5.0 Alternatives

5.1 Introduction

This section of the Environmental Impact Statement (EIS) describes the alternatives considered by Gladstone Pacific Nickel Limited (GPNL) when planning the project and designing the process plant.

5.2 Ecologically Sustainable Development

The world has a growing need for more nickel, primarily due to the increasing demand for stainless steel (refer to Section 1.6). Stainless steel has a number of properties that support its sustainable use, including corrosion resistance, high-temperature stability, strength, ductility and recyclability. Most applications of nickel are based on the nickel-containing product having high-corrosion resistance. Coupled with recyclability, this generally results in high service life and reduced life cycle impacts compared to other alternatives. The Gladstone Nickel Project (GNP) is aimed at assisting in filling the widening gap between existing global nickel metal production and worldwide demand.

GPNL has applied the principles of ecologically sustainable development (ESD) (as per Section 3A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)) when planning the project and in selecting the most appropriate alternatives in designing the process plant: These principles as described in the EPBC Act are:

> "(a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;
>
> (b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
>
> (c) the principle of inter-generations equity – that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;
>
> (d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making;
>
> (e) improved valuation, pricing and incentive mechanisms should be promoted."

This approach ensures that the gap in global nickel demand that the GNP will assist to fill is done so with nickel that is produced with sustainability in mind.

The sustainable use of resources has been considered when selecting utility requirements and the process route. The high pressure acid leach (HPAL) process for nickel production is greenhouse gas friendly compared to other nickel processing alternatives. This is because the bulk of the power and steam requirements is raised from the exothermic reaction of burning sulphur to manufacture of the leaching reagent - sulphuric acid (refer to Section 5.7 for further details).

Other examples of the application of ESD principles in the GNP include:

- Value-adding to Australian and imported nickel laterite ores through the production of nickel and cobalt metal products for export.
- Using seawater rather than fresh water in the process and for cooling requirements.
- Use of existing infrastructure in the project area.
- Consideration of raw material and waste synergies with other industries in the area.

5.3 Site Alternatives

The development of the former Marlborough Nickel Project, comprising the Marlborough mine and a nickel refinery to produce approximately 25,000 t/y nickel and 2,000 t/y cobalt from Marlborough ore, was approved following submission of the project EIS (Lagoon Hill Nickel N.L., 1998). GPNL, the current owner of the proposed Marlborough mine, has identified that there are significant advantages in increasing the scale of the project to 126,000 t/y of nickel through processing imported ore from the south-west Pacific in addition to using Marlborough ore. These advantages include:

- Increase in the project life and hence increased utilisation of the plant assets.
- Increase in average ore grade resulting in reduction in ore waste per tonne of metal produced.
- Improvement in return on investment through reduced operating costs per tonne of metal produced.

To minimise the costs and potential impacts associated with the transport of imported ore from a port to the refinery, it was determined that the refinery should be located close to a suitable port rather than inland at Marlborough. Gladstone was selected over other alternatives for the following reasons:

- Proximity to existing port facilities and the proposed Wiggins Island Wharfs (WIW).
- Proximity to Marlborough mine and potential delivery options for ore from Marlborough to Gladstone (refer to Section 5.3).
- Ready access to existing infrastructure including power, natural gas, water, roads and communications.
- Availability of land assigned for industrial activities within the Gladstone State Development Area (GSDA) for the refinery and residue storage facility (RSF), and associated service corridors in the GSDA.
- Skilled industrial workforce located in the area and broader region.
- Existing community facilities and services for project workforce.
- Existing heavy industry service companies located in the area.

5.3.1 Refinery

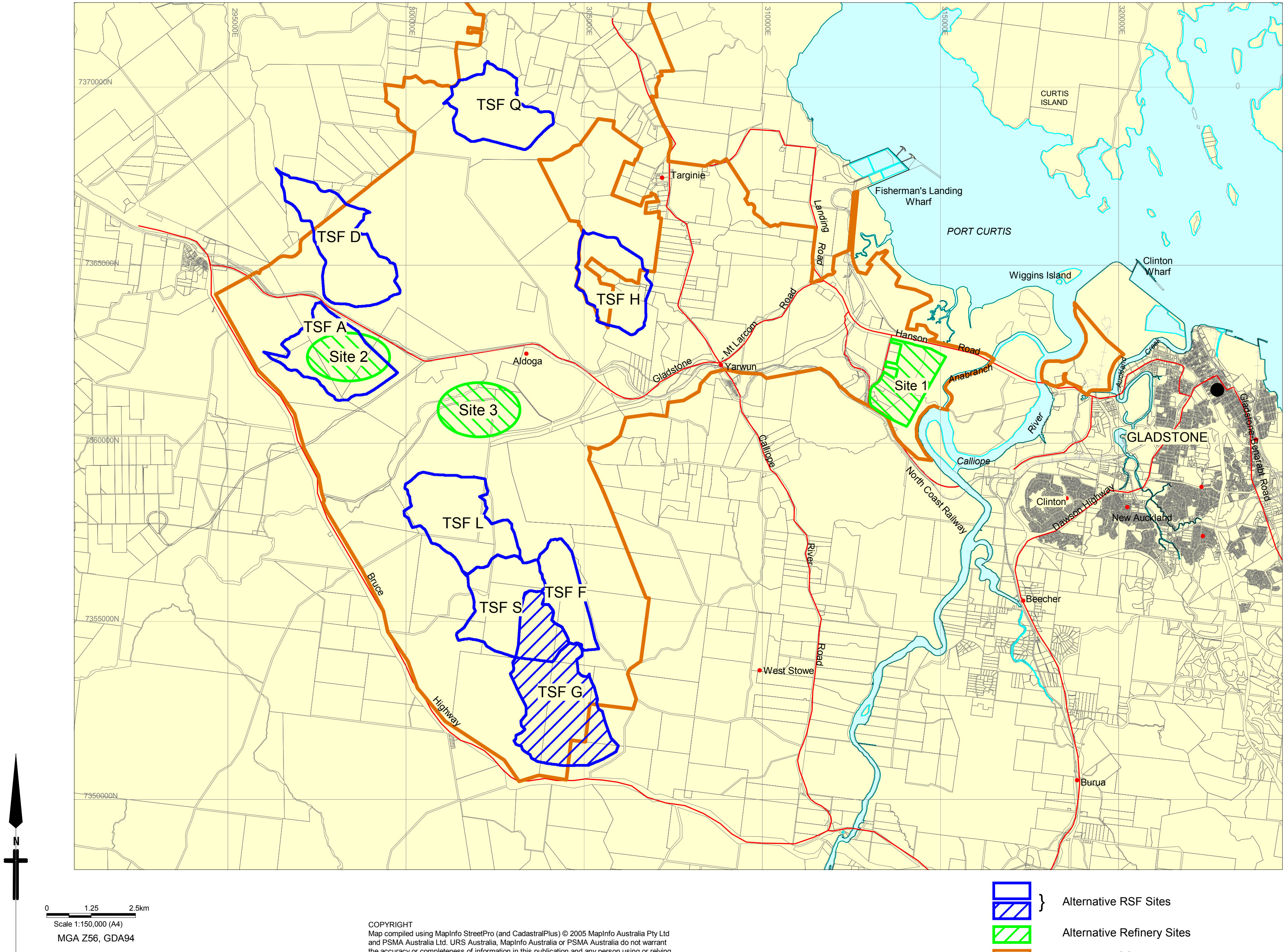
A number of sites were investigated for the refinery within Gladstone; one at Yarwun and two at Aldoga, approximately 20 km inland from Port Curtis (refer to Figure 5.3.1). Yarwun was selected as the preferred refinery site due its proximity to suitable wharf facilities for importing ore and sulphur.

5.3.2 Residue Storage Facility

GPNL commissioned a study (Connell Wagner, 2005) of eight potential RSF sites lying within the GSDA (refer to Figure 5.3.1). The key selection criteria adopted included potential environmental impacts, land requirements (storage capacity efficiency), catchment area, geological constraints and design considerations.

The environmental investigation considered vegetation, topography, hydrology, approval requirements and included a review of aerial photography. Environmental differences between the alternative sites were marginal, but vegetation clearing requirements will be relatively low for the selected site when compared to other site alternatives.

The proposed location for the RSF was the preferred site resulting from the study.



Alternative RSF Sites

Alternative Refinery Sites

Expanded GSDA Boundary

Source: Environmental Protection Agency - Estate 23/03/2006.

URS

Client: Gladstone Pacific Nickel Ltd

Project: GLADSTONE NICKEL PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Drawn: VH | Approved: CMP | Date: 21-11-06

Job No: 4262 5791 | File No: 42625791-g-101.wor

Title: SITE ALTERNATIVES
REFINERY AND RSF

Figure: 5.3.1 | Rev:B | A4

5.4 Ore Delivery Alternatives

5.4.1 Marlborough Ore

GPNL has considered two alternatives for transporting ore from Marlborough to the refinery at Yarwun:

- By pipeline with the beneficiated ore slurried using water.
- By rail transport with the ore beneficiated at either Marlborough or the refinery.

For the pipeline alternative, the ore will be beneficiated at a plant at Coorumburra (Marlborough) to concentrate the nickel content of the ore. It will then be pumped as a slurry in seawater to the refinery. For the rail transport alternative, beneficiation can take place at either Coorumburra, adjacent to the rail loop at Marlborough, or at the refinery.

Currently, GPNL's preferred method of transporting ore from Coorumburra is by slurry pipeline. The major reasons for this are:

- Proven and established technology.
- Reduced potential for noise and visual impacts during operations.
- Energy requirements for pumping the slurried ore will be substantially lower than for rail.
- The pipeline will be installed underground and does not impact on surrounding visual or productive amenity.
- The pipeline may be installed over parts of the route in a state government multi-user pipeline corridor (refer Section 5.5) reducing the overall disturbance footprint outside of the multi-user pipeline corridor.

However, a slurry pipeline requires additional water supply infrastructure and additional plant infrastructure to enable the product to be pumped and thickened to higher solids content for processing. Hence, additional evaluation will be undertaken during the detailed design phase of the GNP to confirm the suitability of using a pipeline rather than rail. Adequate space has been provided in the refinery layout for a rail siding (off the Wiggins Island Coal Terminal (WICT) project rail network) and dump station to keep the rail option open, should that be the preferred option finally selected for Stage 1. In the eventuality that the part of the WICT project required for the GNP doesn't proceed or is delayed, options for rail include a stand-alone siding or use of the Comalco Alumina Refinery (CAR) rail loop.

Investment in rail generally has a positive impact by increasing utilisation of the network. The rail system also offers flexibility in annual throughput through scheduling of rail deliveries.

5.4.2 Imported Ore

GPNL has considered three Central Queensland Ports Authority (CQPA) alternatives in Gladstone for importing ore and sulphur:

- Fisherman's Landing
- RG Tanna
- The proposed WIW

The proposed WIW is the preferred option due to:

- Ability to use conveyors to transport ore and sulphur from the port to the refinery, minimising disturbance created by possible haul roads and associated road traffic impacts which may be the case for the other alternatives.
- Proximity to the refinery – shorter conveyor length, minimising disturbance.

- Ready land access for conveyors - for the RG Tanna alternative, the conveyor would have to cross the Calliope River.
- Sufficient port capacity – RG Tanna is at capacity already with coal loading.
- Ability of the proposed WIW to accept Capesize vessels, minimising the number of ship movements and improving efficiency of ore supply.

Should the WICT project not proceed or the WIW not be completed in time to meet the GNP timetable for the import of ore and sulphur, the use of the Fisherman's Landing facility is a viable (but less preferred) alternative for the project.

5.5 Slurry Pipeline Route Alternatives

5.5.1 Identification of Preferred Route

In early 2005, Resource and Land Management Services (RLMS), a specialised land management and environmental company, was engaged by GPNL to conduct a corridor study to identify a preferred route option for the construction of the slurry pipeline between the proposed mine site at Marlborough and the refinery at Gladstone.

During the corridor study a range of route options between Marlborough and Gladstone were examined, taking into account the general terrain, environmental and construction constraints associated with the corridor, cultural issues, and the location of existing infrastructure corridors.

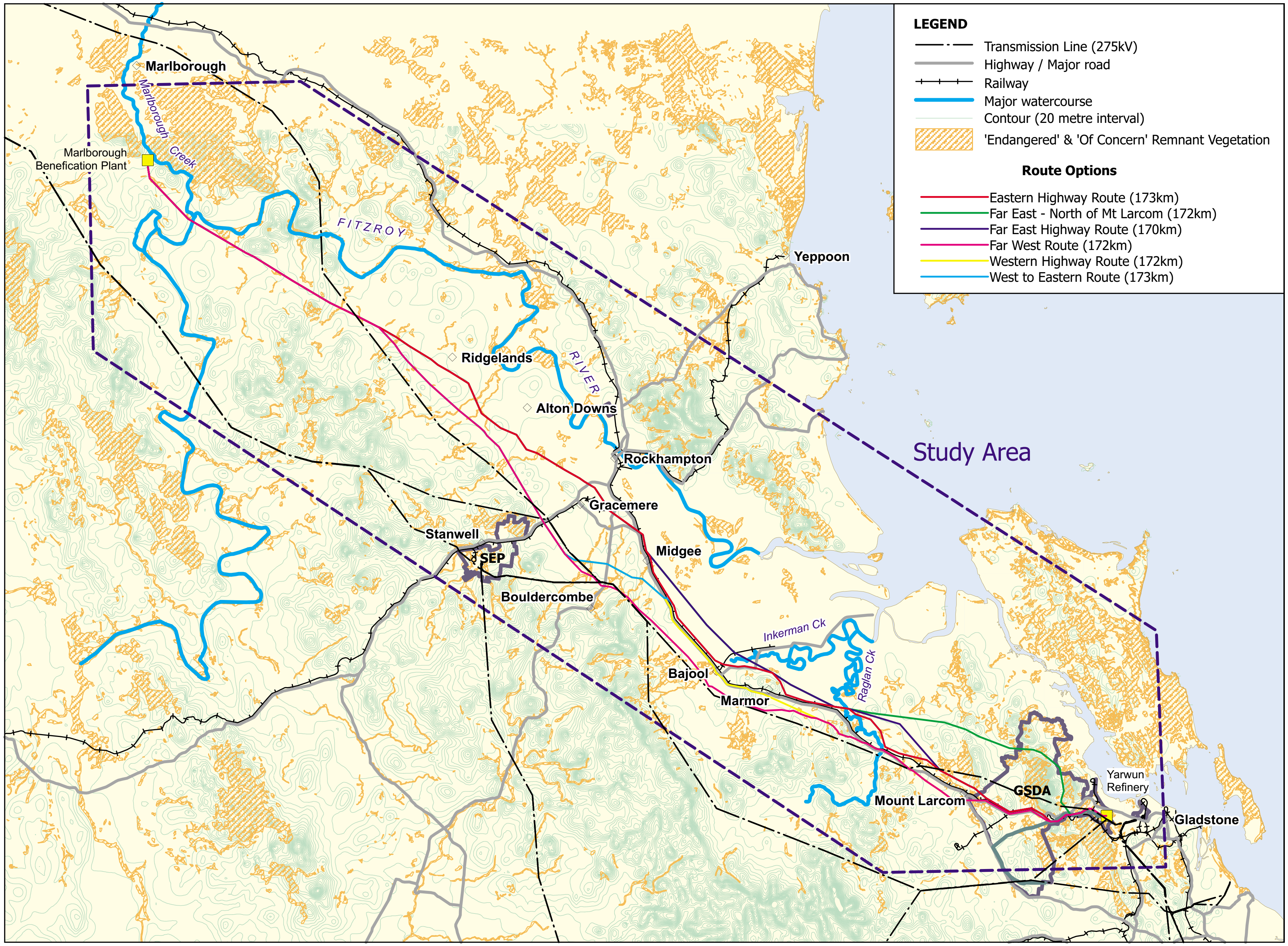
The initial study area covered a broad region (up to 50 km wide) between Marlborough and Gladstone (refer Figure 5.5.1).

5.5.1.1 Objectives

A range of objectives for the selection of the route options were developed and these are presented in Table 5.5.1.

Table 5.5.1 Route Option Selection Objectives

Category	Objective	Rationale
Land	Minimise community disturbance and interruption to land use	Route that avoids high density areas and areas of intense agriculture that will result in less disturbance during construction.
	Minimise disturbance to third party infrastructure	Minimising the requirement to cross existing infrastructure will assist in minimising impacts and construction constraints.
	Preserve landscape quality	Minimising landscape disturbance will assist in minimising community disturbance and achieving successful rehabilitation.
Environment	Avoid protected areas and areas of high ecological value	It is preferable to avoid known areas of high ecological value during the route selection process. Minor realignments can be made during the route refinement process to further minimise adverse impacts.
	Minimise disturbance to remnant and/or isolated vegetation	
	Minimise disturbance to wetland and riparian areas	



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0 5 10 15 20
Kilometres
MGA Z56, GDA94

Source: Queensland Herbarium 2003, Geodata 9 Second DEM, Geodata V2

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URS

RLMS

Client
Gladstone Pacific Nickel Ltd

Project
GLADSTONE NICKEL PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Drawn: DBJ
Approved: KD
Date: 20-10-06
Job No: 4262 5791
File No: A4_Pipeline_Layout.WOR

Title
SLURRY PIPELINE ROUTE OPTIONS

Figure: 5.5.1
Rev: A
A4

Table 5.5.1 Route Option Selection Objectives

Category	Objective	Rationale
	Utilise previously disturbed areas where practical	Utilisation of previously disturbed areas, subject to technical and construction constraints, will assist in minimising the extent of vegetation clearing and environmental impact.
Cultural Heritage	Minimise disturbance to cultural heritage values	It is preferable to locate the route options to avoid the location of known cultural heritage sites, where data are available.
Technical and Economic	Minimise pipeline length	Minimising pipeline length can provide economic advantages to the project.
	Minimise extent of terrain constraints (must not exceed 10-15º slope throughout pipeline length)	Slopes above 10-15^{o} and significant pipeline bends have the potential to limit the ability to efficiently pump slurry over large distances.
	Minimise pipeline bends	
	Maximise ease of access for construction and operations	Providing a route with easy access for construction and operations can assist in minimising construction costs, logistical issues and impacts during construction and operations.
	Minimise construction constraints such as: – Areas subject to inundation – Potential salinity – Soil stability / erodability – Number of watercourse crossings – Number of infrastructure crossings – Extent of rock – Working in third party easements	Minimising construction constraints in route selection will assist in minimising the extent of disturbance required for construction, the duration of construction and hence the scale of potential impacts.

One of the most important criteria was to avoid areas with a slope of greater than 15^{o} (15 m in 100 m), due to the technical requirements associated with pumping a slurry over a significant distance.

5.5.1.2 Methodology

The study involved the detailed assessment of desktop information and a limited field review to gain an understanding of the general terrain in relation to constructability constraints.

The primary sources of information for the desktop review and global information system (GIS) mapping included:

- Commonwealth Environment Protection and Biodiversity Conservation (EPBC) database (protected flora, fauna, ecological communities, heritage places, sites of international significance such as world heritage and Ramsar wetlands).
- National Native Title Tribunal (native title).
- Geoscience Australia.
- Queensland Herbarium (protected flora).
- Queensland Museum records (protected fauna).
- Queensland Department of Natural Resources, Mines & Water (cadastral data, mining tenements).
- Commonwealth Australian Heritage database.
- Queensland Heritage Register (items listed under Qld Heritage Act 1992).

5.5.1.3 Identification of Route Options

Upon completion of the investigation of the study area, six potential pipeline routes were identified (refer Figure 5.5.1). The relevant strengths and constraints associated with each option are presented in Table 5.5.2.

Table 5.5.2 Summary of Route Options

Route Option (length)	Strengths	Potential Constraints
Far West (172.1km)	Good access. Minimises community disturbance (further from highway). Minimises pipeline bends Close to existing pipeline (previously disturbed land). Avoids important wetlands.	Disturbance to third party infrastructure (275kv powerlines). Terrain constraints. Land use interruption (Fitzroy Shire zoning).
Western Highway (172.5km)	Good access Avoids the Gladstone to Bouldercombe 275kV power lines. Avoids important wetlands.	Pipeline bends (highway). Terrain constraints. Disturbance to third party infrastructure (highway and powerlines). Land use interruption (Fitzroy Shire zoning).
West to East (170.7km)	Good access. Minimises community disturbance. Avoids the Gladstone to Bouldercombe 275kV power lines. Avoids important wetlands. Flat, low lying terrain between Midgee and Raglan.	Some disturbance to third party infrastructure (275kv powerlines). Land use interruption (Fitzroy Shire zoning). Coastal lowlands east of the highway.
Eastern Highway (173.5km)	Good access. Minimises construction constraints. Flat, low lying terrain between Midgee and Raglan.	Community disturbance near Rockhampton Number of landowners affected. Some disturbance to third party infrastructure. Land use interruption (Fitzroy Shire zoning) Intersects several important wetlands.
Far East (north of Mt Larcom) (172km)	Flat, low lying terrain between Midgee and Raglan. Avoids the concentration of infrastructure between Mount Larcom and Gladstone Minimises community disturbance (further from highway).	Community disturbance near Rockhampton. Number of landowners affected. Some disturbance to third party infrastructure. Land use interruption (Fitzroy Shire zoning). Terrain constraints (north of Mt Larcom) Regional Ecosystems crossed (north of .Mt Larcom). Intersects several important wetlands. Remnant Vegetation Clearing (north of Mt Larcom). Pipeline bends.
Far East (via Gladstone – Mount Larcom Road) (170.2km)	Minimises community disturbance (further from highway). Minimises disturbance to remnant vegetation.	Community disturbance near Rockhampton Number of landowners affected. Interruption to land use (Fitzroy Shire zoning and horticulture east of Mt Larcom). Some disturbance to third party infrastructure Intersects several important wetlands.

5.5.1.4 Identification of Preferred Route Option

The preferred route option was identified through a comparative assessment of each route option against the route selection criteria (refer to Table 5.5.3). Based upon this assessment, the West to East Route option was identified as the preferred route option as it was the least constrained route and offered the best option in terms of topography for the slurry pipeline.

Table 5.5.3 Assessment of Route Options

Objective	Far West	Western Highway	West to East	Eastern Highway	Far East (North Mt Larcom)	Far East (G-ML Rd)
Land						
Minimise community disturbance						
Minimise interruption to landuse						
Minimise disturbance to third party infrastructure						
Preserve landscape quality						
Environment						
Avoid protected areas and areas of high ecological value						
Minimise disturbance to remnant and/or isolated						
Minimise disturbance to wetlands and riparian areas						
Utilise previously disturbed areas where practical						
Cultural Heritage						
Minimise disturbance to cultural heritage values						
Technical and Economic						
Minimise pipeline length						
Minimise extent of terrain constraints						
Minimise pipeline bends						
Maximise ease of access for construction and operations						
Minimise construction constraints						

Objective

Meets Objective **Marginal** **Fails**

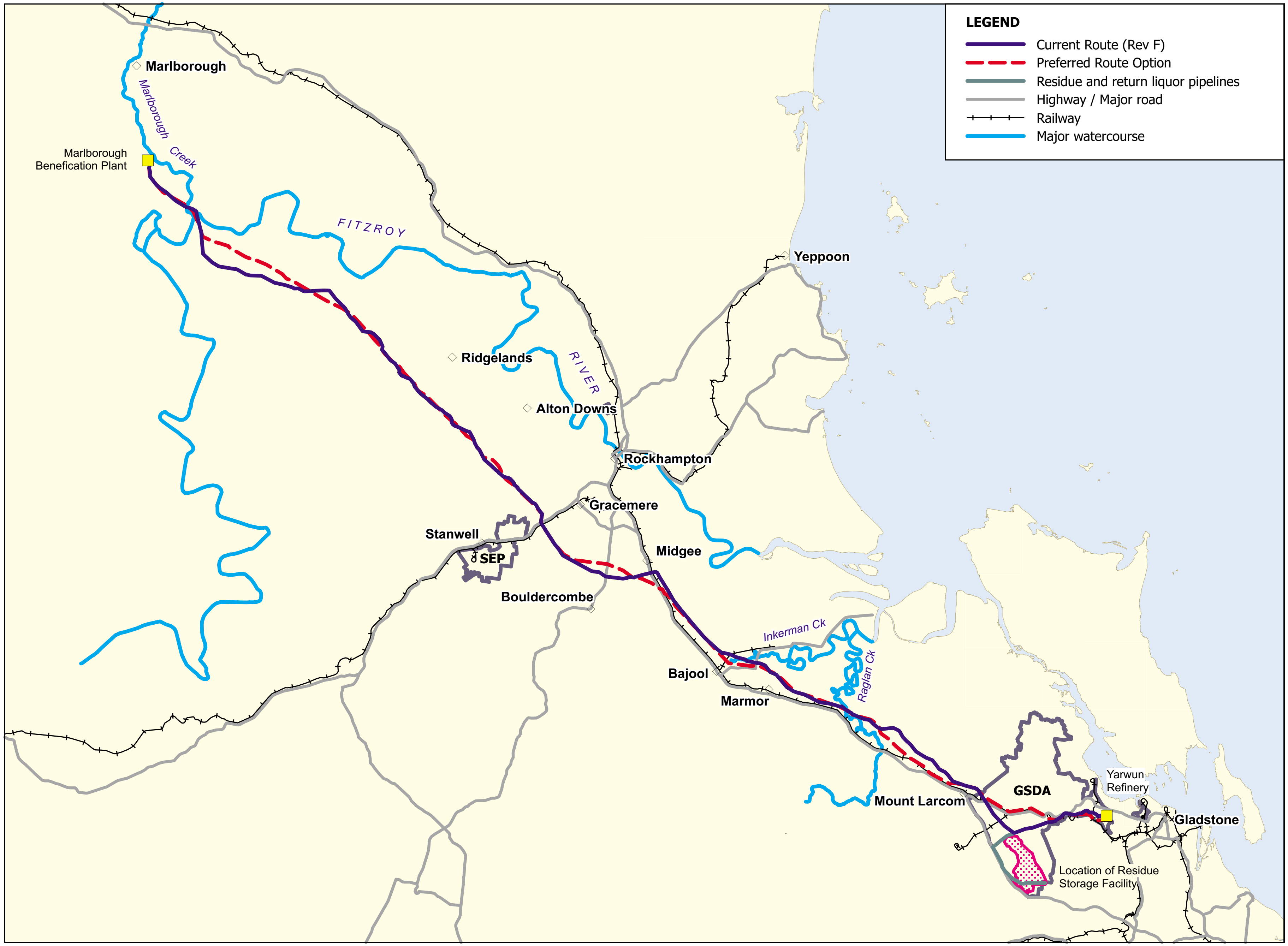
5.5.2 Route Refinement

Refinement of the preferred route option started in late 2005 and has continued to the time of preparation of this EIS. A summary of the specific refinement activities and outcomes is provided in Table 5.5.4.

Table 5.5.4 Route Refinement Investigations

Activity	Outcome
Helicopter Flyover	Identified preferred crossing of Fitzroy River and other water courses. Identified appropriate saddles to cross areas of hilly terrain (Kabra & Midgee). Located numerous landowner facilities that are to be avoided. Scoped approach to the refinery site in the highly constrained GSDA.
Cathodic Protection Study	Confirmed feasibility of route closely paralleling 275 kV transmission line through the Mt Lion area. Identified constraint associated with closely paralleling 275 kV transmission line through the Gracemere-Bouldercombe region, which was proposed to reduce impacts to landowners. Identified constraint associated with locating the pipelines within 500 m of the rail corridor for any significant distance.
Landowner Consultation Pipeline Brochure Face to Face Contact Project Newsletter	Identified landowners unlikely to sign an option agreement and re-aligned to avoid if possible. Accommodated landowners requests where possible, such as future dams, house sites or subdivision boundaries.
Environmental Survey Flora/Fauna Soils/Topography /Geology Water	Identified plant species protected by the EPBC Act and the *Nature Conservation Act 1992* (NCA) that require clearing permits. Identified areas of high habitat value and requirement for specific management plans. Identified alternate watercourse crossing points to minimise clearing of protected plant species Identified alternate route alignments to avoid clearing protected plant species and habitat of protected fauna species.
Desktop Cultural Assessment	Identified a number of cultural heritage sites within the area of the proposed pipeline route. However, concluded that it is unlikely that there would be any significant new issue or substantial deviation from the results of the previous investigations that would impact detrimentally on the project as proposed.
Construction Feasibility Survey (walkover)	Confirmation of constructability of watercourse crossing locations while minimising environmental impacts. Confirmation of constructability through coastal plains. Confirmation of likely construction method at key watercourses crossing points. Confirmation of constructability of the pipeline route through the GSDA where space is limited due to use of existing infrastructure corridor.

Six major revisions of the preferred route option have been completed as a result of the detailed investigations. A summary of the major constraints identified and route refinements completed is presented in Table 5.5.5. Where route refinements have been made as a result of the field studies for the EIS, a reference to the appropriate section of the EIS has been provided. An illustration of the preferred route (from the corridor investigation) and the current route is illustrated in Figure 5.5.2.



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MGA Z56, GDA94

Source:

Client: Gladstone Pacific Nickel Ltd

Project: GLADSTONE NICKEL PROJECT ENVIRONMENTAL IMPACT STATEMENT

Drawn: DBJ | Approved: KD | Date: 12-09-06

Job No: 4262 5791 | File No: A4_Pipeline_Layout.WOR

Title: ROUTE REFINEMENT

Figure: 5.5.2

Rev: A

A4

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Table 5.5.5 Summary of Route Refinement

Kilometre Point (All KPs refer to the Current Route)	Constraint Identified	Refined Route (Current Route)
KP 1.5-2 - Coorumburra Station	Endangered Zamia Palms, ecologically sensitive area	Route was adjusted to west to avoid Zamia Palms (refer to Section 7.4).
KP 10 - Fitzroy River Crossing	High cliffs (10 m) on south bank of Fitzroy River, the existence of a gravel bar and significant riparian vegetation (primarily on north bank). High construction cost for directional drill.	Refined route utilises a gravel bar to minimize construction cost and riparian vegetation clearing. The main body (~80 m) of water will be directional drilled.
KP 10-15 – Intensive Agriculture	Extensive section of the Bannockburn property that has both irrigated and dryland cropping.	The route was adjusted to the south-west to avoid cropping areas and to align the route closer to established farm tracks.
KP 35-80 – Transmission Line, Bouldercombe to Nebo	275 kV transmission line, Bouldercombe to Nebo.	The route was re-aligned to minimise areas in close proximity to powerlines (minimum distance ~500 m), and to cross powerlines as perpendicularly as possible.
KP 51-54 – Landowner and Terrain	Terrain constraints and unwilling landowner.	Route was realigned along the transmission line boundary and along bottom fence boundary of a recently cleared paddock.
KP 52 -53 - Faraday Rd	Brigalow woodland, ecologically sensitive area	Route was re-aligned north to avoid area of Brigalow (refer to Section 7.4).
KP 69–77 - Landowner, Terrain and 3rd Party Infrastructure	Terrain constraints, landowner request and 275 kV transmission line.	Route was re-aligned along the transmission line where possible as a request from landowner and minor adjustments were made to avoid steep terrain.
KP 80-101 – Gracemere Region	Many small acreages, highly disturbed area from previous infrastructure, transmission lines and terrain, landowner and tenure constraints,	The route was re-aligned as much as possible along boundary fences or future proposed boundary fences, road reserves were utilised where possible, and a 500 m buffer from transmission lines was established.
KP 100-175 – Electrified Rail Network	AC rail network and increased rail usage from WICT project.	A 500 m buffer from rail was established for as much of this section as possible to minimise electrical interference from the rail network.
KP 102-137 - Coastal Wetland	Coastal and marine plans and habitat for protected bird species located on eastern side of the Bruce Highway. Could not be avoided due to topographic constraint associated with western side of the highway.	The route has been realigned as far east as possible to avoid as far as possible lagoons, wetlands and shallow saline and freshwater drainage lines which provide potential habitat for protected bird species (refer to Section 7.5).
KP 136 - Raglan Creek Crossing	Closed mangrove forest.	The route was re-aligned to reduce the clearing of mangroves (refer to Section 7.4).
KP 141-149	Significant remnant vegetation inside unformed road reserve (old stock route – 200 m wide).	Route was re-aligned into the adjoining property along the boundary where clearing for grazing has already occurred.
KP 160-181 - GDSA	Industrial Park.	Worked closely with DSDI to determine the best place to locate pipeline corridor.

GPNL will continue the process of route refinement during the detailed design phase of the project.

5.5.3 Multi-User Pipeline Corridor

The Queensland Government announced on 22 November 2006 that it is considering the development of a multi-user pipeline corridor between the western or north-western edge of the GSDA and the Stanwell Energy Park (SEP) west of Rockhampton. The southern section of the proposed route for the corridor is aligned with the GNP pipeline route. To minimise environmental disturbance and impacts to landholders along the pipeline route, it is GPNL's preference to use the multi-user corridor if it proceeds, is technically suitable, and its timing does not constrain the GNP schedule.

Should the multi-user corridor not eventuate or the timing constrains the GNP schedule, the mining lease covering the project pipeline corridor will apply to the whole route from GPNL's mining lease boundaries/freehold property boundaries in the Marlborough project area to the GSDA boundary. If the multi-user pipeline eventuates in a timely way, the mining lease will extend from GPNL's mining lease boundaries/freehold property boundaries in the Marlborough project area to the northern end of the multi-user corridor.

5.6 Alternative Residue Pipelines Route

Due to the capacity of the existing materials transport corridor between the Yarwun and Aldoga precincts of the GSDA being constrained, GPNL is considering an alternative route for the pipelines between the refinery and the RSF (refer to Figure 5.6.1). This alternative route offers the following advantages:

- Reduced length.
- Largely follows road reserves and power easements, minimising disturbance.
- Avoids state forests and conservation parks (compared with a more direct route shown in Figure 5.6.1). GPNL has had preliminary discussions with the Environmental Protection Agency (EPA) regarding the most direct route following an existing power easement through the Calliope Conservation Park and the northern adjoining portion of the Mount Stowe State Forest. The EPA prefers that, to the fullest extent practicable, infrastructure is located outside of these areas.

However, while GPNL has commenced discussions with landowners who may be affected by this alternative route, its feasibility is yet to be confirmed and GPNL currently prefers the existing materials transport corridor which is the route that has been assessed in this EIS. Should GPNL decide to further investigate this alternative, appropriate environmental and engineering studies will be undertaken and reported as supplementary information to this EIS and landowners will be provided with relevant additional information.

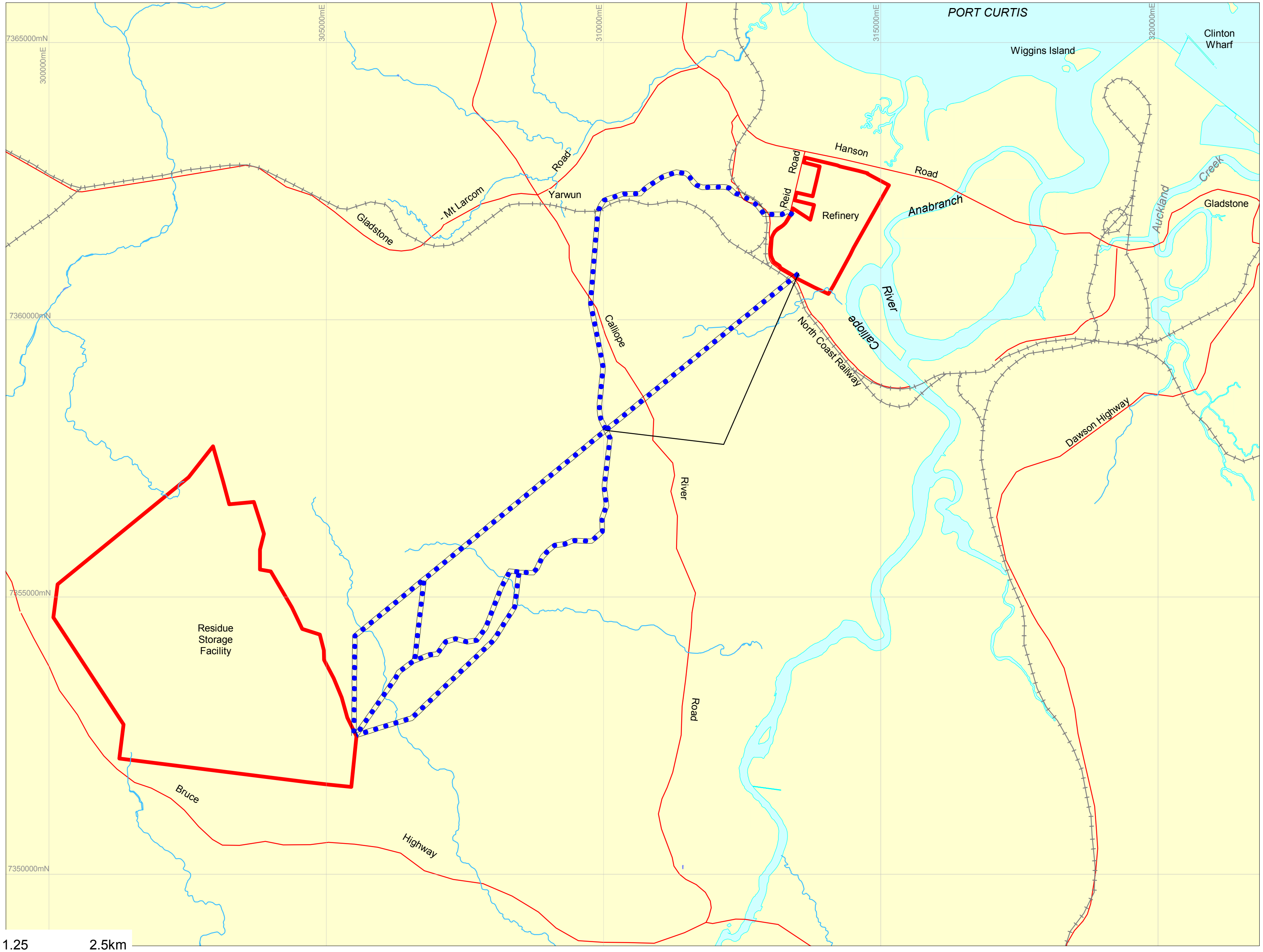
5.7 Process Alternatives

5.7.1 Nickel Extraction

There are two main alternatives available for processing nickel laterite ores:

- Pyrometallurgy; and
- Hydrometallurgy.

Pyrometallurgical processes involve the application of heat to melt the ore feed and effect reactions, with subsequent separation of the liquid phases. The two alternative nickel pyrometallurgical processes are matte smelting and ferronickel smelting. In matte smelting, the ore is roasted before smelting, or in the case of flash smelting, the roasting is combined with the primary smelting. A nickel matte is produced for further refining to metal. Ferronickel smelting, in which feeds are heated to high temperatures in large kilns or shaft furnaces, is used to produce ferronickel which is subsequently used for stainless steel production.



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Scale 1:80,000 (A4)

MGA Z56, GDA94

Source: Water bore locations obtained from NRM & W.

Alternate Residue and Return Liquor Pipeline Routes

Proposed Development Site Boundary

URS

Client: Gladstone Pacific Nickel Ltd

Project: GLADSTONE NICKEL PROJECT ENVIRONMENTAL IMPACT STATEMENT

Title: ALTERNATE RESIDUE PIPELINE ROUTE

Drawn: VH | Approved: CMP | Date: 02-02-2007

Job No: 4262 5791 | File No: 42625791-g-109b.wor

Figure: 5.6.1

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Pyrometallurgical processes are energy intensive – all free and combined moisture is evaporated, materials are calcined and melting occurs at very high temperatures. These processes are only considered suitable for ores with low iron/nickel ratios (less than 4:1), high nickel grades, and low moisture content.

The two main hydrometallurgical processes currently used are:

- Ammonia leach (Caron) process.
- HPAL process.

The ammonia leach (Caron) process uses an ammoniacal solution to extract the nickel and cobalt. It has several disadvantages. The front-end of the process, which involves drying, calcining and reduction, is energy intensive. The back-end of the process is hydrometallurgical, and the recovery of nickel and cobalt is lower than for either the pyrometallurgical processes or the HPAL process.

5.7.2 High Pressure Acid Leach Process

The HPAL process selected by GPNL is considered to be the most efficient for the ore types proposed for the GNP. The ore is leached using sulphuric acid at high temperature and pressure. The leach solution is neutralised and treated to extract nickel and cobalt for refining to nickel and cobalt metal. The two main reagents are sulphur for the production of sulphuric acid and limestone for neutralisation.

The HPAL process requires less energy per tonne of metal produced than alternative processes, and hence emissions of greenhouse gases per tonne of metal produced are lower than the alternative processes. Energy released from the exothermic reaction which produces sulphur dioxide for sulphuric acid manufacture is recovered as steam and used within the HPAL process for heating purposes or to generate power.

The HPAL process was originally developed in Cuba in the 1950s. During the 1990s, the advantages of the process became more widely known and modern versions of the process were developed and implemented at three nickel plants constructed in Western Australia (WA), namely:

- Murrin Murrin
- Bulong
- Cawse.

Many lessons have been learnt from the design and operation of these three plants and are now being applied to the following HPAL plant projects:

- Coral Bay Nickel Project in the Philippines (in production).
- Ravensthorpe Nickel Project in the south-west of WA (under construction).
- Vermelho Nickel Project in Brazil (under construction).
- Goro Project in New Caledonia (under construction).

The HPAL process is now considered to be a well-defined technology with a low level of technical risk.

5.7.3 Comparison of Potential Environmental Impacts

5.7.3.1 Air Quality

GPNL has compared the expected energy consumption for the GNP with the energy consumption at other major nickel plants. Information for these other plants has been taken from annual sustainability reports. All of the nickel plants used in this comparison are well known and understood examples of alternative processes to HPAL for processing laterite nickel ores.

The expected energy consumption per tonne of nickel metal produced for the GNP is much less than that derived from reported figures for:

- BHP Billiton's Cerro Matoso ferronickel smelting plant (BHP Billiton, 2005).
- BHP Billiton's Western Australia nickel operation (BHP Billiton, 2004), which is based on milling, flotation, a flash smelting process and an ammonia leach refinery.
- BHP Billiton's Yabulu nickel refinery in Queensland (BHP Billiton, 2005) which uses the Caron reduction roast / ammonia leach process.

The emission of greenhouse gases (carbon dioxide equivalent per tonne of nickel metal produced) is consequently also lower than for these three other processes, despite contribution from carbon dioxide generation when acidic liquors are neutralised with limestone in the HPAL process. The expected emissions from the GNP are less than 50% of those emitted by the Yabulu nickel refinery (based on information from the 2005 sustainability report).

In pyrometallurgical processing of sulphide ores, sulphur present in the ore is oxidised to sulphur dioxide during smelting. The sulphur dioxide is generally captured and used to generate sulphuric acid, which becomes a by-product of the process. However, in many plants a significant proportion of the sulphur dioxide generated is emitted to the atmosphere due to inefficiencies in capture, particularly for converter furnaces, which are used to refine the nickel matte after flash smelting. In contrast, sulphur dioxide is only generated in the HPAL process for the production of sulphuric acid. The sulphuric acid plant will be designed to convert a minimum of 99.7% of the sulphur dioxide to sulphuric acid.

If the fuel source is heavy fuel oil, pyrometallurgical laterite treatment plants and Caron processes can also emit significant quantities of sulphur dioxide.

This has been reinforced by comparing the expected air emission rate of sulphur dioxide per tonne of nickel produced with sulphur dioxide emissions reported by other major nickel plants. Based on data presented in annual sustainability reports, the proposed GNP will emit much less sulphur dioxide per tonne of nickel produced than BHP Billiton's WA operations and BHP Billiton's Yabulu nickel refinery.

5.7.3.2 Water

Because the HPAL process is hydrometallurgical in nature, expected fresh water consumption per tonne of nickel produced is higher than for the Cerro Matoso ferronickel plant. However, expected unit water consumption is less than reported for the Yabulu nickel refinery and BHP Billiton's WA operation. This has largely been achieved through designing cooling systems in the plant to use once-through seawater from Port Curtis rather than recirculating fresh cooling water, which would otherwise result in large losses due to evaporation and blowdown discharge.

5.7.3.3 Solid Residues

Because solid residues are generated from acid neutralisation in the HPAL process, the generation rate of solid residue per tonne of nickel produced for the GNP will be higher than that reported for the Yabulu nickel refinery. The expected rate is also higher than for the Cerro Matoso plant (where the residue is essentially slag). In this case, iron in the ore reports to the product as it is used for steel production. However, the expected residue-generation rate for the GNP is lower than the reported residue-generation rate for BHP Billiton's WA nickel operations, which generates:

- Solid mineral wastes during mining (especially from the open pit mines).
- Tailings from the nickel concentrator prior to smelting.
- Slags during smelting.
- Residues from the refining process.

On balance, the HPAL process for extracting nickel and cobalt from lateritic ores has significant environmental advantages over other process alternatives.

5.7.4 Intermediate Product and Refining Alternatives

A number of process alternatives are available and technically proven, for processing nickel and cobalt that has been extracted by high pressure acid leaching.

GPNL has selected to produce an intermediate mixed nickel cobalt sulphide product prior to metal refining. The alternatives are:

- Production of an intermediate mixed nickel and cobalt hydroxide product.
- Direct metal solvent extraction.

The alternatives do not, on balance, offer any significant environmental benefits over the mixed sulphide process route. The decision to produce an intermediate mixed sulphide product was based on technical risk and metal recovery.

Mixed sulphide is an intermediate product that can be processed in refineries elsewhere to produce metals. While GPNL has a preference to refine the intermediate product at the refinery, changes to market or other forces may lead GPNL to produce a mixed sulphide product for export.

Technically proven alternatives for refining of the mixed nickel-cobalt sulphide product and recovery of metal were considered. Differences in regard to potential environmental impacts were minor, and process decisions were made based on minimising technical risk and maximising metal recovery.

5.8 Energy Alternatives

The refinery will produce steam in excess of process requirements. Consequently, the plant has the ability to generate electricity for some of the refinery's demand from this surplus steam. The balance of the refinery's energy requirement needs to be supplied from an external source. Options considered for the supply of external electricity include:

- Connection to either the Ergon 66 KV or the Powerlink electrical grid from a new 132 kV transmission line.
- Additional on-site power generation using natural gas from the proposed Central Queensland Gas Pipeline (CQGP).

The refinery design is based on a grid connection to source the electricity shortfall and to supply excess electricity during periods of partial plant downtime. However, GPNL is continuing to investigate a full on-site power generation option, which may prove to have efficiency advantages.

5.9 Water Alternatives

5.9.1 Process Water

The largest demand for water in the HPAL process is for slurrying ore and for leaching. Alternative sources considered for this process water were raw water from the Gladstone Area Water Board and seawater from Port Curtis. Seawater was selected due to:

- Improved leaching kinetics and ultimate metal extractions due to the presence of sodium ions. This increases the efficiency of use of plant assets with an associated reduction in both plant size and disturbance area for a given metal production.
- Reduction in consumption of a higher value freshwater resource (raw water).
- Proximity to seawater supply (Port Curtis).

5.9.2 Cooling Water

Both seawater and fresh water were considered for cooling water for the refinery. Fresh water cooling systems include evaporative cooling and closed circuit cooling using air to cool water in a closed system.

The majority of cooling duties within the refinery can be met using seawater to extract heat from a closed cooling water circuit before being discharged back to Port Curtis.

Seawater has been selected for provision of the majority of the refinery's cooling requirements due to:

- Reduction in consumption of a higher value fresh water resource (raw water).
- Reduction in cooling water treatment reagents and cooling water effluents.
- Proximity to seawater supply (Port Curtis).
- Reduction in potential impacts to the marine environment from liquid effluent discharge due to the ability to dilute it with seawater used for cooling, prior to discharge.

5.9.3 Marlborough Ore Slurry Water

The existing environmental approval for development at the Marlborough mine and Coorumburra beneficiation plant includes the use of water from the Fitzroy River for process use. However, due to the advantages explained above in using saline water for leaching and the realisation that fresh water in the region is becoming an increasingly valued commodity, GPNL has considered a number of saline water alternatives for the water used for beneficiation at Coorumburra and ore slurrying to Gladstone to reduce demand on fresh water resources in the region. These options are:

- Seawater from Port Curtis by pipeline to Coorumburra.
- Seawater from an alternative coastal location, for example Broome Head east of Coorumburra.
- Groundwater from the Stanage Road area east of Coorumburra.

Currently the preferred option for the supply of saline water is a seawater pipeline from Port Curtis for the following reasons:

- Infrastructure to supply seawater from Port Curtis to the refinery will already be required for the project.
- The seawater pipeline will be located parallel to the ore slurry pipeline in the same corridor, minimising additional disturbance and potential environmental impacts.
- Potential saline groundwater sources near Marlborough are not technically proven.
- Environmental values and access constraints in the coastal regions to the east of Coorumburra.

While GPNL has carefully explored a number of alternatives for the supply of water to Coorumburra, additional evaluation will be undertaken at the detailed design stage to confirm the optimum water supply.

5.10 Residue Storage Alternatives

Once it reaches full production (Stage 2), the refinery will produce an estimated 10.8 Mt of solid residue each year for disposal. This residue contains substantial quantities of iron, magnesium, aluminium, calcium and sulphate.

The preferred method of disposal of this residue is land-based impoundment using a facility that is designed to minimise the disturbed area required. Several types of residue storage facilities were considered with the preferred option selected providing the following favourable features:

- Pre-thickening of residue slurry prior to discharge into the impoundment, reducing the volume of residue to be stored and the potential impacts from any seepage.
- Placement of residue in discrete areas in shallow layers (beaching) to assist in draining retained liquid to a low elevation point for recovery.
- “Mud farming” to accelerate the residue dewatering process and evaporation, and increase residue consolidation.
- Use of residue material for internal RSF wall construction for upstream raising, reducing the disturbance to other areas for provision of construction materials.

There are a number of variations on the design of the preferred option, all based on similar principles, and the optimal method will be used for this project following detailed design work.

The initial RSF embankment has been designed to contain the first 14 years of residue production. To store the residues from years 15 to 25, the capacity of the RSF will need to be increased. The options considered to increase the storage capacity are as follows:

- Upstream Embankment Raising: Once the residue has reached its design level, a new embankment will be built upstream of the existing embankment crest over the already-deposited residue to contain the additional residue. This method enables significant increases in storage capacity without increasing the RSF footprint and requires less construction material to build the new embankment than does downstream lifting. However, upstream lifting relies on the residue beach developing sufficient bearing capacity to support the embankment raise.
- Downstream Embankment Raising: This method involves increasing the height of the original embankment by placing more material on its crest and downstream face. Downstream raising is a more costly way of increasing the RSF capacity because more rock-fill material is required and the storage efficiency decreases with each embankment raise. Its advantage is that downstream raising is achievable regardless of the residue beach strength, thereby providing a defensible ‘fall-back’ residue storage solution. It will, however, increase the RSF footprint.

The preferred method is upstream embankment raising because it provides greater storage efficiency, uses fewer resources, and does not increase the footprint of the RSF. However, the option of downstream raising will be considered if the residue beach does not develop adequate bearing capacity to support the upstream raising.

While the above is the preferred method of residue disposal, the plant residue stream will have a high iron content (~24%) and potential downstream processing options (e.g. brick manufacture) will be investigated during the detailed design phase of the project.

The residue will be acidic and requires neutralisation before disposal. The acidic GNP residue could potentially be combined with alkaline residues from alumina refining produced elsewhere in the locality, to the mutual benefit of both parties. The use of alkaline residues for neutralisation reduces the consumption of neutralising reagents and potentially the volume of solid wastes produced in neutralisation. Initial test work with a sample of residue from an alumina refinery in Gladstone indicates that this alternative has potential for Stage 2, but further investigation is required. GPNL has initiated a higher level test work and development program. This will be progressed during the detailed design phase of the project.

5.11 Barren Liquor Disposal Alternatives

When metals are removed from the process liquor in the HPAL process, the resulting barren liquor cannot be reused in the process due to its high concentration of magnesium (leached from the lateritic ores) and because it is saturated with calcium from neutralisation with limestone and lime. Consequently, the barren liquor will be a waste stream from the process.

The barren liquor will be essentially seawater with increased concentration of magnesium sulphate and minor impurities. A number of alternatives for disposing of the barren liquor have been investigated including:

- Disposal to Port Curtis.
- Evaporation in ponds located in the Marlborough project area.
- Crystallisation of metal salts using forced evaporation (thermal or mechanical vapour compression).
- Removal of metal contaminants using membrane technology.

Each of these alternatives is discussed below.

5.11.1 Disposal to Port Curtis

Disposal of barren liquor to Port Curtis is the preferred option for dealing with barren liquor waste because:

- Minimal additional plant and infrastructure will be required as the barren liquor will be transported to Port Curtis in the return cooling water pipeline.
- The barren liquor will be diluted with the return cooling water (seawater) before discharge, minimising any potential environmental impacts in the discharge area.

Options exist for discharge location and the design of discharge piping and outlets that minimise any potential environmental impacts in the discharge area. Discharge from the proposed WIW and the Clinton Wharf has been investigated. Several designs for the discharge piping and outlets have also been investigated. The Clinton Wharf option is preferred and is addressed further in Section 8.3.

5.11.2 Pond Evaporation

Solar evaporation of the barren liquor in ponds located in close proximity to the refinery has not been considered as there is no suitable land available. However, solar evaporation in ponds located on land owned by GPNL near Marlborough or on land subject to a mining lease for the Marlborough component of the project, has been considered.

Investigations undertaken for the former Marlborough Nickel Project indicated that evaporation of the barren liquor was technically feasible in the Rockhampton district (Dover Consultants, 1998). As the barren liquor will contain sodium chloride from seawater as well as magnesium sulphate and will be saturated in calcium; sodium chloride, magnesium sulphate and calcium sulphate crystals will form during evaporation. While the use of seawater improves leaching efficiencies in the HPAL process (refer to Section 5.7), separation of useful products from barren liquor becomes more difficult when seawater is used.

The predicted size of evaporation ponds required for the Marlborough Nickel Project has been adjusted for the higher barren liquor generation rate for the GNP, with the result that an area of over 4,000 hectares would be required for evaporation ponds and crystallising ponds to allow sodium, magnesium and calcium salt crystals to be harvested. This estimate does not include areas required to allow for pond flooding from rainfall events and by-product stacking bays.

The environmental difficulty in recovering sodium, magnesium and calcium crystals through this option is the containment of the by-products during storage and handling, given the inherent high mobility in the environment (high solubility). Additionally, availability and access to potential markets for the crystal by-products are not considered to be viable, creating a highly mobile solid waste disposal issue.

An option for dealing with crystals recovered from solar evaporation or forced evaporation (see below) is thermal decomposition. Sodium chloride salts are separated from calcium and magnesium salts through staged evaporation ponds. The salts are subjected to high temperatures in a kiln to produce calcium / magnesium oxide and sulphur dioxide, which can be captured and converted to sulphuric acid in a sulphuric acid plant. Oxides and acid produced would then be transported to potential markets. This process is not viable for the GNP because it is very capital intensive with high operating costs (energy consumption of kilns) and there is no guarantee that markets for the by-products can be secured. Also, the quality of the by-product will be variable, adding a further difficulty to marketing this by-product.

5.11.3 Forced Evaporation

Crystallisation of sodium, magnesium and calcium salts can be undertaken by forced evaporation using steam or mechanical vapour recompression. The advantage of this process when compared to solar evaporation is that the water evaporated can be recovered and reused in the process.

GPNL has investigated this option and concluded that it is not viable from the perspective of capital and operating costs. As for the solar evaporation alternative, the quality of the crystals formed in regard to potential markets and disposal of highly mobile solid wastes when there is no market for the by-products, are significant issues.

5.11.4 Membrane Technology

GPNL has investigated the alternative of using membrane technology to separate ions from the liquor so that the liquor can be reused in the process. Laboratory test work has indicated that this alternative is not technically feasible due to the very high total dissolved solids in the liquor (Filtek, 2006). GPNL will further consider membrane technologies only in so far as these potentially support other alternatives.

5.12 Barren Liquor Treatment Alternatives

The following alternatives have been considered for the treatment of the barren liquor before discharge to Port Curtis:

- Reuse for neutralisation of alumina refining residues and subsequent reuse of process water in GNP refinery following neutralisation.
- Removal of metal salt contaminants by additional lime neutralisation.
- Removal of manganese salts through oxidative precipitation with sulphur dioxide

Each of these alternatives is discussed below.

5.12.1 Neutralisation of Alumina Refining Residues

Currently alumina refineries operating in Gladstone use the magnesium ions naturally occurring in seawater to neutralise alkaline residues, with about seven tonnes of seawater used per tonne of residue. Two potential options for treating barren liquor while providing an alternative means of neutralising alumina refining residues have been investigated by GPNL:

- Combination of pre-neutralised alumina residue (alkaline) and GNP residue (acidic). GPNL could take alumina refinery residue before it is neutralised with seawater and use it to reduce the acid load contained within the GNP residue. In that instance, existing residue areas and transfer systems would be available for use by each party to enable ongoing operation if one plant or the other is out of operation. Mixing of residues might offer significant advantages to both GPNL and alumina refiners located in the area, and is a potential opportunity to develop integrated practices for managing wastes in the longer term.

- Combination of barren liquor/RSF return liquor and pre-neutralised alumina residue. GPNL could send magnesium-rich barren liquor to one or more alumina refineries to assist in neutralising the alumina refinery's residues. GPNL could then receive the sodium-rich magnesium-depleted liquor from the alumina refineries to be used in the GNP process to make a slurry suitable for HPAL processing.

Initial test work on a sample of alumina refinery residue using synthesised barren GNP liquor has indicated that both options show a lot of potential. The magnesium and manganese ions are largely removed to the solid phase, so that there is potential for the liquor to be recycled to the nickel refinery post-neutralisation. The potential benefits of this alternative for the project are:

- Reduction / elimination of the need to dispose of the barren liquor as it can be reused.
- Reduction in magnesium and manganese loads to Port Curtis.
- Reduction in consumption of neutralisation reagents leading to lower residue storage volume.
- Improved RSF solids disposal characteristics.
- Less greenhouse gas emissions per unit of metal production by displacing other neutralisation reagents.
- Reduced residue processing infrastructure (e.g. separate dams, pipelines, thickeners, personnel, etc.).

Additionally the potential benefit to alumina refiners in Gladstone is reduction/elimination of seawater required for neutralisation and disposal of waste water to the marine environment post-neutralisation enabling local alumina refiners to approach zero liquid discharge.

GPNL has initiated a higher level test work and development program which will be progressed during the detailed design phase of the project, and pilot work (subject to agreement between the alumina refiners and GPNL that the opportunity has mutual, tangible nett benefits) could be undertaken during Stage 1 operations. Considerable test work with local alumina refiners is required to ensure that appropriate levels of operational stability would prevail in the event that residue systems are linked, and that there are no new indemnity issues that cannot be dealt with. Test work is critical to provide a basis for ensuring mutually beneficial sustainability and commercial advantages. Consequently, the timeframe for this work will preclude this approach being used in Stage 1. During the operation of Stage 1, process liquors from the GNP can be used to undertake reliable pilot tests. This would enable synergies with alkaline alumina residues and acidic nickel residues to potentially be exploited in Stage 2.

5.12.2 Lime Neutralisation

Barren liquor and residue can be neutralised with limestone and lime to pH 7 before being pumped to the RSF. Investigations have shown that as lime is added to the barren liquor beyond pH 7, conditions for magnesium and manganese precipitation become more favourable. This results in a reduction in magnesium and manganese concentration in the barren liquor, with the metals reporting to the residue for disposal in the RSF.

This is currently the preferred option for barren liquor treatment for Stage 1.

5.12.3 Oxidative Precipitation of Manganese

GPNL has undertaken some initial test work on oxidative precipitation of manganese as manganese oxide with sulphur dioxide and air, following neutralisation with limestone. This work has indicated that it may be a feasible alternative to reduce the manganese content of the barren liquor prior to disposal to Port Curtis. The process has been investigated by others (e.g. Zhang et. Al. (2002)) but GPNL is not aware of any nickel laterite plants currently using this process.

Initial test work results are encouraging, demonstrating that manganese levels can be significantly reduced with this regime. It is expected that any sulphur dioxide emissions from this system would be minimal. Despite this, a vent capture and scrubbing system would be incorporated into the engineering design.

GPNL is continuing to investigate this option and will stay abreast of any developments for other nickel refineries.

5.13 Accommodation Alternatives

In order to avoid major disruption to the local housing market during the construction phase, a number of accommodation alternatives are being considered to:

- Stimulate construction of new dwellings including housing, townhouses, units, permanent villages for temporary accommodation, motels and hotels.
- Coordinate leasing of existing rental properties.
- Promote of utilising accommodation options in the larger region.
- Develop a temporary workers village.

A combination of the alternatives outlined above will be considered in developing suitable housing for the project. Further details on the accommodation demand, housing options being considered, and a housing strategy are provided in Section 10.7.

5.14 Modularisation

GPNL is considering the off-site construction of major plant components into pre-assembled modules (PAMs). This would shorten the construction schedule of the refinery and simultaneously reduce construction housing requirements. However, a port facility for importing PAMs is not currently available in Gladstone. GPNL is consulting with government and industry in regard to a common-user port facility for PAMs. Should such a facility be available in time for the GNP, GPNL will apply this approach for plant construction.

An initial engineering study of project modularisation undertaken by GPNL indicated that the peak construction workforce could be reduced from 2,600 to 1,500. This could significantly mitigate housing and other social impacts. However, a port facility for the import of large plant modules is not currently available in Gladstone. GPNL is consulting with government and industry in regard to a common-user port facility for large modules. Should such a facility be available in time for the GNP development, GPNL will consider using this modular approach for plant construction.

5.15 “No Project” Alternative

The consequences of not proceeding with the project would be the loss of the project benefits and the avoidance of the adverse impacts.

The world has a growing need for more nickel, primarily due to the increasing demand for stainless steel (refer to Section 1.6). If the project did not proceed, the opportunity for filling the widening gap between existing global nickel metal production and worldwide demand would be lost.

The cost of not proceeding would include:

- Loss of market opportunity for GPNL and its stakeholders.
- Loss of opportunity to supply the global nickel and cobalt markets using a process which offers significant environmental advantages compared to other alternatives.

- Loss of employment opportunities during the construction phase peak of up to 2,600 during Stage 1 and 1,750 during Stage 2.
- Loss of 1,700 flow-on jobs (Stage 1 construction and operation) and 1,500 flow-on jobs (Stage 2 construction and operation) across the Gladstone/Calliope region.
- Loss of 450 direct local employment opportunities during the operational phase of Stages 1 and 2.
- Loss of the community benefits described in Section 10.

The major benefits of not proceeding would be that the potential environmental impacts of the project would not be incurred. However, to meet global demand for nickel, other projects around the world will proceed, and there is no guarantee that these projects will be designed based on the principles of ESD.