Initial Environmental Evaluation

for

Proposed Reintroduction of Hydro Electric Power at Grytviken, South Georgia

MORRISON

CONTENTS

NON-TECHNICAL SUMMARY

South Georgia is an isolated sub-Antarctic island situated in the Southern Ocean. It has no permanent inhabitants, but there are year-round residents at two locations: King Edward Cove (Grytviken and King Edward Point) and Bird Island. In addition, the unique landscape, fauna and flora attract an increasing number of ship-based tourists.

The buildings at King Edward Point (KEP) and Grytviken are powered by three diesel generators and heated by three oil fired boilers, consuming a total of 153m^3 of fuel per year emitting 410,040kg per year of carbon dioxide (Morrison, 2005). The fuel is transported to the island by ship, resulting in further fuel consumption and carbon dioxide emissions.

In 2004, the Government of South Georgia and the South Sandwich Islands (GSGSSI) commissioned a study into renewable energy options for Grytviken and KEP. The study concluded that the site at Grytviken was technically viable for hydro power, with sufficient water resources to meet the current demand.

From 1914 to 1964 hydro power was used to power Grytviken whaling station. The proposed reintroduction of hydro power will utilise the existing dam, and repairs will be undertaken to make it safe. Partial drainage of Gull Lake will be required to undertake this work. New intake, penstock (pipeline), powerhouse, turbine and generator will also be installed. A track will be required to access the dam with vehicles and will be prepared using natural materials from the beach, Gull Lake shore and scree material. Cables will be laid around the cove to KEP in the existing trench under the main track. The scheme is being designed for an operating life of at least 40 years.

If the proposed project does not proceed, it is recommended that the dam is made safe by conducting some remedial works. This alternative would have similar, though less, impacts compared with the proposed project. The environmental impacts of dam removal are considered. Alternative renewable energy options have been assessed, but none of these would be able to provide a cost effective main source of power. Finally, some alternatives to track construction are considered, but it is thought at this stage that these are not viable.

Many aspects of the proposed activities will add slightly to the impacts of current operations in the cove, such as additional emissions, discharges to the cove etc. Whilst these impacts should be mitigated as much as possible to reduce the cumulative impact, they are on a very small scale.

The most significant temporary impacts are possible disturbance to breeding birds and damage to vegetation. Vegetation should re-establish relatively quickly and bird populations, if impacted, should also recover once the construction activities are complete. Small numbers of breeding fur seals on the beach may also be disturbed.

The most significant permanent impact is the visual impact of the track. Although there will also be permanent vegetation loss, as the vegetation is of low conservation value and common in the surrounding area, loss of vegetation is not considered to be of long-term significance.

This activity will reduce the requirement for fossil fuel combustion at King Edward Point for a period of at least 40 years. This will have a very significant positive environmental impact in reducing emissions of greenhouse gases and other combustion products to the atmosphere.

The environmental benefits of the proposed project are therefore considered to outweigh the environmental impacts.

1. INTRODUCTION

1.1 Purpose

The purpose of this activity is to provide a source of renewable energy for use at Grytviken and King Edward Point (KEP). This will reduce the amount of fossil fuels that have to be brought to South Georgia and considerably reduce CO_2 and other emissions to the atmosphere from the burning of fossil fuels.

In addition, the repairs to the dam at Gull Lake and removal of redundant equipment will improve the safety and visual appearance of the derelict hydro electric infrastructure.

1.2 History of hydro electric power at Grytviken

The first whaling station on South Georgia was established at Grytviken in 1904. In 1912–13 a reservoir was constructed by damming a natural watercourse and in 1914 hydro power was installed to provide for the growing whaling operation. The reservoir had a capacity for 200,000m^3 of water. The dam wall was extended in 1928, almost doubling the amount of water contained in the reservoir, now known as Gull Lake.

The water fed through two penstocks (pressure pipelines) to the powerhouse, located close to the beach on the south side of King Edward Cove. Three impulse turbines generated a total of 800 HP (approx. 600 kW).

Grytviken whaling station was powered primarily by hydro power from 1914 until the station's closure in the mid 1960s. Since this time the infrastructure for hydro electric generation has fallen into disrepair.

1.3 Legislation, standards and guidelines

Legislation for South Georgia is the responsibility of the Commissioner for SGSSI. Legislation is currently being reviewed and new legislation prepared in order to modernise the laws governing activities on South Georgia.

There is currently no legal requirement for environmental impact assessments to be undertaken before projects are approved on South Georgia. However, the Government is committed under the Environment Charter (see Appendix 1), to ensure that environmental impact assessments, including consultation with stakeholders, are undertaken where appropriate.

The environmental impact assessment procedures which have been developed for the Environmental Protocol to the Antarctic Treaty, Annex I, form the basis of GSGSSI policy on EIA. The South Georgia: Plan for Progress (Pasteur and Walton, 2006) provides further details of South Georgia environmental management policies. Up-to-date information for visitors and environmental guidelines are available on the South Georgia website (www.sgisland.org; also see Appendix 2 and Appendix 3).

1.4 Technical reports and documentation

The following technical report and documents prepared for the GSGSSI have been used in the preparation of this IEE:

- A study into renewable energy options for Grytviken and King Edward Point (Morrison Falklands Ltd., 2005) which includes:
- Report on an inspection of Gull Lake dam at Grytviken, South Georgia (Morrison Construction Services, 2005)

- Report on a visit to Grytviken, South Georgia to examine the existing power station (Gilkes Hydro, 2004)

1.5 Project management structure

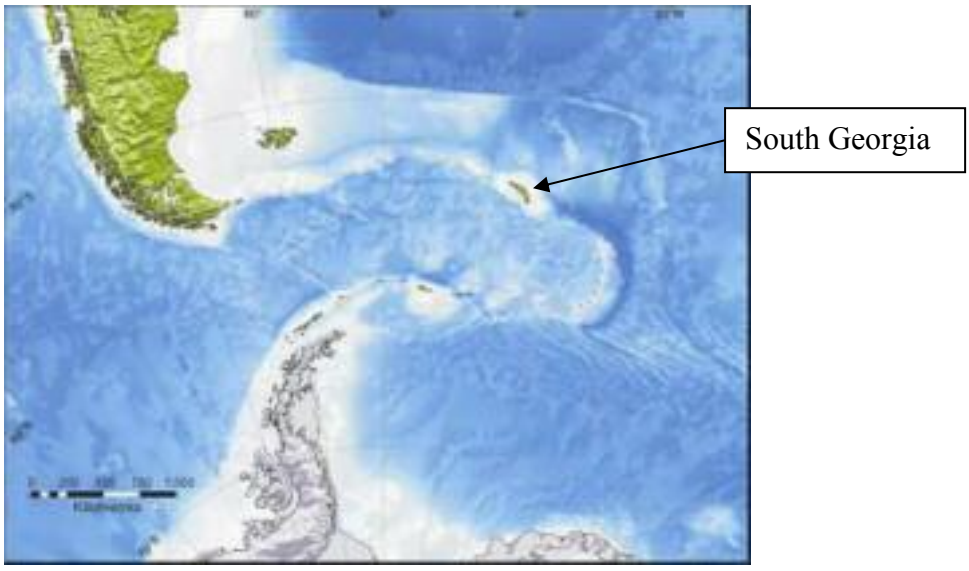
Morrison (Falklands) Ltd., as part of the Morrison South Atlantic Operation, will be the managing contractor for the project. The project will be the responsibility of the regional manager based at the Stanley Office.

The Project Manager will manage around ten operatives. It is likely that most of the people working on the project will have previous experience of working on Antarctic or sub-Antarctic projects. Specialists will be brought to South Georgia to commission the turbines and install the electrical distribution equipment.

2. DESCRIPTION OF THE PROPOSED ACTIVITY

2.1 Location

South Georgia is a sub-Antarctic island situated around 1,400km east of the Falkland Islands. Grytviken (54º15'S, 36º45'W) is located at the head of King Edward Cove, part of Cumberland East Bay on the northern coast of South Georgia.



Map to show location of South Georgia

A more detailed map of the Grytviken area is in section 4.1.

2.2 Principle characteristics of the proposed activity

2.2.1 Re-commissioning of the 2003 construction camp

A construction camp was erected in 2003 for the Grytviken clean-up project, undertaken by Morrison. The accommodation comprises of a 36-person dormitory, ablution unit, kitchen, dining area, laundry room, boot room, medical unit and cold storage facility. The camp was designed to be used for 2–3 seasons and some maintenance work may be required to allow the accommodation to be used for a further two seasons.

2.2.2 Preparation of access track from Grytviken to Gull Lake dam

An access track is required to take materials, equipment and people to repair the dam. The track will be 5.5–6m wide and 841m long. Approximately 50% of the proposed track is existing hard rock surface and therefore will not require significant modification.

A careful study, including a site visit in February 2006, was undertaken by Morrison to identify the best route for the track. A natural line trending from the south side of Grytviken westwards and then back across towards the dam is proposed. The route is shown on the photograph below and the technical drawings and gradients are shown in Appendix 4.

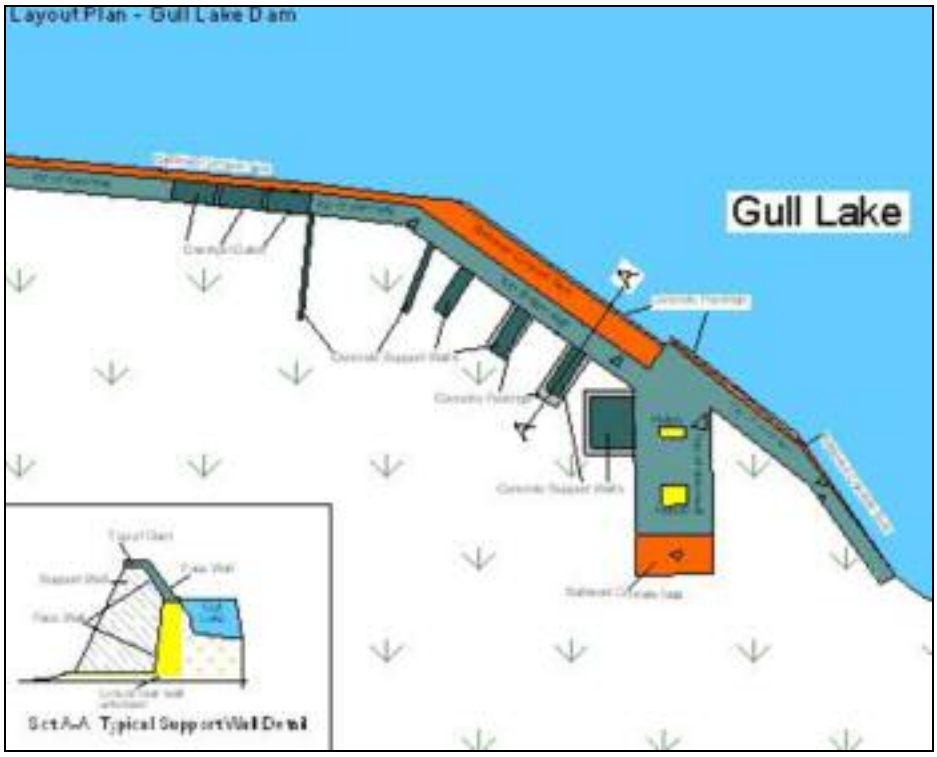
Proposed track route

Areas of the track where the gradient is steep or where the ground is soft will require work, including:

- Cutting and filling a section of the track (the steepest section, about 25m in total; see Appendix 4) to make the slope a more even gradient suitable for vehicles;
- Use of natural hardcore material from the shore of the King Edward Cove, from scree runs below Orca Peak and from the shore of Gull Lake to form a base structure where there is not already a rocky surface; and
- Use of reinforcing membranes (geotextiles) to enable better traction on softer parts of the track.

2.2.3 Dam repairs

The dam requires significant repair work to ensure that it can safely contain water for hydro electric generation. There are four main sections to the dam: the eastern gravity wall section (approx 27m long), the western gravity wall section (approx. 20m long), the central buttressed wall section (approx. 14m long) and the valve chamber section (see layout plan below).



The following works will be undertaken:

1. Provision of a new reinforced concrete lining to the upstream face (Gull Lake side) of the dam, integrated with a new concrete cut-off trench to close off potential water leakage under the dam.
2. Improve the resistance of the dam to sliding under horizontal loading, by installing inclined rock anchors.
3. Widen the existing concrete support walls on the downstream face of the dam wall to reduce stress levels and carry out remedial work to their undermined foundations (removal of defective concrete, preparation of rock surface and construction of suitably designed concrete pads).
4. Repairs to draw-off works may be necessary when accumulated debris has been removed to allow proper inspection. Likely works are breaking out and replacement of parts of this section of dam wall.
5. Repairs to downstream face to improve the visual appearance of the dam with a gunite concrete layer.
6. Repairs to eastern wall section. A trial section of this wall will be broken down to the large horizontal crack. If the crack is significant then the upper part of the wall will be removed and rebuilt.
7. Improvement to tailrace area, by building a channel to drain spillway water away from the dam structure to prevent the build up of water around the foundations.

Engineering drawings showing existing dam plan and new construction details are in Appendix 5. Further details on the condition and recommended works to the dam are available

in *Report on an Inspection of Gull Lake Dam at Grytviken, South Georgia* (Morrison Construction Services, 2005), produced for the GSGSSI.

A dry working area will be required around the dam in order to undertake the majority of the repairs. This will be achieved by opening the valve to the old penstocks and allowing the water to drain from the reservoir, via the penstocks, into the cove. This will achieve a level of around 0.5m lower than the level shown in the photo below.

Photo of upstream face of Gull Lake dam showing water level

A temporary dam will then be built to protect from the influx of water while work is in progress. The dam will use natural materials from the lake bottom/sides, lined on the upstream side and reinforced with sandbags where necessary.

2.2.4 Intake

The intake is where water is taken from Gull Lake into the top of the penstock. The existing intake structure and building will be removed. The new intake will consist of a simple vertical metal bar screen, with bar spacing to allow good water flow, but restrict any debris (around 15-20mm). As the water in Gull Lake is of good quality and there is little large vegetation, there is unlikely to be large floating debris.

2.2.5 Penstock

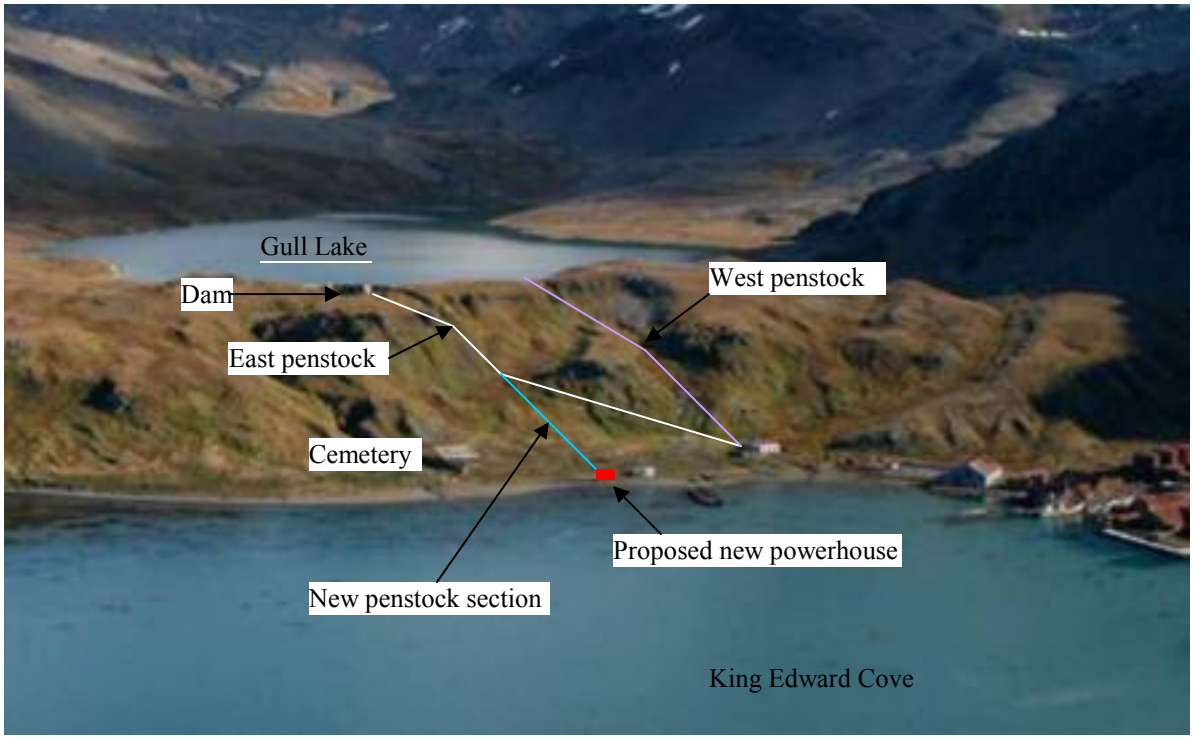
The original hydro system used two penstocks to feed the turbine from the dam, the 16 inch diameter east penstock and the smaller 8 inch diameter west penstock (see photo below).

In order to ensure the maximum lifetime of the hydro scheme, and taking into account the cost of replacing the penstock at a later stage, replacement of the old penstock with modern 400mm diameter plastic pipe is proposed. The new penstock will be laid in a trench, secured at intervals with thrust blocks. The trench will be back filled so that the penstock is completely buried.

The new penstock will initially follow the line of the east penstock from the dam, but will continue directly to the location of the new powerhouse. For the upper section, the old penstock will be removed and the new one placed in the same trench. A new trench will be excavated for the lower section of penstock.

In order to improve the visual appearance of the area below the dam, exposed redundant sections of the east and west penstock will be cut out and removed. Buried sections will be sealed off and left in situ.

Tracked vehicles will be used to dig out the trench to bury the penstock. Where the ground is marshy, plastic or aluminium removable temporary road surface ('trackway') will be used to reduce erosion.



Location of dam, penstocks and proposed powerhouse (adapted from Morrison, 2005)

2.2.6 Powerhouse

The old powerhouse was removed in 2005 because the structure was no longer safe. The proposed new powerhouse will be used to house the turbine, generator and associated equipment. It will be smaller than the previous powerhouse, at about 30m^2. It will be constructed on the foundations of the old radar building above the beach between Grytviken and Grytviken cemetery and below the direct line of fall of the penstock. The powerhouse will have double doors to allow removal of the turbine equipment, a small window, ventilation louvres and will be a green colour, to blend in with the landscape.

2.2.7 Turbine and generator

The turbines used in the original hydro scheme, three Francis turbines, are no longer serviceable. A single jet Turgo Impulse Turbine is proposed for the new scheme with a synchronous generator rated for a supply of 250V/3phase/50Hz, fitted with a Flywheel. A hydraulic control module, turbine shut-off valve and electrical control equipment will also be installed. The turbine will require weekly inspection once operational.

2.2.8 Electrical distribution

Transformers will be needed to convert from the generated 400V to around 960V (or up to 11000 to save on copper costs). Cabling and safety interlocks will be installed in line with

current regulations to ensure the safe distribution of power. The overall cable diameter will be less than 75mm.

Most of the power demand will come from KEP, which is on the opposite side of the cove from the new powerhouse. The cable will be run around the cove, in the existing subsurface trench running underneath main track, a distance of approximately 1800m. The existing cabling which runs from the generator shed at KEP to Grytviken will be used to service activities at Grytviken.

2.2.9 Water output

The tailrace, an open concrete culvert, will divert water from the turbine to the sea.

Water flow into the penstock will be controlled by a valve at the dam, which can be closed to allow the penstock to be drained. There is also a valve system at the powerhouse to divert the water from the penstock directly to the tailrace, bypassing the turbines.

When Gull Lake is full to overflowing, water will flow over the overspill gates on the dam (see layout plan, section 2.2.3) into the natural stream bed below, and down to the sea.

2.2.10 Existing generators and fuel tanks

Three diesel generators and three oil fired boilers currently operate at KEP will be kept for emergency backup. At the present time, it is planned that the bulk fuel tanks will be kept and will store back up fuel.

Following the successful operation of hydro power over successive seasons, the requirement for back-up generators and fuel tanks will be reviewed.

2.2.11 Summary of proposed hydro operation

Once the refurbishment is complete, water from Gull Lake will pass through an intake screen at the dam into the top of the penstock and flow down to the new powerhouse. It will then pass through the turbine to generate power and discharge from the turbine into a tailrace to the beach.

The turbine will be configured to respond to power demands at KEP and Grytviken and to water levels in Gull Lake. Power will be transferred to Grytviken Museum and KEP via buried cables running beneath the main track.

The hydro scheme will be designed for an operating life of at least 40 years. Routine inspection will be undertaken weekly and the equipment will be serviced annually.

2.3 Area of disturbance

2.3.1 Area of operations

The area of operations will include the jetty at KEP, where all construction materials, plant and personnel will be offloaded. Transportation from KEP to Grytviken will be via the main track, upgraded in 2003. The construction camp is at the south end of Grytviken whaling station.

These areas are all used regularly by the residents at Grytviken and KEP and by visitors to the Cove. However, there will be a very significant increase in the amount of vehicular traffic on the track while cargo is being moved to the construction camp site.

Construction materials will be stored near to the construction camp on an existing concrete slab that remains from the demolished whaling station freezer store.

The area of operations will extend from the construction camp, along the coast to the site of the powerhouse, and up the slope from the power house to the dam, where the penstock will be laid. The main access to the dam from the construction camp will be via a track (see section 2.2.2). Some material will be taken from the lake shore and from Gull Lake beach and possibly from the hillside scree for use as hardcore for the track. Operations will take place along the length of the dam.

2.3.2 Duration and intensity

It is proposed that the project will take place over two summer seasons:

Season 1: Track construction – requiring three people at Grytviken for 6 weeks.
Season 2: Project manager and ten operatives at Grytviken for around 4 months plus commissioning engineer for around 1 month at the end of the season.

The proposed start of the project will be in 2006–07 so that Morrison can utilise the construction camp at Grytviken, which was built in 2003 to last for 2–3 seasons.

2.3.3 Fuel storage and refuelling

The fuel storage facility at KEP, operated by BAS, will be used for bulk storage of fuel. This consists of six 54,500 litre self-bunded rectangular welded tanks (total capacity 327,000). Oil spill equipment is kept at the research station to deal with spills and certain BAS staff are trained in oil spill response. Oil spill exercises are carried out at the station.

Plant fuel will be stored in a mobile bunded bowser at the construction camp. Fuel for the construction camp will be stored in bunded 1000 litre day tanks, which will be re-fuelled using the bowser. A mobile bunded bowser will also be used at the dam during the project. Oil spill kits will be kept on each of the bowsers and a more comprehensive spill kit will be stored at the construction camp. Some fuel and oils will also be transported in UN classified 205 litre tight-head drums. Jerry cans will be used at the construction camp for storage and transportation of smaller quantities of fuel.

The approximate amount of fuel which will be required for this project will be around 60m^3.

2.4 Transport

2.4.1 Shipping

An estimated 700m^3 of cargo required for the project will be shipped from the UK to the Falkland Islands using a commercial freighter. Some surplus materials from recent Morrison projects at Grytviken and KEP will be used where possible, reducing the need for shipping.

Shipping arrangements have not yet been finalised, but it is likely that the construction equipment and personnel will be delivered to South Georgia on the GSGSSI Fishery Patrol Vessel MV *Pharos SG*. If this is not possible, or if the BAS ships cannot take the cargo, a suitable vessel will be chartered.

2.4.2 Construction vehicles

The following vehicles, used on previous Morrison projects, are already on site at Grytviken:

- 35 tonne tracked excavator
- 10 tonne wheeled dump truck
- Tracked cherry picker

The following additional vehicles will be shipped to Grytviken for this project:

- JCB 540 Telehandler
- Mitsibushi pick-up
- Concrete mixer

2.5 Site waste collection and disposal

An incinerator will be used to burn combustible materials. Grey water, sewage and macerated food waste will be discharged directly into the cove.

All other waste will be removed from South Georgia for recycling or safe disposal. A Site Waste Data Sheet (see Appendix 6) will be completed as part of the project planning process, and maintained throughout the project. Waste will be split into six types, these are:

1. Biodegradable Waste
2. Non-recyclable/ Non-hazardous Waste
3. Waste fuel and Oil Products
4. Hazardous Waste and Chemicals
5. Reusable Materials
6. Recyclable Waste

Special care will be taken with waste poultry products, including eggs and egg shells, due to their potential to transmit avian viruses such as Newcastle disease to birds. Only boneless poultry meat and eggs will be used. No food scraps will be left accessible to birds.

All waste will be separated at source, processed and compacted where possible, ready for transportation and removal. When separating waste, it will be correctly packaged, clearly marked and documented. All waste will be transferred to the Jetty for removal by BAS shipping. All wastes exported will be accompanied by accurate Bills of Lading (BoLs)

Waste management at Grytviken/KEP is organised by BAS. Preparation of waste for shipping will be undertaken with reference to the procedures set out in the BAS Waste Management Handbook (2005).

2.6 Standard procedures

Standard procedures are defined in *Morrison Business Process Maps* (MCSL Manual, 2005; see Appendix 7) and include the following:

- Environmental Impact /Aspect Register & Risk Assessment (FM-ENV-300)
- Site Waste Management Plan (FM-ENV-301)
- Site Safety Responsibility Check sheet (FM-CON-014)
- Safety Briefing Record (FM-H&S-002)
- Incident Response Plan ((FM-ENV-350)
- Environmental Incident Response form (FM-ENV-351)
- Checklist of possible site environmental constraints (FM-ENV-311)
- Environmental Policy
- BoLs (Bill of Lading)

The procedures are described in full on the Morrison intranet and will be included in a folder in the site office.

3. ALTERNATIVES TO PROPOSED ACTIVITY

3.1 Do not proceed

The dam and associated neglected equipment and penstocks are man-made structures that, in their present state of repair, could be considered to have a negative visual impact on the environment.

If no action is taken, the dam at Gull Lake will continue to deteriorate and there will be further leakage under the dam wall. Leakage from the penstocks will continue, causing erosion to the hillside.

The safety of the dam can no longer be guaranteed and when the lake is full, the dam may fail. The risk of failure will increase over time. If the dam fails, the region below will be washed out, including the Grytviken cemetery.

3.2 Do not proceed with hydro scheme, but make dam safe

In its present condition the dam does not meet the criteria for the safe operation of a hydro scheme. However, if the hydro project does not go ahead, it is recommended that the dam is either stabilised or demolished and exposed penstock sections and other unsightly equipment removed.

3.2.1 Stabilising the dam

A less comprehensive programme of works would be required to stabilise the dam. Vehicles would still need to access the area and so a track would be required as described in section 2.2.2. Repair work would be required on the upstream face of the dam, necessitating partial drainage of Gull Lake and the building of a temporary dam as described in section 2.2.3. The impacts of the track and to the Lake would therefore be similar to carrying out the complete project, except that the track would not be so heavily used.

The penstocks would not need to be replaced, so there would be minimal vehicle access to the slopes below the dam in order to remove exposed sections of penstock.

3.2.2 Removal of the dam

The dam at Gull Lake is listed as a historic site. An assessment of its historical significance should be conducted before a decision is made regarding its removal.

If this option was chosen, the dam would be demolished using a pneumatic hammer mounted on the tracked excavator. This could be undertaken following partial drainage of Gull Lake via the penstock as described in section 2.2.3 and by overpumping (pumping water out of the lake and down to the cove via a pipeline).

Following demolition the rubble would be removed and buried. A large hole would be dug at a suitable site to the side of the dam and all of the old dam material buried and covered over. If the material were to be taken to Grytviken, this would require a lot of vehicle journeys which would increase erosion.

If the dam was demolished and buried close to the site using the tracked vehicle, then constructing a proper track to access the dam would not be necessary. Some erosion of the slopes below the dam would be caused by the vehicle and there may be erosion around the dam site. Removal of exposed sections of penstock would require some vehicle access to the slopes below the dam.

Physical disturbance would be caused by digging a hole large enough to bury all of the dam material. This would have the aesthetic impact of leaving man made materials buried at the site. Concrete dust would be generated by the demolition, which could damage vegetation. If this alternative were chosen instead of the proposed activity, there would be no environmental benefits from the renewable hydro energy source.

3.3 Alternate renewable energy options

Alternative renewable energy options were considered by *A study into renewable energy options for Grytviken and King Edward Point* (Morrison, 2005) undertaken on behalf of the GSGSSI.

3.3.1 Solar photovoltaic (PV)

Solar PV panels produce electricity when the sun shines on them. KEP does not receive direct sunlight during 3 months of the winter and costs for PV panels are very high, particularly for large power applications. PV is therefore not suitable as a main power source for Grytviken and KEP. There is a role for PV for smaller applications such as battery charging, remote monitoring stations and communication devices.

3.3.2 Solar thermal

Solar thermal panels use solar energy to heat water. Solar thermal systems are simple and easy to operate and have a minimum life span of around 20 years. Panels are roof mounted and collect heat even if there is no direct sunlight. Solar thermal provides heat and not electricity and is therefore not suitable as a main power source for Grytviken and KEP. However, it has a significant role to play in reducing the heating loads on electrical power requirements. Solar thermal panels have been successfully installed on Carse House at KEP.

3.3.3 Tidal stream and wave power

Tidal streams and waves can be used to generate power from the flow of water. The technology is still being developed and there are no commercially available systems. This is therefore not suitable for use at Grytviken and KEP at present.

3.3.4 Wind power

Wind turbines convert the mechanical energy of rotating blades into electricity. South Georgia is windy and therefore a suitable place for using turbines. Disadvantages are that wind turbines generate DC electricity and an inverter and battery storage are therefore required. A 6kW Proven turbine is currently operating successfully at KEP. In order to be the main source of power, a further ten or more, larger (15kW) turbines would be required. This would have a visual impact and may also increase the risk of bird strike with the turbine blades.

3.3.5 Conclusions

The study concluded that the site at Grytviken was technically viable for hydro power, with sufficient water resources to meet the current demand. In addition, passive solar thermal panels installed on roof space, energy efficient design and equipment would reduce the demands on the hydro system, and wind turbines could be used in conjunction with the system.

3.4 Alternatives to track construction

3.4.1 Don't built a track - use tracked vehicles to access dam

If tracked vehicles were used rather than wheeled vehicles, then they could get up the steeper slopes and across rough terrain from the beach to the dam without the need for the construction of a track. However, this would require the purchase of different vehicles and then shipping to the South Georgia, increasing costs and possibly making the project unviable. Tracked vehicles would also cause considerable erosion in soft areas.

3.4.2 Cable system

A cable system could be used to move materials from the beach to the dam. However, an affordable cable system would not be able to move large loads and vehicles. Heavy mechanical equipment and vehicles will be required at the dam for earth moving, construction of rock anchors and concrete mixing. This alternative is therefore not practical.

3.4.3 Use of temporary track (trackway)

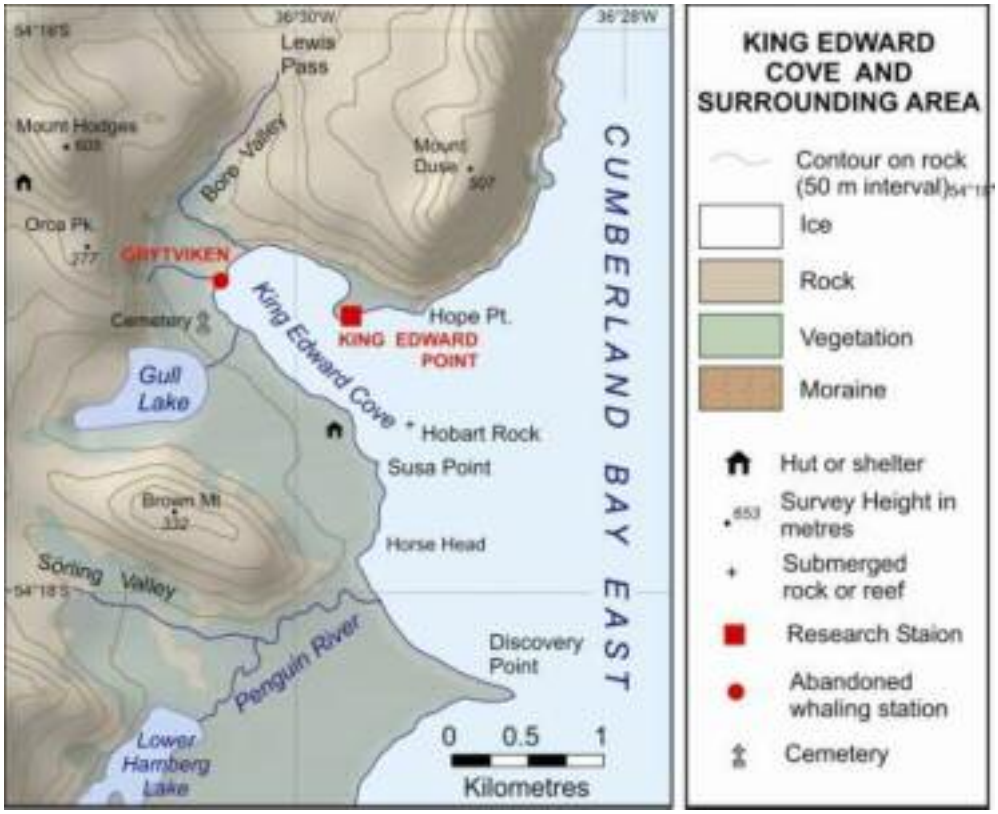
Over 400m of the proposed track is already rock surface and will therefore not need to be modified. Temporary plastic or aluminium trackway could be used for the remaining sections of the track and could be removed after the project. Some "cut and fill" would still be required to even out the gradient of the track and the surface would need to be partially prepared to provide a good enough base for wheeled vehicles. Damage to vegetation would therefore occur.

The trackway may not be robust enough for heavy use and erosion of the hillside would probably occur. However, the hillside would recover with time after the completion of the project.

Temporary track is very costly and would probably make the project unviable.

4. INITIAL ENVIRONMENTAL REFERENCE STATE OF GRYTVIKEN AREA

4.1 Location



Grytviken and KEP are located in King Edward Cove, a sheltered cove on the western side of Cumberland Bay East on the north-eastern coast of South Georgia. Grytviken is on a level area of land at the head of the cove, with steep mountains rising to the west. Gull Lake is around 500m to the south at an altitude of around 70m.

4.2 Geology

Grytviken is situated to the north of the Allardyce Mountain range, which includes the highest peaks on South Georgia. The rock is part of the Cumberland Bay formation, which is composed of sandstones formed from volcanic sediments eroded from the sides of a marine basin.

4.3 Geomorphology

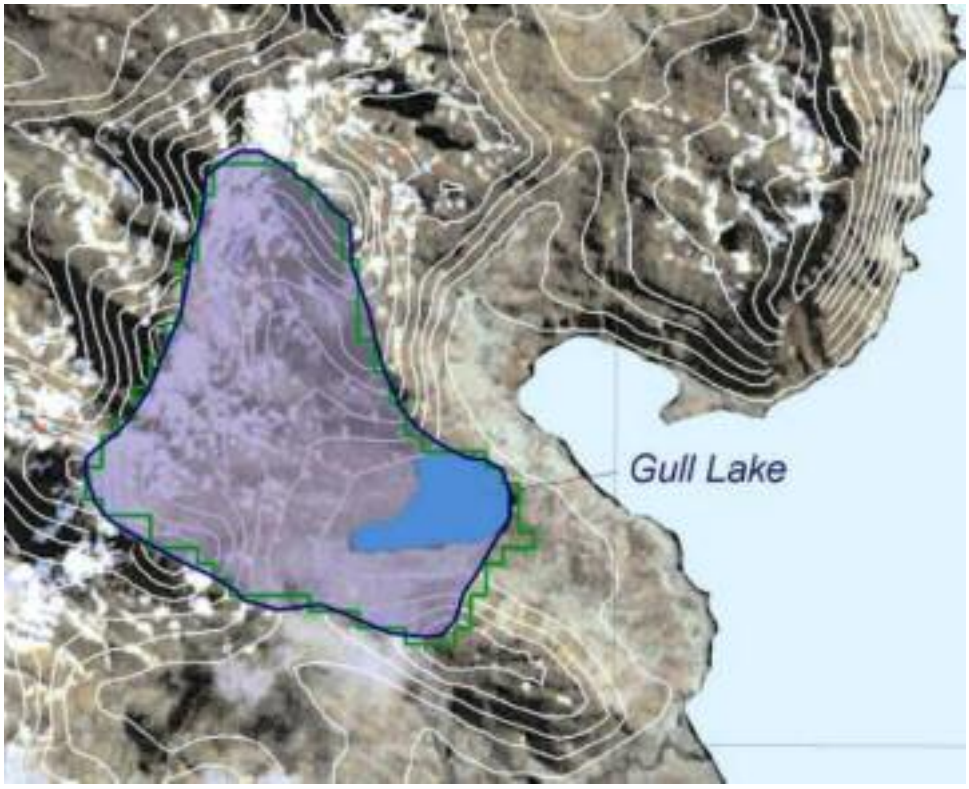
King Edward Cove is surrounded by mountains, showing many classical glacial landforms including corries. There are extensive areas of scree on the steep mountain sides and lower slopes around the cove.

KEP is situated on a series of raised beaches, formed by the rebound of the land when the weight of glaciers was removed during deglaciation.

4.4 Hydrology

Water feeds into King Edward Cove from a number of small streams. A small dam in Bore Valley supplies water to King Edward Cove and Grytviken.

The catchment area of Gull Lake, calculated as around 3.5km^2, is shown on the map below. Before the dam was built, water from the catchment would have fed into streams, flowing into King Edward Cove.



Catchment area of Gull Lake (adapted from Morrison, 2005)

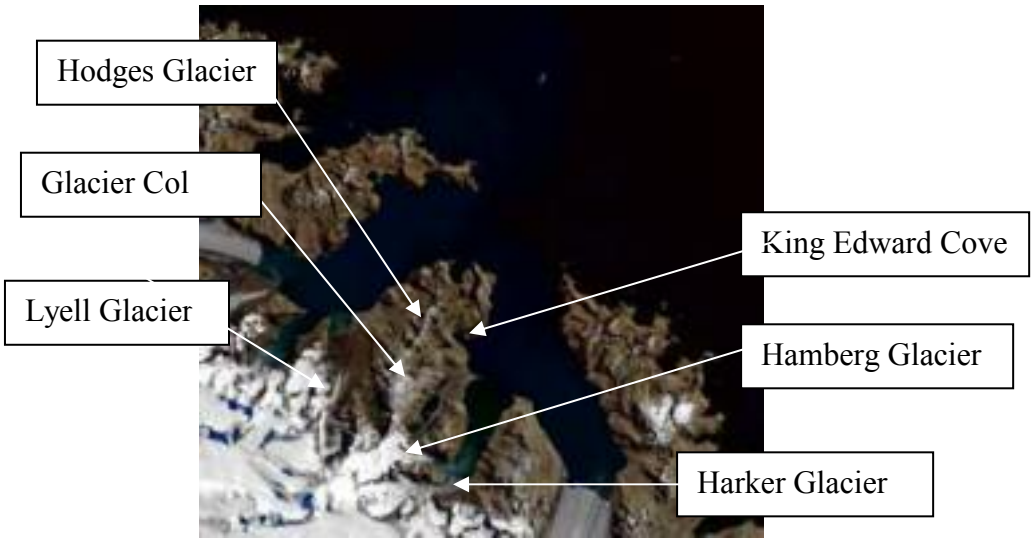
4.5 Glaciology

Glaciers cover over half the land area of South Georgia. There are no glaciers or permanent ice fields in the catchment of Gull Lake.

The small Hodges Glacier flows from the south side of Petrel Peak to Mt Hodges, around 1.5km from Grytviken. Glacier Col, another small ice field, is 4km southwest of Grytviken. Studies of these glaciers during the 1970s and 1980s show that they are retreating and are likely to respond more quickly to climate warming than larger glaciers (Gordon and Timmis, 1992).

The nearest large glacier is Lyell Glacier, which flows down from Mt. Sugartop and Paulsen Peak towards Harpon Bay. The Hamberg Glacier and Harker Glacier both flow into Moraine Fjord to the south of King Edward Cove.

Most of the icebergs seen at South Georgia have travelled north from the Antarctic continent. The largest of these are tabular icebergs that have broken off ice shelves. Smaller icebergs and bergy bits may break off the glaciers on South Georgia particularly in the spring. Icebergs drift into Cumberland Bay East and King Edward Cove and may occasionally restrict ship access.

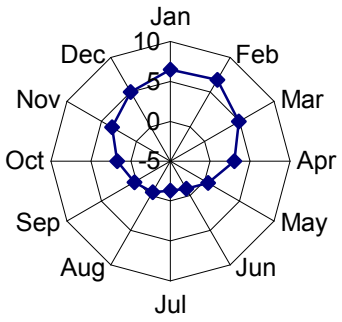


Aerial photograph of Cumberland Bay showing location of glaciers.

4.6 Climate

South Georgia has a sub-Antarctic climate, characterised by deep depressions which originate in the Southern Ocean. Grytviken is on the more sheltered northeast coast of the island and has a mean annual temperature of 1.8ºC and total annual precipitation is 148cm. Conditions are changeable and temperatures vary considerably from day to day. Summer temperatures are generally around +5 to +10ºC.

Snow cover usually lies down to sea level during winter and sea ice may form in sheltered bays. Wind speeds are generally high throughout the year, with monthly averages of 7–10 knots. Katabatic winds and violent squalls are a feature of South Georgia weather.



Average temperature at King Edward Point for 2001–05 [from http://www.antarctica.ac.uk/met/READER/data.html]

4.7 Flora

The vegetation in the region of King Edward Cove consists of low-growing plants and no trees or shrubs. The area around KEP is largely bare ground, but there is some tussac (*Parodiochloa flabellata*) along the shoreline in places and *Festuca contracta*, moss (*Polytrichastrum strictum, Chorisodontium aciphyllum*) and introduced annual meadow grass *Poa annua.* There are some small patches of *Acaena magellanica* herbfield at the foot of the slopes of Mt Duse (Scott and Poncet, 2003).

Environmental Mapping Report: map of Grytviken (Scott and Poncet, 2003)

The area around the whaling station and the low lying land above the beach towards the cemetery is bare ground or short mixed grassland, including Antarctic hair grass (*Deschampsia Antarctica*) and a variety of introduced grasses *Poa annua*, *Poa pratensis, Deschampsia caespitose* and *Agrostis tenuis*. Other common introduced species are chickweed (*Cerastium fontanum*), sheep's sorrel (*Rumex acetosella*), dandelion (*Taraxacum officinale*) and the most recent introduction hairy bittercress (*Cardamine hirsuta*) (Scott and Poncet, 2003).

The proposed track will be mainly on short mixed grassland, *Fetuca* and bare rock. The region around and below the dam and around the penstocks has a mixture of plant communities including *Fetuca* grassland, fellfield, *Acaena* herbfield, a small amount of tussac and close to the beach some mire and bog (Scott and Poncet, 2003).

Offshore kelp (*Macrocystis pyrifera)* forests grow around the coastal fringes of most of the cove, with the exception of KEP and the foreshore around the whaling station. This provides habitat for smaller marine flora and fauna.

4.8 Fauna

4.8.1 Mammals

The main locations for elephant seals (*Mirounga leonina*) are on the long gravel beach next to the buildings at KEP (around 150 breeding females), on the beach below Grytviken cemetery and near to Suza Point.

Compared to other areas on South Georgia, King Edward Cove has a low number of breeding Antarctic fur seals (*Arctocephalus gazella*) though counts are increasing. There were at least 23 pups between Grytviken and Horse Head in 2004, compared with approximately 14 in the previous year (South Georgia online newsletter, December 2004).

The introduced species Norwegian rats (*Rattus norvegicus*) are common at Grytviken, despite the laying of bait and traps. They live under buildings, scavenge any food left accessible and may also feed on ground-nesting birds. The population is likely to have decreased following the environmental clean-up of Grytviken, as many buildings were removed.

4.8.2 Birds

Large numbers of king penguins (*Aptenodytes patagonicus*) come ashore to moult during the summer months. They do not breed in King Edward Cove.

Small numbers of the endemic South Georgia pintail (A*nas georgica georgica*), white-chinned petrels (*Procellaria cinerea*), occasional light-mantled sooty albatross (*Phoebetria palpebrata*) and Antarctic terns (*Sterna vittata georgiae*) nest in on the tussac slopes above the cove. Kelp gulls (*Larus dominicanus*) nest on low rock outcrops along the shore in significant numbers and may also be found around the shores of Gull Lake.

All of these birds breed during the summer months. The longest breeding cycle is that of the light-mantled sooty albatross, which lays eggs in October, incubates for two months, hatching in early January and fledging in May. The most important months for incubating and hatching are December and January (Poncet and Crosbie, 2006).

Locations of breeding birds are shown on the map in section 4.7. This suggests that there are no nesting birds directly within the operational area of this project. The Antarctic terns marked on the map at the south end of Grytviken no longer nest at this location. The brown

skuas indicated on the map are now thought to nest to the south-east, near to Susa Point (D. Edwards, personal communication).

Breeding Birds	Estimated pairs (date of count)	Population status
Light-mantled sooty albatross *Phoebetria palpebrata*	7,500 (1976)	Stable/not known
White-chinned petrel *Procellaria cinerea*	2 million (1979)	Stable/not known
South Georgia pintail A*nas georgica georgica*	1,000 (1987)	Stable/not known
Kelp gull *Larus dominicanus*	2,000	Stable/not known
Antarctic (South Georgia) tern *Sterna vittata georgiae*	10,000	Increasing

Table 1. Total South Georgia population of birds breeding in King Edward Cove (from McIntosh and Walton, 2000)

4.8.3 Invertebrates

Invertebrates are the most abundant terrestrial fauna on South Georgia, though they are less numerous than on other sub-Antarctic islands. These include beetles, flies, spiders, earthworms, mites and springtails. A study in 1982 found that the beetle *Ptinus tectus* was the commonest insect at Grytviken (excluding the numerous ticks, mites and springtails). The most common fly was *Prosopantrum austrinum* and the only spider found was *Notiomaso australis*, the most common spider on South Georgia (Vogel and Nicolai, 1983).

The highest predator species in Gull Lake is likely to be the beetle *Lancetes clausii* and the next largest species the zooplankton *Parabroteus*. These species occur in many lakes on South Georgia and can survive in around 1m depth of water (Rod Arnold, personal communication).

4.8.4 Marine fauna

King Edward Cove is a spawning ground for fish. Patagonian toothfish (*Dissostichus eleginoides*) and mackerel icefish (*Champsocephalus gunnari*), both important fisheries species, are collected by BAS researchers as well as other fish species and invertebrates.

4.8.5 Alien diseases and species

A wide range of alien species, including microbes, algae, fungi, mosses, lichens, vascular plants, invertebrates, fish, birds and mammals, have been brought to South Georgia by visitors since its discovery in the 1700s. New species can also reach the island by natural means, carried on birds or attached to marine debris. Many of the species introduced to the Grytviken area have not survived, but some of those which have, such as rats (*Rattus norvegicus*) and the grass Poa annua have altered the natural ecosystems significantly.

The introduction and transfer of non-native species on South Georgia is of great concern. The policy of the GSGSSI, as with other sub-Antarctic islands, is to remove all non-native species where possible and prevent further introductions or transfer of species from one part of the island to another. The Government 'Guidelines for prevention of introduction and translocation of alien species' (see Appendix 3) must be followed at all times.

4.9 Current usage

The main current use of Grytviken is as a visitors' site. The only residents are the two Museum Curators who run the South Georgia Museum.

KEP is now the main settlement in King Edward Cove where the Government administrative centre Carse House and the BAS research station are located. There is a small jetty. The total number of residents at KEP is around 12 during winter. Numbers vary during the summer, depending on the season's activities, but the baseline number is around 20–25 people.

4.9.1 Government administration

Two Government Officers and a Deputy Postmaster represent the GSGSSI on South Georgia. The Government Officers are responsible for customs and immigration for all visitors to South Georgia and for ensuring that visitors and residents are briefed about general and environmental issues before they go ashore. Fishing vessels are inspected to ensure that they meet legal requirements before they can fish in the South Georgia Maritime Zone, and licences and invoices are issued. The Government Officer also collects and records information about activities on South Georgia including fishing vessel positions and catch data and visitors' post visit reports. The Deputy Postmaster runs the Post Office, processes all the philatelic mail and sells stamps, first day covers and postcards, and acts as Registrar.

Fishery Patrol Vessels, chartered by the GSGSSI, visit the Cove whilst patrolling the South Georgia Maritime Zone. Fishing vessels may also return to Cumberland Bay East to trans-ship their catch onto transport vessels.

There were 214 vessel visits, to Cumberland Bay East in 2004 (Lurcock, 2005). Table 2 shows the type of vessels and seasonality of the visits. Fishing vessels visit mainly during the winter toothfish season, whilst tourists are concentrated in the summer months from November to March.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2004
Cruise Ship	12	8	9								10	5	44
Yacht	8	2	2							4	9	4	29
MOD		2	1						1		1		5
BAS	2	1	1	1							2	1	8
Fishery Patrol	3	2		2	1	1	2	1	2	1	2	4	21
Reefer					3	8	5	6	1				23
Fishing Ships	5	1		8	14	21	15	9	2		1	6	82
Other	1					1							2
TOTAL:	31	16	13	11	18	31	22	16	6	5	25	20	214
Key: Yacht = sail or motor vessels under 12m length; MOD = Military of Defence; BAS = British Antarctic Survey; Reefer = vessel used for transporting fish catch													

Table 2. Summary of number and type of vessel visits to Cumberland Bay East (including Grytviken/King Edward Cove) for each month during 2004 [From Lurcock, 2005]

4.9.2 Fisheries research

The BAS operates a research station at KEP to conduct applied fisheries research for the South Georgia Government in support of the sustainable management of the fisheries. During the winter, there are three scientists and six support staff, including a base commander, a doctor, two boatmen, a mechanic and an electrician. This number doubles during the summer,

with more scientists as well as support staff. The scientists collect samples from Cumberland Bay and perform monitoring in a science fishing boat.

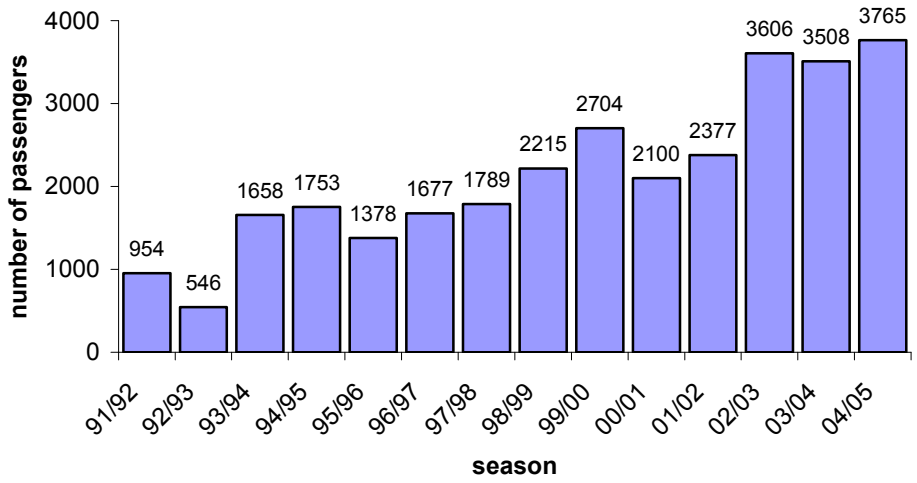
BAS research vessels visit the islands around four times per year during the summer months. Visits are primarily for delivery of stores, collection of waste and transfer of personnel. Staff and crew will assist with the station re-supply and usually also have some time to explore the area. They may go for more extensive walks than tourists (i.e. to the lower peaks around the Cove). BAS have travel regulations defining the areas which may be visited, which includes the Gull Lake area.

4.9.3 Tourism

Cruise ship tourism currently accounts for some 40–45 cruise ships per year (3,765 paying passengers in 2004–05 season) and there are usually 15–20 yacht-based visits per season (Lurcock, 2005). All of these vessels visit KEP, usually at the beginning of their visit, for customs clearance and briefing.

The size of cruise ship varies, but ships with excess of 500 passengers may be granted permission to visit Grytviken. However, a maximum of 300 passengers are allowed ashore at any one time, with a limit of 100 at the cemetery, Museum and church respectively. Shore landings usually last for 2–3 hours and tourists are supervised by guides.

Yacht and expedition visitors are more likely to stay for longer and go for walks to the local peaks and bays.



Numbers of cruise ship passengers 1991-2005 [Lurcock, 2005]

4.9.4 Military

Royal Navy ships visit South Georgia regularly, including HMS *Endurance, an* ice patrol and hydrographic survey ship, other Royal Navy and Royal Fleet Auxiliary vessels. The Royal Air Force undertake aerial surveillance for illegal fishing and local flying by helicopter is undertaken from navy vessels. Military personnel visit Grytviken and KEP for foot patrols, search and rescue exercises, and in support of scientific, conservation and other activities on the island.

4.10 Heritage

4.10.1 Grytviken whaling station and church

Sealers came to South Georgia from the late 1700s, first taking Antarctic fur seals for their fur, and later elephant seals to extract oil from their blubber. Sealers worked the coasts of South Georgia and their remains testify that they worked in the sheltered bay of King Edward Cove.

Grytviken was the first shore-based whaling station on South Georgia, operating from 1904 to 1964. Thousands of whales were taken from South Georgia waters to produce oil and guano (meat and bone meal). As many as 300 men, mainly from Norway, worked there. After the station closed, the buildings gradually deteriorated and began to collapse. In 2003–05 the site was made safe by the removal of asbestos, fuel oils and other hazardous materials. Most of the buildings were also removed as they were unstable and potentially dangerous. Machinery has been left exposed.

The church, still used on occasions for services, was built in 1913. There is a small library of books from the whaling station at the back of the church.

4.10.2 Grytviken whalers' cemetery

The Grytviken cemetery lies to the south of the abandoned whaling station, above the beach in King Edward Cove. Sixty-four people are buried there, including sealers and whalers and the well-known explorer, Sir Ernest Shackleton. Many visitors come to see the cemetery – Shackleton's grave in particular.

4.10.3 South Georgia Museum

The South Georgia Museum was established in 1992 in the former whaling station manager's villa. There are eight rooms containing information on all aspects of the island. In addition there is a shop, a library, archives, storerooms and a further building (the Little Villa) with accommodation for the curators and summer staff.

4.10.4 King Edward Point

The settlement at KEP was established in 1912, so that the magistrate could live separately from the whaling companies. A customs officer, police, jail, post office and communications and meteorological station were gradually added. Most of the original structures have been removed and replaced with modern research station buildings and accommodation for Government staff and the post office. Discovery House, built in 1925 for Discovery investigations' scientists, and the jail (built in 1914) remain. There are plans to convert Discovery House into a visitors' centre. To the north of KEP a path leads to Hope Point, where Shackleton's memorial cross stands.

4.11 Protected Areas and Historic Sites

There are no Specially Protected Areas in the area of the proposed activities. Historic sites close to Grytviken are listed in Table 3.

Site	Description
Brown Mountain / Gull Lake 54°17'S, 36º32'W	*Whaling*: Whalers' hydro dam *Military*: Argentine Puma helicopter wreck (1982) *Scientific/Expeditions*: Meridian transit beacons established by Shackleton's *Endurance* (1914)
Horse Head 54°17'S, 36°30'W	*Military*: Gun hut (from Second World War); harbour defence gun (100mm); observation post; magazine
Grytviken whaling station 54º17'S, 36º31'W	*Whaling and sealing*: Remains of whaling station; sealers' (1846) and whalers' cemetery (1912), including Shackleton's grave. Norwegian church; trypots and other sealing equipment; *Shipwrecks*: *Dias* (1974); *Albatros* (1975); *Sante Fe* and *Fenix* (1982); *Albatros* (1983); *Petrel* and *Louise*.
King Edward Point 54°17'S, 36°30'W	*Sealing*: trypots; shallop; blubber press *Scientific research*: Discovery House (1924); beacon (1906); wireless tower bases (1925), etc. *Military*: Argentine landing craft 'Fenix'; battlefield tour / battle for KEP (1982) - notice/plaque; battle positions of Royal Marines from HMS *Endurance* in 1982; defensive bunkers *Other*: Sites of other early buildings (most demolished in 1978-79, 1996 or 2000-01); gaol (1912);
Hope Point 54°17'S, 36º29'W	*Military*: Gun emplacement foundation (from Second World War) *Other*: Shackleton's memorial cross

Table 3. Historic sites in King Edward Cove area

4.12 Baseline monitoring information

Meteorlogical measurements are made at KEP every 6 hours. The measurements include temperature, atmospheric pressure, precipitation, sunshine and windspeed. Monthly measurements of the sea water temperature and salinity are also taken in King Edward Cove by BAS researchers.

Information on the flora and fauna of the King Edward Cove area was collected as part of the South Georgia Environmental Mapping Report (Scott and Poncet, 2003; see section 4.7). This provides a baseline with which future changes can be compared.

Monitoring of the marine environment in King Edward Cove is undertaken by BAS researchers, on an ongoing basis. This includes setting nets and longlines, undertaking plankton trawls and deploying pots to monitor the occurrence and development stages of fish and invertebrate species within the bay. This ongoing data is used to achieve a better understanding of the life cycles and development of fish species within Cumberland Bay and the waters of South Georgia.

4.13 Future environmental reference state in the absence of the proposed activity

In the absence of the proposed activity, the area of King Edward Cove, South Georgia is likely to stay broadly the same. Increasing tourism may cause environmental effects such as erosion of walking tracks around the cove and to the local peaks and areas of interest. Heavier ship traffic in Cumberland Bay East may result in an increase in local pollution and in the chance of significant oil spills.

The fur seal population is likely to increase in line with other areas around South Georgia. Plans are underway to eradicate rats from South Georgia and this is likely to result in the recovery of populations of ground-nesting birds.

Erosion from the leaking penstocks will continue and the dam structure at Gull Lake will continue to deteriorate and may eventually fail. Failure when the dam is full would cause considerable erosion and may also wash out Grytviken cemetery. The visual impact of the redundant equipment and pipelines will remain.

There will be a gradual increase in fossil fuel emissions as electrical demand increases. This will require an increase in the amount of fuel shipped to KEP and will increase the likelihood of a spill.

5. ASSESSMENT, MINIMISATION AND MITIGATION OF LIKELY IMPACTS

The following section identifies the likely impacts on the environment of the proposed reintroduction of hydro electric power at Grytviken as described in section 2. Minimisation and mitigation measures to reduce these impacts are then described. The assumption is made that the minimisation and mitigation measures described will be applied. Finally, a summary of the impacts and mitigating measures is given in the impact matrix table in section 5.12.

5.1 Atmospheric emissions

One of the reasons for the proposed reintroduction of hydro power at Grytviken is to reduce atmospheric emissions caused by the use of fossil fuel generators as a primary power source at Grytviken and KEP. The potential reduction in emissions far outweighs emissions which will be caused during the proposed works.

Estimated fuel consumption during the two season project is $60m^3$, compared with an annual consumption of around $150m^3$ for Grytviken and King Edward Point. Therefore, the emissions from the project could be balanced within the first year of operation of the hydro plant.

During the two season programme, atmospheric emissions will come primarily from:

- Ship transport to South Georgia and unloading/loading of cargo
- Vehicle movement of cargo to construction camp
- Operation of construction camp (generators)
- Construction activities
- Waste incineration
- Fuel vapour emissions during refuelling activities and from fuel spills

The fossil fuel requirement for the project will be kept as low as possible. Fuels used will include:

- Fuel oil (ships, vehicles, generators)
- Lubricants and hydraulic oils (mechanical equipment and vehicles)

Use of fossil fuels will generate carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxides and particulates. Refuelling activities and fuel spills will cause some emissions to the atmosphere as much of the fuel may evaporate. The vapours will include hydrocarbons and carbon dioxide, which are greenhouse gases and contribute to climate change.

Emissions due to incineration of food and other wastes will depend on the type of incinerator used and the materials burned, but will include particulate matter and greenhouse gases. However, this will be on a very small scale.

Emissions will be at or close to the sea in an area where wind speeds are generally high. They will therefore be rapidly dispersed and are unlikely to have any significant impact of wildlife, marine or air quality. Heavy particulates, such as carbon may deposit a short distance down-wind and may be detectable in soil and marine sediments.

Atmospheric emissions are cumulative and certain gases emitted may contribute the local burden of pollutants caused by past and current activities in the area and to regional atmospheric pollution.

Minimisation and Mitigation

- Use of BAS ships for the transfer of cargo and personnel will reduce the impact of atmospheric emissions compared to having a dedicated ship
- Use of energy conservation practices, including minimal use of vehicles, not leaving vehicles idling for long periods and use of "clean" fuels where ever practicable. BAS ships use low sulphur fuels.
- Choice of vehicles and generators based on their fuel efficiency and environmental performance where possible.
- Vehicles and generators maintained to high standards and serviced regularly. Where practical, catalytic converters will be fitted to reduce emissions.
- Energy efficiency measures will be implemented at the construction camp, such as the use of a reduced output generator overnight.
- Minimisation of waste at source and reuse and recycling of materials where possible to reduce need for incineration.
- Effective use of incinerator: only permitted materials to be burnt and at the recommended temperature.

5.2 Impacts on soil and hydrology

Water for domestic use is taken from Bore Valley dam. This will not be affected by the proposed activity.

5.2.1 Impacts of partial lake drainage, dam repairs and penstock replacement

Gull Lake is a man made lake containing no fish and the highest predator is likely to be a beetle (see section 4.8.3), which can survive in around 1m depth of water. Any impacts associated with the partial drainage of the lake are therefore likely to be minor and temporary.

When the dam is repaired, there will be no further leakage under the dam walls or from the old east and west penstocks. Water has been leaking from these areas for some time and has changed the local habitat as the ground has become saturated. The ground will be returned to the state it was in when the dam and penstocks were in good condition.

Before the dam was built, the water from the catchment area flowed down into the cove via a series of streams. The path of the main streams can be seen, due to the erosion caused. The existence of the dam means that these streams are largely dry, though the main stream takes any overflow from the dam. This change in drainage, compared to the original state before the dam was built, will have a local effect on the flora or fauna of the area around the former streams.

5.2.2 Fuel and Oil Spills

Information on fuel storage and handling is given in section 2.3.4.

Fuel and oil spills may occur during maintenance and fuelling of vehicles and generators and by leakage from bulk fuel tanks, drums or jerry cans. Fuelling of vehicles and leakage from damaged drums are the most likely sources of fuel spills. Most spills are likely to be less than 5 litres and the maximum risk is the loss of a bulk fuel tank (54,500 litres).

Fuel is relatively volatile and spills will rapidly evaporate but a waxy residue may remain. Larger fuel spills may lead to biological effects on vegetation and contamination of soil layers.

If washed into the sea, fuel will be rapidly dispersed. Fuel spills in vegetated areas will cause physiological and physical damage to plants and animals.

It should be noted that King Edward Cove has been polluted by past human activities. Hydrocarbon levels measured in benthic invertebrates in the cove were significantly higher than similar samples collected from a pristine site (Clarke and Law, 1981), indicating localised industrial pollution. Research also indicates that marine invertebrates recovered from a "once grossly polluted" state within around 8 years of the closure of the whaling station (Platt, 1978).

Minimisation and Mitigation

- Standard procedures for transport, handling, transfer and use of fuels will be followed (see section 2.3.3).
- Correct equipment will be used and handling and transfer of fuels will be minimised.
- All tanks and bowsers will be bunded. Secondary containment drum stands will be used for fuel transfers. Delivery pipework and trigger guns will be kept within the bunded area.
- Bowsers will be sited where they are least likely to be damaged and fuel drums will be clearly marked to avoid accidental collisions.
- Fuelling points will have suitable absorbent mats, drip trays and clean-up equipment.
- Staff involved in refuelling operations will be trained appropriately and spill response exercises will be held.
- All spills will be reported to the Project Manager and an Environmental incident response form (FM-ENV-351) completed.
- A fuel spill response plan (FM-ENV-350) will be posted on the site notice board.
- Fuel handling and spill response procedures will be regularly audited.

5.2.3 Sewage and waste water (grey water)

Domestic waste water (grey water) will result from washing, food preparation and ablution activities. Grey water and sewage will be discharged to King Edward Cove via a pipe from the construction camp.

The effluent will add nutrients, including bacteria, yeasts and viruses that are not native to South Georgia, as well as heavy metals and organic pollutants. In summer, human derived fecal coliform cells are likely to be killed off by the biologically damaging effects of solar radiation (Hughes, 2003). The impact of the effluent is likely to be localised.

The direct effect of sewage and grey water disposal will be a temporary increase in the contamination of the water in King Edward Cove. This will add to the cumulative impact of sewage and waste water produced at King Edward Point and Grytviken Museum.

Minimisation and Mitigation

- Care will be taken that no sewage and grey water discharges are made in the vicinity of wildlife.
- A macerator will be used to break down food waste.

5.2.4 Waste water from construction activities

Water will be used for making concrete, for washing down vehicles and washing out the concrete mixer. Most of the water will be taken from Gull Lake, but some water from the Bore Valley dam may be used.

These activities could cause contamination of drainage systems, soil and vegetation with concrete and small amounts of fuels and oils. Loss of habitat may result with a consequent impact on wildlife.

Minimisation and Mitigation

- Appropriate concrete washout facilities will be established at the dam and near to the proposed powerhouse. This will include a pit, where contaminated water will be discharged. The pit will be covered on completion of the project.
- Vehicles will be washed down on the beach, where drainage is directly to the sea.

5.3 Solid waste

Site waste disposal is discussed in section 2.5. An incinerator will be used to burn combustible materials including some food waste. All other waste will be removed from South Georgia for recycling or safe disposal.

If not correctly managed, some waste may be scattered by winds. Wastes could be scavenged by the local avian population or contaminate soil and vegetation if not contained.

The main component of non-hazardous waste will be shuttering plywood and concrete sacks. The plywood will be banded and shipped to the Falkland Islands for recycling. Concrete sacks will be compacted for removal. Limited quantities of hazardous waste, such as adhesives, batteries, solvents, oily wastes and paints will also be generated.

The disposal of wastes is likely to be with a licensed waste contractor in the Falkland Islands.

Minimisation and Mitigation

- Minimisation by reduction of packaging where practicable.
- Hazardous materials brought to site will be kept to an absolute minimum and all hazardous material will be removed from South Georgia.
- No prohibited products (listed in Environmental Management Plan for South Georgia, 2000) will be brought to South Georgia.
- Waste items will be re-used and recycled as much as possible.
- A Site Waste Management Plan Data Sheet (see Appendix 6) will be completed as part of the project planning process, and maintained throughout the project.
- A Waste Management Plan (FM-ENV-301) will be prepared to document the procedures for the collection, storage, reduction, recycling and disposal of wastes.
- Poultry food waste will be incinerated and all food wastes will be stored in secure containers to prevent scavenging by birds and rats.
- All waste will be sorted, labelled and securely contained at the construction camp, to prevent wind dispersal or scavenging.
- The Project Manager will assign one of the operatives the responsibility for implementing correct waste procedures.

- All site personnel will be briefed on waste management procedures.
- Regular litter collection will be conducted around the site.
- A macerator will be used for food waste.

5.4 Physical disturbance

The construction of the track will cause disturbance to an area of up to c2,500m^2 where the proposed track route does not have a rocky base. Disturbance will also be caused by the digging of the trench for the penstock. Vegetation will be damaged and there may be disturbance to birds. Even where there is already a rocky surface, the repeated passage of vehicles may disturb lichens or mosses.

Removal of material from the beach at King Edward Cove and bottom of Gull Lake for use on the track will cause physical disturbance in both of these areas. Disturbance to birds may occur and breeding fur seals, elephant seals or moulting penguins on the beach, may be affected. Material has been taken from the beach in the cove on previous occasions for Morrison projects and is taken from below the high tide level to a depth of around 1.5m. No adverse effects on wildlife were observed and recovery of the site to its original state occurred within one year. Material taken from the lake will be taken from below the water line, while the temporary dam is in place. This will fill in naturally over time.

Some scree material may also be taken from the slopes of Orca Peak for the track surface. This could disturb nesting birds and damage vegetation and habitat and may also have a visual impact.

Erosion may be caused during the construction of the track as topsoil is moved to even out the gradient. Even when the track is covered with hard core material and compacted, erosion will be more likely in certain areas following the loss of vegetation cover. Erosion and loss of vegetation will also result from the installation of the penstock.

Dust will be generated by vehicle movements, earthmoving activities during the construction of the track to the dam, digging the trench for the penstocks and re-digging the trench for cable to KEP and during concrete preparation. The amount of dust produced will depend on the ground and weather conditions. The impact of dust emissions will be local.

A significant amount of concrete will be required for the dam repairs and for the construction of the powerhouse. Concrete dust is highly alkaline and may cause damage to vegetation or invertebrates.

Physical disturbance may be caused by the presence of people. Antarctic terns are known to attack people who walk near to the Gull Lake dam, which indicates that there may be a breeding colony nearby.

Minimisation and mitigation

- The track will be constructed as late in the season as possible to minimise disturbance to breeding birds.
- Temporary ‘trackway’ material will be used to minimise erosion during the installation of the penstock.
- Concrete preparation not to be undertaken in strong winds and will be conducted in a sheltered area.
- Earthmoving activities will be minimised during dry, windy conditions.

5.5 Noise

Noise will be generated by ship movements, cargo handling, all vehicular moments and operation of generators.

Breeding bird species that nest in the rocks above the cove and on the slopes below the dam and seals breeding on the beach adjacent to the cove may be disturbed by noise.

Minimisation and Mitigation
Disturbance by ship and cargo activity is unavoidable.

- Vehicle movements will be kept to a minimum.
- Activities will be conducted in such a way as to minimise noise.
- Vehicles will be routinely serviced to minimise noise output.
- Particular care should be taken in the vicinity of breeding birds during the breeding season.

5.6 Light pollution

Construction activities will take place during daylight hours. Lighting at the construction camp during dark evenings may cause disturbance to birds.

Minimisation and Mitigation

- External lighting will be designed to minimise stray light emission, particularly above the horizontal.
- Construction camp windows will be covered (lined curtains) if the base operates during dark periods to prevent disorientating birds.

5.7 Impacts to flora and fauna

Impacts to flora may occur as described in sections 5.1 to 5.4 and impacts to fauna also include sections 5.5 and 5.6.

The breeding season for elephant seals will have finished before the project starts and although seals will be hauled out on the beach, disturbance will not have any significant impacts. Fur seals have recently started to breed in the cove and small numbers breed on the beaches in the area of operation. They may be disturbed by vehicle operations on the beach. King penguins are not breeding, so minor disturbance should not impact them significantly. Disturbance may result in a temporary increase in metabolic rate and consequent energy expenditure.

Noise or physical disturbance to breeding birds may result in loss of eggs or chicks through abandonment of nests. Disturbance may also lead to loss of eggs or chicks due to raiding by skuas, northern giant petrels and gulls. However, it is likely that there are no nesting birds in the main operational area.

There are a variety plant groups in the area of the proposed operations (see section 4.7). There are no rare plant species, the area is not pristine and the vegetation is of low conservation value and common in the surrounding area. Previous work conducted at Grytviken by Morrison indicates that vegetation will recover over a period of 2–3 years.

Minimisation and Mitigation

- Operatives will be given an environmental briefing by the Government Officer, including guidance on minimising disturbance to local fauna and flora (see Appendix 2).
- Prior to the commencement of works, the precise locations of nesting birds should be established where possible. The locations will be marked on a map and all operatives briefed so that disturbance of birds can be avoided where possible.
- If the project commences early in the season, birds may site their nests away from the area of disturbance.

See also relevant minimisation and mitigation in sections 5.1 to 5.6.

5.8 Aesthetic and heritage values

The construction of a track to Gull Lake will have a visual impact in the locality but only within line of sight. The proposed route of the track follows a natural line and the upper part of the track would not be visible from the cove. The new powerhouse will also have visual impact, but will be designed to blend into the landscape. It is being built on the foundations of the old radar building which has been removed.

The reintroduction of hydro power at Grytviken will effectively be the restoration of a heritage site as the dam and associated structures were installed during the whaling era. It will also protect Grytviken cemetery from potential damage that may result if the existing dam structure were to collapse. The project will not affect the heritage values of any other sites.

Minimisation and Mitigation

- The proposed track will follow as natural line as possible.
- The proposed track will be made using local materials.

5.9 Introduction of alien species and translocation of diseases

The refurbishment of the hydro dam and equipment, presents a moderate risk of the introduction of alien species or diseases into South Georgia. Introduction may occur through imported food or contaminated packaging or plant and equipment brought to KEP.

Scavenging of unsecured food wastes by birds is a simple pathway for alien species or diseases to enter the system. Soil and seeds may be introduced by unclean footwear, vehicles or equipment. The recent introduction of hairy bittercress (*Cardamine hirsuta*) to KEP highlights the need to be vigilant.

South Georgia's bird populations are susceptible to infection by disease. Viral diseases (i.e. morbillivirus, Newcastle disease), immunosuppressant diseases (i.e. infectious bursal disease, morbillivirus) and agricultural and zoonotic diseases (i.e. brucellosis, tuberculosis) are considered to be the greatest potential risk to the health of wildlife.

Minimisation and mitigation

- The 'Guidelines for prevention of introduction and translocation of alien species' (see Appendix 3) will be followed.
- Particular care will be taken to pressure wash any plant and machinery that is being brought into South Georgia from elsewhere.

- Imported construction materials such as crushed rock, will be carefully sourced, stored and transported to reduce the possibility of introduction of alien species.
- Careful control of foodstuffs (see section 5.3).

5.10 Adjacent and Associated Ecosystems

The features of the proposed activities which are most likely to impact associated ecosystems are

- Atmospheric emissions (see section 5.1) as these contribute to regional air pollution burdens; and
- Removal of waste (see section 5.3) resulting in increased landfill, probably in the Falkland Islands. This has the indirect effect of contamination of soil and groundwater.

Purchasing of materials for the project may also cause impact on other ecosystems, for example, the purchasing of non-sustainable timber.

5.11 Indirect and cumulative impacts

Indirect impacts may result from the detailed design of the project and purchasing activities.

Cumulative impacts are those impacts which are repeated and therefore, even though the individual impact may be small, the continuing effect may cause a built up. The impacts of the project will add to the impacts of the existing activities at Grytviken and KEP for the duration of the construction phase. This includes emissions to air, fuel spills and local discharge of sewage and grey water.

These cumulative impacts may affect the biota in the region and reduce the scientific value of the area.

5.12 Impact matrix

An impact matrix (Table 4) has been prepared to summarise the environmental impacts of the proposed reinstatement of hydro power at Grytviken. Activities which will have an impact are identified and the duration and output (potential results of the activity that may cause the impact) are stated.

The following columns predict the probability of the impact occurring as L = Low (<25% probability); M = Medium (25–75%) and H = High (>75%) and the importance of the impact (L, M, H). The final two columns in the impact matrix describe the predicted impacts and indicate the measures that will be put in place to mitigate or prevent them from occurring.

Table 4. Impact matrix, showing preventative or mitigating measures

Activity	*Output*	*Probability*	*Importance*	*Predicted Impacts*	*Mitigation*
Shipping and cargo handling	Atmospheric emissions	H	M	Cumulative contribution to regional and global air pollution	• Minimise ship movements. • Shared use of ship. • Use of low sulphur fuel. • Minimal use of vehicles.
	Noise / physical disturbance of wildlife	L	L–M	Disturbance of wildlife decrease in number of breeding birds; loss of biodiversity	• Operatives briefed on minimising disturbance of fauna • Activities will be conducted in such a way as to minimise noise. • Equipment to be routinely serviced to minimise noise output.
	Introduction of alien species	L	H	Spread of alien diseases; loss of biodiversity	• Follow 'Guidelines for prevention of introduction and translocation of alien species' (see Appendix 3). • Clean equipment and clothing prior to departure. • Careful control of foodstuffs to prevent scavenging. • Poultry waste stored securely and incinerated. • Pressure washing of all plant and machinery brought into South Georgia. • Careful sourcing and packaging of materials brought on site (i.e. aggregate).
Running vehicles and generators	Atmospheric emissions	H	L–M	Cumulative contribution to regional contamination of local ecosystems	• Maintain equipment to high standard and service regularly. • Minimal use of vehicles and generators. • Not leaving vehicles idling for long periods. • Use of "clean" fuels where practicable. • Choice of vehicles and generators based on fuel efficiency and environmental performance where possible. • Use of catalytic converters where practicable. • Use of a reduced output generator overnight at construction camp.
	Noise	H	M–H	Cumulative if repeated. Disturbance of wildlife; loss of biodiversity	• Use acoustic protection on generators. • Minimise vehicle activity in vicinity of wildlife. • Maintain minimal distances so that wildlife are not disturbed. • Ensure that operatives drive in considerate manner.
	Erosion	M	M–H	Damage to vegetation; visual impacts	• Use of temporary 'trackway' material.

Activity	*Output*	*Probability*	*Importance*	*Predicted Impacts*	*Mitigation*
Fuelling and handling of oil and fuel	Fuel spill: <200 litre. Oil: <5 litre	M	M–H	Cumulative contamination of soil, water, fauna and flora; reduction in scientific value	• Standard procedures for transport, handling, transfer and use of fuels • Minimise handling and transfer of fuels. • Fully bunded tanks and bowsers to be used. • Secondary containment drum stands used for fuel transfers. • Delivery pipework and trigger guns kept within the bunded area. • Bowsers sited where they are least likely to be damaged. • Fuel drums clearly marked to avoid accidental collisions. • Absorbent mats, drip trays and clean-up equipment at fuelling points. • Appropriate training of operatives; spill response exercises. • All spills reported to Project Manager and Environmental incident response form (FM-ENV-351) completed. • Fuel spill response plan (FM-ENV-350) to be posted on site notice board. • Fuel handling and spill response procedures regularly audited.
Construction activities	Removal of vegetation	H	M	Permanent loss of vegetation and habitat	Unavoidable impact.
	Visual impact of track	H	H	Visual impact	• Chose natural route on hillside. • Use of natural materials for track surface.
	Noise/ physical disturbance	M	M–H	Disturbance to wildlife; chick mortality; reduction in breeding bird population	• Timing of track construction • Prior to start of project, verify if there are any nesting birds in operational area and map out their locations so that they can be avoided as much as possible.
	Dust			Contamination of watercourses, fauna and flora	• Earthmoving activities minimised during dry, windy conditions.
	Removal of stone from beach, lake shore and scree slopes	H	M	Disturbance/loss of habitat; visual impacts; damage to vegetation; disturbance or harm to wildlife	• Avoid locations where there is wildlife. • Consideration of potential dangers to wildlife during removal operations.
	Discharges from cleaning vehicles and concrete mixer	H	M–H	Contamination of soil, water, fauna and flora	• Establish concrete washout facilities and disposal pits. Cover pits on completion of works. • Wash vehicles down in designated areas where drainage directed to a suitable soak-away

Activity	*Output*	*Probability*	*Importance*	*Predicted Impacts*	*Mitigation*
	Generation of concrete dust	M	M–H	Damage to vegetation	• Concrete preparation not to be undertaken in strong winds and will be conducted in a sheltered area.
Waste generation	Discharge of grey water and sewage	H	L	Contamination of King Edward Cove; loss of scientific value	• No sewage and grey water discharges to be made in the vicinity of wildlife. • Use of macerator to break down food waste.
	Removal of hazardous and non-hazardous waste	H	M–H	Contamination of soil, water, fauna and flora if not stored securely. Indirect effect of waste disposal outside South Georgia;	• Store waste securely; minimise packaging; recycle / reuse where possible. • Minimisation by reduction of packaging where practicable. • Waste items will be re-used and recycled as much as possible. • Minimise hazardous materials brought to site; all hazardous materials to be removed from South Georgia. • No prohibited products to be brought to South Georgia. • Complete Site Waste Management Plan Data Sheet (see Appendix 6). • Prepare Waste Management Plan (FM-ENV-301). • Poultry food waste will be incinerated and • Store all wastes in secure containers. • Project Manager to assign responsibility for implementing correct waste procedures to one of operatives. • All site personnel briefed on waste management procedures. • Regular litter collection around the site. • Investigate the use of a macerator for food waste.
	Atmospheric emissions from incineration	H	M–H	Cumulative contribution to regional contamination of local ecosystems	• Minimisation of waste at source and reuse and recycling of materials where possible to reduce need for incineration. • Effective use of incinerator: only permitted materials to be burnt and at the recommended temperature.
Light pollution	Disturbance of birds	M	L	Disturbance and disorientation of birds; decrease in number of breeding birds	• Use blinds during periods of darkness. • Minimise use of outside lights. • Outside lights to be angled below the horizontal.

6. MONITORING AND VERIFICATION

The initial environmental reference state of the Grytviken area is described in section 4. This information can be used as a baseline when assessing impacts on the environment resulting from the proposed project. Past and current monitoring activities are described in section 4.12.

During the project, records will be kept of any environmental incidents (using Environmental Incident Response form FM-ENV-351). These will be reported to the GSGSSI.

When the project is complete and the hydro system is up and running a post project review will be undertaken, which will include and assessment of whether the predictions contained in this IEE were correct and that the recommended mitigation measures were effective.

The expertise of some of the local residents of Grytviken and KEP may be drawn upon to assess whether the proposed activity causes any disturbance to the flora or fauna of the area.

7. GAPS IN KNOWLEDGE AND UNCERTAINTIES

Minor changes may be made to the project during the detailed design phase. Further surveys will be carried out to the penstock and water flow rates assessed. The GSGSSI will be notified of any changes as necessary.

The main uncertainties associated with this project are:

- Lack of precise and up-to-date information on the location of breeding bird species in the operational area.
- Lack of precise information about numbers and locations of fur seals, elephant seals and king penguins in the operational area.

8. ENVIRONMENTAL MANAGEMENT

The Morrison Environmental Policy Statement (see Appendix 8) will be adopted for this project. This policy will be clearly displayed on the main site notice board. Morrison also acknowledges and respects the client's conditions of contract and will operate in accordance with these requirements at all times.

Environmental management activities are set out in the *Morrison Business Process Maps* (MCSL, 2005; see Appendix 7). These set out standard procedures for environmental planning, operations and reporting.

Prior to the start of the project responsibilities of parties involved in carrying out the proposed works will be defined. For example, the Morrsion Project Manager will be responsible for ensuring that the minimisation and mitigation measures described in section 5 are implemented and an operative will be nominated responsibility for waste coordination.

A plan will be prepared for the implementation of the recommended mitigation measures presented in this IEE.

9. CONCLUSION

The region around King Edward Cove is not pristine. It has been regularly visited since the late 1700s and was significantly polluted during the 20th century during whaling operations.

Many aspects of the proposed activities will merely add to the impacts of current operations in the cove, such as additional emissions, discharges to the cove etc. Whilst these impacts should

be mitigated as much as possible to reduce the cumulative impact, they are on a very small scale.

The most significant temporary impacts are potential bird disturbance and damage to vegetation which may result from vehicle activities and concreting works during the construction of the track and powerhouse, repair work to the dam and installation of the penstock. Vegetation should re-establish relatively quickly and bird populations, if impacted, should also recover once the construction activities are complete. Small numbers of breeding fur seals on the beach may also be disturbed.

The proposed track will displace vegetation and cause a visual impact. As there are no rare plant species and the vegetation is of low conservation value and common in the surrounding area, loss of vegetation is not considered to be of long-term significance. The most significant permanent impact will result from the visual impact of this track.

A key impact of this activity is to reduce the requirement for fossil fuel combustion at King Edward Point for a period of at least 40 years. This will have a very significant positive environmental impact in reducing emissions of greenhouse gases and other combustion products to the atmosphere.

The environmental benefits of the proposed project are therefore considered to outweigh the environmental impacts.

10. PREPARERS AND ADVISORS

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12. ABBREVIATIONS AND ACRONYMS

Acronym	Meaning
BAS	British Antarctic Survey
CEE	Comprehensive Environmental Evaluation, as defined by the Protocol to the Antarctic Treaty (1992)
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GSGSSI	Government of South Georgia and South Sandwich Islands
IEE	Initial Environmental Evaluation, as defined by the Protocol to the Antarctic Treaty (1992)
KEP	King Edward Point
PV	Photovoltaic
SPA	Specially Protected Area

13. APPENDICES

Appendix 1: Environment Charter

Environment Charter

SOUTH GEORGIA AND THE SOUTH SANDWICH ISLANDS

Guiding Principles

For the UK government, and for the government of South Georgia and the South Sandwich Islands.

1. To recognise that all people need a healthy environment for their well-being and livelihoods and that all can help to conserve and sustain it.
2. To use our natural resources wisely, being fair to present and future generations.
3. To identify environmental opportunities, costs and risks in all policies and strategies.
4. To seek expert advice and consult openly with interested parties on decisions affecting the environment.
5. To aim for solutions which benefit both the environment and development.
6. To contribute towards the protection and improvement of the global environment.
7. To safeguard and restore native species, habitats and landscape features, and control or eradicate invasive species.
8. To encourage activities and technologies that benefit the environment.
9. To control pollution, with the polluter paying for prevention or remedies.
10. To study and celebrate our environmental heritage as a treasure to share with our children.

Donald A. Lamont
South Georgia and the South Sandwich Islands
26 September 2001

Valerie Amos
United Kingdom
26 September 2001

Commitments

The government of UK will:

1. Help build capacity to support and implement integrated environmental management, which is consistent with SGSSI's own plans for sustainable development.
2. Assist in reviewing and updating environmental legislation.
3. Facilitate the extension of the UK's ratification of Multilateral Environmental Agreements of benefits to SGSSI and which SGSSI has the capacity to implement.
4. Keep SGSSI informed regarding new developments in relevant Multilateral Environmental Agreements and invite SGSSI to participate where appropriate in the UK's delegation to international environmental negotiations and conferences.
5. Help SGSSI to ensure it has the legislation, institutional capacity and mechanisms it needs to meet international obligations.
6. Promote better cooperation and the sharing of experience and expertise between SGSSI, other Overseas Territories and small island states and communities, which face similar environmental problems.
7. Use UK, regional and local expertise to give advice and improve knowledge of technical and scientific issues. This includes regular consultation with interested non-governmental organisations and networks.
8. Use the existing Environmental Fund for the Overseas Territories, and promote access to other sources of public funding, for projects, of lasting benefit to SGSSI's environment.
9. Help SGSSI identify further funding partners for environmental projects, such as donors, the private sector or non-governmental organizations.
10. Recognise the diversity of the challenges facing Overseas Territories in very different socio-economic and geographical situations.
11. Abide by the principles set out in the Rio Declaration on Environment and Development and work towards meeting International Development Targets on the environment.

The government of South Georgia and South Sandwich Islands, so far as is appropriate in the circumstances of the territory, will:

1. Bring together representatives of government of local user, of scientific communities and of environment and heritage organizations in a forum to formulate a detailed strategy for action.
2. Ensure the protection and restoration of key habitats, species and landscape features through legislation and appropriate management structures and mechanisms, including a protected areas policy, and attempt the control and eradication of invasive species.
3. Ensure that environmental considerations are integrated within social and economic planning processes; promote sustainable use of natural resources within the territory.
4. Ensure that environmental impact assessments are undertaken before approving major projects.
5. Commit to open and consultative decision-making on developments and plans which may affect the environment; ensure that environmental impact assessments include consultation with stakeholders.
6. Implement effectively obligations under the Multilateral Environmental Agreements already extended to SGSSI and work towards the extension of other relevant agreements.
7. Review the range, quality and availability of baseline data for natural resources and biodiversity.
8. Ensure that legislation and policies reflect the principle that the polluter should pay for prevention remedies; establish effective monitoring and enforcement mechanisms.
9. Promote the value of our environment as a part of the world's natural heritage of regional and global significance.
10. Promote publications that spread awareness of the special features of the environment in SGSSI; promote within SGSSI the guiding principles set out above.
11. Abide by the principles set out in the Rio Declaration on Environment and Development and work towards meeting International Development targets on the environment.

Appendix 2: South Georgia Code of Conduct for Visitors

All Wildlife in South Georgia is protected by law
Always give animals the right of way.
Do not harm any animals, or damage vegetation.
Do not kill any animal, including introduced species.
Do not collect specimens of plant or animal origin without a permit.
Be alert in tussock grass for bird burrows, nests and seals.
Do not attempt to touch or feed any animal.

Stay on the edge of animal groups. Keep at a distance from animals to prevent them changing their behaviour, do not cause them to move. This is most important when they have eggs or young.

Do not disturb plants or animals to get a better photograph.

Do not bring any plants or animals ashore. Ensure that footwear and clothing are free of any seeds, soil or vegetation.

The whaling stations, sealing camps and huts around the coast are part of the history of South Georgia and are protected by law
A major site remediation project has been undertaken at Grytviken to remove hazardous materials and dangerous structures, rendering the area safe for visitors and those who work and live there.

Do not enter or approach within 200m of any other whaling station
They contain hazardous materials, including asbestos. The structures, including the jetties, are in a highly dangerous state and must not be approached.
Most, but not all, display warning notices.
High winds make these sites particularly dangerous, due to flying debris such as corrugated iron sheets as well as airborne hazardous materials.

Do not smoke in any building or hut, or anywhere there is a risk of fire.

Do not remove, disturb or destroy any artefacts. Not only is this illegal, but what may seem an unimportant souvenir is in fact an artefact vital for interpreting the history of a site.

Do not leave litter
Not only does litter pollute the environment, but it poses a real danger to wildlife.
Take everything back to your ship, including other people's litter you may find.
Do not pollute any lakes or streams

Appendix 3: Guidelines for prevention of introduction and translocation of alien species

The South Georgia Government requires the following procedures be observed by all visitors to protect South Georgia from further introduction or translocation of alien species and disease.

Before departure from port

1. All boots and clothing must be cleaned.
2. Other equipment such as cargo boxes, scientific and filming equipment, tripod stands, walking sticks, backpacks and any items which come into contact with the ground or vegetation must also be checked.
3. The contents of pockets must be emptied and any Velcro cleaned, both with vacuum cleaner process to ensure seeds or other material do not adhere to the cloth.
4. Large items of equipment such as plant and machinery must be checked and, if necessary, steam-cleaned.

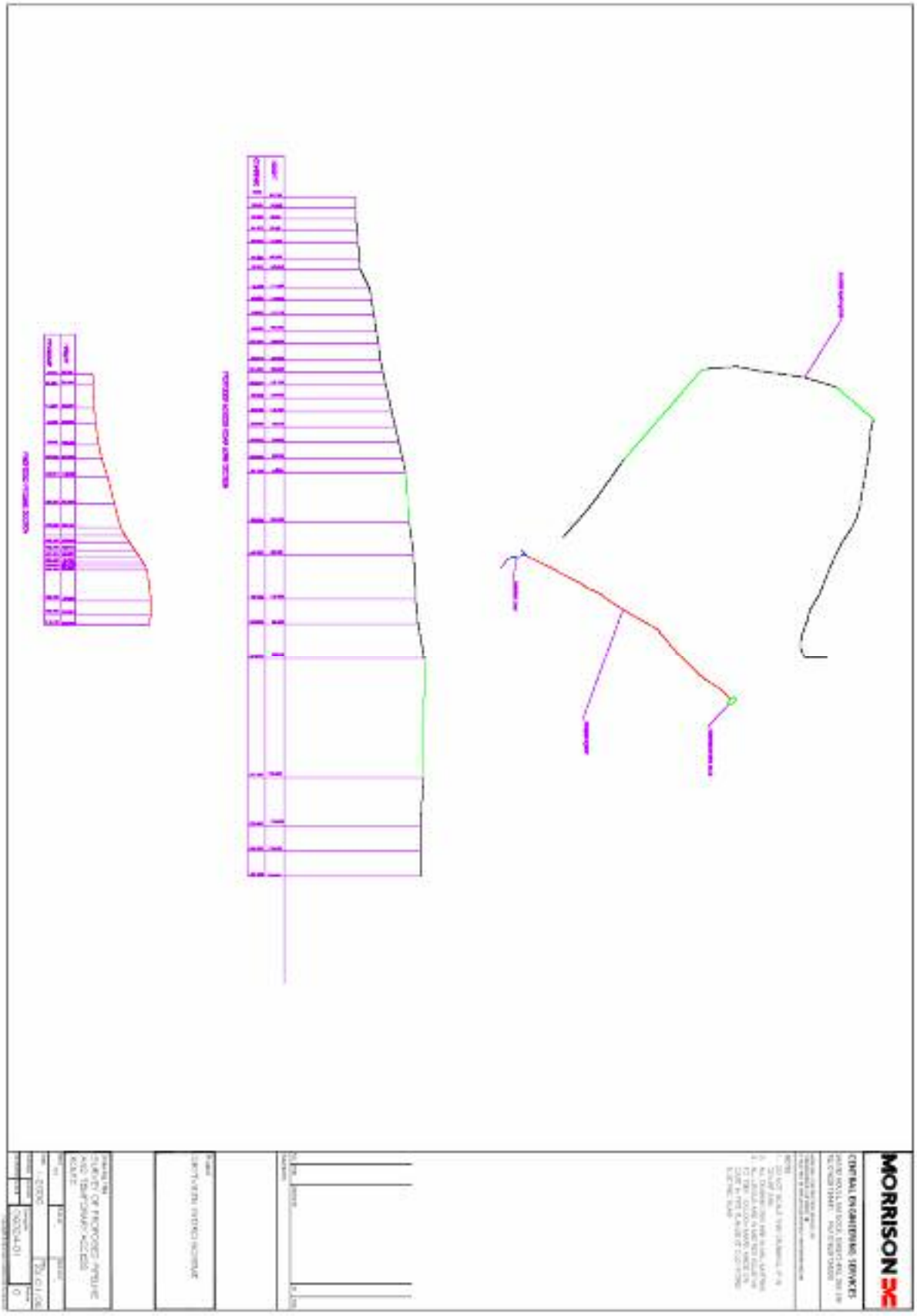
Landings at South Georgia

1. Visitors must check again that all boots, clothing and equipment are clean prior to making any landings.
2. Where possible, cleaning facilities should be provided on deck, such as brushes for clothing, boot washing stations (buckets of disinfectant, stiff brushes, running water etc.).
3. Boots, clothing and equipment must be cleaned as well as possible before re-entering the landing craft or helicopter to return to the ship/yacht. Where possible, brushes should be provided to facilitate this.
4. On returning to the ship, boots and clothing must be cleaned thoroughly at the boot washing station.
5. Boots and clothing should be dried completely between landings if possible.

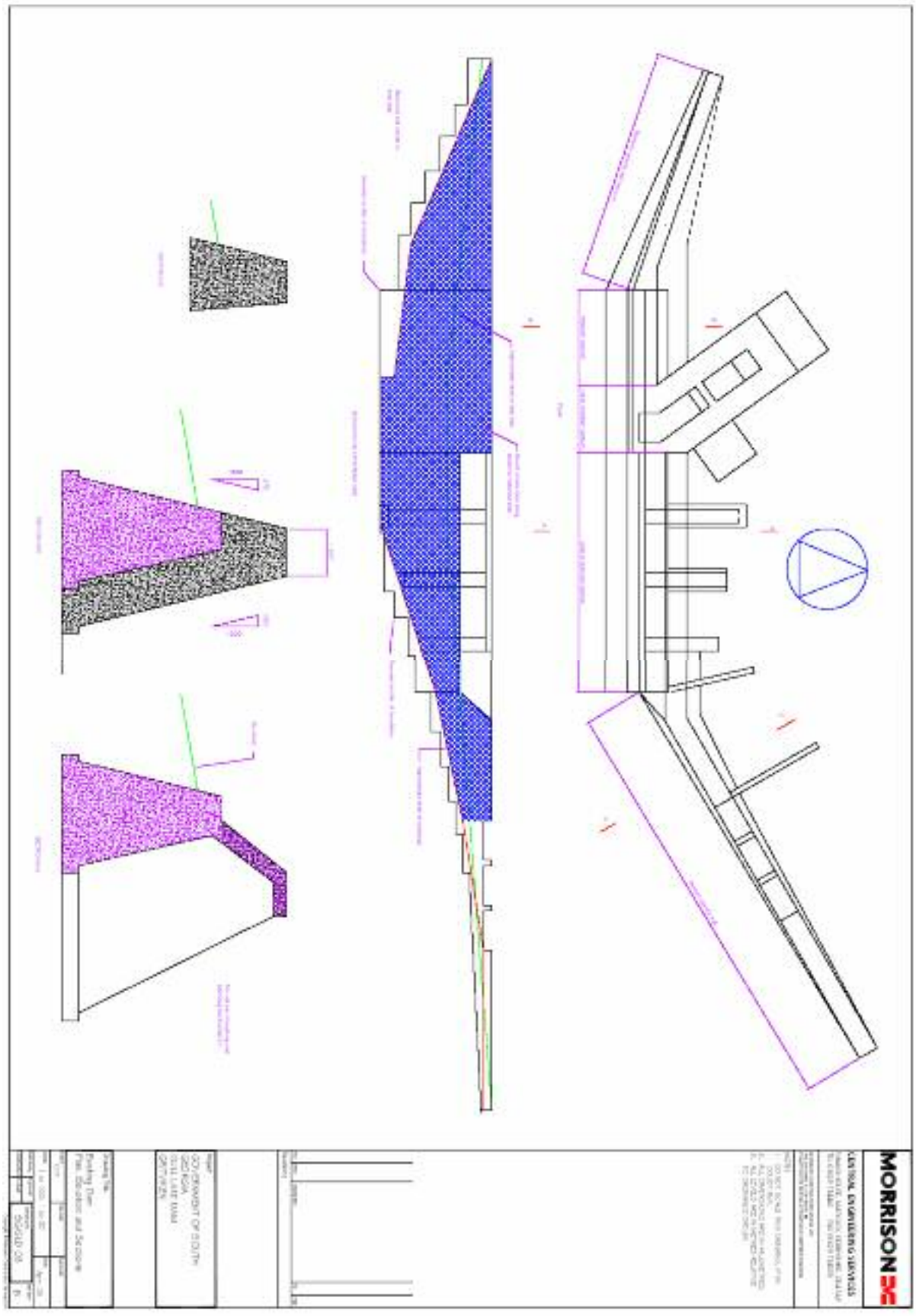
Prevention of introduction and transfer of rats

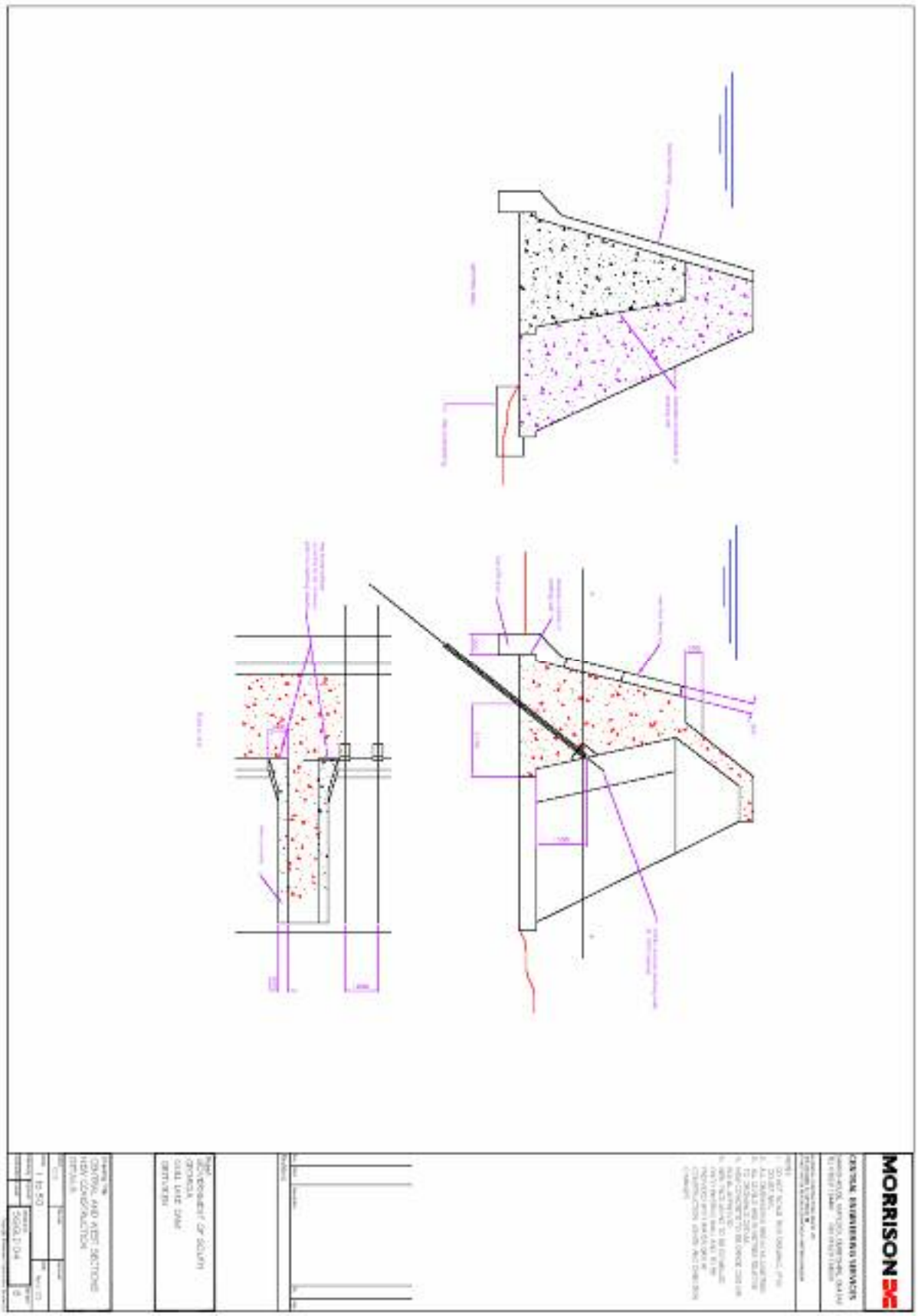
1. All vessels over 100 tonnes must have a current de-ratting certificate
2. Bait stations or traps must be maintained on board all vessels and food wastes must be correctly disposed of
3. All vessels berthing anywhere on the island must use rat guards and raise the gangway at night, and ensure that no foodstuffs are left on deck and that hatches are secure
4. Precautions must be taken when packing cargo in areas where rats may be present.
5. Food must be packed in rat-proof containers
6. Regular inspections for the presence of rats must be made when packing, loading, unloading and unpacking

Appendix 4: Track survey plot



Appendix 5: Dam construction plans





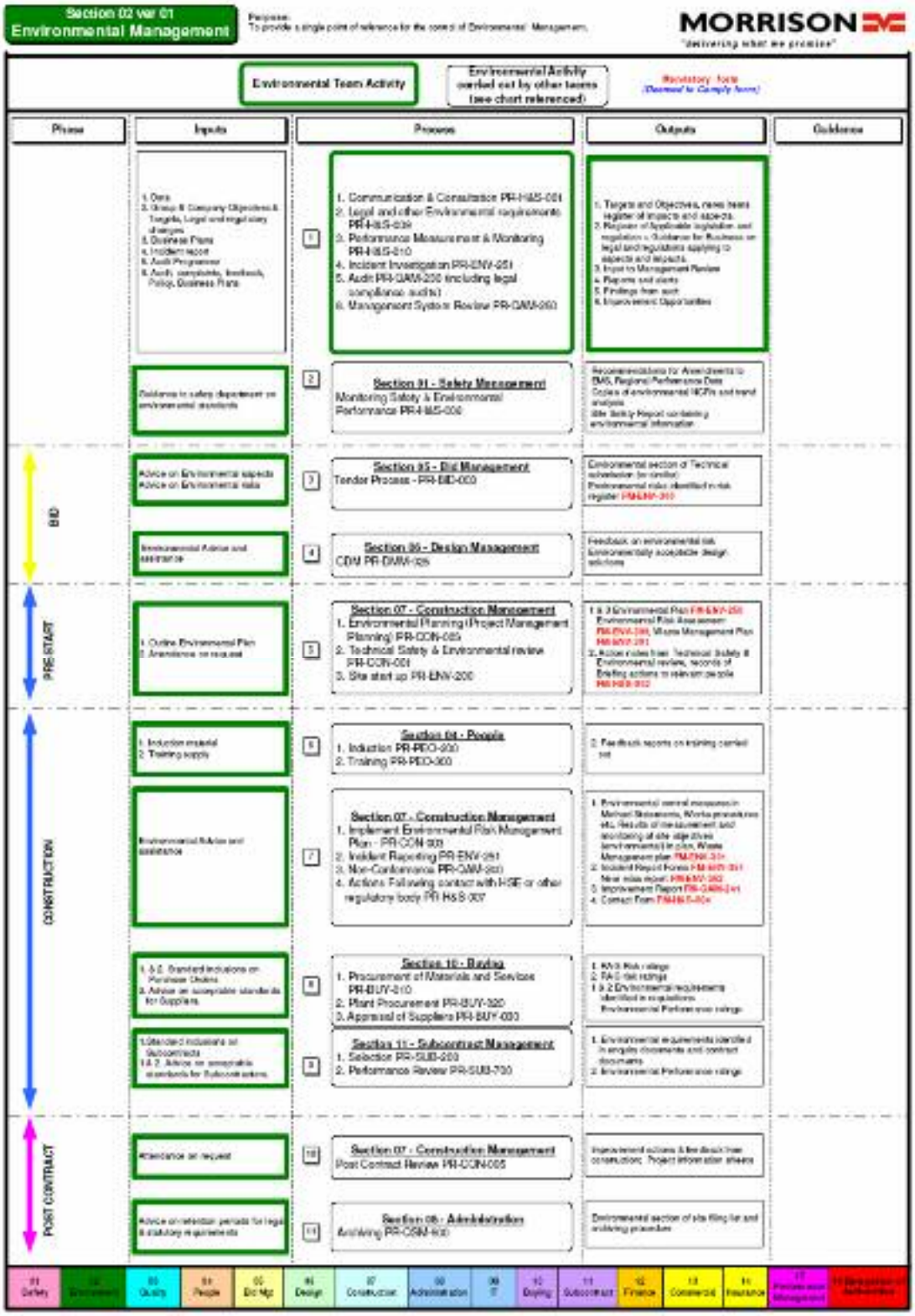
Appendix 6: Site Waste Management Plan Data Sheet

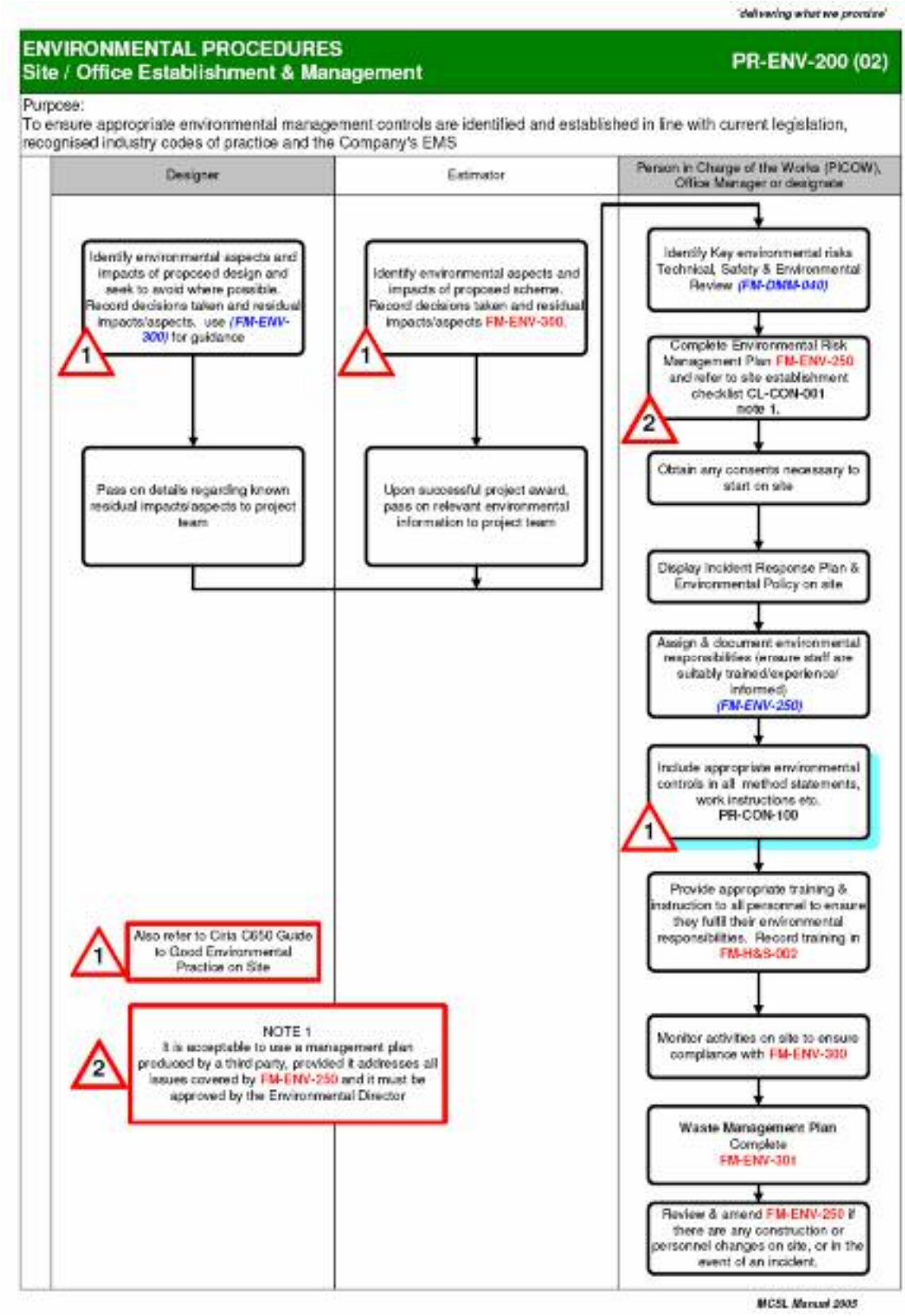
Project Name: Grytviken Hydro Contract Number: xx

EWC CODE	WASTE TYPE (SPECIFY)	QUANTITY (m^3)							
		Reused on site	Reused off site	Recycled for use on site	Recycled for use off site	Sent to recycling facility	Sent to exempt site	Disposal to landfill	Other Disposal
	Bio-degradable Waste								
	Non recyclable/ Non-hazardous Waste								
	Waste Fuel and Oil Products								
	Hazardous Waste & Chemicals								
	Reusable Materials								
	Recyclable Waste								
	TOTAL (m^3)								

Date This Sheet Completed: Revision N

Appendix 7. Business Process Maps – Environmental Management




'delivering what we promise'
ENVIRONMENTAL PROCEDURES
Site / Office Establishment & Management
PR-ENV-200 (02)
Purpose:
To ensure appropriate environmental management controls are identified and established in line with current legislation, recognised industry codes of practice and the Company's EMS
Designer
Estimator
Person in Charge of the Works (PICOW), Office Manager or designate
Identify environmental aspects and impacts of proposed design and seek to avoid where possible. Record decisions taken and residual impacts/aspects, use (FM-ENV-300) for guidance
1
Identify environmental aspects and impacts of proposed scheme. Record decisions taken and residual impacts/aspects FM-ENV-300.
1
Identify Key environmental risks Technical, Safety & Environmental Review (FM-DMM-040)
Complete Environmental Risk Management Plan FM-ENV-250 and refer to site establishment checklist CL-CON-001 note 1.
2
Obtain any consents necessary to start on site
Pass on details regarding known residual impacts/aspects to project team
Upon successful project award, pass on relevant environmental information to project team
Display Incident Response Plan & Environmental Policy on site
Assign & document environmental responsibilities (ensure staff are suitably trained/experience/ informed) (FM-ENV-250)
Include appropriate environmental controls in all method statements, work instructions etc. PR-CON-100
1
Provide appropriate training & instruction to all personnel to ensure they fulfil their environmental responsibilities. Record training in FM-H&S-002
1
Also refer to Ciria C650 Guide to Good Environmental Practice on Site
2
NOTE 1
It is acceptable to use a management plan produced by a third party, provided it addresses all issues covered by FM-ENV-250 and it must be approved by the Environmental Director
Monitor activities on site to ensure compliance with FM-ENV-300
Waste Management Plan Complete FM-ENV-301
Review & amend FM-ENV-250 if there are any construction or personnel changes on site, or in the event of an incident.
MCSL Manual 2005

Appendix 8. Morrison Environmental Policy

We undertake building and civil engineering projects for a wide range of public and private clients. It is our policy that all our activities are carried out in a responsible and considerate manner and comply with legal and any other requirements to which Morrison Plc subscribes.

Our core values of Safety, Integrity and Intelligence require a commitment to maintaining the highest environmental standards in all our activities by:

- Utilizing best available techniques to prevent pollution from our activities.
- Managing resource use in order to contribute the least environmental impact.
- Controlling those aspects of our activities affecting the environment in its widest sense.

In order to meet our commitments we will:

- Communicate this policy to everyone working for us or on our behalf.
- Respect all our employees and encourage their responsible behaviour.
- Provide training and support for our employees and our supply chain to allow compliance with our environmental responsibilities and targets.
- Maintain an environmental management system certified to ISO 14001:1996
- Set ourselves environmental objectives and targets.
- Monitor and review our achievements to continually improve our performance.
- Communicate and implement our environmental objectives through local action plans.
- Initiate proactive dialogue with our stakeholders in order to promote our aim to conserve and enhance the environment.
- Strive to influence or produce acceptable designs, which incorporate efficient use of natural resources both in the construction and operation of the asset.
- Identify the aspects and manage the impacts associated with nuisance, waste, water, wildlife and resource use that result from our operations.
- Specify construction materials that are environmentally benign, suitable and fulfil our contractual obligations.
- Review this policy and its implementation through our management systems review process.
- Report publicly on our performance.

K. Gillespie.
MANAGING DIRECTOR. Morrison Construction Services Ltd.
20.01.05.