



HITCHCOCK ROAD SAND EXTRACTION AND REHABILITATION PROJECT, MAROOTA



WATER MANAGEMENT PLAN

PF Formation

HITCHCOCK ROAD MAROOTA

Sand Extraction and Rehabilitation Project

WATER MANAGEMENT PLAN

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Hitchcock Road sand extraction and rehabilitation project Maroota Environmental strategy

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Terms and abbreviations

Term:	Definition
AEMR	Annual Environmental Management Report
AHD	Australian Height Datum. The standard reference level used to express the relative elevation of various features. A height given in metres AHD is essentially the height above sea level.
Ambient	The background level at a specific location, being a composite of all sources.
Annual Exceedance Probability (AEP)	The probability of a flood event exceeding a nominated level in a year. A one percent AEP is the probability of an event exceeding a nominated level in 100 years.
Aquifer	Geologic formation, group of formations, or part of a formation capable of transmitting and yielding economic quantities of water.
ARI	Average Recurrence Interval-average or expected period between exceedance of a flood.
Batter	The side slope of walls, embankments and cuttings or the degree of such slope, usually expressed as a ratio of horizontal distance to one vertical height.
Bore	A cylindrical drill hole sunk into the ground from which water is pumped for use or monitoring.
Buffer	A physical barrier, structure or width of land which encloses, partially encloses or defines a particular environment. It serves to minimise the impacts of non-desirable external influences on the adjoining environment.
Bund Wall	A wall erected to prevent the escape of various emissions into the environment (liquids, noise or views).
Catchment	The area drained by a stream or body of water or the area of land from which water is collected.
Clay	Very fine grained sediment, often defined as having a particle size less than 2 microns (0.002mm) in diameter.
Compaction	The process of compressing individual grains in a soil or sediment in response to pressure.
Conservation	The management of resources in a way that will benefit both present and future generations.
Contaminant	Any physical, chemical, biological or radiological substance or matter in water or soil that is not of natural origin.
Contamination	The degradation of the natural environment as a result of human activities.
Council	The Hills Shire Council.
Day	The period from 7.00am to 6.00pm on Monday to Saturday and 8.00am to 6.00pm on Sunday and public holidays.

Term:	Definition
DECC	NSW Department of Environment and Climate Change.
Department	NSW Department of Planning.
Director-General	Director-General of the Department of Planning or delegate.
DPI	NSW Department of Primary Industries
DWE	NSW Department of Water and Energy
EA	Environmental Assessment of the project entitled <i>Hitchcock Road Sand Extraction and Rehabilitation Project Environmental Assessment and Appendices</i> (3 volumes) dated November 2007, prepared by DFA Consultants, including the response to submissions and Preferred Project Report.
Ecology	The relationship between living things and their environment.
Ecologically Sustainable Development	Using, conserving and enhancing the resources of the community so that ecological processes on which life depends, are maintained and the total quality of life, now and in the future, can be increased.
Ecosystem	A functional unit of energy transfer and nutrient cycling in a given place. It includes all relationships within the biotic community and between the biotic components of the system.
Emission	Discharge of a substance to the environment.
Environment	A term for all the conditions (physical, chemical, biological and social) in which an organism or group of organisms, including humans, exists.
Environmental Assessment (EA)	A formal description of a project and an assessment of its likely impact on the physical, social and economic environment. It includes an evaluation of alternatives and an overall justification of the project. The EA is used as a vehicle to facilitate public comment and as the basis for analysing the project with respect to granting approval under relevant legislation.
Environment Protection Licence	A licence that allows pollution of the environment under controlled conditions regulated by the Department of Environment and Climate Change.
EMP	Environmental Management Plan
EP&A Act	<i>Environmental Planning and Assessment Act 1979.</i>
EP&A Regulation	<i>Environmental Planning and Assessment Regulation 2000.</i>
EPL	Environmental Protection Licence issued under the <i>Protection of the Environment Operations Act 1997.</i>
Erosion	The wearing away of the land surface by the action of water, wind and ice.
Evening	The period from 6.00pm to 10.00pm.
Excavate	Dig into natural material and remove using specialist machinery.

Term:	Definition
Extraction	A term referring to the removal of material from the earth synonymous with quarrying.
Extraction area	The land described as the extraction area in Appendix 1 of the Project Approval.
Evapotranspiration	Loss of water from a land mass through transpiration from plants and evaporation from the soil.
Fauna	All animals including birds, reptiles, marsupials and fish.
Flora	All plants
Frequency	Similar to the pitch of a musical note in sound pressure fluctuations of cycles per second (Hertz). Most sounds comprise a composite of frequencies of varying sound pressure levels in the range of 20 Hertz to 20,000 Hertz.
Friable	Easily crumbled.
Front-end loader	Machine used to lift and place soil, earth, rocks and other materials within an extraction site or to load products into trucks.
Gradient	Rate of change of a given variable with distance, such as temperature or elevation.
Greenhouse effect	Changes in climate that could occur due to increases in atmospheric concentrations of certain gases.
Groundwater	Subsurface water contained within the saturated zone.
Hawkesbury Sandstone	Prominent cliff-forming sandstone occurring across the Sydney basin.
Head (hydraulic head)	Energy contained in a water mass produced by elevation, pressure or velocity.
Hydrocarbon	Any organic compound, gaseous, liquid or solid, consisting only of carbon and hydrogen.
Hydrogeology	The study of subsurface water in its geological context.
Impact	The effect of human-induced action on the environment.
Infiltration	The process of surface water soaking into the soil.
Infrastructure	Supporting installations and services supplying the needs of a project.
Introduced species	Plants and animals not native to Australia and known or thought to have been brought here by humans.
Land	Land means the whole of a lot or contiguous lots owned by the same landowner in a current plan registered at the Land Titles Office at the date of the approval.
Landform	A specific feature of the landscape or the general shape of the land.
$\mu\text{g}/\text{m}^3$	micrograms per cubic metre
$\mu\text{s}/\text{cm}$	microsiemens per centimetre

Term:	Definition
micron	Unit of measure-one millionth of a metre.
mg/L	milligrams per litre
Mitigation measures	Measures put in place to reduce an impact.
Modelling	Use of mathematical equations to simulate and predict real events and processes.
Monitoring	Regular measurement of components of the environment to understand their condition and establish if necessary standards are being met.
Minister	NSW Minister for Planning or delegate.
Night	The period from 10.00pm to 7.00am on Monday to Saturday and 10.00pm to 8.00am on Sunday and public holidays/
Observation well	A well constructed or utilised for the purpose of observing groundwater parameters such as water levels, pressure changes and water quality.
Palaeochannel	An ancient river bed, often filled with more recent sediments.
Perched water	Unconfined groundwater separated from an underlying body of groundwater by an unsaturated zone.
pH	A measure of acidity or alkalinity of a solution, numerically equal to 7 for neutral solution, increasing with increasing alkalinity and decreasing with increasing acidity. Originally stood for the words potential of hydrogen.
Piezometer	A pipe in which the elevation of the water level or potentiometric surface can be determined.
Privately owned land	Land not owned by a public agency or the proponent or its related companies.
Preferred Project Report	The proponent's Preferred Project Report dated September 2008 prepared by DFA Consultants as modified in the Proponent's email to the Department of Planning on 18 November 2008.
Process plant	Equipment used to clean and separate sand into various sizes.
Project	The development as described in the EA.
Proponent	PF Formation or its successors in title.
Recharge	Addition of water to the zone of saturation; also the amount of water added.
Recovery	The difference between the observed water level during the recovery period after cessation of pumping and the water level measured immediately before pumping stopped.
Rehabilitation	Preparation of a final landform following extraction and its stabilisation with vegetation.
Remnant vegetation	Native vegetation remaining after widespread clearing has taken place.

Term:	Definition
Resource	Potentially usable material in a defined area that can be economically extracted.
Response to Submissions	The proponent's response to issues raised in submissions dated March 2008 prepared by DFA Consultants and subsequent submissions to the Department of Planning dated 27 August 2008.
RL	Reduced level, usually in metres to an arbitrary datum.
RTA	NSW Roads and Traffic Authority
Run-off	The proportion of precipitation discharged through surface water systems.
Sand	Sediment comprising particles ranging between 0.063mm and 2mm.
Sandstone	A fine grained rock of sedimentary origin composed primarily of sand-sized particles (0.06 to 2 mm).
Sedimentation basin	An area where runoff is ponded to allow sediment to be deposited. The longer the period that the runoff is held, the smaller the size of the sediment deposited. Such basins have to be regularly cleaned.
SHTW	Sydney Hinterland Transition Woodland
Silt	Sediment comprising most particles between 0.004mm and 0.063mm.
Species	Taxonomic grouping of organisms that are able to interbreed with each other but not with other species.
Stakeholder	An individual or group with an interest in the proposal.
Statement of Commitments	The proponent's commitments in Appendix 3 of the Project Approval.
Stockpile	Mound used to store material.
Stormwater	Rainwater which runs off catchments following rain events. The untreated water is carried into creeks, rivers and lakes.
Strategy A, Strategy B	The alternative rehabilitation proposals described in the Preferred Project Report.
Terrestrial	Relating to the land as distinct from air or water.
Tertiary	Geologic time at the beginning of the Cainozoic era, 65 to 2 million years ago, after the Cretaceous and before the Quaternary.
Topography	The physical relief and contours of the area.
Topsoil	The surface layer of a soil profile containing most of the organic material and viable life forms and seeds.
Total Dissolved Solids (TDS)	The dissolved mineral content of groundwater, commonly expressed in milligrams/Litre.
Total Suspended Solids	A measure of suspended solids concentrations in a water body and expressed in terms of mass per unit of volume.

Term:	Definition
Triassic	The earliest of the three periods that constitute the Mesozoic Era. Approximately between 230 and 180 million years before present.
TSC Act	NSW Threatened Species Conservation Act.
Turbidity	A measure of light penetration through a water column containing particles of matter in suspension.
Underflow	The volume of groundwater that flows through a cross sectional area of an aquifer. It depends on permeability and the prevailing gradient.
Unsaturated zone	That part of an aquifer between the land surface and water table.
Vegetation Offset	The conservation and enhancement program described in the Preferred Project Report to occur on the land shown on the plan in Appendix 5 of the Project Approval.
VENM	Virgin Excavated Natural Material as defined in the <i>Protection of the Environment Operations Act 1997</i> .
Wash plant	Equipment designed to wash unwanted sized materials from the product.
Water quality	Degree or lack of contamination.
Water table	The surface of saturation in an unconfined aquifer at which the pressure of the water is equal to that of the atmosphere.
Well	A hole sunk into the ground and completed for the abstraction or injection of water or for water observation purposes. Generally synonymous with bore.
1 in 100 Year Flood Level	The flood which occurs on average once every 100 years. Also known as the 100 year Average Recurrence Interval of a flood.

*Chapter One***INTRODUCTION**

The water management plan has been prepared in compliance with **Condition 16** of **Schedule 3** of the Project Approval. It includes:

- Site water balance (**Condition 17**);
- Erosion and sediment control plan (**Condition 18**);
- Surface water monitoring program (**Condition 19**); and
- Groundwater monitoring program (**Condition 20**).

The management of surface and groundwater at the Hitchcock Road site and the associated site on Lot 198 DP752025, which accommodates the process plant, has been undertaken over the past ten years on the basis of the provisions of the current EMP. This has been amended to comply with the requirements of the Project Approval.

Water levels, flows and quality have also been monitored and regularly reported over the same period providing a long term data set. Current monitoring procedures and reporting protocol will be amended, where necessary, to reflect the requirements of the relevant approval conditions.

*Chapter Two***APPROVAL REQUIREMENTS**

The project approval contains a number of conditions relating to the monitoring and management of potential impacts on surface and groundwaters. These are:

Schedule 3 Condition 16

The proponent is to prepare and implement a Water Management Plan for the project. This will include:

- Site water balance;
- Erosion and sediment control plan;
- Surface water monitoring program; and
- Groundwater monitoring program.

The plan is to be prepared in consultation with the Department of Water and Energy and the Department of Environment and Climate Change.

Schedule 3 Condition 17

The Site Water Balance will include details of:

- sources and security of water supply;
- water use on site;
- water management on site including the location and capacity of water storages on site and means of access;
- off-site water transfers; and
- reporting procedures.

Measures to minimise water use on site will also be investigated and described.

Schedule 3 Condition 18

The Erosion and Sediment Control Plan will be consistent with the requirements of *Managing Urban Stormwater, Soils and Construction, Volume 1, 4*

The plan will also:

- identify activities that could cause soil erosion and generate sediment;
- describe measures to minimise soil erosion and the potential for transport of sediment to downstream waters;
- describe the location, function and capacity of erosion and sediment control structures;

- demonstrate that the design capacity of basins intended to collect storm runoff will not be compromised by storage of operational water; and
- describe what measures would be implemented to maintain, and if necessary decommission, the structures over time.

Schedule 3 Condition 19

The Surface Water Monitoring Program will include:

- detailed baseline data on surface water flows and quality in downstream watercourses that could be affected by the project;
- surface water quality and stream health assessment criteria, including trigger levels for investigating any potentially adverse surface water impacts; and
- a program to monitor:
 - surface water flows, quality and impacts on water users;
 - stream health; and
 - channel stability.

Schedule 3 Condition 20

The Groundwater Monitoring Program will include:

- provision of additional monitoring bores around the periphery of the site;
- detailed baseline data on groundwater levels, flows and quality in the region and particularly any groundwater bores, springs and seeps (including spring and seep fed dams) that may be affected by operations on site;
- groundwater assessment criteria including trigger levels for investigating any potentially adverse groundwater impacts;
- a program to monitor:
 - groundwater levels and quality in new and existing monitoring bores;
 - impacts of the project on any groundwater bores, springs and seeps (including spring and seep fed farm dams) on privately-owned land and any groundwater dependent ecosystems; and
- a protocol for further groundwater modelling to confirm the limits to excavation depth across the site permitted in accordance with **Condition 9 of Schedule 2**.

Chapter Three

OBJECTIVES OF THE PLAN

The objectives of the water management plan are to:

- maintain water quality in adjacent waterways;
- ensure that any discharge from the Hitchcock Road site and Lot 198 DP752025 meets the guidelines for protection of aquatic ecosystems (ANZECC 2000);
- minimise the volume of water discharged from the site by providing retention basins capable of capturing the total runoff from the 100 year t_c storm event;
- protect groundwater under the site from possible contamination;
- maintain availability of groundwater for downstream users;
- monitor the impact of the project on groundwater levels, quality and availability;
- minimise erosion and sedimentation from all active and rehabilitated areas on the site; and
- monitor the effectiveness of surface water controls and achieve all relevant surface and groundwater quality criteria.

*Chapter Four***RESPONSIBILITIES**

PF Formation is responsible for the management of the project in a manner which achieves the environmental outcomes set out in the approval conditions. The project team members responsible for the implementation of the EMP have been nominated although these may be changed with approval over the life of the approval. Their responsibilities are:

Site manager - responsible for the day to day activities on the extraction and process sites.

Environmental manager - responsible for the environmental management of the activities on the extraction and process sites.

Each person with responsibilities (as identified above) will hold a controlled copy of the EMP.

Site inspections during operations, the assessment of environmental impacts and the performance of mitigation measures will be carried out regularly by a nominated ***environmental officer***. Such inspections will be documented in a standard format and a copy submitted to the ***site manager***. Issues arising from these inspections will be addressed immediately. Overall environmental performance will be addressed at management meetings as appropriate.

All persons undertaking any form of work on the site subject to the EMP will be required to attend an induction. This will provide instruction in the environmental rules, procedures and processes applying to their activities on the site.

*Chapter Five***SITE WATER BALANCE****5.1 Introduction**

Water is required for plant washing operations and the transport of sand in the form of slurry from the site to the central processing plant on Lot 198 DP752025. This is obtained from clean water dams at the end of a series of settling dams provided to remove sediment fines from the dirty wash water. This system recycles wash water from production and once in operation does not require an external source of water except for make-up to compensate for losses occurring during the process.

Clean water is derived from the supply dams located on Lot 167 DP752039 and Lot 198 DP752025. The water from Lot 167 is mixed with extracted material in a hopper to form a sand slurry suitable for transportation by pipeline. The slurry is piped to the central processing plant on Lot 198 DP752025 where the water from Lot 198 is used in the production operations. Wash waters from this process are pumped back to settling dams on the site. Here the suspended sediments gradually settle out while the clear water is recycled. A clean water pipeline is used, if needed, to balance the water from the two dams. The water management system is shown on **Figure 5.1**

All process water is recycled within a closed system. None is directly discharged from the site without passing through a treatment system. No significant changes in water quality or quantity of runoff discharged from the site will occur as a result of the development. The clean water balance pipe system will also assist in the storage of water to reduce discharges during storm events.

Site topography has been modified as a result of ongoing extraction activities. Surface water flows are directed into a number of large detention basins which are part of the process system employed at the site. These allow the silt in the water returned from the wash plant on Lot 198 DP752025 to settle out before progressing to the clean water basin located in the lowest part of the site.

The site where sand extraction has taken place to date is inwardly draining due to a combination of topography and the effect of the peripheral bunds constructed as part of the project. No surface water is therefore discharged beyond its boundaries. Most of the site can therefore be considered to be a detention basin capable of accommodating far in excess of the runoff from the 100 year ARI time of concentration event.

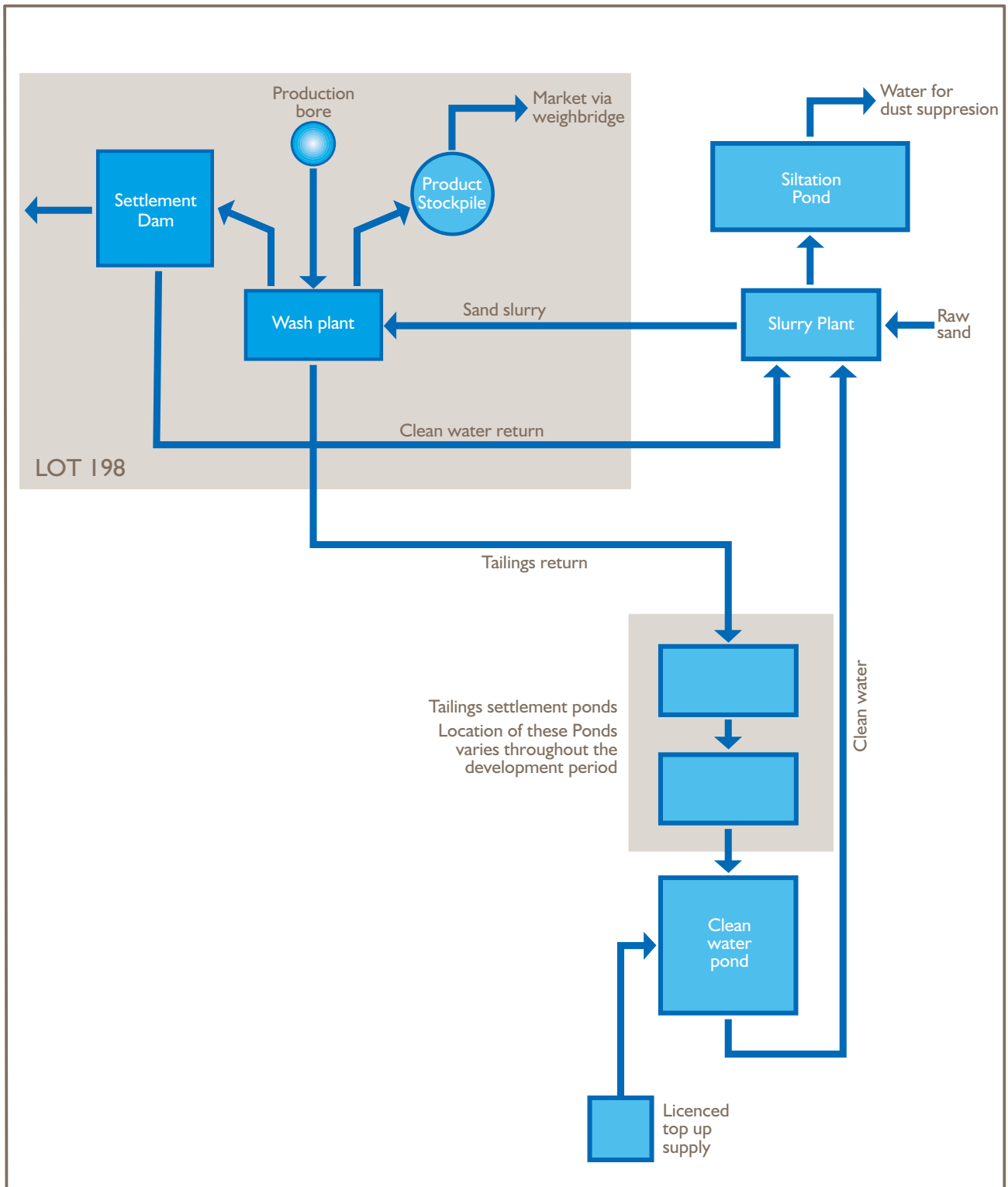


Figure 5.1
WATER MANAGEMENT SYSTEM

5.2 Site water storage and use

The water management system is shown on **Figure 5.1**. Clean water is stored in a large dam on Lot 167 DP752039 at the lowest point in the system, with its supply derived from the tailings settlement ponds further up the system where the fines in return water from the wash plant on Lot 198 DP752025 settle out. Water from the clean water pond is pumped to the slurry plant at the northern end of the Hitchcock Road site to continue the cycle. The clean water pond has a capacity of approximately 25ML. The system is topped-up from a small adjacent supply dam (PF167DAM) originally excavated to the base of the Maroota sand. In addition to compensating for losses within the closed system, water from this source is used for dust suppression and irrigation of site vegetation. Extraction from this source is limited to 50ML per year by licence.

A smaller settlement dam is located on Lot 198 DP752025 to receive silt-laden run-off from the wash plant area. Clean water from this dam is returned to the slurry plant on the Hitchcock Road site as part of the sand transport system. Additional water on this lot has been derived from two production bores with extraction limited to 60ML per year by licence.

The dams on Lot 167 DP52039 and Lot 198 DP52025 are the only permanent water storages serving the system. The others are temporary silt ponds which, when full, will be allowed to dry then capped. Vehicle access is available to both dams.

Water is used for a number of purposes on both the Hitchcock Road site and Lot 198. These uses are all part of the total water balance for the operations.

Sand washing and retention of water in tailings dams

The project approval allows the production and sale of a maximum of 400,000 tonnes per year of washed sand. This requires the preparation of approximately 540,000 tonnes of raw material with the difference (140,000 tonnes per year of silt and clay) deposited in tailings dams. This material binds approximately 1,000 litres of water per tonne resulting in the removal of 140ML of water from the cycle each year for retention in the tailings and subsequent gradual evaporation.

Dust suppression

Water is used in the extraction and process plant areas for dust suppression on the roads, stockpiles and other exposed surfaces for approximately 250 days per year. Some 10ML are used for this purpose each year.

Off-site transfers

There are no direct transfers of water off either the Hitchcock Road site or Lot 198 DP752025. However, sand exported to market contains a variable proportion of moisture, assumed to be five percent by mass. The project approval limits production to 400,000 tonnes of processed sand equating to 20ML of water per year.

Evaporation

Data from the Bureau of Meteorology Richmond Station Number 067105, the nearest station to the site measuring evaporation, indicate a yearly average of 4.3mm/day, giving a total of 1,570mm/year.

A number of dams and open water bodies are present on the processing plant area and on the Hitchcock Road site. Several of these dams are temporary structures which are capped and sealed when the level of tailings reaches the maximum level. The water level in these dams may vary from time to time, but do present a large surface area subject to evaporation.

Two permanent structures, such as the clean water dam (approximate capacity 25 ML) and the licensed water supply dam in Lot 167 DP752039 (approximately 0.3 ML), have generally constant levels, although the water supply dam may also vary for short periods during pumping.

The total water surface area is estimated to be 70,000 square metres, subdivided as approximately 10,000 square metres on Lot 198 and approximately 60,000 square metres on the Hitchcock Road site, giving a total volume of evaporation from the surface water of 110ML/year.

Evapotranspiration

The Hitchcock Road site and Lot 198 DP752025 include some vegetated areas and considerable expanses of exposed sand. It is conservatively estimated that these two elements generate an average rate of evaporation of 1mm per day or 365mm/year over an area of 71 hectares on the Hitchcock Road site (excluding the area of open water) and 32.7 hectares for Lot 198. Evapotranspiration from the two sites equates to 379ML/year.

Recharge of the aquifer

A proportion of the incident rainfall will enter the aquifer and provide recharge to the water table. These percentages are estimated as follows:

Lot 167 located on Maroota sand	30 percent of incident rainfall giving a total of 200ML/year; and
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Lot 198 DP752025 on Hawkesbury sandstone	10 percent of incident rainfall giving a total of 30ML/year
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The combined total aquifer recharge is estimated to be 230ML/year.

5.3 Water sources and availability

Rainfall

Bureau of Meteorology records for the Maroota weather station (Number 067014) located on Roberts Road which has operated with some minor interruptions since 1925 indicate an average annual rainfall of 887.7mm over the period.

The Hitchcock Road site is entirely internally draining and all rainfall is captured within the site boundaries. There no run-off into the area from external sources.

The processing plant area on Lot 198 also captures most internal run-off into the site storage dams. Run-off from this site occurs occasionally when the dams reach full storage capacity.

The total area of the Hitchcock Road site is 75 hectares and that of the whole process plant site is 33.5 hectares giving a combined area of 108.5 hectares or 1,085 000 square metres. The total volume of incident rainfall is, therefore, 963.5ML/year, subdivided as 297.5ML/year on Lot 198 and 666ML/year on the Hitchcock Road site.

Groundwater

Records of pump operations have been kept for PF167DAM since January 1997. Annual pumpage for the current year (21.5ML) has been below the licensed limit (50ML/year) mainly due to improved management of the central process plant.

The total pumpage of 24.5ML for the two water supply bores on Lot 198 DP595538 for 2007/2008 was similar to that of the previous 12 months (27.7ML) and below the combined annual allocation of 60ML. Bore PF198PB1 was out of service for part of the year.

Due to modifications carried out at the wash plant on Lot 198, these bores are no longer required for continuous supply.

5.4 Water balance

The water inputs/outputs to the system on the Hitchcock Road site and Lot 198 DP752025 can be summarised as follows:

Water inputs

• Groundwater	110ML/year
• Rainfall	963ML/year
Total	1,073ML/year

Water outputs (losses)

• Off-site transfer	20ML/year
• Tailings-bound	140ML/year
• Dust suppression	10ML/year
• Evaporation	110ML/year
• Evapotranspiration	379ML/year
• Aquifer recharge	230ML/year
Total	889ML/year

Water balance **184ML/year**

It must be assumed that there are other avenues for loss which have not been included in this estimate. In addition, the volumes quoted above are broad estimates with a high level of variability. The most significant variable is annual rainfall which, historically has fluctuated between a low of 353.9mm to a high of 1,636.6mm. The figure used in the water balance is the long term average which may not be representative of real conditions at Maroota which in practice can result in water shortages and loss of production.

Experience on site indicates that variability in sand production rates is more closely related to market demand than water availability as, overall, production has remained stable even over the recent period of sustained drought. Water use has been substantially reduced over this period by the introduction of improved water management practices at the wash plant.

*Chapter Six***EROSION AND SEDIMENT CONTROL PLAN****6.1 Introduction**

The Erosion and Sediment Control Plan has been prepared in compliance with the requirements of *Managing Urban Stormwater, Soils and Construction, Volume 1, 4th Edition, 2006* (Landcom). All necessary erosion and sediment control structures will be constructed in accordance with the recommendations in the standard drawings and notes in that document.

The erosion and sediment control plan is structured in the following sections:

- Sources of sediment;
- Control of erosion and sediment transport;
- Capacity of on-site basins; and
- Sediment control.

6.2 Sources of sediment

The main potential sources of sediment during the operation of the proposed extraction areas on the Hitchcock Road site would include:

- topsoil stripping and overburden removal;
- runoff from unsealed surfaces including haul roads;
- loading and unloading the raw feed and products to trucks and stockpiles;
- uncontrolled runoff from stockpiles and exposed unpaved areas;
- possible spillages or overflows of silt-laden water from retention basins or pipelines;
and
- accidental release of slurry or rupture of the process pipeline between the Hitchcock Road site and the wash plant on Lot 198 DP752025.

6.3 Control of erosion and sediment transport

The avoidance of uncontrolled discharges from both the Hitchcock Road site and Lot 198 DP752025 and ensuring that any controlled discharge achieves the appropriate water quality criteria are the principal objectives of surface water management. These would be achieved using the following approaches:

- provision of buffers and installation of silt fences where appropriate to prevent sediment transport to adjoining land;
- minimising the area of disturbance by only clearing areas immediately prior to extraction within each stage and progressive rehabilitation of the completed area;
- diversion of upslope drainage away from disturbed areas;
- diversion of sediment laden runoff to sediment basins;
- regular inspection and maintenance of sediment controls to ensure that designed capacities are maintained; and
- designing and implementing an appropriate revegetation and maintenance program for the site.

6.4 Capacity of on-site basins

That part of the site from which sand has been extracted comprises a large basin from which, due to the topography of the area and the peripheral bunds constructed as part of the project, no surface water can discharge. A number of settlement ponds have been constructed within this lowered area together with a large clean water dam and a smaller supply dam at the lowest point. These ponds and the clean water dam are part of the processing system employed at the site. Silt-laden water is returned to the ponds where the silt is gradually deposited and the clean water is decanted for reuse in the process.

Once full, the basins are allowed to dry (a process that may take 2-3 years) and are capped as part of the rehabilitation process. Additional basins are added to the system to provide the necessary capacity once one is removed when filled with deposited fines. At present, five detention basins are included in the system with an additional one located adjacent to the slurry plant. All are partially filled with varying capacity remaining. Some airspace is available above the surface in the clean water dam and two detention basins contain little silt-laden water at present.

The large lowered area is approximately 32 hectares in extent providing substantial capacity to accommodate the runoff from any major storm without discharging beyond the site boundaries. The current capacity of the various on-site basins is approximately 120,000 cubic metres. This is more than twice the storage volume (48,000 cubic metres) required to accommodate the runoff from the 100 year ARI storm for the two main catchment areas on the site.

6.5 Sediment control

Site disturbance

The soil erosion hazard on the site will be kept as low as practicable by minimising surface disturbance. General vegetation clearance and soil stripping will not be undertaken until earthwork operations are about to commence. All proposed erosion and sediment control measures will be implemented in advance of, or in conjunction with, clearing and stripping operations. Prior to the start of clearance, clearing limits will be clearly marked with pegs placed at intervals on each side of the disturbed areas. All operations will be planned and undertaken to ensure that there is no damage to trees and revegetating areas outside the limits of the extraction areas.

Soil stockpiles

The stripping of topsoil will be undertaken as far as possible when in a moist condition to reduce damage to the soil structure. Stripping will not be undertaken in wet conditions and the soil will be moistened if very dry. The stripped soil will be placed directly onto disturbed areas or areas prepared for revegetation and spread immediately if the extraction sequence and weather conditions allow.

If longer term storage is required, a maximum stockpile height of three metres will be maintained to preserve biological viability and minimise soil deterioration. Soil stockpiles will be sown with a sterile cover crop.

Stockpiles will be located in areas avoiding local drainage lines and minimising the possibility of surface water ponding against the upstream face. Temporary sediment control measures including sand bags and silt fences will be used to prevent sediment from leaving the area.

Topsoil derived from the stockpiles will be spread so that the organic layer containing seed and local vegetation is returned to the surface. It will be spread to a minimum depth of 50mm on 3:1 or steeper slopes and to a depth of 100mm on flatter slopes. The topsoil will be levelled to achieve an even surface avoiding over-compaction.

Surface water diversion

Even during periods of heavy rainfall, no clean surface water enters the Hitchcock Road site from the surrounding areas. The site is entirely internally draining and runoff from the extraction areas is therefore considered to be silt-laden requiring suitable treatment while that from those parts of the site remaining in its pre-development condition is considered to be clean water. All silt laden runoff plus any clean runoff from the undeveloped areas is directed to the operational detention basins where settlement of the silt takes place and the clean water is decanted to the clean water basin from which it is recycled through the water management system. No separation of clean water runoff is undertaken as this is considered to be unnecessary due to the configuration of the site and the operating water recycling system.

On-site water management

Silt-laden water is directed towards the settlement basins which drain to the clean water basin as part of the overall water management system. The active extraction areas comprise a series of pits within the floor of the quarry. The floors of the active pits are graded to sump areas which allow the controlled removal of the runoff by pumping to the larger settlement basins. These sumps are sized to accommodate the 20 year ARI event if their life expectancy is less than five years. Under normal conditions, surface drainage is rapid due to the efficient absorptive capacity of the underlying sand and the sumps allow some settlement of silt prior to pumping to the larger basins.

Haul roads

The internal haul road has been constructed to achieve effective surface drainage to reduce roadside erosion and sedimentation. It will be regularly inspected and all necessary maintenance undertaken to ensure that all drainage structures are working effectively.

Additional erosion and sediment controls

Additional controls include sediment fencing, sand bag filters and revegetation which are applied where required and suitable.

Sediment fencing and sandbag weirs will be used in the longitudinal drainage adjoining roads and disturbed areas and sandbag sediment filters will be installed where necessary during construction of any additional road and drainage works. However, these will only be used where controls are required for short periods.

6.6 Maintenance of erosion controls

Regular inspections will be undertaken by the Site Manager particularly following major rainfall events to ensure that all water management controls are functioning as required. Site drainage and sediment control structures will be inspected regularly after runoff events to check for scouring and accumulation of materials in sediment traps and sedimentation ponds. Inspections will include:

- **Haul road** – visual inspections to ensure that the appropriate mitigation measures are functioning to convey surface flows from the road surface without excessive erosion of the road surface, work areas or adjacent land. Any culverts will be inspected for any signs of erosion around the culvert or the drainage line downstream. Where controls are not operating effectively, restoration to the required standard will be undertaken. Where significant erosion has taken place, additional controls will be constructed. This may include additional mitre drains, scour protection and/or the regrading of the road surface.
- **Sediment controls** – regular visual checks will be undertaken to ensure that there is no increased discolouration of the water decanted to the clean water dam.
- **Water storage dam** - regular visual checks will be undertaken to ensure that there is no increased discolouration of the water in the clean water dam.
- **Additional sediment controls** – all sediment fencing and sandbag filters will be inspected to ensure that they are functioning adequately.

Where controls are functioning correctly, any erode area will be restored to the required standard. Where significant erosion is occurring on a regular basis, additional controls will be constructed in compliance with *Managing Urban Stormwater: Soils and Construction Manual* (Department of Housing 2004).

On completion of sand extraction and rehabilitation of the relevant part of the site, all temporary erosion and sediment controls will be removed from the site.

*Chapter Seven***SURFACE WATER MONITORING PROGRAM****7.1 Introduction**

The surface water monitoring program has been prepared in compliance with **Condition 19** of **Schedule 3** of the Project Approval and includes:

- detailed baseline data on surface water flows and quality in downstream water courses that could be affected by the project;
- surface water quality and stream health assessment criteria, including trigger levels for investigating any potentially adverse surface water impacts; and
- a program to monitor;
 - surface water flows, quality and impacts on water users;
 - stream health; and
 - channel stability.

The Hitchcock Road site will be internally draining throughout the operational phase of the project and no surface water will be discharged beyond the site boundaries. A creek which originates from a large farm dam on Lot 2 DP555184 (not included in the project) flows across the eastern part of Lot 214 DP752039 which is part of the Hitchcock Road site to drain into Little Cattai Creek. Sand extraction will not encroach within 200 metres of this creek and it is not considered that project related activities will have any impact on its water quality or channel stability.

Lot 198 DP752025 is located in the upper reaches of one of the creek systems which drain to the Hawkesbury River at Lower Moon Bend. Surface water quality in the creek downstream of Lot 198 has been monitored at one location on a regular basis since 1999.

7.2 Downstream water quality

Receiving waters that could potentially be affected by discharge from Lot 198 DP752025 are the unnamed intermittent creek downstream to the west of the process plant. Results of previous monitoring are shown in **Table 7.1**. Electrical conductivity was not included in the previous monitoring program. Future surface water monitoring criteria are listed in **Section 7.3**.

The available data indicates that pH is consistent with other surface water in the area (4.6 to 5.4) with a low salinity between 8 and 20mg/L total dissolved solids. Turbidity is also generally low with no evidence of the presence of oil or grease in the samples. The higher levels in the sample taken in February 2008 result from the effects of heavy rainfall in the area.

Table 7.1 Summary of water quality downstream of Lot 198 DP752025

Analyte	Unit	Date					
		03.09.07	05.02.08	20.06.08	15.09.08	11.12.08	02.03.09
pH		5.0	5.4	5.3	4.8	5.0	4.4
Total Suspended Solids	mg/L	2.8	71.0	5.7	0.7	6.8	0.4
Turbidity	NTU	2.8	170	9.8	3.5	8.9	4.2
Oil and Grease	mg/L	<1	<1	<1	<1	<1	<1

7.3 Water quality monitoring

Surface water quality will be monitored quarterly when flowing with samples taken from water at the existing monitoring site on the creek below Lot 198 DP752025. Monitoring of channel stability will be based on visual inspections undertaken at the same time.

Water samples will be taken in accordance with the requirements of Environment Protection Licence 3407 under the *Protection of the Environment Operations Act 1997* administered by the Department of Environment and Climate Change. The assessment will include analysis applying the following criteria:

- pH; +/-1 unit from background
- Electrical conductivity; <1,500µS/cm
- Total suspended solids; <50mg/L
- Oil and grease. <10mg/L

Samples will also be taken and analysed following heavy rain events and any incidents on Lot 198 which could have an impact on water quality.

7.4 Response to exceedances

Water quality results will be compared to the assessment criteria in the plan and any other criteria that may be defined by DECC following each monitoring event. Any exceedance of the criteria will result in an immediate investigation to determine its cause and the preparation of corrective action to re-establish or introduce necessary controls as required following confirmation of the exceedance by re-sampling.

Reporting of monitoring and measurement data will be undertaken in compliance with the requirements of the Project Approval including notification of the results to external organisations, if required. All results will be reported in the AEMR.

Results will also be reported to DECC immediately following any incident with actual or potentially significant off-site impacts on the down-stream environment.

7.5 Erosion and sediment control monitoring

The assessment of suspended solids concentrations over time has established the effectiveness of the various erosion and sediment controls in place on the site. The water quality monitoring results will be reviewed in conjunction with visual observations undertaken as part of the routine maintenance procedures.

*Chapter Eight***GROUNDWATER MONITORING PROGRAM****8.1 Introduction and background**

Groundwater is monitored at three locations on the Hitchcock Road site. These are:

- monitoring bore PF166MW1, located in Lot 2 DP57096; and
- monitoring bore PF167MW1, located in Lot 167 DP752039;
- supply dam in Lot 167 DP752039.

Groundwater is also monitored at two locations on Lot 198 DP752025. These are:

- water supply bore PF198PB1, located at the wash plant; and
- water supply bore PF198PB2, located at the rear of the workshop.

Groundwater samples for chemical analysis have been collected from these bores since they were drilled in 1998. Their location is shown on **Figure 8.1**.

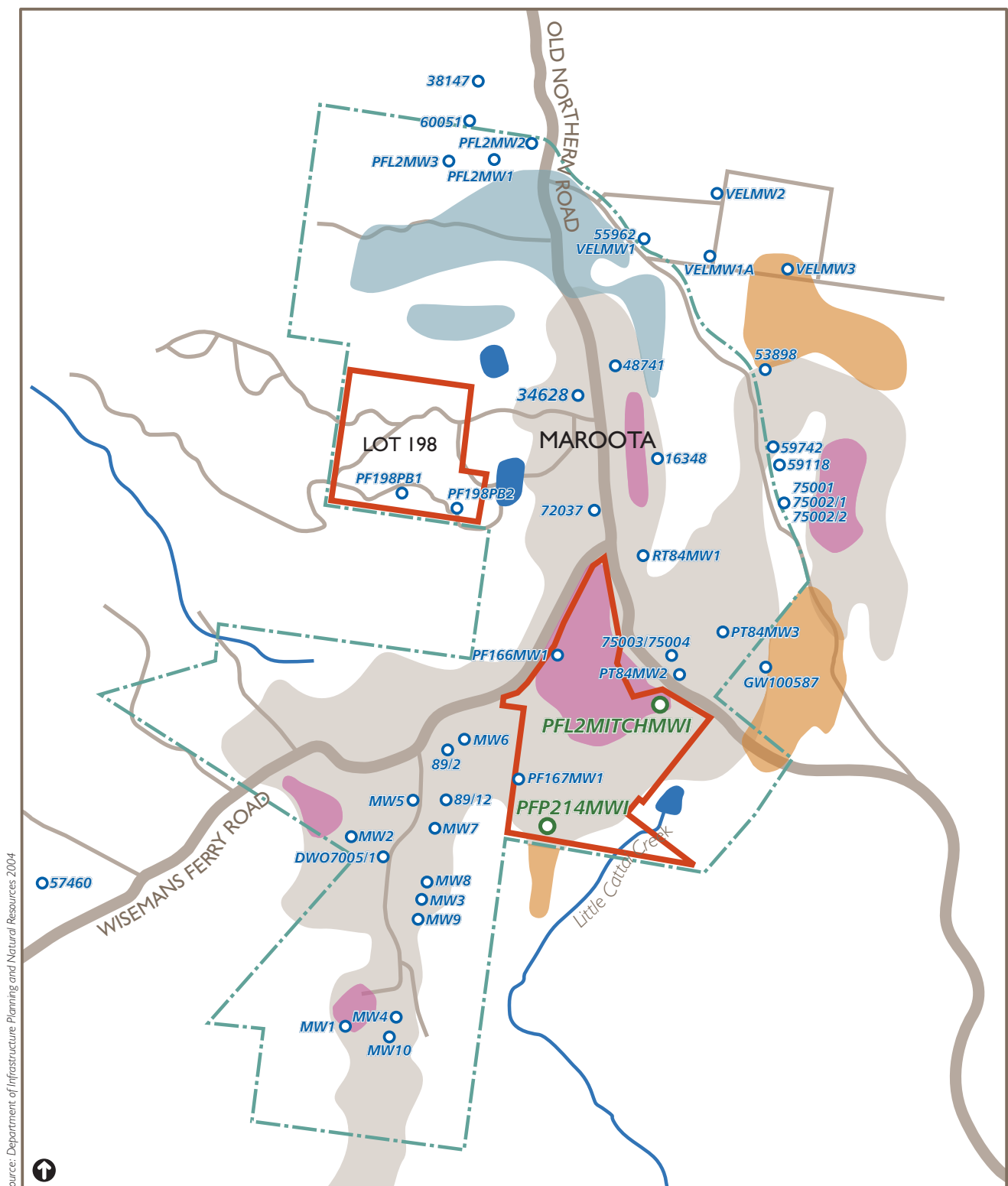
Groundwater monitoring has been carried out at these sites since 1996. Initially, water levels in bores PF166MW1 and PF167MW1 were measured manually at weekly intervals together with chemical field parameters such as pH and electrical conductivity (EC). The manual measurements continued until December 1998. In January 1999, the two bores were equipped with Dataflow Systems automatic data loggers.

Data loggers were downloaded quarterly between January 1999 and June 2000. Since June 2000, the data loggers have been downloaded bi-annually. The old style data loggers were replaced in January 2006 with Solinst Levellogger units with a battery life of approximately 10 years capable of storing 40,000 readings in memory. These allow data downloading at annual monitoring intervals which started in July 2006.

Groundwater samples for chemical analysis have been collected at the same time for the monitoring and pumping bores and the analytical results plotted on individual graphs to assess possible trends with time.

Water samples are collected and submitted for chemical analysis under *chain of custody procedures* to Australian Laboratory Services Pty Ltd. The analytical list, which was discussed and agreed with the former Department of Land and Water Conservation (DLWC) (now the Department of Natural Resources), includes the following:

- pH, Electrical Conductivity and Total Dissolved Solids
- Calcium, Magnesium, Sodium and Potassium
- Chloride, Sulphate and Bicarbonate
- Oil and Grease.



Source: Department of Infrastructure Planning and Natural Resources 2004

Figure 8.1

LOCATION OF LICENSED BORES



- Hitchcock Road site
- Sydney Regional Environmental Plan 9 area boundary
- Maroota Sand
- Clay occurrence
- Ferruginised sand
- Hawkesbury sandstone
- 57460 Licensed bore
- New bore

8.2 Existing levels, flows and water quality

Groundwater levels

Groundwater levels in the Maroota Sand measured in the monitoring bores indicate that the aquifer is variable and contains numerous perched water tables. The plots of bore PF167MW1, which taps the full saturated thickness of the Maroota Sand and bore PF166MW1, which taps an unconfined aquifer perched at a higher elevation, indicate a rapid response to rainfall infiltration. The plots also show that water levels recover quickly after periods of sustained rainfall.

The average yearly rainfall for July 2007 to June 2008 was 1,291.5mm, substantially above the long term average of 884.8mm. Rainfall data are reported from the PF Formation recording system as the Bureau of Meteorology data have not been updated since January 2008.

Bore PF167MW1

The range of fluctuations in water levels has been in the order of 5 metres in bore PF167MW1 (from a minimum of 177.7mAHD in April 1998 to a maximum of 182.75mAHD in May 2000). The largest variations have been recorded in the period prior to the installation of the Dataflow Systems data loggers in January 1999. Since then, the range of fluctuations in this bore has been less than three metres. The plot shows that from mid 2002 to the end of June 2004, the water level in PF167 MW1 has shown an overall decline as a result of the persistent drought conditions during this period. However, since that period, a minor water table recovery is visible following good rainfall during the first few months of 2005.

The rapid response of the water table to the rainfall pattern is evident in these records as shown in the April 2003 and June 2007 periods following some significant rainfall, when the water level stabilised and partly recovered. During the year 2006 and the first half of 2007, the water level shows a marginal declining trend due to persistent dry conditions and fell by approximately one metre over the period.

Since June 2007, the water level has risen by 4.5 metres to a level similar to the highest recorded value in mid 2000 as a result of the heavy rainfall recorded in the area.

Bore PF166MW1

Bore PFMW166MW1 recorded a range of fluctuations of 1.2 metres, from a minimum of 199.8mAHD in April 1998 to a maximum of 201.0mAHD in May 2002. The smaller variation in water table movement around PF166MW1 is the result of the perched nature of the aquifer, as excess groundwater is readily discharged upon reaching saturation of the limited aquifer storage capacity at that site.

A rapid response to the rainfall pattern is also evident at this site following the rain since the end of April 2003. However, since April 2002 the water table here has recorded a steady fall in response to the persistent drought conditions. By June 2004, the water level in the bore fell to the bottom of the casing and beyond the measurable range of the installed data logger. The bore was cleaned of some accumulated sediment and a new logger installed in January 2006. However, the perched water table is within 150mm of the bottom of the bore indicating a depletion of the perched water table as a result of the drought.

Following a sustained period of significant rainfall since June 2007, the water level in this bore has risen by 1.5 metres, approximately one metre short of the highest level recorded in the first half of 2002.

PF167Dam

Water levels in the PF167DAM, which was originally excavated to the base of the Maroota Sand within the deep palaeochannel, have been kept above 180mAHD over the year to June 2007 by regulating pumping so that this level is not exceeded.

Following heavy rainfall during June 2007 (384.5 mm) and the following, above-average year, the water level in the dam has risen to just over 183mAHD, the highest level recorded at this location since monitoring started in September 1996. This is considered to be the result of the combined effects of the high rainfall, reduced need for pumping from this source since November 2006 and general aquifer recovery and recharge.

Although water is pumped from the dam for a variety of purposes, such as dust suppression and irrigation of rehabilitated areas and more recently for sand slurring, records show that water levels return rapidly to the average values indicated above even after higher levels are experienced following heavy rainfall and consequent runoff. The combined effects of rainfall and runoff on the water level in the dam suggest that the Maroota sand aquifer at the site is capable of sustaining the required pumpage even under low rainfall recharge conditions and the additional demand placed upon it in the wider Maroota area by the many groundwater users.

Groundwater quality

Water quality in bores PF167MW1 and PF166MW1 has been monitored for pH and EC since monitoring started. From June 1999 to March 2000 groundwater quality has been analysed quarterly for a range of analytical parameters to obtain background data. The analytical results are summarised in **Tables 8.1** and **8.2**. Bore PF166MW1 could not be sampled during the latest monitoring round due to the low level of water in the bore.

Table 8.1 Summary of chemical analysis at Bore PF167MW1

Analyte	Unit	Date					
		15.12.04	22.06.05	19.01.06	06.07.06	05.07.07	03.07.08
pH		4.68	5.42	4.32	4.27	4.88	5.29
Electrical Conductivity EC	µS/cm	240	215	205	199	188	161
Total Dissolved Solids TDS	mg/L	143	137	141	119	76	100
Calcium Ca	mg/L	5	5	4	4	2	6
Magnesium Mg	mg/L	4	4	4	4	3	5
Sodium Na	mg/L	26	28	25	23	16	13
Potassium K	mg/L	3	3	3	3	2	4
Chloride Cl	mg/L	50	57	57	53	36	26
Sulphate SO ₄	mg/L	13	13	10	6	10	30
Bicarbonate HCO ₃	mg/L	<1	2	2	>1	<1	<1
Oil and Grease	mg/L	<5	<5	<5	<5	<5	<5

The electrical conductivity (EC) plots show a sympathetic variation with rainfall, indicating the effects of dilution generated by recharge (decrease in EC) and by a lower water table. In the latter case, the improved EC is interpreted as the effect of aquifer recharge by fresher water. The plots confirm the dependence of the aquifer on rainfall to maintain storage and supply. No analysis has been carried out of the water from the dam because extraneous influences, such as direct rainfall and run-off, make that water unrepresentative of the groundwater at the site.

The waters in the two monitoring bores are similar and have a characteristic meteoric composition, with low pH, low TDS and a Sodium-Chloride type. The samples were also analysed for Oil and Grease to monitor the possible effect of the sand extraction operations. Oil and grease was detected in the groundwater in Bore PF198PB1 in January 2006 (6mg/L), in Bore PF198PB2 in December 2001 (11mg/L) and in Bore PF166MW1 (6mg/L). As no oil and grease was detected in all other sampling occasions, it is considered that such occurrences do not represent a cause for concern.

Table 8.2 Summary of chemical analysis at Bore PF166MW1

Analyte	Unit	Date ¹					
		26.06.02	23.01.03	09.07.03	30.01.04	29.06.04	15.12.04
pH		4.48	4.82	7.86	4.39	4.27	4.06
Electrical Conductivity EC	µS/cm	219	203	221	193	235	203
Total Dissolved Solids TDS	mg/L	280	128	134	204	280	120
Calcium Ca	mg/L	2	1	1	1	<1	1
Magnesium Mg	mg/L	6	5	4	5	5	4
Sodium Na	mg/L	24	19	20	18	18	19
Potassium K	mg/L	1	<1	<1	<1	1	1
Chloride Cl	mg/L	61	46	50	47	44	36
Sulphate SO ₄	mg/L	2	<1	<1	2	<1	2
Bicarbonate HCO ₃	mg/L	<1	<1	1	<1	<1	<1
Oil and Grease	mg/L	<5	6	<5	<5	5	<5

Note 1: Bore PF166MW1 was dry for the monitoring events between 22.06.05 and 05.07.07 and no sample was taken on 03.07.08.

Groundwater quality has also been monitored at bores PF198PB1 and PF198PB2, the two process plant water supply bores on Lot 198 DP752025. The water in these bores is derived from the Hawkesbury Sandstone aquifer. Quality records are summarised in **Tables 8.3** and **8.4**.

The water here displays a slightly different character to that in the shallow Maroota Sand aquifer in the Hitchcock Road area and from shallow Hawkesbury Sandstone aquifer in other areas of Maroota. The deeper groundwater has a slightly higher TDS, pH (PFPB1) and bicarbonate content (PF198PB2) than the shallower Maroota Sand groundwater. However, its overall low salinity content and a sodium-chloride meteoric composition indicate a dynamic groundwater regime with regular and rapid rainfall recharge.

Overall, all the bores in both the Hawkesbury Sandstone and the Maroota Tertiary Sand show a marginal decrease in Total Dissolved Solids over time, the deeper bores showing a more consistent character.

Table 8.4 Summary of chemical analysis at Bore PF198PB1

Analyte	Unit	Date ¹					
		29.06.04	15.12.04	22.06.05	19.01.06	06.07.06	03.07.08
pH		4.53	4.28	5.22	5.74	5.16	4.59
Electrical Conductivity EC	µS/cm	291	197	157	158	155	144
Total Dissolved Solids TDS	mg/L	174	88	105	115	98	85
Calcium Ca	mg/L	4	1	1	2	1	<1
Magnesium Mg	mg/L	5	2	2	4	3	2
Sodium Na	mg/L	40	25	23	21	20	18
Potassium K	mg/L	3	2	2	2	2	1
Chloride Cl	mg/L	83	42	47	43	44	31
Sulphate SO ₄	mg/L	9	8	8	6	2	10
Bicarbonate HCO ₃	mg/L	<1	<1	1	12	5	<1
Oil and Grease	mg/L	<5	<5	<5	5	<5	<5

Note 1: No sample was taken on 05.07.07.

Table 8.5 Summary of chemical analysis at Bore PF198PB2

Analyte	Unit	Date					
		15.12.04	22.06.05	19.01.06	06.07.06	05.07.07	03.07.08
pH		5.39	6.43	5.30	5.46	4.37	5.25
Electrical Conductivity EC	µS/cm	156	133	126	122	195	135
Total Dissolved Solids TDS	mg/L	105	87	104	79	88	79
Calcium Ca	mg/L	1	<1	<1	1	<1	1
Magnesium Mg	mg/L	2	4	3	4	3	8
Sodium Na	mg/L	20	17	19	16	21	18
Potassium K	mg/L	2	2	1	2	1	2
Chloride Cl	mg/L	35	35	39	30	45	32
Sulphate SO ₄	mg/L	4	4	1	1	4	2
Bicarbonate HCO ₃	mg/L	2	14	7	24	<1	24
Oil and Grease	mg/L	<5	<5	<5	<5	<5	<5

Water quality records from all available bores in both aquifers (Tertiary sand and sandstone), indicate that the groundwater is generally of potable quality, of low salinity, slightly acidic and often iron-rich.

Pumpage records

Records of pump operations have been kept for PF167DAM since January 1997. Annual pumpage for the current year (21.5ML) has been below the licensed limit (50ML/year) mainly due to improved management of the central process plant.

Pumping records for the two water supply bores in Lot 198 DP752025 also show that total pumpage for 2007/2008 (24.5ML) was similar to that of the previous 12 months (27.7ML) and below the combined annual allocation of 60ML. Bore PF198PB1 was out of service for part of the year.

Due to modifications carried out at the wash plant on Lot 198, these bores are no longer required for continuous supply.

8.3 Assessment criteria

Monitoring data presented annually since records began in 1998 show that the measured parameters have remained fundamentally constant:

- Bore PF167MW1 ph between 4.21 and 5.42 with an average of 5 units
EC between 161 and 240µS/cm with an average of 197µS/cm
TDS between 76 and 207mg/L with an average of 121mg/L
Oil and grease has remained below 5mg/L

8.4 New monitoring bores

Two new monitoring bores have recently been introduced on the Hitchcock Road site. These are:

- PFL2HITCHMV1 located towards the eastern end of Lot 2 DP1063296, the former eastern Crown road access to the former Maroota Trig reserve was drilled through the whole thickness of the Maroota sand; and
- PFP214MW1 located in the south western part of Lot 214 DP752039 was drilled through the weathered profile of the Hawkesbury sandstone as Maroota sand is absent along the southern boundary of the site..

The location of these bores is shown on **Figure 8.1**.

8.5 Rainfall and evaporation

Rainfall in the area was recorded from 1925 to 1998 at the Maroota Bush Fire Brigade Station located opposite the junction of Roberts Road with Old Northern Road. The station was closed in 1998 due to a lack of personnel. The records show that the average annual rainfall over this period was 884.8 millimetres. This rainfall was, however, highly variable with a maximum of 1,637 millimetres in 1990 and a minimum of 354 millimetres in 1953.

The station was reopened in 1999 a short distance away in Roberts Road. Records for this station indicate that during the period from 2000 to 2003 rainfall has been below average with the lowest occurring in 2003 (636.6 millimetres). Rainfall data for the period between 1925 and 1998 are shown in **Table 8.6** together with mean daily pan evaporation.

Table 8.6 Monthly rainfall at Maroota 1925 to 1998 and mean daily pan evaporation

Month	Monthly rainfall 1925 to 1998 (mm)				Mean daily pan evaporation (mm)
	Mean	Median	Highest	Lowest	
January	101.5	73.6	395.5	0.0	6.3
February	104.8	75.9	464.9	0.0	5.4
March	103.9	84.0	437.7	2.1	4.4
April	90.5	58.8	467.2	0.0	3.3
May	61.2	41.9	370.1	1.5	2.1
June	89.9	50.8	445.4	0.0	1.8
July	46.6	26.0	250.6	0.0	2.0
August	55.2	22.8	497.4	0.0	3.1
September	53.9	40.3	174.0	0.4	4.3
October	64.7	53.7	220.3	0.6	5.4
November	76.9	66.6	208.3	0.5	5.9
December	76.4	69.1	375.0	0.0	7.0
Annual	884.8	869.2	1,636.6	353.9	4.3

8.6 Groundwater dependent ecosystems and vegetation

There are no groundwater dependent ecosystems or vegetation located on either the Hitchcock Road site or Lot 198 DP752025. However, the Maroota Sands Swamp Forest is located immediately to the south west and downstream of Lot 198. The swamp forest is listed as an endangered ecological community on the *TSC Act*. It is a groundwater dependent community heavily reliant on groundwater seepages from the Maroota sand and possibly from the Hawkesbury sandstone (Department of Land and Water Conservation 2001). Hydrological assessment of Lot 198 (URS 2004) has concluded that there is unlikely to be any change in the extent of groundwater or water quality. No changes are proposed on Lot 198 as a result of the Project Approval and no impacts on the ecological community are therefore expected.

8.7 Further groundwater modelling

The limits of extraction will be confirmed on the basis of the groundwater monitored in the wells equipped with data loggers and reported annually in the AEMR.

8.8 Groundwater monitoring protocol

Monitoring of groundwater on the Hitchcock Road site and Lot 198 DP752025 will be carried out using the same procedures as implemented prior to the present approval with the addition of data derived from the two new bores noted in **Section 8.4**.

All four bores on the Hitchcock Road site are equipped with Solinst Levellogger units with a battery life of approximately 10 years capable of storing 40,000 readings in memory. These allow annual data downloading, a monitoring interval started in July 2006.

Groundwater samples will be collected at the same time from the monitoring bores and the two supply bores on Lot 198 for chemical analysis. Records of water volumes pumped from the supply bores and the supply dam on Lot 167 DP752039 will also be kept.

Water samples will be collected and submitted for chemical analysis under *chain of command procedures* to Australian Laboratory Services Pty Ltd. The analytical list, which was discussed and agreed with the former Department of Land and Water Conservation (DLWC) (now the Department of Natural Resources), includes the following:

- pH, Electrical Conductivity and Total Dissolved Solids
- Calcium, Magnesium, Sodium and Potassium
- Chloride, Sulphate and Bicarbonate
- Oil and grease.

The analytical results together with water levels in the bores and rainfall will be plotted on individual graphs to assess possible trends with time.

8.9 Monitoring and reporting schedule

An annual audit report (now called the AEMP) covering all the requirements of the previous Court consent conditions has been prepared and submitted every year since 1999 including monitoring results starting in November 1998. This has been submitted in July/August each year up to 2008. In the latest version, monitoring data relating to a separate approval for extraction on Lot 198 DP752025 under Part 4 of the EP&A Act has been included in this document as many of the results apply to both operations.

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