). The outcomes of community consultation and field surveys undertaken with other cultural groups during the 2010-2011 program (Sepik River and May River Iwam, Owininga, Saniyo-Hiyowe, Yahe and Wogamusin) are not presented as they are no longer relevant to the revised mine, FRHEP and infrastructure corridor study areas.

2.4.5.3 Miyan Cultural Heritage Site Survey Results

A total of 66 Miyan cultural heritage sites were recorded in 2010 (Figure 12). These can be summarised in terms of the following categories, many of which combine to form composite site typologies at a single location (Denham and Hitchcock 2011: 50–60):

- origin sites
- *masalai* sites
- economic sites (e.g. clay source locations)
- ceremonial sites (e.g. *singsing* places)
- story sites
- old settlements (linked to the itineraries of ancestors)
- burials
- ossuaries
- archaeological cave sites (including rock-art)

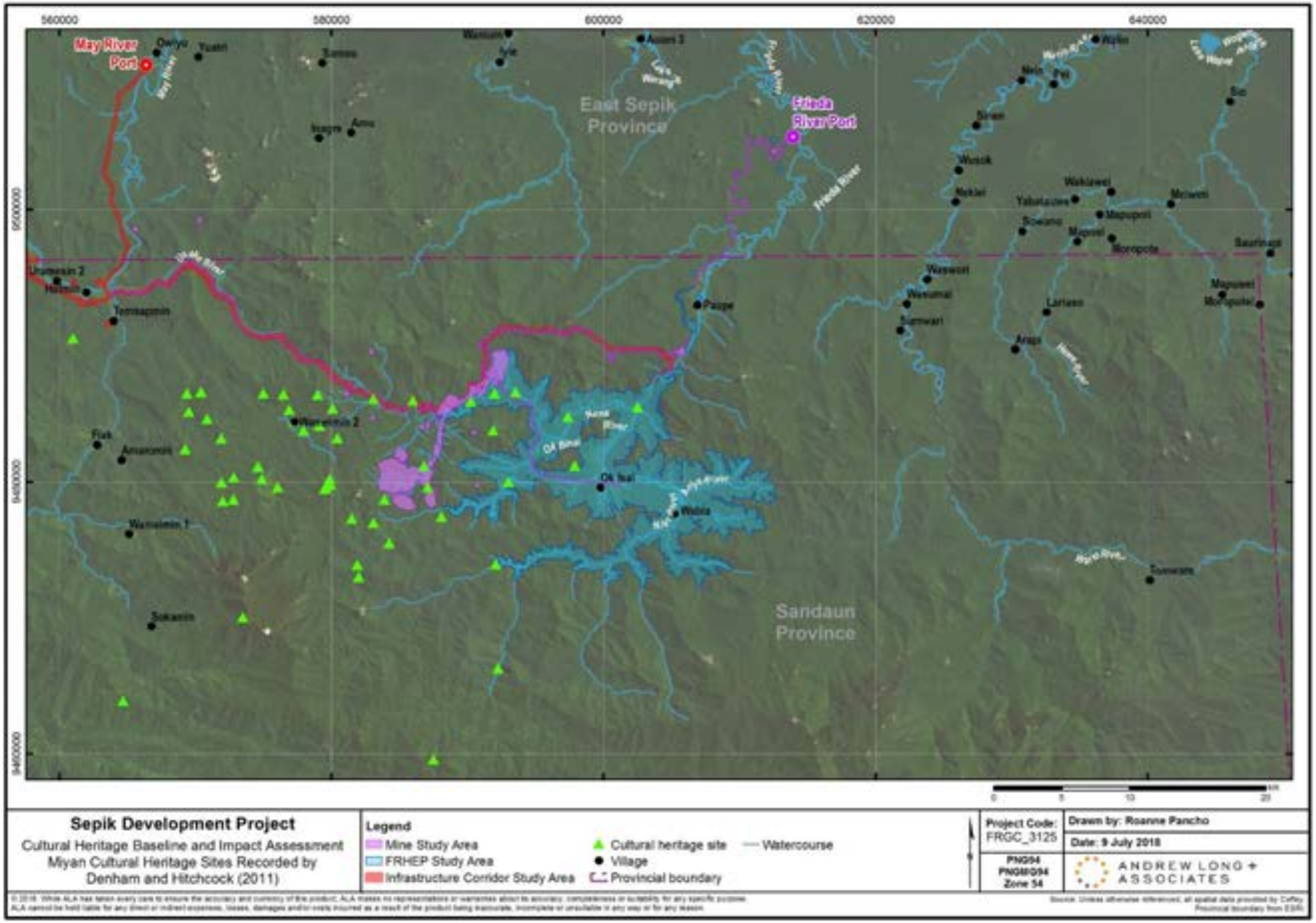


Figure 12: Miyan cultural heritage sites documented by Denham and Hitchcock (2011)

Of these 66 sites, eight were previously recorded and registered on the NSF (Section 2.3) and/or previously noted by either Dan Jorgensen or Don Gardner (Denham and Hitchcock 2011: 29, 31):

- Frogobe seme (D046), Frogobe kesawa (D047), Fogorobe (D081) Fogorobe (D101) origin/spirit sites all relate to NSF site RDS.
- Inika (D053) archaeological/ceremonial rockshelter site relates to NSF site RDR.
- Sipia (D068) and Sipia/Sibia (H084) story sites (mountain/boundary) were previously noted by Dan Jorgensen (J7).
- Urepmitabip (D093) old settlement site previously recorded as NSF site RDU and located by Don Gardner (G12).

As noted in Section 2.1.1.1, a series of Miyan cultural heritage sites recorded in 2010 are significant in relating to what Morren (1996) terms the period of 'marking the landscape' and Miyan origins in relation to the Project study areas. The following is a brief description of these, drawn from Morren (1996: 265–286) and Denham and Hitchcock (2011: 53–55).

According to Miyan oral history and sacred texts, Dimoson (sister of Afok) and the founding ancestress of Miyan had a son named Waneya – the 'first man' – who in turn had a son named Oiyap (a variation is that Dame was the son of Waneya and father of Oiyap). Oiyap is closely linked (including as a guardian) with the taro crop. In Miyan language the suffix *–bip* indicates a former settlement. Wamei clan identify their settlement chronology as starting at Ewauwobip (D041) and continuing westward. Waneya lived at Dabwebip (D073) and during his travels came to Wandagu (unverified location) and then to the headwaters of the Melia (Nena) where he named and discovered the Frogobe (or Fulkobe) site (D047/RDS). He then travelled downstream and established Bilokbip (unverified location) and on to establish Ewauwobip (D041), where he died and had a son, Oiyap. Later Oiyap left Ewawobip and followed the Niar (Frieda River) to its headwaters and founded Damabip (D043) before settling at Dabwebip (D073) where he asked his descendants to kill him. Wamei kept Oiyap's skull, mandible and long bones while his finger and toe bones were taken and shared among other core Miyan groups and planted with *tanket* (*Cordyline terminalis*) in taro gardens; when the garden is moved the *tanket* is dug-up and the bone re-used. Oiyap's skull was first kept at Frogobe (D047) then moved in 1977 to a cave named Ibafib (D054).

A total of 38 cultural heritage sites was recorded during interviews at Wameimin 2 (and no further sites were added during interviews at Wameimin 1); Denham and Hitchcock (2011: 54–55) highlighted the most significant cultural heritage sites for Wamei communities:

- Frogobe *kesau* (D047), a *masalai* cave site linked with Biauwabo (D050) and Mawena (D051).
- Ifumbli or Ifumblitomkuwandim (D045), a *masalai* site associated with specific ceremonial rituals.
- Ibafip *seme* (D054), an ossuary site.
- Mikil (D056; Mount Stolle), a *masalai* story site and ossuary.

Also significant, the Inikia (D053/RDR) rockshelter site (Plate 2; also referred to in Section 2.3 above) was ground surveyed and noted to remain in good condition and retain the materials and artefacts reported by Wilde (1978: 1–3) (e.g. the wooden adze handle depicted in Plate 3). However, Denham and Hitchcock (2011: 55) note that while Wilde (1978: 2) reported the site was not being 'used or visited' it appears to have been reincorporated into Wamei cultural traditions.

A total of 28 cultural heritage sites was recorded with the two Miyan sub-groups (Henamo and Spia Sorolnomoy) represented at the Amaromin community; however at least 11 of these appear to involve some degree of duplication with Wamei sites (see Denham and Hitchcock 2011: 58–60).

Plate 2: View along Inikia rock shelter (D053) (photo taken by Tim Denham in 2010) (Source: Denham and Hitchcock 2011:56)

Plate 3: Wooden adze handle at Inikia rock shelter (D053) (photo taken by Tim Denham in 2010) (Source: Denham and Hitchcock 2011:57)

Denham and Hitchcock (2011: 57–58) highlighted a number of key points regarding cultural heritage sites recorded at Amaromin:

- Cultural heritage site distribution varied considerably between Henamo (largely located west or north of Nena Mountain or Biauwabo) and Spia Sorolnomoy – largely overlapping with Wamei sites although displaying a higher density on the slopes of Gisiar (or Horse-Ivaal) (D077).
- Amaromin informants were 'restricted to indicate cultural sites within proximity of proposed mining operations, namely east from Inikia (D053) … Both groups may have considerable sites outside of this limited geographical region; for example, Henamo stated that there are many sites between Iku/Kiku (The Knob), Urepmitabip (D093) and Inekaubip (D094) (which presumably overlap with Wamei sites in this area).'
- Sites were often not accurately mapped and some were not mapped at all (i.e. not formally recorded nor included in the Project site database).

2.4.5.4 Telefol Cultural Heritage Site Survey Results

A total of 142 Telefol cultural heritage sites (including one previously omitted site – see Section 2.4.5.7) were recorded in 2010 (Figure 13), and can be summarised in terms of the following site types (Denham and Hitchcock 2011: 72–73):

- *masalai* (spirit) sites
- story sites
- old settlement sites (villages vs. smaller hamlets)
- economic sites (gardens, sago stands, pyrite sources, stone axe/adze sources, mineral seeps)
- open burial and modern graves sites
- 'fighting' or 'bloodshed' sites
- ceremonial/ritual sites (e.g. initiation grounds)
- artefact collections (held at Ok Isai)

Of the 142 recorded Telefol sites, 18 (and possibly 20) had been previously noted by either Dan Jorgensen or Don Gardner (Denham and Hitchcock 2011: Appendix B).

Significantly, only three of the fifteen Telefol *amemtem* ('sacred sites') reported by Jorgensen (1996: 50) to be within the Project study areas appear to have been recorded during the 2010 fieldwork ('Ekwai Tum Tem', 'Kong Amem Tem' and 'Emteiip Tem'); Denham and Hitchcock (2011: 78) suggest this could be due to 'the limitations of our rapid assessment, Jorgensen's long-term engagement with the Telefol and familiarity with their language and stories, and the possibility that he worked with an earlier generation of informants … further work will be necessary to map and record these important sites, many of which are in close proximity to the Project Base Camp and deposit areas.'

Denham and Hitchcock (2011: 77–80) highlighted the following key points regarding recorded Telefol cultural heritage sites:

- Site names often incorporate geographical terms: e.g. *imal* or *tem* (cave), *ok* (river/creek), *debom* or *dubom* (mountain), *fondam* (waterfall) and *fip* or *fif* (confluence), while former settlements are identified by the suffix –*abiip* or –*abip* (village).
- The large number of sites recorded probably relates to the Telefol practice of obtaining such information from captured original inhabitants (Jorgensen 1997: 623 n.16). Oral histories that Telefol ancestors 'seeded' the landscape with stone axes and ultimately created (amongst other things) the Nena deposit (see Jorgensen 1996 and references in Section 2.1.1.2 above) involve links to specific cultural heritage sites (e.g. NSF site RDW – see Section 2.3 above) and are seen to be supported by the pyrite sources on the Amosai.

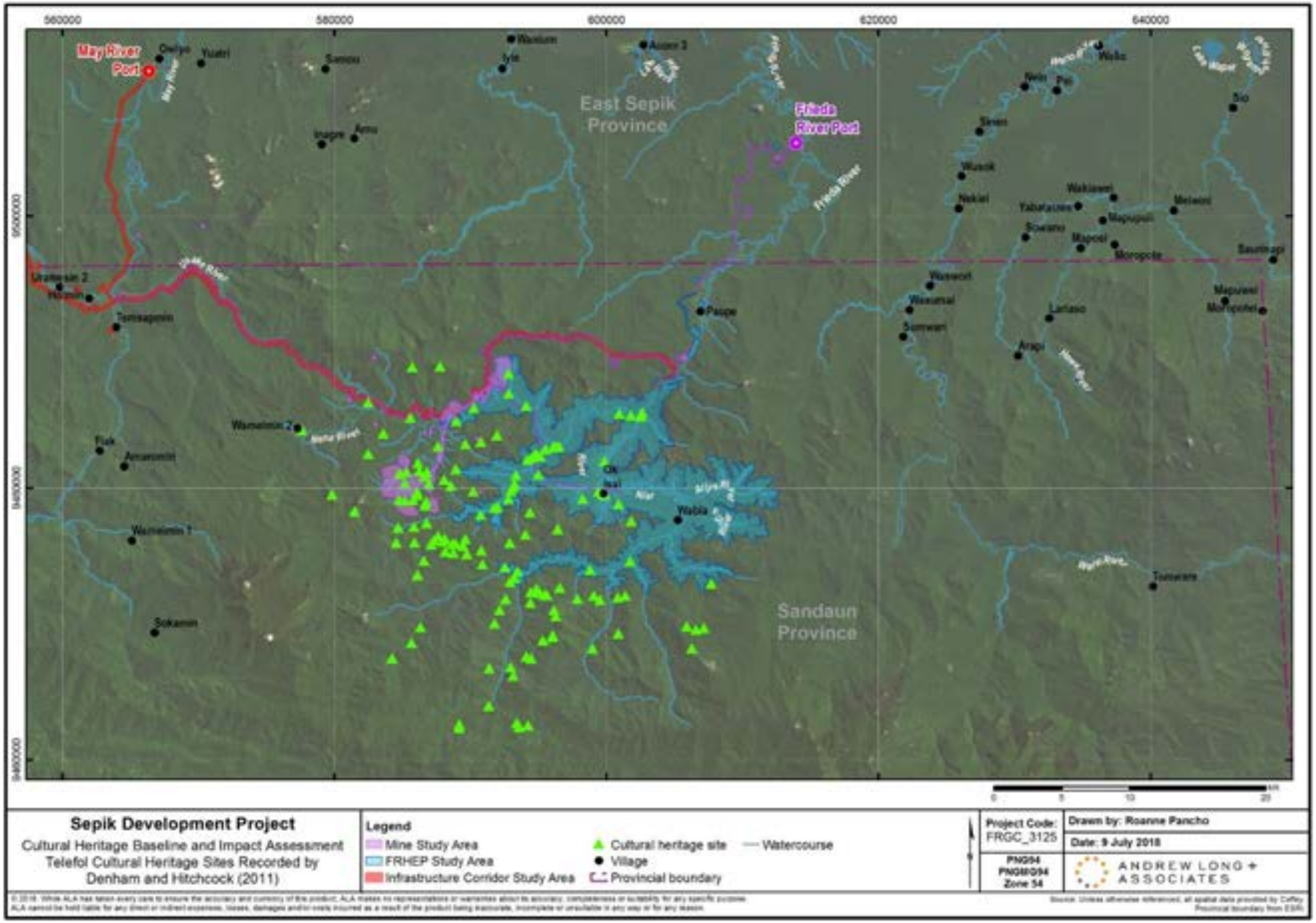


Figure 13: Telefol cultural heritage sites documented by Denham and Hitchcock (2011)

2.4.5.5 Paiyamo Cultural Heritage Site Survey Results

A total of 43 Paiyamo cultural heritage sites were recorded in 2010 (Figure 14) and can be summarised in terms of the following categories, with many sites representing composites of more than one type (Denham and Hitchcock 2011: 48–50; Appendix B):

- origin mountains: significant ancestral sites linked to the origins of each *sane* (see also Jorgensen 1996:10–12)
- *masalai* sites
- economic sites (including clay source locations and places of sago harvesting)
- *tumbuna* sites (including fighting grounds, ceremonial *singsing* places, story places)
- old settlements (often also spirit and/or story sites)
- burials
- ossuaries
- archaeological cave sites (including rock-art)
- artefact finds (collections held at Paupe)

In terms of survey methods: one site (recorded as D019 and previously CFH on the NSF) was visited and recorded during ground survey; a canoe survey was conducted to record sites near the Frieda River; a helicopter survey targeted some sites identified as significant; and topographic map locations were recorded for the remaining (and majority) of sites.

In terms of the ground surveyed site (a story/archaeological site named Uniayow somoyo, codes D019 and CFH) (Plate 4 and Plate 5), Denham and Hitchcock (2011: 48) report the following:

> Jacob Aiyepnai, our main Merepare informant, also discussed the cave called Uniayow *somoyo.* The GPS reading from fieldwork for DO19 should be used to locate the site, rather than the estimated location in the Museum records for CFH … D019 (which is the same as the previously identified CFH; *tok ples*: *somoyo* = cave) in the hill called Pokowamo just west of the southern end of Frieda River Airstrip. The cave was recorded by Wilde (1978), and subsequently visited and excavated by Swadling, Araho and Ivuyo (in 1989). Jacob stated that he had not given permission for the excavation, although another leader had. On visiting the site on foot for the current preliminary survey, it was noted that the test unit excavation had not been backfilled. Local people say that since the excavation, water comes into the base of the cave through the excavation unit, whereas before the floor had been dry. Artefacts, manuports and charcoal litter the surface, with charcoal staining on the roof. Local people have collected artefacts from the cave.

Plate 4: Jacob Aiyepnai standing at the mouth of Uniayow somoyo (D019) (Source: Denham and Hitchcock 2011:48)

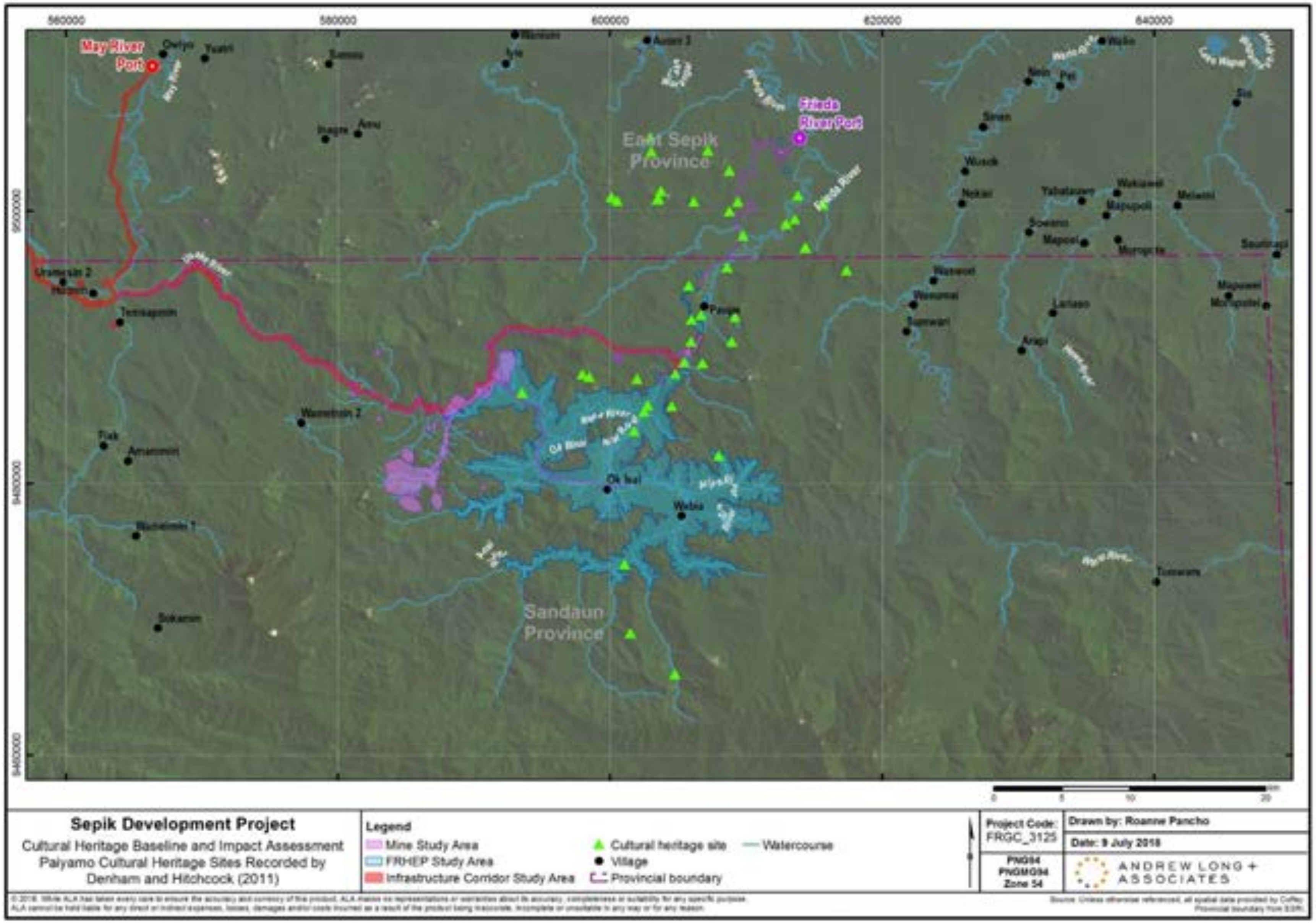


Figure 14: Paiyamo cultural heritage sites documented by Denham and Hitchcock (2011)

Plate 5: Artefacts collected by Tipak Namasia at Uniayow somoyo (D019) (photo taken by Tim Denham in 2010) (Source: Denham and Hitchcock 2011:48)

Denham and Hitchcock (2011: 48) highlighted the following as significant cultural heritage sites for Merepare *sane* ('clan'):

- Kemeti (D001): a former settlement said to have been occupied by a variety of groups, who subsequently dispersed in multiple directions (links to Henamo and Wiame), and is said to be known as Nenematan by Telefol and as Aiwayobip by Miyan. It is also a place of major mythical origin for Merepare. There is a story regarding *masalai* that explains how people dispersed from Kemeti to surrounding regions (in a time before the historical narrative) and is linked to Siarema (D002) where a spirit crocodile, *masalai pukpuk*, went and killed a Waime man, and to the *masalai* stones of Miyanow and Seremowa in the Frieda River (D006).
- Several mountains in the vicinity that have important *masalai* - a few of which are forbidden (Tok Pisin: *tambu*) - include Arimogu (D003; *masalai* snake; *tambu*) (given as Arimuku in Jorgensen 1996:10), Biamogu (D005; *masalai* man and woman) and Madri (D009; tree that bears leaves that turn into cowries). Arimogu is where Highlands Gold Limited (HGL) began work in the 1990s without proper permission and there were lots of accidents which required various ceremonies to placate the spirit (see Jorgensen 1996:10-11).
- Places of ritual importance or for *singsing* (D020; Alinumakai[yo]), as well as fight grounds (D011; Prisuwo) and settlement chronologies following the break-up of Kemeti after Telefol raids (however, not all former settlements have been located and mapped).

- *Masalai* in waterways (four within upper reaches of the Frieda and associated with Serékemé; D014), and one *masalai* place on the Frieda River, Wamisibuni (D021), which is considered the boundary between Merapare and Inago.

In terms of significant sites for other Paiyamo *sane* ('clans'), Denham and Hitchcock (2011: 48–50) reported:

- Inago informants listed *masalai* places associated with a mountain and whirlpool in the Frieda River (mountain noted as D033; Unariamo), another whirlpool (D039; Suanebuni), a swamp (D034; Murugume) and a mountain (D035; Soowamo), as well as old settlements at Ikapiso (D036), (old) Paupe (D037) and Maluso (D038).
- Suna informants listed a mountain called Mimuku (D028) in which the spirits of the dead live, including people from different sub-groups and even from some Miyan groups (although see Jorgensen 1996: 11-12 who states differently that each Paiyamo 'clan' has its own mountain). There is a cave on the mountain (Mimuku soyomo; D029), which is considered to be a tunnel through which spirits enter the mountain. Another cave, Pelinaei (D032), is mentioned that contains rock art, the bones of named ancestors and old structures. Suna also note *masalai* places in the course of a river (D030; Anaremowyo) and where a waterfall goes underground (D031; Orogome), as well as former settlements at Sownape and Apuwamoroko (neither of which were accurately mapped).
- Nesiya cultural sites include mountains of spiritual or ritual importance (D025-D027), as well as places of former settlement (not mapped).

Three cultural heritage sites associated with a string of mountains north and west of Paupe were also reported to be significant for Paiyamo generally and recorded as D022, D023 and D024 (Denham and Hitchcock 2011: 48–50).

2.4.5.6 Constraints of the 2010–2011 Cultural Heritage Assessment

Denham and Hitchcock (2011: 40–41) identified the following constraints in terms of their field investigations and preliminary archaeological and cultural heritage assessment:

- Time constraints (i.e. the preliminary nature of the fieldwork), meaning that not all sites known to local people may have been recorded, even at the communities visited (in some cases this may be due to knowledgeable people being away from the community at the time of fieldwork).
- Some people may have been disinclined to speak during field visits because they felt uncomfortable or perhaps they were opposed to the FRCGP or with other members of the community.
- The majority of the field team were men, and it may be that women at each community have special places associated with female practices.
- Several smaller hamlets within the 2010-2011 study area were not visited due to the absence of safe landing areas.
- Groups who are further removed from the 2010-2011 study area may have individuals or groups who should be consulted, such as Miyan at Hotmin and Sokamin.
- Variability in terms of local people's familiarity with, and ability to read topographic maps.
- Many rivers and other topographic features have more than one name which is not always available on topographic maps.
- The enormous size of the 2010-2011 study area, difficult terrain and seasonal inundation of the Sepik River floodplain precluded visits to cultural and archaeological sites, other than to those located within close proximity to settlements.

In addition, the use of helicopters presented another set of problems:

- Time and logistical constraints: helicopter time was under constant demand and limited by weather (heavy rain, wind and visibility), emergency situations and other unforeseen events.
- Disorientation: most informants have only ever visited or seen the places being located on foot; sometimes informants were unable to find their bearings when viewing the landscape from the air.
- The combination of the above, together with the mountainous terrain and speed of flight meant that recording GPS positions directly over cultural sites was not always possible

Additionally, the preliminary investigation of significant cultural sites was restricted to communities within the 2010-2011 study area – and even then, not all communities could be visited. The results of the 2010-2011 assessment may therefore be limited in terms of reflection of historical trends and cultural senses of connection to place, and Denham and Hitchcock (2011: 41) noted that additional communities may need to be consulted.

2.4.5.7 Summary of 2010–2011 Cultural Heritage Fieldwork Results

Denham and Hitchcock (2011: Appendix B) listed a total of 331 recorded cultural heritage sites, of which 225 are categorised as 'Map' and 105 are categorised as 'GPS'. However, subsequent analysis of cultural heritage site data during the 2016 phase of the EIS, including consultation with a member of the field team (Garrick Hitchcock, pers. comm.) indicates that this is erroneous. It appears that a total of 332 cultural heritage sites were recorded, of which 260 (78%) should be categorised as 'Map' and 72 (22%) categorised as 'GPS'.

The additional cultural heritage site relates to a duplicated site code (H183) which was originally applied to a Telefol (Ok Isai) settlement site named Dungamavip, and then to a Saniyo-Hiyowe former village site named Fetawe. Dungamavip was inadvertently omitted from the report, but its omission was subsequently identified by Hitchcock (pers. comm.), and it has been included in this study as H183a for clarity.

Although it has been possible to establish the survey method employed to capture GPS locations relating to 41 of the 72 sites, 31 GPS locations remain uncertain in terms of which survey method was employed. This breakdown is presented in Figure 15. Ultimately, 15 cultural heritage sites can be confirmed to have been visited during ground survey, representing 4.5% of the total recorded sites. However, it should be noted that seven of these confirmed visited sites (sequentially coded H176–H182) represent a tight spatial cluster of modern burials (i.e. within 165m of one another).

Potentially as many as 46 sites (13.9%) may have been visited (if all uncertain GPS locations were to represent ground survey).

Amended site location source information is presented in the Project cultural heritage site database (Appendix 8). However, there remain some anomalies and potential discrepancies in terms of the source location information that cannot be clarified with available records.

Summary Site Typology Proportions

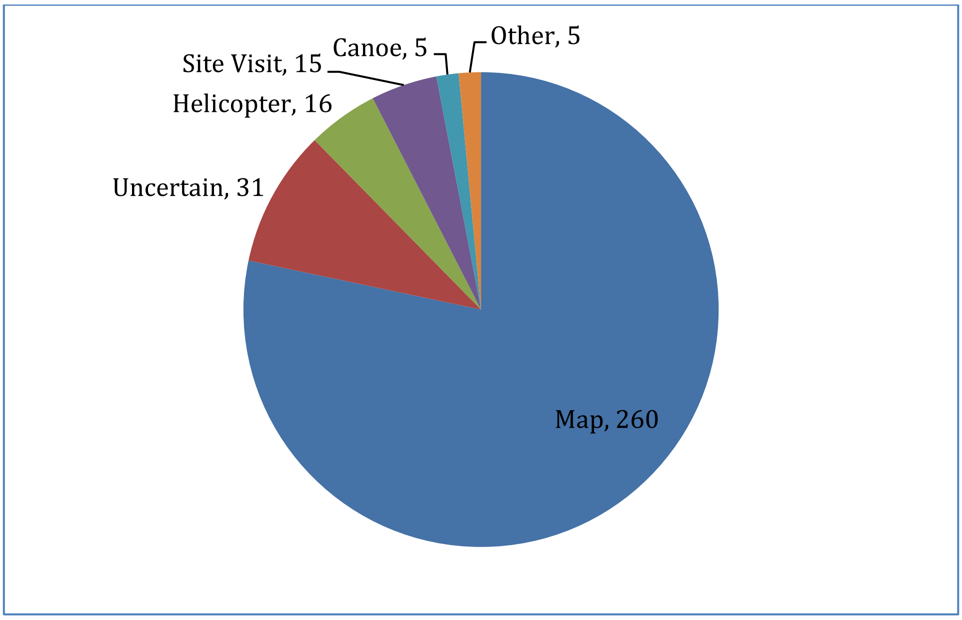
The large number of cultural sites recorded by Denham and Hitchcock (2011) with multiple site types assigned to them means that it is not practical to break down the inventory into its component site types in order to assess their relative representation.

Preliminary Cultural Heritage Site Significance Rating

Denham and Hitchcock (2011: 96) reported that 'the majority of old settlement sites and economic resources are not considered by local communities to be as valuable or significant as some other site types, except those that are associated with mythological narratives that effectively legitimise a group's right to live in part of the landscape'. The three site types they identified as being considered the most significant by communities were:

- origin story places (mythical/semi-mythical);
- *masalai,* ritual and spiritual places (often in combination, and often associated with origin narratives); and
- ossuaries or locations of traditional sacra.

Figure 15: Proportion of cultural site location methods employed during 2010–2011 field program



However, only the ‘social and political’ criterion of significance was considered by Denham and Hitchcock (2011: 96) when they generated a provisional list of ‘high-value/high-significance’ sites. Of the total of 331 sites they documented during the 2010-2011 field program, 119 (36%) were identified as ‘high-value/high-significance’ (Denham and Hitchcock 2011: 97–100).

Taking recognised site duplications into account, the proportion of ‘high value/high significance’ sites recorded by Denham and Hitchcock (2011) across the Miyan, Telefol and Paiyamo cultural groups are presented in Table 19. The proportions are remarkably constant (around 30%) across the three cultural groups.

Table 19: Proportion of Miyan, Telefol and Paiyamo ‘high value/high significance’ sites identified by Denham and Hitchcock (2011)

Cultural Group	Total sites recorded	‘High Value/High Significance’
Miyan	62	19 (31%)
Telefol	148	43 (29%)
Paiyamo	43	13 (30%)

Of the 75 discretely located ‘high value/high significance’ sites referenced in Table 19, 25 Telefol, three Miyan, one shared Miyan/Telefol and one Paiyamo site are located within the mine, FRHEP and infrastructure corridor study areas investigated in the present study (Figure 16).

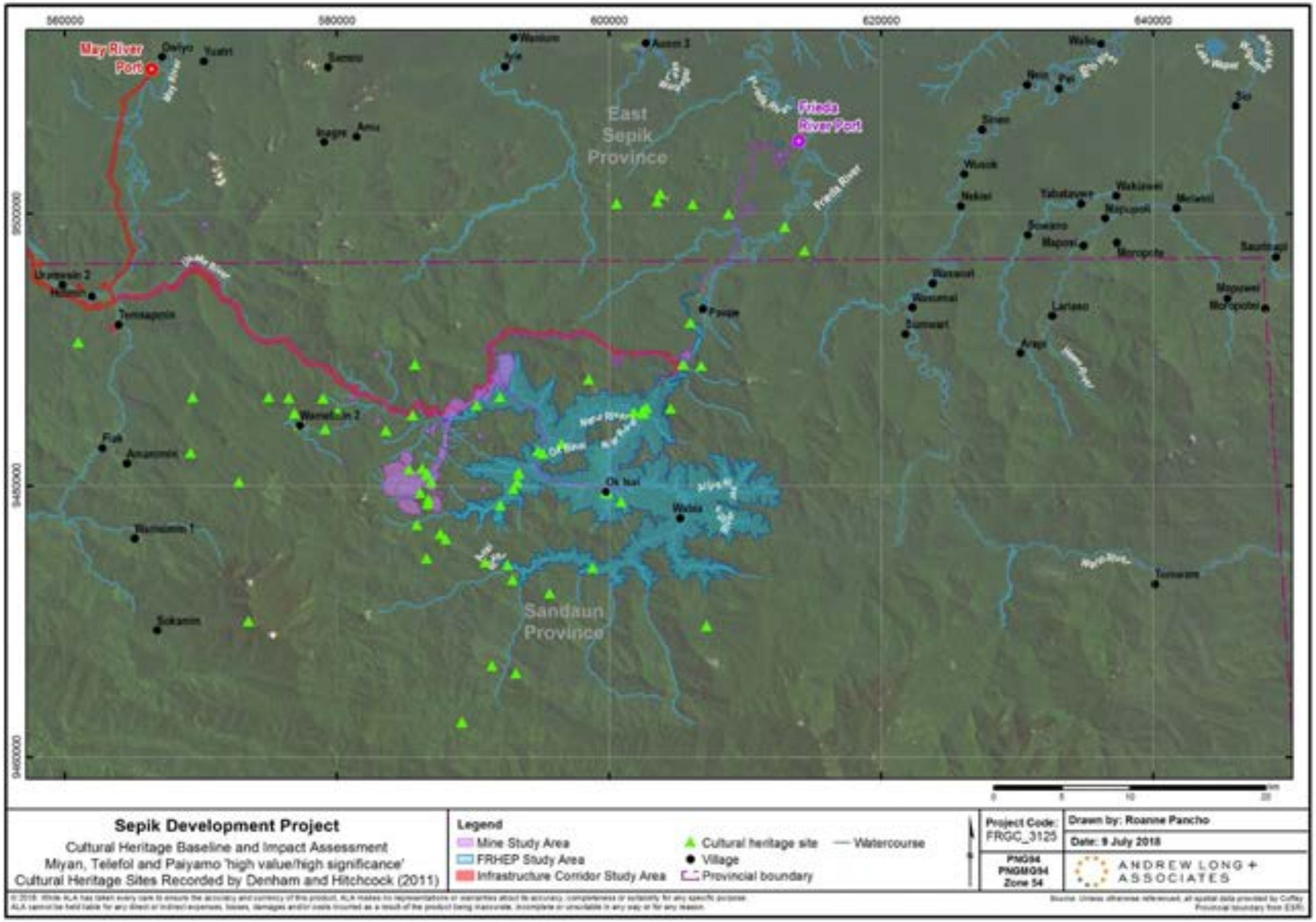


Figure 16: Miyan, Telefol and Paiyamo 'high value/high significance' sites identified by Denham and Hitchcock (2011), mapped in relation to the mine, FRHEP and Infrastructure Corridor study areas

2.5 2016 FRCGP EIS Targeted Cultural Heritage Field Program

2.5.1 Aim and Objectives of the Cultural Heritage Assessment

As outlined in Section 2.4.5, much of the preliminary cultural heritage survey and assessment was completed during the 2010–2011 phase of fieldwork documented by Denham and Hitchcock (2011). A second cultural heritage field program undertaken in 2016 was designed as a targeted extension to their preliminary assessment.

The principal objectives of the 2016 cultural heritage field program were to:

- Complete detailed recording and ground-truthing of twenty sites recorded by Denham and Hitchcock (2011) in 2010-2011 from interviews with landowners and located using topographic maps or helicopter fly-overs. The selected sites were situated within or near areas likely to be directly impacted by the construction of the proposed mine and adjacent facilities, based on the FRCGP layout in use at that time.
- Undertake surveys and meetings with community members regarding a proposed Sepik River port site, near Kubkain village, Ambunti Rural LLG. This proposed location was an addition to the layout assessed during cultural heritage fieldwork in 2010-11, and therefore no previous surveys had been completed in this area. Although a survey was completed for this proposed project component, the outcomes are not presented in the present study as the Sepik River Port is no longer required.

Ground-truthing Cultural Heritage Survey

Twenty cultural heritage sites identified by Denham and Hitchcock (2011) as being potentially impacted by Project activities were targeted for ground-truthing (Table 20). These sites belong to five communities (Amaromin, Ok Isai, Paupe, Wabia and Wameimin 2) of three different language groups (Miyan, Paiyamo and Telefol).

Although seven of the sites were provisionally identified as 'high value-high significance' by Denham and Hitchcock (2011), measures of significance were only based on assessments of their social and political significance (see Section 2.4.5.7 for further details), and did not include an assessment of their scientific or spiritual significance. However, a number of these sites have the potential to have scientific significance, as they include caves, burials and former settlement sites.

Given the potential for scientific significance, along with statutory requirements to protect cultural heritage sites, recent revisions to the Project layout, and the necessity to engage with communities where sites are likely to be impacted by Project activities, the purpose of this field survey was to reassess which sites had the potential to be directly or indirectly impacted by the FRCGP (according to the Project layout in use at the time), and to ground-truth as many of them as possible using pedestrian surveys.

Table 20: Cultural heritage sites targeted for onsite ground truthing during the 2016 field program

Site Code	Site Name	Site Type	Community
D097	Ifumbri	Ceremonial (*singsing*)	Amaromin
H139	Tum Amemdim	Story (sacred stone)	Ok Isai
H042	Ekwai Imaal	Story (cave)	Wabia
H162	Ekwai Cave	Archaeological (cave)	Ok Isai
H089	Finamtem	Old settlement	Ok Isai
H138	Solafuvip	Old settlement/burial	Ok Isai
H170	Sumomelia Dagal	Economic (mineral seep)	Ok Isai

Site Code	Site Name	Site Type	Community
D044	Timarimbip	*Masalai*/old settlement	Wameimin 2
D002	Siarema	*Masalai*	Paupe
H169	Nena-Sumomelia Junction	Burial	Ok Isai
D062	Oobaibip	Old settlement	Wameimin 2
H091	Ubaivip	Old settlement (hamlet)	Ok Isai
H038	Ekwaitem	*Masalai* (waterfall)	Wabia
H158	Ekwaiamemtem	*Masalai* (tambu)	Ok Isai
H129	Ok Milia (Nena) Ubai	Burial	Ok Isai
D045	Ifublitomkuwandim	*Masalai* /ceremonial (*singsing*)	Wameimin 2
H037	Mowaitem	*Masalai* (creek junction)	Wabia
H043	Emteip Imaal	Ossuary	Wabia
H045	Mowai Imaal	Story/Archaeological (cave)	Wabia
H092	Ubaikulelim	Old settlement/hamlet	Ok Isai

2.5.2 Fieldwork Schedule and Team

The cultural heritage and archaeological site survey fieldwork was conducted on 13–27 June 2016. The cultural heritage fieldwork team included both an archaeologist (John Sepe) and an anthropologist (Yawan Alo) from the Social Research Institute (SRI). The field team was also supported by Nelson Sukwianomb from Coffey and relied on the guidance and experience of the FRL Community Affairs team.

2.5.3 Community Cultural Heritage Site Interviews

Cultural heritage site interviews were conducted with six village communities:

- Wameimin 2 (16–17 June 2016)
- Ok Isai (18 June 2016)
- Wabia (19–20 June 2016)
- Paupe (24 June 2016)
- Amaromin (25 June 2016)

The language group, village, clan and name of each person who attended the community interviews are listed in Table 21, and the names of people who participated in the field program are listed in Table 22. All attendees were men. Some supplementary cultural heritage site discussions were also conducted (e.g. with Telefol informants at Frieda Base Camp on 23 June 2016).

Table 21: Project community cultural heritage interview attendees (16–26 June 2016)

Name	Clan	Village	Language Group
Enoch Aiyak	Merepare	Paupe	Paiyamo
Peter Tikap	Merepare	Paupe	Paiyamo
Jacob Aiyepnai	Merepare	Paupe	Paiyamo
Deiman Meneg	Henemo	Amaromin	Miyan
Apasep Tiptop	Henemo	Amaromin	Miyan
Dickson Talak	Henemo	Amaromin	Miyan
Alex Wen	Henemo	Amaromin	Miyan
Helix Deiman	Henemo	Amaromin	Miyan

Ebin Deiman	Henemo	Amaromin	Miyan
Fatiap Dringsep	Wamei/Outomin	Wameimin 2	Miyan
Baring Dringsep	Wamei/Outomin	Wameimin 2	Miyan
Sexton Dringsep	Wamei/Outomin	Wameimin 2	Miyan
Karlsen Kauri	Wamei	Wameimin 2	Miyan
Jeremy Sikidon	Wamei	Wameimin 2	Miyan
Ensco Keniap	Wamei	Wameimin 2	Miyan
Kave Deipkemin	Wamei	Wameimin 2	Miyan
Thomas Tilapning	Wamei	Wameimin 2	Miyan
Limie Drotem	Wamei	Wameimin 2	Miyan
Bill Kikimap	Wamei	Wameimin 2	Miyan
Lebin Ulam	Wame	Wameimin 1	Miyan
Aki Singeni	Kialik	Wabia	Telefol
Aiyum Singeni	Kialik	Wabia	Telefol
Sep Dumusok	Kialik	Wabia	Telefol
Warapsep Frabinok	Kialik	Ok Isai	Telefol
Sam Miseng	Kialik	Ok Isai	Telefol
Naron Kabileng	Atemkiak	Ok Isai	Telefol
Bob Onemgim	Atemkiak	Ok Isai	Telefol
Bani Kabileng	Atemkiak	Ok Isai	Telefol
Anare Maisep	Ontou	Ok Isai	Telefol
Sam Maisep	Ontou	Ok Isai	Telefol

Table 22: Community informants present during cultural heritage site ground-truthing (16–26 June 2016)

Site Code	Site Name	Date	Name	Language Group	Village	Clan
D002	Siarema	24/06/2016	Enoch Aiyak	Paiyamo	Paupe	Merepare
			Inake Kasaime	Paiyamo	Paupe	Merepare
D044	Timarimbip	17/06/2016	Ensco Keniap	Miyan	Wameimin 2	Wamei
			Lebin Ulam	Miyan	Wameimin 1	Wamei
D062	Oobaibip	16–17/06/2016	Fatiap Dringsep	Miyan	Wameimin 2	Wamei
			Ensco Keniap	Miyan	Wameimin 2	Wamei
			Lebin Ulam	Miyan	Wameimin 1	Wamei
H091	Ubaivip			Telefol	Ok Isai	N/A
D097	Ifumbri	15/06/2016	Apasep Tiptop	Miyan	Amaromin	Henemo
			Lebin Ulam	Miyan	Wameimin 1	Wamei
H139	Tum Amemdim	22/06/2016	Sam Maisep	Telefol	Ok Isai	Ontou
			Makino Fotisep	Telefol	Wabia	Kialik
H038	Ekwaitem	21/06/2016	Aki Singeni	Telefol	Wabia	Kialik
H158	Ekwaiamemtem		Sam Maisep	Telefol	Ok Isai	Ontou
			Dusam Maisep	Telefol	Ok Isai	Ontou
H042	Ekwai Imaal	20/06/2016	Aki Singeni	Telefol	Wabia	Kialik
H162	Ekwai Cave		Sam Maisep	Telefol	Ok Isai	Ontou
			Dusam Maisep	Telefol	Ok Isai	Ontou

H089	Finamtem	22/06/2016	Aki Singeni	Telefol	Wabia	Kialik
			Dusam Maisep	Telefol	Ok Isai	Ontou
H129	Ok Milia (nena) Ubai	22/06/2016	Sam Maisep	Telefol	Ok Isai	Ontou
			Makino Fotisep	Telefol	Wabia	Kialik
H138	Solafuvip	22/06/2016	Sam Maisep	Telefol	Ok Isai	Ontou
			Makino Fotisep	Telefol	Wabia	Kialik
H169	Nena River Sumomelia Junction	22/06/2016	Sam Maisep	Telefol	Ok Isai	Ontou
			Makino Fotisep	Telefol	Wabia	Kialik
H170	Sumomelia Dagal	22/06/2016	Sam Maisep	Telefol	Ok Isai	Ontou
			Makino Fotisep	Telefol	Wabia	Kialik
SAS001	Alimbip	21/06/2016	Aki Singeni	Telefol	Wabia	Kialik
			Dusam Maisep	Telefol	Ok Isai	Ontou
			Sam Maisep	Telefol	Ok Isai	Ontou

The field team was equipped with standardised community interview forms (Appendix 1) to systematically record oral tradition and archaeological site information along with intangible cultural heritage. Oral tradition sites are not mutually exclusive from archaeological sites and were discussed in terms of five categories:

- Burials, Cemeteries, Ossuaries
- Temporary Camp Sites
- Former Villages and Cave/Rockshelter Occupation Sites
- Story Sites
- Subsistence/Trade Sites

Interviews also encompassed community rated site significance along with reactions, permissions and desired management responses to potential site impacts.

In addition to the cultural heritage and archaeological sites targeted for discussion at respective communities (Table 20), the existence of any further sites not reported by Denham and Hitchcock (2011) with the potential to be directly impacted by FRCGP activities was also discussed, and where possible ground-truthed.

Community members at Wameimin 2 and Ok Isai presented a range of stone artefacts to the field team for discussion and photography (e.g. Plate 6). These items were described as having been passed down from generation to generation and relate to group cultural heritage. Some items appear to be the same as those presented for inspection during 2010–2011 cultural heritage fieldwork (Plate 7).

2.5.4 Targeted Cultural Heritage Survey Results

Of the 20 cultural heritage sites targeted for ground-truth recording during the 2016 field program, the field team established that there are potentially five pairings of spatially duplicated sites. These pairings are indicated in Table 22 (wherever two site numbers are separated by a dotted line, e.g. D002/D044) and Table 23 (paired rows). However, only two of these pairings were directly confirmed through interviews and ground-survey (D097/H139 and H042/H162).

The overall results of the targeted site survey are summarised in Table 23, and their locations are mapped in relation to the mine, FRHEP and infrastructure corridor study areas in Figure 17. Of the 20 cultural heritage sites targeted, eight can now be regarded as completed in terms of ground-truth recording; i.e. site locations and the spatial extent of each site are now relatively well defined. These eight include the two confirmed spatially duplicated cultural heritage site pairs D097/H139 and

H042/H162. On this basis, these eight previously recorded cultural sites can now be spatially regarded as six ground-truthed recorded locations (see Table 23). Of the remaining 12 targeted sites, three were partially ground-truthed and nine were not visited.

Importantly, one of the sites not visited – Miyan (Wamei) ceremonial *singsing* site D045 named Ifumlitomkuwandim – was thought by Denham and Hitchcock (2011: 60) to be a duplication of D097 (and thus H139): '…[the site] is a flat stone on the side of the Nena River associated with a *masalai* and specific rituals'. However, an attempted ground-truth survey of D045 conducted on 17 June 2016 with Wamei representatives failed to reach the site, and the duplication cannot therefore be verified with certainty. Denham and Hitchcock (2011: 60) noted that the Spia Sorolnomoy cultural site distribution might suggest that their main cultural associations were outside of the immediate Project area, but that Ifumbri (D097) is an exception and '…it's association as a *singsing* place may indicate that groups from different regions sometimes met here or used the stone for ritual purposes'.

Plate 6: Stone vessel (mortar) discussed during cultural heritage interviews at Ok Isai village (18 June 2016)

Plate 7: Warapsep Frabinok (Kialik sub-group from Ok Isai) with stone axe and mortar. The mortar (measuring 19.5 cm wide and 9.5 cm high) was found by his ancestors in cave site Suale Imaal (H159), located on the Amosai River (photo: Garrick Hitchcock) (Source Denham and Hitchcock 2011: 80)

Table 23: Summary data on ground-truthed targeted survey cultural heritage sites

Site Code	Site Name	Site Type	Community	Language Group	Ground-Truthed	Comments
D097	Ifumbri	Ceremonial (*singsing*)	Amaromin	Miyan	Yes	Established site extent polygon (15 June 2016)
H139	Tum Amemdim	Story (sacred stone)	Ok Isai	Telefol	Yes	Established that site is a spatial duplicate of D097 (24 June 2016)
H042	Ekwai Imaal	Story (cave)	Wabia	Telefol	Yes	Established site extent polygon (20 June 2016)
H162	Ekwai Cave	Archaeological (cave)	Ok Isai	Telefol	Yes	Established site is a spatial duplicate of H042 (20 June 2016)
H089	Finamtem	Old settlement	Ok Isai	Telefol	Yes	Established site extent polygon (22 June 2016)
H138	Solafuvip	Old settlement/burial	Ok Isai	Telefol	Yes	Established site centroid (22 June 2016)
H170	Sumomelia Dagal	Economic (mineral seep)	Ok Isai	Telefol	Yes	Established site centroid (22 June 2016)
D044	Timarimbip	*Masalai*/old settlement	Wameimin 2	Miyan	Yes	Established site extent polygon including spirit and settlement components (17 June 2016)
D002	Siarema	*Masalai*	Paupe	Paiyamo	Partial	Identified spirit component approx. 350m south of site D044 (24 June 2016) but site extent and spatial relationship to D044 requires clarification through further ground-survey
H169	Nena-Sumomelia Junction	Burial	Ok Isai	Telefol	Partial	Identified approximate site location (22 June 2016)
D062	Oobaibip	Old settlement	Wameimin 2	Miyan	Partial	Preliminary site polygon established (16–17 June 2016) requires further ground-truthing
H091	Ubaivip	Old settlement (hamlet)	Ok Isai	Telefol	No	Deemed a spatial duplicate of site D062 but no verification ground-truthing conducted with Telefol informants
H038	Ekwaitem	*Masalai* (waterfall)	Wabia	Telefol	No	Survey failed to reach site (21 June 2016)
H158	Ekwaiamemtem	*Masalai* (tambu)	Ok Isai	Telefol	No	Survey failed to reach site (21 June 2016)
H129	Ok Milia (Nena) Ubai	Burial	Ok Isai	Telefol	No	Informants interviewed could not recall site location (18 June 2016)
D045	Ifublitomkuwandim	*Masalai* /ceremonial (*singsing*)	Wameimin 2	Miyan	No	Survey failed to reach site (17 June 2016)
H037	Mowaitem	*Masalai* (creek junction)	Wabia	Telefol	No	Survey failed to reach site (22 June 2016)
H043	Emteip Imaal	Ossuary	Wabia	Telefol	No	Site deemed inaccessible without closer helipad (19 June 2016)
H045	Mowai Imaal	Story/Archaeological (cave)	Wabia	Telefol	No	Site deemed inaccessible without closer helipad (19 June 2016)
H092	Ubaikulelim	Old settlement/hamlet	Ok Isai	Telefol	No	Site deemed inaccessible without closer helipad (18 June 2016)

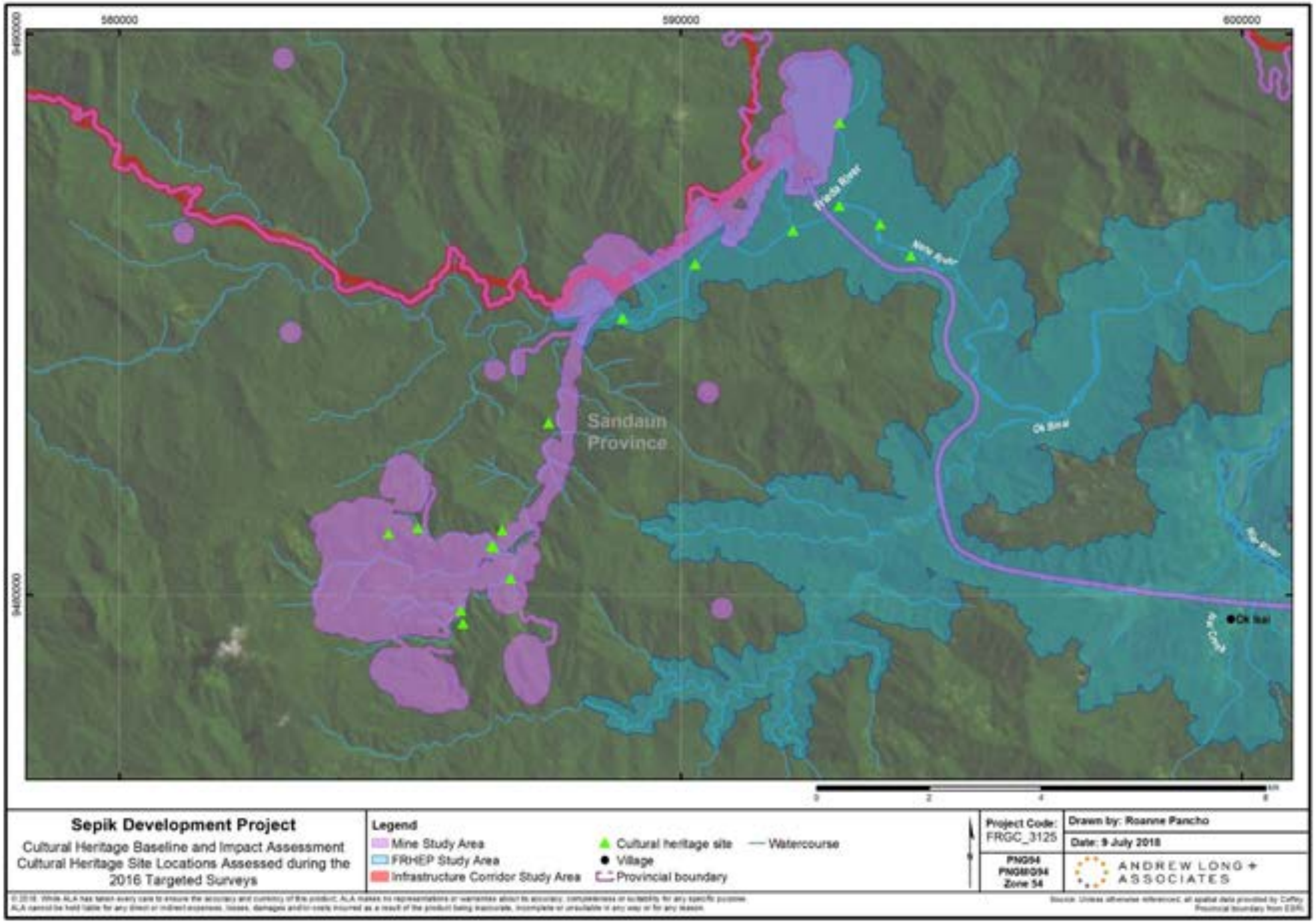


Figure 17: Cultural heritage site locations assessed during the 2016 cultural heritage field program targeted surveys

Sites H089 and H170 were recorded by Hitchcock in 2010-11, and at the time were respectively identified as an old settlement site and an economic site (mineral seep). These sites were both visited and ground-truthed during the 2016 field program, and background information regarding the nature of these locations was recorded. Further details on each of these sites are presented in Section 2.5.7 below, which summarises the site record forms.

Although H089 was originally recorded as an old settlement site by Denham and Hitchcock (2011), the 2016 field program recorded the location as a temporary camp associated with sago processing and exploitation of a stand of sago that was planted by the father of the two Telefol informants. No other information regarding specific cultural associations with the location was recorded at the time.

H170 is a mineral seep identified as an important hunting location due to the fact that the seep attracts game, and the rocky terrain offers plenty of hiding locations for hunters to ambush the game attracted to the seep. For this reason, Denham and Hitchcock (2011) recorded the place as an economic cultural heritage site. However, their report did not note any evidence of specific cultural associations with the location, nor were any recorded during the 2016 field program.

Although H089 and H170 are clearly important natural resource sites with associated economic value, based on the information collected to date there are currently insufficient grounds to classify either of them as cultural heritage sites. That said, it should be recognised that H170 has the potential to be a cultural heritage site, given that it has probably been used by many generations of hunters and is therefore likely to have some degree of oral tradition associated with it.

Additional work is required in order to gather further information on these two locations so that their status as economic sites with or without cultural heritage associations can be confirmed.

2.5.5 New Cultural Heritage Sites

In addition to the 20 previously recorded cultural heritage sites targeted for onsite ground-truthing during the 2016 cultural heritage field program, a further 10 cultural heritage sites were discussed during cultural heritage interviews and fieldwork (Figure 17, Table 24). The field team was able to ground-truth one of these sites (SAS001). Subsequent analysis indicates that at least two more (SAS002 and SAS003) are probably duplicates of sites recorded during 2010-2011 cultural heritage fieldwork with additional and/or alternate information. As mentioned above, a further two sites were recorded during a Sepik River dinghy survey and point locations represent site margins only (spatial extent requires further definition).

Table 24: Summary information on additional places recorded during the 2016 field program

Site Code	Traditional Name	Language Area	Site Type	Likely Site Duplicate	Location
SAS001	Alimbip	Telefol	Temp Resource Camp		Ground-truthed (see Figure 2)
SAS002	Benaifip	Telefol	Sacred (ancestral spirit)	H137 Binaifip; H146 Binaiavip	Described in interviews: upslope from the junction of Ok Binai and Nena River
SAS003	Mt. Wareni	Telefol	Sacred (ancestral spirit)	H147 Mt. Warren	Described in interviews: vicinity of Mt. Wareni/Warren
SAS004	Kuiyamokfip	Telefol	Sacred (ancestral spirit)		Described in interviews: approx. 5km from SAS002 (base of slope)
SAS005	Wepauvip	Telefol	Ancestral settlement		Described in interviews: elevated island between Frieda and Nena
SAS006	Ok Binai	Telefol	Burial		Described in interviews: proximal to Ok Binai

SAS001 was recorded as a temporary camp site used by the Telefol to process sago. No other information regarding specific cultural associations with the location was recorded at the time. Based on the information collected to date there is currently insufficient grounds to classify this place as a cultural heritage site, and additional work is required in order to confirm the status of this location as an economic site with or without cultural heritage associations.

2.5.6 Cultural Heritage Site Descriptions

Brief descriptions of each cultural heritage site recorded by the field team are provided below along with selected photos for each site.

2.5.6.1 D097/H139 Ifumbri/Tum Amemdim (Plate 8)

Physically this site takes the form of a massive (approx. 450m^2) and relatively flat rock, outcropping adjacent to the Nena River. The field team established this is a spatial duplicate site. Ifumbri is the Miyan name and Tum Amemdim the Telefol name.

The site is a ceremonial *singsing* and spirit site. Oral history provided by Miyan informants (Henemo and Wamei clans) identifies the site as a repository for a clan totemic being to which the singing rituals were performed for different purposes. The site is also believed to be guided by a spirit crocodile and a wild dog. Henemo and Wamie clans used to chant different songs for respective purposes:

- seek remedy when sick;
- ask for big catch when hunting;
- seek support before going for war;
- ask for support and guidance when travelling a long distance;
- seek support when clan plans to host a ceremony; and
- seek blessing in garden yield, pig litter, growth etc.

Plate 8: D097/H139 Ifumbri/Tum Amemdim ceremonial *singsing* site adjacent to the Nena River; view west across site from its eastern boundary (photo John Sepe, 15 June 2016)

2.5.6.2 D002/D044 Siarema/Timarimbip (Plate 9)

The field team established that this site involves spatial duplication but also appears to include places specific to different language groups. Siarema is the Paiyamo name previously recorded for the spirit site and Timarimbip is the Miyan settlement site name.

The Siarema/Timarimbip settlement site and associated ancestral spirit place situated adjacent to the Nena River (Plate 9) was ground-truthed with Miyan informants and also appears to be linked with a spirit pool located c. 350m further south which was identified by Paiyamo informants. The site components are linked through oral history concerning an apical clan ancestor and spirit movements.

Plate 9: D002/D044 Siarema/Timarimbip ancestral village and spirit site; view east towards site across the Nena River (photo John Sepe, 24 June 2016)

2.5.6.3 D062 Oobaibip (

Plate 10)

This is an old settlement site complex that incorporated a range of component features, including gardens, temporary houses, gathering areas, a burial site, an ornamental soil extraction site, and tracks. Ethnobotanical plants associated with past settlement, including cordyline, casuarina, breadfruit, bamboo and sago palms, were observed during a ground-truth survey with Miyan informants. The settlement complex was too extensive to be fully ground-truthed, however a preliminary site extent polygon was established and point locations recorded for some of the site features outlined above.

The field team established that this site is a likely duplicate of Telefol site H091 Ubaivip, however no site visitation or ground-truth survey was attempted with Telefol informants and the spatial extent and associated site information has the potential to vary considerably between language groups.

Plate 10: D062 Oobaibip settlement complex site; detail of collapsed burial location feature (photo Yawan Alo, 17 June 2016)

2.5.6.4 H042/H162 Ekwai Imaal/Ekwai Cave (Plate 11)

This is an oral tradition and archaeological site. Physically, the main component of the site is a rockshelter that includes at least one rock-art motif (Plate 11). The field team confirmed that this site represents a spatial duplicate.

Ok Isai and Wabia community informants noted that it remains actively used as a hunting camp and is an oral tradition site with spiritual significance: here a Telefol man married a *masalai* woman and their offspring are ancestors of Kialik, Atemkiak and Ontou clans. A location approx. 30m south of the rockshelter was recorded as a part of an ancestral walking track linked to this oral tradition site.

Plate 11: H042/H162 Ekwai Imaal/Ekwai Cave, detail of rock-art (photo John Sepe, 20 June 2016)

2.5.6.5 H138 Solafuvip (Plate 12)

This is an old temporary Telefol settlement site located on the southern bank of the Nena River. Secondary regrowth vegetation characterises the site area (approx. 2 hectares). The site is also associated with the death of a clan leader named Konfomnok. Variations in oral histories suggest that he was either buried within the settlement or died processing sago near the Nena River bank when it flooded and washed him downstream.

Plate 12: View southeast of settlement area showing planted sago in background (photo Yawan Alo, 22 June 2016)

2.5.6.6 H169 Nena River-Sumomelia Junction (Plate 13)

This is a Telefol burial location of an infant who died during birth. The site is situated on a forested ridge between the Nena and Sumomelia Rivers; however, only an approximate location for the burial site could be identified. Undergrowth vegetation was relatively dense at the time the site was inspected.

Plate 13: Vegetation near H169 Nena River Sumomelia Junction burial site (photo Yawan Alo, 22 June 2016)

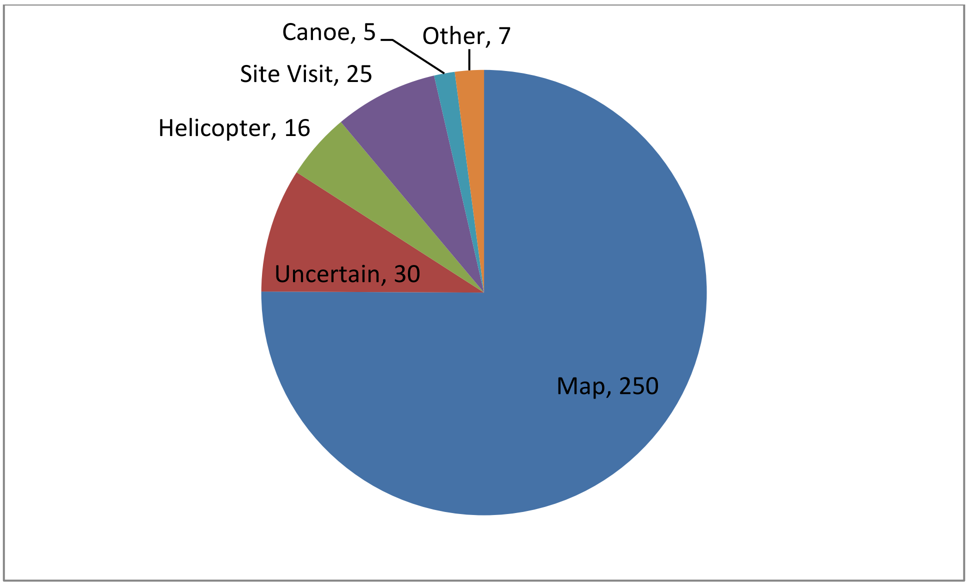
2.5.7 Comparison of 2010-2011 and 2016 Cultural Heritage Site Location Survey Methods

The results of the 2016 cultural heritage field program fieldwork slightly alter the proportions of the cultural site recording location methods discussed in Section 2.4.5.7 and are illustrated in Figure 18. Omitting H089, H170 and SAS001 from further consideration as cultural heritage sites for the remainder of this study, completed ground-truth surveys of nine previously recorded sites (which included eight 'map' sites and one 'uncertain' GPS site as described by Denham and Hitchcock (2011)), and including two pairs of now confirmed duplicates (D097/H139 and H042/H162), increases the visited site tally to 22. Two new cultural heritage locations recorded during the 2016 Sepik River Port dinghy survey (SAS007 and SAS008) are categorised as 'other'. On this basis, the total number of cultural heritage sites identified as a result of the 2010-2011 and 2016 field programs remains unchanged at 332, of which 25 (7.5%) can be confirmed as visited and at least partially ground-truthed.

2.5.8 Locational accuracy of cultural sites indicated on topographic maps during community interviews in 2010–2011

The accuracy of GPS coordinates associated with cultural site locations not directly visited during ground survey is likely to vary markedly. While this type of location data has the potential to be relatively precise (e.g. waypoints generated directly above a site from a low hovering helicopter, or pinpointed with a precision range finder from an accurately recorded remote location), without confirmatory ground-truth survey this location data is potentially inaccurate.

Figure 18: Adjusted proportion of cultural heritage site location methods employed upon completion of the 2016 fieldwork



The ground-truth survey program conducted in June 2016 provides an avenue to gauge the degree of accuracy of cultural site locations plotted on topographic maps with informants during community interviews. Of the 11 sites that were subjected to ground-truth recording in 2016, 10 were noted to have been indicated on topographic maps in 2010-2011, and another (D097), although reported to have a GPS location, displays a highly rounded coordinate that was almost certainly derived from being indicated on a topographic map.

The 11 pairs of site location coordinates (2010-2011 map coordinate versus the 2016 GPS coordinate) were individually plotted, and in each case the degree of displacement of the map coordinate from the more accurate GPS coordinate was measured. The displacement measurement for each site is listed in Table 25. This information provides an insight into the relative accuracy of the map-based coordinates recorded during community interviews in 2010-2011. The minimum displacement was 230m, and the maximum was 2.8km, for an overall average of 1.55km.

Table 25: Displacement measures between map-based (2010-2011) and ground-truthed (2016) cultural heritage site locations

Site Code	Displacement (m)
D002	1,200
D044	1,400
D062	2,700
H042	230
D097	2,000
H089	1,000
H138	590
H139	1,600
H162	1,300
H169	2,200
H170	2,800

2.6 Sepik Development Project EIS Cultural Heritage Baseline Assessment Summary

Combined cultural heritage site data from the 2010-2011 and 2016 field programs is tabulated in Appendix 8. In addition to the cross-referencing already conducted by Denham and Hitchcock (2011: Appendix B), the table has been updated to identify survey location methods for each site (where known) based on the most recent review presented in this study, and an attempt has been made to identify the confirmed and potential site duplicates that exist within the dataset itself.

In addition, cultural heritage sites noted by Gardner and Jorgenson (Appendix 6)[6] and sites included on the NMAG's National Site File which were not identified as duplicates during cross-referencing with the outcomes of the 2010-2011 and 2016 field programs have also been included in Appendix 8.

The site list presented in Appendix 8 therefore constitutes a master cultural heritage site catalogue for the Sepik Development Project. It includes the Sepik River and May River Iwam, Owininga, Saniyo-Hiyowe, Wogamusin and Yahe cultural heritage sites recorded by Denham and Hitchcock during the 2010-2011 field program. The spatial distribution of the full cultural heritage site catalogue is mapped against the mine, FRHEP and infrastructure corridor study areas in Figure 19 and Figure 20.

[6] The place list and accompanying locational data provided to Denham and Hitchcock (2011) by Morren does not differentiate between natural geographical features and cultural heritage places and has therefore not be included in the Sepik Development Project master cultural heritage site catalogue.

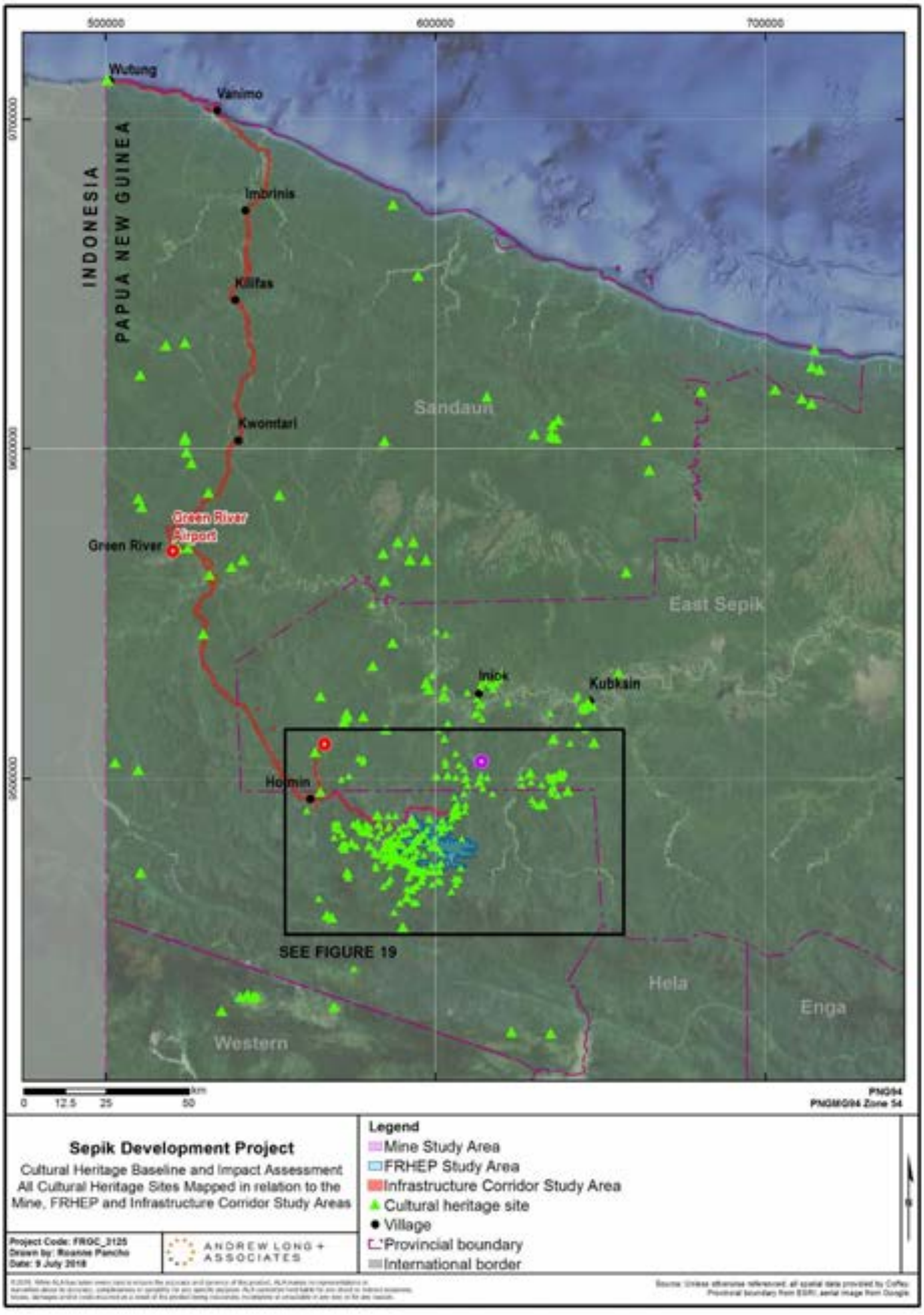


Figure 19: All cultural heritage sites mapped in relation to the mine, FRHEP and infrastructure corridor study areas

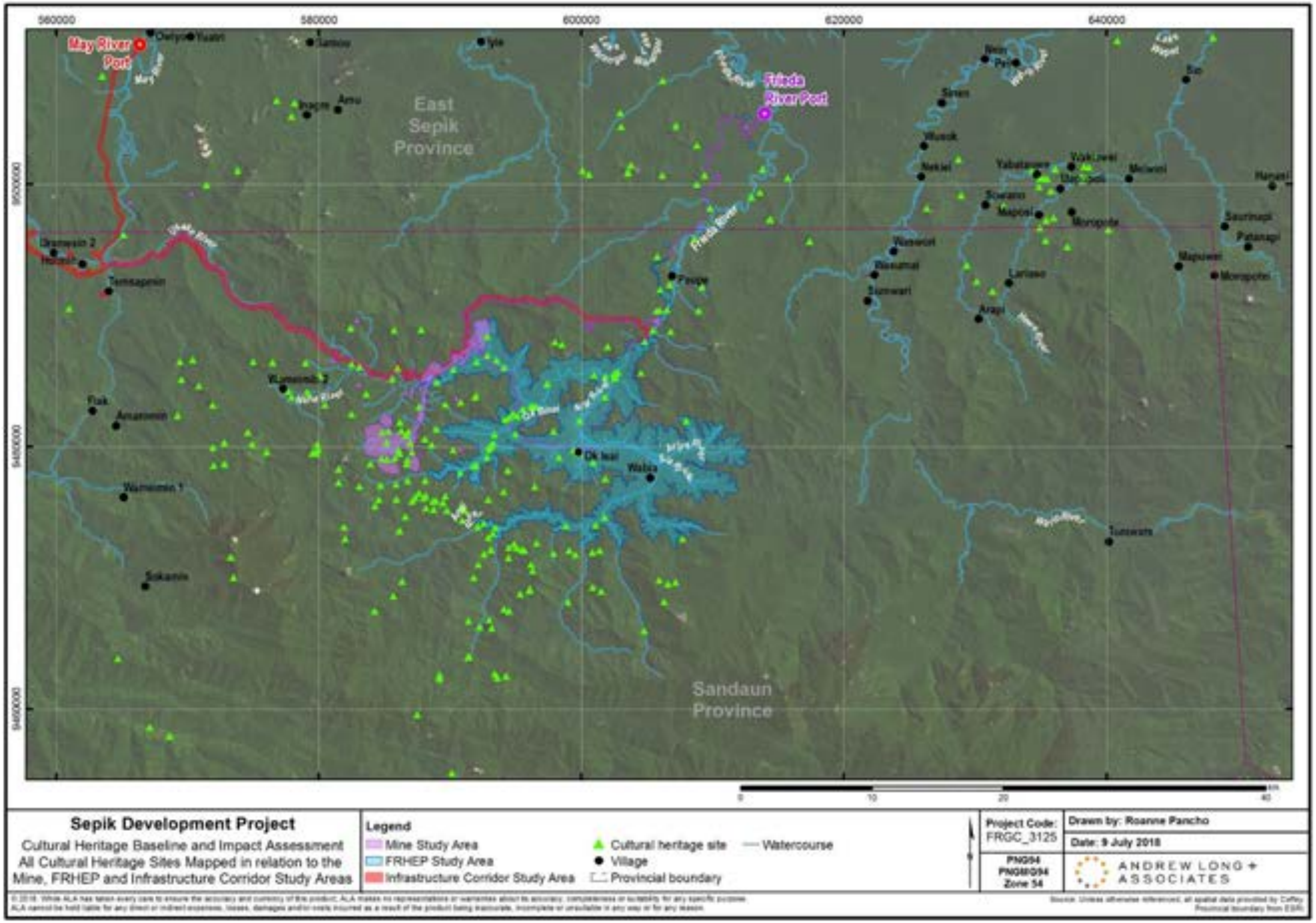


Figure 20: Cultural heritage sites mapped in relation to the mine, FRHEP and infrastructure corridor study areas – close-up

In addition to these cultural sites that have location coordinates, there are also a set of cultural heritage sites that were not mapped beyond verbal description of location. For example, information regarding five burial sites was related to FRL Community Affairs by Fatiap Dringsep (Wamei sub-group from Wameimin 2) (see Appendix 5). While one of these appears to relate to settlement site Afeibip (D070), additional location data would be required to adequately assess these cultural heritage sites in relation to potential Project impacts.

Likewise, Denham and Hitchcock (2011) report basic information (i.e. site name only) for numerous cultural heritage sites. During the 2016 cultural heritage assessment, information regarding five cultural heritage sites (SAS002–SAS006; see Table 24) was obtained with limited location data and only verbal descriptions.

All components of the Frieda River Copper-Gold Project (FRCGP), Frieda River Hydroelectric Project (FRHEP), Sepik Power Grid Project (SPGP) and the Sepik Infrastructure Project (SIP) were formally assessed during the baseline assessment regarding the potential for each component to contain cultural heritage sites that may be impacted by the development of the Project. Based on the locational data currently available, 61 cultural heritage sites are identified as being located within the study areas assessed for the Sepik Development Project cultural heritage EIS baseline.

However, on closer inspection of the available information regarding these sites, one (D012) has been identified as not strictly meeting the definition of a cultural heritage site. The site is identified by Paiyamo people (Merepare clan at Paupe) as an important economic site used for sago processing. However, Denham and Hitchcock simply list this site in their cultural heritage site catalogue (2011: Appendix B), and they do not provide any other contextual information in their report regarding specific cultural associations with the location. On this basis, there is currently insufficient grounds to classify the place as a cultural heritage site, and for this reason it will not be included in the impact assessment. Additional work is required to confirm the status of this location as an economic site with or without cultural heritage associations. Excluding D012, the 60 cultural heritage sites that will form the basis of the impact assessment presented in Section 3 below are listed in Table 26 and mapped in Figure 21. The table differentiates sites located within proposed worksites from those identified within study area buffers.

Section 2.5.8 discussed uncertainties regarding the accuracy of locational data recorded during the 2010-2011 cultural heritage field program for sites identified solely on the basis of a review of topographic maps during local community interviews (hereafter referred to as 'Map' sourced data). As a means of recognising these uncertainties and dealing with them in the context of the baseline (and subsequent impact) assessment, a secondary component of the baseline assessment was conducted which identified cultural heritage sites with 'Map' sourced locational data only (as listed in the master cultural heritage site catalogue presented in Appendix 8) which situates them within 1.5km of the mine, FRHEP and infrastructure corridor study areas.

The figure of 1.5km is based on the mean measure of displacement between 'Map' sourced and 'GPS' sourced locational data for those sites that were originally recorded as 'Map' in 2010-11, and which were subsequently ground-truthed during pedestrian surveys in 2016. This figure becomes a rough measure of the degree of inaccuracy inherent in the 'Map' sourced locational data, and identifies additional cultural heritage sites that have a potential to be impacted by proposed Project activities.

Table 27 lists 73 cultural heritage sites with 'Map' sourced locations only which are situated within 1.5km of the current Project EIS cultural heritage study area. These sites will be included as a subsidiary component of the impact assessment presented in Section 3 of the present study.

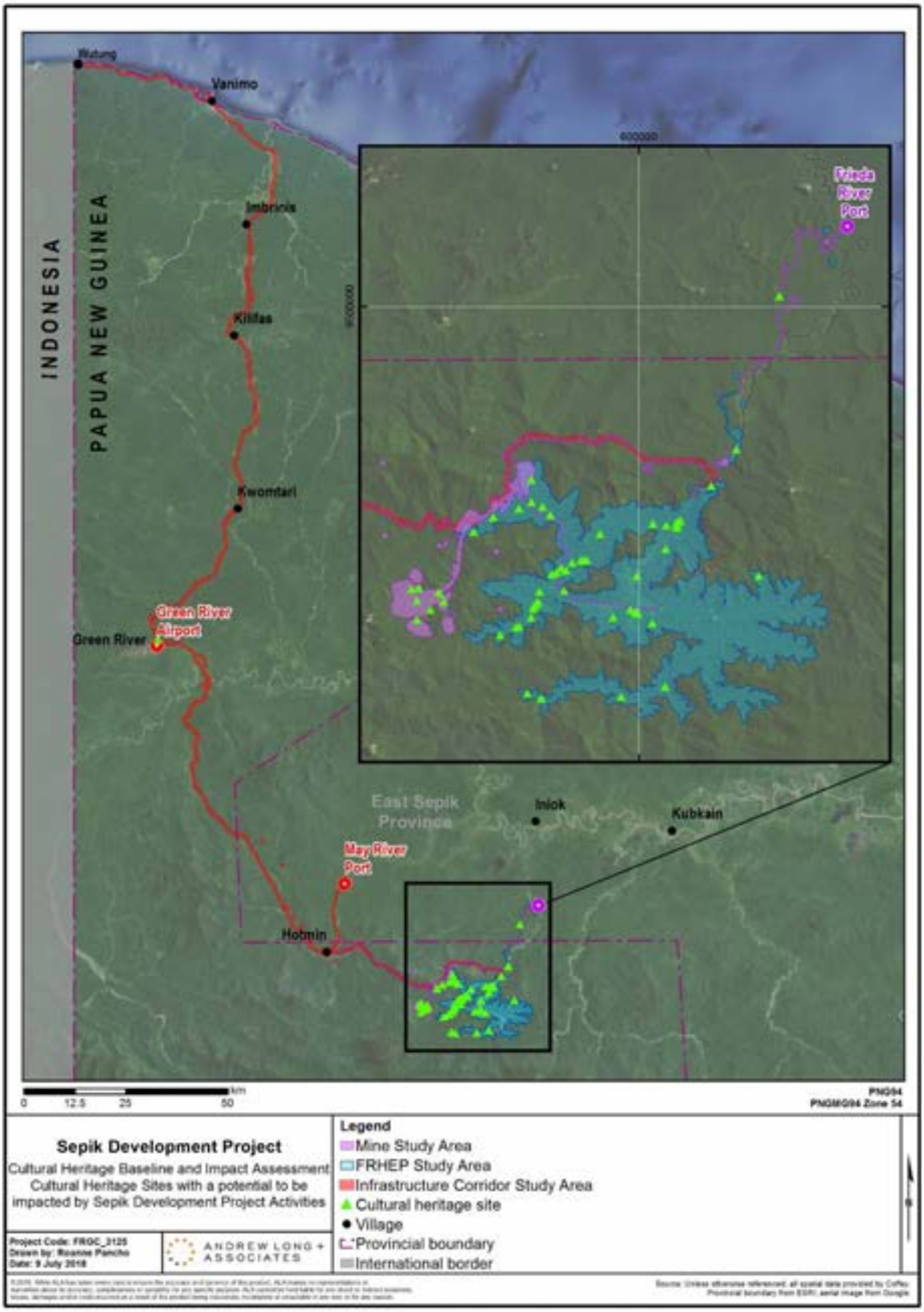


Figure 21: Cultural heritage sites identified in the baseline assessment has having a potential to be impacted by Sepik Development Project activities

Table 26: Summary data on cultural heritage sites located within the Sepik Development Project EIS cultural heritage study areas

Site Code	Site Name	Site Type	Project (Worksite)	Project (Buffer)
D001	Kemeti	Story/Former Settlement	FRHEP (ISF)	
D002/D044	Siarema/Timarimbip	Story/Former Settlement	FRHEP (ISF)	
D007	Memusu	Economic	FRHEP (Frieda River Diversion	
D013	Kaluasikeme/Kowruasekeme	Story	FRHEP (ISF)	
D014	Serekeme	Story	FRHEP (ISF)	
D018	Soko somoyo	Archaeological	FRHEP (ISF)	
D024	Piapaupi/Piapauke	Burial		FRCGP (road)
D041	Awayuabip	Story/Former Settlement/Burials	FRHEP (ISF)	
D045	Ifublitomkuwandim	Story	FRHEP (ISF)	
D061	Emoriabip	Former Settlement	FRHEP (ISF)	
D075	Emeiblu	Story/Former Settlement	FRHEP (ISF)	
D097/H139	Ifumbri/Tuym Amemdim	Story	FRHEP (ISF)	
H037	Mowaitem	Story	FRCGP (quarry)	
H038	Ekwaitem	Story		FRCGP (road)
H042/H162	Ekwai Imaal/Ekwai Cave	Story/Archaeological	FRCGP (crusher and stockpiles)	
H045	Mowai Imaal	Story/Archaeological	FRCGP (mine)	
H070	Wepwao	Story	FRHEP (ISF)	
H079	Uyuvi or Amorai	Story	FRHEP (ISF)	
H098	Amulaifife	Former Settlement	FRHEP (ISF)	
H099	Yongfale Dang	Former Settlement/Burial	FRHEP (ISF)	
H116	Frieda-Nena Junction	Masalai	FRHEP (ISF)	
H126	Bengemdebom	Burial	FRHEP (ISF)	
H127	Ok Binai-Misitem Junction	Burial	FRHEP (ISF)	
H128	Ok Binai-Dinomtem Junction	Burial	FRHEP (ISF)	
H129	Ok Milia (Nena)-Ubai	Burial	FRHEP (ISF)	
H131	Alivaifif	Burial	FRHEP (ISF)	
H132	Ok Isai Kongamemtem	Story	FRHEP (ISF)	
H133	Aune	Burial	FRHEP (ISF)	
H134	Frieda-Nena Junction	Story	FRHEP (ISF)	
H135	Warenia	Story/Former Settlement	FRHEP (ISF)	
H136	Mebluavip	Former Settlement	FRHEP (ISF)	
H137	Binaifip	Story	FRHEP (ISF)	
H138	Solavufip	Former Settlement/Burial	FRHEP (ISF)	
H141	Cave	Burial	FRHEP (ISF)	
H143	Ubai Bagan	Economic		FRCGP (road)
H150	Imma Imaal	Archaeological	FRHEP (ISF)	
H151	Nokomen Am	Story	FRHEP (ISF)	
H152	Unamemtem	Story	FRHEP (ISF)	

Site Code	Site Name	Site Type	Project (Worksite)	Project (Buffer)
H153	Kongamemtem	Story	FRHEP (ISF)	
H154	Yongfareavip	Former Settlement	FRHEP (ISF)	
H155	Atalavip	Former Settlement	FRHEP (ISF)	
H156	Uyubi Bengemdebom	Story	FRHEP (ISF)	
H158	Ekwaiamemtem	Story	FRCGP (crusher and stockpiles)	
H161	Cave at Henumai-Frieda Junction	Story	FRHEP (ISF)	
H163	Cave at Ima-Bina Junction	Story	FRHEP (ISF)	
H166	Uviaiamemtem	Story	FRHEP (ISF)	
H167	Foliaivip	Former Settlement	FRHEP (ISF)	
H168	Ok Binai-Apoiya Junction	Burial	FRHEP (ISF)	
H169	Nena River-Sumomelia Junction	Burial	FRHEP (ISF)	
H171/H172	Ok Esai Collection 1/Ok Esai Collection 2	Archaeological	FRHEP (ISF)	
H176	Ok Esai Grave 1	Burial	FRHEP (ISF)	
H177	Ok Esai Grave 2	Burial	FRHEP (ISF)	
H178	Ok Esai Grave 3	Burial	FRHEP (ISF)	
H179	Ok Esai Grave 4	Burial	FRHEP (ISF)	
H180	Ok Esai Grave 5	Burial	FRHEP (ISF)	
H181	Ok Esai Grave 6	Burial	FRHEP (ISF)	
H182	Ok Esai Grave 7	Burial	FRHEP (ISF)	
CRD	Frieda Airstrip	Archaeological	SIP (Frieda River airstrip)	
RAK	Panganggan Cave	Cave/Rockshelter	SPGP (transmission line)	
J10	Ok Amurai	Unknown	FRHEP (ISF)	

Table 27: Recorded cultural heritage sites with 'Map' sourced locational data situated within 1.5km of the mine, FRHEP and infrastructure corridor study area boundaries

Site Code	Site Name	Site Type
D003	Arimogu/Aremagu	Story
D004	Sabumogu	Story
D005	Biamogu	Story
D009	Madri	Story
D010	Madri somoyo	Archaeological
D017	Sanemakayo	Story
D020	Alinumakai	Story
D025	Wahomakai	Story
D042	Waramea/Nogoso	Story
D048	Telemebip	Former Settlement
D049	Omabip	Former Settlement
D051	Mawena	Story

Site Code	Site Name	Site Type
D059	Henemaibip	Former Settlement/Burial
D071	Aliamobip	Former Settlement/Burial
D073	Dabuaebip	Former Settlement
D076	Teni Ansum (Siliyo)	Story
D079	Awamem (Nena)	Story
D100	Amowem	Story
D102	Monosavo	Story
D103	Monosabo	Story
H039	Restricted Area	Story
H043	Emteip Imaal	Ossuary
H044	Anai Imaal	Archaeological
H046	Uwaining	Economic
H047	Afaiwip	Former Settlement
H058	Unamoiwip	Former Settlement
H059	Ansetok Begolfrin	Story
H061	Simana	Former Settlement
H062	Kunfagamawip	Former Settlement
H063	Yaramlia	Former Settlement
H068	Atkomkrukma	Economic/Story
H069	Atkomkrukma Debom or Uyuvi Debom	Story
H071	Tumolah	Story
H072	Dungfumawip	Former Settlement
H073	Sum Mentalim	Economic
H080	Mimokavip	Former Settlement
H081	Milifenavip	Former Settlement
H083	Unamo (Old Unamo)	Former Settlement
H090	Bogolamkala	Former Settlement/Economic
H092	Ubaikulelim	Former Settlement
H093	Honiai	Former Settlement
H094	Uyuvi 2?	Former Settlement/Economic
H095	Asekumikilin	Former Settlement
H096	Emtevipnagalim	Former Settlement
H097	Binaivip (2)	Former Settlement/Story/Burial
H100	Drumtevip	Former Settlement/Burial
H106	Mimokmun (2)	Former Settlement/Burial
H108	Frunengtikin	Former Settlement
H109	Dungfumavip	Former Settlement/Burial
H111	Dokinapiv	Former Settlement
H112	Simanadang	Former Settlement/Burial
H113	Simanadang (hamlet 1)	Former Settlement
H140	Flobai	Story
H142	Dagalkil	Economic
H144	Emteip Debom	Story

Site Code	Site Name	Site Type
H145	Emteip Imaal	Archaeological
H146	Binaiavip (2)	Former Settlement
H149	Aliamuvip 2	Former Settlement
H157	Tenidebom	Story
CFH	Paupe Village	Rock Shelter
RAH	Dieru Settlement	Archaeological
RAJ	Green River Gravel Rise	Archaeological
RAQ	Unkown	Cave/Rockshelter
RCC	Mukwasi Village	Archaeological
RCD	Unknown	Archaeological
RCR	Biaka Village	Archaeological
RDO	Unknown	Subsistence/Trade
RDP	Anataman- Upper Frieda	Archaeological
RDS	Fogorobe Tem Ancestral Spirit Site	Story
RDW	Tan De Bom Quarry	Archaeological
RED	Bipan Village	Archaeological
RGC	Wai'ou	Ossuary
J1	Womkiimmun	Unknown

3 IMPACT ASSESSMENT

3.1 Potential Impacts to Cultural Heritage

Tangible and intangible cultural heritage sites identified within the mine study area, the Frieda River Hydroelectric Project (FRHEP) study area and the infrastructure corridor study area have the potential to be impacted by Project activities as a result of:

- Direct disturbance of cultural heritage sites due to on-ground works including vegetation clearance, topsoil stripping, subsoil excavation, quarrying, and the creation of borrow pits and spoil dumps.
- Direct and indirect disturbance due to impoundment of the integrated storage facility (part of the FRHEP), which will result in flooding, disturbance to materials and loss of access cultural heritage places.
- Direct disturbance due to the movement of Project employees and contractors and their vehicles (e.g. erosion, unauthorised removal of artefacts).
- Indirect disturbance due to associated population growth that increases the movement of people and vehicle traffic.
- Physical modifications to the land resulting in the destruction of some sites and their loss from living memory and, hence, from oral tradition.
- Disturbance to ecosystems through environmental impacts on landform and soils, water resources and hydrology, and biodiversity, which have the potential to affect the immediate utility and long-term viability of cultural heritage sites that are identified based on these extant systems (e.g. *ples tambu* or *masalai* story sites associated with water).
- Restricted physical access of communities to cultural heritage sites on account of Project activities and operational requirements. This includes the likely resettlement of Ok Isai and Wabia villages, which are located within the area to be inundated by the FRHEP.

The baseline assessment presented in Section 2 considered the potential for Project-related activities to directly impact cultural heritage sites within the study areas defined in Section 1.5. The baseline assessment determined that these activities have the potential to impact 60 cultural heritage sites (Table 26), given that the sites are located within the proposed Project disturbance footprint.

These direct impacts have the potential to affect cultural heritage sites in the following ways:

- the loss of connection between people and their places of cultural value through the destruction or damage of a site;
- the loss of information which could otherwise be gained by conducting research today;
- the loss of the archaeological resource for future research using methods and addressing questions not available today; and
- the permanent loss of the physical record.

The 60 cultural heritage sites listed in Table 26 form the core of the impact assessment presented in the following sections. However, a further 73 cultural heritage sites with potentially inaccurate locational data which situates them within 1.5km of the mine, FRHEP and infrastructure corridor study area (Table 27) also have a potential to be impacted by proposed Project activities. Although these sites are not included in the formal impact assessment, recommendations for further work confirming their locations as either inside or outside the proposed Project disturbance footprint, and relevant impact mitigation strategies if they are subsequently identified as likely to be impacted by Project activities, are presented in Section 3.4.

3.2 Recorded Cultural Heritage Site Significance Assessment

The significance of each of the 60 cultural heritage sites included in the formal impact assessment was determined using the criteria and rating scales outlined in Section 1.4.2.2. The overall significance rating determined for each cultural heritage site was derived as a cumulative score across four cultural heritage criteria (historical, scientific, social and spiritual). The assessment of each criterion for sites recorded during the 2010-2011 and 2016 field programs was based on the information collected during fieldwork, which in all cases included community interviews and, in some cases, direct field inspection. The assessment of each criterion for sites included on the PNG National Museum and Art Gallery's National Site File (NSF), or sites recorded by other field researchers prior to 2010, was based solely on the information presented in Sections 2.3, 2.4.3 and Appendix 6.

In instances where there is insufficient information on which to form an assessment for any one cultural heritage criterion (including informed professional opinion), the criterion has been generically assessed as low.

3.2.1 Local Community Perspectives on Cultural Heritage Site Significance

The following observations regarding the various ways in which local communities across the mine and FRHEP study areas view the relative significance of cultural heritage sites is derived from observations made by Denham and Hitchcock (2011: 100-104).

<u>Paiyamo</u>

For these sub-groups the most significant sites, and the ones that they do not wish to see disturbed, are landforms associated with various *masalai* spirits (who regulate the Paiyamo world-order), ossuaries containing the bones of ancestors, and mountains that house the spirits of the dead. For example, Merepare express concern regarding the way that D003 Arimogu was disturbed by HGL in the 1990s (Jorgensen 1996:10-11). Furthermore, and if Jorgensen is correct, each Paiyamo *sane*, or sub-group, has its own ossuary and its own mountain of origin.

<u>Miyanmin</u>

The overwhelming impression from people living at Wameimin 2 is that even though places are of varying significance, nearly all of them could be disturbed or destroyed during development if need be (although of course through consultation, negotiation and compensation). The most notable exceptions are Ewauwabip (island at the junction of Nena and Frieda Rivers) and Fogorobe cave (RDS), which Miyan groups cited as being important because they link into origin stories regarding first/second generation ancestors. However, among Miyanmin and Merapare groups there was a general acceptance that Ewauwabip/Kemeti (D001) was likely to be flooded, despite its mythical and historical importance.[7] From an archaeological point of view, the rock shelter at Inikia (RDR) is of regional and, potentially, national significance, although its significance to Miyanmin is unclear and warrants further investigation; however, given that the site is more than 10km northwest of the open pit, the site would not be directly impacted by the Project.

<u>Telefol</u>

Telefol had the greatest number and density of cultural sites compared to any other group. Of greatest significance are ossuaries and some *masalai* places. A major complicating factor in the consideration of Telefol claims to sites, as noted for land claims per se, is that the groups now resident at Ok Isai and Wabia incorporate refugees and captives from groups who formerly inhabited the area. Consequently,

[7] Apart from references to 'Ewauwabip' on pp. 100 and 101 of Denham and Hitchcock (2011), the site is not given a site code and is not listed in their site catalogue in Appendx B of the report.

it is not clear whether the resemblance of Telefol stories regarding the junction of the Nena and Frieda Rivers to Merepare traditions is an overt attempt to co-opt the traditions of others or whether it represents the inheritance within some Telefol of a group who resided in the area before Telefols arrived.

3.2.2 Individual Site Assessments

The results of the cultural heritage site significance assessment are presented in Table 28. Individual site assessments are summarised below.

<u>D001 Kemeti (Story/Former Settlement)</u>

This site is identified by Paiyamo people (Merepare clan at Paupe) as a former settlement and an origin story site. The following site description is derived from Denham and Hitchcock (2011: 48):

> Kemeti (D001): a former settlement said to have been occupied by a variety of groups, who subsequently dispersed in multiple directions (links to Henamo and Wiame), and is said to be known as Nenematan by Telefol and as Aiwayobip by Miyanmin. It is also a place of major mythical origin for Merepare. There is a story regarding *masalai* that explains how people dispersed from Kemeti to surrounding regions (in a time before the historical narrative). The site is linked to Siarema (D002) where a spirit crocodile (*masalai pukpuk*) killed a Waime man, and to the *masalai* stones of Miyanow and Seremowa in the Frieda River (D006).

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low scientific and social significance, medium historical significance and high spiritual significance, the site is currently assessed as being of <u>**medium**</u> cultural heritage significance.

<u>D002/D044 Siarema/Timbarimbip (Story/Former Settlement)</u>

This site is identified by Paiyamo people (Merepare clan at Paupe) as an active spirit site believed to be inhabited by an apical ancestor who has a continuing relationship with the local community. However, Miyan clans at Wameimin 2 (Outomin and Wamei) state that the site has a wider significance for Miyan, Telefol and Paiyamo communities given its specific history, which involves the movement and dislocation of different communities at the former settlement due to death by sorcery and the fear of retribution.

Although Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list, the site was rated as being of high significance by all Miyan communities interviewed during the 2016 field program. Based on the application of the significance assessment methodology and classifying the site as having low scientific and social significance, medium historical significance and high spiritual significance, the site is currently assessed as being of <u>**medium**</u> cultural heritage significance.

<u>D007 Memusu (Economic)</u>

This site is identified by Paiyamo people (Merepare clan at Paupe) as a location where sago is presumably harvested and processed, and possibly associated with unnamed ancestors (*tumbuna saksak* site). However, Denham and Hitchcock simply list this site in their cultural heritage site catalogue (2011: Appendix B), and they do not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of <u>**low**</u> cultural heritage significance.

Table 28: Cultural heritage site significance assessment

Site Code	Site Name	Site Type	Significance Criteria								Significance Rating	
			Historical	Scientific					Social	Spiritual		
				Cont	Cond	Rep	Total	Overall			Score	Rating
D001	Kemeti	Story/Former Settlement	2	1	1	1	3	1	1	3	7	Medium
D002/D044	Siarema/Timarimbip	Story/Former Settlement	2	1	1	1	3	1	1	3	7	Medium
D007	Memusu	Economic	1	1	1	1	3	1	1	1	4	Low
D013	Kaluasikeme/Kowruasekeme	Story	1	1	1	1	3	1	1	1	4	Low
D014	Serekeme	Story	1	1	1	1	3	1	1	3	6	Low
D018	Soko somoyo	Archaeological	1	1	1	1	3	1	1	3	6	Low
D024	Piapaupi/Piapauke	Burial	1	3	3	3	9	3	1	3	8	Medium
D041	Awayuabip/Ewauwobip	Story/Former Settlement/Burials	2	3	1	1	4	2	2	3	9	High
D045	Ifublitomkuwandim	Story	1	1	1	1	3	1	3	3	8	Medium
D061	Emoriabip	Former Settlement	1	1	1	1	3	1	1	1	4	Low
D075	Emeiblu	Story/Former Settlement	1	1	1	1	3	1	1	1	4	Low
D097/H139	Ifumbri/Tum Amemdim	Story	1	1	1	1	3	1	3	3	8	Medium
H037	Mowaitem	Story	1	1	1	1	3	1	1	3	6	Low
H038	Ekwaitem	Story	1	1	1	1	3	1	1	3	6	Low
H042/H162	Ekwai Imaal/Ekwai Cave	Story/Archaeological	1	3	3	3	9	3	2	3	9	Medium
H045	Mowai Imaal	Story/Archaeological	1	1	1	1	3	1	2	1	5	Low
H070	Wepwao	Story	1	1	1	1	3	1	1	1	4	Low
H079	Uyuvi or Amorai	Story	1	1	1	1	3	1	1	1	4	Low
H098	Amulaifife	Former Settlement	1	1	1	1	3	1	1	1	4	Low
H099	Yongfale Dang	Former Settlement/Burial	1	3	1	1	4	2	1	1	5	Low
H116	Frieda-Nena Junction	Masalai	1	1	1	1	3	1	1	1	4	Low
H126	Bengemdebom	Burial	1	3	3	3	9	3	1	1	6	Low
H127	Ok Binai-Misitem Junction	Burial	1	3	3	3	9	3	1	1	6	Low
H128	Ok Binai-Dinomtem Junction	Burial	1	3	3	3	9	3	1	1	6	Low
H129	Ok Milia (Nena)-Ubai	Burial	1	3	3	3	9	3	1	1	5	Low
H131	Alivaifif	Burial	1	3	3	3	9	3	1	1	6	Low

Site Code	Site Name	Site Type	Significance Criteria								Significance Rating	
				Scientific								
			Historical	Cont	Cond	Rep	Total	Overall	Social	Spiritual	Score	Rating
H132	Ok Isai Kongamemtem	Story	1	1	1	1	3	1	2	3	7	Medium
H133	Aune	Burial	1	3	3	3	9	3	1	1	6	Low
H134	Frieda-Nena Junction	Story	1	1	1	1	3	1	1	3	6	Low
H135	Warenia	Story/Former Settlement	1	1	1	1	3	1	1	3	6	Low
H136	Mebluavip	Former Settlement	1	1	1	1	3	1	1	3	6	Low
H137	Binaifip	Story	1	1	1	1	3	1	1	3	6	Low
H138	Solavufip	Former Settlement/Burial	2	3	3	3	9	3	1	1	7	Medium
H141	Cave	Burial	1	3	3	3	9	3	1	1	6	Low
H143	Ubai Bagan	Economic	1	1	1	1	3	1	1	1	4	Low
H150	Imma Imaal	Archaeological	1	1	1	1	3	1	1	1	4	Low
H151	Nokomen Am	Story	1	1	1	1	3	1	1	3	6	Low
H152	Unamemtem	Story	1	1	1	1	3	1	1	3	6	Low
H153	Kongamemtem	Story	1	1	1	1	3	1	1	3	6	Low
H154	Yongfareavip	Former Settlement	1	1	1	1	3	1	1	3	6	Low
H155	Atalavip	Former Settlement	1	1	1	1	3	1	1	3	6	Low
H156	Uyubi Bengemdebom	Story	1	1	1	1	3	1	1	3	6	Low
H158	Ekwaiamemtem	Story	1	1	1	1	3	1	1	3	6	Low
H161	Cave at Henumai-Frieda Junction	Story	1	1	1	1	3	1	1	3	6	Low
H163	Cave at Ima-Bina Junction	Story	1	1	1	1	3	1	1	3	6	Low
H166	Uviaiamemtem	Story	1	1	1	1	3	1	1	3	6	Low
H167	Foliaivip	Former Settlement	1	1	1	1	3	1	1	1	4	Low
H168	Ok Binai-Apoiya Junction	Burial	1	3	3	3	9	3	1	1	6	Low
H169	Nena River-Sumomelia Junction	Burial	1	3	1	3	7	3	1	1	6	Low
H171/H172	Ok Esai Collection 1/Ok Esai Collection 2	Archaeological	1	1	2	3	7	3	1	1	6	Low
H176	Ok Esai Grave 1	Burial	1	3	3	3	9	3	1	1	6	Low
H177	Ok Esai Grave 2	Burial	1	3	3	3	9	3	1	1	6	Low
H178	Ok Esai Grave 3	Burial	1	3	3	3	9	3	1	1	6	Low

Site Code	Site Name	Site Type	Significance Criteria								Significance Rating	
			Historical	Scientific					Social	Spiritual		
				Cont	Cond	Rep	Total	Overall			Score	Rating
H179	Ok Esai Grave 4	Burial	1	3	3	3	9	3	1	1	6	Low
H180	Ok Esai Grave 5	Burial	1	3	3	3	9	3	1	1	6	Low
H181	Ok Esai Grave 6	Burial	1	3	3	3	9	3	1	1	6	Low
H182	Ok Esai Grave 7	Burial	1	3	3	3	9	3	1	1	6	Low
CRD	Frieda Airstrip	Archaeological	1	3	3	3	9	3	1	1	6	Low
RAK	Panganggan Cave	Cave/Rockshelter	1	1	1	1	3	1	1	1	4	Low
J10	Ok Amurai	Unknown	1	1	1	1	3	1	1	1	4	Low

<u>D013 Kaluasikeme/Kowruasekeme (Story)</u>

This site is identified by Paiyamo people (Merepare clan at Paupe) as a story site regarding an apical ancestor. However, Denham and Hitchcock simply list this site in their cultural heritage site catalogue (2011: Appendix B), and they do not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **<u>low</u>** cultural heritage significance.

<u>D014 Serekeme (Story)</u>

This site is identified by Paiyamo people (Merepare clan at Paupe) as one of a series of important *masalai* sites (Denham and Hitchcock 2011: 48):

> *Masalai* in waterways, four within the upper reaches of Frieda and associated with Serékemé (D014), and one *masalai* place on the Frieda River, Wamisibuni (D021), which is considered the boundary between Merepare and Inago.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific and social significance and high spiritual significance, the site is currently assessed as being of **<u>low</u>** cultural heritage significance.

<u>D018 Soko somoyo (Archaeological/Cave)</u>

This site is identified by Denham and Hitchcock (2011: Appendix B) as a cave site with archaeological potential. However, Denham and Hitchcock simply list this site in their cultural heritage site catalogue and do not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **<u>low</u>** cultural heritage significance.

<u>D024 Piapaupi/Piapauke (Burial)</u>

This site is identified by Paiyamo people (Aiyamo/Inaylu clan at Paupe) as one of a series of important spiritual places (Denham and Hitchcock 2011: 50):

> Paiyamo communities have an attachment to a string of mountains and associated landforms north and west of Paupe (D022-D024). The mountains are important spiritual places, which formerly had ritual associations, and settlements were located nearby. Similarly, Nesiya cultural sites include mountains of spiritual or ritual importance (D025-D027), as well as places of former settlement (not mapped).

The site is described as a burial by Denham and Hitchcock (2011: Appendix B). They did not include the site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical and social significance and high scientific (due to the presence of a burial) and spiritual significance, the site is currently assessed as being of **<u>medium</u>** cultural heritage significance.

D041 Awayuabip/Ewauwobip (Story/Former Settlement/Burial)

This site is identified by Miyan people (Waime clan at Wameimin 2 and Henamo clan at Aramomin) as one of a series of important places associated with an origin story narrative (see Section 2.4.5.3 for further details).

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having medium historical, scientific (based on the presence of burials) and social significance and high spiritual significance, the site is currently assessed as being of **high** cultural heritage significance.

D045 (Ifublitomkuwandim) and D097/H139 (Ifumbri/Tum Amemdim) (Story)

These three sites have been grouped together based on the likelihood that D045 is a duplicate of D097/H139 (see Section 2.5.4 for further details).

This location on the bank of the Nena River is associated with a rich oral tradition regarding ritual magic and ceremonial gatherings that is recognised by both Miyan (Henemo clan at Amaromin) and Telefol (Kialik, Ontou and Atemkialik clans at Ok Isai) communities. Although Denham and Hitchcock (2011) rated the location as having 'high value/high significance' for the Miyan community only, the 2016 field program identified it as being of high significance for both Telefol and Miyan communities. Based on the application of the significance assessment methodology and classifying the place as having low historical and scientific significance and high social and spiritual significance, the place is currently assessed as being of **medium** cultural heritage significance.

D061 Emoriabip (Former Settlement)

This site is identified by Miyan people (Waime clan at Wameimin 2) as a former settlement site (Denham and Hitchcock 2011: Table 4.2, Appendix B). Denham and Hitchcock do not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

D075 Emeiblu (Story/Former Settlement)

This site is identified by Miyan people (Waime clan at Wameimin 2) as a former settlement site and a place where ceremonies were conducted (Denham and Hitchcock 2011: Table 4.2, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H037 Mowaitem (Story)

This site is identified by Telefol people (Sivio clan at Wabia) as a *masalai* site located at the junction of two creeks (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

The name of this site was recorded as Ubaitem during Telefol community interviews at Wabia (Kialik clan) in 2016.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. The site was also identified as being of high significance by Telefol communities interviewed during the 2016 field program. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social significance and high spiritual significance, the site is assessed currently as being of **low** cultural heritage significance.

H038 Ekwaitem (Story) (possibly a duplicate of H158 Ekwaiamemtem)

This site is identified by Telefol people (Sivio clan at Wabia) as a *masalai* site located at a waterfall (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social significance and high spiritual significance, the site is assessed currently as being of **low** cultural heritage significance.

H042/H162 Ekwai Imaal/Ekwai Cave (Story/Archaeological)

Physically, the main component of the site is a rockshelter that includes at least one rock-art motif. The site is identified by Telefol people (Kailik clan at Wabia and Atemkiak and Ontou clans at Ok Isai) as an important location based on the fact it is actively used as a hunting camp, and its association with an oral tradition with spiritual significance: here a Telefol man married a *masalai* woman and their offspring are ancestors of Kialik, Atemkiak and Ontou clans. A location 30m south of the rockshelter was also recorded as a part of an ancestral walking track linked to this oral tradition site.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Telefol communities at Ok Isai (Kialik, Ontou and Atemkialik clans) and Wabia (Kialik) also identified this site as being of high significance during interviews in 2016. Given the presence of rock art and the fact the site comprises a rockshelter with the potential to retain deposits containing archaeological materials, the site was also rated as being of high scientific significance.

Based on the application of the significance assessment methodology and classifying the site as having low historical significance, medium social and spiritual significance and high scientific significance, the site is currently assessed as being of **medium** cultural heritage significance.

H045 Mowai Imaal (Story/Archaeological)

This site is identified by Telefol people (Sivio clan at Wabia) as a story site (Denham and Hitchcock 2011: Table 4.15, Appendix B). Given that the site is a cave, Denham and Hitchcock also identified the place as a potential archaeological site. They did not provide any other contextual information regarding specific cultural associations with the location.

During community interviews in 2016, the Kialik clan at Wabia (Telefol) described the cave as being used by hunters and by men travelling out along the Mowai River when they were looking for stone to use in the manufacture of axes.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list, and the Kialik clan specifically identified this site as being of low significance to them during interviews in 2016. In the absence of any specific information regarding its archaeological potential, the site has also been rated as being of low scientific significance. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific and spiritual significance and medium social significance, the site is currently assessed as being of **low** cultural heritage significance.

H070 Wepwao (Story)

This site is identified by the Telefol community at Wabia as a story site (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H079 Uyuvi or Amorai (Story)

This site is identified by Telefol people (Kialik clan at Wabia and Ok Isai) as a story site (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H098 Amulaifife (Former Settlement)

This site is identified by the Telefol community at Ok Isai as a former settlement (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H099 Yongfale Dang (Former Settlement/Burial)

This site is identified by the Telefol community at Ok Isai as a former settlement with burials (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and spiritual significance and medium scientific significance (based on the presence of burials), the site is currently assessed as being of **low** cultural heritage significance.

H116 Frieda-Nena Junction (Story) (possible duplicate of H134)

This site is identified by the Telefol community at Ok Isai as a *masalai* site associated with a fish *tambu* (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

It should be noted that the coordinates recorded for this site locate it at the junction of the Niar and Spia rivers, 12km south-southwest of the Frieda-Nena junction. It is possible that this site is a duplicate of H134, which is also a *masalai* site located at the Frieda-Nena junction recorded using GPS.

H126 Bengemdebom (Burial)

This site is identified by the Telefol community at Ok Isai as a burial site (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and spiritual significance and high scientific significance (based on the presence of a burial), the site is currently assessed as being of **low** cultural heritage significance.

H127 Ok Binai-Misitem Junction (Burial), H128 Ok Binai-Dinomtem Junction (Burial), H129 Ok Milia (Nena)-Ubai (Burial), H131 Alivaifif (Burial)

These four sites are identified by the Telefol community at Ok Isai as burial sites (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include these sites in their 'high value/high significance' list. Telefol informants could not provide any further information regarding H129 during subsequent interviews in 2016, and the site was not given a significance rating at that time.

Based on the application of the significance assessment methodology and classifying the sites as having low historical, social and spiritual significance and high scientific significance (based on the presence of burials), the sites are currently assessed as being of **low** cultural heritage significance.

H132 Ok Isai Kongamemtem (Story)

This site is identified by Telefol people (Ontou clan at Ok Isai) as a *masalai* place with an associated *tambu* (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical and scientific significance, medium social significance (based on the *tambu*) and high spiritual significance, the site is currently assessed as being of **medium** cultural heritage significance.

H133 Aune (Burial)

This site is identified by Telefol people (Ontou clan at Ok Isai) as a burial site that is apparently located on an island within the Niar River (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and spiritual significance and high scientific significance (based on the presence of a burial), the site is currently assessed as being of **low** cultural heritage significance.

H134 Frieda-Nena Junction (Story) (possible duplicate of H116)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a *masalai* site associated with crocodile and snake beings (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H135 Warenia (Story/Former Settlement)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a former hamlet which is associated with an oral tradition regarding a special tree (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H136 Mebluavip (Former Settlement)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a former settlement (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H137 Binaifip (Story)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a *masalai* site (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H138 Solavufip (Former Settlement/Burials)

This site is identified by the Telefol people (Ontou, Atemkiak and Kialik clans at Ok Isai) as a former settlement site with associated burials (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

The site was described in greater detail during the 2016 field program as a former Telefol settlement site associated with the death of a clan leader named Konfomnok. Variations in the oral history suggest that he was either buried within the settlement or died processing sago near the Nena River bank when it flooded and washed him downstream (see Section 2.5.7.5 for further details).

Although Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list, the Telefol community at Ok Isai (Kialik clan) identified the site as being of high significance during interviews in 2016. Based on the application of the significance assessment methodology and classifying the site as having low social and spiritual significance, high historical significance and high scientific significance (based on the presence of a burial), the site is currently assessed as being of **medium** cultural heritage significance.

H141 Cave (Burial)

This site is identified by Telefol people (Ontou clan at Ok Isai) as a burial site (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and spiritual significance and high scientific significance (based on the presence of a burial), the site is currently assessed as being of **low** cultural heritage significance.

H143 Ubai Bagan (Economic)

This site is identified by Telefol people (Ontou clan at Ok Isai) as a clay source site, presumably used for ceremonial purposes (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H150 Imma Imaal (Archaeological)

This site is identified by Denham and Hitchcock (2011: Table 4.15, Appendix B) as a cave site with archaeological potential. Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H151 Nokomen Am (Story)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a *masalai* cave site (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H152 Unamemtem (Story)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a *masalai* site with an associated *tambu* (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H153 Kongamemtem (Story)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a *masalai* site with an associated *tambu* (Denham and Hitchcock 2011: Table 4.15, Figure 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H154 Yongfareavip (Former Settlement)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a former settlement (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H155 Atalavip (Former Settlement)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a former settlement (Denham and Hitchcock 2011: Table 4.15, Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H156 Uyubi Bengemdebom (Story)

This site is identified by the Telefol people (Ontou clan at Ok Isai) as a *masalai* site with an associated *tambu* (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H158 Ekwaiamemtem (Story) (possibly a duplicate of H038 Ekwaitem)

This site is identified by the Telefol people Ok Isai as a *masalai* site with an associated *tambu* (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

During subsequent interviews in 2016, members of the Kialik, Ontou and Atemkialik clans explained that the site is inhabited by a dreadful male spirit who harms locals passing through the area.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Telefol communities at Ok Isai (Kialik, Ontou and Atemkialik clans) also identified this site as being of high significance during interviews in 2016. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H161 Cave at Henumai-Frieda Junction (Story)

This site is identified by the Telefol people at Ok Isai as a sacred cave (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H163 Cave at Ima-Bina Junction (Story)

This site is identified by the Telefol people at Ok Isai as a sacred cave (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H166 Uviaiamemtem (Story)

This site is identified by the Telefol people at Ok Isai as a *masalai* site with an associated *tambu* related to a spiritual stone (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and scientific significance and high spiritual significance, the site is currently assessed as being of **low** cultural heritage significance.

H167 Foliaivip (Former Settlement)

This site is identified by the Telefol people at Ok Isai as a former settlement (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

H168 Ok Binai-Apoiya Junction (Burial)

This site is identified by the Telefol people at Ok Isai as a burial site (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and spiritual significance and high scientific significance (based on the presence of a burial), the site is currently assessed as being of **low** cultural heritage significance.

H169 Nena River-Sumomelia Junction (Burial)

This site is identified by the Telefol people (Atemliak clan at Ok Isai) as a burial site (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

The site was subsequently inspected during the 2016 field program, accompanied by members of the Kialik, Ontou and Atemkialik clans (Telefol), who could not recall the precise location of the burial. They commented that the burial was that of a child who died during childbirth and that the remains have already decomposed.

Denham and Hitchcock (2011) did not include this site in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the site as having low historical, social and spiritual significance and medium scientific significance (based on the presence of a decomposed burial), the site is currently assessed as being of **low** cultural heritage significance.

H171/H172 Ok Esai Collection 1/Ok Esai Collection 2 (Archaeological/Archaeological)

These two sites were identified as separate artefact collections held by residents of Ok Isai Village and recorded by Denham and Hitchcock (2011: 73, Table 4.15 Appendix B). H171 comprises a stone mortar and a stone axe, while H172 comprises a single stone axe.

Denham and Hitchcock (2011) included both sites in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the sites as having low historical, social and spiritual significance and medium scientific significance, both sites are currently assessed as being of **low** cultural heritage significance.

H176 Ok Esai Grave 1, H177 Ok Esai Grave 2, H178 Ok Esai Grave 3, H179 Ok Esai Grave 4, H180 Ok Esai Grave 5, H181 Ok Esai Grave 6 and H182 Ok Esai Grave 7 (all Burial)

These seven sites are identified by the Telefol people at Ok Isai as burial sites (Denham and Hitchcock 2011: Table 4.15 Appendix B). Denham and Hitchcock did not provide any other contextual information regarding specific cultural associations with the location.

Denham and Hitchcock (2011) included all seven sites in their 'high value/high significance' list. Based on the application of the significance assessment methodology and classifying the sites as having low historical, social and spiritual significance and high scientific significance (based on the presence of burials), all seven sites are currently assessed as being of **low** cultural heritage significance.

CRD Frieda Airstrip (Archaeological)

This site was recorded on the basis of a single artefact, a *Tridacna* hinge shell adze blade dated to around 5,000 years before present, which was recovered from a depth of at least 3m below the current ground surface during drainage works at the Frieda River Airport (Swadling *et al*. 1989: 109) (see Section 2.3 for further details). It remains one of the earliest dated artefacts recovered from the Upper Sepik region.

Based on the application of the significance assessment methodology and classifying the site as having low historical, social and spiritual significance and high scientific significance, the site is currently assessed as being of **low** cultural heritage significance.

RAK Pangangaan Cave (Cave/Rockshelter)

According to the NSF extract obtained in January 2018 (see Section 2.3 for further details), RAK is a cave or rockshelter site near Green River Patrol Station that was first identified by Laurie Bragge in 1964. No other information regarding this site is currently available.

Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

J10 Ok Amurai (Unknown)

J10 was included in the site list provided to Denham and Hitchcock (2011: Table 2.3) by Dan Jorgenson in 2010. Apart from its name and location, no other information regarding the site is currently available.

Based on the application of the significance assessment methodology and classifying the site as having low historical, scientific, social and spiritual significance due to the lack of further information, the site is currently assessed as being of **low** cultural heritage significance.

3.3 Impact Assessment

3.3.1 Impact Assessment – Recorded Cultural Heritage Sites

The significance of an impact on a cultural heritage site was determined according to the impact assessment matrix presented in Section 1.4.2.4, which assessed:

- The significance of an individual recorded cultural heritage site as a function of its historic, scientific, social and spiritual value; and
- The magnitude of the impact of proposed Project activities on the site, considering the severity, extent and duration of the impact.

The initial impact assessment assumed that all cultural heritage sites located in in the mine, FRHEP and infrastructure corridor study areas (including buffers) have a 100% chance of being impacted by unmanaged and/or unmitigated Project activities.

The results of the impact assessment on the 60 cultural heritage sites included in the formal impact assessment are presented in Table 29. The potential for impacts to cultural heritage sites was assessed as ranging from Minor to Extreme, **prior to mitigation**.

The absence of any Negligible impact ratings is due to the fact that none of the impact magnitudes were rated as low; in fact, 56 of the 60 rated impact magnitudes (96%) were assessed as high, which is itself the result of a consistent rating for the duration of the expected impacts as either long-term (extending beyond the life of the Project) or permanent, and the extent/severity of the impact (in almost every instance seen as 100% loss of the site). This to be expected given the nature of the potential impacts as outlined above.

Summary data on the distribution of impact significance ratings by site type is presented in Table 30. All 60 cultural heritage sites have the potential to be impacted by Project activities included in the EIS. Of these, prior to mitigation:

- 2 sites (3%) are likely to experience a Minor impact.
- 48 sites (80%) are likely to experience a Moderate impact.
- 9 sites (15%) are likely to experience a Major impact.
- 1 site (2%) is likely to experience an Extreme impact.

Summary data on the distribution of impact significance ratings across the each of the cultural heritage study areas included in the impact assessment is presented in Table 31.

In summary, prior to mitigation:

- Most of the cultural heritage sites that have a potential to be impacted by the Project will be flooded by the proposed ISF.
- Potential impacts to six cultural heritage sites arising from the construction of the mine and its associated infrastructure are mostly Moderate, due to the low cultural heritage significance ratings determined for four sites.
- Potential impacts arising from the construction of the hydroelectric power facility and associated power distribution infrastructure will mostly be Moderate, although one will be minor, seven will be major and one will be extreme.
- Potential impacts arising from the construction of the infrastructure corridor are limited to one minor impact to a cultural heritage site.

Table 29: Impact assessment prior to mitigation

Site Code	Site Name	Site Type	Project Component	Nature of Impact	Cultural Heritage Significance	Impact Magnitude	Impact Significance
D001	Kemeti	Story/Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Medium	High	Major
D002/D044	Siarema/Timarimbip	Story/Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Medium	High	Major
D007	Memusu	Economic	FRHEP – Frieda River diversion	Vegetation clearing; ground disturbance (surface and subsurface); flooding/inundation	Low	High	Moderate
D013	Kaluasikeme/Kowruasekeme	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
D014	Serekeme	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
D018	Soko somoyo	Archaeological	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
D024	Piapaupi/Piapauke	Burial	FRCGP – Road (buffer)	Vegetation clearing; ground disturbance (surface and subsurface)	Medium	High	Major
D041	Awayuabip/Ewauwobip	Story/Former Settlement/Burials	FRHEP – ISF	Flooding/permanent inundation	High	High	Extreme
D045	Ifublitomkuwandim	Story	FRHEP – ISF	Flooding/permanent inundation	Medium	High	Major
D061	Emoriabip	Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
D075	Emeiblu	Story/Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
D097/H139	Ifumbri/Tum Amemdim	Story	FRHEP – ISF	Flooding/permanent inundation	Medium	High	Major
H037	Mowaitem	Story	FRCGP – Quarry	Vegetation clearing; ground disturbance (surface and subsurface)	Low	High	Moderate
H038	Ekwaitem	Story	FRCGP – Road (buffer)	Vegetation clearing; ground disturbance (surface and subsurface)	Low	High	Moderate
H042/H162	Ekwai Imaal/Ekwai Cave	Story/Archaeological	FRCGP – Mine	Vegetation clearing; ground disturbance (surface and subsurface)	Medium	High	Major
H045	Mowai Imaal	Story/Archaeological	FRCGP – Mine	Vegetation clearing; ground disturbance (surface and subsurface)	Low	High	Moderate
H070	Wepwao	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H079	Uyuvi or Amorai	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H098	Amulaifife	Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H099	Yongfale Dang	Former Settlement/Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H116	Frieda-Nena Junction	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H126	Bengemdebom	Burial	FRHEP – ISF	Flooding/permanent inundation	Medium	High	Major
H127	Ok Binai-Misitem Junction	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H128	Ok Binai-Dinomtem Junction	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H129	Ok Milia (Nena)-Ubai	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H131	Alivaifif	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate

Site Code	Site Name	Site Type	Project Component	Nature of Impact	Cultural Heritage Significance	Impact Magnitude	Impact Significance
H132	Ok Isai Kongamemtem	Story	FRHEP – ISF	Flooding/permanent inundation	Medium	High	Major
H133	Aune	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H134	Frieda-Nena Junction	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H135	Warenia	Story/Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H136	Mebluavip	Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H137	Binaifip	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H138	Solavufip	Former Settlement/Burial	FRHEP – ISF	Flooding/permanent inundation	Medium	High	Major
H141	Cave	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H143	Ubai Bagan	Economic	FRCGP – Road (buffer)	Vegetation clearing; ground disturbance (surface and subsurface)	Low	High	Moderate
H150	Imma Imaal	Archaeological	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H151	Nokomen Am	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H152	Unamemtem	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H153	Kongamemtem	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H154	Yongfareavip	Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H155	Atalavip	Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H156	Uyubi Bengemdebom	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H158	Ekwaiamemtem	Story	FRCGP – Mine	Vegetation clearing; ground disturbance (surface and subsurface)	Low	High	Moderate
H161	Cave at Henumai-Frieda Junction	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H163	Cave at Ima-Bina Junction	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H166	Uviaiamemtem	Story	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H167	Foliaivip	Former Settlement	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H168	Ok Binai-Apoiya Junction	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H169	Nena River-Sumomelia Junction	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H171/H172	Ok Esai Collection 1/Ok Esai Collection 2	Archaeological	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H176	Ok Esai Grave 1	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H177	Ok Esai Grave 2	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H178	Ok Esai Grave 3	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate
H179	Ok Esai Grave 4	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	Moderate

Site Code	Site Name	Site Type	Project Component	Nature of Impact	Cultural Heritage Significance	Impact Magnitude	Impact Significance
H180	Ok Esai Grave 5	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	**Moderate**
H181	Ok Esai Grave 6	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	**Moderate**
H182	Ok Esai Grave 7	Burial	FRHEP – ISF	Flooding/permanent inundation	Low	High	**Moderate**
CRD	Frieda Airstrip	Archaeological	SIP - Frieda River Airstrip	Vegetation clearing; ground disturbance (surface and subsurface)	Low	Medium	**Minor**
RAK	Panganggan Cave	Cave/Rockshelter	SPGP - Transmission Line	Vegetation clearing; ground disturbance (surface and subsurface)	Low	Medium	**Minor**
J10	Ok Amurai	Unknown	FRHEP - ISF	Flooding/permanent inundation	Low	High	**Moderate**

Table 30: Impact assessment ratings by cultural heritage site type prior to mitigation

	Site Type[1]										
Impact Rating	**A**	**B**	**C**	**E**	**F**	**S**	**F/B**	**S/A**	**S/F**	**S/F/B**	**U**
Minor	1		1								
Moderate	3	15		2	6	17	1	1	2		1
Major		2				3	1	1	2		
Extreme										1	

1 A – Archaeological E–Economic U – Unknown
B – Burial F – Former Settlement
C – Cave/Rockshelter S – Story

Table 31: Impact assessment ratings by Project component prior to mitigation

	Project Component			
Impact Rating	**FRCGP**	**FRHEP**	**SIP**	**SPGP**
Minor			1	1
Moderate	5	43		
Major	2	7		
Extreme		1		

3.3.2 Managing Impacts to Cultural Heritage

3.3.2.1 General

The assessment of cultural heritage significance is a fundamental component of heritage management. It informs which items, sites, places, landscapes and other features should be avoided or preserved. If avoidance/preservation is not possible due, for example, to engineering requirements or other technical constraints, appropriate management measures can then be developed that mitigate adverse impacts to the greatest extent practicable.

The significance assessment process underpins heritage site protection by establishing a structure within which various types (assessment criteria) and levels (significance ratings) of heritage value can be identified and allocated, as outlined in Section 1.4.2.2.

Based on the outcomes of the cultural heritage consultations and fieldwork and the subsequent significance assessment process reported in Section 3.2, FRL will develop a Cultural Heritage Management Plan designed to:

- Promote the conservation and management of cultural heritage sites within and near all proposed Project-related disturbance areas.
- Establish management measures that reduce the level of impact, and outline the implementation of the recommended management measures detailed in Section 3.3.2.2 below for recorded cultural heritage sites.
- Develop and implement a cultural awareness program for all non-local national and expatriate employees and contractors.
- Require pre-construction cultural heritage clearance surveys along the final alignment of linear infrastructure corridors, and within the facility footprints of previously unsurveyed areas, to identify any new cultural heritage sites requiring management or impact mitigation. This will

be particularly important regarding the Sepik Infrastructure Project, given that road, concentrate pipeline and transmission line alignments within the proposed infrastructure corridor have not yet been surveyed, and communities with cultural heritage-related interests along the alignments have not been consulted regarding the potential for the infrastructure corridor to adversely impact on cultural heritage sites.

- Specify salvage activities (whether it be surface artefact collections or subsurface archaeological excavations) where required, including but not limited to:
    - Development of an appropriate salvage methodology to be implemented prior to ground disturbing Project activities taking place.
    - Establishing specific measures for the exhumation of any human remains that may be unearthed as chance finds or during cultural heritage salvage investigations.
- Where the recording of oral traditions is recommended, engage a suitably qualified professional to complete the fieldwork prior to ground disturbing Project activities taking place.
- Require the development and implementation of a Chance Finds Protocol with clear processes for reporting, investigation and management of cultural heritage chance finds discovered during Project-related activities.
- Maintain a cultural heritage site database and update the database as new information becomes available. The database will inform planning and design, and will assist in the implementation of recommended management measures. It will include the precise locations of all sites, particularly those to be avoided.
- Require engagement with men and women in local communities regarding:
    - The content of the Cultural Heritage Management Plan, including the community engagement methods that will be employed in recognition of community values.
    - The development of culturally appropriate methods for the practical management of cultural heritage sites that are to be protected from impacts.
    - The development of appropriate management measures in relation to their oral tradition sites. Culturally appropriate responses to the management of sites and places that would be unavoidably impacted by Project-related activities may include avoidance, exhumation/relocation of the site and traditional ceremonies (that should precede the commencement of Project-related activities).

The relationship between living people and the spirit world is complex and often very personal for many communities in PNG. Individuals, families, clans and sometimes entire village communities will communicate with *masalai* or ancestral spirits as required when passing through a *ples tambu*, or even just going about their daily business. Unexplained deaths, sickness, accidents and poor luck are often attributed to *masalai*, and people will often call out to them or leave offerings of food or other gifts to appease them so that they be able to enjoy both their lives and their environment.

It is not unusual for many communities across PNG to conduct ceremonies prior to disturbing any place considered to be a *ples tambu* or the home of *masalai* or ancestral spirits, so that future works can proceed safely and without delay. These ceremonies may request that *masalai* and other malevolent beings remove themselves completely from the area and find a new home away from the work site. Alternatively, the ceremony may ask these beings to simply stay away from men and women while they go about their business, and not harm them in any way.

These concepts were explained to members of the 2010-2011 and 2016 cultural heritage field teams by local community members during formal interviews, and in almost every instance the requirement for ceremony was supported by examples where, in the past, local community members, PNG nationals from other parts of the country, and even expatriates, have disturbed the forest within *ples tambu* or *ples masalai*, always with disastrous results.

Some of the story sites that will be impacted by Project-related activities involve detailed oral traditions regarding specific places and geographic features and the ways in which these places and spirits interact with the human world. Measures to mitigate the effects of unavoidable Project-related impacts to these significant spirit sites should include opportunities for the relevant local clans to conduct appropriate ceremonies tailored to their specific need, prior to the work proceeding. They should also include the full recording of the associated oral traditions by qualified professionals, so that the local community can retain detailed knowledge of these stories in the absence of the physical prompts that the sites themselves provide.

However, other *ples tambu* story sites that will be impacted by Project activities are more generic or nonspecific, and are only identified because of the misadventures that befall local people due to the presence of unnamed *masalai*. In cases such as these, especially where the *ples tambu* involves a large area of which only a portion will be disturbed by Project activities, it may be sufficient to limit the mitigation measure to include an offer of support for appropriate clan ceremonies without the need for detailed oral history recording, although this should be confirmed after discussions with the relevant local communities.

Amto, Abau, Anggor, Kwomtari, Baibai, Momu, Pagi, Vanimo and Wutung-speaking communities living beside the proposed infrastructure corridor between Hotmin and Wutung villages have not yet been formally consulted about the potential for the Project to impact on their cultural heritage sites. The 14 village communities belonging to these nine cultural groups (identified in Table 16) and the Miyan communities at Fiak, Temsapmin, Hotmin and Uramusin, should be consulted as a matter of priority.

A full appreciation of impacts associated with resettlement activities is subject to further consultation with the affected villages and, as such, is not detailed in this impact assessment. Planned activities to identify and address potential impacts include:

- Consultation with affected villages to identify how communities' physical access to cultural heritage sites may be impacted.
- Identify and agree actions to address these impacts, including protocols for accessing sites.
- Record and implement the agreed actions as part of resettlement agreements and the Project's Cultural Heritage Management Plan, as appropriate.

3.3.2.2 Site Specific

The potential to avoid impacts to each of the recorded cultural heritage sites included in the impact assessment through infrastructure relocation or realignment was carefully considered. In each instance, rated cultural heritage site significance and a consideration of the impact of the loss of each site to PNG's cultural heritage at the local, provincial and national level was assessed against the nature of the infrastructure or mining activity that would impact on it, and whether avoidance through infrastructure relocation or realignment was possible given technical, safety, environmental, terrain and economic constraints.

Given the essential nature of the proposed open cut mining technique at the HITEK porphyry copper-gold deposits, impacts to cultural heritage sites within the open cut mine area have been treated as unavoidable.

With regard to the construction of related FRCGP, FRHEP, SPGP and SIP infrastructure, the development of appropriate avoidance, management and mitigation measures proceeded on the assumption that decisions regarding the location of these critical Project components had already considered the constraining factors outlined in Section 3.1, including the potential for impacts to cultural heritage. On this basis (cultural heritage considerations aside), cultural heritage site impact avoidance through infrastructure relocation was therefore not a feasible option.

The roads, pipeline and transmission line that will be constructed or upgraded along the proposed infrastructure corridor as currently proposed would be constructed along a linear alignment, and given the width of the corridor investigated, there may be some capacity for realignment during detailed design at locations where the currently mapped alignment would impact on recorded cultural heritage sites. However, in each instance, the need for realignment will ultimately be weighed against the nature and significance of the cultural heritage site, the nature and effect of the unmitigated impact, and the potential for other management measures to reduce the impact to an acceptable level.

The following proposed management measures have been developed drawing on the baseline assessment described in Section 2, and the results of the impact assessment reported in Section 3.3.1. They also include a careful consideration of previous management recommendations developed for relevant cultural heritage sites or site types investigated by Denham and Hitchcock (2011: 107, Appendix C), and where relevant to the current project configuration, these recommendations have been incorporated into the site-specific management measures outlined below.

It should be noted that where recording of relevant oral traditions is recommended, such would be (a) undertaken with the agreement of the affected community, (b) told by appropriate community representative(s) as determined by the community, and (c) recorded in languages as determined by the community. The affected community would also determine relevant disclosure provisions.

Proposed management measures for each cultural heritage site are set out below in Table 32. **It is recommended that these are discussed with men and women in relevant local communities and agreed prior to implementation.**

3.3.3 Residual Impact Assessment

Residual impacts are those potential impacts that remain after the application of the recommended management measures described above, and is based on a review of the original impacts identified in the impact assessment.

The results of a residual impact assessment on each of the 60 cultural heritage sites included in the formal impact assessment are presented in Table 33.

In every instance where a recorded cultural heritage site will be impacted by Project infrastructure or mining activities, the application of the management measures outlined in Section 3.3.2.2 reduced the magnitude of the impact by at least one rating level, and in many instances by two rating levels. The net result is that only one recorded cultural heritage site will experience an impact rated as greater than Moderate, and 54 sites (90%) will experience impacts rates as either Negligible or Minor.

Summary information on the impact ratings to recorded cultural heritage sites before and after the application of the proposed management measures is presented in Table 34.

Table 32: Proposed site-specific management measures

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
D001	Kemeti	Story/Former Settlement	FRHEP - ISF	Medium	Major	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
D002/D044	Siarema/Timarimbip	Story/Former Settlement	FRHEP - ISF	Medium	Major	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
D007	Memusu	Economic	FRHEP – Frieda River Diversion	Low	Moderate	Prior to the diversion of the Frieda River: o Recording of oral traditions by an anthropologist.
D013	Kaluasikeme/Kowruasekeme	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
D014	Serekeme	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
D018	Soko somoyo	Archaeological	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
D024	Piapaupi/Piapauke	Burial	FRCGP - Road	Low	Moderate	Prior to construction of the FRCGP road: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site complex, investigate the potential to avoid impacts by project realignment. If avoidance is not possible,

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
						conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
D041	Awayuabip/Ewauwobip	Story/Former Settlement/Burials	FRHEP - ISF	High	Extreme	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist. o Confirm the locations of any burials that may be present within the site complex, and conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
D045	Ifublitomkuwandim	Story	FRHEP - ISF	Medium	Major	Prior to inundation of the ISF: o Confirm whether D045 is a duplicate of H042/H162. o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
D061	Emoriabip	Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
D075	Emeiblu	Story/Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
D097/H139	Ifumbri/Tum Amemdim	Story	FRHEP - ISF	Medium	Major	Prior to inundation of the ISF: o Confirm whether H042/H162 is a duplicate of D045. o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H037	Mowaitem	Story	FRCGP - Quarry	Low	Moderate	Prior to construction and operation of the FRCGP quarry: o Recording of oral traditions by an anthropologist.

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
						o Assist with culturally appropriate ceremonies.
H038	Ekwaitem	Story	FRCGP - Road	Low	Moderate	Prior to construction and operation of the FRCGP mine: o Confirm whether this site is a duplicate of H158 Ekwaiamemtem. o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H042/H162	Ekwai Imaal/Ekwai Cave	Story/Archaeological	FRCGP - Mine	Medium	Major	Prior to construction and operation of the FRCGP mine: o Investigate the potential to avoid impacts by project realignment. o If avoidance is not possible: ♦ Recording of oral traditions by an anthropologist. ♦ Assist with culturally appropriate ceremonies. ♦ Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. ♦ Record all rock art present within the site. ♦ Salvage collection of visible surface artefacts by an archaeologist. ♦ If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H045	Mowai Imaal	Story/Archaeological	FRCGP - Mine	Low	Moderate	Prior to operation of the FRCGP mine: o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H070	Wepwao	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H079	Uyuvi or Amorai	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H098	Amulaifife	Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist. o Confirm the locations of any burials that may be present within the site complex, and conduct legally and culturally sanctioned exhumation of the remains if requested by the community.

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
H099	Yongfale Dang	Former Settlement/Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist. o Confirm the locations of any burials that may be present within the site complex, and conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H116	Frieda-Nena Junction	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H126	Bengemdebom	Burial	FRHEP - ISF	Medium	Major	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H127	Ok Binai-Misitem Junction	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H128	Ok Binai-Dinomtem Junction	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H129	Ok Milia (Nena)-Ubai	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H131	Alivaifif	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
						o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H132	Ok Isai Kongamemtem	Story	FRHEP - ISF	Medium	Major	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H133	Aune	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H134	Frieda-Nena Junction	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H135	Warenia	Story/Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H136	Mebluavip	Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H137	Binaifip	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H138	Solavufip	Former Settlement/Burial	FRHEP - ISF	Medium	Major	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
						o Confirm the locations of any burials that may be present within the site complex, and conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H141	Cave	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H143	Ubai Bagan	Economic	FRCGP - Road	Low	Moderate	Prior to construction and operation of the FRCGP mine: o Recording of oral traditions by an anthropologist.
H150	Imma Imaal	Archaeological	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H151	Nokomen Am	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H152	Unamemtem	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H153	Kongamemtem	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H154	Yongfareavip	Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H155	Atalavip	Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist.

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
						o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H156	Uyubi Bengemdebom	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H158	Ekwaiamemtem	Story	FRCGP - Mine	Low	Moderate	Prior to operation of the FRCGP mine: o Confirm whether this site is a duplicate of H038 Ekwaitem. o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H161	Cave at Henumai-Frieda Junction	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o Salvage collection of visible surface artefacts.
H163	Cave at Ima-Bina Junction	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o Salvage collection of visible surface artefacts.
H166	Uviaiamemtem	Story	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.
H167	Foliaivip	Former Settlement	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. o Salvage collection of visible surface artefacts by an archaeologist. o If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
H168	Ok Binai-Apoiya Junction	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H169	Nena River-Sumomelia Junction	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies if requested by the community.

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
H171/H172	Ok Esai Collection 1/Ok Esai Collection 2	Archaeological	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Artefact recording by an archaeologist. o Possible donation of the artefacts to the NMAG.
H176	Ok Esai Grave 1	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H177	Ok Esai Grave 2	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H178	Ok Esai Grave 3	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H179	Ok Esai Grave 4	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H180	Ok Esai Grave 5	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H181	Ok Esai Grave 6	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies. o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
H182	Ok Esai Grave 7	Burial	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Recording of oral traditions by an anthropologist. o Assist with culturally appropriate ceremonies.

Site Code	Site name	Site Type	Project Component	Cultural Heritage Significance	Pre-mitigation Impact Significance	Management Measures
						o If a burial is confirmed as being located within the site, conduct legally and culturally sanctioned exhumation of the remains if requested by the community.
CRD	Frieda Airstrip	Archaeological	SIP - Frieda River Airstrip	Low	Minor	Prior to the commencement of works at the Frieda River Airstrip: o Confirm the location of the site in relation to the proposed works. o Investigate the potential to avoid impacts by project realignment. o If avoidance is not possible: • Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. • Salvage collection of visible surface artefacts by an archaeologist. • If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
RAK	Panganggan Cave	Cave/Rockshelter	SPGP - Transmission Line	Low	Minor	Prior to construction of the Northern Transmission Line at this location: o Confirm the location of the site in relation to the proposed works. o Investigate the potential to avoid impacts by project realignment or appropriate positioning of towers. o If avoidance is not possible: • Further investigation of the site by an archaeologist to identify whether there is potential for it to retain subsurface cultural deposits. • Salvage collection of visible surface artefacts by an archaeologist. • If subsurface archaeological deposits are identified, salvage excavation of a suitable proportion of the site by an archaeologist.
J10	Ok Amurai	Unknown	FRHEP - ISF	Low	Moderate	Prior to inundation of the ISF: o Carry out further research to confirm that nature and location of the site. o Determine if the site will be impacted by Project-related activities. o If avoidance is not possible, identify and carry out management measures as outlined above suitable to the nature of the cultural heritage site.

Table 33: Residual impact assessment (recorded cultural heritage sites)

Site No.	Site Name	Site Type	EIS Study Area	Cultural Heritage Significance	Unmitigated Impact Significance		Residual Impact Significance	
					Impact Magnitude	Impact Significance	Impact Magnitude	Impact Significance
D001	Kemeti	Story/Former Settlement	FRHEP - ISF	Medium	High	Major	Medium	Moderate
D002/D044	Siarema/Timarimbip	Story/Former Settlement	FRHEP - ISF	Medium	High	Major	Medium	Moderate
D007	Memusu	Economic	FRHEP – Frieda River diversion	Low	High	Moderate	Low	Negligible

Site No.	Site Name	Site Type	EIS Study Area	Cultural Heritage Significance	Unmitigated Impact Significance		Residual Impact Significance	
					Impact Magnitude	Impact Significance	Impact Magnitude	Impact Significance
D013	Kaluasikeme/Kowruasekeme	Story	FRHEP - ISF	Low	High	Moderate	Low	Negligible
D014	Serekeme	Story	FRHEP - ISF	Low	High	Moderate	Low	Negligible
D018	Soko somoyo	Archaeological	FRHEP - ISF	Low	High	Moderate	Low	Negligible
D024	Piapaupi/Piapauke	Burial	FRCGP - Road (buffer)	Low	High	Moderate	Low	Negligible
D041	Awayuabip/Ewauwobip	Story/Former Settlement/Burials	FRHEP - ISF	High	High	Extreme	Medium	Major
D045	Ifublitomkuwandim	Story	FRHEP - ISF	Medium	High	Major	Medium	Moderate
D061	Emoriabip	Former Settlement	FRHEP - ISF	Low	High	Moderate	Low	Negligible
D075	Emeiblu	Story	FRHEP - ISF	Low	High	Moderate	Low	Negligible
D097/H139	Ifumbri/Tum Amemdim	Story	FRHEP - ISF	Medium	High	Major	Medium	Moderate
H037	Mowaitem	Story	FRCGP - Quarry	Low	High	Moderate	Medium	Minor
H038	Ekwaitem	Story	FRCGP - Road	Low	High	Moderate	Low	Negligible
H042/H162	Ekwai Imaal/Ekwai Cave	Story/Archaeological	FRCGP - Mine	Medium	High	Major	Medium	Moderate
H045	Mowai Imaal	Story/Archaeological	FRCGP - Mine	Low	High	Moderate	Low	Negligible
H070	Wepwao	Story	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H079	Uyuvi or Amorai	Story	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H098	Amulaifife	Former Settlement	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H099	Yongfale Dang	Former Settlement/Burial	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H116	Frieda-Nena Junction	Story	FRHEP - ISF	Low	High	Moderate	Medium	Minor
H126	Bengemdebom	Burial	FRHEP - ISF	Medium	High	Major	Low	Minor
H127	Ok Binai-Misitem Junction	Burial	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H128	Ok Binai-Dinomtem Junction	Burial	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H129	Ok Milia (Nena)-Ubai	Burial	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H131	Alivaifif	Burial	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H132	Ok Isai Kongamemtem	Story	FRHEP - ISF	Medium	High	Major	Low	Minor
H133	Aune	Burial	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H134	Frieda-Nena Junction	Story	FRHEP - ISF	Low	High	Moderate	Medium	Minor
H135	Warenia	Story/Former Settlement	FRHEP - ISF	Low	High	Moderate	Medium	Minor
H136	Mebluavip	Former Settlement	FRHEP - ISF	Low	High	Moderate	Low	Negligible
H137	Binaifip	Story	FRHEP - ISF	Low	High	Moderate	Medium	Minor
H138	Solavufip	Former Settlement/Burial	FRHEP - ISF	Medium	High	Major	Low	Minor
H141	Cave	Burial	FRHEP - ISF	Low	High	Moderate	Low	Negligible

Site No.	Site Name	Site Type	EIS Study Area	Cultural Heritage Significance	Unmitigated Impact Significance		Residual Impact Significance	
					Impact Magnitude	Impact Significance	Impact Magnitude	Impact Significance
H143	Ubai Bagan	Economic	FRCGP - Road	Low	High	**Moderate**	Low	**Negligible**
H150	Imma Imaal	Archaeological	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H151	Nokomen Am	Story	FRHEP - ISF	Low	High	**Moderate**	Medium	**Minor**
H152	Unamemtem	Story	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H153	Kongamemtem	Story	FRHEP - ISF	Low	High	**Moderate**	Medium	**Minor**
H154	Yongfareavip	Former Settlement	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H155	Atalavip	Former Settlement	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H156	Uyubi Bengemdebom	Story	FRHEP - ISF	Low	High	**Moderate**	Medium	**Minor**
H158	Ekwaiamemtem	Story	FRCGP - Mine	Low	High	**Moderate**	Medium	**Minor**
H161	Cave at Henumai-Frieda Junction	Story	FRHEP - ISF	Low	High	**Moderate**	Medium	**Minor**
H163	Cave at Ima-Bina Junction	Story	FRHEP - ISF	Low	High	**Moderate**	Medium	**Minor**
H166	Uviaiamemtem	Story	FRHEP - ISF	Low	High	**Moderate**	Medium	**Minor**
H167	Foliaivip	Former Settlement	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H168	Ok Binai-Apoiya Junction	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H169	Nena River-Sumomelia Junction	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H171/H172	Ok Esai Collection 1/Ok Esai Collection 2	Archaeological	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H176	Ok Esai Grave 1	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H177	Ok Esai Grave 2	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H178	Ok Esai Grave 3	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H179	Ok Esai Grave 4	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H180	Ok Esai Grave 5	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H181	Ok Esai Grave 6	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
H182	Ok Esai Grave 7	Burial	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**
CRD	Frieda Airstrip	Archaeological	SIP - Frieda River Airstrip	Low	Medium	**Minor**	Low	**Negligible**
RAK	Panganggan Cave	Cave/Rockshelter	SPGP - Transmission Line	Low	Medium	**Minor**	Low	**Negligible**
J10	Ok Amurai	Unknown	FRHEP - ISF	Low	High	**Moderate**	Low	**Negligible**

Table 34: Residual impact assessment summary data

Impact Significance	Number of Sites Before Implementation of Management Measures		Number of Sites After Implementation of Management Measures	
	N	%	N	%
Nil	0	0	0	0
Negligible	0	0	39	62
Minor	2	0	15	28
Moderate	49	41	5	9
Major	8	59	1	1
Extreme	1	0	0	0
Total	**60**	**100**	**60**	**100**

3.4 'Map' Sourced Cultural Heritage Sites

The baseline assessment identified 73 cultural heritage sites with potentially inaccurate locational data which situates them within 1.5km of the mine, FRHEP and infrastructure corridor study area boundaries (Table 27). Given this degree of inaccuracy, these sites are also considered to have a potential to be impacted by proposed Project activities.

The cultural heritage sites listed in Table 27 should all be further investigated by a qualified cultural heritage specialist and their locations confirmed as being situated either inside or outside the proposed Project impact footprint. If any sites are confirmed as being situated within the proposed Project impact footprint, then appropriate impact management measures should be developed for each site, consistent with the range of measures outlined in Section 3.3.2.2 above regarding the needs of each site type.

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Appendix 1: 2016 Field Program Community Interview Reporting Template

COMMUNITY INTERVIEW – CULTURAL HERITAGE
FRIEDA RIVER PROJECT

Community Interview – Cultural Heritage

Interviewer	
Date	
Names of people interviewed and their clan affiliations and village of residence	Name: ______ Clan: ______ Village of Residence: ______ Name: ______ Clan: ______ Village of Residence: ______ Name: ______ Clan: ______ Village of Residence: ______ Name: ______ Clan: ______ Village of Residence: ______ Name: ______ Clan: ______ Village of Residence: ______ Name: ______ Clan: ______ Village of Residence: ______
Location of interview	
Photo reference	

A Oral Tradition Sites – Burials, Cemeteries, Ossuaries

A1 Are there any ancestral burials, cemeteries or caves/rockshelters containing human remains situated in or in close to the Project study area?

ID#	Traditional Name	Clan Owners	Identified Landowners	1:100,000 mapsheet	Easting	Northing	Description (e.g. number of individuals, names, grave markers)	Significance Rating
A1								
A2								
A3								
A4								
A5								

Significance

01 Low
02 Medium
03 High

A2 If the Project had to damage or destroy any of these places, what would the community's reaction be? Would the community require any specific responses from the Project in order for the damage/destruction to be permitted?

ID#	Community Reaction	Project Response
A1		
A2		
A3		
A4		
A5		

Community Reaction

01 Not allow site to be harmed in any way
02 Allow site to be harmed but with conditions
03 Allow site to be unconditionally harmed
04 Other (specify)

Project Response

01 Ceremony prior to works commencing
02 Exhumation and relocation of human remains
03 Archaeological investigation/excavation of the site
04 Compensation
05 Other (specify)

B Oral Tradition Sites – Temporary Camp Sites

B1 Are there any places situated in or close to the Project study area that were used in the past as temporary camp sites (e.g. overnight hunting camps)?

ID#	Traditional Name	Clan Owners	Identified Landowners	1:100,000 mapsheet	Easting	Northing	Description	Significance Rating
B1								
B2								
B3								
B4								
B5								

Significance

01 Low
02 Medium
03 High

B2 If the Project had to damage or destroy any of these places, what would the community's reaction be? Would the community require any specific responses from the Project in order for the damage/destruction to be permitted?

ID#	Community Reaction	Project Response
B1		
B2		
B3		
B4		
B5		

Community Reaction

01 Not allow site to be harmed in any way
02 Allow site to be harmed but with conditions
03 Allow site to be unconditionally harmed
04 Other (specify)

Project Response

01 Ceremony prior to works commencing
02 Exhumation and relocation of human remains
03 Archaeological investigation/excavation of the site
04 Compensation
05 Other (specify)

C Oral Tradition Sites – Former Villages and Cave/Rockshelter Occupation Sites

C1 Are there any old or abandoned villages, or caves/rockshelters that were once used as occupation sites, situated in or close to the Project study area?

ID#	Traditional Name	Clan Owners	Identified Landowners	1:100,000 mapsheet	Easting	Northing	Description	Significance Rating
C1								
C2								
C3								
C4								
C5								

Significance

01 Low
02 Medium
03 High

C2 If the Project had to damage or destroy any of these places, what would the community's reaction be? Would the community require any specific responses from the Project in order for the damage/destruction to be permitted?

ID#	Community Reaction	Project Response
C1		
C2		
C3		
C4		
C5		

Community Reaction

01 Not allow site to be harmed in any way
02 Allow site to be harmed but with conditions
03 Allow site to be unconditionally harmed
04 Other (specify)

Project Response

01 Ceremony prior to works commencing
02 Exhumation and relocation of human remains
03 Archaeological investigation/excavation of the site
04 Compensation
05 Other (specify)

D Oral Tradition Sites – Story Sites

D1 Are there any places or natural features (such as mountains, lakes, waterfalls, caves, boulders, trees) situated in or close to the Project study area that are associated with important stories relating to religious events, ancestral figures or spirits, clan origins, warfare or *masalai*?

ID#	Traditional Name	Clan Owners	Identified Landowners	1:100,000 mapsheet	Easting	Northing	Description	Significance Rating
D1								
D2								
D3								
D4								
D5								

Significance

01 Low
02 Medium
03 High

D2 If the Project had to damage or destroy any of these places, what would the community's reaction be? Would the community require any specific responses from the Project in order for the damage/destruction to be permitted?

ID#	Community Reaction	Project Response
D1		
D2		
D3		
D4		
D5		

Community Reaction

01 Not allow site to be harmed in any way
02 Allow site to be harmed but with conditions
03 Allow site to be unconditionally harmed
04 Other (specify)

Project Response

01 Ceremony prior to works commencing
02 Exhumation and relocation of human remains
03 Archaeological investigation/excavation of the site
04 Compensation
05 Other (specify)

E Oral Tradition Sites – Subsistence/Trade Sites

E1 Are there any places situated in or close to the Project study area that are identified as particularly important sources of animals or plants, or raw materials used to make artefacts or that was traded with neighbouring communities?

ID#	Traditional Name	Clan Owners	Identified Landowners	1:100,000 mapsheet	Easting	Northing	Description (e.g. resources obtained, used to make?, traded with?)	Significance Rating
E1								
E2								
E3								
E4								
E5								

Significance

01 Low
02 Medium
03 High

E2 If the Project had to damage or destroy any of these places, what would the community's reaction be? Would the community require any specific responses from the Project in order for the damage/destruction to be permitted?

ID#	Community Reaction	Project Response
E1		
E2		
E3		
E4		
E5		

Community Reaction

01 Not allow site to be harmed in any way
02 Allow site to be harmed but with conditions
03 Allow site to be unconditionally harmed
04 Other (specify)

Project Response

01 Ceremony prior to works commencing
02 Exhumation and relocation of human remains
03 Archaeological investigation/excavation of the site
04 Compensation
05 Other (specify)

F Archaeological Sites

F1 Are there any places situated in or close to the Project study area that have the physical remains of past human activities, such stone tools or broken pottery, on the surface of the ground or in the ground?

ID#	Traditional Name	Clan Owners	Identified Landowners	1:100,000 mapsheet	Easting	Northing	Description	Significance Rating
F1								
F2								
F3								
F4								
F5								

Significance

01 Low
02 Medium
03 High

F2 If the Project had to damage or destroy any of these places, what would the community's reaction be? Would the community require any specific responses from the Project in order for the damage/destruction to be permitted?

ID#	Community Reaction	Project Response
F1		
F2		
F3		
F4		
F5		

Community Reaction

01 Not allow site to be harmed in any way
02 Allow site to be harmed but with conditions
03 Allow site to be unconditionally harmed
04 Other (specify)

Project Response

01 Ceremony prior to works commencing
02 Exhumation and relocation of human remains
03 Archaeological investigation/excavation of the site
04 Compensation
05 Other (specify)

G Intangible Cultural Heritage

G1 Are there any aspects of your community's culture that does not exist physically but which is knowledge that is either shared by everyone or known only to sections of the community (e.g. song, dance, language, histories, rituals, ceremonies) that you are concerned will be affected by the Project?

ID#	Type of Knowledge	Practiced By	Description	Project Impact
G1				
G2				
G3				
G4				
G5				

Type of Knowledge

01 Song
02 Dance
03 Language
04 History
05 Ritual/Ceremony
06 Other (specify)

G2 What would the community's reaction be to any impacts on this knowledge? Would the community require any specific responses from the Project in order for the impact to be permitted?

ID#	Community Reaction	Project Response
G1		
G2		
G3		
G4		
G5		

Community Reaction

01 Not allow site to be harmed in any
02 Allow site to be harmed but with conditions
03 Allow site to be unconditionally harmed
04 Other (specify)

Project Response

01 Ceremony prior to works commencing
02 Compensation
03 Other (specify)

COMMUNITY INTERVIEW – CULTURAL HERITAGE
FRIEDA RIVER PROJECT

Additional comments if any

COMPLETION CHECKLIST:

All questions complete / filled in:	
GPS waypoint taken:	Easting:__________________ Northing:___________________
Photo record taken:	

Appendix 2: 2016 Field Program Cultural Heritage Site Recording Form

Frieda River Project – Cultural Heritage Site Recording Form

Field Site #__________ **PNG National Museum Site Code**__________ **Recorder**__________ **Date**__________

Field Site Name__________ **Traditional Name**__________

Language Area__________ **Clan**__________

Site Owners__________

GPS Location – Easting__________ **Northing**__________ ☐ AGD66 ☐ WGS84 **Elevation ASL**______m

GPS Make/Model__________ **Locational Accuracy**__________m

1:100,000 Mapsheet Name__________ **Easting**__________ **Northing**__________

	Site Landscape																
Site Vegetation	Hill Top	Hill Slope	Base of Hill	Cliff	Rocky Outcrop	Sinkhole	Lakeside	Lake/Waterhole	Spring	River/Creek	Freshwater Swamp	Mangrove/Saltwater Swamp	Plain	Floodplain	River Levee	Beach	Other
Vine Thicket																	
Grassland																	
Open Woodland																	
Forest																	
Rainforest																	
Mangrove																	
Garden																	
Other																	

Other__________

Surface Sediment Type at Site

☐ Clay ☐ Silt ☐ Sand ☐ Loam ☐ Gravel ☐ Rock ☐ Freshwater ☐ Saltwater ☐ Other__________

Ground Surface Visibility at Site

☐ 0% ☐ 1-24% ☐ 25-49% ☐ 50-74% ☐ 75-100%

Bedrock ☐ Exposed ☐ Not Exposed

☐ Limestone ☐ Other__________

Site Type

☐ Open Shell Midden
☐ Rock Shelter
☐ Cave
☐ Stone Arrangement
☐ Shell Arrangement
☐ Isolated Shell
☐ Grinding Stone
☐ Isolated Stone/Ceramic
☐ Cultural Materials Scatter
☐ Quarry
☐ Rock Art
☐ Burial/Ossuary
☐ Garden
☐ Temporary Encampment
☐ Village
☐ Mound
☐ Ritual/Spirit/Sacred Site
☐ Fishing/Hunting Site
☐ Sago Processing Site
☐ Tree
☐ Other__________

Cultural Materials Present

☐ Ochre
☐ Hearth/Earth Oven
☐ Charcoal/Ash
☐ European/Asian Contact materials
  ☐ Bottle Glass
  ☐ Metal Items
  ☐ Ceramics
  ☐ Other__________
☐ Stone Artefacts
  ☐ Quartz ☐ 1-10 ☐ 11-50 ☐ 50+
  ☐ Volcanic ☐ 1-10 ☐ 11-50 ☐ 50+
  ☐ Metamorphic ☐ 1-10 ☐ 11-50 ☐ 50+
  ☐ Sedimentary ☐ 1-10 ☐ 11-50 ☐ 50+
☐ Shell MNI ☐ 1-10 ☐ 11-50 ☐ 50+
☐ Melanesian Ceramics ☐ 1-10 ☐ 11-50 ☐ 50+
☐ Animal Bone MNI ☐ 1-10 ☐ 11-50 ☐ 50+
☐ Human Bone
☐ Wooden Structures/Posts/Post Holes
☐ Macrobotanical Remains__________
☐ Other__________

Stratification

☐ Surface Site
☐ Stratified/Buried Deposit
☐ Site Exposed by Disturbance__________
____
____
☐ Unknown

Human Skeletal Remains

Skulls	MNI	☐ 1-10	☐ 11-50	☐ 50+
Mandibles	MNI	☐ 1-10	☐ 11-50	☐ 50+
Postcranial Bones	N	☐ 1-10	☐ 11-50	☐ 50+
	MNI	☐ 1-10	☐ 11-50	☐ 50+

Rock Art

☐ Paintings	☐ 1-10	☐ 11-50	☐ 50+
☐ Drawings	☐ 1-10	☐ 11-50	☐ 50+
☐ Stencils	☐ 1-10	☐ 11-50	☐ 50+
☐ Prints	☐ 1-10	☐ 11-50	☐ 50+
☐ Engravings	☐ 1-10	☐ 11-50	☐ 50+

☐ Other____________________

Shells

☐ *Anadara* sp ☐ *Polymesoda* sp ☐ *Syrinx* sp ☐ *Cypraea* sp ☐ *Oliva* sp ☐ *Conus* sp ☐ *Melo* sp

☐ Other Bivalve____________________

☐ Other Gastropod____________________

Modified Shells

____________________ ☐ 1 ☐ 2-4 ☐ 5-10 ☐ 11+

Distance to Nearest Freshwater

Closest permanent water__________m ☐ Swamp ☐ River ☐ Creek ☐ Water Hole/Lake

☐ Other____________________

Closest temporary water__________m ☐ Swamp ☐ Creek ☐ Water Hole/Lake

☐ Other____________________

Vertebrate Remains

☐ Bird
☐ Fish
☐ Turtle
☐ Dugong
☐ Pig
☐ Other Mammal__________

Distance to High Water Mark__________m

Site Dimensions

Max Length__________m Max Width__________ Max Area__________m^2

Max Height (Rockshelters/Caves) __________m

Site Description

____

Environmental Description (include information on vegetation assemblage, landforms, slope, topography and drainage)

____

Oral Histories Relevant to the Site

Informant____________________

History____________________

Photo Numbers____________________

Drawings?____________________

Audio?____________________

Management Recommendations

☐ Large Site (>1000m^2) ☐ Medium Site (25-1000m^2) ☐ Small Site (<25m^2)

☐ Protect ☐ Salvage ☐ Further Mapping Required ☐ Other____________________

Comments____________________

Appendix 3: NMAG Cultural Heritage Mapping Permit No. 004

PNG NATIONAL MUSEUM & ART GALLERY

P.O. BOX 5560, BOROKO, PAPUA NEW GUINEA

Telephone: 3252405 Fax: 3251779 Email: nationalmuseum@museumpng.gov.pg Webpage: www.museumpng.gov.pg

PERMIT FOR CULTURAL HERITAGE MAPPING IN PAPUA NEW GUINEA

PERMIT 004

Permission is granted to DR JOHN MUKE & YAWAN YALO
JOHN SEPE

(as required by the National Cultural Property Schedule for 18 May 1967) for consultation and physical cultural heritage mapping of tangible and intangible cultural heritage inclusive of archaeological, traditional, social, historical, natural sites at both marine and terrestrial environments in
FRIEDA MINE EXPLORATION LICENCE AREAS, FRIEDA RIVER,
TELEFOMIN DISTRICT, WEST SEPIK PROVINCE

Providing you agree to the following conditions:

1. Conduct (a) oral documentation of spatial arrangements of cultural properties, and (b) physical cultural heritage landscape mapping.
2. Provide to NMAG a proposal specifying plans for documentation of intangible and tangible components of indigenous cultural heritage and living components.
3. Applicable only for field site (s) covered in application and only for period specified in this permit document.
4. Permit will only be issued under an individual's name and to persons with cultural heritage management background.
5. Provide resumes of archaeologists and anthropologist and/or competent cultural heritage specialists.
6. Provide material evidence of valid visa and work permit if you are participating in consultancy work.
7. Submit report of your field activities and findings to Curator of Prehistory within one month of completion of your fieldwork.
8. Ensure impartial and independent reporting to NMAG upon discovery of cultural properties including reporting on deliberate and/or accidental damages to known (existing) or undocumented cultural heritage properties.
9. Unrestricted accessibility for inspection and monitoring by officers and/or authorised agents of the NMAG.
10. We also request that subsequent publications, thesis, reports and a representative selection of black/white photographs and slides taken should be sent as and when they become available. A copy of any unpublished formal lectures and seminars on your fieldwork and field findings should also be sent.
11. The cultural heritage mapping permit should not be used to conduct archaeological surveys and/or excavations, neither should be used to collect, move, relocate and modify, deface any cultural properties and/or content of a site.
12. Person (s) who breach conditions of a permit and/or who have been blacklisted will not be issued permit.
13. NMAG reserves the right to refuse, cancel or withdraw the permit at any time if the terms and conditions of the permit are abused, or change at any time.

Validity period of Permit: 1 JUNE TO 30 NOVEMBER 2016

NATIONAL MUSEUM & ART GALLERY
P.O. BOX 5560
BOROKO
PH: 25 2458, 25 2405

Permission is granted by

ALOIS KUASO

Date: 24/05/2016

I accept the above conditions

Address:
Social Research
Institute LTD
P.O. BOX 172
UNI. P.O.

Date: 24/05/2016

Appendix 4: NMAG Archaeological Survey Permit No. 202

PNG NATIONAL MUSEUM AND ART GALLERY

P.O. BOX 5560, BOROKO, PAPUA NEW GUINEA
Telephone: 3252405 Fax: 3251779 Email: nationalmuseum@museumpng.gov.pg Webpage: www.museumpng.gov.pg

PERMIT FOR ARCHAEOLOGICAL SURVEY IN PAPUA NEW GUINEA

PERMIT 202

Permission is granted to DR JOHN MUKE & YAWAN YALO
JOHN SEP

(as required by the National Cultural Property Schedule for 18 May 1967) for survey only to document cultural heritage inclusive of archaeological, traditional, historical, natural sites both marine and terrestrial environments in/on/at FRIEDA MINE EXPLORATION LICENCE AREAS, FRIEDA RIVER, TELEFOMIN DISTRICT, WEST SEPIK PROVINCE

Providing you agree to the following conditions:

1. Permit applicable only for archaeological survey for field site (s) covered in application and only for period specified in this permit document.
2. Undertake not to excavate a site and/or collect, move, relocate and modify, deface any cultural properties and/or content of a site.
3. Provide to NMAG a proposal specifying plans (including names of participating researchers) for documentation of archaeological surveys of intangible and tangible cultural heritage.
4. Permit will only be issued under an individual's name and restricted to persons with background in archaeology and/or cultural heritage management. No open permit to be issued to persons (including company persons) with no background in archaeology or cultural heritage management.
5. Provide to the Curator of Prehistory resume of principle and lead investigators/researchers.
6. Provide material evidence of valid visa and work permit if you are participating in consultancy work.
7. Return to the Curator of Prehistory all completed cultural heritage site recording forms which may include map, sketches, photos and reports.
8. A report of your field activities and findings should be submitted to Curator of Prehistory within one month of completion of your fieldwork.
9. We also request that subsequent publications, thesis, reports and a representative selection of black/white photographs and slides taken should be sent as and when they become available. A copy of any unpublished formal lectures and seminars on your fieldwork and field findings should also be sent.
10. Ensure impartial and independent reporting to NMAG upon discovery of cultural properties including the reporting of deliberate and/or accidental damages to known (existing) or undocumented cultural heritage properties.
11. Unrestricted accessibility for inspection and monitoring by officers and/or agents of the NMAG.
12. Person (s) who breach conditions of a permit and/or who have been blacklisted will not be issued permit.
13. NMAG reserves the right to refuse, cancel or withdraw the permit at any time if the terms and conditions of the permit are abused or changed at anytime.

Validity period of Permit: 1 JUNE TO 30 NOVEMBER 2016

Permission is granted by

ALOIS KUASO

NATIONAL MUSEUM & ART GALLERY
P.O. BOX 5560
BOROKO
PH: 25 2458, 25 2405

Date: 24/05/2016

I accept the above conditions

Address: Social Research Institute LTD
P.O. BOX 172
UNI. P.O.

Date: 26/05/2016

Appendix 5: Review of Burial Sites Identified by Fatiap Dringsep

Five burial sites were identified by Fatiap Dringsep (Miyan speaker from Wameimin 2 village) in relation to potential Project impacts. Some description of site locations was provided by him but no location coordinates (or other form of mapping) were included. These details are presented below and reviewed in comparison to available site details from the 2010-2011 cultural heritage field program (Denham and Hitchcock 2011).

Table A9.1: Burial sites identified by Fatiap Dringsep in 2015 (supplied by Project Community Affairs)

Name of Deceased	Sex	Apprx. # of Yrs Buried	Burial Site name	Comments	
Santolap	Male	30 yrs	At Ubai Kalmon	Close to Frieda Base camp	Fatiap says he remembers clearly where each grave site is located and can be able to locate them as there are plantings there to indicate those burial sites
Dringsep Dalman	Male	70 yrs	Afaibip, old settlement	Headwater of Ok Binai, behind Frieda Base	
Dokomayom Tekbonaining	Female	78 yrs	Afeimon settlement	Headwater of Ok Binai, behind Frieda Base	
Feiyapilap Kopsikinap	Male	30 yrs	Topinamon camp	At bank of Mikiltem creek near Ok Binai	
Keolip Dipena	Male	72 yrs	Hawanebip Settlement	Mikiltem creek & Henemai Valley near Ok Binai	

- In terms of site name the burial site of Dringsep Dalman matches site D070 recorded in 2010 (just slight variation in spelling: Afeibip vs. Afaibip). The site was recorded as an old settlement – no burial was noted. Site location was indicated on the topographic map.
- Otherwise there are no clear correlations. Although the burial site of Keolip Dipena could potentially relate to site D057 (settlement/burial site) also recorded in 2010. The recorded site name (Henemaibip) does not match the burial site name but does relate to the location comment (Henemai Valley). Site location was indicated on topographic map.
- Site D057 is one of four Miyan burial sites (see below) recorded during interviews with people at Wameimin 2 in 2010 and Denham and Hitchcock (2011: 52) specifically noted that Fatiap Dringsep was their main informant. Sites D069 and D071 are indicated to have some proximity to the Ok Binai headwaters

Table A9.2: Miyan burial sites recorded during 2010 cultural heritage interviews at Wameimin 2

Site Name	Code	Source	Site Type	Community	Language
Awayuabip	D041	Map	*Masalai* ples/old settlement/burials	Wameimin 2	Miyan
Henemaibip	D059	Map	Old settlement/burial site	Wameimin 2	Miyan
Metrobip	D069	Map	Old settlement/burial site	Wameimin 2	Miyan
Aliamobip	D071	Map	Old settlement/burial site	Wameimin 2	Miyan

- Outside of the Wameimin 2 sites there are some additional site name partial correlations.
- In relation to the burial site of Santolap where Ubai is a component of the supplied site name, there are five sites (D098, H091, H092, H129 and H143), of which only one (H129) was recorded as a burial but was not indicated as proximal to Frieda Base Camp (and H129 could not be verified/relocated during the 2016 cultural heritage assessment fieldwork). The other four were all recorded as settlement sites with no burial component noted. Of these sites D098 is indicated to have the most proximity to Frieda Base Camp.

- In relation to the burial site of Drinsep Dalmon, there are two partial name correlations in relation to Afaibip, both recorded as old settlement sites with no burial component recorded (D099 and H047). Both sites are located in the general vicinity of the Ok Binai headwaters.
- In terms of the burial sites of Keolip Dipena and Feiyapilap Kopsikinap, where Mikiltem creek is noted in relation to burial location, besides Mikil being the Miyan word for Mt Stolle (i.e. D056), H095 (old settlement site) is the only apparent partial match.
- The Ok Binai has seven partial name matches (all Telefol sites) of which four sites were recorded as burials and/or having a burial component (H097, H127, H128 and H168). All these burial sites are located along and/or south of the Ok Binai (indicative locations).

Table A9.3: Cultural sites recorded during 2010 interviews at Amaromin, Wabia and Ok Isai displaying partial name correlation with burial sites information supplied by Fatiap Dringsep

Site Name	Code	Source	Site Type	Community	Language
Ubaibip	D098	GPS	Old settlement	Amaromin	Miyan
Ubaivip	H091	Map	Old settlement	Ok Isai	Telefol
Ubaikulelim	H092	Map	Old settlement	Ok Isai	Telefol
Ok Milia (Nena)-Ubai	H129	Map	Burial	Ok Isai	Telefol
Ubai Bagan	H143	Map	Old settlement	Ok Isai	Telefol
Afaiwip	H047	Map	Old settlement	Wabia	Telefol
Afaifib	D099	GPS	Old settlement	Amaromin	Miyan
Asekumikilin	H095	Map	Old settlement	Ok Isai	Telefol
Binaiavip	H078	Map	Old settlement	Wabia & Ok Isai	Telefol
Binaivip (2)	H097	Map	Old settlement/fight ground/burial	Ok Isai	Telefol
Ok Binai-Misitem Junction	H127	Map	Burial site	Ok Isai	Telefol
Ok Binai-Dinomtem Junction	H128	Map	Burial site	Ok Isai	Telefol
Binaifip	H137	Map	*Masalai* place	Ok Isai	Telefol
Binaiavip	H146	Map	Old settlement	Ok Isai	Telefol
Ok Binai-Apoiya Junction	H168	Map	Burial site	Ok Isai	Telefol

Appendix 6: Previous Cultural Site Information Obtained by Anthropologists Relating to the Mine and FRHEP Study Areas

Miyan place names within the study area vicinity provided by George Morren (Source: Denham and Hitchcock 2011: Appendix A)

The following place names were obtained by George Morren during extensive discussions with Fatiap Dringsep and his associates.

*Oiyap, Sebandriyap and Waneya are legendary Miyan leaders who first conquered/settled the Nena area and then disappeared into afterlife

<u>Green Numerals Starting near Nena (Malia)-Frieda Rivers Junction. Unless noted otherwise, these names refer mostly to minor streams feeding into Nena River:</u>

G1 Bingtem (4 streams entering Nena River from north)
G2 Baitem (2 streams entering Nena River from north)
G3 Glolok (Tel. Kwiyamok) (stream)
G4 Mokoyobumin (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
G5 Kal (stream)
G6 Waleniya
G7 Bilok
G8 Simombliya (noted as boundary with Paupe)
G9 Eptline
G10 Nelinondona
G11 Nenamo
G12 Binai
G13 Aiyolitemok
G14 Soliai (for some reason Morren lined this out)
G15 Meblu (Meblubil) (memblu=swamp)
G16 Solial (see 14)
G17 Aiyolitem
G18 Gnamenmita (Oiyap planted yellow marita)
G19 Ifumbli
G20 Yanima
G21 Ubai
G22 Mentalim
G23 Biyana
G24 Ton (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
G25 Wata
G26 Tongfubi
G27 Dimkeyemin
G28 Tedibime
G29 Ya (Ya debal, ground around site)
G30 Wamogluwa
G31 Ibiya
G32 Oma
G33 Mowena
G34 Wentem
G35 Isuyamunim (2 streams)
G36 Sumalamin
G37 Omalin
G38 Aliya (old name); Sambola (new name)
G39 Dakamining
G40 Binala
G41 Klibiyame (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
G42 Amauwem (3 streams)
G43 Emauwoiyap
G44 Dangan
G45 Elabumita
G46 Mona (2 streams)
G47 Sitema

G48 Dakamunim
G49 Idema (on the south bank was the site of sago and marita groves exploited by line of Oiyap, Sebandriyap & Waneya*)
G50 Mokime
G51 Wasauwa
G52 Mokwa (tributary of Wasauwa)
G53 Motolim (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
G54 Ketdalmita
G55 Moiyaumau
G56 Skimia
G57 Tebenon
G58 Spiyadona
G59 Dimida
G60 Use
G61 Bubeyo
G62 Abakia (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
G63 Aninga
G64 Iba
G65 Melefofona
G66 Fokoyakle
G67 Namu
G68 Ikenau
G69 Iken (site of sago grove exploited by Henemo)
G70 Skobuwa
G71 Takameya
G72 Yomblobo

Red Uppercase letters starting near Nena (Malia)-Frieda rivers Junction:

RA Ewawobip (village site)
RB Meliagobil (ridge line)
RC Selikeme
RD Bingmanobil
RE Walaniya (source of Kwal fresh water mussels used in sing sing finery)
RF Mokoyopbuminbil (ridge)
RG Bilokgolim (mountain)
RH Biloktetal Island (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
RI Simobliafip (old village site and current camp)
RJ Nelinongolim (mountain)
RK Nakaklepdak-Unebiyabip (site where a defecating man was killed by a pukpuk)
RL Askotembil (ridge)
RM Ifumbli
RN Tomkwak (site of sacred stone destroyed by blasting without compensation by HGL)
RO Yanimagolim (mountain)
RP Mentalimbip (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
RQ Dimkekeyembip (Oiyap village site)
RR Tedimegolim (mountain)
RS Tedimebip (old village name); Yaweitembip (new)
RT Ikobebip (village site)
RU Sumalalingolim (mountain)
RV Aliyabil (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
RW Aumawem (site of sago grove exploited by line of Oiyap, Sebandriyap & Waneya*)
RX Idemafipbip and Amokebip (old names for villages on M14 site)
RY Motolimgolim (mountain)
RZ Malowagolim or Spiagolim (interchangeable names for mountain)

Red double lower case letters to be found near green 50 numerals south of Nena River (Malia):

Raa Ulepmitabip

Rbb Useabakiabip
Rcc Fokoyaklebip (sacred site; cave serving as reliquary for the bones of Oiyap and his line; Ibasema is name of cave itself)
Rdd Telibmebip
Ree Fulokobe (name and site of a bush spirit)
Rff Kaimanogolim (mountain)
Kulibiyan (rock shelter used by Oiyap)
Kesausak (demon associated with cave/s)
Rgg Not debone
Rii Sekobuafip old (village site, shared by Wame with Amalo)

<u>Blue Numerals starting near Nena (Malia)-Frieda rivers junction. This involves sites elicited from Amaloten on their occupation of Meliataman (Nenataman) jointly with Wame. Most names refer to streams:</u>

B1 Ibia
B2 Oma
B3 Abouning
B4 Wentem (2 streams)
B5 Yokobe
B6 Omani
B7 Boldakama
B8 Wengtem (5 separate streams)
B9 Nokobe
B10 Dekaminin
B11 Imaoiyap (2 streams)
B12 Edabumita (3 streams)
B13 Edama
B14 Kesawa
B15 Motalim
B16 Ketdalmita
B17 Baitema
B18 Ketdalmita
B19 Ketdalmita
B20 Dotema
B21 Gnenin (5 streams)
B22 Ilema
B23 Mokime
B24 Skimia
B25 Spiyadona
B26 Tebenon
B27 Yomblobo
B28 Menefofone (2 streams)
B29 Skobwa
B30 Fokyakle

<u>Green letters (one lower case, the rest upper case):</u>

Ga Omabip (on Oma Ck; originally planted by Feye; Henemo cut sago here also, Fatiyap was clearing for garden in 1995)
GA Alibipgolim (mountain)
GB Biyavabo
GC Abowiyagolim (mountain)
GD Robugolim (mountain)
GE Inamogolim (mountain)

List of Telefol sites in Nenataman (Upper Frieda River system) located by Don Gardner in 1995 (Denham and Hitchcock 2011:29)

Site I.D.	Site Name	Alternative Site Name
G1	Simanabil	Silmanabil
G2	Unamo	Nutabil, Nutapbil
G3	Dubumabib	
G4	Yatemkot	
G5	Mimokmun	
G6	Dusam's ancestral sago	
G7	Binaiabib	Binaiavip, Binaiabip
G8	Emteitbib de bom	Emteiipdebom, Emtevipdebom
G9	Ekwai-imal	
G10	Ivaalabib	Ivaalavip, Ibaalabip
G11	Wamei settlement: Amukefip	

Important Telefol sites in Nenataman (Upper Frieda River system) identified by Dan Jorgensen based on fieldwork in 1995 (Denham and Hitchcock 2011:31; source is Jorgensen, pers. comm.)

Site I.D.	Alternative Site Name
J1	Womkiimmun (Womkiim-mun)
J2	Binaiavip
J2A	Ariamuvip
J3	Ekwai-dubom
J4	Dubalbang-dubom
J5	Kongaamin-dubom
J7	Sibia-dubom
J7A	Wisiliya-dubom
J8	Tom-dubom
J9	Miimokmun (Miimok-mun)
J10	Ok Amurai
J11	Inaiavip
J	First Unamo site
JW	Ekwai-imal
JX	Ok Nele-nele / Emteiip-dubom (Emtevip-dubom)
JY	Kongaamin
JZ	Ibaalabip

Telefol 'Sacred Sites (*amemtem*)' in the vicinity of the mine and FRHEP study areas listed by Jorgensen (1996:50–51)

Name	Location
Ekwai Tum Tem	A cave in Ekwaitaman (Womkiim-mun)
Emteiip (Emtevip) Tem	A cave in Ekaitaman near an old village site
Ubai Tem	A cave in Ekwaitaman
Waren Tum Tem	A cave near Waren Dubom in Northeast quadrant of Nenataman
Buro Tum Tem	A cave in Amosaitaman
Malia Tum Tem	A cave in Amosaitaman
Amosai Tem	A cave in Amosaitaman
Aribai Tem	A cave in Aribaitaman (near Amosai)
Mameya Dubom; Mameya Imaal	Mountain and cave in Henumaitaman
Melia Dubom (= Ningkiya Dubom, Ingkiya Dubom)	Nena Mountain
Kasauwa-Afip	Junction of the Kasauwa and Nena (upper Melia)
Sibiatefap	Below Sibia Dubom (? The Knob) near the Kasauwa
Kasauwa-imaal	Cave at Kasauwa near Sibiatefap
Kong Amem Tem	A cave in the vicinity of Ok Isai
Frobayi Tem	Cave near cliffs known as Teni-Kot (Southeast quadrant of Nenataman)

Appendix 7: Frieda River Project 2010–2011 Cultural Heritage Assessment Informants

Name	Clan/Sub-Group	Village	Language Group
Jacob Aiyepnai	Merepare	Paupe	Paiyamo
John Kaiyani	Inago/Inako	Paupe	Paiyamo
Thomas Nano	Suna	Paupe	Paiyamo
Aluware Nano	Suna	Paupe	Paiyamo
Amos Soapnai	Aiyamo/Aiyawo	Paupe	Paiyamo
Tipak Namasia*	Nesiya	Auom	Paiyamo
Afatning Sikilon	Wamei	Wameimin 2	Miyan
Barang Dringsep	Wamei	Wameimin 2	Miyan
Jerry Sikilon	Wamei	Wameimin 2	Miyan
Kauri Eniepi	Wamei	Wameimin 2	Miyan
Marvin Fatiap	Wamei	Wameimin 2	Miyan
Fatiap Dringsep	Wamei	Wameimin 2	Miyan
Yanminin Sipmap	Wamei	Wameimin 2	Miyan
Lebin Ulam	Wamei	Wameimin 1	Miyan
Deiman Minang	Henamo	Amaromin	Miyan
Apasep Tiptop	Henamo	Amaromin	Miyan
Aiba Wakaeb	Henamo	Amaromin	Miyan
Robin Afum	Solmoy/Spia Sorolnomoy	Amaromin	Miyan
Michael Komnan	Oüyen	Iniok (Nenuwe)	Sepik River Iwam
David Megwe	Pauwan Nübit	Iniok	Sepik River Iwam
Willie Oboglo	Nainwan	Iniok	Sepik River Iwam
Phillip Wamsu	Pauwan Ogü	Iniok	Sepik River Iwam
Jeffery Numsal	Pauwan Ogü	Iniok	Sepik River Iwam
James Ausu**	Pauwan Ogü (Tunak)	Iniok (Nenuwe)	Sepik River Iwam
Damien Namano	Inokon	Iniok	Sepik River Iwam
Simon Waniap	Mowan	Iniok	Sepik River Iwam
Sari Megi	Senapien	Iniok	Sepik River Iwam
Alphonse Namagol	Yaiwan	Iniok	Sepik River Iwam
Steven Honugu	Tauri	Tauri	Sepik River Iwam
Rafael Yamki	Auna; Omguman	Tauri	Sepik River Iwam
Nangu	Yaiwan	Tauri	Sepik River Iwam
Tom Yapsu	Inokon	Tauri	Sepik River Iwam
Elijah Yaisino	Weiwan	Tauri	Sepik River Iwam
Phillip Nobai	Anun (sub-group of Pauno)	Auom	May River Iwam
Tennison Nomukam	Nauno	Auom	May River Iwam
Benson Wani	Yano	Auom	May River Iwam
Moses Iwanis	Yano	Auom	May River Iwam
Bob Itauna	Biinake (and sub-group Inamuna)	Inagre	Owininga
Basabo Faruna	Tiberasou	Inagre	Owininga
Micah Aiafo	Oüe	Inagre	Owininga
Suckhi Sagalwai	Sivio	Wabia	Telefol
Leni Alialusep	Iligim	Wabia	Telefol
Aki Singeni	Sivio/Kialik	Wabia	Telefol
Bob Onengim	Atemkialik	Ok Isai	Telefol

Nalon Kabileng	Atemkialik	Ok Isai	Telefol
Simeon Kabileng	Atemkialik	Ok Isai	Telefol
John Tenisep	Kialik	Ok Isai	Telefol
Warapsep Frabinok	Kialik	Ok Isai	Telefol
Fexian Fotisep	Ontou	Ok Isai	Telefol
Mark***	Limbum (also Trangau)	Yabatauwe	Saniyo-Hiowe
Amos Isu***	Don (also Trangau)	Yabatauwe	Saniyo-Hiowe
Augustine Jacob	Dok	Yabatauwe	Saniyo-Hiowe
Mediu	Fe (Naruwe sub-clan)	Sowano	Saniyo-Hiowe
Peter	Limbum	Sowano	Saniyo-Hiowe
Steven Yaruwapi	Fe (Tumusu sub-clan)	Nekiei	Saniyo-Hiowe
Leo Deiyarowa	Woru	Nekiei	Saniyo-Hiowe
Michael Ale	Tapiye and Wewe	Nekiei	Saniyo-Hiowe
Mark Ma’i’u	Inamali and Waliali	Wakiawei	Saniyo-Hiowe
Peter Faia	Uwa’alaso	Wakiawei	Saniyo-Hiowe
Moses Abraham	Walamu	Wakiawei	Saniyo-Hiowe
James Patoi	Malak	Wakiawei	Saniyo-Hiowe
Dominic James	Malak	Wakiawei	Saniyo-Hiowe
Andrew Ana’ou	Paiari	Wakiawei	Saniyo-Hiowe
David Wy	Paiari	Wakiawei	Saniyo-Hiowe
Paulus Umo	Limbum	Maposi	Saniyo-Hiowe
Tu’o Wari	Wewe	Maposi	Saniyo-Hiowe
Benjamin Yefawe	Mei’ne’isei	Maposi	Saniyo-Hiowe
Markus Tanafu	Hara’ma’oro	Maposi	Saniyo-Hiowe
Joshua Niatawe	Hara’ma’oro	Maposi	Saniyo-Hiowe
Jackson Auro	Mei’pati’yawei	Maposi	Saniyo-Hiowe
Matthew Nama	Wushmiyan	Kubkain	Wogamusin
Eric Seni	Yenoyan	Kubkain	Wogamusin
Toby Bulu	Wulaiyan	Kubkain	Wogamusin
John Yembanaiom	Wulaiyan	Kubkain	Wogamusin
Jachariah Dokani	Wulaiyan	Kubkain	Wogamusin
Henry Paul	Wulaiyan	Kubkain	Wogamusin
Martin Yamkanu	Wiyubiyan	Kubkain	Wogamusin
Austin Yenges	Wiyubiyan	Kubkain	Wogamusin
Stanley Yum	Nasidiyan	Kubkain	Wogamusin
Peter Yum	Nasidiyan	Kubkain	Wogamusin
Lando Yum	Nasidiyan	Kubkain	Wogamusin
Jack Yalis	Nasidiyan	Kubkain	Wogamusin
Philip Sunu	Mongalyan (inc. Lapdikyan sub-group)	Kubkain	Wogamusin
Malachi Lackien	Mongalyan (inc. Lapdikyan sub-group)	Kubkain	Wogamusin
Andrew Lackien	Mongalyan (inc. Lapdikyan sub-group)	Kubkain	Wogamusin
Chinaizer Nebi	Nandiyan	Kubkain	Wogamusin
Tom Manu	Nembriyan	Kubkain	Wogamusin
Justice Isimbu	Nembriyan	Kubkain	Wogamusin
Malcolm Andrew	Nembriyan	Kubkain	Wogamusin

Florian Bida	Abuiyan	Kubkain	Wogamusin
Peter Yieta	Nariari	Paru	Yahe
Joseph Kula******	Opanahi (and Wano)	Paru	Yahe
Jacob Yabufle	Wisau	Paru	Yahe

* Tipak Namasia from Auom spoke for the Nesiya, as the appropriate informant, Jonah Inume, was absent (unclear if Nesiya is a primary 'clan' or a sub-grouping of Aiyamo/Aiyawo)

** Tunak is an extinct sub-group and informant related information regarding their site

*** These informants also represented Trangau (including sub-group Iloiye) whose members were absent

**** Informant also provided information in behalf of Wano sub-group whose members were absent

Appendix 8: Sepik Development Project EIS Cultural Heritage Site Database

The following table is an extract from the master cultural heritage site catalogue. It comprises the most current information on all identified cultural heritage sites. Information included in the catalogue is derived from:

- The NMAG's national Site File;
- Denham and Hitchcock (2011);
- data provided directly by Don Gardner and Dan Jorgenson to Tim Denham in 2011; and
- data recorded by the Social Research Institute during the 2016 field program reported in Section 2.5 of the main report.

Corrected and refined site location source information is included where possible for GPS locations which are categorised as U (Uncertain), H (Helicopter), C (Canoe), V (Visited, i.e. ground-truthed), and O (Other, including extrapolations and informed estimations).

Note that separate entries and coordinates have been retained in the master site catalogue for the following sets of potential site duplicates: H038/H158, H078/H097/H146, H072/H109/H183a. The separate entries have been maintained in instances where there is some confusion as to which coordinate most accurately marks the correct location of the site, to provide an added buffer against the risk of incorrectly selecting one location over another.

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
D001		Kemeti	Origin story	GPS (U)	Paiyamo	Paupe
D002/D044		Siarema/Timarimbip	*Masalai*	GPS (V)	Paiyamo/Miyan	Paupe/Wameimin 2
D003		Arimogu/Aremagu	*Masalai* (mountain)	Map	Paiyamo	Paupe
D004		Sabumogu	Story (mountain)	Map	Paiyamo	Paupe
D005		Biamogu	*Masalai* (mountain)	Map	Paiyamo	Paupe
D006		Waikeme'	*Masalai* (stones in Frieda)	GPS (U)	Paiyamo	Paupe
D007		Memusu	Economic (*tumbuna saksak*)	GPS (U)	Paiyamo	Paupe
D008		Wamasibi/Wamisibuni	*Masalai*	GPS (U)	Paiyamo	Paupe
D009		Madri	*Masalai* (mountain)	Map	Paiyamo	Paupe
D010		Madri somoyo	Archaeological (cave)	Map	Paiyamo	Paupe
D011		Prisuwo (ridge)	Fight ground	Map	Paiyamo	Paupe
D012		Prisuwo (sago) (CURRENTLY DELISTED)	Economic (*saksak*)	Map	Paiyamo	Paupe
D013		Kaluasikeme/Kowruasekeme	Story/*tumbuna*	GPS (U)	Paiyamo	Paupe
D014		Serekeme	*Masalai*	GPS (U)	Paiyamo	Paupe
D015		Maoyamo	*Tumbuna*	Map	Paiyamo	Paupe
D016		Wambemakayo	*Tumbuna*	Map	Paiyamo	Paupe
D017		Sanemakayo	*Tumbuna*	Map	Paiyamo	Paupe
D018		Soko somoyo	Archaeological (cave)	Map	Paiyamo	Paupe
D019	CFH	Uniayow somoyo	Story/Archaeological (cave)	GPS (V)	Paiyamo	Paupe
D020		Alinumakai	*Tumbuna* (*singsing*)	Map	Paiyamo	Paupe
D021		Wamisibuni	*Masalai*	GPS (U)	Paiyamo	Paupe
D022		Ainaseneme-tabiabi	*Masalai*	GPS (U)	Paiyamo	Paupe
D023		Nuyamo	*Masalai*	GPS (U)	Paiyamo	Paupe
D024		Piapaupi/Piapauke	Burial	Map	Paiyamo	Paupe
D025		Wahomakai	*Masalai*	Map	Paiyamo	Paupe
D026		Tabiso	*Masalai*	GPS (U)	Paiyamo	Paupe
D027		Urugume aiyayuo	*Masalai*	GPS (U)	Paiyamo	Paupe
D028		Mimuku	Spirits of the dead (mountain)	GPS (U)	Paiyamo	Paupe
D029		Mimuku soyomo	Spirits of the dead (cave)	GPS (U)	Paiyamo	Paupe
D030		Anaremoywo	*Masalai*	GPS (U)	Paiyamo	Paupe
D031		Orogome	*Masalai*	GPS (U)	Paiyamo	Paupe
D032		Pelinaei	Ossuary	GPS (U)	Paiyamo	Paupe
D033		Unariamo	*Masalai* (mountain)	Map	Paiyamo	Paupe

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
D034		Murugume	*Masalai* (swamp)	Map	Paiyamo	Paupe
D035		Soowamo	*Masalai* (mountain)	Map	Paiyamo	Paupe
D036		Ikapiso	Old settlement	Map	Paiyamo	Paupe
D037		Paupe (old)	Old settlement	GPS (U)	Paiyamo	Paupe
D038		Maluso	Burial	Map	Paiyamo	Paupe
D039		Suanebuni	*Masalai*	GPS (U)	Paiyamo	Paupe
D040		Awakeme	*Masalai*	Map	Paiyamo	Paupe
D041		Awayuabip	*Masalai*/old settlement/burials	Map	Miyan	Wameimin 2
D042		Waramea/Nogoso	Story (mountain)	Map	Miyan	Wameimin 2
D043		Damabip	*Masalai*/old settlement	Map	Miyan	Wameimin 2
D045		Ifublitomkuwandim	*Masalai*/ceremonial (*singsing*)	Map	Miyan	Wameimin 2
D046/D081/D101	RDS	Frogobe seme/Fogorobe/Fogorobe	Origin story/*Masalai* place (cave)	GPS (U)	Miyan	Wameimin 2/Amaromin
D047	RDS	Frogobe kesawa	Origin story/*Masalai* place (cave)	GPS (U)	Miyan	Wameimin 2
D048		Telemebip	Old settlement	Map	Miyan	Wameimin 2
D049		Omabip	Old settlement	Map	Miyan	Wameimin 2
D050		Biawapo	*Masalai*	GPS (U)	Miyan	Wameimin 2
D051		Mawena	Origin story (ridge linked to Frogobe)	Map	Miyan	Wameimin 2
D052		Ilimabip	*Masalai*/old settlement	Map	Miyan	Wameimin 2
D053	RDR	Inikia	Archaeological/ceremonial (rock shelter)	GPS (V)	Miyan	Wameimin 2
D054		Ibafib	Ossuary (cave)	GPS (U)	Miyan	Wameimin 2
D055		Blubakarin holbubil	Economic (sharpening stones)	Map	Miyan	Wameimin 2
D056		Mikil (Mt Stolle)	*Masalai*/story site/ossuary	Map	Miyan	Wameimin 2
D057		Daima	*Masalai*	Map	Miyan	Wameimin 2
D058		Umeni	*Masalai*	Map	Miyan	Wameimin 2
D059		Henemaibip	Old settlement/burial	Map	Miyan	Wameimin 2
D060		Uliawa	*Masalai*	Map	Miyan	Wameimin 2
D061		Emoriabip	Old settlement	Map	Miyan	Wameimin 2
D062/H091		Oobaibip/Ubaivip	Old settlement	GPS (V)	Miyan/Telefol	Wameimin 2/Ok Isai
D063		Ubiame seme	Archaeological (cave with rock art)	GPS (U)	Miyan	Wameimin 2
D064		Kisauwabip	Old settlement	Map	Miyan	Wameimin 2
D065		Uleiya	*Masalai*	Map	Miyan	Wameimin 2
D066		Feibabip	Old settlement	Map	Miyan	Wameimin 2
D067		Marua	Story	Map	Miyan	Wameimin 2

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
D068/D096/H084	J7	Sipia/Sipia/Sipia (Sibia)	Story (mountain/boundary)	GPS (U)/GPS (H)/Map	Miyan	Waweimin 2/Amaromin
D069		Metrobip	Old settlement/burial	Map	Miyan	Wameimin 2
D070		Afeibip	Old settlement	Map	Miyan	Wameimin 2
D071		Aliamobip	Old settlement/burial	Map	Miyan	Wameimin 2
D072		Sibia amuk	Economic (clay source)	Map	Miyan	Wameimin 2
D073		Dabuaebip	Old settlement	Map	Miyan	Wameimin 2
D074		Usaibip	Old settlement	Map	Miyan	Wameimin 2
D075		Emeiblu	Ceremonial (*singsing*)	Map	Miyan	Wameimin 2
D076		Teni Ansum (Siliyo)	Story	Map	Miyan	Wameimin 2
D077		Gisiyar	Story (two mountain peaks)	Map	Miyan	Wameimin 2
D078		Sikiraisa	Story (mountain)	Map	Miyan	Wameimin 2
D079		Awamem (Nena)	Story (mountain)	Map	Miyan	Amaroumin
D080		Biawampo	Story (mountain)	GPS (U)	Miyan	Amaromin
D082		Ilemabip	Old settlement/story	Map	Miyan	Amaromin
D083		Amipbip	Old settlement	GPS (H)	Miyan	Amaromin
D084		Inikia semay	Ossuary	Map	Miyan	Amaromin
D085		Kainowbip	Old settlement	Map	Miyan	Amaromin
D086		Abowiabip	Old settlement	Map	Miyan	Amaromin
D087		Saya	Story (sinkhole)	GPS (H)	Miyan	Amaromin
D088		Abowmano	Story	Map	Miyan	Amaromin
D089		Kobunaka	Story (sinkhole)	GPS (H)	Miyan	Amaromin
D090		Segabaidabap	Old settlement	Map	Miyan	Amaromin
D091		Gololbip	Ossuary	GPS (H)	Miyan	Amaromin
D092		Kikobip	Old settlement	Map	Miyan	Amaromin
D093	RDU, G12	Urepmitabip	Old settlement	Map	Miyan	Amaromin
D094		Inekaubip/Ikenaubip	Old settlement	Map	Miyan	Amaromin
D095		Usabip	Old settlement	Map	Miyan	Amaromin
D097/H139		Ifumbri/Tuym Amemdim	Ceremonial (*singsing*)	GPS (V)	Miyan/Telefol	Amaromin/Wamaimin 2/Ok Isai
D098		Ubaibip	Old settlement	GPS (U)	Miyan	Amaromin
D099		Afaifib	Old settlement	GPS (U)	Miyan	Amaromin
D100		Amowem	Story (mountain)	Map	Miyan	Amaromin
D102		Monosavo	Story	Map	Paiyamo	Paupe

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
D103		Monosabo	Story	Map	Paiyamo	Paupe
D104		Weemagu	Story	Map	Paiyamo	Paupe
H001		Tiamwe	*Masalai*/old settlement	Map	Sepik River Iwam	Iniok
H002		Wanu	Old settlement	GPS (C)	Sepik River Iwam	Iniok
H003		Eru	Old settlement	GPS (C)	Sepik River Iwam	Iniok
H004		Homopiok	*Masalai*	Map	Sepik River Iwam	Iniok
H005		Iapiok	Old settlement	GPS (O)	Sepik River Iwam	Iniok
H006		Apasap	*Masalai*	Map	Sepik River Iwam	Iniok
H007		Panai	*Masalai*/old settlement	GPS (H)	Sepik River Iwam	Iniok
H008		Ongompamisok	Old settlement	GPS (H)	Sepik River Iwam	Iniok
H009		Inogui (old Iniok)	Old settlement	Map	Sepik River Iwam	Iniok
H010		Aum	Haus tambaran	GPS (C)	May River Iwam	Oum 3
H011		Iombui	*Masalai*/old settlement	Map	May River Iwam	Oum 3
H012		Tuam Yok	*Masalai*/old settlement	Map	May River Iwam	Oum 3
H013		Oum 3 Collection 1	Find location	GPS (O)	May River Iwam	Oum 3
H014		Wei or Way	Old settlement	Map	Sepik River Iwam	Tauri
H015		Aiomtome	*Masalai*	Map	Sepik River Iwam	Tauri
H016		Emarbogo	Haus tambaran	Map	Sepik River Iwam	Tauri
H017		Omwi or Owmui	*Masalai*/old settlement	Map	Sepik River Iwam	Tauri/Iniok
H018		Nowi	*Masalai*/old settlement	Map	Sepik River Iwam	Tauri
H019		Yapsu	*Masalai*	Map	Sepik River Iwam	Tauri
H020		Naiei	Old settlement	Map	Sepik River Iwam	Tauri
H021		Tauri clan - Iapiok *haus tambaran*	*Haus tambaran*	GPS (C)	Sepik River Iwam	Tauri
H022		Inogon clan - Iapiok *haus tambaran*	*Haus tambaran*	GPS (C)	Sepik River Iwam	Tauri
H023		Irapu	*Masalai*	Map	Sepik River Iwam	Iniok
H024		Uramapi	*Masalai*	Map	Sepik River Iwam	Iniok
H025		Panewai	Old settlement (Inogon clan history)	Map	Sepik River Iwam	Iniok
H026		Imombi	Old settlement (Inogon clan history)	Map	Sepik River Iwam	Iniok
H027		Namusin	Ritual/ceremonial	Map	Sepik River Iwam	Iniok
H028		Mawe (Iniok No. 1)	Ritual/ceremonial	GPS (O)	Sepik River Iwam	Iniok
H029		Owiap	*Masalai*	Map	Sepik River Iwam	Iniok
H030		Nowi 2	Story/Old settlement	Map	Sepik River Iwam	Iniok
H031		Afame	*Masalai*	GPS (H)	Owininga	Inagri

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
H032		Debunagau	*Masalai*	GPS (H)	Owininga	Inagri
H033		Are	*Masalai*	GPS (H)	Owininga	Inagri
H034		Nausetema	*Masalai*	GPS (H)	Owininga	Inagri
H035		Teve'imo	*Masalai*	GPS (H)	Owininga	Inagri
H036		Owi	*Masalai*	Map	May River Iwam	Oum 3
H037		Mowaitem	*Masalai* (creek junction)	Map	Telefol	Wabia
H038	J3	Ekwaitem	*Masalai* (waterfall)	Map	Telefol	Wabia
H039		Restricted Area	*Masalai*	Map	Telefol	Wabia
H040	J2A	Ariamuwip	Old settlement	Map	Telefol	Wabia
H041		Inaiyawip	Old settlement	Map	Telefol	Wabia
H042/H162	JW	Ekwai Imaal/Ekwai Cave	Story (cave)/Archaeological (rock art)	GPS (V)	Telefol	Wabia/Ok Isai
H043		Emteip Imaal	Ossuary	Map	Telefol	Wabia
H044		Anai Imaal	Archaeological (cave)	Map	Telefol	Wabia
H045		Mowai Imaal	Story/Archaeological (cave)	Map	Telefol	Wabia
H046		Uwaining	Economic (stone axe source)	Map	Telefol	Wabia
H047		Afaiwip	Old settlement	Map	Telefol	Wabia
H048		Eliptimin	Origin story (Iligim clan)	Map	Telefol	Wabia
H049		Kuyawip	Old settlement	Map	Telefol	Wabia
H050		Friluwip	Old settlement	Map	Telefol	Wabia
H051		Wabia (Old Wabia)	Old settlement	Map	Telefol	Wabia
H052		Kutbama	Story	Map	Telefol	Wabia
H053		Dawawip	Old settlement	Map	Telefol	Wabia
H054		Dawa Imaal	Ossuary	Map	Telefol	Wabia
H055		Awa Debom	Story (sacred mountain)	Map	Telefol	Wabia
H056		Uri Debom	Story (sacred mountain)	Map	Telefol	Wabia
H057		Awawip	Old settlement	Map	Telefol	Wabia
H058	G2	Unamoiwip	Old settlement	Map	Telefol	Wabia
H059		Ansetok Begolfrin	Story	Map	Telefol	Wabia
H060		Nutabil	Story	Map	Telefol	Wabia
H061	G1	Simana	Old settlement	Map	Telefol	Wabia
H062		Kunfagamawip	Old settlement	Map	Telefol	Wabia
H063		Yaramlia	Old settlement	Map	Telefol	Wabia
H064		Dumukemdang or Illigimdang	Story (mountain range)	Map	Telefol	Wabia

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
H065		Blo	Economic (firestone/pyrite ore source)	Map	Telefol	Wabia
H066		Bogopneokmuk	Economic (pond)	Map	Telefol	Wabia
H067		Haiwawip	Economic (garden and boundary)	Map	Telefol	Wabia
H068		Atkomkrukma	Economic (garden)/fight ground	Map	Telefol	Wabia
H069		Atkomkrukma Debom or Uyuvi Debom	Story (mountain)	Map	Telefol	Wabia
H070		Wepwao	Story	Map	Telefol	Wabia
H071		Tumolah	Ritual/ceremonial (stone monument)	Map	Telefol	Wabia
H072		Dungfumawip	Old settlement	Map	Telefol	Wabia
H073		Sum Mentalim	Economic (garden)	Map	Telefol	Wabia
H074		Titonkil	Old settlement	Map	Telefol	Wabia/Ok Isai
H075		Tofia'avip	Old settlement	Map	Telefol	Wabia/Ok Isai
H076		Frimtevip	Old settlement	Map	Telefol	Wabia/Ok Isai
H077		Anaiavip	Old settlement	Map	Telefol	Wabia/Ok Isai
H078	J2	Binaiavip	Old settlement	Map	Telefol	Wabia/Ok Isai
H079		Uyuvi or Amorai	Story	Map	Telefol	Wabia/Ok Isai
H080		Mimokavip	Old settlement	Map	Telefol	Wabia/Ok Isai
H081		Milifenavip	Old settlement	Map	Telefol	Wabia/Ok Isai
H082		Kariakot	Old settlement	Map	Telefol	Wabia/Ok Isai
H083		Unamo (Old Unamo)	Old settlement	Map	Telefol	Wabia/Ok Isai
H085		Amipbip	Old settlement	GPS (H)	Miyan	Amaromin
H086		Saya	Story (sinkhole)	GPS (H)	Miyan	Amaromin
H087		Kobunaka	Story (sinkhole)	GPS (H)	Miyan	Amaromin
H088		Gololbip	Ossuary	GPS (H)	Miyan	Amaromin
H089		Finamtem	Old settlement (CURRENTLY DELISTED)	GPS (V)	Telefol	Ok Isai
H090		Bogolamkala	Old settlement (hamlet)/Economic (sago)	Map	Telefol	Ok Isai
H092		Ubaikulelim	Old settlement (hamlet)	Map	Telefol	Ok Isai
H093		Honiai	Old settlement (hamlet)	Map	Telefol	Ok Isai
H094		Uyuvi 2?	Old settlement (hamlet)/Economic (sago)	Map	Telefol	Ok Isai
H095		Asekumikilin	Old settlement (hamlet)	Map	Telefol	Ok Isai
H096		Emtevipnagalim	Old settlement (hamlet)	Map	Telefol	Ok Isai
H097	J2	Binaivip (2)	Old settlement/fight ground/burial	Map	Telefol	Ok Isai
H098		Amulaifife	Old settlement (hamlet)	Map	Telefol	Ok Isai
H099		Yongfale Dang	Old settlement (hamlet)/burial	Map	Telefol	Ok Isai

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
H100		Drumtevip	Old settlement (hamlet)/burial	Map	Telefol	Ok Isai
H101		Aliamuvip	Old settlement (hamlet)	Map	Telefol	Ok Isai
H102	J11	Inaiyavip (2)	Old settlement (village)	Map	Telefol	Ok Isai
H103	G10, JZ	Ivalavip	Old settlement (hamlet)	Map	Telefol	Ok Isai
H104		Dumukepdang	Old settlement (village)/burial	Map	Telefol	Ok Isai
H105		Flimtevip	Old settlement (hamlet)	Map	Telefol	Ok Isai
H106	G5, J9	Mimokmun (2)	Old settlement (hamlet)/burial	Map	Telefol	Ok Isai
H107		Nofuma	Old settlement (hamlet)	Map	Telefol	Ok Isai
H108		Frunengtikin	Old settlement (hamlet)	Map	Telefol	Ok Isai
H109	G3	Dungfumavip (= the 'Unamo' shown on topo)	Old settlement (village)/burial	Map	Telefol	Ok Isai
H110		Takamoktebin	Old settlement (hamlet)/burial	Map	Telefol	Ok Isai
H111		Dokinapiv	Old settlement (hamlet)	Map	Telefol	Ok Isai
H112		Simanadang	Old settlements (village, two hamlets)/burial	Map	Telefol	Ok Isai
H113		Simanadang (hamlet 1)	Old settlement (hamlet)	Map	Telefol	Ok Isai
H114		Simanadang (hamlet 2)	Old settlement (hamlet)	Map	Telefol	Ok Isai
H115		Simanofon	*Masalai*	Map	Telefol	Ok Isai
H116		Frieda-Nena Junction	*Masalai* (fish *tambu*)	Map	Telefol	Ok Isai
H117		Nutabil (2)	Old settlement (village)/burial	Map	Telefol	Ok Isai
H118		Okungavip	Old settlement (hamlet)	Map	Telefol	Ok Isai
H119		Unamuavip (= old Unamo)	Story/Old settlement (village)/burial	Map	Telefol	Ok Isai
H120		Alfumavip	Old settlement (hamlet)	Map	Telefol	Ok Isai
H121		Murumengbil	Old settlement (hamlet)	Map	Telefol	Ok Isai
H122		Altonabil	Old settlement (hamlet)	Map	Telefol	Ok Isai
H123		Atamanipnakal	Old settlement (hamlet)	Map	Telefol	Ok Isai
H124	G4	Yetemdang (=Yetemkot)	Old settlement (village)	Map	Telefol	Ok Isai
H125		Tumaradang	Old settlement (hamlet)	Map	Telefol	Ok Isai
H126		Bengemdebom	Burial (*tambu*)	Map	Telefol	Ok Isai
H127		Ok Binai-Misitem junction	Burial	Map	Telefol	Ok Isai
H128		Ok Binai-Dinomtem junction	Burial	Map	Telefol	Ok Isai
H129		Ok Milia (Nena)-Ubai	Burial	Map	Telefol	Ok Isai
H130		Durankil	Burial	Map	Telefol	Ok Isai
H131		Alivaifif	Burial	Map	Telefol	Ok Isai
H132	J5?/JY?	Ok Isai Kongamemtem	*Masalai* place (*tambu*)	Map	Telefol	Ok Isai

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
H133		Aune	Burial (island)	Map	Telefol	Ok Isai
H134		Frieda-Nena Junction	*Masalai* place	GPS (V)	Telefol	Ok Isai
H135		Warenia	Story (special tree)/Old settlement (hamlet)	Map	Telefol	Ok Isai
H136		Mebluavip	Old settlement	Map	Telefol	Ok Isai
H137		Binaifip	*Masalai*	Map	Telefol	Ok Isai
H138		Solavufip	Old settlement/burial	GPS (V)	Telefol	Ok Isai
H140		Flobai	*Masalai* (cave, *tambu*)	Map	Telefol	Ok Isai
H141		Cave	Burial	Map	Telefol	Ok Isai
H142		Dagalkil	Economic (mineral seep)	Map	Telefol	Ok Isai
H143		Ubai Bagan	Economic (clay source)	Map	Telefol	Ok Isai
H144	G8	Emteip Debom	Story (mountain)	Map	Telefol	Ok Isai
H145	G9	Emteip Imaal	Archaeological (cave)	Map	Telefol	Ok Isai
H146	G7	Binaiavip (2)	Old settlement	Map	Telefol	Ok Isai
H147		Ifinungavip	Old settlement	Map	Telefol	Ok Isai
H148		Mongsomoavip	Old settlement	Map	Telefol	Ok Isai
H149		Aliamuvip 2	Old settlement	Map	Telefol	Ok Isai
H150		Imma Imaal	Archaeological (cave)	Map	Telefol	Ok Isai
H151		Nokomen Am	*Masalai* (cave)	Map	Telefol	Ok Isai
H152		Unamemtem	*Masalai* (*tambu*)	Map	Telefol	Ok Isai
H153	J5/JY	Kongamemtem	*Masalai* (*tambu*)	Map	Telefol	Ok Isai
H154		Yongfareavip	Old settlement	Map	Telefol	Ok Isai
H155		Atalavip	Old settlement	Map	Telefol	Ok Isai
H156		Uyubi Bengemdebom	*Masalai* (*tambu*)	Map	Telefol	Ok Isai
H157		Tenidebom	Story	Map	Telefol	Ok Isai
H158	J3?	Ekwaiamemtem	*Masalai* (*tambu*)	Map	Telefol	Ok Isai
H159		Sualefondam / Suale Imaal	Story (waterfall/cave)	Map	Telefol	Ok Isai
H160		Ayovip	Story/old settlement (village)	Map	Telefol	Ok Isai
H161		Cave at Henumai-Frieda junction	Story (sacred cave)	Map	Telefol	Ok Isai
H163		Cave at Ima-Bina junction	Story (sacred cave)	Map	Telefol	Ok Isai
H164		Annai Imaal	Story (sacred cave)	Map	Telefol	Ok Isai
H165		Brovip	Story/fight ground/economic (firestone source)	Map	Telefol	Ok Isai
H166		Uviaiamemtem	*Masalai* place (*tambu*, spiritual stone)	Map	Telefol	Ok Isai
H167		Foliaivip	Old settlement	Map	Telefol	Ok Isai

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
H168		Ok Binai-Apoiya junction	Burial	Map	Telefol	Ok Isai
H169		Nena River-Sumomelia junction	Burial	GPS (V)	Telefol	Ok Isai
H170		Sumomelia Dagal	Economic (mineral seep) (CURRENTLY DELISTED)	GPS (V)	Telefol	Ok Isai
H171		Ok Esai Collection 1	Find location (stone mortar and axe)	GPS (O)	Telefol	Ok Isai
H172		Ok Esai Collection 2	Find location (stone axe)	GPS (O)	Telefol	Ok Isai
H173	J8	Tomdibom	Story (sacred mountain)	GPS	Telefol	Ok Isai
H174		Mount Waren	Other (mountain)	GPS	Telefol	Ok Isai
H175	JX	Oknerenere	Other (place name – cave with sacra)	GPS	Telefol	Ok Isai
H176		Ok Esai Grave 1	Burial	GPS (V)	Telefol	Ok Isai
H177		Ok Esai Grave 2	Burial	GPS (V)	Telefol	Ok Isai
H178		Ok Esai Grave 3	Burial	GPS (V)	Telefol	Ok Isai
H179		Ok Esai Grave 4	Burial	GPS (V)	Telefol	Ok Isai
H180		Ok Esai Grave 5	Burial	GPS (V)	Telefol	Ok Isai
H181		Ok Esai Grave 6	Burial	GPS (V)	Telefol	Ok Isai
H182		Ok Esai Grave 7	Burial	GPS (V)	Telefol	Ok Isai
H183		Fetawe	Old settlement	Map	Saniyo-Hiyowe	Yabatauwe
H184		Weweomo	Old settlement	Map	Saniyo-Hiyowe	Yabatauwe
H185		Iloiye	Old settlement	Map	Saniyo-Hiyowe	Yabatauwe
H186		Kruba	Old settlement	Map	Saniyo-Hiyowe	Yabatauwe
H187		Neisapo	Old settlement	Map	Saniyo-Hiyowe	Suwano
H188		N/A [no name]	*Masalai*	Map	Saniyo-Hiyowe	Suwano
H189		Sifo	*Masalai*	Map	Saniyo-Hiyowe	Nikiei
H190		Nikiei	Origin story	GPS (V)	Saniyo-Hiyowe	Nikiei
H191		Omoeiwariye	*Masalai* (*tambu*)	Map	Saniyo-Hiyowe	Nikiei
H192		Haus Tamberan	Haus tambaran (spirit house)	GPS (V)	Wogamusin	Kubkain
H193		Nongto	*Masalai*	Map	Wogamusin	Kubkain
H194		Gulsu cave	Archaeological (cave)	Map	Wogamusin	Kubkain
H195		Gulsu	Story	Map	Wogamusin	Kubkain
H196		Dughaiyeir Mountain	Old settlement	Map	Wogamusin	Kubkain
H197		Kubka	Story	Map	Wogamusin	Kubkain
H198		Mongyuwui	Story	Map	Wogamusin	Kubkain
H199		Biglim	Story	Map	Wogamusin	Kubkain
H200		Baldab	Story	Map	Wogamusin	Kubkain

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
H201		Nganguwel	Story	Map	Wogamusin	Kubkain
H202		Fahotarohe	*Masalai*	Map	Yahe	Paru
H203		Kasawatu	Old settlement	Map	Yahe	Paru
H204		Nanalu	Old settlement	Map	Yahe	Paru
H205		Pa-o	Old settlement	Map	Yahe	Paru
H206		Waplomo	*Masalai*	Map	Yahe	Paru
H207		Ya'u'fatawi	Old settlement	GPS (V)	Saniyo-Hiyowe	Wakiawe
H208		Wa'alasonapauwi	Old settlement	Map	Saniyo-Hiyowe	Wakiawe
H209		Yenalo	Old settlement	Map	Saniyo-Hiyowe	Wakiawe
H210		Wariame	*Masalai* (*tambu*)	Map	Saniyo-Hiyowe	Wakiawe
H211		Wafeyame	*Masalai* (*tambu*)	Map	Saniyo-Hiyowe	Wakiawe
H212		He'i'omo	*Masalai*	Map	Saniyo-Hiyowe	Wakiawe
H213		Saple	Old settlement	Map	Saniyo-Hiyowe	Wakiawe
H214		Mopa'yo	*Masalai* (*tambu*)	Map	Saniyo-Hiyowe	Wakiawe
H215		Ta'ho'lo'la'we	Old settlement	Map	Saniyo-Hiyowe	Wakiawe
H216		Feta'u'e	Old settlement	Map	Saniyo-Hiyowe	Wakiawe
H217		Ai-hi-o	*Masalai*	Map	Saniyo-Hiyowe	Wakiawe
H218		Saloweili	*Masalai* (*tambu*)	Map	Saniyo-Hiyowe	Wakiawe
H219		Filisa'i	*Masalai* (*tambu*)	GPS (V)	Saniyo-Hiyowe	Maposi
H220		Maposi	Origin place	Map	Saniyo-Hiyowe	Maposi
H221		Maso	Old settlement	Map	Saniyo-Hiyowe	Maposi
H222		Pe'e'amo	Old settlement	Map	Saniyo-Hiyowe	Maposi
H223		Pe'e'amo	*Masalai* (*tambu*)	Map	Saniyo-Hiyowe	Maposi
H224		Oteni	Old settlement	GPS (V)	Saniyo-Hiyowe	Maposi
H225		Owano	*Masalai*	Map	Saniyo-Hiyowe	Maposi
H226		Oteni	*Masalai*	GPS (U)	Saniyo-Hiyowe	Maposi
H227		Ni'eri	Old settlement	Map	Saniyo-Hiyowe	Maposi
SAS001		Alimbip	Temporary encampment (CURRENTLY DELISTED)	GPS (V)	Telefol	Ok Isai
SAS007		Tubha Huktal	Cultural heritage location - *tumbuna* spirit site	GPS (V)	Wogamusin	Kubkain
SAS008		Wunwun Akor	Cultural heritage location - spirit site	GPS (V)	Wogamusin	Kubkain
CFH		Paupe Village	Rock Shelter	Transformed NSF Grid Ref		
CFM		??	Former Village	Transformed NSF Grid Ref		
CFY		May River Village	Artefact Collection	Transformed NSF Grid Ref		

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
CGE		Waskuk AREA	Artefact Collection	Transformed NSF Grid Ref		
CGL		Buremai Village	Artefact Collection	Transformed NSF Grid Ref		
CGS		YAIMONBI /YAUMBI Village	Artefact Collection	Transformed NSF Grid Ref		
CHB		??	Artefact Collection	Transformed NSF Grid Ref		
CHF		Bifrou Village	Artefact Collection	Transformed NSF Grid Ref		
CHG		Tipas Village	Artefact Collection	Transformed NSF Grid Ref		
CHH		Wamu Village	Artefact Collection	Transformed NSF Grid Ref		
CHN		Wogamush River	Artefact Collection	Transformed NSF Grid Ref		
CHX		Waniap Village	Artefact Collection	Transformed NSF Grid Ref		
CLA		Hotmin Village	Engraved human footprint	Transformed NSF Grid Ref		
CLI		Walio Village	Artefact Collection	Transformed NSF Grid Ref		
CNT		Arai Village	Artefact Collection	Transformed NSF Grid Ref		
CNU		Nimo Village	Artefact Collection	Transformed NSF Grid Ref		
CNV		Wosini Village	Artefact Collection	Transformed NSF Grid Ref		
CNW		Mapisi Village	Artefact Collection	Transformed NSF Grid Ref		
CQX		Kwemi Village	Archaeological	Transformed NSF Grid Ref		
CRB		Arai Village	Artefact Collection	Transformed NSF Grid Ref		
CRD		Frieda Airstrip	Artefact Collection	Transformed NSF Grid Ref		
CSY		Kupkein(Kupkain)	Artefact Collection	Transformed NSF Grid Ref		
RAB		Ivieg	Ossuary	Transformed NSF Grid Ref		
RAC		Leitre Old Viilage	Stone Figures	Transformed NSF Grid Ref		
RAD		??	Archaeological	Transformed NSF Grid Ref		
RAH		Dieru Settlement	Artefact Collection	Transformed NSF Grid Ref		
RAJ		Green River Gravel Rise	Artefact Collection	Transformed NSF Grid Ref		
RAK		Panganggan Cave	Cave/Rockshelter	Transformed NSF Grid Ref		
RAM		??	Artefact Collection	Transformed NSF Grid Ref		
RAN		NAMSIS Village	Story	Transformed NSF Grid Ref		
RAO		King Village	Archaeological	Transformed NSF Grid Ref		
RAP		Melonsonkun Rockshelter	Cave/Rockshelter	Transformed NSF Grid Ref		
RAQ		??	Cave/Rockshelter	Transformed NSF Grid Ref		
RAR		Imonda Rockshelter	Cave/Rockshelter	Transformed NSF Grid Ref		
RAU		Nimbitiberi Origin Site	Story	Transformed NSF Grid Ref		
RAV		Imal Migration Site	Story	Transformed NSF Grid Ref		

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
RAW		Bubeneika or Subak Hanu- Migration Site	Story	Transformed NSF Grid Ref		
RAX		Suain No.2 Origin site	Story	Transformed NSF Grid Ref		
RBA		Skel Waap Mal	Cave/Rockshelter	Transformed NSF Grid Ref		
RBB		Selminumitem (1) Cave	Cave/Rockshelter	Transformed NSF Grid Ref		
RBC		Selminumitem (2) Cave	Cave/Rockshelter	Transformed NSF Grid Ref		
RBD		??	Ossuary	Transformed NSF Grid Ref		
RBE		At Tem Luun Tem Cave	Cave/Rockshelter	Transformed NSF Grid Ref		
RBF		Bal Kurinin or Bal Kuun Luun Tem	Ossuary	Transformed NSF Grid Ref		
RBG		Wok dubim Tem	Ossuary	Transformed NSF Grid Ref		
RBH		Keneng Keneng Tem	Ossuary	Transformed NSF Grid Ref		
RBS		Yasipik Village	Former Village	Transformed NSF Grid Ref		
RBT		??	Former Village	Transformed NSF Grid Ref		
RBU		Wiit Yaap	Former Village	Transformed NSF Grid Ref		
RBV		Anguganak	Former Village	Transformed NSF Grid Ref		
RBW		Bogasip	Former Village	Transformed NSF Grid Ref		
RBX		Hamlet of Anguganak	Former Village	Transformed NSF Grid Ref		
RBY		Hamlet of Anguganak	Former Village	Transformed NSF Grid Ref		
RCA	CFX	??	Artefact Colleciton	Transformed NSF Grid Ref		
RCC		Mukwasi Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCD		??	Artefact Colleciton	Transformed NSF Grid Ref		
RCE		Mahane Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCF		Mukadane Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCG	CGP	Umeda Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCJ		Bapi Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCK	CGU	Yawani Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCL	CGV	Yegelapi Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCM		Nagitman Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCN	CGX	Nami Klamet Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCO	CGY	Akwom village	Artefact Colleciton	Transformed NSF Grid Ref		
RCQ	CHA	Amenais village	Artefact Colleciton	Transformed NSF Grid Ref		
RCR	CHC	Biaka Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCS	CHE	Halakori Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCT		Bifrou Village	Artefact Colleciton	Transformed NSF Grid Ref		

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
RCU		Tipas Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCX		Kwieftim Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCY	CHZ	Yuri Village	Artefact Colleciton	Transformed NSF Grid Ref		
RCZ	CIB	Wamu Village/Nia Village	Artefact Colleciton	Transformed NSF Grid Ref		
RDD		Aitape Skull	Burial	Transformed NSF Grid Ref		
RDE		Stolle Stone Quarry	Archaeological	Transformed NSF Grid Ref		
RDF		??	Archaeological	Transformed NSF Grid Ref		
RDG		Monnadim	??	Transformed NSF Grid Ref		
RDH		??	Ossuary	Transformed NSF Grid Ref		
RDI		??	Artefact Colleciton	Transformed NSF Grid Ref		
RDJ		Telefolip	Ossuary	Transformed NSF Grid Ref		
RDN		??	Subsistence/Trade	Transformed NSF Grid Ref		
RDO		??	Subsistence/Trade	Transformed NSF Grid Ref		
RDP		Anataman- Upper Frieda	Sculpted Figurine	Transformed NSF Grid Ref		
RDQ		Mianmin Airstrip	Artefact Collection	Transformed NSF Grid Ref		
RDR		Inika De Bom	Cave/Rock Shelter	Transformed NSF Grid Ref		
RDS		Fogorobe Tem Ancestral Spirit Site	Story	Transformed NSF Grid Ref		
RDT		Wabia Gorge	Cave/Rock Shelter	Transformed NSF Grid Ref		
RDU		Urepmilap Cult House	Story	Transformed NSF Grid Ref		
RDV		Mianmin Airstrip	Artefact Collection	Transformed NSF Grid Ref		
RDW		Tan De Bom Quarry	Archaeological	Transformed NSF Grid Ref		
RDX		Tumolbil Airstrip	Artefact Collection	Transformed NSF Grid Ref		
REB		Nabnbut Village	Artefact Collection	Transformed NSF Grid Ref		
REC		Wamu Village	Artefact Collection	Transformed NSF Grid Ref		
RED		Bipan Village	Artefact Collection	Transformed NSF Grid Ref		
REU		Bamblediam Village -Idam River	Artefact Collection	Transformed NSF Grid Ref		
RGB		Buap Olsel	Ossuary	Transformed NSF Grid Ref		
RGC		Wai'ou	Ossuary	Transformed NSF Grid Ref		
RHC	CHD	Rawei Village	Artefact Collection	Transformed NSF Grid Ref		
CQV		Arapi Village	Artefact Collection	Transformed NSF Grid Ref		
CQU		Lariaso Village	Artefact Collection	Transformed NSF Grid Ref		
G6		Dusam's ancestral sago	Story	TDenham 18-06-2011	Telefol	
G11		Wamaei settlement: Amukefip	Former Village	TDenham 18-06-2011	Telefol	

Site Code	Alternative Site Code	Site Name	Site Type	Coordinate Source	Language	Village
J1		Womkiimmun	??	TDenham 14-06-2011	Telefol	
J4		Dubalbang-dubom	??	TDenham 14-06-2011	Telefol	
J7A		Wisiliya-dubom	??	TDenham 14-06-2011	Telefol	
J10		Ok Amurai	??	TDenham 14-06-2011	Telefol	
J		First Unamo site	??	TDenham 14-06-2011	Telefol	

Appendix 3

Community Health and Nutrition Baseline Report

Baseline Health, Diet and Nutrition Survey
Frieda River Copper-Gold Project

BY

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Glossary

BCG	Vaccine for immunisation against tuberculosis
BMI	Body Mass Index anthropometric criteria used for adolescent and adult nutritional assessments
CEH	Centre for Environmental Health
CHC	Department of Health child health cards
DPT3	Combined vaccine for diphtheria, pertussis (whooping cough) and poliomyelitis
HEO	Health Extension Officer
NGO	Non-government organisation
NSO	PNG National Statistics Office
PNG	Papua New Guinea
UNICEF	now referred to as the United Nations Children's Fund
URTI	Upper respiratory tract infection
WHO	World Health Organization
FRL	Frieda River Limited

Executive Summary

Introduction

Frieda River Limited (FRL) is proposing to develop the Sepik Development Project in northern Papua New Guinea (PNG).

The Sepik Development Project consists of four interdependent projects:

- Frieda River Copper-Gold Project.
- Frieda River Hydroelectric Project.
- Sepik Infrastructure Project.
- Sepik Power Grid Project.

The Sepik Development Project is primarily located within the Sepik River catchment and comprises development of a copper-gold deposit in Sandaun Province and supporting infrastructure and facilities in the Sandaun and East Sepik provinces

This report was prepared for the Frieda River Copper-Gold Project (the Project) which will comprise open pit mining at the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) porphyry copper-gold deposits over a 33 year mine life (with an additional 7-year implementation period). Processing of ore will be by crushing, grinding and flotation circuit, to produce a copper-gold concentrate. Tailings and waste will be stored subaqueously in an engineered integrated storage facility (ISF) located in the Frieda Valley which will be constructed as part of the Frieda River Hydroelectric Project. The concentrate will be transported via pipeline to a concentrate dewatering, storage and export facility at the upgraded Vanimo Ocean Port

The Centre for Environmental Health (CEH) baseline environmental health, diet and nutrition survey is a supporting study to the Environmental Impact Statement prepared by Coffey. The survey broadly examines the socio-economic circumstances, public and environmental health, diet and nutritional status, and clinical health of sentinel communities living around and down river from the Project area.

This report has been prepared in accordance with accepted practice for environmental health and nutrition characterisation for resource development projects in PNG.

Scope of work

The overall objective of the baseline environmental health, diet and nutrition survey was to characterise the health status of the population of potentially affected communities in the mine area, 2011 concentrate pipeline corridor (including the mine access road), and along the Sepik River corridor. The survey results are one element of a broad range of social and environmental studies to assist in the identification of potential Project impacts that will inform mitigation and community development strategies.

The detailed scope of work included:

- custom-designed village and household surveys implemented to establish household demographics of the survey group in relation to age, sex, ethnicity and length of residence;
- an examination of the selected households' social, economic and environmental health conditions, including income, access to social and health infrastructure,

overcrowding, availability of ventilation, control of vector-borne diseases and consumption of addictive substances;
- a 24-hour dietary recall and annual food consumption frequency survey, supported by anthropometric measurements to determine the nutritional status of the communities in comparison with other PNG groups; and
- individual clinical examinations and a medical questionnaire to determine the health status of the survey communities, including examination of liver, kidney, spleen and lymph nodes, prevalence of eye and skin infections and dental health. The questionnaire elicited details of perceived health status and medical conditions during the previous 12 months and over the preceding week. The vaccination status of infants was also investigated.

This work also contributed to the fulfilment of the following issues identified in the Environmental Inception Report (prepared by Coffey in 2009 and subsequently updated in 2011, 2015 and 2017) and addressed in the Social Impact Assessment (Coffey 2018):
- Enhanced or deteriorated general quality of life of local communities and those living downstream from the Project, with particular focus on their livelihoods, subsistence resources, income derivation, land connection and use, and local culture and customs. (In some aspects quality of life will be enhanced, eg., improved access to markets and social services, and in others, such as the disturbance to daily activities on the Sepik River from barging, they have the potential to be negative, eg., increased spread of communicable diseases.)
- Increased migration and associated potential impacts on social cohesion, safety and security, health, land use, services, infrastructure and accommodation. This may also result in increased demand for local food products and timber, as well as increased local incomes through the expansion of cultivation of gardens for produce, fishing activity and small-scale logging, with consequent changes in the consumption patterns of local villagers and associated impacts such as increased generation of domestic wastes.
- Increased rate of the contraction and spread of HIV/AIDS.
- Impacts on social and physical infrastructure (including infrastructure at the nearby regional centres) and the capacity for existing infrastructure to support development associated with new business opportunities.

The baseline environmental health, diet and nutrition study was undertaken over three separate field campaigns, as follows:
- Mine area – January 2010.
- Sepik River Corridor – May 2010.
- 2011 concentrate pipeline corridor (including mine access road) – May 2011.[1]

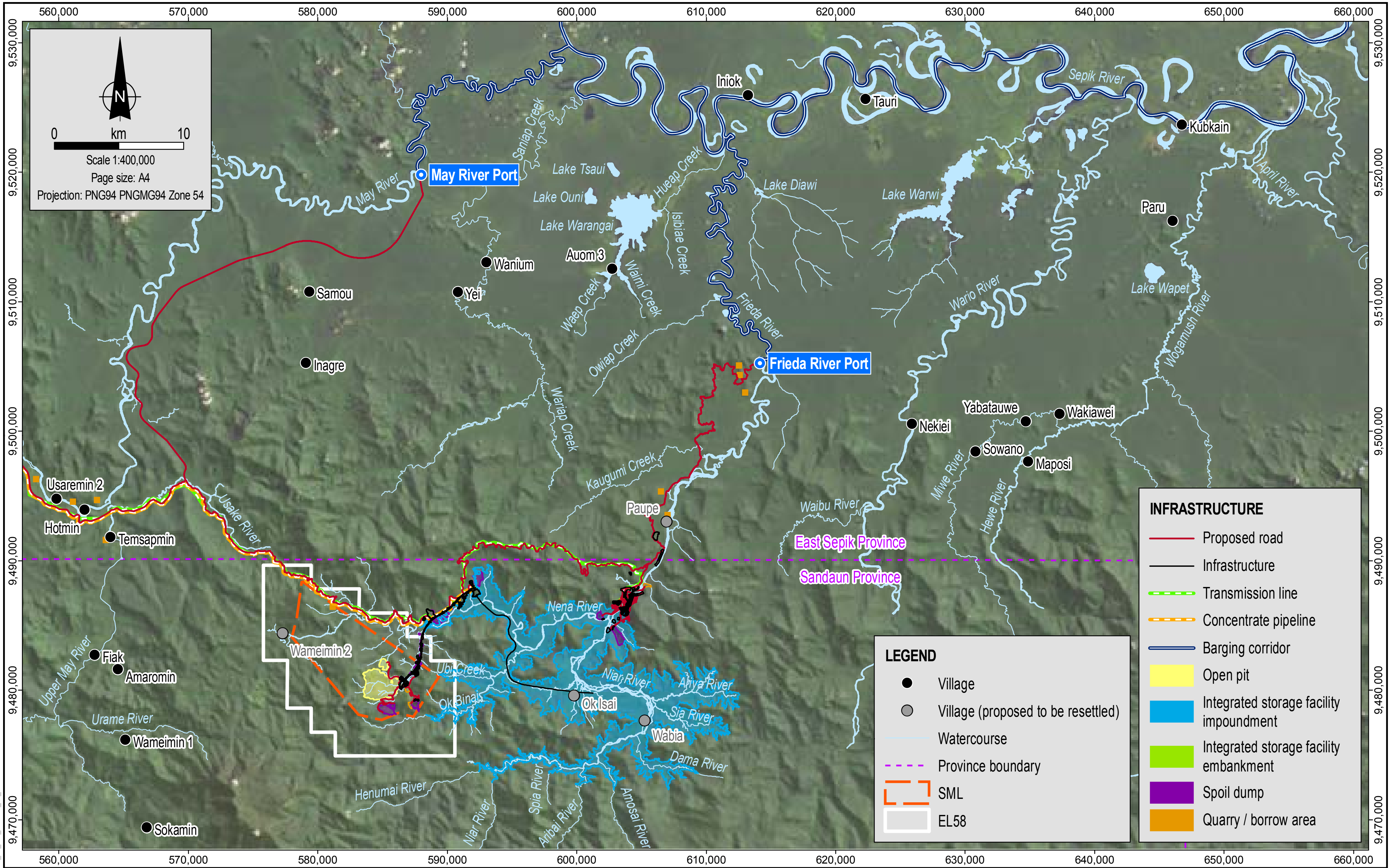
Table 1 indicates the villages surveyed in each Project area for the baseline environmental health, diet and nutrition study.

[1] The location of the infrastructure corridor, including the concentrate pipeline and main access route, has been revised since the completion of the surveys. This report refers to a previous infrastructure corridor alignment from 2011.

Table 0-1: Villages surveyed in baseline environmental health, diet and nutrition study

Language Group	Community	District	Province
Mine area			
Miyan	Hotmin	Ambunti-Dreikikir	East Sepik
	Wameimin 1	Telefomin	Sandaun
	Wameimin 2	Telefomin	Sandaun
	Amaromin	Telefomin	Sandaun
Owininga	Samou	Ambunti-Dreikikir	East Sepik
Telefol	Ok Isai	Telefomin	Sandaun
	Wabia	Telefomin	Sandaun
Paiyamo	Paupe	Ambunti-Dreikikir	East Sepik
May River Iwam	Auom 3	Ambunti-Dreikikir	East Sepik
Sepik River Iwam	Iniok - Nenuwe	Ambunti-Dreikikir	East Sepik
2011 infrastructure corridor (including mine access road)			
Saniyo-Hiyowe	Nekiei	Ambunti-Dreikikir	East Sepik
	Sowano	Ambunti-Dreikikir	East Sepik
	Yabatauwe	Ambunti-Dreikikir	East Sepik
Wogamusin	Kubkain	Ambunti-Dreikikir	East Sepik
Sepik River corridor			
Kanda	Bin	Angoram	East Sepik
Iatmul, Ampa, Kanda, Kakra	Angoram	Angoram	East Sepik
Kam, Manung, May River, Mamara	Ambunti	Ambunti-Dreikikir	East Sepik
Galadup	Swagup	Ambunti-Dreikikir	East Sepik
Not recorded	Sapanaut	Wosera-Gawi	East Sepik
Yessan-Mayo	Yessan	Ambunti-Dreikikir	East Sepik

Figure 1-1 shows the mine area villages and 2011 concentrate pipeline corridor villages.



Source:
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown).
Hillshade DEM from SRTM.

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File Name: 11575_11_BM_F003a_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Mine and Frieda River Hydro-electric Project area, and downstream corridor

Figure No: 1-1

MXD Reference: 11575B_11_BM_GIS003_v0_9

This document brings together three separate reports prepared following fieldwork in each of the different Project areas by CEH.

Survey Methodology

The following methodology was applied to each of the surveys conducted over the three separate field campaigns. Where the approach differed, or a variation was required, an additional methodology section has been included in each section of the report pertaining to each separate field campaign and geographic component of the Project.

Village selection

Villages were selected in order to give representative coverage of potentially Project-affected communities to adequately characterise the health of the population in each of three Project areas. Village selection is further discussed in each section of the report pertaining to each of the separate field campaigns and geographic components of the Project.

The majority of villages were contacted prior to the visit of the study team by staff from the Project Community Affairs team, and the agreement of the respective Village Councillors/Leaders obtained. Before commencement of any activities at the villages or questionnaire-clinical examination at the participant households, the Community Affairs staff again discussed (in detail), the purpose of the survey and provided an opportunity for questions and gained permission from the participating households.

Questionnaire format and implementation

Three questionnaire instruments and two clinical physical measurement examinations were designed for the survey. These are provided in Appendices 1 to 11. The questionnaires comprised numerous distinct components: a village-level questionnaire, a household questionnaire to elicit details on health and social parameters and household nutrition. Another survey questionnaire was designed to be used in association with a non-invasive medical examination to obtain an overall assessment of the health of the communities.

Village questionnaire

The village questionnaire elicited information on demographic, environmental, social and economic circumstances of the entire village communities. The village questionnaire is provided in Appendix 1. The questionnaire was not designed to obtain detailed census information. This was undertaken in parallel by Coffey as a separate survey.

The village questionnaire was completed by the Project Health Extension Officer (HEO) in discussion with the Village Councillor/Leader and included a visual survey of the community to observe the facilities first hand.

Household, nutrition and mother and child health questionnaire

The household questionnaire was designed to provide a more detailed analysis of each participating household, with a primary focus on environmental health circumstances, household economic details and healthy behaviour and lifestyles. These factors are the main determinants of population health. The household questionnaire was directed at the head of household, or when the head of household was unavailable, the most senior member of the household present. The household questionnaire is provided in Appendix 2.

The household nutrition questions targeted short-term dietary information and was designed to examine both food security and household dietary preferences. The 24-hour dietary recall was designed to be compatible with the Household Survey Component of the Poverty Assessment for Papua New Guinea (World Bank 1996).

Establishing total dietary intakes requires consumption frequencies of dietary items of varying seasonal availability to be presented on an annual consumption basis. This was achieved in the present work, by the conduct of a food frequency survey using the food classifications of the 1996 Poverty Assessment for Papua New Guinea (World Bank1996).

The nutrition component was generally directed at the mother/caregiver, as being the most appropriate person, although on a number of occasions, responses were provided jointly by both the head of household and the mother.

To avoid any variation in approach, and hence potential bias between the responses, all household-level interviews were conducted by a single interviewer with substantial experience in similar survey work in PNG. Using this approach also assisted in minimising the time spent at each household (approximately 25 - 30 minutes).

Medical questionnaire (undertaken in conjunction with non-invasive clinical examination)

The medical questionnaire targeted the individual's perception of their health, medical diagnosis and treatment in the previous 12 months and medical complaints over the previous 7 days. The questionnaire focused on those clinical conditions which are routinely included into the Ministry of Health national health indicators for disease prevalence in rural and remote PNG communities[2]. The medical questionnaire is provided in Appendix 3.

All data entries were cross-checked at the survey team meeting at the end of each day and any anomalies resolved before moving on to the next village. Following the completion of coding and data analysis of the medical questionnaire, individual identifiers have been removed from the report appendices.

Medical examinations

A general body observation, with the patient in a sitting position, was made for any abnormality. The neck, thorax and abdomen were examined for any enlargement of the lymphatic system and the abdomen palpated for enlargement of the kidneys liver and spleen. Splenomegaly was graded according to Hackett (1943). The clinical examination form is provided in Appendix 4.

Blood pressure was taken, either with a standard adult aneroid sphygmomanometer, or a paediatric sphygmomanometer for infants and children under 10 years of age. The cuff was applied to the right upper arm whilst resting in a sitting position. The diastolic

[2] According to the National Health Plan 2001 - 2010 Provincial and District Health Profiles Volume III Part Two, Papua New Guinea Ministry of Health, Port Moresby; and the 2006 Demographic and Health Survey, PNG National Statistical Office, October 2009.

sound was taken as the last muffling sound before its disappearance or the fifth Korotkoff.

Eye and skin infections were estimated for each patient. Dental and periodontal health was also assessed to monitor the number of missing teeth, dental caries and fillings and to determine the prevalence of gum disease.

Although not formally part of the survey, routine ante-natal checks were undertaken for late-term pregnant mothers present at the time of the survey. Similarly, when the survey medical officer Dr Alphonse Tay, or the Project HEO identified the need for further health support, these participants were treated either with the limited range of medications available, or formally referred to the appropriate government health centre.

Anthropometric measurements

Height, length and recumbent length (for children less than two years of age) and waist circumference were measured using the village line-up method. This had advantages over undertaking measurements in association with the medical examinations at the individual households. This approach required a less frequent recalibration of the weighing scales and the height-measuring device and ensured a much greater coverage, with a lower measurement error. The village line-up data was correlated with the individual medical examination results at the end of each survey day. The anthropometric form is provided in Appendix 5.

In almost all of the villages there were no suitable vertical walls to attach a microtoise (a height-measuring tape). This was overcome by using a custom-designed tripod (with levelling capacity) to which was added an extension to support the microtoise. In practice this procedure has proved extremely effective in a number of PNG health surveys.

The subject’s height was measured without shoes and eyes looking straight ahead while keeping heels on the ground. Height was recorded to the nearest 0.5 centimetre. Recumbent length for infants under two years of age was measured, using a baby mat (a recumbent height-measuring mat for babies), with the knees extended and feet flexed at right angles. Length was determined to the nearest 0.5 centimetre.

Weights were recorded in normal clothing. Babies’ weights were obtained by weighing with an adult. The adult was weighed first, and the baby’s weight was obtained by subtracting the adult’s weight from the combined weight. Weight was recorded to the nearest 0.5 kilogram. An allowance of 0.5 kg was made for clothing for all participants over 2 years of age and 0.3 kilograms for clothed infants 0 – 2 years of age.

Waist measurements were undertaken against the skin or, on occasions for adult females, over a single layer of clothing, with the person standing erect with the weight evenly balanced on both feet, the feet approximately 30 centimetres apart and the arms hanging loosely at the sides. The tape was passed horizontally around the body, midway between the interior margin of the last rib and the crest of the ilium in the mid-axillary plane as recommended by WHO (1995). Measurements were recorded to the nearest 0.5 centimetre. All female adolescent and adult female measurements were undertaken by female personnel from the Frieda River Copper-Gold Project Community Affairs Department.

Constraints

The adoption of a household-level strategy for the survey enabled the development of a detailed assessment of the particular environmental health and nutritional circumstances at the family level. The restrictions on the sample size that could be achieved using this approach were, to some degree, overcome by using a village line-up method for the collection of the anthropometric data.

As for most village-level surveys conducted in PNG, it was impractical to conduct individual question-response interviews even though interviews were conducted at the individual households. Thus, many interview situations were conducted in a communal environment. To the extent practical (eg. by constant eye contact), responses were elicited from the target individual. However, it has to be accepted that an unknown and unquantifiable bias may have entered into the interview responses when dealing with sensitive questions (eg. cleaning the household and surrounds to eliminate mosquito breeding sites).

The study participants were generally given their physical examinations and medical questions away from other non-family community members. On the relatively few occasions when private consultation was preferred, the examination was conducted inside the house. However, this does not exclude responses being made to meet the perception of other family members.

The anthropometric data is a record of those people who were actually present on the date of the survey, and does not take into account absentees.

Analysis of the aggregated data for all villages by age group revealed a relatively young population, typical of that observed in other PNG studies of rural communities (Taufa 1997, Flew 1999). The population pyramid had a typical broad base, reflecting high fertility and subsequent high mortality. In the absence of village census books, the population data collected in the present survey was insufficiently robust to make quantitative estimation of infant and child mortality rates.

Further constraints relevant to each Project area are discussion in the individual sections of this report pertaining to each field campaign.

1.0 Mine Area

For the mine area (Figure 1-1), the baseline environmental health, diet and nutrition study was undertaken at 10 villages in the Telefomin and Ambunti-Drekikier districts of Sandaun (West Sepik) and East Sepik provinces, respectively.

The overall environmental health results, while differing markedly between villages, are reasonably typical for remote low-altitude rural and remote communities in PNG. Drinking water supplies were mainly from unprotected creek and river sources, the use of household pit latrines varied widely with sanitary wastes being frequently discharged to the surrounding environment and solid waste disposal was at best disorganised. For most village households, the results confirmed that overcrowding and ventilation were not of health concern.

The nutritional surveys identified significant differences in the range of food consumed and consumption frequencies between the more isolated inland villages and those along the Frieda and Sepik Rivers. The degree of isolation, local environmental conditions and household access to a cash income stream were the main determinants for food diversity and food consumption frequency.

The village anthropometric measurement data gave a profile of above average nutritional health with little wasting, stunting or underweight in children under 5 years of age. The village of Samou, however, was a notable exception.

The survey villages had widely variable immunisation coverage rates. On a whole-of-population basis, immunisation coverage was markedly below the average in PNG.

For all villages the percentage of household participants reporting very good or good health circumstances in the previous 12 months exceeded 65%. Results at the village level corresponded well with the results of the clinical examinations.

The measurement of blood pressure indicated that there were few hypertensive individuals, as to be expected in a group with very low levels of adult obesity. Examination of liver, kidney and lymph nodes identified a very low prevalence of clinical conditions associated with these organs. Spleen enlargement was typical of communities living in hyperendemic malaria areas of rural and remote PNG.

The prevalence of eye infections was similar to the results reported for a number of other inland village groups, but markedly higher than that observed along the Ramu River system in Madang Province CEH (2007a). The prevalence of skin infections varied between villages and on a whole-of-population basis was somewhat higher than that reported in other recent PNG studies (CEH (2003), (2007a), (2007b)).

The ethnically diverse mine area villages are in an area of very low population density. The villages to the west of the proposed mine (Amaromin, Hotmin, Wameimin 1 and Wameimin 2) and Samou to the north-west, continued to practice subsistence agriculture. Cash income sources for all but Samou village included working for the Frieda River Copper-Gold Project. Some households in each of these communities derived a supplementary income from panning for gold dust and nuggets.

For the villages located to the east of the proposed mine (including Ok Isai, and Wabia in the Niar River valley) and to some degree Paupe, subsistence agriculture was less dominant with many village households deriving their main source of income from alluvial gold mining. The villages to the north of the mine and ISF area (Auom 3and Iniok) subsisted principally on a diet of sago and fish. These villagers derived a large proportion of their income from crocodile farming and at Iniok, trade along the Sepik and Frieda rivers systems.

Figure 1-1 shows the mine area and infrastructure corridor villages.

1.1 Survey methodology

1.1.1 Village selection

The villages surveyed as part of this field campaign are considered to be representative of those in the mine area, and are listed in Table 1-1: Villages surveyed in baseline environmental health, diet and nutrition study.

The villages selected varied widely in size from Amaromin (25 households and total population of 116) to Hotmin and Iniok with populations of approximately 450 each. The villages were all predominantly original ethnic groups with a limited number of settler families. The altitude, local environment and agricultural systems, and health and socio-economic circumstances varied widely between the communities.

Examples of the variability in access to health and education facilities are shown in Tables 1-1 and 1-2.

Table 1-1: Access to public health facilities

Village	Village aid post		Health Centre		Hospital		Comment
	Nearest location	Distance (hours)*	Nearest location	Distance (hours)*	Nearest location	Distance (hours)*	
Amaromin	Mowi	24	Ambunti	72	Telefomin	336	Walking
Hotmin	May R Station	4	Ambunti	8	Wewak	30	By motor canoe
Iniok	Mowi	3	Hauna	12	Wewak	36	Combined motor canoe and truck
Ok Isai			Telefomin (15 minutes by air, 168 hours walking)				
Auom 3	Mowi	0.5	Pekwai	3	Wewak	60	Combined motor canoe and truck
Paupe	Wabia	1	Hauna	4	Wewak	72	
Samou	May R Station (10 hours by paddle canoe)				Wewak	84	
Wabia	Wabia	0	Telefomin (17 minutes by air, 72 hours walking)				
Wameimin 1	Meiamin	72	Telefomin (336 hours walking)				
Wameimin 2	Meiamin	72	Telefomin (336 hours walking)				

* Distance is estimated by survey participants and would vary depending on the speed at which they are able to travel and their comprehension of time and distance. It is provided for indicative purposes only.

Amaromin (at the neighbouring village of Fiak), Ok Isai, Paupe and Wameimin 2 had unmanned aid posts. The aid post at Fiak was functional in 2007, but had since closed (Mimat et al 2007).

The village aid post at Wabia was located in a permanent building, and was serviced by a local trained nursing officer, following the departure of the community health worker.

There was no village-trained midwife. The aid post had stocks of in-date drugs and basic supplies (bandages, etc). There was no capacity for sterilisation of medical equipment.

Similar to all of PNG in recent years, and particularly in rural and remote environments, the health infrastructure at the survey villages was seriously degraded in both core and targeted program funding (eg. for key drugs, tuberculosis management and immunisation). Health service delivery in these environments was at best intermittent, being further conditional on the availability of qualified and motivated staff (from the district health centres).

Table 1-2: Access to education facilities

Village name	Elementary school	Trained teachers	Adequate* classrooms	Adequate* teaching materials	High school	
	Yes/No	Yes/No			Nearest location	Distance** hours (mode)
Amaromin	See note 1	Yes (3)	Yes	Yes	Telefomin	336 (walk)
Hotmin	Yes	Yes (2)	Yes	Yes	Telefomin	96 (walk)
Iniok	Yes	Yes (2)	Yes	No	Ambunti	12 (motor canoe)
Ok Isai	Yes	Yes (1)	No	No	Telefomin	168 (walk)
Auom 3	Yes	Yes (2)	Yes	No	Ambunti	12 (motor canoe)
Paupe	No	No	No	No	Ambunti	9 (motor canoe)
Samou	Yes	Yes (1)	Yes	No	Ambunti	24 (motor canoe)
Wabia	No	No	No	No	Telefomin	72 (walk)
Wameimin 1	Yes	Yes (2)	Yes	Yes	Telefomin	336 (walk)
Wameimin 2	Yes	Yes (2)	No	No	Telefomin	336 (walk)

* Adequacy is the opinion of survey respondents and in some cases observed by the study team.
** Distance is estimated by survey participants and would vary depending on the speed at which they are able to travel and their comprehension of time and distance. It is provided for indicative purposes only.

Amaromin had access to an elementary school at Fiak village (one hour walking). The school at Fiak had three trained teachers (Certificate in Community School Teaching). Amaromin also had churches and a community hall. There was an air strip at Fiak, which was also used by the Hotmin, Wameimin 1 and Wameimin 2 communities. This involved 24 hours of walking for the Wameimin 1 and 2 communities.

There was elementary and primary teaching available at Ok Isai. Ok Isai had its own air strip. The water front at Ok Isai comprised a number of motorised canoes and about 20 tents selling a wide range of trade store goods, including beer, cosmetics and second-hand electronic goods. Ok Isai had a number of permanent residences, some with their own generators and a wide range of electronic and white goods.

Paupe had access to the air strip at Ok Isai (one hour by motorised canoe). The village had both churches and a community hall.

The village at Samou had a regular market exchange with the May River communities. The lack of any employment opportunities and cash income limited the exchanges largely to vegetables (Samou) and fish (May River). Access to an air strip at Etare was 18 hours walking. Tok Pisin was widely spoken, resulting from a historical association (1992 – 2003) with resident New Tribes Mission missionaries.

Wabia had access to an elementary school at Ok Isai, some two hours distant. Wabia had its own air strip, with regular bi-weekly flights operated by the Mission Airline Foundation. Charter flights were used fairly frequently by gold buyers and the Councillor. Gold was the major income source and some families had 3 to 4 dredges operating. Store goods were readily available, being shipped upriver by motorised canoes, or brought in by air.

Wameimin 1 and 2 had above average elementary school facilities, with all teachers at both villages having elementary school teaching certificates.

1.1.2 Constraints to the conduct of the campaign

None of the survey villages had a village map showing household locations. As a result, the use of a stratified fully random survey methodology was not practical. As a compromise, household selection at nine of the villages was undertaken by selecting houses from each of the edges and centre of the village. Where there were a number of groups of houses, each group was surveyed in numbers approximate to the number of households as a fraction of total village households. At Hotmin, the survey was implemented after a number of delays due to poor weather conditions, resulting in most of the residents being absent from the village at the time of the survey, therefore every available occupied household was included into the survey. There were no inclusion or exclusion criteria for participation.

The anthropometric data is a record of those people who were actually present on the date of the survey, and does not take into account absentees. For example, at Hotmin many groups were unavailable for the survey, being involved in hunting preparations for the end-of-year school closing party, had gone on a shopping trip to Vanimo by motorised canoe, were in the village gardens or away from the village panning for gold. Although with the school year completed there was a good representation from the child and adolescent groups, many adult males were away fulfilling their employment commitments with the Project.

For the 24-hour and food preference frequency, more than 97% of all villages had residents who had at least 15 years residency and normally a whole-of-lifetime residency. The survey, therefore, did not distinguish between households of local indigenous people and settler families. Similarly, with very few households being recorded as of the Seventh Day Adventist faith, concerns regarding cultural dietary restriction were irrelevant.

1.2 Results and discussion of findings

1.2.1 Demography

The household questionnaire survey population and the group available for anthropometric measurements and for clinical assessments by village, age and sex is shown in Table 1-3. In the absence of quantitative age-sex groupings for the total village populations from the demographic census survey, the percentage participation rates can only be derived on a whole-of-population basis. This is shown in Table 1-4.

Table 1-3: Household, anthropometric measurement and medical examination survey populations by age and sex (number of participants)

Village	0 - 5 years		6 - 10 years		11 - 16 years		17 – 44 years		45 + years		Total participants	
	M	F	M	F	M	F	M	F	M	F	M	F
	Household survey											
Amar	7	4	4	5	1	7	12	11	5	6	29	33
Hotmin	10	10	8	3	4	7	16	17	6	2	44	39
Iniok	8	9	8	7	5	4	16	16	4	2	41	38
Ok Isai	13	20	10	12	8	5	22	30	6	6	59	73
Auom 3	6	5	4	5	7	6	11	12	4	4	32	32
Paupe	14	5	7	11	8	7	20	23	9	12	58	58
Samou	11	14	9	9	15	7	17	20	5	4	57	54
Wabia	6	13	8	10	10	11	26	19	9	8	59	61
Wam 1	4	6	8	6	5	7	25	12	7	5	49	36
Wam 2	10	12	6	4	8	4	16	19	9	8	49	47
Total	**89**	**98**	**72**	**72**	**71**	**65**	**181**	**179**	**64**	**57**	**477**	**471**
	Anthropometric measurement											
Amar	16	8	9	11	2	5	16	29	9	6	52	59
Hotmin	10	8	3	0	2	3	11	9	2	5	28	25
Iniok	9	5	17	7	10	7	40	14	2	2	78	35
Ok Isai	14	17	8	11	5	7	23	56	7	6	57	97
Auom 3	7	8	1	5	1	5	5	17	3	4	17	39
Paupe	19	7	4	11	3	2	14	18	5	4	45	42
Samou	10	15	14	9	11	4	19	19	6	5	60	52
Wabia	8	16	6	10	5	8	35	29	12	8	66	71
Wam 1	7	3	15	11	3	7	9	11	3	5	37	37
Wam 2	10	10	6	4	1	6	10	21	6	3	33	44
Total	**110**	**97**	**83**	**79**	**43**	**54**	**182**	**223**	**55**	**49**	**473**	**502**
	Medical examination											
Amar	8		7		1		8		7		31	
Hotmin	13		4		5		16		4		42	
Iniok	13		4		2		15		3		37	
Ok Isai	16		6		3		20		6		51	
Auom 3	13		4		3		12		9		41	
Paupe	17		7		5		18		6		53	
Samou	15		10		8		27		7		67	
Wabia	15		8		1		26		12		62	
Wam 1	7		10		3		11		5		36	
Wam 2	13		5		6		13		6		43	
Total	**130**		**65**		**37**		**166**		**65**		**463**	

As shown in Table 1-4, the coverage for the household survey at all villages other than Hotmin (19.2%) and Iniok (18.4%), was greater than 35% of the total village population. This data can be considered to be representative of the respective village households.

For the anthropometric measurements, as discussed elsewhere in this report, a large percentage of the Hotmin villagers were unavailable on the survey date, and this data is less than robust. At Iniok, there is no clear explanation as to why there were more than two-fold the number of males interviewed as compared with the female group. The apparent anomaly at Amaromin, with more people being measured than the total census population, is readily explained, by the fact that a significant number of people from the nearby village of Fiak had their measurements recorded. This has no material impact on the data analysis for this village.

An overall participation rate of 18.7% for the medical examination is more than satisfactory. However, at the more populous villages of Hotmin, Iniok and Ok Isai (8.5 – 14.7% participation rates) the data cannot be considered fully representative for other than the infant 0 – 5 years of age group, who had participation rates of 18%, 16.5% and 25% respectively.

Table 1-4: Household, anthropometric and clinical assessment survey participants as a percentage of total population

Village	Household survey (% of total population)		Anthropometric measurement (% of total population)		Medical examination (% of total population)
	M	F	M	F	All participants
Amaromin	43.9	66.0	78.8	118.0	26.7
Hotmin	18.9	19.5	12.0	12.5	9.7
Iniok	19.2	17.1	36.4	15.8	8.5
Ok Isai	33.3	42.7	32.2	56.7	14.7
Auom 3	43.2	42.7	23.0	52.0	27.5
Paupe	70.7	71.6	54.9	51.9	32.5
Samou	54.3	46.2	57.1	44.4	30.2
Wabia	37.8	37.4	42.3	43.6	19.4
Wameimin 1	56.3	63.2	42.5	64.9	25.0
Wameimin 2	59.0	77.0	39.8	72.1	28.5
Total	**37.4**	**39.3**	**37.0**	**41.9**	**18.7**

1.2.2 Socio-economic factors relevant to health

Religious activities
The Social Impact Assessment (SIA) survey question on household participation in social groups was repeated for comparative purposes in the present survey households. At eight of the 10 villages, all households participated in the activities of the local religious groups. At each of Iniok and Paupe, one family reported no involvement in church or social groups.

The responses to the question regarding involvement in men's and women's groups were somewhat confounded. The men's and women's groups at Wabia were clearly church-linked fellowship groups. At Ok Isai, it was not identified if the groups had any particular affiliation.

Sporting activities
Involvement in sporting groups was apparent at Ok Isai, Samou and Wabia. These appeared to be primarily for netball, with approximately 50% of households at Ok Isai, 20% of households at Samou and 30% of households at Wabia, having at least one family member participating.

Household income
The question examining household sources of cash income was also purposefully selected from the SIA questionnaire. The primary objective was to ascertain if, on this parameter, the present household survey group were comparable with, and representative of the broader group, surveyed in October 2009. The results from the present survey are shown in Table 1-5.

The sources of cash income varied widely between communities, with the mine area villagers (excluding Samou), identifying their major family income source as employment with the Frieda River Copper-Gold Project. In some households, several family members received an income from this source.

The communities at Hotmin, Paupe and Samou derived significant income from the sale of garden produce. The Samou villagers traded fruit and vegetables and sandalwood, collected from the surrounding forest with the May River villagers in exchange for fish and other goods (including some clothing) during market day exchanges. The Hotmin villagers sold vegetables and fish to outside people panning for gold.

The growing of young crocodiles in household pens was a major income source for the communities at Iniok, Auom 3 and Paupe.

The primary major income source for most households at Ok Isai and Wabia was from artisanal gold mining. The recovery of gold dust and nuggets was also a regular income source for a number of other villages. The participation in gold recovery by village is further discussed in Table 1-6.

Table 1-5: Household sources of cash income (No. of households)

Village (Total no households)	Salary	Remittances	Trade store	Sale of garden produce	Timber	Fish and crocodile products	Alluvial gold mining	Hunted animals	Handicrafts	Canoes
Amaromin (12)	8	5	2	11	1	7	10	7	3	0
Hotmin (16)	7	0	0	1	2	1	16	0	0	0
Iniok (12)	11[1]	1	0	5	1	12	0	2	1	1
Ok Isai (16)	6	0	3	0	0	0	16	0	0	2
Auom 3(9)	3	0	1	0	0	8	3	0	0	0
Paupe (14)	12	1	2	11	0	12	5	2	3	8
Samou (16)	1	1	0	16	8	3	12	2	0	0
Wabia (16)	2	2	2	2	0	1	16	1	1	3
Wameimin 1 (13)	11	0	0	4	0	0	6	1	0	0
Wameimin 2 (16)	16	3	0	7	3	0	15	1	3	0

1. Only two survey individuals had a formal salary. The other nine undertook occasional labouring for Frieda River Copper-Gold Project, unloading boats at the storage area.

Table 1-6: Participation in artisanal gold mining by village

Village (No households)	Comments
Amaromin (11/12), Auom 3 (4/9), Paupe (5/14)	Not a major source of income (40 – 60 Kina/month/household). Frequently used as a supplementary income source to meet school and other family expenses
Hotmin (16/16), Wameimin 1 (12/13), Wameimin 2 (15/16)	Regular income source
Iniok (0/12)	One head of family is a part-time gold buyer
Ok Isai (16/16)	Primary major income source for most households
Samou (12/16)	Occasional activity and very little gold is recovered;
Wabia (16/16)	Major income source, and for many non-Frieda River Copper-Gold Project employee families, the only cash stream. About 35% of village adolescent and adult population away recovering gold at the time of the survey

Note: At none of the villages, was mercury amalgam used in gold recovery. This was confirmed both by the villagers and by a number of gold buyers.

1.2.3 Village and household environmental health circumstances

1.2.3.1 Village Environmental Health

The survey villages' environmental health circumstances were obtained by directing questions to the Village Councillors, or other senior local leaders, and by direct observation, with the Frieda River Copper-Gold Project HEO conducting a visual survey of the villages and surrounds (Table 1-7).

Table 1-7: Village environmental health conditions

Village name	Drinking water		Communal sanitation facilities		Solid waste disposal	
	Source	Condition	Pit	River	Bury	Open dump
Amaromin	Mountain spring	Good	✓	✓	✓	✓
Hotmin	River	Satisfactory	✓	✓		✓
Iniok	River	Poor	✓	✓		✓
Ok Isai	River	Good	100%		✓	✓
Auom 3	Tank and lake	Satisfactory	100%		100%	
Paupe	River	Poor	35%	65%		✓
Samou	River	Good	✓	✓		✓
Wabia	River	Good	100%			✓
Wameimin 1	Creek	Good	100%			✓
Wameimin 2	River	Good	100%			✓

Notes: Condition of drinking water was determined by the researcher based on direct observation and/or discussions with local leaders and considering factors such as whether the water source was used for other purposes (such as the disposal of human waste) or had the potential to be contaminated in some way.

At Amaromin, the water supply was from a local mountain spring, gravity fed to the village through a polyethylene pipe. At Iniok and Paupe, water supplies for some households were supplemented from rain catchment on the permanent structures into metal drums.

At Hotmin, Iniok, Paupe and Samou the rivers were used for toilet facilities only during heavy rain periods when water filled the pit latrines. At Amaromin, only a small proportion of the households had pit toilets, with most human wastes being disposed to the local river. In general, the maintenance of the pit latrines, with the exception of lacking a close fitting lid to keep out flies and mosquitos, was good, with only a minority poorly maintained.

Solid waste disposal (open dump) frequently involved the throwing of waste into the rivers (eg. Iniok into the Sepik River, Paupe into the Frieda River, Samou into a local creek). No village households used burning as a disposal method for solid wastes.

1.2.3.2 Household Environmental Health

The household approach permitted a good assessment of both occupant density (ie. space per person) and household ventilation (Table 1-8). Overcrowding and poor ventilation is widely recognised as an important factor in health, particularly the prevalence of respiratory infections. Pneumonia is a major cause of hospital and health centre admissions and mortality in the survey districts (PNG MOH 2001). In a number of PNG provinces, there is a clearly defined causal link between ventilation and the prevalence of respiratory disease (Anderson 1978).

Occupant density

There was a very wide range of occupant density between households at all of the study communities, with ranges between 1.1 – 24.0 m^2 per occupant. This varied widely between households within each village and with a few notable exceptions, seemed to be related more to status (eg. Village Councillor) than to cash income. As expected, Samou had the lowest mean area per occupant (3.6 m^2) and Iniok the highest (7.5 m^2).

The range of mean occupant densities between villages of 2.6 – 7.5 m^2 per occupant was quite similar to that for comparable inland communities in the Usino-Bundi District of Madang Province (1.7 and 8.8 m^2 per occupant) and for the Morobe Province Hidden Valley communities (3.0 – 5.6 m^2) (Bentley 2003, CEH 2007a, b).

The observed values for individual household occupant densities are unusually diverse, being 8% -160%of that recommended by the US Centre for Disease Control (US CDC 2003) for maintenance of respiratory health. However, the village mean values 24 – 50% of the recommended value are typical for rural inland PNG. The US CDC criterion is equally applicable to developed and developing country circumstances. Neither the PNG Government nor WHO have provided guidelines for acceptable house space per person.

Ventilation

Ventilation was rated good or adequate for all of the communities except for one household at Ok Isai. At Ok Isai, Paupe, Wabia and Wameimin 2, almost all of the households had separate cooking and food preparation areas away from the main house.

Table 1-8: Persons per household, occupant density, availability of ventilation and presence of cooking and open fires

Village (No households)	Persons per household		Area per occupant (m^2)			Ventilation			Cooking and open fires	
	NSO 2002 census	This study	Mean	Minimum,	Maximum	Good	Adequate	Poor	Sleeping area	Separate area
Amaromin (12)	5.0	5.2	5.7	1.1	17.5	12/12	-	-	12/12	-
Hotmin (16)	6.1	5.3	4.6	2.3	8.0	10/16	6/16	-	12/16	4/16
Iniok (12)	5.4	6.5	7.5	2.0	19.3	9/12	3/12	-	12/12	-
Ok Isai (16)	-	8.3	5.8	1.2	24.0	13/16	2/16	1/16	3/16	13/16
Auom 3 (9)	5.0	7.2	7.1	3.8	15.0	8/9	1/9	-	9/9	-
Paupe (14)	5.4	8.1	6.6	4.4	9.0	13/14	1/14	-	3/14	11/14
Samou (16)	-	6.9	3.6	1.8	9.0	9/16	7/16	-	16/16	-
Wabia (16)	8.2	7.5	5.3	1.4	14.0	16/16	-	-	6/16	10/16
Wameimin 1 (13)	5.3	5.9	4.3	2.0	8.0	9/13	4/13	-	10/13	3/13
Wameimin 2 (16)	6.0	5.9	5.2	2.8	16.0	15/16	1/16	-	5/16	11/16

Key

Good ventilation = No indoor cooking in the main residence, adequate windows and a minimum of two doorways to the external environment or the house is on stilts

Adequate ventilation = Internal cooking, adequate windows and at least one doorway to the external environment

Poor ventilation = Internal cooking and heating fires, few windows and a single doorway to the external environment

Vector-borne disease control
Malaria was hyperendemic in all of the study communities (refer section 1.2.6.2 Examination of liver, kidney, spleen and lymph nodes). As indicated in Table 1-9, other than at Samou where no household reported having any mosquito nets, the majority of village households generally had at least one mosquito net, but insufficient bed nets for all of the family. This is particularly notable at Auom 3(89%), Wabia (81%) and Iniok (58%). The general practice at these communities appeared to be to reserve the mosquito nets for babies and infants. None of the bed nets were had been treated with pesticides, since purchase, at any of the villages.

Excluding Samou, insect screens were also installed at a majority of the survey households in each village. The availability of screens and use of mosquito nets did not appear to be effective as a means of vector control, considering the observed high malaria incidence (discussed further in sections 1.2.6.2 and 1.2.7.3).

Table 1-9: Vector borne disease control (all values % households)

Village (No households)	Protection measures		Mosquito bed nets[1]	
	Screens	Cleaning around house[2]	At least one	Nets for all family
Amaromin (12)	83	75	92	75
Hotmin (16)	100	69	100	69
Iniok (12)	83	67	83	42
Ok Isai (16)	88	50	88	56
Auom 3 (9)	100	67	100	11
Paupe (14)	86	64	93	79
Samou (16)	0	25	0	0
Wabia (16)	94	44	88	19
Wameimin 1 (13)	86	50	93	57
Wameimin 2 (16)	81	81	94	94

1. No household in any village had their mosquito nets treated with pesticide since purchase.
2. It is likely that many households indicated that they cleaned up mosquito breeding areas to avoid embarrassment. The data likely overestimates the actual situation. In practice, water pooling, particularly in surface constructed drains was commonplace. The use of insect repellents was not identified by any of the survey households.

Consumption of addictive substances
The use of tobacco and other stimulants among adults (17 years of age) is shown in Table 1-10. Cultivation of tobacco plants was common in all of the villages and village gardens. The consumption of tobacco was higher in the male population (36 – 100%) at all communities than in the females (10 – 79%). Consumption was highest at the remote village of Samou (males 100%, females 79%). The unusually low smoking rates in females at Paupe and Wabia may be a result of the influence of the Baptist Church, which very actively discouraged smoking.

The overall smoking rate (54%) was markedly higher than that reported both nationally (37%), as measured in the Mt Obree area of Central Province (30%) and in a recent study of inland villages in Madang Province (37%). These latter communities have a similar level of economic development to the present survey group (FMR 1990, Taufa 1995, CEH 2007b).

The level of consumption of betel nut was similar in males and females and also comparable at all of the surveyed villages, with the exception of Wabia (males 41%, females 19%), where female consumption was unexpectedly low. This observation is unexplained.

Alcohol consumption was largely restricted to adolescent and adult males in all of the communities except Ok Isai. The reason for a significant number of females at Ok Isai consuming alcohol is unexplained.

Table 1-10: Consumption of addictive substances all adults 17+ years of age (all values %)

Village (total households (HH))	Tobacco			Betel nut			Alcohol		
	No HH	M	F	No HH	M	F	No HH	M	F
Amaromin (12)	*10*	82	71	*10*	53	71	*3*	18	0
Hotmin (16)	*12*	55	47	*13*	64	58	*3*	14	0
Iniok (12)	*3*	55	39	*3*	55	39	*2*	35	0
Ok Isai (16)	*10*	55	50	*10*	62	53	*9*	52	17
Auom 3(9)	*7*	67	35	*8*	80	65	*8*	80	0
Paupe (14)	*8*	46	19	*11*	79	65	*7*	29	0
Samou (16)	*14*	100	79	*14*	100	88	*2*	9	0
Wabia (16)	*10*	44	10	*10*	41	19	*8*	38	0
Wameimin 1 (13)	*10*	92	41	*11*	100	70	*1*	20	0
Wameimin 2 (16)	*5*	36	44	*10*	52	67	*3*	12	0

The unexpectedly high percentage of individuals smoking, consuming betel nut and alcohol at Iniok is in part at least a result of the disproportionately large family sizes of the three consuming households. In particular, there were a large number of adult males. The large number of non-consuming households was undoubtedly the result of the influence exerted by the Baptist Church in Iniok, with some areas sign-posted as "No smoking".

1.2.4 Anthropometry

The interpretation of anthropometric measurements as indicators of various forms of malnutrition, was in accord with the standard deviations and percentiles presented in the guidelines recommended by UNICEF for Developing Country circumstances (Table 1-11) (WHO/PAHO/ICRC/UNHCR/Sphere Project/UNICEF 2001). These guidelines were originally published by Jelliffe (1966) and WHO (1995).

Table 1-11: UNICEF criteria for assessment of malnutrition

Weight-for-age/weight-for-height classification		Height-for-age classification	
Severely underweight	≤ -3sd	Severely underheight	≤ -3sd
Moderately underweight	> -3sd to ≤ P5	Stunted	> -3sd to ≤ P5
Mild underweight	> P5 to ≤ P25	Mild underheight	> P5 to ≤ P25
Average/Normal	> P25 to ≤ P95	Average/Normal	> P25 to ≤ P95
Mild underweight	> P95 to ≤ 3sd	Above average	> P95
Height-for-age		**Weight-for-height**	
		> P5	≤ P5
> P5		Normal	Wasted Alone (Acute malnutrition)
≤ P5		Stunted Alone	Both Wasted and Stunted (Severe Chronic Malnutrition)

sd=standard deviation; p=percentile

The weight-for-height index reveals whether a child is thin or not, and is the index used to measure acute malnutrition or 'wasting'. Causes include inadequate food intake, incorrect feeding practices, disease and infection, or more frequently, a combination of these factors. Levels of wasting in individual children and population groups can change rapidly depending on changes in food availability or disease prevalence, to which they are very sensitive.

Measurement of weight-for-age is the primary anthropometric parameter tested. A low weight-for-age index reflects both past (chronic) and/or present (acute) under nutrition, although it does not necessarily differentiate between the two. Underweight, based on weight-for-age, is a composite measure of stunting and wasting, and is recommended as the indicator to assess change in the magnitude of malnutrition over time.

A low height-for-age index is referred to as stunting, and normally reflects chronic malnutrition. Stunting is an indicator of past growth failure. It is associated with a number of long-term factors, including chronic insufficient protein and energy intake, frequent infection, sustained inappropriate feeding practices and poverty. However, the results for stunting in all infant and child PNG groups, highland, mid-altitude and lowland needs to be interpreted with caution. Direct comparison with the WHO 'average' developing country values is likely inappropriate in PNG, with ethnicity, rather than past growth failure (or a combination of these factors) introducing significant confounding.

Respectively, < 2 standard deviation (sd) and < 3 sd equate to about 80% and 70% percent of the population median value. This is the approach adopted by Taufa and is continued in the present report (Taufa 1997). This means children with a z-score for underweight, stunting or wasting below -2 sd are considered moderately or severely malnourished, or suffering from the effects of chronic malnutrition.

The summary anthropometric data for the survey population is given in Tables 1-12 to 1-15 and Figures 1-2 and1-3. With a sample population of 975 (males 473, females 502), the statistical quality of the data is robust. The anthropometric data for the participants, by household and village is provided in Appendix 2.

A comparison of the mean adult values for weight and height as shown in Table 1-12, indicated that there were no statistically significant differences in these parameters between the 10 village communities that can be attributed to differences in ethnicity. The results do suggest that male weights were markedly higher in those communities that are transitional towards urban PNG lifestyles. The villagers at Iniok, Ok Isai and Wabia, by example, were generally more affluent and had better food diversity and food quality. This observation was far less apparent in the female groups and may be culturally related. There was little difference in stature for either males or females between villages.

Table 1-12: Comparison of anthropometric values for adults 17 – 55 years of age

Village	Age (mean)		Weight (mean ± sd) kg		Height (mean ± sd) metres	
	Males	Females	Males	Females	Males	Females
Amaromin	36.0	30.7	59.0 ± 5.9	47.4 ± 6.1	1.54 ± 0.08	1.47 ± 0.05
Hotmin	31.8	33.8	59.7 ± 13,1	54,4 ± 6.7	1.54 ± 0.15	1.51 ± 0.05
Iniok	30.8	31.8	70.2 ± 9.2	54.6 ± 5.8	1.65 ± 0.06	1.54 ± 0.04
Ok Isai	33.2	33.6	64.8 ± 5.7	54.6 ± 7.9	1.60 ± 0.04	1.47 ± 0.14
Auom 3	38.1	34.1	60.2 ± 3.6	50.2 ± 7.2	1.63 ± 0.05	1.51 ± 0.05
Paupe	37.5	36.6	61.4 ± 9.0	51.3 ± 9.6	1.59 ± 0.07	1.49 ± 0.05
Samou	34.5	32.7	58.3 ± 6.4	47.8 ± 5.5	1.60 ± 0.06	1.50 ± 0.05
Wabia	32.1	33.3	61.4 ± 7.7	53.8 ± 7.0	1.54 ± 0.05	1.48 ± 0.06
Wameimin 1	35.0	35.0	57.6 ± 4.2	48.0 ± 3.9	1.54 ± 0.04	1.50 ± 0.02
Wameimin 2	38.9	31.7	60.0 ± 4.6	51.0 ± 7.0	1.55 ± 0.05	1.46 ± 0.06

Sd=standard deviation

Figure 1-2 gives the results for the mean height and weight of all survey participants for infants 0 – 71 months of age. As expected, the results indicate a progressively increasing height and weight with age. The results are comparable with those observed in a number of other anthropometric measurement surveys in PNG (Flew 1999, CEH 2007a).

The results for mean height and weight for children, adolescents and adults by gender is shown in Figure 1-3. In the child group, males generally exceeded their female counterparts both in height and weight. The situation was reversed in the adolescent group, with females being somewhat heavier than their male counterparts, by about 2 kilograms. This is normal and related to females earlier onset of puberty.

Adult males between 17 and 44 years of age were markedly higher in stature than their female counterparts by about 10 centimetres. They were also markedly heavier than the female group, although undoubtedly to some degree, this included a contribution from the employment of a significant number of males from the villages, by the Project. This observation was confirmed by a small survey of Frieda River Copper-Gold Project employees (35) at the Project Base Camp. This indicated that on average, employees were approximately 10 kilograms heavier than their village lifestyle counterparts.

Male and female adults groups over 45 years of age were significantly lighter and of lower stature than their younger counterparts. This was particularly noticeable in the females, with the mature age group being some 10 kilograms lighter and 3 centimetres less in stature.

Figure 1-2: Infant mean height and weight (all survey participants)

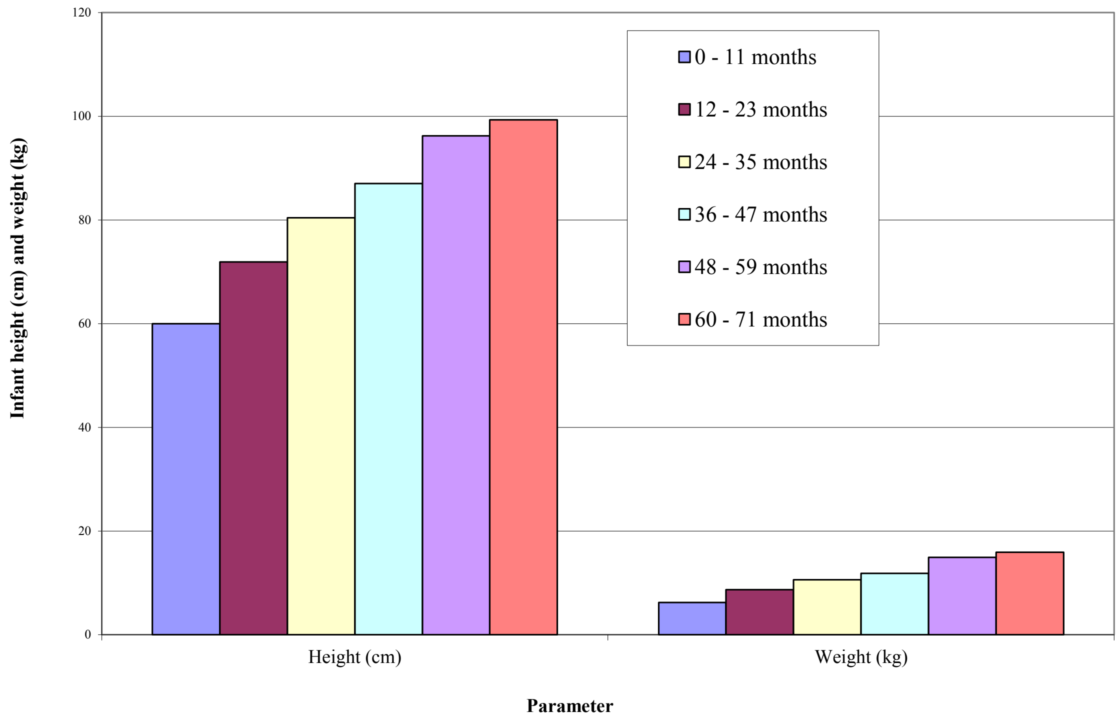
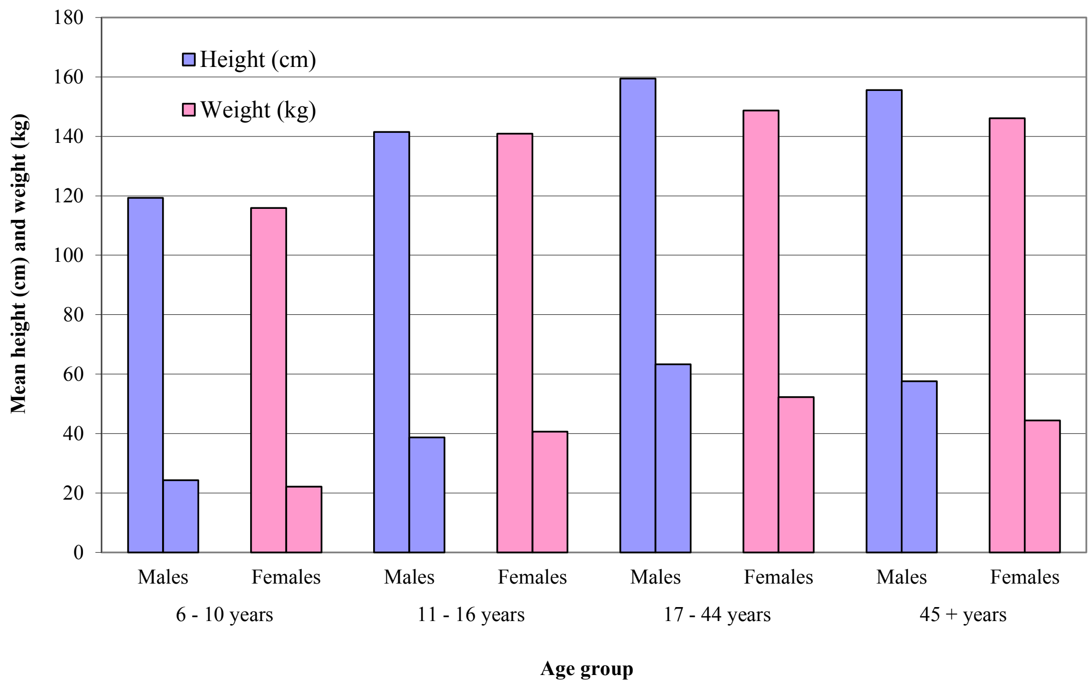


Figure 1-3: Mean height and weight of child, adolescent and adult survey participants by age and gender



1.2.4.1 Anthropometry of infants

The nutritional status of children under 5 years of age is commonly assessed using three indices:

- Weight-for-height (wasting) which reflects acute growth disturbances.
- Height-for-age (stunting) which reflects long-term growth faltering.
- Weight-for-age (underweight) which is a composite indicator of both long- and short-term effects.

The data in Table 1-13 is presented as the percentage of children under 71 months of age, falling below two or three standard deviations reference population median value for each of the three indices weight-for-age, height-for-age and weight-for-height. Whilst accepting the normal caveats associated with such a small sample, it can be seen that there is little child malnourishment in the first five years of life. Mildly overweight children in all of the age groups are of some significance, but not of health concern.

The results can be favourably compared with the World Bank anthropometric database for lowland and highland fringe communities in PNG, which although using different criteria nationally, identified a prevalence of stunting in these geographic groups of 35% - 59%. The results for wasting in the present population is also at the lower end of the values recorded in the World Bank survey of 0% - 14.8% and similar to the prevalence observed in Madang and Morobe Provinces in 2007 (0% and 2% respectively) (Gibson and Roselle 1998, CEH 2007a, b, World Bank (2006b).

Table 1-13: Anthropometric data of children 12 – 71 months of age (all values %)

Age (months)	Number	Weight-for-age		Height-for-age		Weight-for-height	
		Underweight		Stunting		Wasting	Overweight
		< -3 sd	< - 2 sd	< -3 sd	< -2 sd	< -2 sd	< + 2 sd
12 – 23	17	0	0	0	5.9	0	5.9
24 – 35	31	0	0	0	3.2	0	6.5
36 – 47	49	0	0	0	2.0	0	2.0
48 – 59	38	0	0	0	2.6	0	5.3
60 – 71	34	0	5.9	0	3.0	3.0	3.0

sd = standard deviation.

1.2.4.2 Anthropometry of pre-pubertal adolescents and adolescents (6-16 years of age)

Consistent with the anthropometric data for the infant group, the height-for-age measurements, indicated there were no children below < -2 sd in the surveyed 6-10 years of age population for stunting, and only 1.2 % in the 11-16 years of age group.

Table 1-14 shows the nutritional status as measured by BMI values for children and adolescents 6-16 years of age, by age group and gender. This data has been derived by comparing the present results on an age basis (by year) with those of the WHO International Obesity Taskforce 1998 (Cole et al 2000). There were a total of 157 participants in the 6-10 years of age group (males 80, females 77) and 92 participants in the 11-16 years of age group (males 40, females 52).

The results indicate that underweight in both the child and adolescent groups was predominantly at Samou (75% and 70% respectively).There was one underweight individual at Wameimin 1 in the 6-10 years of age group. The 11-16 years of age group had two underweight individuals at Amaromin and one at Wabia.

The results for overweight were similar between males and females. Overweight in the 6-10 years of age group, was markedly higher at Amaromin (3), Ok Isai (3), Wabia (4) and Wameimin 2 (3), with the other six villages having a total of only three overweight participants. Overweight for the 11-16 years of age group was highest at Ok Isai (4), with only a single participant at each of six of the other nine villages.

Table 1-14: Nutritional status of children and adolescents by age group and gender (all values % of total participants)

Age group (years)	Underweight		Normal		Overweight		Obese	
	Males	Females	Males	Females	Males	Females	Males	Females
6 – 10	2.5	2.6	83.8	89.6	13.7	7.8	0	0
11 – 16	15.0	7.7	75.0	76.9	10.0	11.0	0	1.9

1.2.4.3 Anthropometry of adults

The nutritional status of adults is usually assessed using the BMI calculated as weight (kg) over height squared (m^2). For classifying individuals according to their nutritional status, adults with a BMI of less than 18.5 kg/m^2 are considered to suffer from chronic energy deficiency; a BMI of over 25 kg/m^2 indicates overweight and over 30 kg/m^2 obesity.

A comparison of the mean adult values for body mass index, as shown in Table 1-15, indicated that there were statistically insignificant differences between the 10 village communities that could be attributed to differences in ethnicity. The results do suggest that the male BMI values were markedly higher in those communities which were in a transition to adopting urban PNG lifestyles. The villagers at Iniok, Ok Isai and Wabia were for example, generally more affluent and had better food diversity and food quality.

Table 1-15: BMI values of adults 17 – 55 years of age

Village	Age (mean)		BMI (mean ± sd) h/m^2	
	Males	Females	Males	Females
Amaromin	36.0	30.7	24.9 ± 2.4	22.0 ± 2.4
Hotmin	31.8	33.8	24.7 ± 2.8	23.8 ± 2.4
Iniok	30.8	31.8	25.8 ± 2.9	23.0 ± 2.2
Ok Isai	33.2	33.6	25.2 ± 2.2	24.8 ± 3.3
Auom 3	38.1	34.1	22.8 ± 1.1	22.0 ± 2.4
Paupe	37.5	36.6	24.4 ± 3.4	23.0 ± 3.6
Samou	34.5	32.7	22.8 ± 2.9	21.2 ± 2.3
Wabia	32.1	33.3	25.1 ± 2.6	24.4 ± 2.7
Wameimin 1	35.0	35.0	24.2 ± 1.7	21.3 ± 1.7
Wameimin 2	38.9	31.7	25.0 ± 1.9	23.8 ± 2.7

An alternative explanation may be that the adult male weights were influenced by employment with the Frieda River Copper-Gold Project and the high carbohydrate and fat-rich diets provided at the company messes. The female group, from which few employees are sourced, had BMI values comparable between all of the 10 villages.

As indicated in Table 1-16, BMI decreases with age. This was more marked in the female group (47 +) than the corresponding male group, a result to be expected and consistent with the international literature.

Table 1-16: Nutritional status of all adults 17 – 70 years of age

Age group (years)	Males (mean ± sd)	Females (mean ± sd)
17 – 26	24.9 ± 2.2	23.6 ± 2.7
27 – 36	25.0 ± 2.5	23.5 ± 2.8
37 – 46	24.6 ± 2.8	23.1 ± 3.3
47 +	23.8 ± 3.2	20.3 ± 2.8

Table 1-17 derives the nutritional status (measured by BMI) of adults using the above classification. At the village level, reporting the results by sex is not robust. However, it is notable that contrary to other studies in PNG, the obese group appears to be largely comprised of males who are over-represented in the overweight group when compared with other studies. This result is consistent with, but without more definitive data, not causally associated with employment by the Frieda River Copper-Gold Project.

Table 1-17: Nutritional status of adults by village (all values %)

Village (No participants)	Underweight %	Normal %	Overweight %	Obese %
Amaromin (59)	5.1	76.3	16.9	1.7
Hotmin (25)	4	52	44	0
Iniok (56)	1.8	50	41	7.2
Ok Isai (88)	1.1	53.4	37.5	8.0
Auom 3 (29)	13.8	75.8	10.4	0
Paupe (41)	7.3	61	29.3	2.4
Samou (50)	6	88	6	0
Wabia (83)	0	56.6	39.8	3.6
Wameimin 1 (28)	3.6	78.5	17.9	0
Wameimin 2 (40)	5	50	45	0

Table 1-18, compares the waist circumference measurements of adults with the WHO-International Association for the Study of Obesity recommended cut-off points for urban Asians of < 90 cm for men and < 80 cm for women (WHO IASB 2000).

The waist circumference results of all participants indicated that for males approximately 96% were at low risk of cardiovascular disease. The corresponding value for females was about 70%. While there are no reported values for waist measurements in PNG, this result is very similar to a recent report for rural and remote communities in Sumbawa Province, Indonesia (males 97% and females 72%) (University of Indonesia 2009).

Table 1-18: Comparison of survey group with WHO (2004) intermediate public health action points

Risk level	Males	Females
Normal range (low risk) (<18.5 cm)	1	18
Increased but acceptable risk (18.5 – 22.9 cm)	59	107
High risk (23.0 – 27.4 cm)	145	119
Higher high risk (27.5 – 32.5 cm)	28	20
Very high risk (>32.5 cm)	2	0

1.2.5 Food and nutrition

Twenty-four hour dietary recall and food frequency surveys were completed at the household level for all survey villages. The results of the dietary recall and food frequency surveys are summarised in Tables 1-19 and 1-20, and provided in detail in Appendix 3.

Whenever practical, the mother of the household was interviewed for the dietary questionnaire (89% of households). In a number of cases the head of household responded (7% of households), generally with the mother present. In only 4% of households was the mother or head of household unavailable for interview.

As is usual for surveys conducted in remote PNG locations, there were both extended family and neighbours present. Although every effort was made to concentrate on the responses of the specific household, the possibility of overstating food selection for the 24-hour recall component of the nutrition work cannot be discounted. However, this influence would be much less when discussing the question on longer term food consumption frequencies.

In response to the question on food security and perceived food insufficiency, all households reported that they had sufficient food available on the day prior to interview at Hotmin, Samou, Wabia, Wameimin 1 andWameimin 2.Food insufficiency was reported at Amaromin (1 of 12 households), Ok Isai (1 of 16 households), Paupe (2 of 13 households) and Iniok (3 of 12 households).Food insufficiency was invariably either a short-term issue, relating to insufficient taro or other crops planted, unexpected visitors, or was a consequence of large family size (Paupe and Iniok).

Food shortages and specifically shortages of high-protein foods were clearly a serious long-term issue at Auom 3 and Samou. At Auom 3, two-thirds of interviewed families expressed concern that they harvested insufficient fish from the local ox-bow lake. The 'food sufficiency' indicated by the Samou villagers, was likely an anomaly resulting from the nature of the question (ie. "yesterday"). This is discussed in further detail below. The chronic lack of dietary protein is clear for the adult group anthropometric results (see Table 1-15).

The results of the food frequency survey (Table 1-20), while in general agreement with the 24-hour dietary recall, also emphasised the widely varying food consumption circumstances between the survey villages. With food availability being dependent on household commitment and in many villages, the local environmental circumstances, rather than seasonal effects, food frequency results from the survey villages, would not provide robust data for energy or protein intake. Calculation of these depends on comparability with the results of the 1996 World Bank Survey, which has only a very limited application at the village level. While disappointing, there was no scientific justification for attempting to derive nutritional adequacy for these parameters.

The 24-hour recall and food frequency surveys identified a wide diversity in food consumption patterns between the 10 villages. This relates in part to the availability of agriculturally suitable land for cropping and local climatic and environmental circumstances.

Tubers supplemented by banana, provided the main carbohydrate source at Amaromin, Hotmin, Ok Isai, Wabia and Wameimin 1 and 2. At the time of the survey, consumption of sweet potato dominated at Amaromin, Wabia and Wameimin1 and 2, while taro was more widely consumed at Hotmin and Ok Isai. Cassava was included in the diet of about 30% of the households at Amaromin and Wameimin1 and 2.

Consumption of sago was the exclusive carbohydrate source at Auom 3and the main source (supplemented by some consumption of banana) at Iniok. Consumption of sago was a minor energy source at the other eight villages. Consumption of rice dominated at the more affluent communities of Ok Isai and Wabia. At the other villages between 0 and 15% of households had consumed rice on the previous day. Coconut appeared to be a significant contributor to energy intake at Samou village (25% of households).

Consumption of green leafy vegetables appeared nutritionally adequate at Hotmin, Ok Isai, Paupe, Samou, Wabia and Wameimin1 and 2. At Amaromin, only 50% of households had consumed green vegetables and at Iniok about 30%.Few households maintained wet season gardens at Iniok, due to frequent flooding.

At Auom 3, no household reported having eaten leafy greens on the previous day. With little garden cultivation, due to the local environmental conditions (frequent flooding from the ox-bow lake and problems with wild pigs) consumption of leafy greens largely depended on sourcing them from the surrounding bush.

Consumption of yellow vegetables, fresh fruit, sugar cane and nuts had played little part in the diet of the 10 villages. In part at least, this was a consequence of the timing of the survey, when yellow vegetables (eg. corn, tomato and pumpkin) were recently planted, and most nuts were outside of their normal harvest period. Marita pandanus was being consumed at Ok Isai and Wameimin 1. Some villages had pineapple and pawpaw readily available, but mango and other fruits were not yet in season.

The consumption of protein-rich foods differed widely between villages. Pork had been consumed by a majority of households at Paupe on the previous day, but this was an unusual event, related to a particularly successful hunting trip by a group of young men. Consumption of pork and other bush meats on the day prior to interview was limited to one or two households at Samou, Wabia and Wameimin 1.

The principal protein source for Hotmin, Iniok, Auom 3and Samou villages (> 80% of households) was fresh fish. More than 50% of the households at Paupe had also consumed fresh fish on the previous day. The high level of consumption at Samou was likely due to the survey being conducted the day following the weekly market when fish is purchased from the May River villagers. Fresh fish consumption at Amaromin, Wabia and Wameimin1 and 2, included only about 10 – 20% of households. However, at Wabia and Wameimin1 and 2, this had been supplemented by the consumption of tinned fish and tinned meat (8 – 30% of households). Tinned fish and tinned meat have almost entirely replaced fresh fish at Ok Isai (90% of households).

The diet at Ok Isai, while still including the traditional consumption of tubers and green vegetables, is largely dominated by store-purchased foods. For example, in addition to the tinned meat and fish, a majority of householders had consumed sugar, bread (mainly Navy biscuits) and flour products and vegetable oil. Snacks had also been consumed by more than 30% of households. To some degree, a similar situation occurred at Wabia, where about 25% of all households had consumed these products. Consumption of store foods by household in the other eight villages was very low.

Table 1-19: Food consumed in the previous 24 hours at the survey villages (all values % of households)

Food commodity	Amar	Hot	Iniok	Ok Isai	Auom 3	Paupe	Sam	Wabia	Wam 1	Wam 2
Sweet potato	100	25	0	25	0	22	32	75	72	82
Cassava	33	0	0	6	0	7	6	0	4	31
Taro	67	94	0	50	0	0	6	63	86	81
Other tubers	0	0	0	0	0	0	0	0	0	0
Banana	50	19	17	31	0	0	44	38	43	31
Sago	17	0	100	0	100	71	100	13	0	31
Coconut	0	0	17	6	0	0	25	0	0	0
Rice	0	6	0	94	0	14	0	50	14	13
Pork	0		0	0		71	6	13	7	0
Other meats	0	0	0	6	0	0	0	13	14	0
Fresh fish	8	81	92	0	100	57	88	19	0	13
Eggs	0	0	0	0	0	0	0	0	0	0
Sugar cane	0	0	0	0	0	0	0	6	7	0
Fresh fruit	0	0	0	6	0	0	0	0	21	6
Nuts	0	0	0	0	0	0	0	0	0	0
Green vegetables	67	94	33	88	0	93	94	69	86	94
Yellow vegetables	0	13	0	6	0	0	0	0	0	6
Flour	0	0	0	25	0	0	0	25	0	0
Tinned fish	0	6	0	88	0	0	0	31	21	6
Tinned meat	0	6	0	13	0	7	0	19	14	0
Milk	0	0	0	25	0	0	0	13	0	0
Sugar	0	6	8	69	0	0	0	25	0	0
Bread	0	0	0	69	0	7	0	31	14	0
Vegetable oil	0	6	0	75	0	0	0	19	0	0
Snacks	0	0	0	31	0	0	0	13	7	0

Table 1-20: Food consumed in the previous year at the survey villages (in days/year)

Food	Amar	Hot	Iniok	Ok Isai	Auom 3	Paupe	Samou	Wabia	Wam 1	Wam 2
Sweet potato	365	187	56	293	24	124	219	365	356	365
Cassava	93	38	69	41	24	62	82	57	160	255
Taro	321	365	60	365	24	163	138	357	365	365
Yam	0	0	51	41	0	0	62	34	64	0
Banana	221	90	38	224	24	54	262	305	132	236
Sago	151	167	365	41	365	24	365	198	28	78
Coconut	0	24	24	24	24	24	31	38	0	0
Rice	24	27	24	339	24	28	24	161	24	41
Pork	24	24	24	24	24	28	34	24	24	24
Other meats	24	24	24	24	24	28	44	24	24	24
Fresh fish	24	357	365	34	365	365	133	45	24	24
Eggs	24	24	24	24	24	24	24	24	24	24
Sugar cane	70	45	24	24	24	24	24	34	39	24
Fresh fruit	51	24	47	24	24	32	61	44	58	31
Nuts	24	24	38	24	24	39	41	31	32	24
Green veg	237	365	70	303		365	365	357	335	365
Yellow veg	66	48	88	54	24	24	110	62	72	24
Flour	24	24	38	160	24	24	24	92	24	24
Tinned fish and meat	24	24	52	340	24	28	24	197	28	24
Milk	24	24	24	237	24	24	24	69	24	24
Sugar	24	24	24	288	24	24	24	115	28	24
Bread	24	24	29	357	24	24	24	264	39	24
Veg oil	24	24	29	332	24	24	24	251	28	24
Snacks	24	24	29	238	24	24	24	72	24	24

Note: The food frequency survey was designed to take into account seasonal availability of food products and the stated frequency of consumption. For some villages, no consumption was recorded, where particular foods were never available. Deriving the annual consumption has used frequency (times/year) as every day = 365, 3 – 6 times a week = 234, 1 – 2 times a week = 78 and occasional = 24.

1.2.6 Clinical measurements

Summary data for each of the clinical measurements is discussed in sections 1.2.6.1 – 1.2.6.5. The detailed clinical results by village are provided as coded datasets in Appendix 9.

The medical examinations clinically identified four unreported cases of tuberculosis at Wabia (2) and Amaromin(2) confirming that there are pockets of uncontrolled tuberculosis in these communities. Since the examinations involved only 19% and 26.7% of the respective total populations at Wabia and Amaromin, the prevalence is significant.

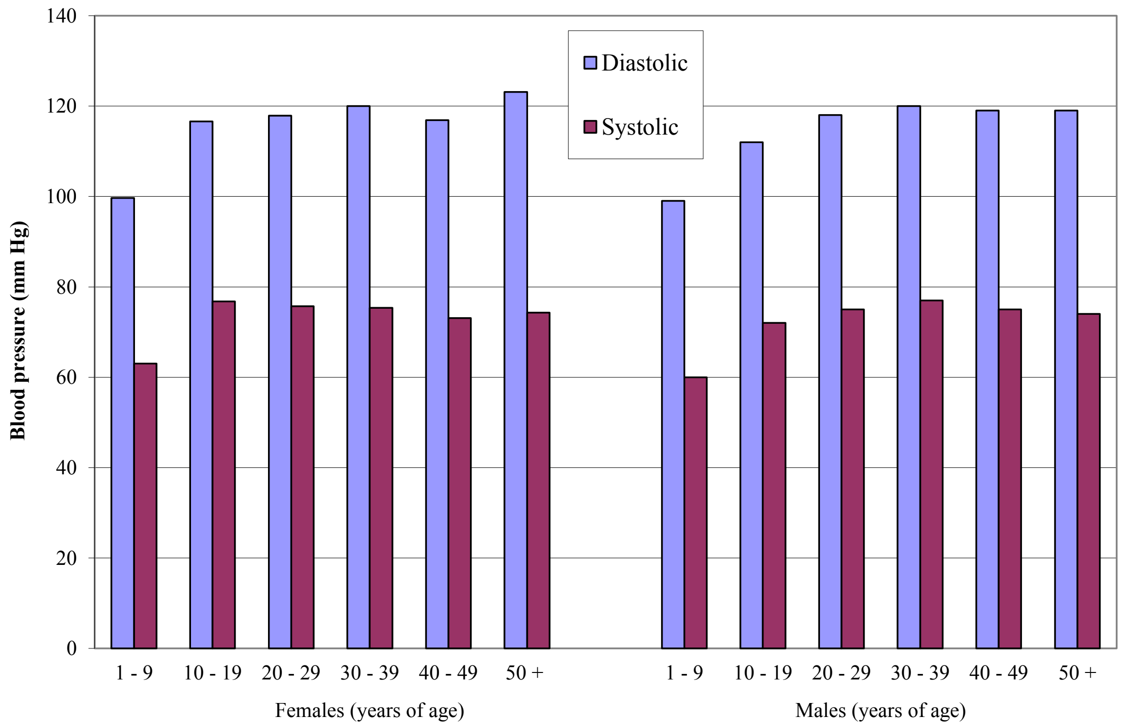
Other reported conditions identified in the course of the survey, included leprosy at Iniok (1), Downs Syndrome at Amaromin(1), uterine fibroids at Wameimin 2 (1), hepatoma- advanced liver cancer at Auom 3(1) and gall bladder disease at Samou (1).

None of the villages appeared to have an awareness of family planning. Girls marry at very young ages, multiple births are routine and although unconfirmed, there would appear to be unusually high maternal and 0 – 12 months infant mortality.

1.2.6.1 Blood pressure

Blood pressure results were almost universally in the normal to low range, with little difference between the males and females of all age groups. There were no noticeable differences discernable in the mean values between those resident at the more isolated villages, with their largely traditional diets, or at the riverside villages of Ok Isai and Wabia where the diets had markedly changed towards a more PNG urban and Western consumption pattern of rice and store foods. There were very few hypertensive individuals in the study population and these generally linked to recognised medical conditions. This result is as to be expected, in a group largely without problems associated with overweight and obesity. The results are graphically presented in Figure 1-4.

Figure1-4: Blood pressure in survey villages by age and sex



1.2.6.2 Examination of liver, kidney spleen and lymph nodes

Hepatomegaly and kidney enlargement

Hepatomegaly (liver enlargement) has long been reported as being highly prevalent in PNG, particularly in the lowlands in association with malaria and hepatitis B (Murthy et al 1995). However, a recent study in the remote Fly River communities did not support the association between hepatomegaly and hepatitis B with a reported population hepatomegaly rate of less than 0.5. Hepatitis B had been detected by seroprevalence at 26% (Flew 1999). A baseline health study conducted in the Rai Coast and Usino-Bundi District inland villages in Madang Province in 2007 also gave a population rate of only 1.5% (CEH 2007b).

Hepatomegaly is also frequently associated with early onset infection, poor sanitation, crowded living conditions and low immunisation rates for hepatitis B. In the present study population there were only two cases of liver enlargement recorded, giving a population rate of 0.4%.

There were no cases of kidney enlargement in any of the villagers examined.

Splenomegaly

Splenomegaly (spleen enlargement) in PNG is most commonly due to infections, including Epstein Bar virus, which is closely associated with malaria infection and malaria protozoa. Other causal agents include intestinal parasites and fungal infections. Splenomegaly has frequently been reported as associated with generalised lymphadenopathy (swelling of lymph nodes).

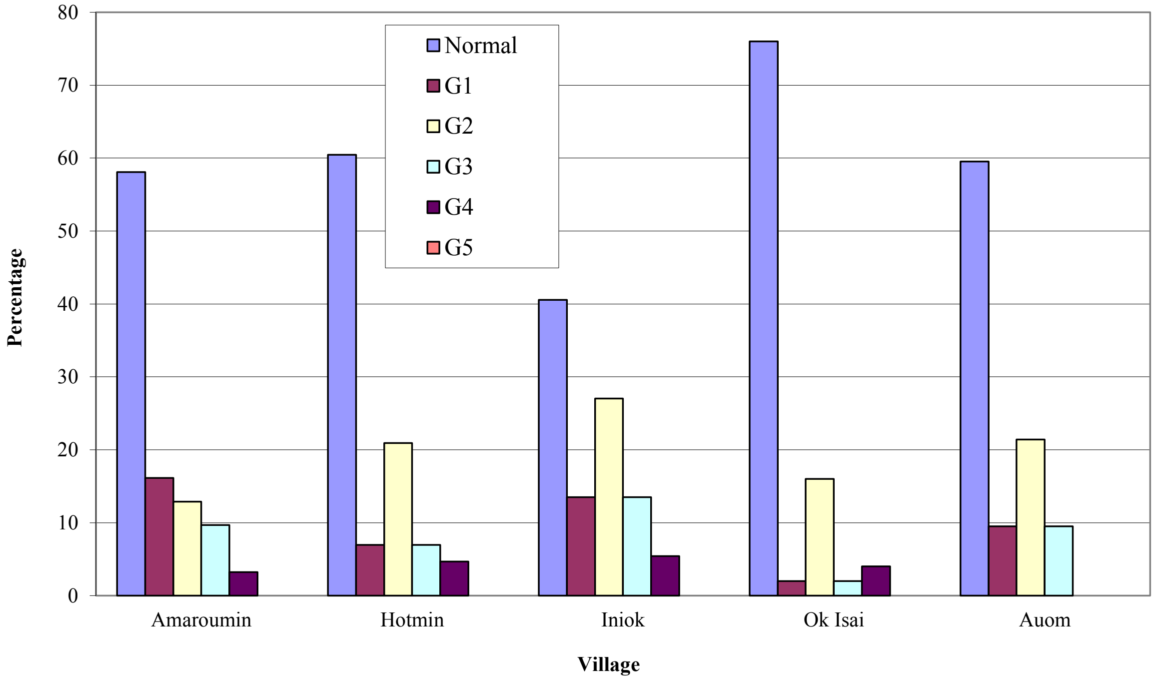
Historically, there has been a correlation noted between the incidence of splenomegaly and altitude, with the rates and degrees of enlargement falling with increasing altitude. Communities living at greater than 1500 metres ASL normally have no palpable spleen (Taufa 1999). By comparison, the levels observed in recent studies conducted in the Western Province lowland zone were 82% in 1996 and 90% in 2000 (Taufa 1997, Reto 2005). A 2007 study of the Rai Coast and Usino-Bundi District inland villagers gave an overall prevalence (ie sum of Grade 1 – Grade 5) of 43% at the coastal villages and 41% at the inland villages. This result was typical of other areas in PNG where malaria is hyperendemic (CEH 2007b).

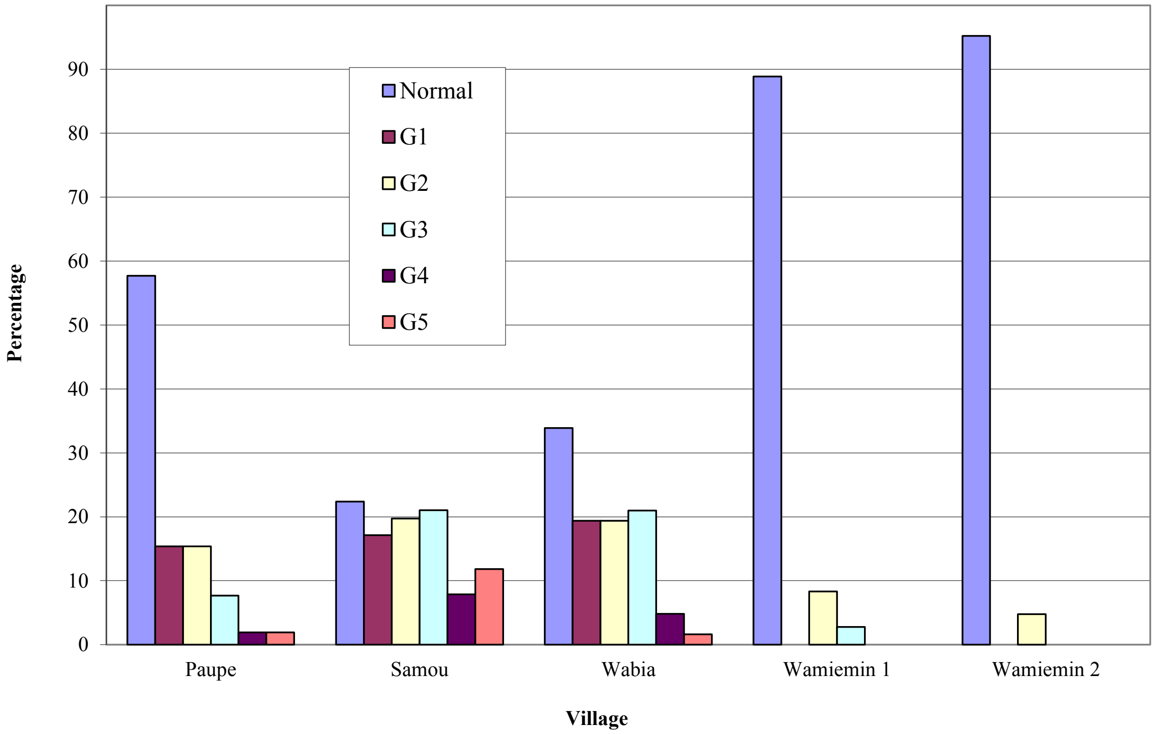
In the present survey, splenomegaly was assigned five grades of enlargement, according to the system developed by Hackett (1943). The results by village and grade are shown in Table1-21 and Figure 1-5. While there are very distinct differences between the villages, the overall prevalence, using the same summed grading was 44%, a result very similar to that reported in Madang Province for mid-altitude rural villagers. The prevalence of splenomegaly at Wameimin 1 and 2 was unexpectedly low, and warrants further detailed study.

Table 1-21: Prevalence of splenomegaly in the study communities (no. of cases)

Village	Normal	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Total
Amaromin	18	5	4	3	1	0	31
Hotmin	25	3	9	3	2	0	42
Iniok	15	5	10	5	2	0	37
Ok Isai	38	1	8	1	2	0	50
Auom 3	25	4	9	4	0	0	42
Paupe	30	8	8	4	1	1	52
Samou	17	13	14	16	6	0	66
Wabia	21	12	12	13	3	1	62
Wameimin 1	32	3	1	1	0	0	37
Wameimin 2	40	3	0	0	0	0	43
Total	**261**	**57**	**75**	**50**	**17**	**2**	**462**

Figure 1-5: Spleen enlargement by village and graded in accord with Hackett (1943)





Lymphadenopathy

Lymph node enlargement generally occurs as a result of malaria, tuberculosis, respiratory tract, bacterial and fungal infections and intestinal parasites. In some studies multiple lymph node enlargements have been observed in more than 50% of the study population. This prevalence was greatly reduced following medical intervention using multiple drug therapies. The initial high prevalence was attributed to the extreme remoteness of the communities and a historical lack of any access to medical support (Reto 2005).

In the present survey population, despite the high prevalence of malaria and exceptionally high levels of fungal infections, lymphadenopathy in any of the cervical, popliteal, submandibular and auxiliary foci examined occurred at a very low frequency, (6 participants 1.3%). This result was similar to that observed in the 2007 study of the Madang Province coastal and inland communities (2.6%) (CEH 2007b).

1.2.6.3 Eye infections

There are an estimated 38,000 cases of cataract-caused blindness in PNG (PNG Medical Symposium 1996). The present survey of eye disease in the study communities as shown in Table 1-22, identified seven cases of conjunctivitis (1.5%),nine cataract (2%) and 35 cases of pterygium (7.6%). The low incidence of conjunctivitis was unexpected, considering the general living circumstances of the villagers.

The prevalence of eye infections were somewhat comparable with those reported for rural and remote villages in the remote Fly River region (6.4% cataract and 2.4% pterygium) (Flew 1996). In marked contrast, comparing the present group with a recent study of inland groups in Madang Province (0% conjunctivitis, 1% cataract and 1% pterygium) clearly demonstrated the long-term benefits of the specialist medical intervention program, conducted along the Ramu River villages in 1996.

Table 1-22: Prevalence of eye infections by village (all values number of cases)

Village	Conjunctivitis	Cataract	Pterygium	Other eye infections	Total
Amaromin	1	2	4	3	10
Hotmin	0	0	5	0	5
Iniok	0	0	5	0	5
Ok Isai	0	0	3	0	3
Auom 3	1	0	3	0	4
Paupe	0	0	2	1	3
Samou	0	1	1	1	3
Wabia	2	2	5	0	9
Wameimin 1	1	1	4	1	7
Wameimin 2	2	3	3	1	9
Total	**7 (1.5%)**	**9 (2.0%)**	**35 (7.6%)**	**7 (1.5%)**	**58 (12.5%)**

1.2.6.4 Skin infections

Tropical ulcers due to anaerobic fusiform bacilli, especially found on the lower legs, were formerly rife in mid-altitude and lowland riverine areas of PNG (Radford 1974), but are now reported as comparatively rare.

The prevalence of skin infections by community is shown in Table 1-23 and graphically in Figure 1-6. On a whole-of-study population basis, the prevalence of skin infections was scabies 0.2%, scalp infections 1.1% sores and tropical ulcers 21.2%, ringworm 18.4% and other skin infections 43.2%. These results were similar to those reported for Western Province lowland communities, where the corresponding prevalence rates were sores and tropical ulcers 12% and all tinea/fungal infections 42% (Flew 1999). The results for sores and tropical ulcers and ringworm were also similar to the results reported in 2007 for rural coastal and inland villages in Madang Province (sores and tropical ulcers 15.3%, ringworm 14.6%). The results for other fungal infections (including various tinea species) were however more than three-fold those reported in the Madang Province study (ie 43.2% versus13.1%) (CEH 2007b).

Sores and ringworm appeared to be predominantly present in the school-age children and adolescents and most likely as a consequence of their behavioural patterns. Other fungal skin infections, including tinea versicolour (white spot) and tinea circinatum appeared to be equally distributed between all age groups and were sufficiently common as to hardly be considered a disease by many people.

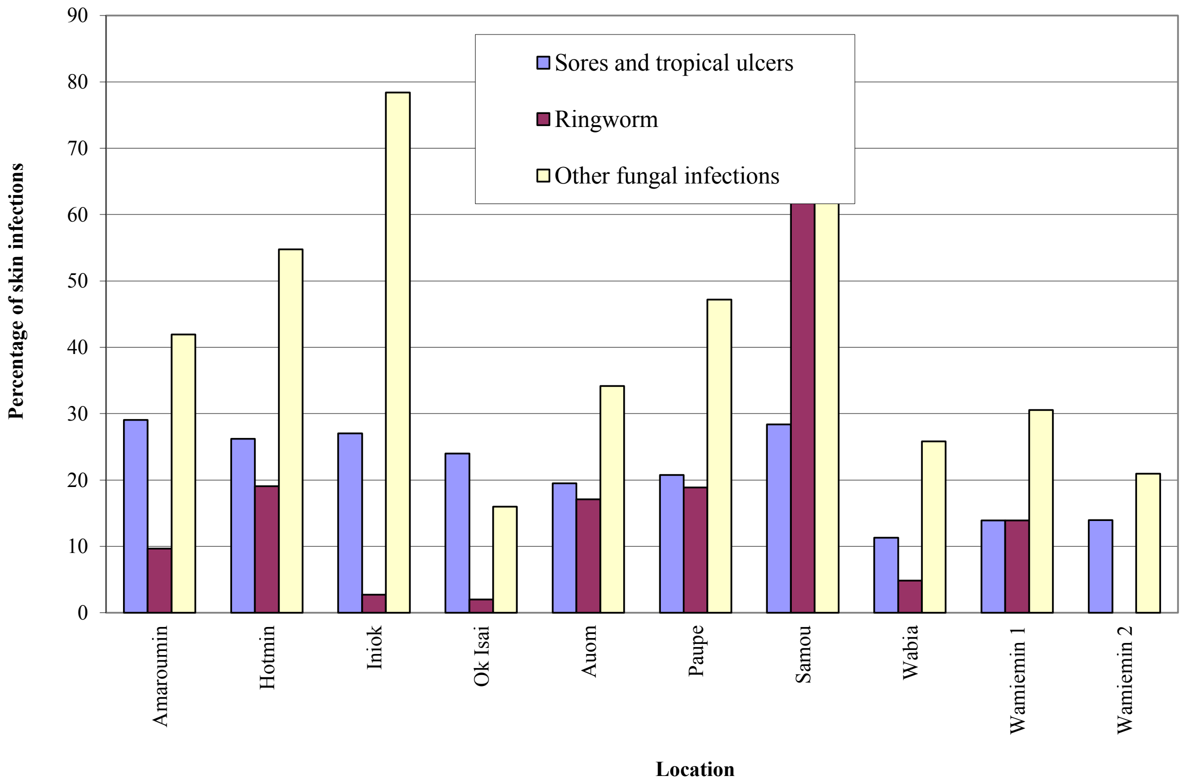
Of note, in the present results were the very high levels of skin infections in Samou village. The clinically determined average of these was 1.8 infections per participant, and for the infant and child groups ringworm had a prevalence approaching 100%.

Table 1-23: Prevalence of skin infections by village (all values number of cases)

Village	Scabies	Scalp infections	Sores and tropical ulcers	Ringworm	Other fungal skin infections	Total
Amaromin	0	0	9	3	13	25
Hotmin	0	1	11	8	23	43
Iniok	0	0	10	1	29	40
Ok Isai	1	0	12	1	8	22
Auom 3	0	0	8	7	14	29
Paupe	0	0	11	10	25	46
Samou	0	2	19	47	52	120
Wabia	0	1	7	3	16	27
Wameimin 1	0	0	5	5	11	21
Wameimin 2	0	1	6	0	9	16
Total	**1 (0.2%)**	**5 (1.1%)**	**98 (21.2%)**	**85 (18.4%)**	**200 (43.2%)**	**389**

Note: Scabies was identified at Ok Isai (1). There were four cases of scalp fungal infections at Hotmin (1), Samou (2) and Wabia (1).

Figure 1-6: Prevalence of skin infections by village and condition



1.2.6.5 Dental health

Exceptionally good dental health has been reported in a number of rural and remote coastal and inland communities in PNG (Hardham 1998, Flew 1996). A recent survey in Madang Province, reported a low prevalence of dental caries (4.2%) and missing teeth (12%). Missing teeth were found exclusively in the 40 + years of age group (CEH 2007b).

While in the present survey there were no cases of oral submucosal fibrosis identified at any village, there were five cases of oral malignancy at Amaromin(3) andWameimin2 (2), giving an overall incidence of 1.1%. The overall incidence of dental caries in the present study population was 19.7%. The incidence varied widely between villages, with Samou, Paupe and Auom 3, ranging between 7% and 12% and for Hotmin, Ok Isai, Wabia, Wameimin 1 and 2, 27 – 29%. Amaromin and Iniok were intermediate with 16%.

The overall incidence of missing teeth was 16%. The incidence at Samou (4%) and Auom 3 (2%) were almost an order of magnitude less than that observed at Amaromin (23%), Ok Isai (18%), Wabia (31%), Wameimin 1 (25%) and Wameimin 2 (28%). The incidence at the other three villages were between 10 – 13%. The incidence at Wabia may have been influenced by the unusually high percentage of people over 45 years of age who were medically examined. This was not however, the situation in the other nine villages.

The marked difference between the incidence of both dental caries and missing teeth between villages was likely due in part at least, to the low consumption of refined carbohydrates (store foods, sugar, snacks) and a high fibre diet at Auom 3 and Samou.

All of the communities displayed extensive staining of the teeth due to the chewing of betel nut (betel nut). Plaque was also common, due to the lack of toothbrushes and toothpaste.

1.2.7 Medical Questionnaire

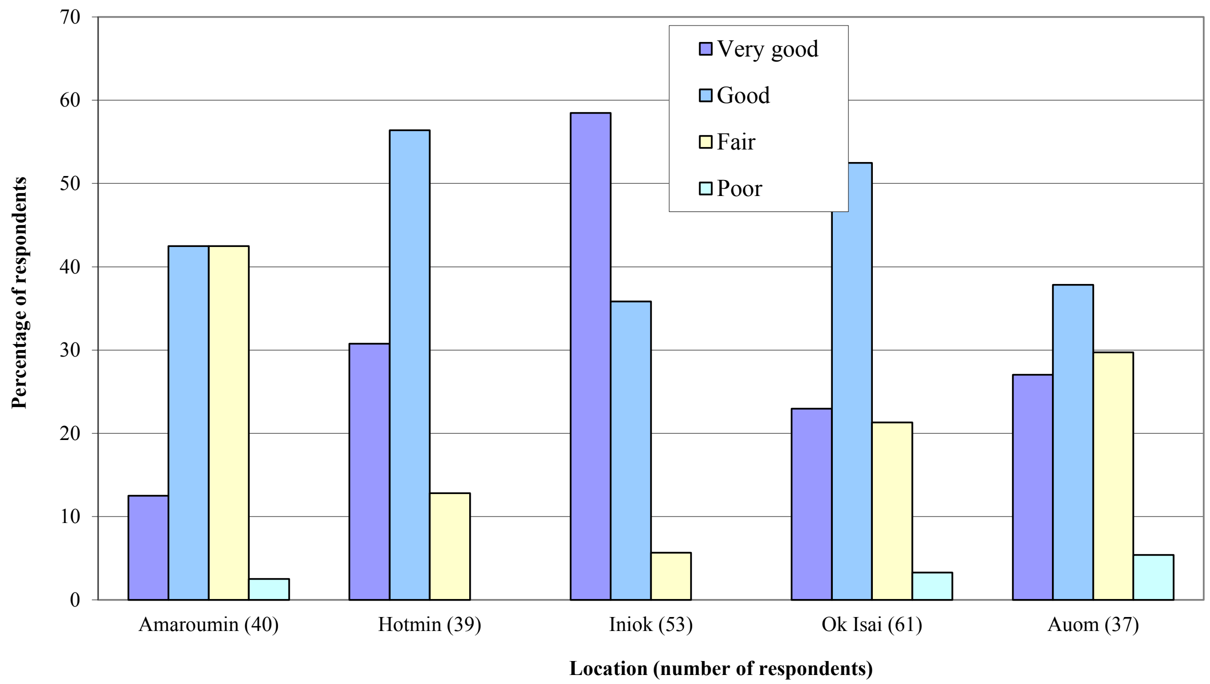
The summarised data is discussed in sections 1.2.7.1 – 1.2.7.4. The individual medical questionnaire responses are provided in Appendix 3, and the data for child immunisation coverage by village, is provided in Appendix 11.

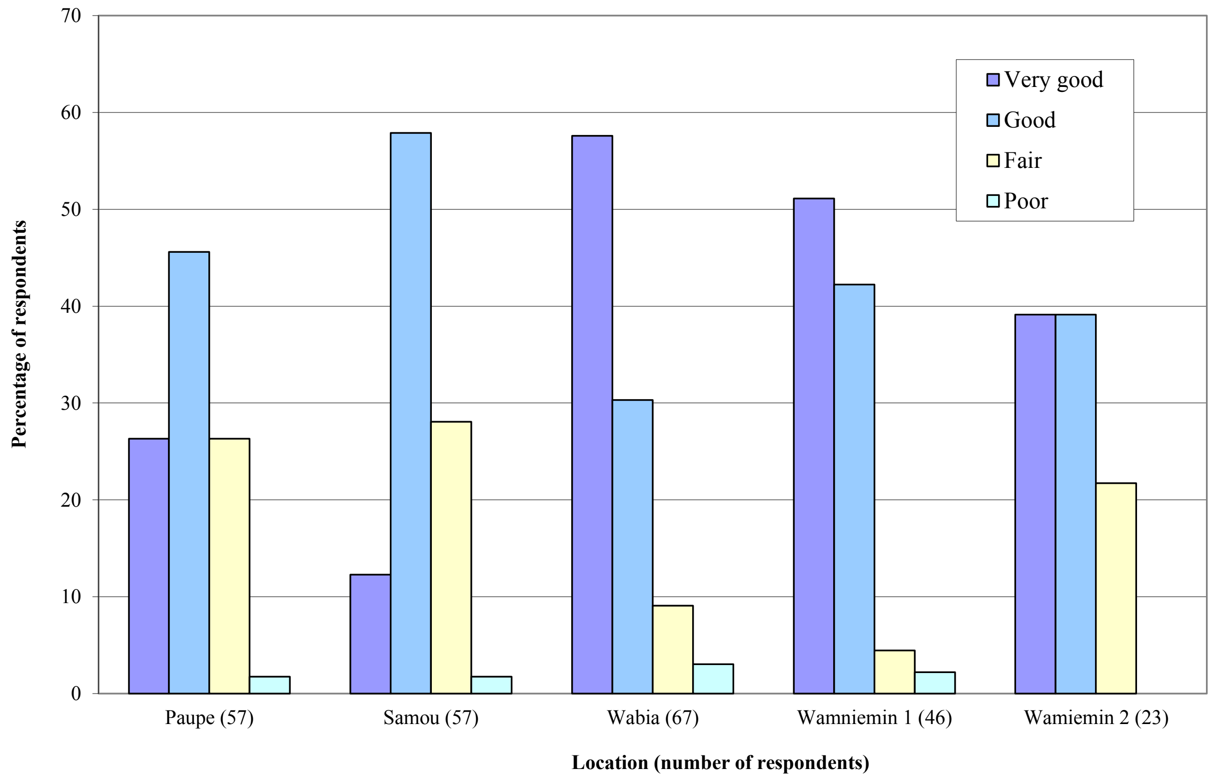
1.2.7.1 General state of health

The general state of health by survey village is shown graphically in Figure 1-7. Current symptoms of sickness in the last 7 days are discussed in section 1.2.7.3. Overall, there wereabout 78% of villagers whose health in the last 12 months was perceived either by themselves or on behalf of their children, as good or very good. Of the remaining 22% only 1.5% described their health as poor. As expected, this latter group was evenly distributed across all communities.

A comparison between villages, identified Amaromin (56%), Auom 3 (65%), Samou (70%) and Paupe (72%), as reporting the lowest health satisfaction ratings. This outcome was in overall agreement with the village disease prevalence identified by the medical examinations for Auom 3, Samou and Paupe. The result was also generally in agreement with the incidence of self-reported medical complaints over the previous 7 days. The high percentage of medical complaints over the previous 7 days at Wameimin 2, which was not reflected in the longer-term general state of health, gives some confidence that the results were not strongly influenced by present health impairments.

Figure 1-7: Self-reported general state of health by village and grading





1.2.7.2 Medical treatment in previous 12 months

The Frieda River Copper-Gold Project HEO questioned a random sample of the survey participants about clinical diagnosis and medical treatment over the previous 12 months. The participants from all communities had sought little treatment for medical complaints, other than malaria (369 of 480, a total of 77%) and internal parasites (186 of 480, a total of 39%). There were five cases of childhood asthma identified in the study population. There were no cases of typhoid or cholera and only three clinical presentations for splenomegaly, despite the high prevalence of this condition in all of the communities.

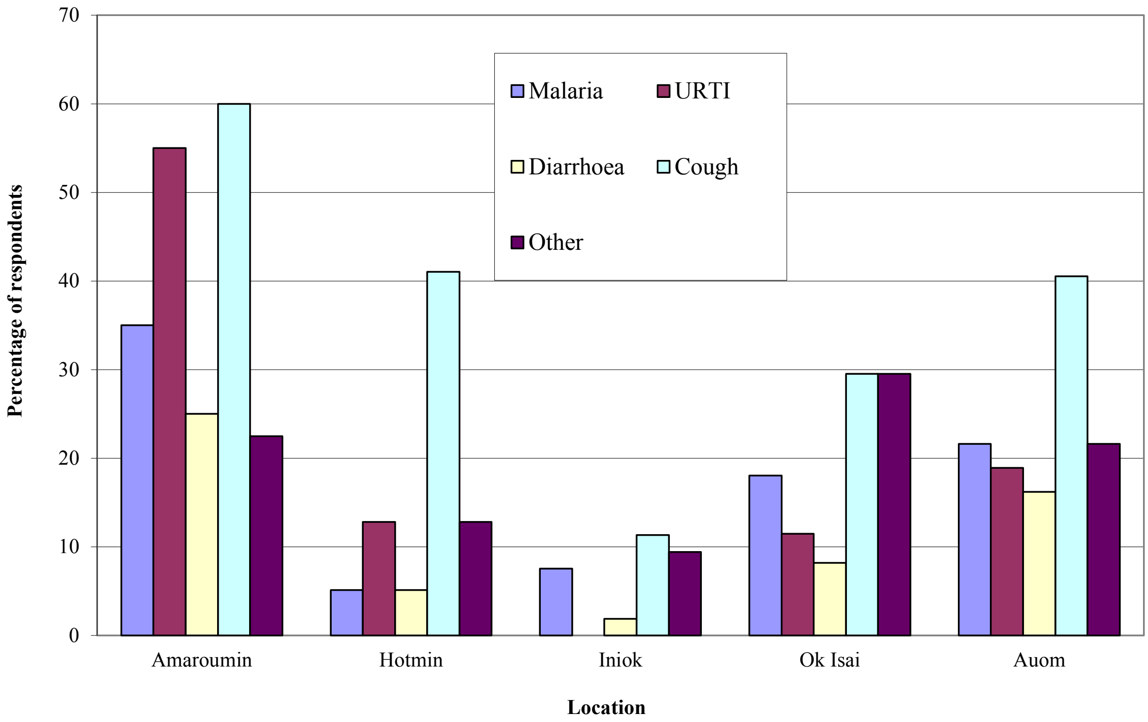
The incidence of hypertension (total 21 cases or 4.4% of the study population) was markedly higher at the villages of Iniok (3 cases), Ok Isai (6 cases) and Wabia (5 cases). While it is tempting to relate these with the evident changes in lifestyles at these villages, it is more probably that these communities had greater access to medical diagnostic services.

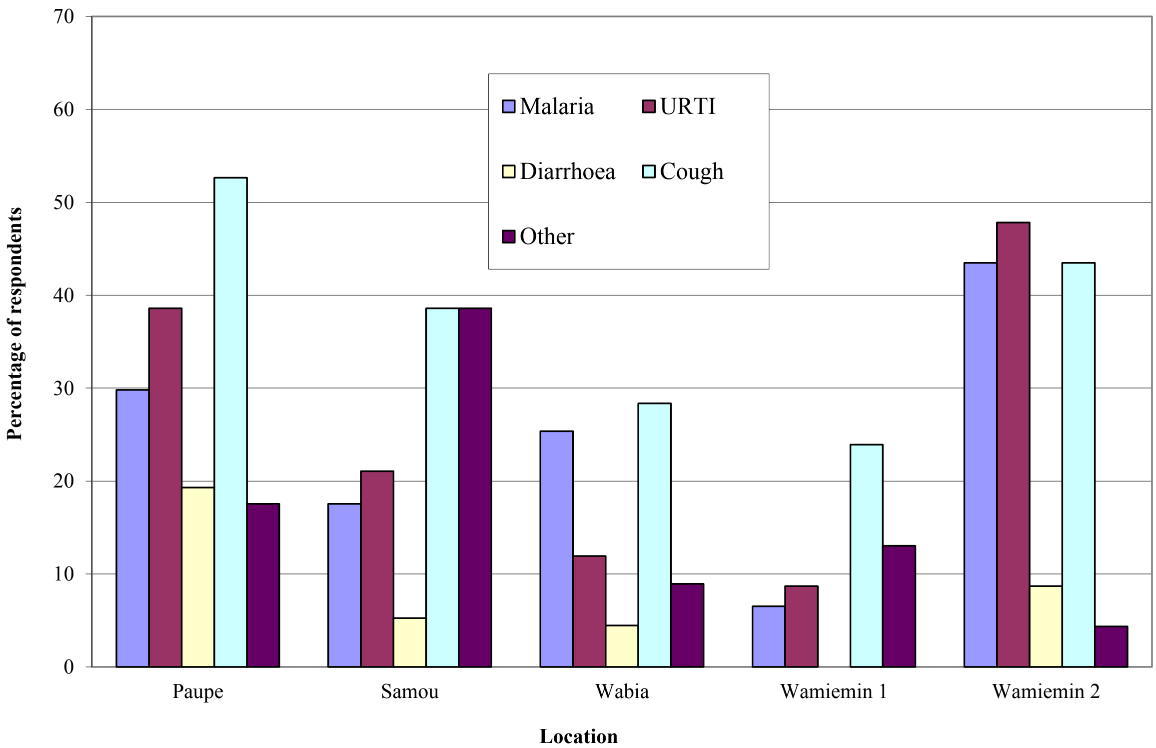
Diagnosis of malaria was reported by the respondent group as ranging between 57% at Iniok and 97% at Samou. Diagnosis of internal parasites between villages varied between 20% at Wabia and 61% at Samou.

1.2.7.3 Medical complaints over previous 7 days

The self-reported medical complaints are summarised in Figure 1-8. The results indicate a high prevalence of fever associated with malaria and upper respiratory tract infections. These results, from a survey taking place during the wet season, do not necessarily represent the annual prevalence.

Figure 1-8: Self-reported medical complaints over previous 7 days





1.2.7.4 Immunisation of children under 72 months of age

Infectious diseases such as measles, mumps, rubella, diphtheria, typhoid and whooping cough are some of the most important contributors to childhood morbidity and mortality and are readily preventable through universal childhood immunisation. The measure of childhood immunisation rates are therefore, one of the most important indicators of health status in the community and of the success of national public health measures.

The immunisation status of children at the study communities is shown in Table 1-24, and compared with the overall PNG coverage in Figure 1-9 (WHO WPRO 2009). The immunisation coverage was derived from the Child Health Care cards (CHC) and a cross-check for the characteristic BCG scar on the right shoulder for tuberculosis inoculation.

The availability of CHC cards varied widely between villages, being 100% at Wameimin 2 and only 8% at Samou. It was notable at Samou that many households had CHC cards for their older children. This was likely due to the presence of the New Tribes Mission who had staff present in the village between 1991 and 2003.At Hotmin, due to the nature of the survey, which gathered together the remaining community members, mothers were unable to bring their cards to the interview (see section 1.5).

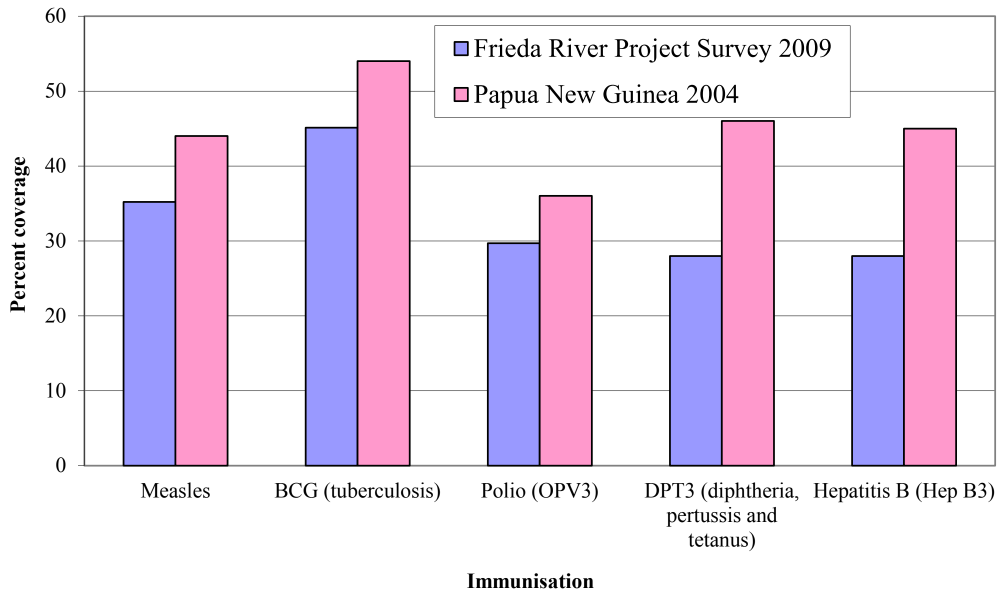
Table 1-24: Immunisation of children under 72 months of age (all values % coverage)

Village (No infants surveyed)	Child Health Care card %	Immunisation status		
		Complete %	Incomplete or behind schedule %	Not started %
Amaromin (12)	83	33	41.7	16.7
Hotmin (20)	25	10	5	15
Iniok (16)	50	25	12.5	12.5
Ok Isai (32)	47	40.6	6.3	6.3
Auom 3 (11)	82	54.5	18.2	18.2
Paupe (20)	40	15	20	5
Samou (26)	8	7.7	Not quantifiable	
Wabia (20)	70	65	5	5
Wameimin 1 (11)	64	54.5	9.1	27.3
Wameimin 2 (14)	100	14.3	85.7	0
Mean coverage		30.2		

Key:

Complete	=	Confirmed full course coverage from immunisation records
Incomplete	=	Some vaccinations have been omitted, or the child is over 12 months of age
Behind schedule	=	Vaccinations are not completed in the designated timeframe. The Ministry of Health Schedule of Immunisations (2007) has measles (6 and 9 months of age); BCG (at birth and at the beginning and end of schooling); polio and triple antigen (at 1, 2 and 3 months of age) and Hepatitis B (at birth, 1 and 3 months of age) (Tay 2007)
Not started	=	Includes both infants possessing a baby health care card, but showing no immunisation records and other infants under 12 months of age, having no records. It is possible to purchase blank cards, which in addition to immunisation records, are used for general medical records

Figure 1-9: Immunisation coverage of infants



1.3 Summary of Findings

Within the resource and logistical constraints of the baseline environmental health, diet and nutrition study, and bearing in mind the compromises (and benefits) that needed to be adopted using a combined household and village line-up methodology, the study has identified the principal public and environmental health and nutritional parameters of the study villages.

The environmental health component of the survey, while differing markedly between villages, overall gave results that are reasonably typical for remote lowland communities in PNG. The survey identified significant issues in relation to drinking water supplies, disposal of human sanitary wastes and solid waste disposal. For most village households overcrowding and exposure to air contaminants was not of concern.

The anthropometric data indicated a profile of above average nutritional health with little wasting, stunting or underweight in children under 5 years of age, adolescents or adults. Samou, however was a notable exception.

The nutritional surveys identified significant differences between the more isolated inland communities and those resident along the Frieda and Sepik rivers in the range of food consumed and consumption frequencies. The degree of isolation and household access to a cash income stream was the major determinant in the low consumption of store goods in the survey communities.

The present villages had very variable immunisation coverage rates. Generally, these were below those reported nationally in PNG. The immunisation rates for Samou and Hotmin were not reliably confirmed.

The measurement of blood pressure indicated that there were few hypertensive individuals, as to be expected in a group with minimal adult obesity. Examination of liver, kidney and lymph nodes identified a very low prevalence of clinical conditions associated with these organs. Spleen enlargement was typical of communities living in hyperendemic malaria areas of PNG.

The prevalence of eye infections was similar to the results reported for a number of other inland village groups in Morobe and Western Provinces. The prevalence of skin infections varied widely between villages and on a whole-of-population basis was somewhat higher than reported in other recent studies in remote and rural communities of PNG.

2.0 Concentrate Pipeline Corridor

For the 2011 concentrate pipeline corridor (including the mine access road), the baseline environmental health, diet and nutrition survey was undertaken at four Upper-Middle Sepik (Kubkain), Wario (Nekiei) and Wogamush (Sowano and Yabatauwe) river villages in the Ambunti-Drekikier, and Tunap-Hustein Districts of East Sepik Province. The same methodology was applied to this survey as described in the Executive Summary.

The villages included in this field campaign are listed in Table 1.

The overall environmental health results, while differing markedly between the Sepik River village of Kubkain and the more remote rural villages (Nekiei, Sowano and Yabatauwe) were reasonably typical for low-altitude riverine communities in PNG. In the remote rural villages, drinking water supplies were mainly from unprotected river and creek sources, with shallow wells replacing these sources during the wet season. The wide availability of household pit latrines was compromised at Nekiei and Kubkain during the wet season with sanitary wastes being of necessity, discharged to the surrounding environment. Solid waste disposal was at best disorganised.

Overcrowding was of health concern for all village households at Yabatauwe and Sowano and approximately half of the households at Nekiei. However, the range of mean values (6.1 – 11.6 m^2/occupant) is markedly higher than that observed at the Middle-Lower Sepik River villages (range of values 3.5 – 4.6 m^2/occupant). The occupant density at Kubkain was extraordinarily low, with almost 50% of houses being > 300 m^2 (maximum area 1000 m^2) and a range of household densities between 14 and 125 m^2/occupant. Indoor ventilation at the villages was generally poor, with all houses at Kubkain, Nekiei and Sowano having indoor cooking facilities and few windows. At Yabatauwe approximately 45% of houses had separate cooking areas.

The nutritional surveys identified that the principal diet consisted of sago and fish, supplemented by banana, green vegetables and coconut. The more remote villages had significant production of a variety of tubers and fruit/nut trees, including citrus, lau lau and mango. Papaya and pineapples were generally available. Village gardens, inundated at the time of the survey at Kubkain, appeared to be productive only in the relatively short dry season (June to September).

The anthropometric data indicated a profile of above average nutritional health with little wasting, stunting or underweight in infants under 5 years of age, children, adolescents and adults. The presence of a significant adult population (both males and females) in the overweight and obese categories, determined by body mass index and waist measurements will require further monitoring as the communities transition towards a more urbanised diet.

The villages had variable immunisation coverage rates. The survey results are not robust, and comparisons with national PNG averages unreliable.

The measurement of blood pressure indicated that there were few hypertensive individuals, as to be expected in a group with low levels of adolescent and adult obesity. Examination of liver and kidney identified no clinical conditions associated with those organs. Similar to the Middle Sepik River villagers, spleen enlargement rates were exceptionally low, and atypical of communities living in hyperendemic malaria areas of PNG. The reason for this is unclear. There were a significant number of individuals at Nekiei (17%) with lymph node enlargement (primarily cervical). This appeared to be related to an unusually high prevalence of ear lobe infections.

The prevalence of cataract was intermediate between the rates observed for the mine area villagers and the Sepik River communities, but not exceptional for rural and remote PNG. The prevalence of pterygium was markedly lower than that observed in the Sepik River villagers (as described in Section 3), being similar to those observed in the mine area villagers.

On a whole-of-study population basis, sores and tropical ulcers and ringworm were similar in prevalence, to that observed at the mine area villages. In contrast with the mine area village survey, tropical ulcers were evenly distributed between all age groups. Ringworm was mainly observed in the infants and children.

The pipeline communities are located either on the low escarpment of the highland fringe or at the top of the Sepik River flood plain. The pipeline communities are dependent on the Wario, Wogamush and Sepik rivers system for of the majority of their daily survival needs. All of the pipeline village communities had a largely subsistence economy, with a diet based on sago and fish, supplemented by bananas and coconut. Tubers, green vegetables and some soft fruits from the village gardens are reliably available 5 – 6 months a year at Nekiei, Sowano and Yabatauwe. Kubkain, on the Sepik River flood plain has only dry season gardens, generally available between June and September.

The pipeline villagers had few cash income sources. Fish smoking and crocodile harvesting did not appear to be a significant income source. Betel nut was widely available, but it was not apparent if this was harvested and sold to traders for re-sale in the coastal communities and the highlands as was prevalent at the Sepik River villages. Gold recovery was a significant income source at Sowano and Yabatauwe, with the young males working in the upper Frieda River system.

The overall objective of the work was to characterise the health status of the population along the proposed pipeline corridor (including the mine access road), located between the mine site and the river port facility (see Figure 1-1).

2.1 Survey methodology

2.1.1 Village selection

The villages and townships selected varied widely in size from Sowano (5 occupied households and total populations of about 43) to Kubkain with 57 households and a population of approximately 270.

It was not necessary to visit all communities within proximity of the 2011 concentrate pipeline to adequately characterise the health of communities within the infrastructure corridor. A small number of other villages near to the proposed pipeline route, such as Wakiawei, were within walking distance of surveyed communities and it was considered that the surveyed villages would be sufficiently representative of those. The village of Simowe originally proposed as part of the survey, had been abandoned at some point after the 2000 PNG National Census.

The villages were all of original ethnic groups. The villages of Nekiei, Sowano and Yabatauwe are of a single language group (Saniyo-Hiyowe). The Kubkain villagers are of the Wogamusin language group. All survey heads of household were born in East Sepik Province.

The access to health and education facilities is shown in Tables 2-1 and 2-2.

Table 2-1: Access to public health facilities

Village	Village aid post/health centre		Comment	Hospital		Comment
	Nearest location	Distance * (hours)		Nearest location	Distance * (hours)	
Kubkain	Hauna	5	By ordinary canoe or (motorised canoe)	Wewak	14	By motorised canoe and road
Nekiei	Hauna	16 (6)		Wewak	17	
Sowano	Maposi	11 (4)		Wewak	16	
Yabatauwe	Maposi	9 (2 ½)		Wewak	16	

* Distance is estimated by survey participants and would vary depending on the speed at which they are able to travel and their comprehension of time and distance. It is provided for indicative purposes only.

Kubkain did not have a government aid post. However, there were four trained first aid people and a village birth assistant. Medicines were provided by the New Tribes Mission.

Similar to all of PNG in recent years, and particularly in rural and remote environments, the health infrastructure at the survey villages was seriously degraded in both core and targeted program funding (eg. for key drugs, tuberculosis management and immunisation). Health service delivery in these environments was at best intermittent, being further conditional on the availability of qualified and motivated staff (from the district health centres).

Table 2-2: Access to education facilities

Village name	Elementary school	Trained teachers	Adequate* classrooms	Adequate* teaching materials	High school	
	Yes/No	Yes/No			Nearest location	Distance (hours)
Kubkain	Yes	3	Yes	Yes	Ambunti	6 – 10 by motorised canoe
Nekiei	No	-	-	-		
Sowano	No	-	-	-		
Yabatauwe	Yes	1	Yes	Inadequate		

* Adequacy is the opinion of survey respondents and in some cases observed by the study team.
** Distance is estimated by survey participants and would vary depending on the speed at which they are able to travel and their comprehension of time and distance. It is provided for indicative purposes only.

The children from Sowano attended school at Yabatauwe, about one hour away by normal canoe, with teachers qualified to diploma level.

The nearest school for Nekiei was at Hauna, but it appeared that no children from Nekiei attended any school.

2.1.2 Constraints to the conduct of the survey

None of the pipeline survey villages had a village map showing household locations. As a result, the use of a stratified fully random survey methodology was not practical. At Nekiei and Sowano, all occupied households were included into the survey. At Yabatauwe the coverage was approximately 50% of households. At Kubkain, households were randomly identified by request to the local village heads of household present at the anthropometric village line-up. Since approximately 25% of all households were surveyed, the sample is considered representative of the Kubkain community.

At the time of the survey the river system was in flood. There was extensive flood water inundation at Kubkain and to some degree at Nekiei. At Kubkain, it was not practical to conduct interviews at the individual households. As a compromise, household groups were invited to assemble at the nearest dry area to the village. At all villages the response was excellent, as confirmed by the percentage of participants in the village line-up anthropometric survey (range 52%– 92% of total population).

The need to adopt a modified household approach at Nekiei and Kubkain impacted on the development of a detailed assessment of the environmental health circumstances. In particular, it was not possible to make an assessment of the presence and number of insect vector breeding sites around the villages and households.

While there was no impediment to the development of longer term nutritional estimates at the family level, undoubtedly the 24-hour dietary estimation ("food consumed by the family on the previous day") was influenced by the high river levels at Kubkain, with many families reporting that their gardens had been destroyed and access to the sago palms was limited.

At the pipeline villages, it was virtually impossible to ensure any privacy for the conduct of individual question-response interviews, which were carried out in a communal environment. To the extent practical (eg. by constant eye contact), responses were elicited from the target individual. However, it has to be accepted that an unknown and unquantifiable bias may have entered into the interview responses when dealing with sensitive questions.

The study participants were generally given their physical examinations and medical questions away from other non-family community members. At Nekiei, the interviews and medical examinations were of necessity undertaken in a communal environment. At Sowano, the adolescent and adult males were medically examined at the haus men. At Kubkain, the medical examinations were conducted at the local school, away from the general area.

2.2 Results and discussion of findings

2.2.1 Demography

The household questionnaire survey population and the cohorts available for anthropometric measurements and clinical assessments by village, age and gender is shown in Table 2-3.

Table 2-3: Household, anthropometric measurement and medical examination survey populations by age and gender (number of participants)

Village	0 - 5 years		6 - 10 years		11 - 16 years		17 – 44 years		45 + years		Total participants	
	M	F	M	F	M	F	M	F	M	F	M	F
	Household survey											
Kubkain	9	5	6	5	15	13	24	27	12	12	66	62
Nekiei	7	3	5	8	0	4	11	9	8	8	31	32
Sowano	3	3	0	2	3	2	10	9	1	2	17	18
Yabatauwe	4	3	2	5	1	2	8	5	2	3	17	18
Total	**23**	**14**	**13**	**20**	**19**	**21**	**53**	**50**	**23**	**25**	**131**	**130**
	Anthropometric measurement											
Kubkain	14	22	15	14	17	21	48	60	17	22	111	139
Nekiei	5	3	5	10	0	1	10	12	7	6	27	32
Sowano	5	2	3	1	2	2	7	9	4	2	21	16
Yabatauwe	5	4	3	5	2	2	9	9	2	4	21	24
Total	**29**	**31**	**26**	**30**	**21**	**26**	**74**	**90**	**30**	**34**	**180**	**211**
	Medical examination											
Kubkain	5		10		10		50		12		87	
Nekiei	8		8		1		20		4		41	
Sowano	4		4		3		13		4		28	
Yabatauwe	8		2		3		14		3		30	
Total	**25**		**24**		**17**		**97**		**23**		**186**	

Notes:

1. The reluctance of participation by male and female adolescents due to the public nature of the examinations (rather than the privacy given by household examination) is reflected in Table 2-3.
2. For the adult (17 – 44 years of age group) males dominated at Sowano. The males were examined at their separate residence with a large number being insistent on being included into the survey.

In the absence of quantitative age-gender groupings for the total village populations from a demographic census survey, the percentage participation rates were derived on a whole-of-population basis. This is shown in Table 2-4.

The coverage for the household survey at all communities other than at Kubkain (47%), and Yabatauwe (41%) was greater than 80% of the total village population. This data can be considered to be representative of the respective village households.

An overall participation rate of 39% for the medical examination is more than satisfactory. However, as discussed above, children and adolescents were somewhat under-represented. This is typical for PNG surveys.

Table 2-4: Household, anthropometric and clinical assessment survey participants as a percentage of total population

Village	Household survey	Anthropometric measurement	Medical examination
Kubkain	47	92	32
Nekiei	93	87	60
Sowano	82	86	65
Yabatauwe	41	52	35
Total	**55.6**	**83.2**	**39.6**

Notes:

1. The comparator populations used for the villages are those derived by the Coffey population head count census. These values are markedly different from the 2000 NSO census data. (Kubkain population 273 (NSO 2000 247); Nekiei population 68 (NSO 2000 29); Sowano population 43 (NSO 2000 90) and Yabatauwe population 86 (NSO 2000 52).
2. In the NSO census 2000 Kubkain (Kupkain) is in Ambunti rural. Nekiei, Sowano and Yabatauwe are in Tunap-Hustein. Simowe, abandoned at the time of the present survey, had a NSO 2000 census total population of 71, living in 14 households.

2.2.2 Socio-economic factors relevant to health

The question examining household sources of cash income was purposefully selected from the Coffey Environments questionnaire. The primary objective was to ascertain if on this parameter, the present household survey group were comparable with, and representative of the broader group, surveyed in the census and socio-demographic survey conducted in parallel with the present work. The results are shown and discussed in Table 2-5.

Table 2-5: Household sources of cash income (% of households)

Village (Total no households)	Salary	Remittances	Trade store	Canoe rental	Sale of agricultural	Timber	Fish and crocodile	Gold mining	Hunted animals	Handicrafts
Kubkain	6	0	19	6	0	0	12	0	6	0
Nekiei	14[1]	0	14	0	14	0	0	0	0	14
Sowano	0	20	0	40	20	0	20	20	0	0
Yabatauwe	29	29	14	14	0	14	0	43	0	0

Notes: 1. Occasional for the Frieda River Copper-Gold Project.

The trade store classification included retail of goods at the local Kubkain markets. At Nekiei, one household derived an income from property rental.

Agricultural products included banana, green vegetables, betel nut, cocoa, rubber and tobacco. Although sago and betel nut were widely harvested in the Sepik River corridor, the relative isolation of the pipeline villages appeared to limit trade.

Crocodile skins and meat were the main income source at Kubkain and Sowano.

Similar to their down-river neighbours at Angoram and Bin, the villagers at Sowano and Yabatauwe participated in small-scale gold mining. This activity was largely one involving young males in the community who went as a group into the upper reaches of the Sepik and Frieda rivers and recovered gold directly or worked for some of the gold-dredge owners.

Income from hunted animals at Kubkain was generally crocodile eggs and baby crocodiles that were sold to other households for growing to marketable skin size.

2.2.3 Village and household environmental health circumstances

2.2.3.1 Village Environmental Health

The survey villages' environmental health circumstances were obtained by directing questions to the Village Councillor, or other senior local leader. The results are shown in Table 2-6.

Table 2-6: Village environmental health conditions (all values % households)

Village name	Drinking water		Sanitation facilities		Solid waste disposal	
	Source	Condition	Pit	River	Bury	Open dump
Kubkain	Sepik River	Unsatisfactory	100	0	0	100
Nekiei	Wario River	Unsatisfactory	100	0	0	100
Sowano	Wogamush River	Satisfactory	100	0	0	100
Yabatauwe	Wogamush River (85%) Shallow well (15%)	Satisfactory	100	0	0	100

Rivers and local creeks were the sole drinking water supply at Nekiei and Sowano. At Yabatauwe households supplemented their drinking water from shallow hand-dug wells in the dry season. At Kubkain, shallow wells were used during period of flooding. The school at Kubkain had a drinking water tank in good condition.

At Kubkain and Nekiei, the rivers were used for toilet facilities during heavy rain periods when water filled the pit latrines.

Solid waste disposal (open dump) frequently involved the throwing of waste into the local rivers. At the time of the survey, no village had the capacity to bury wastes. The use of burning as a disposal method for solid wastes was not a practical option for Kubkain and Nekiei.

2.2.3.2 Household Environmental Health

Occupant density

The household approach permitted a good assessment of both occupant density (ie space per person) and household ventilation. The results are shown in Table 2-7. Overcrowding and poor ventilation is widely recognised as an important factor in health, particularly the prevalence of respiratory infections. Pneumonia is a major cause of hospital and health centre admissions and mortality in the survey districts (PNG MOH 2001). As discussed in section 2.2.7.2, the present survey households reported a high incidence of asthma, pneumonia and upper respiratory tract infections.

There was a very wide range of occupant density between households at all of the pipeline villages, with ranges between 4.2 – 125.0 m^2 per occupant. The houses at Kubkain were extraordinarily large, with correspondingly low occupant densities.

The range of mean occupant densities was much lower than that observed in the Sepik River villages (3.5 – 4.6 m^2 per occupant).

Ventilation was rated poor at all of the communities with the exception of Kubkain.

Table 2-7: Persons per household, occupant density, availability of ventilation and cooking facilities

Village (No households)	Persons per HH	Area per occupant (m^2)				
		Mean	Median	Minimum	Maximum	
Kubkain	8.0	48.6	37.5	13.8	12.5	
Nekiei	8.9	11.6	9.3	4.2	21.4	
Sowano	7.2	10.1	10.0	5.0	16.7	
Yabatauwe	6.3	6.1	5.4	2.5	10.2	
Village (No households)	**Ventilation (%)**			**Cooking and open fires (%)**		Cooking using open fires in the sleeping area, relates to permanent arrangements
	Good	**Adequat e**	**Poor**	**Sleeping area**	**Separate area**	
Kubkain	0	100	0	100	0	
Nekiei	0	0	100	100	0	
Sowano	0	0	100	100	0	
Yabatauwe	0	29	71	57	43	

Key:

Good ventilation = No indoor cooking in the main residence, adequate windows and a minimum of two doorways to the external environment or the house is on stilts

Adequate ventilation = Internal cooking, adequate windows and at least one doorway to the external environment

Poor ventilation = Internal cooking and heating fires, few windows and a single doorway to the external environment

Vector-borne disease control

Malaria was hyperendemic in all of the study communities (refer Section 2.3.6.2 Examination of liver, kidney, spleen and lymph nodes). As indicated in Table 2-8, virtually all village households had at least one mosquito net, but insufficient bed nets for the whole family. This was particularly notable at Nekiei (14%). The general practice at these communities appeared to be to reserve the mosquito nets for babies and infants.

Table 2-8: Vector borne disease control (all values % households)

Village (No households)	Protection measures		Mosquito bed nets		
	Screens	Cleaning around house	At least one	Nets for all family	Regular pesticide treatment of nets
Kubkain	0	0*	100	94	0
Nekiei	0	72	86	14	0
Sowano	0	80	100	80	0
Yabatauwe	0	57	86	57	0

*Flooded at time of survey.

It is likely that many households indicated that they cleaned up mosquito breeding areas to avoid embarrassment. The data likely overestimates the actual situation. In practice, with the survey being conducted at Kubkain, at a time when almost all village households were inundated, the use of environmental measures at this village could not be checked.

There was no reported use of insect repellents at any village.

It would appear that most of the participants did not understand the need for regular pesticide treatment of nets.

Use of addictive substances

The use of tobacco and other stimulants among adults (17+ years of age) is shown in Table 2-9. The overall consumption of tobacco was some two-fold in the male (50.7%) when compared with the female (24.4%) population. The consumption rate for males is very similar to that reported for the Middle-Lower Sepik River villagers (50.8%) (CEH 2011).

The overall smoking rate (38%) was less than that observed in the Middle-Lower Sepik River (48%) and mine area villagers (54%), and very similar to that reported nationally (37%), and in a recent study of inland villages in Madang Province (37%). This latter community has a similar level of economic development to the present survey group (FMR 1990, CEH 2007b).

The level of consumption of betel nut was similar in males and females and also comparable at all of the surveyed villages, with the exception of females at Kubkain (males 82%, females 55%). The overall consumption of betel nut (95.5%) is some two-fold that of the Middle-Lower Sepik River villagers.

Alcohol consumption appeared quite different in the pipeline villagers when compared with the Sepik River villagers and comparable with the more isolated mine area villagers (CEH 2011). Similar to the mine-area communities, consumption was restricted to adolescent and adult males (18%).

Table 2-9: Consumption of addictive substances all adults 17 + years of age (all values percentage)

Village (total households)	Tobacco		Betel nut		Alcohol	
	Male	Female	Male	Female	Male	Female
Kubkain (16)	64	27	82	55	46	0
Nekiei (7)	84	64	100	100	25	0
Sowano (5)	78	24	100	100	6	0
Yabatauwe (7)	25	13	97	90	14	0
Mean participation rate	**50.7**	**24.4**	**98.7**	**92.0**	**18.2**	**0**
Overall adult rates	**37.5**		**95.5**		**9.1**	

Note: Betel nut consumption commenced at an early age, with some infants consuming as young as 2 years of age.

2.2.4 Anthropometry

The interpretation of anthropometric measurements as indicators of various forms of malnutrition is as described in Section 1.2.4.3.

The summary anthropometric data for the survey population is given in Tables 2-10 to 2-16 and Figures 2-1 and 2-3. With a sample population of 391 (males 180, females 211), the statistical quality of the data is reasonable. The detailed anthropometric data, by village is provided in Appendix 2.

A comparison of the adult mean values for weight and height as shown in Table 2-10, indicated that while there were no statistically significant differences between villages, the Kubkain group would appear to be ethnically different from the other villages.

Table 2-10: Comparison of anthropometric values for adults 17 – 55 years of age

Village	Age (mean)		Weight (mean ± sd) kg		Height (mean ± sd) metres	
	Males	Females	Males	Females	Males	Females
Kubkain	29.6	37.6	65.9 ± 9.0	58.8 ± 8.2	160.1 ± 5.6	154.4 ± 4.8
Nekiei	37.8	37.4	59.4 ± 8.1	47.3 ± 7.0	157.9 ± 4.5	151.2 ± 4.5
Sowano	37.3	28.3	57.0 ± 7.1	46.0 ± 7.3	153.6 ± 7.2	150.0 ± 3.9
Yabatauwe	36.1	37.0	61.1 ± 7.3	48.1 ± 7.4	155.4 ± 4.1	146.3 ± 2.9

sd= standard deviation

Figure 2-1 gives the results for the mean height and weight of all infants 0 – 71 months of age. As expected, the results indicated a progressively increasing height and weight with age. The results are comparable with those observed in a number of other anthropometric measurement surveys in rural and remote PNG communities (Flew 1999, CEH 2007a).

The results for mean height and weight of children, adolescents and adults by gender are shown in Figure 2-2. In the child and adolescent groups, there is little difference between the males and females. This result is somewhat unusual, with females normally of greater stature and weight than their male counterparts, due to the earlier onset of puberty in girls.

This effect continues into the adult males and females between 17 and 44 years of age, with the females higher in stature than their male counterparts. Male and female adult groups over 45 years of age, were heavier and similar in height to their younger counterparts. This was in sharp contrast with the Middle-Lower Sepik River villagers where the female mature age group were some 10 kilograms lighter and 3 centimetres less in stature than the female 17 – 44 years of age group.

Figure 2-1: Infant mean height and weight (all survey participants)

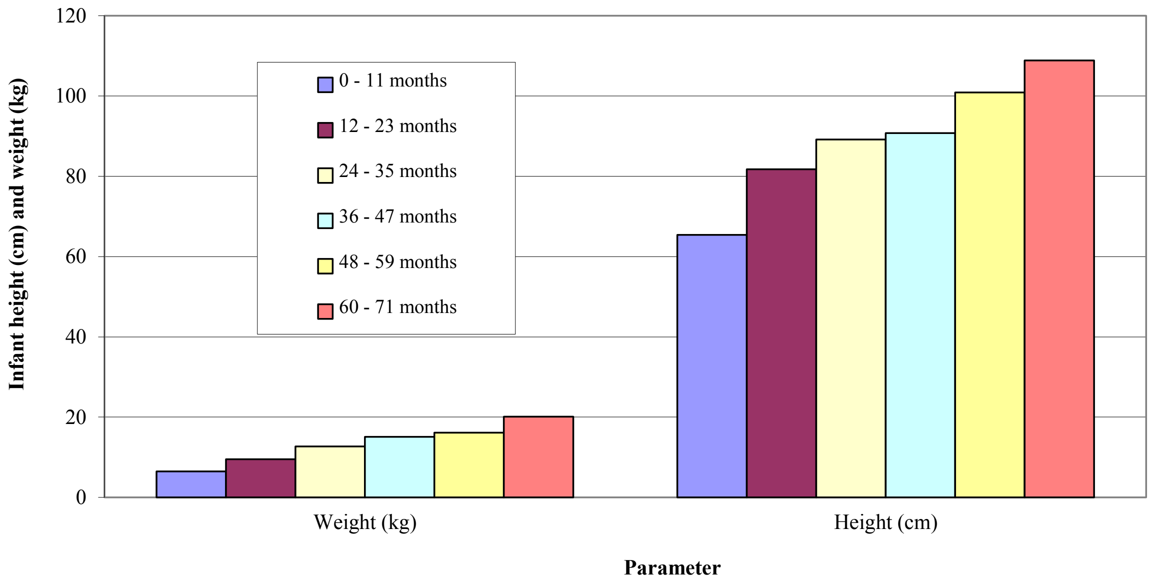
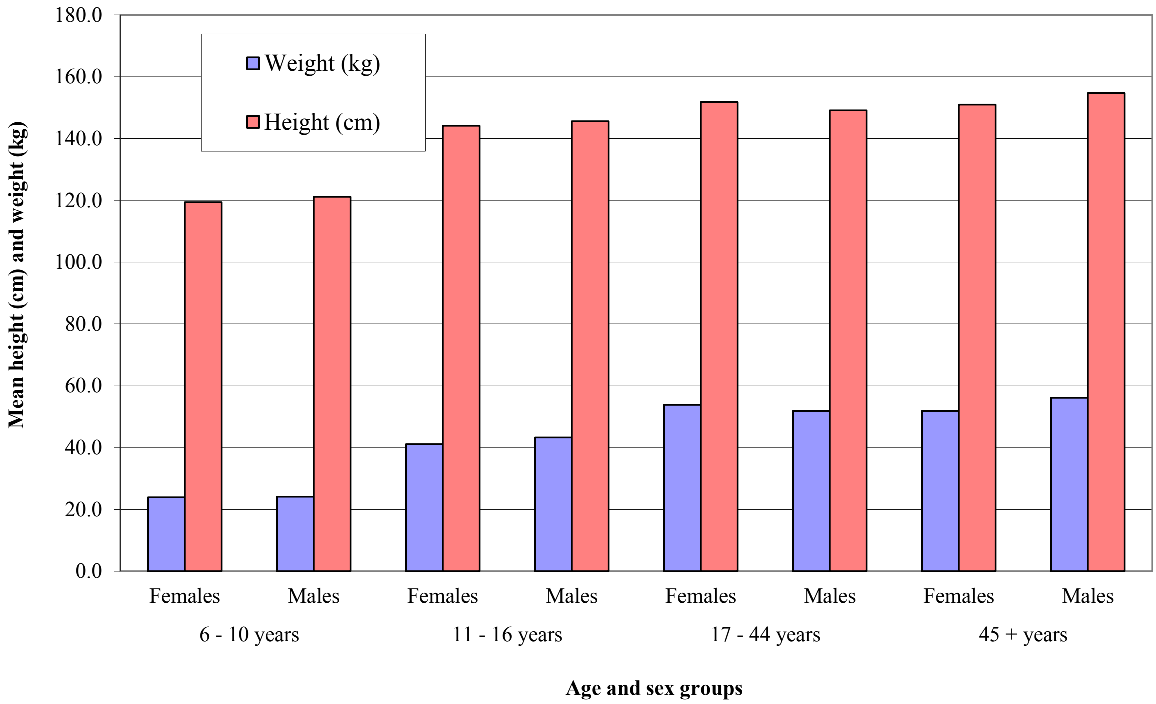


Figure 2-2: Mean height and weight of child, adolescent and adult survey participants by age and gender



2.2.4.1 Anthropometry of infants

The nutritional status of children under 5 years of age is commonly assessed using the method described in Section 1.2.4.1.

The data in Table 2-11 is presented as the percentage of children under 72 months of age, falling below two or three standard deviations reference population median value for each of the three indices weight-for-age, height-for-age and weight-for-height. While accepting the normal caveats associated with such a small sample, it can be seen that there is no child malnourishment in the first five years of life. Mildly overweight children in the 12 – 59 months of age groups are of no particular health concern.

The results can be favourably compared with the World Bank anthropometric database for lowland and highland fringe communities in PNG, which although using different criteria nationally, identified a prevalence of stunting in these geographic groups of 35% - 59%. There is no wasting in the present population. This result is consistent with that of the Lower-Middle Sepik River survey (2.1%) and similar to the prevalence observed in Madang and Morobe Provinces in 2007 (0% and 2% respectively) (Gibson and Roselle 1998, CEH 2007a, b).

Table 2-11: Anthropometric data for children 12 – 71 months of age (all values %)

Age (months)	Number	Weight-for-age		Height-for-age		Weight-for-height	
		Underweight		Stunting		Wasting	Overweight
		< -3 sd	< - 2 sd	< -3 sd	< -2 sd	< -2 sd	< + 2 sd
12 – 23	14	0	0	0	0	0	0
24 – 35	8	0	0	0	0	0	12.5
36 – 47	10	0	0	0	0	0	10.0
48 – 59	9	0	0	0	0	0	11.2
60 – 71	11	0	0	0	0	0	9.1

sd= standard deviation

2.2.4.2 Anthropometry of pre-pubertal adolescents and adolescents (6 – 16 years of age)

Table 2-12 shows the nutritional status as measured by BMI values for children and adolescents 6 – 16 years of age, by age group and gender. This data has been derived by comparing the present results on an age basis (by year) with those of the WHO International Obesity Taskforce 1998 (Cole et al 2000). There were a total of 56 participants in the 6 – 10 years of age group (males 26, females 30) and 47 participants in the 11 – 16 years of age group (males 21, females 26).

The results indicated that overall, underweight in the child groups was marginally higher in the males. In the adolescent groups, underweight was higher in the females (11.6%) than the males (4.8%). The limited sample size did not permit estimation of underweight children and adolescents by village.

The results for overweight in the pipeline adolescent villagers by gender, was similar to that observed at the mine area villagers and quite dissimilar to the results for the Sepik River villagers. The pipeline adolescents had a markedly higher percentage of males in the overweight category (14.3%) when compared with their female counterparts (7.7%). For the Sepik River villagers, there were a much higher percentage of overweight females (19.7%) than males (4.5%). There was no obesity recorded in the adolescent pipeline villagers.

The overall percentage of overweight adolescent pipeline villagers (11.0%) was very similar to that observed in the Sepik River villagers (10.9%) and in the mine-area villagers (10.5%) (CEH 2011).

Table 2-12: Nutritional status of children and adolescents by age group and gender (all values % of total participants)

Age group (years)	Underweight		Normal		Overweight		Obese	
	Males	Females	Males	Females	Males	Females	Males	Females
6 – 10	3.9	3.3	92.2	90.0	3.9	6.7	0	0
11 – 16	4.8	11.6	80.9	80.7	14.3	7.7	0	0

2.2.4.3 Anthropometry of adults

A comparison of the mean adult values for body mass index, as shown in Table 2-13, indicated that there were no statistically significant differences between the two village groups, although for both males and females the BMI values are higher at Kubkain.

Table 2-13: BMI of adults 17 – 55 years of age by village

Village	Age (mean)		BMI (mean ± sd) kg/m^2	
	Males	Females	Males	Females
Kubkain	30.1	31.6	25.6 ± 2.9	24.1 ± 3.3
Nekiei, Sowano Yabatauwe	37.1	34.8	24.3 ± 2.4	21.2 ± 3.3

sd= standard deviation

As indicated in Table 2-14, body mass index decreases in males over 47 years of age and females over 37 years of age. While this result is generally consistent with the international and PNG literature, the drop in body mass index for the females is at a younger age than generally reported.

Table 2-14: BMI by age groups adults 17 – 70 years of age (all values kg/m^2)

Age group (years)	Males (mean ± sd)	Females (mean ± sd)
17 – 26	24.0 ± 1.8	23.6 ± 2.3
27 – 36	25.6 ± 1.9	23.5 ± 3.8
37 – 46	26.3 ± 4.0	21.8 ± 3.3
47 – 56	23.7 ± 3.8	22.2 ± 4.8
57 +	22.8 ± 2.3	22.6 ± 5.7

sd= standard deviation

Table 2-15 derives the nutritional status of adults by village group. Reporting of the results by gender was not robust for the pipeline villagers. However, it is notable that similar to the results for the mine area villagers, the overweight and obese groups are predominantly male. This is in contrast with the results of the Middle-Lower Sepik River villagers, where the obese group appeared to be largely comprised of females (82%). The results for the pipeline and mine area villagers by gender are inconsistent with other studies in PNG. The reason for this is unclear.

Table 2-15: Nutritional status of adults 17 – 70 years of age by village based on BMI (all values %)

Village	Underweight % < 18.5		Normal % 18.5 – 24.9		Overweight % > 25.0		Obese % > 30.0	
	Males	Females	Males	Females	Males	Females	Males	Females
Kubkain	0	2.7	41.8	69.6	47.3	22.4	10.9	5.3
Nekiei, Sowano Yabatauwe	0	24.4	67.5	65.8	29.5	9.8	3.0	0

There were 24% of females, but no males who were underweight in the adult remote pipeline villages' survey group, an order of magnitude higher than that observed at Kubkain.

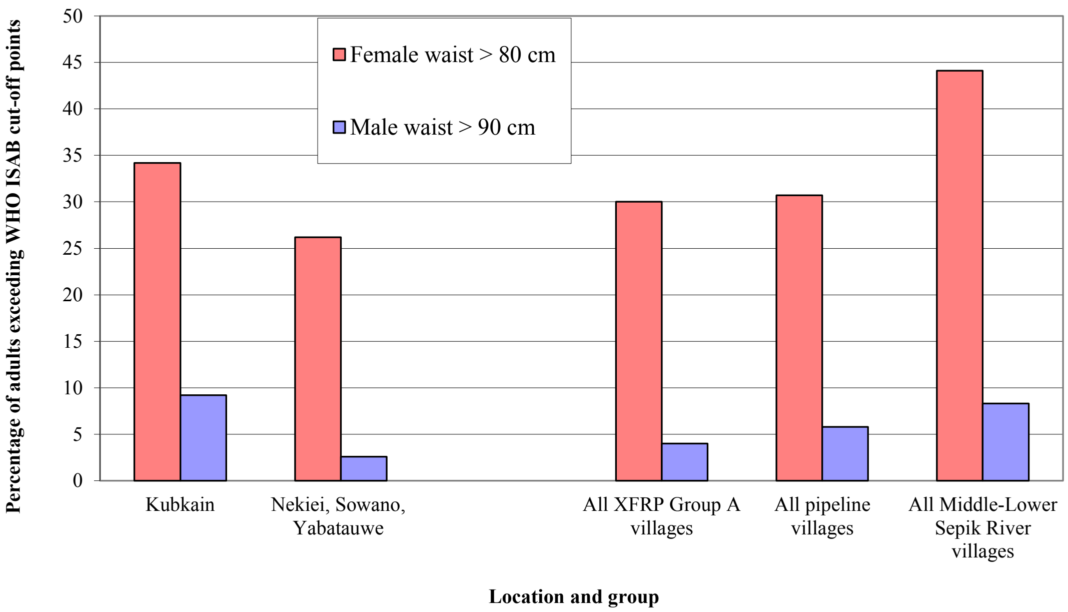
A comparison of the results for the pipeline survey adults with the WHO intermediate public health action points is given in Table 2-16. The results are unusual, in that there are more males in each of the high risk – very high risk categories than females. This result is in agreement with that shown in Table 2-15, but differs markedly from the Middle-Lower Sepik River villages, where the risk of heart conditions is higher in the females.

Table 2-16: Comparison of adult survey group BMI values with WHO (2004) intermediate public health action points

Risk level	Males	Females
Normal range (low risk) (< 18.5 cm)	0	10.3
Increased but acceptable risk (18.5 – 22.9 cm)	16.9	38.2
High risk (23.0 – 27.4 cm)	68.4	39.1
Higher high risk (27.5 – 32.5 cm)	12.4	10.3
Very high risk (>32.5 cm)	2.3	0.9

Figure 2-3 compares the waist circumference measurements with the WHO-International Association for the Study of Obesity recommended cut-off points for urban Asians of < 90 cm for men and < 80 cm for women (WHO IASB 2000).

Figure 2-3: Adult waist measurements by village compared with the WHO IASB 2000 recommended cut-off points



The waist circumference results of adult all participants, indicated that for males approximately 95% were at low risk of cardiovascular disease, with the risk at Kubkain some three-fold that observed in the remote villagers. The corresponding values for the females were about 30% (Kubkain 34% and remote villages 26%). Consistent with the mine area villagers and Middle-Lower Sepik River villagers, the cardiovascular risk was higher for the females than for the males. However, this result is not in agreement with the results from Tables 2-15 and 2-16, where the males are at higher risk than the females. This result is unexplained.

2.2.5 Food and nutrition

Twenty-four hour dietary recall and food frequency surveys were completed at the household level for all pipeline survey villages. The results are summarised in Tables 2-17 and Table 2-18, and provided in detail in Appendix 7.

As is usual for surveys conducted in remote PNG locations, there were both extended family and neighbours present. Every effort was made to concentrate on the responses of the specific household, and in the present circumstances when almost 100% of village households in the survey had a similar response ie, sago, fish, tubers and green vegetables and limited or no purchases of store foods, the possibility of overstating food selection for the 24-hour dietary recall component of the nutrition work can be discounted, and is summarised in Table 2-17.

The results of the food frequency survey (Table 2-18), were in reasonable agreement for most foods with the 24-hour dietary recall. This is as expected, with both the short- and long-term food consumption patterns being largely a diet of fish, sago and green vegetables together with a more variable (by village) consumption of banana and coconut. At Nekiei, Sowano and Yabatauwe seasonally consumed tubers provided a significant carbohydrate source. At the time of the survey, sweet potato was consumed by 100% of households at Kubkain. At Yabatauwe a variety of tubers were being consumed. There was virtually no consumption of tubers at Nekiei or Sowano. This result is unexpected.

Table 2-17: Food consumed in the previous 24 hours at the survey villages (all values % of households)

Food commodity	Kubkain %	Nekei %	Sowano %	Yabatauwe %
Sweet potato	100	0	0	29
Cassava	0	0	0	14
Taro	6	0	20	43
Yams	31	0	0	29
Banana	63	50	20	72
Sago	94	100	100	100
Coconut	63	33	60	100
Rice	0	0	0	14
Pork	44	20	100	14
Other meats	0	20	0	14
Fresh fish	100	67	100	86
Eggs	0	0	0	14
Sugar cane	0	0	0	29
Fresh fruit	0	17	0	14
Nuts	0	17	0	0
Green vegetables	31	67	100	100
Yellow vegetables	0	67	80	72
Flour	0	0	0	0
Tinned fish	0	0	0	0
Tinned meat	0	0	0	0
Milk	0	0	0	0
Sugar	0	0	0	0
Bread	0	0	0	0
Vegetable oil	0	0	0	0
Snacks	0	0	0	0

The annual food consumption frequency survey indicated that sago was the main staple carbohydrate food at all of the survey communities. At all villages, sago was seasonally supplemented by a range of tubers, banana and coconut. The annual consumption frequency of tubers at Kubkain was approximately 50% of that of the other villages, likely due to the shorter seasonal availability period, and the annual inundation of the vegetable gardens. The carbohydrate consumption patterns were intermediate between the sago dependent Middle-Lower Sepik River villagers and the less affluent tuber consuming inland mine area villagers.

Consumption of green vegetables (31 - 100%) was higher than that observed at the Middle Sepik River villages (25 – 65%). With the notable exception of Kubkain, this could readily be attributed to the availability of food gardens at all seasons.

The consumption pattern for protein-rich food was very similar between the survey communities, with 67 - 100% of households having consumed fish, fresh or smoked on the day prior to interview. Consumption of hunted pork and other meats were unusually high for Sepik Province communities and markedly higher than that observed in either the Middle-Lower Sepik or mine area villagers.

Table 2-18: Food consumed in the previous year at the survey villages (in days/year)

Food commodity	Kubkain	Nekiei	Sowano	Yabatauwe
Sweet potato	24	34	21	33
Cassava	21	40	30	46
Taro	27	38	47	46
Yam	19	29	47	46
Banana	71	62	66	52
Sago	100	100	100	100
Coconut	100	90	100	100
Rice	1244	15	10	15
Pork	59	39	100	44
Other meats	19	17	16	33
Fresh fish	100	100	100	100
Eggs	7	7	7	7
Sugar cane	7	7	7	39
Fresh fruit	15	13	13	15
Nuts	11	11	15	15
Green vegetables	100	100	100	100
Yellow vegetables	18	56	100	61
Flour	7	7	0	9
Tinned fish and meat	9	7	7	9
Milk	0	0	0	0
Sugar	8	7	7	9
Bread	7	7	7	9
Vegetable oil	7	7	7	9
Snacks	7	7	7	9

Note: The food frequency survey was designed to take into account seasonal availability of food products and the stated frequency of consumption. For some villages, no consumption was recorded, when particular foods were never available. Deriving the annual consumption has used frequency (times/year) as:

Every day.	=	365	1 – 2 times a week	=	78
3 – 6 times a week	=	234	Occasional	=	24

2.2.6 Clinical measurements

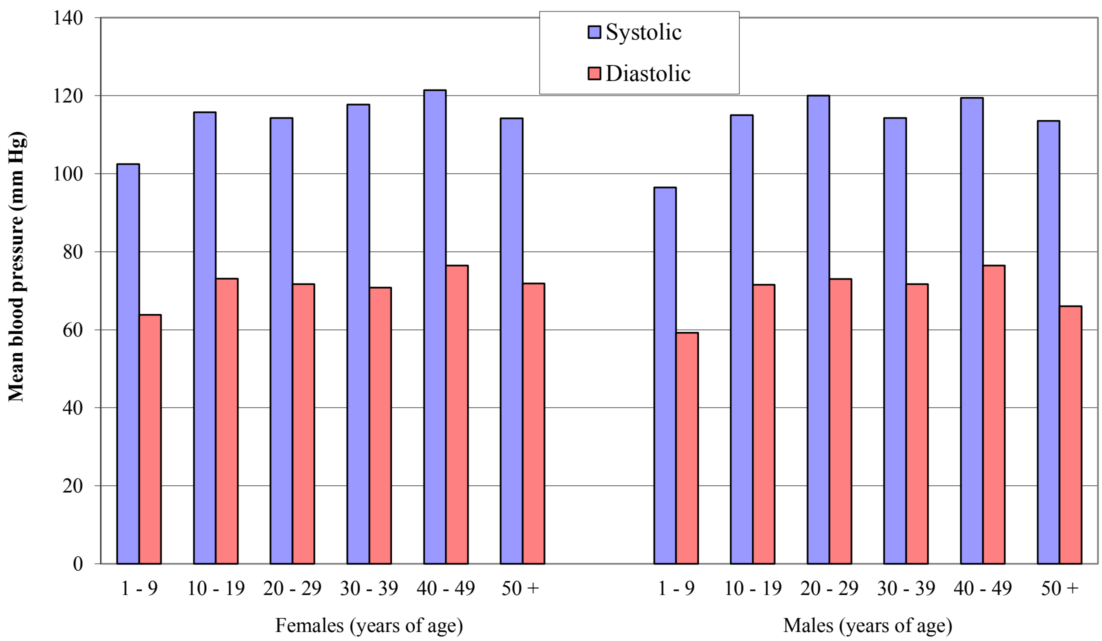
Summary data for each of the clinical measurements is discussed in sections 2.2.6.1 – 2.2.6.5. The detailed clinical results by village are provided as coded datasets in Appendix 9.

The medical examinations clinically identified a significant prevalence of asthma and chronic bronchitis in all age groups and arthritis, primarily in the elderly participants. To some degree at least, this may be related to the poor ventilation at all of the villages and the inundation of the Kubkain and Nekiei villages. As noted for the mine area villagers and those from the Middle-Lower Sepik River communities, lack of family planning was a significant problem, involving marriage at an early age and frequent multiple births. Uniquely, at Sowano there were a significant number of patients whose conditions required the prescription of malarial and other drugs.

2.2.6.1 Blood pressure

Blood pressure results were almost universally in the normal to low range, with little difference between the males and females of all age groups. There was no noticeable difference in the adolescent and adult mean values (males 119/72; females 116/74) between the pipeline villagers and the Middle-Lower Sepik River communities (males 120/76; females 124/79). There were very few hypertensive individuals in the study population and these generally linked to recognised medical conditions. This result is as to be expected, in a group largely without problems associated with overweight and obesity. The results are presented in Figure 2-4.

Figure 2-4: Blood pressure in survey villages by age and gender



2.3.6.2 Examination of liver, kidney, spleen and lymph nodes

Hepatomegaly and kidney enlargement

Hepatomegaly (liver enlargement) has long been reported as being highly prevalent in PNG, particularly in the lowlands in association with poor sanitation, crowded living conditions, low immunisation rates for hepatitis B, malaria and clinically diagnosed hepatitis B (Murthy et al 1995).

Hepatitis B was determined in a Western Province lowlands population by seroprevalence at 26%, but this study did not support the association between hepatomegaly and hepatitis B with a reported population rate of 0.5% (Flew 1999). The health baseline studies conducted in Madang Province and in the mine area villagers also gave population rates of 1.5% and 0.4% respectively. There were no cases recorded for the Sepik River villagers (CEH 2007b, CEH 2011).

There were no cases of kidney or liver enlargement in any of the pipeline villagers surveyed. With results from a number of studies now available, the original 1995 reported results appear to be unsupported by the evidence.

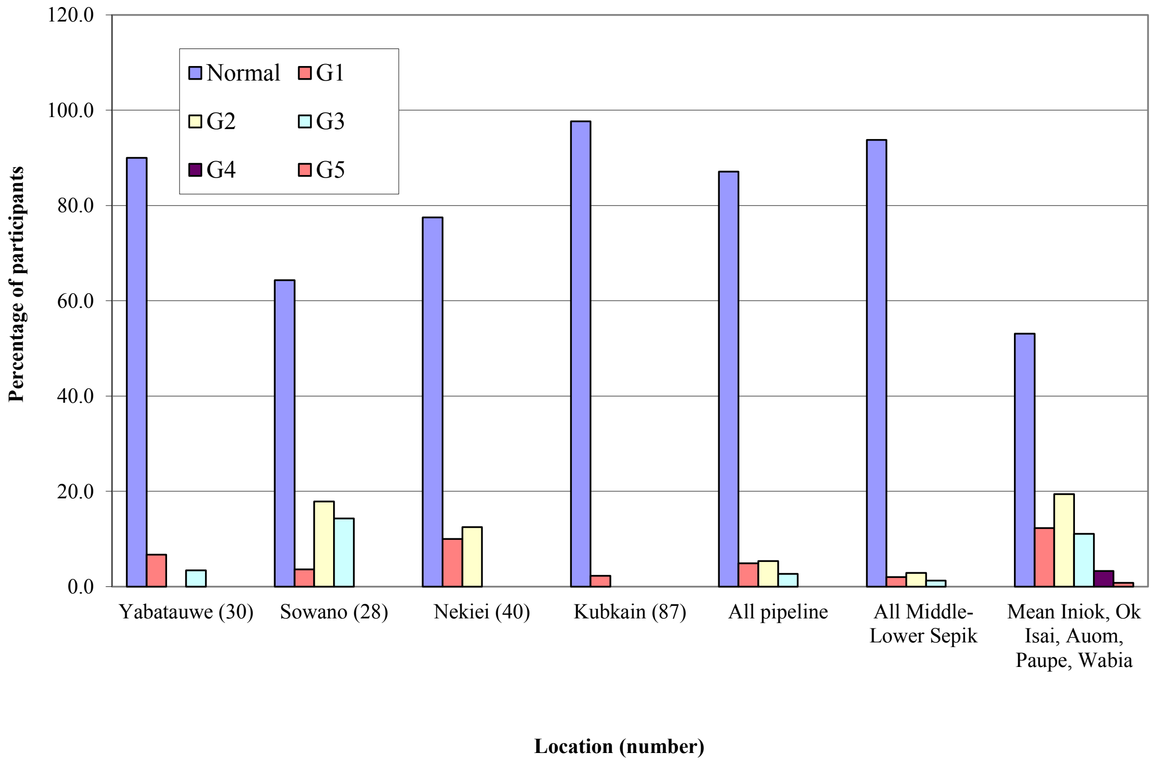
Splenomegaly

Splenomegaly (spleen enlargement) in PNG is most commonly due to infections, including Epstein Bar virus, which is closely associated with malaria infection and malaria protozoa. Other causal agents include intestinal parasites and fungal infections. Splenomegaly has frequently been reported as associated with generalised lymphadenopathy (swelling of lymph nodes).

A 2007 study of the Rai Coast and Usino-Bundi District inland villagers using the five grades of enlargement, according to the system developed by Hackett gave an overall prevalence (ie sum of Grade 1 – Grade 5) of 43% at the coastal villages and 41% at the inland villages. The 2009 survey of mine area villagers, using the same criteria gave an overall prevalence of 44%. These results are typical of other areas in PNG where malaria is hyperendemic (Hackett 1943, CEH 2007b, CEH 2011). For the Sepik River villagers, the overall prevalence of splenomegaly was surprisingly low (< 6%).

In the pipeline survey, the results by village and grade are shown in Figure 2-5. The overall prevalence of 13% was, with the notable exception of Samou (74%) similar to that observed in the more remote mine area villagers (9%), but markedly less than for the riverine mine area communities of Iniok, Ok Isai, Auom 3, Paupe and Wabia (45%).

Figure 2-5: Spleen enlargement by village graded in accord with Hackett (1943)



Lymphadenopathy

Lymph node enlargement generally occurs as a result of malaria, tuberculosis, respiratory tract, bacterial and fungal infections and intestinal parasites. In some studies multiple lymph node enlargements have been observed in more than 50% of the study population. This prevalence was greatly reduced following medical intervention using multiple drug therapies. The initial high prevalence was attributed to the extreme remoteness of the communities and a historical lack of any access to medical support (Reto 2005).

In the present survey population, lymphadenopathy in the cervical, popliteal, submandibular and auxiliary foci examined occurred at a six-fold higher frequency, (14 participants 7.6%) than in the mine area villagers. The result was also some two-fold that observed in the Sepik River villagers. There was a particular cluster of elevated cervical lymph node individuals at Nekiei (17%). This cluster appeared to be related to an unusually high prevalence of ear lobe infections. With the exclusion of Nekiei, the data indicates that the results for all of the Project surveys (range 1.2 – 4.8%) were similar to that observed in the 2007 study of the Madang Province coastal and inland communities (2.6%), and an order of magnitude less than that reported by Dr Cathy Reto for the Middle Strickland River communities (Reto 2005, CEH 2007b).

2.2.6.3 Eye infections

The prevalence of eye infections is shown in Figure 2-6. The prevalence of cataract in the pipeline communities (7.6%) was comparable with the results reported for the Sepik River villagers (6.2%) and results from the remote Fly River region (6.4%) (Flew 1999, CEH 2011). The prevalence is some three-fold that of the mine area survey communities (2%) (CEH 2011).

The level of pterygium at 11.9%, was intermediate between those of the mine area villagers (7.6%) and the Sepik River villagers (20.9%). It would appear that there is a transitional shift from a low pterygium prevalence at the inland communities, towards markedly increased prevalence nearer to the coast. The reason for this transition is unclear, however, it would support a hypothesis of extended exposure to sunlight in early childhood, rather than as proposed for the Sepik River communities, a consequence of ethno-genetic background.

2.2.6.4 Skin infections

The prevalence of skin infections by village is shown in Figure 2-7. On a whole-of-study population basis, the mean prevalence of skin infections was significantly higher than that generally observed at the mine area villagers (excepting Samou) and Sepik River villagers for fungal infections. The reported prevalence of sores and tropical ulcers (20%) was comparable with the results of the mine-area villagers (21.2%) and markedly higher than that observed in the Sepik River communities (5.9%).

Ringworm, mainly observed in the infants and children was at a prevalence rate of 22.2%, somewhat higher than observed in both the Sepik River villagers of 13.0% and the mine-area villagers of 18.4%.

Figure 2-6: Prevalence of eye infections by village and condition

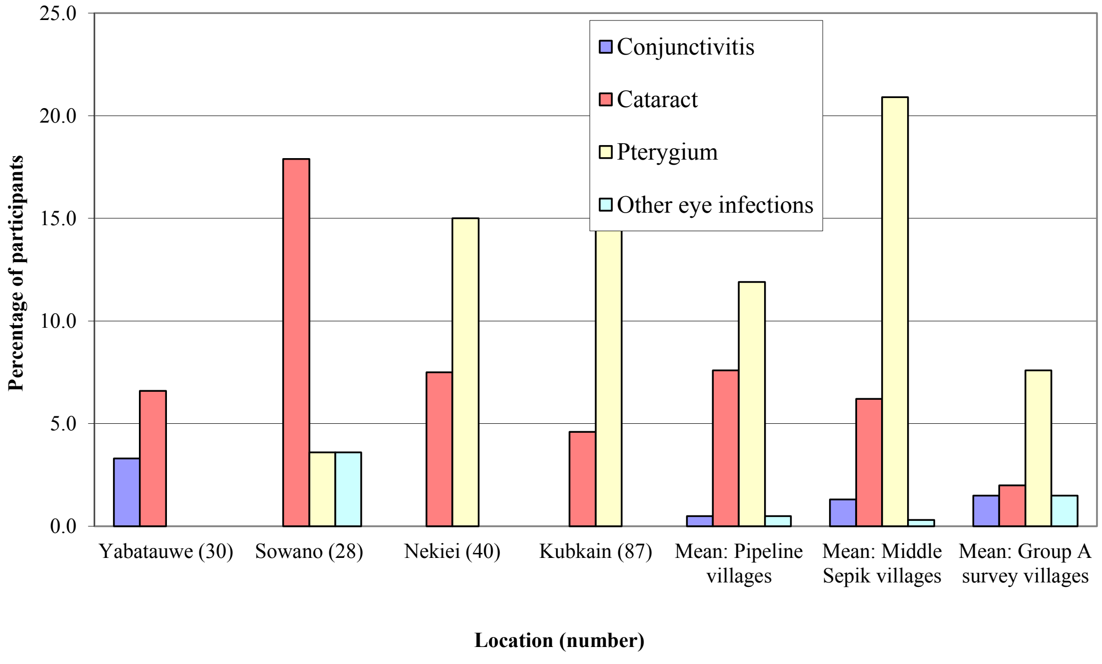
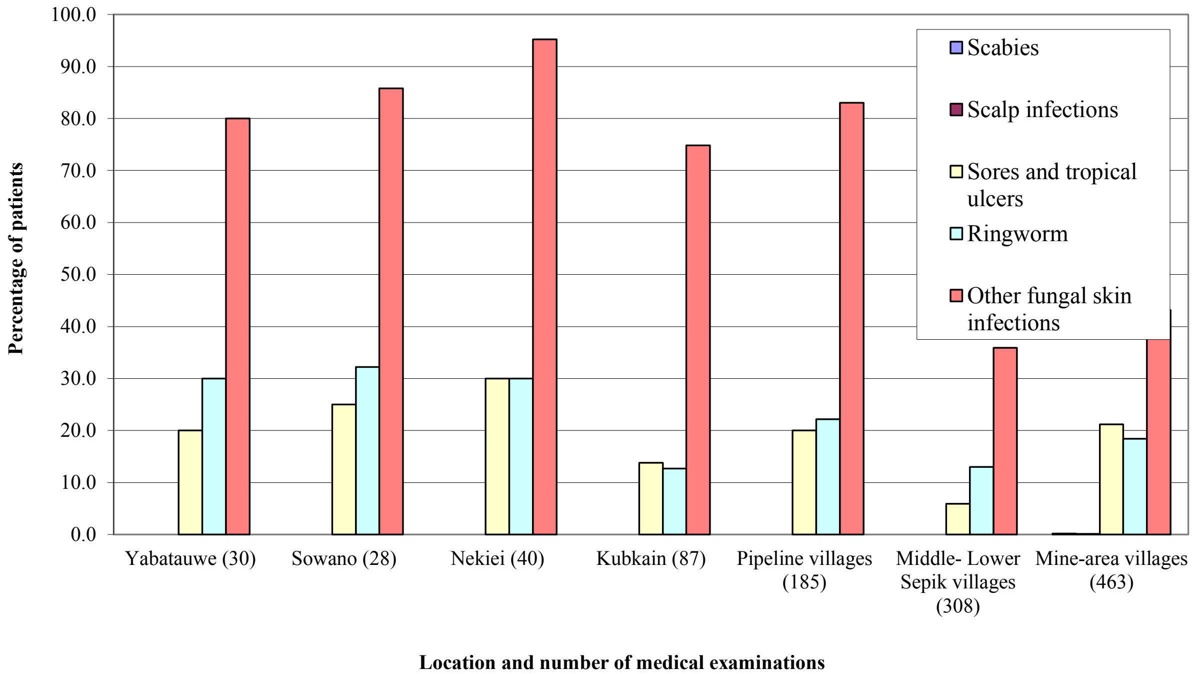


Figure 2-7: Prevalence of skin infections by village and condition



2.2.6.5 Dental health

In the pipeline survey villagers, there were no cases of oral submucosal fibrosis and three cases of oral malignancy (overall prevalence 1.6%). The overall incidence of dental caries in the present study population was 17.2%. The incidence was quite similar between villages (26.7 – 39.3%) with the exception of Kubkain (6.9%).

The overall incidence of missing teeth in the pipeline survey villagers was 8.1%. This was similar to that observed in the Sepik River villagers (5.2 – 10.0%).

All of the pipeline survey communities displayed extensive staining of the teeth due to the chewing of betel nut. Plaque was also common, due to the lack of toothbrushes and toothpaste.

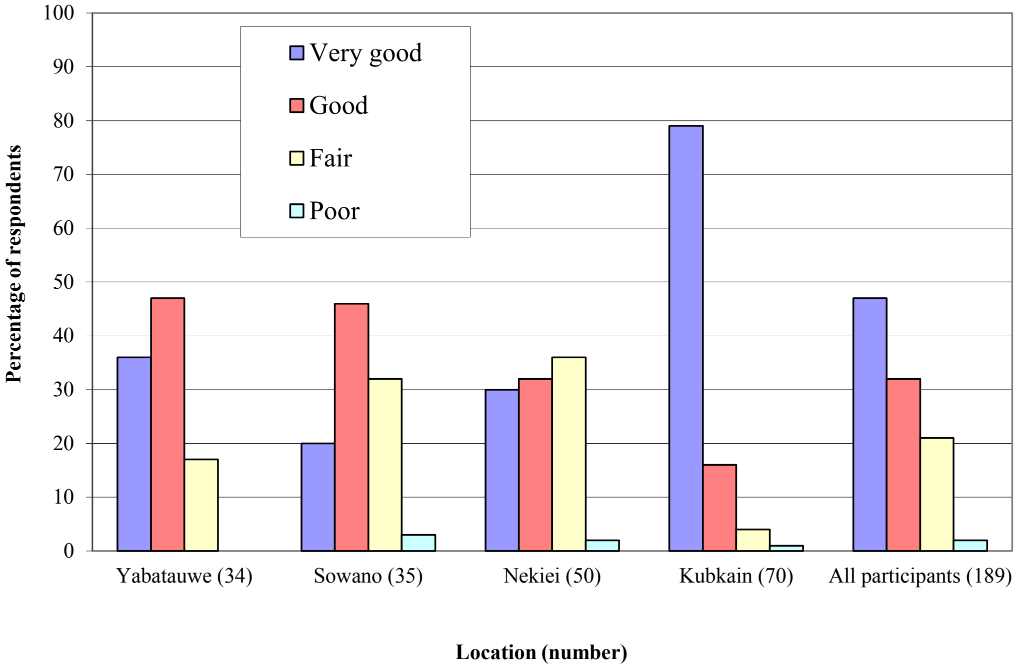
2.2.7 Medical questionnaire

The summarised data is discussed in sections 2.2.7.1 – 2.2.7.4. The individual medical questionnaire responses are provided in Appendix 9.

2.2.7.1 General state of health

The general state of health by survey village is shown in Figure 2-8.Overall, there wereabout 79% of villagers, whose health in the last 12 months was perceived, either by themselves or on behalf of their children, as good or very good, compared with the mine area villagers of 78%. The health satisfaction rating at Nekiei and Sowano (62 and 66% respectively) was the lowest, with the rating at Yabatauwe 83% and at Kubkain 94%. Overall of the 21% who reported fair or poor health, only 2.0% were in the poor health category. The low rating at Nekiei and Sowano was in overall agreement with the village disease prevalence identified by the medical examinations. As discussed previously, there was a significant unmet need for medications at Sowano.

Figure 2-8: Self-reported general state of health by village and grading



2.2.7.2 Medical conditions in previous 12 months

The results from the pipeline random survey of personal medical conditions over the previous 12 months are shown in Table 3-19. There were 14 cases of asthma identified in the study population (7.4%). This outcome was comparable with that of the Sepik River villagers (5.1%), but significantly higher than the mine area villagers (1.1%). The overall prevalence of diagnosed hypertension (0.5%) was markedly less than that in the mine area villagers (4.4%) and the Sepik River villagers (3.3%).

The reported incidence of malaria (50% – 89%) and internal parasites (29% - 60%) were similar at all of the villages except Kubkain (malaria 50% and internal parasites 29%).

The overall prevalence for pneumonia (6.9%) is intermediate between that of the Sepik River villagers (22.5%) and that reported in the mine area villagers (1.9%). Both of the pipeline and the Sepik River surveys were conducted in the same month (April 2010 and April 2011) during flood events.

Table 2-19: Reported medical conditions in the previous 12 months (all values percentage respondents)

Village and group	Asthma	Pneumonia	Hypertension	Intestinal parasites	Malaria	Dengue-like fever
Yabatauwe (34)	6	6	0	36	59	9
Sowano (35)	15	6	0	66	89	14
Nekiei (50)	12	12	2	52	88	26
Kubkain (70)	2	4	0	29	50	15
All participants pipeline villages (189)	7.4	6.9	0.5	42.9	68.8	16.4
All participants Middle-Lower Sepik River villages (333)	5.1	22.5	3.3	59.5	65.2	17.1
All participants mine area villages (480)	3.1	1.3	4.4	39.0	77.0	-

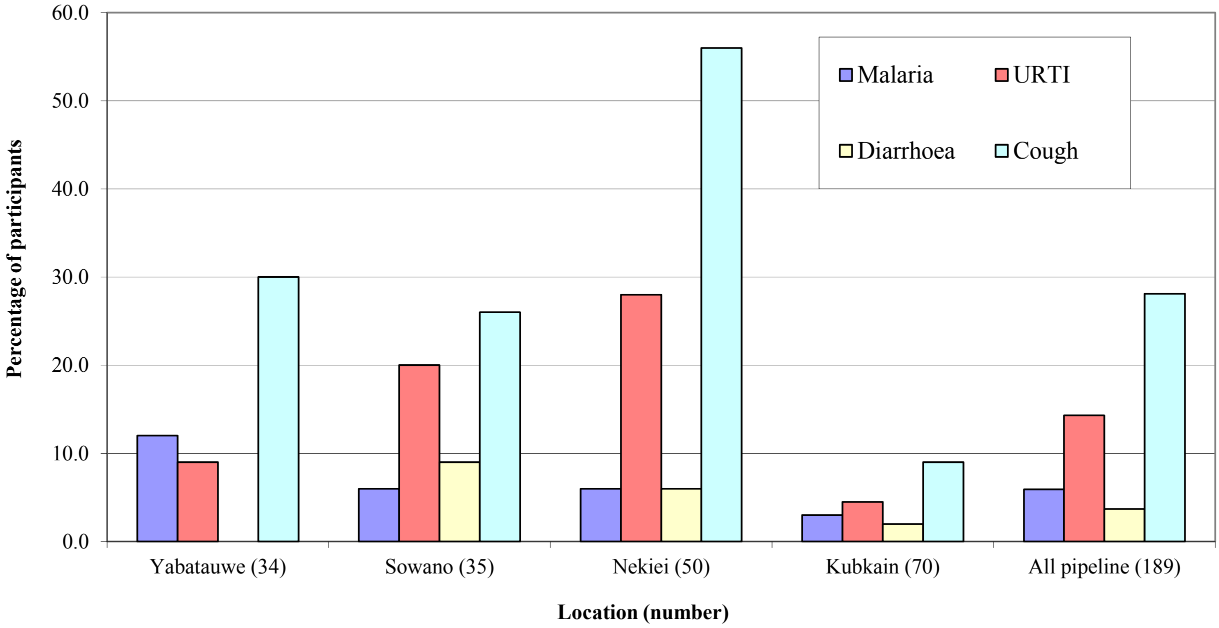
Note: The description "dengue-like fever" is based on the observed symptoms. In many instances, the individual had suffered from viral infections.

2.2.7.3 Medical complaints over previous 7 days

The self-reported medical complaints over the previous 7 days for the pipeline survey villagers are summarised in Figure 2-9. The overall symptomatic malaria prevalence of 5.9% (range 3 – 12% by village) is less than that reported from the mine area villagers in December 2009 (20%) and the Sepik River villagers in April 2010 (9.6%).

The overall prevalence of upper respiratory tract infections in the pipeline survey villagers (14.3%) is very similar to that reported for the mine area riverine villagers (Iniok, Ok Isai, Auom 3, Paupe and Wabia) of 16.0% and the Sepik River villagers (15.9%).

Figure 2-9: Self-reported medical complaints over previous 7 days



2.2.7.4 Immunisation of children under 72 months of age

Infectious diseases such as measles, mumps, rubella, diphtheria, typhoid and whooping cough are some of the most important contributors to childhood morbidity and mortality and are readily preventable through universal childhood immunisation. The measure of childhood immunisation rates are therefore, one of the most important indicators of health status in the community and of the success of national public health measures.

The immunisation status of children at the pipeline survey villages are shown in Table 2-20. The immunisation coverage was derived from the child health care cards and a cross-check for the characteristic BCG scar on the right shoulder for tuberculosis inoculation.

The mean coverage from the pipeline survey villages of 63% was somewhat higher than the overall PNG coverage of 44% (WHO WPRO 2009). However, the number of children surveyed was small and therefore, the data not robust.

Table 2-20: Immunisation of children under 72 months of age (all values % coverage)

Village (No infants surveyed)	Child Health Care card	Immunisation status		
		Complete or up-to-date	Incomplete or behind schedule	Not started
Kubkain (13)	75	75	25	13
Nekiei (8)	43	66	14	14
Sowano (5)	50	60	40	20
Yabatauwe (8)	85	57	14	7
Mean coverage	**67**	**63**	**19**	**12**

Note: The sample size for Nekiei, Sowano and Yabatauwe is very small and hence subject to significant error. The vaccination status of seven infants could not be determined.

Key:

Complete = Confirmed full course coverage from immunisation records

Incomplete = Some vaccinations have been omitted, or the child is over 12 months of age

Behind schedule = Vaccinations are not completed in the designated timeframe. The Ministry of Health Schedule of Immunisations 2007 has measles (6 and 9 months of age); BCG (at birth and at the beginning and end of schooling); polio and triple antigen (at 1, 2 and 3 months of age) and Hepatitis B (at birth, 1 and 3 months of age)

Not started = Includes infants possessing a baby health care card, but showing no immunisation records and other infants under 12 months of age, having no records. It is possible to purchase blank cards, which in addition to immunisation records, are used for general medical records

2.3 Summary of Findings

Within the limitations imposed by the flooding and village inundation at Kubkain and Nekiei that imposed logistical constraints, the baseline health survey has identified the principal public and environmental health and nutritional parameters of the pipeline villages.

The environmental health component of the survey overall gave results that are reasonably typical for rural and remote riverine communities in PNG.

The anthropometric data indicated a profile of above average nutritional health with no wasting, stunting or underweight in infants under 5 years of age, and children 6 – 10 years of age.

In marked contrast with the mine area villagers, the nutritional survey found little difference in food consumption patterns between the villagers, with all having a predominantly sago and fish diet, supplemented by bananas, coconut and at the more elevated villages, tubers. Store-purchased foods did not make a significant contribution to total dietary intakes.

The measurement of blood pressure indicated that there were few hypertensive individuals, as to be expected in a group with minimal adult obesity. Examination of liver and kidney identified no clinical conditions associated with these organs. Spleen enlargement was comparable with that observed in the mine area villagers, but lower than that to be anticipated for communities living in hyperendemic malaria areas of PNG. The reason for this is unclear.

The prevalence of cataract was similar to the level observed in the Sepik River villagers, but not exceptional for rural and remote PNG. The prevalence of pterygium was intermediate between the markedly elevated levels observed in the Sepik River villagers, but higher than that observed in the mine area villagers.

3.0 Sepik River Corridor

For the Sepik River corridor, the baseline environmental health, diet and nutrition study was undertaken at six villages in the Ambunti-Drekikier, Angoram and Wosera- Gawi districts of East Sepik Province. The same survey methodology as described in the Executive Summary was applied to this campaign also.

The villages included in this field campaign are listed in Table 1.

The overall environmental health results, while differing markedly between the urban township settlements of Bangus (Ambunti) and Saksak (Angoram) and the more remote rural villages (Bin, Sapanaut, Swagup and Yessan) were reasonably typical for low-altitude riverine communities in PNG. In the remote rural villages, drinking water supplies were mainly from unprotected Sepik River sources, the use of household pit latrines varied widely with sanitary wastes being frequently discharged to the surrounding environment and solid waste disposal was at best disorganised. Overcrowding and ventilation were not of health concern for all village households.

The nutritional surveys identified that with the exception of Angoram where some store foods were included into the diet, the principal diet consisted of sago and fish, supplemented by banana, green vegetables and coconut. Village gardens, inundated at the time of the survey at four of the six villages, were productive only in the relatively short dry season (June to September).

The anthropometric data indicated a profile of above average nutritional health with little wasting, stunting or underweight in infants under 5 years of age, children, adolescents and adults. The presence of a significant adolescent and adult female population in the overweight category, determined by body mass index and waist measurements will require further monitoring as the communities transition towards a more urbanised diet.

The present villages had variable immunisation coverage rates, generally below those reported nationally in PNG. As a result of the extensive flood water inundation, the immunisation rates for Sapanaut, Swagup and Yessan could not be reliably confirmed.

The measurement of blood pressure indicated that there were few hypertensive individuals, as to be expected in a group with minimal adult obesity. Examination of liver, kidney and lymph nodes identified a very low prevalence of clinical conditions associated with those organs. Spleen enlargement rates were exceptionally low, and atypical of communities living in hyperendemic malaria areas of PNG. The reason for this is unclear.

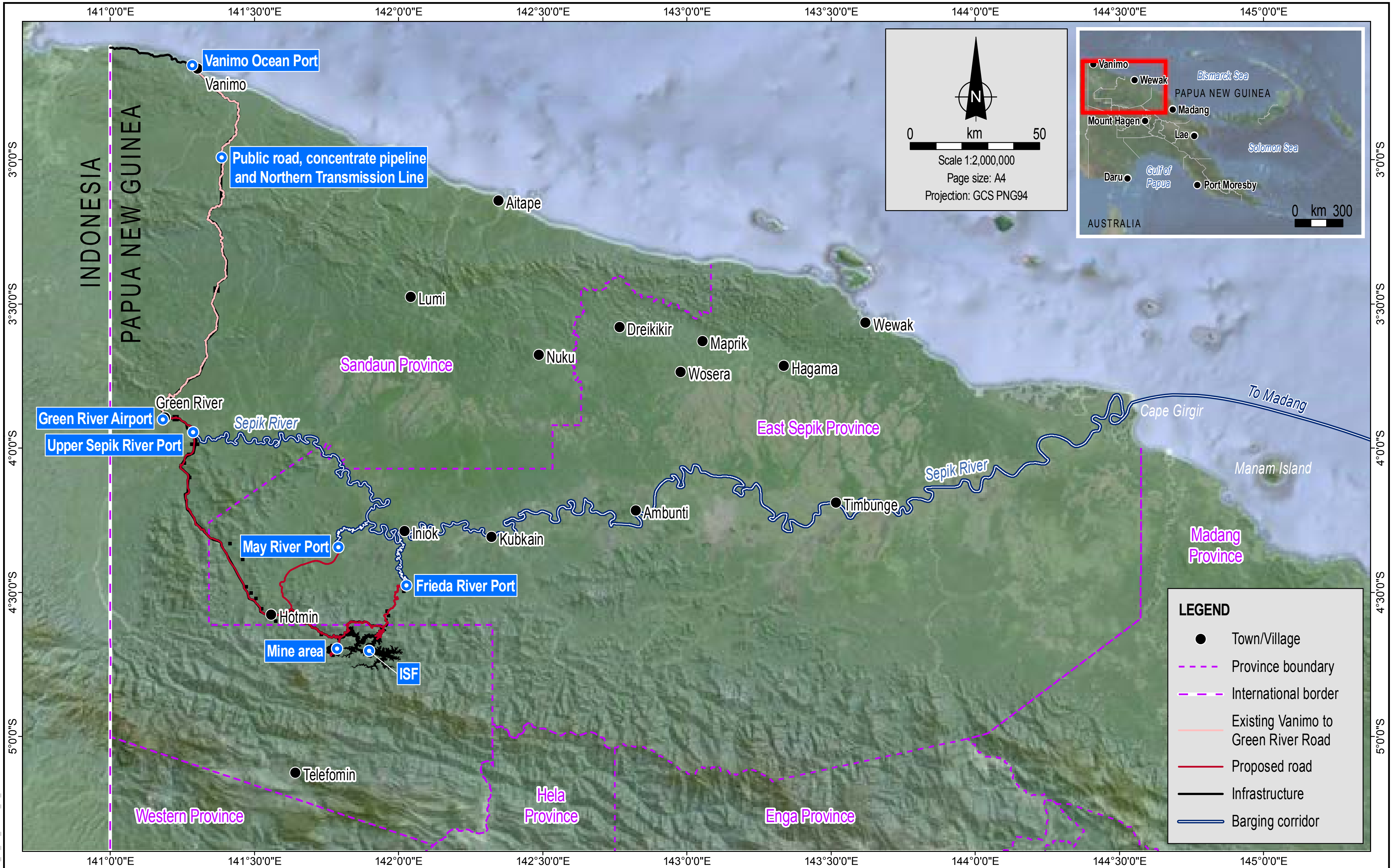
The prevalence of cataract was some three-fold that observed in the Frieda-Upper Sepik villagers, but not exceptional for rural and remote PNG. The prevalence of pterygium was unusually high and some 10-fold that observed in the mine area villagers. The prevalence was significantly higher than that previously reported in PNG.

On a whole-of-study population basis, the prevalence of skin infections was significantly less than that observed at the mine area villages for all classes of fungal infections. The prevalence of sores and tropical ulcers was about 25% of the levels reported in the Frieda River-Upper Sepik survey. In contrast with the mine area village survey, tropical ulcers were evenly distributed between all age groups. Ringworm was mainly observed in the infants and children.

The Sepik River includes an extensive flood plain, with numerous off-river water bodies. The middle and lower reaches are relatively densely populated, with most communities dependent on the river for all of their needs. In particular, the largely subsistence communities have a traditional diet, largely based on the extensive sago palm areas and fish. Their diet is supplemented by bananas and coconut and in the dry season tubers, green vegetables and some soft fruits from the village gardens.

Cash income sources for villages away from the main townships are primarily from the Sepik River, which provides fish (for sale after smoking), crocodiles (for growing and sale of the skins), betel nut harvested from the river banks and a corridor for trade.

Figure 3-1 shows the Sepik River Corridor area.



Source:
Infrastructure and roads from FRL.
Villages from FRL and Coffey.
Provinces from NMB.
Imagery from Google Earth (capture date unknown).
Hillshade DEM from SRTM.

coffey
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Project: 754-ENAUABTF11575B
File Name: 11575_CHS_F03.01_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Sepik River corridor

Figure No: 3-1

MXD Reference: 11575B_11_BM_GIS004_v0_2

3.1 Survey methodology

3.1.1 Village selection

The villages and townships selected varied widely in size from Sapanaut (63 households and total populations of about 350) to Ambunti and Angoram with populations of approximately1500 and 2100 respectively. At Ambunti and Angoram, the survey selected Bangus settlement (34 households, population 196) and Saksak settlement (approximately 35 households, population 200), respectively.

The villages were all predominantly of original ethnic groups with almost no settler families. Of the households included into the survey, with the exception of Angoram, 100% of heads of household were born in East Sepik Province. At Angoram, 85% of household heads were from East Sepik Province, with the three remaining households originating from Gulf, Madang and Morobe Provinces.

Examples of the variability in access to health and education facilities are shown in Tables 3-1 and 3-2.

Table 3-1: Access to public health facilities

Village	Village aid post		Health Centre		Hospital		Comment
	Nearest location	Distance * (hours)	Nearest location	Distance* (hours)	Nearest location	Distance * (hours)	
Ambunti	Ambunti	-	Ambunti	-	Wewak	4	By road
Angoram	Angoram	-	Angoram	-	Wewak	3	By road
Bin	Marabek	2	Marabek	2	Wewak	4	Motorised canoe
Sapanaut			Pagwi	2	Wewak	4	By road
Swagup	Ambunti	4	Ambunti	4	Wewak	10	By motorised canoe (6 hours) and road (4 hours)
Yessan	Ambunti	2	Ambunti	2	Wewak	8	By motorised canoe (4 hours) and road (4 hours)

* Distance is estimated by survey participants and would vary depending on the speed at which they are able to travel and their comprehension of time and distance. It is provided for indicative purposes only.

Ambunti had two health centres: one operated by the Government, while the other was provided by the Seventh Day Adventist Mission. The Government Health Centre was being upgraded and provided a limited range of facilities.

The health centre at Angoram was operational only for outpatients. The facilities were in need of maintenance. The centre had both solar and gas for electricity and water was from rain water tanks. The health centre had stocks of in-date drugs and basic supplies (bandages, etc). Sterilisation of medical equipment was unavailable.

The village aid post at Bin was unmanned. There were no facilities available at Sapanaut, nor apparently at Pagwi. There were no aid posts at Swagup or Yessan. Similar to all of PNG in recent years, and particularly in rural and remote environments, the health infrastructure at the survey villages was seriously degraded in both core and targeted program funding (eg. for key drugs, tuberculosis management and immunisation). Health service delivery in these environments was at best intermittent, being further conditional on the availability of qualified and motivated staff from the district health centres.

Table 3-2: Access to education facilities

Village name	Elementary school	Trained teachers	Adequate* classrooms	Adequate * teaching materials	High school	
	Yes/No	Yes/No			Nearest location	Distance (hours)
Ambunti	Yes	Yes	Yes	Yes	Ambunti	-
Angoram	Yes	Yes	Yes	Yes	Angoram	-
Bin	Yes	Yes	Yes	Yes	Angoram	2 hours motorised canoe
Sapanaut	No	-	-	-	Pagwi	45 minutes motorised canoe
Swagup	Yes	Yes	-	No	Ambunti	4 hours motorised canoe
Yessan	Yes	Yes	-	No	Ambunti	2 hours motorised canoe

* Adequacy is the opinion of survey respondents and in some cases observed by the study team.
** Distance is estimated by survey participants and would vary depending on the speed at which they are able to travel and their comprehension of time and distance. It is provided for indicative purposes only.

Ambunti had two elementary schools, two top-up primary schools, a vocational technical school and a high school. Ambunti had an operational air strip and NGO (Pacific Island Ministry, WWF Resources Centre and an Oxfam community support program). The European Union also had a centre at Ambunti.

Angoram had schooling available up to high school. There were two primary schools, and two high schools. The air strip at Angoram had not been operational for a number of years.

Bin had both elementary and primary school facilities, with qualified teachers to diploma level. The nearest operational air strip was at Wewak.

Sapanaut did not have schooling facilities, but these were available at Pagwi some 45 minutes distant by canoe. Pagwi had elementary, primary and reputedly high school facilities.

Swagup had training programs run by the Seventh Day Adventist Church for the adult females (domestic science and health education).

3.1.2 Constraints to the conduct of the survey

None of the survey villages had a village map showing household locations. As a result, the use of a stratified fully random survey methodology was not practical. For the larger townships of Ambunti and Angoram the survey households were selected by first randomly selecting one of the township settlements (Ambunti – Bangus and Angoram – Saksak) followed by selection of houses from each of the edges and centre of the settlement.

At the time of the survey the Sepik River was experiencing some of the highest river levels recorded in the last decade. This had resulted in extensive flood water inundation at the villages of Sapanaut, Swagup, Yessan and to some degree at Bin. At the first three of these villages it was not practicable to conduct interviews at the individual households. As a compromise, household groups were invited to assemble at the nearest dry area to the village. At all villages the response to this request was excellent as confirmed by the number of participants in the village line-up anthropometric survey (range Sapanaut 132 – Yessan 178 participants). Similarly, the inundation meant that the walking tour of the community to observe facilities, normally undertaken during the village questionnaire, was only able to be achieved at Ambunti, Angoram, Bin and to a limited degree by canoe at Yessan.

The need to adopt a modified household approach at the three inundated survey villages, impacted on the development of a detailed assessment of the environmental health circumstances. In particular, it was not possible to make an assessment of the level of overcrowding, which requires both household family size and an estimation of the dimensions of the dwelling. Estimation of the presence and number of insect vector breeding sites around the villages and households was also not practical.

While there was no impediment to the development of longer term nutritional estimates at the family level, undoubtedly the 24-hour dietary estimation ("food consumed by the family on the previous day") was influenced by the high river levels, with many families reporting that their gardens had been destroyed and access to the sago palms was limited.

At the inundated villages, it was virtually impossible to ensure any privacy for the conduct of individual question-response interviews which were carried out in a communal environment. To the extent practical (eg. by constant eye contact), responses were elicited from the target individual. However, it has to be accepted that an unknown and unquantifiable bias may have entered into the interview responses when dealing with sensitive questions.

The study participants were generally given their physical examinations and medical questions away from other non-family community members. On the relatively few occasions, when private consultation was preferred, at Ambunti, Angoram and Bin the examination was conducted inside the house. At Sapanaut, Swagup and Yessan the interviews and medical examinations were of necessity undertaken in a communal environment. This has impacted by reducing the proportion of adolescent males and females who participated in the medical examination at these villages.

Given that the length of residence by the respective heads of household, for five of the six villages was 100% a whole-of-lifetime residency response, the survey did not distinguish between households of local indigenous people and settler families for the 24-hour and food preference frequency surveys. (Angoram was the exception with 85% of heads of household having lived in East Sepik Province since birth).

3.2 Results and Discussion of Findings

3.2.1 Demography

The household questionnaire survey population and the cohorts available for anthropometric measurements and clinical assessments by village, age and sex is shown in Table 3-3.

Table 3-3: Household, anthropometric measurement and medical examination survey populations by age and sex (number of participants)

Village	0 - 5 years		6 - 10 years		11 - 16 years		17 – 44 years		45 + years		Total participants	
	M	F	M	F	M	F	M	F	M	F	M	F
	Household survey											
Ambunti	4	8	10	8	18	12	35	31	8	10	75	69
Angoram	20	5	7	5	10	12	12	24	12	8	61	54
Bin	4	10	7	12	20	14	27	27	13	9	71	72
Sapanaut	3	8	9	7	7	2	21	22	10	6	50	45
Swagup	15	12	10	9	7	6	17	20	6	2	55	49
Yessan	4	10	10	10	11	13	22	25	8	6	55	64
Total	**50**	**53**	**53**	**51**	**73**	**59**	**134**	**149**	**57**	**41**	**367**	**353**
	Anthropometric measurement											
Ambunti	8	5	5	9	4	17	38	35	11	6	66	72
Angoram	21	19	13	20	12	10	16	48	8	11	70	108
Bin	13	6	12	14	9	9	30	21	8	8	72	58
Sapanaut	19	18	12	9	8	10	18	27	7	4	64	68
Swagup	20	12	15	8	8	12	23	31	8	5	74	68
Yessan	14	24	13	16	3	17	31	48	6	6	67	111
Total	**95**	**84**	**70**	**76**	**44**	**75**	**156**	**210**	**48**	**40**	**413**	**485**
	Medical examination											
Ambunti	0		1		2		21		9		33	
Angoram	12		7		7		18		11		55	
Bin	5		6		5		22		13		51	
Sapanaut	16		9		2		18		2		47	
Swagup	15		11		7		36		8		77	
Yessan	12		4		0		20		9		45	
Total	**60**		**38**		**23**		**135**		**52**		**308**	

Of particular note in the household survey results, was the excess of widowers in the 45+ years of age group at all of the villages, except Ambunti.

In keeping with international practice, analysis of the anthropometric data has excluded pregnant females and mothers having a child under three months of age. Inclusion of this data would introduce bias into the measurement statistics.

The high flood levels precluded the medical officer from conducting examinations at individual households at most communities. This made it impossible to avoid at least some degree of self-selection for the medical examinations. This has resulted in the over-representation of people 45 + years of age at most communities.

The reluctance of participation by male and female adolescents due to the public nature of the examinations (rather than the privacy given by household examination) is also reflected in Table 3-3.

The infant and child groups are markedly under-represented at Ambunti. It is likely that with two health centres being available the older age groups took the opportunity for personal examination, rather than prioritising the infant and child groups.

For the adult (17 – 44 years of age group) males dominated at Ambunti (males 15, females 6) and at Swagup (males 27, females 9). While the reason for this at Ambunti is unclear, at Swagup the males were examined at their separate compound with a large number insistent on being included into the survey.

In the absence of quantitative age-sex groupings for the total village populations from a demographic census survey, the percentage participation rates have been derived on a whole-of-population basis. This is shown in Table 3-4.

The coverage for the household survey at all communities other than at Ambunti (9.6%), Angoram (5.5%) and Bin (19.1%), was greater than 25% of the total village population. This data can be considered to be representative of the respective village households. For Ambunti and Angoram the percentage coverage of households at the settlement level is Ambunti – Bangus 73.9% and Angoram - Saksak 55%. These households clearly can be used to represent these settlements.

An overall participation rate of 14.1% (using the settlement population data at Ambunti and Angoram) for the medical examination is more than satisfactory. However, as discussed elsewhere in the text, at some villages, males and females 45+ years of age groups were unavoidably over-represented and adolescent males and females under-represented.

Table 3-4: Household, anthropometric and clinical assessment survey participants as a percentage of total population (by gender)

Village	Household survey		Anthropometric measurement		Medical examination
	M	F	M	F	All participants
Ambunti	9.8	9.3	8.6	9.7	16.8
Angoram	5.8	5.3	6.6	10.7	27.5
Bin	19.5	18.8	19.7	15.2	6.8
Sapanaut	31.7	27.1	40.5	41.0	24.0
Swagup	27.0	25.5	36.3	35.4	19.5
Yessan	36.0	36.4	43.8	63.1	13.7
Total	**13.6%**	**13.2%**	**15.3%**	**18.2%**	**14.1%**

The survey at Ambunti was conducted at Bangus Settlement (population 196: males 109, females 87). The data for the Ambunti household survey provided above, uses the 2000 National Statistics Office census results for Ambunti urban (population 1509: males 768, females 741). The comparative data for the medical examinations is the Bangus population values.

The survey at Angoram has of necessity, been compared with the NSO census data for Angoram urban (population 2071: males 1058, females 1013). Saksak settlement where the survey was conducted has an approximate total population of 200. This value is used for the medical examination comparison.

The comparator populations used for the other villages are those of the 2000 NSO census data (Bin population 748: males 365, females 383; Sapanaut population 324: males 158, females 166; Swagup population 396: males 204, females 192 and Yessan population 329: males 153, females 176) (PNG NSO 2002).

In the 2000 NSO census Swagup and Yessan are in Ambunti rural, Bangus settlement in Ambunti urban, Angoram urban in Angoram, Bin in Marienberg rural and Sapanaut in Gawi rural. Pagwi Station trading post had a 2000 NSO census total population of 196, comprising males 110 and females 86.

3.2.2 Socio-economic factors relevant to health

Religious activities

The question of household participation in social groups was repeated for comparative purposes at the present survey households. At Angoram, Sapanaut and Yessan, all households participated in the activities of the local church groups. At each of Ambunti and Bin, one family reported no involvement in church-based activities. At Swagup, only 13 households reported participation in church activities, although this result may underestimate the actual situation, with both the Assembly of God and the Catholic churches having men's and women's church-associated organisations.

At Ambunti and Sapanaut, 85% and 80% respectively, of the survey households were of the Seventh Day Adventist faith. Catholic households predominated (65% of households) at Yessan, while the Assembly of God was the main faith at the Swagup households (60%). Angoram had a wide range of faiths represented, including Catholic, Seventh Day Adventist, Christian Revival Church, Assembly of God and the Four Square Church. In many households, particularly at Bin and Yessan, the families included adherents of a number of different faiths.

The responses to the question regarding involvement in men's and women's groups were somewhat confounded. The men's and women's groups at Bin, Swagup and Yessan were clearly church-linked fellowship groups, organised by the Assembly of God and Catholic pastors. At Angoram and Bin 55% and 50% of household women were members of the local AP Meri Association. At Swagup, with the clear cultural divisions between the males and females, it was difficult to discern between formal and cultural men's groups.

Sporting activities

Involvement in sporting groups was particularly evident at Swagup (primarily males involved in soccer and netball) and at Bin where most households had at least one male involved in the soccer club and females (about 40%) in basketball. Sporting clubs appeared less popular at Ambunti (30% of households) and Angoram (15% of households). At Yessan, there appeared to be no involvement in sporting activities.

Household income

The question examining household sources of cash income was also purposefully selected to allow comparison between Project areas. The primary objective was to ascertain if on this parameter, the present household survey group were comparable with, and representative of the broader group, surveyed in the socio-demographic survey in February – March 2010. The results from the present survey are shown and discussed in Table 3-5.

Table 3-5: Household sources of cash income (% of households)

Village (Total no households)	Salary	Remittances	Trade store	Agricultura l products	Timber	Fish and crocodile	Alluvial old mining	Hunted animals	Handicrafts	"Sepik Kina"
Ambunti (20)	55	15	10	95	10	10	0	0	5	0
Angoram (20)	50	10	60	25	0	15	10	0	5	0
Bin (20)	10	0	5	95	5	85	10	15	25	40
Sapanaut (20)	5	0	0	0	0	100	0	0	5	0
Swagup (20)	0	0	5	0	0	100	0	5	80	0
Yessan (20)	10	0	0	25	5	100	0	0	20	0

The trade store classification included retail of goods at the local markets (eg. products baked from flour) and at Angoram money lending. At Bin, one household derived an income from property rental.

Agricultural products included banana, green vegetables, betel nut, cocoa, rubber and tobacco. Sago was widely harvested for sale in Maprik, Wewak, Lae and Madang. Sago was a major source of income at Bin. Betel nut was also widely traded to intermediaries who then sold it at the coast and the highland provinces. Sale of cocoa was a significant income source at Yessan.

Fish, and particularly smoked fish,was the principal income source at Sapanaut, Swagup and Yessan. Smoked fish was sold locally and exported to Maprik and Wewak and shipped up river to Ok Isai, Wabia, etc. Crocodile skins and meat were the main income sources at Swagup, supplemented by the sale of handicrafts. Buyers regularly come from other provinces of PNG and from Australia to purchase the handicrafts.

Somewhat unexpectedly, was the involvement of households from Angoram and Bin in small-scale gold mining. This activity was largely one involving young males in the community who go as a group into the upper reaches of the Sepik and Frieda rivers and recover gold directly or work for some of the gold dredge owners.

Income from hunted animals was generally crocodile eggs and baby crocodiles. The latter were sold to other households for growing to marketable skin size. Hunted animals also included the collection and sale of live animals for pets.

Income from 'Sepik Kina' (processed shells) at Bin village was largely undertaken by the women, who dive for shells which are then converted into lime by heating and grinding and used for chewing with betel nut.

3.2.3 Village and household environmental health circumstances

3.2.3.1 Village Environmental Health

The survey villages' environmental health circumstances were obtained by directing questions to the Village Councillor, or other senior local leader. The results are shown in Table 3-6.

Table 3-6: Village environmental health conditions (all values % households)

Village name	Drinking water		Communal sanitation facilities		Solid waste disposal	
	Source	Condition	Pit	River	Bury	Open dump
Ambunti	River and tank	Tanks in good condition	80	20	70	30
Angoram			75	25	30	65 (burning 5%)
Bin	River and shallow wells	Satisfactory	0	100	0	100
Sapanaut	Sepik River	Unsatisfactory	20	80	0	100
Swagup			100	0	0	90 (burning 10%)
Yessan			100	0	20	80

At Ambunti and Angoram water supplies for most households were supplemented from rain water catchment on the permanent structures into tanks and metal drums. The Sepik River was the sole drinking water supply at Sapanaut, Swagup and Yessan. In the dry season, Bin households supplemented their drinking water from shallow hand-dug wells.

At Swagup and Yessan the Sepik River was used for toilet facilities only during heavy rain periods when water filled the pit latrines. At Sapanaut, only a small proportion of the households owned pit toilets, with most human wastes being disposed into the Sepik River.

Solid waste disposal (open dump) frequently involved the throwing of waste into the Sepik River. At the time of the survey, only Ambunti and Angoram had the capacity to bury wastes. The use of burning as a disposal method for solid wastes was not a practical option at Bin, Sapanaut, Swagup and Yessan.

3.2.3.2 Household Environmental Health

Occupant density

For those communities where it could be implemented, the household approach permitted a good assessment of both occupant density (ie. space per person) and household ventilation. The results are shown in Table 3-7. Overcrowding and poor ventilation is widely recognised as an important factor in health, particularly the prevalence of respiratory infections. Pneumonia is a major cause of hospital and health centre admissions and mortality in the survey districts (PNG MOH 2001). As discussed in section 2.7.2, the present survey households reported a high incidence of pneumonia and upper respiratory tract infections.

There was a very wide range of occupant density between households at Ambunti and Angoram, with ranges between 0.9 – 15.0 m^2 per occupant. As to be expected this was not the case at the largely economically homogenous Yessan village. The maximum area per occupant observed at Ambunti was in a household where only two elderly adults now lived. Similarly, at Angoram the maximum (14.0 m^2) was a house provided by the community to the head teacher at the local school.

The range of mean occupant densities between villages of 3.5 – 4.6 m^2 per occupant was quite similar to that for comparable Morobe Province Hidden Valley communities (3.0 – 5.6 m^2) (Bentley 2003, CEH 2007a).

The village mean values of 23 – 31% of the recommended US Centre for Disease Control (US CDC 2003) value for maintenance of respiratory health are typical for rural inland PNG. The US CDC criterion is equally applicable to developed and developing country circumstances. Neither PNG, nor the WHO had provided guidelines for acceptable house space per person.

Ventilation

Ventilation was rated good for all of the communities except for three households at Yessan. At Ambunti and Angoram, a majority of the households had separate cooking and food preparation areas away from the main house. This contrasts markedly with the other four villages, where almost all households normally undertook their cooking in the same area used for sleeping.

Table 3-7: Persons per household, occupant density, availability of ventilation and cooking facilities

Village (No households)	Persons per household		Area per occupant (m^2)			
	NSO 2002 census	This study	Mean	Median	Minimum	Maximum
Ambunti	5.8	7.1	4.6	4.0	2.3	14.0
Angoram	6.4	6.2	4.2	3.6	0.9	15.0
Bin	7.6	7.2	Owing to extensive inundation at these villages from the Sepik River flood waters, it was not possible to collect individual data for household living area			
Sapanaut	5.1	4.2				
Swagup	5.0	5.3				
Yessan	5.5	6.3	3.5	3.0	1.5	3.5

Village (No households)	Ventilation (%)			Cooking and open fires (%)		
	Good	Adequate	Poor	Sleeping area	Separate area	
Ambunti	100			15	85	Cooking using open fires in the sleeping area, relates to permanent arrangements
Angoram	100			50	50	
Bin	Not determined			95	5	
Sapanaut				100	0	
Swagup				100	0	
Yessan	85	15		90	10	

Key:

Good ventilation	=	No indoor cooking in the main residence, adequate windows and a minimum of two doorways to the external environment or the house is on stilts
Adequate ventilation	=	Internal cooking, adequate windows and at least one doorway to the external environment
Poor ventilation	=	Internal cooking and heating fires, few windows and a single doorway to the external environment

Household income

The preparation of smoked fish for sale was a significant source of income for the households at Bin, Sapanaut, Swagup and Yessan. At the time of the survey, smoking of the fish was undertaken indoors, due to the high flood levels. Many households were subject to extensive indoor air pollution from this activity. This may have been a contributor to the reported high levels of upper respiratory tract infection and cough (Figure 3-10).

Vector-borne disease control

Malaria was hyperendemic in all of the study communities (refer Section 3.2.6.2 Examination of liver, kidney, spleen and lymph nodes). As indicated in Table 3-8, virtually all village households had at least one mosquito net, but insufficient bed nets for the whole family. This was particularly notable at Bin (35%) and Sapanaut (10%). The general practice at these communities appeared to be to reserve the mosquito nets for babies and infants. It is unclear if many of the participants understood the need for regular pesticide treatment of nets. The data for Ambunti and Angoram is likely reliable. The high result for the Swagup households is unexplained, but possibly a result of NGO (Oxfam) health activity at this village.

Insect screens were installed at 45%, 20% and 15% of the survey households at Ambunti, Angoram and Bin respectively.

Table 3-8: Vector borne disease control (all values % households)

Village (No households)	Protection measures		Mosquito bed nets		
	Screens	Cleaning around house	At least one	Nets for all family	Regular pesticide treatment of nets
Ambunti	45	100	100	70	10
Angoram	20	95	100	50	10
Bin	15	65	100	35	0
Sapanaut	0	20	80	10	0
Swagup	5	50	100	65	30
Yessan	0	35	100	60	5

It is likely that many households indicated that they cleaned up mosquito breeding areas to avoid embarrassment. The data probably overestimates the actual situation. In practice, with the survey being conducted at a time when almost all village households were inundated, the use of environmental measures could not be checked. At Ambunti and Angoram, stagnant water pooling, particularly in surface constructed drains was commonplace.

The use of insect repellents was identified at only one survey household in Angoram.

Use of addictive substances

The use of tobacco and other stimulants among adults (17+ years of age) is shown in Table 3-9. The overall consumption of tobacco was similar in the male (mean 50.8%) and female (mean 44.9%) population.

The overall smoking rate (48%) was less than that observed in the mine area villagers (54%), but higher than that reported nationally (37%), as measured in the Mt Obree area of Central Province (30%) and in a recent study of inland villages in Madang Province (37%)(FMR 1990, Taufa 1995, CEH 2007b). These latter communities had a similar level of economic development to the present survey group.

The level of consumption of betel nut was similar in males and females and also comparable at all of the surveyed villages, with the exception of Ambunti (males 44%, females 32%). This observation was unexplained.

Alcohol consumption appeared quite different in the Middle Sepik communities when compared with the mine area villagers. In the mine area communities, with the exception of Ok Isai, consumption was largely restricted to adolescent and adult males. On a whole-of-population basis, female consumption was < 2%. The Sepik River communities (with the exception of Bin) had greater than 40% of all males as consumers. Female consumption was above 25% at Ambunti, Angoram and Sapanaut, and likely the result of the ready availability through trade stores. Male and female consumption was inexplicably low at Bin (males 8%, females 0%). Female consumption at Swagup and Yessan was also low (< 5%), probably due to the separate male and female traditional cultures at these communities.

Table 3-9: Consumption of addictive substances all adults 17 + years of age (all values %)

Village	Tobacco			Betel nut			Alcohol		
	No HH	Male	Female	No HH	Male	Female	No HH	Male	Female
Ambunti	*12*	41	20	*13*	44	32	*11*	46	28
Angoram	*13*	58	67	*17*	79	81	*10*	54	33
Bin	*13*	38	43	*20*	95	97	*3*	8	0
Sapanaut	*11*	55	34	*14*	72	48	*9*	50	27
Swagup	*15*	74	64	*17*	100	77	*13*	90	5
Yessan	*13*	57	55	*16*	83	81	*6*	32	0
Mean participation rate		**50.8**	**44.9**		**76.6**	**69.0**		**42.7**	**16.1**

Note: Twenty households (HH) were surveyed at each village.

3.2.4 Anthropometry

The interpretation of anthropometric measurements as indicators of various forms of malnutrition is as described in Section 1.2.4.3.

A comparison of the mean adult values for weight and height as shown in Table 3-10, indicated that there were statistically insignificant differences in these parameters between the six village communities that can be attributed to ethnicity. In contrast with the results for the mine area villagers, the Sepik River village results do not indicate any impact from changes in the diets towards urban PNG lifestyles. This is consistent with the results of the food frequency survey where only at Angoram has store purchased foods become a significant contributor to total dietary intakes.

Table 3-10: Comparison of anthropometric values for adults 17 – 55 years of age

Village	Age (mean)		Weight (mean ± sd) kg		Height (mean ± sd) metres	
	Males	Females	Males	Females	Males	Females
Ambunti	27.1	27.1	67.5 ± 6.7	63.4 ± 10.8	165.8 ± 5.8	157.5 ± 4.4
Angoram	30.5	29.3	67.2 ± 6.7	53.7 ± 9.4	160.9 ± 8.6	150.9 ± 6.9
Bin	33.8	30.5	65.0 ± 10.9	58.0 ± 5.9	156.3 ± 5.5	147.0 ± 5.8
Sapanaut	31.4	30.0	66.8 ± 6.9	58.5 ± 9.0	162.2 ± 7.3	152.2 ± 5.9
Swagup	33.2	28.6	66.8 ± 6.1	55.4 ± 8.1	162.3 ± 3.8	148.8 ± 6.0
Yessan	27.4	30.6	62.8 ± 4.8	52.5 ± 8.0	159.1 ± 4.5	150.2 ± 5.2

Figure 3-2 gives the results for the mean height and weight of all survey participants for infants 0 – 71 months of age. As expected, the results indicated a progressively increasing height and weight with age. The results are comparable with those observed in a number of other anthropometric measurement surveys in rural and remote PNG communities (Flew 1999, CEH 2007a).

The results for mean height and weight for children, adolescents and adults by gender is shown in Figure 3-3. In the child and adolescent groups, females generally exceeded their male counterparts both in height and weight. While the difference in the child group is likely a result of the small sample size, for the adolescents this is normal, and related to the earlier onset of puberty in girls.

Adult males between 17 and 44 years of age were higher in stature than their female counterparts by about 10 centimetres. Other than at Ambunti, the males were heavier by between 8 – 10 kilograms. Male and female adult groups over 45 years of age, were significantly lighter and of lower stature than their younger counterparts. This was particularly noticeable in the females, with the mature age group being some 10 kilograms lighter and 3 centimetres less in stature.

Figure 3-2: Infant mean height and weight (all survey participants)

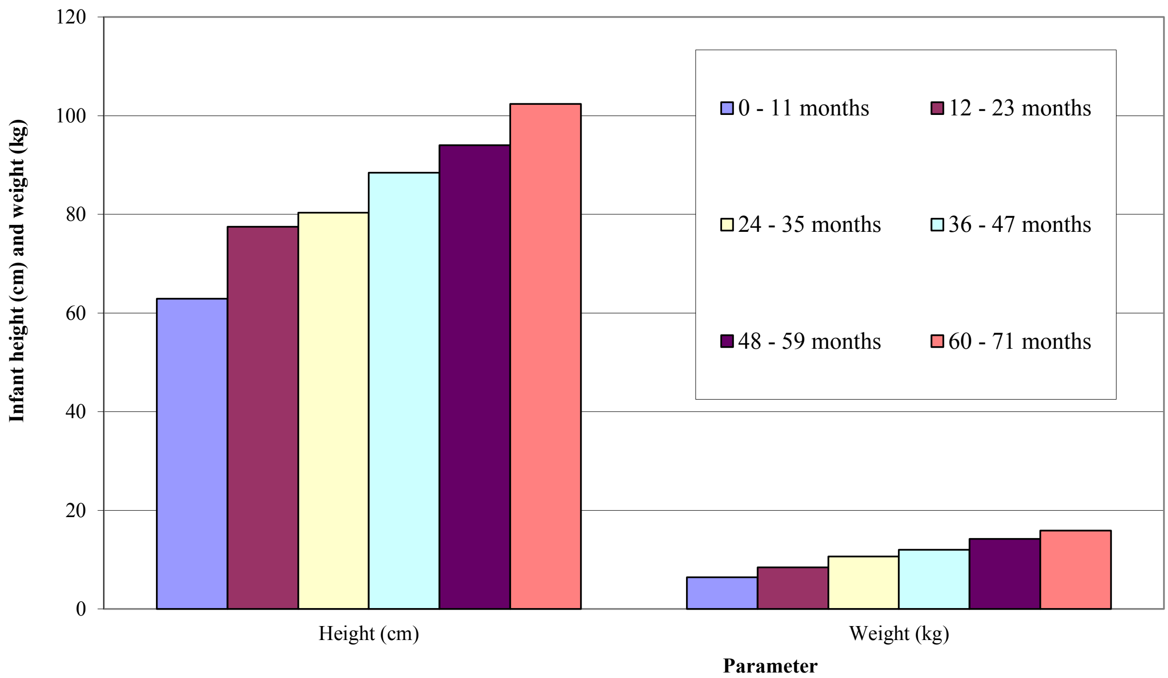
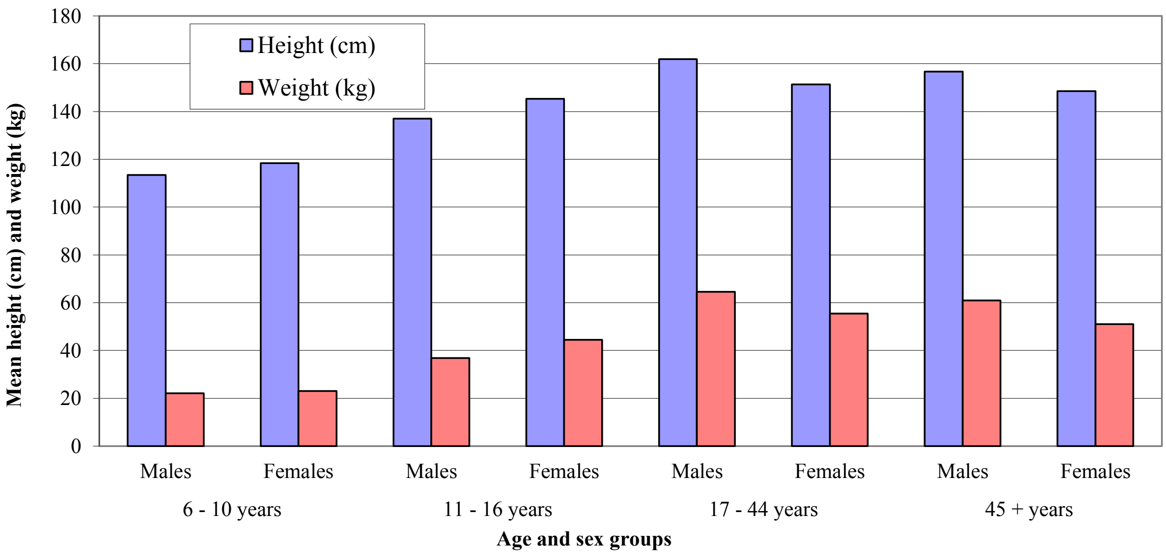


Figure 3-3: Mean height and weight of child, adolescent and adult survey participants by age and gender



3.2.4.1 Anthropometry of infants

The nutritional status of children under 5 years of age is commonly assessed using the method described in Section 1.2.4.1.

The data in Table 3-11 is presented as the percentage of children under 71 months of age, falling below two or three standard deviations reference population median value for each of the three indices weight-for-age, height-for-age and weight-for-height. Whilst accepting the normal caveats associated with such a small sample, it can be seen that there is little child malnourishment in the first five years of life. Mildly overweight children in the 12 – 59 months of age groups are of no particular health concern.

The results can be favourably compared with the World Bank anthropometric database for lowland and highland fringe communities in PNG, which although using different criteria nationally, identified a prevalence of stunting in these geographic groups of 35% - 59%. The overall results for wasting in the present population is also at the lower end of the values recorded in the World Bank survey of 0% - 14.8% and at 2.1% similar to the prevalence observed in Madang and Morobe provinces in 2007 (0% and 2% respectively) (Gibson and Roselle 1998, CEH 2007a, b).

Table 3-11: Anthropometric data for children 12 – 71 months of age (all values %)

Age (months)	Number	Weight-for-age		Height-for-age		Weight-for-height	
		Underweight		Stunting		Wasting	Overweight
		< -3 sd	< - 2 sd	< -3 sd	< -2 sd	< -2 sd	< + 2 sd
12 – 23	32	0	0	0	0	0	6.3
24 – 35	22	0	4.6	0	0	4.6	4.6
36 – 47	21	0	0	0	0	4.8	4.8
48 – 59	27	0	0	0	0	0	3.7
60 – 71	41	0	0	0	0	2.4	0

sd=standard deviation

3.2.4.2 Anthropometry of pre-pubertal adolescents and adolescents (6 – 16 years of age)

Consistent with the anthropometric data for the infant group, the height-for-age measurements, indicated there were no children below < -2 sd in the surveyed 11 – 16 years of age population for stunting, and only 0.7 % in the 6 – 10 years of age group.

Table 3-12 shows the nutritional status as measured by BMI values for children and adolescents 6 – 16 years of age, by age group and gender. This data has been derived by comparing the present results on an age basis (by year) with those of the WHO International Obesity Taskforce 1998 (Cole et al 2000). There were a total of 146 participants in the 6 – 10 years of age group (males 70, females 76) and 121 participants in the 11 – 16 years of age group (males 45, females 76).

The results indicated that overall, underweight in both the child and adolescent groups were higher in the females (13) than the males (2). The distribution of underweight children and adolescents was uneven, varying between 0% (Sapanaut) and 10.2% (Yessan). The other villagers ranged between 4.4% at Bin and 7.3% at Ambunti.

The results for overweight in the Sepik River villagers were quite dissimilar to that observed at the mine area villages, with a much higher percentage of females (19.7%) than males (4.5%) in the adolescent group. Overweight in the 6 - 10 years of age group, was markedly higher at Swagup (11.6%), with Angoram and Ambunti having 5.5% and 5.7% respectively. There were no overweight children at Bin and Sapanaut.

Overweight for the 11 – 16 years of age group was highest at Ambunti (17.2%), with Swagup and Yessan having 9.3% and 8.2% respectively. The percentage of overweight adolescents at Sapanaut (5.1%) and Angoram (2.0%) was lower and entirely in the female group. There were no overweight adolescents at Bin. Only one individual (at Ambunti) in the child and adolescent groups was obese. The percentage of overweight participants in the adolescent Sepik River villagers (10.9%) was very similar to that observed in the mine area villagers (10.5%).

Table 3-12: Nutritional status of children and adolescents by age group and gender (all values % of total participants)

Age group (years)	Underweight		Normal		Overweight		Obese	
	Males	Females	Males	Females	Males	Females	Males	Females
6 – 10	2.9	5.3	87.1	88.1	10.0	5.3	0	1.3
11 – 16	2.2	10.5	93.3	69.8	4.5	19.7	0	0

3.2.4.3 Anthropometry of adults

A comparison of the mean adult values for body mass index, as shown in Table 3-13, indicated that there were no statistically significant differences between the six village communities that could be attributed to ethnicity. The results are in agreement with the food consumption results (Table 3-18) that indicates that the Sepik River villagers primarily continue to consume a traditional sago and fish diet.

Table 3-13: BMI of adults 17 – 55 years of age by village

Village	Age (mean)		BMI (mean ± sd) kg/m^2	
	Males	Females	Males	Females
Ambunti	27.1	27.1	24.4 ± 1.8	25.5 ± 3.8
Angoram	30.5	29.3	24.9 ± 2.8	23.5 ± 3.5
Bin	33.8	30.5	23.8 ± 2.3	23.3 ± 3.3
Sapanaut	31.4	30.0	25.4 ± 2.4	25.3 ± 3.7
Swagup	33.2	28.6	25.4 ± 2.4	25.1 ± 4.3
Yessan	26.5	30.6	24.9 ± 1.5	23.2 ± 3.0

Sd=standard deviation

As indicated in Table 3-14, BMI decreases in males and females over 55 years of age, a result to be expected and consistent with the international and PNG literature.

Table 3-14: BMI by age groups adults 17 – 70 years of age (all values kg/m^2)

Age group (years)	Males (mean ± sd)	Females (mean ± sd)
17 – 26	24.2 ± 1.8	24.0 ± 3.1
27 – 36	24.8 ± 2.0	25.3 ± 4.1
37 – 46	25.6 ± 2.8	23.6 ± 4.0
47 – 56	25.5 ± 2.7	23.0 ± 4.3
57 +	23.8 ± 3.4	22.4 ± 4.6

Sd=standard deviation

Table 3-15 derives the nutritional status of adults by village. At the village level, reporting the results by sex is not robust. However, it is notable that contrary to the results for the mine area villagers and consistent with other studies in PNG, the obese group appears to be largely comprised of females (82%).

Table 3-15: Nutritional status of adults 17 – 70 years of age by village based on BMI (all values %)

Village (No participants)	Underweight % < 18.5	Normal % 18.5 – 24.9	Overweight % > 25.0	Obese % > 30.0
Ambunti (90)	1.1	57.8	34.5	6.7
Angoram (83)	3.6	63.9	28.9	3.6
Bin (65)	4.6	72.3	21.1	3.1
Sapanaut (56)	0	46.4	48.2	5.4
Swagup (67)	0	53.7	38.8	7.5
Yessan (103)	7.8	60.2	32.0	0

There were no males underweight and 15 females were underweight in the Sepik River adult survey group. Of the underweight females, those living at Ambunti and Angoram had a mean age of 26 years. The underweight females at Bin and Yessan were almost exclusively mature adults, with a mean age of about 54 years. These results may reflect lifestyle choices at the township communities, and almost certainly are a result of childhood under-nutrition at Bin and Yessan.

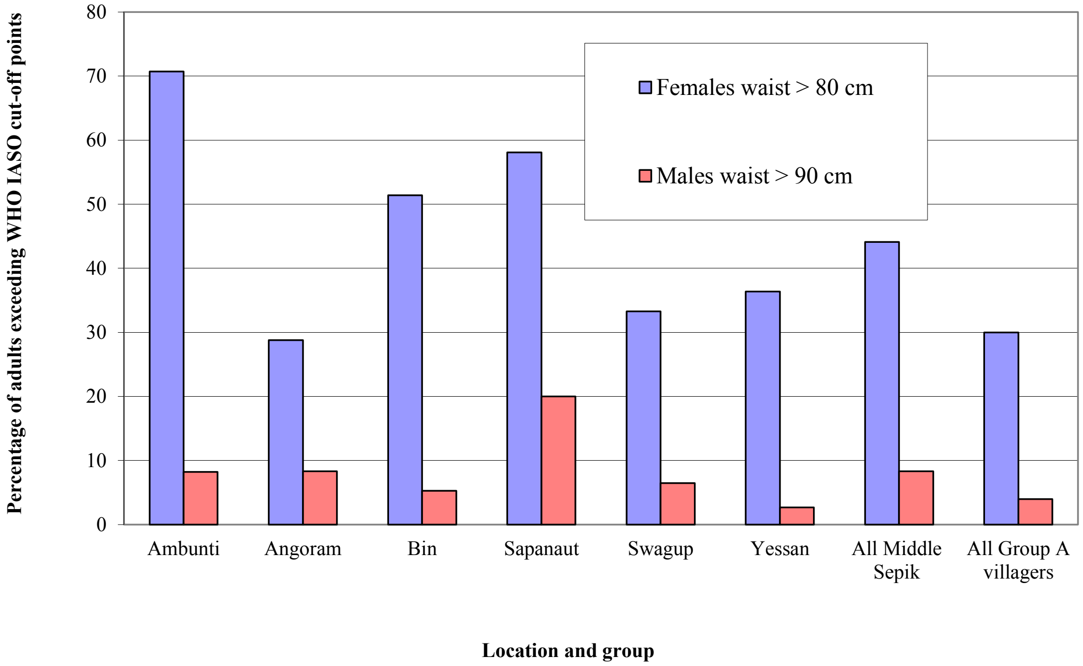
Table 3-16: Comparison of adult survey group BMI values with WHO (2004) intermediate public health action points

Risk level	Males	Females
Normal range (low risk) (<18.5 cm)	0 (0.0%)	15 (5.5%)
Increased but acceptable risk (18.5 – 22.9 cm)	49 (25.3%)	102 (37.6%)
High risk (23.0 – 27.4 cm)	121 (62.4%)	114 (42.1%)
Higher high risk (27.5 – 32.5 cm)	24 (12.4%)	33 (12.2%)
Very high risk (>32.5 cm)	0 (0.0%)	7 (2.6%)

All of the very high risk individuals were females.

Figure 3-4 compares the waist circumference measurements of all survey adults (males 192, females 270) with the WHO-International Association for the Study of Obesity recommended cut-off points for urban Asians of < 90 cm for men and < 80 cm for women (WHO IASB 2000).

Figure 3-4: Adult waist measurements by village compared with the WHO IASB 2000 recommended cut-off points



The waist circumference results of all participants indicated that for males approximately 91.3% were at low risk of cardiovascular disease. The corresponding value for females was about 55.9%. As expected, the cardiovascular risk is higher for the two township communities. The unexpectedly high result at Sapanaut was unexplained. The results are similar to a recent report for rural and remote communities in Sumbawa Province, Indonesia (males 97% and females 72%) (University of Indonesia 2009).

3.2.5 Food and nutrition

Twenty-four hour dietary recall and food frequency surveys were completed at the household level for all survey villages. The results of the dietary recall and food frequency surveys are summarised in Tables 3-17 and 3-18, and provided in detail in Appendix 7.

Whenever practical, the mother of the household was interviewed for the dietary questionnaire (86% of households). In a number of cases the head of household responded (7% of households), generally with the mother present. In 7% of households the mother or head of household was unavailable for interview and another adult household member was recruited.

As is usual for surveys conducted in remote PNG locations, there were both extended family and neighbours present. Every effort was made to concentrate on the responses of the specific household, and in the present circumstances when almost 100% of village households in the survey had a similar response ie, sago, fish and green vegetables and limited or no purchase of store foods, the possibility of overstating food selection for the 24-hour recall component of the nutrition work can be discounted.

In response to the question on food security and perceived food insufficiency, a number of households at all of the villages (varying between 10% at Ambunti to 30% at Bin, Swagup and Yessan) expressed concerns regarding insufficient food being available on the day prior to interview. Food insufficiency was invariably a short-term issue, relating to the high flood levels inundating the village gardens (lack of green vegetables, bananas) or limiting access to the sago palms (shortage of sago). Shortages of fish were also reported by some households at Bin, Swagup and Yessan. However other families at these villages reported more than ample fish being caught. The issue appeared to be one of a lack of fishing nets and a lack of commitment, combined with large family size.

The results of the food frequency survey (Table 3-19), were in very good agreement with the 24-hour dietary recall. This is as expected, with both the short- and long-term food consumption patterns being largely a diet of fish, sago and green vegetables together with a more variable (by village) consumption of banana and coconut. At Ambunti and Angoram and to a lesser degree at Bin, tubers provided a significant carbohydrate source.

Table 3-17: Food consumed in the previous 24 hours at the survey villages (all values % of households)

Food commodity	Ambunti % (20)	Angoram % (20)	Bin % (20)	Sapanaut % (20)	Swagup % (20)	Yessan % (20)
Sweet potato	15	20	5	0	0	0
Cassava	0	0	0	0	0	0
Taro	10	5	5	0	0	5
Other tubers	0	0	0	0	0	0
Banana	50	45	50	10	0	20
Sago	90	85	90	95	100	95
Coconut	10	5	5	50	35	25
Rice	10	25	15	5	5	0
Pork	0	0	5	0	0	10
Other meats	0	0	0	0	0	0
Fresh fish	100	75	95	100	95	90
Eggs	0	0	0	0	0	0
Sugar cane	0	0	0	5	0	0
Fresh fruit	0	0	0	0	0	5
Nuts	0	0	0	5	0	0
Green vegetables	45	65	25	30	25	40
Yellow vegetables	0	5	0	0	0	0
Flour	0	0	0	0	5	0
Tinned fish	0	20	0	0	5	0
Tinned meat	0	5	0	0	0	0
Milk	0	15	0	0	0	0
Sugar	5	35	0	0	10	0
Bread	0	5	0	0	5	0
Vegetable oil	20	0	0	0	10	0
Snacks	0	0	0	0	0	0

The annual food consumption frequency survey indicated that sago was the main staple carbohydrate food at all of the survey communities. At Ambunti, Angoram and Bin, sago was seasonally supplemented by tubers (mainly kau kau and taro), banana and coconut. At the villages of Sapanaut, Swagup and Yessan, coconut provided the only alternative carbohydrate source. This pattern of consumption contrasts markedly with the inland mine area villagers, for whom sago is the staple energy source only for Auom 3. The more affluent riverine villagers at Ok Isai and Wabia had store-purchased rice as their staple carbohydrate. The other seven communities had tubers, mainly sweet potato and taro, as their main energy source.

Consumption of green vegetables was low at all of the Middle Sepik villages (25 – 65%) of households at the time of the survey. This could readily be attributed to the loss of those food gardens that are maintained in the wet season. However, the food frequency survey indicated that the low consumption pattern was ongoing, irrespective of the season. This was particularly evident at the low lying and hence flood prone villages of Sapanaut, Swagup and Yessan.

The consumption pattern for protein-rich food was very similar between the survey communities, with 100% of households having consumed fish, fresh or smoked (supplemented at Angoram by tinned fish) on the day prior to interview. Consumption of other high protein foods was consistently reported by all villagers and householders as "occasional".

Table 3-18: Food consumed in the previous year at the survey villages (in days/year)

Food commodity	Ambunti	Angoram	Bin	Sapanaut	Swagup	Yessan
Sweet potato	19	21	21	6	6	6
Cassava	6	10	13	6	6	6
Taro	10	22	21	6	6	7
Yam	6	6	9	6	6	6
Banana	29	47	66	6	7	10
Sago	100	100	100	100	100	100
Coconut	38	49	66	34	41	20
Rice	20	50	10	6	7	6
Pork	6	10	6	6	6	6
Other meats	13	15	13	13	12	13
Fresh fish	100	100	98	100	100	100
Eggs	6	6	6	6	6	6
Sugar cane	6	6	6	6	6	6
Fresh fruit	8	7	6	6	6	6
Nuts	7	6	6	6	6	6
Green vegetables	51	51	61	30	47	22
Yellow vegetables	14	13	20	6	6	6
Flour	20	10	6	6	6	6
Tinned fish and meat	11	36	6	6	7	6
Milk	10	23	6	6	6	6
Sugar	10	26	6	6	11	6
Bread	10	24	6	6	7	6
Vegetable oil	18	28	6	6	7	6
Snacks	8	27	6	6	6	6

Note: The food frequency survey was designed to take into account seasonal availability of food products and the stated frequency of consumption. For some villages, no consumption was recorded, where particular foods were never available. Deriving the annual consumption has used frequency (times/year) as:

Every day.	=	365	1 – 2 times a week	=	78
3 – 6 times a week	=	234	Occasional	=	24

The results of Table 3-18 are derived from the data in Appendix 8.

3.2.6 Clinical measurements

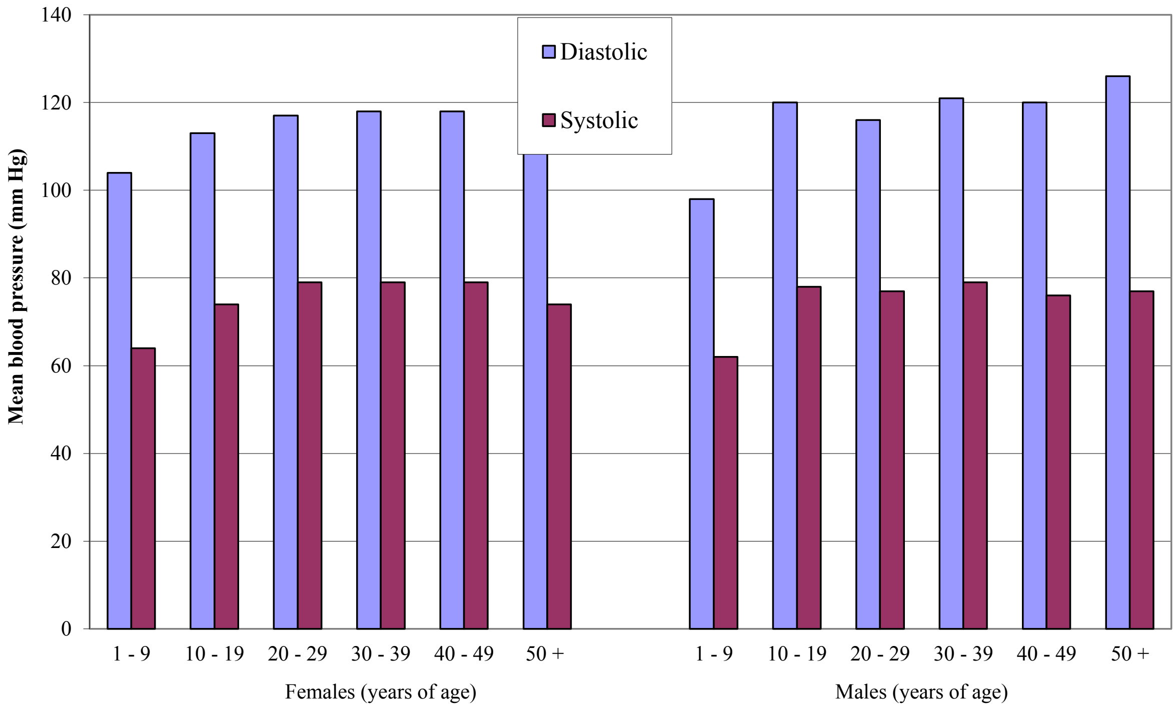
Summary data for each of the clinical measurements is discussed in sections 3.2.6.1 – 3.2.6.5. The detailed clinical results by village are provided as coded datasets in Appendix 4.

The medical examinations clinically identified a significant prevalence of chronic bronchitis and arthritis, primarily in the elderly participants. To some degree at least, this may be related to the extensive inundation of the villages. There were also three cases of possible malignant tumour (two ovarian and one mouth tumour). All three cases were referred to Wewak for follow up. As noted for the mine area villagers, lack of family planning was a significant problem, involving marriage at an early age and frequent multiple births.

3.2.6.1 Blood pressure

Blood pressure results were almost universally in the normal to low range, with little difference between the males and females of all age groups. There was no noticeable difference in the adolescent and adult mean values between those resident at the more isolated villages, with their largely traditional diets (males 120/76; females 124/79), when compared with the township settlements of Ambunti and Angoram (males 118/80, females 118/74). In these townships, the diets had somewhat changed, but not markedly towards a PNG urban and Western consumption pattern of rice and store foods. There were very few hypertensive individuals in the study population and these generally linked to recognised medical conditions. This result is as to be expected, in a group largely without problems associated with overweight and obesity. The results are presented in Figure 3-5.

Figure 3-5: Blood pressure in survey villages by age and sex



3.3.6.2 Examination of liver, kidney, spleen and lymph nodes

Hepatomegaly and kidney enlargement

Hepatomegaly (liver enlargement) has long been reported as being highly prevalent in PNG, particularly in the lowlands in association with poor sanitation, crowded living conditions, low immunisation rates for hepatitis B, malaria and clinically diagnosed hepatitis B (Murthy et al 1995).

Hepatitis B was determined in a Western Province lowlands population by seroprevalence at 26%, but this study did not support the association between hepatomegaly and hepatitis B with a reported population rate of 0.5% (Flew 1999). The health baseline studies conducted in Madang Province and in the mine area villagers also gave population rates of 1.5% and 0.4% respectively (CEH 2007b, CEH 2011).

There were no cases of kidney or liver enlargement in any of the Sepik River villagers surveyed. With results from a number of studies now available, the original 1995 reported results appear to be unsupported by the evidence.

Splenomegaly

Splenomegaly (spleen enlargement) in PNG is most commonly due to infections, including Epstein Bar virus, which is closely associated with malaria infection and malaria protozoa. Other causal agents include intestinal parasites and fungal infections. Splenomegaly has frequently been reported as associated with generalised lymphadenopathy (swelling of lymph nodes).

Historically, there has been a correlation noted between the incidence of splenomegaly and altitude, with the rates and degrees of enlargement falling with increasing altitude. Communities living at greater than 1500 metres ASL normally have no palpable spleen (Taufa 1999). By comparison, the levels observed in recent studies conducted in the Western Province lowland zone were 82% in 1996 and 90% in 2000 (Taufa 1997, Reto 2005).

A 2007 study of the Rai Coast and Usino-Bundi District inland villagers using the five grades of enlargement, according to the system developed by Hackett (1943) gave an overall prevalence (ie sum of Grade 1 – Grade 5) of 43% at the coastal villages and 41% at the inland villages. The 2009 survey of mine area villages, using the same criteria gave an overall prevalence of 44%. These results are typical of other areas in PNG where malaria is hyperendemic (CEH 2007b, CEH 2011).

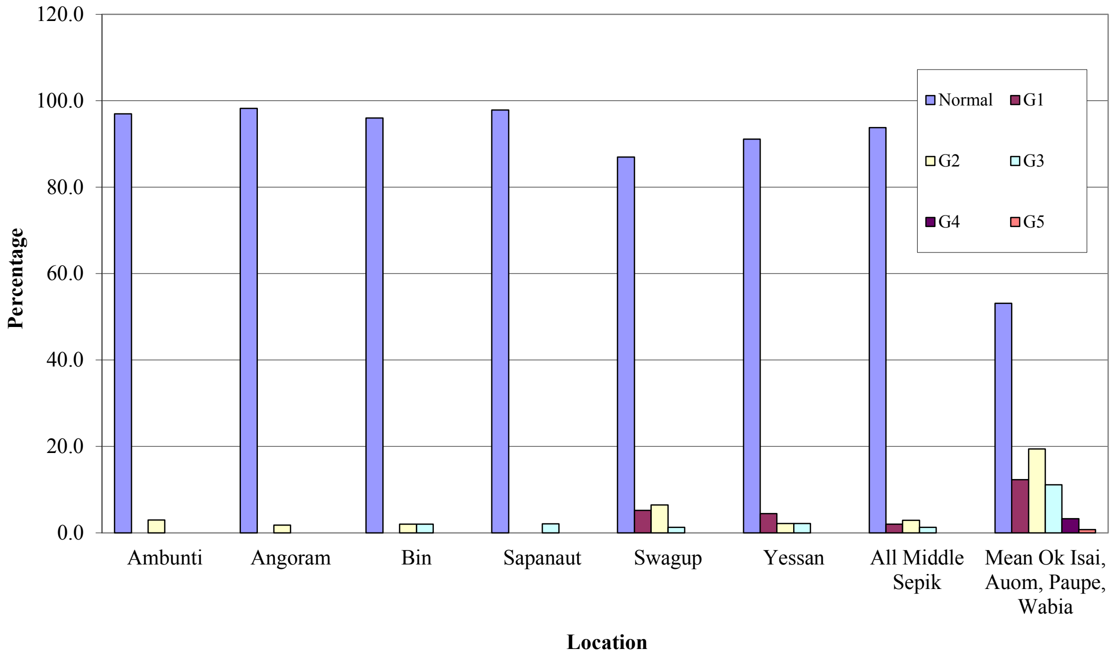
In the present survey, the results by village and grade are shown in Table 3-19 and Figure 3-6. Somewhat surprisingly, the results indicated a very low overall prevalence of splenomegaly (< 6%). This result is similar to that observed at the Wamiemin 1 and Wamiemin 2 villagers in December 2009. Both results are unexplained.

Table 3-19: Prevalence of splenomegaly in the study communities, using Hackett's grading system (all values number of cases)

Village (total)	Normal	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Ambunti (33)	32	0	1	0	0	0
Angoram (55)	54	0	1	0	0	0
Bin (50)	48	0	1	1	0	0
Sapanaut (47)	46	0	0	1	0	0
Swagup (77)	67	4	5	1	0	0
Yessan (45)	41	2	1	1	0	0
Total (307)	288	6	9	4	0	0
% Sepik River villages	93.8	2.0	2.9	1.3	0	0
% Group A riverine villages	53.1	12.3	19.4	11.1	3.3	0.8

Note: The Group A riverine villages used for comparison are: Iniok, Ok Isai, Auom 3, Paupe and Wabia.

Figure 3-6: Spleen enlargement by village graded in accord with Hackett (1943)



Lymphadenopathy

In the present survey population, despite the lower prevalence of malaria and fungal infections compared with the mine area villagers, lymphadenopathy in the cervical, popliteal, submandibular and auxiliary foci examined occurred at a three-fold higher frequency, (11 participants 3.6%). This result may be a temporary consequence of what appeared to be a higher level of respiratory infections at all of the communities except Ambunti and Angoram, due to the inundation of the villages by floodwaters. The results from both of the Frieda River Copper-Gold Project surveys was similar to that observed in the 2007 study of the Madang Province coastal and inland communities (2.6%), and an order of magnitude less than that reported by Cathy Reto for the Middle Strickland River communities (Reto 2005, CEH 2007b).

3.2.6.3 Eye infections

The survey of eye disease in the mine area survey communities, gave prevalence rates of conjunctivitis (1.5%), cataract (2%) and pterygium (7.6%).

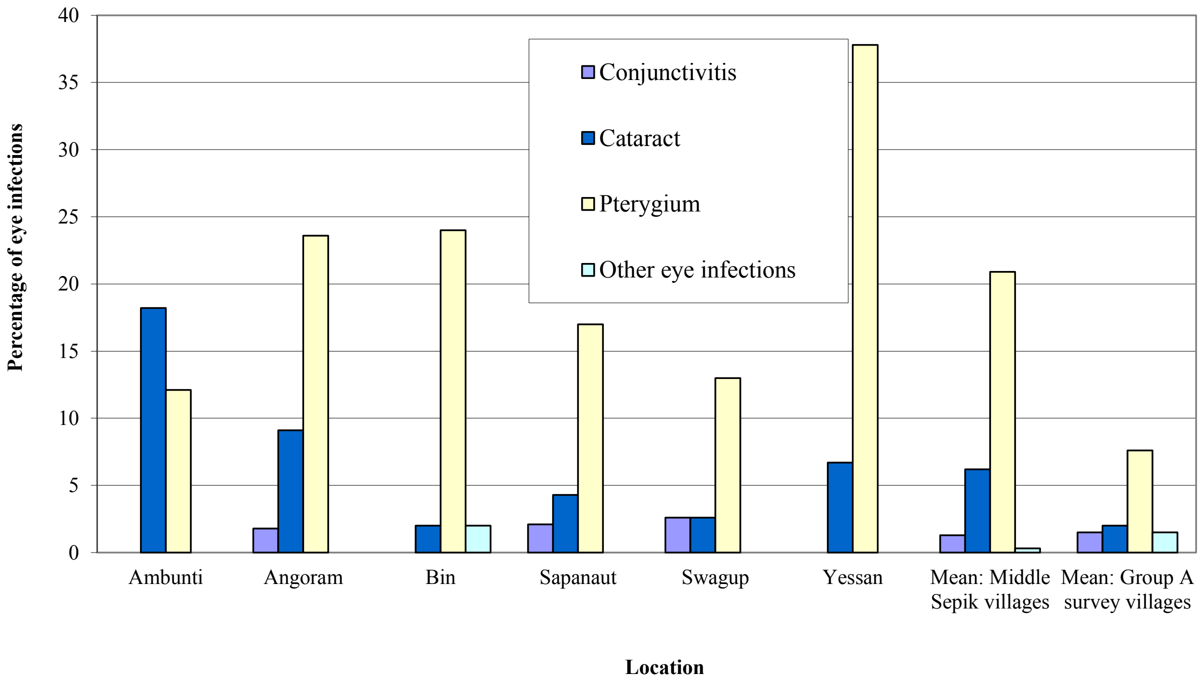
In the Sepik River survey villagers, the prevalence of cataract and pterygium were both some three-fold those observed in the mine area villagers. The prevalence of cataract (6.2%) was comparable with the results reported for the remote Fly River region (6.4%) (Flew 1999). The level of pterygium at 20.9%, with no difference between males and females, was almost an order of magnitude higher than in the Western Province study (2.4%) (Flew 1996). The results for pterygium are some 20-fold those observed at the coastal communities in Madang Province (CEH 2007b). The reason for this elevated prevalence is unclear, however, it may be a consequence of ethno-genetic background and/or extended exposure to sunlight in early childhood.

Table 3-20: Prevalence of eye infections by village (all values number of cases and %)

Village	Conjunctivitis	Cataract	Pterygium	Other eye infections	Total
Ambunti	0	6 (18.2%)	4 (12.1%)	0	10
Angoram	1 (1.8%)	5 (9.1%)	13 (23.6%)	0	19
Bin	0	1 (2.0%)	12 (24%)	1 (2.0%)	14
Sapanaut	1 (2.1%)	2 (4.3%)	8 (17.0%)	0	11
Swagup	2 (2.6%)	2 (2.6%)	10 (13.0%)	0	14
Yessan	0	3 (6.7%)	17 (37.8%)	0	20
Middle Sepik villages	1.3%	6.2%	20.9%	0.3%	
Mine area villages	1.5%	2.0%	7.6%	1.5%	

Note: All of the 10 villages surveyed in the December 2009 baseline health survey have been used for comparison.

Figure 3-7: Prevalence of eye infections by village and condition



3.2.6.4 Skin infections

Tropical ulcers due to anaerobic fusiform bacilli, especially found on the lower legs, were formerly rife in mid-altitude and lowland riverine areas of PNG, but are now reported as comparatively rare (Radford 1974).

The prevalence of skin infections by village is shown in Table 3-21 and graphically in Figure 3-8. On a whole-of-study population basis, the prevalence of skin infections was significantly less than that observed at the mine area villagers for all classes of fungal infections. The reported prevalence of sores and tropical ulcers (5.9%) was markedly less than that observed in the December 2009 survey (21.2%). The results for sores and tropical ulcers were also markedly less than the results reported for the coastal and inland villagers in Madang Province (15.3%). The results for other fungal infections (including various tinea species) were very similar to those reported in the Madang study (ie 13.0% versus 13.1%) (CEH 2007b).

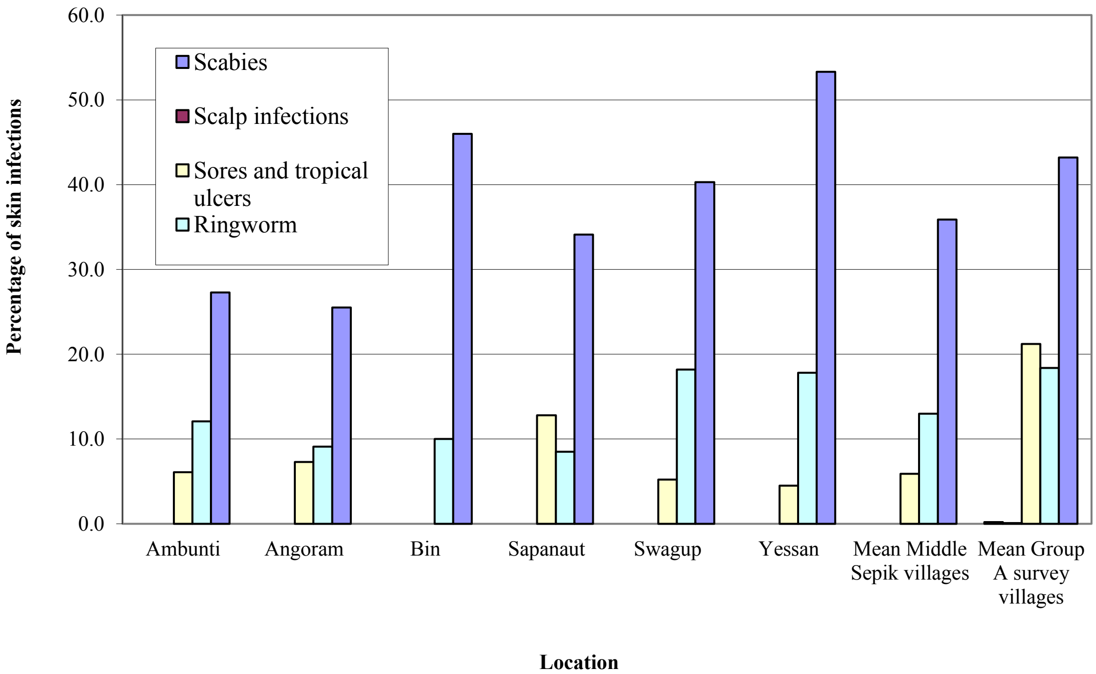
In contrast with the mine area village survey, tropical ulcers were evenly distributed between all age groups. Ringworm was mainly observed in the infants and children.

Table 3-21: Prevalence of skin infections by village (all values number of cases and %)

Village	Scabies	Scalp infections	Sores and tropical ulcers	Ringworm	Other fungal skin infections
Ambunti	0	0	2 (6.1%)	4 (12.1%)	9 (27.3%)
Angoram	0	0	4 (7.3%)	5 (9.1%)	14 (25.5%)
Bin	0	0	0	5 (10.0%)	23 (46.0%)
Sapanaut	0	0	6 (12.8%)	4 (8.5%)	16 (34.1%)
Swagup	0	0	4 (5.2%)	14 (18.2%)	31 (40.3%)
Yessan	0	0	2 (4.5%)	8 (17.8%)	24 (53.3%)
Middle Sepik villages	0%	0%	5.9%	13.0%	35.9%
Mine area villages	0.2%	1.1%	21.2%	18.4%	43.2%

Note: All of the 10 villages surveyed in the December 2009 baseline health survey have been used for comparison.

Figure 3-8: Prevalence of skin infections by village and condition



3.2.6.5 Dental health

Exceptionally good dental health has been reported in a number of rural and remote coastal and inland communities in PNG (Flew 1996, Hardham 1998). A recent survey in Madang Province, reported a low prevalence of dental caries (4.2%) and missing teeth (12%). Missing teeth were found exclusively in the 40 + years of age group (CEH 2007b).

In the Sepik River survey there was one case of oral submucosal fibrosis and two cases of oral malignancy. The overall incidence of dental caries in the present study population was 11.1%. The incidence was quite similar between villages (7.8 – 12.1%) with the exception of Sapanaut (21.3%).

The overall incidence of missing teeth was 12.7%. The incidence at Ambunti, Angoram and Sapanaut (18.2 – 21.2%) was some two-fold that at Bin, Swagup and Yessan (5.2 – 10.0%). While to some degree this is influenced by the higher number of elderly people at the first group, this is not sufficient to explain the difference. A more likely explanation is the availability and uptake of dental services at Ambunti, Angoram and Pagwi.

All of the communities displayed extensive staining of the teeth due to the chewing of betel nut. Plaque was also common, due to the lack of toothbrushes and toothpaste.

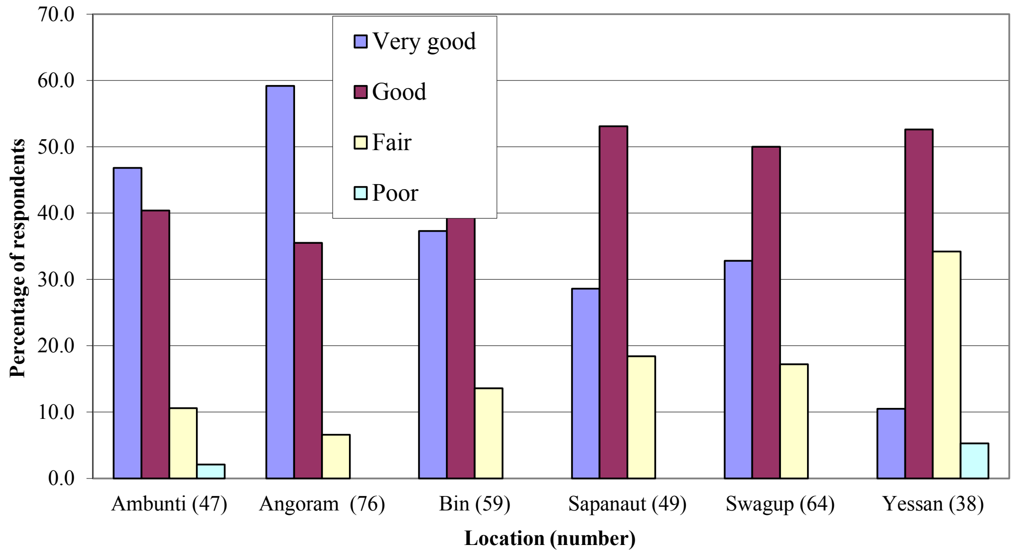
3.2.7 Medical questionnaire

The summarised data is discussed in sections 3.2.7.1 – 3.2.7.4. The individual medical questionnaire responses are provided in Appendix 3, and the data for child immunisation coverage by village,is provided in Appendix 11.

3.2.7.1 General state of health

The general state of health by survey village is shown graphically in Figure 3-9. Overall, there were about 84% of villagers whose health in the last 12 months was perceived, either by themselves or on behalf of their children, as good or very good, compared with the mine area villagers of 78%. The health satisfaction rating at Yessan was the lowest at 63%, with the rating at all of the other villages being between 82% and 95%. Overall, of those villagers who reported fair or poor health, (16%) only 0.9% were in the poor health category. The low rating at Yessan was in overall agreement with the village disease prevalence identified by the medical examinations and generally in agreement with the incidence of self-reported medical complaints over the previous 7 days.

Figure 3-9: Self-reported general state of health by village and grading



3.2.7.2 Medical conditions in previous 12 months

The Frieda River Copper-Gold Project HEO questioned a random sample of the survey participants about their personal medical conditions over the previous 12 months. The results are shown in Table 3-22. In the present population, there was only a single confirmed case of cholera from the recent outbreak in the East Sepik Province. There were 17 cases of asthma identified in the study population (5.1%). The overall prevalence of diagnosed hypertension (3.3%) was similar to that in the mine area villagers (4.4%). The cases were predominantly at Angoram and Sapanaut (each 36% of all cases) and likely reflect the greater accessibility to medical diagnostic services.

The reported incidence of malaria (58% – 81%) and internal parasites (46% - 64%) were similar at all of the villages except Yessan (malaria 90% and internal parasites 82%). The incidence reported for dengue-like fevers was much lower at Ambunti and Angoram than at the other villages. A similar but less striking result is also evident from the results for pneumonia. It is notable that the overall prevalence for pneumonia (22.5%) is an order of magnitude higher than that reported in the mine area villagers (1.9%). This is unlikely to be a consequence of the relatively recent inundation of the villages by flood waters, and warrants further and more detailed clinical investigation.

Table 3-22: Reported medical conditions in the previous 12 months

Village (No)	Asthma (cases)	Hypertension (cases)	Internal parasites %	Malaria %	Dengue-like fever %	Pneumonia %
Ambunti (47)	1	1	63.8	59.6	6.4	14.9
Angoram (76)	6	4	46.1	57.5	4.0	11.9
Bin (59)	2	1	64.4	81.4	30.5	18.7
Sapanaut (49)	2	4	51.0	67.4	18.4	40.8
Swagup (64)	3	0	60.9	57.8	21.9	23.4
Yessan (38)	3	1	81.6	89.5	26.3	34.2
All participants (333)	17 (5.1%)	11 (3.3%)	198 (59.5%)	217 (65.2%)	57 (17.1%)	75 (22.5%)

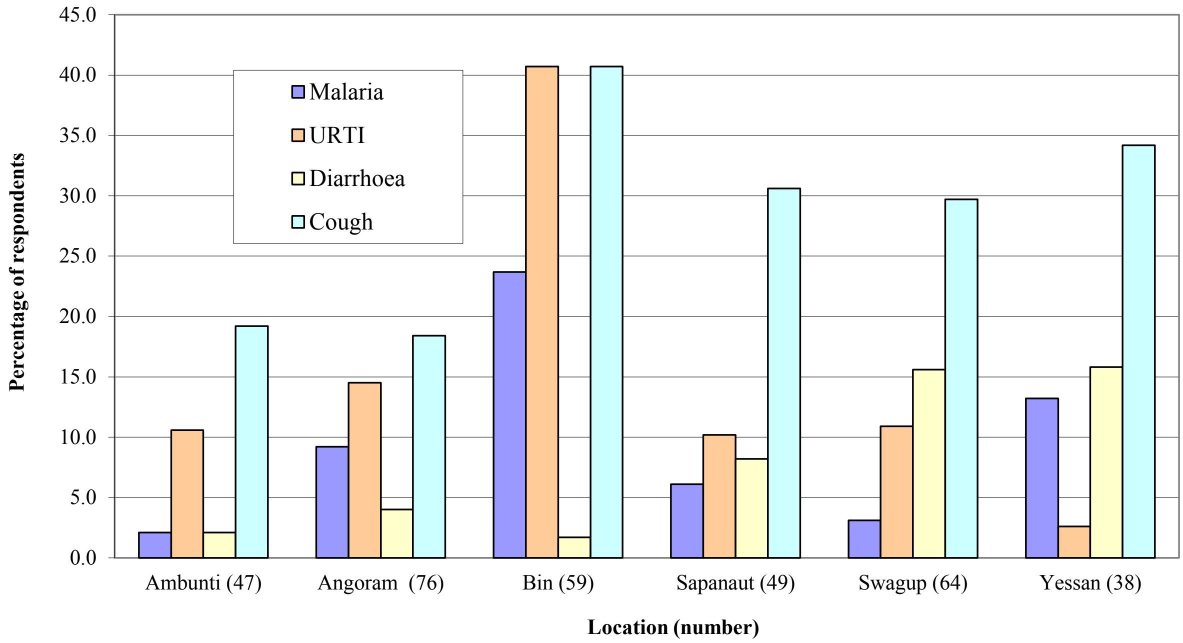
3.2.7.3 Medical complaints over previous 7 days

The self-reported medical complaints over the previous 7 days are summarised in Figure 3-10. The overall malaria prevalence of 9.6% masks the wide diversity in reported malaria fever between the villages (range 2.1% – 23.7%). The overall level of malaria is markedly less than that reported from the mine area villages (20%) in December 2009.

The overall prevalence of upper respiratory tract infections in the Sepik River survey (15.9%) is very similar to that reported for the mine area riverine villagers (Iniok, Ok Isai, Auom 3, Paupe and Wabia) of 16.0%.

The incidence of diarrhoea was low at Ambunti, Angoram and Bin (1.7% – 4.0%) when compared with the villages of Sapanaut, Swagup and Yessan (8.2% - 15.8%). While not necessarily causally related, it appeared likely that the higher levels of current diarrhoea were related to the degree by which the respective villages were inundated by flood waters, resulting in contamination of the drinking water sources and lack of sanitation facilities.

Figure 3-10: Self-reported medical complaints over previous 7 days



3.2.7.4 Immunisation of children under 72 months of age

Infectious diseases such as measles, mumps, rubella, diphtheria, typhoid and whooping cough are some of the most important contributors to childhood morbidity and mortality and are readily preventable through universal childhood immunisation. The measure of childhood immunisation rates are therefore, one of the most important indicators of health status in the community and of the success of national public health measures.

The immunisation status of children at Ambunti, Angoram and Bin is shown in Table 3-23. The immunisation coverage was derived from the Child Health Care cards (CHC) and a cross-check for the characteristic BCG scar on the right shoulder for tuberculosis inoculation. The availability of CHC cards was compromised at the other three villages, due to the need for the mothers to move away from their residences to a central dry area for the survey.

Comparing the mean coverage from the three surveyed villages with the overall PNG coverage, indicated that the percentage coverage at the Sepik River communities (36.7%) was somewhat less than the overall PNG coverage (44%) (WHO WPRO 2009).

Table 3-23: Immunisation of children < 72 months of age (all values % coverage)

Village (No infants surveyed)	Child Health Care card %	Immunisation status		
		Complete %	Incomplete or behind schedule %	Not started %
Ambunti (12)	75	58	17	0
Angoram (23)	35	26	9	0
Bin (14)	57	36	21	0
Sapanaut	Note: The participating survey families needed to travel some considerable distance to a dry area by canoe. Many indicated that they had cards, but that these had been left at home			
Swagup				
Yessan				
Mean coverage		36.7	14.3	0

Key:

Complete	=	Confirmed full course coverage from immunisation records
Incomplete	=	Some vaccinations have been omitted, or the child is over 12 months of age
Behind schedule	=	Vaccinations are not completed in the designated timeframe. The Ministry of Health Schedule of Immunisations (2007) has measles (6 and 9 months of age); BCG (at birth and at the beginning and end of schooling); polio and triple antigen (at 1, 2 and 3 months of age) and Hepatitis B (at birth, 1 and 3 months of age) (Tay 2007)
Not started	=	Includes infants possessing a baby health care card, but showing no immunisation records and other infants under 12 months of age, having no records. It is possible to purchase blank cards, which in addition to immunisation records, are used for general medical records

3.3 Summary of Findings

Within the limitations imposed by the extensive flooding and village inundation that imposed logistical constraints, the baseline health survey has identified the principal public and environmental health and nutritional parameters of the Sepik River corridor survey villages. The high water levels impacted on the collection of data for childhood immunisation, household occupant density and ventilation and at a number of villages required the adoption of a line-up, rather than individual household approach for the medical examinations.

The environmental health component of the survey, while differing markedly between the semi-urban villages of Ambunti and Angoram and the more isolated villages, overall gave results that are reasonably typical for rural and remote riverine communities in PNG.

The anthropometric data indicated a profile of above average nutritional health with little wasting, stunting or underweight in infants under 5 years of age, and children 6 – 10 years of age. The presence of a significant number of adolescent and adult females in the overweight category (as determined both by body mass index and waist measurements) warrants further monitoring as the communities transition towards a more urbanised diet.

In marked contrast with the mine area villagers, the nutritional survey found little difference in food consumption patterns between the villagers, with all having a predominantly sago and fish diet, supplemented by bananas, coconut and at the more elevated villages, tubers. Angoram was the only village where store-purchased food made any significant contribution to total dietary intakes of energy and protein.

The Sepik River villagers had variable immunisation coverage rates, generally below those reported nationally in PNG. The immunisation rates for Sapanaut, Swagup and Yessan were not reliably confirmed, due to flood water inundation.

The measurement of blood pressure indicated that there were few hypertensive individuals, as to be expected in a group with minimal adult obesity. Examination of liver, kidney and lymph nodes identified a very low prevalence of clinical conditions associated with these organs. Spleen enlargement was exceptionally low, and atypical of communities living in hyperendemic malaria areas of PNG. The reason for this is unclear.

The prevalence of cataract was some three-fold the level observed in the mine area villagers, but not exceptional for rural and remote PNG. The prevalence of pterygium was unusually high and some 10-fold that observed in the mine area villagers. The level is at the upper end of data previously reported in PNG.

On a whole-of-study population basis, the prevalence of skin infections was significantly less than that observed at the mine area villages for all classes of fungal infections. The prevalence of sores and tropical ulcers was about 25% of the levels reported in the mine area survey. In contrast with the mine area village survey, tropical ulcers were evenly distributed between all age groups. However, ringworm, as at December 2009, was mainly observed in the infants and children.

Acknowledgements

The mine area campaign was conducted by a team comprising the report author from the Centre for Environmental Health in Canberra, Australia, together with Dr Alphonse Tay, Port Moresby General Hospital and Mr David Yok. The survey team was most ably supported by Ms Anna Apop, Frieda River Copper-Gold Project Community Affairs (anthropometric measurements) and Mr Francis Pena the Frieda River Copper-Gold Project HEO (medical questionnaire). The author is greatly appreciative of the efforts of all of his study collaborators.Logistic arrangements were largely the efforts of Mr Nick Fog, Superintendent,
Community Relations Department at the Frieda River Copper-Gold Project. Appreciation is also given to the community leaders, village councillors and the survey participants who unstintingly gave of their time in assisting the survey team.

The pipeline corridor campaign was conducted by a team comprising the report author from the Centre for Environmental Health in Canberra, Australia together with Dr Alphonse Tay, Port Moresby General Hospital and Mr Lysaght Griffin. The survey team was most ably supported by Mr Francis Pena the Frieda River Copper-Gold Project HEO (village and medical questionnaire) and Ms Sheila Akila Frieda River Copper-Gold Project Community Affairs (anthropometric measurements). The author is greatly appreciative of the efforts of all of his study collaborators. Appreciation is also given to the community leaders, village councillors and the survey participants who unstintingly gave of their time in assisting the survey team.

The Sepik River corridor campaign was conducted by a team comprising the report author from the Centre for Environmental Health in Canberra, Australia together with Dr Alphonse Tay, Port Moresby General Hospital and Mr David Yok. The survey team was most ably supported by Mr Nathan Hukula, Frieda River Copper-Gold Project Community Affairs (survey logistics and anthropometric measurements) and Mr Francis Pena the Frieda River Copper-Gold Project HEO (village and medical questionnaire). Sincere appreciation is also given to the nursing staff from the Ambunti Health Centre, Jennifer Waipeli and Timothy Ausomb, who provided support at Ambunti, Swagup and Yessan villages. The author is greatly appreciative of the efforts of all of his study collaborators.

Pre-survey logistic arrangements were largely the efforts of Mr Peter Nawara from the Frieda River Copper-Gold Project Community Affairs Department. The assistance of the boat crew Thomas Joshiah and Michael Taipet and the support given by Mr Peter Chris in all aspects of the logistics, community consultation and security was greatly appreciated.

Appreciation is also given to the community leaders, village councillors and the survey participants who unstintingly gave of their time in assisting the survey team.

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Appendix 4

Health Impact Assessment

SEPIK DEVELOPMENT PROJECT
HEALTH IMPACT ASSESSMENT (SCREENING LEVEL)
EXAMINING HUMAN EXPOSURE TO PROJECT RELATED CHEMICAL ELEMENTS

(September 2018)

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Glossary and abbreviations

ADI	Acceptable Daily Intake: expressed on a body weight basis the amount of material that can be ingested for a lifetime without appreciable risk to health
AMBS	Australian Market Basket Surveys published by the Australia and New Zealand Food Authority and more recently by Food Standards Australia New Zealand
ATSDR	Agency for Toxic Substances and Disease Registry (United States)
BMI	Body Mass Index (weight (kg)/(height (m))^2 recommended by WHO as the index of choice in adult assessment of nutritional status
CDC	Centres for Disease Control and Prevention (United States)
CHS FFS	The OTML Community Health Study Food Frequency Survey
CHS MBS	The OTML Community Health Study Market Basket Survey (total diet study)
CHS UFC	The OTML Community Health Study Unit Food Consumption measurement study
Codex	The FAO/WHO Codex Alimentarius Commission
Control villages	In the OKTFLY CHS Control villages are located away from the zone of impact of the OTML mine operations. Generally located on a control river or other water body these villages do not receive contaminant metal impacts from the OTML mine operations
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAD	Dermally absorbed dose
DL (LoD)	Analytical Detection Limit (Limit of Detection)
DRI	Dietary Reference Intakes for nutritional sufficiency endorsed by the US Institute of Medicine
FFS	Food Frequency Survey
FSANZ	Food Standards Australia New Zealand
HIL	Health Investigation Levels for contaminated land (Australia) (NEPM 2013)
IARC	International Agency for Research on Cancer (WHO/UNEP)
ICRP	International Commission on Radiological Protection
Impact villages	Villages within the Ok Tedi-Fly River system that potentially receive contaminant metal impacts from the OTML mine operations
IMR	PNG Institute for Medical Research
IOM	Institute of Medicine, US National Academy of Science
IQ	Intelligence quotient
IPCS	International Program on Chemical Safety
JECFA	WHO/FAO Joint Evaluation Committee for Food Additives
LADD	Lifetime average daily dose (for carcinogenic chemical assessments)
MAC	Maximum Acceptable Concentrations (Environment Canada)
MBS	Market Basket Survey
MCL	Maximum Contaminant Levels (US Drinking Water Standards)
MCLG	Maximum Contaminant Level Goal (US Drinking Water Guideline protective of public health)
MOE	Margin of Exposure
NEPM	National Environment Protection Measures (Australia)

NHMRC	National Health and Medical Research Committee (Australia)
NNS	1982 - 83 National Nutrition Survey for Papua New Guinea
NOAEL	No Observed Adverse Effect Level
NSO	National Statistics Office of Papua New Guinea
OKTFLY CHS	A 2-volume report by Bentley of communities on the Ok Tedi/fly rivers impacted by OTML
ORWB	Off-river water bodies
OTDF	Ok Tedi Development Foundation
OTML CHS	The Ok Tedi Mining Limited Community Health Study
pica	Behaviour in young children associated with the consumption of soil
PM 10, PM 2.5	Respirable particulates of mean aerodynamic diameter of 10 and 2.5 micron
PNG	Papua New Guinea
Project communities	The villages within the defined Project disturbance area
PTMI	The WHO Provisional Tolerable Monthly Intake values represent permissible human weekly exposure to a contaminant which has a cumulative effect on the body and is unavoidably present in otherwise wholesome and nutritious food
PTWI	The WHO Provisional Tolerable Weekly Intake values represent permissible human weekly exposure to a contaminant which has a cumulative effect on the body and is unavoidably present in otherwise wholesome and nutritious food.
RDI	Recommended Daily Intake for nutritional requirements
Region	The four geographic regions described in the SIA (Mine area, FRHEP area, infrastructure corridor and Vanimo Ocean Port.
TSP	Total suspended particulates (air)
TSS	Total suspended solids
UFC	Unit Food Consumption measurement
UK FSA	United Kingdom Food Standards Authority
UL	Tolerable Upper Intake Level for nutritional elements (US IOM)
US EPA	United States Environmental Protection Agency
US FDA	United States Food and Drug Administration
US NRC	United States National Research Council
WHO	World Health Organization
WHO PTWI/TWI	The WHO Provisional Tolerable Weekly Intake values represent permissible human weekly exposure to a contaminant which has a cumulative effect on the body and is unavoidably present in otherwise wholesome and nutritious food

Executive Summary

Frieda River Limited is assessing the feasibility of developing a potentially nation-building Project in northern Papua New Guinea (PNG). The Sepik Development Project (the Project) is primarily located within the Sepik River catchment and will comprise development of the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) copper-gold deposits in the Sandaun Province and supporting infrastructure and facilities in the Sandaun and East Sepik provinces. The Project consists of four interdependent projects:

- Frieda River Copper-Gold Project (FRCGP).
- Frieda River Hydroelectric Project (FRHEP).
- Sepik Infrastructure Project (SIP).
- Sepik Power Grid Project (SPGP).

Coffey has conducted extensive Study area social profiles for the communities potentially impacted by the Project (Coffey, 2018) and defined six social catchments as follows:

- Social Catchment 1A: Mine area (Figure 1).
- Social Catchment 1B: New infrastructure and road corridor, Hotmin to Green River (Figure 1).
- Social Catchment 1C: Existing infrastructure and road corridor, Green River to Vanimo (Figure 2).
- Social Catchment 1D: Vanimo Ocean Port (Figure 2).
- Social Catchment 2: Sepik River corridor (Figure 3).
- Social Catchment 3: Sandaun and East Sepik Provinces (Figure 3).

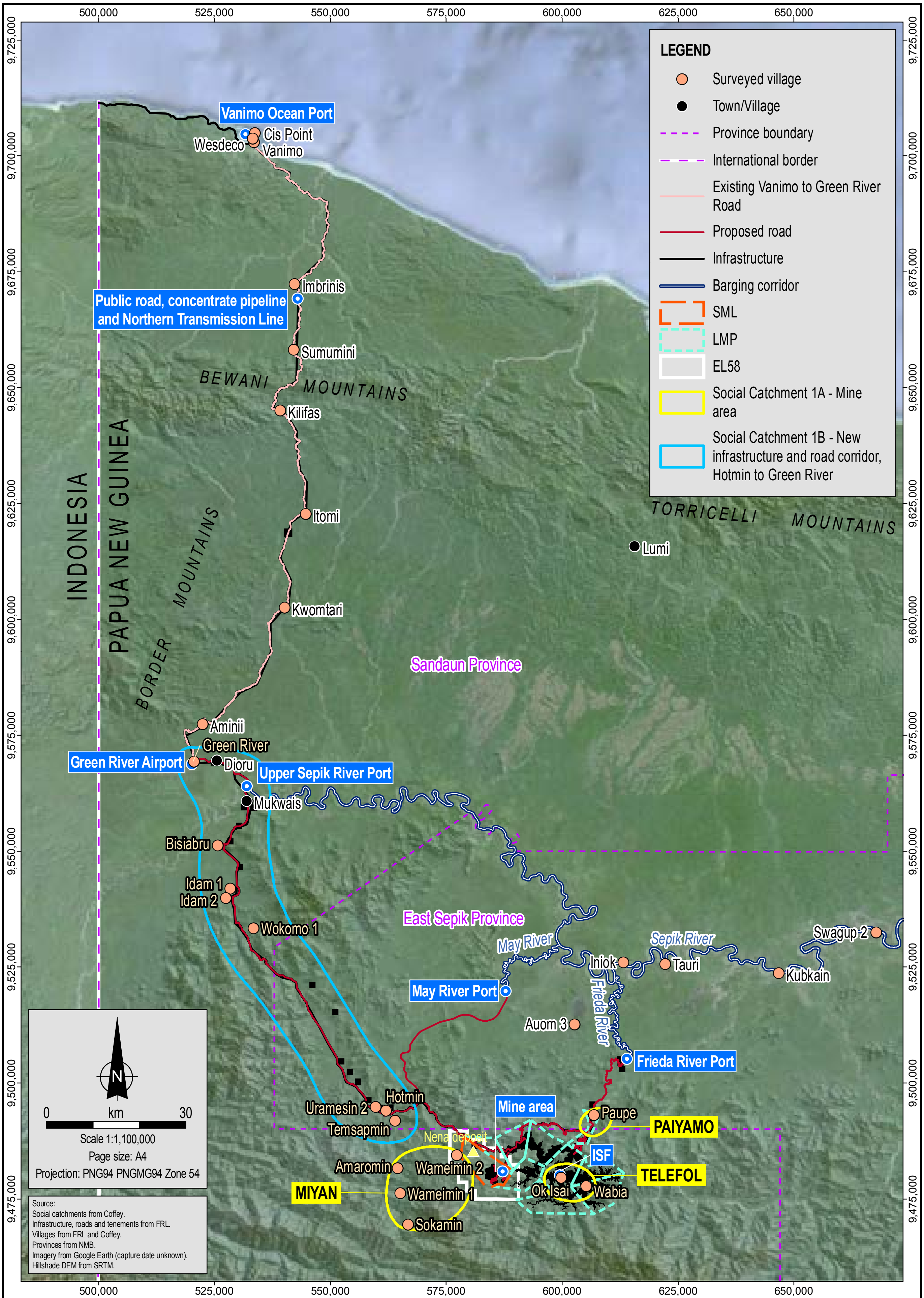
For the purposes of the HIA, representative Project villages in the social catchments were divided into three geographic regions:

- Mine area (Social Catchment 1A).
- Infrastructure corridor (Social Catchment 1B and Catchment 1C).
- Sepik River corridor (Social Catchment 2).

Social Catchment 1D has not been included as there are no expected impacts from mine-derived chemical contaminants. Social Catchment 3 is a generic overview of the whole of Sandaun and East Sepik provinces including the potentially impacted Social Catchments described above.

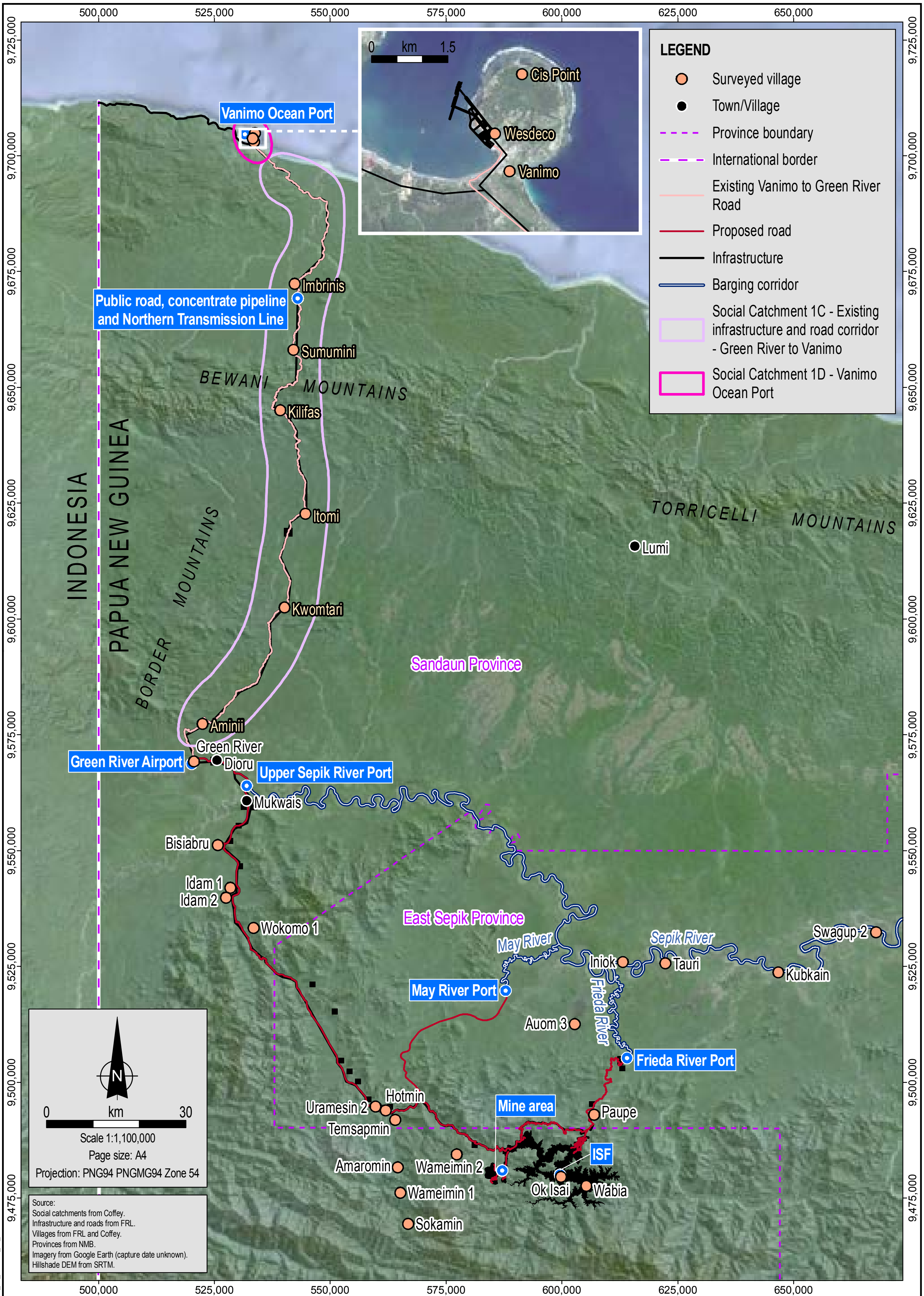
It is noted that some villages in the mine area (Ok Isai, Wabia, Paupe and Wameimin 2) will be relocated to other areas as they are within, or close to, the Project disturbance area, nonetheless they have been included in the HIA.

This report details a screening level health impact assessment examining the exposure of Project community villages to the essential micronutrient metals copper, selenium and zinc, and the contaminant elements arsenic, cadmium, mercury and lead associated with the development of the Project. Exposure pathways modelled included drinking water, food, village soils and sediments and surface/recreational water through the ingestion and dermal absorption routes.

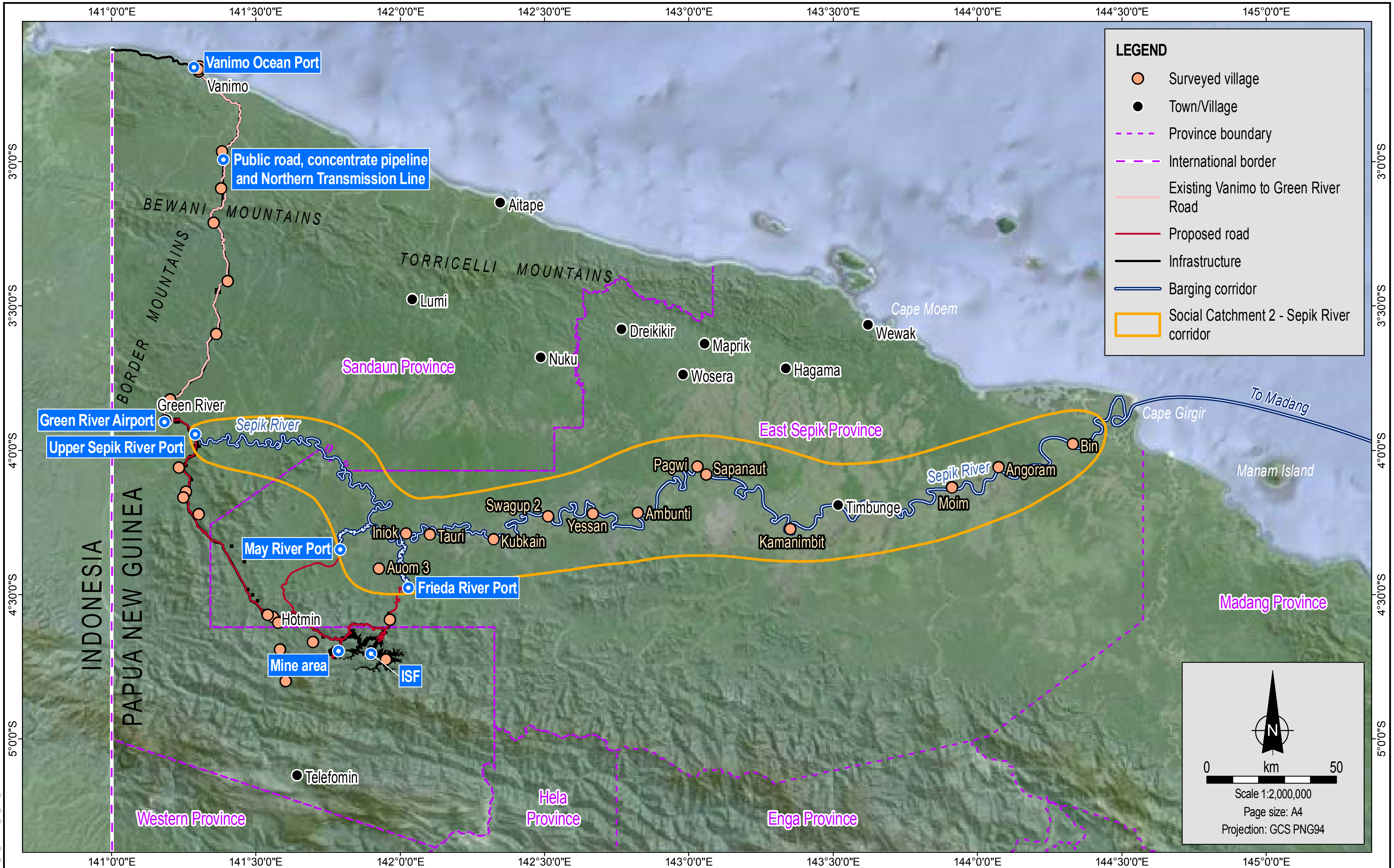


MXD Reference: 11575B_15_GIS004_v0_4

coffey A TETRA TECH COMPANY	Date: 07.09.2018 Project: 754-ENAUABTF11575B File Name: 11575_15_HIA_F001_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Social Impact Assessment catchments 1A and 1B	Figure No: 1



coffey A TETRA TECH COMPANY	Date: 04.10.2018 Project: 754-ENAUABTF11575B File Name: 11575_15_HIA_F002_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Social Impact Assessment catchments 1C and 1D	Figure No: 2



MXD Reference: 11575B_15_GIS006_v0_HIA_5

Source:
Social catchments from Coffey.
Infrastructure and roads from FRL. Villages from FRL and Coffey.
Provinces from NMB.
Imagery from Google Earth (capture date unknown).
Hillshade DEM from SRTM.

coffey
A TETRA TECH COMPANY

Date: 31.10.2018
Project: 754-ENAUABTF11575B
File Name: 11575_15_HIA_F003_GIS

Frieda River Limited
Sepik Development Project

FRIEDA RIVER

Social Impact Assessment catchments 2 and 3

Figure No: 3

These elements were chosen for analysis as they are common mine-derived contaminants of health significance. Aluminium was not included as no data was available for the food pathway, the major route for contaminant intake. Additionally, aluminium has relatively low toxicity compared to the other contaminant elements considered in this report and is unlikely to pose a health concern.

The air exposure pathway was not modelled as this pathway has been demonstrated in previous studies in PNG to represent an insignificant percentage of the total aggregated exposures (Bentley, 2004a). The SLR (2018) report confirms that air quality is likely to be a negligible contributor to contaminant metal intakes by the Project communities; however, the modelling results do indicate that during construction fugitive dust management measures may need to be implemented when works are being performed within 800 m of populated areas.

The HIA methodology used was that of a standard deterministic health risk assessment with modelled exposure being compared with international standards and guidelines. Much of the data used in the assessment were derived from previous studies of Western Province communities. These communities which are considered as surrogates for the Project communities are from the Highland areas around Tabubil and along the Ok Tedi and Fly rivers corridor above the Fly estuary region, hereafter described as the Ok Tedi/Fly Community Health Survey (OKTFLY CHS) which was a comprehensive health risk assessment (HRA). The surrogate villages are not subject to impacts from the Ok Tedi mine. Limited data other than the social profiles were available for the Project community villages but it is expected that further work may be undertaken to validate the results.

The use of surrogate data is justified by the overall similarity in the environmental health circumstances of the Project community villages and the chosen surrogate communities. The surrogate data has been utilised in a conservative manner by restricting the analysis to use of the means of all the data for each exposure pathway and modelling exposure to adults only because this is the largest and most robust database. The modelling of age-group-specific exposures (e.g. infants, children, adolescents) cannot be supported by the available datasets.

Additionally the Project communities have been divided into regions that match as closely as possible to the geographical circumstances of the regions described for the surrogate communities. Additional drinking water, food and soil and sediment sampling and analysis from the mine area and Frieda and Sepik rivers will be required to confirm the background exposure of communities within these areas to contaminant metals.

Conclusions of this risk analysis are constrained by some caveats, in particular the fact that surrogate data was used for nearly all of the exposure pathways (see Section 1.3). Nonetheless the conclusions are robust because the surrogate and Project communities show close similarities as follows:

- The OKTFLY CHS included a detailed social and anthropometric study of the relevant communities. Considering only the control villages in the surrogate communities, they are demonstrably similar to the matched Project communities for the physical/geographic and social circumstances, environmental health factors, diet, and physique.

- Data from a Market Basket Survey in the Porgera Valley gave similar findings in terms of dietary patterns and metal contaminant levels in foods.
- Empirical data available for Project communities (food, sediment and water samples) was consistent with those parameters measured in the surrogate communities.

Present Project community circumstances

The outcomes of the analysis are clear: the current average levels of intake of essential micronutrient metals, arsenic and the contaminant metals from all exposure media are well below international guideline values and do not pose a health risk to the Project communities. The results do not mean that some individuals or even specific age groups are not at higher risk than the average community member. Activities such as artisanal gold mining by some individuals can increase their exposure and hence intake of all contaminant metals. The potentially greater exposure cannot be estimated without a time-activity study.

Future Project community circumstances

As the Project is developed there is the possibility that Project communities will become exposed to increased mine-related above current background contaminant metal levels. However, a screening risk assessment (modelling) of water quality in the open-pit, the integrated storage facility (ISF), the Frieda River and the Sepik River during mine life and closure predicts that sub-aqueous waste rock and tailings deposition and pH control of water from the open-pit through lime addition will maintain contaminant metal values below Australian health-based water quality guidelines. A worst case scenario in which communities access drinking water from waterways impacted by predicted maximum total metal concentrations predicts no adverse impacts from this activity. This includes consumption of fish and wildlife from the potentially impacted areas.

Risks to the communities remain through unpredictable events such as accidents e.g. spillage of concentrate due to a pipeline rupture, and major disturbances such as earthquakes or mega-floods. As the food and drinking water pathways are the major sources of contaminant intake these potential exposure pathways should be prioritised in planning and responses to incidents.

1 Introduction

1.1 Background

The Sepik Development Project (the Project) is held by the Frieda River Joint Venture, an unincorporated joint venture between Frieda River Limited, a wholly owned subsidiary of PanAust Limited, and Highlands Frieda Limited, a wholly-owned subsidiary of Highlands Pacific Limited. Frieda River Limited manages the Project and holds an 80% interest; Highlands holds the remaining 20% interest. The Independent State of Papua New Guinea (PNG) has a right, prior to the grant of a Special Mining Lease (SML) or Mining Lease (ML), to purchase up to 30% equity in the Project.

The Project is located in the northern foothills of the New Guinea Highlands (Central Range) in Sandaun Province, with key infrastructure and transport corridors located in the East Sepik Province. It lies in a remote area approximately 200 kilometres (km) from the northern coast and 35 km from the Sepik River.

Coffey Services Australia Pty Ltd (Coffey) was engaged by PanAust to prepare the Environmental Impact Statement (EIS) for the Project. The PNG Conservation and Environment Protection Authority (CEPA) has assessed the Project's Environmental Inception Report and stressed the importance of conducting a Health Impact Assessment (HIA) for the Project, including a community health baseline survey to record the pre-mining health status of potentially impacted and non- impacted communities against which the health status of the potentially impacted communities can be tracked over time.

The objectives of this assessment were to use existing information and surrogate studies from PNG non-mine-impacted communities in other mining areas to describe and assess the potential exposure pathways and uptake of contaminant metals in villages within the mine area, along the Frieda and Sepik rivers and along the infrastructure corridor. This health risk analysis will provide a baseline and a predicted HIA for communities potentially impacted by the Project during its development, operation and after closure.

1.2 Legislative context

The environmental and socio-economic aspects of the Project are regulated primarily by the *Mining Act 1992* and the *Environment Act 2000*. The Project is a Level 3 activity under the *Environment Act 2000* (Sub-category 17), for which an EIS and HIA is required.

1.3 Existing information

Existing information relevant to the HIA includes:

- Social baseline surveys and Social Impact Assessment conducted by Coffey from 2009 to 2018
- Draft Baseline Health, Diet and Nutrition Survey prepared by the Centre for Environmental Health Pty Ltd (Bentley and Bentley 2016).
- Aquatic Biology and Surface Water Quality Study prepared by Hydrobiology (Hydrobiology 2011).
- BMT WBM 2018 Sepik Development Project EIS-Water Quality, Sediment Quality and Aquatic Ecology Baseline Ref: R.B22024.001.11Revised Baseline.docx
- SRK water quality modelling Doc. No 20180711 for 13 Assessment Points around the mine site and along the Frieda and Sepik rivers.

- Assessments for water quality and sediment transport which provide information on potential changes in concentrations of metals in surface water and potential exceedances of recreational water quality guidelines. These include:
  - A sediment transport assessment (Golders, 2018).
  - A Frieda River Project water and load balance study (SRK Consulting, 2018) which models site-wide water and load balance throughout the Project period and after closure.
- Results from a comprehensive health risk assessment (HRA) conducted in five distinct highland and lowland regions in Western Province, PNG. The regions encompass the villages around the Ok Tedi mine and the communities of the Ok Tedi-Fly River corridor from the Ok Tedi River headwaters to the Fly estuary and from the Porgera valley. The data available are from the extensive and comprehensive work by Bentley (2003, 2004, 2004a, 2004b, 2005, 2007a, 2007b, CEH 2004, CEH 2006), Bentley & Bentley 2016. These studies provide contaminant metal concentrations in all environmental exposure media including food via a Total Diet Study for the selected Ok Tedi and Fly River control communities. In the present report, these studies are referred to as the OKTFLY CHS.

2 Project description, physical, demographic and socio-economic characteristics

2.1 Project description

The Sepik Development Project consists of four interdependent projects:

- Frieda River Copper-Gold Project (FRCGP). Includes the FRCGP open-pit, process plant, site accommodation camp and mine access roads.
- Frieda River Hydroelectric Project (FRHEP). Including a 600 MW hydroelectric power facility.
- Sepik Infrastructure Project (SIP). Including the Vanimo Ocean Port (an upgrade to the existing Port of Vanimo), Green River Airport and a public road from Vanimo to Hotmin. Sepik Power Grid Project (SPGP). Including a 370 km 275 kV Northern Transmission Line from the FRHEP to the Indonesian border, via Vanimo.

FRL will own and operate the FRCGP, while it is anticipated that third-party entities will own and operate the remaining independent projects.

The Project is primarily located within the Sepik River catchment and comprises development of a copper-gold deposit in Sandaun Province and supporting infrastructure and facilities in the Sandaun and East Sepik Provinces (Figure 1).

2.2 Frieda River Copper-Gold Project

The greenfield FRCGP is based on the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) porphyry copper-gold deposits which contain an estimated total combined Measured, Indicated and Inferred Mineral Resource (JORC classifications) of approximately 2.7 billion tonnes at an average grade of 0.44% copper and 0.23 grams per tonne gold. Copper mineralisation was first identified at Frieda River in 1966/67 and the long history of exploration and study activities undertaken by several companies has generated a considerable body of information.

Figure 2 shows the general FRCGP layout around the open-pit including the HITEK deposits and supporting infrastructure. Mined ore will be processed at a process plant located approximately 8 km northeast of the large-scale conventional open-pit mine operation feeding ore to a comminution and flotation process plant producing a copper-gold concentrate for export to custom smelters.

Mining inventory comprises approximately 1,500 Mt of mill feed. The average annual copper-gold concentrate production will be 735,000 wet metric tonnes and the average annual metal in concentrate production will be 175,000 tonnes (t) copper and 230,000 ounces (oz) gold. The FRCGP will have mine life of approximately 33 years preceded by a seven-year implementation period.

A concentrate pipeline that follows the road corridor will transport the copper-gold concentrate produced at the process plant to a concentrate dewatering, storage and export facility located at the Vanimo Ocean Port.

The FRCGP's power demand will be approximately 180 MW increasing up to 280 MW by Year 8. Offsite power demands for the Vanimo facilities and two concentrate booster stations will require approximately 4 MW and 7 MW respectively.

2.3 Frieda River Hydroelectric Project

The FRHEP reservoir will be located within the Frieda, Nena and Niar river valleys downstream of the mine site. A 600 MW hydroelectric facility will use water from the FRHEP reservoir to generate low-cost power to the FRCGP and supply excess power to other consumers via the SPGP's Northern Transmission Line. The hydroelectric power generation facility will have an annual maximum energy generation of 2,800 gigawatt hours per year (up to 490 MW).

The FRHEP final embankment will be approximately 187 m (238 m RL) in height, utilising 26 million cubic metres (Mm^3) of fill material and creating a total storage capacity of 9.6 billion cubic metres (Bm^3). The operating water level will be approximately 226 m RL.

The FRHEP will provide an integrated storage facility (ISF) for the subaqueous storage for both process tailings and mine waste rock. This best practice waste management strategy will limit downstream sedimentation and the potential for the deposited, submerged material to generate acid and metalliferous drainage.

2.4 Sepik Infrastructure Project

The mine and FRHEP will be accessed by the 325 km-long infrastructure corridor, which consists of an existing road from Vanimo to Green River and a new road through to Hotmin and to the mine site. The road will be a public road from Vanimo to Hotmin and a private mine road from Hotmin to the site. The existing airstrip at Green River is located 150 km from the mine site. It will be upgraded to cater for larger aircraft.

Diesel trucks will transport fuel to the mine using the road corridor. The existing Port of Vanimo will be upgraded (and termed the Vanimo Ocean Port) to include two new berths to support the FRCGP and other port users.

2.5 The Sepik Power Grid Project

The SPGP consists of a new 370 km 275 kV Northern Transmission Line from the FRHEP to the Indonesian border via Vanimo, which will provide power for the offsite FRCGP facilities. The Northern Transmission Line will be located within the infrastructure corridor.

The excess power from the FRHEP also provides an opportunity to supply power to communities along the infrastructure corridor and to industries such as agriculture, fisheries, food and timber processing, mining and manufacturing.

2.6 Social baseline surveys

The social baseline surveys completed by Coffey (2018) characterise the social, economic and cultural context of potentially affected communities within and surrounding the Project footprint. A Social Impact Assessment (SIA) has been prepared and presents the projected impacts of the Project for each of six social catchments as below:

- Social Catchment 1A: Mine area (Figure 1).
- Social Catchment 1B: New infrastructure and road corridor, Hotmin to Green River (Figure 1).
- Social Catchment 1C: Existing infrastructure and road corridor, Green River to Vanimo (Figure 2).
- Social Catchment 1D: Vanimo Ocean Port (Figure 2).
- Social Catchment 2: Sepik River corridor (Figure 3).
- Social Catchment 3: Sandaun and East Sepik Provinces (Figure 3).

For the purposes of the HIA, representative Project villages in the social catchments were divided into three geographic regions:

- Mine area (Social Catchment 1A)
- Infrastructure corridor (Social Catchment 1B and Social Catchment 1C).
- Sepik river corridor (Social Catchment 2).

Social Catchment 1D has not been included as there are no expected impacts from mine-derived chemical contaminants. Social Catchment 3 is a generic overview of the whole of Sandaun and East Sepik provinces including the potentially impacted Social Catchments described above.

It is noted that some villages in the mine area (Ok Isai, Wabia, Paupe and Wameimin 2) will be resettled to other areas as they are within, or close to, the Project disturbance area. The resettlement locations are yet to be determined; a resettlement consultation process is underway and it is anticipated that the villages will be resettled within the same region and therefore these villages have been considered in the HIA.

The 2009 - 2011 Frieda River Baseline Health Surveys by the Centre for Environmental Health (CEH) reported community health and nutrition information at 20 villages potentially impacted by the then proposed Project plan (CEH 2016). The surveyed villages are shown in Table 1.

Table 1: Villages surveyed in baseline environmental health, diet and nutrition studies 2009 – 2011 (CEH, 2016)

Community	District	Province	Project location[1]
Mine area			
Amaromin	Telefomin	Sandaun	Mine area
Wameimin 1	Telefomin	Sandaun	Mine area
Wameimin 2	Telefomin	Sandaun	Mine area
Hotmin	Ambunti-Drekikier	East Sepik	Mine area
Ok Isai	Telefomin	Sandaun	Mine area
Wabia	Telefomin	Sandaun	Mine area
Paupe	Ambunti-Drekikier	East Sepik	Mine area
Samou	Ambunti-Drekikier	East Sepik	Mine area
Road/pipeline and Frieda River corridor			
Iniok	Ambunti-Drekikier	East Sepik	Road/pipeline and Frieda River corridor

Community	District	Province	Project location[1]
Auom 3	Ambunti-Drekikier	East Sepik	Road/pipeline and Frieda River corridor
Nekiei	Ambunti-Drekikier	East Sepik	Road/pipeline and Frieda River corridor
Sowano	Ambunti-Drekikier	East Sepik	Road/pipeline and Frieda River corridor
Yabatauwe	Ambunti-Drekikier	East Sepik	Road/pipeline and Frieda River corridor
Sepik River corridor			
Angoram	Angoram	East Sepik	Sepik River corridor – Urban township
Kubkain	Ambunti-Drekikier	East Sepik	Sepik River corridor – Rural
Ambunti	Ambunti-Drekikier	East Sepik	Sepik River corridor – Urban township
Bin	Angoram	East Sepik	Sepik River corridor - Rural
Sapanaut	Wosera-Gawi	East Sepik	Sepik River corridor - Rural
Swagup	Ambunti-Drekikir	East Sepik	Sepik River corridor - Rural
Yessan	Ambunti-Drekikir	East Sepik	Sepik River corridor - Rural

1. Designations based on previous Project description

As part of the Sepik Development Project, the list of communities described in the Coffey (2018) SIA included most of the communities surveyed in the CEH (2016) survey. However the SIA included additional villages along the proposed infrastructure corridor from the mine to Green River and from Green River to Vanimo. Table 2 below lists these villages with their SIA Catchment designation and an indication of whether they were included in the CEH (2016) surveys.

Table 2: Villages surveyed in 2018 SIA (Coffey, 2018)

Community	Project location	SIA catchment (Coffey, 2018)	Villages surveyed in CEH (2016)
Sokamin	Mine area	1A	
Wameimin 1	Mine area	1A	yes
Wameimin 2	Mine area	1A	yes
Amaromin	Mine area	1A	yes
Ok Isai	Mine area	1A	yes
Wabia	Mine area	1A	yes
Paupe	Mine area	1A	yes
Samou	Mine area	1A	yes
Uramesin 2	Infrastructure corridor (new road)	1B	
Temsapin	Infrastructure corridor (new road)	1B	
Hotmin	Infrastructure corridor (new road)	1B	yes
Idam 1	Infrastructure corridor (new road)	1B	
Idam 2	Infrastructure corridor (new road)	1B	
Wokomo 1	Infrastructure corridor (new road)	1B	
Bisiabru	Infrastructure corridor (new road)	1B	
Aminii	Infrastructure corridor (existing road)	1C	

Community	Project location	SIA catchment (Coffey, 2018)	Villages surveyed in CEH (2016)
Kwomtari	Infrastructure corridor (existing road)	1C	
Itomi	Infrastructure corridor (existing road)	1C	
Kilifas	Infrastructure corridor (existing road)	1C	
Sumumini	Infrastructure corridor (existing road)	1C	
Imbrinis	Infrastructure corridor (existing road)	1C	
Auom 3	Frieda River corridor	2	yes
Iniok	Sepik River corridor	2	yes
Kubkain	Sepik River corridor – rural	2	yes
Tauri	Sepik River corridor - rural	2	
Swagup	Sepik River corridor - rural	2	yes
Yessan	Sepik River corridor - rural	2	yes
Ambunti	Sepik River corridor – township	2	yes
Pagwi	Sepik River corridor - rural	2	
Sapanaut	Sepik River corridor - rural	2	yes
Moim	Sepik River corridor - rural	2	
Kanamimbit	Sepik River corridor - rural	2	
Angoram	Sepik River corridor – township	2	
Bin	Sepik River corridor - rural	2	yes

The communities of Wesdeco and CIS point at Vanimo are not considered further in this assessment as they are coastal urban communities with no close match in the surrogate communities of the OKTFLY CHS and no data on dietary patterns, food frequency or unit food consumption is available.

The communities of Nekei, Sowano and Yabatauwe were surveyed in the CEH (2016) report but are not considered further in the present assessment. They are considered to be distant from the mine-site and any of the direct impacts from the Sepik Development Project.

The baseline environmental health, diet and nutrition study field work was undertaken by CEH (2016) over three separate field campaigns, and the scope of each of the three studies included:

- Household demographic, health indicators, nutritional status (as determined by anthropometric measurements and food consumption frequency surveys), environmental health conditions of the study communities and specific mother and child health circumstances.
- Non-invasive physical examinations, supported by the sourcing, as practicable, of local health centre data.

A conceptual model for contaminant metal intake by villagers requires an understanding of the possible exposure routes and the contaminant intake from each of these routes. The routes of exposure include drinking water, food, recreational water, soils and sediments and air. For each of the three regions (previously defined as the mine area, road/pipeline corridor and Sepik River corridor), the CEH (2016) summary report provides a basic understanding of the environmental health of the representative villagers in each region, as summarised below. The drinking water and food exposure pathways are critically important in estimating contaminant intake levels as they typically account for up to 85% of those levels (Bentley, 2016).

2.6.1 Environmental health circumstances of the Project communities

Social Catchment 1A: Mine area

The mine area encompasses the area around and within the land over which the Project will hold leases for the establishment of project infrastructure, and/or conduct its mining and concentrate processing activities. It includes the villages of Sokamin, Wameimin 1, Wameimin 2, Amaromin, Ok Isai, Wabia, Paupe and Samou.

Coffey (2018) identifies three social sub-catchments (language groups) of villages either within or in proximity (15 to 20 km) to the proposed FRCGP footprint, or immediately downstream of the FRHEP. Physically the area is comprised of a series of distinct topographical types: mountains, foot hills, inter-fluvial plains and swampy alluvial flats, each supporting distinctive patterns of subsistence use. It is noted that the communities of Ok Isai, Wabia, Wameimin 2 and Paupe are located within river catchment areas that have the potential to be impacted by FRCGP and FRHEP construction and operations and these communities will likely be resettled.

All these mine area communities are characterised by relative remoteness, being located a considerable distance from any township and not able to be accessed by road. In addition, there is substantial geographic separation between villages and the proposed Project footprint, in particular Amaromin, Sokamin and Wameimin 1. Wameimin 2 is located just outside the proposed Special Mining Lease (SML) boundary in close proximity to the Nena deposit and is therefore also proposed for resettlement.

For the mine area, the baseline environmental health, diet and nutrition study was undertaken at eight villages (Table 2 above). The overall environmental health results, while differing markedly between the isolated hilltop and riverine villages, are reasonably typical for remote highland-fringe/low-altitude rural and remote communities in PNG. Drinking water supplies are mainly from unprotected creek and river sources. The nutritional surveys identified significant differences in the range of food consumed and consumption frequencies between the more isolated inland villages and those along the Frieda and Sepik rivers. The degree of isolation, local environmental conditions and household access to a cash income stream are the main determinants for food diversity and food consumption frequency.

The ethnically diverse mine area villages are in an area of very low population density. The villages to the west of the Project footprint (Amaromin, Wameimin 1 and Wameimin 2) continue to practice subsistence agriculture. Cash income sources for all villages included working for FRL. Some households in these communities derive a supplementary income from panning/dredging for gold. For the villages located to the east of the proposed Project footprint (including Ok Isai and Wabia in the Niar River valley, and to some degree Paupe), subsistence agriculture is less dominant with many village households able to supplement their diets with purchased goods derived through income from alluvial gold mining.

Coffey (2018) identifies some minor changes in dietary consumption in these mine communities in Table 3 below. There has been no significant change in the types of food grown and consumed, however there are indications that the diversity of foods consumed has increased, possibly indicating greater availability of cash facilitating travel to neighbouring communities and the consumption of store bought foods.

Table 3: Food consumption patterns in Social Catchment 1A

Community	Foods consumed by a higher percentage of surveyed households in 2015 compared to 2010	Water
Sokamin	Not surveyed	Creek, tank
Wameimin 1	Sweet potato, cooking banana, sago, fresh fish, yellow vegetables, tin meat, vegetable oil	River, reticulated water from mountain spring (in 2015 often unserviceable after heavy rain), tank
Wameimin 2	Cassava, cooking banana, fresh fish, pork, other meat, vegetable oil	River, tank, spring
Amaromin	Sago, rice, fresh fish, green vegetables, tin fish, tin meat, vegetable oil	River, reticulated water from mountain spring (in a state of disrepair in 2017)
Ok Isai	Sweet potato, taro, cooking banana, sago, fresh fish, tin meat	River, spring, tanks
Wabia	Cassava, taro, cooking banana, sago, rice, fresh fish, yellow vegetables, fresh fruit, tin fish, tin meat, milk, sugar, bread, vegetable oil	River, spring, reticulation from tanks
Paupe	Not surveyed	River, tanks, springs

Social Catchment 1B: New infrastructure and road corridor, Hotmin to Green River

The villages grouped as Social Catchment 1B include: Hotmin, Idam 1, Idam 2 and Wokomo 1, Uramesin 2, Temsapin and Bisiabru. With the exception of Hotmin, these villages were not among those surveyed by CEH (2016). The discussion below is adapted from Coffey (2018).

The villages are remote with limited access to cash or markets. There appears little involvement with alluvial gold as a cash income and the cash economy is skewed, with Hotmin experiencing the greatest level of participation due to access to markets along with Temsapin and Uramesin 2.

Villages within the catchment live primarily subsistence-based lives by developing mixed staple gardens including crops of banana, sweet potato and taro. Sago is the most important food in the catchment, some of which is managed in naturally occurring stands, with other staples being banana, Chinese taro, coconut and taro. Hunting and fishing are also important activities for protein food sources. Household diets generally consist of a variety of plant-based products, such as taro, sago and banana, aibika, kumu and other vegetables. Protein food sources predominantly included fish and to a lesser extent bush meat and chicken.

The main sources of carbohydrate in Hotmin are taro, sago and banana, with at least two thirds of households surveyed consuming these products within the last 24 hours (Coffey, 2018). A comparison between the survey data of household food consumption in Hotmin in 2011 and 2017 indicates that there is an increasing importance of cassava, banana, sago and rice but a decreased consumption of fresh fish, taro and sweet potato. Apart from rice consumption in Hotmin, the penetration and consumption of store bought food appears minimal within the catchment. The most commonly consumed carbohydrate rich foods in Idam 1 were sago and banana with at least 70% of households surveyed consuming them in the past 24 hours. Coconut was also widely consumed. Vegetables including aibika and kumu were regularly consumed within the village. Fresh fish was the main source of protein, however the frequency of consumption varied, with six households consuming fish weekly while at least four households only ate it occasionally (Coffey, 2018).

All of the villages surveyed within the catchment (Hotmin, Idam 1, Idam 2 and Wokomo 1, Uramesin 2, Temsapin and Bisiabru) obtain their drinking water from natural untreated sources either from a river or natural spring. None of the villages have water tanks so water supply is totally reliant on these natural sources year round. Water quality and reliability is generally considered satisfactory or better, except within Bisiabru, where quality and reliability is considered poor, and within Idam 1 where reliability is deemed poor (Coffey, 2018).

Social Catchment 1C: Existing infrastructure and road corridor, Green River to Vanimo

These villages were not among those surveyed by CEH (2016). The discussion below is adapted from Coffey (2018).

The existing infrastructure and road corridor social catchment consists of villages located in proximity to the existing public road between Vanimo and Green River. The six villages surveyed within the Social Catchment 1C, Aminii, Kwomtari, Itomi, Kilifas, Sumumini and Imbrinis, were selected as they are considered to be representative of villages within the catchment in terms of size and location.

Heading north from Green River, Catchment 1C encompasses the existing road corridor of the Vanimo to Green River Road on the edge of western hills to Kwomtari, from where it crosses alluvial plains and back swamps to Kilifas. From here the corridor crosses the Bewani Range to Sumimini, and then proceeds across alluvial plains and hilly terrain to Imbrinis and on to the Nemayer River from where it tracks northwest to Vanimo. Villages in the south of Social Catchment 1C are largely isolated with few settlements spread out along the existing road corridor. Moving further north in the catchment, commercial operations including logging and palm oil plantations increasingly dominate the landscape.

The primary food source in the catchment is sago, complemented by important crops of banana and taro. Game and fish are important sources of protein within the catchment. Fishing is mainly carried out for subsistence purposes within the Vanimo/Green River District, including the Sepik River and the coast in the north of the district. Villages within the catchment rely primarily on rivers, springs and bore water for their domestic water.

Villages within the catchment source water from a variety of sources including rivers, springs, bores and tanks. Half of the villages surveyed in 2017 described the condition of their water as poor, while the other half described it as satisfactory to good (Coffey, 2018).

Depending on the location along the corridor, villages can derive cash income from the forestry operations near Vanimo and Aitape which provide employment opportunities and royalties. Villages in the northern section of the catchment such as Imbrinis have access to roadside markets, and food/trade stores and fuel stations in Vanimo.

Social Catchment 2: Sepik River corridor

Social catchment 2 includes Auom 3 (Frieda River) and twelve representative communities along the Sepik from Iniok to the Sepik River mouth (Iniok, Kubkain, Tauri, Swagup, Yessan, Ambunti, Pagwi, Sapanaut, Moim, Kanamimbit, Angoram, Bin). The Sepik River basin is home to significant populations of people who rely heavily on the river for their health and wellbeing.

The Sepik River is referred to in three sections – Upper, Middle and Lower. The Upper Sepik is located primarily in the Ambunti-Dreikikir district of East Sepik Province, the Middle Sepik commences in Ambunti-Dreikikir (above Ambunti) and continues through Wosera-Gawi District into Angoram District and the Lower Sepik continues its journey through Angoram District to the coast. The Sepik River includes an extensive flood plain, with numerous off-river water bodies. The middle and lower reaches are relatively densely populated, with most communities dependent on the river for all of their needs. In particular, the largely subsistence communities have a traditional diet, largely based on the extensive sago palm areas and fish. Their diet is supplemented by bananas and coconut and in the dry season tubers, green vegetables and some soft fruits from the village gardens.

Villagers of Auom 3 are also highly dependent on fishing for household consumption and for their livelihood (Coffey, 2018); all households surveyed reported the consumption of fish on the previous day of the survey. Approximately 44% of households consumed green leafy vegetables on the previous day of the survey. Sago is the principal source of carbohydrate, however significant proportions of households also consumed rice (25%) and banana (38%) on the day prior to the survey (Coffey, 2018).

For the Sepik River corridor, the baseline environmental health, diet and nutrition study (CEH, 2016) was undertaken at eight villages (Auom 3, Iniok, Kubkain, Swagup, Yessan, Ambunti, Sapanaut, Angoram, Bin). The overall environmental health results were reasonably typical for low altitude riverine communities in PNG. In the remote rural villages, drinking water supplies were mainly from unprotected Sepik River sources. The nutritional surveys identified that, with the exception of Angoram where some store foods were included into the diet, the principal diet consisted of sago and fish, supplemented by banana, green vegetables and coconut. Village gardens, inundated at the time of the survey at four of the six villages, were productive only in the relatively short dry season (June to September).

While the formal labour market in the Sepik River corridor is limited, there is large informal sector of labour activity engaged in harvesting and selling aquatic and terrestrial resources and producing craft for the tourism market. In addition, the Sepik has traditionally been a significant source of labour for work on smallholder settlements and plantations in other areas of PNG.

2.7 Overview of surrogate communities from the Ok Tedi/Fly river studies

The extensive and comprehensive work by Bentley (2003, 2004, 2004a, 2004b, 2005, 2007a, 2007b, CEH 2004, CEH 2006) over many years has included the collection and analysis of data on food consumption patterns and individual age-related food consumption quantities of mine-impacted and non-impacted control communities from five distinct highland and lowland regions in Western Province, PNG (Bentley 2007a, 2007b). The regions encompass the villages around the Ok Tedi mine and the communities of the Ok Tedi-Fly River corridor from the Ok Tedi headwaters to the Fly estuary.

Data utilised in the present study were from populations from non-impacted (control) villages only.

The food consumption data was collected primarily to identify the core foods for a region-specific Market Basket Survey (total diet study) of the concentrations of contaminant and essential metals in specific foods and food groups. From this, the total dietary intakes of the metals of interest have been derived. The study has also undertaken an extensive anthropometric measurement survey (4000+ participants) to examine the nutritional status of the Ok Tedi/Fly River communities. For the present study the data from the ‘control’ communities surveyed provides robust surrogate data for the Project communities.

As noted above, the OKTFLY CHS (Bentley (2007a, 2007b) studies divided the Ok Tedi/Fly River communities into 5 geographic regions (Regions 1-5), briefly described below (Figure 4). The control populations surveyed were households and individuals from control populations located outside the footprint of the mine impact. The diverse circumstances of the populations also required taking into account the types and quantities of consumption of village food crops, bush-sourced food, and where relevant, store-purchased food.

OTML Mine area communities - Region 1
The highland region communities (situated between 580 and 840 metres above sea level (ASL)) include the OTML mine-area villages of Bultem and Finalbin, together with control villages located at Ok Ma and Derengo. The control villages are unavoidably located in an area somewhat more isolated from the range of urban services and social, educational and health infrastructure at the regional centre of Tabubil. While Ok Ma has road access and transportation to Tabubil, Derengo has no ready access.

These control communities are considered a surrogate for the Coffey (2018) Social Catchment 1A.

Ok Tedi communities - Region 2
The impact lowland villages (situated at 50 – 80 metres ASL, with the village of Kwiloknae situated on a ridge at 280 ASL) are located between Ningerum-Tamaro and the Ok Tedi-Fly River junction (D’Albertis Junction). Thus these villages are located some 80 – 170 river

kilometres below Tabubil. These villages were selected to represent communities living both proximal to the Ok Tedi and those located along the Tabubil-Kiunga Highway. The Region 2 control villages of Songty Valley and Walawam are located near the Ok Ma and an unnamed spring respectively. Both are distant from any possible mine tailing impacts. The Region 2 villagers have variable access to health and social services support, which is largely dependent on their ease of access to Tabubil and the township of Kiunga.

These control communities are considered a surrogate for the Coffey (2018) Social Catchments 1B and 1C.

Middle Fly Communities – Region 3
The Region 3 impact villages are situated in the Middle Fly River region between D'Albertis Junction and the Fly River-Strickland River junction (Everill Junction). The Region 3 control villages are located either away from the Fly River or within the north western reaches of Lake Murray. The Region 3 villagers are characterised as having only very limited access to social, education and health facilities.

These control communities are unsuitable for inclusion in the present HIA due to the elevated mercury levels observed in some bioaccumulating food sources (fish, pork liver, crocodile) in this region which are not relevant to the Project area communities.

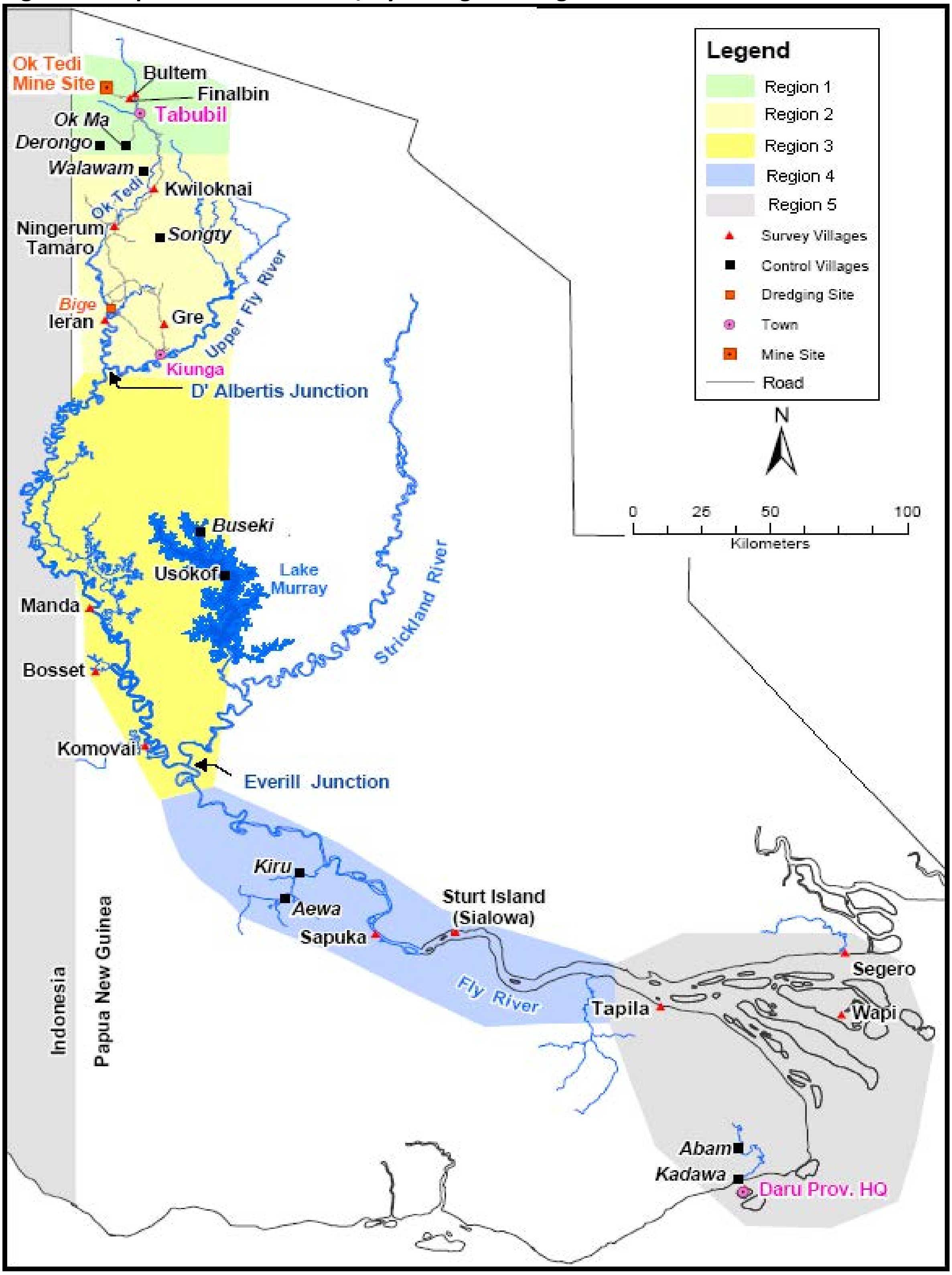
Suki Fly Gogo communities – Region 4
The Region 4 impact villages of Sapuka and Sialowa are located on the Lower Fly River. The control villages of Kiru and Aewe are located near to Lake Suki/Suki Creek some considerable distance away from the Fly River channel. Similar to the corresponding Region 3 communities, the Region 4 villagers have only a minimum level of access to modern infrastructure.

These control communities are considered a surrogate for the Coffey (2018) Social Catchment 2.

South Fly communities – Region 5
The Region 5 impact villages are located either on the banks of the Fly estuary (Tapila and Sagero-Koavisi) or on an island in the estuary (Wapi). The control communities for Region 5 are located either adjacent to the Oriomo River (Abam) or on the coast (Kadawa) further west from the Fly River mouth. The communities have variable access to facilities, ranging from very limited (Tapila) to fairly good (Kadawa), with ready access to the provincial capital of Daru.

These control communities are not utilised as surrogates in the present work.

Figure 4: Map location of Ok Tedi/Fly surrogate villages[1]



Food consumption is a major exposure pathway to contaminant metals. In the absence of suitable data from the Project area communities it is necessary to use data from the OKTFLY CHS as a surrogate. A brief description follows:

[1] www.oktedi.com/media-items/reports/environmental/human...2/file (Accessed Dec 12 2015)

- The 24-hour dietary recall and food frequency surveys were undertaken at a minimum of two control villages in each region. The household individual (unit) food consumption survey was undertaken at one control village in each region. While the approach gave a reasonable representation of age-related consumption quantities, the data is robust in all five regions only for adults.

- The Market Basket Survey for food contaminants, using a priority list of foods based on consumption patterns and specific bioaccumulator foods examined a total of 24 food categories representing all major dietary groups. While not all food products were available at every survey site, greater than 95% of the target was achieved. Product substitution by "like commodities", as agreed by Codex was adopted to maximise coverage. For example the category "green vegetables" includes a range of leafy greens, cucurbits and legumes.

- Estimates of dietary exposure to chemical contaminants for the study population were obtained by integrating data on the food consumption patterns and per capita consumption of the population, together with measurement of contaminant levels in the food actually consumed. The significance in terms of health risks of the estimated dietary exposures was obtained by comparison of the dietary intake estimates with the World Health Organization (WHO) Joint Expert Committee on Food Additives Provisional Tolerable Weekly Intakes (JECFA PTWIs).

2.8 Project communities and comparable surrogate communities

The local geography and water sources are clear determinants of the available food sources in the Project communities.

Table 2 below groups the Project communities into 3 categories based primarily on their location which in turn determines the available water sources. The BMT WBM (2018) report describes the available water sources in the Project area as follows: five rivers near and downstream of the mine area (the Frieda, Niar, Nena, Wario and Sepik rivers) and three rivers along the Infrastructure Corridor (Idam, Usake/May and Horden rivers). Four broad meso-habitat types were examined (upland creeks/rivers, mid-catchment rivers, lowland rivers, and off-river water bodies (ORWBs)/lakes) and typically had different habitat characteristics, reflecting differences in geological and hydrological conditions.

Sites which were higher in the catchment (i.e. upland creek and rivers) tended to have lower turbidity than lowland rivers which were typically more turbid with higher Total Suspended Solids (TSS) loads. Upland creeks and rivers were also characterised by coarser sediments relative to ORWBs and lowland rivers. This is typical of many river systems in PNG and is consistent with general stream models. Upland habitats had cooler, clear, rocky, fast flowing streams in mountainous areas. Due to the steep gradient of these waterways, stream velocities were high, resulting in the development of an incised water course with a bed comprised mostly of rocks and coarse sediments. By contrast, lowland rivers were warmer, slow flowing and relatively large water bodies with high turbidity and limited habitat complexity.

Habitat conditions in mid-catchment rivers were similar to that found at upland river sites, however typically had a lower gradient than upland rivers. Channels were either confined or partially confined with floodplains and areas of deposition occurring around confluences and bends. Water velocities were relatively high, as a result a similar range of meso-habitat types as found in upland rivers/creeks was also present (i.e. run, riffle, pool and rapid habitat). Substrate was comprised of a matrix of sands, gravel and cobbles, reflecting the higher flow conditions than found in in lowland rivers. Turbidity was generally lower than lowland rivers. Both stream flow and turbidity can vary greatly over time in response to catchment rainfall patterns.

Lowland rivers occur in areas where the stream gradient and associated water velocities are low, typically on the alluvial plain (BMT WBM, 2018).

Suitable surrogate villages from the Ok Tedi/Fly River system can be matched to the Project communities based mainly on geographical and social characteristics, but drinking water source and food sources and diversity give a reasonable match as well. Table 2 below indicates the match of surrogate communities to the Project communities.

Communities will always have unique characteristics, however analysis of the food frequency data for Project and surrogate communities shows considerable equivalency in food consumption between the regions chosen e.g. sago and fresh fish consumption are limited food sources in hilltop mine area villages and the OKTFLY CHS Regions 1 and 2, while tubers form an important part of the diet in the mine area villages and in the OKTFLY CHS Regions 1.

Table 4: Social catchment communities with matched[1] surrogate communities

Community	Project location	SIA catchment (Coffey, 2018)	Villages surveyed in CEH (2016)	OKTFLY CHS region
Sokamin	Mine area	1A		1
Wameimin 1	Mine area	1A	yes	1
Wameimin 2	Mine area	1A	yes	1
Amaromin	Mine area	1A	yes	1
Ok Isai	Mine area	1A	yes	1
Wabia	Mine area	1A	yes	1
Paupe	Mine area	1A	yes	1
Samou	Mine area	1A	yes	1
Uramesin 2	Infrastructure corridor (new road)	1B		2
Temsapin	Infrastructure corridor (new road)	1B		2
Hotmin	Infrastructure corridor (new road)	1B	yes	2
Idam 1	Infrastructure corridor (new road)	1B		2
Idam 2	Infrastructure corridor (new road)	1B		2

Community	**Project location**	**SIA catchment (Coffey, 2018)**	**Villages surveyed in CEH (2016)**	**OKTFLY CHS region**
Wokomo 1	Infrastructure corridor (new road)	1B		2
Bisiabru	Infrastructure corridor (new road)	1B		2
Aminii	Infrastructure corridor (existing road)	1C		2
Kwomtari	Infrastructure corridor (existing road)	1C		2
Itomi	Infrastructure corridor (existing road)	1C		2
Kilifas	Infrastructure corridor (existing road)	1C		2
Sumumini	Infrastructure corridor (existing road)	1C		2
Imbrinis	Infrastructure corridor (existing road)	1C		2
Auom 3	Frieda River corridor	2	yes	4
Iniok	Sepik River corridor	2	yes	4
Kubkain	Sepik River corridor – rural	2	yes	4
Tauri	Sepik River corridor - rural	2		4
Swagup	Sepik River corridor - rural	2	yes	4
Yessan	Sepik River corridor - rural	2	yes	4
Ambunti	Sepik River corridor – township	2	yes	4
Pagwi	Sepik River corridor - rural	2		4
Sapanaut	Sepik River corridor - rural	2	yes	4
Moim	Sepik River corridor - rural	2		4
Kanamimbit	Sepik River corridor - rural	2		4
Angoram	Sepik River corridor – township	2		4
Bin	Sepik River corridor - rural	2	yes	4

1. Community groupings are based on dietary similarities as well as location.

3 Health risk assessment methodology

The international health risk assessment model is based on comparing the actual measured exposures for the Project communities, summed over the various pathways, with the independently derived simple but robust FAO/WHO Provisional Tolerable Weekly Intake (PTWI) value for each metal contaminant and the United States Institute of Medicine (US IOM) Recommended Dietary Allowance (RDA) and Tolerable Upper Limit (UL) for each essential micronutrient.

One of the principal benefits of the deterministic approach is that the end product is transparent and readily understood by a wide lay audience. The disadvantage is that a deterministic health risk assessment is critically based on extensive data sets, gathered from every exposure route. This data are, in the main, lacking for the Project communities at this time. Hence the present assessment will use the extant data and high quality surrogate data collected from non-impacted i.e. control villages in Ok-Tedi/Fly River catchment regions to conduct a HIA for the Project communities. While the use of surrogate data introduces some caveats about the conclusions, the data are robust enough to be confident that the outcomes of this desktop study will indicate whether there is a necessity for future sampling, and the nature and extent of such on-site sampling and analysis of environmental samples.

It is important to note that the contaminant exposure of the mine-impacted communities in the Ok Tedi/Fly River catchment regions is the result of historical events such as the continual discharge of mine waste into the Ok Tedi and Fly River. The ISF proposed for the Sepik Development Project will mitigate, if not eliminate, such exposures to the Project communities.

Data gaps

Modelling potential health impacts associated with discharged surface water and fugitive sediment from the Project to the Frieda and then Sepik rivers necessarily involves modelling total exposure to contaminant and/or essential metals in food, drinking water, soils and sediments, and recreational water for identified potentially impacted villages. Contaminants in air comprise an insignificant pathway except for potential exposures to total suspended particulates in the villages immediately adjacent to the proposed mine road as indicated in the SLR (2018) report. For potentially impacted villages there are data on contaminant concentrations in surface water, sediments and some fish species in the BMT WBM (2018) report but only limited village soil data and the data do not comprise a comprehensive cross section of plants and animal species used as food sources. Where possible, the levels of essential metals in biota, especially plants, have been sourced from the literature i.e. existing reports from the Ok Tedi/Fly river valley control communities. While it has been discussed and used where possible, the empirical data set for the Project communities is limited and it has been necessary to use surrogate data for nearly all the exposure pathways. The most reliable use of this surrogate data is to model exposures for adults only and use mean values for the exposure pathway surrogate data. The modelling of age-group-specific exposures (e.g. infants, children, adolescents) cannot be supported by the available datasets. The collection of further baseline data in the form of appropriate age-group-specific data would be useful for confirming the conclusions of the HIA.

Drinking water

For estimating intake of contaminant metals from drinking water, the total element contaminant levels in settled raw water can be used as drinking water levels. Data for some communities and water sources is available in the BMT WBM (2018) report albeit in form of values for dissolved metals and total metals but not 'settled water', which is the most relevant data for a HIA.

Food

Existing databases on contaminant metals in foodstuffs developed for non-impacted communities along the Ok Tedi-Fly River systems and their associated ORWBs (developed by CEH) have been used to provide estimates of food-intake of contaminants for similar villages in each of the project regions. Some data were available on a small number of fish-flesh metal levels from the BMT WBM (2018) report but these are very limited and not prepared using Codex methods. They were not suitable for use in the present report.

Soil, sediments, recreational water

Studies at other mining projects in PNG have shown that these media make significant contributions to total contaminant intake and can be up to 25% combined for activities such as artisanal mining. In the present study there is no opportunity to model such exposure groups as no time-activity data is available. Again suitable data on contaminant levels in soil and recreational water for the Ok Tedi/Fly River and other communities have been used as surrogates for the matched Project communities. The BMT WBM (2018) study on sediment quality has also provided relevant data for sediments and is used in this report.

Uncertainties and assumptions

Studies at other mining projects in PNG e.g Ok Tedi and Porgera(Bentley (2004a, 2007b) have shown that the air pathway is not a significant source of metal intake and this was assumed to be the case in the current study. This is a robust assumption except for roadside villages during construction and possibly operation (SLR, 2018). This assumption can be revisited if needed in subsequent studies.

It has not been necessary to select control villages for this study i.e. villages distant from any possible future impact from the Project. This will only be required if the study suggests there is a risk of high or extremely variable contaminant intakes in the potentially affected currently surveyed villages in the Project area. Some villages have been identified as having intrinsic adaptability e.g. those with a variety of reliable food sources and means of earning external income, versus more fragile villages relying solely on subsistence farming, for which villages a contamination event or chronically elevated contaminant levels might compromise their major food sources e.g. sago or fish.

3.1 Exposure pathways and regulatory limits

In general, an exposure pathway describes how a contaminant travels through the environment from its source to humans or other living organisms. An exposure pathway consists of five elements: source of contamination; environmental media; point of exposure; exposed population; and route of exposure.

Once released from its source, a contaminant will travel through environmental media to points where human exposure can occur. In humans, the major environmental media include water, air, food, soil and sediment. The approach taken by this exposure assessment was to examine the potential exposures from each of these media:

- The food compartment includes exposure to food grown in areas where the soil or aquatic environment is contaminated. Exposure potentially may also occur when consuming contaminated plants, native fruits and fish and wildlife gathered during hunting trips.
- The water compartment includes village drinking water and surface water sources, generally tanks, springs, creeks at various on- and off-river sites. Exposure occurs through drinking, bathing, washing of clothes and recreational use.
- The air compartment includes ambient respirable particles in air. These may arise from diverse sources, including mine-derived dust and motor vehicle exhausts.
- The soil compartment includes exposure to bare ground (inhalation, ingestion and skin contact with soil), contaminated soil blown as dust in the air and particles deposited on other surfaces (such as food) and contaminated mine-derived river sediment.

The point of exposure is the location where contact with a contaminant occurs. For example, people can be exposed to contaminants in the home, at work, in a play area, or while bathing or washing clothes in a contaminated water body. Hunters and their families may be exposed by consuming contaminated bush meats.

The route of exposure describes how a contaminant enters the human body. There are three routes by which humans may take contaminants into their bodies:

- Ingestion - swallowing something containing the contaminant.
- Inhalation - breathing in a substance, as airborne particles.
- Skin contact - some contaminants can be absorbed through the skin.

Traditionally, one avenue for protection of human health has been through the establishment of exposure limits (variously referred to as standards or quality criteria). These are established in a two-step process, the first involving consideration of the health-based scientific data and the second involving the establishment of regulatory limits, taking into account the health-based recommendation along with other factors. These regulatory limits provide estimates of chemical-specific doses, which, if not grossly exceeded, may be regarded as safe, or having no adverse effects.

Examples of health-based exposure guidelines include the WHO Acceptable Daily Intake and the FAO/WHO PTWI. Acceptable/tolerable intakes are the amounts of a contaminant, expressed on a body weight basis which has cumulative properties and may possibly accumulate in the body to levels which might result in adverse health effects. Ingestion of the chemical at levels at or below the PTWI does not pose an appreciable risk to health even when consumed over a lifetime.

For essential trace elements, however, a tolerable intake alone does not provide adequate health-based guidance. Because such elements are essential for human health, as well as being toxic at some higher dose, public health protection requires setting both a recommended minimum intake guideline based on essentiality as well as a maximum exposure based on toxicity. This has been done by a joint United States/Canadian activity of the US IOM. For human health protection, a RDA has been developed for essential nutrients to ensure adequate human intakes and in most cases, a Tolerable UL to ensure exposure from all sources that will not lead to human health risks. These health-based guidance recommendations for the essential trace elements copper, selenium and zinc are discussed further in Section 4.0 – Hazard Assessment.

3.2 Definition and quantification of exposure

The objective of exposure assessment is to determine the nature and extent of contact with chemical substances experienced or anticipated under different conditions. Approaches for assessing exposure and characterising uncertainties and/or variability in resulting estimates presented here are derived primarily from the United States Environmental Protection Agency (US EPA), the WHO and the Australian Environmental Health Committee (enHealth) (US EPA 1992, 1996, 1997, 2004, 2008, 2011 IPCS 2005, 2006, 2009; enHealth 2010a, 2010b).

An exposure assessment is the quantitative or qualitative evaluation of the contact between the chemical substance and the human system, which includes consideration of the intensity, frequency and duration of contact, the route of exposure (dermal, oral or respiratory), rates (chemical intake or uptake), the resulting amount that actually crosses the boundary (a dose) and the amount absorbed (internal dose).

Doses are often presented as dose rates on a per unit body weight per unit time, for example, in microgram per kilogram body weight per week (µg/kg bw/wk). The HIA for the Project communities has used dose-response relationships, as represented in the regulatory health limits and the outputs expressed as an estimate of dose. The exposure can be estimated by separately evaluating the exposure concentration and the duration of contact and combining this information i.e. developing an exposure scenario. This is the approach used in this report.

For cancer effects, where the biological response has been described in terms of lifetime probabilities, doses are best presented as Life time Average Daily Doses (LADDs) (US EPA 1992).

4 Hazard assessment

In order to evaluate whether exposure to metals in open-pit water, waste rock and tailings poses a threat to health, the mean metal concentrations in the environmental media have been compared with standards and guidelines, established by the Government of PNG, the WHO and national criteria from the United States, Canada and Australia. Contaminant metals that are present in concentrations below the applicable criterion are not considered to pose health risks to humans.

The WHO has considered the possibility of synergism in toxicity between contaminant metals. For the metals being considered in the present report there is no known synergism in health impacts, other than for copper and zinc. An excess of zinc can reduce the absorption of copper, particularly in infants, children and adolescents and pregnant or breastfeeding mothers, resulting in copper deficiency and increased uptake of lead in severely iron-deficient people.

The health risk assessments on which standards and guidelines are based, invariably include conservative factors to address susceptible population sub-groups. These groups include the developing foetus (i.e. pregnant women), infants and young children (including lactating women), health-compromised groups, and the elderly that may be at higher risk of accumulating toxic levels of contaminant metals. The standards and guidelines are developed to be protective of these susceptible populations.

A detailed hazard summary for each of the contaminant substances (arsenic (As) cadmium (Cd), lead (Pb), mercury (Hg)) and the essential metals (copper (Cu), selenium (Se) and zinc (Zn)) is provided in **Appendix 1**. These summaries include the derivation of the Toxicity Reference Values (TRVs) for each substance.

Aluminium (Al) and iron (Fe) have not been included in the present HIA. The SRK (2018) report lists exceedances of the WHO drinking water guidelines for these elements at various Assessment Points. However, Al and Fe have not been quantified in the MBS of food contaminants and since food is by far the major exposure pathway to contaminants there are insufficient data to conduct a risk assessment for these elements. Additionally they have relatively low toxicity compared to the other contaminant elements considered in this report and are unlikely to pose a health concern.

5 Exposure assessment

5.1 Drinking water

5.1.1 National and international guidelines

Table 3 lists the international drinking water health guideline and national standard and criteria values for the contaminant metals from WHO, PNG, the United States and Australia. Drinking water standards and criteria can be compared with both dissolved and preferably raw (settled) water metal concentrations. Aesthetic values for copper and zinc based on soiling and colour are available, however the focus of this assessment is on health impacts and therefore these values have not been presented in Table 3.

Table 5: Drinking water health-based guidelines (all dissolved values mg/L)

Guideline	As	Cd	Cu	Cu	Pb	Hg	Se
WHO Drinking Water Quality Guidelines [1, 2]	0.01(P)	0.003	2.0	2.0	0.01	0.006	0.04 (P)
PNG Standards for raw drinking water [3]	0.007	0.002	2 health[6]	2 health	0.01	0.001	0.01
Australian Drinking Water Guidelines [4]	0.007	0.002	2 health	2 health	0.01	0.001	0.01
United States Maximum Contaminant Level [5]	0.01	0.005	1.3	1.3	0.015	0.002	-

1. WHO Guidelines for Drinking Water Quality Fourth Edition incorporating the first addendum (WHO 2017).
2. Mercury is for the inorganic species. (P) for total arsenic and selenium is a Provisional value.
3. Environment (Water Quality Criteria) Regulations 2002 (DE&C 2002).
4. Australian Drinking Water Guidelines 2003 (NHMRC 2004).
5. Maximum Contaminant Levels used as enforceable standards (US EPA 2010).
6. 'health' refers to a human health guideline value as distinct from an ecological value

5.1.2 Project communities drinking water

The drinking water sources for the Project communities (CEH 2010a, b, CEH 2011, Coffey, 2018) are summarised in Table 4 below.

The drinking water was obtained from unprotected river and spring sources with tanks installed in some communities. Most communities rely heavily on the rivers and springs as their water supply for drinking, cooking and washing.

Table 6: Project communities' drinking water sources

Community	Project location	Drinking water source
Sokamin	Mine area	Creek, rainwater tank
Wameimin 1	Mine area	River, spring
Wameimin 2	Mine area	River rainwater tank, spring
Amaromin	Mine area	River, spring
Ok Isai	Mine area	River rainwater tank, spring
Wabia	Mine area	River, spring, rainwater tank
Paupe	Mine area	River, spring, rainwater tank
Samou	Mine area	River

Community	Project location	Drinking water source
Uramesin 2	Infrastructure corridor (new road)	River, spring
Temsapin	Infrastructure corridor (new road)	River, spring
Hotmin	Infrastructure corridor (new road)	River, spring
Idam 1	Infrastructure corridor (new road)	River, spring
Idam 2	Infrastructure corridor (new road)	River, spring
Wokomo 1	Infrastructure corridor (new road)	River, spring
Bisiabru	Infrastructure corridor (new road)	River, spring
Aminii	Infrastructure corridor (existing road)	River, spring, bore, tank
Kwomtari	Infrastructure corridor (existing road)	River, spring, bore, tank
Itomi	Infrastructure corridor (existing road)	River, spring, bore, tank
Kilifas	Infrastructure corridor (existing road)	River, spring, bore, tank
Sumumini	Infrastructure corridor (existing road)	River, spring, bore, tank
Imbrinis	Infrastructure corridor (existing road)	River, spring, bore, tank
Auom 3	Frieda River corridor	Lake, spring
Iniok	Sepik River corridor	River, tank
Kubkain	Sepik River corridor – rural	River, tank
Tauri	Sepik River corridor - rural	River, tank
Swagup	Sepik River corridor - rural	River, tank
Yessan	Sepik River corridor - rural	River, tank
Ambunti	Sepik River corridor – township	River, tank
Pagwi	Sepik River corridor - rural	River, tank
Sapanaut	Sepik River corridor - rural	River, tank
Moim	Sepik River corridor - rural	River, tank
Kanamimbit	Sepik River corridor - rural	River, tank
Angoram	Sepik River corridor – township	River, tank
Bin	Sepik River corridor - rural	River, tank

Hydrobiology (2011) performed multiple water and sediment quality investigations between September 2007 and October 2010. Aquatic biological investigations were also undertaken by Hydrobiology on three occasions: November 2008-January 2009, November/December 2009 and August/October 2010. Sampling sites were classified into the following four catchment units: Usake/May, Frieda/Nena, Wario and Sepik floodplain.

BMT WBM collected water and sediment quality data between April 2011 and April 2013. Aquatic biology assessments of habitat were performed biannually between June/July 2011 and April 2013, while fish and macro-invertebrate assessments were undertaken by BMT WBM on two occasions in 2012 and in 2017. Metal concentrations in the tissues of selected aquatic fauna species were assessed between 2008 and 2011. Table 3.2 in the BMT WBM (2018) report details the sampling events. This is an extensive water- and sediment-quality database effectively covering the entire Project area. This sampling was conducted as part of the environmental studies and was not designed to be a comprehensive study of community drinking water sources such as tanks or wells. The data can however, be utilised in assessing exposure to recreational water and sediments.

Water quality parameters measured in collected water samples included dissolved (< 0.45 µm) and total metals (Al, Sb, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag and Zn). Mercury was included in all sampling events from September 2009 but was not present above the laboratory limit of reporting at any site during any sampling event.

BMT WBM (2018) states that in the Project area, background levels of dissolved metals/metalloids in water are generally low, but where naturally occurring acid and metalliferous drainage (AMD) was found, dissolved metals were elevated. The total metals fraction generally correlated to TSS though this was not the case in upland creeks where naturally occurring AMD impacts were occurring.

Noting that human health protection guideline values for contaminant metals/metalloids in drinking water are significantly higher than ecosystem protection guideline values, the BMT WBM (2018) report indicates that dissolved metal concentrations for the metals relevant to human health that were measured in potential drinking water are unlikely to exceed the health guideline values. This was evidenced by data collected over multiple campaigns with repeat sampling at the same locations. However, concentrations of total manganese (0.835 mg/L) and total nickel (0.277 mg/L) at site W101 (Yellow River) exceeded the PNG and WHO (2011) drinking water guideline values of 0.4/0.5 mg/L and 0.07 mg/L respectively. Also, concentrations of total lead (0.019 mg/L) at W114 (Niar River @ Ok Isai) exceeded the WHO (2011) drinking water guideline value (0.01 mg/L).

In terms of ecosystem protection values, dissolved copper was elevated across most sites, with only four sites not recording a median copper concentration above the ANZECC/ARMCANZ (2000) trigger value for 95% ecosystem protection. The highest overall dissolved zinc levels were recorded in lowland rivers, some ORWBs and in an upland creek site, W27, affected by AMD (BMT WBM Figure 4-26) where median values were also above the ANZECC/ARMCANZ (2000) trigger value.

Table 4.3 in BMT WBM (2018) is a summary table showing median dissolved metal concentrations compared to water quality guideline values. A number of sites reported median dissolved metal concentrations (for aluminium, copper and zinc) exceeding ANZECC/ARMCANZ (2000) trigger values for 95% ecosystem protection. The highest median values for dissolved metal concentrations (mg/L) were 0.053 for Cu at W27 and 0.061 for Zn in an ORWB. The vast majority of results were below the laboratory limit of reporting. The ANZECC/ARMCANZ (2000) trigger values for 95% ecosystem protection are more stringent than the PNG drinking water guideline (settled water) for Cu and Zn.

Additional water quality data was provided (Report 476518-W, dated Oct 12, 2015) in the form of three samples from: Paupe (tank), Iniok (tank) and Auom 3 (groundwater) which represented the drinking water sources in these villages. As shown in Table 7, the contaminant values are well below the WHO drinking water guideline values.

Table 7: Drinking water samples from three Project communities (mg/L)

Contaminant	WHO guideline (dissolved)	Paupe		Iniok		Auom 3	
		Total	Dissolved	Total	Dissolved	Total	Dissolved
As	0.01p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cd	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cu	2.0	0.008	0.009	0.004	0.004	<0.001	<0.001
Pb	0.01	0.001	0.001	0.001	<0.001	<0.001	<0.001
Hg	0.006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Se	0.04p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	*	0.24	0.25	0.29	0.29	0.005	<0.001

p = provisional guideline
*There is no WHO Drinking Water Guideline for Zn.

For all sources of drinking water, the OKTFLY CHS and the present report uses the Total (T) contaminant concentration values as a conservative estimate of intake. This 'Total' value is for settled raw water and assumes 100% bioavailability by the ingestion route for the metals. Dissolved (D) sample data (i.e. the 0.45 µm filtered metal values) are also used for intakes in risk assessments. However, this approach does not capture all of the potentially bioavailable metal in the surface waters. The adoption of the Limit of Detection as the analytical default value, introduces a further layer of conservatism. It is noteworthy that the Total and Dissolved values in Table 7 above are effectively identical.

In the absence of a more comprehensive analytical survey of Project drinking water supplies, the data from the drinking water in the surrogate communities will be used in the present HIA to assess the drinking water compartment. The control communities in the Ok Tedi/Fly River study generally sourced their drinking water from rivers and creeks similarly to the Project communities. Table 8 reports the total values for each metal/metalloid from two communities in each region.

Table 8: Ok Tedi-Fly River community drinking water supplies – total metals (all mean values mg/L)

	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Region 1 control	0.005	0.001	0.014	0.005	0.0002	0.01	0.02
	0.005	0.001	0.01	0.005	0.0002	0.01	0.02
Region 2 control	0.005	0.001	0.007	0.004	0.0002	0.01	0.02
	0.005	0.001	0.005	0.005	0.0002	0.01	0.05
Region 4 control	0.005	0.001	0.008	0.004	0.0002	0.01	0.08
	0.005	0.001	0.005	0.002	0.0002	0.01	0.12
Mean	0.005	0.001	0.008	0.004	0.002	0.010	0.05

Comments - drinking water

There were no material differences between the metal results for the drinking water sources sampled in different regions or between villages within a single region. The results indicated that all primary use water supplies have relatively low total and dissolved concentrations of the metals of concern. All values are markedly less than the WHO, United States and Australian Drinking Water Guideline and criteria values and the PNG standards for raw drinking water. This is consistent with the BMT WBM (2018) data for dissolved metal values in the Project regions. Similarly the samples from three Project communities (Table 5) are, with the exception of Zn, all lower than the OKTFLY mean values.

It is considered reasonable to use the drinking water contaminant metal levels from the control communities in the OKTFLY CHS study in the HIA as surrogate values for the Project community drinking water levels. There is insufficient drinking water quality data from the Project communities to provide a robust summary for inclusion in the HIA. The collection of such data in any future environmental surveys would be recommended.

5.2 Surface/Recreational water

5.2.1 National and international guidelines

The potential health risks from chemical contamination of surface water in most environments is low. Even repeated exposure is unlikely to result in discernible ill effects at the concentrations of contaminants generally found in water and with the exposure patterns of recreational water users (WHO 2003). Generally, skin and mucous membrane surface exposure is the greatest contributor to intake, but for activities involving immersion or partial immersion, ingestion may become a significant factor. Children 5 – 10 years of age are likely to ingest proportionally greater amounts of water than adults.

PNG has developed water quality standards for surface/recreational water and aesthetic uses in fresh and marine water. However, these are for microbiological and physico-chemical parameters only.

The WHO Guidelines for Safe Recreational Water Environments assumed a contribution for recreational use of 10% of drinking water consumption i.e. an intake of 100 mL/hour and 2 hours/day (WHO 2003). These estimations are now generally considered to be overly conservative (US EPA 2008).

Following a review of recent studies, the USEPA has adopted a consumption rate of 49 mL/hour for children under 16 years of age and 21 mL/hour for adults (US EPA 2008, 2011). Australia has adopted the US EPA values (enHealth Council 2010a). The US EPA values have been adopted for the Project communities and for the purpose of developing a guideline value, recreational water exposure has been given a value of one hour per day for all age groups and an acceptable daily intake of 10% of the respective WHO Drinking Water Guideline values. The adopted guideline criteria values are shown in Table 7.

Table 9: Derived health-based guideline values for recreational water (all values µg/L)

Age group	As	Cd	Cu	Pb	Hg	Se	Zinc*
Infant and child under 16 years	20	6	4000	20	12	80	-
Adult	100	30	20,000	100	60	400	-

*There is no WHO Drinking Water Guideline for Zn.

5.2.2 Project communities surface water

There have not been any studies of community river-use patterns for the Project communities in the three designated regions. Recreational water-use patterns would almost certainly differ greatly between the mine area villages, the infrastructure corridor and the middle Sepik villages. For example, river use by the mine area villagers would be limited while the middle Sepik villages regularly use the waterways as a transportation corridor, for subsistence fishing, preparing food, harvesting of sago crops and for washing of clothes, bathing and recreation.

In the absence of studies of community river-use patterns in the Project area the recreational water values from the surrogate communities on the Ok Tedi/Fly River will be used for this exposure compartment as a conservative approach. It is noted that low total metal values for the relevant metals were seen in the BMT WBM (2018) data and the use of surrogate data is thus conservative.

5.2.3 Surrogate community recreational waters

Noting that for the control surrogate communities the recreational water is often the same as the drinking water, the mean results for total extractable metals in surface water samples are shown in Table 8. For all of the measured analytes, concentrations of total extractable metals in the OKTFLY CHS control village surface water samples were generally at or below the method Limit of Detection. Table 8 reports the total values for each metal/metalloid from two communities in each region.

Table 10: Total metal concentrations in surrogate community surface/recreational water (mg/L)

	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Region 1 control	0.005	0.001	0.005	0.005	0.0002	0.01	0.02
	0.005	0.001	0.012	0.005	0.0002	0.01	0.31
Region 2 control	0.005	0.001	0.005	0.004	0.0002	0.01	0.02
	0.005	0.001	0.005	0.005	0.0002	0.01	0.02
Region 4 control	0.005	0.001	0.005	0.004	0.0002	0.01	0.05
	0.005	0.001	0.005	0.002	0.0002	0.01	0.12
Mean	**0.005**	**0.001**	**0.006**	**0.004**	**0.000**	**0.01**	**0.09**

Comment – Surface waters

The surface water monitored for Region 1 control communities drains from potentially highly mineralised areas. However, other than a minor elevation in copper and zinc in one village (Ok Ma), this did not result in significantly elevated mean background levels of any metal. Similarly the BMT WBM (2018) data show some elevation of Cd, Cu and Zn in the upland rivers and creeks. The observed concentrations of metals at all of the control sites were at least an order of magnitude below the derived Recreational Water Guidelines (Table 7), and similar to non-impacted rivers in other PNG and international environments.

Surface water contaminant metal levels from the control communities in the OKTFLY CHS study were used in the HIA as surrogate values for the Project community surface water levels.

5.3 Ambient Air

5.3.1 International guidelines

The WHO has evaluated the health effects of total and inorganic arsenic, cadmium, lead and total mercury in ambient air. Threshold levels have been established for lead and mercury together with quantitative estimates of life time cancer risk for arsenic (WHO 2000). The guidelines are detailed in Table 9.

Table 11: Health-based guideline values for total metals in ambient air

Substance	Guideline value (ng/m^3)	Averaging time
Arsenic (total)	10	UR/life time[1]
Cadmium	5 – 20	Annual
Lead	500 – 1000	Annual
Mercury (total)	1000	Annual

1. UR is the unit life time risk associated with a life time exposure of 1 $\mu g/m^3$. The present value corresponds to a life time risk of 3×10^{-5}.

5.3.2 Project communities ambient air

Studies at other mining projects in PNG have shown that the air pathway is not a significant source of metal intake. This is a robust assumption although higher than normal, but still safe, levels of air pollution can be expected for roadside villages during construction and possibly operation. Monitoring of ambient air at the surrogate sites in the OKTFLY CHS (Regions 1 &2) reported that the levels of the target contaminant metals in both the fine and coarse fractions were consistently low for all monitored sites. The level of metals in both PM_{10} and $PM_{2.5}$ were not statistically different between any sites and did not exceed Australian NEPM levels. The level of metals in all fractions was comparable with that observed in international baseline locations and orders of magnitude below polluted urban centres. The SLR (2018) air quality assessment conducted for the Project confirms these findings. Maximum predicted ground level sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations as well as TSP, PM_{10} and $PM_{2.5}$ concentrations downwind of the road and pipeline construction activities are predicted to be below relevant international health-based air quality criteria during the construction and operational phases of the mine. For these reasons, the air pathway was not modelled in the exposure assessment.

5.4 Soil and sediments

5.4.1 National criteria and guidelines

Soil and sediment screening provides a cost-effective approach to the identification of the hazard potential from exposure to these media. Levels of the contaminant metals are compared with previously determined health investigation levels (HILs) to assess risks both to the general population and to specific vulnerable sub-populations, particularly infants 2 – 3 years of age. This age group is well recognised as having disproportionate soil intakes by ingestion due to hand-to-mouth behaviour.

The WHO does not provide guidance for soil contamination. However, other national agencies have published health “screening levels” and “investigation levels” (US EPA 1996, NEPC 2012). The present report has used the 2012 Australian National Environment Protection Measure (NEPM) residential and recreational HIL values for comparative purposes. These values are shown in Table 10.

Table 12: Australian health-based soil investigation levels (all values mg/kg)

Substance	Australian NEPM HILs (2012) [1]	
	Residential A [2]	Recreational E [3]
Arsenic (total)	100	200
Cadmium	20	40
Copper	1000	2000
Lead	300	600
Mercury (inorganic)	15	30
Selenium	200	700
Zinc	7000	14,000

1. Investigation levels are derived by assigning a fixed value (i.e. fraction of the total theoretical baseline exposure) to the soil compartment by using the respective PTWI. It is important to note that HILs are not “response levels”, which would be far less conservative.
2. Low-density residential including a sizeable garden and sites where children are likely to be the most sensitive human receptors.
3. Recreational areas including parks, playgrounds and playing fields where the public may potentially spend a significant amount of time.

5.4.2 Project communities natural sediments

The BMT WBM (2018) report divides the watercourses within the Project area into four main types. These are:

- Upland creeks and rivers – occur above 150 m RL.
- Lowland rivers - Those creeks and rivers located on the Sepik floodplain were considered as lowland systems (i.e., not confined by surrounding landforms).
- Mid-catchment rivers - any creeks / rivers between these demarcations. Mid-catchment rivers were generally more confined by the surrounding geology.
- Lakes and off-river water bodies.

These waterbody types are located throughout the Project Area and all form parts of the Sepik River catchment. However, the water bodies can also be categorised based on the specific catchment or river system to which they belong. Most waterbody types are represented within each of the catchment or river systems in the Project Area. Nominally, these systems include:

- Five rivers near and downstream of the Mine Area (the Frieda, Niar, Nena, Wario, and Sepik rivers).
- Three rivers along the Infrastructure Corridor (Idam, Usake/May, Horden rivers).

Hydrobiology (2011) reports that sediment was sourced from non-flowing areas at the edge of the stream. The smallest available particle sizes were chosen visually from each site and the top two cm of the sediment profile were sampled providing a 'worst-case' where the finest and most recently deposited sediments were collected. BMT WBM (2018) used a similar methodology in accordance with relevant international standards. Sediment samples were analysed for particle size distribution and total metals/metalloids both in the <63 µm and < 2000 µm fractions. Sand and gravel dominated upland rivers, creeks and mid-catchment sites while silt and clay dominated the lower reaches of the catchments. Silt fractions (20-60 µm) tend to hold a greater proportion of bioavailable metals as trace metals/metalloids bind more readily to finer sediment fractions than sands and gravels that are often dominated by silicates.

The BMT WBM (2018) report of sediment quality in the <63µm fraction indicates that arsenic, chromium, copper and nickel are elevated at several sites across the Project area, exceeding ecological sediment quality guidelines. In addition, cadmium, lead and zinc also exceed sediment quality guidelines (eco-toxicological) at a reduced range of sites. Table 11 below shows sediment values from the Hydrobiology (2011) report. Additional data is provided in the BMT WBM (2018). A comparison shows that most values are almost an order of magnitude below the Australian residential HILs with the exception of one anomalous lead value. The mean values from the Hydrobiology report were used in the HIA.

Table 13: Total metal concentrations in Project community sediments (mg/kg) (Hydrobiology 2011)

		As	Cd	Cu	Pb	Hg	Se	Zn
HIL A Residential		**100**	**20**	**6000**	**300**	**10**	**200**	**7400**
HIL C Recreational		**300**	**90**	**17000**	**600**	**13**	**700**	**30000**
Upland creeks and rivers Mine area	Mean	13.6	0.5	124.0	100.1	0.1	1.9	196.7
	Max	24.9	1.9	374.0	706.0	0.3	7.0	575.0
	Min	4.4	0.2	59.0	8.4	0.1	1.0	104.0
	Median	11.5	0.2	90.2	25.0	0.1	1.0	152.0
		As	**Cd**	**Cu**	**Pb**	**Hg**	**Se**	**Zn**
Mid catchment rivers Infrastructure corridors	Mean	13.1	0.5	77.2	19.9	0.1	1.6	121.2
	Max	39.8	1.0	104.0	61.1	0.2	6.0	181.0
	Min	5.1	0.1	51.0	8.9	0.1	1.0	94.0
	Median	8.7	0.3	77.5	15.0	0.1	1.0	112.5
Lowland Rivers Sepik	Mean	10.0	0.5	78.9	15.5	0.1	1.6	122.2
	Max	21.4	1.0	329.0	27.3	0.4	8.0	305.0
	Min	5.7	0.0	29.4	10.4	0.1	1.0	58.8

		As	Cd	Cu	Pb	Hg	Se	Zn
	Median	9.0	0.3	50.7	14.6	0.1	1.0	100.9
Project communities Mean		**12.57**	**0.5**	**101.0**	**58.9**	**0.1**	**1.75**	**159.2**

1. Non-detects have been assigned the value of the laboratory limit of reporting.

A comparison of the above results with the Ok Tedi/Fly River natural sediments (OKTFLY CHS) is shown in Table 14.

Table 14: Comparison of sediment contaminant values for Project and OKTFLY communities (mg/kg)

		As	Cd	Cu	Pb	Hg	Se	Zn
Project sediments	Mine	13.6	0.5	124	100.1	0.1	1.9	196.7
	Infrastructure corridor	13.1	0.5	77.2	19.9	0.1	1.6	121.2
	Sepik	10	0.5	78.9	15.5	0.1	1.6	122.2
Ok Tedi/Fly River sediments	R1	6	0.5	25	12	0.3	4	69
(Controls only)	R2	4.4	0.4	72	9.6	0.4	4	76.1
	R4	5.3	0.4	14	12.1	0.3	4	36.9

The two datasets are similar. Arsenic, copper, lead and zinc levels are slightly higher in the mine area Project communities compared to the Ok Tedi/Fly River communities but this is to be expected as the OKTFLY control communities are generally distant from the mine-impacted areas and natural mineralisation. The lead level in the Project upland rivers and creeks is below the HIL but high enough to pose risk to high-exposure individuals such as children with pica activity.

Comment

As there is adequate data, the Hydrobiology (2011) overall mean for total metal concentrations in Project community sediments is used in the HIA.

5.4.3 Project communities soils

There was limited village soil data available for communities in the Project area. Report EB1532218 (Coffey, 2015) presents metal/metalloid analysis of 10 soil samples from different villages in Project Regions 1 and 2. The soil samples within the communities were taken from village gardens. The data is presented in Table 13 below.

Table 15: Village soil contaminant levels in some Project villages (mg/kg)

	As	Cd	Cu	Se	Hg
Amaromin	10	<1	65	<5	<0.1
Wameimin 2	<5	<1	31	<5	0.1
Wabia	<5	<1	34	<5	0.1
Timbunge	8	1	38	<5	<0.1
Paupe	9	<1	59	<5	<0.1
Pagwi[1]	7	<1	38	<5	<0.1

	As	Cd	Cu	Se	Hg
Ok Isai	<5	<1	45	<5	<0.1
Iniok	7	<1	26	<5	<0.1
Auom 3	<5	<1	45	<5	<0.1

[1]These communities are not included in the HIA as no health data has been collected.

The small number of soil samples confirms the elevation of copper and arsenic in village soils (ranges 20-65 mg/kg and 7-15 mg/kg respectively). These values are very comparable to the extensive datasets from the control surrogate communities on the Ok Tedi/Fly rivers which will be used in the risk assessment (see Table 14 below).

Surrogate communities

The mean metal concentrations for village and garden soils for the surrogate communities Regions 1 - 4 are given in Table 14.

The mean concentration of arsenic in village and garden soils in Regions 1 - 4 ranges between 4 – 11 mg/kg. The observed levels were typical of those reported in the literature for international background levels (4.8 – 7.2 mg/kg) and an order of magnitude below the Australian HIL for residential soil.

Table 16: OKTFLY CHS Village and village garden surface soils total extractable metals (all mean values mg/kg)

	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Zinc
HIL A Residential	**100**	**20**	**1000**	**300**	**15**	**200**	**7000**
HIL C Recreational	**300**	**90**	**17000**	**600**	**13**	**700**	**30000**
Region 1 control	11.0	0.6	84.6	0.3	31.1	4.0	211.6
Region 2 control	4.7	0.4	92.0	0.5	10.9	4.0	79.9
Region 4 control	6.7	0.4	29.6	1.0	11.3	4.0	19.4

In the surrogate communities there was little difference between the levels of arsenic in village and garden soils or the natural sediments in the four regions. The mean concentrations for copper, lead and zinc in the village soils and natural sediments were slightly elevated at the communities in Region 1, resulting from natural mineralisation.

5.5 Food

5.5.1 International guidelines

Considering only the toxic contaminant metals, the dietary exposure for arsenic, cadmium, lead and mercury in the Project communities has been derived on a body weight basis, to permit comparison with the FAO/WHO PTWI values derived from toxicological studies. The toxicological and environmental characteristics of each of the essential micronutrients and contaminant metals are examined in detail in Appendix 1. The reference health-based values for food risk assessment for each contaminant metal are regularly reviewed by JECFA, with significant changes introduced for arsenic, lead and mercury in 2010 – 2011 (WHO/JECFA 2010a,b, 2011a).

The JECFA reference health value for arsenic is based on exposure to inorganic arsenic (III) and (V) compounds in drinking water. Arsenic occurs as a large number of organic or inorganic chemical forms in food. In the marine environment arsenic is often found in high concentrations of organic species, up to 50 mg/kg of arsenic on a wet weight basis in some seafood including seaweed, fish, shellfish and crustaceans. In the terrestrial environments arsenic is normally found in much lower levels (typically 0 - 20 µg/kg) in crop plants and in livestock. Higher levels may be found in some food including rice, mushrooms and ferns. Methylated forms of arsenic have a low acute toxicity; arsenobetaine which is the principal arsenic form in fish and crustaceans is considered non-toxic. Only a few per cent of the total arsenic in fish is present in the inorganic form, which is the only form that has been evaluated by JECFA (e.g. UK FSA 2004).

In 2010, JECFA withdrew the previous PTWI for inorganic arsenic because a threshold for adverse effects could not be determined. The Committee noted that the PTWI of 15 µg/kg bw (equivalent to 2.1 µg/kg bw per day) is in the region of the inorganic arsenic lower limit on the benchmark dose for a 0.5% increased incidence of lung cancer Benchmark Dose Lower Limit (BMDL 0.5) (WHO/JECFA 2010a). For ease of comparison, the previous PTWI of 15 µg/kg bw/wk is used in this evaluation. While the analytical method measured total arsenic, the amount of inorganic arsenic in food is estimated to be only 10% of the measured result. Published literature reports that inorganic arsenic makes up 7.3 percent of total arsenic for finfish and 25 percent of total arsenic for shellfish (Mohri et al. [1990]; Suñer et al.[2002]). Rather than correcting all of the analytical results, the PTWI has been adjusted by a factor of 10 to 150 µg/kg bw/wk so that it can be directly compared with the total arsenic results (WHO/JECFA 2010a).

The risk assessment approach now adopted by JECFA for non-threshold effects of inorganic arsenic is based on a margin of exposure (MOE) approach. While this approach does not lend itself to clear risk management judgments, the assessment of non-threshold effects expressed by the MOE can provide useful comparison with those reported for populations in other countries.

The JECFA reference health value for cadmium is based on the accumulation of cadmium into renal tissue. Shellfish, crustaceans, a range of nut species and fungi are natural accumulators of cadmium. Regular consumption of these items can result in increased exposure. Tobacco is an important source of cadmium uptake in smokers. In 2010, JECFA withdrew the PTWI for cadmium and replaced it with a provisional tolerable monthly intake (PTMI). The rationale adopted by the committee was that owing to cadmium's exceptionally long biological half-life in humans, a monthly value was more appropriate (WHO/JECFA 2010b). The previous PTWI of 7 µg/kg bw/wk has been used in this evaluation for comparative purposes since it is essentially numerically equivalent to the PTMI.

The JECFA health-based reference value for lead is based on the neurobehavioral impact in infants and the developing foetus i.e. pregnant women. There is no known lower threshold for exposure. In 2010 JECFA withdrew the PTWI of 25 µg/kg bw because the dose-response analyses did not identify a threshold for the key adverse effects of lead, and the Committee concluded that it was not possible to establish a new PTWI that would be health protective of non-threshold adverse effects. The risk assessment approach now adopted by JECFA for the non-threshold effects of lead is based on the MOE approach. The derivation of the MOE used the JECFA benchmark dose (lower) (BMDL) associated with a decrease of at least three intelligence quotient (IQ) points in children and an increase in systolic blood pressure of approximately 3 mm Hg (0.4 kPa) in adults. In view of the ongoing controversy of the MOE approach being adopted to provide guidance for risk managers, the present work has used the previous PTWI for both threshold and non-threshold effects.

The PTWI for total mercury was revised in 2011 from 5 ug/kg bw/wk to 4 ug/kg bw/wk. This value also applies to inorganic mercury in food. For fish and shellfish, the methylmercury PTWI is 1.6 ug/kg bw/wk. In the present risk assessment, where fish consumption is a mixture of wild caught and store-purchased tinned fish, the total mercury PTWI has been adopted for all food.

Table 15 summarises both the PTWI values current in 2010 (and adopted for this study) and the revised JECFA reference health-based values used for each contaminant metal.

Table 17: Health-based reference values for ingestion of contaminant metals

Contaminant	PTWI adopted for this study	JECFA
Total arsenic (food)[1]	150 µg/kg bw/wk	MOE
Inorganic arsenic[2]	15 µg/kg bw/wk	MOE
Cadmium	7 µg/kg bw/wk	25 µg/kg bw (PTMI)
Lead	25 µg/kg bw/wk	MOE
Inorganic mercury	4 µg/kg bw	4 µg/kg bw (PTWI)
Methylmercury	1.6 µg/kg bw	1.6 µg/kg bw (PTWI)

1. The arsenic PTWI of 15 µg/kg bw/wk has been adjusted to take into account that inorganic arsenic is only about 10% of the total arsenic in food (US FDA 1993; Kohlmeyer et al 2003).
2. The total arsenic in food is converted to inorganic arsenic by dividing by 10 when food is considered in the aggregated multi-media exposure scenarios.

5.5.2 Estimation of contaminant metal exposure and essential micronutrient intake for the food exposure route

Estimated adult dietary exposures for the contaminant metals for the Project communities is derived from a combination of data from the:

- Surveys reported in the SIA (bodyweights and food frequency) (Bentley, 2016).
- Surrogate communities on the Ok Tedi/Fly River (unit food consumption and Market Basket Survey) (OKTFLY CHS). This is a comprehensive dataset collected and verified with repeated sampling over many years. Other datasets from similar communities were considered for use in the HIA but the OKTFLY CHS is the most robust.

There are some caveats in the necessary utilisation of the data from the surrogate communities. In an analysis of several extensive Total Diet Studies in PNG, Bentley (CEH 2006) notes that it is important to ensure a comprehensive coverage of food samples for contaminant metal analysis. The food items are selected on the basis that these are:

- Consistent with a “realistic” nutritionally acceptable diet.
- Include the most common foods from each food category actually consumed in each region.
- Specifically target foods (such as pork liver, prawns) that, while of anticipated low consumption are known to be metal bioaccumulators.

Bentley (CEH 2006) notes specifically that arsenic levels in foods can be elevated in fish and prawns. While it is common to see elevated levels in prawns the elevated levels in fish are “almost certainly a consequence of the particular fish species analysed, and does not reflect any difference in the overall environmental levels.” Bentley (CEH 2006) also notes that the levels of cadmium can be significantly elevated in pork liver but that this food component is a minor component of total food consumption.

With respect to mercury levels in foods, Bentley (CEH 2006) notes that mercury in fresh water fish samples in the OKTFLY CHS were somewhat higher than that of the other international total diet studies, but comparable with other total diet studies in PNG. Similarly, the levels of mercury in pork flesh and pork liver were considerably higher than the results from international studies while for all other food products, including all nuts, fruit, vegetables and store purchased foods the mercury levels were at the laboratory analytical detection limits. The elevated mercury in aquatic foods (and some terrestrial mammalian meats) is a well-recognised feature of the OKTFLY CHS Regions 3 and 4.

The BMT WBM (2018) reports sampling undertaken to determine the baseline tissue metal concentrations in aquatic biota (i.e. fish and prawns). The report notes that there were distinct differences in the composition of fish fauna between lowland and mid-catchment river ecosystem types and those found in upland river types. Of note were the apparent absence/ low abundance of non-native species in upland river sites, but a numerical dominance of these species in mid-catchment and lowland river systems. Many of the exotic fish species have been introduced to PNG to provide a human food source. Samples were collected from eight fish species and one prawn species (a total of 179 flesh samples). Mercury concentrations of one fish flesh tissue sample at a Lowland River site in the Sepik River equalled the ANZFA Maximum Level (ML) guideline and FAO WHO Standard value of 0.5 mg/kg. All other samples had concentrations below relevant guidelines and standards. Zinc was recorded in all fish tissue samples, ranging from 2.3 to 25 mg/kg in fish flesh tissue. The majority of sites had fish tissue samples with zinc concentrations greater than the 15 mg/kg ANZFA Generally Expected Levels (GEL). Lead was typically recorded in non-detectable to low concentrations in flesh tissue samples, with the exception of one sample that had a slightly higher concentration than recorded elsewhere (0.13 mg/kg). Low concentrations of selenium were recorded in fish tissue samples (0.05 to 1.9 mg/kg). Arsenic and cadmium were usually below the Limit of Detection for flesh tissue samples. There were no major differences in arsenic and cadmium concentrations between catchments or habitat types. In the Hydrobiology (2011) report, samples were collected from nine species of fish and one prawn (a total of 368 flesh samples). Only three samples of fish flesh showed exceedances against ANZFA/FSANZ Generally Expected Levels (1 for Se, 2 for Zn. BMT WBM 2018 Table 5-16). Mercury concentrations were relatively high in single samples of the flesh of two species; however, neither of these tissue concentrations is above ANZFA Food

Standards for Hg for single fish (1.0 mg/kg). Arsenic was detected at low levels in fish tissue samples at three Sepik River sites. Selenium, manganese and zinc were detected in all fish throughout the catchment, at similar concentrations (for each individual metal). These fish samples are of limited utility in the present report especially as the flesh samples were not analysed in the manner recommended by Codex for a total diet study. It is likely that if the fish samples had been prepared to Codex standards (i.e. ready to eat) the mercury levels would be lower. Further baseline work will be needed to confirm this. As there is no easy rationale for removing or substituting particular food results from the OKTFLY CHS reports, that surrogate data is used as-is.

An inspection of the food frequency data from the Project communities (Table 16 below) shows that fresh fish is an important dietary component in all communities except the mine area communities (with one exception) and that pork is a low frequency staple in most of the communities. The surrogate Region 2 communities have relatively low fish consumption and for this commodity may not be a good match for the infrastructure corridor communities; the absence of food frequency data for this Social Catchment should be remedied for any future analyses. The need to use surrogate metal concentration data for all bioaccumulating foods in the present report risks an artefactual finding of elevated levels of metals in some food products in the Project villages. While this may be an artefact it is part of the surrogate community dataset and is the most representative data available without a total diet study in the Project communities. This constitutes a very conservative assumption of dietary exposure to metals.

Table 18: Food frequency in Project and OKTFLY communities (days/year)

Village	Location	Sweet potato	Cassava	Taro	Yam	Banana	Sago	Coconut	Rice	Pork	Other meats	Fresh fish
Sokamin	Mine area											
Wameimin 1	Mine area	356	160	365	64	132	28	0	24	24	24	24
Wameimin 2	Mine area	365	255	365	0	236	78	0	41	24	24	24
Amaromin	Mine area	365	93	321	0	221	151	0	24	24	24	24
Ok Isai	Mine area	293	41	365	41	224	41	24	339	24	24	34
Wabia	Mine area	365	57	357	34	305	198	38	161	24	24	45
Paupe	Mine area	124	62	163	0	54	24	24	28	28	28	365
Samou	Mine area											
Uramesin 2	Infrastructure corridor (new road)											
Temsapin	Infrastructure corridor (new road)											
Hotmin	Infrastructure corridor (new road)	187	38	365	0	90	167	24	27	24	24	357
Idam 1	Infrastructure corridor (new road)											
Idam 2	Infrastructure corridor (new											

Village	Location	Sweet potato	Cassava	Taro	Yam	Banana	Sago	Coconut	Rice	Pork	Other meats	Fresh fish
	road)											
Wokomo 1	Infrastructure corridor (new road)											
Bisiabru	Infrastructure corridor (new road)											
Aminii	Infrastructure corridor (existing road)											
Kwomtari	Infrastructure corridor (existing road)											
Itomi	Infrastructure corridor (existing road)											
Kilifas	Infrastructure corridor (existing road)											
Sumumini	Infrastructure corridor (existing road)											
Imbrinis	Infrastructure corridor (existing road)											
Auom 3	Frieda River corridor	24	24	24	0	24	365	24	24	24	24	365
Iniok	Sepik River corridor	56	69	60	51	38	365	24	24	24	24	365
Kubkain	Sepik River corridor	88	78	96	71	260	365	365	44	215	58	365
Tauri	Sepik River corridor											
Swagup	Sepik River corridor	24	24	24	24	27	365	148	27	24	45	365
Yessan	Sepik River corridor	24	24	27	24	38	365	73	24	24	48	365
Ambunti	Sepik River corridor	70	24	35	24	107	365	138	72	24	48	365
Pagwi	Sepik River corridor											
Sapanaut	Sepik River corridor	24	24	24	24	24	365	125	24	24	48	365
Moim	Sepik River corridor											
Kanamimbit	Sepik River corridor											
Angoram	Sepik River corridor	77	37	80	24	170	365	179	183	37	54	365
Bin	Sepik River corridor	75	48	78	32	241	365	241	35	24	48	358
OKTFLY CHS communities												
Region1		78	78	78	24	234	234	24	234	24	78	234
Region 2		78	24	234	78	365	234	24	24	24	24	24
Region 4		365	365	78	24	234	365	234	78	2	78	365

Village	Location	Sugar cane	Fresh fruit	Nuts	Green vegetables	Yellow vegetables	Flour	Tinned fish/meat	Milk	Sugar
Sokamin	Mine area									
Wameimin 1	Mine area	39	58	32	335	72	24	28	24	28
Wameimin 2	Mine area	24	31	24	365	24	24	24	24	24
Amaromin	Mine area	70	51	24	237	66	24	24	24	24
Ok Isai	Mine area	24	24	24	303	54	160	340	237	288
Wabia	Mine area	34	44	31	357	62	92	197	69	115
Paupe	Mine area	24	32	39	365	24	24	28	24	24
Samou	Mine area									
Uramesin 2	Infrastructure corridor (new road)									
Temsapin	Infrastructure corridor (new road)									
Hotmin	Infrastructure corridor (new road)	45	24	24	365	48	24	24	24	24
Idam 1	Infrastructure corridor (new road)									
Idam 2	Infrastructure corridor (new road)									
Wokomo 1	Infrastructure corridor (new road)									
Bisiabru	Infrastructure corridor (new road)									
Aminii	Infrastructure corridor (existing road)									
Kwomtari	Infrastructure corridor (existing road)									
Itomi	Infrastructure corridor (existing road)									
Kilifas	Infrastructure corridor (existing road)									
Sumumini	Infrastructure corridor (existing road)									
Imbrinis	Infrastructure corridor (existing road)									
Auom 3	Frieda River corridor	24	24	24		24	24	24	24	24
Iniok	Sepik River corridor	24	47	38	70	88	38	52	24	24
Kubkain	Sepik River corridor	24	54	41	365	64	24	34	0	28
Tauri	Sepik River corridor									
Swagup	Sepik River corridor	24	24	24	172	24	24	27	24	41
Yessan	Sepik River corridor	24	24	24	80	24	24	24	24	24
Ambunti	Sepik River corridor	24	29	26	185	51	72	40	35	35
Pagwi	Sepik River corridor									
Sapanaut	Sepik River corridor	24	24	24	109	24	24	24	24	24
Moim	Sepik River corridor									
Kanamimbit	Sepik River corridor									
Angoram	Sepik River corridor	24	27	24	187	48	37	132	83	94
Bin	Sepik River corridor	24	24	24	224	72	24	24	24	24
OKTFLY CHS communities										
Region1		78	234	234	365	78	234	312	41.6	78
Region 2		78	234	78	365	24	78	102	10	24
Region 4		234	24	24	365	78	234	156	83	78

Data for OKTFLY CHS Regions 1-4 is based on per/week food consumption adjusted for seasonal unavailability while data for Project villages is from unadjusted Food Frequency questionnaires.

Contaminants and essential metals in food

The following data have been used to estimate mean contaminant metal exposure and essential micronutrient intake from the food pathway for the Project communities (see Chapter 7 Risk Characterisation).

- The adult (18+ years) weight values for the Project communities, as shown in Table 19. Only the adult mean values are used in the aggregated risk assessment. These data are from the anthropometric values reported in CEH (2010a, 2010b, 2011, 2016). Only one dataset is available for Social Catchments 1B and 1C therefore collection of additional baseline anthropometric data is recommended for future analyses.
- The weekly food intakes for the OKTFLY surrogate communities, as shown in Table 18.
- The Market Basket Survey of contaminant levels in food products from the OKTFLY CHS, as shown in Table 21.

Table 19: Adult Weight-for-age for the Project communities (all values kilogram)

Community	Project location	Male	Female
Sokamin	Mine area	-	-
Wameimin 1	Mine area	57.6	48
Wameimin 2	Mine area	60.1	51
Amaromin	Mine area	59.1	47.4
Ok Isai	Mine area	64.9	54.6
Wabia	Mine area	61.4	53.8
Paupe	Mine area	61.4	51.3
Samou	Mine area	58.3	47.8
Mean		**60.3**	**50.6**
Uramesin 2	Infrastructure corridor (new road)	-	-
Temsapin	Infrastructure corridor (new road)	-	-
Hotmin	Infrastructure corridor (new road)	59.7	54.4
Idam 1	Infrastructure corridor (new road)	-	-
Idam 2	Infrastructure corridor (new road)	-	-
Wokomo 1	Infrastructure corridor (new road)	-	-
Bisiabru	Infrastructure corridor (new road)	-	-
Aminii	Infrastructure corridor (existing road)	-	-
Kwomtari	Infrastructure corridor (existing road)	-	-
Itomi	Infrastructure corridor (existing road)	-	-
Kilifas	Infrastructure corridor (existing road)	-	-
Sumumini	Infrastructure corridor (existing road)	-	-
Imbrinis	Infrastructure corridor (existing road)	-	-

Community	Project location	Male	Female
Auom 3	Frieda River corridor	60.2	50.2
Iniok	Sepik River corridor	70.2	54.6
Kubkain	Sepik River corridor – rural	65.9	58.8
Tauri	Sepik River corridor - rural	-	-
Swagup	Sepik River corridor - rural	66.8	55.4
Yessan	Sepik River corridor - rural	62.8	52.5
Ambunti	Sepik River corridor – township	67.5	63.4
Pagwi	Sepik River corridor - rural	-	-
Sapanaut	Sepik River corridor - rural	66.8	58.5
Moim	Sepik River corridor - rural	-	-
Kanamimbit	Sepik River corridor - rural	-	-
Angoram	Sepik River corridor – township	67.2	53.7
Bin	Sepik River corridor - rural	65	58
Mean		**65.8**	**56.1**

Table 20: OKTFLY CHS surrogate - Regional adult food consumption (grams/week)

	Region 1	**Region 2**	**Region 4**
Food	g/week	g/week	g/week
Sweet potato	1,582	1,062	223
Cassava	202	363	748
Taro	387	801	68
Yam	0	646	1,222
Irish potato	16	-	-
Banana	1,101	2,881	218
Sago	27	1,049	1,427
Coconut	29	14	31
Rice	3,069	232	477
Pork	72	-	23
Lamb	16	-	-
Chicken	817	39	-
All other meats		27	608
Fresh fish	24	22	9
Sugar cane	48	79	-
Fresh fruit		60	-
Peanut and local nuts	3	-	-
Smoked fish	-	-	96
Prawn/shrimps	-	-	16
Aibika/other green vegetables	918	1,206	102
Yellow vegetables	13		254
Tinned fish	308	26	-
Tinned meat	32	38	-

	Region 1	**Region 2**	**Region 4**
Food	g/week	g/week	g/week
Flour	126	-	30
Eggs	-	-	-
Milk powdered	35	-	-
Sugar	92	-	-
Bread and other cereals	202	19	-
Biscuits	204	-	-
Total	**9,323**	**8,563**	**5,551**

Table 21: Contaminant levels in food products - selected Market Basket Survey data from OKTFLY CHS - Regions 1-4, adults only (Region 3 values are included for information only and were not used in the total contaminant intake calculations)

Contaminant and essential metals in food products. All values mg/kg									
Arsenic					Cadmium				
	Region 1	Region 2	Region 3	Region 4		Region 1	Region 2	Region 3	Region 4
Banana	0.025	0.03	0.025	0.025	Banana	0.005	0.01	0.005	0.005
Cassava tuber	0.025	0.03	0.025	0.025	Cassava tuber	0.005	0.01	0.005	0.005
Chicken	0.025	0.03	0.025	0.025	Chicken	0.013	0.08	0.005	0.005
Coconut	0.025	0.03	0.025	0.025	Coconut	0.005	0.01	0.005	0.005
Fish fresh	3.812	0.03	0.025	0.025	Fish fresh	0.011	0.01	0.005	0.005
Fish (tinned)	1.34	1.34	1.34	1.34	Fish (tinned)	0.06	0.06	0.06	0.06
Flour and products	0.025	0.025	0.025	0.025	Flour and products	0.005	0.005	0.005	0.005
Fruit fresh	0.025	0.03	0.025	0.025	Fruit fresh	0.005	0.01	0.005	0.01
Green vegetables	0.025	0.03	0.025	0.025	Green vegetables	0.005	0.01	0.005	0.005
Meat (other) and bush meat		0.03	0.025	0.032	Meat (other) and bush meat		0.01	0.005	0.005
Meat (tinned)	0.025	0.025	0.025	0.025	Meat (tinned)	0.005	0.005	0.005	0.005
Milk powder	0.025	0.025	0.025	0.025	Milk powder	0.005	0.005	0.005	0.005
Peanuts and local nuts	0.025	0.03	0.025		Peanuts and local nuts	0.005	0.02	0.005	
Pork	0.025	0.03	0.025	0.028	Pork	0.005	0.02	0.005	0.007
Potato	0.025				Potato	0.005			
Prawns and shellfish		0.05	0.638	1.279	Prawns and shellfish		0.03	0.405	1.176
Rice	0.07	0.07	0.07	0.07	Rice	0.005	0.005	0.005	0.005
Sago	0.025	0.03	0.025	0.025	Sago	0.005	0.01	0.005	0.009
Sugar	0.025	0.025	0.025	0.025	Sugar	0.005	0.005	0.005	0.005
Sugar cane	0.025	0.03	0.025	0.025	Sugar cane	0.005	0.01	0.013	0.005
Sweet potato	0.025	0.03	0.025	0.025	Sweet potato	0.005	0.01	0.005	0.005
Taro tuber	0.025	0.03	0.025	0.025	Taro tuber	0.005	0.01	0.005	0.005
Yam tuber		0.03	0.025	0.03	Yam tuber		0.01	0.005	0.01
Yellow vegetables	0.025	0.03	0.025	0.025	Yellow vegetables	0.005	0.01	0.005	0.005

Contaminant and essential metals in food products. All values mg/kg									
Copper					Lead				
	Region 1	Region 2	Region 3	Region 4		Region 1	Region 2	Region 3	Region 4
Banana	1.03	0.95	0.84	0.71	Banana	0.025	0.05	0.025	0.025
Cassava tuber	0.75	0.47	0.96	0.53	Cassava tuber	0.025	0.03	0.025	0.095
Chicken	1.1	1.59	1.65	0.82	Chicken	0.025	0.13	0.025	0.101
Coconut	2.77	3.95	2.35	6.34	Coconut	0.025	0.03	0.025	0.025
Fish fresh	0.15	0.29	0.37	0.23	Fish fresh	0.109	0.12	0.025	0.116
Fish (tinned)	1.28	1.28	1.28	1.28	Fish (tinned)	0.025	0.025	0.025	0.025
Flour and products	1.82	1.82	1.82	1.82	Flour and products	0.025	0.025	0.025	0.025
Fruit fresh	0.74	0.59	0.54	1.11	Fruit fresh	0.033	0.03	0.025	0.054
Green vegetables	1.31	1.39	0.97	1.04	Green vegetables	0.047	0.05	0.044	0.044
Meat (other) and bush meat		1.04	1.43	2.04	Meat (other) and bush meat		0.05	0.025	0.037
Meat (tinned)	1.39	1.39	1.39	1.39	Meat (tinned)	0.025	0.025	0.025	0.025
Milk powder	0.14	0.14	0.14	0.14	Milk powder	0.025	0.025	0.025	0.025
Peanuts and local nuts	7.76	3.01	11.96		Peanuts and local nuts	0.025	0.03	0.025	
Pork	1.82	1.16	2.05	1.68	Pork	0.268	0.03	0.158	0.025
Potato	1.2				Potato	0.025			
Prawns and shellfish		8.62	5.5	29.89	Prawns and shellfish		0.1	1.605	0.333
Rice	0.85	0.85	0.85	0.85	Rice	0.025	0.025	0.025	0.025
Sago	0.25	0.33	0.21	0.5	Sago	0.025	0.03	0.025	0.145
Sugar	0.05	0.05	0.05	0.05	Sugar	0.025	0.025	0.025	0.025
Sugar cane	0.13	0.12	0.15	0.09	Sugar cane	0.025	0.03	0.025	0.025
Sweet potato	1.39	1.67	0.94	0.95	Sweet potato	0.025	0.03	0.025	0.025
Taro tuber	1.09	1.22	1.63	1.8	Taro tuber	0.025	0.03	0.025	0.025
Yam tuber		1.55	1.97	0.81	Yam tuber		0.03	0.025	0.03
Yellow vegetables	0.43	1.78	0.85	1.01	Yellow vegetables	0.061	0.08	0.025	0.025

Contaminant and essential metals in food products. All values mg/kg									
Mercury					Selenium				
	Region 1	Region 2	Region 3	Region 4		Region 1	Region 2	Region 3	Region 4
Banana	0.005	0.01	0.005	0.005	Banana	0.025	0.03	0.025	0.025
Cassava tuber	0.005	0.01	0.005	0.005	Cassava tuber	0.025	0.03	0.025	0.025
Chicken	0.005	0.01	0.102	0.035	Chicken	0.231	0.4	0.449	0.344
Coconut	0.005	0.01	0.005	0.005	Coconut	0.025	0.03	0.025	0.025
Fish fresh	0.005	0.18	0.398	0.335	Fish fresh	0.835	0.29	0.324	0.257
Fish (tinned)	0.05	0.05	0.05	0.05	Fish (tinned)	1.03	1.03	1.03	1.03
Flour and products	0.005	0.005	0.005	0.005	Flour and products	0.18	0.18	0.18	0.18
Fruit fresh	0.005	0.01	0.005	0.005	Fruit fresh	0.025	0.03	0.025	0.025
Green vegetables	0.007	0.01	0.005	0.006	Green vegetables	0.025	0.03	0.025	0.025
Meat (other) and bush meat		0.5	0.019	0.005	Meat (other) and bush meat		1.08	0.891	0.251
Meat (tinned)	0.005	0.005	0.005	0.005	Meat (tinned)	0.09	0.09	0.09	0.09
Milk powder	0.005	0.005	0.005	0.005	Milk powder	0.14	0.14	0.14	0.14
Peanuts and local nuts	0.005	0.01	0.035		Peanuts and local nuts	0.025	0.03	0.066	
Pork	0.054	0.07	0.569	0.143	Pork	0.186	0.6	1.321	1.205
Potato	0.005				Potato	0.025			
Prawns and shellfish		0.02	0.057	0.127	Prawns and shellfish		0.35	0.452	0.902
Rice	0.005	0.005	0.005	0.005	Rice	0.025	0.025	0.025	0.025
Sago	0.005	0.01	0.005	0.012	Sago	0.025	0.03	0.025	0.025
Sugar	0.005	0.005	0.005	0.005	Sugar	0.025	0.025	0.025	0.025
Sugar cane	0.005	0.01	0.005	0.005	Sugar cane	0.025	0.03	0.025	0.025
Sweet potato	0.005	0.01	0.005	0.005	Sweet potato	0.025	0.03	0.025	0.025
Taro tuber	0.005	0.01	0.005	0.005	Taro tuber	0.025	0.03	0.025	0.025
Yam tuber		0.01	0.005	0.01	Yam tuber		0.03	0.025	0.03
Yellow vegetables	0.005	0.01	0.005	0.005	Yellow vegetables	0.025	0.05	0.025	0.025

Contaminant and essential metals in food products. All values mg/kg				
Zinc				
	Region 1	Region 2	Region 3	Region 4
Banana	1.75	1.48	1.76	1.68
Cassava tuber	8.32	4.71	4.46	2.21
Chicken	21.92	23.78	26.98	17.5
Coconut	3.87	5.65	5.46	7.5
Fish fresh	8.97	7.13	5.44	7.22
Fish (tinned)	13.5	13.5	13.5	13.5
Flour and products	6.95	6.95	6.95	6.95
Fruit fresh	1.05	0.75	1.73	1.55
Green vegetables	5.43	4.83	3.82	3.69
Meat (other) and bush meat		30.12	51.6	45.61
Meat (tinned)	22.95	22.95	22.95	22.95
Milk powder	25.43	25.43	25.43	25.43
Peanuts and local nuts	17.54	6.63	29.38	
Pork	39.12	41.03	52.45	41.7
Potato	3.7			
Prawns and shellfish		19.53	120.07	27.39
Rice	4.67	4.67	4.67	4.67
Sago	0.3	0.86	0.17	1.17
Sugar	0.06	0.06	0.06	0.06
Sugar cane	0.32	0.41	0.38	0.31
Sweet potato	3.13	2.58	1.6	1.8
Taro tuber	6.3	8.84	19	7
Yam tuber		3.69	3.27	2.16
Yellow vegetables	1.32	11.33	5.96	7.28

Bioaccumulation
Fish are potential bioaccumulators of toxic elements and a bioaccumulation study was conducted by Tetra Tech (2018) to model the potential bioaccumulation of Al, Cu and Cd in the aquatic food chain in the ISF. The modelling scenarios investigated the aquatic food zones in the littoral (<7 m deep) and pelagic (>7 m deep) zones during mine operation when tailings and waste rock will be deposited in the ISF (modelled at Year 10) and post-closure (50 years after deposition has ceased). Average flow and low flow conditions were modelled and estimates of bioaccumulation in various trophic levels algae, plants, aquatic invertebrates and fish were generated.

There are expected to be limited fish species that would likely be harvested from the ISF: assumed to be Red-bellied pacu, Papillate catfish, Rubber mouth, Tilapia and Silver barb. The Tetra Tech (2018) literature review found that edible fish harvested for consumption have much lower bioaccumulation rates than the lower trophic levels, and the literature does not support food chain biomagnification of the selected metals in freshwater lentic systems such as the ISF.

The modelling predicts that all three metals will have higher fish tissue concentrations in the majority of scenarios examined than what is predicted under the baseline condition (measured fish concentrations – see Hydrobiology, 2011, and, BMT WBM, 2018). Table 6 in Tetra Tech (2018) summarises the results of the modelling. However, all the values for Cd and Cu are predicted to remain below the health guideline values (HGV) set by the European Commission (EC) and Food Safety Australia New Zealand (FSANZ) (Cu 2.0 mg/kg – FSANZ; Cd 0.05 mg/kg, EC); Al does not have a health guideline value. Additionally, the maximum values for Cu and Cd are comparable to the values seen in the surrogate communities and used in the risk calculations. The table below shows the values for Cu and Cd concentrations in fresh fish from Regions 1, 2, and 4 as used in the risk calculations, and the baseline and maximum values for these metals modelled for various scenarios by Tetra Tech (2018).

Health guideline value		Cu	Cd
		2.0	0.05
Values in risk calculations for fresh fish (mg/kg)	Region 1	0.15	0.011
	Region 2	0.29	0.01
	Region 4	0.23	0.005
Tetra Tech (2018) modelling	Baseline	0.23	0.002
	Pelagic, low flow, Active FRCGP operations	0.18	0.013
	Littoral, average flow, FRCGP post-closure	0.36	0.007

In the littoral zone, fish tissue concentrations of Al, Cu and Cd are predicted to be nearly the same for the active operations and post-closure scenarios. Compared to the baseline values, all three metals had elevated concentrations but were below health guideline values for fish tissues.

In the pelagic zone, predicted metal concentrations in fish tissue were highest during low flow conditions. Post-closure concentrations of Al and Cd were predicted to be lower than during active operations.

All predicted values in all scenarios were below health guideline values for each metal and hence consumption of fish caught in the ISF during operations or post-closure are not predicted to pose a health risk to humans.

6 Risk estimation

General approach

Health hazard characterisation involves the identification of environmental hazards via the collection, evaluation and interpretation of the available evidence concerning the association between environmental factors and health. Health risk assessment involves the quantification of the anticipated health burden due to an environmental exposure in a specified population.

The main variables that lead to different exposure rates are:

- Human activity patterns, such as variations in occupation, recreation and lifestyle. These patterns determine actual exposures from a diverse range of micro-environments.
- Dietary patterns resulting from different socio-economic, climatic and agronomic circumstances.
- Differences in breathing rate, water and food consumption, body weight and surface area of the potentially exposed population arising from different age groups and gender.
- Adoption of different exposure factors such as soil adherence, skin permeability, bioavailability.

The previous sections have discussed the contaminant and micronutrient metal concentrations for food and the environmental media, and the possible routes of exposure and uptake of contaminated metals for the Project communities. Exposure routes taken into consideration for the Project communities were: soil (ingestion, dermal through skin contact); drinking water (ingestion); recreational water (ingestion, dermal through skin contact) and food (ingestion).

The exposure estimates can be compared with the FAO/WHO/JECFA and the US IOM internationally endorsed health values, and the national health guidelines and criteria from the US EPA and the Australian NEPC. For modelling purposes, the limit of reporting was reported by Bentley (OKTFLY CHS) as the default value for non-detects in drinking water, recreational water and soil and sediment. It is noted that adoption of these default values for non-detects does not markedly impact on the contribution of drinking water, recreational and surface water, and soil and sediment to the most realistic and maximum exposure assessment calculations. A value of 50% of the respective limits of reporting for the food data was used in the exposure assessment calculations.

The default exposure factors and limits of reporting adopted for the Project communities represented best conservative approximations for calculating the aggregated metal exposures of the adult villagers under various scenarios of daily life. While it would not be realistic to expect these values to represent every individual in a population, they have been presented as transparently as possible to permit comparisons with the approaches and factors adopted by other studies.

Mean values have been used in the actual models to ensure the use of the most reliable and robust data. Monte-Carlo analysis using ranges would give distributions of exposures, but the “tails” of the distributions, where exceedances of guidance values were likely, would be the most uncertain/unlikely parts of the distribution. The means gave an unsophisticated but highly reliable estimate of the exposure.

It is sometimes possible to evaluate all scenarios at two levels of probable contaminant exposure. The central tendency (50th percentile of the population) is the most likely amount of contaminant that a member of the population will absorb for each scenario. The upper bound (95th percentile of the population) represents the largest intake that can reasonably be expected for any individual member of the population i.e. except the most exposed 5%. However, Hattis and Silver (1994) propose that there will be greater uncertainties in estimates for the variability of the mean (standard deviation) than the actual estimate of the mean itself. A point estimate of a mean will be more certain than a point estimate of the level intended to represent the 95th percentile. The mean values have therefore been adopted for this assessment.

Caveats

This HIA must be considered a preliminary risk assessment only. Of all the data required to conduct a human health risk assessment only the metal levels in sediments from the Project area had sufficient data available to include in the assessment (see Table 20 below). The use of surrogate data in a screening risk assessment also means that the modelling of contaminant element intakes in all age groups is neither justified nor reliable. While children may have higher exposure on a bodyweight basis than adults and may be more susceptible to the greater exposure, the intrinsic uncertainties in modelling age-related differences in metal intake using surrogate data are likely to render the outcomes non-interpretable. The present report has considered intakes in healthy adults only.

Table 22: Summary of sources of exposure data

Exposure data substitution matrix	
Exposure compartment	**Data source**
Ambient air	Not required
Drinking water	OKTFLY CHS drinking water (3 Project community samples noted but not used)
Recreational water	OKTFLY CHS surface water
Soils	OKTFLY CHS (7 Project community samples noted but not used)
Sediments	Hydrobiology (2011) sediments

Exposure data substitution matrix		
Food	Bodyweights	Bentley SIA reports (CEH 2010a, b, 2011)
	Food frequency	OKTFLY CHS (The CEH SIA FF data are not useable without a matching Unit Food Consumption survey)
Food	Unit Food Consumption	OKTFLY CHS
	Market Basket Survey	OKTFLY CHS

6.1 Estimation of dietary contaminant metal exposure and essential micronutrient intake for the food pathway

Estimates of dietary exposure to contaminant metals and essential micronutrients for the Project communities were obtained by integrating the results of the mean per capita consumption of each food in Table 16, together with the results for the mean concentrations of the analyte in the individual food given in Table 17.

The results have been converted to weekly intakes per kilogram of body weight (µg/kg bw/week) by dividing the total dietary exposure by the body weight of the adults in the Project regions.

Expressing the exposures on a body weight basis permits comparison with the FAO/WHO PTWI values derived from toxicological studies. These values represent the permissible human exposure to a contaminant that has a cumulative effect on the body and is unavoidably present in otherwise wholesome and nutritious food.

6.1.1 Results and discussion

Dietary intake for the essential micronutrients copper, selenium and zinc and the contaminants arsenic, cadmium, lead and mercury

The intake of essential metals can be compared to the Recommended Dietary Intake (RDI) which is equivalent to Recommended Dietary Allowance as used in US IOM (2006). The Recommended Maximum Intake (RMI) is equivalent to the Upper Limit (UL) used by the US IOM (US IOM 2006) and represents the tolerable upper intake level from all sources (i.e. food, drinking water, air, soil and dietary supplements) which will not lead to human health risks.

The contaminant metal and arsenic intakes can be compared to the PTWI noting that the JECFA Reference Health Value for arsenic and lead are now based on a MOE approach. The PTWI values for arsenic and lead are shown here to allow a numerical comparison.

The results for the Project communities are shown in Table 21.

Table 23: Mean food contaminant metal exposure and essential micronutrient intake based on adult body weight (all values µg/kg bw/wk)

	Mean wt (kg)	As	Cd	Cu	Pb	Hg	Se	Zn
Mine	*55.5*	15.4	1.2	172.6	4.7	1.1	13.7	1,149.0
Infrastructure corridor	*57.1*	5.2	1.5	161.0	6.0	1.8	5.8	513
Sepik River corridor	*61.0*	3.1	0.96	88.4	6.4	1.4	5.8	689
PTWI		**150[1]**	**7**		**25**	**4**		
RDI				**116**			**7**	**1,227**
RMI				**1,291**			**52**	**5,165**

1. The arsenic PTWI of 15 µg/kg bw/wk has been adjusted to take into account that inorganic arsenic is only about 10% of the total arsenic.

Comment

All values of contaminant metals in the three Project groupings are below the respective PTWI values.

Intake of essential metals is below the RMI for each of copper, selenium and zinc. None of the contaminant element intakes exceed the PTWI guideline values.

6.2 Estimation of contaminant metal exposure and essential micronutrient intake for the environmental pathways water, soil and sediment

Standard default values for exposure factors

Exposure factors represent realistic input parameters for calculating the media-specific and total contaminant metal exposures and essential nutrient intakes of the adults in the Project communities. The exposure default values in all cases are conservative estimates (Table 22). The justifications for selecting each of the exposure parameters for the Project communities are described in the following sections. Only adult exposures have been modelled.

Table 24: Standard default values in exposure assessment scenarios

Variable		**US EPA 1997a**	**US EPA 2008**	**Aust enHealth 2010a**	**Project Communities[1]**
Soil ingestion (mg/d)	Adult	20	-	50	**50**
Drinking water ingestion (L/day)	Adult	1.4	1.2	1.2	**1.5**
Recreational water exposure (mL/hr)		All ages 50 mL/hr	Adults 21 mL/hr	Adults 20 mL/hr	**Adults 20 mL/hr**
Bodyweight (kg)	Adult 18 + years	70	70	70	**57.4**

1. Values adopted by the present study for the Project communities are in bold.

6.2.1 Soil ingestion values

Soil is the most important non-occupational exposure pathway which is amenable to environmental controls. The US EPA has adopted soil ingestion values of 50 mg/day for infants and 20 mg/day for children, adolescents and adults (US EPA 1997, 2008). There are orders of magnitude difference in published estimates of the prevalence, affected age groups and exposures from pica behaviour in children. The US EPA has proposed 500 mg/day, with an exposure default value of 1000 mg/day (US EPA 2008). The default values adopted for the Project villages were those recently adopted for the Australian population of 50 mg/day for adults (enHealth Council 2010a). This is a recently adopted and fairly conservative value.

6.2.2 Drinking water consumption

The Australian enHealth Council (2010a) uses a mean adult value of 2 L/day for their risk assessments. This value is acknowledged to be an over-estimate for the general population, but is used to represent “a long term average consumption rate”. The US EPA has recently revised their mean for adults from 1.4 L/day to 1.2 L/day (US EPA 1997, 2011). The consumption rates for infants, children and adolescents adopted by the US EPA are for temperate climates. Drinking water consumption rates for the Project communities (1.5 L/day for adults) have been adopted to allow for higher consumption in a tropical climate.

The amount of a contaminant absorbed through drinking water exposure has been estimated using the formula:

$ED_{DW} = (C \times IR \times EF)/BW$ where:

ED_{DW}	=	Dose from drinking water ingestion expressed as mg/kg/day
C	=	Concentration of the contaminant in the drinking water mg/L
IR	=	Ingestion Rate - the amount of drinking water consumed for the age group being considered (L/day)
EF	=	Exposure Factor generally over a life time (unitless)
BW	=	Body Weight for the age group being considered

Table 25: Contaminant element intakes from ingestion of drinking water (µg/kg bw/wk)

	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Mean	0.9	0.2	1.5	0.8	0.04	1.8	35.9

Mean values for adults - Total metals.

The calculated total metal intakes from drinking water are shown in Table 25 above. These values are an order of magnitude below the total intake values with the exception of cadmium and lead which both constitute ca. 3% of the respective PTWI values.

6.2.3 Surface/Recreational water exposure – oral route

The WHO Guidelines for Safe Recreational Water Environments assumed a contribution for recreational use of 10% of drinking water consumption i.e. ingestion of about 100 mL/hour (WHO 2003). The US EPA following a review of more recent studies, has adopted 49 mL/hour for children under 16 years of age and 21 mL/hour for adults (US EPA 2008, 2011). Australia has adopted 20 mL/hour for adults based on the US EPA value (enHealth Council 2010a). The present report has adopted a value of 20 mL/hour for the adults and an exposure duration of 2 hours/day during recreational activities.

Table 26: Arsenic and metal intakes from ingestion of surface water (µg/kg bw/wk)

	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Mean	0.080	0.016	0.096	0.068	0.003	0.161	2.372

Mean values for adults - Total metals.

The calculated total metal intakes from ingestion of surface water during recreational activities are shown in Table 26 above. These intake values are at most a tenth of the drinking water intakes and at least an order of magnitude below the total intake values.

6.2.4 Bioavailability

The bioavailability of metals is typically a function of the physical state, chemical properties and the ability to take up the specific metal in human physiological processes. While accepting that 100% bioavailability for inorganic substances from environmental media will likely over-estimate the true absorbed dose, a number of national jurisdictions have, where there is no valid evidence to support adoption of metal-specific values, accepted 100% bioavailability equating to 100% absorption as a matter of policy (e.g. enHealth Council 2010b).

Following an extensive review of the literature, Owen (1990) derived absorption coefficients for 39 chemicals via oral and inhalation routes of exposure. The absorption coefficients for the oral route are shown in Table 25. As stated above, the conservative approach of using 100% bioavailability for absorbed metals has been adopted in this HIA.

Table 27: Absorption coefficients for the oral exposure route[1]

Element	Oral (range)
Arsenic	0.88 (0.7 - 0.98)
Cadmium	0.06 (0.023 - 0.01)
Copper	0.5 (0.32 - 0.9)
Lead	0.1 (0.01 - 0.14)
Mercury (inorganic)	0.15 (0.02 - 0.15)
Selenium	0.6 (0.44 - 1.0)
Zinc	0.5

1. Applicable to all age groups.

6.3 Dermal exposures to water and soil

6.3.1 Surface waters

An approach for deciding whether to consider dermal absorption in a risk assessment is by comparing it with other pathways of exposure. For example, for a contaminated drinking-water scenario, the dermal pathway (i.e. bathing) is evaluated only if the screening analysis suggests that it will contribute at least 10% of the dose from drinking the water (USEPA, 2004b). As this is a screening risk assessment the pathway was considered in the present report to determine its significance.

Calculation of dermally absorbed doses for recreational waters used the respective permeability constants (representing the rate at which a chemical penetrates the skin) recommended by the US EPA (2011).
These values are:

- Lead: 4×10^{-6} cm/hr
- Zinc: 6×10^{-4} cm/hr
- Other metals, and arsenic and selenium: default value 1×10^{-3} cm/hr

Values representing whole body exposures were adopted (e.g. swimming) as the most conservative values. The WHO maximum length of time for daily exposure is 2 hours for adults and this has been assumed in the present report. The calculated mean surface area of Project community adults is 15,400 cm^2.

Using the mean total metal concentrations from surrogate communities (using total concentrations is a conservative approach), the calculated Dermally Absorbed Doses for the Project communities are shown in Table 26.

The amount of a contaminant in surface recreational water absorbed through dermal contact has been estimated using the formula:

$$ED_{SWD} = (C \times P \times SA \times ET \times 10^{-3})/BW \text{ where:}$$

ED_{SWD}	=	Estimated Dose through dermal water absorption expressed as µg/kg bw/wk
C	=	Concentration of the contaminant metal in the water mg/L
P	=	Permeability Constant (cm/hour) as discussed in the text above
SA	=	Surface Area of the skin that is exposed to the contaminated water expressed as cm^2
ET	=	Exposure Time (hours/day) converted to ET x 7 for weekly values and assuming one immersion per day for adults
BW	=	Body Weight for the age group being considered

Table 28: Dermally Absorbed Doses from surface/recreational water (all values µg/kg bw/wk)

Group	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Zinc
Adult 18 + years	0.019	0.004	0.023	6.4E-05	0.001	0.038	0.338

All these values are at least 2 orders of magnitude below the intakes from the food pathway. Despite the small contribution from this exposure pathway it was included in the exposure scenarios for this screening risk assessment.

6.3.2 Soil and sediments

Soil adhesion factors

The ICRP (2002) provides estimates of the amount of soil that might adhere to the skin of people of various ages estimated from the total body surface area for each age group. Re-calculation of the data, taking into account the mean height and weight of the Project village adult populations resulted in values approximately 85% of the ICRP (2002) data.

Dermally absorbed doses for the soil and sediment compartment were calculated allowing an exposed area of 30%. The Australian soil adherence factor of 0.5 mg soil/cm^2 was adopted, together with a default dermal bioavailability factor of 1% for all metals as specific data was unavailable (US EPA 1996, enHealth Council 2010a). Adults were assumed to have a surface area of 1.54 m^2 and this equates to a mean value of 2,310 mg of soil attached. The dermally absorbed doses are shown in Table 29 below.

Table 29: Dermally Absorbed Doses from village soils (all values µg/kg bw/wk)

Group	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Zinc
Adult 18 + years	0.019	0.001	0.176	0.048	0.002	0.011	0.259

All these values with the exception of lead are at least two orders of magnitude below the intakes from the food pathway and make little impact on total exposure in the intake modelling and scenarios. However they were modelled in the exposure scenarios of this screening risk assessment.

The dataset for the sediment exposure compartment was derived from the Hydrobiology (2011) report. All values in Table 30 below, except for lead, are at least two orders of magnitude below the calculated food intake. However they were modelled in the exposure scenarios of this screening risk assessment.

Table 30: Dermally Absorbed Doses from natural sediments (all values µg/kg bw/wk)

Group	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Zinc
Adult 18 + years	0.035	0.001	0.284	0.166	0.0003	0.005	0.448

6.4 Estimation of cancer risk for As

The published literature indicates that total arsenic exposure induces a range of health effects including cardiovascular diseases, developmental effects, neurological and neurobehavioral disorders, diabetes, hearing loss, haematological disorders and various types of cancer. It is clear that the severity of adverse health effects are related to the chemical form of arsenic, and is also time- and dose-dependent (Tchounwou et al 2004).

Ingestion of inorganic arsenic in drinking water has been associated with increased risk of cancers of the skin, bladder, lung, liver, kidney, and prostate. The International Agency for Research on Cancer classifies inorganic arsenic compounds within Group 1 i.e. carcinogenic to humans. The US EPA has also classified arsenic as “known to produce cancer in humans”, a Group A carcinogen (see Appendix 1, Section A.1.4). Cancer risks for inorganic arsenic are calculated with the assumption that there is no level without risk i.e. no threshold.

6.4.1 Inhalation route

Exposure to contaminant metals in ambient air has not been modelled as part of this assessment. The SLR (2018) report indicates that this pathway will not produce levels of dust or particles containing contaminant metals or notifiable air quality pollutants (NO_2, SO_2) that exceed international guidelines during construction or operation of the mine.

6.4.2 Ingestion route

Differences in behaviour and physiology may result in infants and children receiving higher absorbed doses in relation to their body weight than adults for a given set of exposure conditions. For example, children are more likely to ingest arsenic-contaminated soil, either intentionally, or by putting dirty hands in their mouths. To take into account these differences, and that the exposures may be intermittent or of varying levels over time, the most reliable figures for cancer induction by arsenic are based on the calculation of life time exposure using the life time average daily dose LADD (US EPA 2005). In order to compare the estimated exposures to inorganic arsenic calculated for each of the receptor age groups, it is necessary to convert the individual exposures into a life time chronic daily intake (∑ LADD). The total life time LADD for the four life stages are shown in the formula:

$$\boldsymbol{\sum LADD = \frac{(EDI_{INFANT} \times Time_A) + (EDI_{CHILD} \times Time_B) + (EDI_{ADOLESCENT} \times Time_C) + (EDI_{ADULT} \times Time_D)}{70\ Years}}$$

where:

$\sum LADD$	=	Life time Average Daily Dose µg/kg bw/day
EDI_{GROUP}	=	Estimated Daily Intake of age group µg/kg bw/day
Time ($_{A-D}$)	=	Time spent in each life stage (years) infant 5, child 6, adolescent 6, adult 53

From the formula it can be seen that the total LADD is the sum of the fractional LADD contributions made by exposures that occur in each life stage (receptor age group).

In the absence of suitable data for each life stage, no estimates of cancer risk are presented in the present report. As further baseline data becomes available these calculations will be conducted using the methodology outlined below. The multi-compartment risk analysis (Section 7.2) indicates that total arsenic intake from all routes is very unlikely to present a cancer risk to Project communities.

7 Risk characterisation

7.1 Single compartment risk analysis

7.1.1 Drinking water

The data from the control villages in Regions 1, 2 and 4 of the OKFLY CHS were used as surrogate values for the Project communities.

Within the OKTFLY CHS area, there were no significant differences between the mean metal results for all of the study analytes for the main drinking water sources (tanks, springs, creeks and Lake Murray) either between regions or in impact and control villages within a single region. The results indicated that the water supplies had relatively low dissolved concentrations of the metals of concern. That this data is an appropriate surrogate for the Project communities is supported by the limited dissolved metal data from Hydrobiology (2011). All values were markedly less than the WHO, United States and Australian drinking water guidelines and criteria values and the PNG raw drinking water standards.

7.1.2 Surface/Recreational waters

The OKTFLY CHS surface/recreation water contaminant and essential metal levels were used as surrogate values for the Project communities. There are no studies of community river-use patterns for any of the five geographic regions in the OKTFLY CHS nor for the Project villages and hence the present study assumes that for all Project villages the recreational water-use patterns are identical. The present study also assumes, as part of the worst case approach, that recreational water use occurs on a daily basis at all regions. Clearly, this significantly exaggerates the situation, particularly in Region 1, but without time-activity data for the communities, this is a valid approach.

In the surrogate communities, the mean dissolved metal concentrations for recreational waters for all of the target contaminants at all monitored impact and control communities within the four relevant geographic regions were an order of magnitude below the respective WHO Recreational Water Guideline values.

The BMT WBM (2018) and Hydrobiology (2011) reports show that the dissolved metal levels in the mine area Project communities resulting from natural mineralisation led to slightly elevated dissolved Cd, Cu and Zn in the upper rivers and creeks. All other metals analysed generally were present at or below the respective analytical detection limits. All total metal concentrations at all locations were within the limits derived from criteria established in the WHO Recreational Water Guidelines.

7.1.3 Soil and sediments

For the surrogate communities, the metal levels in the natural sediments were generally comparable with the corresponding village and garden soils. Typically, the observed values for Regions 1 and 2 expressed as a percentage of the Australian HIL residential values were: arsenic 4% – 9%; cadmium 2%; copper 2.5% – 10%; mercury 3%; lead 3% – 10% and zinc 1%. Soils and natural sediments in the Regions 3 and 4 villages were consistently less than 5% of the respective HILs.

The data for the sediments in the Project communities was from the Hydrobiology (2011) report while the soils were modelled using surrogate values from the OKTFLY CHS. In the Project sediments the mean concentrations for copper, lead and zinc in the natural sediments were slightly elevated at the communities in Region 1, resulting from natural mineralisation. Table 31 below shows that all reported values were well below the Australian NEPM standards (HILs).

Table 31: Total metal concentrations in Project community sediments (mg/kg)

	As	Cd	Cu	Pb	Hg	Se	Zn
Project communities Mean	12.57	0.5	101	58.9	0.1	1.75	159.2
HIL A Residential	100	20	6000	300	10	200	7400
HIL C Recreational	300	90	17,000	600	13	700	30,000
% of HIL A	13	2.5	1.7	20	1	1	2

7.1.4 Food

The data from the control villages in Regions 1, 2 and 4 of the OKFLY CHS were used as surrogate values for the Project communities.

The OKTFLY CHS Market Basket Survey (OKTFLY CHS MBS) provided a picture of the dietary patterns and dietary-contaminant intakes for the people of the regions in the OTML mine area and along the Ok Tedi-Fly River system to the Fly estuary. The results showed that there were no substantial differences in contaminant and essential metal concentrations in individual food products between the control villages of any single geographic region. Between regions, the mean metal concentrations in food were again similar, other than a minor elevation in lead from the Region 2 villages and mercury at the Middle-Lower Fly River, Fly estuary and Lake Murray.

For those products that were targeted for inclusion in the Market Basket Survey on the basis of their known bioaccumulation of the metals of concern, almost without exception, proved to have metal concentrations comparable with the corresponding values from the Market Basket Survey conducted in the Porgera-Lagaip-Strickland Rivers and Lake Murray between 2002 – 2004, (Bentley 2004b). Where there were comparable food commodities, the results were also similar to those reported in the Australian Market Basket Surveys 1994 - 2000, and the US FDA Total Diet Studies 1991 – 1999.

Table 32 below demonstrates that contaminant levels in food (derived from the surrogate data) are well below the PTWI for all metals and regions with the exception of mercury in the Infrastructure corridor. As noted earlier this is an anomalous result specific to the communities at Lake Murray in the OKTFLY CHS. However it does illustrate the importance of gathering empirical data for study populations.

Table 32: Contaminant levels in food (all values µg/kg bw/week)

Project Region	As-T	Cd-T	Pb-T	Hg-T
Food – Mine area	15.4	1.2	4.7	1.1
Food – Infrastructure corridor	5.2	1.5	6.0	1.8
Food – Sepik corridor	3.1	0.96	6.4	1.4
PTWI	150.0	7.0	25.0	4.0

7.2 Multi-compartment risk analysis

Table 31 details the calculated total metal, arsenic and selenium intakes for adults in the four regions of the Project, using the exposure factors derived from Tables 19 and 20 and the mean values found for contaminant metals in each medium from the surrogate communities and the Project sediments.

The results are presented as weekly intakes per kilogram body weight to allow comparison with international guideline values. Table 33 lists conservative estimates for intake of each of the contaminants through all of the significant routes for Project villages, noting that only the food compartment has region-specific values (i.e. only whole population mean values were modelled for the other exposure media). Using these inputs it is possible to derive total exposure to each contaminant for the Project communities.

Table 33: Summary of mean contaminant and essential metal intakes from all exposure routes (all values µg/kg bw/week)

	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Exposure route							
Drinking water	0.9	0.2	1.5	0.8	0.04	1.8	35.9
Food - mine area	15.4	1.2	173	4.7	1.1	13.7	1,049
Food - infrastructure corridor	5.2	1.5	161	6.0	1.8	5.8	513
Food - Sepik corridor	3.1	0.96	88.4	6.4	1.4	5.8	689
Soil Ingestion	0.041	0.003	0.381	0.104	0.004	0.024	0.561
Soil ingestion + DAD	0.059	0.004	0.556	0.152	0.006	0.036	0.820
sediments - ingestion	0.077	0.003	0.616	0.359	0.001	0.011	0.970
sediments + DAD	0.112	0.004	0.900	0.525	0.001	0.016	1.418
Surface water - ingestion	0.080	0.016	0.096	0.068	0.003	0.161	2.372
Surface water + DAD	0.099	0.020	0.119	0.068	0.004	0.198	2.710

	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Worst case total intake[1]							
Mine area	16.77	1.45	177.17	6.78	1.2	15.9	1,093.8
Infrastructure corridor	6.57	1.75	165.17	8.08	1.86	8.05	557.75
Sepik corridor	4.47	1.21	92.57	8.48	1.46	8.05	733.75
PTWI[2]	**150[2]**	**7**		**25**	**4**		
RDI			**116**			**7**	**1,227**
RMI			**1,291**			**52**	**5,165**

1. Worst case values do not factor in bioavailability i.e. 100% absorption is assumed
2. Arsenic PTWI is multiplied by 10 to account for the proportion of inorganic arsenic in food
DAD = Dermally absorbed dose

The most significant observation is that the combined food and drinking water intakes account for 90-100% of total contaminant and essential metal intakes for all Project areas. The contributions from ingestion and dermal absorption of surface water during recreation, and village soils and sediments is thus <10% in all modelled cases. The modelled contaminant and essential metal uptake from exposure to soils and sediments could reduce this (maximum) 10% to lower values by using specific bioavailability values. However for this screening risk assessment only the 'worst-case' values are discussed i.e. the bioavailability modification to intakes was not included in the modelling.

Major pathways

Table 34 below shows the percentage contribution of the drinking water and the food pathways to the total aggregated exposure of the Project communities to arsenic and the contaminant metals, as well as the essential metals. It can be seen that the food pathway is very much the major contaminant pathway. The drinking water contribution to copper, mercury and zinc intake is very small but is significant for arsenic, cadmium, lead and selenium.

Table 34: % contribution of drinking water and food to total consumption

	Drinking water % of total contribution						
	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Total mine area	5.37%	13.79%	0.85%	11.80%	3.33%	11.32%	3.28%
Total infrastructure corridor	13.70%	11.43%	0.91%	9.90%	2.15%	22.36%	6.44%
Total Sepik corridor	20.13%	16.53%	1.62%	9.43%	2.74%	22.36%	4.89%
	Food % of total contribution						
	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Total mine area	91.83%	82.76%	97.65%	69.32%	91.67%	86.16%	95.90%
Total infrastructure corridor	79.15%	85.71%	97.48%	74.26%	96.77%	72.05%	91.98%
Total Sepik corridor	69.35%	79.34%	95.50%	75.47%	95.89%	72.05%	93.90%

Minor pathways

Dermal exposures for surface waters, soil and sediments make only a very small contribution to the total weekly intakes for the contaminants and essential metals. These contributions become even more insignificant when the bioavailable fraction is considered.

Ingestion exposures for surface waters during recreational activities and for soil and sediments are considered minor pathways.

Some routes such as ambient exposure have not been included. The work by Bentley in the Ok Tedi/Fly River (CEH, 2004, 2006) and Porgera valley communities (Bentley, 2004) has noted that weekly intakes from ambient air (dermal) and ambient air (bioavailable) have been demonstrated to be insignificant. The SLR (2018) report confirms that ambient air is at best an insignificant contributor to total exposure.

7.2.1 Water and load balance

SRK Consulting (Australasia) Pty Ltd (SRK) has developed a site-wide water balance (SRK, 2018a) and a site-wide load balance for the Project (SRK, 2018b). The load balance model provides water quality predictions for watercourses within the Project area throughout mine life and into the closure period. The load balance provides water quality information for the FRCGP operational period from impoundment of the ISF (Year -2 to Year 33) as well a post-FRCGP closure period of 20 years (Year 34 to Year 54). The objective of the load balance modelling was to generate predictions of potential water qualities associated with the open-pit, ISF and a range of Assessment Point (AP) locations in creeks and rivers both upstream and downstream of the ISF.

The site-wide load balance model for the Project was constructed using the GoldSim modelling platform (SRK, 2018b). The analysis presents predictions of water quality including dissolved and total metals/metalloids in wet and dry periods at various stages of the mine operations including the current background levels.

SRK states that all water collecting in the open pit sumps and from the bench diversions is likely to require treatment. The modelling therefore incorporated a treatment plant, through which all water from these sources was assumed to be directed. The water quality predictions confirm that the open pit contact water would need to be treated prior to release. The results also show that treatment would be required post closure.

A central component of the Project and thus the modelling is the ISF. The ISF will have solid inputs (tailings, waste rock and natural sediment) and liquid inputs (tailings water, runoff and rain falling directly on to the lake surface). Outputs from the ISF will include evaporation from the pond surface, water entrained in tailings and waste rock, seepage through the embankment and into natural ground, outflow through the hydroelectric power facility and outflow through the spillway. Excess water flows to the downstream catchment by either the spillway or through the hydroelectric power facility. This means that dissolved metals and tailings in the form of TSS will enter the receiving river systems and potentially impact downstream communities. The treatment plant and the ISF are designed to minimise those potential impacts. Background TSS concentrations and suspended solids released from Project activities were generated by Golder (2018). The estimates of TSS loadings were used to assess the natural sediment loadings into the ISF. The mine waste rock and tailings related TSS releases were then estimated based on the waste deposition and tailings deposition in the ISF. Based on the TSS capture assessment for the ISF, discharge TSS concentrations were then estimated by SRK and provided to Golder. Golder then incorporated the ISF outputs into their TSS loading assessment for all the downstream assessment points. The TSS loadings were then incorporated into the load balance to provide predictions for total metals in rivers downstream of the ISF.

The results of the modelling by SRK (20180711_SRK_WQ_Data_combined_v2), reported as the Mean contaminant levels (mg/L, as total, not dissolved) for various phases of the mine operation (see Figure 5) are shown in Table 357. For convenience, Table 8 of this report is reproduced here as Table 36 to allow direct comparison to the values that were used for the baseline screening health risk assessment.
It can be seen that lead, arsenic, copper and zinc levels will be elevated around the mine site (AP1-AP3) during construction but concentrations decrease to background levels at later times and in the rivers below the ISF with the exception of AP1 where levels will remain elevated throughout mine life. Beyond AP6 modelled contaminant levels will not pose a health risk to communities accessing the water for any purpose.

Table 35: Contaminant concentrations at various Assessment Points (AP) during and after construction of the ISF

Location	Period	Arsenic (As)- mg/L	Cadmium (Cd)- mg/L	Copper (Cu)- mg/L	Lead (Pb)- mg/L	Zinc (Zn)- mg/L
Ubai Creek upstream of Nena River (AP1)	FRCGP post closure	0.009	0.003	0.340	0.029	0.236
Uba Creek upstream of Nena River (AP2)	FRCGP post closure	0.002	0.001	0.155	0.009	0.088
Nena River upstream of Uba Creek (AP3)	FRCGP post closure	0.002	0.001	0.127	0.011	0.092
ISF – Nena River arm (AP4)	FRCGP post closure	0.001	0.000	0.005	0.001	0.005
ISF – Niar River arm (AP5)	FRCGP post closure	0.001	0.000	0.001	0.001	0.005
ISF Discharge (AP6)	Construction	0.002	0.001	0.117	0.010	0.085
	FRCGP operations	0.002	0.001	0.102	0.009	0.074
	FRCGP post closure	0.001	0.000	0.021	0.003	0.018
Frieda River airstrip (AP7)	Construction	0.002	0.001	0.113	0.010	0.083
	FRCGP operations	0.002	0.001	0.101	0.009	0.073
	FRCGP post closure	0.001	0.000	0.022	0.003	0.019
Frieda River upstream of Kaugumi Creek (AP8)	Construction	0.003	0.001	0.127	0.012	0.097
	FRCGP operations	0.003	0.001	0.103	0.010	0.079
	FRCGP post closure	0.002	0.000	0.024	0.004	0.024

Location	Period	Arsenic (As)-mg/L	Cadmium (Cd)-mg/L	Copper (Cu)-mg/L	Lead (Pb)-mg/L	Zinc (Zn)-mg/L
Frieda River - Frieda Mountain (AP9)	Construction	0.003	0.001	0.123	0.012	0.095
	FRCGP operations	0.003	0.001	0.100	0.009	0.077
	FRCGP post closure	0.002	0.000	0.024	0.004	0.025
Lower Frieda River Gauging Station (AP10)	Construction	0.003	0.001	0.157	0.015	0.119
	FRCGP operations	0.003	0.001	0.103	0.010	0.080
	FRCGP post closure	0.002	0.000	0.030	0.004	0.030
Frieda River upstream of Sepik River (AP11)	Construction	0.003	0.001	0.128	0.012	0.099
	FRCGP operations	0.003	0.001	0.119	0.011	0.091
	FRCGP post closure	0.002	0.000	0.049	0.006	0.043
Sepik River at Iniok (AP12)	Construction	0.003	0.001	0.171	0.015	0.125
	FRCGP operations	0.003	0.001	0.138	0.012	0.101
	FRCGP post closure	0.002	0.001	0.126	0.011	0.093
Sepik River at Kubkain (AP13)	Construction	0.003	0.001	0.204	0.018	0.148
	FRCGP operations	0.003	0.001	0.149	0.013	0.109
	FRCGP post closure	0.002	0.001	0.132	0.012	0.098

Table 36: Ok Tedi-Fly community drinking water supplies – total metals (all mean values mg/L).

	As-T	Cd-T	Cu-T	Pb-T	Hg-T	Se-T	Zn-T
Region 1 control	0.005	0.001	0.014	0.005	0.0002	0.01	0.02
	0.005	0.001	0.01	0.005	0.0002	0.01	0.02
Region 2 control	0.005	0.001	0.007	0.004	0.0002	0.01	0.02
	0.005	0.001	0.005	0.005	0.0002	0.01	0.05
Region 4 control	0.005	0.001	0.008	0.004	0.0002	0.01	0.08
	0.005	0.001	0.005	0.002	0.0002	0.01	0.12
Mean	0.005	0.001	0.008	0.004	0.002	0.010	0.05

Assuming a worst-case scenario where communities used the receiving rivers and creeks as drinking water sources, it can be seen that lead and copper levels in some receiving waters may exceed the mean total metals in the surrogate community drinking water supplies. It is noted that the total lead concentrations in the Frieda River are naturally elevated above the WHO (2017) drinking water guidelines, with background concentrations of up to 0.05 mg/L recorded. In communities affected by discharges from the ISF (i.e. below AP6) and assuming a worst-case scenario from comparing the maximum predicted total metals concentrations in Table 33 and the mean total metals concentrations in Table 34 is that lead intake from drinking water may be six-fold higher (0.004 vs 0.024 mg/L) and copper two-fold higher

(0.008 vs 0.018 mg/L) than the baseline screening assessment in some communities downstream from the ISF. Table 32 shows that drinking water contributes about 10% of total intake for lead, and 1-2% for copper. Importantly there is no evidence that mercury concentrations in receiving waters ever reach detectable levels.

The extra copper intake from drinking this predicted maximum total concentration water is insignificant compared to the PTWI. The worst case for the lead ingestion from drinking water would raise the total intake from 8.03 to 12.08 µg/kg bw/week which is still less than half the PTWI of 25 µg/kg bw/week (see Table 31 above). It can be concluded that the worst-case discharges from the ISF to the receiving waterways will not pose a health risk to the downstream communities from drinking water. There is no reasonable way to quantitatively predict the impact on contaminant intake from the food pathway from the available data.

7.2.2 Essential trace elements

The OKTFLY CHS data showed that for adults the weekly dietary intake of the essential metals was within recommended dietary reference guidelines and does not pose a risk of adverse effects through excessive intake. Food was the major source of copper intake (97-98%) for all adults. Total copper intakes were well within the intake range recommended by the US IOM. For selenium, drinking water provided 5-28% of the intake and food the vast majority of the rest. For zinc food was the major intake source (92-97%). The increase in dissolved copper and zinc concentrations in the Frieda River will have an insignificant impact on intake of these metals from either food or drinking water.

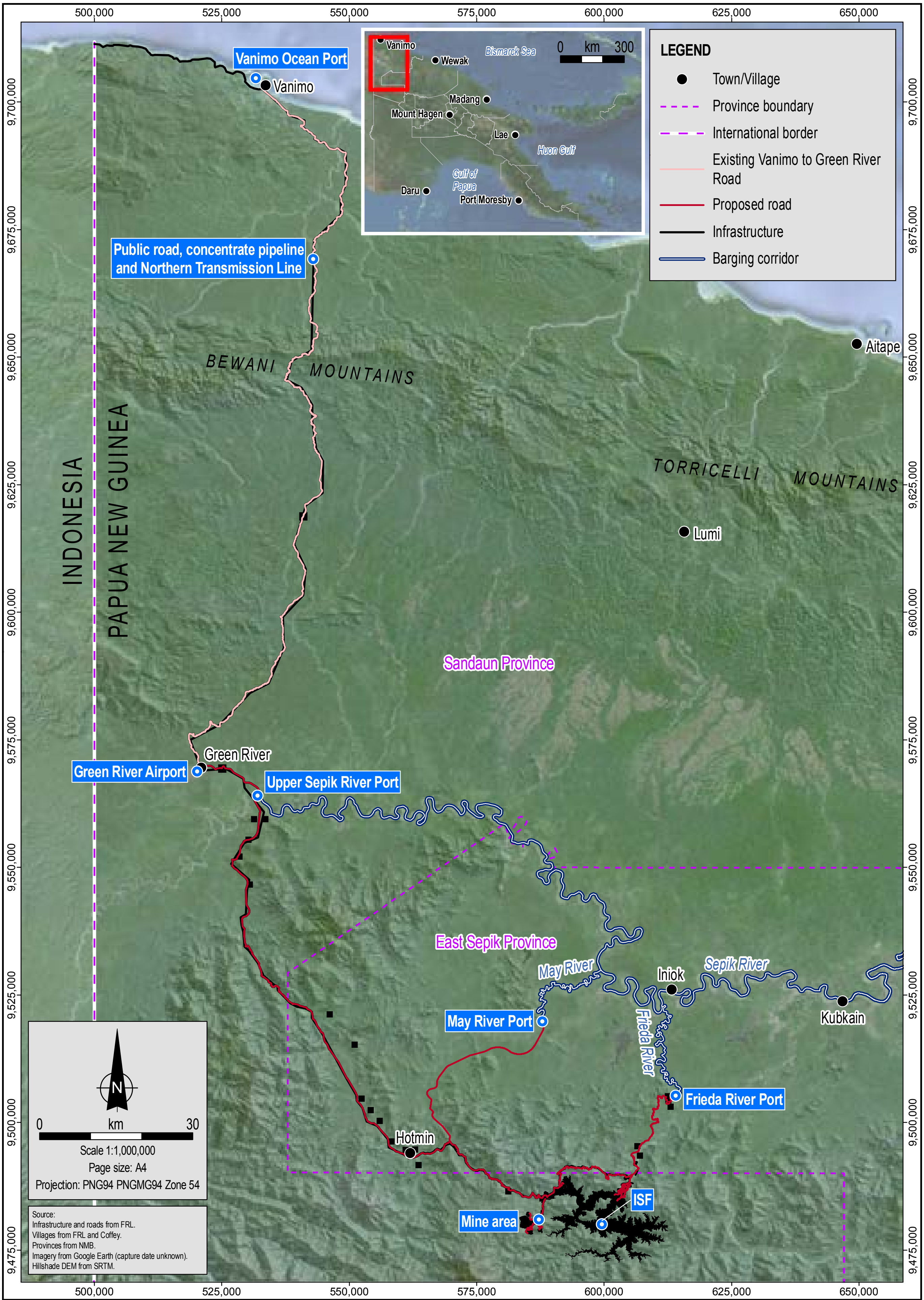
7.2.3 Contaminant elements

Modelling using the surrogate data shows that none of the villagers in the mine area, infrastructure corridor or Sepik River corridor will have aggregate intakes from all routes of exposure that exceed health guideline values.

7.3 Discussion

Conclusions of this risk analysis are considered robust and could be validated by further data collection as the Project proceeds. The caveat introduced by the use of surrogate data for nearly all the exposure pathways is considered acceptable for several reasons:

- The OKTFLY CHS included a detailed social and anthropometric study of the relevant communities. Considering only the control villages in the surrogate communities, they are demonstrably similar to the matched Project communities for the physical/geographic and social circumstances, environmental health factors, diet, and physique.
- Data from a Market Basket Survey in the Porgera Valley gave very similar findings in terms of dietary patterns and metal contaminant levels in foods.
- The sparse empirical data available for Project communities (limited food, sediment and water samples) was consistent with those parameters measured in the surrogate communities.



coffey A TETRA TECH COMPANY	Date: 07.09.2018 Project: 754-ENAUABTF11575B File Name: 11575_15_HIA_F005_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Project overview	Figure No: 5

- The use of adult data only and mean values for contaminant levels in most exposure media is the most appropriate way to deal the uncertainties arising from data substitution.

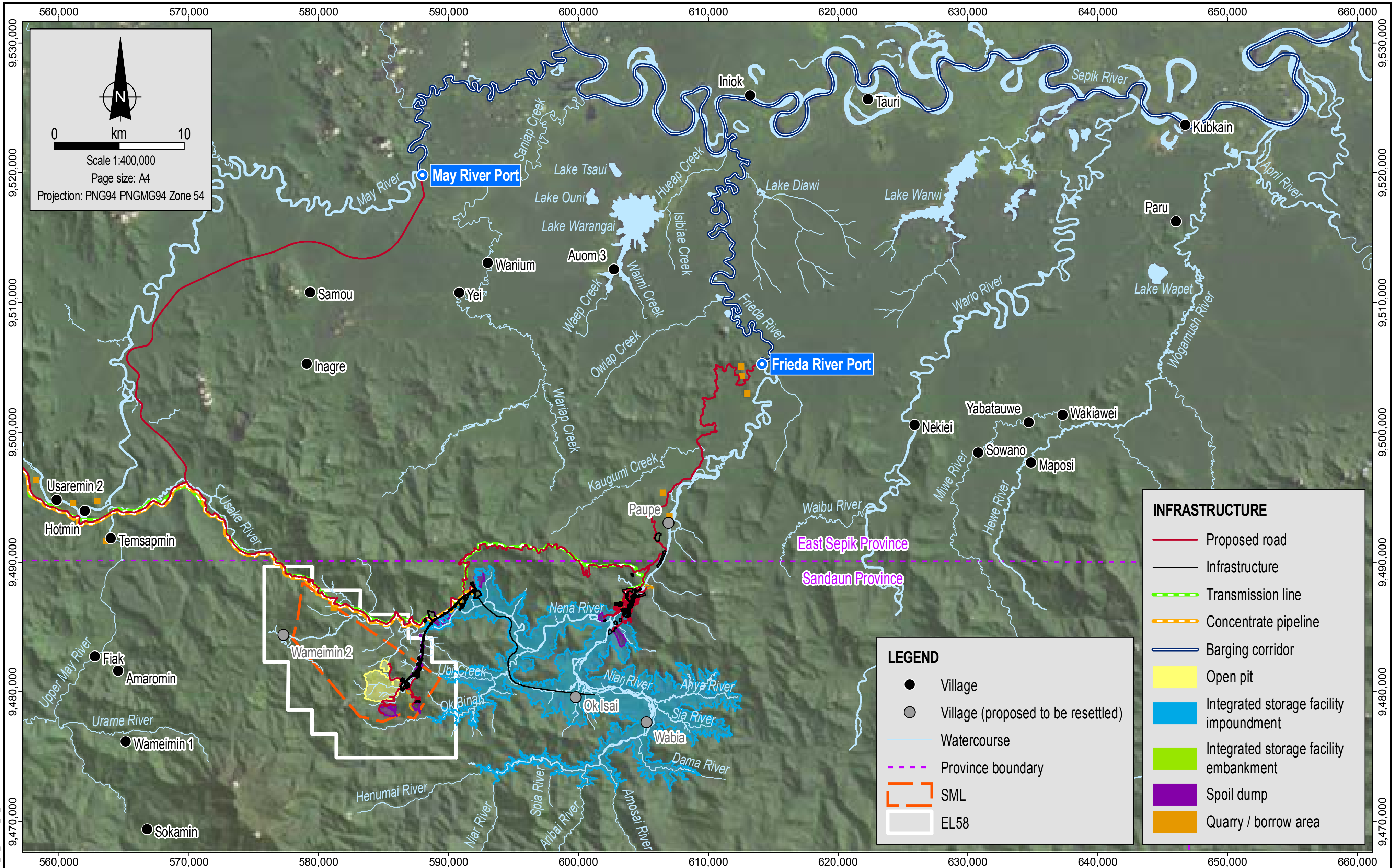
Present Project community circumstances

The outcomes of the analysis are clear: the current levels of contaminant elements in all exposure media but primarily drinking water and food, do not pose a risk to healthy adults in the Project communities; this conclusion applies to all contaminant metals/metalloids including mercury. This does not mean that some individuals or even specific age groups are not at higher risk than healthy adults in the community. As noted earlier, infants and children are not 'little adults' and may have both greater exposure and susceptibility to contaminant metals in the environment.

With respect to greater exposure, some infants or children engage in pica activity (deliberately ingesting soil) and children may spend more time in exposure-related activities such as swimming and working in village gardens or simply playing outdoors. Activities such as artisanal gold mining in which the entire family may be engaged may lead to greater exposure of children to environmental media. The potentially greater exposure cannot be estimated without a time-activity study. With respect to greater susceptibility, the generally subsistence lifestyle and the prevalence of disease in some communities may exacerbate the intrinsic physiological susceptibility of infants and children.

Future Project community circumstances

As the Project is developed there is the possibility that Project communities will become exposed to increased mine-related rather than the current natural contaminant metal levels. However, modelling of water quality and sediment in the open-pit, the ISF, the Frieda River and the Sepik River during mine life and closure has been undertaken. This models a suite of metals for concentration in water assuming addition of lime for pH control of the open-pit contact water. The model predicts that the relevant contaminant metal values will not exceed the health-based WHO drinking water guidelines during mine-life or after closure in downstream receiving water bodies due to project discharges. It is noted that the total lead concentrations in the Frieda River are naturally elevated above the WHO drinking water guidelines.



Source:
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown).
Hillshade DEM from SRTM.

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Project: 754-ENAUABTF11575B
File Name: 11575_15_HIA_F006_GIS

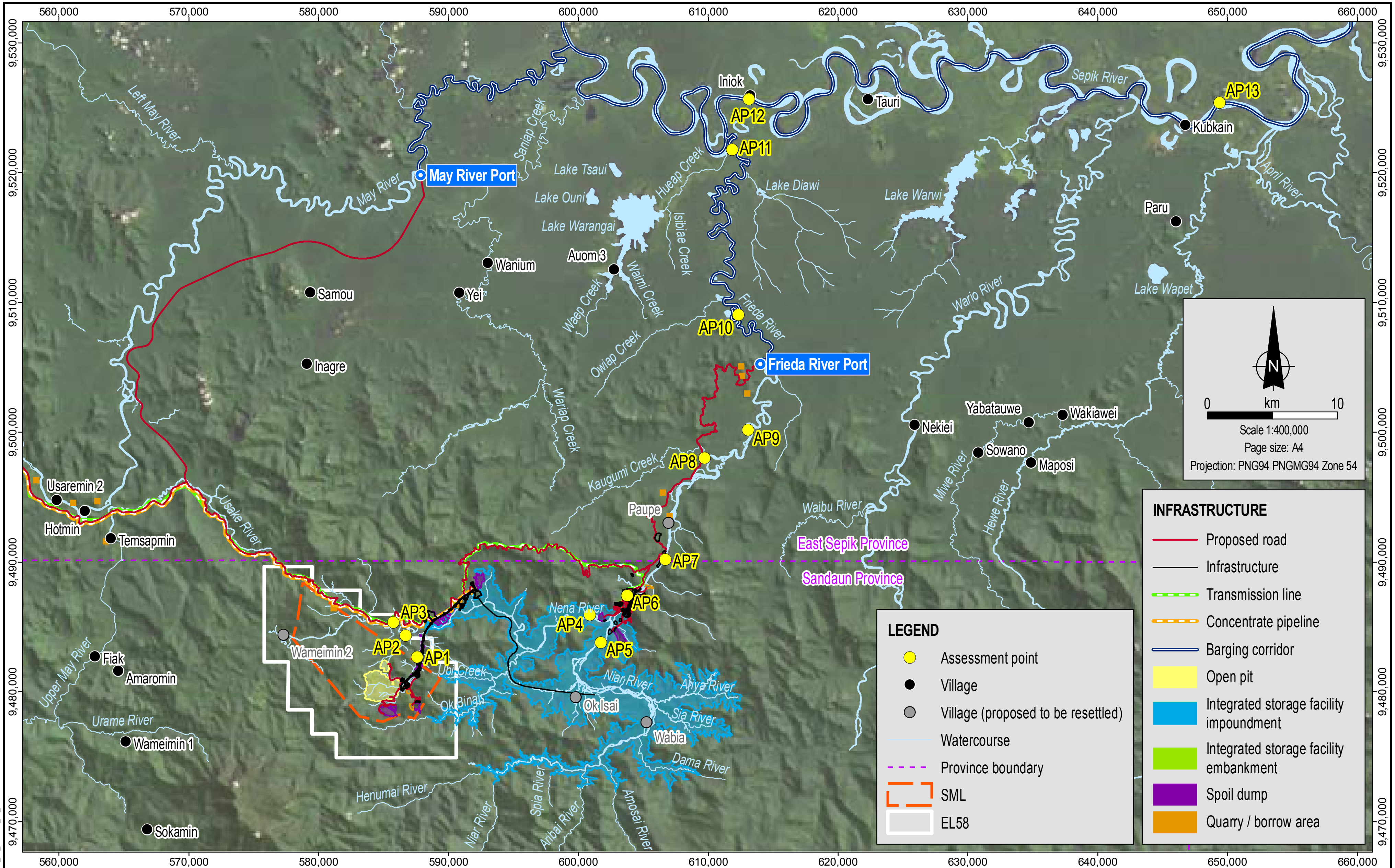
Frieda River Limited
Sepik Development Project

FRIEDA RIVER

Mine and FRHEP area, and downstream corridor

Figure No: 6

MXD Reference: 11575B_15_GIS003_v0_9



Source:
Assessment points from SRK and Coffey.
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown). Hillshade DEM from SRTM.

MXD Reference: 11575B_11_GIS017_v0_2

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Date: 24.08.2018
Project: 754-ENAUABTF11575B
File Name: 11575_15_HIA_F007_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Assessment points

Figure No: 7

Recommendations

As the Project is developed, opportunities for further sampling should be taken to validate the overarching conclusion that the Project will not cause harm to Project communities through exposure to drinking water, food, village soils and sediments and surface/recreational water through the ingestion and dermal absorption routes.

Specifically:

- Further sampling of Project village drinking water, especially tanks and springs, for analysis of Total metals would give support to the use of the surrogate data from the Ok Tedi/Fly River communities.

- Market Basket Sampling of known bioaccumulator foods such as fish and pigs in conjunction with a Unit Food Consumption survey for the Project villages would give further support to the use of surrogate data in the risk characterisation. This data would also enable risk assessments to be conducted for specific age groups such as infants and children.
- A time/activity study of exposure for those populations engaged in artisanal mining would enable more detailed risk assessments for these potentially highly exposed groups.

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Appendix 1 – Hazard summaries

A.1 Arsenic

A.1.1 Toxicity

Arsenic occurs ubiquitously and naturally in the environment in both organic and inorganic forms. Inorganic arsenic exposure from consumption of drinking water at concentrations greater than 0.01 mg/L is recognised as causal for acute and chronic human toxicity and as a carcinogen causally related to increased risks of human cancers in the lungs, bladder, kidney and skin as well as other skin changes such as hyperkeratosis and pigmentation changes. However, many organic arsenic compounds, including the main species in fish tissue have little or no toxic effects in humans.

A.1.2 Intake from food, water, air, soil and sediment

Arsenic in environmental media is almost exclusively inorganic arsenic. Arsenic concentrations in air from remote and rural locations typically range from 0.02 - 4 ng/m^3 and in urban areas 3 - 200 ng/m^3 (IPCS 2001a). In natural waters the concentrations of inorganic arsenic are generally less than 1 - 2 µg/L, although some “oxygen-depleted” ground water supplies may exhibit very high concentrations of up to 3 mg/L. Background levels in soil range from 1 - 40 mg/kg. Mean sediment inorganic arsenic concentrations range from 5 – 3,000 mg/kg with the higher levels occurring in areas of known contamination.

Arsenic has been found in all food analysed with varying ratios of organic to inorganic species. The total arsenic concentration will vary depending on the food type (marine fish/shellfish, vegetables, etc), growing conditions and processing techniques.
Total arsenic concentrations in marine fish sold in the United Kingdom for human consumption range from 0.4 - 118 mg/kg with speciation results indicating that the organic arsenic comprised more than 98% of the total arsenic (UK FSA 2004). Dietary intakes in the United Kingdom from all total diet studies were 89 µg/day, with fish and some meat products the only significant contributor to the diet. Assuming that the arsenic in fish was all organic, the mean intake of inorganic arsenic was no more than 40 µg/day. Typical adult inorganic arsenic intakes for the low fish-consuming populations of Europe and North America are in the range of 2 – 30 µg/kg bw/wk.

A.1.3 Derivation of a tolerable weekly intake

The Joint FAO/WHO Expert Committee on Food Additives assigned a Provisional Tolerable Weekly Intake (PTWI) for inorganic arsenic of 15 µg/kg bw/wk applicable to all age groups including infants (WHO/JECFA 1989). The available data was insufficient for JECFA to set a PTWI for organic arsenic in food. However, it was noted that organic arsenic intakes of about 50 µg/kg bw/day (i.e. 3,000 – 3,500 µg/day for adults) produced no reports of ill effects, and that organoarsenicals found in fish, although almost completely absorbed, are rapidly excreted unchanged by humans.

The inorganic arsenic PTWI was withdrawn by JECFA in 2010. The Committee noted that the provisional tolerable weekly intake of 15 µg/kg bw (equivalent to 2.1 µg/kg bw per day) was in the region of the inorganic arsenic lower limit on the benchmark dose for a 0.5%

increased incidence of lung cancer and therefore was no longer appropriate (WHO/JECFA 2010a). However, the PTWI can still be used as an indicator of safety from the adverse effects of arsenic that have a threshold of toxicity. The assessment of for non-threshold effects are expressed by the WHO Margin of Exposure (MOE), which uses a Benchmark Dose (BMD) approach.

A.1.4 Estimation of cancer risk

Although arsenic is capable of producing a variety of adverse health effects, the effect currently of greatest concern from chronic, low-level exposure, such as from drinking water and soil, was carcinogenicity (IARC 1987). The International Agency for Research on Cancer classifies inorganic arsenic compounds in Group 1 (carcinogenic to humans). Ingestion of arsenic in drinking water has been associated with increased risk of cancer of the skin, bladder, lung, liver, kidney, and prostate. Inorganic arsenic has also been classified by the US EPA as a Group A carcinogen ("known to produce cancer in humans") (US EPA IRIS 2011).
A large study of skin cancer in Taiwan has been used by the US EPA to derive ingestion Cancer Slope Factors for arsenic. The US EPA Cancer Slope Factor (CSF) for arsenic ingestion is 1.5/(mg/kg)/day. The rationale and methodology underpinning the derivation of life time average daily doses (LADD) and the derivation of the CSF for inorganic arsenic has been detailed in the US Guidelines for Carcinogen Risk Assessment (US EPA 2005).

A.2 Cadmium

A.2.1 Toxicity

The primary toxic effect from chronic exposure to cadmium is renal dysfunction. This results from the accumulation of cadmium in the renal cortex over many years of exposure, and can lead to impaired re-absorption of proteins, glucose and amino acids. A characteristic sign of this renal impairment is the excretion of low molecular weight proteins. The critical value for cadmium in the renal cortex is generally assumed to be about 200 mg/kg at which level about 10% of the population will have symptoms of kidney damage, resulting in low molecular weight proteinuria.

A.2.2 Intake from food, water, air, soil and sediment

The background levels in air in remote locations are typically 0.01 - 0.04 ng/m^3 and for urban areas 5 - 15 ng/m^3.

Food is the main source of cadmium intake for non-occupationally exposed people. The cadmium levels in cultivated crops are largely dependent on species, variety cultivated, soil type, pH, agricultural practices and season. Peanuts, soybeans, rice and tubers and some green vegetables are known bioaccumulators of cadmium. However, the available data are from areas where there are significant inputs of phosphate fertilizers containing cadmium as a contaminant. Levels in fruit, meat and vegetables are typically 5 - 10 µg/kg, in mammalian liver 10 - 100 µg/kg and in kidney 100 – 1,000 µg/kg. Fish concentrations are in the range 20 - 30 µg/kg and shellfish 200 – 1,000 µg/kg (IPCS 1992).

The United Kingdom Ministry of Agriculture, Fisheries and Food has published data indicating that cadmium intake from food, water and air gave average daily per capita intakes of 10 - 17 µg for food, less than 2 µg for water and less than 0.1 µg from air (UK CLEA 2009a). Thus, food provides approximately 90% of the total intake. Using conservative assumptions, the UK MAFF calculated that an infant 2 years of age, has an intake of about 8 µg per day. The estimated adult dietary intake in Europe is in the range 10 - 35 µg/day and for the United States 41 µg/day. Indigenous people worldwide, consuming organ meats and/or shellfish on a regular basis would have a far larger intake of cadmium than 30 µg/day.

Tobacco contains relatively high concentrations of cadmium, with smoking being an important source of exposure in adults. Results suggest that consumption of 20 cigarettes per day will give rise to absorption of about 1.4 µg of cadmium. This is equivalent to an additional daily intake of 25 - 30 µg of dietary cadmium.

A.2.3 Derivation of a tolerable weekly and monthly intake

The JECFA health-based reference values for cadmium are based on the accumulation of cadmium into renal tissue. Shellfish, crustaceans, a range of nut species and fungi are natural accumulators of cadmium. Regular consumption of these items can result in increased exposure. Tobacco is an important source of cadmium uptake in smokers (IPCS 1992). In 2010, JECFA withdrew the PTWI for cadmium in 2010 and replaced it with a provisional tolerable monthly intake (PTMI). The rationale adopted by the committee was that owing to cadmium's exceptionally long half-life, a monthly value was more appropriate (WHO/JECFA 2010b). The previous PTWI of 7 µg/kg bw/wk is used in this evaluation for comparative purpose since it is essentially numerically equivalent to the PTMI.

A.2.4 Estimation of cancer risk

The International Agency for Research on Cancer classifies cadmium and its compounds as a Group 2A (probable human carcinogen) based on exposure of workers (IARC 1987). The WHO reported no elevated cancer incidence in animal studies, but induction of lung tumours in occupational workers following high dose inhalation of inorganic cadmium compounds, concluding that it was not currently possible to determine if cadmium exposure causes cancer in humans (IPCS 1992). The US EPA using the same occupational database as IARC and IPCS, accepting that the studies were compromised by the presence of other carcinogens (arsenic, smoking) proposed that cadmium was a probable human carcinogen by the inhalation route. The US EPA has not developed quantitative estimates of carcinogenic risk from oral exposure (US EPA 1992).

A.3 Copper

A.3.1 Toxicity and essentiality

Copper is an essential micronutrient for humans. Adverse health effects may result from intakes below that needed for good health (deficiency) and also concentrations well above the nutrient requirement (toxicity). As an essential micronutrient, copper concentrations within the human body are regulated by homeostasis. Adverse health effects from deficiency or toxicity will only be observed on those infrequent occasions when these homeostatic mechanisms are unable to maintain internal copper concentrations within normal ranges.

In humans, the most consistent clinical signs of copper deficiency are anaemia, non-response to iron therapy, blood dyscrasias, including neutropenia, reduced reticulocyte counts and osteoporosis and bone fractures. Toxicity due to copper is rarely observed and then usually in patients with special metabolic problems.

A.3.2 Intake from food, water, air, soil and sediment

Background levels of copper in uncontaminated soil typically range from 2 - 250 mg/kg. Copper concentrations in air in rural areas range from 5 - 50 ng/m^3. The US EPA in a major study (23,814 samples, 1997 - 1998) reported values in the range 0.003 - 7.32 µg/m^3. Copper levels in fresh water are normally in the range 1.0 - 20 µg/L.

The major route of exposure to copper in healthy, non-occupationally exposed humans, is through food and drinking water consumption. These pathways together account for more than 90% of total intakes in infants and adults. Concentrations of copper in human diets vary considerably depending upon type of food consumed, sources of the food and the methods used in preparation. Organ meats and seafood have the highest concentrations of copper, while nuts and grains also have high concentrations of copper. The mean daily dietary intake of copper in adults ranges between 0.9 and 2.2 mg/day, with most intakes nearer the lower end of this range.

A.3.3 Derivation of recommended dietary allowance and tolerable upper intake level

Based on a No Observed Adverse Effects Level (NOAEL) of 5 mg/kg bw/day for the end point of liver toxicity in dogs, and taking into consideration the essentiality of copper, a provisional tolerable daily intake of 0.5 mg/kg bw/day was recommended by JECFA (WHO/JECFA 1982). An allocation of 10% to drinking water gave a guideline value in water of 2 mg/L. It was considered that the safety margin adopted would ensure that the value was equally appropriate for infants and children.

The US IOM Recommended Dietary Allowance (RDA) for copper by life stage group is given below. The Recommended Dietary Allowance (RDA) is the average daily dietary intake level, sufficient to meet the nutrient requirements of nearly all (97 - 98 %) healthy individuals in a group. It is calculated from an Estimated Average Requirement (US IOM 2006).
The Tolerable Upper Intake Limit (UL) is also provided by age group for copper.

Life stage group – Copper (all values µg/day)

Group	RDA	UL
Infant 1 – 3 years	340	1,000
Child 4 – 8 years	440	3,000
Males and Females		
9 – 13 years	700	5,000
14 – 18 years	890	8,000
Adult	900	10,000

A.3.4 Estimation of cancer risk

Based on the results of a number of animal studies, involving exposure to copper compounds, copper and its salts are considered to be non-carcinogenic in humans.

A.4 Lead

A.4.1 Toxicity

While there is a clear consensus on the clinical effects of acute doses, chronic exposures to low levels of lead are still the subject of considerable debate. The developing foetus and infant are accepted as the most sensitive at-risk group, because of the sources and pathways and elevated susceptibility of developing organ systems. Hand-to-mouth activity and elevated dietary absorption are key contributors to the increased susceptibility. Asymptomatic effects include impaired neurobehavioral development, lowered birth weight, decreased growth and disturbance of Vitamin D metabolism (IPCS 1995). Despite a number of cross-sectional and longitudinal studies it has not been possible to establish a threshold below which lead has no effect on the IQ of children.

A.4.2 Intake from food, water, air, soil and sediment

Many factors can influence the absorption of lead such as nutritional status, the chemical and physical form of the lead and the nature and route of exposure. Typical lead intake results for countries that have introduced lead-free petrol and other lead abatement initiatives, reported as µg/kg bw/week, are: Australia (adults) 1.6 – 6.3, (infant 2 years of age) 7 – 11.9; Canada (adults) 3.3, (infant 1 – 4 years of age) 5.3; and the United States (adults) 0.3 – 0.4, (infant 2 years of age) 1.1. The levels in children are generally two to three times that of adult intakes in the same country when evaluated on the basis of body weight.

Lead in water supplies are generally below 5 µg/L. The United Kingdom recommends that for children, water lead concentrations should not exceed 10 - 15 µg/L. Airborne lead concentrations have decreased in situations where leaded petrol is no longer used, to less than 0.2 µg/m^3 corresponding to daily intakes from air for adults and children of 4 µg and 1 µg respectively.

The exposure of lead from soil is often several times that of the dietary intakes depending on nutritional status, ground cover, chemical form etc. Setting a “soil standard” based on an allowable intake alone, presents considerable problems. Most commonly the values adopted are determined by reference to blood lead levels in the population at risk. This approach has particular merit in that it is independent of soil lead bioavailability.
Food, air, water, dust and soil are the major routes of exposure to lead for infants and young children. In the general non-smoking adult population, the main exposure pathway is from food and drinking water.

A.4.3 Derivation of a tolerable weekly intake

The Provisional Tolerable Weekly Intake (PTWI) of 25 µg/kg bw/week was maintained at the fifty-third meeting of JECFA in 2000. This value, originally endorsed in 1987, is based on evidence that a mean daily intake of 3 – 4 µg/kg bw/week of lead by infants and children was not associated with an increase in blood lead levels. The committee considered the results of a quantitative risk assessment, and concluded that the concentrations of lead found currently in food would have negligible effects on the critical effect in humans namely, the neurobehavioral development of infants and children.

The PTWI for lead was withdrawn by JECFA in 2010. The PTWI estimated by JECFA of 25 µg/kg bw was associated with a decrease of between three and seven intelligence quotient points in children and an increase in systolic blood pressure of approximately 3 mmHg in adults. The dose-response analyses do not identify a threshold for the key adverse effects of lead and consequently JECFA concluded that it was impossible to establish a new PTWI that would be protective of health. The risk assessment approach now adopted by JECFA for lead is based on a margin of exposure approach (WHO/JECFA 2010b).

A.4.4 Estimation of cancer risk

Inorganic lead has been classified by the US EPA as a probable human carcinogen, although the studies supporting this contention are from occupational exposures, and to multiple contaminants. The World Health Organization and the International Agency for Research on Cancer both consider that the overall evidence for carcinogenicity is inadequate and there is a lack of control of confounding factors in the available studies.

A.5 Mercury

A.5.1 Toxicity

Organic mercury (e.g. methylmercury) is more toxic than elemental or inorganic mercury. The prudent approach, is usually to assume that all mercury present, is available to humans in its most toxic form. The developing central nervous system in the foetus and early post-natal infant is far more sensitive to the adverse effects of methylmercury than the adult nervous system. Humans are at their most sensitive prenatally, with foetal damage occurring at concentrations if the mother is asymptomatic. The adult general population does not face a significant health risk from methylmercury. However, adults consuming very large quantities of fish, particularly the predator species in fresh and salt water, may attain hair methylmercury concentrations of 50 mg/kg which is associated with a 5% risk of paraesthesia.

The kidney is the most critical organ for inorganic mercury compounds, although there is insufficient human data to establish reliable dose-effect relationships at environmental exposure levels.

A.5.2 Intake from food, water, air, soil and sediment

Mercury exposure in non-occupationally exposed humans occurs primarily through the diet, with the uptake being almost exclusively through the consumption of fresh and marine fish and other aquatic food. The levels of total mercury in other food product classes, such as grains is generally very low, but large consumption of such products can result in significant exposure (US FDA 2006).

Mercury in fish concentrations differ significantly between species. For example, the range of levels in marine planktivorous fish was 0.01 – 0.16 mg/kg and for predator species 0.21 – 1.33 mg/kg (US EPA 1997b). These values are comparable with those for fish species such as shark, tuna and swordfish determined by the United Kingdom (UK FSA 2002). Many countries have recommended pregnant women, or those likely to become pregnant and breastfeeding women, to limit their intake of marlin, swordfish and tuna. For example the United Kingdom has recommended a limit on the intake of these three species to one portion (about 140 grams) per week.

Food is the major source in non-occupationally exposed populations with average daily intakes for total mercury in the range 2 - 20 µg/day of which 3 - 4 µg/day are from inorganic mercury. The fish and meat groups are the major contributors to dietary exposures. The average dietary exposures in the United Kingdom range between 2 - 3 µg/day, but some "high fish consuming" individuals may exceed 25 µg/day.

The WHO reports mean levels of mercury in lakes and rivers of 5 - 100 ng/L (IPCS 2003). Mean ambient air concentrations seldom exceed 10 - 20 ng/m^3. WHO proposes that the exposure from air should not exceed 0.03 µg/day.

Typical background levels in soil range from 50 – 80 µg/kg, although levels in volcanic soil may be up to 10 mg/kg.

A.5.3 Derivation of a tolerable weekly intake

In 2003, JECFA re-evaluated its PTWI for methylmercury, based on an examination of the Seychelles and Faroe Islands studies (WHO/JECFA 2003). Using the average between a NOAEL of 15.3 mg/kg mercury in hair (Seychelles) and a benchmark dose Lower Confidence Limit of 12.0 mg/kg mercury (Faroe Islands), a steady state intake of methylmercury of 1.5 µg/kg bw/day was derived. This value was considered to have no appreciable adverse effects in the offspring of these populations. Allowing a factor of 3.2 for inter-individual variability, and a factor of 2 for variability in the hair to blood ratio, gave a PTWI of 1.6 µg/kg bw/week for the most sensitive sub-group in the population.

The PTWI for inorganic mercury is also applicable for dietary exposure to total mercury in food, other than fish and shellfish. The PTWI for methylmercury for fish and shellfish is more appropriate, while recognising that the ratio of inorganic mercury to methylmercury differs markedly between fish species (WHO 2011a).

The WHO has recommended a guideline concentration of mercury (total) in drinking water of 1 µg/L. This value was chosen on the basis that consumption of 2 litres of water containing 1 µg of methylmercury (the most toxic form) per litre would normally contribute to less than 10% of the tolerable intake of mercury.

A.5.4 Estimation of cancer risk

The WHO considers that mercury is not carcinogenic in humans. The US EPA considers inorganic mercury is not classifiable owing to the absence of any significant human database, and the animal and supporting data are inadequate. Neither organisation has evaluated methylmercury for its potential carcinogenicity.

A.6 Selenium

A.6.1 Toxicity and essentiality

Selenium, while an essential trace element for nutrition, is potentially toxic to humans. Adverse health effects have been reported for intakes below the required amount as well as for exposures in excess of the required intake. Deficiency is associated with endemic diseases including Kashin-Beck disease, a chronic osteoarthrosis, when the intake of selenium is extremely low. Selenium toxicity (values in excess of 1,000 µg/day) result in hair and nail loss, lowered haemoglobin levels, skin lesions and central nervous system abnormalities. From the very extensive database available a NOAEL of 850 µg/day has been established.

A.6.2 Intake from food, water, air and soil and sediment

The WHO reports environmental levels in most non-industrial urban air as ranging from 0.1 - 10 ng/m^3 (WHO 2000). The corresponding levels in ground water and surface water range from 0.06 - 400 µg/L, but generally do not exceed 10 µg/L. Most food is low in selenium (< 0.01 mg/kg), with the exception of fish and meat (0.3 - 0.5 mg/kg) and cereals (< 0.01 - 0.67 mg/kg).

Of food consumed by humans, meat products have the highest concentration of selenium, while vegetables and fruit have lower concentrations. The selenium concentration of grains and cereals, staples in the diet of many people worldwide, vary greatly depending upon the type of processing and whether selenium fortification of soil was carried out.

The daily intake of selenium in the United Kingdom is about 65 µg/day, with a range of 25 - 130 µg/day. About 50% is derived from cereals, with the bulk of the remainder from meat and fish. The United Kingdom Reference Nutrient intake is 75 µg/day. There are few data on infant intakes, but on the basis that an infant 2 years of age, consumes some 40% by weight of an adult diet, the value of 25 µg/day has been adopted.

A.6.3 Derivation of recommended dietary allowance and tolerable upper intake level

Recommended daily intakes range from 0.9 - 1.13 µg/kg bw for adult males to 1.65 µg/kg bw for infants. The WHO has not yet recommended a PTWI for selenium.
The US IOM Recommended Dietary Allowance (RDA) for selenium by life stage group is given below. The Recommended Dietary Allowance (RDA) is the average daily dietary intake level, sufficient to meet the nutrient requirements of nearly all (97 - 98 %) healthy individuals in a group. It is calculated from an Estimated Average Requirement (US IOM 2006). The Tolerable Upper Intake Limit (UL) is also provided by age group for selenium.

Life stage group – Selenium (all values µg/day)

Group	RDA	UL
Infant 1 – 3 years	20	90
Child 4 – 8 years	30	150
Males and Females		
9 – 13 years	40	280
14 – 18 years	55	400
Adult	55	

A.6.4 Estimation of cancer risk

Both the International Agency for Research on Cancer (IARC) and the US EPA have concluded that the data are insufficient or inadequate to evaluate selenium for its carcinogenicity.

A.7 Zinc

A.7.1 Toxicity and essentiality

The essential nature of zinc, together with its relatively low toxicity in humans and the limited sources of human exposure, suggests that normal, healthy, non-occupationally exposed individuals are at greater risk from the adverse effects associated with zinc deficiency, than from adverse effects associated with normal environmental exposure to zinc. The human health effects associated with zinc deficiency are numerous, and include neurosensory changes, oligospermia, impaired neuropsychological functions, growth retardation, delayed wound healing, immune disorders and dermatitis.

A.7.2 Intake from food, water, air, soil and sediment

The most significant source of zinc for the general population is from food. Flesh food (i.e. meat, poultry and fish) and other seafood are rich sources of readily available zinc, while vegetables and fruit contain relatively low zinc concentrations. In humans, the absorption of zinc depends on the nutritional, physiological and health status of the individual, as well as the composition of the diet.

Estimated daily dietary intakes of total zinc for infants and children from two months to 11 years of age, range from 5.6 to 10 mg/day; for children 12 - 19 years of age, from 12.3 to 13.0 mg/day; and for adults 20 - 50 years of age, from 8.8 to 14.4 mg/day (IPCS 2001b). Low dietary intakes of zinc have been reported for populations in school age children in East Sepik Province, PNG (mean 7 mg/day) from diets containing mainly roots, tubers and leaves (Gibson et al 1991).

A.7.3 Derivation of recommended dietary allowance and tolerable upper intake level

The US IOM Recommended Dietary Allowance (RDA) for zinc by life stage group is given below. The Recommended Dietary Allowance (RDA) is the average daily dietary intake level, sufficient to meet the nutrient requirements of nearly all (97 - 98 %) healthy individuals in a group. It is calculated from an Estimated Average Requirement (US IOM 2006). The Tolerable Upper Intake Limit (UL) is also provided by age group and gender.

Life stage group – Zinc (all values µg/day)

Group	RDA	UL
Infant 1 – 3 years	3000	7000
Child 4 – 8 years	5000	12,000
Males		
9 – 13 years	8000	23,000
14 – 18 years	11,000	34,000
Adult		40,000

Group	RDA	UL
Females		
9 – 13 years	8000	23,000
14 – 18 years	9000	34,000
Adult	8000	40,000

A.7.4 Estimation of cancer risk

Zinc has been assessed as non-carcinogenic by both the IARC and US EPA (IARC 1987, US EPA IRIS 2011).

Appendix 5

Pre-mitigated and Residual Risk Assessment Table

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Physical disturbance									
SV1 - The capacity to support subsistence livelihoods	Vegetation clearance and/or land inundation reduces the availability of food for hunting, catching or gathering	Inadequate supply of subsistence resources from hunting and gathering	Catchment 1A – Miyan and Telefol	C	Almost certain / major	Very high	SEM011: Compensation – cash economy, SEM001: Vegetation clearance mitigation measures, SEM002: Terrestrial fauna mitigation measures, SEM006: Pre-construction surveys, SEM007: Information on construction impacts, SEM008: Fish and crocodile stocks	Almost certain / major	Very High
			Catchment 1A – Paiyamo		Almost certain / moderate	High		Almost certain / moderate	Medium
			Catchment 1B		Likely / minor	Medium		Likely / negligible	Low
			Catchment 1C		Possible / minor	Low		Possible / minor	Low
	Project development reduces the availability of land for gardens	Inadequate supply of subsistence resources from gardening	Catchment 1A – Telefol	C	Almost certain / major	Very high	SEM011: Compensation – cash economy, SEM006: Pre-construction surveys, SEM007: Information on construction impacts	Almost certain / major	Very high
			Catchment 1A – Paiyamo		Likely / major	High		Likely / moderate	Medium
	Project development reduces the availability of land for gardens (cont'd)	Inadequate supply of subsistence resources from gardening	Catchment 1B		Likely / minor	Medium	SEM011: Compensation – cash economy, SEM006: Pre-construction surveys, SEM007: Information on construction impacts	Likely / negligible	Low
			Catchment 1C		Possible / minor	Low		Possible / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Physical disturbance (cont'd)									
SV1 - The capacity to support subsistence livelihoods (cont'd)	Vegetation clearance reduces the availability of building materials, medicines and other resources	Inadequate supply of resources to support subsistence livelihoods	Catchment 1A – Telefol	C	Almost certain / moderate	High	SEM011: Compensation – cash economy, SEM004: Resettlement Action Plans, SEM006: Pre-construction survey, SEM007: Information on construction impacts	Almost certain / minor	Low
	Construction earthworks interferes with existing water supplies	Pollution of water affects drinking water and food sources such as gardens or aquatic resources	Catchment 1A, 1B and 1C	C	Likely / moderate	Medium	SEM003: Water management and monitoring, SEM006: Pre-construction surveys, SEM007: Information on construction impacts, SEM010: Erosion and sediment control	Possible / moderate	Medium
SV2 - Opportunities for participation in the cash economy	Land use change and loss of land associated with Project works reduce the availability of land to grow cash crops.	Inadequate land to support cash crops and access the cash economy	Catchment 1A – Telefol	C, O, PC	Almost certain / minor	Medium	SEM011: Compensation – cash economy, SEM001: Vegetation clearance mitigation measures, SEM004: Resettlement Action Plans, SEM007: Information on construction impacts, SEM021: Livelihood surveys	Almost certain / negligible	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	**Risk rating**		**Likelihood/ consequence**	**Residual risk rating**
Physical disturbance (cont'd)									
SV2 - Opportunities for participation in the cash economy (cont'd)	Reduced income from alluvial gold due to sterilisation from inundation	The FRHEP will sterilise the majority of alluvial gold areas currently accessed by near-Project communities, which will reduce income	Catchment 1A	C, O, PC	Almost certain / major	Very high	SEM011: Compensation – cash economy, SEM028: Employment maximisation	Almost certain / moderate	High
SV3 - Enduring ability to sustain cultural identity and traditions	Construction earthworks disrupt or destruct items or sites of cultural significance	Erosion of cultural understandings and sense of place	Catchment 1A – Miyan and Telefol and Paiyamo	C, O	Almost certain / moderate	High	SEM029: CHMP, SEM030: Cultural heritage induction, SEM031: Informing cultural heritage custodians, SEM032: Support for cultural research programs	Almost certain / minor	Medium
			Catchment 1B		Possible / moderate	Medium		Unlikely / moderate	Medium
			Catchment 1C		Unlikely / moderate	Medium		Remote / moderate	Low
SV4- An enduring ability to maintain customary rights to land access and resource use	Changes to existing land uses and major alterations of the appearance of the landscape cause a sense of loss	Impaired health and well-being	Catchment 1A	C, O, PC	Likely / moderate	Medium	SEM011: Compensation – cash economy, SEM007: Information on construction impacts	Possible / moderate	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Physical disturbance (cont'd)									
SV4- An enduring ability to maintain customary rights to land access and resource use (cont'd)	Loss of access to and use of lands	Land within the SML will not be accessible and there may be restrictions around land use in accordance with customary rights. Land within the FRHEP will be lost permanently.	Catchment 1A	C, O, PC	Almost certain / Major	Very High	SEM004: Resettlement Action Plans	Almost certain / Moderate	High
	Modification of landscape	FRHEP inundation or pit excavation may lead to ambiguity around land boundaries as previous boundary features and markers no longer exist	Catchment 1A	C, O, PC	Almost certain / Moderate	High	SEM004: Resettlement Action Plans	Almost certain / Minor	Medium
Physical displacement									
SV1 - The capacity to support subsistence livelihoods	Reduced availability of subsistence produce	Elevated dependence of store food	Catchment 1A – Telefol and Paiyamo	C, O	Likely / Moderate	Medium	SEM004: Resettlement Action Plans	Likely / Minor	Medium
	Reduced access to food through gardens, hunting and foraging activities	Elevated dependence of store food	Catchment 1A – Telefol and Paiyamo	C, O	Likely / Moderate	Medium	SEM004: Resettlement Action Plans	Likely / Minor	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Physical displacement (cont'd)									
SV1 - The capacity to support subsistence livelihoods (cont'd)	Obstructed access to resources (including alluvial gold) and alienation from traditional lands	Reduced ability to support subsistence livelihoods	Catchment 1A – Miyan, Telefol and Paiyamo	C	Almost certain / major	Very high	SEM004: Resettlement Action Plans	Almost certain / moderate	High
SV2 – Opportunities for participation in the cash economy	Limited river trade due to restricted river usage and access	Reduced income through trading	Catchment 1A – Telefol, Paiyamo	C	Almost certain / Moderate	High	SEM004: Resettlement Action Plans	Almost certain / Minor	Medium
SV3 - Enduring ability to sustain cultural identity and traditions	Reduced access to traditional lands	Erosion of cultural understandings, sense of place and traditional leadership, including from changes in economic status	Catchment 1A – Miyan and Telefol	C	Almost certain / moderate	High	SEM004: Resettlement Action Plans	Almost certain / minor	Medium
			Catchment 1A – Paiyamo	C	Almost certain / moderate	High		Almost certain / minor	Medium
Access and communications infrastructure									
SV1 - The capacity to support subsistence livelihoods	Vegetation clearance associated with construction of the main access road and SIP reduces the availability of food for hunting, catching or gathering	Inadequate supply of subsistence resources from hunting and gathering, and marine resources	Catchment 1A, 1B	C	Likely / minor	Medium	SEM011: Compensation – cash economy, SEM001: Vegetation clearance mitigation measures, SEM002: Terrestrial fauna mitigation measures, SEM006: Pre-construction surveys, SEM007: Information on construction impacts, SEM008: Fish and crocodile stocks	Possible / minor	Low
			Catchment 1C		Unlikely / minor	Low		Remote / minor	Very low
			Catchment 1D	C, O	Unlikely / minor	Low		Remote / minor	Very low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequenc e	Residual risk rating
Access and communications infrastructure (cont'd)									
SV1 - The capacity to support subsistence livelihoods (cont'd)	Road construction facilitates the spread of weeds and plant pathogens through the incidental movement of contaminated soil and plant materials and reduces crop yields	Inadequate supply of garden produce for subsistence	Catchment 1A, 1B and 1C	C	Possible / moderate	Medium	SEM011: Compensation – cash economy, SEM001: Vegetation clearance mitigation measures, SEM002: Terrestrial fauna mitigation measures, SEM006: Pre-construction surveys, SEM007: Information on construction impacts, SEM008: Fish and crocodile stocks	Possible / minor	Low
	Earthworks associated with road construction and extraction of construction water compromise clean water supplies	Health impairment through drinking contaminated water	Catchment 1A, 1B and 1C	C	Likely / moderate	Medium	MM050: Hazardous materials, SEM006: Pre-construction surveys, SEM007: Information on construction impacts, SEM010: Erosion and sediment control	Possible / moderate	Medium
SV2 - Opportunities for participation in the cash economy	Increased access provided by road construction leads to increased business competition	Reduced opportunity for business activity and income not realised due to increased business competition	Catchment 1A, 1B	C, O, PC	Almost certain / minor	Medium	SEM016: Employment and commercial opportunity awareness, SEM017: Pre-employment training, SEM018: Contractor development plans, SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Likely / minor	Medium
			Catchment 1C		Possible / moderate	Medium		Possible / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequenc e	Residual risk rating
Access and communications infrastructure (cont'd)									
SV3 - Enduring ability to sustain cultural identity and traditions	Improved access and communications infrastructure erodes traditional cultural practices with greater exposure to alternate ideas and practices	Loss of traditional lifestyles and practices	Catchment 1A, 1B	C, O	Likely / moderate	Medium	SEM032: Support for cultural research programs	Possible / moderate	Medium
	Improved access	Damage or destruction to cultural heritage sites	Catchment 1A, 1B	C, O	Possible / moderate	Medium	SEM029: CHMP, SEM030: Cultural heritage induction, SEM031: Informing cultural heritage custodians, SEM032: Support for cultural research programs	Unlikely / moderate	Medium
	Improved access	Damage or destruction to cultural heritage sites	Catchment 1C	C, O	Unlikely / moderate	Medium	SEM029: CHMP, SEM030: Cultural heritage induction, SEM031: Informing cultural heritage custodians, SEM032: Support for cultural research programs	Remote / moderate	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk: Likelihood/ consequence	Pre-mitigated risk: Risk rating	Mitigation measures	Residual risk: Likelihood/ consequence	Residual risk: Residual risk rating
Access and communications infrastructure (cont'd)									
SV4 – An enduring ability to maintain customary rights to land access and resource use	Access to customary lands impacted by road corridor	The main access road corridor runs through customary lands; access to lands and resource use may become an issue should in-migration occur or external service industries seek to establish themselves in the area	Catchment 1A, 1B and 1C	O	Likely / Moderate	Medium	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Likely / Minor	Medium
SV5 - An environment amenable to personal and family health, education, safety and security	Air emissions (e.g. dust, vehicle emissions), noise, vibration and / or light generated from the construction and operation of the road and Vanimo Ocean Port	Impaired community amenity and health concerns	Catchment 1A – Miyan and Telefol	C, O	Unlikely / minor	Low	SEM004: Resettlement Action Plans, SEM040: Air, noise, vibration management measures, MM144: EMMP measures, SEM007: Information on construction impacts	Remote / minor	Very low
			Catchment 1A – Paiyamo		Likely / minor	Medium		Unlikely / minor	Low
			Catchment 1B		Likely / moderate	Medium		Possible / moderate	Medium
			Catchment 1C		Likely / moderate	Medium		Possible / moderate	Medium
			Catchment 1D		Likely / moderate	Medium		Likely / minor	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Access and communications infrastructure (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	Improved access to and greater interaction with townships and markets due to completion of the road increases the availability of alcohol and drugs	Decrease in security for women and children and increase in inter-personal violence	Catchment 1A, 1B and 1C	C, O, PC	Likely / moderate	Medium	SEM049: Workforce induction, SEM054: Health and education programs	Possible / moderate	Medium
	Improved access to and greater interaction with townships and markets due to completion of the road leads to increased interpersonal interaction	Higher exposure to infectious diseases	Catchment 1A, 1B, and 1C	C, O, PC	Likely / moderate	Medium	SEM054: Health and education programs, SEM051: Infectious disease control	Possible / moderate	Medium
Traffic									
SV2 - Opportunities for participation in the cash economy	Construction of port infrastructure and use of rivers for transport may interfere with fishing activity	Decreased in income generated from fishing	Catchment 1A, 1B, 1C, 1D	C, O	Possible / minor	Low	MM144: EMMP measures	Unlikely / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	**Risk rating**		**Likelihood/ consequence**	**Residual risk rating**
Traffic (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security	Accident associated with Project vessel or vehicular movements	Fatality, injury and / or trauma	Catchment 1A, 1B and 1C	C, O	Possible / critical	High	SEM041: Project emergency response measures, SEM043: Vehicle awareness training	Unlikely / critical	High
			Catchment 1D	C, O	Possible / critical	High	SEM041: Project emergency response measures, SEM044: Vessel management protocols	Unlikely / critical	High
	Movement of Project vehicles, machinery and vessels may generate dust, vibration, noise and light	Impairment of community health	Catchment 1A, 1B, 1C, 1D	C, O	Unlikely / minor	Low	MM144: EMMP measures, SEM040: Air, noise, vibration management measures	Unlikely / negligible	Very low
Employment and procurement									
SV1 - The capacity to support subsistence livelihoods	Absence of male labour for farming or gardening activities due to Project employment	Reduction in the availability of food from gardens	Catchment 1A, 1B	C, O, PC	Possible / moderate	Medium	SEM016: Employment and commercial opportunity awareness	Unlikely / moderate	Medium
			Catchment 1C	C, O, PC	Unlikely / minor	Low		Unlikely / negligible	Very Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Employment and procurement (cont'd)									
SV1 - The capacity to support subsistence livelihoods (cont'd)	Absence of female labour for farming or gardening activities due to Project employment	Reduction in the availability of food from gardens	Catchment 1A, 1B	C, O, PC	Possible / moderate	Medium	SEM016: Employment and commercial opportunity awareness	Unlikely / moderate	Medium
			Catchment 1C		Unlikely / minor	Low		Unlikely / minor	Low
	Increased disposable income leads to an increase in the consumption and cost of store bought food	Loss of food production skills	Catchment 1A, 1B	C, O, PC	Almost certain / minor	Medium	SEM016: Employment and commercial opportunity awareness	Possible / minor	Low
SV2 - Opportunities for participation in the cash economy	Reduction in local employment opportunities when Project transitions from construction to operation, and when FRCGP transitions from operation to closure	Loss employment leads to social unrest	Catchment 1A, 1B	C, O, PC	Likely / major	High	SEM017: Pre-employment training, SEM015: Business development, supply and procurement support, SEM022: Transition to closure support	Likely / moderate	Medium
SV3 - Enduring ability to sustain cultural identity and traditions	Availability of regular high levels of income and formal employment from Project	Erosion of traditional cultural practice	Catchment 1A, 1B	C, O, PC	Likely / moderate	Medium	SEM032: Support for cultural research programs, SEM039: Capacity building programs,	Likely / minor	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Employment and procurement (cont'd)									
SV3 - Enduring ability to sustain cultural identity and traditions (cont'd)	Long term involvement with and dependency on the Project erodes traditional cultural practices	Loss of traditional lifestyles and practices	Catchment 1A	C, O, PC	Almost certain / moderate	High	SEM022: Transition to closure support, SEM032: Support for cultural research programs, SEM039: Capacity building programs	Likely / moderate	Medium
			Catchment 1B		Likely / moderate	Medium		Possible / moderate	Medium
SV4 - An enduring ability to maintain customary rights to land access and resource use	Change in traditional leadership as non-traditional forms of knowledge and skill related to Project employment become more central to social life	Reduced ability to mediate land access and resource use issues	Catchment 1A, 1B	C, O, PC	Almost certain / moderate	High	SEM036: Land dispute resolution, SEM039: Capacity building programs, SEM056: Community and government justice	Likely / moderate	Medium
SV5 - An environment amenable to personal and family health, education, safety and security	Local workers in accommodation camps exposed to higher levels of morbidity due to an increase in disease exposure and changes to diets	Increase in the prevalence of disease and health problems	Catchment 1A	C, O	Likely / moderate	Medium	SEM046: Workforce health screening, SEM047: Workforce accommodation, SEM048: Health awareness education, SEM051: Infectious disease control	Possible / moderate	Medium
			Catchment 1B		Likely / moderate	Medium		Possible / moderate	Medium
	Dietary changes due to eating in Project camps and a shift to store bought food in villages due to higher incomes	Unhealthy weight increases due to dietary changes	Catchment 1A	C, O	Possible / moderate	Medium	SEM047: Workforce accommodation, SEM049: Workforce induction	Unlikely / minor	Low
			Catchment 1B		Possible / moderate	Medium		Unlikely / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Employment and procurement (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	A decrease in gardening, hunting or fishing effort due to more time spent in Project employment results in an increased reliance on store bought food	Changes to community nutritional status	Catchment 1A	C, O	Possible / moderate	Medium	SEM054: Health and education programs	Unlikely / moderate	Medium
	A decrease in gardening, hunting or fishing effort due to more time spent in Project employment results in an increased reliance on store bought food	Changes to community nutritional status	Catchment 1B	C, O	Possible / moderate	Medium	SEM054: Health and education programs	Unlikely / moderate	Medium
	Change in the distribution of labour within the household where parents of children are employed by Project and children are required to take on additional household duties	Decreased attendance at school	Catchment 1A	C, O	Possible / moderate	Medium	SEM054: Health and education programs	Unlikely / moderate	Medium
			Catchment 1B		Possible / moderate	Medium		Unlikely / moderate	Medium
SV6 – The availability of services supportive of personal health, education, safety and security	Project employment of local community public service workers leads to inability to recruit or retain community service provider staff	Reduced access to health and education services	Catchment 1A, 1B	C, O	Possible / moderate	Medium	SEM054: Health and education programs	Possible / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Project workforce									
SV1 - The capacity to support subsistence livelihoods	Population growth due to the Project workforce impacting and / or damaging surrounding land and resources	Reduced ability to lead subsistence livelihoods	Catchment 1A, 1B	C, O	Possible / minor	Low	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Unlikely / minor	Low
SV3 - Enduring ability to sustain cultural identity and traditions	Project workforce inadvertently or maliciously damaging or destroying items or areas with cultural heritage values	Damage or destruction to cultural heritage	Catchment 1A, 1B	C, O, PC	Possible / moderate	Medium	SEM030: Cultural heritage induction	Unlikely / moderate	Medium
			Catchment 1C		Unlikely / moderate	Medium		Remote / moderate	Low
SV5 - An environment amenable to personal and family health, education, safety and security	Community grievances about Project employment or inappropriate workforce behaviour	Tension between Project workforce and communities	Catchment 1A -Miyan, Telefol and Paiyamo; 1B and 1D	C, O	Likely / minor	Medium	SEM004: Resettlement Action Plans, SEM042: Workforce code of conduct	Possible / minor	Low
	Presence of the Project workforce leading to the increased availability of alcohol and drugs in communities	Decrease in security for women and children and increase in inter-personal violence	Catchment 1A – Miyan, Telefol and Paiyamo	C, O	Likely / moderate	Medium	SEM004: Resettlement Action Plans, SEM042: Workforce code of conduct, SEM049: Workforce induction, SEM050: Security personnel training	Possible / moderate	Medium
			Catchment 1B		Likely / moderate	Medium		Possible / moderate	Medium
			Catchment 1C		Possible / moderate	Medium		Unlikely / moderate	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Project workforce (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	Local people employed by the Project exposed to diseases as a result of mixing with the broader workforce and subsequently introducing these into the village	Higher incidence of sexually transmitted and infectious diseases	Catchment 1A – Miyan, Telefol and Paiyamo; 1B	C, O	Likely / moderate	Medium	SEM042: Workforce code of conduct, SEM046: Workforce health screening, SEM049: Workforce induction	Possible / moderate	Medium
	Project security workers misusing power and using excessive force when dealing with members of the public	Human rights abuse by members by Project security personnel	Catchment 1A; 1B, 1C, 1D	C, O	Possible / moderate	Medium	SEM042: Workforce code of conduct, SEM049: Workforce induction, SEM050: Security personnel training	Unlikely / moderate	Medium
	State police force using excessive force when dealing with members of the public	Human rights abuse by members by State security personnel	Catchment 1A – Miyan, Telefol and Paiyamo; 1B, 1C, 1D	C, O	Possible / moderate	Medium	SEM042: Workforce code of conduct, SEM049: Workforce induction, SEM050: Security personnel training	Unlikely / moderate	Medium
Discharges, emissions and waste disposal									
SV1 - The capacity to support subsistence livelihoods	Project discharge / emissions that exceed guidelines and / or inappropriate waste disposal pollutes land and / or water resources	Food sources are affected by pollution of land and / or water resources	Catchment 1A	C	Possible / moderate	Medium	SEM011: Compensation – cash economy, SEM003: Water management and monitoring, SEM006: Pre-construction surveys, SEM007: Information on construction impacts, SEM010: Erosion and sediment control	Unlikely / moderate	Medium
			Catchment 1D		Possible / moderate	Medium		Unlikely / moderate	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Discharges, emissions and waste disposal (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security	Air emissions (e.g. dust, vehicle emissions), water discharges noise, vibration and light generated from movement of Project vehicles, machinery and vessels.	Impaired community amenity and health concerns	Catchment 1A, 1B	C, O	Likely / moderate	Medium	SEM003, Water management and monitoring, SEM010: Erosion and sediment control, SEM040: Air, noise, vibration management measures	Possible / moderate	Medium
			Catchment 1C		Likely / minor	Medium		Possible / minor	Low
			Catchment 1D		Likely / Major	High		Likely / moderate	Medium
	Community concern about Project effects on beneficial environmental values of waterways leads to heightened levels of anxiety	Impaired health and well-being	Catchment 1A, 2	C, O, PC	Likely / moderate	Medium	SEM009: Engagement process, MM144: EMMP measures	Possible / moderate	Medium
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	Community concerns as to the Projects effect on the beneficial environmental and social values of Dakriro Bay	Heightened level of anxiety	Catchment 1D	C, O, PC	Possible / moderate	Medium	SEM009: Engagement process, MM144: EMMP measures	Unlikely / moderate	Medium
Accidental spills and leaks									
SV1 - The capacity to support subsistence livelihoods	Project accidental spills or leaks pollute land and / or water resources	Food sources are affected by pollution of land and / or water resources	Catchment 1A, 1B, 1C and 1D	C, O	Likely / moderate	Medium	SEM003: Water management and monitoring, MM050: Hazardous materials	Possible / moderate	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Accidental spills and leaks (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security	Inappropriate transport, storage and handling of hazardous materials leads to loss of containment	Increased human health risk due to exposure to spills of hazardous materials	Catchment 1A, 1B, 1C, and 1D	C, O	Likely / moderate	Medium	MM050: Hazardous materials	Possible / moderate	Medium
	Community concern about Project effects on beneficial environmental values of waterways leads to heightened levels of anxiety	Impaired health and well-being	Catchment 1A – Paiyamo	C, O, PC	Likely / moderate	Medium	SEM009: Engagement process, MM144: EMMP measures	Possible / moderate	Medium
	Community concerns as to the Project's effect on the beneficial environmental values of Dakriro Bay	Heightened levels of anxiety	Catchment 1D	C, O, PC	Possible / moderate	Medium	SEM009: Engagement process	Unlikely / moderate	Medium
In-migration									
SV1 - The capacity to support subsistence livelihoods	Population growth due to in-migration placing pressure on land used to support gardens which reduces garden productivity	Reduced ability to lead subsistence livelihoods	Catchment 1A – Miyan and Telefol	C, O	Possible / moderate	Medium	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Unlikely / moderate	Medium
			Catchment 1A – Paiyamo		Almost certain / moderate	High		Likely / moderate	Medium
			Catchment 1B		Almost certain / moderate	High		Likely / moderate	High

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
In-migration (cont'd)									
SV1 - The capacity to support subsistence livelihoods (cont'd)	Population growth due to in-migration resulting in greater demand and subsequent scarcity of terrestrial and aquatic resources	Reduced ability to support subsistence livelihoods	Catchment 1A – Miyan and Telefol	C, O	Possible / moderate	Medium	SEM001: Vegetation clearance mitigation measures, SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Unlikely / moderate	Medium
			Catchment 1A – Paiyamo		Almost certain / moderate	High		Likely / moderate	Medium
			Catchment 1B		Almost certain / moderate	High		Likely / moderate	High
	In-migration and an increase in earning capacity puts pressure on land and resources and results in increased cost of store bought and market food	Reduced opportunity for people to purchase food, and insufficient dietary intake, which leads to an increased reliance on subsistence lifestyles	Catchment 1A – Miyan and Telefol	C, O	Likely / moderate	Medium	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Possible / moderate	Medium
			Catchment 1A – Paiyamo		Almost certain / moderate	High		Likely / moderate	Medium
			Catchment 1B		Almost certain / moderate	High		Likely / moderate	Medium
SV2 - Opportunities for participation in the cash economy	Availability of business opportunities due to higher levels of disposable income resulting from the Project leads to in-migration and increased competition	Reduced availability of business opportunities for local communities	Catchment 1A – Miyan and Telefol	C, O	Likely / moderate	Medium	SEM015: Business development, supply and procurement support, SEM016: Employment and commercial opportunity awareness, SEM017: Pre-employment training, SEM018: Contractor development plans, SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Possible / moderate	Medium
			Catchment 1A – Paiyamo		Almost certain / moderate	High		Likely / moderate	Medium
			Catchment 1B		Almost certain / moderate	High		Likely / moderate	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
In-migration (cont'd)									
SV2 - Opportunities for participation in the cash economy (cont'd)	In-migration of people with higher levels of education and work experience	Reduced opportunity to gain formal employment	Catchment 1A – Miyan and Telefol	C, O	Likely / moderate	Medium	SEM015: Business development, supply and procurement support, SEM016: Employment and commercial opportunity awareness, SEM017: Pre-employment training, SEM018: Contractor development plans, SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Possible / moderate	Medium
			Catchment 1A – Paiyamo		Almost certain / moderate	High		Almost certain / minor	Medium
			Catchment 1B		Almost certain / moderate	High		Almost certain / minor	Medium
SV3 - Enduring ability to sustain cultural identity and traditions	In-migration creating pressure on land and resources	Reduced ability to maintain customary rights and practices	Catchment 1A – Miyan and Telefol	C, O, PC	Likely / moderate	Medium	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS), SEM036: Land dispute resolution	Possible / moderate	Medium
			Catchment 1A – Paiyamo, 1B		Almost certain / moderate	High		Likely / moderate	Medium
	In-migration resulting in the clearing of areas for new settlements	Damage or destruction to cultural heritage	Catchment 1A: Miyan and Telefol	C, O, PC	Unlikely / moderate	Medium	SEM029: CHMP, SEM032: Support for cultural research programs, SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Remote / moderate	Low
			Catchment 1A: Paiyamo, 1B		Possible / moderate	Medium		Unlikely / moderate	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
In-migration (cont'd)									
SV4 - An enduring ability to maintain customary rights to land access and resource use	People migrating to the Project area asserting rights to land and residency so as to claim a share of royalties and compensation	Disputes over customary rights and access to lands	Catchment 1A – Miyan and Telefol	C, O, PC	Likely / moderate	Medium	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS), SEM036: Land dispute resolution	Possible / moderate	Medium
			Catchment 1A – Paiyamo		Almost certain / moderate	High		Likely / moderate	Medium
			Catchment 1B		Almost certain / moderate	High		Likely / moderate	Medium
SV5 - An environment amenable to personal and family health, education, safety and security	In-migration effects on access to land and resources resulting in tensions in social relations	Disruption to social relations and community wellbeing	Catchment 1A, 1B	C, O	Almost certain / moderate	High	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Likely / moderate	Medium
	Population growth due to in-migration resulting in increased violations of law and order and a reduced level of safety	Deterioration of community safety and security	Catchment 1A, 1B	C, O	Likely / moderate	Medium	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Possible / moderate	Medium
			Catchment 1D		Possible / moderate	Medium		Unlikely / moderate	Medium
SV6 - The availability of services supportive of personal health, education, safety and security	In migration increasing the demand for health, emergency and education services	Reduced availability of health, emergency and education services for local residents	Catchment 1A, 1B	C, O	Possible / moderate	Medium	SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS), SEM054: Health and education programs	Unlikely / moderate	Medium

<table>
<tr><th rowspan="2">Social value</th><th rowspan="2">Threat</th><th rowspan="2">Impact</th><th rowspan="2">Catchment</th><th rowspan="2">Project phase</th><th colspan="2">Pre-mitigated risk</th><th rowspan="2">Mitigation measures</th><th colspan="2">Residual risk</th></tr>
<tr><th>Likelihood/ consequence</th><th>Risk rating</th><th>Likelihood/ consequence</th><th>Residual risk rating</th></tr>
<tr><td colspan="10">Distribution of monetary wealth</td></tr>
<tr><td rowspan="2">SV1 - The capacity to support subsistence livelihoods</td><td rowspan="2">The ongoing regular availability of increased levels of cash allowing people to purchase items such as guns and traps which will enhance the effectiveness of hunting practices and lead to overharvesting</td><td rowspan="2">Reduction in the availability of terrestrial fauna for subsistence purposes</td><td>Catchment 1A – Miyan and Telefol</td><td rowspan="2">C, O</td><td>Possible / moderate</td><td>Medium</td><td rowspan="2">SEM002: Terrestrial fauna mitigation measures</td><td>Possible / minor</td><td>Low</td></tr>
<tr><td>Catchment 1A – Paiyamo, 1B</td><td>Almost certain / moderate</td><td>High</td><td>Almost certain / minor</td><td>Medium</td></tr>
<tr><td rowspan="2">SV2 - Opportunities for participation in the cash economy (cont’d)</td><td rowspan="2">Project procurement and increase in cash incomes increases the demand for local food, goods and services</td><td rowspan="2">Increased cost of local food, goods and services</td><td>Catchment 1A – Miyan and Telefol, 1B</td><td rowspan="2">C, O</td><td>Likely / moderate</td><td>Medium</td><td rowspan="2">SEM019: Income management training, SEM012: Wealth capture and creation, SEM013: Wealth distribution</td><td>Likely / minor</td><td>Medium</td></tr>
<tr><td>Catchment 1A – Paiyamo</td><td>Almost certain / moderate</td><td>High</td><td>Almost certain / minor</td><td>Medium</td></tr>
<tr><td>SV3 - Enduring ability to sustain cultural identity and traditions</td><td>Project income results in a transition to a cash-based economy and directly changes traditional behaviour and practices</td><td>Accelerated change to cultural identity and traditions</td><td>Catchment 1A, 1B</td><td>C, O</td><td>Almost certain / moderate</td><td>High</td><td>SEM019: Income management training, SEM039: Capacity building programs, SEM012: Wealth capture and creation, SEM013: Wealth distribution</td><td>Likely / moderate</td><td>Medium</td></tr>
<tr><td>SV5 - An environment amenable to personal and family health, education, safety and security</td><td>The distribution of Project benefits leading to disputes amongst landowners</td><td>Reduced safety and security of communities</td><td>Catchment 1A, 1B</td><td>C, O</td><td>Almost certain / moderate</td><td>High</td><td>SEM036: Land dispute resolution, SEM024: Benefit distribution agreements</td><td>Likely / minor</td><td>Medium</td></tr>
</table>

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequence	Residual risk rating
Distribution of monetary wealth (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	Disparities in income due to non-uniform participation in Project opportunities and differential access to Project benefits	Increased inequality within communities	Catchment 1A, 1B	C, O	Almost certain / moderate	High	SEM036: Land dispute resolution, SEM024: Benefit distribution agreements	Likely / minor	Medium
	Higher income levels resulting in less emphasis given to formal education	Reduction in school attendance	Catchment 1A, 1B	C, O	Likely / moderate	Medium	SEM054: Health and education programs	Possible / moderate	Medium
	Changes in lifestyle and behaviour, particularly for young adult males removed from social restraints with high levels of disposable income, leading to sexual behaviour which increases risk of infection	Increase in the incidence of sexually transmitted diseases	Catchment 1A, 1B	C, O	Likely / moderate	Medium	SEM054: Health and education programs	Possible / moderate	Medium
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	Weakened traditional authority, combined with high levels of disposable income and the presence of outsiders increasing the general availability of alcohol and drugs in communities	Decrease in security for women and children and increase in inter-personal violence, prostitution, bride prices etc.	Catchment 1A, 1B	C, O	Likely / moderate	Medium	SEM054: Health and education programs, SEM035: Develop and implement a Project-Induced In-Migration Management Strategy (PIIMMS)	Possible / moderate	Medium

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Social value	Threat	Impact	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
				Likelihood/ consequence	**Risk rating**		**Likelihood/ consequence**	**Residual risk rating**
SV1 - The capacity to support subsistence livelihoods	Barge movements on the Frieda River disrupts fishing activities	Inadequate supply of fish for subsistence	C, O	Unlikely / moderate	Medium	SEM006: Pre-construction surveys, SEM007: Information on construction impacts	Remote / moderate	Low
	Barge movements on the Sepik River disrupt subsistence activities	Inadequate supply of fish for subsistence		Unlikely / moderate	Medium		Remote / moderate	Low
		Inadequate supply of garden produce for subsistence		Unlikely / moderate	Medium		Remote / moderate	Low
SV2 - Opportunities for participation in the cash economy	Construction of Frieda River port and barge movements along the Frieda and Sepik rivers interfere with opportunities to generate an income	Reduced income from fishing and crocodile farming	C	Unlikely / moderate	Medium	SEM008: Fish and crocodile stocks, SEM021: Livelihood surveys	Unlikely / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequenc e	Residual risk rating
Traffic (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	Accident associated with Project vessel movements	Fatality, injury and / or trauma	Catchment 2	C, O	Possible / critical	High	SEM041: Project emergency response measures, SEM044: Vessel management protocols	Unlikely / critical	High
	Air emissions (e.g. dust, vehicle emissions) noise and / or light generated from movement of Project vehicles, machinery and vessels	Impaired community amenity and health concerns	Catchment 2	C	Unlikely / minor	Low	SEM040: Air, noise, vibration management measures, SEM044: Vessel management protocols	Remote / minor	Very low
	Erosion of riverbank from wash effect of barges	Impaired use and amenity of riverbank as a place for living and meeting	Catchment 2	C, O	Unlikely / moderate	Medium	SEM044: Vessel management protocols	Remote / moderate	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequenc e	Residual risk rating
Employment and procurement									
SV2 - Opportunities for participation in the cash economy	Reduction in local employment opportunities when Project transitions from construction to operation	Loss of income and employment leads to alienation and social unrest	Catchment 2	C, O	Possible / minor	Low	SEM015: Business development, supply and procurement support, SEM017: Pre-employment training,	Unlikely / minor	Low
	Perceived reduced share of Project benefits and/or preferential employment given the change to road access rather than barging during operations	Perceived loss of income and employment leads to alienation and social unrest	Catchment 2	C, O	Possible / moderate	Medium	SEM015: Business development, supply and procurement support	Unlikely / moderate	Medium

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequenc e	Residual risk rating
Employment and procurement (cont'd)									
SV5 - An environment amenable to personal and family health, education, safety and security	Local workers in accommodation camps exposed to higher levels of morbidity due to an increase in disease exposure and changes to diets	Increase in the prevalence of disease and health problems	Catchment 2	C, O	Unlikely / moderate	Medium	SEM046: Workforce health screening, SEM047: Workforce accommodation, SEM048: Health awareness education, SEM051: Infectious disease control, SEM054: Health and education programs	Unlikely / minor	Low
SV5 - An environment amenable to personal and family health, education, safety and security (cont'd)	Dietary changes due to eating in Project camps and a shift to store bought food in villages due to higher incomes	Unhealthy weight increases due to dietary changes	Catchment 2	C, O	Possible / minor	Low	SEM047: Workforce accommodation, SEM049: Workforce induction	Unlikely / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequenc e	Residual risk rating
Discharges, emissions and waste disposal									
SV1 - The capacity to support subsistence livelihoods	Project discharge/emission s that exceed guidelines and / or inappropriate waste disposal pollute land and / or water resources	Food sources are affected by pollution of land and / or water resources	Catchment 2	C, O, PC	Possible / moderate	Medium	SEM011: Compensation – cash economy, SEM003: Water management and monitoring, SEM006: Pre-construction surveys, SEM007: Information on construction impacts, SEM010: Erosion and sediment control	Unlikely / moderate	Medium
SV5 - An environment amenable to personal and family health, education, safety and security	Air emissions (e.g. dust, vehicle emissions) noise, vibration and / or light generated from movement of Project vehicles, machinery and vessels.	Impaired community amenity and health concerns	Catchment 2	C, O	Unlikely / minor	Low	SEM040: Air, noise, vibration management measures, MM144: EMMP measures	Remote / minor	Very low
	Community concern about Project effects on beneficial environmental values of waterways leads to heightened levels of anxiety	Impaired health and well-being	Catchment 2	C, O, PC	Possible / moderate	Medium	SEM009: Engagement process, MM144: EMMP measures	Possible / minor	Low

Social value	Threat	Impact	Catchment	Project phase	Pre-mitigated risk		Mitigation measures	Residual risk	
					Likelihood/ consequence	Risk rating		Likelihood/ consequenc e	Residual risk rating
Accidental spills and leaks									
SV1 - The capacity to support subsistence livelihoods	Project accidental spills or leaks pollute land and / or water resources	Food sources are affected by pollution of land and / or water resources	Catchment 2	C, O	Possible / minor	Low	SEM003: Water management and monitoring, MM050: Hazardous materials, MM144: EMMP measures	Unlikely / minor	Low
SV5 - An environment amenable to personal and family health, education, safety and security	Inappropriate transport, storage and handling of hazardous materials leads to loss of containment and increased exposure to hazardous materials	Increased risk to human health	Catchment 2	C, O	Possible / moderate	Medium	MM050: Hazardous materials	Remote / moderate	Low
	Community concern about Project effects on beneficial environmental values of waterways leads to heightened levels of anxiety	Impaired health and well-being	Catchment 2	C, O, PC	Possible / moderate	Medium	SEM009: Engagement process, MM144: EMMP measures	Possible / minor	Low

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