2.3 Construction

This section provides an overview of the proposed construction activities associated with the GKI Revitalisation Plan.

2.3.1 Pre-construction Activities

2.3.1.1 Construction Equipment

It is anticipated the following construction equipment will be required throughout the 12 year construction period:

- rollers;
- bulldozers;
- compactors;
- grader(s);
- excavators;
- backhoes;
- bobcats;
- loaders;
- tip trucks;
- water truck;
- flat top truck;
- bitumen spraying and laying equipment;
- prime-mover;
- concrete truck(s);
- miscellaneous building equipment (hoists, generators, power tools etc);
- mobile crane(s); and
- concrete batching plant.

The size, make and type of the construction equipment will need to be carefully considered as part of the Principal Contract to ensure energy consumption and impacts to the environment are minimised. The majority of the construction equipment will be barged from Keppel Bay Marina to the Island.

Exact numbers and types of equipment to be brought to the Island remains unknown until the construction contracts are assessed by the Proponent.

2.3.1.2 Site Access

It is proposed that the first facility to be constructed as part of the development will be the new barge terminal at the proposed marina to provide permanent construction access to the Island. When operational, all construction staff, equipment and material will access the Island via the barge terminal.

As there is currently no jetty facility on the Island, prior to the barge terminal becoming operational, access to the Island for construction staff and the transport of limited material and equipment will take place via currently available water transport options (ferries, water taxis or barge) onto Fisherman's Beach.

Refer **Appendix U** for the location of site access points.

2.3.1.3 Erosion and Sediment Control Plan

Prior to each stage of construction commencing, the Principal Contractor (the Contractor) will be required to prepare, and have approved by Rockhampton Regional Council, an Erosion and Sediment Control Management Plan (ESCMP). The plan will detail measures to be adopted by the Contractor such as sediment basins, silt traps, sediment fences and other measures to minimise the deposition of sediment runoff on the receiving environment.

The ESCMP will be developed in accordance with the International Erosion Control Association (2008) *Best Practice Erosion and Sediment Control Guidelines.*

Refer to the preliminary ESCMP prepared by Opus International Consultants (2011) as **Appendix I** to the Water Cycle Management Report (**Appendix AN**), for preliminary details of proposed control measures.

The following construction philosophies will apply to civil earthworks activities and will be reflected in the ESCMP:

- follow existing terrain and contour lines (rather than crossing them) as much as possible to minimise soil disturbance;
- balance cut and fill to minimise the amount of material required to be imported or material to be removed from the site;
- limit earthworks operations to the confined area necessary to construct the building and infrastructure works;
- disturbance areas for individual building works should be limited to less than two hectares. If the proposed works require a larger area, staging will be implemented to limit the disturbance area as much as possible;
- site works will generally be graded so the need for retaining walls is minimised wherever possible; and

- excess material from earthworks will be stockpiled in approved bunded locations within the proposed footprint of the Resort component under construction. The stockpiles will be located to ensure minimum of five metres clearance within the stage boundaries and be a maximum of two metres in height. Batters to the stockpiles are to be at a maximum grade of one in four.

2.3.1.4 Site Establishment

(a) Contractor's Site Areas

Once the new barge terminal is available a secured set down area will be provided for the Principal Contractor. This will allow the Contractor to load and unload the barge in the shortest timeframe possible.

Refer to the Construction Management Plan (**Appendix U**) for the proposed location of the contractor's set down area.

Within each stage, there will be a secured contractor's work area allowing for infrastructure such as; site offices, tool and equipment storage, site amenities and other facilities required for the satisfactory performance of the work.

These will be temporary facilities to be removed from the Island at the completion of the work.

(b) Access Restriction

The contractors' access onto and around the Island, and use of the site for temporary works and construction plant, including working and storage areas, location of offices, workshops, sheds, roads, parking and the like, will be restricted to designated areas, and subject to such conditions as are stated in the construction contract or imposed by the relevant authorities.

2.3.1.5 Services

The following temporary services will be secured for the construction phase:

- **power:** supply by standby diesel generators will be organised pre-construction. Mainland electricity will be utilised to power later construction phases once the connection is made;
- **telecommunication:** the existing Telstra/radio mobile tower will be utilised during the early construction period. Connection to the mainland exchange will be available during later construction phases; and
- **water:** initial construction water supply will be obtained from two production bores in the Long Beach Aquifer, captured roof water and stormwater, and recycled effluent.

Recycled effluent is likely only to be used for landscape irrigation and/or watering to the disturbed areas adjacent to the upgraded airstrip. Once the mainland water supply via the submarine pipeline is commissioned, construction water will be obtained from this supply. Captured roof water and stormwater, and recycled effluent will continue to be used in later construction phases and the operational phase.

2.3.1.6 Construction Workforce Accommodation

Given that the Island is only approximately 12 kilometres off the coast of Yeppoon, the construction workforce will have the option of travel to and from the Island via ferry on a daily basis where possible and practical. Alternatively, some of the construction workforce is likely to be located on the Island during the main construction activities.

The following accommodation options are currently available on the Island:

- existing staff village, villas, resort accommodation (**Photograph 2.2**) and units owned by the Proponent may be used after some repair works;
- portable accommodation units provided by the contractors; and
- two existing commercial backpacker's facilities on the Island and a number of individually owned guest accommodation facilities on the Island (not affiliated with the Proponent).

The choice of workforce accommodation will be decided when the detailed design is completed and a Principal Contractor is selected.

Photograph 2.2 OLD RESORT VILLAS - WHITE ROOFED IN FOREGROUND

2.3.1.7 Temporary Works

It will be the contractors' responsibility to alter, adapt and maintain temporary works (e.g. concrete batching plant, scaffolding etc) as necessary, and remove them progressively as construction stages are completed.

The existing sewerage treatment plant will need to be re-commissioned if the accommodation units owned by the Proponent are to be used for the construction period, as these units have not been used since 2008.

2.3.1.8 Roads

Roads and associated earthworks required to build them will be one of the critical items to construct in advance of the building facilities.

The strategy for land access on the Island is to use the existing roads (sealed and unsealed) and vehicular tracks where possible.

All existing roads will be inspected by an experienced road engineer during the detailed design phase to assess their suitability, and required improvements, for the Project construction and operation phases.

Based on Livingstone Shire Council's Deemed to Comply Requirements, access places and access streets are to have a maximum grade of 16 percent. In order to comply with this, parts of the vehicular track connecting Fisherman's Beach Precinct and Clam Bay Precinct will require realignment. The current proposed road layout shown on the preliminary design drawings has been modelled using 12D and the maximum grade does not exceed 16 percent.

All imported material (sand, soil and rocks) will need to be free of contamination as defined under the relevant legislation. The Contractor will be required to provide validation certificates to the Proponent's environmental advisers for all material to be used prior to delivery to the Island.

2.3.1.9 Demolition

(a) Materials and Quantities

The old resort buildings will be demolished to allow development of the new Resort within its footprint (refer to **Table 2.3**).

TABLE 2.3 SUMMARY OF CONSTRUCTION AND DECOMMISSIONING TIMETABLE

Infrastructure Component	Year	Description of Works
Transport infrastructure	2013	Decommission existing runway
	2013-2015	Construct marina facility
	2013-2015	Construct ferry terminal
	2013-2015	Construct barge facility
	2013-2015	Construct runway and airport terminal
	2014-2023	Construct roads
	2014-2023	Construct public walkways and bicycle tracks
Services infrastructure	2014	Decommission existing fuel storage
	2014	Decommission existing wastewater treatment plant
	2013	Construct power supply to island
	2013	Construct water supply to the island
	2013-2022	Construct wastewater treatment facilities
	2013-2022	Construct power and water reticulation systems
Social infrastructure	2015-2023	Landscaping
	2015	Sport and recreation oval
	2015-2019	Environmental protection areas
	2014	Research Centre
	2014	Police Centre
	2014	Passive open space areas
Tourism infrastructure	2013	Decommission existing resort
	2013-2014	Construct Marine Services Precinct, Eco Resort Apartments (150 apartments), Fisherman's Beach Hotel, Staff Accommodation
	2015	Construct Fisherman's Beach Precinct Eco Resort Apartments (75 apartments), Fisherman's Beach Precinct Eco Resort Villas (75 villas)
	2015-2016	Construct Golf Course and Golf Resort Facility
	2016	Construct Fisherman's Beach Precinct Eco Resort Apartments (75 apartments), Fisherman's Beach Precinct Eco Resort Villas (75 villas)

TABLE 2.3 SUMMARY OF CONSTRUCTION AND DECOMMISSIONING TIMETABLE (CONTINUED)

Infrastructure Component	Year	Description of Works
	2017	Construct Fisherman's Beach Precinct Eco Resort Villas (75 villas)
	2018	Construct Fisherman's Beach Precinct Eco Resort Villas (75 villas)
	2019	Fisherman's Beach Precinct Eco Resort Villas (83 villas)
	2020	Clam Bay Precinct Eco Resort Villas (75 villas)
	2021	Clam Bay Precinct Eco Resort Villas (75 villas)
	2022	Clam Bay Precinct Eco Resort Villas (75 villas)
	2023	Clam Bay Precinct Eco Resort Villas (75 villas)
	2024	Clam Bay Precinct Eco Resort Villas (67 villas)

Timing assumes Project is approved in 2012

Turner and Townsend (refer to **Appendix E** in **Appendix AK**) estimate that the demolition work will generate approximately 13,391 cubic metres of waste building materials. This quantity is inclusive of concrete, timber and fibreboard, furniture and whitegoods, roof metal, hardware, pipes, and glass.

(b) Storage, Processing and Transport of Waste

Waste reuse and recycling will be mandated in the demolition contract/s to minimise the volume of waste requiring disposal. The Contractor will be required, where feasible, to salvage and reuse building materials (e.g. crushed concrete, bricks and pavers for road base and salvage suitable timber and steel for building framework).

Separate bulkbins will be provided to enable efficient segregation of waste materials according to whether the material is intended for reuse, recycling or disposal.

Construction wastes will be collected and temporarily stored in bulk bins within the industrial compound on the Island. Where reuse and recycling options are not available, the waste will be collected and transported to the mainland by an appropriately licensed waste contractor and disposed of at Council's Yeppoon Waste Management Facility.

As outlined in **Appendix AM**, it is estimated that demolition of the existing resort and associated infrastructure will generate approximately 10,301 cubic metres of waste material.

2.3.1.10 Construction Workforce Numbers

Foresight Partners Pty Ltd (refer **Appendix AC**) estimated the construction workforce numbers throughout the Project's lifespan, refer **Table 2.4**. This table provides a summary of the workforce numbers and description of works for the corresponding stages/ years of development.

TABLE 2.4 SUMMARY OF ESTIMATED WORKFORCE FOR STAGES OF DEVELOPMENT

Stage	Year	Description of Works	Anticipated Workforce Numbers per year
1	2013-2014	Marina, Marine Services Precinct, Eco Resort Apartments (150 apartments), Ferry Terminal, Barge Facilities, Airstrip and Terminal, Fisherman's Beach Hotel, Staff Accommodation	450
2	2015	Fisherman's Beach Precinct Eco Resort Apartments (75 apartments), Fisherman's Beach Precinct Eco Resort Villas (75 villas)	341
3	2015-2016	Golf Course and Golf Resort Facility	341
4	2016	Fisherman's Beach Precinct Eco Resort Apartments (75 apartments), Fisherman's Beach Precinct Eco Resort Villas (75 villas)	330
5	2017	Fisherman's Beach Precinct Eco Resort Villas (75 villas)	277
6	2018	Fisherman's Beach Precinct Eco Resort Villas (75 villas)	197
7	2019	Fisherman's Beach Precinct Eco Resort Villas (83 villas)	197
8	2020	Clam Bay Precinct Eco Resort Villas (75 villas)	192
9	2021	Clam Bay Precinct Eco Resort Villas (75 villas)	192
10	2022	Clam Bay Precinct Eco Resort Villas (75 villas)	192
11	2023	Clam Bay Precinct Eco Resort Villas (75 villas)	170
12	2024	Clam Bay Precinct Eco Resort Villas (67 villas)	157

(Timing assumes Project is approved in 2012)

2.3.2 Construction Program

2.3.2.1 Construction Timetable

The proposed construction period for the GKI Revitalisation Plan is outlined in the Project Schedule (refer **Table 2.3**). Anticipated start up and commissioning dates for each of the stages are summarised in **Table 2.5**. The development program commencement date will be subject to the time taken for statutory approvals, followed by the time needed to complete detailed design and physical construction.

The proposed staging of the GKI Revitalisation Plan is shown in the Staging Plans **(Appendix T)** which show the extent of each development stage.

TABLE 2.5 SUMMARY OF START-UP AND COMMISSIONING DATES

Stage	Start-up date	Commissioning date
1	July 2013	November 2014
2	January 2015	December 2015
3	January 2016	December 2016
4	January 2017	December 2017
5	January 2018	November 2018
6	January 2019	November 2019
7	January 2020	December 2020
8	January 2021	December 2021
9	January 2022	December 2022
10	January 2023	December 2023
11	January 2024	November 2024

Timing assumes Project is approved in 2012

(a) Hours of Operation

The intended hours of work for construction are listed below:

Monday to Friday	6.00am to 6.00pm;
Saturday	6.00am to 2.00pm; and
Sundays and public holidays	No work.

An exception to these working hours is in relation to the construction of the marina breakwaters which is proposed to be undertaken seven days per week to ensure that environmental impacts on the marine environment are minimised (shorter timeframe).

2.3.2.2 Construction Methodologies

In the absence of detailed design specifications, the objective of this section is to outline the framework within which construction works may be undertaken. This will be subject to further review as design proceeds and a Principal Contractor is appointed, who then will provide the detailed construction methodologies.

The methodology adopted for the construction stages is as follows:

- construction equipment will remain on the Island for the duration of relevant development stages, as required. The construction equipment may be barged to and from the mainland to meet the requirements of the relevant development stages;
- all construction vehicles will park within designated areas to allow local traffic to pass without hindrance;
- traffic control will be provided where necessary;
- work areas will be fully fenced and secured; and
- dedicated pedestrian access within work areas will be provided, where necessary, with full scaffolding and barriers for separation.

2.3.2.3 Sequence of Construction

In order to establish a sequenced construction process, to minimise adverse impacts on water quality and watercourse, and allow efficient use of construction resources, all bulk earthworks, access roads and infrastructure provisions (stormwater system, water reticulation, treated effluent, sewer reticulation, power and telecommunications) will be completed for each stage prior to the initiation of building works.

The civil works design and construction will ensure that there will be no additional ponding of water on adjoining established stages/neighbouring properties or blockage to natural watercourses as a result of construction activities.

It is anticipated that the stormwater system, including underground pipes, detention basins, temporary bio-retention basins and vegetated swales will be constructed during civil works stages, where practical. This will ensure that surface runoff from building hardstand areas can be captured in the established stormwater system. Nonetheless, some building platforms may still cause runoff into the temporary cutoff drains. This stormwater will be transported to the relevant bio-retention system via vegetated swales for settlement.

Building construction works and roadworks will take place simultaneously. Management of the sediment and erosion control measures by the Contractor will be facilitated and contained within the works areas. Silt overflow from disturbed areas will be managed with silt fences and silt traps.

2.3.2.4 Logistics, Material Handling and Storage

The loading and delivery of construction materials is one of the key factors for the construction works to meet the anticipated project timeframe.

A secured set-down area will be provided close to the new barge terminal. This will allow the Contractor to load and unload the barge in the shortest timeframe possible, thus allowing the barge to operate efficiently without a long downtime. A mobile concrete batching plant will be located within the Industrial Compound. Sand, cement and aggregate will feed to this concrete batching plant and concrete trucks will transport ready-mix concrete to the required areas.

Within each development stage, there will be a secured contractor's work area allowing for site office, tool and equipment storage, and site amenities as required for the satisfactory performance of the work.

In order to promote a safe environment for Island residents and resort visitors, the following construction management strategies are recommended:

- construction of the Fisherman's Beach Hotel, Eco Resort Villas and Eco Resort Apartments will occur in an anti-clockwise direction whilst the construction vehicles will enter the construction site in a clockwise direction; and
- where possible, construction vehicles will use different access roads than those used by visitors to the Resort.

Refer to the Construction Management Plan (refer **Appendix U** for more information on the logistics planning).

2.3.2.5 Source and Transportation of Construction Materials

The source and origin of construction materials will remain undefined until the various contractors are appointed for each stage of construction.

At this stage, it is anticipated that all construction materials will be transported to the Keppel Bay Marina at Rosslyn Bay to be barged to the Island, with the exceptions of rock armour, which may be sourced from a suitable nearby quarry and barged to the Island via a public boat ramp on the Fitzroy River near Nerimbera (refer **Figure 2.1**).

Refer to the Traffic Impacts Report in **Appendix AK** for preliminary information regarding the proposed origin of construction materials.

Concrete will be manufactured on the Island via a mobile batching plant with all materials barged to the Island.

2.3.2.6 Proposed Blasting

Given the generally sandy nature of the Island's geology, blasting is not expected to be necessary in any stages of the GKI Revitalisation Plan.

Should any blasting be required a separate management plan for these activities will be developed for the review and approval by DEHP and SEWPaC.

2.3.2.7 Utilities Services Corridor Construction

(a) Services Requirements

Preliminary designs have been carried out by Opus International Consultants Pty Ltd and AECOM (refer **Appendix Q**) for the services that are required to supply the Island from the mainland, namely:

- a submarine power cable (22 kV high voltage supply);
- a submarine communications cable: A fibre optic cable to supply telephone and IP telephony, video phone/ conferencing, television, video (movie) on demand and radio; and
- a water main to supply potable water.

The preliminary design will be confirmed during the detailed design stage of the Project.

Submarine power cables have been provided to several islands including Hamilton Island, Magnetic Island, Hayman Island, South Molle Island and Daydream Island. All are connected to the mainland power grid and have operated successfully over a substantial period of time.

(b) Mainland Point of Connection

The current preferred point of connection for submarine services on the mainland is at the end of Ritamada Road, Emu Park (refer **Figure 2.17**). This includes the connection of the submarine cable to Ergon's mainland supply (power) and telecommunications carriers (including Telstra and Optus), and submarine water pipe to Council's water supply system.

The final location of the mainland point of connection, layout and exchange building are yet to be determined with the completion of final agreements being required from a number of parties including Ergon, Rockhampton Regional Council, telecommunication carriers, Traditional Owners and land owners.

To date, discussions have commenced with the mainland energy provider, Ergon Energy and a formal Connection Enquiry has been lodged. Preliminary advice has been received from Ergon indicating in principal that the mainland connection is possible along with a range of potential commercial options.

(c) Island Point of Connection

The current preferred point of connection for submarine services on the Island is within the Marine Services Precinct.

(d) Hydrographic Survey

A hydrographic survey has been completed between the mainland and the Island (refer **Appendix Q**) to determine the appropriate alignment location for the submarine services. The proposed Utilities Services Corridor Route is indicated in **Figure 2.17**. The preliminary alignment has been selected to avoid ecologically sensitive marine communities such as coral reefs and seagrass beds and to minimise impacts on the marine environment.

Prior to the installation works being carried out, the submarine cable and pipeline installation specialist contractor may carry out another detailed hydrographic survey to confirm the exact alignment and determine the seabed conditions and final alignment. The final alignment will need to be approved by the relevant authorities, including the GBRMPA.

The hydrographic survey shows the current proposed submarine services alignment. The seabed ranges from -0.3 metres to -10 metres in relation to Australian Height Datum (AHD) and the route is approximately 16 kilometres in length.

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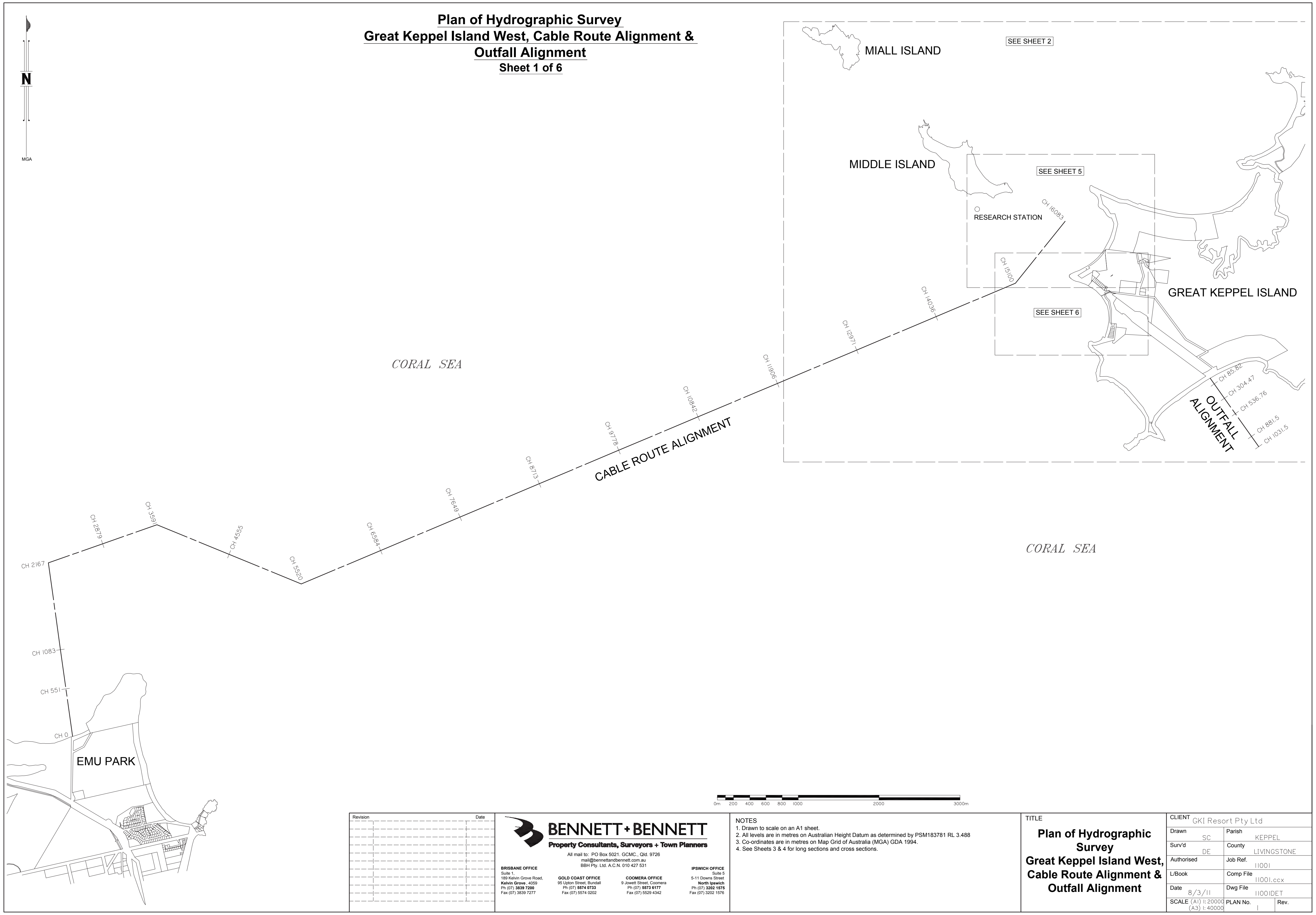
Figure 2.17 PROPOSED UTILITIES SERVICES CORRIDOR ROUTE



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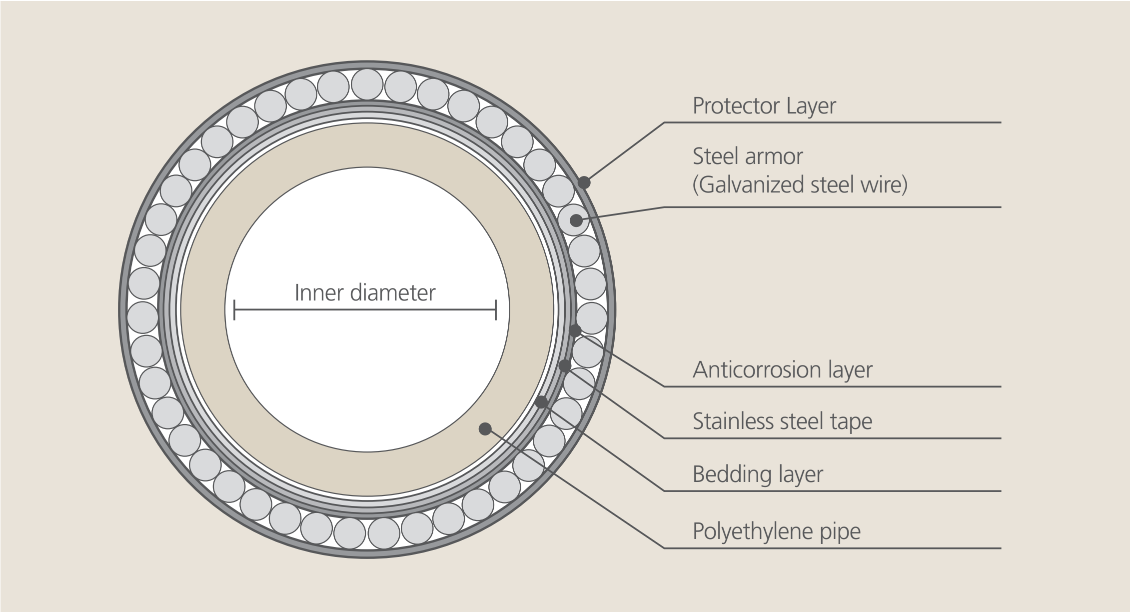
(e) Service Configuration

A submarine multiple core cable is proposed to provide power and communications to the Island. The anticipated diameter of the cable is approximately 100 millimetres. **Figure 2.18** is an example of a multiple core cable.

Figure 2.18 EXAMPLE OF INSULATED SUBMARINE MULTIPLE CORE CABLE

A *submarine water pipe* is proposed to provide water supply to the Island from the mainland. The anticipated internal diameter of the pipe will be between 200 millimetres and 250 millimetres. **Figure 2.19** shows a typical cross section of a submarine water pipe.

Figure 2.19 EXAMPLE OF SUBMARINE WATER PIPE



(f) Installation – Indicative Methodology

The power / communications cable and the water pipeline would be manufactured in one length for off-loading onto a cable laying barge. A Dynamic Positioning (DP) vessel/ barge would be used to lay the cable and pipeline.

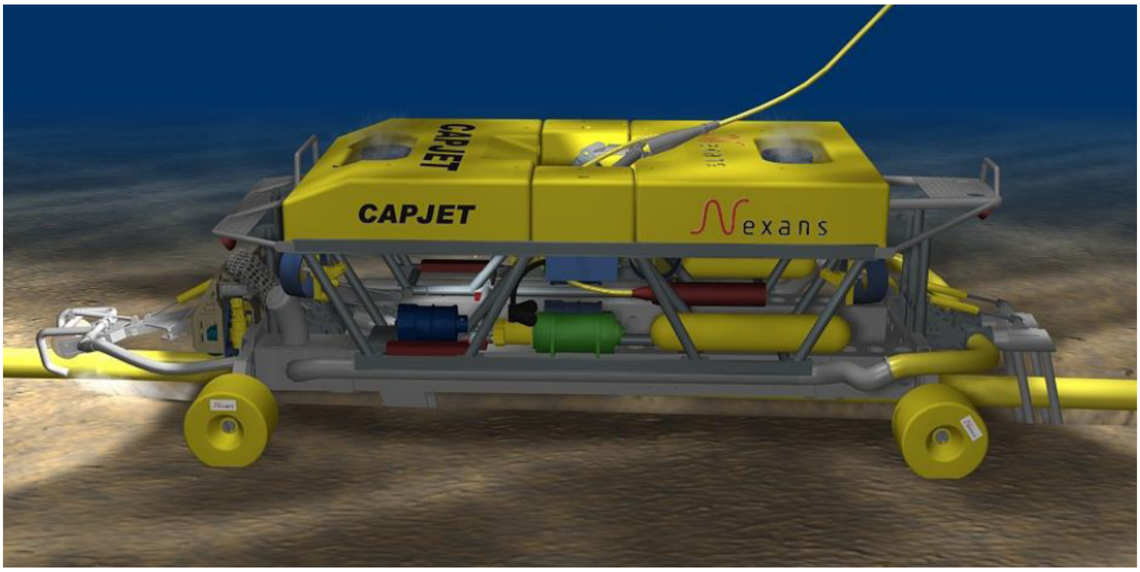
Such a vessel would provide many advantages. When stationary in DP mode the vessel employs bow, side and stern thrusters which enable it to hold on station without anchors with remarkable accuracy. Marine survey data and cable route coordinates are loaded into the navigation system on the vessel and when set to 'Auto- Track' mode, allowing the vessel to autopilot the cable and pipeline route.

Historically, most submarine cable and pipeline failures have been attributed to external damage (such as dragging anchor and fishing equipment) as the cables and pipelines are laid directly on the seabed. To minimise the risk of cable/ pipeline damage due to such occurrences, it is proposed that both services are buried in the seabed by continuous jet trenching (such as the Capjet trenching system shown as **Figure 2.20**) or similar process. Once the cable and pipe are laid on the seabed, the jet trenching machine will trench the cable and pipeline and cover them as it travels along the cable and pipeline. The disturbance to the seabed will be localised to the width of the trench and because it is immediately backfilled, the impact to the marine environment and aquatic visual amenity will be minimised.

The method of submarine burial of the power and communications cable and the water pipeline is very similar. The exception is that the water pipeline will need to be weighed down by adding concrete collars to anchor it against flotation in the event that it is empty at any time.

It is expected that the water and power infrastructure are installed simultaneously. Specific construction details and methodologies will be agreed with the relevant local, state and federal government authorities prior to any works commencing.

Figure 2.20 EXAMPLE OF JET TRENCHING MACHINE



The jet trenching system is likely to be well suited to the channel between the Island and the mainland because of the sedimentary layer of seabed (comprising sand or alluvial sediment), relatively shallow water depths (one metre to 100 metres) and relatively short pipeline lengths (less than 20 kilometres long). In addition, the jet trenching device can be operated from a small barge and supply boat. In comparison, typical ploughs and jet sleds trenching options are not as economical under these conditions. These methods require larger barges that are more expensive and require eight to 10 times the power to operate. In addition, these methods cannot operate in shallow water depths.

The open trench method is generally employed in beach, tidal flat and very shallow water areas where wave action can have a significant impact. Trenches are excavated by a grab dredger or backhoe and the services are buried in the trench by using the excavated soil.

Potential environmental impacts associated with the utilities services corridor are described in **Section 3.3.4**.

2.3.3 Dredging

Dredging will be required for the following components of the GKI Revitalisation Plan:

- marine facility basin; and
- marine facility approach channel.

Dredged materials are to be reused in the reclamation of land and construction of the breakwater associated with the marine facility.

A detailed assessment of the dredging requirements has been undertaken by coastal engineers Water Technology (refer **Appendix Y**) outlines specific details regarding dredge volumes, processes and impact assessment.

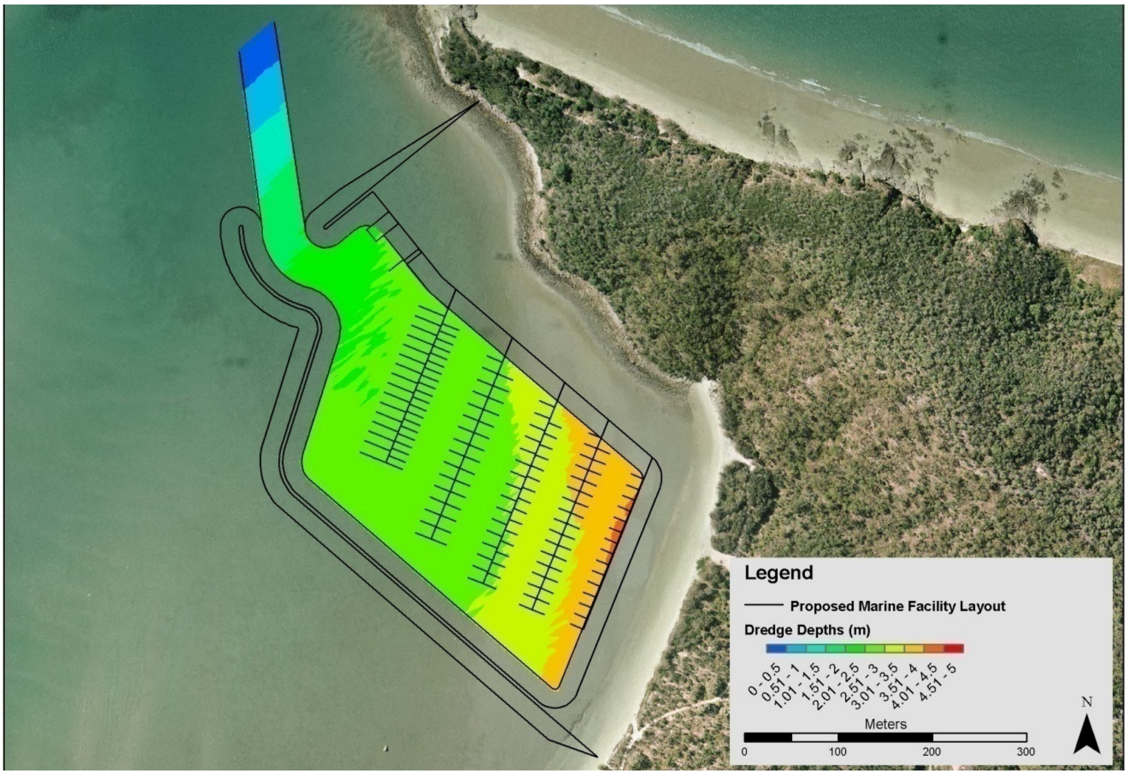
Detailed hydrographic surveys and seabed contours which were developed by Water Technology confirm that there is a navigable channel from the north of the marina which would allow the entrance channel to be re-aligned from the south-west to the north-west. The result of this re-alignment from the original design has reduced the length of the entrance channel by over 1,070 metres which has significantly reduced the dredge volume - refer **Figure ES.5** (Marina Entrance Channel Options).

It is proposed that all the material from the marina basin dredging be utilised to form the core of the breakwaters and to provide the majority of the material required for land reclamation. The breakwater cores will be constructed with geotextile containers, filled with sediment excavated from the marina basin.

The beneficial reuse all of the marina dredge material will eliminate the need for sea dumping.

The volume of material to be dredged, with reference to the above mentioned components and including an allowance for over-dredging, has been determined to be approximately 300,000 cubic metres. The depth of dredging required is generally in the order of 2.5 to 3.5 metres, as shown in **Figure 2.21**.

Figure 2.21 DREDGED DEPTHS FOR CONSTRUCTION OF THE MARINE FACILITY



Construction of the marine facility and associated works is proposed to be undertaken in four main stages. A discussion of the various stages and their respective dredging requirements is as follows:

- **Stage 1 - Western Breakwater Construction and Basin Dredging**

  Construction of the western breakwater in Stage 1 will eliminate the majority of the current and wave action from the marine facility basin and minimise weather related downtime and risks for the remaining construction of the marine facility. Construction of the western breakwater first will also help to contain the extent of any turbid plumes, generated during construction, within the marine facility footprint.

  Stage 1 will require approximately 57,000 cubic metres of material to be dredged from the marina basin to fill the geotextile tubes to create the core of the western breakwater.

  It is expected that a small cutter suction dredge (CSD) will be able to achieve a dredging rate of 120 cubic metres per hour, enabling a 20 metre long by 16 metre circumference tube to be filled within approximately three hours. Assuming four geotextile tubes a day can be filled at this rate for seven days a week and including some contingency, it is estimated that the western breakwater core construction can be completed in 12 weeks with this method.

- **Stage 2 – Marina Basin Revetment and Basin Dredging**

  Stage 2 will involve the construction of the marina basin revetments. A total of approximately 40,000 cubic metres of material will be dredged in this stage from the marina basin to fill the geotextile tubes to create the marina revetments. Based on a similar dredging and geotextile tube fill rates as adopted for the western breakwater core construction, a total of 12 weeks is expected to be required to construct the marina revetments.

- **Stage 3 – Northern Reclamation**

  Stage 3 will require the remainder of the marina basin excavation and approach channel dredging to be completed. The total remaining volume of material to be dredged in Stage 3 has been determined as approximately 185,000 cubic metres. It expected that a medium sized cutter dredge, achieving a dredge rate of approximately 500 cubic metres per hour and operating eight hours a day, seven days a week could complete the dredging within eight weeks.

  Dredge material will be pumped directly into the reclamation area to the north of the marina basin. The reclamation area will be designed with a number of settling basins to allow fines to settle out of suspension before the decant overflow is allowed to return to the marina basin.

- **Stage 4 – Placement of Breakwater Armour and Marina Basin Rip Rap**

  Following completion of the geotextile core, armour rock will be placed over the breakwaters and marina revetments. The placement of the armour rock is likely to be undertaken from a barge mounted excavator, with the armour rock barged from sources on the mainland.

- **Maintenance Dredging**

  Maintenance dredging is likely to be required periodically over the course of the marina's operation to maintain the minimum navigable depths required in the entrance channel. As the sediment transport modelling predictions provide only very small rates of sediment transport, maintenance dredging of the entrance channel is only expected to be required occasionally (estimated at less than once every five years on average) or following a major cyclone. Based on advice from International Marina Consultants, a sediment basin has also been incorporated into the proposed works at the Putney Creek mouth. The sediment basin will be constructed in the lined transition section of the channel. The sediment basin will reduce siltation within the marina thereby avoiding the need for ongoing maintenance dredging within the marina basin, which would result in ongoing disturbance of the marine environment.

  This thereby reduces the overall maintenance dredging requirements. The design will include full provision for easy maintenance access by appropriate de-silting equipment.

The small quantities of maintenance dredging material will be generated through the operation of the facility. This material will be used to replenish Putney Beach in addition to the sand bypassing operations (refer to discussions at **Section 3.6.2.1**). No sea disposal of dredged material is proposed for the Project.[12]

The following impacts on sediment transport and coastal processes have been identified:

- maintenance dredging is likely to be required over the course of the marina's operation to maintain minimum required depths for navigation in the entrance channel. Low rates of sediment transport into the entrance channel are predicted, apart from an initial flux of sediment resulting from local morphological adjustment following construction of the breakwaters. Maintenance dredging of the entrance channel is therefore only expected to be required at a frequency of approximately five years or greater, or following a severe tropical cyclone;
- to prevent siltation of the entrance channel by this accreting sand and to maintain the long term sand transport continuity on Putney Beach, periodic bypassing of approximately 5,000 – 7,000 cubic metres of sand every five years would be required from the area between the marina entrance and Putney Point; and
- construction of the marina will result in changes to the size and incident angles of waves on Putney Beach relative to existing conditions. In turn this is predicted to reduce the net sediment transport potential along Putney Beach. The impact of this change is expected to result in a reduction in the rate of shoreline recession currently being observed along Putney Beach and over-time, gradual accretion and progradation of the beach widths along Putney Beach.

2.4 Associated Infrastructure

This section details the requirements for new infrastructure and any proposed upgrades or relocation of existing infrastructure that are associated with the GKI Revitalisation Plan.

2.4.1 Airstrip

The existing airstrip is located between two hills on a 320 degree heading between Fisherman's Beach and toward Long Beach. The airstrip in its current form is only suitable for small aircraft up to the size of Metro II and Twin Otters.

An upgrade of the existing airstrip is necessary to accommodate larger aircraft and greater passenger volumes.

12. *For the purpose of this EIS, beach replenishment is not considered as 'sea disposal' or 'sea dumping'. However, if considered to be 'sea disposal' or 'sea dumping' relevant State and/or Commonwealth approvals would be required.*

The preferred airstrip upgrade option designed by RANDL PTY Limited, as shown in **Appendix R** (refer Option 7b), has the following key components:

- a 30 metre wide, paved and asphalt surfaced runway with an operational length of approximately 1,400 metres compliant with Civil Aviation Safety Authority (CASA) standards for aircraft such as the 74-seat Bombardier Dash 8 Q-400, the 68 seat ATR 72-500/600 and the 104-seat Embraer 190 aircraft;
- an alignment approximately parallel to and offset some 350 metres north of the existing airstrip (**Photograph 2.3**);
- taxiway and apron to park up to two of the design aircraft, one scheduled and one delayed; and
- a basic terminal equipped to provide passenger and checked bag screening appropriate to these aircraft operations as prescribed by the Office of Transport Security.

Photograph 2.3 EXISTING AIRSTRIP

2.4.1.1 Anticipated Flight Frequency and Passenger Numbers

The number of daily arrivals/departures by air once the Resort is fully operational has been forecast by Foresight Partners Pty Ltd as 243 passengers averaged over each year, with a minimum daily average of 189 and a maximum daily average of 309 passengers in the busiest month.

Assuming an 80 percent load factor in the busiest month and 65 percent load factor in the least busy month this would require an available capacity of 290 seats a day would be required, which is equivalent to four Q-400 or ATR 72 aircraft per day upon completion of the entire Resort. This has been adopted as the likely airline schedule with the occasional substitution of the larger Embraer 190 in peak demand periods.

This theoretical schedule equates to eight movements (four return flights) a day or 2,920 movements year, transporting around 180,000 passengers annually.

2.4.1.2 Additional Infrastructure and Ground Activities

Additional infrastructure required to manage these airline operations include typical aircraft ground servicing equipment such as baggage trolleys, belt loader and aircraft ground power unit(s).

To satisfy present-day aviation security requirements a terminal building will be required to house passenger and checked bag screening equipment and to provide a secure departure lounge in which screened passengers can be isolated prior to boarding their aircraft.

2.4.1.3 Impacts on Anchorages Around GKI

The proposed airstrip orientation and formation has been designed to ensure that there is no conflict with high-masted yachts moored at the proposed marina, and no impact other than potential overflights of other anchorages around the Island.

2.4.1.4 Air Service Management Planning

The airstrip will be aligned approximately north-west to south-east (at 125° magnetic) and be designated as Runway 12/30.

Operations at the following airports listed below nautical miles (nm) would not conflict with air traffic to/from the Island:

- Mackay (156 nm NW);
- Proserpine (208 nm NW);
- Hamilton Island (202 nm NNW);
- Bundaberg (238 nm SSE);
- Hervey Bay (307 nm SE); and
- Thangool/Biloela (76 nm SW).

Potential impacts in relation to air transport operations at the nearest regional airports; Rockhampton, 27 nautical miles west-south-west and Gladstone, 44 nautical miles to the south of the Island are discussed below.

The main runway at Rockhampton is aligned north-west to south-east and is designated Runway 15/33. This is the sole runway available for jet and larger turboprop aircraft and it is the preferred runway for noise abatement purposes. The secondary runway, aligned north-east to south-west and designated as Runway 04/22, is used by light aircraft. Operations to the east of the airport are constrained due to the proximity of Rockhampton's metropolitan area.

Aircraft operating in the circuit area could be expected to remain within five nautical miles of the airport. Departures from the Rockhampton Airport turn to the west after take-off.

Large, wide-bodied Regular Public Transport (RPT) aircraft operate to Rockhampton and fast military jet aircraft are also frequent users of the airport. A total of 33,748 movements occurred in 2010/11 of which 40 percent were classed as medium or heavy aircraft (above seven tonnes). There were also 1,548 military aircraft movements at the Rockhampton Airport during 2010/2011.

Rockhampton Airport is designated as Class D airspace and is serviced by an Air Traffic Control Tower. Surrounding airspace steps up to the north and south of Rockhampton to incorporate the air routes and provide airspace protection for instrument flight rules aircraft on descent from or on climb to cruising altitudes. The majority of regular public transport aircraft operating to Rockhampton would be contained within this airspace.

Air traffic in the vicinity of the Island is not impacted by this airspace design and there are no designated air routes except for those to the north and south of Rockhampton, the nearest traversing around 35 nautical miles to the west-north-west of the Island. On this basis there would be little, if any conflict between the Rockhampton and the Island air traffic except for aircraft flying between the two destinations where designated air routes may be established if air traffic levels warrant this.

Military training is conducted at Shoalwater Bay north of Rockhampton. Military aircraft may operate from Rockhampton or Townsville. Several major exercises are conducted annually and Restricted Airspace is prescribed according to the type of activity. This can extend from ground/sea level to as high as 60,000 feet. Civil aircraft may not operate in these areas when they are active and alternate routes clear of the area would have to be planned. This would preclude operations from the Island to the north during periods of activity and require routing over or just north of Rockhampton to avoid these military Restricted Areas.

Gladstone has a single runway running north-west/south-east and is designated as Runway 10/28. Circuits are conducted to the north of the airport to avoid populous areas. None of the local traffic would be impacted by traffic at the Island.

Air routes from Gladstone to the north to Rockhampton follow the coast or track inland and are well clear of the Island.

In summary there are no airports in sufficiently close proximity to impact adversely on air traffic operations on the Island. As the envisaged air services are primarily to service Brisbane or Sydney it is likely that air routes would be established to provide tracking via Gladstone or Bundaberg, and overflying these airports at altitudes that have no impact on local traffic.

The additional volume of air traffic on routes south of Gladstone or Bundaberg will have no substantive impact on air safety.

2.4.2 Road Transport

The Traffic Impacts Report prepared by Opus International Consultants (Australia) Pty Ltd (**Appendix AK**) contains a detailed assessment of the proposed traffic movements on the Island and the mainland associated with the construction and operation phases of the Project. A brief overview of these issues is provided below.

2.4.2.1 Proposed Roads on GKI

To allow for the safe and efficient movement of all road users, it is proposed to have a three tier road hierarchy on the Island as listed in **Table 2.6**.

TABLE 2.6 SUMMARY OF ESTIMATED WORKFORCE FOR STAGES OF DEVELOPMENT

Roadway Classification	Carriageway Width (metres)	Max Design Speed (kph)	Location
GKI access place[1]	5.5	30	Roads serving the majority of the Eco Resort Villas and Eco Resort Apartments in Fisherman's Beach Precinct and Clam Bay Precinct.
GKI access street[2]	5.5	40	• Roads connecting Marine Services Precinct and Fisherman's Beach Precinct. • Main entry roads serving villas and apartments in Fisherman's Beach Precinct. • Main entry roads serving villas in Clam Bay Precinct.
Clam Bay Precinct access road[3]	5.5*	60**	Road connecting Fisherman's Beach Precinct and Clam Bay Precinct.

1. *"Urban Access Place" in **Figure 2.23.***
2. *"Urban Access Street" in **Figure 2.23.***
3. *"Rural Access Road" in **Figure 2.23.***

Source: 'Traffic Impacts Report – Great Keppel Island Resort EIS' (2011) – Opus International Consultants Pty Ltd

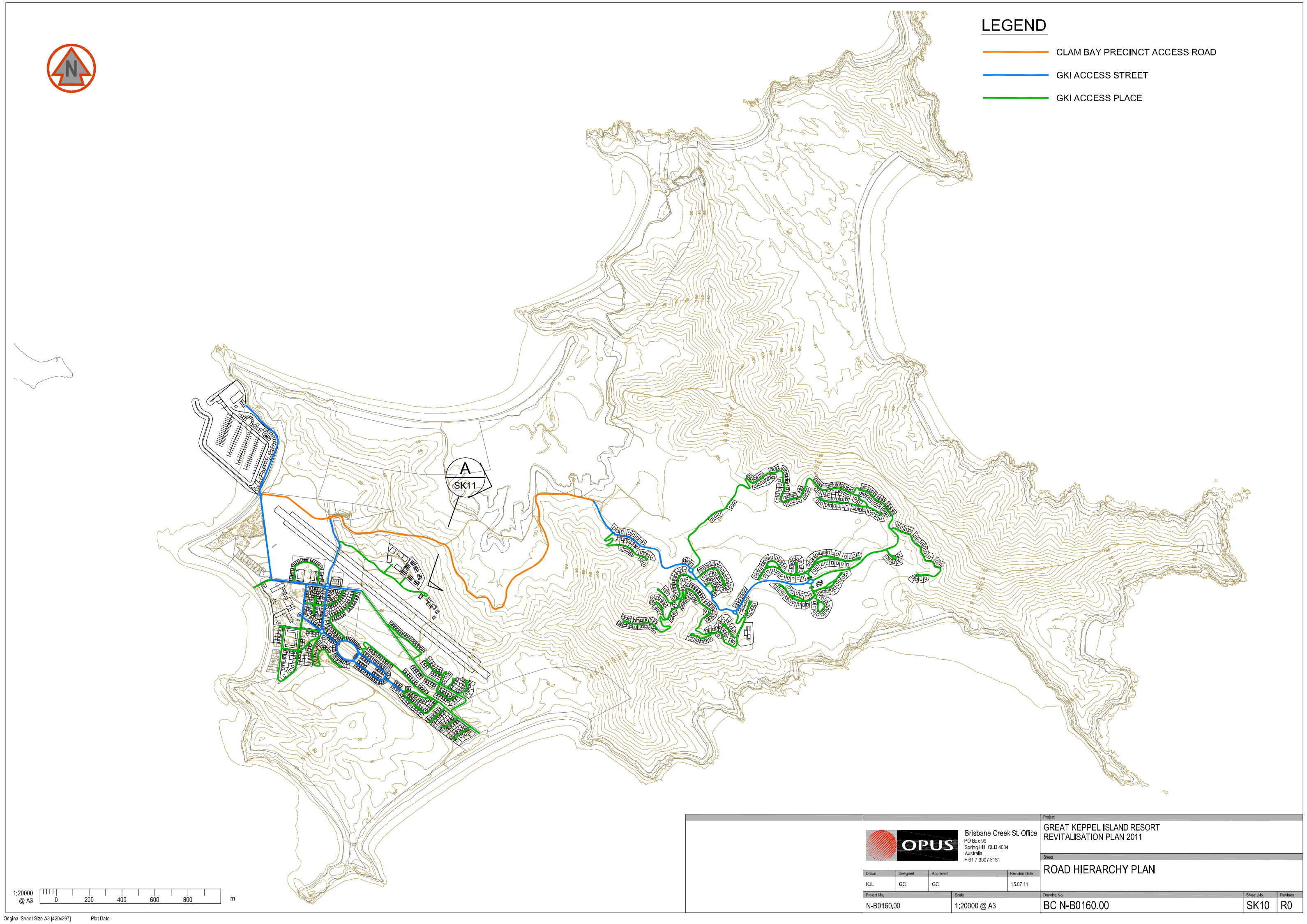
** Additional pavement width may be required for the installation of safety barriers if deemed necessary in the detailed design.*
*** Reduced where road curvature and/or grade warrants reduction.*

It is considered that some roads serving only the Eco Resort Villas could have a carriageway width of four metres, on the basis these roads will be predominantly used by EMRV's and occasional service vehicles. This will be further considered in the detailed design stage at which point the Road-Use Management Plan will be finalised. Traffic volumes on GKI will not be in excess of the design capacity of the road types identified on the Great Keppel Island Resort Road Hierarchy Plan (refer **Figure 2.22**).

The four metre carriageway road discussed above is not shown on the road hierarchy plan and the ultimate locations will be determined during the detailed design stage.

It is proposed to impose a of 30 kilometres per hour speed limit for EMRV use throughout the Resort in the interest of protecting fauna and reducing the risk of collisions or hitting pedestrians.

Figure 2.22 PROPOSED ROAD CLASSIFICATION ON GREAT KEPPEL ISLAND



Source: 'Traffic Impacts Report – Great Keppel Island Resort EIS' (2011) – Opus International Consultants Pty Ltd

2.4.2.2 Traffic Movements on GKI and the Mainland

(a) Traffic Generated Due to Construction Material Transport

Construction-generated truck and barge volumes for the construction phase of the Project were quantified by matching material volumes estimated by Turner and Townsend (**Appendix E** in **Appendix AK**) with the tentative Project Schedule (**Appendix S**), Material Supply Programme (**Appendix F** in **Appendix AK**), and Foresight Partners' construction workforce estimates (refer **Appendix AC**). These reports calculated the required volume of building materials that would be removed and brought onto the Island for the GKI Revitalisation Plan.

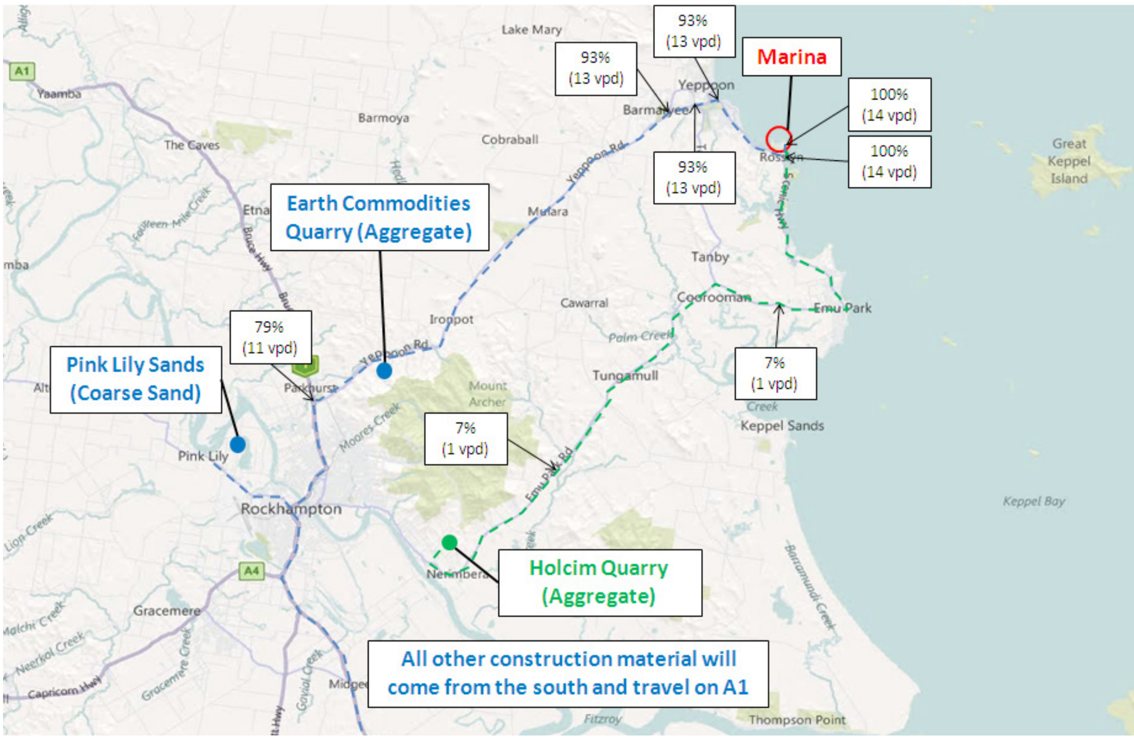
The number of heavy vehicles movements required to transport the total volume of materials was calculated based on the total cubic metres of the material and the likely payload of the vehicles.

The majority of construction materials will be transported to Rosslyn Bay from distribution centres or quarries (**Figure 2.23**). Once the barge terminal is opened, it is proposed that materials will be barged to the Island, where materials will be delivered to a laydown yard to be located on the east side of the public marina (within the Project footprint). The barges will then dock at the newly constructed Island marina which is to be constructed in the first phase of the Project (refer to **Section 2.3.1.4**).

As part of the transport study, assumptions were made on the origin of the trips. Manufactured or pre-fabricated materials are assumed to originate from the major industrial areas in southern Queensland, therefore, materials would be largely expected to come through Rockhampton and Yeppoon via truck to arrive at Rosslyn Bay. Concrete, sand and quarry materials have been assumed to be sourced from local quarries around Rockhampton and Yeppoon.

Resulting analysis identifies a total of 15,310 barge trips to Rosslyn Bay over the course of the 12 year construction program. This averages out to 16 truck trips per day on the mainland over the life of the GKI Revitalisation Plan construction phase and 28 truck return movements for an average day in the peak construction year (currently proposed for 2013). The 28 truck trips per day during the peak construction period comprises less than five percent of total traffic along the Department of Transport and Main Roads state controlled roads. The DTMR's *Guidelines for Assessment of Road Impacts of Development* indicate that impacts of less than five percent on the road network are considered insignificant.

Figure 2.23 ORIGIN OF CONSTRUCTION MATERIALS



The rock armour proposed for the marina is not included in the above truck and barge movement analysis. The present proposal is to source the rock armour from the quarry near Nerimbera (on the Rockhampton to Emu Park Road). There is a boat ramp on the Fitzroy River near the quarry and this would be used to ferry the rock amour to the Island minimising any traffic impact on the local mainland road network.

The anticipated timing of truck deliveries will vary depending on the tide times. These will need to coincide with the barge which may not be able to operate at low tide.

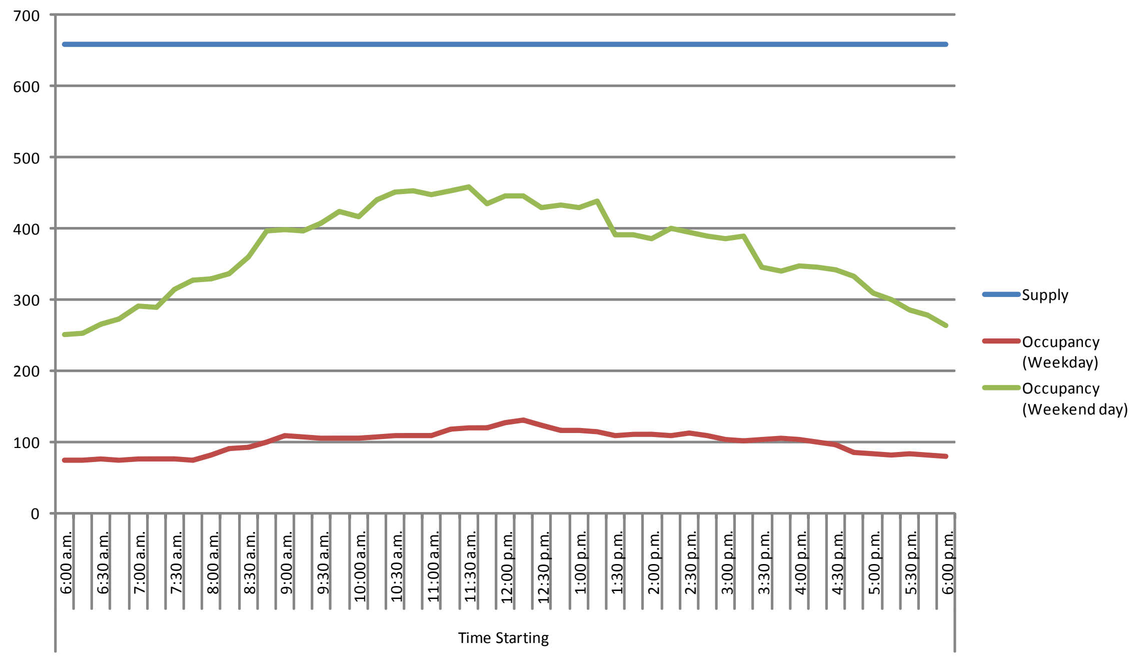
(b) Traffic generated due to Construction Workforce

The construction workforce is expected to average 263 full time equivalent positions per annum over the 12 year construction period. A Traffic Management Plan (TMP) will need to be prepared to address traffic and parking management issues during construction.

The peak times for construction worker traffic generation will typically be between 6:00am to 7:00am when the workers are travelling to the Island. The afternoon peak would normally occur around 3:00pm to 4:00pm, when people are travelling back to their homes, largely via Yeppoon and Rockhampton.

Figure 2.24 presents a supply and demand analysis of car parks by Opus at the Keppel Bay Marina (comprising three public car-parks and one private car park) based on current utilisation. The findings show that presently the car parks are under-utilised (refer **Appendix AK**).

Figure 2.24 EXISTING CAR PARK SUPPLY AND DEMAND (INCLUDING CAR PARK 4)



Source: 'Traffic Impacts report – Great Keppel Island Resort EIS' (2011) – Opus International Consultants Pty Ltd

In addition, the Great Keppel Island Security Car Park at Rosslyn Bay (422 Scenic Highway) contains 270 car parks could also be utilised during and after the construction period, with a shuttle bus link to the Keppel Bay Marina. Based on this information and the proposed program, there are currently sufficient car parks for the construction workforce, without compromising present visitors access to the marina.

(c) Traffic Generated During Operation

The traffic impacts analysis identifies a forecast total of 477 vehicle trips per day by the GKI Revitalisation Plan in its future peak month of operation. Approximately 53 percent of these trips will be from daily commuting staff and 35 percent from visitors. This averages 40 additional vehicle trips per hour over a 12 hour day and, whilst representing an increase in traffic generation in the local streets around the marina, constitutes a small increase elsewhere in the broader road network.

The *DTMR's Guidelines for Assessment of Road Impacts of Development* indicate that impacts of less than five percent on the road network are considered to be insignificant. Several intersections were modelled by Opus taking into account potential traffic growth figures agreed with DTMR and the traffic generated by the Project. The increase in traffic generation due to the GKI Revitalisation Plan was considered negligible and less than the five percent specified by DTMR.

The increase in traffic at the Yeppoon-Emu Park Road / Vin E Jones Memorial Drive intersection was modelled at 10 percent.

Based on traffic counts the majority of current marine traffic entering the Keppel Bay Marina is travelling from the north. This traffic generation corresponds with the population centres of Yeppoon and Rockhampton with 93 percent of commuters living north of Rosslyn Bay. The majority of increased traffic is likewise expected to come from the north to the marina both during construction and operation of the Resort.

It is relevant to note that due to the inclusion of the preferred airstrip option which allows for direct flights to the Island from other centres including Brisbane, Cairns, Sydney and Townsville that the GKI Revitalisation Plan once fully operational is expected to generate traffic on the mainland at levels less than the peak operation of the former resort.

(d) Proposed Transport Routes

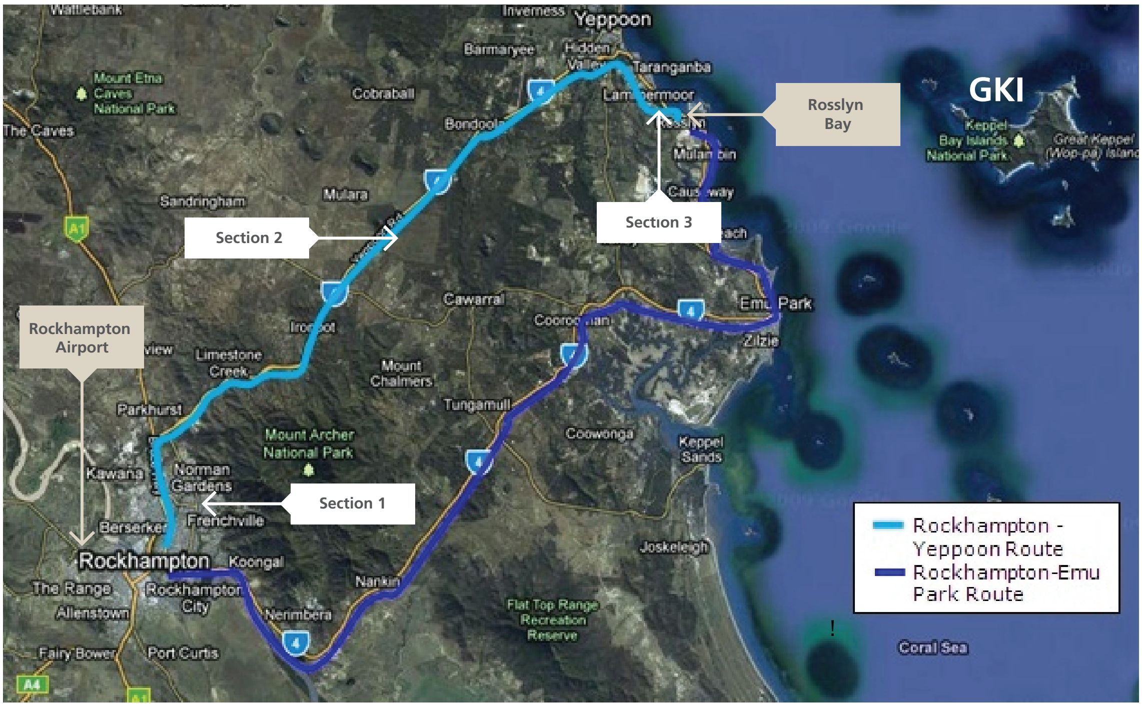
The road network to and from Keppel Bay Marina is relatively limited. **Figure 2.25** shows the two most direct access routes to the marina to be from Brisbane and Cairns. The Rockhampton Region is accessible via the A1 and from Central Queensland via the Capricorn Highway (A4).

From Rockhampton, the most direct route to Rosslyn Bay is the northerly route along the Rockhampton-Yeppoon Road, which then makes a right turn at Yeppoon and continues on Scenic Highway. This is approximately a 40 kilometre trip. An alternative route is the southerly SH4 route along the Rockhampton-Emu Park Road (via Yeppoon, Rosslyn Bay and Emu Park)to the Scenic Highway. This is approximately 55 kilometres long.

The Bruce Highway, Rockhampton-Yeppoon Road and Rockhampton-Emu Park Road are all State-controlled arterial roads providing access between Rockhampton and the coast. The Bruce Highway also provides an inter-regional link for medium and long-haul passenger and freight traffic.

Rockhampton-Emu Park Road and Tanby Road both have two vehicle lanes in each direction. There are no signalised intersections between Rockhampton and Rosslyn Bay along this alternative route.

Figure 2.25 ROUTES TO ROSSLYN BAY FROM ROCKHAMPTON



Source: 'Traffic Impacts Report – Great Keppel Island Resort EIS' (2011) – Opus International Consultants Pty Ltd

The road access to Rosslyn Bay along the Rockhampton - Yeppoon Road route can be divided into the following three key sections (**Figure 2.25**):

- Section 1: Rockhampton and airport along Bruce Highway (A1) to Rockhampton-Yeppoon Road (SH4), approximately eight kilometres;
- Section 2: Rockhampton-Yeppoon Road/ Yeppoon Road to Yeppoon, approximately 30 kilometres; and
- Section 3: Yeppoon-Emu Park Road / Scenic Highway to Keppel Bay Marina, approximately six kilometres

Refer to **Appendix AK** for further detail in relation to the mainland transport routes.

2.4.3 Energy

The GKI Revitalisation Plan has adopted an ambitious sustainability strategy to position it as Australia's first carbon-positive island resort that will produce more energy than it consumes each year. While many eco-resort destinations around the world have sought to achieve sustainability, there are very few that have established this environmental goal as the cornerstone of a comprehensive sustainability strategy.

AECOM (refer **Appendix AG**) have assessed the Resort's proposed energy demands, power infrastructure options, preferred power strategy and potential impacts.

Furthermore, ARUP Engineers (refer **Appendix AH**) have outlined how the preferred power strategy will achieve its 'carbon positive' objective.

2.4.3.1 Existing Energy Infrastructure

The former resort generated its energy from a set of four diesel generators located at the main resort industrial compound. The generators were housed within a corrugated iron structure with no acoustic treatment. In addition, a separate set of diesel generators were located at Long Beach to supply energy for the water supply bore field in the same location.

Now decommissioned, the former resort's energy system was noisy, inefficient and relied solely on the burning of fossil fuels. This was typical of many of the older tourism resorts similarly located on a remote island setting. The GKI Revitalisation Plan's objective to use solar power will re-set the energy supply benchmark for island developments.

2.4.3.2 Estimated GKI Resort Population

The values presented in **Table 2.7** have been adopted in the assessment of power (and telecommunications) demands for the Project.

TABLE 2.7 GKI FORECAST PERSONS (OPERATIONAL PHASE)

Great Keppel Island Forecast Persons	Units	Avg. Annual Occupancy Rate	Persons / Occupied Unit	Annual Person Days
Hotel rooms	250	65 percent	2.2	130,488
Villas and Apartments	1,050	50 percent	2.5	479,063
Marina berths	250	20 percent	2.2	40,150
Day visitors	N/A	N/A	N/A	36,500
Staff accommodation	200	95 percent	1.3	95,760
Staff commuting	N/A	N/A	N/A	48,000
Annual Total	-	-	-	**829,960**
Average per Day	-	-	-	**2,274**

Source: 'Forecast Economic Impacts - Proposed Revitalisation of Great Keppel Island' (2011) – Foresight Partners Pty Ltd (Appendix AC)

2.4.3.3 Estimated GKI Energy Consumption

The estimated annual energy consumption and peak demand of the Resort is to be in the order of:

Energy Consumption (electricity)	11,430,000 kWh/year
Energy Consumption (gas)	2,120,000 kWh/year
Consumption (diesel)	8,376 Litres/year
Peak Demand	6,900 kW

The above indicative energy consumption values are based on all equipment being provided with an electrical supply with the exception of:

- hotel and restaurant kitchens where a gas supply will be utilised; and
- villa and apartment hot water supply where a solar hot water system will be utilised. Solar hot water usage is very common throughout Australia and has a high level of certainty. In the event of solar failure, electric hot water backup will be applied.

The above estimate of energy consumption may be reduced during the future stages of the Project by utilising high performance, energy efficient designs for the buildings to be constructed. The final power demand will be confirmed during the detailed design stage, however, the nominated figures are considered to be the maximum power demand.

The resort buildings will be designed in accordance with the philosophies of Green Star and NABERs (National Built Environment Rating System) 5 star ratings with regard to energy efficient design principles. There are no NABERs rating scheme for any of the buildings being constructed as part of the GKI Revitalisation Plan, hence the philosophies only will be utilised.

The design philosophies will be applied to all components of the buildings (for example, façade design, building design and building orientation) and the systems installed within the buildings, including:

- reliable, high performance, cost effective and energy efficient appliances;
- reliable, high performance, cost effective and energy efficient building services (mechanical, electrical and hydraulic); and
- Building Management Systems (where applicable).

2.4.3.4 Estimated GKI Energy Generation

The GKI Revitalisation Plan has the objective to provide energy in a manner that achieves a carbon positive result for the electrical energy consumed post construction works. To achieve a carbon positive result, a renewable energy supply is required to generate energy which is to be supplied back into the Authority's Electrical Grid. The minimum energy to be generated to achieve a carbon positive outcome (and supplied back into the grid) is dependent on the following factors:

- the Island energy consumption (as discussed in **Section 2.4.3.3**).
- a carbon factor (greenhouse gas coefficient) – as every kilo watt hours (kWh) of electricity consumed produces 1.02 kg CO_2:
    - 11,430,000 x 1.02 = 11,658,600 kg CO_2.
- a carbon factor (greenhouse gas coefficient) – as every kWh of gas consumed produces 0.2 kg CO_2:
    - 2,120,000 x 0.2 = 424,000 kg CO_2.
- a carbon factor (greenhouse gas coefficient) – as every litre of diesel consumed produces 0.73 kg CO_2:
    - 8,376 x 0.73 = 6,114 kg CO_2.
- a five percent buffer factor has been allowed for a carbon positive result during operations and to offset the energy consumed during the construction phase:
    - (11,658,600 + 424,000 + 6,114) x 1.05 = 12,690,000 kg CO_2.

Based on the above consumption figures and factors, the energy required to be generated by a renewable source equates to (dividing the above figure by the carbon factor for electricity):

12,690,000 / 1.02 = 12,440,000 kWh/year (12,440,MWh/year)

2.4.3.5 Power Supply Requirements

A renewable energy supply is required to power the Resort that has the capacity to generate the following:

- Energy Generation 12,440,000 kWh/year

A secondary energy supply is also required to power the Resort that has the capacity to meet the electrical energy consumption and peak power demand of:

- Energy Consumption 11,430,000 kWh/year
- Peak Power Demand 6,900 kW

Alternative standby energy sources are also required to allow for energy generation during times on the Island when the secondary energy source is unavailable, and the renewable power source cannot meet the peak power demand.

2.4.3.6 Power Supply Options

There are several options available for the supply/generation of energy to the Resort. The options fall into two categories:

- those that provide a primary renewable source of energy (the preferred energy supply alternative); and
- those that provide a standby source of power for the Resort. The options for the supply of standby power are limited by the initial decision to create a carbon positive result (refer **Appendix AG** for detail on the options).

2.4.3.7 Preferred Energy Supply Alternative

The energy supply strategy is to position the GKI Revitalisation Plan as Australia's first carbon-positive resort island, that is, it will produce more energy than it consumes each year.

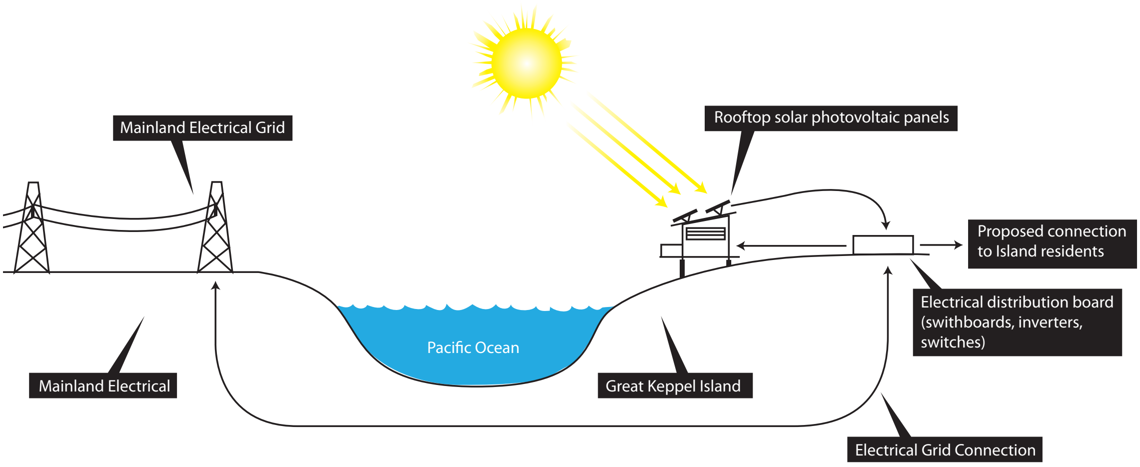
Embracing one of Australia's most significant natural resources – its abundant sunshine – the Project is committed to achieving a carbon positive status through the installation of solar photovoltaic panels on the rooftops of the Eco Resort Villas, hotel and apartment complexes that will generate enough electricity to offset and surpass the emissions resultant from the operation of the Resort.

Since solar power is dependent on available sunlight to generate electricity, photovoltaic installations cannot provide electricity during night time hours without the use of battery storage. While battery storage can be appropriate for totally off-grid installations in remote areas or for small-scale residential development, it often does not make financial or environmental sense for large-scale developments due to the significant size of batteries required to meet potential electrical demands. This is certainly the case with the GKI Revitalisation Plan, which would be expected to have significant night-time electrical demands for cooling and lighting.

In lieu of a battery storage facility, the Project will include a connection to the mainland electrical grid (refer **Figure 2.26**). During sunlight hours, the Resort's expansive solar photovoltaic system will feed excess electricity into the national electrical grid, in effect providing carbon-free electricity to Australian customers. This "feed-in" operation is made possible through synchronising the Resort's electrical infrastructure to the same voltage frequency as that of the national electrical grid connection. Once the sun sets, the Resort will then draw power in reverse to supply its electrical loads at night.

The "carbon positive" aspect of the design is based on the goal of ensuring that the quantity of "feed-in" electricity provided to the grid is greater than the electricity drawn from the grid at night.

Figure 2.26 ELECTRICAL GRID CONNECTION FOR THE PROPOSED SOLAR PHOTOVOLTAIC INSTALLATION FOR THE GKI RESORT



Source: 'Renewable Energy Analysis Report' (2011) - ARUP

In order to achieve 'carbon positive' status, the GKI Revitalization Plan includes the action to install a photovoltaic system of the following size:

- Proposed PV system size - 5.9MW
- Proposed number of panels - 24,320
- Total carbon positive resort-wide buffer - 5 percent
- Total carbon emissions offset - 12,693,150kgCO²/year
- Annual generating potential - 12,444MWh/year

Further information regarding the renewable energy strategy is contained within the ARUP Renewable Energy report in **Appendix AH**.

(a) Electricity Reticulation

An underground electrical infrastructure system is required on the Island to deliver the energy supply to buildings, equipment and services. It is proposed that a 22 kV high voltage grid-connected back-up power supply will also be made available to the Island via a submarine cable which will be terminated into the Island's main substation.

The high voltage will be stepped down to 11 kV for underground reticulation around the Island to supply buildings, equipment and services. Ring main units and transformers will be installed at required locations around the Island to further step down the voltage to 400 V for consumer use. Refer to the AECOM report in **Appendix AG** for a pictorial description of potential substation and generator locations and for schematics of the systems.

As the Proponent will own the infrastructure services from the point of connection on the Island, an easement on the Island is not required. Underground services will be located to enable maintenance access as required.

(a) (i) *Point of Connection*

Several locations on the mainland were selected as potential points of connection, with the main locational considerations being:

- absence of prevailing south-east winds and tides;
- services are either present or can be easily reticulated to the area, including:
    - electricity;
    - telecommunications; and
    - water.
- services present are suitable for the Island needs; for example, voltage of the electrical supply;
- that the community will not be adversely affected; and
- land is available for services buildings; including a telecommunications building and potentially a water pumping station.

Refer to **Appendix Q** for further details regarding the preferred location and proposed submarine cable route.

The solar cells will generate energy at a low voltage which will be stepped up to 400 V for connection to the Island's low voltage reticulated installation. When the solar cells produce more energy than that being consumed, the excess energy will be automatically fed back into the mainland grid via the submarine cable. During the period when the solar cells produce less energy than that being consumed, the grid will provide the excess via the submarine cable.

(b) Diesel Generators

Diesel power generation is to be used as an emergency backup energy source only. Should the submarine cable fail, or any power outages occur, the diesel power generation can be utilised to supply the Resort.

The diesel generators will produce a 400 V supply, which will either be utilised at that location or stepped up to 11 kV for connection to the Island's high voltage reticulated installation. Low voltage (400 V) generators are being considered instead of high voltage (11 kV) due to lead time and costs and to ensure generator maintenance can be carried out by local low voltage contractors rather than high voltage specialists.

For scenarios where the voltage needs to be stepped up to 11 kV for reticulation, transformers will be required.

It is proposed that the stand-by generator power would only service the following:

- Fisherman's Beach Hotel
- sections of the marina, including:
  - emergency services facility;
  - ferry terminal;
  - yacht club;
  - cafes;
  - restaurants;
  - clothing shops;
  - waste collection area; and
  - fire fighting and emergency services hub.
- the golf course facility;
- waste water treatment plant; and
- airstrip operations.

The generators will undergo monthly preventative maintenance tests to ensure optimal performance.

The expected fuel consumption rate during preventative maintenance will be in the order of 698 litres per hour – each generator will be loaded to approximately 80 percent of full load power for a one hour period each month. This equates to a fuel usage of 698 x 12 = 8,376 litres per year for maintenance purposes.

(c) Capital Costs

The following works will need to be undertaken based on the recommendations provided in this section:

- connection to the mainland grid – capital costs to be discussed with Ergon Energy;
- submarine cable – to be paid for by the Proponent;
- solar PV cells – to be paid for by the Proponent;
- diesel generators – to be paid for by the Proponent; and
- reticulation of underground services on the Island – to be paid for by the Proponent.

The proposed energy supply option requires the installation of a submarine power cable between the Island and the mainland. A detailed hydrographic survey and ecology survey have been undertaken to determine the most appropriate route of this cable. Further information regarding the cable route and construction methodology is contained in **Section 2.3.2.7**. To date, discussions have commenced with the mainland energy provider, Ergon Energy and a formal Connection Enquiry has been lodged. Preliminary advice has been received from Ergon indicating in principal that the mainland connection is possible along with a range of potential commercial options.

In the event that the submarine cable is damaged and cannot be repaired promptly, higher powered diesel generators will be hired and transported to the Island to continue to provide additional power required to keep the Resort operational, including providing power to the villas and apartments.

2.4.3.8 Summary of the Proposed Energy Strategy

The GKI Revitalisation Plan has adopted an ambitious sustainability strategy to position it as Australia's first carbon-positive island resort that will produce more energy than it consumes each year.

In order to achieve 'carbon positive' status, the Resort has proposed to install a photovoltaic system of the following size:

- Proposed PV System Size - 5.9MW
- Proposed number of panels - 24,320
- Total Carbon Positive Resort-wide Buffer - 5 percent
- Total Carbon Emissions Offset - 12,693,150kgCO_2/year
- Annual Generating Potential - 12,440MWh/year

In summary, the following measures will be implemented:

- solar PV cells will be mounted on the roof tops of the villas, apartments and hotel to generate electricity;
- energy produced by the solar PV cells will be supplied to the Resort and/or the mainland as detailed below:
    - if supply exceeds demand, the excess generated energy is supplied to the mainland grid via the submarine cable; and
    - if demand exceeds supply, the excess required energy is supplied from the mainland grid via the submarine cable.
- sufficient solar PV cells will be installed to ensure more energy is generated than is consumed by the Project over an annual period; and
- energy demand reduction measures will be explored during the design stages to reduce the overall demand of the Project. This will be achieved by:
    - reliable, high performance, cost effective and energy efficient appliances;
    - reliable, high performance, cost effective and energy efficient building services (mechanical, electrical and hydraulic); and
    - Building Management Systems (where applicable).

2.4.4 Telecommunications

A telecommunications technical report has been prepared by AECOM and is provided in **Appendix AG**. This report outlines the Resort's proposed telecommunication demands, telecommunication infrastructure options, preferred telecommunication strategy and potential impacts.

2.4.4.1 Existing GKI Telecommunications Infrastructure

The former resort utilised communications originating from Telstra and Optus telecommunications networks. The infrastructure consisted of towers serving as a mobile phone bases, ADSL capable equipment, normal telephony and ISDN equipment.

The energy required for the equipment on the towers was supplied via solar panels and a diesel generator backup independent of the Resort.

2.4.4.2 Estimated GKI Telecommunications Requirements

A telecommunications system is required to serve the requirements of the Revitalisation Plan, including:

- telephone and IP telephony;
- video phone / conferencing;
- television;
- video on demand; and
- radio.

Usage of the telecommunications service has been divided into two categories: low users and high users. The estimated average daily usage amounts for low and high users is provided in **Table 2.8**:

TABLE 2.8 TELECOMMUNICATIONS USAGE DETAILS

Description	Low User (LU)	High User (HU)	Comments
Internet	0.55 Mbps	10 Mbps	-
Telephone	0.1 Mbps	0.15 Mbps	HU includes VoIP
2 SDTV Channels	-	6 Mbps	Streaming TV
1 HDTV Channels	-	32 Mbps	Streaming TV
Mobile Devices	-	1 Mbps	Blackberry's, I-phones and I-pads
Totals	**0.65 Mbps**	**49.15 Mbps**	**-**

Source: 'GKI Power and Telecommunications Infrastructure' (2011) - AECOM

During the high season when the number of visitors is at peak levels, the broadband usage per day is estimated at two hours per visitor. The number of people on line at any one time during the high season has been conservatively estimated at 40 percent. Based on the assumptions of internet usage (presented in **Table 2.8**) the average bandwidth requirements have been determined, as presented in **Table 2.9**):

TABLE 2.9 BANDWIDTH REQUIREMENTS

Great Keppel Island Forecast Persons	Bandwidth Requirements HU (Mbps)	Diversity HU (Mbps)	Bandwidth Requirements LU (Mbps)	Diversity LU (Mbps)
Hotel rooms	12,038	261	163	3.52
Villas and Apartments	50,558	843	683	11.38
Marina berths	12,038	80	163	1.08
Day visitors	-	-	-	-
Staff accommodation	9,630	305	130	4.12
Staff commuting	-	-	-	-
Totals	**84,263**	**1,489**	**1,138**	**20.10**

Source: 'GKI Power and Telecommunications Infrastructure' (2011) - AECOM

High Users (cumulative)	1,489 Mbps
Low Users (cumulative)	20 Mbps

The current capacity of the existing telecommunications towers is 16 Mbps, which is less than the predicted requirement for low end users alone. Installation of additional telecommunications services will be required to meet the demand of both low and high end users.

2.4.4.3 Telecommunications Supply Options

There are several options available for the supply of communications to the Island, these options include the below.

(a) Mobile / Radio Tower – Existing Situation

The existing telecommunications on the Island is limited in capacity . While it can be utilised as a standby supply, there is insufficient capacity to provide the level of service typically required for a Project of this size and type.

The advantages of the tower include:

- existing installation – no additional impact to the environment.

The disadvantages of the tower include:

- limited capacity; and
- slow speeds.

(b) Mainland Exchange

A connection can be made to the mainland exchange by installing a fibre optic submarine cable from the mainland to an exchange on the Island. The cable will be buried in the sea bed for protection (as outlined in **Section 2.3.2.7**).

There are several carriers available (including Telstra and Optus) for connection to the Island. A small air conditioned exchange building (approximately 7 metres x 4 metres) will be constructed at the mainland point of connection (refer to **Appendix Q**) for the installation of telecommunication racks. Typically the building will house one rack per carrier as well as one rack for the Proponent. The Proponent's rack will be connected to the submarine cable which will incorporate a set number of fibre cores for each of the carriers.

The advantages of the fibre optic submarine cable include:

- having access to a reliable exchange when required;
- access to multiple carriers; and
- fast internet and download performance.

The disadvantages of the submarine cable include:

- the environmental impact of disturbing the sea bed during installation;
- potential loss of visual amenity as an exchange building will be required to house telecommunications equipment at the "Point of Connection" and another exchange building on the Island (in the Industrial Compound); and
- the Proponent will be required to own and maintain the cable that is buried within the sea bed.

(c) Preferred Telecommunication Infrastructure Alternative

A submarine cable is required for connection back to Ergon's mainland grid for the exporting of excess renewable energy to allow for a carbon positive result. A fibre cable can be incorporated into this power cable and connected to the mainland exchange. This will allow several high speed telecommunications systems to be utilised on the Island. Additional fibre cores can be installed to allow for spare capacity and changes in use as future devices allow for faster download speeds without having to upgrade the submarine cable. A number of fibre cores (say 144 within the submarine cable) will provide an abundance of bandwidth for users.

It is recommended to retain the existing Telstra tower as a standby system to allow for limited communications to continue in the event of the submarine cable experiencing any problems.

2.4.5 Water Supply and Storage

A Water Cycle Management Report has been prepared by Opus International Consultants (Opus) which provides an overview of proposed water cycle management strategies associated with the GKI Revitalisation Plan, including water supply, wastewater and stormwater management (refer **Appendix AN**).

The GKI Revitalisation Plan has been developed in accordance with the principles of Water Sensitive Urban Design (WSUD). WSUD is a holistic approach to the planning and design of urban development that aims to minimise negative impacts on the natural water cycle and protect the health of aquatic ecosystems. It promotes the integration of stormwater, water supply and sewage management at the development scale.

WSUD represents a fundamental change in the way urban development is conceived, planned, designed and built. Rather than using traditional approaches to impose a single form of urban development across all locations, WSUD considers ways in which urban infrastructure and the built form can be integrated with a site's natural features. In addition, WSUD seeks to optimise the use of water as a resource through the following key principles:

- protect existing natural features and ecological processes;
- maintain the natural hydrologic behaviour of catchments;
- protect water quality of surface and ground waters;
- minimise demand on the reticulated water supply system;
- minimise sewage discharges to the natural environment; and
- integrate water into the landscape to enhance visual, social, cultural and ecological values.

The proposed water cycle management strategy for the Revitalisation aims to:

- minimise demand on limited water resources, particularly potable water supplies, by maximising water use efficiency and maximising the use of alternative water supplies (e.g. rainwater, treated effluent, harvested stormwater) for non-potable purposes;
- maximise the beneficial reuse of wastewater and reduce the volume of wastewater requiring disposal;
- ensure wastewater is adequately treated to a standard 'fit for purpose' prior to reuse or disposal to reduce the risk of potential environmental and public health impacts;
- ensure the collection, storage and reuse or disposal wastewater during construction and operation of the GKI Revitalisation Plan does not adversely impact on the natural environment or communities on and off the Island;
- ensure stormwater is adequately treated to reduce the risk of potential impacts on the environmental values of receiving waters;
- ensure stormwater is managed to maintain existing hydrologic behaviour by providing appropriate detention where necessary to ensure non-worsening of peak discharge velocities;

- ensure water cycle management infrastructure, including stormwater quality improvement devices, detention basins and treated effluent storages, is designed and located to integrate into the landscape to enhance visual, social, cultural and ecological values; and
- continually improve the process for managing water supply, wastewater and stormwater associated with the GKI Revitalisation Plan by conducting regular audits to identify opportunities to reduce, reuse or recycle waste, including wastewater, and to prevent environmental harm.

The Proponent acknowledges that valuable water resources on the Island were poorly managed during operation of the former resort and outlines a strategy that will provide water security for the GKI Revitalisation Plan.

Photograph 2.4 DAM ON GKI

2.4.5.1 Construction Water Supply Requirements

Water supply (including for fire fighting) for Stage 1 construction will be sourced from two production bores installed within the Long Beach Aquifer. These bores will only be operational for a short period of time whilst the mains supply is brought across from the mainland. These bores will need to be equipped, possibly with solar operated pumping systems. The maximum continuous extraction rate per production bore is 50 kL/day (Douglas Partners, 2011), or a combined total of 100 kL/day for the aquifer.

Estimated water demand for Stage 1 construction is approximately 5 megalitre per annum for construction (say an average of 20 kL/day for 250 working days and, with a peaking factor of two, a peak day of 40 kL/day) and up to 50 kL/day for domestic purposes for construction workers. Total Stage 1 construction water demand would thus peak at around 90 kL/day. This is within the sustainable yield of the Long Beach Aquifer. Accordingly, the existing production bores within the Long Beach Aquifer are expected to provide adequate water supply to meet the full demand for Stage 1 of construction until the water supply connection from the mainland is installed and commissioned. Once the mainland water supply connection is operational, no further extraction of groundwater resources is proposed for construction or operation of the Resort.

2.4.5.2 Operational Water Supply Requirements

Information derived from Section 3.2 of the "Forecast Economic Impacts Report"(**Appendix AC**) prepared by Foresight Partners has been used as the basis for an estimation of equivalent persons and for occupancy levels for the Project.

Table 8.8 in **Appendix AN – Water Cycle Management Report** presents the EP calculations adopted for the purpose of determining the water supply and sewage demands for the GKI Revitalisation Plan.

Based on the analysis contained in the Water Cycle Report, the maximum projected population for design purposes for the GKI Revitalisation Plan is estimated to be 3,973 EP.

(a) Water Demand by Project Stage

The predicted increase in the volume of water required from the mainland water supply and the volume of recycled water available for irrigation based on the proposed staging is provided in Table 2.14 of **Appendix AN**.

(b) Per Capita Water Demand

As outlined in **Appendix AN**, the average daily water demand of the Resort per EP would be:

- 180 L/EP/day (internal demand);
- 48 L/EP/day (external demand); and
- 228 L/EP/day (total water demand).

The adopted average daily water demand of 228 L/EP/day with water saving fixtures compares to the following:

- 137 to 194 L/person/day from the Draft Urban Water Use Study of South East Queensland (NRM, 2005) for a "resort, hotel, motel" unit with standard fixtures. The adopted figure of 228 L/EP/day thus includes a significant design contingency of 17.5 percent (228 / 194 = 1.175) and / or is a reflection of the likely higher usage of water associated with the tropically located Resort.
- 540 L/person/day from the Livingstone Shire Planning Scheme based on three persons per ET. Note that this is for urban situations with larger housing lot sizes and thus more garden watering etc.
- 180 to 300 L/person/day estimated range derived from Great Keppel Island Water, Wastewater Infrastructure Audit Report, 13 September 2007 prepared by Sustainable Solutions International Pty Ltd. The median value was 250 L/person/day.
- 177 L/person/day for internal residential consumption Hummock Hill Island Feasibility Investigation, 11 July 2007 prepared by Cardno. In comparison, an internal water demand of 180 L/EP/day out of the total 228 L/EP/day is estimated for the GKI Revitalisation Plan.
- 134 to 199 L/person/day from Draft Urban Water Use Study of Southeast Queensland (NMR, 2005) for Holiday Accommodation (houses, units, townhouses).

The average daily water demand for each of the facilities within the GKI Revitalisation Plan will be confirmed during the detailed design stage.

(c) Fire Fighting Water Supply

Fire fighting flows will be provided by the provision of dedicated fire storage within the water storage reservoirs, fire pumps (if required following assessment in the detailed design stage) and the provision of fire hydrants and hose reels within the water reticulation system adjacent to the various buildings.

A fire flow of 25 L/sec with a minimum of four hours fire storage capacity (a total of 360 kL) would be proposed for all Resort facilities. The fire fighting flow for the larger buildings such as the Resort / core facilities will depend upon the final level of fire compartmentalisation provided through structural building design. The system will be assessed during the design stage to cater for fire flows commensurate with the level of fire compartmentalisation provided.

It is anticipated that fire fighting services for the GKI Revitalisation Plan will be:

- similar to a small rural fire service with light vehicle(s), small tank and pumps for minor grass fires and hydrant hoses for use with the fixed hydrants in the reticulation system; and
- operated by the maintenance staff supplemented by volunteers from the general Resort staff, with appropriate training.

(d) Golf Course Irrigation

The reuse of wastewater on the golf course is a critical element of the water management system. Estimated rates of irrigation required to maintain the golf course based on average rainfall and evapo-transpiration have been provided by Greg Norman Golf Course Design. Irrigation at the rates specified by the golf course designer is only proposed for parts of the golf course comprising tees, greens and fairways rather than the entire golf course.

As such, estimation of the total volume of irrigation water required is based on the rates specified by the golf course designer multiplied by the estimated area of tees, greens and fairways. Based on reference to a report published by the Environmental Institute of Golf (2006), it has been estimated that the area of tees, greens and fairways accounts for approximately 49 percent of the total area of maintained turf, which in this case, equates to 49 percent of 31 hectares or approximately 15.2 hectares

Photograph 2.5 GREG NORMAN GOLF COURSE, DOONBEG, IRELAND

(e) Total Water Demand

Monthly water demand figures for the golf course and core resort facilities as described have been used to formulate **Appendix E** in the *Water Cycle Management Report* (refer **Appendix AN**) which includes the following:

- Overall Water Balance Summary; and
- Monthly Water Balance - January to December.

Table 2.10 summarises relevant average and peak water demand figures. The sources of water proposed to meet this demand are listed in **Section 2.5.5.6**.

TABLE 2.10 COMPARISON OF AVERAGE DAILY WATER DEMAND WITH PEAK DAILY WATER DEMANDS

Estimated Water Demand	Internal	External	Total
Average Daily Water Demand[1]	493 kL/day	1,391 kL/day	1,884 kL/day
Peak Occupancy Month - Water Demand (January)[2]	855 kL/day	1,426 kL/day	2,281 kL/day
Peak Month – Water Demand (November)[3]	527 kL/day	1,942 kL/day	2,469 kL/day
Maximum Internal and External Water Demand	855 kL/day	1,942 kL/day	2,797 kL/day

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

Note:

1. Average over 12 months based on total water usage over 12 months assuming average occupancy from **Appendix E** *in* **Appendix AN** - *Water Cycle Management Report.*

2. Peak Occupancy occurs in January. Internal water demand is at its highest during this month, but total water demand is not at its highest as rainfall and availability of recycled water for irrigation reduce the demand for external irrigation water supplies.

3. Peak Monthly Water Demand occurs in November. Although typical occupancies are less than in January, total water demand is at its highest due to the demand for irrigation water supplies at the end of the typical dry season.

There will always be a degree of uncertainty in relation to the actual water supply demand figures that should be used for water supply schemes both in terms of the expected occupancy and per capita water usage. This is not a unique issue for an island resort, but is exacerbated by the high variability in terms of occupancy. As such, the adopted water supply system will need to be designed with a degree of flexibility to account for these uncertainties.

2.4.5.3 Water Supply Sources

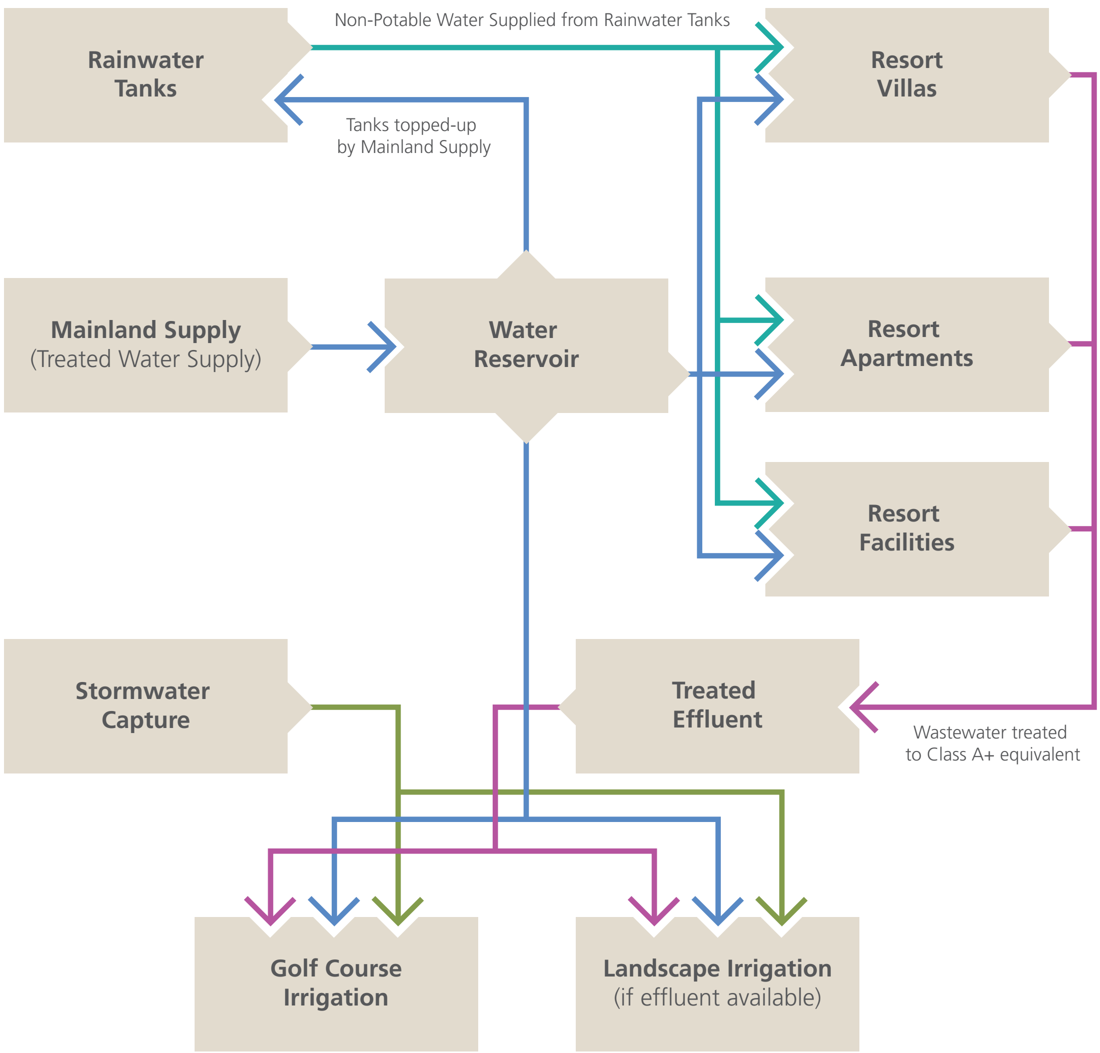
A number of water supply sources are available to meet the projected water demands of the GKI Revitalisation Plan. The preferred water supply sources for operation of the Resort as determined through the review of options and available water sources, as discussed below, are further outlined in **Appendix AN -** *Water Cycle Management Report* and summarised in the following sections. **Figure 2.27** shows a schematic of the proposed water cycle scheme on the Island.

- Potable Water Supply:
  - potable water sourced from the water treatment facilities operated by Rockhampton Regional Council / Fitzroy River Water on the mainland
- Non-Potable Water Supply:
  - treated effluent produced from treatment of sewage effluent at the Island-based WWTPs;
  - harvested stormwater runoff from the golf course;
  - harvested stormwater runoff from resort hardstand areas;
  - rainwater collected from roof areas; and
  - potable water sourced from Rockhampton Regional Council/'s water treatment facilities (to supplement above sources only)

Groundwater resources are also available; however this resource has been identified for water supply to the Stage 1 construction only and will not form a fundamental component of the overall water supply strategy for the GKI Revitalisation Plan during operation.

The following section provides an estimate of the amount of water supply that is likely to be derived from each of the above sources to meet the total water demands of the Project.

Figure 2.27 GKI REVITALISATION PLAN – WATER SUPPLY SCHEMATIC



Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

(a) Rainwater Collection

In accordance with the Queensland Development Code (QDC), once the facilities are connected to a mains water supply, such as is proposed by the mainland connection to Council water supply, rainwater collection and reuse for toilet flushing, laundry and external use is mandatory. As such, rainwater collected from roof areas will be used as the primary source of water supply for internal non-potable uses (e.g. toilet flushing, laundry) and some external non-potable uses (e.g. car and boat washdown, garden watering, hosing down of hardscape).

Notwithstanding, the extent of rainwater use also depends on the availability of stored rainwater. The availability of stored rainfall depends on the amount of rainwater that can be collected, which depends primarily on the amount of rainfall, the roof area available for collection and the storage capacity of the rainwater tanks. During the design stage of the Project, the viability of increased rainwater reuse for apartments and villas will be investigated. This would involve ultra violet (UV) disinfection of the potable use component. Opus International Consultants Pty Ltd estimated that 100 percent of the demand for the apartments and villas would be available for the months of December to June inclusive and, in median rainfall years, up to 50 percent or more in the months of July to November inclusive.

It is estimated that approximately 68 L/EP/day or about 30 percent of total water demand for apartments and villas is likely to be met by rainwater reuse. This compares to a total potential rainwater reuse of 103 L/EP/day that could be achieved if sufficient rainfall, tank storage capacity and roof area was available to ensure enough rainwater was stored and available to meet demand throughout the year.

For the other resort facilities, such as the Hotel and retail / commercial components, which have limited roof area for rainwater collection relative to the numbers of occupants, it has been assumed that only approximately 28 L/EP/day or about 12 percent of total water demand is likely to be met by rainwater reuse.

As the level of rainwater use depends largely on the availability of rainwater, it has also been assumed in the water balance calculations, that during lower rainfall months (i.e. July through to November), rainwater reuse for the apartments and villas may be approximately 28 L/EP/day.

Rainwater collected from roof areas of individual buildings / facilities will be stored in on-site tanks (**Photograph 2.6**) adjacent to the collection location. Rainwater tank storage will be plumbed back into the buildings / facilities for use in toilets and washing machines as well as connection to external hose cocks for rainwater use in garden watering and other external use.

Photograph 2.6 RAINWATER TANKS

(b) Recycled Water

Recycled water produced from treatment of sewage effluent at the Island-based WWTPs will be used as the primary source of water supply for irrigation of the golf course. Although not expected, any excess recycled wastewater (if available) would be used for irrigation of other landscaped areas.

Although the estimated wastewater flow (ADWF) for the GKI Revitalisation Plan is 180 L/EP/day, to account for losses in the treatment process (e.g. water content in sludge), it has been conservatively assumed for the purpose of the water balance, that only about 95 percent or 171 L/EP/day of wastewater influent to the WWTP will be discharged from the WWTP as recycled water available for reuse.

As such, during peak occupancy in January, the average daily volume of recycled water available is estimated to be approximately 641 kL/day. The daily volume of recycled water available on average over a year is estimated to be approximately 370 kL/day.

(c) Harvested Stormwater (Golf Course)

Harvested stormwater runoff from the golf course will be used as a supplementary source of water supply for irrigation of the golf course and other landscaped areas. Harvested stormwater runoff from the golf course will be collected in a series of ponds incorporated into the golf course and stored for reuse.

In addition to providing an alternative source of water to reduce demand from Council's potable water supply, harvesting of stormwater from the golf course will also enable runoff from the golf course to be monitored and where necessary, treated, prior to release to downstream waterways. Stormwater harvesting ponds will therefore be multi-purpose serving as water features enhancing the amenity of the golf course and surrounding villas while also providing a source of irrigation water supply and stormwater quality improvement.

(d) Harvested Stormwater (Other Areas)

Harvested stormwater runoff from resort hardstand areas may be used as a source of water supply for irrigation of landscaping and washdown of hardscape areas around the Resort, adjacent to areas of collection.

The harvesting of stormwater from these areas will be assessed in detail during the detailed design stage. Depending upon the practicalities and economics, it may be more beneficial to collect additional rainwater from roof water collection via larger storage tanks.

(e) Mainland Water Supply

Connection to Council's mainland water supply will provide a reliable, flexible and secure high-quality water source for the Resort. Although a mainland connection has the potential to supply 100 percent of the Project's water demands, this approach would not be consistent with the sustainability objectives of the GKI Revitalisation Plan, which aim to maximise water use efficiency and use of alternative water supplies for non-potable purposes to reduce pressure on limited water resources.

As such, the mainland water supply connection will be capable of providing 100 percent of the total potable water demand for the Project but will only be used to supplement other available water supplies for non-potable purposes as described above. Potable water sourced from Council/ Fitzroy River Water's water treatment facilities on the mainland will therefore be used as the sole source of water supply for potable purposes such as drinking water, cooking and showers. This will be subject to further assessment of rainwater reuse for potable purposes to the apartments and villas – which will be further assessed in the design stage.

Advice from Rockhampton Regional Council indicates that sufficient water is available from its facilities to meet the above demands projected for the GKI Revitalisation Plan. However access and usage charges will apply.

The total volume of water derived from this source will depend on demand but is expected to range between an average of approximately 1,275 kL/day and a maximum peak of 2,270 kL/day, including water required for potable and non-potable purposes."

Photograph 2.7 FITZROY RIVER

2.4.5.4 Emergency Water Supply

In the event of a disruption to the potable water supply connection to the mainland the following contingency strategy is proposed:

- stored potable water in reservoirs on the Island will be preserved by restricting water usage from this supply to essential purposes only (i.e. domestic use only). Assuming reservoirs are full and allowing for dedicated fire storage, at least three days storage at peak day demand of 968 kL/day and at least seven days storage at average day demand of 397 kL/day would be available for domestic uses. With water restrictions in place, the number of days of supply should be able to be significantly extended;
- suspend use of mainland water supply for irrigation and limit irrigation to use of recycled water and harvested stormwater;
- if required, arrange for additional potable water supplies to be transported by barge across from the mainland; and
- undertake remedial repairs of the mainland water supply connection..

In the event of an extended disruption to the mainland water supply connection, consideration may need to be given to reducing guest occupancy and staffing to ensure that adequate water is available.

2.4.5.5 Water Supply Infrastructure

(a) Mainland Connection

A 16 kilometre water main will be installed within the Utility Services Corridor to connect water supply infrastructure on the Island with Council/ Fitzroy River Water's existing water supply infrastructure located near the Scenic Highway at Emu Park on the mainland. This water will be treated water from the Fitzroy River (**Photograph 2.7**)

(b) Storage

Potable water storage on the Island will consist of the following:

- storage tank (to receive the mainland supply) and pumps adjacent to the Marine Services Precinct to pump to high level water storage tanks;
- high level water storage tanks to serve the two potable water reticulation systems: one for the Fisherman's Beach and Marine Services Precincts and the other for the Clam Bay Precinct. Both systems are proposed to be serviced by high-level water storage tanks fed by trunk delivery mains from the mainland supply via the tank and pumps adjacent to the marina;

- the storage tank(s) for the Fisherman's Beach and Marine Services Precincts is likely to be in the order of three megalitres in size. This would allow for 0.36 megalitres of fire storage and around 3.5 days storage capacity at the January day peak domestic demand of 726 kL/day (75 percent of 968 kL/day) and around eight days storage capacity at the annual average daily domestic demand of 298 kL/day (75 percent of 397 kL/day); and
- the storage tank(s) for the Clam Bay Precinct is likely to be in the order of one megalitre in size. This would allow for 0.36 megalitres of fire storage and around three days storage capacity at the January day peak domestic demand of 242 kL/day (25 percent of 968 kL/day) and around seven days storage capacity at the annual average daily domestic demand of 99 kL/day (25 percent of 397 kL/day).

Other water storage on the Island will include the following:

- rainwater tanks associated with the collection and storage of roof water for reuse for non-potable purposes (toilets, laundries, garden watering and washdown);
- individual rainwater tanks will be provided for each apartment and villa (either proprietary above-ground tanks or underground tanks built within the foundations under the buildings where space or amenity issues exist);
- combined rainwater storage tanks will be provided for central core facilities including the Hotel, as well as other commercial/retail facilities such as the Marina Village, golf clubhouse and airport terminal;
- underground or open surface storages for harvested stormwater. These could be open lined ponds, proprietary underground storage systems or purpose built underground tanks depending on space availability and amenity issues. Alternatively, if determined in final design to be more efficient and economic, larger tanks may be incorporated into the rainwater tanks to capture additional roof rainwater. This would generally be advantageous with roof rainwater being of higher quality than stormwater runoff from ground areas;
- open lined storage ponds on the golf course for collection and reuse of stormwater runoff for irrigation purposes. These ponds will incorporate stormwater quality improvement to treat stormwater runoff from the golf course prior to discharge of captured stormwater not required for irrigation; and
- an open lined storage pond for recycled water to provide balancing storage associated with the reuse of recycled water for irrigation of the golf course (and other areas if required). This pond system has been sized to balance the storage of inflow recycled water produced by the WWTP with the volume of water required for irrigation, such that recycled water will be stored during wet weather when soil conditions preclude irrigation.

(c) Distribution

Potable water distribution will consist of the following:

- two potable water reticulation systems are proposed, including one servicing the Fisherman's Beach and Marine Services Precincts and the other servicing the Clam Bay Precinct;
- both systems are proposed to be serviced by high-level water storage tanks fed by trunk delivery mains from the mainland supply via tank and pumps near the Marine Services Precinct. Some higher elevation accommodation facilities may require small booster pumps to deliver reticulated water supply; and
- potable water reticulation will be installed to service all resort accommodation, commercial and retail facilities, along with some landscaped areas such as the golf course to supplement irrigation supplies.

A risk assessment of potential environmental impacts associated with water supply component of the water cycle management aspects of the GKI Revitalisation Plan has been undertaken and is described in Table 2.22 of the Water Cycle Management Report (**Appendix AN**), along with proposed mitigation measures to address each identified risk.

2.4.5.6 Summary of the Proposed Water Supply Strategy

The proposed water supply management strategy has been designed to:

- protect existing natural features and ecological processes;
- maintain the natural hydrologic behaviour of catchments;
- protect water quality of surface and groundwaters;
- minimise demand on the reticulated water supply system;
- minimise sewage discharges to the natural environment; and
- integrate water into the landscape to enhance visual, social, cultural and ecological values.

Based on an evaluation of available water resources, the most suitable and sustainable means of providing water supply to the GKI Revitalisation Plan will include a combination of the following:

- a mainland water supply connection via a new pipeline installed within the Utility Services Corridor;
- installation of rainwater storage tanks for all resort buildings to capture and reuse roof water for non-potable purposes (e.g. toilet flushing, washing machines and garden watering);
- installation of stormwater harvesting and storage facilities throughout the Resort area, and reuse of harvested stormwater for landscape irrigation and hardscape hose down (subject to further assessment in the design stage);
- reuse of recycled water produced from effluent generated by the Resort for irrigation of the golf course and possibly other landscaped areas; and
- incorporation of stormwater harvesting ponds within the golf course to capture runoff and reuse for irrigation of the golf course.

Substantial groundwater resources are available on the Island and have the potential to supply up to 36 percent of the total mains water demand for the GKI Revitalisation Plan with a total combined maximum yield for all aquifers of 460 kL/day, including a maximum yield of 270 kL/day from the North East Aquifer alone. However, use of groundwater as a primary water supply source during operation was not considered appropriate due to the potential for saline intrusion as shown by the historically poor management of this resource on the Island. Rather, apart from short-term, small-scale use for Stage 1 construction water supply, groundwater aquifers will be allowed to recover from past overuse so as to provide a better quality and more sustainable resource for other Island users.

Although desalination could potentially meet the full water demands of the Project and was used by the previous resort, operation of a desalination plant on the Island would significantly increase energy consumption and would involve discharge of highly saline brine into the Marine Park. As such, this water supply option was not considered to be consistent with the sustainability objectives of the GKI Revitalisation Plan.

Rainwater tanks are considered to be an integral component of the proposed water supply strategy for the GKI Revitalisation Plan. Although not capable of supplying the total water demands of the Project, rainwater tanks comprise a relatively low energy, low cost, easy to maintain and sustainable method of supplying water to significantly reduce overall mains water supply requirements.

Opportunities have also been identified within the GKI Revitalisation Plan to capture and reuse stormwater runoff for irrigation of the golf course and landscaped areas. In addition to providing an additional source of irrigation water supply, harvesting of stormwater runoff from the golf course will assist in intercepting any residual fertilisers that may remain on the golf course enabling these nutrients to be reused via irrigation and preventing their release to natural waterways downstream.

2.4.6 Stormwater Management

This section describes the proposed stormwater management strategy developed for the GKI Revitalisation Plan to prevent any adverse impacts on receiving water quality and stability, and to prevent any flooding of resort facilities and neighbouring properties. Further details regarding the stormwater management strategy are contained in **Appendix AN – Water Cycle Management Strategy.**

Construction of buildings and infrastructure associated with the GKI Revitalisation Plan will increase the total area of impervious surfaces on the Island and will decrease the area of pervious surfaces. An increase in impervious area will increase surface runoff volumes and peak flow rates for stormwater discharges to receiving waterways, which has the potential to cause scouring and erosion, and decreased waterway stability within receiving waters and increase the risk of flooding if unmitigated.

Stomwater runoff from developed areas within the GKI Revitalisation Plan also has the potential to transport pollutants via stormwater drainage systems to downstream waterways. The main pollutants of concern for this type of project typically comprise gross pollutants, hydrocarbons, sediment and nutrients, particularly nitrogen and phosphorous. These pollutants have the potential to impact on water quality in receiving waters, affecting the health of aquatic ecosystems they support and the suitability of these waters for uses such as recreation.

A stormwater management strategy incorporating flow mitigation and stormwater quality improvement devices has therefore been developed to reduce the potential impacts.

In accordance with WSUD principles and best practice environmental stormwater management, stormwater drainage systems incorporated into the GKI Revitalisation Plan will primarily utilise surface drainage techniques (such as grassed swales) rather than traditional underground piped drainage systems. This will minimise the need for significant excavation for installation of stormwater pipe trenches while also enabling stormwater drainage systems to be utilised as landscape features.

Development areas proposed under the GKI Revitalisation Plan primarily fall within the following catchments (refer **Figure 2.28**):

- 5 - Clam Bay (66.78 hectares);
- 7 - Long Beach (39.10 hectares);
- 8 - Fisherman's Beach (57.90 hectares);
- 9 - Putney Creek (110.70 hectares);
- 10 - Leeke's Creek (0.28 hectares);
- 11 - Central Clam Bay / Leeke's Beach (discharging via Leeke's Beach) (324.45 hectares); and
- 14 - Marine Services Precinct (17.63 hectares).

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Figure 2.28 WATER CATCHMENTS

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

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(To allow for A3 pages to be included within hardcopy submissions.)

No project related work is proposed in the remaining catchments and no changes to runoff behaviour will occur in those areas as a result of the GKI Revitalisation Plan. Accordingly, only Catchments 5, 7, 8, 9, 10, 11 and 14 (refer **Figure 2.28**) have been considered in the modelling and analysis described in this section.

Stormwater modelling and analysis as described in this section, also generally excludes land not leased or intended to be leased by the Proponent. As such, model catchments have been identified based on topographic boundaries, modified as necessary to exclude land not expected to be leased by the Proponent.

2.4.6.1 Stormwater Quantity Management

Existing and post-development hydrologic behaviour within catchments containing elements of the GKI Revitalisation Plan has been analysed using two main methods:

- peak surface flow rates have been calculated using probabilistic methods outlined in Australian Rainfall and Runoff (Institution of Engineers Australia, 2001); and
- annual runoff volumes, and particularly the distribution of rainfall to surface flow and groundwater flow, has been analysed using continuous simulation analysis in the hydrologic module of Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software.

The primary objectives for managing stormwater quantity have been derived from *State Planning Policy (SPP) 4/10 - Healthy Waters (May 2011)* and include the following:

- the waterway stability objective of SPP 4/10 requires that new developments manage flows such that the post-development one-year ARI event discharge rate within the downstream waterway is no greater than the pre-development peak one-year ARI event discharge rate; and
- to protect in-stream ecology of ephemeral freshwater waterways, SPP 4/10 requires new development to manage the increase in the number of small runoff events that occur from impervious surfaces compared to natural vegetated surfaces. This objective is typically satisfied by capturing and managing the first 10mm of runoff from impervious surfaces each day.

Full details of stormwater quantity analyses are provided in **Appendix J** of **Appendix AN - Water Cycle Management Report**. A discussion of relevant results is provided below.

Roof water runoff from the Resort and marina facilities will be collected in gutters and piped to rainwater storage tanks for reuse. All rainwater tank overflows will be directed to bio-retention cells. Where rainwater tanks are not provided, roof runoff will be taken directly to the bio-retention cells for treatment prior to absorption into the natural underlying sandy soils.

The installation of rainwater tanks for capture and reuse of roofwater runoff will reduce the increase in surface runoff with the modelling suggesting that installation of rainwater tanks to capture and reuse roof water from the Eco Resort Villas alone will remove approximately 19 megalitres per annum from the volume that would otherwise become surface runoff. This is based on installation of 1,500 litres of rainwater storage for each Eco Resort Villa. Given that it is proposed to provide rainwater capture and reuse on all core resort and marina facilities as described in **Appendix AN - Water Cycle Management Report**, mitigation of surface runoff volumes achieved by installation of rainwater tanks will be significantly higher than indicated by the current modelling.

It is proposed that stormwater runoff from all hardstand areas (roads, paved and sealed areas, airstrip and apron, parking areas) throughout the Resort and marina facilities will drain off the sealed area in a dispersed flow via flush kerbs or the like, and into adjoining bio-retention "cells". Where bio-retention cells are not able to be sited immediately adjacent to the sealed area, flows will be directed to the relevant bio-retention cell via vegetated swales (as opposed to piped systems) wherever possible. Where piping is unavoidable, gully inlets will be sited in collector swales adjoining the sealed area, rather than in the sealed area itself to facilitate infiltration and some level of water quality improvement prior to entering the piped system.

An exception to this is the Marine Services Precinct where stormwater pollutant concentrations at the point of entry to the receiving water can be reduced by limiting the flow into the subsoils. Bio-retention basins in the Marine Services Precinct will have impermeable liners. As such, treated stormwater filtrate from these bio-retention basins will be collected in under-drainage pipes and discharged into the marina rather than being discharged into the subsoil.

Predicted increases in surface runoff volumes will be mitigated by infiltration from the surface drainage and detention basin network. This infiltration would be expected to be relatively high given the high permeability of the sandy soils on the Island.

By allowing bio-retention filtrate to drain directly to the sandy subsoils, the need for an extensive network of drainage pipes and associated trenching that would otherwise be required will be significantly reduced or avoided. As such, the extent of ground disturbance and vegetation clearing likely to be required for installation of the stormwater management system will generally be limited to that required for installation of the stormwater treatment devices. Infiltration of treated stormwater through the base of the bio-retention facilities will also contribute to recharge of groundwater resources mimicking the natural rainwater infiltration that occurs on the Island. It will also eliminate the concentration of drainage flows to a limited number of discharge points, which significantly reduces the potential for scouring and erosion. All stormwater discharge points will incorporate appropriate scour protection and /or spreaders where necessary to further reduce the potential for scouring.

Infiltration losses were not accounted for in the modelling. Taking infiltration losses into account, the proportion of annual rainfall contributing to surface runoff will be somewhat less than predicted by the modelling while the proportion of annual rainfall contributing to groundwater recharge may be somewhat higher. The harvesting of stormwater runoff for irrigation water supply proposed as part of the total water cycle management strategy for the GKI Revitalisation Plan will also contribute to reducing surface runoff volumes.

On this basis, it can reasonably be expected that actual surface runoff volumes discharging to the main waterways post-development will be considerably less than the modelling predicts.

Tables 2.11 A to **2.11 F** provide a comparison of pre-development and post-development peak flow rates in catchments containing elements of the GKI Revitalisation Plan.

To achieve non-worsening of peak flow rates and demonstrate compliance with the waterway stability objective of SPP 4/10, routing analyses have been undertaken to determine preliminary sizes of detention structures required. Details of the preliminary sizing of detention required for each catchment to achieve non-worsening of peak flow rates in downstream waterways is provided in **Tables 2.11 A** to **2.11 E**.

TABLE 2.11 A: CATCHMENT 5 (PEAK FLOW RATES FROM CATCHMENT TO CLAM BAY)

Average Recurrence Interval (years)	Pre-development Peak Discharge (m3/s)	Post-development Peak Discharge - Unmitigated (m3/s)	Post-development Peak Discharge - Mitigated (m3/s)	percent Reduction in Peak Flow	"No worsening" achieved?
1	3.22	3.23	3.19	0.9	Yes
2	4.42	4.44	4.37	1.1	Yes
5	6.34	6.37	6.29	0.8	Yes
10	7.58	7.61	7.51	0.9	Yes
20	9.24	9.28	8.98	2.8	Yes
50	12.02	12.08	11.36	5.5	Yes
100	14.11	14.18	13.14	6.9	Yes

TABLE 2.11 B: CATCHMENT 7 (PEAK FLOW RATES TO LONG BEACH FROM GKI PROPERTY AND CATCHMENTS DOWNSTREAM)

Average Recurrence Interval (years)	Pre-development Peak Discharge (m3/s)	Post-development Peak Discharge - Unmitigated (m3/s)	Post-development Peak Discharge - Mitigated (m3/s)	percent Reduction in Peak Flow	“No worsening” achieved?
1	3.08	3.89	2.62	14.9	Yes
2	4.23	5.34	3.89	8.0	Yes
5	6.05	7.65	5.91	2.3	Yes
10	7.24	9.14	7.21	0.4	Yes
20	8.82	11.14	8.64	2.0	Yes
50	11.48	14.50	10.65	7.2	Yes
100	13.47	17.02	12.20	9.4	Yes

TABLE 2.11 C: CATCHMENT 8 (PEAK FLOW RATES TO FISHERMAN’S BEACH FROM GKI PROPERTY).

Average Recurrence Interval (years)	Pre-development Peak Discharge (m3/s)	Post-development Peak Discharge - Unmitigated (m3/s)
1	3.37	4.44
2	4.63	6.09
5	6.63	8.72
10	7.91	10.41
20	9.64	12.68
50	12.53	16.48
100	14.69	19.33

TABLE 2.11 D: CATCHMENT 9 (PEAK FLOW RATES AT THE MOUTH OF PUTNEY CREEK)

Average Recurrence Interval (years)	Pre-development Peak Discharge (m3/s)	Post-development Peak Discharge - Unmitigated (m3/s)	Post-development Peak Discharge - Mitigated (m3/s)	percent Reduction in Peak Flow	"No worsening" achieved?
1	3.46	6.58	2.60	25.3	Yes
2	4.75	9.03	3.97	16.4	Yes
5	6.77	12.88	6.28	7.2	Yes
10	8.07	15.35	7.76	3.8	Yes
20	9.82	18.68	9.18	6.5	Yes
50	12.75	24.24	11.79	7.5	Yes
100	14.93	28.40	13.54	9.3	Yes

TABLE 2.11 E: CATCHMENT 11 (PEAK FLOW RATES AT THE MOUTH OF LEEKE'S CREEK)

Average Recurrence Interval (years)	Pre-development Peak Discharge (m3/s)	Post-development Peak Discharge - Unmitigated (m3/s)	Post-development Peak Discharge - Mitigated (m3/s)	percent Reduction in Peak Flow	"No worsening" achieved?
1	7.03	7.61	6.59	6.3	Yes
2	9.68	10.49	9.31	3.8	Yes
5	13.99	15.16	13.79	1.4	Yes
10	16.81	18.20	16.46	2.1	Yes
20	20.57	22.27	19.45	5.4	Yes
50	26.88	29.11	24.33	9.5	Yes
100	31.64	34.27	28.23	10.8	Yes

Table 2.11 F summarises the estimated size (volume and surface area) of required detention basins for each catchment. The surface area of each basin has been based on a maximum basin depth of 1.2 metres for a Q20 event. The nominated detention basin sizes mitigate all runoff events up to the 100 year recurrence interval. This significantly exceeds the requirements of SPP 4/10, which only requires flow mitigation up to the one year recurrence level.

TABLE 2.11 F: REQUIRED DETENTION BASINS SIZES FOR EACH CATCHMENT

Catchment	Basin Volume (ML)	Basin Surface Area (Ha)
9	13.5	1.1
11	8.1	0.7
5	1.8	0.2
7	5.5	0.5

Although the exact location and design of detention basins will need to be confirmed during detailed design stages, modelling undertaken to date indicates that detention requirements to mitigate post-development peak flow rates to, or below, pre-development levels are relatively small. Accordingly the required detention basins can be readily integrated into landscaped elements of the GKI Revitalisation Plan.

It is envisaged that detention structures will comprise low impact designs utilising relatively low grassed or vegetated mounds enclosing open space, which will be integrated with landscaped areas to provide multi-purpose stormwater management and landscape amenity.

Detention structures will be located such that runoff from storm events exceeding the detention basin design event can bypass safely around the outside of the structure to reduce the risk of embankment collapse that could occur if ponds are allowed to overflow in an uncontrolled manner. Civil designs (building pads, roads, surface flow paths and piped networks) will direct stormwater runoff from catchments to the relevant detention basins, primarily though the use of overland flow paths consisting of grassed swales or similar to contribute further to stormwater quality improvement and environmental health.

2.4.6.2 Stormwater Quality Management

To mitigate potential impacts from pollutants in stormwater runoff discharging to downstream waterways, a range of stormwater quality improvement devices will be installed within the stormwater drainage system.

To assess the effectiveness of proposed stormwater quality improvement devices in reducing potential impacts of stormwater runoff generated by the Project on surface water quality in receiving waters, modelling has been undertaken using MUSIC software. MUSIC is a software tool that simulates the behaviour of stormwater in catchments and is the preferred tool for demonstrating the performance of stormwater quality treatment systems within urban areas.

MUSIC modelling is used to quantify stormwater pollutant concentrations and average annual loads, and to assess the effectiveness of various stormwater quality improvement devices in reducing pollutant loads and concentrations. Subsequent pollutant load reductions and discharge concentrations can then be compared to relevant water quality objectives and guidelines to determine compliance.

The primary objectives for managing stormwater quality have been derived from *State Planning Policy (SPP) 4/10 - Healthy Waters (May 2011)* and the *Draft Urban Stormwater - Queensland Best Practice Environment Management Guidelines 2009*, which are the primary documents used in Queensland for the planning, design and assessment of stormwater management systems.

SPP 4/10 (and supporting documents) nominates specific minimum stormwater pollutant load reductions required to be met by development throughout Queensland. The nominated minimums have been based on research and modelling work undertaken by a number of Australian organisations, which research has included operational testing of constructed stormwater quality management devices.

Stormwater quality improvement objectives for the GKI Revitalisation Plan have been derived from Table 2.1b of the *Draft Queensland Best Practice Environmental Management Guidelines*. For the relevant region (Central Coast South), minimum target reductions in mean annual loads for the modelled pollutants are as follows:

- Suspended Solids (TSS) = 85 percent
- Total Phosphorus (TP) = 70 percent
- Total Nitrogen (TN) = 45 percent
- Gross Pollutants (GP) = 90 percent

The target load reductions detailed in the *Draft Queensland Best Practice Environmental Management Guidelines* were derived using a "diminishing returns" analysis balancing incremental community costs against improved environmental benefits. Whilst the target load reductions are not necessarily the maximum that can possibly be achieved, they have been derived following rigorous analysis.

In addition to demonstrating compliance with pollutant load reduction targets as specified above, the analysis demonstrates that the stormwater quality improvement methods proposed to achieve the nominated load reductions will also reduce modelled pollutant concentrations in runoff below those which presently exist. Accordingly, the modelling predicts that, as a result of the Project, there will be no worsening of the existing stormwater discharge quality.

Detailed analysis results are provided in Appendix K of the **Water Cycle Management Report** (refer **Appendix AN**).

A description of proposed stormwater quality improvement devices is provided in the following text, followed by a discussion of stormwater quality improvement modelling demonstrating that the proposed devices are capable of achieving appropriate water quality outcomes.

(a) Bio-retention Systems

The primary means of improving stormwater quality as part of the GKI Revitalisation Plan will involve the installation of a series of bio-retention basins, bio-retention swales and infiltration areas. These devices utilise bio-filters comprised of native vegetation and natural sand materials to remove sediment and nutrients from stormwater before allowing the stormwater to infiltrate into the natural sandy soils mimicking the natural process of groundwater recharge through rainwater infiltration that occurs on the Island.

Bio-retention basins, bio-retention swales and infiltration areas are low impact structures that are robust and well proven as key components of best practice water sensitive urban design. These devices are not visually intrusive and can generally be integrated with landscaping features. Maintenance requirements for such systems are not onerous and performance can be readily monitored by visual means, which assists in maintaining the effectiveness of these devices over time. Regular maintenance of these devices is generally limited to plant health checks and removal of sediments and litter, which can largely be carried out by general landscaping maintenance personnel.

Although wetland treatment systems could achieve the same water quality outcomes as bio-retention systems, wetlands are not considered to be desirable for treatment of stormwater runoff from the GKI Revitalisation Plan, on the basis that wetland treatment systems:

- typically require at least 10 times the surface area of a bio-retention basin to achieve the same reduction in pollutant loads and would therefore be likely to increase the development footprint;
- are also more prone to problems that can reduce their effectiveness and attractiveness, including attraction of pests (i.e. Ibis); and
- are often much more difficult to repair if required, due to accessibility issues for machinery within wet areas.

MUSIC modelling has determined the minimum sizing (area and depth) required for proposed bio-retention basins in the various catchments to achieve the relevant water quality objectives. To enhance the overall environmental benefits, it is proposed that a distributed or decentralised network of smaller bio retention “cells” be provided, rather than larger, centralised catchment scale structures. Accordingly, sizing details have been provided in a “per unit” format (refer **Table 2.11**).

As the detailed architectural, landscaping and civil engineering designs are developed, bio-retention structures for each specific contributing catchment area should be located in a distributed fashion throughout the developed areas to suit surface flow patterns and to enhance local landscaping.

Typical details of the proposed stormwater quality improvement structures are illustrated on drawing number R02 contained in Appendix L of **Appendix AN - Water Cycle Management Report**. Relevant components of the stormwater quality improvement devices will be detailed generally in accordance with details and specifications contained in the *Water Sensitive Urban Design Guidelines for South East Queensland* (Healthy Waterways - Version 1 June 2006).

Operational testing of full-scale constructed stormwater quality management devices has shown that correctly designed and constructed devices actually perform better than is anticipated by modelling. Accordingly, no specific operational testing of bio-retention systems is necessary provided that stormwater quality management devices are:

- modelled using appropriate software (MUSIC);
- detailed in accordance with the WSUD Technical Design Guidelines; and
- constructed as detailed.

As with all stormwater quality improvement devices, regular maintenance of bio-retention systems is necessary to ensure continued effective operation of the devices over time. A preliminary stormwater quality maintenance plan has been prepared for the GKI Revitalisation Plan and is included in Appendix H of **Appendix AN** - **Water Cycle Management Report.**

(b) Gross Pollutant Traps

Although bio-retention systems are capable of removing gross pollutants such as litter, frequent removal of debris is required to maintain effectiveness. In order to prevent litter from the Resort areas entering waterways where it may harm wildlife, proprietary gross pollutant traps will be installed as part of the stormwater treatment train in key locations where litter generation is most likely to be concentrated and where the risk of entering waterways is greatest (e.g. the Marine Services Precinct).

(c) Stormwater Quality Improvement Modelling

As noted previously to assess the effectiveness of proposed stormwater quality improvement devices, modelling has been undertaken using MUSIC Version 4. This section summarises the key inputs and assumptions adopted in the modelling, and provides an overview of the key results.

Full details of the extensive MUSIC analyses (including model structure and parameters) and results are included in Appendix K of **Appendix AN** - **Water Cycle Management Report**.

(d) MUSIC Model Inputs and Assumptions

Rainfall and evaporation data from the Bureau of Meteorology's nearest recording (Site No. 39083 Rockhampton) has been used in MUSIC modelling, with the adopted rainfall data sequence being in accordance with that required by the *Urban Stormwater – Queensland Best Practice Environmental Management Guidelines 2009* (i.e. 1980 – 1989 at 6 minute time steps).

Soil characteristics adopted in the MUSIC have been calibrated in accordance with MUSIC calibration based on soil conditions using information from the geotechnical investigations (Douglas Partners, 2010) and are summarised in **Table 2.12**.

TABLE 2.12 SOIL CHARACTERISTICS IN MUSIC MODEL

Soil Characteristic	Calibrated Input
Soil Storage Capacity	175 mm
Field Capacity	75 mm
Infiltration Capacity Coefficient - a	200
Infiltration Capacity Exponent - b	0.5
Initial Depth	50 mm
Daily Recharge Rate	75 percent
Daily Baseflow Rate	50 percent
Daily Deep Seepage Rate	0 percent

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

For the purpose of MUSIC modelling, it was assumed that rainwater from roof surfaces associated with the proposed apartments and villas only was captured and reused. This provides a conservative assessment to modelling of potential stormwater quality impacts given that it is likely that rainwater capture and reuse will occur from the majority of roof surfaces within the Resort. The assumption of less roofwater capture and reuse conservatively overestimates the volume of runoff and thus pollutant loads in the modelling.

Pollutant generation rates adopted for various land uses within the catchments containing elements of the GKI Revitalisation Plan have been derived from the *Southeast Queensland MUSIC Modelling Guidelines – Version 1*. Pollutant generation parameters for developed precincts within the GKI Revitalisation Plan have been modelled using the "Rural Residential" pollutant export parameters derived from Table 3.9 of the *Southeast Queensland MUSIC Modelling Guidelines – Version 1*. The pre-development scenario and undeveloped areas within the GKI Revitalisation Plan have been modelled using the "Forest" pollutant export parameters derived from Table 3.9 of the *Southeast Queensland MUSIC Modelling Guidelines – Version 1*.

MUSIC modelling and analysis results demonstrate that the proposed mitigation measures described will achieve two key results:

- reductions in mean annual loads for modelled pollutants that exceed (i.e. are better than) the target values specified in SPP 4/10 - Healthy Waters; and
- modelled post-development pollutant concentrations at the point of discharge to receiving waters during flow events that are equal to or lower than the modelled concentrations at the same discharge points under the existing conditions (i.e. non-worsening).

2.4.6.3 Specific Stormwater Management Issues

A number of elements of the GKI Revitalisation Plan will require specific management of stormwater issues. Proposed strategies for these areas are described below:

(a) Golf Course

The proposed 18 hole championship golf course will primarily be located within Catchment 11, which subsequently drains into Leeke's Creek and via Catchment 10 to discharge at Leeke's Beach. A small part of the golf course will be located within Catchment 5, which drains in dispersed flow to discharge into Clam Bay.

If erosion and sediment controls plans or the application of fertilisers and pesticides on the golf course are not implemented appropriately there would be a potential to impact on water quality of receiving waters.

A range of measures will be implemented to minimise the potential for stormwater to come into contact with contaminants to reduce the risk of causing adverse impacts on water quality in receiving waters.

Stormwater management measures proposed for the golf course will consist of the following:

- all surface runoff from areas outside of the golf course will be prevented from draining onto the course through the use of diversion drains incorporated grassed swales;
- all surface runoff from the proposed golf course will be diverted to stormwater harvesting ponds for reuse for irrigation of the golf course;
- golf course runoff will be directed to the stormwater harvesting ponds through a series of grassed swales and/or bio-retention basins to facilitate removal of gross pollutants (e.g. litter) sediment and nutrients prior to entering the stormwater harvesting ponds;
- stormwater harvesting ponds will incorporate an overflow provided with appropriate scour protection and outletting to a grassed overland flow channel providing further treatment prior to ultimately discharging to Leeke's Creek;
- stormwater will be prevented from draining into wet weather storage ponds containing recycled water for irrigation of the golf course; and
- monitoring of water quality within the stormwater harvesting ponds will be undertaken as part of the irrigation management plan proposed for the golf course to ensure water quality is 'fit for purpose' (refer Appendix H of **Appendix AN - Water Cycle Management Report**).

(b) High Risk Areas

Specific stormwater management measures will be provided in high risk areas likely to contain significant quantities or types of contaminants not consistent with the assumptions of the stormwater quality improvement modelling. This includes, but may not be limited to, areas used for the storage and handling of hazardous substances (e.g. chemicals, fuels and oils), bulk waste storage areas and maintenance workshops.

High risk areas will be designed to prevent overland stormwater coming into contact with contaminants through the use of perimeter diversion systems, to divert surface runoff from flowing into these areas, possibly combined with covering or roofing of the area where appropriate to prevent direct rainfall runoff. In addition, use of perimeter bunding and hardstand surfaces will be used for particularly high risk areas to prevent the release of contaminants accidentally spilled or leaked within the area. Any stormwater that does enter such areas would be collected and tested to ensure compliance with relevant water quality standards prior to disposal. Where appropriate, additional treatment devices may be installed including triple interceptors to separate oils and grease from water prior to release.

Further details are provided in Appendix M of the **Water Cycle Management Report** (refer **Appendix AN**).

(c) Putney Creek Mouth

The natural hydrology of Putney Creek is believed to have been modified as a result of historic land use activities, including but not limited to, construction of the existing airstrip, which it is understood, was built over semi-permanent waterholes and lagoons that blocked the natural drainage (CEPLA, 2011). Construction of the existing airstrip is likely to have modified flows within Putney Creek.

Based on observations made by engineers during site inspections and a review of historical data, it is understood that the mouth of Putney Creek is regularly blocked by a sand bar (refer **Photograph 2.8**). The sand bar is washed out occasionally by large storm runoff events and is then slowly rebuilt by normal wave processes on the beach. The sand bar effectively provides a sediment trap at the mouth of Putney Creek for smaller flow events (i.e. those that do not wash out the bar).

When the bar is washed out, tidal flows are able to move in and out of the mouth until beach wave processes rebuild the bar and the wetland gradually reforms until the next large storm event. As a result, ecosystems within the creek mouth are influenced by both periodic tidal and freshwater flows. Observations made during site visits indicate that dieback of more salt-tolerant vegetation may occur during prolonged periods of sand bar formation, depending on the duration of the tidal freshwater phases (refer **Photograph 2.8** and **2.9**).

Photograph 2.8 VEGETATION NEAR MOUTH OF PUTNEY CREEK, SHOWING APPARENT DIE-BACK OF SHE-OAKS (20 OCTOBER 2010).

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

Photograph 2.9 VEGETATION FURTHER INLAND OF PUTNEY CREEK MOUTH COMPARED TO PHOTOGRAPH 2, SHOWING MORE EXTENSIVE EVIDENCE OF APPARENT DIE-BACK OF SHE-OAKS (20 OCTOBER 2010).

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

Construction of the proposed marina will prevent the sand bar building wave processes from occurring, which would likely result in the Putney Creek mouth opening up to tidal influence. However, this opening up of the creek mouth would also result in sediment deposition within the proposed marina basin. Three options for the rectification of Putney Creek mouth were considered by the EIS team:

1. remove the bar and reopen the creek mouth so that the lower reaches of the creek become tidal; OR
2. re-construct the creek mouth with an artificial bar (a weir set at the existing bar level) so that the creek at the mouth is always a freshwater wetland; OR
3. re-construct the creek mouth with a moveable artificial bar (a collapsible or moveable weir set normally at the existing bar level but designed to be lowered occasionally to allow occasional washing out).

In relation to the above options, EIS specialists frc environmental, Water Technology, CQG Consulting ,CEPLA and International Marina Consultants, identified that creation of an 'open' tidal creek system to be the most appropriate solution from both an ecological, amenity and maintenance perspective.

By reopening the creek mouth to regular tidal movement, fisheries productivity within the lower reaches of Putney Creek is expected to be increased significantly (frc environmental, 2011). Creation of a temporary or permanent barrier in an effort to replace the existing sand bar formation / removal process, would likely result in either permanent or temporary formation of a freshwater wetland system, which is likely to be less productive from a fisheries perspective. Given the levels of nutrients recorded within Putney Creek during water quality monitoring by frc environmental (2011), a closed system would likely be characterised by eutrophied conditions that could result in algal blooms with potential for consequent impacts on aquatic fauna and odour generation. For these reasons, opening of the Putney Creek mouth to reinstate what is likely to resemble the more natural hydrology prior to construction of the existing runway, would result in increased flushing and fisheries productivity.

Accordingly, at the discharge point of Putney Creek into the marina, a permanent, lined, discharge channel will be established below the boardwalk and esplanade. The boardwalk and esplanade will bridge over the channel. A lined transition zone will be established within the channel upstream of the bridged area. Lining of the channel is required to prevent scouring, which would result in increased deposition of sediment within the marina basin. A range of options are available for lining the channel to prevent scouring with the preferred material to be selected on the basis of not only being able to reduce scour, but also to provide fisheries habitat and contribute to the aesthetics of the Marine Services Precinct. This may involve the use of placed rock, which will provide a relatively natural substrate for establishment of various encrusting marine species, as well as creating crevices and gaps to provide habitat and refuge for a wide range of marine flora and fauna.

Based on advice from International Marina Consultants, a sediment basin has been incorporated into the proposed works at the Putney Creek mouth. The sediment basin will be constructed in the lined transition section of the channel. The sediment basin will reduce siltation within the marina thereby avoiding the need for ongoing maintenance dredging within the marina basin, which would result in ongoing disturbance of the marine environment. The design will include full provision for easy maintenance access by appropriate de-silting equipment.

2.4.6.4 Stormwater Risk Assessment

A risk assessment of potential environmental impacts associated with the stormwater aspects of the GKI Revitalisation Plan has been undertaken and is described in **Appendix AN - Water Cycle Management**, along with proposed mitigation measures to address each identified risk.

2.4.6.5 Summary of Proposed Stormwater Strategy

The proposed stormwater management strategy for the GKI Revitalisation Plan has been designed to:

- comply with the requirements of the *State Planning Policy 4/10 Healthy Waters and the draft Urban Stormwater - Queensland Best Practice Environment Management Guidelines 2009*,
- minimise the use of underground piped drainage systems by utilising surface drainage techniques that reduce the need for extensive excavation while enabling drainage systems to be integrated into landscape design and reducing the concentration of drainage flows to a limited number of discharge points;
- support the collection and reuse of rainwater from impervious roof surfaces to mitigate peak flow rates while also providing an alternative water supply for resort facilities; and
- support the harvesting of stormwater runoff from the golf course and possibly other areas around the Resort, to reduce the potential discharge of pollutants while also providing an alternative water supply for irrigation.

A series of detention basins and bio-retention systems will be installed throughout catchments contained in the GKI Revitalisation Plan to:

- attenuate peak discharge flow rates to lower than existing levels for all standard average recurrence interval storm events from one year to 100 years;
- facilitate infiltration of increased surface runoff volumes into highly permeable, sandy subsoils mimicking the natural groundwater recharge process that occurs on the Island; and
- intercept and temporarily store surface flows from small runoff events so as to avoid any increase in the number of small runoff events discharging to ephemeral waterways that could potentially alter in-stream ecology.

Detention structures will comprise low impact designs utilising low grassed or vegetated mounds enclosing open space that can be readily incorporated as part of the landscape design for the Project.

Best practice vegetated bio-retention systems, including bio-retention basins, swales and infiltration areas will be installed to remove gross pollutants, sediments and nutrients from stormwater flows prior to discharge. Modelling demonstrates that proposed stormwater quality improvement measures will readily achieve required annual pollutant load reduction targets and will result in no worsening of stormwater pollutant concentrations compared to modelling of the pre-developed catchment.

The proposal to permanently reopen the mouth of Putney Creek to tidal movements, will increase fisheries productivity and flushing to prevent the formation of eutrophied conditions that may contribute to algal blooms and subsequent odour nuisance. To achieve this, a lined discharge channel will be constructed below the boardwalk and esplanade, with a sediment basin incorporated towards the upstream end of the new channel. This will reduce the potential for silting up of the marina basin thereby reducing the need for ongoing maintenance.

2.4.7 Wastewater

Opus International Consultants (Australia) Pty Ltd prepared an overview of proposed water cycle management strategies associated with the GKI Revitalisation Plan, including addressing water supply, wastewater and stormwater management (refer **Appendix AN**).

2.4.7.1 Wastewater Treatment and Reuse

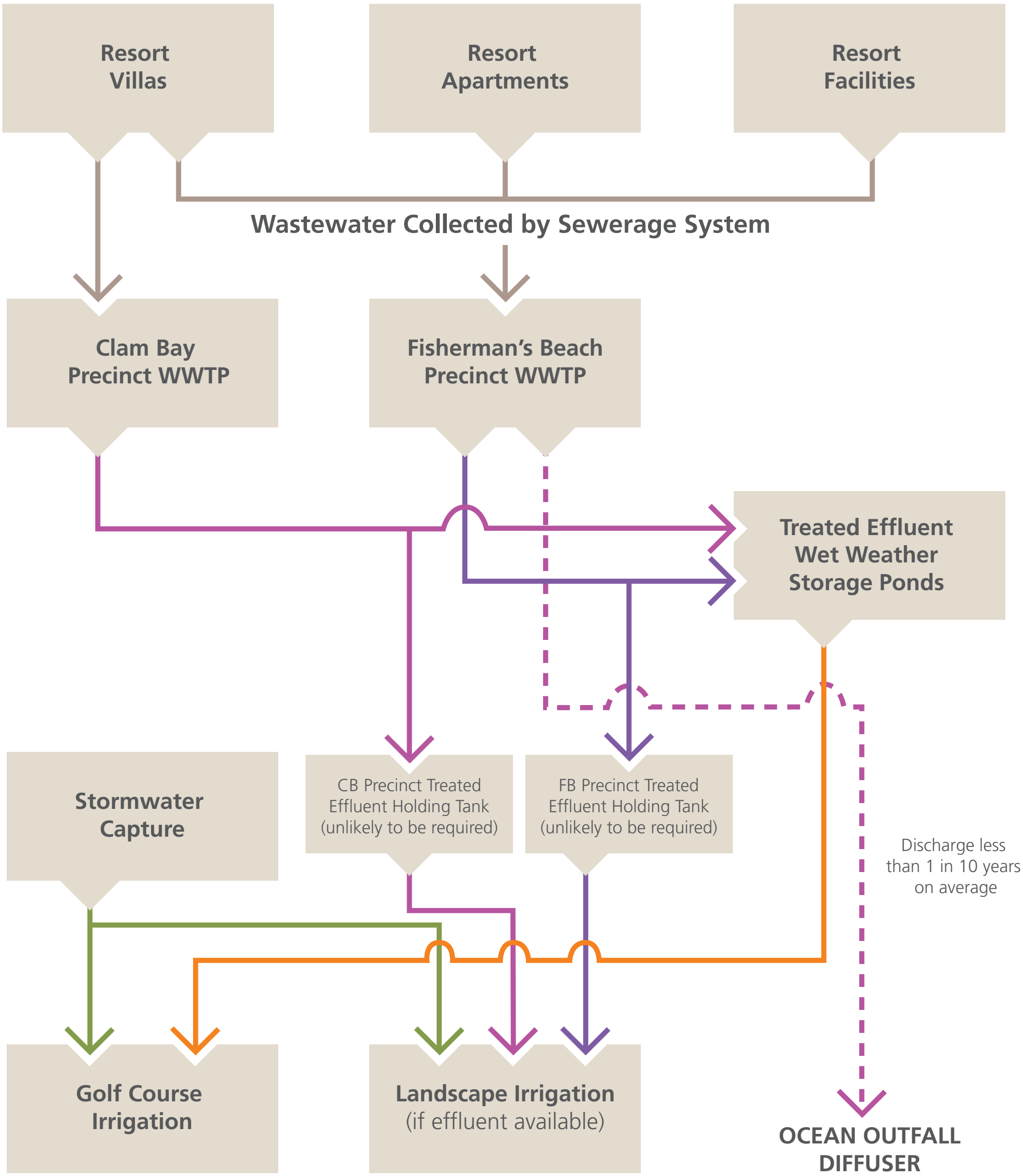
Based on consideration of relevant options as described in **Section 2.4.7.3**, the wastewater treatment and reuse scheme proposed for the Island will likely consist of:

- a wastewater collection system comprised of:
  - a combination of traditional gravity sewers, by using the NuSewer or similar system to minimise groundwater infiltration (due to the high water table on the Island) and pumped systems where appropriate;
  - a specialist proprietary pump out system for the marina berths; and
  - pumping stations for transfer of the wastewater, after collection, to the WWTPs.
- either two services, including one WWTP servicing the Fisherman's Beach and Marine Services Precincts and one WWTP servicing the Clam Bay Precinct OR a single WWTP servicing all precincts within the GKI Revitalisation Plan;
- all wastewater will be treated to a standard consistent with the minimum water quality requirements specified for "Municipal Use – open spaces, sports grounds, golf courses, dust suppression, etc or unrestricted access and application" under the *Australian Water Quality Guidelines for Water Recycling: Managing Health and Environmental Risks* (Phase 1) (ANZECC, 2006), with nutrient levels reduced to 20mg/L of Total Nitrogen and 7mg/L of Total Phosphorous;
- in most years, 100 percent of all wastewater generated by the GKI Revitalisation Plan and treated at the Island-based WWTP(s) will be used for irrigation of the golf course and possibly other landscaped areas around the Resort;

- wet weather storage ponds with a capacity of at least 44 megalitre (including a seven megalitre storage buffer to account for potential increase in rainfall intensity due to climate change) will be provided, most likely in the form of open ponds incorporated into the golf course; and
- during extreme wet weather events, when soil conditions are unsuitable for irrigation and wet weather storage ponds reach capacity, a small proportion of recycled water may be discharged via an ocean outfall extending from Long Beach. Current modelling based on a 37 megalitre storage indicates that overtopping of the wet weather storage and subsequent ocean discharge may occur on average, once every 10 years. However, provision of an additional 20 percent storage capacity to account for climate change is likely to reduce this frequency further, particularly during the early years of the scheme.

A schematic outline of the wastewater collection, treatment and reuse scheme is shown in **Figure 2.29**. Further details in relation to core wastewater infrastructure components are provided in the following sections.

Figure 2.29 GKI REVITALISATION PLAN – WASTEWATER COLLECTION AND TREATED EFFLUENT REUSE SCHEMATIC



Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

Prior to commissioning of the new wastewater treatment and reuse scheme, it is proposed that the existing wastewater treatment plant located on the Island be refurbished and re-commissioned to temporarily service the early construction stages of the Project.

2.4.7.2 Existing Wastewater Treatment and Disposal System

From late 2004 until closure of the former resort in 2007-2008, wastewater from the former resort was collected by gravity reticulation and pumped to a central wastewater treatment facility located on Lot 46 on LN2763, which is situated along the access road at the western end of the airstrip (refer **Figure 2.1**).

The treatment process for the existing wastewater treatment plant consisted of the following:

- inflows of raw effluent passed through a static screen where gross solids were collected and transferred for storage in an adjacent bunded area;
- screened liquid was then transferred to an old oxidation ditch that served as a balancing tank and was utilised for pH correction;
- wastewater was then pumped to two parallel treatment trains consisting of aeration, clarification and sludge aging:
- the nitrification / denitrification process was conducted in the aeration phase;
- wastewater was then transferred to the two clarifiers;
- alum dosing was conducted in the clarifiers to precipitate phosphorus; and
- the settled sludge in the clarifiers was transferred to a sludge stabilisation tank.
- clarified wastewater was then pumped to a Dyna sand filter;
- after being filtered, wastewater was then dosed with chlorine and stored in a 250kL treated effluent holding tank; and
- backwash from the sand filter was returned to the balance tank for retreatment.

Treated effluent within the 250 kilolitre holding tank was then metered and pumped to the golf course for irrigation with a portion being pumped to a 50 kilolitre holding tank above the Hillside Villas for irrigation of landscaped areas.

2.4.7.3 Sewerage Collection Options Analysis

Table 2.13 provides an analysis of sewerage collection options considered for the GKI Revitalisation Plan.

TABLE 2.13 SEWERAGE COLLECTION OPTIONS ANALYSIS

Description/ Comment	Advantages	Disadvantages	CONCLUSION
Traditional Gravity System			
Conventional precast concrete manholes connected with uPVC, HDPE and/or ductile iron/cement lined rubber jointed pipes which gravity feed to sewage pumping stations that deliver raw wastewater to the treatment works.	• Materials readily sourced from local providers. • Long established, well understood construction methodology.	• Potentially high groundwater infiltration rates due to joints and high water table. • System becomes progressively deeper to construct as the system increases with size. • Odour control may be required at sewage pumping station(s) unless sealed.	This is not a preferred option due to the potential for significant groundwater infiltration.
"NuSewer" Low Leak System			
Similar to traditional gravity sewer in function. Pipes are made of welded polyethylene eliminating most joints, which reduces infiltration and root intrusion. System can accommodate vertical and horizontal bends, which reduces the number of manholes. As with traditional sewers, the pipes gravity feed to sewage pumping stations that deliver raw wastewater to the treatment works.	• Significantly lower groundwater infiltration compared to traditional sewer system resulting in lower treatment costs and energy consumption. • Fewer manholes required as the pipes are flexible.	• Materials not as readily available as traditional systems. • Requires some specialist knowledge for installation. • Odour control may be required at sewage pumping station(s) unless sealed.	This is the preferred option primarily on the basis of the low infiltration potential.

TABLE 2.13 SEWERAGE COLLECTION OPTIONS ANALYSIS (CONTINUED)

Description/ Comment	Advantages	Disadvantages	CONCLUSION
Vacuum System			
A vacuum system collects sewage from buildings via gravity into a collection tank. A centralised vacuum chamber draws the sewage from the individual tanks along a shallow vacuum rising main towards the treatment works or a traditional sewage pumping station.	• Entire system is relatively shallow to construct. • Few if any manholes required. • Piping system can be installed within a narrow trench, which can bend around obstacles such as trees.	• Materials not as readily available as traditional systems. • Requires specialist knowledge for installation and operation. • System performs better on low topography due to the limit a vacuum can draw sewage uphill. • Individual grinders may be needed in collection tanks to reduce solids to a manageable size so as not to block the system. • Odour control may be required at sewage pumping station(s) unless sealed.	This is not the preferred option largely due to the relatively steep topography of parts of the Island and the need for speciality materials and technical expertise for installation and maintenance.
Pressure System			
A pressure system consists of a small collection tank at each building serviced by sewerage. Each tank is fitted with a small grinder pump that feeds a common rising main that discharges to treatment works or a sewage pumping station.	• Entire system is relatively shallow to construct. • Few if any manholes required. • Piping system can be installed with a narrow trench, which can bend around obstacles such as trees.	• Requires some specialist knowledge of installation and operation. • Greater chance of individual pump malfunction due to increased quantity to service every building.	This is one of the preferred options in conjunction with the NuSewers: This option is recommended for low density areas such as the Eco Resort Villas; System reduces construction footprint and therefore vegetation clearing requirements; Individual grinders needed in collection tanks to reduce solids to a manageable size so as not to block the system; and Odour control may be required at sewage pumping station(s).

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

2.4.7.4 Wastewater Treatment Options Analysis

Table 2.14 provides an analysis of wastewater treatment options considered for the GKI Revitalisation Plan.

TABLE 2.14 WASTEWATER TREATMENT OPTIONS ANALYSIS

Description/ Comment	Advantages	Disadvantages	CONCLUSION
Pre-treatment and pump to mainland for treatment at Council WWTP			
Rockhampton Regional Council has indicated its wastewater treatment and recycled water infrastructure has the capacity to accept all effluent from the GKI Revitalisation Plan. In order to transfer wastewater approximately 16 kilometres back to the mainland for treatment, raw wastewater must be pre-treated to reduce the negative effects of hydrogen sulphide build-up due to septicity issues associated with long detention times.	• No treatment plant required on the Island. • No issues with regard to effluent disposal including contamination of groundwater, ocean discharge of effluent.	• Increased potable water needed to make up for shortfall by not reusing any recycled water produced from Island-based treated wastewater. • Increased risk of potential environmental impacts associated with accidental damage to pipeline resulting in relatively untreated wastewater discharge to the ocean. • Hydrogen sulphide corrosion of infrastructure due to the long period of time it will take for wastewater to travel from the Island to the mainland treatment plant. • Relatively high ongoing cost to GKI Resort Pty Ltd to provide at least primary treatment and pumping as well as ongoing charges for sewage treatment and purchase of potable water that could not be offset by reuse of recycled water use produced at Island-based WWTP. • Relatively high capital cost associated with constructing mainland pipeline connection. • Mainland connection potentially subject to damage causing disruption to supply during cyclonic events or boat anchor strike. • Does not fully reflect the self-sustainability objectives of the GKI Revitalisation Plan.	This is not a preferred option due to the potential environmental impacts of accidental discharge of untreated wastewater and the lost opportunity to reuse treated wastewater to offset non-potable water supplies on the Island.

TABLE 2.14 WASTEWATER TREATMENT OPTIONS ANALYSIS (CONTINUED)

Description/ Comment	Advantages	Disadvantages	CONCLUSION
Individual On-Site Treatment and Disposal Systems			
Installation of individual treatment and disposal systems for each villa with separate on-site treatment and disposal systems to service core facilities such as the Fisherman's Beach Precinct and Marine Services Precinct.	• Individual treatment would provide for easier staging of the Project.	• Many individual treatment units do not support the large-scale reuse of recycled water for irrigation of areas such as the golf course. • Small-scale treatment units unlikely to achieve the same high level of treatment able to be achieved by a larger scale plant. • Many individual units with relatively high level of inspection and maintenance, including pump out of septic tanks. • High risk of degradation of groundwater due to lower standard of treatment. • Requires relatively large area of land near each villa and other facilities to contain treatment and disposal infrastructure.	This is not a preferred option due to the ongoing maintenance difficulties and costs, and the potential for water quality impacts due to lower standard of treatment.
Single WWTP on GKI			
Installation of a single wastewater treatment plant servicing the entire Resort. Preferred location would depend on providing buffers to sensitive receivers, and considering the proximity to wastewater sources and recycled water reuse sites.	• Only one wastewater treatment plant to license, operate, maintain and monitor. • Larger treatment systems are typically more efficient than smaller treatment systems. • Less time and fewer staff required to operate a single plant as opposed to multiple plants. • Ensures consistent standard of treatment for all wastewater generated across the Island. • A single WWTP would consume less energy than multiple WWTPs.	• A single plant would require multiple, expandable treatment trains to accommodate progressive increase in flows over the 12 year construction period (Note: Two or more parallel plants enable greater operational flexibility).	This could be and is a viable option with the preferred location of the plant to be in the Clam Bay Precinct in close proximity to the recycled water irrigation area.

TABLE 2.14 WASTEWATER TREATMENT OPTIONS ANALYSIS (CONTINUED)

Description/ Comment	Advantages	Disadvantages	CONCLUSION
Multiple WWTPs on GKI			
Installation of two wastewater treatment plants, including: • One WWTP servicing the Fisherman's Beach and Marine Services Precincts - most likely located on the north-eastern side of the airstrip within the vicinity of the facilities maintenance compound; and • One WWTP servicing the Clam Bay Precinct - most likely located to the north-west of the golf course. • However, the exact location would depend on providing buffers to sensitive receivers.	• Provides greater flexibility to support staging of the Project. • Reduces the need to pump wastewater from Clam Bay Precinct to Fisherman's Beach Precinct or vice versa for treatment.	• Double the ongoing licence fees and monitoring would be required for two WWTPs. • Need to pump recycled water from Fisherman's Beach WWTP across to the Clam Bay Precinct for irrigation of the golf course. • Treatment likely to be less efficient than a single plant due to the smaller size of each individual plant. • Higher energy consumption than a single plant.	Preferred option. However, with reuse of recycled water largely intended for the golf course, the single WWTP option is to be further considered during the design phase.
Wastewater Treatment Plant Options			
Sludge sedimentation and stabilisation / oxidation lagoons as follows: • Grit chambers / screens to remove floating solid items and grit. Screened solids and grit disposed of at a licensed landfill facility on the mainland; • Primary sedimentation tanks with collected sludge to sludge digestion tanks, sludge removed, dewatered, dried and used for landscaping, liquid from sludge process passed to the stabilisation lagoons; • Stabilisation / oxidation lagoons for treatment of liquid from sedimentation tanks; • Effluent from the stabilisation lagoons pumped to the golf course storage pond(s).	• Robust system with minimal power requirement. • Simple technology and low maintenance. • Relatively low cost solution. • With minimal power requirement, system is not significantly affected by power outages.	• System would need to be combined with a membrane or similar filtration system and disinfection in order to achieve the required recycled water quality for unrestricted use. • Likely to require significant buffer (e.g. 500 to 800m) between plant and to tourist / residential facilities. • Odour may be an issue from time to time. • Requires relatively large area of land for plant.	This option is not preferred on the basis that the treatment system is not likely to be capable of achieving the required recycled water quality.

TABLE 2.14 WASTEWATER TREATMENT OPTIONS ANALYSIS (CONTINUED)

Description/ Comment	Advantages	Disadvantages	CONCLUSION
Sludge sedimentation and oxidation ditches: • Grit chambers / screens to remove floating solid items and grit. Screened solids and grit disposed of at a licensed landfill facility on the mainland; • Primary sedimentation tanks with collected sludge to sludge digestion tanks, sludge removed, dewatered, dried and used for landscaping, liquid from sludge process passed to the oxidation ditches; • Oxidation ditches for treatment of liquid from sedimentation tanks; • Finishing lagoons; and • Effluent from the finishing lagoons pumped to the golf course storage pond(s).	• Robust system with minimal power requirement. • Simple technology and low maintenance. • Relatively low cost solution.	• System would need to be combined with a membrane or similar filtration system and disinfection in order to achieve required recycled water quality for unrestricted use. • Likely to require significant buffer (e.g. 500 to 800m) between plant and to tourist / residential facilities. • Odour may be an issue from time to time. • Requires relatively large land area for plant.	This option is not preferred on the basis that the treatment system is not likely to be capable of achieving the required recycled water quality.
Proprietary package treatment plants (MBR or similar): • Grit chambers / screens (within package plant) to remove floating solid items and grit. Screened solids and grit disposed of at a licensed landfill facility on the mainland. • Package plant with treatment and retention times to meet the required treatment standard for unrestricted reuse for irrigation of the golf course and ocean outfall. Note that the package treatment plants could be based on membrane bioreactor technology (MBR system) with UV disinfection after the plant. • Effluent from the package plant pumped to the golf course storage pond(s), or, when required, direct to the ocean outfall.	• Package plant capable of producing recycled water quality suitable for irrigation of golf course with unrestricted access. • Package plant capable of producing recycled water quality suitable for direct discharge via the ocean outfall. • MBR technology is well proven and capable of producing high quality effluent. • MBR type and other package plants generally have a small footprint (i.e. are compact and require minimal land area). • Odour issues are generally low to non-existent – allowing these plants to be located close to residential dwellings etc.	• Relatively higher cost than stabilisation lagoon or oxidation ditch systems above. • Relatively high maintenance requirements needing specialist skills and knowledge. • Relatively higher operating and maintenance costs than stabilisation lagoon or oxidation ditch systems above. • Require substantial power for operation.	This is the preferred option due to the smaller footprint, proven ability to produce high quality effluent and less odour generation issues.

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

2.4.7.5 Wastewater Effluent Reuse and Disposal Options Analysis

Table 2.15 provides an analysis of wastewater effluent reuse and disposal options considered for the GKI Revitalisation Plan.

TABLE 2.15 WASTEWATER EFFLUENT REUSE AND DISPOSAL OPTIONS ANALYSIS

Description/ Comment	Advantages	Disadvantages	Conclusion
100 percent discharge of treated wastewater via ocean outfall.			
Discharge all treated wastewater to the ocean via an outfall pipeline extending from Long Beach.	• Avoids requirement for construction of large wet weather storage ponds. • Requires fewer pumps than an irrigation / non-potable water supply system or mainland return rising main.	• Increased risk of potential impacts including cumulative impacts on water quality and ecological communities near the outfall due to reliance solely on the treatment plant to achieve required water quality as opposed to additional treatment achieved through assimilation of treated wastewater by plants and soils during irrigation. • To achieve water quality objectives given volume and frequency of discharge, wastewater will require a very high level of nutrient removal, which typically involves significant energy consumption and / or use of chemical treatment processes. • Does not achieve any beneficial reuse of water or nutrients contained in treated wastewater and is therefore not consistent with sustainability objectives of the GKI Revitalisation Plan. • Increased requirement for potable water sources to be used for non-potable purposes. • Negative perception of ocean disposal by potential guests as well as within the broader community.	This option is not preferred primarily on the basis that it is inconsistent with the sustainability objectives of the GKI Revitalisation Plan, which aims to maximise beneficial reuse wastewater and minimise environmental harm.

TABLE 2.15 WASTEWATER EFFLUENT REUSE AND DISPOSAL OPTIONS ANALYSIS (CONTINUED)

Description/ Comment	Advantages	Disadvantages	Conclusion
95 percent Reuse of recycled water for irrigation of golf course and other landscaped areas with 5 percent discharge of treated wastewater via ocean outfall			
Reuse of 95 percent of recycled water produced by an Island-based WWTP for irrigation of the golf course and other landscaped areas. Discharge up to 5 percent of treated wastewater to the ocean via an outfall pipeline extending from Long Beach. Assuming a 31 hectare irrigation area, this option would require a wet weather storage pond of approximately 13ML plus 2.6ML climate change buffer.	• Achieves 95 percent beneficial reuse of treated wastewater averaged over a 50 year period, which is consistent with DERM's (now know as DEHP) general policy for sewage treatment plants involving effluent reuse. • Provides a controlled point of release to the ocean in the event of wet weather storage reaching capacity as opposed to possible uncontrolled release to the environment from overtopping of wet weather storage. • Requires only a relatively small wet weather storage (less land area and materials for lining) compared to irrigation schemes achieving a higher level of reuse.	• Due to the volume and frequency of discharge, subject to more detailed dispersion modelling, a greater level of nitrogen and phosphorus removal may be required compared to recycled water used for irrigation meaning multiple treatment trains could be needed. • Not considered to maximise beneficial reuse of treated wastewater in accordance with the sustainability objectives of the GKI Revitalisation Plan.	This is not the preferred option largely on the basis that the level of reuse does not meet the sustainability objectives of the GKI Revitalisation Plan.

TABLE 2.15 WASTEWATER EFFLUENT REUSE AND DISPOSAL OPTIONS ANALYSIS (CONTINUED)

Description/ Comment	Advantages	Disadvantages	Conclusion
100 percent Reuse recycled water for irrigation of golf course and other landscaped areas with, with emergency discharge			
Reuse of practically 100 percent of recycled water produced by an Island-based WWTP for irrigation of the golf course and other landscaped areas. Discharge only in extreme weather events (i.e. one in 10 year event) when treated wastewater may be discharged to the ocean via an outfall pipeline extending from Long Beach. Assuming a 31 hectare irrigation area, this option would require a wet weather storage pond of approximately 37ML plus approximately 7ML climate change buffer.	• Achieves practically 100 percent beneficial reuse of recycled water for irrigation of golf course and other landscaped areas. • During extreme weather events the dispersion modelling of the outfall demonstrates water quality objectives can be achieved within small mixing zone based on same standard of nutrient removal proposed for reuse by irrigation (N=20mg/L, P=7mg/L) meaning multiple treatment trains are not required. • Provides a controlled point of release to the ocean in the event of extreme weather storage reaching capacity as opposed to possible uncontrolled release to the environment from overtopping of wet-weather storage.	• A small proportion of treated wastewater potentially remains unused (i.e. less than one percent averaged over 50 years). • Capital costs associated with construction of irrigation infrastructure as well as outfall pipeline which will have limited use.	This is the preferred option on the basis that it achieves the maximum reuse of recycled water while providing a feasible wet weather storage, and limiting discharge to the ocean to extreme wet weather events (i.e. one in 10 years on average) when water quality will likely be degraded by more significant land-based pollutant sources.

TABLE 2.15 WASTEWATER EFFLUENT REUSE AND DISPOSAL OPTIONS ANALYSIS (CONTINUED)

Description/ Comment	Advantages	Disadvantages	Conclusion
Installation of non-potable water reticulation to enable use of recycled water for non-potable purposes such as toilet flushing, laundry and garden use.			
Installation of a network of "third pipe" or "purple pipe" reticulation to enable recycled water to be used for non-potable internal purposes such as toilet flushing and laundry as well as external irrigation and washdown.	• Provides an alternative source of non-potable water supply to replace potable water demand for certain purposes, that is not dependent on rainfall as is the case for harvested stormwater runoff and roof water collection. • Consistent with sustainability objectives of the GKI Revitalisation Plan.	• High ongoing compliance costs associated with ongoing monitoring and reporting required for dual reticulation schemes to protect public health. • The volume of recycled water produced would achieve only limited reduction in demand for potable water supplies, given that non-potable water supply for toilet flushing, washing machines, garden watering, car and boat washdown, can also be derived from rainwater harvesting. • The availability of recycled water will be highly variable due to the fluctuating occupancies and therefore generation of wastewater effluent associated with tourist facilities, and is therefore not considered to be a sufficiently reliable source of water for these types of non-potable purposes. • Not all recycled water produced by the GKI Revitalisation Plan could be reused for this purpose. As such, dual reticulation would need to be combined with an alternative reuse option such as irrigation. • Significant ground disturbance and ongoing pumping costs / energy consumption would be associated with the extensive recycled water distribution and storage system required for a dual reticulation scheme. • Achieves beneficial reuse of water component of recycled water only, not beneficial reuse of nutrients as occurs through irrigation to the golf course.	This option is not preferred due to the high establishment and ongoing maintenance / compliance costs and the relatively small proportion of recycled water that could be used for this purpose relative to the cost of the scheme. Note also, that the estimated quantity of effluent available can more readily and economically be used for golf course irrigation.

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

2.4.7.6 Projected Wastewater Flows

An Average Dry Weather Flow (ADWF) of 180 L/EP/day has been calculated for the GKI Revitalisation Plan. The estimated ADWF of 180 L/EP/day is equivalent to the estimated internal water demand.

Notwithstanding, preliminary assessment of recycled water reuse has been based on an ADWF of 200 L/EP/day. This is to ensure a conservative assessment of irrigation area and wet weather storage requirements for the recycled water irrigation scheme given the environmentally sensitive nature of the site. An ADWF of 200 L/EP/day is consistent with the ADWF used for calculating peak design capacity for ERA 63 - Sewerage treatment works under schedule 2, part 13, item 63 of the *Environmental Protection Regulation 2008*.

The estimated EP for the purpose of establishing wastewater flows for the GKI Revitalisation Plan is the same as for the water demand. The maximum estimated EP for the GKI Revitalisation Plan is 3,973 EP. As such, the proposed WWTP will conform to the definition of ERA 63(2)(c) which is defined in schedule 2 of the *Environmental Protection Regulation 2008* as follows: *ERA 63(2)(c) – Sewage treatment – operating sewage treatment works, other than no release works, with a total peak design capacity of – 1,500 to 4,000EP.*

Based on an ADWF of 180 L/EP/day estimated for the Project, the following average monthly wastewater flows have been estimated by Opus and shown in **Table 2.16**:

TABLE 2.16 ESTIMATED MONTHLY WASTEWATER FLOWS (@180L/EP/DAY)

		ADWF for Month @ 180 L/EP/day	
Month	**EP x Occupancy**	**ML/day**	**ML/month**
January	3750.1	0.675	20.925
February	1724.5	0.310	8.692
March	1847.5	0.332	10.309
April	2143.8	0.386	11.577
May	1069.3	0.192	5.967
June	1193.2	0.215	6.443
July	1666.6	0.300	9.300
August	1570.6	0.283	8.761
September	3075.1	0.554	16.606
October	2262.7	0.215	12.626
November	2313.4	0.416	12.492
December	3303.3	0.595	18.432

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

As can be seen from **Table 2.16**, the quantity of wastewater generated by the Resort will vary significantly throughout the year depending on occupancy rates.

It should be noted that while **Table 2.16** represents the estimated ADWF for the Project, figures adopted for modelling of recycled water irrigation to land have been based on 200 L/EP/day to provide a conservative assessment of irrigation area and wet weather storage requirements.

2.4.7.7 Wastewater Treatment and Reuse Scheme

Although it is intended that the existing wastewater treatment plant that serviced the former resort will be demolished and replaced with a new facility, the existing treatment plant will temporarily be re-commissioned to treat wastewater during the initial phases of construction prior to construction of the new treatment plant, which is scheduled to occur during Stage 1.

Prior to being re-commissioned, the existing wastewater treatment plant will be refurbished to ensure it is capable of effectively treating sewage effluent generated during construction to the required standard to comply with the conditions of Licence No. CR0061.

The volume of sewage effluent expected to be generated during Stage 1 of construction prior to commissioning of the first stage of the new WWTP(s) is estimated to be up to approximately 50 kL/day for 350 EP at a maximum of 150 L/EP/day (say, 250 EP for up to 250 construction workers in facilities on the Island 40 EP for messing facilities and 60 EP for up to 200 workers ferried to the Island each day). This is based on a maximum of 450 workers in Stage 1 as outlined in the Construction Report. As outlined in above, this is within the capacity and licence limits specified for the existing wastewater treatment plant.

Treated effluent generated during Stage 1 of construction will be discharged via irrigation of a pre-designated area, likely to include the area of the former golf course previously used for irrigation of recycled water, in accordance with the conditions of the existing environmental licence. Alternatively, it may also be partly used to for irrigation of disturbed areas of the new airstrip to assist with turf / landscaping establishment.

Core components of the proposed wastewater treatment (Post construction Stage 1) and reuse scheme are described in detail in the following sections.

(a) Wastewater Collection

Wastewater collection to deliver sewage from the generation source to the WWTP(s) is proposed as follows:

- throughout the Resort generally (unless listed below), a gravity system using "NuSewers" (or similar) will be used due primarily to their lower infiltration rates compared to traditional sewers and the lower cost compared to a vacuum or pumped system. The NuSewers Design and Construction Specification, Queensland Urban Utilities, Sewerage Standards describes "NuSewers' as:

NuSewers comprise fully welded PE pipes, fittings and maintenance shafts. The elimination of rubber ring joints will minimize groundwater infiltration and tree root intrusion reducing maintenance and sewage treatment costs.

NuSewers are designed on the basis that inspection will be undertaken with CCTV equipment and blockages cleared using jet rodders. This approach allows the sewer alignment to include both horizontal and vertical curves minimising the number of maintenance access structures compared to a traditional sewer system. With NuSewers the majority of access structures will be PE maintenance shafts. However, manholes will be required for complex sewer junctions and at strategic locations for the removal of miscellaneous items that occasionally enter the sewer system.

- for marina apartments and any apartments / villas located on steep ground, either a "NuSewer" gravity system or individual unit grinder pump stations with small diameter common rising main following ground contours will be used. These individual units require less ground disturbance compared to traditional gravity sewers. These individual units will only be used as demand requires.
- for the marina berths, a specialised wastewater pump-out facility will be necessary within the Marine Services Precinct for the acceptance of wastewater pumped from berthed watercraft. New marina waste management facilities will be provided in accordance with the Best Practice Guidelines for the Provision of Waste Reception Facilities at Ports, Marinas and Boat harbours in Australia and New Zealand (reference) and relevant legislation.

In the event of power failure or equipment breakdown, the following contingency measures would apply within the collection system:

- the gravity sewer system would be unaffected up until the collection well of pumping stations;
- any individual unit grinder pump stations (where installed to villas) would have a storage capacity within the pump collection well for at least four hours at ADWF. This would typically involve around 100 litres of storage within the collection well for each villa;
- main pumping stations would be provided with:
  - 100 percent standby pumping capacity within the station to cover pump mechanical breakdown;
  - an alarm system to advise maintenance staff of power or mechanical failure;
  - capacity within the emergency back-up generator for the Resort and/or provision (i.e. power bypass switch) within the pumping station to connect up an individual emergency generator brought to the pumping station to cover power failures; and
- minimum of two hours storage capacity at ADWF within the pump station wet wells and contributing reticulation mains (and overflow storage if required with any overflow being returned to the wet well).

Odour control within the collection system would be achieved by sealing of all manholes and pumping stations, thus containing any odours within the system.

(b) Treatment Standard

The proposed treatment standard has been determined in relation to the proposed uses of recycled water, which include:

- irrigation of the golf course;
- irrigation of other sporting fields and landscaped areas (where the availability of recycled water exceeds the sustainable irrigation requirements of the golf course); and
- emergency discharge of recycled water during extreme wet weather events via ocean outfall.

It is proposed that all effluent generated by the GKI Revitalisation Plan will be treated to comply with the minimum water quality criteria specified in **Table 2.17**.

TABLE 2.17 PROPOSED MINIMUM TREATED EFFLUENT QUALITY CRITERIA

Quality Characteristic	Unit	Release Limit	Limit Type	Monitoring Frequency
E. coli	cfu/100mL	<1 (<10)	Median (95th percentile)	Weekly
5-day Biological Oxygen Demand	mg/L	<20	Median	Weekly
Turbidity	NTU	<2 (<5)	Median (Maximum)	Continuous
Suspended Solids	mg/L	<5	Median	Weekly
Total Dissolved Solids	mg/L	<1,000	Median	Weekly
pH		6.0 – 8.5	Range	Weekly
Total Nitrogen	mg/L	<20	Median	Monthly
Total Phosphorous	mg/L	<7	Median	Monthly
Free Chlorine Residual[1]	mg/L	0.5-1.0	Range	Continuous

Source: 'Water Cycle Management Report' (2011) – Opus International Consultants Pty Ltd

1: Only applies where chlorination is used for disinfection. Disinfection is not preferred where discharge to the ocean is likely to occur.

The proposed standard of treatment is consistent with the specified water quality objectives for "Municipal Use – open spaces, sports grounds, golf courses, dust suppression, etc or unrestricted access and application" as defined under the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (ANZECC, 2006). Proposed total nitrogen and total phosphorous concentrations have been determined as appropriate based on a comprehensive assessment of the nutrient assimilation capacity of soils and vegetation within the proposed irrigation area. The proposed standard of treatment is considered to be suitable for the following recycled water reuse options:

- irrigation of the golf course;
- irrigation of other sporting fields and landscaped areas (where the availability of recycled water exceeds the sustainable irrigation requirements of the golf course); and
- emergency discharge of recycled water during extreme wet weather events via ocean outfall.

It is anticipated that monitoring of recycled water quality will occur at the outlet of the WWTP(s) at the approximate frequencies listed in the **Table 2.17** to ensure recycled water quality achieves the above levels at discharge from the WWTP(s).

(c) Treatment Process

Based on consideration of the available options as discussed above, the preferred option for treatment of wastewater generated by the GKI Revitalisation Plan is an Island-based WWTP(s). Treatment of wastewater on the Island may be undertaken using a single WWTP or multiple WWTPs.

If two wastewater treatment plants (WWTPs) are to be provided on the Island these would most likely be located as follows, subject to final design, plant selection and buffer zone requirements:

- a WWTP servicing the Marine Services Precinct and Fisherman's Beach Precinct (including marina facilities, hotel, apartments, villas, commercial / retail, airport terminal and staff accommodation) – most likely located on the north-eastern side of the airstrip within the vicinity of the facilities maintenance compound; and
- a WWTP servicing the Clam Bay Precinct – most likely located to the north-west of the golf course.

If a single WWTP is to be provided on the Island this would most likely be located to the north-west of the golf course, noting that this would be located in close proximity to the primary area of proposed recycled water irrigation. However, a site to the north-west of the airstrip and near the maintenance facility would also be considered. This latter site would involve pumping of wastewater from the Clam Bay Precinct and then pumping of all effluent from the WWTP to the golf course storage pond.

Another aspect to review in the final design of the wastewater treatment facilities is the early completion of the golf course and associated facilities with villas in the Clam Bay Precinct not commencing until around 2017 – according to the staging plans within the Construction Report. An option is to provide a temporary self contained package WWTP for the golf course facilities with effluent pumped to the storage pond. This temporary plant would then be removed from the Island once the villas came on line with the permanent connection to the main WWTP constructed.

Selection of the preferred type of treatment system will need to take into account a range of factors including, but not limited to:

- the staging of the Project over 12 years and associated EP growth;
- the variability of the hydraulic loading on the treatment system with the fluctuating occupancy over the year ranging (for the completed Project) from approximately 1,069EP to 3,750EP;
- potential for odour nuisance and requirements for buffer zones to prevent adverse impacts on the amenity of residential and tourist accommodation on the Island; and
- ability to consistently achieve the high standard of treatment, including disinfection and nutrient removal, required to be 'fit for purpose' for proposed recycled water reuse, to prevent potential public health impacts and to prevent contamination of groundwater aquifers, soils and water quality within the GBRMP.

A number of wastewater treatment processes and systems would be capable of achieving the required standard of treatment. Although the exact treatment process and system used will be determined at detailed design stage, one of the preferred options at this stage comprises a proprietary package treatment plant utilising membrane bio-reactor (MBR) or similar technology system. This type of system would incorporate:

- grit chambers/screens to remove floating solid items and grit. Screened solids and grit would be collected and disposed of at a licensed landfill facility on the mainland;
- sedimentation/sludge tanks contained within the package plant – settled sludge directed to sludge digestion tanks (within the package plant), sludge removed, dewatered, dried and used for landscaping;
- liquid from sedimentation/sludge processes is then passed through the bio-reactor membrane to remove suspended solids and solids returned to the sedimentation/sludge tanks for re-processing;
- effluent passed through the bio-reactor membrane is then disinfected with UV to achieve an E. coli level of <1 cfu/100mL before being pumped to the wet weather storage pond(s) on the golf course; and
- treated effluent from the wet weather storage ponds before irrigation across the golf course.

Advantages and disadvantages of the above package plant system, compared to the other options assessed, are discussed above.

In the event of power failure or equipment breakdown, the following contingency measures would apply within the treatment system:

- as outlined in the Power and Communications Report (AECOM 2011), there will be dedicated standby generator provision made for the WWTP(s). Primary power for the Resort is also based on solar supply with the mainland power connection main as the next primary supply. Given the relatively high security of power supply for the WWTP(s), the risk of wastewater overflows is accordingly considered to be relatively low;
- due to staging requirements and operational flexibility, treatment systems would involve duplication (or triplication) of treatment plant processes, thus allowing for one system to be out of service for short periods in the event of maintenance requirements (programmed maintenance being undertaken at low flow / low occupancy times) or emergency breakdown situations;
- in the event of power failures, the package plants would be designed to contain up to approximately 10 hours x ADWF within various components of the treatment plant and/or within a separate bypass storage pond. After power is restored, the bypassed flow is then returned from the storage pond back through the package plant for treatment. The storage requirement (within the plant and/ or separate storage pond) would be 312 kL (10/ 24 hrs x 200 L/EP/day x 3750 @98 percent occupancy). Ten hours storage should be more than sufficient time for maintenance staff to respond to system monitoring with warnings of overflows and any issues with the starting up of standby generators.
- in accordance with the DERM (now known as DEHP) *Guideline Framework for Managing Sewerage Infrastructure to Reduce Overflows and Environmental Impacts* and noting the sensitive area of the Island within the GBRMPA, there would be, as part of the contingency planning for the operation of the wastewater treatment:
    - a 24/7 Emergency Response Plan incorporating remediation and clean up procedures investigation and improvement plans. Remediation and clean up in this case would be expected to mainly involve ensuring the return of any overflow from the storage pond and clean up of the storage pond area on completion;
    - "Due Diligence" Practices in the design and operation including risk management principles to minimise the potential for overflows and environmental harm (including the features as outlined above, risk of overflows minimised with back-up power generation), community exposure to overflows minimised with any overflow contained within the WWTP and associated overflow storage pond within the fenced WWTP compound;

- organisational management with clearly defined accountabilities within the maintenance hierarchy for the appropriate operational and maintenance aspects of the wastewater system, pumping stations, WWTP, back-up generators etc; and
- reporting procedures as outlined.

Odour issues are unlikely with a packaged plant such as MBR as the process components are effectively sealed within the plant. Odour issues may arise in the event of power failure when influent is diverted to temporary storage in open ponds adjacent to the plant. However, such events are expected to be rare with a number of treatment trains and back-up power being provided. Nevertheless, appropriate buffer distances should be provided between the WWTP and sensitive receivers to reduce the potential for odour nuisance.

(d) Recycled Water Reuse

Following consideration of the range of options available for reuse of recycled water produced by the Island-based WWTP, the preferred reuse scheme consists of:

- reuse of recycled water for irrigation primarily of the golf course, with any excess recycled water produced used for irrigation of other landscaped areas, preferably around the golf course villas to minimise the need for pumping recycled water across to the Fisherman's Beach Precinct; and
- during extreme wet weather events (i.e. one in 10 years on average), excess recycled wastewater may be discharged via an ocean outfall extending from Long Beach.

As construction of the golf course will occur in Stage 2-3, commencing about two years after other components of the GKI Revitalisation Plan, an alternative recycled water irrigation area will need to be provided in the early stages. It is anticipated that irrigation of recycled water to assist in establishing turf adjacent to the airstrip will occur during the early stages of the Project prior to construction of the golf course. Treated effluent may also be used in the early stages for irrigation within the 'turf nursery' that is likely to be established to grow the turf required to construct the golf course.

Although consideration was given to reuse of recycled water for other non-potable purposes within the Resort (e.g. toilet flushing, washing machines, garden watering, washdown) through a dual reticulation system, this option was not considered preferable on the basis that:

- the volume of recycled water produced would achieve only limited reduction in demand for potable water supplies, given that non-potable water supply for toilet flushing, washing machines, garden watering, hardscape and boat washdown, will be derived from rainwater harvesting;

- the availability of recycled water will be highly variable due to the fluctuating occupancies and therefore generation of wastewater effluent associated with tourist facilities, and is therefore not considered to be a sufficiently reliable source of water for these types of non-potable purposes;
- in excess of 99 percent of recycled wastewater produced can be sustainably and beneficially reused for irrigation of the golf course thereby minimising the need to secure other water supply sources for this purpose; and
- significant ground disturbance and ongoing pumping costs/energy consumption would be associated with the extensive recycled water distribution and storage system required for a dual reticulation scheme.

Reuse of recycled water for irrigating landscaping, open spaces and sports fields has gained widespread use across Australia and other countries as a way to conserve valuable water resources. Given the limited availability of water resources on the Island and the relatively high irrigation water demands of the proposed golf course, the use of recycled wastewater to meet the irrigation demands for landscaping, and particularly the proposed golf course, is considered to comprise the most beneficial reuse for recycled wastewater produced from wastewater generated by the GKI Revitalisation Plan. This view is supported by Technical Report 34 prepared for the CRC Reef Research Centre (Gallagher and Volker, 2004) with the statement referring to GBRMPA's sewage system requirements introduced in 1991, "One of the principal strategies of the sewer management policy was encouragement to reuse effluent on the islands for irrigation of gardens, golf courses and other grasslands".

Reuse of recycled wastewater for irrigation of the golf course and possibly other landscaped areas (where excess recycled water is available), will not only reduce pressure on other water supply sources, but will also enable the beneficial reuse of nutrients contained in the recycled wastewater to support plant growth within the irrigation area. Application of nutrients contained in recycled water to vegetation enables natural biological processes to be used to further reduce nitrogen and phosphorus components before potentially entering groundwater or surface water systems, rather than using chemical reaction processes within a treatment plant. Such chemical treatment processes typically require large inputs in terms of energy to achieve the levels of nutrient reduction that can be achieved by healthy vegetation. Application of nutrients contained in recycled water to vegetation also reduces the need to apply additional fertilisers, which are usually derived from synthetic or inorganic sources.

While nutrients applied to the golf course and other landscaped areas are beneficial to plant growth within these areas, it is necessary to ensure that the amount of nutrients applied does not exceed the hydraulic and nutrient assimilation capacity of soils and plants within the irrigation area, otherwise nutrients may be leached into groundwater and ultimately surface water bodies. To determine the amount of nutrients contained in recycled water and the rate of application that can be sustainably applied to the irrigation area, a detailed water and nutrient balance has been undertaken as described in the following section.

All recycled water irrigation will be undertaken in accordance with an approved irrigation management plan.

2.4.7.8 MEDLI Modelling

To determine a sustainable strategy for application of recycled water for irrigation on the Island the computer-based MEDLI (Model for Effluent Disposal using Land Irrigation) Version 1.30 program developed by the former Department of Natural Resources and Mines was used. MEDLI is a government approved complex, daily time step, hydrological and nutrient balance simulation model for effluent irrigation systems. The program incorporates historical climatic data for the locality, along with input parameters specific to each effluent irrigation system (i.e. effluent quality and quantity, land area, storage size, soil nutrient adsorption and vegetation nutrient uptake capacities) to assess the hydrological and nutrient balance of the system.

The objective of MEDLI modelling undertaken for this project was to determine an appropriate standard of treatment, irrigation schedule, irrigation area and wet weather storage volume requirements to maximise the beneficial reuse of sewage effluent generated by the GKI Revitalisation Plan without resulting in any adverse environmental or human health impacts.

The MEDLI model simulates operation of the proposed irrigation system over a fifty-three (53) year period based on climatic data for the period between 1 January 1957 and 31 December 2009. Relevant inputs and outputs to the model are described in the following sections:

Based on the above results, the preferred recycled water irrigation scheme based on proposed effluent quality characteristics and hydraulic loading consists of:

- Irrigation Area = 31 hectares
- Wet Weather Storage = 37 megalitres (plus 7 megalitres climate change buffer)
- Trigger irrigation at 80 percent PAWC and irrigate up to 5 millimetres beyond DUL.

This scheme achieves over 99 percent reuse of recycled water generated by the GKI Revitalisation Plan, with discharge from wet weather storages expected to occur only during extreme wet weather periods or approximately once every 10 years.

To achieve 100 percent reuse, a minimum 75 megalitres (plus 15 megalitres climate change buffer) wet weather storage would need to be provided. Construction of this additional storage volume would require significant amounts of additional land area (> two hectares) and earthworks, including associated vegetation clearing as well as the importation of significant quantities of material to reduce seepage in the natural sand soils.

It was determined that in order to achieve 100 percent reuse, significant additional storage volume and clearing would be required and therefore it was decided to proceed with a recycled water irrigation scheme that achieves only 99 percent reuse.

The proposed golf course is currently expected to comprise approximately 31 hectares of maintained turf that would be suitable for irrigation using recycled water. Depending on final design of the golf course, additional areas may be required for irrigation. In this case, landscaped gardens and turf surrounding Eco Resort Villas located within the same Clam Bay Precinct as the golf course would be the first preference for alternative irrigation area to minimise costs and energy consumption associated with pumping recycled water around the Island. However, landscaped gardens and turf within the Fisherman's Beach Precinct would also be acceptable for reuse of recycled water for irrigation if required being based on the same underlying soil type.

In order to ensure the ongoing sustainability of the proposed recycled water irrigation scheme and to mitigate potential environmental and public health risks associated with the scheme, a Preliminary Irrigation Management Plan has been developed and is included in the Water Cycle Report.

2.4.7.9 Emergency Wet Weather Discharge

MEDLI modelling for the proposed recycled water irrigation scheme indicates that in excess of 99 percent of all recycled water generated by the GKI Revitalisation Plan will be reused on the Island for irrigation of the golf course and possibly other landscaped garden and turf areas. During prolonged or extreme wet weather events, expected to occur approximately once every 10 years on average, wet weather storage ponds may reach capacity and a proportion of the recycled water may subsequently be discharged via an ocean outfall.

The likelihood of ocean discharge occurring is expected to be somewhat less than the one in 10 years predicted by MEDLI given that the MEDLI modelling was based on provision of a 37 megalitres wet weather storage. However, to account for potential increases in rainfall intensity that are predicted to occur as a result of climate change, it is proposed to provide 44 megalitres wet weather storage or almost 20 percent more storage than considered in the MEDLI modelling. This is considered to be an extremely conservative approach to sizing of the wet weather storage given that although increased rainfall intensity is predicted to occur as a result of climate change, a decrease in average annual rainfall is also expected to occur meaning that:

- irrigation is likely to be triggered more often based on a soil water deficit, resulting in more recycled water being used for irrigation and less recycled water going into wet weather storage; and
- less direct rainfall will be captured by the open wet weather storage ponds providing more capacity for storage of recycled water.

It is noted that the proposed wet weather discharge is significantly lower than the volume of discharge permitted under the environmental licence conditions for the existing wastewater treatment plant servicing the former resort, which allowed for up to 250 cubic metres per day of effluent to be discharged on dry weather days and up to 500 cubic metres per day to be discharged on wet weather days.

To determine the location of the proposed ocean outfall, consideration has been given to GBRMPA's Sewage Discharge Policy - *Sewage Discharges from Marine Outfalls to the Great Barrier Reef Marine Park, March 2005*. This policy states that:

> *Marine outfalls should not be constructed:*
>
> *i.* *Within 50 metres of a permitted mooring or anchorage; or*
>
> *ii.* *Within 1000 metres of aquaculture operations, or an area regularly used for*
>
> *iii.* *swimming or other water-based activities, unless it can be demonstrated that there will be no adverse impacts on the operation or activities; or*
>
> iv. *Within 1000 metres of sensitive environments, unless it can be demonstrated that there will be no adverse impacts on the protection of aquatic ecosystems.*
>
> *For a marine outfall to be approved the GBRMPA will require that:*
>
> *i.* *The outfall structure be of a design which optimises diffusion and dispersal; and*
>
> *ii.* *The design of the system includes consideration of water depth (deep water is preferred i.e. greater than 10 metres), current velocity, tidal range and proximity to reefs or other sensitive environments.*

A bathymetric survey has been conducted offshore to the south of Long Beach. This location was selected to provide adequate distance away from the shore, sufficient depth and exposure to offshore ocean currents to facilitate dispersion of recycled water. This location avoids identified coral reefs and has minimal impacts to existing seagrass beds (frc environmental, 2011).

The proposed ocean outfall for excess treated wastewater will comprise a pipeline of approximately 1,000 metres in length extending from Long Beach (refer **Figure 3.40 in Section 3.4.3**). The outfall will be located within an area of water at least 10 metres deep to ensure sufficient depth of water is available above the diffuser across the full tidal range. The outfall will incorporate a T-shaped diffuser comprising two ports approximately 75 millimetres diameter. Modelling of predicted dispersion of discharges from the ocean outfall has been undertaken by Water Technology and is contained in **Appendix Y**.

Based on the estimated volume and duration of discharge events predicted by MEDLI modelling and assuming effluent nutrient concentrations of 20 mg/L for total nitrogen and seven mg/L of total phosphorous, dispersion modelling by Water Technology has predicted that concentrations of total nitrogen and total phosphorous will reduce to below relevant trigger values within a small mixing zone in the immediate vicinity of the outfall. On this basis, the proposed emergency wet weather discharge of recycled water via an ocean outfall is not anticipated to have any significant impact on ecological communities near the outfall.

2.4.7.10 Summary of Proposed Wastewater Strategy

The proposed strategy to manage wastewater generated by the GKI Revitalisation Plan, will involve:

- a wastewater collection system utilising "NuSewers" or other similar technologies that are designed to minimise groundwater infiltration (due to the high water table on the Island), thus reducing treatment costs, along with sewage pumping stations (where required);
- an Island-based wastewater treatment plant (or treatment plants) designed to treat wastewater to a standard suitable for "Municipal Use – open spaces, sports grounds, golf courses, dust suppression, etc or unrestricted access and application" under the Australian Water Quality Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (ANZECC, 2006) with nutrient removal to achieve a total nitrogen concentration of 20mg/L and a total phosphorous concentration of 7mg/L;
- beneficial reuse of almost 100 percent of recycled water produced by Island-based WWTPs for irrigation of the golf course (approximately 31 hectares) and possibly other landscaped areas around the Resort;
- emergency discharge of recycled water via an ocean outfall extending from Long Beach, during periods of extreme wet weather, which is expected to occur once every 10 years on average, resulting in less than one percent of total recycled water produced being discharged over a 50 year period; and
- a wet weather storage facility with a capacity of 44 megalitres incorporating a seven megalitre buffer to account for projected increases in rainfall intensity as a result of climate change, which will be incorporated into the golf course design.

Although the exact treatment system to be used for the Island-based WWTP(s) will be determined at a later design stage, a package treatment plant utilising MBR technology or similar is preferred as such systems are capable of achieving the required standard of treatment, have a relatively small footprint, can be almost fully sealed to reduce odour generation and allow for the installation of multiple parallel treatment plants to support staging of the Project and provide operational flexibility.

A comprehensive water and nutrient balance has been modelled and demonstrates that the proposed recycled water irrigation scheme will not increase nutrient leaching or runoff rates compared to modelling of a no irrigation scenario. Modelling of nutrient concentrations in groundwater at the point of discharge to Leeke's Creek has demonstrated compliance with relevant water quality objectives. Modelling of possible emergency discharge of recycled water via ocean outfall has also demonstrated that nutrient levels will achieve compliance with relevant water quality objectives within a very small mixing zone and are therefore unlikely to impact on ecological communities.

The high standard of treatment proposed for recycled water will not only mitigate potential impacts on the environment, but will also significantly reduce potential human health impacts should persons come into contact with recycled water. To further reduce this risk, additional controls have been proposed including the use of large droplet fixtures on spray irrigators, use of sub-surface or surface dripper systems in the vicinity of sensitive receivers, scheduling irrigation to occur at night and installing signage for all irrigation areas and recycled water storages.

By maximising beneficial reuse of wastewater generated by the GKI Revitalisation Plan and ensuring such reuse is undertaken in a manner to prevent adverse impacts on the environment or human health, the Resort will establish a benchmark in sustainable tourism development within the GBRMP.