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Reducing Vulnerability of Pacific ACP States

FIJI PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT REPORT –

AGGREGATE EXTRACTION IN SELECTED SITES OF THE NAVUA AND SIGATOKA RIVERS AND THE SIGATOKA SAND DUNES, SOUTH VITI LEVU

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Important Notice

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CONTENTS

ABBREVIATIONS AND TERMS

ANZECC	Australia and New Zealand Environmental Coordinating Council
BOD	Biochemical Oxygen Demand
DoE	Department of Environment
EIA	Environmental Impact Assessment
EMP	Environment Management Plan
ERMC	Environmental & Resource Management Consultants
EMA	Environment Management Act 2005
EU	European Union
FBSAP	Fiji Biodiversity Strategy and Action Plan
GDP	gross domestic product
Ha	Hectare
IAS	Institute of Applied Science
km	kilometre
km^2	square kilometre
lawa	Fishing net
LOR	Limit of Reporting
MPA	Marine Protected Area
MRD	Mineral Resources Department
NLTB	Native Lands Trust Board
NTU	Nephelometric Turbidity Unit
NV	No Guideline Value
PICs	Pacific Island Countries
PWD	Public Works Department
qoliqoli	indigenous ocean/freshwater use area/group
SOPAC	Pacific Islands Applied Geoscience Commission
SCIL	Standard Concrete Industries Limited
SSD	Sigatoka Sand Dunes
TDS	Total Dissolved Solids
TOR	Terms of Reference
TSS	Total Suspended Solids
Turaga ni Koro	Village Headman
USP	University of the South Pacific
Vanua	Fijian social structure and obligations

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We commend Akuila Tawake of SOPAC for the development and implementation of this part of the Project in Fiji. An earlier version of this document was reviewed by Akuila Tawake and Arthur Webb also of SOPAC.

EXECUTIVE SUMMARY

Introduction

The Naduri and Nakavu villages intend to develop gravel deposits that are adjacent to their villages. Contractors at Kulukulu propose to extract sand on the Kulukulu end of the Sigatoka Sand Dunes (SSD) in Sigatoka. This report comprises the Preliminary Environmental Impact Assessment (EIA) of these proposed resource developments.

The assessment of impacts for the purpose of this report has been carried out based on the proposed development and associated work.

Proposed Development

This EIA report has been prepared for the following proposed works:

- the total area of aggregates extraction in Naduri, Sigatoka and Nakavu, Navua;
- site preparation which includes putting in cut off drains or trenches on the boundary of the property, backfilling the subject area, construction of additional drainage control, construction of rest house and toilet facilities, and associated crusher site facilities;
- rehabilitation, landscaping to minimise the effects of site disturbance; and
- construction of appropriate fencing for security and delineation of the crusher property.

Review of Environmental Impacts

The primary consideration in the evaluation and assessment of environmental impacts were the potential negative effects on the surrounding area of the proposed project. The principal issues investigated were any likely changes in water quality, noise, terrestrial and marine flora and fauna, visual amenity and social issues. The conclusions of the EIA are summarised in this report.

Water Quality

Water supply to the site will be provided through PWD water main sources for drinking.

A water quality assessment was undertaken at Nakavu (4 sites), Naduri (4 sites) and the SSD foreshore (4 sites) on the boundary of the property at three different areas.

In-situ water measurements and laboratory analysis of water samples were undertaken at these sites along the properties' boundaries. In-situ measurements on the following parameters: pH, temperature, conductivity, turbidity, salinity and dissolved oxygen were also undertaken.

Laboratory analysis for TDS, TSS, Sulphate, Bicarbonate, Carbonate, Magnesium, Phosphorus, Silica, and Nitrate were also undertaken. Apart from high turbidity levels, the other physical and biological parameters were within acceptable limits of the ANZECC Guideline for Protection of Aquatic Ecosystems (ANZECC 2000).

Noise Impacts

It is recommended that machines and equipment to be used during the project incorporate standard noise mitigation measures. These measures should safeguard the neighbouring community from adverse noise impacts during the construction stage of the project. Adverse impact may only derive from traffic noise and from operating machinery. However, this is only noticeable in the proximity of the project area during the operational phase of the project and machinery noise during gravel extraction and crushing.

The restriction of construction activities to daylight hours will minimise annoyance due to loss of acoustic amenity to nearby residential dwellings. Planting trees on the boundary bordering the crusher site should mitigate noise levels during operation of the crusher. This screen would act both as a noise and security barrier for the occupants.

Terrestrial and Marine Flora and Fauna Impacts

Terrestrial flora and fauna present on site are common in other parts of the country and are not on the list of rare and endangered species of flora and fauna.

Apart from a few rare plants at Kulukulu, the development would not have any significant impact on flora and fauna both marine and terrestrial based.

Air Quality Impact

The only likely impact envisaged is that of dust created by screening and crushing and trucks entering the site. Water to control dust will be sourced from the water main or from the river. Watering of the project site during extreme dry conditions will reduce dust emission to acceptable levels.

Visual Amenity

The proposed development area will have local vegetation planted within and on the boundaries. Beautification of the access and project area with plants will have a positive visual impact to the barren landscape and the general roadside scenery.

Social and Economic Impact

There is potential for new employment opportunities for local residents in the Naduri, Nakavu areas. However, any shortfall in terms of skills and qualification required on site will be met by workers outside these project areas.

On a national scale, this development meets the requirements and needs of the Government to encourage investment that would assist in boosting its revenues.

Conclusion

The villagers' development is justified on the basis of it complying with the requirements of the Ministry of Environment's EIA Guideline and the Environmental Management Act 2005.

The development has no particular engineering constraints and meets the environmental assessment criteria.

The development design, operation, proposed environmental mitigation measures and Environmental Management Plan (EMP) will ensure that all requirements are met and there will be no significant impact on the environment.

The EIA undertaken, therefore, supports this resource development.

1. INTRODUCTION AND OBJECTIVES

1.1 Introduction

Fiji as a developing country/nation relies heavily on aggregate for constructing infrastructure like buildings, roads, pavements etc. Aggregate are presently sourced from river gravel and hard rock to meet local and sometimes regional demand. Most quarrying companies see river gravel to be the more cost efficient of the two and this source is often vigorously exploited.

As development increases, aggregate demands increase; such demand puts pressure on local river gravel sources. The need for increased production to meet the market demand has in turn given rise to unsustainable methods of extraction, which has serious environmental ramifications.

On Viti Levu, development is centred around the Suva area, the Coral Coast and the Nadi/Lautoka corridor. The two major suppliers of aggregate within this region are Standard Concrete Industries Limited (SCIL) and Winstone Aggregates, with majority of their material being sourced from the Navua River, adjacent to and downstream from Nakavu Village. This has been exploited for many years with increasing intensity of extraction witnessed in the last five years.

One of the key focal areas of the SOPAC-EU Reducing Vulnerability Project is the identification and assessment of sand and gravel resources for construction in the Pacific Island Countries (PICs) including Fiji. One such area is the potential of river gravel to provide sources of income for resource owners. This led to an EIA being conducted at certain identified sites along the Sigatoka and Navua rivers that have gravel deposits with potential for commercial benefits. In addition, the previously low-profile sand extraction being conducted at the Sigatoka Sand Dunes (SSD) is included in this study (Figure 1).

1.2 Purpose

The preliminary EIA of proposed operations to exploit selected aggregate deposits in the Navua and Sigatoka rivers is undertaken as part of the task implementation of Key Result Area 1 of the SOPAC-EU Reducing Vulnerability Project. This Project is under the Ocean and Islands Programme Work Plan, Task Nos OI 4.1.1 and 4.1.2.

The study is also part of the aggregates assessment in the identified areas of these two rivers.

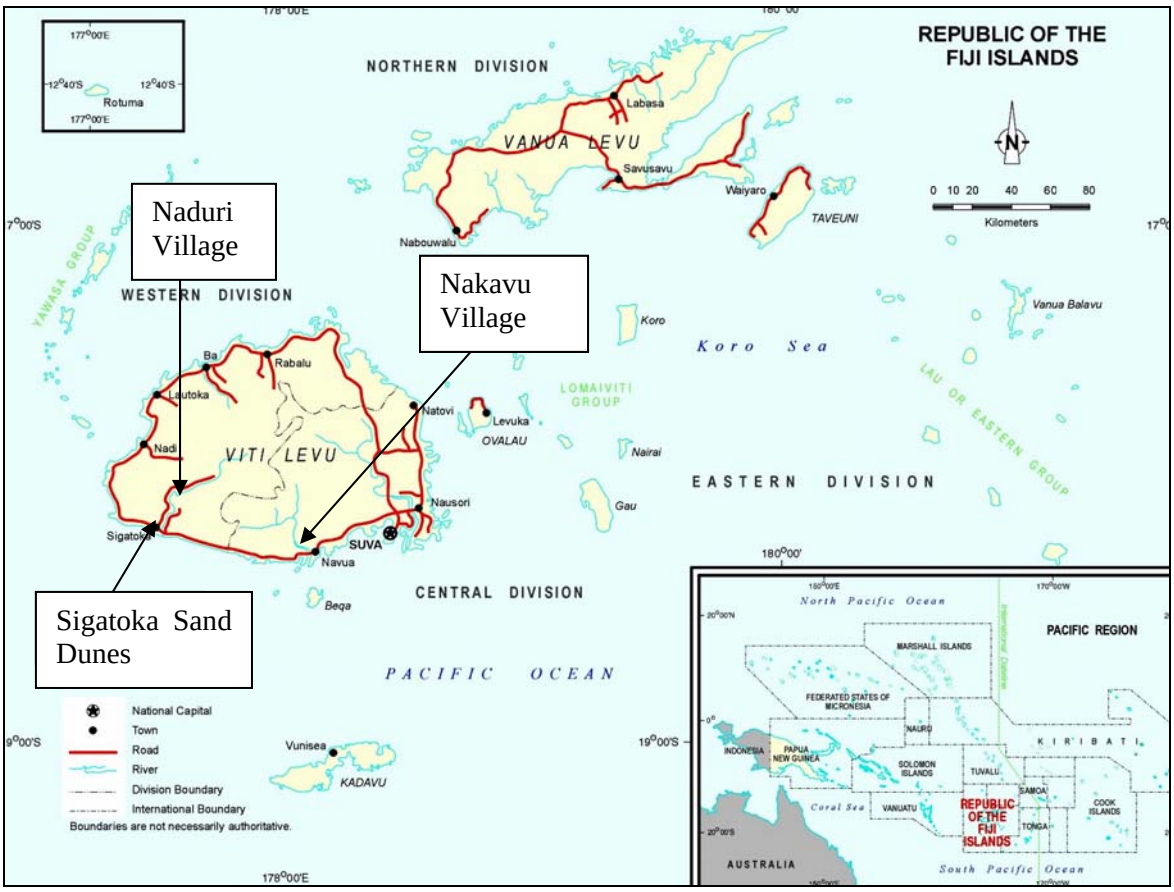

Figure 1. Locality Map of Project Areas.

1.3 Background and Objectives

A number of developers ranging from SCIL, Winstone Aggregates, Public Works Department (PWD), Pioneer Concrete to individual developers have been operating crushers to supply a range of river metal products for use as concrete aggregate in the Suva-Navua corridor and the Navua-Sigatoka-Nadi area within the main island of Viti Levu.

These developers are suppliers of processed aggregate. Their products are mainly for road metalling and concrete. These products cater for domestic and commercial construction and infrastructure development.

The principal objectives of systematically developing sand and gravel aggregate at:

1. Nakavu Village, along the Navua River;
2. Naduri Village, along the Sigatoka River; and
3. Sand extraction on the periphery of the SSD in Sigatoka are listed below.

- ❖ To meet, local market demands for sand and gravel aggregate for a variety of applications.
- ❖ The provision of environmental safeguards and ongoing environmental monitoring programmes in order to achieve an environmentally acceptable extraction and crushing operation.
- ❖ The optimal extraction and utilisation of an identified resource in accordance with requirements of the Mineral Resources Department (MRD), the Department of Environment (DoE) and the Native Land Trust Board (NLTB).

In November 2006, SOPAC commissioned Environmental and Resource Management Consultants (ERMC) to carry out a preliminary EIA for this development. The EIA Report has been prepared to assess the likely environmental consequences of sand and gravel extraction at Navua and Sigatoka with the development of relevant mitigating measures.

The study was undertaken according to the Terms of Reference drawn up by SOPAC and approved by the MRD (see Appendix 1).

The findings and recommendations are contained in this report.

1.4 Literature Review of Aggregate Extraction

The three areas under study lacked previous studies focussing on the environmental impact of sand and gravel extraction. Nevertheless, there had been a number of reports which covered the geological, archaeological and terrestrial flora appraisal of the Nakavu and the SSD area.

Geological assessments indicate that the Navua Delta consists of silts, sand and gravel and is predominantly flat with residual hills. Following drowning of the coastal areas in the Flandrian eustatic sea-level rise, negative changes have rejuvenated drainage systems and still affect the Navua River (Rahiman, 2002).

The geology map of the Sigatoka area shows that the Naduri and the SSD sites occur on the same alluvium flats of the Sigatoka River (Houtz, 1960).

In the flora assessment, the local plant (flora) names used are those by Smith (1979-1991) for higher vascular plants and by Brownlie (1974) for ferns and their allies. A detailed SSD flora assessment was also carried out by a group of scientists from the University of the South Pacific (Thaman et al, 2003).

An overview of sand and gravel extraction in Fiji has been observed during the course of this exercise, through local experience and from literature on alluvial mining of sand and gravel in other countries that have similar settings to Fiji.

Detailed research in Jamaica on environmental impacts of alluvial mining of sand and gravel revealed major disturbances (both an increase and decrease) to the overall biodiversity of the benthic macro-invertebrate fauna at two of their rivers as one moved downstream. The greatest change in faunal assemblage occurred in the immediate vicinity and immediately downstream of gravel mining localities. Biological recovery from these activities is slow following the catastrophic removal of stream bed, which results in massive habitat loss for the benthic fauna. Recolonisation of these disturbed habitats is also slow, resulting in areas of very low diversity. A serious stressor of these rivers would appear to be the removal of benthic sediments (gravel and sand) from the watercourse (Weeks, J. M. et al. 2003).

Further longer-term studies, more data collection from a larger number of impacted rivers, and enhanced dialogue with both stakeholders and decision makers are needed to demonstrate the extent and longer-term impacts of river mining activities (Week, J. M. et al. 2003).

1.5 The Environmental Impact Assessment Process

In 2005, the Government of Fiji enacted the nation's environmental legislation. The EIA Report is now part of a legal consent document under the Environmental Management Act (EMA) 2005. In accordance with the EMA 2005, the EIA TOR is normally drafted by the DoE, or the environmental consultant or as in this case the project co-ordinator, SOPAC.

The EIA process followed by this study is as follows:

1) The development of a TOR.
2) Carrying out the study.
   - Establishing socio-environmental baselines.
   - Identifying and assessing the impacts.
   - Recommend mitigative and management measures for significant negative impacts.
   - Recommend a monitoring programme within a management plan for operational activities.
3) Submit draft to client for review.
4) Consider, address and integrate comments where necessary.
5) Submit the final EIA report to SOPAC.

For an EIA of an extraction operation, one of the key components of the study is the provision of a resource budget (included in a preliminary Extraction Management Plan). This enables the assessor to overlay the proposed extraction plan over a defined existing physical, biological and social environment. The resultant prediction of the likely impacts from this development would than be close to actual.

Since this was not made available, the EIA was conducted based on the author's conceptual plans of onshore crushing and sand and gravel extraction of unknown quantities. However, SOPAC will produce a separate technical report on the aggregate resource assessment of the study areas.

1.6 Key EIA Study Personnel

Table 1. Key EIA Study Personnel.

NAME	POSITION	QUALIFICATIONS	ROLE IN THE EIA STUDY
Akuila Tawake	Senior Aggregates Geology Advisor, SOPAC	BSc (USP). MSc (Geology) University of Wollongong, NSW, Australia.	Project Director. Client Representative Aggregate Resource Assessment
Maleli Naiova	Principal, Environmental & Resource Management	MEnvSc (Hons), University of Wollongong, NSW. Australia. (MEIANZ) BSc (Bio/Earth Sc) USP.	Project Manager. Water Quality, Physical Characteristics, Biological Characteristics, Social Study, Impact Assessment, Client liaison
Apete Soro	On Secondment to ERMC, Senior EIA Officer, MRD	BSc and MSc in Applied Science (University of Auckland)	Assistant in Physical and Biological Assessment and Social survey.
Jerry Taganesia	Senior Resource Mapping Geologist, MRD	BSc (University of Otago), MSc (UNSW)	Assistant in Geophysical survey and Resource Mapping, and social survey

1.7 Key Stakeholders Consultation

Table 2. Stakeholder Consultation Method.

COMMUNITY NAME	METHOD
Naduri Village, Sigatoka	Community Meeting, House to house interviews
Nakavu Village, Navua	Community Meeting, House to house interviews
Kulukulu and nearby communities, Sigatoka	House to House Interview

2. STUDY METHODOLOGY

2.1 Proposed Development

A brief description of the proposed resource development inclusive of operating details, access, extraction method, crushing, loading and hauling, development of site drainage and sediment control works, rehabilitation plans, fire safety issues, energy required, waste management, excavation programme and future developments was made.

2.2 Description of Existing Environment

2.2.1 Biological Environment

Terrestrial Flora and Fauna

A field survey was conducted and involved the documentation of vascular plants and macro fauna found around the proposed extraction site. For animals and vascular plants, details were compiled based on field observations.

Plants and vertebrates specimens not identified in the field were noted for later identification by other flora and fauna specialists. A checklist of flora and fauna of the proposed crusher site and its surrounding was developed. The presence of recognised rare and threatened species was assessed and conservation strategies for their protection (if applicable) were devised.

Assessment of the macro fauna, and in particular the avifauna, was done by observing them or through the local knowledge of residents.

Aquatic Flora and Fauna

Aquatic flora and fauna was assessed as protein source for local diet. The survey was conducted through interviews with locals who use the river to gather food. Catches were made by locals assisting in the study using nets or diving using goggles and spear with rubber.

An assessment was also made of the biological characteristics of the river bed/bank and the water column.

2.2.2 Physical Environment

Physical characteristics of the environment river bed/bank and neighbouring works area (e.g. water quality, stability of the river bank, access, etc) were described.

Identification of other uses of the river and neighbouring environs, e.g. tourism, transport, agriculture, forestry, domestic, etc. was made.

Impacts on the surrounding environment were assessed for the operation area, crushing plant, washing, stockpiling, access roads (including impacts of haulage on existing roads).

Impacts (if any) on neighbouring communities (dust, noise, heavy equipment movements, etc.) were also assessed.

2.2.3 Social Environment

Group meetings and house-to-house surveys were conducted with relevant stakeholders from the Government, non-government organisations, local communities and resource owners for environmental awareness and identification of areas that would be vulnerable to aggregate extraction operations.

Issues and concerns raised by potentially impacted communities were noted and addressed in the EIA Report.

2.2.4 Impact Assessment

The likely environmental effects of aggregate extraction were assessed after overlaying the proposed extraction and crushing scenario on the existing environment.

The assessment results in light of other activities being carried out in the study areas and other potentially impacted sites including short- and long-term impacts of small- or large-scale extraction operations are also discussed, and include the following:

- Recommended appropriate [extraction] practices and mitigation actions that need to be adopted and undertaken prior to, during, and after any aggregate extraction operation.
- Recommended appropriate monitoring activities that will detect and minimise any impacts resulting from aggregate extraction at either site.
- Identified rehabilitation measures that need to be undertaken during and soon after the cessation of the extraction operation.

3. THE PROPOSED EXTRACTION

3.1 Development Brief

This section describes the features of the proposal to allow an assessment of the environmental consequences. This includes proposed extraction procedures, operation details and rehabilitation works.

The following is based on a conceptualised aggregate extraction plan that would suit the proposed resource development and environmental controls.

3.2 Location and Deposit Sites

3.2.1 Naduri River Gravel Deposit, Sigatoka

Naduri is one of the many villages along the Sigatoka River that lives off the resources from the watercourse. The river is a source of protein and freshwater for their farms. One such resource, which was identified under the SOPAC-EU Project, is the potential of the river to generate aggregate from gravel deposits for commercial development.

The river aggregate deposit identified on Naduri land occurs at two locations. Deposit 1 (Naduri) is adjacent to the village and Deposit 2 (Naceva) is about 3 km upstream from the village (Figure 2). The surrounding land areas are mostly under ALTA in which local farmers have leased the land for subsistence and commercial farming. The surrounding vegetation of each deposit is typical riverbank plant species in farming areas. There were no species identified to be listed under the endangered plant species.

The riverbanks on the Naduri Village end of the deposit has a gradual slope and is stable in its current state, when no major excavation or extraction is taking place. The opposite bank is relatively steep and has been exposed to erosion and landslides for years. This is the same with the Naceva deposit. The Naduri deposit was mined intermittently in the late 70s, mid 80's and late 1990's. The resource has been naturally replenished over the last 10 years.

Another use of the river is for sightseeing by tourists along the river or from the road.

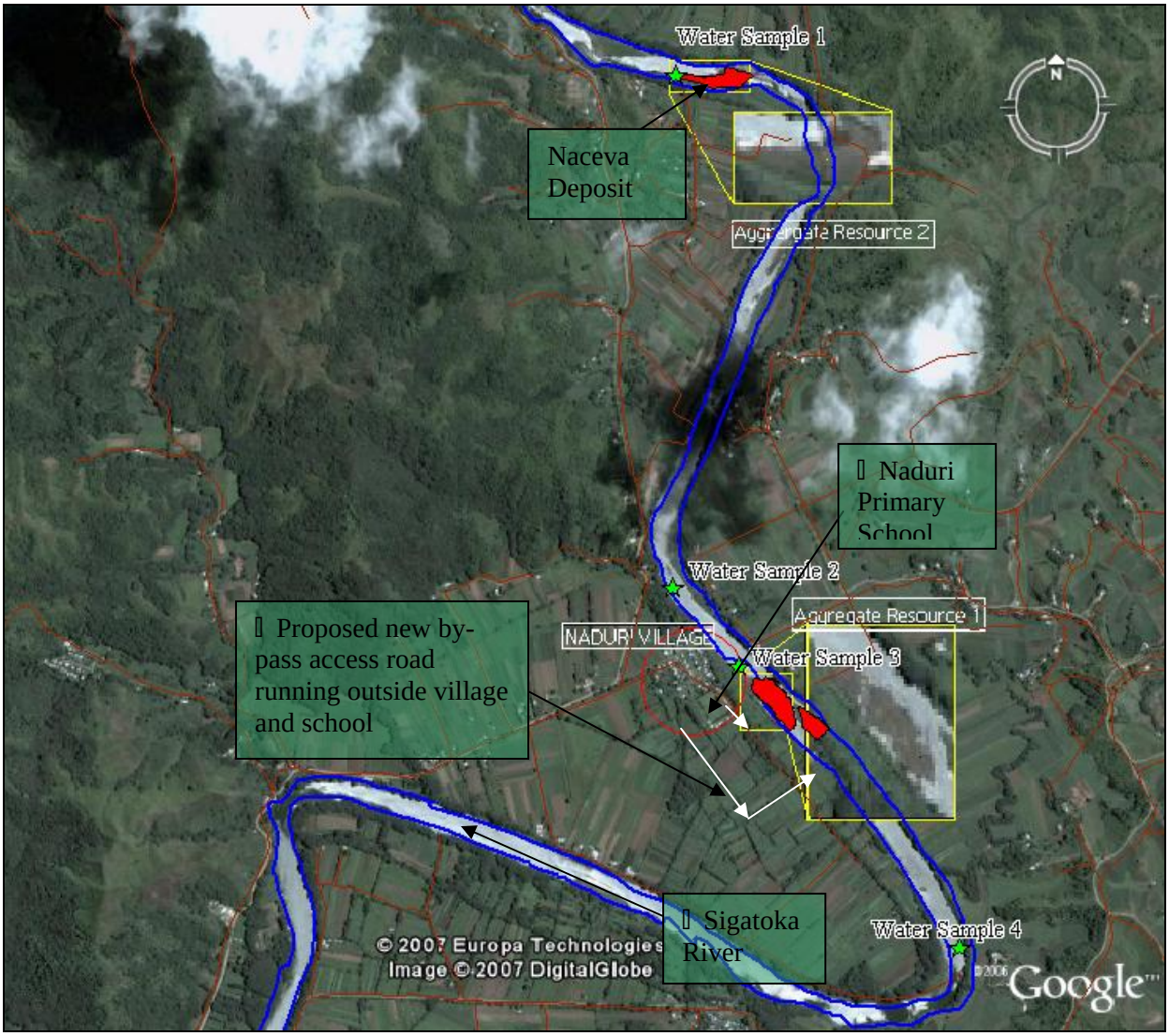

Figure 2. Aerial view of the gravel deposits identified and surveyed on Naduri Village land. Also in view are the water sampling locations.

3.2.2 Nakavu River Gravel Deposit, Navua

The Nakavu aggregate resource is deposited mainly along the right bank of Navua River (Figure 3). The exact village location is on an inland build up alluvial deposit on the foot of the Nakavu Mountains.

The gravel deposit at Nakavu has been vigorously extracted over the years to a point where it has become unsustainable due to over extraction. The rate of replenishment has been overtaken by overexploitation which has resulted in extraction being moved out to the middle of the river by building access to it and the loader scooping material from deep within the river (Figure 4).

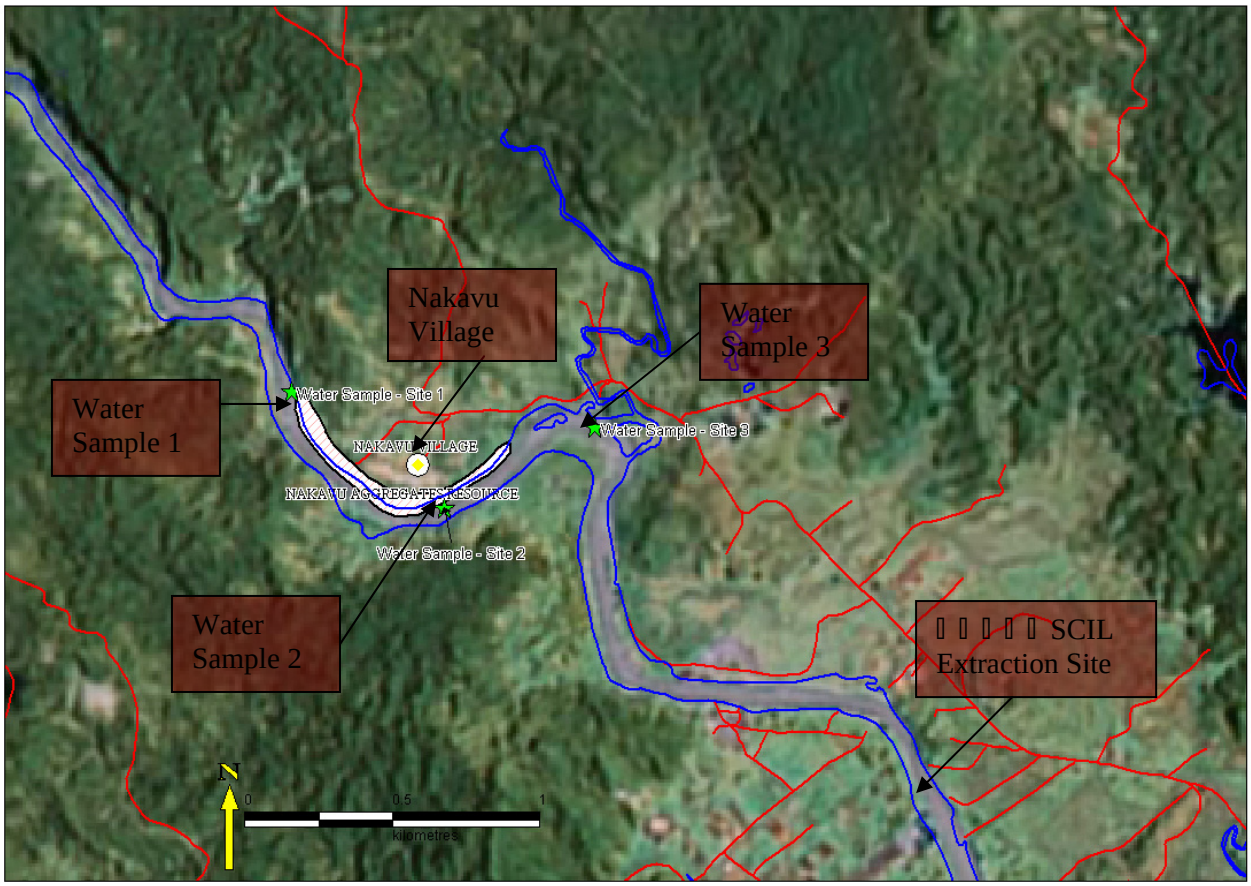

Figure 3. Aerial view of the Nakavu aggregates resource along the Navua River with respect to the village and the locations of where water samples were collected.

The whole gravel deposit along the Nakavu Village river shore shows lack of proper extraction planning and management which has resulted in the undulating topography of the shore front, characterised by dug-outs/borrow pits (Figure 4), stock piles and overburden scattered along the approach.

Figure 4. An example of unsustainable and poorly managed extraction practice at Nakavu.

Apart from gravel extraction, the river is also part of their dietary protein source and is also currently used daily by tourists on river safari cruises upstream (Figure 5).

Figure 5. Gravel extraction adjacent to Nakavu Village as a tourist boat makes its way up the Navua River. Extraction of aggregates from within the river channel is increasing the sediments build up downstream from the Nakavu extraction site.

3.2.3 Sigatoka Sand Dunes (SSD)

The SSD is the location of one of Fiji's earliest recorded prehistoric sites. The area is now become an important landmark and is now legislated under the National Trust of Fiji. Evidence of the past is clearly visible throughout the dune system as pottery shards; stone tools, human remains and other archaeological relics continue to be uncovered by natural processes.

The SSD is located directly west of the mouth of the Sigatoka River (Figure 6) the second largest river in Fiji. The dunes are the product of fluvial erosion in the coastal hinterland and coastal dune forming processes. The extensive dune system covers an area of 650 hectares and comprises a series of parabolic sand dunes of various ages and activities. Approximately half the area is unstable, especially in the east.

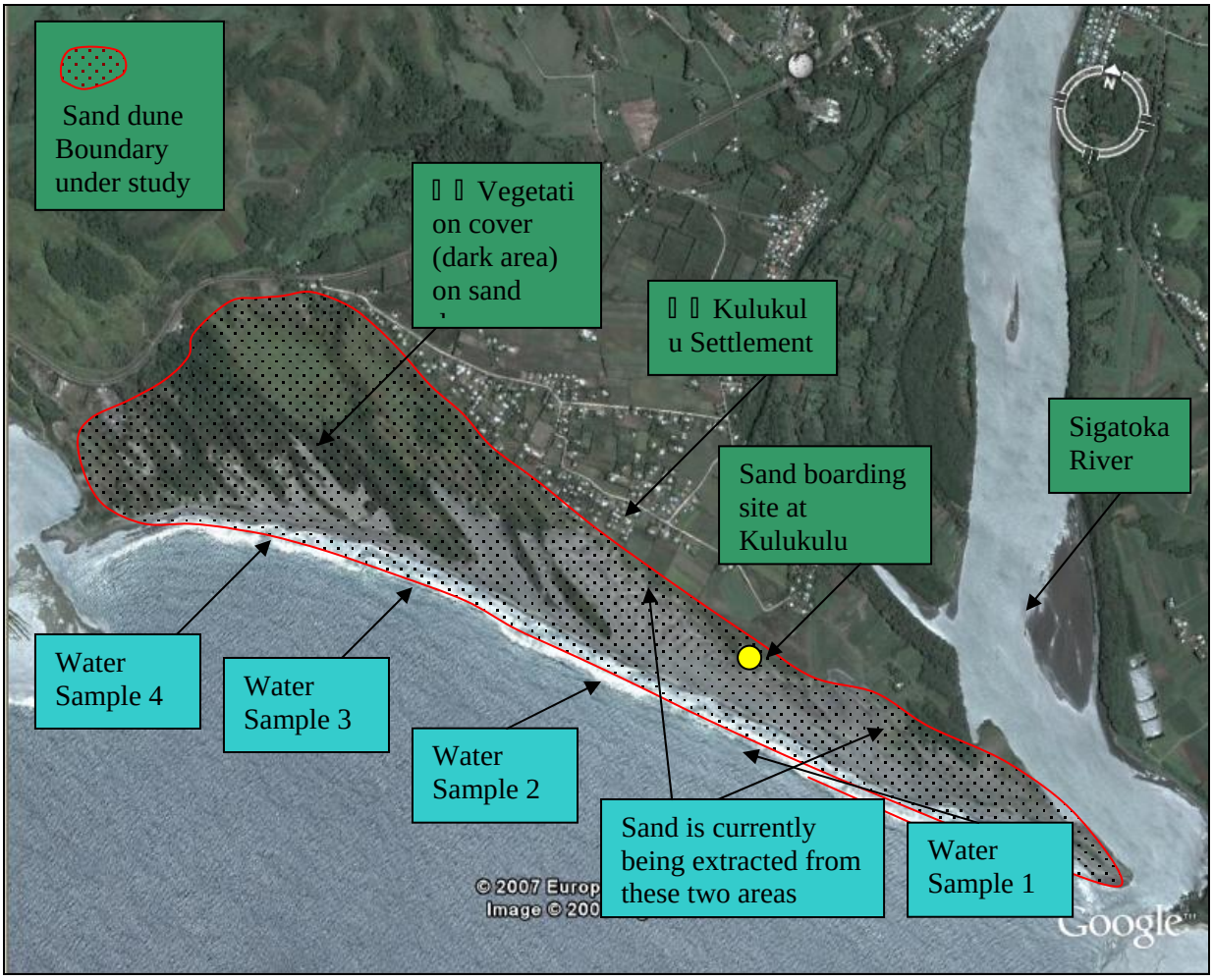

Figure 6. Satellite image of the SSD and surrounding areas. The water sampling sites and the locations of the current sand extraction operations are shown.

3.3 Aggregate Resource

Gravel resources identified along the Navua River at Nakavu Village river front and Sigatoka River at Naduri Village were surveyed to determine the volume and quality of aggregate materials that occur at each site.

A separate technical report on aggregate resource evaluation of these three sites will be produced by SOPAC.

3.4 Proposed Operational Details

Aggregate extraction is active in Nakavu where gravel is being transported to a crusher outside Nakavu. Resource owners at Nakavu are contemplating establishing their own extraction company. Similar but small-scale sand extraction practice is ongoing at the SSD in Sigatoka.

For the Naduri site in Sigatoka, a proposal to establish a river gravel extraction and crushing operation on site next to the village is in the pipeline.

For the Naduri proposal the key elements of the development are listed below.

- The extraction area.
- Crushing, and stockpiling area.
- Water management controls including sedimentation control structures, and contour drains.
- On-site hut/shelter for crusher staff.
- Rehabilitation works.

Prior to the commencement and establishment of a crusher operation, a contour drain will be constructed around the crusher site in order to divert clean runoff from non-operational areas into adjacent waterways leading to the river.

A temporary on-site shed will be established for a tallyman and crusher personnel. A foreman will oversee the day-to-day operation of the quarry and will be employed full time by the local developers.

3.5 Operating Details

The proposed hours of operation or current operating hours are:

Crusher operation: between 8.00 am and 5.00 pm Monday to Friday with possible crushing on Saturday between 8.00 am and 1.00 pm.

During the operating times the following personnel will be engaged:

- Crusher Leading Hand
- Mobile Crusher Operator – 2 persons
- Loader – x 1 person
- Tallyman – x 1 person
- Truck Drivers – x 3 persons

Contractors will undertake initial cleaning, road, drainage construction, and new access routes, if required.

At times when the crusher is not operating, machines and equipment on site will be secured. The crusher will be fenced and if need be, security personnel will be employed on site on a casual basis, particularly at night.

3.6 Roads and Access

A proposed new access road is to be constructed alongside the Naduri Village and Naduri Primary School (refer to Figure 2). Some sections of the existing access road will require minor grading, widening and straightening at some locations. It is important that provisions are made for pedestrians due to the use of the road by school children and adults at different times of the day.

For the SSD and the Nakavu extraction sites, current access routes will or is currently being utilised.

3.7 Extraction Method

It is proposed that the Naduri gravel deposit is extracted by front-end loader to be transported to the mobile crusher on site or transported from other extraction sites to the crusher by truck as required.

3.8 Crushing, Loading and Hauling

The crushing and screening operation will be carried out on site. Six- or ten-wheeler trucks will be carting loads of crushed material directly from the crushing site to offsite market destinations. The extent of sand and gravel resources at any of these three sites are unknown hence the sustainable rate of extraction cannot be determined at this point. Therefore, an expected traffic generation is not available in order to predict expected traffic movement accurately.

Since the crusher operation will be dependent on the market demand, actual truck movements may vary throughout the year. There may be times when additional trucks per day would be required for short periods but there may also be long periods without any truck movements.

3.9 Site Drainage and Sediment Control Works

Sedimentation control ponds will be incorporated into the site drainage works to minimise potential adverse water quality impacts in the Sigatoka and Navua rivers.

Runoff from undisturbed areas will be diverted around the edge of the site by a catch drain or cut-off drain. Runoff will be collected in a non-eroding channel, which will drain to the main detention basin or ponds before discharging into the river.

A simple grassed-lined channel along one side will drain the haul road. Runoff from the crushing area will be collected and drained to the main detention basin before discharge.

3.10 Rehabilitation

Existing vegetation cover will however remain minor disturbance may occur when operation begins. Additional tree planting will be done if any further disturbance to the area is noted. On completion of extraction, water management controls will remain until vegetation has re-established and all exposed areas are stabilised.

An Environment Management Plan (EMP) for any extraction/quarrying operations is given in Appendix 2 of this report.

3.11 Fire Hazard

The following are the likely fire hazards from the proposed crusher areas:

- the sparks from equipment that have the potential to ignite surrounding vegetation;
- crushing operations;
- storage of fuel and oil on site;
- controlled burning during clearing vegetation; and
- human error.

The potential for these hazards to generate a bush fire will be dependent on weather conditions (wind, temperature), moisture and fuel loads (dry leaves) within surrounding areas and the topography. The risk of a fire in Naduri is higher than Nakavu due to temperature and fuel load (dry leaves litter) – an important factor in assessing fire risk for any on-site quarry management.

3.12 Energy Requirement

The primary energy requirement for the haul trucks and crusher for the Naduri site, will diesel fuel. It is not possible at this stage to provide estimates of diesel fuel consumption since details of crusher and actual operating periods are unavailable.

3.13 Future Development

Detailed geological information on the actual reserve will be made available later by SOPAC. In order to maximise the best use of the resources, variation to annual production or extraction life may be necessary; however, this may vary from time to time due to demand.

3.14 Waste Management

Depending on the size of the operation at Naduri, especially if it also receives aggregate to crush from nearby deposits such as Naceva, Namoka and Lawai; proper on-site septic tank based lavatory would need to be constructed to cater for employees and off-site drivers working on sub-contract.

Grey water from any kitchen, hand basins should enter a small soakage pit.

Solid waste or household waste should be separated, recycled, whilst biodegradable material will be used as garden compost. The remainders should be disposed by burying in a proper pit.

The development area should also have drains constructed that run into silt traps and erosion control structures. This should be constructed towards the lower end of the site towards the boundary or cut-off drain. During construction, the structures should assist in filtering or trapping of soil and dirt particles from runoff during rainy conditions before effluent discharges into the cut-off drain and finally into the mangrove areas.

3.15 Extraction Programme

On approval of the EIA Report from the DoE, NLTB and the MRD, the project proponent that would develop the gravel resource would commence immediately to mobilise extraction and crusher equipment.

4. ALTERNATIVE SITE LOCATIONS

4.1 Introduction

Extractive type developments are by nature restricted by the physical location of the geological resource base. When considering alternative sites, the primary considerations should include;

- the location of the base deposit;
- the location of markets;
- the economic viability of extraction; and
- the environmental consequences of proceeding with extraction.

4.2 Naduri

In Naduri, the alternative site, which is the Naceva Deposit (Deposit 2), is located approximately 2 km upstream of the Naduri Deposit (Deposit 1), along the Sigatoka River.

Unfortunately for Naceva, the site lies adjacent to a number of commercial vegetables and crop plots. Even though the gravel belongs to Naduri Village, the access to the main road runs through a dozen of leased properties. Furthermore, a number of sections on the opposite side of the riverbank are already showing signs of erosion.

The proposed Naduri Village site satisfied all site selection criteria. In particular, this deposit is more environmentally and slightly economically favourable. However, if the Naceva site is developed it shall provide additional resources for the crusher that is to be sited at the Naduri Village plains.

Another alternative source that could feed the crusher at Naduri will be gravel deposit at Namoka belonging to Nakalavo Village. The untouched Namoka deposit at the upper end of Qereqere Village appears to have better gravel size and volume than the Naduri and Naceva gravel deposits. The Namoka deposit is “gravel pits” or old riverbeds that are now dry on basically alluvial flats. Another source is the Lawai deposit, which is 3.5 km downstream of Naduri.

4.3 Nakavu

At Nakavu, alternative sites for extraction are limited by the heavy presence of gravel extraction licence holders along the river hence the resource has seen active exploitation to some extent. What is now required at Nakavu is the development and enforcement of a sustainable resource management and monitoring regime.

4.4 Sigatoka Sand Dunes

At the SSD, a number of alternative sites are present inland on the landward side of the Queens Road. These sites meet most of the selection criteria of best-practice extraction.

It is a requirement of the MRD that optimal use of resources must be made where possible.

5. DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 Climate

5.1.1 Naduri and Sigatoka Sand Dunes, Sigatoka

The Sigatoka area lies on the dry side of Viti Levu where the rainfall is not uniform over the whole area. The highland masses in the north-east and south-east are generally wetter than the lowland plains to the west (Bartholomew, 1960). The average annual rainfall shows maximum precipitation recorded during the months of December through to March (wet season) and minimum during July and August (dry season).

Air temperature around the Sigatoka area is relatively constant throughout the year. The average monthly temperature ranges from 24 ^{o}C in July to 30 ^{o} C in December.

Predominant local wind is the south-easterlies and this is felt throughout the day on the sea side of the sand dunes. Extreme wind gusts are 130 knots during cyclones; otherwise it is normally less than 20 knots for the south-easterlies and the occasional westerly. The Sigatoka River is a wind channel for the south-easterlies and westerlies to reach the Naduri area.

5.1.2 Nakavu, Navua

The project site receives annual rainfall that is approximately more than 2000 mm annually. A major portion of rainfall tends to get blown into the high mountains inland through the strong prevailing south-east trade winds.

The site experiences dry conditions and cold fronts during the dry season of the months of late March to August. During the wet season, the weather could be overcast most of the time and on very rare occasions cyclones would have an impact on the area. Strong south-easterly trade winds tend to drift easily over the plain.

5.2 Topography and Geology

5.2.1 Naduri Village and Sigatoka Sand Dunes, Sigatoka

Naduri sits on the elongated Sigatoka River that forms the valley commonly known as the salad bowl of Fiji, due to its many vegetable farms. Along this river, land is continuously cultivated on both sides of the banks, which are the typical landform of the surrounding areas at both sites.

The geology of the Sigatoka area comprises two major formations: the Wainimala Series and the Sigatoka Series. The Sigatoka Series is composed of limestone, argillites and sandstones, andesite intrusives, and breccia agglomerate and flows. Plutonic are intrusive into the Wainimala, whereas the only intrusive into the Sigatoka are andesite plugs. Sediments of the Sigatoka Series could be more than 6 km in thickness (Houtz, 1960).

5.2.2 Nakavu Village, Navua

The geology of the area where the Nakavu aggregate resource is located which is at the beginning of the Navua Delta is best described by Band (1968). The delta is underlain by the

Miocene-Pliocene Serua Conglomerate that un-conformably overlies Lower Tertiary volcanic conglomerates and tuffs.

Active erosion in the middle and upper reaches of the Navua River has caused rapid buildup of the bay-head delta. The lower valley of the Navua River in consequence has filled up with alluvium to a considerable degree with cycles of floodplain silt and fine sands overlying coarse sands and gravel channel-infill deposits (Davies, 1990).

5.3 Land Use and Tenure

The proposed extraction and crusher area in Naduri is on native land which is currently vacant and has been vacant for some time as farming is not feasible due to the subsurface of gravel and sand. The Naceva site is adjacent to vegetable and crop farms. A proposed tourist river safari cruise is supposed to include the village of Naduri. This tourism venture is similar to the one currently operating in the Navua River.

5.4 Noise

The existing noise level of the project areas, in Nakavu, Naduri and the Sigatoka Sand Dunes is considered typical of rural environmental settings. The main sources of noise in the area are birds and wind and occasional traffic noise from nearby roads.

Noise level varies during the day between 50 and 60 dB(A) at the proposed extraction and crushing site. A standardised sound level is given in Table 3 in which one can gauge the noise level at extraction/quarry site.

During gravel extraction and crusher operation, there will be some noise impact as a result of increased traffic (trucks and excavator) during the day.

Table 3. Noise Levels in Common Situations in dB(A).

Sound Level dB (A)	Source
20	Soft Whisper
30	Recording Studios
40	Nearby conversation, residential area at night
50	Business office, restaurant
60	Normal conversation, secretarial area, rural environment
70	Average Street
80	Busy Street
90	Home workshop tools
100	Noisy factory

Adopted from Corbitt R A, Standard Handbook of Environmental Engineering, 1990

5.5 Erosion

There is strong evidence of erosion taking place within or on the edge of the project area of operational areas such as along the Navua River (Figures 7 and 8) and the sand boarding area and backyard of properties adjacent to old extraction sites of the SSD (Figures 9 and 10).

Figure 7. Erosion along the Navua River at the SCIL extraction site. The loader is illegally removing gravel from the other side of the river and transferring it across for loading into the dump trucks.

Figure 8. River bank at Nakavu Village begins to erode and widen due to the impact of extraction upstream of the village.

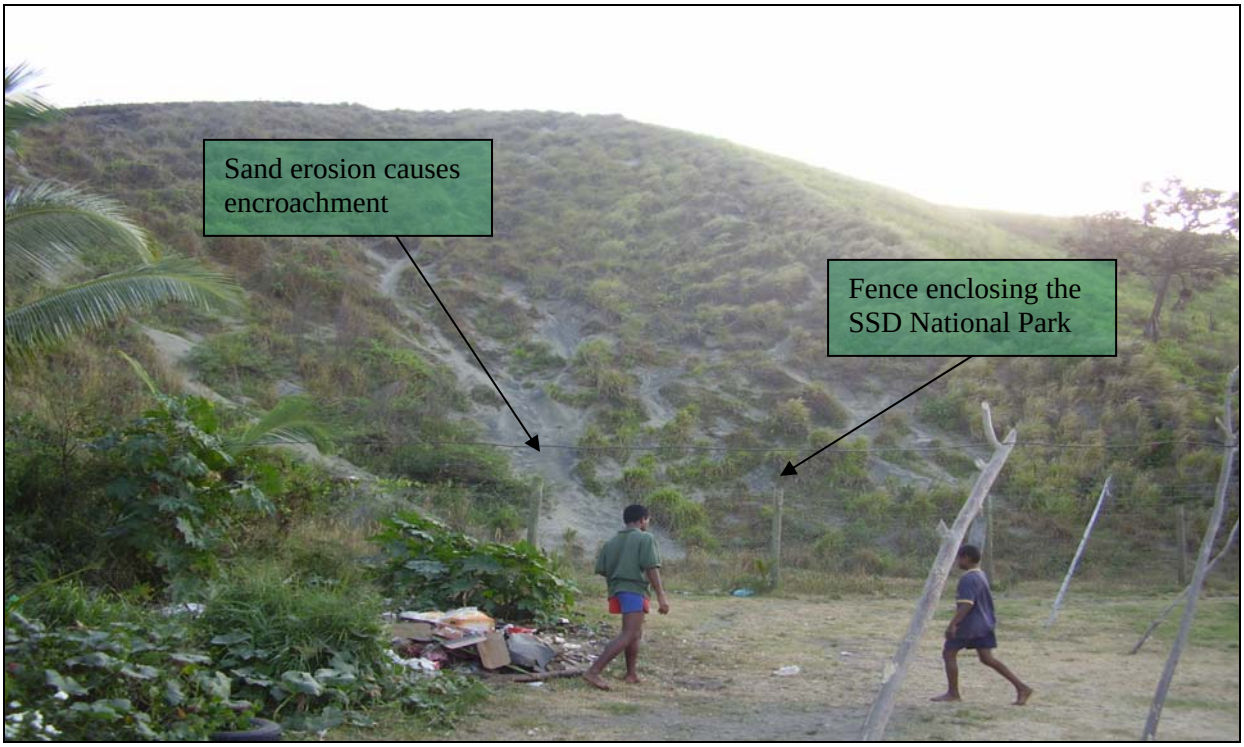

Figure 9. Fenced area of the SSD National Park on the landward slope of the dunes – at the back of residential properties. Erosion has claimed portion of the land due to old extraction operations in this area.

Figure 10. Sand erosion at the sand boarding activity area for tourists opposite Kulukulu Settlement.

5.6 Surface Water Quality

Water samples and in-situ measurement was taken from a number of locations, namely Sites 1, 2, 3, and Site 4 along the Sigatoka River (Naduri project), Sites 1, 2, and Site 3 along the Navua River (Nakavu Project) and Sites 1, 2, 3 and Site 4 along the foreshore of the Sigatoka Sand dunes.

Locality maps of the proposed development site and the sampling sites for the physio-chemical parameters measured are shown in Figures 2, 3 and 6. Photos of water sampling and measurements at each site are shown in Figures 11, 12 and 13 below.

Figure 11. In-situ water quality measurements and grab samples taken for laboratory analysis in the Sigatoka River.

Figure 12. Grab samples taken for laboratory analysis on the sand dunes foreshore.

Figure 13. In-situ water quality measurements and grab samples taken for laboratory analysis in the Navua River.

The water quality of the three proposed areas of extraction were measured for its physical parameters namely pH, dissolved oxygen, turbidity, conductivity, temperature and salinity. Water samples were also collected for laboratory analysis at the MRD Laboratory for the following: pH, conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), SO_4, HCO_3, CO_3, Ca, Mn, P_2O_5, Si and NO_3.

The location of the sampling sites for the three project areas are depicted in Figures 2, 3 and 6. The measurements for these parameters were taken during clear weather. For the SSD, sampling was undertaken at midday during the outgoing tide.

5.6.1 In-situ Water Sampling Field Results

Naduri Sampling Sites

Date of Sampling	: 17th November 2006
Time of Sampling	: 10: 30 – 12 : 00 pm
Weather	: Fine
Flow	: Normal
Sampler	: Apete S and Jerry T

Table 4. Table showing in-situ measurements of physical parameters at Naduri sampling sites.

Location Parameter	Site 1 Gravel Bar Upper resource (Naceva)	Site 2 Outcrop at the corner before the village	Site 3 Gravel Bar at the village resource	Site 4 Sand bar at the corner after village	ANZECC Guideline 2000
Temperature ^{0}C	29.0	30.0	30.0	31.0	<38
pH	7.38	7.29	7.33	7.13	6.0–7.5
Conductivity mS/cm	0.198	0.198	0.197	0.197	20–250 µS/cm
Turbidity NTU	0	0	0	0	2–15 NTU
Dissolved Oxygen mg/L	7.5	8.2	6.3	6.5	>6
Salinity	0	0	0	0	0 for freshwater

Nakavu Sampling Sites

Date of Sampling : 23rd November 2007
Time of Sampling : 10:00 pm –12:00 pm
Weather : Fine
Flow : Normal
Tide : High tide – outgoing
Sampler : Apete S and Maleli N

Table 5. Table showing in-situ measurements of physical parameters at Nakavu sampling sites.

Location Parameter	Site 1 Upstream of Village and 1st extraction site	Site 2 Adjacent to the Village	Site 3 After the Village at the 3rd Extraction site	ANZECC Guideline 2000
Temp.^{0}C	25.61	26.61	26.18	<38
pH	7.18	7.98	7.23	6.0–7.5
Conductivity mS/cm	0.27	0.29	0.29	20–250 µS/cm
Turbidity NTU	0	10	10	2–15 NTU
Dissolved Oxygen mg/L	7.06€	8.23	8.63	>6
Salinity	0	0	0	0 for fresh water

SSD Sampling Sites

Date of Sampling : 14th November 2007
Time of Sampling : 10:00 pm – 12:00 pm
Weather : Fine
Flow : Normal
Tide : High tide – outgoing
Sampler : Apete S and Ilaitia B

Table 6. Table showing in-situ measurements of physical parameters at the SSD sampling sites.

Location / Parameter	Site 1	Site 2	Site	Site 4	ANZECC Guideline 2000
Temp.^{0}C	29.0	30.0	30.0	31.0	<38
pH	7.39	7.40	7.42	7.43	6.0–7.5
Conductivity mS/cm	0.384	0.384	0.388	0.387	20–250 µS/cm
Turbidity NTU	10	30	20	20	2–15 NTU
Dissolved Oxygen mg/L	0.5	0.7	1.60	3.0	>6
Salinity	3.60	3.61	3.70	3.67	0 for freshwater

Table 7. Water quality laboratory results for Naduri and Nakavu sites.

Sampling Sites			Naduri	Naduri	Naduri	Naduri	Nakavu	Nakavu	Nakavu	
Analysis Description	Unit	LOR	Site 1	Site 2	Site 3	Site 4	Site 1	Site 2	Site 3	ANZECC Guideline[a]
pH Value		0.02	7.38	7.29	7.33	7.13	7.18	6.98	7.23	6.0 – 7.5
Conductivity @ 25'c	mS/ cm	0.02	0.198	0.198	0.197	0.200	0.122	0.1235	0.1227	20–250 µS/cm
Total Dissolved Solids (TDS)	mg/l	0.02	150	150	120	130	100	100	100	NV
Total Suspended Solids (TSS)	mg/l	0.01	0.01	0.02	0.026	0.01	<0.01	0.02	0.01	NV
Sulphate	mg/l	0.40	30	3	3	4	1	0	1	NV
Bi carbonate as HCO3	mg/l	0.02	115.9	109.8	103.7	109.8	63.44	70.76	69.54	NV
Alkalinity as CaCO3	mg/l	0.02	0	0	0	0	0	0	0	NV
Calcium	mg/l	0.02	20.36	20.36	20.36	21.93	10.97	10.97	10.97	NV
Magnesium	mg/l	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NV
P_2O_5	mg/l	0.02	0.32	0.02	0.26	0.26	5.0	1.35	3.59	NV
Silica	mg/l	0.02	17.25	17.25	0	17.25	19	19.5	19.75	NV
Nitrate as $N0_3$	mg/l	0.02	40	6	1.2	47	8	30	22	NV

LOR *Limit of reporting*
NV *No guideline value*
[a] *95% species protection level for slightly disturbed systems, default trigger values for tropical rivers*
Highlighted cell indicates above ANZECC (2000) guideline value at 95% species protection level.

Table 8. Water Quality Laboratory Results for the SSD.

Sampling Sites Analysis Description	Unit	LOR	SSD Site 1	SSD Site 2	SSD Site 3	SSD Site 4	ANZECC Guideline[a]
pH Value		0.02	7.39	7.40	7.42	7.43	6.0 – 7.5
Conductivity @ 25'c	mS/cm	0.02	38.4	38.6	38.8	38.7	20–250 µS/cm
Total Dissolved Solids (TDS)	mg/l	0.02	48000	49000	49000	47000	NV
Total Suspended Solids (TSS)	mg/l	0.01	0.0835	0.077	0.01	0.837	NV
Sulphate	mg/l	0.40	10	3400	7900	5000	NV
Bi carbonate as HCO_3	mg/l	0.02	152.5	161.65	152.5	152.5	NV
Alkalinity as $CaCO_3$	mg/l	0.02	128.1	118.95	115.9	109.8	NV
Calcium	mg/l	0.02	20.36	20.36	20.36	21.93	NV
Magnesium	mg/l	0.02	0.067	0.067	0.066	0.065	NV
P_2O_5	mg/l	0.02	0.53	0.24	0.29	0.30	NV
Silica	mg/l	0.02	0	0	0	0	NV
Nitrate as $N0_3$	mg/l	0.02	0.6	12	13	48	NV

5.7 Water Quality Discussion

It is vital that the water quality of these water bodies is maintained because the local population depends on these resources to a large extent. The Sigatoka River (Naduri) and Navua River (Nakavu) are used by villagers for domestic purposes such as occasional bathing and washing as well as fishing. Men use spears and snorkel and masks for catching fish while the women use hand lines to catch fish. Women also use hand-held nets for catching shrimps (*moci*) and fish (grass carp) depending on the net size. Details of flora and fauna are covered in Section 5.8.

During extraction and crushing activities, one of the most common water issues is the erosion of fine particulates and the transfer of suspended solids into surface waters during periods of rainfall. This typically increases proportionally with increasing area of disturbance and it is therefore very important that the total disturbed area be minimised (DPIWE, 1999).

The recording of the current status of the water quality in the project areas is a prerequisite of the EIA as it allows the assessor to predict the likely impact of extraction on water quality.

5.7.1 Naduri Water Quality

Temperature

The temperature was measured in-situ at the time of sampling. There was minimal variance in temperature across all four sites, ranging from 29.0°C to 31°C. This is consistent with typical surface temperatures for the area.

pH

pH was recorded for all sites using in-situ measurements and laboratory analysis. pH is a measure of acidity or alkalinity on a scale of 0 to 14 with pH 7 being neutral.

Field results and laboratory analysis indicates a range of 7.13 to 7.38. The results are within the ANZECC (2000) pH guideline range of 6.0 – 7.5.

Conductivity

Conductivity is dependent on the concentration of dissolved salts in the water and consequently is an indirect measure of salinity.

Electrical conductivity can be influenced by other ions such as potassium, magnesium and sulphates. Sulphate and potassium levels in Naduri correspond with conductivity.

In-situ and laboratory results indicate a conductivity range from 197 μS/cm to 200 μS/cm. This is within the ANZECC Guideline range of 20 – 250 μS/cm.

Turbidity

Turbidity was measured in-situ and recorded 0 NTU. The ANZECC (2000) guidelines recommend turbidity levels of 2 – 15 NTU, so at the time of sampling, all the Naduri sites were within the recommended turbidity level

Nitrate

There is a high nitrate level in Site 1 Naduri, i.e. Naceva site. This is due to the presence of legumes or decaying plant and animal material. Along with high levels of phosphorus and nitrogen from fertiliser run off from adjacent farms on the river banks excessive growth of aquatic plants, including nuisance algae can result.

TDS and TSS

A slightly elevated TDS in Naceva, Naduri was due to the sampling site being downstream of a river crossing.

Dissolved Oxygen

The in-situ dissolved oxygen varied between 6.3 and 8.20 mg/L. The ANZECC (2000) guidelines provide only a guideline of 120% saturation, and these values are not comparable in this situation.

All results are above the recommended ANZECC (2000) guidelines value of more than 6 mg/L, which is favourable for freshwater life.

5.7.2 Nakavu Water Quality

Temperature

The temperature was measured in-situ at the time of sampling. There was minimal variance in temperature across all three sites, ranging from 25.61°C to 26.61°C. This is consistent with typical surface temperatures for the area.

pH

pH was recorded for all sites using in-situ measurements and laboratory analysis. Field results and laboratory analysis indicate a range from 6.98 to 7.9. The results are within the ANZECC (2000) pH guideline range of 6.0 – 7.5.

Conductivity

Conductivity is dependent on the concentration of dissolved salts in the water and consequently is an indirect measure of salinity.

In freshwater systems, where NaCl is not dominant, electrical conductivity can be influenced by other ions such as magnesium and sulphates. In Nakavu, sulphate and potassium levels correspond with conductivity.

In-situ and laboratory results indicate a conductivity range from 123 μS/cm to 290 μS/cm. The tabulated results show that laboratory measurements are within the ANZECC Guideline range of 20 – 250 μS/cm while the in-situ readings are slightly above the standard.

Turbidity

Turbidity was measured in-situ and recorded at 10 NTU at two sampling sites. The slight elevation in turbidity is due to two gravel extraction operations located upstream of the sampling sites.

The ANZECC (2000) guidelines recommend turbidity levels of 2 – 15 NTU, so at the time of sampling, all sites were within the recommended turbidity level.

Nitrate

Detected nitrate level in Site 2 and Site 3 at Nakavu is due to the presence of legumes or decaying plant or animal material. It was noted at Nakavu that a number of areas along the riverbanks have algal growth. This presence is due to trace levels of phosphorus and nitrogen from fertiliser run off from adjacent farms.

TDS and TSS

A slightly elevated TDS in Nakavu was due the sampling site being downstream of gravel extraction and the village.

Dissolved Oxygen

The in-situ dissolved oxygen varied between 7.06 and 8.63 mg/L. The ANZECC (2000) guidelines provide only a guideline of 120% saturation, and these values are not comparable in this situation.

All results are above the recommended ANZECC (2000) guidelines value of more than 6 mg/L, which is favourable for freshwater life.

5.7.3 SSD Water Quality

Temperature

The temperature was measured in-situ at the time of sampling. There was minimal variance in temperature across all six sites, ranging from 29.0 °C to 31 °C. This is consistent with typical surface temperatures for the area.

pH

pH was recorded for all sites using in-situ measurements and laboratory analysis.

Field results and laboratory analysis indicate a range from 7.39 to 7.43. The results are within the ANZECC (2000) pH guidelines range of 6.0 – 7.5.

Conductivity

Conductivity is dependent on the concentration of dissolved salts in the water and consequently is an indirect measure of salinity. The SSD samples, which have conductivity, correspond with high TDS and salinity.

Laboratory results indicate a conductivity range from 38,400 µS/cm to 38,800 µS/cm. This is well above the ANZECC Guideline range of 20 – 250 µS/cm.

Turbidity

Turbidity was measured in-situ and recorded with values in the range of 10 – 30 NTU. The ANZECC (2000) guidelines recommend turbidity levels in the range 2 – 15 NTU. At the time of sampling, only one site was within the recommended turbidity range. The other three readings were above 15 NTU at the SSD sites due to the turbulent water column that was continually being churned by the action of the strong breeze on waves pounding a reef-less coast.

Nitrate

Traces of nitrate levels along the SSD foreshore sampling sites is due to the presence of legumes or decaying plant or animal material.

TDS and TSS

The high TDS and TSS in all SSD samples is due to the highly energised waves churning the sand particles on the beach and the high concentration of dissolved salts (NaCl).

Dissolved Oxygen

The in-situ dissolved oxygen varied between 0.5 and 3.0 mg/L. All results are below the recommended ANZECC (2000) guidelines value of more than 6 mg/L.

5.8 Terrestrial and Marine Flora and Fauna

5.8.1 Introduction

Even though the river can be a source for aggregates for the roading, construction industry and generate economic benefits for the landowners; they and the people living next to them rely heavily on it as a protein source for their diet, which are found in fish, prawn, eels, mussels, water cress and freshwater crabs. Along this river there is also the presence of both on-land (terrestrial) and freshwater flora and fauna which contribute to the biodiversity of the area.

5.8.2 Flora

Naduri

The vegetation type prevalent in the surrounding area is similar to that of dry river plains found on the western side of Viti Levu.

Grass covers an area of about 70 % of the total area proposed for the crusher. Grazing of farm animals like cattle and horses are common. Plant species commonly found in the Naduri and Naceva areas include grasses, herbs, shrubs and trees.

The vegetation covers the immediate banks, and is bordered by huge rain trees *(Samanea saman*) as the dominant tree species and bamboo at random locations. Other vegetation on site are para-grass, sensitive grass (co gadrogadro), soursop (Seremaia), birds nest (epiphyte), eggplant (baigan), yagoyagona, wabosucu, totodro, dalo ni tana, cassava (tavioka), uto (breadfruit), bua, vadra, jack fruit (uto ni idia), dalo, pawpaw, mango tree, niu, bitu ni vavalagi, moli karo, lemon tree (witiwiti), kura, tamarind tree, kaukamea, totonivavalagi (qereqere), kerala, , dovu, vaivai ni vavalagi, vau, bai ni cagi, and ivi.

At Naceva, a number of garden plots are adjacent to the resource. The gardens are for vegetables such as cabbages, long beans, chilli, and pawpaw (Hawaiian).

In the Naduri/Naceva, Nakavu areas of study, the presence of some invasive species of weeds and plants in the area will result in native plants struggling to re-establish themselves in the area. Thus overall the botanical significance of these two assessed areas is low.

Nakavu

The surrounding vegetation cover is predominantly secondary plants and grass species that have re-grown through continuous excavations and extraction of aggregates, like the predominant guava plants. The exact extraction location is right at the river bank and now moved to within the river channel where clean gravel is extracted.

The vegetation cover on the river banks is less dense and consists of the following: co gadrogadro (sensitive grass), Para grass, vadra, moli karo (lemon), guava, maoli (pawpaw), soursop, bitu ni vavalagi, ferns, Pinus carribae (pine trees), tavioka (cassava), wabo sucu, kaukamea and niu (coconut).

Sigatoka Sand Dunes

The vegetation is predominantly native forest and introduced herbaceous communities. The forest is dominated by native trees and shrubs, and the coastal vegetation is dominated by various native and introduced species. Grassland is dominated by introduced species (Kirkpatrick, 1981). The near-coastal and inland forests are discriminated by numerical analysis as three non-forest communities. The dunes are edaphically and climatically capable of supporting a complete cover of native closed-forest.

A diverse vascular plant community exists along the SSD (Figure 14). Some plants are common or abundant, whilst others are uncommon and rare. Sand dune flora includes the following that was identified and noted in their local or Fijian names:

Vativati (scented fern), co ca (burr grass), kabuta (couch grass), gasau/sina (reed), dovu (sugar cane), yabia, maqo, wabosucu (mile a minute), botebotekoro, nokonoko (casuarinas), tavola (tropical almond), kundru (ivy gourd), kai moku, vaivai, rautolu, drautolu, denime, guava, wild passion flower, duva, vere, lantana, sinu, kura, moli, rokete (chilli), baka ni Viti (banyan tree), molau, ba ni dakai, walai, drala, bainicagi, pawpaw, toto and kaukamea.

Figure 14. Typical vegetation cover at the SSD.

The SSD is unique in that the whole sand dune area is host to a number of rare and extinct flora. This has been surveyed in detailed by Professor Randy Thaman and the Institute of Applied Science (IAS) of the University of the South Pacific (USP) in 2003.

5.8.3 Fauna

Naduri

The section of Sigatoka River that stretches alongside Naduri land is well known for its freshwater mussel. Locals have depended on the river as one of the main source of protein for their diet for as long as they can remember.

During the study a number of *lawa* (fishing nets) were put out across part of the river at Sampling Points 2, 3 and 4 from 8 pm to 6 am. The following were caught from the three sites during the 10 hrs (Table 9):

Table 9. Freshwater fauna caught in fishing nets in Naduri.

Sampling Site No	No. of Species	Numbers	Lengths/Weight
2	Grass Carp	2	1. 27 cm/800 gm 2. 30 cm/1100 gm
3	Grass Carp	2	1. 26 cm/550 gm 2. 30 cm/1100 gm
4	Grass Carp	2	1. 22 cm/380 gm 2. 27 cm/750 gm

Figure 15. One of the species of fish (Grass Carp) caught at Naduri.

Apart from the grass carp (Figure 15), which feeds on maleya and filamentous algae, other major organisms caught here are prawns, small crab taimami, duna (eels) , shrimps, vo loa (horo lo), botabota, ika droka, maleya and bau, which are often in abundance in the river.

A number of dives were made close to the three sampling spots for freshwater mussels (kai/tave) (Figure 16). The sizes of the kai varied with the largest upstream and the smallest as one moves away downstream from the village area.

Figure 16. Typical freshwater mussels (kai), which are common along the Sigatoka River, in front of Naduri Village.

Figure 17. Freshwater fish and eels (duna), which are common along the Sigatoka River; caught here at Naceva by a diver visible in the background of the picture on the right.

Additional fish (total 6) and eel (1) was caught upstream of Naduri at the Naceva site by a diver using the kilivati (spear fish with rubber). Fish species caught was the ika droka, maleya and duna (eel) (Figure 17).

Other notable fauna at both sites included dogs, bullocks, mynah, bulbul, qiqi, and bat.

Nakavu

At Nakavu, a lawa (fishing net) was floated overnight between Water Sampling Sites 1 and 2 for collection the next morning. The second day two men assisted using masks, snorkels and spears.

The fishing net was only able to trap moss and filamentous algae (Figure 18). During 1 hr and 10 minutes of diving, three species of fish: soba, veitakau, and kadilase (eel) were caught. Other invertebrates caught along the river were dalulu, sici ni wai, vocara, sakali (small crab), vo (small ika droka), vo loa (large ika droka) (Figures 18 and 19), and moci (young prawns) (Figure 19).

Figure 18. Freshwater fish caught by spear diving on the left. Filamentous algae caught in fishing net in Nakavu on the right.

Figure 19. Freshwater prawn, fish and eel, which are common along the Navua River caught here at Nakavu Village.

Sediment plumes were noted emanating from extraction areas. Algae build up is noted along the bank due to excessive nutrients associated with suspended solid particles. Another possible cause of increased macro-algal biomass is the absence of herbivorous fish such as grass carp. According to local fishermen, freshwater fish have somehow decreased in number compared to when they were in abundance in the past prior to intense aggregate extraction. With continuous extraction in the middle of the river, natural freshwater habitats and niche have been disturbed and potentially polluted.

Other notable fauna at the Nakavu site included dogs, mynah, bulbul and cows.

Sigatoka Sand Dunes

Avifauna observed during the survey included a belo (reef heron), kikau (wattled honeyeater), red-vented bulbul and mynah. Other known avifauna that have been observed in the area include white-collared kingfisher, kula, Fiji bush-warbler, qiqi, and beka (flying fox). Apart from people that frequent the area for sand-surfing (Figure 20), stray horses, dogs and mongoose are the other terrestrial fauna in the sand dunes area.

Figure 20. Tourists sand boarding down on the Kulukulu end of the sand dunes.

All flora and fauna observed at all the areas of study are found in similar habitats in Fiji. No rare and threatened plant species, as listed in the Fiji Biodiversity Technical Report #7, were observed in the surveyed areas of Naduri and Nakavu. The SSD, however, has a number of plants that are rare and extinct (see Thaman et al., 2003). This flora habitat is outside the extraction area.

5.9 Air Quality

The air quality of the project area of Naduri, SSD and Nakavu is very good. The only known air quality impact would emanate from traffic emission from the adjacent road and dust produced from dump trucks, screening and crushing plants. No previous air quality records are available for the project area. No known air quality studies have been undertaken for the subject area.

5.10 Visual Amenity

The proposed development area at Naduri and Naceva in Sigatoka is being earmarked for river cruises due to its good scenic view along the watercourse as it is. The same venture is notable in Nakavu where the pleasant view of travelling on a punt is experienced daily by tourists even with the current uncontrolled manner in which the Navua River is being mined daily (Figure 21).

Figure 21. Tourists enjoying the scenic view of the river cruise, even with extraction operations on the left. On the right is a view of the Sigatoka River in Naceva, Naduri.

Figure 22. A panoramic view of the Sigatoka Sand Dunes.

The inland and seaside views of the Sigatoka Sand Dunes are unique in Fiji. The view of the site from the roadside is visually appealing with a backdrop of blue skies and light vegetation patches on the sand dune landform that stretches for miles into the horizon (Figure 22).

5.11 Archaeological and Historical References

None of the areas in Naduri, Naceva and Nakavu is located near a known archaeological or cultural site according to the locals and records at the Fiji Museum. If any evidence of a cultural site is encountered all work must cease and the Fiji Museum must be informed to carry out an assessment.

In the SSD, the only area of archaeological interest is located at the centre and is away from the areas that are being mined or expected to be mined in the future. However, other areas within the dune system are potential archaeological sites for artefacts and human remains.

6. SOCIO-ECONOMIC ENVIRONMENT

6.1 Introduction

Social surveys were conducted on the villages of Naduri and Nakavu and neighbouring residents. A similar survey was conducted with the Kulukulu community and nearby residents of the proposed development site at the SSD. The survey was conducted for the purpose of informing the locals of the proposal, its likely impact and to gather any issues of concern with respect to any proposed extraction of sand and gravel.

Of major importance is to capture the current social economic environment and the likely effect (positive and negative) of the changes that would occur in the event of the proposed extraction/quarrying project eventuates.

For Naduri and Nakavu villages and the Kulukulu settlement adjacent to the SSD, a random house-to-house interview using questionnaires was conducted (Figure 23). This was complemented with the community consultation meeting conducted only at Naduri and Nakavu villages.

Figure 23. A Kulukulu resident being interviewed on site at Kulukulu during the house-to-house survey by team member.

The ages of those interviewed ranged from 27 to 58 years old. In some cases, some members of the interviewed family were not present during the interview due to work commitments. The younger age group or children were either attending primary or secondary schools; and the older children attended tertiary institutions in either Lautoka, Nadi or Suva.

6.2 Adjacent Settlements

The other settlements next to the Naceva deposit in Naduri are mostly valley vegetable farmers who leased land belonging to Naduri villagers. On the other hand, Nakavu Village is quite isolated with the closest settlement of Waiyanitu 1.5 km away to the northeast.

In Kulukulu, the villages of Vunavutu and Nasama are a fair distance away from the subject area. Volivoli Village is on the other side of the Queens Highway opposite the SSD.

6.3 Land Tenure

All residences interviewed at Naduri and Nakavu villages are on leased native land properties. This includes the Indo-Fijian farmers living on Naduri land near the Naceva deposit area.

Commercial vegetable farming is the major form of land use in Naduri, Naceva and the surrounding area. All land being cultivated in the vicinity of the proposed extraction sites at Naduri and Naceva belong to the landowners of Naduri. At Nakavu Village, as expected, all land are native and are mainly used for subsistence farming.

The status of land ownership in Naduri, Naceva and Nakavu is summarised in Table 10 below.

Table 10. Land tenure at Naduri and Naceva (Sigatoka) and Nakavu (Navua).

Land Tenure	Freehold	Crown	Native Land
Percentage (%)	0	0	100

Kulukulu settlement is adjacent to the SSD and mainly has two types of land tenure: freehold and crown. Of the random number of households interviewed, the distribution in percentage was as follows:

Table 11. Land tenure at Kulukulu, Sigatoka sand dune area.

Land Tenure	Freehold	Crown	Native Land
Percentage (%)	42	58	0

Ninety-five percent residential properties within the surveyed area of Naduri, Nakavu and Kulukulu could be termed above the poverty line. Most of the communities have access to the basic amenities like clean piped water (PWD), energy sources (FEA, kerosene, gas, firewood). At least 83 % in Kulukulu, 65 % in Naduri and 50 % in Naceva have access to some form of telecommunication (Telecom/Vodafone) and television (Fiji TV).

6.4 Solid Waste

Most households' refuse are burnt (paper material/grass/firewood) or buried in their backyard. In the case of Kulukulu Settlement, 25% of those interviewed personally deliver their household refuse to the Sigatoka Town Council dump, which is 200 m from the edge of the SSD National Park.

Some residences currently send cans and bottles to Suva and Lautoka for recycling. Food scraps and wastes are reused or fed to pigs whilst the rest are used for compost.

The summary of waste disposal for the three sites is shown on Tables 12, 13 and 14.

Table 12. Solid waste management in Naduri.

Waste Disposal	Burnt	Bury	Recycle	Reused	Sigatoka Dump
No. of households	100	100	15	65	25

Table 13. Solid waste management in Nakavu.

Waste Disposal	Burnt	Bury	Recycle	Reused	Navua Dump
No. of households	100	100	10	67	25

Table 14. Solid waste management in Kulukulu.

Waste Disposal	Burnt	Bury	Recycle	Reused	Sigatoka Dump
No. of households	75	75	75	25	25

NB: Percentage of separate disposal methods used for houses surveyed is noted below. Some houses may practice a number of methods.

6.5 Housing Conditions and Wastewater Management

About 10-15 % of houses in Naduri, Nakavu and Kulukulu are below average status whilst at least 85 % of the houses in these three areas are above average. Percentage of different categories of houses is shown in Tables 15, 16 and 17 below.

Table 15. Housing conditions in Naduri.

Superior	Well above Average	Average	Below Average
5 %	35 %	50 %	10 %

Table 16. Housing conditions in Nakavu.

Superior	Well above Average	Average	Below Average
5%	35%	45 %	15 %

Table 17. Housing conditions in Kulukulu.

Superior	Well above Average	Average	Below Average
15%	35%	35%	15 %

At Naduri 70 % of the houses have septic tank wastewater systems while the remainder have water-based toilets. Sewer lines do not service the area. For Nakavu 75 % of the houses have septic tank wastewater systems and the remaining 25 % use water-based toilets. For Kulukulu Settlement, the distribution is as follows: 75 % of those interviewed have septic tank systems and the remainder use drop pit toilet.

6.6 Source of Income

In Naduri and Naceva at least 70 % of the residents are commercial farmers. The remainder are employed at the MAAF Nacocolevu Research Station and other paid employment in Sigatoka town or nearby hotels.

At least 41 % of people interviewed at Kulukulu are employed in the tourism industry in the area or hotels down the road. Another 20 % of people do sugarcane and vegetable farming. The remainder are engaged in paid employment in Sigatoka town and nearby business set ups. Twelve percent (12 %) of those interviewed in Nakavu are paid workers in Navua town and nearby industries. The remainder or 88 % are self-employed or farmers.

6.7 Food Supplies

In all the areas of study, there is an abundance of crops. For study areas like Nakavu and Naduri, they are the main suppliers of vegetables and root crops for Navua and Suva; and Nadi and Lautoka, respectively. For groceries and other household items there are small canteens and shops in both villages and settlement. All subject areas have access to supermarkets at their nearest towns.

6.8 Health Care

The local population of Naduri and Kulukulu travel to the Sigatoka Hospital and private doctors in town for medical referrals and utilisation of health services. In Nakavu, the villagers access the Navua Hospital, local private practitioners and the Colonial War Memorial Hospital (CWM) in Suva.

6.9 Interviewed Communities Responses

From the house-to-house survey and community consultation conducted, it was noted that the three surveyed communities had differing opinions and issues of concern with regard to sand and gravel extraction on their land or adjacent properties. The following section records some of the issues of concern and recommendations.

6.9.1 Naduri

Naduri Deposit

Positive Impacts

- Improve housing and other village infrastructure.
- Assist in educational needs.
- Assist in fulfilling church and *vanua* obligations.
- Improve the standard of living in the area.
- Provide more opportunities for employment.
- Provide investment and small business enterprise opportunities for the villagers.
- Improve the current status of the proposed site.
- Would push the potential of the area for other businesses to develop.

Negative Impacts

- Possibility of flooding of the village due to bank erosion.
- Bad management could cause conflict amongst villagers in terms of unequal distribution of funds.

Naceva Deposit

Positive Impacts

- Provide casual work for residents.
- Assist in educational needs.
- Improve the standard of living in the area.
- Developer may upgrade their access road that leads to the river.
- Gravel may be used for the nearby residents for construction on request to landowners.

Negative Impacts

- May deepen the bathing end of the river and may be a risk to the Indo-Fijian community in Naceva.
- Excessive extraction could lead to major bank erosion problems.
- The site is close to the river crossing for farm workers who live on the opposite side of the river. Extraction may deepen it. Need to move development downstream.

6.9.2 Nakavu

Positive Impacts

- Improve housing and other village infrastructure.
- Assist in educational needs such as the school facilities.
- Assist in fulfilling church and *vanua* obligations.
- Improve the standard of living in the area.
- Provide more opportunities for employment.
- Provide investment and small business enterprise opportunities.

Negative Impacts

- Past and current extraction practices have caused river bank erosion.
- Continuous bank erosion may threaten the village in the future.
- Notable decrease in water level in the river.
- Tourist transportation may be affected if unsustainable river aggregate extraction continues.

6.9.3 Sigatoka Sand Dunes

General viewpoints

- Environmental assessment of proposed extraction will be beneficial to all stakeholders.
- Educating developers on the environmental impact of extraction.
- Sand extraction for personal use only is favoured than commercial as it is too detrimental to the environment.

Positive Impacts

- Assist in providing employment opportunities.
- Improve the standard of living in the area.
- Provide more opportunities for employment.
- Provide more investment and business opportunities.
- Improve the current status of the proposed site.

Negative Impacts

- It has caused backyards to be reclaimed by sand encroachment by 5-10 m.
- Possibility of breaking the only barrier between the raging sea and the Kulukulu flats, which may result in the flooding of the area during storms, cyclones and continuous rainfall compounded by any rising high tide.
- Bad extraction management could cause massive sand erosion.
- Risk of inundation of good agricultural land by the inland migration of sand.
- Likely impact of saltwater intrusion if the sand barrier is being excavated at commercial scales.
- Sand dune is our protection from tsunami, storm surges, cyclones and wind.
- Towards the main road it is fine as the fence from the National Trust of Fiji keeps contractors away. As you move towards the sea and the river mouth to the east, past extraction has slowly lowered the sand hill that used to protect the inland properties from strong wind. The effect of sand boarding is also noticeable.
- The SSD is also a major tourist attraction and any large-scale sand extraction will severely affect this.

All residents surveyed were in favour of the proposal only if proper assessment of its impact on the environment (EIA) was done for the project.

6.10 Community Consultation Meeting

A community consultation meeting was conducted at the end of the survey on 17 November in 2006, in Naduri (Figure 24). Community representatives were briefed on the proposed development and the Environmental Impact Assessment process being undertaken in the presence of the Naduri Village *Turaga ni Koro*.

Figure 24. Naduri villagers during the stakeholder consultation and debriefing meeting at Naduri Village at the end of the November 2006 survey.

6.11 Vulnerability of the Project to Natural Hazards and Climatic Change

6.11.1 Naduri

The area lies within the path of tropical rainstorms and cyclones which mainly occur in the period late October to April.

The major geo-hazards to be expected therefore are flooding, river bank and coastal erosion, and ground settlement (Rao 1989). From records the seismic hazards in the area appear to be low.

6.11.2 Nakavu

The site location of the proposed development is within the coastal plains of the Navua flats and may be subjected to inland flooding at extreme high periods of rainfall in conjunction with the high tide. As the area is largely within the floodplain and deltaic deposits of the Navua River, the danger posed by extensive river bank erosion and channel migration should also be considered.

6.11.3 Sigatoka Sand Dunes

Of particular concern in this development is the likelihood of natural hazards like storm surge and sea flooding that increases the vulnerability of the communities near the SSD. Threats are either long-term coastal drift of sand or from waves and storm surges caused by short-term events such as cyclones.

Tsunami events rarely occur along this area. If it eventuates, the sand dunes are natural breakers in the absence of mangroves and reefs. It is what stands between Kulukulu, Nasama, Vunavutu, Volivoli, Sigatoka, Yavulo Village, Sigatoka Town and the open ocean.

7. POTENTIAL SIGNIFICANT ENVIRONMENTAL IMPACTS

7.1 Geology, Soils, Land Use and Land Cover

7.1.1 Naduri

Land use in the three areas will change as the sites are currently idle. For instance, land to site the crushing plant in Naduri is infertile. The land cover will be slightly altered from being a barren grass- or shrub-covered plain to one that would host a crushing plant, small workers' shed and site office.

This includes a new proposed bypass access road that runs outside the village and school to the river.

7.1.2 Nakavu

Extraction has been in operation for a number of years in Nakavu. In terms of geological resources, the river continuously replenishes the gravel aggregates on the Nakavu sites on a daily basis due to the natural flow of the river. Any excessive extraction without proper planning and monitoring could lead to an unsustainable operation. For instance, when the excavator wades into the deeper end of the river and starts to extract gravel on the opposite bank, this often triggers bank erosion on river walls that are not stable. This practice is prevalent in extraction activities along the Navua River from Nakavu to the SCIL and Winstone Aggregates extraction sites (Figure 25).

Figure 25. Excavator on the left is extracting aggregates from the opposite bank and passes it to the second excavator on the right for loading in the dump truck. Bank erosion is noticeable along the banks.

Fine silt, sand and gravel would in turn be flushed out into the mouth of the Navua River, thus causing navigational and flooding problems to Navua Town as experienced over the years.

7.1.3 Sigatoka Sand Dunes

In the SSD, the impact would be similar to the nearby Matage extraction site located about 0.5 km to the west of the western end of the dune on the landward side of the Queens Highway. The existing set up at Matage includes a rest house and an office for the workers.

River bank degradation can cause loss of land for cultivation and village expansion. It also heightens the villages' (Naduri and Nakavu) vulnerability to flooding when the existing flood plain eventually washes away as the extraction rate overtakes nature's ability to replenish the deposit.

Therefore, it is envisaged that some significant impact to soil, resource, land use and land cover will occur.

7.2 Terrestrial Flora and Fauna

A few plants that were recognised as rare and locally extinct are found in the sand dunes (Thaman 2003). These plants are also listed in the botanical report of Technical Group #3, "Botanical Biodiversity in Fiji" – Report submitted in contribution to the development of a Biodiversity Strategy and Action Plan (BSAP), June 1998. However, it should be noted that these endangered plants are not close to the extraction sites.

Other flora and fauna found in Naduri, Nakavu and the SSD areas are relatively common and can be found elsewhere in Fiji where the same conditions exist.

It is envisaged that no significant impact to flora and fauna of the subject areas and their surroundings will occur.

7.3 Freshwater Flora and Fauna

The fish and invertebrate communities observed are typical of those that occur in similar habitats at other locations within southern and western Viti Levu. Increased sediment loading, siltation, and burial of the habitats of the fauna will impact on the abundance and diversity of the aquatic fauna. This is a common occurrence in the rainy or wet areas of Viti Levu such as the Waidina River, Waimanu River, Wainibuka River and Navua River. This impact is temporary and only lasts the duration of the floods.

However, should gravel extraction eventuate these events (siltation, burial of habitats) could be exacerbated by the actual removal of rocks and boulders that make up the habitat (pools and rapids) of insect larvae, gastropods, shrimps, prawns, crab, and other invertebrates that gatherer feeders cling to. Vertebrate fauna, like fish, live on these invertebrates for food. Prawns caught in the Navua River were from areas that have not been impacted.

This disruption affects movement of vertebrate fauna such as ika droka, prawn and eels that migrate downstream to lay their eggs in the river estuary (Sigatoka) or mangrove ecosystem (Navua River mouth). The young, often in larval stage migrate back upstream and if they are not able find their habitats; they either migrate even further upstream and creeks that feed the river or perish. This reproductive behaviour is an important aspect to consider in the event of disturbance or permanent change in any features of a stream or river (pools and rapids) after uncontrolled extraction. In Naduri, the kai (mussel) would be displaced upstream or downstream.

From current study and literature review it is conclusive that any river sand and gravel extraction is deleterious to the ecosystem and a sustained biodiversity. Therefore, it is expected that the impact on the freshwater flora and fauna would be marked if the extraction is not planned, implemented and monitored properly.

7.4 Visual Impact

The clearing of the project area and the planting of new trees and shrubs amongst the proposed development site for crushing in Naduri would greatly enhance the appearance of the site. At the Naduri and Nakavu sites visual effects would be prominent when travelling on the waterway due to the presence of excavators and dump trucks working beside, or in the river. Any impact on the environment will have a negative effect on the tourism industry. This also applies to the SSD.

Some negative visual impacts are expected from gravel extraction on the river at the Naduri and Nakavu sites that will be unsightly to tourists. At the SSD the effect would be to the local and visitors alike, if extraction eventuates at the Kulukulu area.

7.5 Air Quality

Some emission would be noticed during operation of the crusher and gravel extractors from construction vehicle and machinery emissions. Impact from vehicle emissions during operation of the project is expected to be minimal.

The only aspect of concern to the environment and inhabitants of the areas is the generation of dust during very dry conditions. This may result in breathing and respiratory problems. The main causes of agitating dust are dump trucks and the screening and crushing plant. Dust would be a nuisance to residents when it accumulates on clothes, vegetation and interior of homes.

7.6 Social Impacts

The potential for migration and displacement of fish and mussels resources in Naduri and Nakavu is a known fact. Therefore, any proposed sand and gravel extraction will have some negative significant impact to the community when not assessed and planned properly. Some of the expected impacts are discussed below:

7.6.1 River Utilisation

Those interviewed (men and women) acknowledged the immense value of the river to the villagers. The river is utilised for washing clothes as well as for bathing and swimming. The river is one of the main sources of protein in the diet of the people hence fishing is a major activity in the river. Therefore, any development in the river should have proper environmental assessments (EIA and EMP).

7.6.2 Increased Vehicular Movements

The area will witness an increased movement of vehicles between the extraction area and the nearest towns of Sigatoka and Navua to access the markets.

7.6.3 Speeding and Carelessness

Speeding and careless driving are recognised as the major causes of accidents on Fiji roads. Statistics show that minor and fatal cases take place mainly in rural areas. With increasing demand for the resource, the operators will be prone to rush to fulfil orders. This may have an impact in terms of social and economic costs associated with road accidents. The risk of road accidents is likely to increase in the areas under study.

7.6.4 Positive Spin-off Effects

There are a number of positive spin-off effects of the extraction of sand and gravel which include:

Creation of Social Capital

Any market-driven resource-based project creates a social capital for rural dwellers, which can improve their standard of living. Social capital creation can take the form of improving schools, playgrounds, improvements in physical environment, compensation for assets that fall within the project area, improved housing, water supply and other associated village infrastructure.

Opportunity for New Economic Activities

Considering the physical, social, and geographical environment of the extraction sites, the proposed development is conducive for new economic activities and initiatives such as small businesses set up (village canteens, shops, carriers, and mini-van operations, etc).

There is potential for employment for the residents at Naceva, Naduri, Nakavu villages and Kulukulu residents. Both skilled and un-skilled employment will be required during the operational phase of the projects. These employment benefits are part of the positive benefits which includes the improvement to local infrastructure.

7.7 Archaeological and Historic Impacts

Apart from the likely impact on sites of archaeological and historical interest in the SSD area, there is no envisaged impact for Naduri and Nakavu.

7.8 Noise Impact

Potential sources of noise pollution would be machinery and traffic. Noise nuisance is a hazard to health and can induce partial hearing problems, disturbances to sleep and concentration of school children.

Traffic into and out of the areas will be the biggest noise sources and on site excavating machines. The effect on nearby communities is expected to be negligible as the nearest property is approximately 300 m away in between existing tree lines in Naduri on a lower level and 400 m away at Nakavu. In Kulukulu the noise impact would also be minimal due to the dune's form and mass.

It is expected that noise impact would be minimal due to tree shielding, distance to the nearest receptor, and that most machinery will operate only during the day.

7.9 Water Quality

It is to be expected that the gravel extraction and the crusher operation will cause some changes, particularly in the turbidity, flow velocity, and the sediment loading of the Sigatoka and Navua rivers. These changes may in turn affect the fish, prawns, eels, and other life forms in the water for the duration of the extraction.

Suspended solids (silt and clay) from surface runoff and operational activities increase turbidity. Turbidity has a major impact on the fishing and the use of water for bathing or drinking. Turbidity affects the fish spawning grounds, fish gills and the invertebrate species resident in water course sediments; and also reduces penetration by sunlight (Macfarlane and Mitchell 2005).

However, over time, the water quality and the diversity and abundance of aquatic flora and fauna would be re-established in the river. The time lag to re-establish and return the biodiversity of rivers to pre-extraction period may be delayed if the extraction is conducted without proper assessment and planning.

The construction of diversion channels and bunds with upstream settling areas will assist in minimising increased downstream turbidity.

Significant impact to the surrounding environment is envisaged at the outset.

7.10 Waste Management

Poor management of garbage, waste fuel, oil and other solid waste is detrimental to the marine, freshwater and terrestrial flora and fauna in Kulukulu, Naduri and Nakavu.

The extraction and crushing operation proposes to implement best practice solid waste management initiatives within the project area at Kulukulu, Naduri and Nakavu. These initiatives with the community is to enhance a clean environment for the tourists and members of the local community.

Minimal impact to the surrounding environment is envisaged.

8. MITIGATING AND ABATEMENT MEASURES

8.1 Geology, Soils, Land Use and Land Cover

For the crusher development at Naduri, the construction of erosion control structures and silt traps on site would minimise soil particle runoff into the Sigatoka River.

Landscaping, rehabilitation and re-vegetation of the site would commence during the operational phase to enable rapid improvement of the land cover.

Creepers and other local plants that have numerous roots help stabilise the sand and soil on the banks of both rivers.

There is a need to understand the hydraulics of the river system in order to control extraction rates and duration over a portion of any river.

8.2 River Bank Protection

River banks within operation areas should be protected by avoiding gravel excavation within areas along rivers that may cause instability to the river bank. No excavation should be closer to the toe of river banks than a distance equal to twice the height of the adjacent bank.

River banks are not to be excavated to form access ramps. Only excavated river gravel should be used to deposit against the river bank to form access ramps. The gravel should be spread evenly on the river bed at the cessation of extraction.

8.3 Terrestrial Ecology – Flora and Fauna

For the crusher development at Naduri, shrubs and large trees should be retained with very limited removal of existing flora on the site. Canopy cover provided by these trees will reduce the size of the area directly exposed to sunlight thus minimizing the occurrence of the weeds and invasive plants.

The developer should plant shrubs and trees during landscaping on the site to enhance its appearance by screening the crusher and to stop any likely erosion close to the river bank. A vegetation buffer of at least 10 m should be maintained on both sides of the river during gravel extraction.

8.4 Freshwater Environment and Waste Management

Impact to the freshwater environment can be minimised in the following ways:

a) Runoff from disturbed areas can be diverted around the edge of the site by a cut- off drain. Runoff should be collected in a non-eroding channel that drains into the main detention basin or ponds before discharging into the river.
b) Toilet facilities and site office/rest house to have use of on-site septic tanks waste management systems.
c) Any oil and fuel store needs to be built with emergency spill collection equipment such as spill containment structures or bunds around it. All unused or used oil should be collected and reused or sent to Suva's Mobil Oil Station for recycling.
d) No litter should be allowed into the river. Litter bins are to be installed at the crushing site. Solid wastes collected in the bins are to be emptied regularly for burning or burying on site.

e) The development intends to practice good solid waste initiatives such as avoiding use of unnecessary materials; and separation of wastes before recycling, reusing and disposal.

f) Environmental awareness and programmes that allow participation of the locals and tourists should be encouraged.

8.5 Visual Impact

Positive visual impact is expected for the crushing area when plants are used to screen the crusher.

Extraction on the river channel should be planned so that it does not coincide with river tours by tourists.

8.6 Air Quality

The use of low-emission machinery, well-maintained vehicles and machinery would reduce emission rates on site during construction and the operational phase of the project.

The use of cleaner fuels in machinery could also further assist emission controls. Spray water over dusty area or access during dry conditions to minimise the dust nuisance. Selecting the site for the crusher should account for the prevailing wind direction to direct dust movement away from population build-up areas.

8.7 Social Impact

8.7.1 Adverse Impacts and Management

The following section proposes management strategies to deal with the adverse effect of extraction works on the social aspect.

Roading Impact Measures

Preventative measures to deal with the identified risk factors are as follows:

1) The access road shoulder should be wide enough for broken down vehicles to pull on to leaving enough space for other vehicles to pass safely.
2) Road markings, especially around areas of high human traffic such as villages, schools, junctions, etc. should be prominent and maintained regularly.
3) Speed-reducing measures such as humps, rumble strips, or constricted entry and exit points must be constructed at strategic locations in front of villages, schools, and other places where necessary.
4) Improved visibility at access entry and exit points.

The project proponent should assist in community-based social and environmental activities to ensure that a peaceful atmosphere around the area is maintained. These activities assist the management and the community to basically monitor people and their properties from unlawful activities.

Social Capital Impact Measures

Equal representation of landowners in any trust are proposed, so that there is equal distribution of wealth amongst the villagers of Nakavu and Naduri. Percentage of their income from the venture is to be deposited as shares in low-risk and high-return investments such as the Unit Trust of Fiji.

8.8 Archaeological and Historical Impact

Any archaeological site uncovered during the construction should be marked for referral to the Fiji Museum immediately.

8.9 Noise

Construction noise at the site would be minimised by limiting working hours to daylight hours only.

8.10 Economic Benefits

There will be economic spin-offs from the flow-on effect of the project, including increased employment, more investment and business opportunities and improvement to the current status of the proposed sites.

On a national scale, these projects would contribute to the Gross Domestic Product and tax revenue of the country.

8.11 Community Support for the Project

Most residents support the project only when an EIA is part of the project proposal. The project will bring social and financial benefit to the community with minor environmental impacts that should be monitored and controlled during the course of this development.

The nearby settlements and nearby villages are looking forward to the commencement of the project and are very keen to work closely with the project proponents but with good environmental management.

8.12 Proposed Environmental Management Plan

A Proposed Environmental Management Plan (EMP) has been developed as a guide for active and proposed aggregates extraction at Naduri, SSD and Nakavu. The EMP is contained in Appendix 2 of this report.

9. CONCLUSIONS

1. The subject area at Naduri has been lying idle for many years. The proposed development would put the vacant property to productive use.

2. The project would provide employment, and add another alternative source of sand and gravel aggregate for locals in the SSD, Naduri and Navua. These benefits improve the livelihood and welfare of the villagers, settlers and people working for the extraction/quarrying operations.

3. The proposed extraction projects would have very minimal adverse social, economic and environmental impacts when planned and implemented prudently.

10. RECOMMENDATIONS

10.1 The Present

1. Total quantity of gravel to be extracted is to be estimated and corresponding volume of river gravels to be identified in terms of length, breadth, and depth of river over which gravel extraction is likely to be undertaken.

2. Design and build structures that mitigate for flash flooding, cyclones and bank erosion at Naduri, Nakavu and Kulukulu project areas.

3. Gravel extraction should not take place during heavy rain and periods of flooding.

4. No excavation should take place closer to the toe of river banks than a distance equal to twice the height of the adjacent bank.

5. A vegetation buffer of at least 7 m is to be maintained on both sides of the river during gravel extraction.

6. River banks are not to be excavated to form access ramps. Only excavated river gravel should be used to deposit against the river bank to form access ramps. The gravel should be spread evenly on the river bed at the cessation of extraction.

7. Monitor the water quality and the flora and fauna of the surrounding freshwater and marine environment of the project area during the construction and operational phase of the projects.

8. Planting shrub or creepers along the borders of the crusher facilities and river banks for both visual amenity and erosion protection purposes.

9. Improve the water quality of the project areas by developing good drainage systems that reduce sediment from direct inland flushing into the water courses.

10. No disruption towards the surrounding environment with the assistance of the Fishing Right Owners and community as a whole (Licence holders not to extract aggregate beyond the designated areas).

11. Develop and implement a River Dynamics Study of major rivers in the country which hosts quality aggregate material.

12. Develop Integrated Management System of sharing data between the PWD, MRD, Ministry of Primary Industries and others to assist in the use of 'Best Practice' in sand and gravel extraction in rivers and on-land hardrock quarries.

13. Develop and implement a detailed Environmental Management Plan (EMP) for the Nakavu Gravel Extraction Project and the Sand Extraction Project in Kulukulu as soon as possible. These extraction projects are already in progress.

14. Carry out a detailed Environmental Impact Assessment (EIA) of the Naduri, Naceva and Namoka Deposits using this report as a guide when resource and market development is ready to commence. The EIA should include an EMP which would cover details of proposed volume to be extracted, plant and machinery to be used and a plan of river extraction and erosion control measures.

15. Regulatory authorities must continue to inspect/monitor the sites and recommend mitigating measures where and when necessary.

16. Developers must take preventative measures and adhere to the conditions of their licence.

10.2 The Future

17. The developers need to develop and implement appropriate environmental management plans to cater for the construction and operational phase of these extraction projects in accordance with licence/permit conditions.

18. This development should avoid at all cost any use of hazardous chemicals or wastes. Mitigating measures and environmental management plans should be developed to counter any likely environmental impacts such as noise, dust, solid waste, wastewater and sediment control, etc.

19. For active aggregate extraction and quarrying operations, all developers/licensees must immediately develop and enforce an EMP to address environmental issues that arise from their on-site related activities. The EMP must be sighted and approved by regulatory agencies.

20. For any sand or gravel resource that are still has to be developed, a detailed EIA needs to be conducted and submitted to the relevant authority. An EIA Report would include an EMP.

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APPENDIX 1

TERMS OF REFERENCE OF THIS STUDY

Environmental Impact Assessment of selected river aggregate deposits in the Navua and Sigatoka Rivers

TERM OF REFERENCE

Introduction

The Environmental Impact Assessment (EIA) of proposed operations to exploit selected aggregate deposits in the Navua and Sigatoka Rivers is undertaken as part of the task implementation of Key Result Area 1, Reducing Vulnerability SOPAC-EU Project. Under the Ocean and Islands Work Plan, Task Nos. OI 4.1.1 and 4.1.2, the EIA is part of the aggregates assessment in the identified areas (as mentioned below) of these two rivers.

Objectives

The following tasks will be undertaken by the consultant in relation to the EIA of proposed extraction operations in the following areas where sand and gravel deposits occur:

- Nakavu (Navua River)
- Naduri (Sigatoka River)
- Sigatoka Sand Dune (near the entrance of the Sigatoka River).

1. Conduct scoping meeting with relevant stakeholders from the government, non-government organisations, local communities and resource owners for the purpose of:

   - Identifying areas that might be vulnerable to impacts from significant aggregate extraction operations,

   - Obtaining first hand views / opinions from the potentially impacted communities and detailing their concerns regarding aggregates extraction and what should be addressed in the EIA study.

2. Design and conduct EIA in the specified areas and carry out the necessary scientific studies to obtain the relevant information required for accurate prediction of potential environment impacts. The scientific studies should include the following:

   A. Description of the Environment

   - A general description of the aggregate deposit that occurs at each survey site,
   - Physical characteristics of the environment river bed / bank and neighbouring works area (e.g. water quality, stability of the river bank, vegetation, access, etc.),
   - Biological characteristics of the river bed / bank and the water column,
   - Identification of other uses of the river and neighbouring environs, e.g. tourism, transport, agriculture, forestry, domestic, etc

   B. Assessment of the potential effects of aggregate extraction

   - Physical impacts: water quality, river bank erosion, vegetation, extraction pits, sustainable rate of extraction, sediment transport and water flow,
   - Biological impacts: benthic communities and fisheries,
   - Impacts on surrounding environment – works area, crushing plant, washing, stock pilling, access roads (including impacts of haulage on existing roads).

- Broader impacts (if any) on neighbouring communities (dust, noise, heavy equipment movements, etc.).
- Conflict with other uses as stated in (A) above.

3. Prepare an EIA report addressing the following:

   - review previous study reports on aggregates extraction and related issues that may have been carried out in the study areas,
   - assess the environmental effects of aggregate extraction at the proposed sites,
   - detail methods used and the results of the assessment in an appropriate format that shows data pertaining to the individual parameters stated in 3 above, which shall include relevant photos and maps,
   - display the assessment results in appropriate formats (e.g. tables and graphs),
   - discuss the assessment results in light of other activities being carried out in the study areas and other potential impacted sites including short and long-term impacts of small or large scale extraction operations.
   - recommend appropriate extraction practices and mitigation actions that need to be undertaken prior to, during and after any aggregate extraction operation,
   - recommend the most appropriate monitoring activities that will detect and minimise any impacts resulting from aggregate extraction at either site,
   - identify rehabilitation measures that need to be undertaken during and soon after the cessation of the extraction operation.

4. The preliminary findings of the EIA should be presented to the local communities concerned soon after the completion of the survey, so they understand the risks involved and the mitigating actions which may be employed.

5. Incorporate further inputs from the public where necessary after the draft document is subjected to public review.

The consultant, where necessary, will be assisted by members of the survey team from the Mineral Resources Department (MRD) and SOPAC in carrying out all of the above (i.e. Steps 1 – 5).

Expected Output

The consultant will deliver a hard and an electronic copy of the final EIA document to SOPAC and the MRD. The MRD will then be responsible for the delivery of a hard copy of the report to each of the communities concerned.

APPENDIX 2

PROPOSED ENVIRONMENT MANAGEMENT PLAN

1. Environmental Management Plan

A proposed Environmental Management Plan have been developed to cover the following aspects of aggregates extraction at Naduri in Sigatoka, Nakavu in Navua and sand extraction at the Sigatoka Sand Dunes. Prior to extraction, a detailed EMP shall be developed.

1.1 Operational Phase

- Noise
- Dust
- Sedimentation and erosion
- Waste management
- Vegetation
- Surface water monitoring
- Complaints
- Environmental reporting

Site-based management plans have been set out in a tabular format addressing the following:

- Reference — this column has been provided to indicate why a particular action or requirement is necessary.
- Objectives and Strategies — overall goals designed to achieve compliance with regulatory requirements and protect the environment.
- Actions — specific actions taken to implement the management strategies.
- Timing —stating the frequency or completion date of actions nominated.
- Performance Indicators — used to verify that the associated management strategies and objectives are being achieved.
- Corrective Actions — actions that can be taken to satisfy original objectives.
- Responsibility — nominates the person responsible for implementing the associated actions.

1.2 Implementation of the Site-Based Management Plan

The implementation of the EMP will primarily involve extraction and crushing personnel, although some contract staff may also be used subject to the requirements of the management plan. Notwithstanding, it is ultimately the villagers or resource owners who are responsible for the operation of the facility in a way which exercises all reasonable care through the establishment of a proper management system.

The proposed EMP is cognisant of relevant legislation and guidelines, and promotes environmentally sustainable use of the resources.

1.3 Operational Phase Action Plan

1.3.1 Noise — Operation

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	Minimise noise levels during extraction and crushing	Utilise sound insulated equipment where possible	Operation period	Selection of equipment	Improve sound barriers e.g. planting trees to act as noise shield for populated areas	Site Management
2	Prevent disturbance to local residents within the area	Restrict high noise works to daylight hours, e.g. crushing Inform work force	Operation period	Compliance with recommended actions	Enforce recommended actions or adjust work hours as required	Site Management

1.3.2 Dust — Operation

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	Minimise the generation of dust during operation	Ensure use of water sprays on regular basis during crushing and traffic movement during dry weather	Operation Period	Compliance with recommended actions	Enforce recommended actions	Site Management

1.3.3 Sedimentation and Erosion – Operations

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	Reduce runoff and erosion of any stockpiled soils	Ensure stockpiles of soil/sand are covered or appropriate erosion control measures in place	Operation period	Inspection to ensure actions followed	Enforce recommended actions	Site Management
2	Prevent runoff from entering the freshwater or marine environment	Design works to prevent runoff having free access to neighbouring freshwater or marine waters and is contained onsite	Operation Period	Visual inspection to ensure appropriate measures taken, including during rain period	Repair or improve drainage works to satisfy objective	Site Management

1.3.4 Waste – Operation

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	Minimise generation of wastes	Incorporate waste minimisation strategies on site (Avoid, Reduce, Resuse and Recycle)	Prior to operation, phase.	N/A	N/A	Site Management
2	Ensure that no general rubbish (including food items) is allowed to blow or enter by other means into adjacent land, and that they are contained so as inaccessible to native wildlife	Inform work force Provide sufficient general rubbish receptacles with secure lids	Operation phase	Regular site inspections should find no loose rubbish uncontained on site	Contain and collect rubbish that may have moved offsite	Site Management
3	Ensure all wastes are removed from site and disposed of in an approved manner as dictated by management and relevant legislation	Remove all wastes and dispose of as instructed by the management The developer along with other relevant department and authorities can have consultation with regard to the proper disposal of wastes	Operation phase	No visible construction wastes on site or elsewhere around the extraction and crushing areas other than those in designated waste receptacles	Remove and dispose of wastes	Site Management

1.3.5 Vegetation – Operation

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	Do not disturb native vegetation outside of crusher perimeter	• Clearly demarcate crusher area and limit of disturbance • Tag vegetation such as trees that must not be disturbed • Inform work force	Pre-operation phase	Demarcated area and no disturbed areas outside of this area	Demarcate area. Inform work forces	Site Management
2	Rehabilitate and revegetate disturbed areas as close as possible, and where practical, to pre-operation conditions	• Conduct landscaping and planting if necessary to enable re-colonisation of native (local) species	Final stages of Operation	No bare areas unsuitable for re-colonisation by local species. Minimum 80% vegetation covers within 3 months of construction completion	Landscape as required	Site Management
3	Prevent the introduction of weed species	• Ensure all soil and/or sand brought for delopment purposes is from a reputable source and certified pest free	Operation phase		Remove weed species from site	Site Management

1.3.6 Surface Water Monitoring Plan – Operations

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	To characterise the receiving waters and assess the potential for environmental harm	Undertake a survey of the receiving waters to assess the physio-chemical nature of the waters and should also include an assessment of the fisheries community	One month after commissioning	Report is completed	Carry out survey	Operation Management
		Develop a monitoring program and monitor surface water quality at least 3-4 points for the following water quality characteristics: • Total coliforms • pH (in-situ field measurement) • dissolved oxygen (in-situ field measurement) • specific conductance and salinity (in-situ field measurement) • turbidity (in-situ field measurement) • temperature (in-situ field measurement) • general observations of receiving water	Half - yearly	Records of surface water quality monitoring are available	Enforce record keeping procedures	Operation Management
		A person will be appointed to carry out surface water quality monitoring. All monitoring outlined above will be performed in accordance with the relevant guidelines by a person possessing appropriate experience or qualifications	Prior to commencement of operation	An appropriate person has been appointed	Appoint qualified person	Operation Management

1.3.7 Environmental Records and Reporting Management Plan – Operations

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	To maintain all environmental reports and monitoring records in an efficient way	Maintain records of environmental monitoring and any environmental reports for a period of at least 5 years	Ensure all records are filed appropriately annually.	Environmental records are maintained.	Review and update filing records.	Operation Management
2	To ensure that any incidents or emergencies are reported and acted upon within an acceptable timeframe	An emergency and incident log book will be maintained to include: • details of occasions when an incident or emergency which results in the release of contaminants not in accordance with the proposal • details of reporting including who the incident or emergency was reported to and the actions taken	As required	The emergency and incident log book is maintained	Enforce correct use of incident log and follow-up actions	Operation Management

1.3.8 Complaint Response – Operation

	Objectives and Strategies	Actions	Timing	Performance Indicators	Corrective Actions	Responsibility
1	To ensure residents are aware of the extraction activities, possible noise and other inconveniences to minimise complaints	Provide public notices for attention of the general public to inform them of the period of extraction activities	Prior to, and during operation period.	Public notice boards at site entrance.	Ensure notices are clearly identified and posted on site.	Management
2	To maintain a complaints management system that ensures any complaint with regard to the development is dealt with appropriately	When a complaint is received relating to extraction it will be recorded in the complaint log book The complaint log book will include: • nature, time and date of complaint • type of communication (telephone, letter etc.) • name, contact address and contact telephone number of complainant • response and investigation undertaken • name of person responsible for investigating the complaint • action taken as a result of the complaint investigation	As required during the construction phase	Complaint log book is maintained for all complaints received and action has been recorded	Enforce correct use of complaint log and follow-up actions	Management