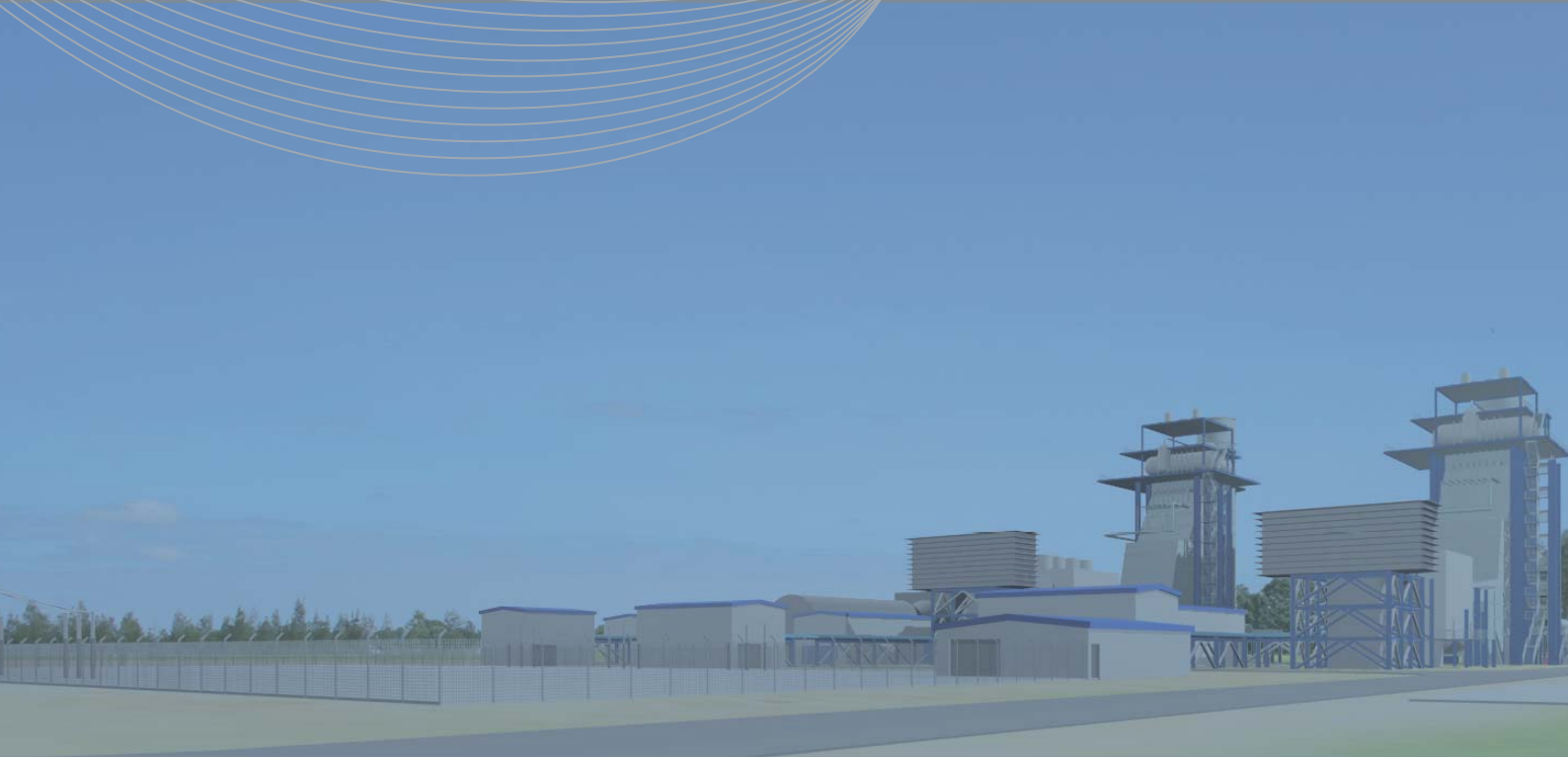
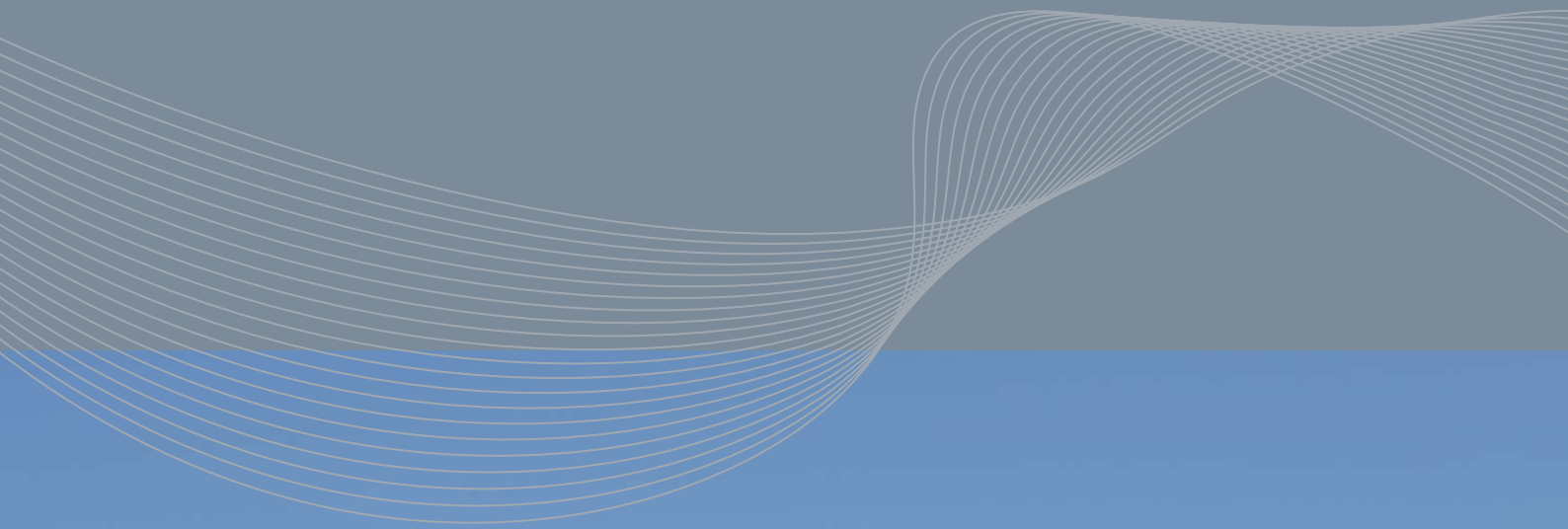




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Appendix G

Water cycle management (GHD)





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Delta Electricity

Proposed Gas Turbine Power
Station at Bamarang, Nowra

Water Cycle Management

December 2005



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- A Supporting Hydrological Simulations
- B Surface Water Management and Mitigation Measures for Key Impacts



1. Introduction

1.1 The Proposal

Delta Electricity (Delta) proposes to facilitate the development of a gas turbine power facility at Bamarang (approximately 8 km south-west of Nowra), to meet future local and regional electricity needs.

The proposed power facility would be developed in two stages:

- ▶ Stage 1 – Two Open Cycle Gas Turbines with generating capacity of 260 - 280 MW; and
- ▶ Stage 2 – Conversion of the power facility to a Combined Cycle Gas Turbine configuration, increasing the total generating capacity up to 400 MW.

A concept (functional) design for the facility has been prepared.

The units to be used at the power facility and the final layout will be determined through a normal design and construction process.

1.2 Water Management Report Overview

The report describes and assesses the water management at the site including:

- ▶ Statutory and Authority requirements;
- ▶ The existing hydrological environment;
- ▶ Water cycle management including consideration of water usage and water supply options;
- ▶ Potential impacts of the proposal with respect to water management;
- ▶ Mitigation of potential adverse impacts of the proposal on water management; and
- ▶ Proposals for ongoing maintenance of surface water management infrastructure at the site.

1.3 Statutory and Authority Requirements

An environmental assessment is to be prepared to address the potential impact of construction and operation of the proposal. This report provides the water management input to the environmental assessment.

The DIPNR Director-General's Requirements (DGRs) has identified that water is a 'key assessment requirement' for the environmental assessment to be prepared under the new Environmental Planning and Assessment Act 1979, Part 3A requirements. This is consistent with the comments received during the statutory consultation period for the environmental assessment, and is supported by the requirements submitted by DEC.

The focus of the DGRs and DEC's requirements is on undertaking a full water cycle assessment. This involves consideration of the integration of water supply/sources (including effluent reuse), sewerage/wastewater and stormwater, so that water is used



optimally within a catchment resource or other defined boundary. In this way, an integrated system will often rely less on natural water sources as more benefit is made of water already being used through demand management, effluent reuse and stormwater use.

Similarly, the DEC requires details on water quantities, sources, water quality (supply, process waters, etc.) and any discharge and reuse options. This refers not just to process water but domestic type waters as well (eg. that used in amenities blocks etc.).

The Protection of the Environment Operations Act 1997 (POEO Act), administered by the Department of Environment and Conservation, is the primary legislative tool for regulating pollution control and waste disposal in NSW. The objectives of the POEO Act are:

- ▶ To protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development;
- ▶ To provide increased opportunities for public involvement and participation in environment protection;
- ▶ To ensure that the community has access to relevant and meaningful information about pollution;
- ▶ To reduce risks to human health and prevent the degradation of the environment by the use of mechanisms that promote the following:
 - ▶ Pollution prevention and cleaner production;
 - ▶ The reduction to harmless levels of the discharge of substances likely to cause harm to the environment;
 - ▶ The elimination of harmful wastes;
 - ▶ The reduction in the use of materials and the re-use or recycling of materials;
 - ▶ The making of progressive environmental improvements, including the reduction of pollution at source;
 - ▶ The monitoring and reporting of environmental quality on a regular basis;
- ▶ To rationalise, simplify and strengthen the regulatory framework for environment protection;
- ▶ To improve the efficiency of administration of the environment protection legislation; and
- ▶ To assist in the achievement of the objectives of the Waste Avoidance and Resource Recovery Act 2001.

In order to ensure that potential impacts on the environment by surface water are managed in accordance with the objectives of the POEO Act, this report identifies mitigation measures that would need to be implemented during the construction and operational phases.



2. Existing Environment

2.1 Location and Site Description

The site is located at Bamarang, approximately 8 km south-west of Nowra on the NSW south coast. The site has frontage to Yalwal Road, which links Nowra with Yalwal.

The site area is approximately 20 hectares, of which 5 hectares would be required for the gas turbine plant and 2 hectares would be required for a switchyard. In addition the development includes transmission line and gas pipeline routes. The site is bounded by Bamarang Nature Reserve to the north and Crown Land elsewhere. Bamarang Dam, which supplies Nowra's water, is located 300 m to the west.

The central portion of the site was previously cleared and developed as an abattoir, although the facility was never operated. Some regrowth has occurred since the site was cleared for the abattoir development. The remainder of the site contains bushland that extends into the adjoining properties owned by the Crown and Council. It is understood, that this bushland is part of a larger parcel that is of high conservation value and includes the Bamarang Nature Reserve, Triplarina Nature Reserve, Wogamia Nature Reserve and the Colymea State Conservation Area.

There are a number of existing buildings on the site, which include stockyards, an administration building, and a processing building. There is also a storage shed and residence.

2.2 Topography and Existing Drainage

The site area is located at an elevation of approximately RL 105 m, in close proximity to the watershed of creeks draining, to the Shoalhaven River:

- ▶ North-west via Bamarang Reservoir; and
- ▶ North-east via Sandy Creek.

Given the close proximity of the site to the watershed, it is considered viable that the future site platform can be orientated to drain the entire site in a north-east direction via Sandy Creek, to the Shoalhaven River. This will have a number of advantages, namely only one site discharge point, better control of water quality and no risk of Bamarang Reservoir contamination.

Regional drainage is along the Shoalhaven River and towards the Tasman Sea to the east. The ocean is approximately 20km east of the power facility site

Only a small area of the site drains to the northwest via Bamarang Reservoir, with the predominant part of the site draining to Sandy Creek. Bamarang Reservoir lies immediately to the west of the proposed site and is part of the Nowra district water supply.

The site has a slightly undulating topography and two tributaries of Sandy Creek convey surface water east to west across the proposed site. No steep escarpment



areas occur in the area with the nearest escarpments occurring to the north and east of the study area near the Shoalhaven River.

Along the proposed electricity transmission line easement from the power facility site to the Nowra transfer station, four creek crossings are encountered as follows:

- ▶ Sandy Creek;
- ▶ Cabbage Tree Creek; and
- ▶ Flat Rock Creek; and
- ▶ Nowra Creek.

These creeks drain northwards to Shoalhaven River.

2.3 Existing Water / Wastewater Services

No water or sewerage services are understood to be present at the site. The Nowra Water Treatment Plant is located at the north western side of Bamarang Reservoir, approximately 1 kilometre north west of the power facility site. This water treatment plant provides reticulated water to Nowra. A raw water pipeline (carrying untreated water from the Bamarang Reservoir) also passes to the north west of the power facility site. This provides a raw water supply for industry in Nowra.

Water is considered a valuable commodity within the Nowra region with a high demand for good quality water arising from both industry (including Manildra Starches and Australian Paper) and agriculture (particularly dairy farms).

The town of Nowra (located some 8 km to the east of the proposed site) is serviced by the Nowra and Bomaderry Sewage Treatment Plants (STPs). Any local sites / farmlet are likely to be serviced by their own onsite treatment systems (eg. septic tanks/ absorption trenches)

2.4 Groundwater

Based on the regional geology map, the Bamarang power facility site is located on the Berry Formation siltstone, sandstone and shale. Groundwater is expected to be fracture controlled with variable yields and salinities (Parsons Brinkerhoff, Bamarang Gas Turbine Water Supply Options Investigation Report, April 2005). Water level in the fractured rock aquifer is believed to vary from 4.5 to 24 metres below ground level with perched groundwater unlikely to exist at the site.

2.5 Climate and Rainfall

While a weather facility exists at Bamarang, no rainfall data has been recorded. For this reason, the Bureau of Meteorology Nowra rainfall gauges (068076) were used to obtain average rainfall statistics for the sites. The mean annual rainfall recorded at the gauge is 1135 mm.

Referring to Figure 1, the mean monthly rainfall is generally higher in the months of January to June. The number of rain days exhibits similar trends, with less rain days in the months July to September.

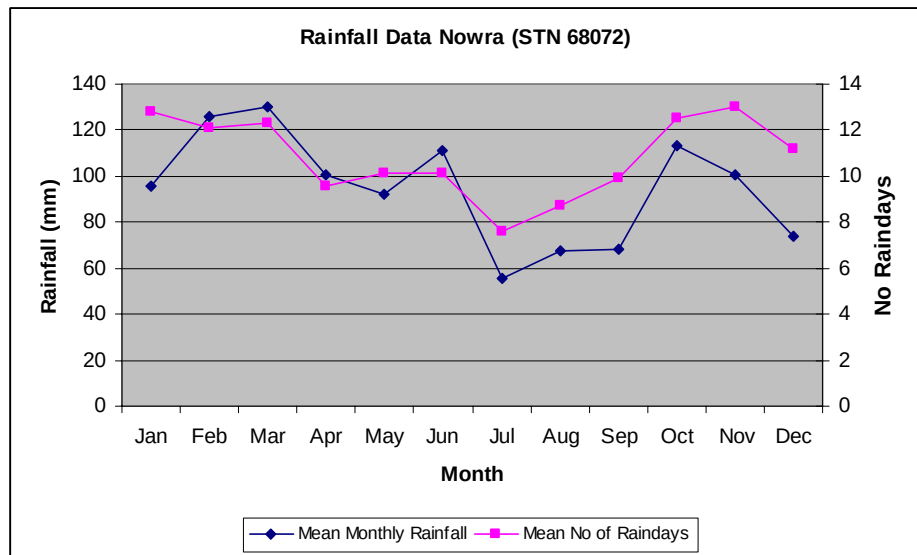


Figure 1 Seasonal Rainfall Distributions at Nowra



3. Water Cycle Requirements

The water cycle refers to the movement of water through each of its phases (solid, liquid and gas) throughout the natural environment. Water changes between these 3 states of matter throughout the water cycle using the processes of:

- ▶ evaporation (where water moves from the surface of the earth into the atmosphere from water bodies),
- ▶ transpiration (whereby water moves from earth to the atmosphere via vegetation),
- ▶ condensation (whereby water vapour stored in the atmosphere begins to form tiny droplets of liquid water) and
- ▶ precipitation (when the water droplets in clouds merge together and return to the Earth's surface as rain, hail, snow etc.)

The water cycle helps to explain the way water moves across the landscape before it collects in watercourses (surface water), how water moves underground (groundwater) and how water moves through creeks, rivers and lakes.

Water cycle management refers to the interaction of water resources so as to meet defined water quantity and quality objectives. The principal infrastructure components required to satisfy water cycle management objectives (Reference: Water Cycle Management, A Draft Position Paper prepared by the National Committee on Water Engineering) include:

- ▶ water supply;
- ▶ sewage collection, treatment and effluent disposal;
- ▶ stormwater collection, treatment and disposal;
- ▶ reclaimed (recycled) water collection, storage, treatment and reuse or disposal.

Delta Electricity has indicated that the aim for the site is to achieve little or no discharge of water from the site. In order to achieve this, a high degree of internal recycling of water streams is necessary.



4. Site Water Requirements

4.1 General

Within the scope of a water cycle assessment, the selection of an appropriate water source/s is dependent on the water demands of the facility particularly with respect to quality and quantity requirements. These are discussed in the following:

4.2 Process Water

Delta Electricity have indicated that the preferred process will use a 'wet cooled' system whereby the system relies on evaporative cooling towers for cooling of the steam from the steam turbines. The water requirements for this process are outlined in this section although it is noted that for the alternative 'dry cooled' system the water demands are substantially less. This system could therefore be adopted if the security of a water supply (to meet the 'wet cooled' process) could not be guaranteed.

For stage 1 the plant and equipment requires only minimal water for use in the inlet air evaporative cooler. The estimated water demand is in the order of 2 ML per year. (based on an hourly demand of 4.1m³/hr for 438 operating hours). While the supply (quantity) and quality of the potable water supply (from the Bamarang Reservoir water treatment plant) is yet to be confirmed, it is likely that this will provide an adequate supply for the Stage 1 requirements and no treatment will be required (i.e. MF/RO process as outlined for Stage 2). Alternatively, in the unlikely event that this water source cannot be secured (or is not of adequate quality e.g. with respect to total dissolved solids) then when water is required, appropriate quality water will be tankered in and stored in the onsite water tanks. This water will be of a quality appropriate for the use and hence no water treatment will be required. A third alternative is to use surface water runoff as a water supply for stage 1. Sufficient surface water runoff is likely to be available to satisfy the quantity requirements of the Stage 1 process however an assessment of the quality of this water supply (following construction of the facility) will be necessary before it can reliably be considered a potential source. It is likely that significant treatment of the surface water would be required (to obtain a suitable standard for use) which may therefore prove it to be an unviable option for the small quantities required for Stage 1.

At stage 2 the CCGT plant requires water for cooling and processes. A water balance for the process plant showing daily water flows is provided in Figure 2. As a wet cooling process has been identified as the preferred technology, there is a high net water demand by the plant with a daily demand of around 8.4ML. Should a dry cooled process be adopted at a later stage then the water demand will significantly decrease.

As noted the water (industrial effluent) received at the plant would undergo minor treatment prior to entering the service water tank. This would likely involve a filtration process (with some chemical dosing) such as sand filters or dual media filters.

Primary process water use will be in the cooling towers. A wet cooled system relies on evaporative (wet) cooling towers that require significant amounts of make up water.



Salinity in the cooling circuit is also controlled by blowdown, which is the removal of saline concentrated water from the cooling tower water recirculation system. A 'fresh' makeup water stream is added to replace the blowdown. For the adopted zero discharge site the blowdown would be treated in a microfiltration / Reverse Osmosis (MF/RO) plant to remove the dissolved salts, with treated water being re-used at site.

The MF/RO plant adopts membrane based desalination technologies, which use exclusion membranes to separate fresh water (containing low salt levels) from saline waters. In brief the process relies on the following treatment processes in series:

Microfiltration is a pre-treatment step undertaken to remove solids, thus providing very low turbidity water, remove pathogens and prolong reverse osmosis membrane life. Backwash from the microfiltration unit will be treated and returned to the service water tank.

Reverse osmosis, which occurs where a solution is placed under pressure causing water to pass through a semi permeable membrane while the solute is retained. The brine concentrate from the RO would pass to a holding tank prior to offsite disposal.

The MF/RO plant will be sized to handle flows of around 1.5ML/day.

Figure 2 Water Mass Balance for Stage 2 Bamarang Combined Cycle Power Plant

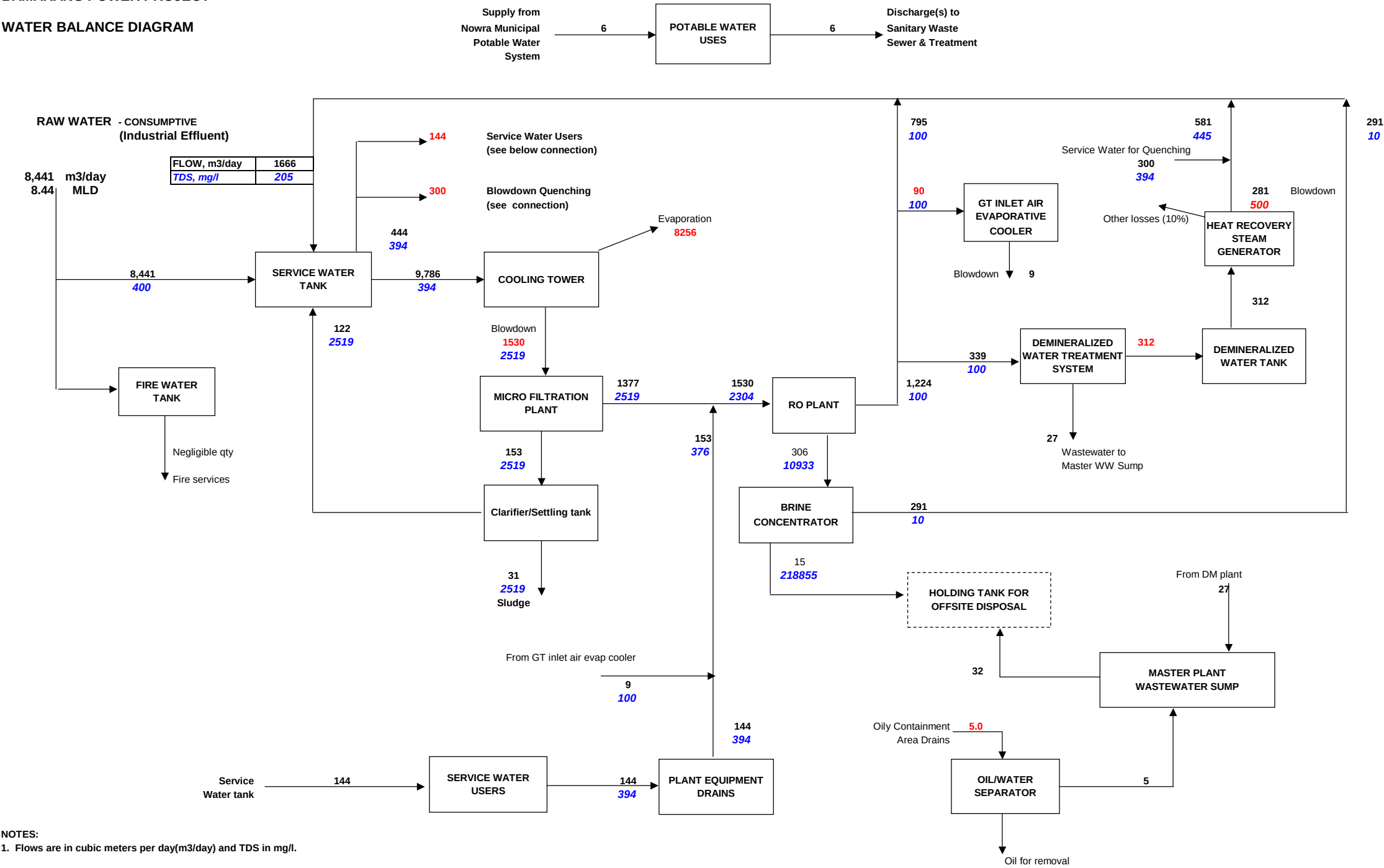
Some process water (from the MF/RO plant) will pass to the steam plant via a demineralised water treatment system. Demineralised water will be produced on site for the steam cycle and other miscellaneous uses. The amount is relatively minor in comparison to the water quantity for make up to the cooling towers. Demineralised water would be produced via an ion exchange process. The ion exchange could be conventional, using acid and caustic chemicals for regeneration or by electrodialysis, requiring significantly less chemicals.

4.3 Domestic Water

A potable (drinkable) water supply will be sourced from the Nowra Municipal Water treatment plant for domestic type uses. A pipeline will be installed from the existing reticulated water supply line that passes to the north west of the site. Alternatively, if an alternative water supply such as raw water from Bamarang Reservoir is adopted for the process water supply then onsite treatment of this water stream as a potable water supply (for domestic uses) may be adopted. This is not considered to be the preferred option as additional risk is associated with the provision of a potable water supply where human consumption is likely to be occurring.

During Stage 1, the total potable water demand (for domestic uses) is expected to be in the order of 200 kL/a with the Stage 2 water demands expected to be around double that of Stage 1.

BAMARANG POWER PROJECT
WATER BALANCE DIAGRAM



- NOTES:
- 1. Flows are in cubic meters per day(m3/day) and TDS in mg/l.
 - 2. Arrangement shown is preliminary and subject to change during detailed design.
 - 3. Water consumption estimate based on GT Pro software output and projects of similar nature
 - 4. RO plant output and reject based on discussions with vendor
 - 5. Raw water quality as per PB's water options report
 - 6. Flows are with plant running at full capacity, reduced capacity factor, ie. mid merit operation, will reduce flows in proportion.

						DELTA ELECTRICITY	JOB	DRAWING	REV
FUEL	Natural Gas	CONDENSER COOLING	WET TOWER			BAMARANG COMBINED CYCLE POWER PLANT	211385111	WMB	1
NET PLANT OUTPUT (MW)	400	COOLING TOWER COC	6.4						
LOAD FACTOR	100%					WATER MASS BALANCE			
						OPTIMUM DESIGN CONDITION- AMBIENT TEMPERATURE			
						25° C			



4.4 Surface Water

Development results in increased impermeable surfaces, which affect the hydrological cycle. This 'hardening' of the surfaces results in reduced infiltration of rainfall to the soil and more rainfall becoming runoff.

As noted in Section 2.2, given the close proximity of the site to the watershed, it is considered viable that the future site platform can be orientated to drain the entire site in a north-east direction via Sandy Creek, to the Shoalhaven River. This will have a number of advantages, namely only one site discharge point, better control of water quality and no risk of Bamarang Reservoir contamination.

As discussed in Section 4 only a portion of the site runoff will be captured for onsite use or disposal. The use of all runoff from the site (once the site was developed) would deprive the receiving waterways of a significant volume of water and potentially adversely impact on the environmental flows of local waterways. In order that the runoff discharged from the site is of an appropriate quality to prevent adverse environmental impacts on the environment, it will be necessary to implement stringent management measures for surface water. Management measures have been outlined in Section 8.2.

In general, clean water will be separated from dirty stormwater at the site. Dirty or contaminated stormwater will pass through treatment devices (oil / water separator, solids separation etc.) prior to the integration into the process water cycle (i.e. disposal or reuse depending on the achievable water quality). The quantities and quality of dirty stormwater cannot be determined until a detailed drainage plan is undertaken for the site. This will be undertaken as part of the detailed design. In general, the aim of the drainage and stormwater management will be to ensure that a similar runoff volume to the present site runoff conditions (in terms of quantity and quality) occurs and that any excess stormwater is captured, treated (as required) and reused onsite. Any excess quantities will be disposed of into the wastewater holding tank (for offsite disposal).

4.5 Wastewater management – collection and treatment

As noted, internal water recycling is integral to the adopted power facility process. This has the benefit of reducing external water demands as well as reducing the volumes of water that require treatment and disposal. While wastewater (or a byproduct) is generated as part of a number of processes, these waters have been integrated into the water cycle to maximise their reuse.

4.5.1 Process wastewater sources

The major "wastewater" stream from the process will be generated by the cooling tower blowdown. As discussed, cooling tower blowdown is undertaken to prevent excessive salinity buildup within the cooling towers (which can lead to scaling and corrosion). The cooling tower blowdown is to be treated via an MF/RO process (as discussed in Section 5.2) and returned to the Service Water Tank (the main source of water supply for the plant).

A summary of wastewater streams from the process are as follows:



Microfiltration backwash water

Backwashing of the MF units is undertaken periodically to prevent solids buildup and hence poor performance of the MF unit. This wastewater stream will pass through a clarifier for solids removal with the clarified effluent being returned to the service water tank. Some chemical dosing of the backwash water may be undertaken to improve the removal of solids from the backwash water (and potential neutralisation) but these chemicals should precipitate out in the sludge for offsite disposal. Approximately 31m³/day of sludge will be generated. The sludge is likely to undergo dewatering prior to offsite disposal to further reduce the volumes requiring disposal.

RO Brine concentrate

The RO unit works by separating saline waters from less saline waters. The saline stream will be further concentrated to further reduce the volumes requiring disposal (with the 'fresh' water being returned to the process water stream). The small volumes of concentrated brine (approximately 15m³/day) will be pumped to a holding tank for offsite disposal.

Demineralisation plant wastewater

This wastewater stream will contain a large number of impurities from the ion exchange process. These volumes (approximately 27m³/day) will also pass to the holding tank together with the brine concentrate for offsite disposal.

Dirty Stormwater

Stormwater or water runoff from designated oily areas of the site will be captured and pass through an oil / water separation unit (and solids removal unit if necessary). Depending on the degree of contamination, this treated water stream will then pass to the holding tank (for disposal) or, if determined to be of adequate quality, returned to the service water tank. It is noted that oily contaminants are of particular concern to the nominated process water treatment cycle as they have serious consequences if they pass through an MF/RO type of plant and may lead to treatment unit failure.

As a result of the plant processes and subsequent wastewater treatment processes, the streams requiring offsite disposal are therefore limited to dewatered sludge from the settling tank and oil from the oil / water separator. These wastes are readily disposed of by waste contractors and can, in some instances, be recycled.

Wastewater Disposal / Holding Tank

The wastewater streams as outlined above will pass to a holding tank prior to offsite disposal. Approximately 50m³ of wastewater will be generated each day (from the RO, demineralisation process and separated water from oil / water separator), which equates to approximately 3 additional truck movements per day for the transport of the waste offsite. (Alternatively, a transfer pipeline / pumpstation might be constructed to transport the waste although this would be determined during detailed design). Offsite disposal is likely to be via an ocean outfall, potentially in conjunction with effluent outfall from an STP (to assist in dilution and dispersion).



If such an option is not available then consideration will be given to the use of an evaporation pond or brine crystalliser. Onsite evaporation in an evaporation pond will require an area of approximately 40,000m² (say an area of 200m x 200m) and will therefore necessitate further (vegetation) clearing of the site. Some of the evaporation pond can however be placed within the fire protection zone to reduce the land clearing required. Following removal of the water content (via evaporation), the remaining solids (saline impurities) will be harvested for offsite disposal.

4.5.2 Domestic Wastewater

Domestic type wastewaters will be generated by the 8 / 18 employees on site (for Stage 1 and 2 respectively). They will be produced by administration and amenities blocks and arise from toilets, showers and kitchen type facilities. This wastewater stream will be kept completely separate from those generated by the process including the 'dirty' stormwater stream as it contains different contaminants and therefore provides differing risks and management.

The wastewater is expected to be typical of domestic type wastewaters with the following characteristics:

- ▶ BOD (Biological Oxygen Demand): 200 - 350 mg/L
- ▶ TSS (Total Suspended Solids): 200 - 300 mg/L
- ▶ Total Nitrogen: 50 - 70 mg/L
- ▶ Total Phosphorous: 8 - 12 mg/L

Domestic wastewater generation is expected to be of the order of 180 kL/a for Stage 1 and doubling for Stage 2 (based on a wastewater generation rate estimate of around 60 L/employee/day).

While the DEC have indicated that the "preference is for the sewage to be discharged to the Nowra Sewage Treatment System operated by Shoalhaven City Council" (correspondence of the 8 August 2005), in general the DEC supports the reuse of effluents where it is safe and practicable to do so and it provides the best environmental outcome. While domestic wastewaters have risks associated with the presence of pathogens these can be adequately managed with a proper onsite treatment and disposal (irrigation) system.

For Stage 1 of the proposal, all domestic wastewaters will be pumped to a septic tank for periodic pumpout and disposal to the Nowra STP by a licensed contractor. At this stage, given the distance to sewerage facilities (approximately 12km to the Nowra STP and approximately 6km to the likely nearest sewer connection), it is not considered warranted to construct a sewer for discharge of the wastewater.

During Stage 2 of the proposal, consideration will be given to the installation of an onsite wastewater treatment system (likely to be a package treatment plant) to allow for treatment and irrigation of the effluent on landscaped areas, if available. The installation of such a system will be in accordance with the National Water Quality Management Strategy document "Guidelines for Sewerage Systems – Guidelines for Sewerage Systems - Use of Reclaimed Water", November 2000. By implementing



onsite treatment and irrigation will further support Delta Electricity's aim for the site to achieve little or no discharge of water from the site. Any onsite treatment and disposal system would need to be in accordance with Council requirements and require an appropriate level of treatment and management. If onsite domestic wastewater management cannot be achieved then the wastewater will continue to be pumped out and disposed of to Nowra STP.



5. Water Sources

5.1 Potential Water Sources

Water is required for a number of uses at the proposed power facility as outlined in Section 4. A number of potential water sources to supply these requirements have been identified and are outlined as follows:

5.1.1 Reclaimed Effluent

Shoalhaven Water (a division of Shoalhaven City Council) are implementing a Reclaimed Water Management (REMS) scheme whereby treated wastewater from a number of their wastewater treatment plants is treated to a level whereby the water is of suitable quality for reuse. The Nowra and Bomaderry wastewater treatment plants are scheduled for upgrade under Stage 1b of the scheme resulting in an additional volume of recycled water available (estimated to be in the order of 7ML/d) at this time.

The use of the reclaimed effluent was identified as the preferred option for the major water supply for a wet cooled plant in an investigation by Parsons Brinkerhoff (Bamarang Gas Turbine Water Supply Options Investigation Report, Parsons Brinkerhoff, April 2005) subject to an adequate supply being available. Subsequent investigations have raised concern over the volumes available under this option. Shoalhaven Council have indicated that there is a preference for supply of reclaimed water to agricultural users and Shoalhaven Water indicated that there is already a high, existing demand for the reclaimed water (by agricultural users) that will be made available under Stage 1b of the REMS scheme.

5.1.2 Raw water

As noted the Bamarang Reservoir is located to the immediate west of the proposed power facility site and is a source of reticulated water supply for Nowra (via the Nowra Water Treatment Plant). The availability of this water is subject to negotiation with Shoalhaven Water. This water source currently supplies an industrial facility in Nowra (with the raw water pipeline passing to the north west of the power facility site). It was indicated that this source is not currently fully utilised by the industrial facility (i.e. the full water entitlement allocated was not utilised) and there may be potential for the use of this water in the future (if the industrial facility does not renew the entitlement). The current water allocation for the industrial facility is understood to exceed that which is required by the power facility (approximately 8.4 ML/d) such that if this water allocation is no longer required by other industry then a single raw water supply will be adequate to supply the Stage 2 requirements (subject to gaining access to the water).

The water quality of the raw water is expected to be very good with low salinity (as Total Dissolved Solids), low suspended solids and minimal algae and bacteria and hence extensive pretreatment of the water prior to use in the process would not be necessary. The major risk with this source may be the reliability of supply (eg during



times of drought) although this would be negotiated with the water authority during confirmation of the source.

5.1.3 Industrial effluent

A number of industrial facilities in the Nowra area are both large water users and wastewater generators. In particular, Manildra Starches and Australian Paper (both located in North Nowra) have indicated that effluent from their processes may be a potential water supply for the Bamarang power facility. While different levels of treatment and effluent quality exist for these two industrial effluent sources, further treatment would be required for both streams prior to use at the Bamarang power facility (as a process water source). Effluent from the Australian Paper plant is secondary treated effluent and is discharged to the Shoalhaven River while effluent from the Manildra Starches plant undergoes only minor physical treatment (prior to irrigation) and significant further treatment may be required. Water quality data from both of these plants indicates that the effluent may be of a suitable quality for minor treatment followed by reuse at the power facility.

Neither of these facilities are understood to generate the total required volumes individually although the combined volumes from these plants (approximately 6ML/d from Australian Paper and 3 ML/d from Manildra Starches) is likely to provide an adequate supply. Again a risk associated with this source is the reliability of supply (quantity and quality arising from process changes etc.) although this could be confirmed during any negotiations for access to the water.

5.1.4 River water

The Shoalhaven River is located to the north west of the proposed power facility site. The Parsons Brinkerhoff (PB) Report (April 2005) indicated that due to the high salinity, a high capital expenditure on treatment was necessary together with a high operating cost. Furthermore, the option generates large quantities of waste and the potential for river extraction has not been confirmed. The PB report recommended that this option be eliminated.

5.1.5 Groundwater

A review of groundwater sources was undertaken as part of the PB report (April 2005) which indicated that, based on the local geological formations, the groundwater was likely to be fracture controlled with variable yields and salinities. Furthermore, PB raised the potential risk in obtaining approval from DIPNR (now Department of Natural Resources, the relevant consenting authority) to extract the required volumes of groundwater.

5.1.6 Stormwater

A water balance analysis indicated that for the nominated site area of 20ha, the existing site runoff would increase from around 48ML/yr to around 96ML/yr once the facility was developed (due to the creation of impermeable surfaces which affects the



hydrological cycle). Further details can be found in Appendix A. The results of these calculations indicate that there is potentially a considerable increase in runoff on account of the development. It is noted that the existing runoff (from the undeveloped site) has an important role in the hydrological cycle of the local and regional environment in that it provides environmental flows for local waterways. Therefore, the use of all runoff from the site (once the site was developed) would deprive these waterways of a significant volume of water and potentially adversely impact on the environmental flows of local waterways. Hence if the runoff were considered to be a source of water supply for the site then only a portion of the runoff (in particular that which is in excess of that which currently occurs, i.e. 48ML/yr) would be utilised.

Demand/storage effects to maximise supply and to reduce the impact on the downstream receiving waterways will be developed during the detailed design of the proposal. In any case, the use of site runoff is only able to provide a small portion of the total water requirements for the site.

5.1.7 Site Wastewater

Any wastewater generated by the site is also a potential water supply. However, depending on the point of generation, significant treatment may be required which may not provide the best environmental outcome. Wastewater is generated from the following: process wastewater (including cooling tower blowdown, brine concentrate from the RO plant, demineralised water treatment wastewater,) oil / water separator (stormwater) and domestic type wastewaters. As the process is a net water user, additional water supply will always be required for the site.

5.1.8 Potable Water

Water from Bamarang Dam is currently pumped to the adjoining water treatment plant and then reticulated to Nowra. While this water is of a high quality it is unlikely that the treatment plant will have the capacity to treat and supply the required volumes (8.4 ML/d) to the Bamarang Power Facility. Furthermore, the costs of a treated water source are likely to be high.

Except for groundwater (which is not considered to be a viable water source option), all of the above streams may form a part of the water cycle for the Bamarang power facility.

5.2 Preferred Water Sourcing Option

Based on the above overview of potential water sources, the preferred water source involves the use of industrial effluent in combination with internal water recycling (of site “wastewaters”) and utilisation of stormwater runoff. This ensures that access to raw water (a source of potable water for the community) is minimised and retained for more sensitive water uses.

For stage 1 the plant and equipment requires only minimal water, which can be sourced from the Nowra potable (treated) water supply or on an as required basis. The power plant facility will also require water for domestic purposes and this will also be



supplied from the Nowra potable water supply system or rain water tanks if a nearby connection is not considered warranted for the required volumes (as determined during detailed design).

At stage 2 the CCGT plant requires water for cooling and processes. The preferred source will be treated industrial effluent (or other effluent if available) which is likely to be sourced directly from Australian Paper and Manildra Starches or through an arrangement with a third party (eg. Shoalhaven Water). However, if at the time of construction of the Stage 2 plant, these sources can not be considered a reliable source then consideration will be given to the use of raw water from Bamarang Reservoir as a preferred source (subject to negotiations with Shoalhaven Water).

Shoalhaven Water have indicated that in the longer term, other water supply options (such as the raw water or water from the REMS scheme) could become available. This availability may coincide with the Stage 2 development and hence a firm commitment to the adopted water source for this stage of the development has not yet been made. Furthermore, if all water sources are found to be unviable then the use of a dry cooled process may be adopted.

The use of industrial effluent will require the following works:

- a. construction of pump station and pipework to transfer water to the Bamarang power facility. To the extent possible, pipework routes would follow existing easements.
- b. storage ponds to allow for process flow variations. Some holding capacity is available at Manildra Starches but would need to be assessed for capacity. Storage capacity is also allowed for within the Bamarang power facility.
- c. Effluent treatment. Both effluents are understood to be of a reasonable quality (Manildras because it consists of a condensate stream only and Australian Paper's because flows pass through a secondary treatment plant). However add on processes such as tertiary filtration and disinfection for these streams might be necessary to achieve a water quality suitable for use in the power facility process water stream. The location of the wastewater treatment process could be either at the industrial facility or at the power station. Alternatively, this water stream might be managed by Shoalhaven Water (which would allow for greater community flexibility in the allocation of water resources). In this case it might be reasonable to assume that the industrial effluent streams would pass through the Nowra treatment plant (although this would probably require augmentation) or another plant specifically built for the purpose.

The final arrangement would be determined during detailed design.

6. Overall Water Cycle

Based on consideration of the available water sources, the required water uses within the plant, the wastewater streams generated and the potential for reclaimed water reuse, a water management outline for the site has been developed for each of the two stages of the Power Facility development.

A simplified process flow diagram showing the major inputs and outputs to the water cycle for the proposed power facility plant for both Stage 1 and Stage 2 is provided in Figure 3.

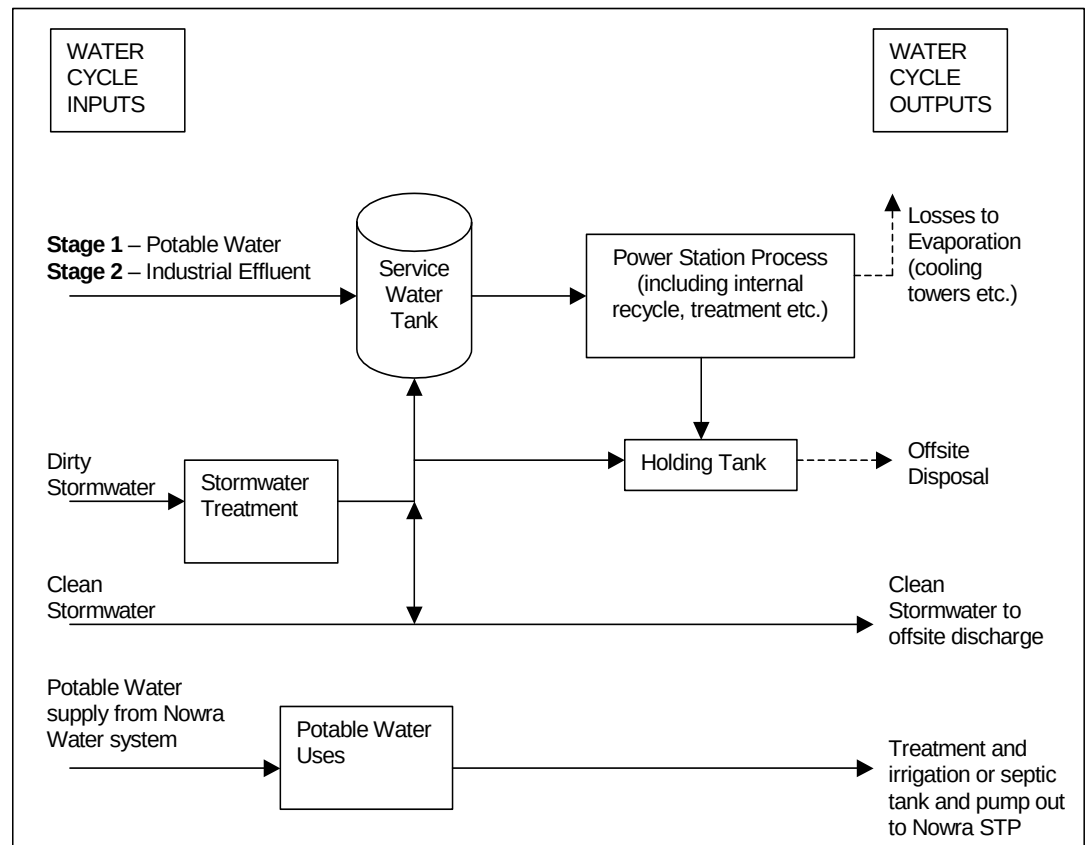


Figure 3 Water process Flow Diagram

For Stage 2 of the development, there is a much higher demand for water use and the water cycle becomes more complex within the power facility process with additional onsite treatment processes including MF/RO and demineralisation plant. A detailed water balance within the Stage 2 process was provided in Figure 2.



7. Potential Impacts

7.1 General

The proposed development of the Power Facility at Nowra has the potential to have significant impacts on a number of aspects of the water cycle.

From Figure 3, it can be seen that the major interaction of the water cycle of the power facility with the environment (i.e. inputs and outputs) will be via the water source / water cycle inputs of raw and potable water and water cycle outputs of vaporisation, domestic wastewater (during Stage 1 and potentially Stage 2), offsite wastewater discharge (to an ocean outfall) and stormwater discharge (site runoff). The use of large amounts of water within the power facility process can impact on the water cycle by diverting water away from existing paths. Where a large wastewater stream is generated, the receiving environment for the discharge may also be impacted. As the proposed development is not intended to have any major water discharges (except through vaporisation and a smaller amount via offsite disposal via ocean outfall, subject to confirmation), the potential for impacts is significantly reduced.

Development results in increased impermeable surfaces, which affect the hydrological cycle. This 'hardening' of the surfaces results in reduced infiltration of rainfall to the soil and more rainfall becoming runoff. If not managed effectively, key impacts from the runoff could include:

- ▶ Impacts to the water balance, in groundwater recharge;
- ▶ Stormwater pollution by runoff and accidental spills entering the stormwater system and discharging off the site;
- ▶ Increased stormwater runoff peak flows and flood risk (both on-site and local); and
- ▶ Construction phases impacts, such as erosion and sedimentation.

7.2 Water Cycle Inputs

Any diversion of water from the current uses may have an impact on the local water cycle. The water required for Stage 1 is proposed to be sourced from the Nowra Potable water supply (from the treatment plant at Bamarang Reservoir). The total water demand is only expected to be in the order of 2 ML per year (for both process and domestic type uses) which is not expected to have a significant impact on the total water demand within the catchment.

The proposed major water source for the plant for Stage 2 is industrial effluent with effluent from Manildra Starches and Australian Paper identified as potential options. Currently these effluents are understood to be discharged into either a receiving waterway (Shoalhaven River) or irrigated to land. By diverting this water source from their receiving environments and to the power facility, there could be a positive impact as these waters may contain impurities that could result in the environmental degradation of their receiving environment. For example, by reusing effluent at the Bamarang Power facility, the release of nutrients such as nitrogen and phosphorous



may be prevented which may reduce the potential for algal growth and eutrophication in a receiving waterway.

Another possible source of water for Stage 2 is to source raw water from the Bamarang Reservoir. It is not envisaged that the water supply for the power facility would be an additional extraction from the Bamarang reservoir but would replace an existing extraction of other industrial users within the Nowra region (subject to confirmation with Shoalhaven Water). Thus there is not expected to be an impact associated with the sourcing of this water.

If these water sources cannot be secured for Stage 2 then the alternative is to adopt dry cooling for the plant.

7.3 Water Cycle Outputs

As noted, the aim for the site is to discharge no waters. While large volumes of water will be received at the site, most water loss will be through release to the atmosphere from water vapourisation (through the cooling tower and steam losses etc.).

Evaporation is a natural part of the water cycle and serves as a precursor to the processes of condensation and precipitation (i.e. the returning of water to the earth's surface). Thus the release of water to the atmosphere is not considered to have an adverse impact on the environment (except from an air quality perspective as discussed in the main environmental assessment document). Some water cycle outputs (approximately 50kL/day of the total 8.4ML/day received at the plant, i.e. approximately 0.6%) as a waste brine solution is likely to be disposed offsite via an ocean outfall during Stage 2 of the development only. This will be subject to confirmation.

Stage 1 of the development will include septic tank pump out of the domestic wastewater stream by licensed contractor and discharge to the Nowra STP. This will account for around 0.5 kL/day of the total 3000 kL/day (approximately) that currently passes through the Nowra STP (i.e. less than 0.1% of the flow). Wastewater at the plant is currently treated and discharged to both a receiving waterway and an utilisation (irrigation) area. It is not expected that for the volume and quality of the wastewater generated at the Bamarang power facility that any impacts will be expected.

For Stage 2 of the development, consideration will be given to onsite treatment and disposal of the domestic wastewater stream (although even if the wastewater continues to be discharged to the Nowra STP, the relative increase and impacts are expected to be minimal). Any disposal of effluent to an irrigation area (eg landscaped areas, if available) environment has the potential to result in similar impacts to surface water runoff of contaminated stormwater (if appropriate management is not in place). Details on stormwater pollution impacts are outlined in Section 7.4.2. Contaminants generated by domestic wastewater streams will include suspended solids, nutrients and organic matter.

Surface water runoff is another of the outputs from the water cycle management of the power facility. This is recognised as one of the main potential impact areas of the



water cycle and the key impacts (as identified in Section 7.1) have been outlined in detail in Section 7.3.

7.4 Surface Water Runoff

The potential key impacts arising from the runoff are detailed in the following subsections.

7.4.1 Water Balance Impacts

If adequate water management processes are not adopted, the increase in impervious area due to the proposed development could result in impacts to the water balance including:

- ▶ Reduced rainfall infiltration to the soil results in decreased groundwater recharge. This has the potential “knock-on” impact on local base flows effecting streams, groundwater and water bodies;
- ▶ Increased stormwater runoff volumes, which could impact downstream habitats such as Shoalhaven River and Sandy Creek. Sensitive habitats could be impacted in terms of flushing regimes (frequency, volume and rate), water quality, and wetting cycles;
- ▶ Development and infrastructure on the site could lead to increased recharge due to removal of vegetation, over-irrigation, and structural leakages; and
- ▶ Site compaction, fill, landform reshaping and underground structures could impact groundwater flow.

7.4.2 Stormwater Pollution

There are potentially a number of causes leading to pollution of stormwater discharging from the site. They include:

- ▶ Increased runoff volume during regular rainfall events would more readily entrain and mobilise pollutants (particularly first flush) and increase pollutant loads to the receiving environment;
- ▶ The type of development and associated activities may introduce differing pollutant profiles; for example, vehicular traffic could increase hydrocarbon introduction. The movement of vehicles, particularly during dry periods, could result in dust, and disturbed surfaces could provide a source of sediment, substantially contributing to the total suspended solids. In general, typical pollutants include litter, sediment, suspended solids, nutrients, hydrocarbons and toxicants;
- ▶ Accidental spills on unbunded areas of the site could discharge to the site stormwater system and the receiving environment. In addition this could lead to groundwater contamination;
- ▶ The generation of wind borne sediment/material by any of the operational activities could be deposited in to the stormwater system;



- ▶ Cross-contamination from on-site waste streams site entering the drainage system and groundwater;
- ▶ Contamination from storage facilities (for example stockpiles, machinery storage and chemical), and covered/uncovered works areas which may include fuel, oil, grease, coolant, chemicals, solvents and/or cleaning agents; and
- ▶ During construction there is a significant risk of increased stormwater pollution.

7.4.3 Stormwater Peak Flows and Flood Risk

- ▶ On-site stormwater runoff peak flow rates and volumes would be increased due to the increased impermeable surfaces. During moderate rainfall events the resultant discharges can be highly erosive to stream beds banks and the receiving environment, thereby causing downstream degradation (for example of aquatic habitat);
- ▶ Increased flood peaks would raise on-site and off-site flood risk if not adequately managed. This could raise the flood risk (to life and property), compromise downstream infrastructure capacity and impact downstream environments leading to increased erosion and sedimentation;
- ▶ Along the transmission and gas pipeline routes a number of major river crossings are required. Structures associated with these crossing have the potential to increase velocities, raise flood levels and redirect flows if not adequately designed; and
- ▶ Flood risk at the site could also be impacted by local drainage channels that bisect or are located in close proximity to the site, and that convey runoff from larger upstream catchment areas either through or past the site. Increased local flood levels could impact directly on the site leading risk to life and property and associated damages.

7.5 Construction Phase Impacts

During the construction phase, clearing and earthmoving activities have the potential to impact on surface water quality in the vicinity of the site and along the transmission and gas pipeline routes, especially during high rainfall events. The activities and aspects of the works that have potential to lead to erosion, sediment transport, siltation and contamination of natural waters include:

- ▶ Earthworks undertaken immediately prior to rainfall periods;
- ▶ Work areas that have not been stabilised, and clearing of land in advance of construction works;
- ▶ Stripping of topsoil, particularly in advance of construction works;
- ▶ Bulk earthworks and construction of pavements;
- ▶ Washing of construction machinery;
- ▶ Works within drainage paths, including depressions;



- ▶ Stockpiling of excavated materials;
- ▶ Storage and transfer of oils, fuels, fertilisers and chemicals; and
- ▶ Maintenance of plant and equipment.

7.6 Process Water Impacts

Process water impacts could impact the environment if not monitored and controlled, particularly accidental cross-contamination of process water into the stormwater system.



8. Mitigation Measures

8.1 Water Cycle

Mitigation measures to minimise the impacts of the water cycle of the power facility on the environment are integral to the selected water management process. In particular, water will be sourced from an existing industrial use (if available) or through the use of an existing raw water allocation. The power facility process is designed for minimal discharge.

In order to minimise water use (and hence any impacts on the water source), best practice water minimisation equipment will be used (eg. High pressure hoses for cleaning, water saving water fixtures for domestic water uses such as dual flush toilets etc.)

During Stage 1, all domestic wastewaters will only be transported in accordance Council requirements and by licensed contractors. During Stage 2 of the development when an onsite treatment and disposal system may be adopted, an irrigation management plan for the discharge of the effluent to the irrigation area should be implemented. The irrigation management plan will consider drainage, irrigation rates, soil monitoring. The treatment plant itself will also be subject to regular maintenance and monitoring to ensure that its performance is maintained.

The impacts of the water requirements of the power plant will generally be minimised through monitoring and ensuring the system is performing as required with minimal discharge.

8.2 Stormwater

As a portion of the stormwater will still be released to the environment, and given the potential impacts which stormwater might have on the environment, management and mitigation of stormwater impacts is considered a high priority for the site. Overall, it is considered viable that the future site platform can be orientated to drain the entire site in a north-east direction via Sandy Creek, to the Shoalhaven River which has a number of advantages for stormwater management as it allows better control of water quality discharging from the site.

In order to effectively manage and mitigate the key impacts identified in Section 7.4, a number of measures can be implemented. These are summarised as follows and outlined in further detail in Appendix B.

- ▶ Water balance
 - Provision of stormwater retention strategies and infiltration;
 - Rainwater harvesting;
 - Management and monitoring of onsite water related activities (irrigation) and infrastructure (leaks) in terms of impacts on groundwater;
- ▶ Stormwater pollution (by runoff and accidental spills entering the stormwater system)



- Treatment of stormwater, by targeting pollutants;
- Bunding;
- First flush systems;
- ▶ Stormwater peak flows and flood risk (on-site and local)
 - Onsite detention strategies;
 - Flood planning levels;
 - Flood evacuation;
- ▶ Construction phases Impacts;
 - Soil and Water Management planning for construction activities;
 - Implementation of erosion and sediment control strategies;
 - Ongoing monitoring and maintenance of erosion and sediment control strategies;

These strategies will be incorporated into the detailed design of the proposal and measures to monitor their effectiveness will be included in the construction and operation Environmental Management Plans.



9. Monitoring Program

Monitoring should be undertaken to ensure that stormwater management measures are working effectively. Monitoring would rely primarily on visual inspections and sampling. Visual inspections should be undertaken of sediment basins, pits, diversion and catch drains and all other stormwater conveyance structures. A general indication of frequencies for inspections is provided in Table 1. An inspection log detailing the monitoring program should be kept.

Table 1 Monitoring Program

Sample location	Collection mechanism	Frequency first six months	Frequency normal operation
Sediment Basins	Visual Inspection	Every runoff event	First runoff event of any month
Inlet Pits	Visual Inspection	Every runoff event	First runoff event of any month
Trunk Drainage Channels	Visual Inspection	Every runoff event	First runoff event of any month
Overland Flow Paths	Visual Inspection	Every runoff event	First runoff event of any month
Trafficable Areas	Visual Inspection	Every month	
Bunded areas	Visual Inspection	Every runoff event	
Other works areas, potentially contaminating stormwater	Visual Inspection and system operation testing	Every month	

Notes:

1. Runoff event must be sufficient;
2. Inspect after 24 hour retention period (i.e. 24 hrs after runoff event);
3. For every inspection, date, time and ambient weather conditions will be recorded.



10.

Summary and Conclusion

Delta Electricity (Delta) propose to facilitate the development of a gas turbine power facility at Bamarang (approximately 8 km south-west of Nowra), to meet future local and regional electricity needs. The site area is approximately 20 hectares, of which 5 hectares would be required for the gas turbine plant and 2 hectares would be required for a switchyard. In addition the development includes transmission line and gas pipeline routes. The site is bounded by Bamarang Nature Reserve to the north and Crown Land elsewhere. Bamarang Dam, which supplies Nowra's water, is located 300 m to the west.

- ▶ The site area is located at an elevation of approximately RL 105 m, in close proximity to the watershed of creeks draining to the Shoalhaven River: Given the close proximity of the site to the watershed, it is considered viable that the future site platform can be orientated to drain the entire site in a north-east direction via Sandy Creek, to the Shoalhaven River.
- ▶ Delta Electricity has indicated that the aim for the site is to achieve little or no discharge of water from the site. In order to adopt this option, a high degree of internal recycling of water streams is necessary. For Stage 1 of the development, minimal water use is expected, with water being supplied by the Nowra potable water supply (from the treatment plant at Bamarang Reservoir) or water being trucked in as required. During Stage 2 of the development, the preferred major water supply for the site is effluent from industrial facilities within the Nowra region with a treated (potable) water supply for minor onsite domestic use. Water will also be sourced through internal recycling and any excess stormwater runoff (above the existing runoff volumes). Water losses from the plant will be via water vapourisation (from the cooling towers and process equipment), with some minor output of concentrated wastewater streams (eg. RO brine, demineralisation plant) to offsite disposal (ocean discharge). Domestic wastewater will pass to a septic tank for periodic pump out and transfer to the Nowra STP.
- ▶ The development will result in increased impermeable surfaces, which affects the hydrological cycle. This 'hardening' of the surfaces results in reduced infiltration of rainfall to the soil and more rainfall becoming runoff. The implementation of appropriate surface water runoff management is considered critical to avoid the key impacts of:
 - Impacts to the water balance (in particular groundwater recharge);
 - Stormwater pollution (by runoff and accidental spills entering the stormwater system);
 - Increased stormwater peak flows and flood risk (on-site and local); and
 - Construction phases impacts, such as erosion and sedimentation;

Hydrological simulations were undertaken to support this assessment, which indicated that detention strategies could effectively mitigate the impacts of development on



stormwater runoff peaks. In addition, on-site opportunities for re-use of runoff have been identified to supplement process water; and

Ongoing monitoring should be undertaken to ensure that stormwater management measures are working effectively.



11. References

- ▶ Parsons Brinkerhoff: Bamarang Gas Turbine Water Supply Options Investigation Report, April 2005
- ▶ National Committee on Water Engineering: Water Cycle Management, A Draft Position Paper,
- ▶ DNR&DE, 1998: Stormwater Quality Control Guidelines for Local Government, Department of Natural Resources and Department of Environment, February 1998;
- ▶ AR&R, 2000: The Institute of Engineers in Australia, Australian Rainfall and Runoff;
- ▶ Landcom, 2004: Soil and Construction, Managing Urban Stormwater (formally the "Blue Book");
- ▶ EPA Website, Stormwater first flush pollution,
<http://www.epa.nsw.gov.au/mao/stormwater.htm>;



Appendix A

Sample

Sample Heading Contents



Supporting Hydrological Simulations

1 General

A number of hydrological simulations have been undertaken to support this assessment. These include:

- Site stormwater analysis, focussing on stormwater management at the site based on storm events covering a range of Annual Exceedance Probabilities (AEP) up to the 1% AEP event (also known as the 1 in 100 year Annual Recurrence Interval (ARI) event); and
- A site water balance based on long-term daily rainfall, to determine non-event based, day-to-day runoff.

2 Stormwater Flood Peak Analysis

On-site

A DRAINS stormwater simulation model was compiled for the site, modelling a number of scenarios. This model was used to calculate on-site flood peaks for the 1%, 5%, and 20% AEP events, according to the procedures of the Australian Rainfall & Runoff (AR&R, 2000). The aim was to:

- Determine the increase in on-site flood peaks runoff on account of the proposed development resulting in increased impervious surfaces;
- Provide design flows for future sizing of water quality management strategies; and
- To permit investigation of the effectiveness of mitigation strategies to manage on-site stormwater.

As the exact development layout and configuration is yet to be decided, the following parameters were assumed for the preliminary developed scenario at each site:

- Hardstand footprint for the plant = 7 ha; and
- Percentage roof area = 70%.

Simulations were undertaken as follows:

- Pre-development assuming the site has a central portion that is impervious (approximately 0.7 ha). This has been estimated from aerial photography;
- Post-development, to determine the increase in on-site flood peaks runoff on account of the proposed development; and
- Post-development with mitigation, to determine the effect of mitigation measures on on-site flood peaks. For this, the DRAINS model was used to size an approximate detention strategy to mitigate any increase in flood discharges from the site.

The 1% AEP event on-site flood peaks were calculated using rainfall Intensity Frequency Duration (IFD) data for Nowra. Table 2 lists the calculated runoff peaks discharging from the site for pre-, post- and post- with mitigation development conditions. Noticeably, the post-development runoff peaks (without mitigation) are larger than pre-development. These larger runoff peaks are effectively mitigated to pre-development condition runoff peaks, by providing approximately 1000 m³ detention at the site. The table thus shows that increased on-site flows can be effectively mitigated using on-site detention strategies.



Table 2 On-site Peak Flows

Site	Pre-development (m ³ /s)			Post-Development (m ³ /s) without mitigation			Post-Development (m ³ /s) With mitigation (1000 m ³ basin)		
	20% AEP	5% AEP	1% AEP	20% AEP	5% AEP	1% AEP	20% AEP	5% AEP	1% AEP
Site	7.95	10.8	13.5	8.65	11.5	14.1	7.98	11.2	13.3

3 Site Water Balance Analysis

A site water balance analysis was undertaken to determine daily water runoff quantities. Daily rainfall for 63 years measured at Nowra was used in a daily water balance simulation (using the SWMM model) for each of the sites, to determine:

- ▶ Runoff from the existing site, pre-development; and
- ▶ Runoff from the developed site, with an estimate of roof runoff and general hardstand runoff.

Results of the modelling are given in Table 3 below:

Table 3 Runoff Calculations

Area (ha)	Rainfall (mm)	Existing Runoff	Developed Runoff without mitigation
Total Annual Mean (ML)			
20	991.55	48.08	96.6

The results of these calculations indicate that there is potentially a considerable increase in runoff on account of the development. Opportunities for re-use of this water have been identified to supplement process water. Demand/storage effects to maximise supply and to reduce the impact on the downstream receiving waterways will be developed during the detailed design of the proposal.



Appendix B

Surface Water Management and Mitigation Measures for Key Impacts



Surface Water Management and Mitigation for Key Impacts

1 Water Balance

The impacts on the water balance at the sites can be mitigated and managed by:

- ▶ Provision of stormwater retention strategies and infiltration-based management, where site conditions permit. These can be provided in the form of dedicated infiltration areas, permeable pavers for paths and roadways, bio-retention swales and extended detention water bodies and basins/wetlands;
- ▶ In general, water reuse on site is dependant upon water quality and locating a suitable use with effective yet minimal water treatment measures. There is an optimum storage volume that will maximise the water supply while minimising the number of overflows from the storage facility. Rainwater harvesting for re-use can be sourced from roofed areas and from on-ground stormwater runoff. Roof water would require adequate first flush treatments and can be directed to a single or a number of holding tanks for re-use as process water, toilet flushing or irrigation of landscaped areas. On-ground stormwater can be directed to in-ground storage facilities and re-used as process water and for landscape irrigation; and
- ▶ Management and monitoring of onsite activities and infrastructure will also be essential in managing the water balance, to prevent over-recharge to the groundwater.

2 Stormwater Pollution

Stormwater quality and pollution can be effectively managed and mitigated by providing a number of strategies, which typically comprise both structural and procedural mitigation measures, and should aim at “source control”:

- ▶ Proposed structural measures (for example first flush basins and drains) are likely to have a direct, measurable effect on water quality while, procedural measures (for example improved housekeeping/maintenance) will play an important role in mitigation and will reduce the pollutant load on the structural mitigation measures. This will manage water quality and reduce the maintenance requirements for the structural measures. Key opportunities identified for the site include:
 - Opportunities for diverting “clean” roof water, preventing contact with contaminated runoff. For example, separation of roof water from primarily the office, process facilities and storage buildings and surface stormwater runoff, if appropriate;
 - Reduction in the sediment load by source controls, particularly from stockpiles, chemical storage or other high-risk contamination areas. This could be achieved through housekeeping, maintenance, treatment of surfaces and diversion and treatment of stormwater runoff using first flush basins and other treatment strategies;
 - Prevention of stormwater runoff contact with by-product stockpiles through the construction of diversion drains and bunds as appropriate;
 - Separation of wastewater and stormwater streams across the site;



- Provision of structural mitigation measures such as sediment traps, gross pollutant traps and oil and water separation devices; and
 - Maximising vegetated overland flow paths for stormwater runoff, by using swales, buffer strips and bio-retention swales.
- All contamination areas, for example chemical storage and treatment areas can be bunded to contain overflows or accidental discharges. A plan would need to be developed to manage disposal of contaminated runoff from within the bunds, potentially for re-use or as a licensed discharge;
 - All hardstand areas can be directed to first flush basins. This captured runoff can be re-used on site, or discharged to the stormwater system if of suitable quality; and
 - Site maintenance will be the key to managing stormwater pollution. This may require frequent sweeping and regular house keeping practices. Regular maintenance of stormwater infrastructure, particularly water quality strategies will be essential.

3 Stormwater Peak Flows And Flood Risk

On-site detention in the form of on-ground basins and storage areas, or in-ground tanks can be used to effectively mitigate the increase in peak flows. In addition, stormwater quantity management can be achieved by:

- A general site grading towards the west;
- Kerbs and gutters on internal roads collecting runoff and discharges, after treatment and reuse, via an internal stormwater pipe network and conveying these to a detention basin; and
- Adopting flood planning levels, which ensure that floor areas are located above any flood levels on account of on-site and local flood peaks; and
- Providing a flood evacuation plan/strategy for the site.

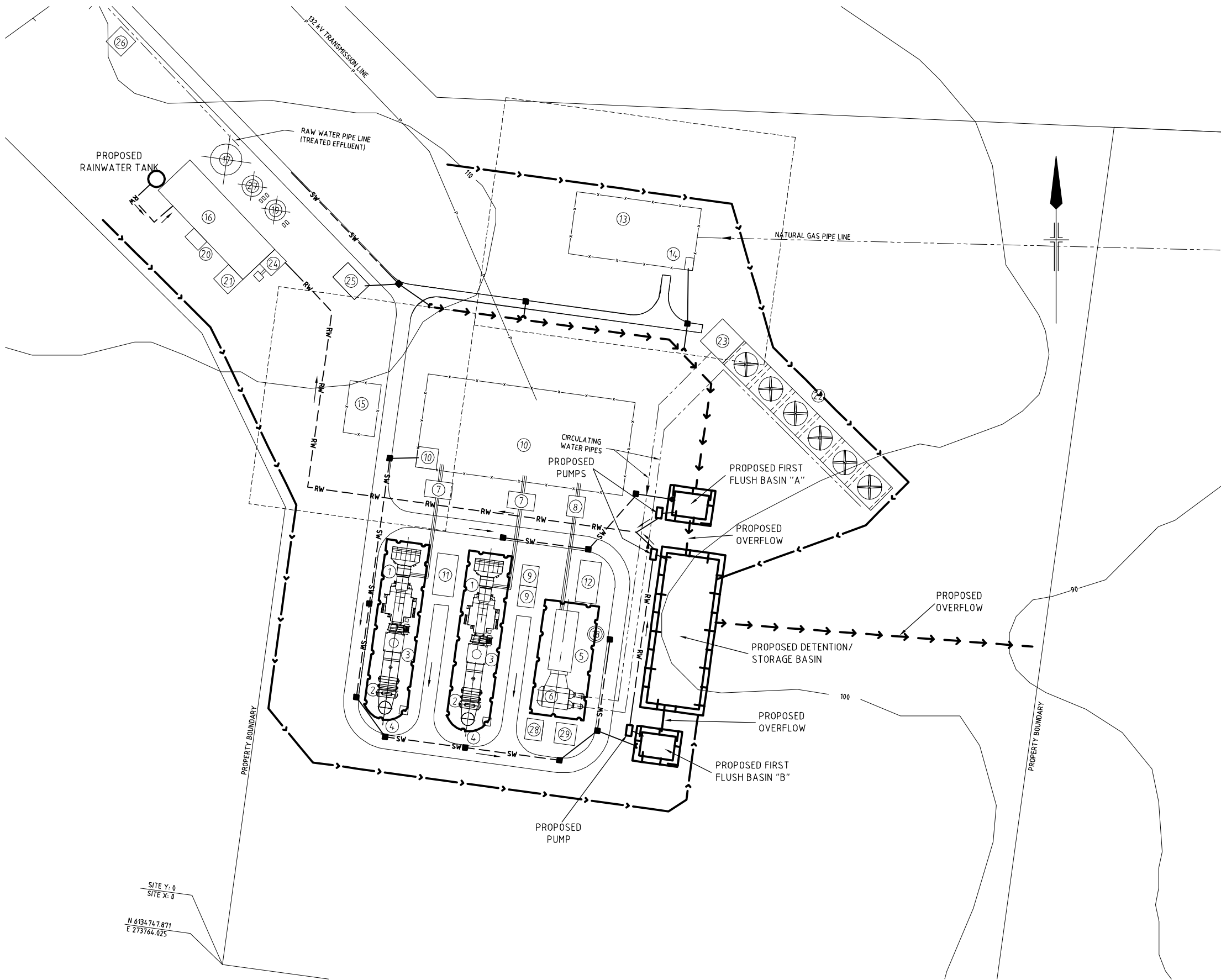
4 Construction Phases Impacts

Construction Phase Impacts can be managed by implementation of a Construction Phase Soil and Water Management Plan detailing stormwater management strategies in accordance with Landcom Soil and Construction, Managing Urban Stormwater (Landcom, 2004). These would include amongst others:

- General site practices and responsibilities
- Material management practices;
- Stockpile practises;
- Topsoil practices; and
- Erosion control practices (earth sediment basins, straw bales, sediment fences, turbidity barriers, stabilised site accesses, diversions and catch drains).

5 Stormwater Management Plan

A concept design for stormwater management at the Bamarang power facility site is provided in Drawing No. 21-13951-SK001, Rev A. This management plan adopts the general mitigation measures outlined in this appendix.



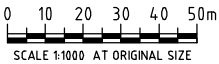
ITEM NUMBER	DESCRIPTION
1	GAS TURBINE GENERATOR
2	HEAT RECOVERY STEAM GENERATOR
3	BYPASS STACK
4	MAIN STACK AND CONTINUOUS EMISSION MONITORING SYSTEM
5	STEAM TURBINE GENERATOR
6	WATER COOLED CONDENSER
7	GAS TURBINE GENERATOR STEP UP TRANSFORMER
8	STEAM TURBINE GENERATOR STEP UP TRANSFORMER
9	UNIT AUXILIARY TRANSFORMER
10	132 kV SWITCHYARD AND SWITCHYARD CONTROL ROOM
11	GAS TURBINE GENERATOR MAIN CONTROL AND ELECTRICAL ROOM
12	STEAM TURBINE GENERATOR MAIN CONTROL AND ELECTRICAL ROOM
13	GAS METERING AND REGULATING STATION
14	GAS METERING STATION CONTROL ROOM / STORE ROOM
15	GAS CONDITIONING SKID
16	WATER TREATMENT PLANT
17	SERVICE WATER TANK
18	CONDENSATE TANK
19	DEMINERALISED WATER TANK AND PUMPS
20	DEMINERALISED PLANT NEUTRALISING PIT
21	ACID/ALKALI TANKS AND PUMPS
22	INDUCED DRAUGHT COOLING TOWER
23	CIRCULATING WATER PUMPS
24	COOLING TOWER AND WATER TREATMENT PLANT ELECTRICAL BUILDING
25	ADMINISTRATION BUILDING
26	SECURITY GATE HOUSE
27	FIRE WATER TANK AND PUMPS
28	OIL/WATER SEPARATOR
29	EFFLUENT COLLECTION TANK AND PUMPS

LEGEND

- SW STORMWATER DRAINAGE LINE AND PIT
- RW RE-USE WATER
- BIO-SWALE/SWALE
- CUT OFF DRAIN
- BUNDING

CONCEPT

C	BASINS RELOCATED AND FIRST FLUSH BASIN ADDED	GW		16.11.05
B	POSITION DETENTION REVISED	JM		11.11.05
A	ORIGINAL ISSUE	GW	RB	27.09.05
No	Revision	Notes: * Indicates signatures on original issue of drawing or last revision of drawing		
		Drawn	Checked	Approved
				Date



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Client	DELTA ELECTRICITY		
Project	COMBINED CYCLE POWER PLANT - BAMERANG		
Title	STORMWATER MANAGEMENT PLAN		
Original Size	A1	Drawing No: 21-13851-SK001	Rev: C



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Document Status

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