WATER QUALITY MANAGEMENT STRATEGY

ELLA BAY RESORT – ACCESS ROAD

Satori Resorts Ella Bay

E4733
March 2008

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1. INTRODUCTION

Satori Resorts Ella Bay has submitted a development application regarding an Integrated Resort located at Ella Bay, north east of Innisfail in Far North Queensland. A subsequent Request for Information has included the need to provide a Water Quality Management Strategy focussed on the proposed access road to the development.

1.1 Contributing Parties

This Water Quality Management Strategy has been written in conjunction with a Water Quality Monitoring Strategy, by Golder Associates (2008) in Cairns.

Additionally, collaboration with Environment North Pty Ltd, also based in Cairns, and past reports compiled by Environment North (2007) regarding road design and water quality management has been carried out to ensure the impacts of Ella Bay Road on water quality and the receiving environment have been minimised.

2. SITE DESCRIPTION

2.1 Location

Located nine kilometres north of Innisfail in Far North Queensland, the Ella Bay Integrated Resort proposes to develop a 450 hectare operating cattle station into a fully master planned, residential resort community. Ella Bay is 3 kilometres north of the township of Flying Fish Point within the Johnston Shire region.

To access Ella Bay, an unsealed road currently exists through a section of the Wet Tropics World Heritage Area north of Flying Fish Point. As part of the Ella Bay Integrated Resort, an upgrade of the existing road is required.

Environment North (2007) outlined the three sections of the access road as follows:

a) Segment 1. Flying fish Point to South of the Fish Farm

Description: a new bypass road west of Flying Fish Point incorporating a cut and cover tunnel. This bypass meets the existing road alignment just north of Flying Fish Point. Key aspects are as follow:

- length is 0.94 km,
- this is a new road bypassing the Flying Fish Point township, thereby avoiding any significant adverse social impacts,
- loss of vegetation and habitat is minimal and is to be offset via the overall Offsets and Additionality Policy, and
- a tunnel will be built which provides over-road connectivity of habitat and significantly mitigates loss of vegetation and habitat.

The bypass has a superior horizontal and vertical alignment to the existing road and this results in reduced travel time to Ella Bay. The land over the tunnel is to be revegetated (0.94 ha).

b) Segment 2: South of the Fish Farm to Start of World Heritage Area
Description: upgrading of the existing Ella Bay Road from the end of the bypass to the beginning of the World Heritage Area opposite the Fish Farm. Key aspects are as follow:
• length is 0.84 km,
• this is an existing flat road that only requires minimal widening (loss of vegetation and habitat is minimal and is to be offset via the overall Offsets and Additionality Policy), and
• a "fauna friendly" bridge is to be provided in this section to allow safe under-road passage for cassowaries and other fauna to move between the Ella Bay National Park and the Flying Fish Point Reserve.

c) Segment 3: Start of World Heritage Area to Little Cove, Ella Bay
Description: upgrading of the existing Ella Bay Road within the World Heritage Area (i.e. to the southern boundary of the Little Cove site). Key aspects are as follow:
• length is 2.00 km,
• the existing steep and winding road will be widened,
• loss of vegetation of habitat is minimal and is to be offset via the overall Offsets and Additionality Policy,
• significant mitigation measures will be put in place to reduce impact such as planted retaining structures,
• constrained sections of road are proposed to reduce road width,
• water runoff measures will be put in place, and
• a second "fauna friendly" bridge is to be provided in this section to allow safe under-road passage for cassowaries and other fauna to move between the Ella Bay National Park and the coastal area.

Figure 1 shows the preferred route for Ella Bay Road between Flying Fish Point and the Ella Bay Integrated Resort, which includes a road tunnel to the west of Flying Fish Point. Ella Bay Road between the hatchery and the Ella Bay Integrated Resort will generally follow the existing track.

2.2 Topography

Along the proposed route for the access road, the terrain is undulating to steep in areas, with slopes ranging from 10% to 35%.

Figure 1: Proposed road location from Flying Fish Point to Ella Bay

There are a few major creeks that the upgraded Ella Bay Road will cross. It is proposed to construct bridges at two of these crossings to minimise riparian disturbances and to keep the aquatic values of the creeks intact. A number of the crossings currently have culverts and pipes already constructed as part of the existing road. These culverts will be modernised as part of the road upgrade, and the creek rehabilitated to improve the riparian and aquatic values.

2.3 Wet Tropics World Heritage Area

The Wet Tropics World Heritage Area stretches from Townsville in the south to Cooktown in the north. The area around Flying Fish Point and Ella Bay is contained within the Ella Bay National Park

The Wet Tropics World Heritage Area is very rich with biodiversity, including its freshwater systems. The Wet Tropics Authority reports that 80 of Australia's 190 freshwater fish species are found within the Wet Tropics region, as well as being a preferred habitat for 30 frog, 16 reptile and 73 bird species (Wet Tropics Authority, 2008). Some species spend part of their life cycle in both the freshwater systems of the Wet Tropics and the marine waters of the adjacent Great Barrier Reef World Heritage Area (Wet Tropics Authority, 2008).

BAAM (2007) completed a terrestrial ecological assessment along the proposed access road from Flying Fish Point to Ella Bay. Twenty eight vulnerable, rare or endangered flora (8 likely, 9 possible) and 24 fauna (10 expected, 2 likely, 3 possible) species were listed in various databases and studies of being present or potentially present within the study area. For full details, please refer to BAAM (2007).

2.4 Great Barrier Reef World Heritage Area

The Great Barrier Reef World Heritage Area is encompassed in the Great Barrier Reef Marine Park, which borders the Wet Tropics World Heritage Area along the coastline in the subject region. There are various creeks and streams directly entering the Great Barrier Reef World Heritage Area from the Wet Tropics World Heritage Area.

3. WATER QUALITY IMPACTS

The preferred alignment for Ella Bay Road traverses several small creeks and gullies. The nature of creeks and gullies mean that they can easily transport pollutants downstream away from a disturbed or impacted area (Walsh, *et al.*, 2004; Wet Tropics Authority, 2008). Due to this dynamic nature, it is imperative that any activities that may cause pollutants to enter the waterways are minimised and mitigated.

The activities and mitigation techniques of Ella Bay Road should take into account the *Reef Water Quality Protection Plan*, (also known as the Reef Plan) produced by the Queensland and Australian Governments (2003) for the improvement of water quality entering the Great Barrier Reef Marine Park from land-based activities.

The Reef Plan has two main objectives (Queensland Government and Australian Government, 2003):

> *Objective 1: Reduce the load of pollutants from diffuse sources in the water entering the Reef.*
>
> *Objective 2: Rehabilitate and conserve areas of the Reef catchment that have a role in removing water borne pollutants.*

Both of these objectives are relevant for the area traversed by Ella Bay Road, and activities carried out may impact on the water quality entering the Great Barrier Reef Marine Park.

3.1 Pollutants

The Kuranda Range Upgrade Project highlighted some of the pollutants associated with roads. These are listed in Table 1. It must be noted that the Ella Bay Road is not a large highway such as the Kuranda Range Upgrade, however these pollutant sources need to be addressed on any road that will convey reasonable volumes of vehicles each day.

Table 1: Pollutants associated with roadways and their sources *(Source: Main Roads, 2005)*

Pollutant	Source
Sediment	Pavement surfacing residue, tyre rubber, bearings and brake wear residue, erosion of batters and unprotected surfaces
Nutrients	Roadside fertiliser
Oil and lubricants	Lubricants and motor fluids (spills leaks).
Heavy Metals (Cr, Cu, Pb, Zn, Fe, CD Ni, Mn)	Emissions, lubricants, corrosion, tyres rubber, bearing and brake residue.
Organics (other)	Herbicides, pesticides
Gross Pollutants (litter & organics)	Leaves and vegetation

Nutrients from roadside fertiliser would only be a concern for Ella Bay Road shortly after construction, as rehabilitation of the exposed soils takes place. Once the vegetation has become re-established, it is not envisaged that the roadside vegetation will require additional fertiliser.

Additionally, the use of any herbicides or pesticides to mange the roadside vegetation from a road safety perspective would be considered as minimal.

3.2 Potential Impacts

Research has shown that urban areas produce nutrient, litter and sediment pollution (Walsh, *et. al*, 2004). Typical impacts of urbanising areas around streams are listed in Table 2. Without appropriate management, Ella Bay Road may impact on the receiving environments in these ways. However Satori Resorts Ella Bay Pty Ltd has in its approach to these issues taken a range of steps to avoid the typical impacts of urbanising areas around streams in both its Integrated Resort Development and the Access Road.

Table 2: Typical impacts of urbanisation on streams *(Source: Walsh,*et al.*, 2004)*

Affected Feature	Response
Hydrology	▪ Decreased low flow volume ▪ Increased frequency and magnitude of peak flow ▪ Decreased groundwater recharge and lower water table
Geomorphology	▪ Increased channel erosion, incision and sediment transport (depending on the age of the catchment development)
Water Quality	▪ Increased contaminant loads and concentrations
Ecology	▪ Reduced frequency of connection between the stream channel and associated floodplain and wetland systems ▪ Habitat simplification ▪ Less diverse biotic communities ▪ Decreased nutrient retention and altered patterns of nutrient and energy cycling
Biodiversity	▪ Decreased biodiversity values (genetic, species and community levels)

Unmitigated release of contaminants into the surface or groundwater can have detrimental impacts on the receiving environments. The toxicity of the contaminants can have both short- and long-term effects on in-stream biota (Walsh, et. al, 2004), including reduction in biodiversity, stunted growth, and bio-accumulation of contaminants in flora and fauna. Frogs are particularly sensitive to contaminants, as are certain invertebrates. The loss of sensitive fauna leads to an increase in more resilient fauna and in certain cases the increase of nuisance species such as mosquitoes and midges.

3.2.1 Sediment erosion

Given the generally steep nature of the proposed access route, the terrain is conducive to erosion if bare soil is exposed during rain events. Sediment transported downstream can damage aquatic and ultimately marine habitats, while the loss of soils within the terrestrial area can lead to habitat loss. Increases in turbidity within the stream limit light reaching plants, reducing their abilities to transpire, while benthic organisms can become smothered. The increases in sediments within the watercourse can also lead to a change in substrate structure, impacting on biota that rely on the original substrate for food, attachment, and habitat. Additionally, the increases in suspended sediments can block the gills of fish and filter-feeding macroinvertebrates (Boulton and Brock, 1999; Walsh, *et al*., 2004).

Currently, Ella Bay Road is unsealed and has exposed batters along the road verges, allowing sediment runoff into the surrounding environment. As part of the upgrade, the road will become sealed with treated, vegetated batters. This will reduce the volume of sediment exposed to the elements and being transported into the creeks and gullies.

3.2.2 Landslip

Landslips can damage road structures, embankments and stormwater management devices. If the management of stormwater runoff associated with the road construction and alignment is poorly dealt with, excessive volumes and rates of water can infiltrate into the soil. In turn, the waterlogged soils sheer away from the terrain structure (Boulton and Brock, 1999). This is pertinent for Ella Bay Road, given the topography and rainfall patterns. It is considered that as Ella Bay Road will be the only access to and from the Ella Bay Integrated Resort, the issue of landslips is very important. Under the existing situation, landslips have been known to occur. It is expected that properly engineered batters and road conditions will minimise the risk of landslips.

In addition to damaging the road and associated infrastructure, the impacts on the receiving waterways would include habitat loss, smothering of in-stream biota, and at the extreme the in-filling of streams by the slump of soil, in turn altering the structure and course of the waterway (Boulton and Brock, 1999; Walsh, *et al*., 2004).

3.2.3 Hydrocarbons and heavy metals

Vehicles inevitably leave hydrocarbons of various forms on roads. Oil, fuel and rubber regularly pollute roadways. The recent monitoring program of the Kuranda Range Project shows the constant presence of hydrocarbons within runoff from the existing Kuranda Range road. Hydrocarbons coat plants, removing the ability to breathe as well as being absorbed into the plant structure, causing toxicity. Additionally, hydrocarbons can be absorbed through the skin of fauna, causing death or illness.

The presence of heavy metals within the water column can result in bioaccumulation – the slow build up of toxicants in flora and/or fauna through the food chain (Boulton and Brock, 1999; Walsh, *et al*., 2004). A constant source of low-concentration heavy metals in stormwater to the receiving waterway can cause slow build up of concentrations, being slow to detect and conducting long-term damage.

The Kuranda Range Project monitoring program highlights some factors that should be considered when completing the final detailed design of the Ella Bay Access Road, regardless of the size difference between the two road projects. The volume of traffic along Ella Bay Road will be minimal in comparison to the Kuranda Range Project, however hydrocarbons will still be produced from oil and tyres.

3.2.4 Increased volume of runoff

Forests work at slowing down the flow of runoff by allowing infiltration into the soil and slowly releasing into streams (Walsh, *et al*., 2004). The removal of a pervious ground increases the volume of surface runoff entering a receiving waterway in peak rainfall periods. Increases in runoff volumes and velocities can scour soil and overland flowpaths, resulting in changes in habitats, erosion, under-cutting of creek banks, and a loss or change of soil hydrological regimes (Boulton and Brock, 1999; Walsh, *et al*., 2004).

3.2.5 Fuel spill from accidents

Ella Bay Road will be the only access road for the proposed development. As part of the development, the road will be widened to accommodate two vehicles on the road at the same time (two-land roadway) and the speed limit is proposed to be kept at 60km/hr (ETS Group, 2007). This reduces the risk of vehicular accidents occurring. However, should vehicular accidents occur along Ella Bay Road, there will be a risk of fuel spillage.

As the Ella Bay Integrated Resort will not have any service stations located on the site, there will be no requirements for any fuel tankers to travel along Ella Bay Road. This therefore minimises the potential risk and volume of fuel spills in relation to vehicular accidents, should they occur along Ella Bay Road.

Unlike bioaccumulation, fuel spills have immediate, focussed impacts on the receiving environment, such as absorption into soils, damage or death to biota through the high toxicity of fuels, and the risk of fire. Spill response features should be incorporated into the overall design of the Ella Bay Road upgrade.

3.2.6 Other goods spill from accidents

This aspect includes chemicals, food or other goods that are transported to or from the Ella Bay Integrated Resort. Various substances have a range of impacts on the receiving environment. For example, should a garbage truck be involved in an accident, the contents of the truck will vary from toxic substances to general litter. Liquefied waste will seep into the soil or enter the waterways. By entering the soil, the risk of effectively killing off the soil structure, microbes, invertebrates and plants can be high. Gross pollutants will cause an aesthetic impact on the immediate area, whilst also posing a risk to wildlife unless quickly removed.

4. ROAD DESIGN MITIGATING MEASURES

The Queensland Department of Main Roads released a document detailing road design considerations and requirements for the Wet Tropics area. (Main Roads, 1998). In addition to this, regular and on-going improvements to water quality and quantity management devices within the Wet Tropics area have been occurring (Wet Tropics Authority, 2008). There are various methods for mitigating water quality impacts from the proposed Ella Bay Road works. These can be summarised as:

- Design
- Operational Practices
- Maintenance

4.1 Design

Water collection methods range in design and the subsequent need for appropriate treatment of runoff. As the complexities and requirements of water management at each site along the roadway vary, the design will ultimately incorporate a range of collection and treatment devices.

Ultimately, the objectives of road runoff for Ella Bay Road are:

- Divert clean stormwater away from contaminated runoff
- Collect and treat contaminated runoff prior to release into the environment
- Transport treated runoff in a manner that avoids erosion
- Ensure that creeks and streams have minimal impacts imposed on them as a result of the runoff conveyance and management
- Develop and implement contingency plans to deal with fuel spills, pollution, accidents, landslips, and any other incidents that could pose a threat to water quality

Environment North (2007) and Main Roads (1998) have outlined various methods for design approaches that would mitigate stormwater runoff from the two-lane road. ETS Group (2007) also provided drawings as part of the engineering preliminary design for the Ella Bay Road diversion and upgrade. Combining these with the best management practices for road design in the Wet Tropics, the following water management devices are recommended as a summary of devices to be utilised along Ella Bay Road.

4.1.1 Diversion Drains

Banks built around a disturbed area help divert clean overland flow away from a potential pollutant source (eg. exposed sediment or roadway), maintaining water quality from areas upstream of the disturbance (Environment North, 2007; Main Roads, 1998). These flows can be directed to suitable cross-road drains or structures to allow the continuance of the clean overland flow downstream without causing backwater, flooding, or other impacts on either the road structure or surrounding environment.

4.1.2 Table / Side Drains

Situated at the toe of the upslope batter, a side drain captures and diverts runoff from the road, reducing the occurrence of waterlogging the batter and / or road structure, thereby reducing the likelihood of landslip.

A correctly designed side drain for Ella Bay Road will also take into account the fauna of the area, particularly frogs that would congregate around pools of water. In this area, it is recommended that the design of the drains are conducted in such a way that there will be no retention of water along the edge of the road, thereby removing the potential for frogs to be injured from vehicles (Environment North, 2007)

4.1.3 Swales

Vegetated swales are used to convey stormwater in lieu of pipes and to provide for the removal of coarse and medium sediment and are commonly combined with buffer strips. The system uses overland flow and mild slopes ($\leq$4% grade) to slowly convey water downstream. Swales also provide a disconnection of impervious areas from hydraulically efficient pipe drainage systems. The results are slower travel times, thus reducing the impact of increased catchment imperviousness on peak flow rates (Healthy Waterways, 2006).

The interaction between flow and vegetation along swales facilitates pollutant settlement and retention. Swale vegetation acts to spread and slow velocities, which in turn aids sediment deposition. Swales alone can rarely provide sufficient treatment to meet objectives for all pollutants, but can provide an important pre-treatment function

4.1.4 Chutes and Drop Drains

Constructed in steep terrain to quickly move stormwater from the roadway to a more appropriate area for treatment, chutes and drop drains mitigate the potential for erosion by directing stormwater down protected, reinforced structures (Main Roads, 1998). Water would be directed off the downslope side of the road via collection drains or kerbing, depending on the location and specific conditions along the road (Environment North, 2007).

4.1.5 Sediment Traps

Particularly during construction, but valuable once the road has been completed, sediment traps generally consist of a basin at the end of drains, allowing water to collect and sediment particles to settle out of the water column. Basins can be either permeable (allowing water to seep through the base) or impermeable with reinforced overflow points, designed to minimise erosion as water flows over the embankment of the basin.

As well as trapping sediments, basins can also take up heavy metals and hydrocarbons that are associated with road runoff. Many fine pollutants are adsorbed onto sediments, making it easy to remove them during the maintenance cleaning of the traps.

Sediment traps can also be rock channels or similar. Rock channels cause a riffle effect, slowing runoff velocities to allow sediment to settle out between the rocks, while dispersing runoff in a manner that does not induce erosion. However, these can become infested with weeds if not maintained properly (Main Roads, 1998).

4.1.6 Gross Pollutant Traps

There are various types of Gross Pollutant Traps (GPTs), removing the larger pollutants such as litter, leaves and twigs. Due to the terrain, the chosen design of GPTs will be site-efficient, removing the most pollutants within the smallest area. However, due to the nature of the road, it is expected that most of the gross pollutants captured will consist of leaves and twigs. This natural aspect of the Wet Tropics World Heritage Area needs to be taken into account when calculating the required and targeted pollutant removal rates. For instance, GPT's may not be required along most of the road, but rather be incorporated into the road design closer to the urban areas, where unnatural gross pollutants are more likely to occur.

Gully pit traps such as Side Entry Pollution Traps (SEPTs) can be utilised along the Ella Bay Road, due to the small nature and high capture efficiency rates (Allison, *et al*., 1998). However, these would require regular cleaning. It is envisaged that, should these be utilised in the final detailed design of the Ella Bay Road, they would be best placed closer to the urban areas, rather than within the heavily-vegetated sections of the road. This would assist in reducing the maintenance frequency.

4.1.7 Bridges

Two bridges are proposed to be constructed as part of the Ella Bay Road upgrade. These will assist in providing a natural flow within the stream, as well as providing fauna pathways without risking injury crossing the roadway (Main Roads, 1998). Beneficial results of minimising the intrusion of structures into the natural waterway also include reductions in the likelihood of increases in velocity, erosion or pollution.

4.2 Construction and Operational Practices

4.2.1 Construction Periods

Construction during the dry season is imperative in the Wet Tropics area, moreso in terrain such as that experienced along Ella Bay Road. All workfaces should be sealed by some form by the start of the wet season to ensure minimal erosion and sediment loss from the site, and resulting impacts on the receiving environment.

4.2.2 Erosion and Sediment Control

An Erosion and Sediment Control Management Plan will be developed and implemented for all stages and aspects of the road construction and upgrade. In addition to the construction timing to coincide with the dry season, the implementation and regular maintenance of structures such as sediment traps, silt fences, minimal soil exposure areas and jute matting will be required. During detailed design of the road, a full Erosion and Sediment Control Plan will be compiled outlining the management devices required along the length of Ella Bay Road.

As an example, the road construction would require a stockpile area to be provided for any excess soil to be retained while the road is being constructed. Depending on the available area, it is most likely that any stockpile areas will be located off-site, outside the Wet Tropics area. Sediment and erosion management techniques will be required to manage the loss of sediment from the stockpile area. These techniques include (but are not limited to):

- silt fences,
- sedimentation basins downhill of the stockpile,
- covering the stockpile through hydromulching and/or jute matting

4.2.3 Risk and Hazard Reduction Management Plans

Other risks associated with the road construction and operation will require management plans to ensure minimal impact on the waterways and receiving environment as a result of incidents occurring. Such plans include:

- Spill Response Plan - responding to and rectifying spills as a result of accidents (fuel, oil, toxic substances, etc), and
- Herbicide / Pesticide Management Plans – management of the roadside verge as a safety issue may use herbicides or pesticides to control visually-impairing vegetation. Preferably vegetation would be maintained by hand, however if required, chemicals should be of organic nature to reduce the impacts on the receiving waterways. Safe handling practices should also be detailed in the plan and implemented out on site.

4.3 Maintenance

Maintenance of the water treatment devices that are implemented within the road design and construction are imperative to the ongoing protection of water quality. Some structures, such as the gross pollutant traps, will require frequent cleaning due to the high volume of leaves and twigs associated with the dense canopy cover along the road. Other structures will require more frequent cleaning during the construction phase than during the operation of the upgraded road, in response to the area of exposed soils and rates of sediment movement.

Table 3 below details the general maintenance regime of the various water management devices. This maintenance regime should be reviewed as part of the detailed design of the road upgrade, as well as once the construction is completed. Several structures can be inspected during the same maintenance period.

Table 3: General maintenance regime of selected devices

Structure	Maintenance Period	Maintenance Works
Sediment Traps	2-4 months during construction dependant on rainfall 6 months following construction	Dewater and remove accumulated sediment and attached pollutants Replace adsorbent material (if integral to sediment trap design) Remove weeds Inspect structure for breaches or damage – repair where necessary Mow/maintain grass vegetation on banks
Gross Pollutant Traps	After heavy rainfall Monthly	Remove accumulated gross pollutants (litter, leaves, twigs, etc) Inspect structure for damage – repair where necessary
Catch and Divert Drains	After heavy rainfall Fortnightly during construction Every 1-2 months following construction	Inspect structure for blockages or damage – remove / repair where necessary
Roadside Swales	After heavy rainfall Fortnightly during construction Every 1-2 months following construction	Mow / maintain to reduce sight hindrance from swale vegetation Inspect structure for breaches or damage, including accumulation of sediment resulting in impairment to fully functional operation of swales
Check Dams	After heavy rainfall Fortnightly during construction Every 1-2 months following construction	Inspect structure for breaches or damage – repair where required

5. WATER QUALITY MONITORING

Golder Associates Pty Ltd has compiled a Water Quality Monitoring Strategy for Ella Bay Road (Golder Associates, 2008). The Monitoring Strategy details monitoring points, parameters for assessment, and frequencies for sampling.

Section 3.6 of the Monitoring Strategy (Golder Associates, 2008) details the interim water quality guidelines for physico-chemical parameters (including pH, turbidity, dissolved oxygen and nutrients), metals, oils, greases, and gross pollutants for the access road. Section 4.5 of the Monitoring Strategy also details the monitoring frequency required.

It is recommended that the locations of the water quality monitoring points during the construction phase are:

- Stream crossings where the upgrade has/is occurring
- Sediment traps
- Entrance of treated runoff into streams (where defined)
- Upstream of the construction works

Once the upgrade of road is completed, monitoring should take place at:

- Sediment traps
- Entrance of treated runoff into streams (where defined)
- Upstream of the road

These locations are subject to change with the final design of the upgraded Ella Bay Road.

6. RECOMMENDED TASKS

While not within the scope of this Water Quality Management Strategy, detailed modelling and design is required to ascertain the correct sizing and type of water management structures for the length of Ella Bay Road. In some areas, the issues of non-natural gross pollutant collection may not be vital to the selection of management devices, whereas the treatment of erosion will be vital throughout all stages of construction and operation of the road.

7. REFERENCES

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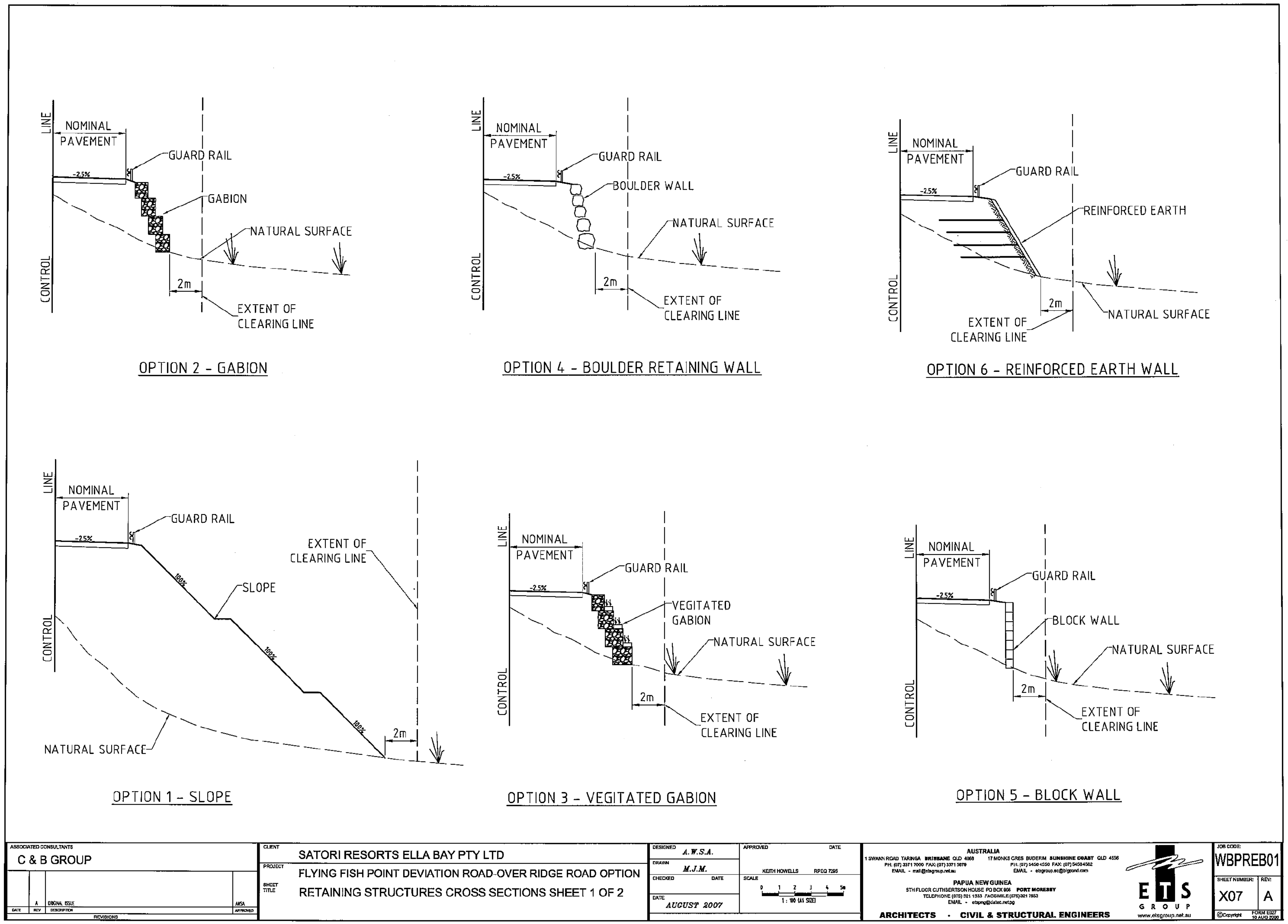
8. APPENDIX

Batter options for upslope and downslope stabilisation along the Ella Bay Road upgrade (Source: ETS Group, 2007)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GUARD RAIL
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NATURAL SURFACE
2m
EXTENT OF CLEARING LINE
OPTION 2 - GABION
BOULDER WALL
OPTION 4 - BOULDER RETAINING WALL
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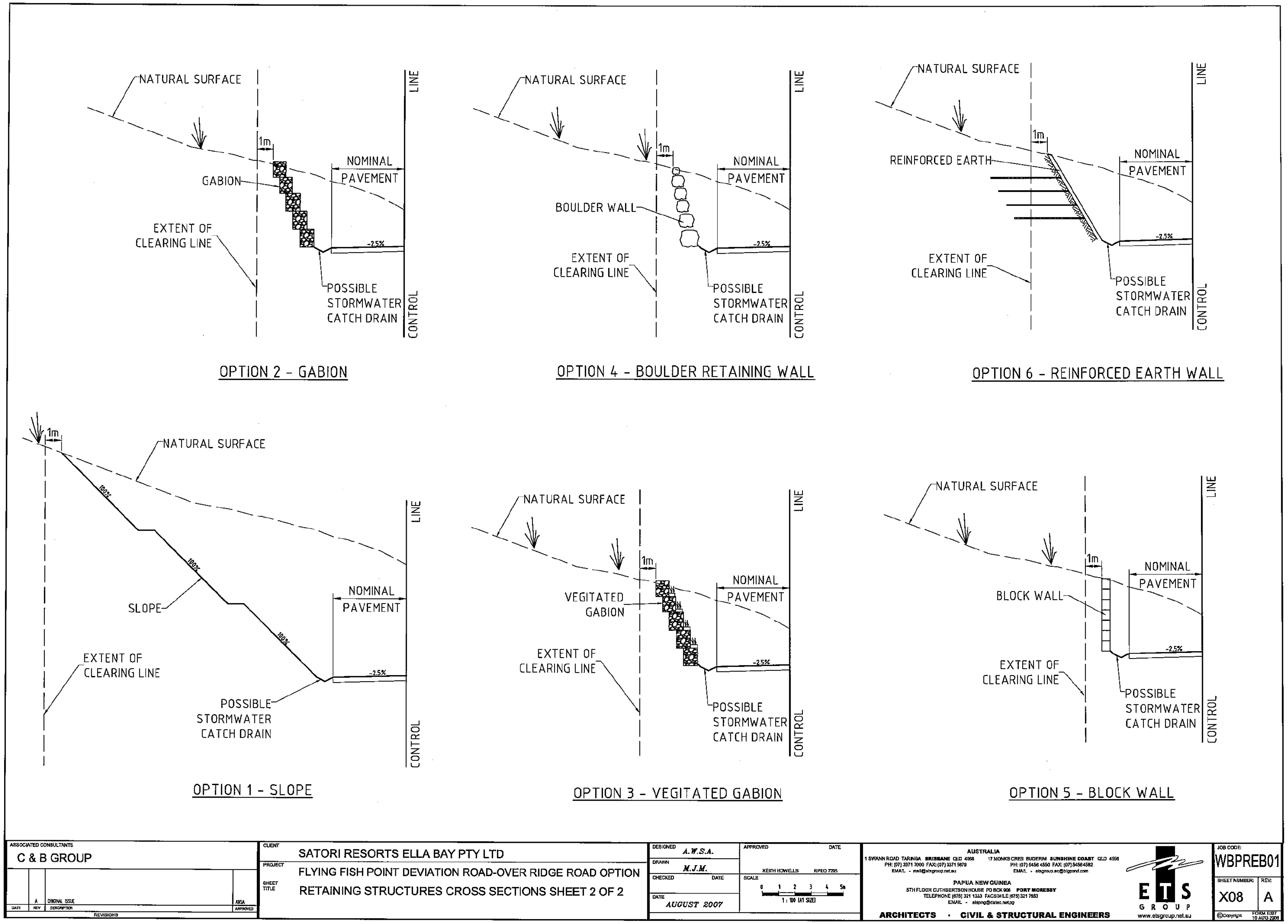
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