VOLUME 4

Appendix L3
Groundwater

Department of Infrastructure and Regional Development

Western Sydney Airport EIS
Groundwater Assessment

October 2015

Limitations

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Glossary and abbreviations

Term	Definition
ADWG	Australian Drinking Water Guidelines
Airport	Western Sydney Airport
Airport site	The airport site is the total of all properties that may become part of Western Sydney Airport. The airport site includes existing Commonwealth land and land to be acquired by the Commonwealth, such as The Northern Road.
Airport features	Specific features of the proposed airport, such as runways, taxiways, terminal buildings or hangars.
Alluvium	Unconsolidated deposit of gravel, sand or mud formed by water flowing in identifiable channels. Commonly well sorted and stratified.
ANZECC	Australian and New Zealand Environment Conservation Council
Aquifer	A groundwater bearing formation sufficiently permeable to transmit and yield groundwater.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrences of a flood as big as or larger than the selected event.
Australian Height Datum (AHD)	A common reference level used in Australia which is approximately equivalent to the height above sea level.
Badgerys Creek	Badgerys Creek is a suburb of Sydney approximately 50 kilometres west of the Sydney central business district, and the general locality of the proposed airport. Badgerys Creek is also the name of a watercourse which is referred to in this report.
BOM	Bureau of Meteorology
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Catchment	The area drained by a stream or body of water or the area of land from which water is collected.
Consent	Approval to undertake a development received from the consent authority.
Construction	In this report the term construction is inclusive of both earthworks and construction of site facilities.
Datum	A level surface used as a reference in measuring elevations.
DEM	Digital elevation model
DTV	Default Trigger Value
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic meters per second or megalitres per day.

Term	Definition
Drawdown	A reduction in piezometric head within an aquifer.
EC	Electrical Conductivity
EIS	Environmental Impact Statement
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
Formation	A fundamental unit used in the classification of rock or soil sequences, generally comprising a body with distinctive physical and chemical features.
Fracture	Cracks within the strata that develop naturally or as a result of underground works.
Groundwater	Subsurface water stored in pores of soil and geological formations.
GDE	Groundwater Dependent Ecosystem
ha	Hectares
Hazard	The potential or capacity of a known or potential risk to cause adverse effects.
Hydraulic conductivity	The rate at which water at the prevailing kinematic viscosity will move under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow, usually expressed in metres per day (this assumes a medium in which the pores are completely filled with water).
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Infiltration	The downward movement of water into soil and rock, which is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
km	Kilometre
Landform	A specific feature of the landscape or the general shape of the land.
LTAAEL	Long Term Average Annual Extraction Limit
Longer term development	A future stage in the development of the proposed airport, where the airport is assumed to comprise parallel runways and handling approximately 82 million passengers annually. The EIS assumes this occurs in 2063 for assessment purposes.
LPMA	NSW Land and Property Management Authority
m	Metres
m/day	Metres per day
m3/day	Metres cubed per day
Max	Maximum

Term	Definition
Min	Minimum
ML	Megalitres
Monitoring well/bore	A hole sunk into the ground and completed for the abstraction or injection of water or for water observation purposes. Generally synonymous with bore.
NWQMS	National Water Quality Management Strategy
Outcrop	Where the bedrock is exposed at the ground surface.
Permeability	The capacity of a porous medium to transmit water.
POEO	Protection of Environment Operation
Recharge	Addition of water to the zone of saturation; also the amount of water added. An area in which there are downward components of hydraulic head in the aquifer. Infiltration moves downward into the deeper parts of an aquifer in a recharge area.
Risk	The chance of something happening that will have an impact measured in terms of likelihood and consequence.
Risk assessment	Systematic process of evaluating potential risks of harmful effects on the environment from exposure to hazards associated with a particular product or activity.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Salinity	The total soluble mineral content of water or soil (dissolved solids); concentrations of total salts are expressed as milligrams per litre (equivalent to parts per million).
Sediment	Material of varying sizes that has been or is being moved from its site of origin by the action of wind, water or gravity.
Stage 1 (or initial) development	The initial stage in the development of the airport, including a single runway and facilities to handle approximately 10 million passengers annually. The EIS assumes 10 million passengers is reached in 2030 for assessment purposes.
Study area	The subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly. The study area extends as far as is necessary to take all potential impacts into account.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Surface water features	These include watercourses and wetlands and their attributes (water quality and geomorphology). The term is generally used in this report to describe natural resources, but may also extend to artificial surface water features including lakes, dams and man-made wetlands.

Term	Definition
TDS	Total Dissolved Solids
Topography	Representation of the features and configuration of land surfaces.
Water quality	Chemical, physical and biological characteristics of water. Also the degree (or lack) of contamination.
Water table	The surface of saturation in an unconfined aquifer, or the level at which pressure of the water is equal to atmospheric pressure.
Western Sydney Airport	The proposed airport at Badgerys Creek and assessed in the Western Sydney Airport environmental impact statement.
WSP	Water Sharing Plan

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Appendices

1. Introduction

1.1 Introduction

Planning investigations to identify a site for a second Sydney airport first commenced in 1946 with a number of comprehensive studies—including two previous environmental impact statements for a site at Badgerys Creek—having been completed over the last 30 years.

More recently, the *Joint Study on Aviation Capacity in the Sydney Region* (Department of Infrastructure and Transport, 2012) and *A Study of Wilton and RAAF Base Richmond for civil aviation operations* (Department of Infrastructure and Transport, 2013) led to the Australian Government announcement on 15 April 2014 that Badgerys Creek will be the site of a new airport for Western Sydney. The airport is proposed to be developed on approximately 1,700 hectares of land acquired by the Commonwealth in the 1980s and 1990s. Construction could commence as early as 2016, with airport operations commencing in the mid-2020s.

The proposed airport would provide both domestic and international services, with development staged in response to demand. The initial development of the proposed airport would include a single, 3,700 metre runway coupled with landside and airside facilities such as passenger terminals, cargo and maintenance areas, car parks and navigational instrumentation capable of facilitating the safe and efficient movement of up to 10 million passengers per year. While the proposed Stage 1 development does not currently include a rail service, planning for the proposed airport preserves flexibility for several possible rail alignments including a potential express service. A final alignment will be determined in consultation with the New South Wales Government, with any enabling work required during Stage 1 subject to a separate approval and environmental assessment process.

In the longer term, approximately 40 years after operations commence and in accordance with relevant planning processes, the airport development could include parallel runways and additional passenger and transport facilities for around 82 million passenger movements per year. To maximise the potential of the site, the airport is proposed to operate on a 24 hour basis. Consistent with the practice at all federally leased airports, non-aeronautical commercial uses could be permitted on the airport site.

On 23 December 2014, the Australian Government Minister for the Environment determined that the construction and operation of the airport would require assessment in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). Guidelines for the content of an environmental impact statement (EIS) were issued in January 2015. Approval for the construction and operation of the proposed airport will be controlled by the *Airports Act 1996* (Cth) (Airports Act). The Airports Act provides for the preparation of an Airport Plan which will serve as the authorisation for the development of the proposed airport.

The Australian Government Department of Infrastructure and Regional Development is undertaking detailed planning and investigations for the proposed airport, including the development of an Airport Plan. The draft Airport Plan is the primary source of reference for, and companion document to, the EIS. The draft Airport Plan identifies a staged development of the proposed airport. It provides details of the initial development being authorised, referred to as Stage 1, as well as a long-term vision of the airport's development. This enables preliminary consideration of the implications of longer term airport operations. Any stages of airport development beyond Stage 1 would be managed in accordance with the existing process in the Airports Act. This includes a requirement that for major developments (as defined in the Airports Act), a major development plan be approved by the Australian

Government Minister for Infrastructure and Regional Development following a referral under the EPBC Act.

The Airport Plan will be required to include any conditions notified by the Environment Minister following this EIS. Any subsequent approvals for future stages of the development will form part of the airport lessee company's responsibilities in accordance with the relevant legislation.

1.2 Project location

The site for the proposed Western Sydney Airport (the proposed airport) covers an area of approximately 1,700 hectares located at Badgerys Creek in Western Sydney as shown in Figure 1. The airport site is located within the Liverpool local government area, around 50 kilometres west of Sydney's Central Business District and 15 to 20 kilometres from major population centres such as Liverpool, Fairfield, Campbelltown and Penrith.

The Northern Road transects the western end of the airport site and Elizabeth Drive borders the site to the north. Badgerys Creek flows in a north-easterly direction and forms the south eastern boundary of the airport site. The airport site is located on undulating topography that has been extensively cleared with the exception of stands of remnant vegetation located predominantly along Badgerys Creek and the south western portion of the site.

1.3 Scope

This groundwater assessment presents a qualitative analysis of potential impacts on groundwater resources based on a review of previous environmental impact statements undertaken for a proposed major airport at Badgerys Creek. The previous investigations reviewed include:

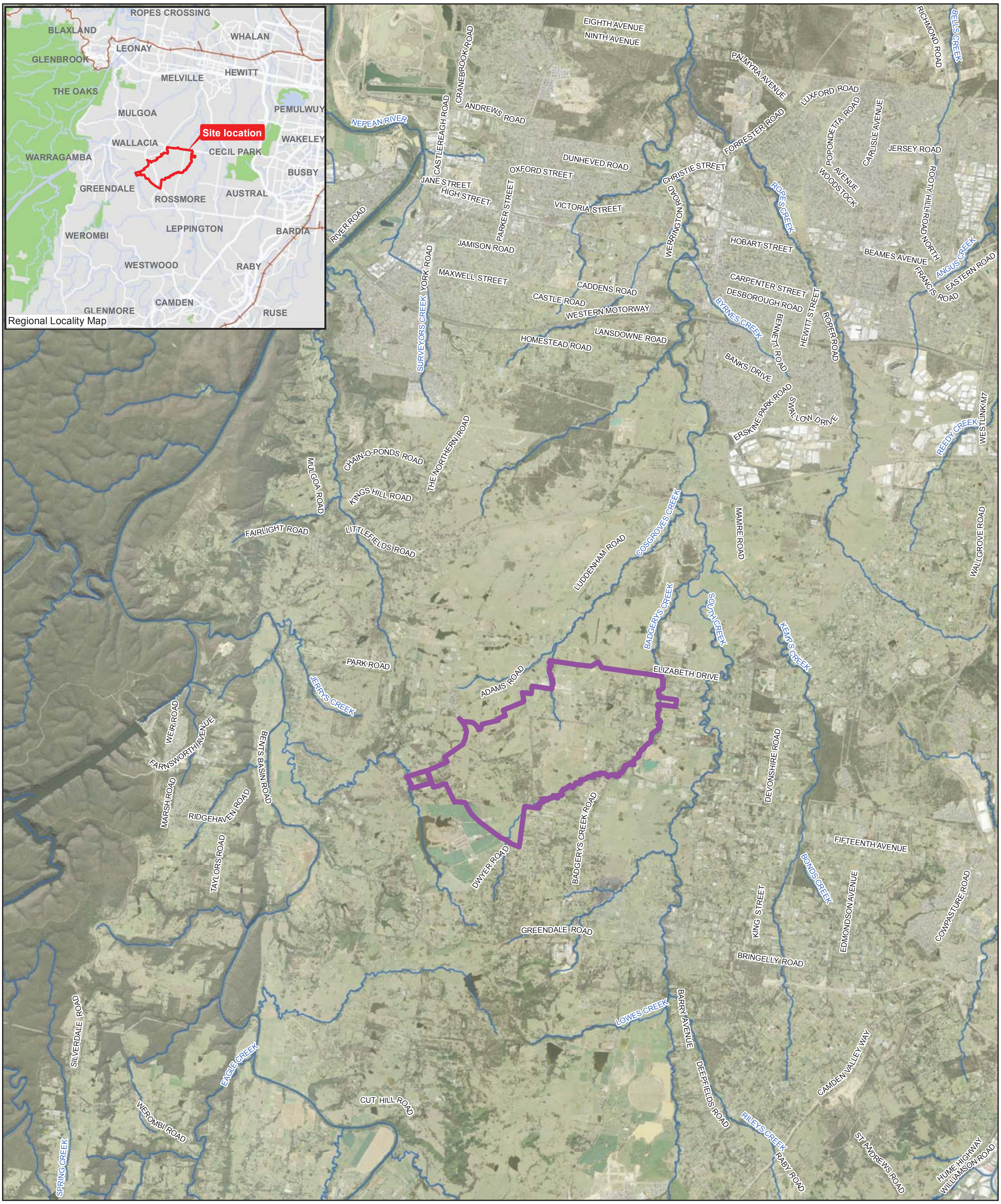
- concept design investigations reported in 1991
- a draft environmental impact statement (EIS) prepared in 1997 and an independent audit of the draft EIS
- a supplement to the draft EIS, prepared in 1999, which was also subject to independent review.

The key technical investigations undertaken for these assessments that relate to groundwater include:

- Coffey & Partners International, January 1991 – Second Sydney Airport at Badgerys Creek Concept Design Report Volume 3 Geotechnical Investigation
- PPK Environment and Infrastructure, 1997 – Geology, Soils and Water – Proposal for Second Sydney Airport at Badgerys Creek or Holsworthy Military Area
- PPK Environment and Infrastructure, 1999 – Appendix E1 – Groundwater Studies
- PPK Environment and Infrastructure, 1999 – Appendix E3 – Existing Environment and Water Quality.

The investigations included characterisation works to highlight geological conditions and hydrogeological conditions (including hydraulic properties) across the site, groundwater elevations, and groundwater and surface water quality. Groundwater modelling was completed using numerical modelling software (MODFLOW) to assess the likely impacts of the project on groundwater elevations.

The final scope of works completed for the previous investigations was based on an independent review of the 1997 Draft EIS (SMEC, 1998) and took into account submissions on the 1997 Draft EIS. This resulted in a comprehensive assessment of the key issues at the Badgerys Creek site.



LEGEND

- Site Boundary
- Major Watercourses

Paper Size A3

0 500 1,000 2,000 3,000 4,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

Department of Infrastructure and Regional Development
Groundwater Impact Assessment

Job Number	21-24265-09
Revision	A
Date	06 Jul 2015

Site Location

Figure 1

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial Imagery: Dept of Lands, 2013. Topo Data: NSW LPI DTDB & DCDB 2012 Created by:mweber

The existing environmental conditions in relation to groundwater have not changed significantly since the completion of previous investigations (see Section 3 for further detail on the existing environment). While the proposed operational capacity of the proposed airport has increased from previous assessments, the configuration of the runway(s) and associated aviation infrastructure remains similar to both the concept design assessed by Coffey and Partners in 1991 and the Option A airport design assessed by PPK Environment and Infrastructure in 1997-1999.

The previous investigations are therefore considered suitable to provide a characterisation of the existing groundwater conditions at the airport site and to form the basis for the assessment of impacts for the current proposal. The desktop investigation has focused on the following key tasks:

- review of the legislative and policy settings for the groundwater assessment;
- characterisation of the current conceptual hydrogeological and groundwater conditions in the region;
- characterisation of existing water quality relative to key trigger/threshold criteria that are protective of potential receiving systems;
- development of measures that would be adopted to identify potential emerging impacts and the requirement for implementing mitigation measures; and
- assessment of the treatment required for discharge of groundwater seepage.

1.4 Structure of this report

To document the works completed, the following report structure has been adopted:

- **Section 1 – Introduction** – which details the project background, objectives and scope, as outlined above;
- **Section 2 – Regulatory Context** – which details key legislative drivers and how these are addressed by the groundwater assessment;
- **Section 3 – Existing Environment** – which details the current understanding of the existing environment;
- **Section 4 – Assessment of Impacts** – which interprets the potential impacts of construction and operational activities on the existing environment as well as potential cumulative impacts;
- **Section 5 – Mitigation and Management Measures** – which describes the further work proposed to be undertaken during the subsequent stages of design and the monitoring framework to identify the potential emergence of any issues; and
- **Section 6 – Summary and Conclusions**.

2. Regulatory Context

2.1 Introduction

The airport site is located on land entirely owned by the Commonwealth.

The Australian and NSW legislative and policy settings and guidelines in regards to groundwater management – even where not directly applicable to the proposed airport – have been considered as part of the review process.

2.2 Environment Protection and Biodiversity Conservation Act 1999

The Australian Government Minister for the Environment determined that the construction and operation of the proposed airport would require assessment in accordance with the EPBC Act. Guidelines for the content of an environmental impact statement (EIS) were issued in January 2015.

The guidelines contain no specific requirements for the consideration of groundwater issues, but do require broad consideration of the potential environmental impacts on all aspects of the environment.

This report has been prepared in accordance with the guidelines.

2.3 Airports Act 1996 and Airports (Environment Protection) Regulations 1997

Following an environmental impact assessment finalised under the EPBC Act, the Airport Plan will be determined under the Airports Act. Stage 1 of the proposed airport will be developed in accordance with the airport plan provisions in the Airports Act.

In the period prior to the grant of an airport lease, any construction activities on the airport site will be conducted in accordance with the Airport Plan and having regard to the requirements of the Airports (Environment Protection) Regulations 1997.

Once an airport lease is granted, environmental management at the Western Sydney Airport site will be undertaken in accordance with Part 6 of the Airports Act and the Airports (Environment Protection) Regulations 1997. The Airports Act specifies offences relating to environmental harm, environmental management standards, and monitoring and incident response requirements, including in relation to water pollution.

2.4 NSW Water Management Act 2000

2.4.1 Introduction

The NSW *Water Management Act 2000* (WM Act) is administered by the NSW Department of Primary Industries (DPI) Water (formerly NSW Office of Water) and is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. The WM Act is also intended to provide a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions. The intent and objectives of the WM Act have been considered as part of this assessment.

2.4.2 Water Sharing Plans

Water Sharing Plans (WSPs) have been developed under the WM Act for all water sources within NSW with the aims of:

- clarifying the rights of the environment, basic landholder rights users, town water suppliers and other licensed users;
- defining the long-term average annual extraction limit (LTAAEL) for water sources;
- setting rules to manage impacts of extraction; and
- facilitating the trading of water between users.

WSP for the Greater Metropolitan Region Groundwater Sources

The WSP for the Greater Metropolitan Region Groundwater Sources covers 13 groundwater sources on the east coast of NSW. The airport is located within the Sydney Basin Central Porous Rock groundwater source area. The porous rock aquifer is referenced in the WSP as sedimentary sandstone and siltstone formations with intervening coal seams.

The background document for the water sharing plan (NOW, 2011) lists the Sydney Basin Central porous rock aquifer as having:

- low to moderate contact with surface water with generally long travel times (years to decades); and
- allocated volumes of 2,592 ML/yr versus a long-term average annual extraction limit of 45,915 ML/yr, which suggests that there is a significant amount of groundwater in the aquifer that has not been released for use. The estimated LTAAEL volumes are based on average recharge rates of six per cent of annual rainfall.

This information suggests that, if required, there would be sufficient available groundwater within the aquifer resource to allow groundwater extraction or collection of groundwater seepage.

The WSP also sets out a number of key water sharing rules for the Sydney Basin Central Porous Rock groundwater resource. These rules may relate to the take of water from the aquifer system beneath the airport site. The water sharing rules are outlined below.

- With regards to eligibility for obtaining water access licences, commercial use is permitted in this area under a controlled allocation. Seepage to subsurface facilities falls under this criterion as an aquifer interference activity and also possibly as a water take.
- The minimum distances allowed between a new water supply works and neighbouring water supply works ranges from 50 metres from a neighbouring property to one kilometre from a major water utility bore. It is assumed that this rule is designed to minimise drawdown impacts between water supply wells. While the site will require water supply wells, any excavations may have seepage that could have drawdown effects. Given the existing environment (see Section 3), it is not expected that there are any surrounding water supply works that would be subject to drawdown impacts.
- The minimum distances allowed between a new water supply works and a contaminated site range from 250 metres to greater than 500 metres depending on the potential for impact. While the subsurface infrastructure may result in a migration of impacted groundwater from the source of impact, the subsurface infrastructure would serve as a capture system for the groundwater. This groundwater would be treated accordingly before discharge to the receiving environment.

- There is a requirement to protect sandstone aquifers by sealing off shale aquifers that are highly saline. The depth of subsurface infrastructure is not expected to create any connection between shales and underlying sandstone aquifers. As such, there is unlikely to be an increased risk for migration into the underlying sandstone aquifer system.
- The distances allowed between new water supply works and high priority groundwater dependent ecosystems range from between 100 metres for basic land rights wells to 200 metres for all other uses. Further to this, no new water supply works are allowed within 40 metres of a river or stream that is 3rd order or above or within 40 metres of a 1st or 2nd order stream unless located within underlying parent material or within 100 metres of an escarpment. Project areas that result in drawdown impacts are unlikely to come within 40 m of surrounding creeks, except the upper reaches of Oaky Creek which will be disturbed as part of the proposed airport development.
- Regarding permission to trade water allocated under an access licence, trading is permitted within this groundwater resource.

Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources

The WSP for the Greater Metropolitan Region Unregulated River Water Sources commenced in 2011 and covers 87 management zones that are grouped into six water sources. The airport site is situated in the Hawkesbury and Lower Nepean Rivers catchment or source.

The Hawkesbury and Lower Nepean Rivers catchment is separated into management areas that include the Upper South Creek management area/unit, which includes Badgerys Creek and its catchment area within the airport site.

The water sharing plan background document (NOW 2011b) suggests that the South Creek region has high economic significance and depends on extraction for irrigation, town and industrial water supply.

South Creek is described as a "*meandering deep and narrow channel with chain of ponds headwaters*". The 20th percentile flow is 34 ML/day which is "*primarily treated effluent discharge*". This flow is expected to be recorded below the gauging station at the Great Western Highway, St Marys (gauge station 212297).

The water access rules for South Creek are as follows:

- Class A approvals must cease to pump when flows are at or less than 0.2 ML/day at the downstream flow gauge 212048 located at the Great Western Highway, St Marys;
- Class B approvals must cease to pump when flows are at or less than 6.2 ML/day; and
- pumping may commence when flows have exceeded 0.2 ML/day for a period of 24 hours.

2.4.3 Protection of the Environment Operations Act (PoEO Act)

The objectives of the NSW *Protection of the Environment and Operations Act 1997* (PoEO Act) are to protect, restore and enhance the quality of the environment, in recognition of the need to maintain ecologically sustainable development. This assessment has taken into account the intent and objectives of that Act.

2.5 Other Policies and Guidelines

2.5.1 National Water Quality Management Strategy (NWQMS)

The NWQMS policy and principles document (ARMCANZ/ANZECC 1994) provides an overview of the principles for water quality management in Australia. The primary objective of the guideline/policy is:

"to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development."

The policy and principles document states that:

"the generally accepted mechanism for establishing in-stream or aquifer water quality requirements is a two-step process which involves:

- *establishing a set of environmental values, and*
- *establishing scientifically based water quality criteria corresponding to each environmental value."*

Environmental values are often interchanged with the term 'beneficial use' and are identified in the guidance to include:

- ecosystem protection;
- recreation and aesthetics;
- drinking water;
- agricultural water (irrigation and stock water); and
- industrial water.

Ecosystem protection, in this context, refers to aquatic ecosystems which depend at least in part on groundwater to maintain ecosystem health (groundwater-dependent ecosystems). Depending on the site setting, this may include surface water bodies such as wetlands, streams and rivers reliant on groundwater base flow, some estuarine and near-shore marine systems, as well as aquifer and cave ecosystems.

Criteria have been developed to characterise water quality relative to these environmental criteria and are outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and the Australian Drinking Water Guidelines (ADWG) and are discussed further below. The criteria specified in these documents have been used as the basis for characterising the current environmental values for this assessment and the treatment requirements for discharge to receiving water environments.

2.5.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The National Water Quality Management Strategy (NWQMS) provides a national framework for improving water quality in Australia's waterways. The main policy objective of the NWQMS is to achieve sustainable use of the nation's water resources by protecting and enhancing their quality, while maintaining economic and social development. The NWQMS process involves community and government interaction, and implementation of a management plan for each catchment, aquifer, estuary, coastal water or other water body. This includes the use of national guidelines for local implementation.

For this project, the national guidelines on water quality benchmarks within the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000) are applicable and provide default trigger values (DTVs) of various analytes for comparison with sampled values. Guideline water criteria are presented in the guidelines for:

- aquatic ecosystems;
- primary industries (which include agricultural and industrial water criteria);
- recreational water quality and aesthetics; and
- drinking water.

The guideline values are not standards and should not be regarded as such (ANZECC, 2000). It should also be noted that the water quality values are not suitable for direct application to stormwater quality. Rather, the guidelines have been derived to apply to the ambient waters that receive stormwater discharges and to protect the environmental values that they support.

Of particular importance is the philosophical approach for using the ANZECC guidelines, which:

"*protect environmental values by meeting management goals that focus on concerns or potential problems"* (ANZECC, 2000).

That is, development of a monitoring programme, including the performance objectives, standards and measurement criteria, should focus on specific issues not on pre-determined guideline values.

The surface water features receiving water from the airport site and surrounding area are located primarily within agricultural catchments and as such are considered to be "slightly modified fresh water systems" (ANZECC, 2000). Based on this a protection level of 95 per cent for freshwater ecosystems, as recommended in ANZECC (2000) is considered to be suitable for the assessment.

ANZECC (2000) also provides screening trigger values for southeast Australia NSW lowland rivers (less than 150 metres in altitude). The lowland rivers criterion has also been used in this assessment.

ANZECC (2000) also provides a range of data for health-based recreational water use, sustainable irrigation and stock water purposes. These values have been adopted in the assessment to characterise the overall environmental value of the groundwater beneath the site.

2.5.3 Australian Drinking Water Guidelines

The *Australian Drinking Water Guidelines* (ADWG) (NHMRC, 2013) provide a framework for the management of drinking water supplies to achieve a safe and appropriate point of supply. The guidelines provide a base standard for aesthetic and health water quality levels. These values have been adopted for the assessment to characterise the suitability of the groundwater for potable use.

2.5.4 NSW Aquifer Interference Policy

The purpose of the Aquifer Interference Policy is to explain the role and requirements of the responsible NSW Minister in administering the water licensing and assessment processes for aquifer interference activities under the WM Act. The Aquifer Interference Policy clarifies the requirements for obtaining water licences for aquifer interference activities under NSW water legislation. The Aquifer Assessment Framework outlines the basic framework which the NSW Office of Water uses to assess project proposals against the NSW Aquifer Interference Policy.

An aquifer interference approval is typically required for any works that involve:

a. the penetration of an aquifer;

b. the interference with water in an aquifer;

c. the obstruction of the flow of water in an aquifer;

d. the taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations; and

e. the disposal of water from an aquifer as referred to in paragraph (d).

The policy applies to all aquifer interference activities, but has been developed to address a range of high risk activities. This includes large infrastructure developments that require dewatering for the construction and maintenance of facilities such as building basements and tunnel cuttings and any activities with the potential to intercept groundwater.

An aquifer interference approval will generally not be granted unless the “Minister is satisfied that adequate arrangements are in force to ensure that no more than minimal harm will be done to any water source, or its dependent ecosystems, as a consequence of being interfered with” by the activities the approval relates to.

The minimal impact criteria, specified in the Aquifer Interference Policy, for the groundwater source at the airport site are summarised below.

- With regard to the water table, impact is considered to be minimal where the water table change is less than ten per cent of the cumulative variation in the water table 40 metres from any high priority groundwater dependent ecosystem (GDE) or high priority culturally significant site listed in the water sharing plan. If an impact is greater than this it must be demonstrated to the Minister’s satisfaction that the variation will not prevent the long term viability of a GDE of cultural significance. There are no high priority sites listed in the water sharing plan near to the site; however, site specific potential GDEs have been identified that are considered to be sensitive and are considered in this assessment.
- With regard to the water table, impact is considered to be minimal where there is less than a cumulative two metre decline at any water supply work. If the impact is greater make good provisions apply.
- With regard to water pressure, impact is considered to be minimal where the cumulative decline in head is less than two metres at any water supply work. If the impact is greater, then further studies are required to satisfy the Minister that long term viability of the affected water supply works will not be affected. Otherwise make good provisions will apply.
- With regard to water quality, impact is considered to be minimal where the change in groundwater quality is within the current beneficial use category of the groundwater source beyond 40 metres from the activity. If this cannot be achieved studies will need to demonstrate that the change will not prevent the long term viability of the dependent ecosystem, or affected water supply works.

If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The Aquifer Interference Policy also provides a list of "defined minimal impact aquifer interference activities" that are considered as having a minimal impact on water-dependent assets. This includes caverns, tunnels, cuttings, trenches and pipelines (intersecting the water table) if a water access licence is not required.

The proposed airport development includes the potential for a cut and cover tunnel to be developed to establish a void for a future underground rail connection. Basement levels for the major terminal buildings may also result in the interception of an aquifer.

2.5.5 NSW State Groundwater Policy Framework Document (DLWC, 1997)

The objective of the NSW State Groundwater Policy Framework Document (NSW Government 1997) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. The NSW groundwater policy has three component parts:

- NSW Groundwater Quantity Protection Policy outlined in DLWC (1997);
- NSW Groundwater Quality Protection Policy (DLWC, 1998); and
- NSW Groundwater Dependent Ecosystems Policy (DLWC, 2002).

NSW Groundwater Quantity Management Policy

The principles of this policy include:

- maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn;
- groundwater extraction shall be managed to prevent unacceptable local impacts; and
- all groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

These principles are implemented under the WM Act and the Aquifer Interference Policy, which have been discussed above.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- slow and halt, or reverse any degradation in groundwater resources;
- direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater;
- establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource; and
- establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

NSW Groundwater Dependent Ecosystems Policy

This policy is designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

This assessment considers the potential for impacts to groundwater dependent ecosystems associated with the proposed airport development.

2.5.6 Risk Assessment Guidelines for Groundwater Dependent Ecosystems

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW, 2012) comprises four volumes and provides a conceptual framework for identifying and assessing ecosystems along with worked examples of assessments. The guidelines discuss the identification of high probability GDEs and also discuss the ecological value of GDEs. The results from the groundwater assessment have been used to inform the assessment of the presence potential impacts on GDEs (GHD, August 2015).

3. Existing Environment

3.1 Topographical Setting

The airport site is located in the south-west portion of the Cumberland Plain (PPK, 1997) in Western Sydney and includes rolling hills dissected by a number of drainage lines. The ridge system trends northwest to southeast in the vicinity of The Northern Road and reaches elevations of just over 120 m AHD. There are some other isolated ridge lines in and around the Luddenham Dyke and The Northern Road with approximate elevations of slightly more than 100 m AHD.

The topography generally slopes away from these ridgelines to the south and east into Oaky, Cosgroves and Badgerys Creeks which form part of the South Creek catchment and to the northwest into Duncans Creek which forms part of the Nepean River Catchment. The lowest points of the site are where Badgerys Creek exits the north eastern extent of the site (approximately 44 m AHD).

3.2 Surface Water Features

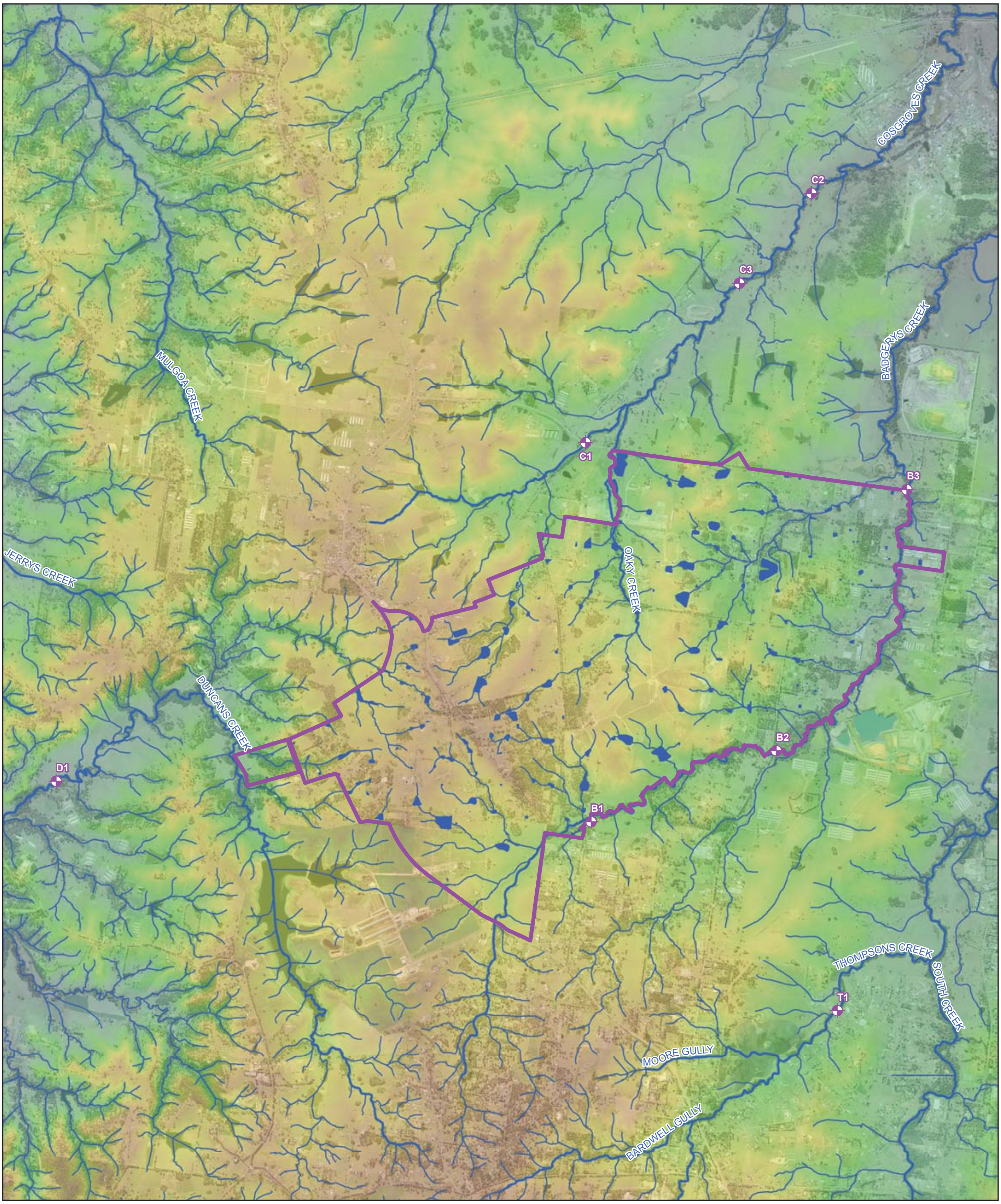
As noted above there are two main catchments that drain the site - the South Creek Catchment and the Nepean River Catchment. These catchments include a number of tributaries that also drain the airport site. Duncans Creek drains into the Nepean River catchment while Oaky Creek, Cosgroves Creek and Badgerys Creek drain into South Creek. There are also numerous farm storage dams, with a notably large dam located at the head waters of Duncans Creek to the west of the airport site boundary.

Figure 2 shows the location of the farm dams and the creek systems draining the airport site.

Previous site investigations undertaken by PPK (PPK 1997), which included a number of site visits during wet and dry conditions, suggest that the creeks draining the site may not flow continuously but that during periods of dry weather, intermittent pools may remain.

Real-time flow data at station 212048 located on South Creek at the Great Western Highway, St Marys for the period 1986 to 2015 has the following flow statistics:

- a median flow of approximately 6 ML/day;
- a 20^{th} percentile flow of approximately 0.6 ML/day; and
- a no flow percentile occurrence rate of approximately 3 per cent.



LEGEND

- Site Boundary
- Major Watercourses
- Dams (within site boundary)
- Tributaries
- Approximate Surface Water Sample Locations (PPK, 1997)

Digital Elevation Model (m ADH)

High : 126.847

Low : 27.779

Paper Size A3

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Surface Water Features

Figure 2

G:\21\24265\GIS\Maps\Deliverables\21-24265-Z073_Groundwater_SurfaceWaterFeatures.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial Imagery: Dept of Lands, 2013. Topo Data: NSW LPI DTDB & DCDB 2012 Created by:mweber

3.3 Geology

According to the 1:250,000 Geological Series Sheet for Sydney, the site is underlain by Triassic rocks (Bringelly Shale) and unconsolidated Quaternary alluvial sediments.

PPK (1997) indicates that Quaternary alluvium appears as accumulated surficial deposits along the main creeks in the area. These creeks include Cosgroves Creek to the north and Badgerys Creek to the south and east of the airport site. The alluvium typically comprises fine grained sand, silt and clay, with isolated areas of gravelly clay and clayey gravel present. An extensive drilling and test pitting program undertaken by Coffey & Partners International (1991) indicated that these sediments can be up to 5 m thick.

Cross-sections in the 1:250,000 Geological Series Sheet for Sydney indicate that the Bringelly Shales overlie the Triassic aged Hawkesbury Sandstone. The Bringelly Shales are shown in the cross-sections to approximate thicknesses of 100 m in the vicinity of the site. Drilling undertaken by Coffey & Partners International (1991) and PPK (1999) has confirmed that Bringelly Shale extends to depths of greater than 42 m across the site. Further characterisation of the geology across the site is currently being undertaken as part of detailed geotechnical investigations being undertaken by the Department of Infrastructure and Regional Development.

The Bringelly Shale is the uppermost unit of the Wianamatta Group and underlies the surface soils across the majority of the site. PPK (1997) notes that the Bringelly Shale is interpreted as a coastal alluvial plain which grades up from a lagoonal coastal marsh sequence at the base to an increasingly terrestrial, alluvial plain sediment sequence towards the top of the formation. Drilling at the site undertaken by Coffey & Partners International (1991) and PPK (1999) suggests that the predominant lithology in the Bringelly Shale includes:

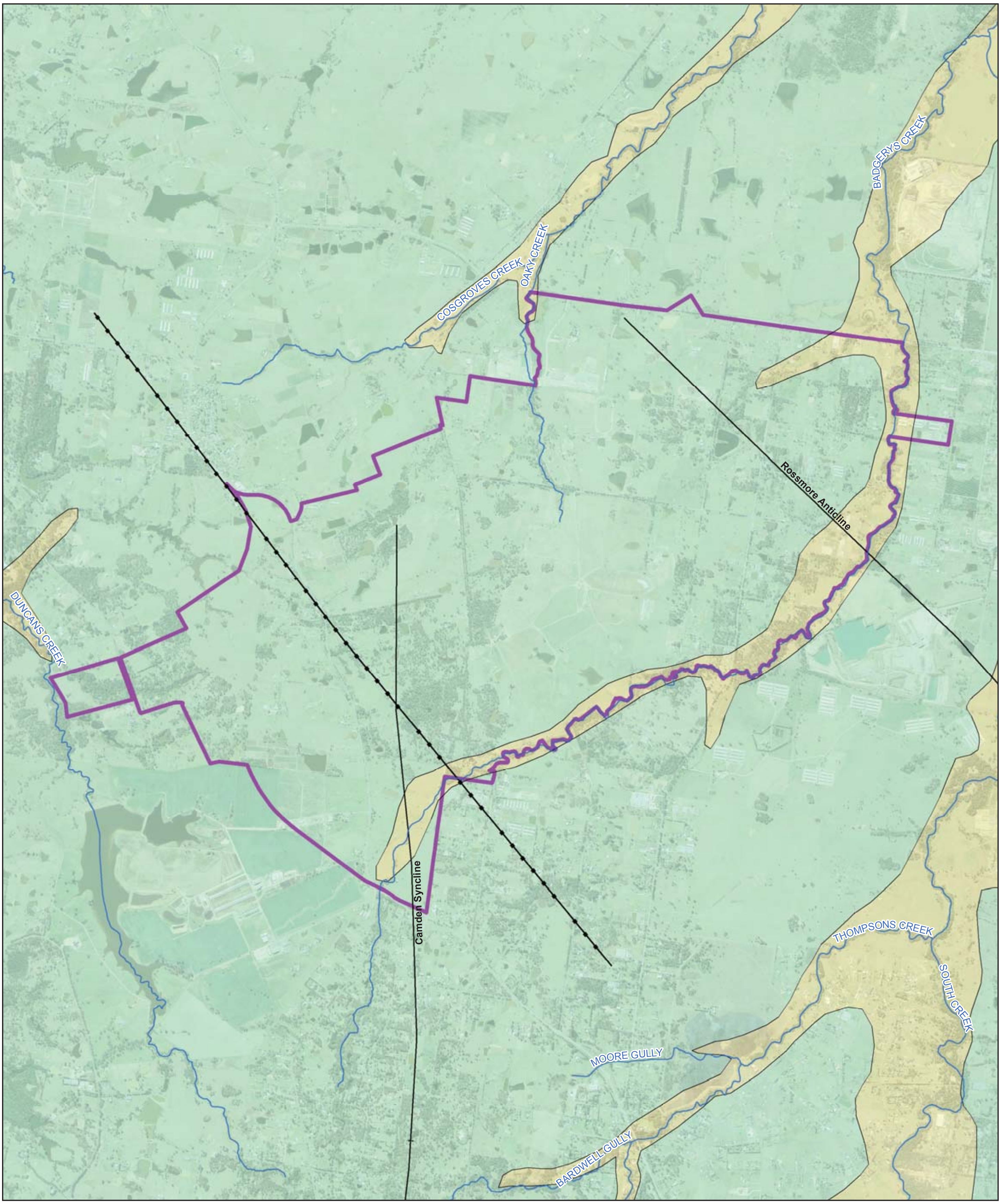
- claystone and siltstone;
- laminate;
- sandstone;
- coal and highly carbonaceous claystone; and
- tuff.

Coffey & Partners reported that the uppermost part of the Bringelly Shale is weathered to depths of between 19 m below ground surface in the vicinity of the Luddenham Dyke and approximately 5.6 m below ground surface in north western areas of the site. The weathered sediments are predominantly clays.

PPK (1997) notes that the Luddenham Dyke outcrops along the top of a ridge at the site in the vicinity of The Northern Road. The dyke consists of olivine basalt carrying analcite. It intrudes the Wianamatta Shale and trends north-west to south-east.

A review of the bore logs of NSW registered groundwater bores GW104979, GW104215 and GW105959 (see Figure 5) surrounding the site suggests that the Hawkesbury Sandstone underlies the Bringelly Shales at depths greater than 100 m below ground surface.

Figure 3 presents the site geology.



LEGEND

Site Boundary	Quaternary Alluvium
Major Watercourses	Bringelly Shale
Geological Boundary	Cranebrook Formation
Camden Syncline	
Rossmore Anticline	
Dyke	

Paper Size A3

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Geology

Figure 3

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial Imagery: Dept of Lands, 2013. Topo Data: NSW LPI DTDB & DCDB 2012 Created by:mweber

3.4 Hydrogeological Conditions

PPK (1999) identified the presence of two main aquifer systems, namely:

- an unconfined aquifer system located within the quaternary alluvium localised around the main creeks draining the site; and
- a confined regional aquifer intersected at depths of approximately 20 m below ground surface that intersects the Bringelly Shale.

Groundwater elevations in the weathered shales were interpreted by PPK (1999) to be intermittent and not to support a significant aquifer system.

A regional aquifer is interpreted to be present within the Hawkesbury Sandstone which underlies the site at depths of greater than 100 m below ground surface. NSW registered groundwater information (see Section 3.9) suggests that this aquifer is used for water supply purposes.

Geological, water strike information and groundwater elevation data suggested that these aquifers had limited hydraulic connection at the time of the PPK study.

3.4.1 Aquifer Parameters

PPK (1999) undertook hydraulic testing of 14 wells. The results suggest that the alluvial and shale aquifers were of low hydraulic conductivity. A summary of the mean values reported for each aquifer system is provided below:

- alluvial aquifer – 0.14 m/day;
- perched weathered clay/shale zone – 0.0027 m/day; and
- shale aquifer – 0.034 m/day.

The hydraulic conductivity data collected by PPK (1999) are presented in Appendix A.

PPK (1999) suggests that vertical hydraulic conductivities within the Bringelly Shale could be expected to be two to three orders of magnitude lower than horizontal hydraulic conductivities for the shales. The standing water elevations relative to well depth in the surrounding registered use bores (presented in Appendix B), suggests there is a strong downward head gradient, which supports the presence of very low vertical hydraulic conductivities.

Storage Parameters

Storage parameters are representative of the ability of an aquifer to store and release water. These parameters have a significant impact on how aquifers respond to rainfall events or to construction of infrastructure below the groundwater table. For example, where groundwater is intersected by construction works, the amount of water that will initially flow into an excavation will be from storage in the surrounding media. Once the storage in the surrounding media completely drains, the flow into an excavation will be controlled by the hydraulic conductivity properties of the aquifer.

Large responses to relatively small rainfall events usually coincide with smaller overall storage properties and are often indicative of fractured conditions.

There are two properties that dictate the amount of storage within an aquifer system and the amount of storage release from an aquifer system. These properties are:

- specific yield (S_y), which generally relates to unconfined aquifer conditions and which will be the primary parameters impacting flow into an excavation. Specific yield is generally equivalent to the effective porosity of an aquifer; and

- storativity (S), which represents the primary factor controlling storage release in confined aquifer systems. Storativity generally represents an ability of the aquifer to release water by expanding and contracting.

At present, specific data outlining these properties are scarce; as such literature values have been adapted to represent site conditions. Values for unconsolidated material have been adapted from Weight and Sonderegger (2001) and are presented in Table 1. For fractured bedrock, the open area associated with fractures represents the primary storage characteristic.

Table 1 – Expected Storage Parameters

Hydrogeological unit	Specific Yield (dimensionless)			Storativity (dimensionless)		
	Min	Pref.	Max	Min	Pref.	Max
Residual clay	0.01	0.06	0.18	0.00001	0.001	0.001
Bringelly Shale	0.001	0.01	0.1	0.00001	0.001	0.001

Source: Weight and Sonderegger (2001)

3.5 Groundwater Elevations

Groundwater elevations were observed in wells drilled across the site by Coffey International (1991) and PPK (1999). The groundwater elevation data for these observations are presented in Appendix A. Key observations regarding the groundwater levels are summarised below.

- The depth to the water table in the alluvial aquifer ranged between 0.7 and 4.7 metres below the measuring point.
- The depth to groundwater observed in the weathered shales ranged between 2.4 m and 4 m below the measuring point.
- The depth to groundwater in the Bringelly Shale aquifer ranged between 3.0 m below ground surface and 11.7 m below the measuring point.

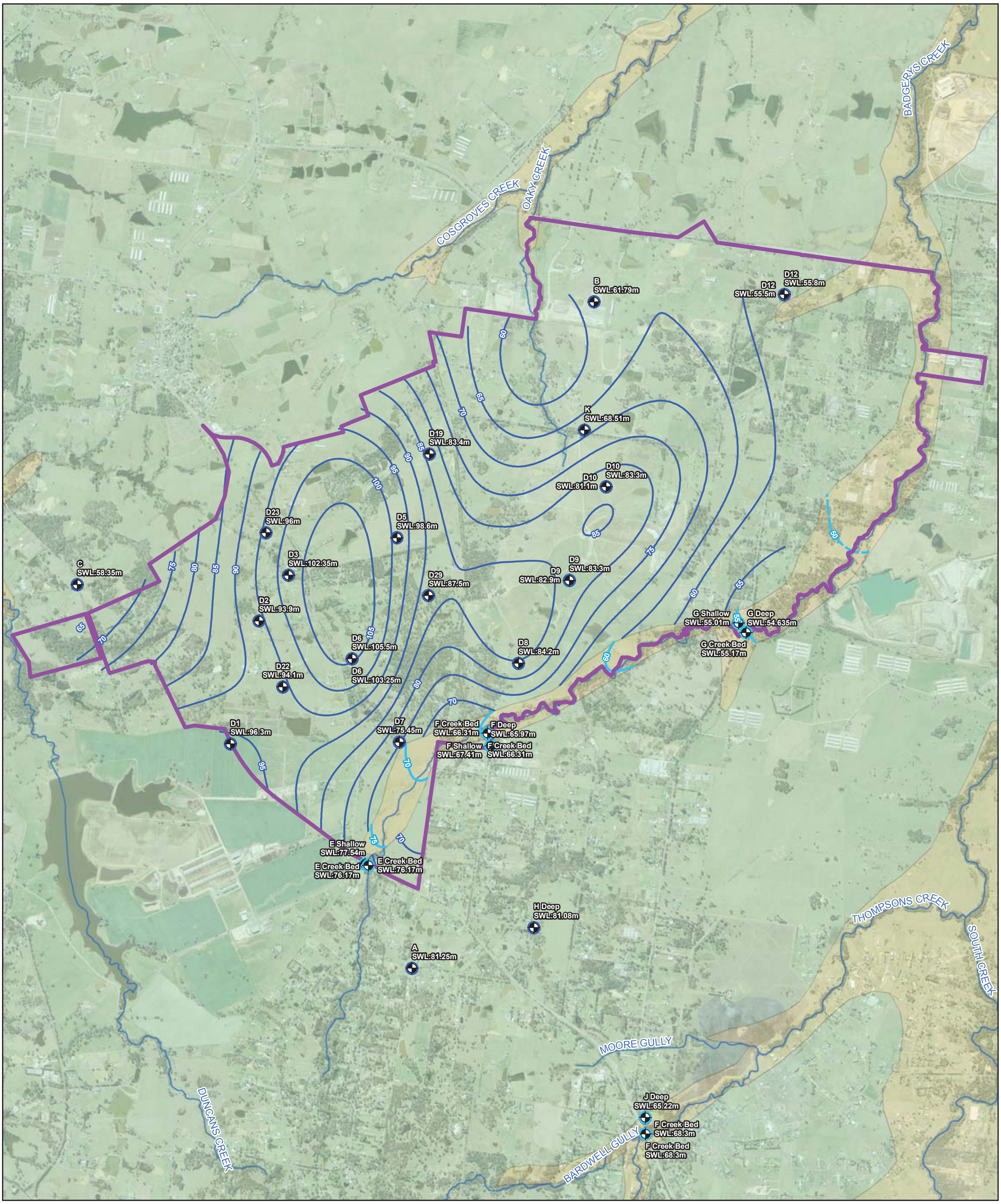
PPK (1999) noted that the water bearing zone for the Bringelly Shale aquifer was intersected at depths greater than 20 m below ground surface. The groundwater elevations in the shale aquifer were generally deeper than in the alluvial aquifer by between 0.4 m and 2.2 m where dual piezometers were installed along Badgerys Creek. This suggests that there is a limited hydraulic connection between the two aquifer systems and supports the presence of low vertical hydraulic conductivities in the Bringelly Shale aquifer.

The standing water elevations relative to well depth in the surrounding NSW registered groundwater bores (and presented in Appendix B), suggest that there is a strong downward head gradient between the Bringelly Shale aquifer and the underlying Hawkesbury sandstone aquifer. This suggests that there is very limited hydraulic connection between these two aquifer systems.

Figure 4 presents the interpolated groundwater contours using the data presented in Appendix B. The trends in the groundwater contour data presented in the figures are summarised below.

- The Luddenham Dyke tends to create a flow divide of elevated groundwater in the Bringelly Shale aquifer with flow east towards Badgerys Creek and west towards Duncans Creek. Badgerys Creek appears to be acting as a discharge point for the shale aquifer, although groundwater elevations for the shale aquifer appear to be between 0.3 m and 0.8 m below the creek bed when observed by PPK (1999). Groundwater elevations range from 105 m AHD near the Luddenham Dyke to 55 m AHD near to Badgerys Creek.
- Groundwater elevations in the alluvium suggest that the alluvial aquifer discharges to surface water features and flows in the same direction as the fall of the creeks to which they discharge. Groundwater elevations ranged between 55 m AHD and 75 m AHD in the alluvial aquifer along Badgerys Creek.

Regionally, the groundwater elevations suggest that the shallow groundwater systems at the site are bounded by discharge points to the west at Duncans Creek, to the south and east by Badgerys Creek, to the north and northwest by Cosgroves Creek and at the base by very low vertical permeabilities through the shales. There may be some groundwater flow offsite to the north; however, it is expected that this groundwater would eventually discharge to either Cosgroves Creek or Badgerys Creek before they intersect South Creek approximately 5 km to the northwest.



LEGEND

- Site Boundary
- Historical Groundwater Bores (Bringelly Shale)
- Historical Groundwater Bores (Alluvial)
- Major Watercourses
- Interpreted Groundwater Contours mADH (Alluvial)
- Extrapolated Groundwater Contours mADH (Alluvial)
- Interpreted Groundwater Contours mADH (Bringelly Shale)
- Quaternary Alluvium
- Bringelly Shale

Paper Size A3

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Groundwater Observations

Figure 4

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Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Aerial Imagery: Dept of Lands, 2013. Topo Data: NSW LPI DTDB & DCDB 2012 Created by:mweber

3.6 Settlement of Soft Sediments

As noted earlier, the alluvial aquifer and weathered shale derived clays are present across the site and are saturated in shallow depths in places. Any dewatering of these sediments has the potential to result in settlement of the ground surface.

3.7 Groundwater Recharge

The mean rainfall over the last 19 years for Bureau of Meteorology Weather Station 067108 located at Badgerys Creek and within the site boundary is 696.2 mm/yr. The maximum mean monthly rainfall is 108 mm for February and minimum mean monthly rainfall is 23 mm for July.

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Resources adopts an annual recharge rate of 6 per cent of annual rainfall for assessing available yields within these groundwater aquifer systems, which would be a groundwater recharge rate of 41.8 millimetres/year (mm/yr).

The CSIRO (Jolly et al, 2011) provides a range of methods for estimating likely recharge rates using scarce site data. This includes a method for estimating the recharge based on clay content in the top two metres of the soil profile. The clay content established from particle size distribution analysis of samples taken from test pits and bore holes completed across the site by Coffey & Partners International (1991). Ten samples from ten locations were used for this method, which estimated a recharge rate of between 0.3 mm/yr and 36 mm/yr with an average of 3.4 mm/yr. Given an average annual rainfall rate in this area of 696.2 mm/yr, these recharge rates represent a minimum of 0.04 per cent, an average of 0.5 per cent, and a maximum of 5.2 per cent of average annual rainfall.

Soil infiltration testing completed by PPK (1999) estimated maximum recharge rates of approximately 0.012 metres/day (m/day) for the clayey shale soils and 0.0057 m/day for the alluvium. This suggests that run-off would be generated from the shale-derived clay soils after a rainfall event greater than 12 mm/day and from the alluvial soils at a rainfall rate greater than 5.7 mm/day. The infiltration testing results also support the presence of very low overall groundwater recharge conditions.

There are a number of farm dams currently present at the site that have the potential to act as a point of recharge across the site. Based on the salinity of groundwater across the site (see Section 3.8.3), it does not appear recharge from these systems is having a significant impact on regional groundwater within the clay and shales. For example if significant freshwater recharge was occurring, shallow groundwater in the Bringelly Shale and overlying weathered clays would be expected to have lower salinity than currently observed.

3.8 Water Quality

Surface water and groundwater sampling was undertaken during the previous EIS investigations for the purposes of characterising the baseline water quality conditions and environmental values. This section summarises the findings of those surface water and groundwater quality investigations.

3.8.1 Basis of Water Quality Assessment

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC guidelines) provide a management framework, guideline water quality triggers, and protocols and strategies to assist water resource managers in assessing and maintaining aquatic ecosystems.

To characterise the overall water quality, the data reported for the site were compared against the ANZECC (2000) freshwater criteria, irrigation criteria, stock water criteria and recreational water use criteria. The surface water features in or near the site are located within rural catchments and as such are considered to be "slightly modified fresh water systems" (ANZECC, 2000). Based on this, a protection level of 95 per cent for freshwater ecosystems, as recommended in ANZECC (2000), was used to assess groundwater and surface water quality.

ANZECC (2000) also provides screening trigger values for southeast Australia NSW low land rivers (less than 150 m in altitude). The lowland rivers criterion has also been used in this assessment to further characterise overall water quality conditions.

The groundwater data were also compared against Australian Drinking Water Guideline values for human health and aesthetic values.

The adopted criteria are listed within the analytical results tables presented in Appendix C.

The data were collected between 1991 and 1999. The surface water sampling events were conducted over a range of climatic (wet and dry) conditions. While this sampling was conducted some time ago, the land use conditions do not appear to have changed significantly and the data are therefore expected to be representative of current water quality conditions. The sampling locations are presented in Figure 2. (surface water) and Figure 1 (groundwater).

3.8.2 Surface Water Quality Data

The data suggest that the surface water has background concentrations for cadmium, iron and zinc consistently above the selected ANZECC (2000) freshwater criteria. Chromium and copper also exceed ANZECC (2000) freshwater criteria on a regular but less frequent basis. This is generally consistent with the findings of additional water sampling undertaken for the biodiversity assessment (GHD, 2015, Section 4.4), although detections were apparent for nickel in recent sampling.

The iron concentrations are also generally above ANZECC (2000) irrigation threshold criteria.

There were no detectable concentrations of petroleum hydrocarbons. This is consistent with the findings of additional water sampling undertaken for the biodiversity assessment (GHD, 2015, Section 4.4).

Nitrate, total nitrogen and phosphorus were regularly above ANZECC (2000) freshwater criteria or general lowland river characteristics. Phosphorus also exceeds long term irrigation criteria. This is expected to be reflective of a catchment that has been disturbed by agricultural and other rural development. This is consistent with the findings of additional water sampling undertaken for the biodiversity assessment (GHD, 2015, Section 4.4).

Electrical conductivity (EC) values ranged between 645 μS/cm and 9,550 μS/cm. When these values are compared to the salinity criteria for lowland rivers of 125 to 2200 μS/cm (ANZECC, 2000), it is apparent that the concentrations generally exceed the range. This is expected to be due to the influence of the surrounding shale geology that has interstitial connate seawater that discharges into surface water features via groundwater. Based on this, locations with higher concentrations such as Thompsons Creek would be expected to have relatively higher interaction with groundwater discharge (see the discussion on groundwater quality below). The findings are consistent with the recent water quality sampling results presented in the biodiversity assessment (GHD, 2015, Section 4.4).

3.8.3 Groundwater Quality Data

The data suggest that the groundwater water quality has background concentrations of lead, zinc and copper consistently above the selected ANZECC (2000) freshwater criteria. Total nitrogen and phosphorus concentrations were all above freshwater criteria for lowland rivers with some exceedances of the irrigation criteria. Isolated samples had concentrations of nitrate above ANZECC (2000) freshwater criteria. Concentrations of sulphate above human health drinking criteria are present at a number of locations across the site.

Recreational water quality criteria and aesthetic human health criteria were generally exceeded by more than an order of magnitude for chloride and sodium.

EC ranged between 1,350 µS/cm and 40,800 µS/cm with average and median concentrations being 21,474 µS/cm and 25,100 µS/cm, respectively. These values are predominantly much higher than the salinity criteria for lowland rivers of 125 to 2200 µS/cm.

A comparison of the EC results for groundwater with the surface water results (as noted in the previous section) indicates that groundwater salinity concentrations are generally an order of magnitude higher on average than surface water concentrations. This suggests that the overall contribution of groundwater to surface water inputs is small.

The high EC values also support a low groundwater flow environment, which also supports the assumption of low rainfall recharge to groundwater.

When the total dissolved solids (TDS) values are converted to TDS using the criteria listed in ANZECC (2000) (21,474 µS/cm EC converts to 14,387 mg/L TDS and 25,100 µS/cm converts to 16,817 mg/L TDS) and compared against stock usage criteria presented in ANZECC (2000), the groundwater can be categorised as being unsuitable for watering all stock types.

The converted TDS data are generally more than an order of magnitude above the "unacceptable" criteria (<1,200 mg/L) for TDS in the Australian Drinking Water Guidelines (ADWG, 2011).

Based on this data, it is concluded that:

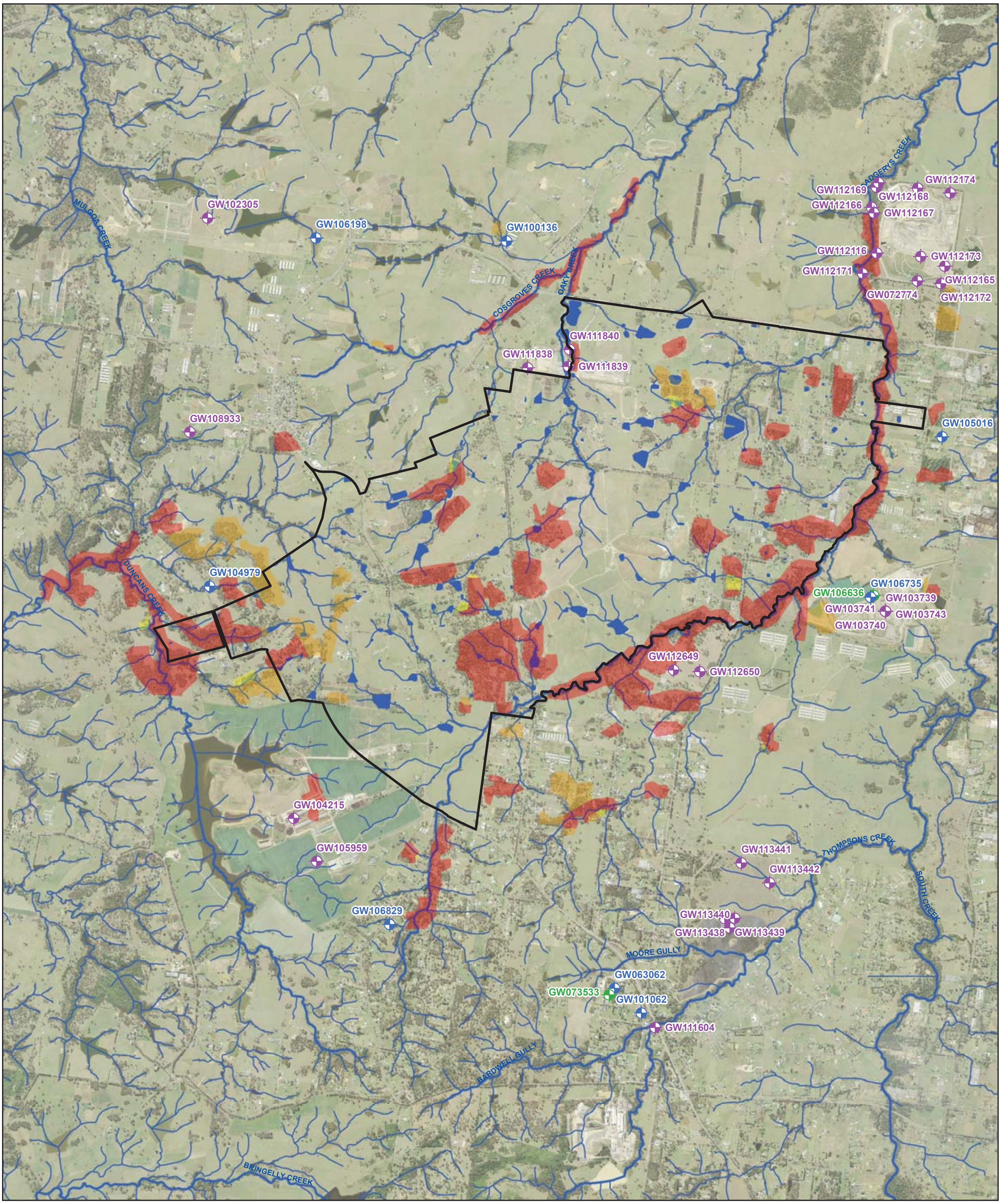
- the groundwater in this area has low beneficial use potential for stock and potable purposes;
- the groundwater contributions to surface water are expected to represent a small part of the overall surface water flows in the area; and
- in terms of groundwater management during construction and operation of the proposed airport, salinity, metals (particularly cadmium, copper, lead and zinc), sulphate, total nitrogen and phosphorus may require further consideration if discharge to surface water is being considered.

3.9 Registered Groundwater Bores

There are in excess of 42 registered groundwater bores within five kilometres of the site centre, which are presented on Figure 5.

Details of the bores are provided in Appendix B. Overall, the available data suggest that groundwater is sparsely used, with only 12 bores for domestic, stock, industrial, farming and irrigation purposes. It is noted that all of these bores are generally screened at significant depth and are expected predominantly to intersect the underlying Hawkesbury Sandstone.

This information suggests that only deeper groundwater in the Hawkesbury Sandstone is suitable for the uses outlined above and that shallow groundwater in the Bringelly Shale is unsuitable for beneficial domestic, stock, irrigation and industrial water use purposes.



LEGEND

- Site Boundary
- Major Watercourses
- Dams (within site boundary)
- Tributaries
- Active Water Supply Wells
- Potentially Active Water Supply Wells
- Wells Not Used For Water Supply
- Vegetation with high groundwater dependence proximal to site
- Vegetation with moderate groundwater dependence proximal to site
- Vegetation with low groundwater dependence proximal to site

Paper Size A3
0 125 250 500 750 1,000
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

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Revision	A
Date	14 Jul 2015

Groundwater Receptors

Figure 5

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial Imagery: Dept of Lands, 2013. Topo Data: NSW LPI DTDB & DCDB 2012 Created by:mweber

3.10 Groundwater Dependent Ecosystems

Communities of potential groundwater dependent ecosystems are identified within the Australian Bureau of Meteorology (BoM) Groundwater Dependent Ecosystems (GDE) Atlas.

The airport site has been cleared extensively with the exception of stands of remnant and regrowth vegetation located predominantly along Badgerys Creek and the south western portion of the site. The remaining vegetation generally comprises Cumberland Plain Woodland and River-flat Forest. These stands of vegetation broadly correlate with the areas identified as potentially groundwater dependent ecosystems shown on Figure 5.

Thompsons Creek and South Creek located in the catchment downstream from the airport site have been identified as reliant on the surface expression of groundwater. However, no creeks within or immediately adjoining the airport site are listed as being reliant on the surface expression of groundwater (i.e. groundwater inflow). This information is supported by the electrical conductivity data (see Section 3.8), which suggests that groundwater inflow is a minor component of creek flow.

The water sharing plan for the greater metropolitan groundwater resources lists two high priority groundwater dependent ecosystem types (being wetlands and vegetation communities) within the Sydney central basin porous rock groundwater source. This includes Salt Pan Creek (wetland), Long Swamp (wetland), Longneck Lagoon (wetland), O'Hares Creek (wetland) and potentially Cumberland Plain Woodland (vegetation community). Other than Cumberland Plain Woodland, these features are located outside the catchments intersected by the airport site.

There are a number of surface water dams present across the site. These have been interpreted by site biodiversity investigations (GHD, 2015) to be 'artificial freshwater wetlands' of good condition. These features are expected to have been developed initially as farm dams to capture surface water run-off and are therefore primarily reliant on surface water inputs rather than groundwater. The low permeability clays in which these dams have been developed will limit the connection with surrounding groundwater.

3.11 Conceptual Model

Figure 6 presents an idealised hydrogeological conceptual model for the existing site and highlights the interactions between groundwater and potential systems reliant on groundwater based on the data presented in Section 3. Key findings of the conceptual model are described below.

- There are three groundwater systems potentially interacting with the project that are located within shallow alluvium, weathered clays (intermittent system only) and the underlying shale. The Hawkesbury Sandstone represents a fourth regional aquifer system, used for water supply purposes, located at depths of more than 100 m below ground surface and at the base of the Bringelly Shale.
- The aquifer systems have poor quality (very high TDS) and low yields (as indicated by low hydraulic conductivities), suggesting that overall there is very limited beneficial use potential for potable and stock use.
- Groundwater elevations generally range between less than 1 m and 12 m below ground surface across the site.
- The aquifer extents are interpreted to be at Duncans Creek, Cosgroves Creek and Badgerys Creek where the aquifers discharge and vertically by the presence of very low vertical hydraulic conductivities of the Bringelly Shales (as evident in vertical head gradients). There is minimal hydraulic connection with groundwater beyond these creeks

and with the Hawkesbury Sandstone aquifer underlying the shales (which is used for water supply).

- Groundwater at the site is interpreted to discharge to Duncans Creek, Cosgroves Creek and Badgerys Creek. However, based on water quality data (mainly EC differences between surface water and groundwater across the site) it is expected that the groundwater inputs are small compared to surface water run-off inputs. Previous field observations suggest that flow in the creeks is intermittent and not reliant on groundwater baseflow. Based on this, the overall reliance of surface water features on groundwater inflow is expected to be minor.
- There is potentially sensitive vegetation located along Badgerys Creek and Cosgroves Creek that is potentially reliant on subsurface groundwater. Groundwater in nested piezometers in these areas suggests that there is some hydraulic disconnection between the isolated alluvial aquifers (i.e. different groundwater elevations) over which the vegetation is generally located and the more regional shale aquifer systems. There also appears to be a downward hydraulic head gradient, with the alluvial aquifer leaking to, rather than relying on, water from the shale aquifer system. This suggests that any disturbance of the more regional shale aquifer system during construction and operation would have only a minor impact on the alluvial aquifer system and the groundwater reliant vegetation in these areas. Vegetation located away from the alluvial aquifer is likely to be primarily reliant on rainfall.
- The inherent hydrogeological and geochemical conditions suggest that the existing groundwater environment has limited environmental value and that there will be a low risk of adverse impact to the groundwater environment from the proposed airport development.

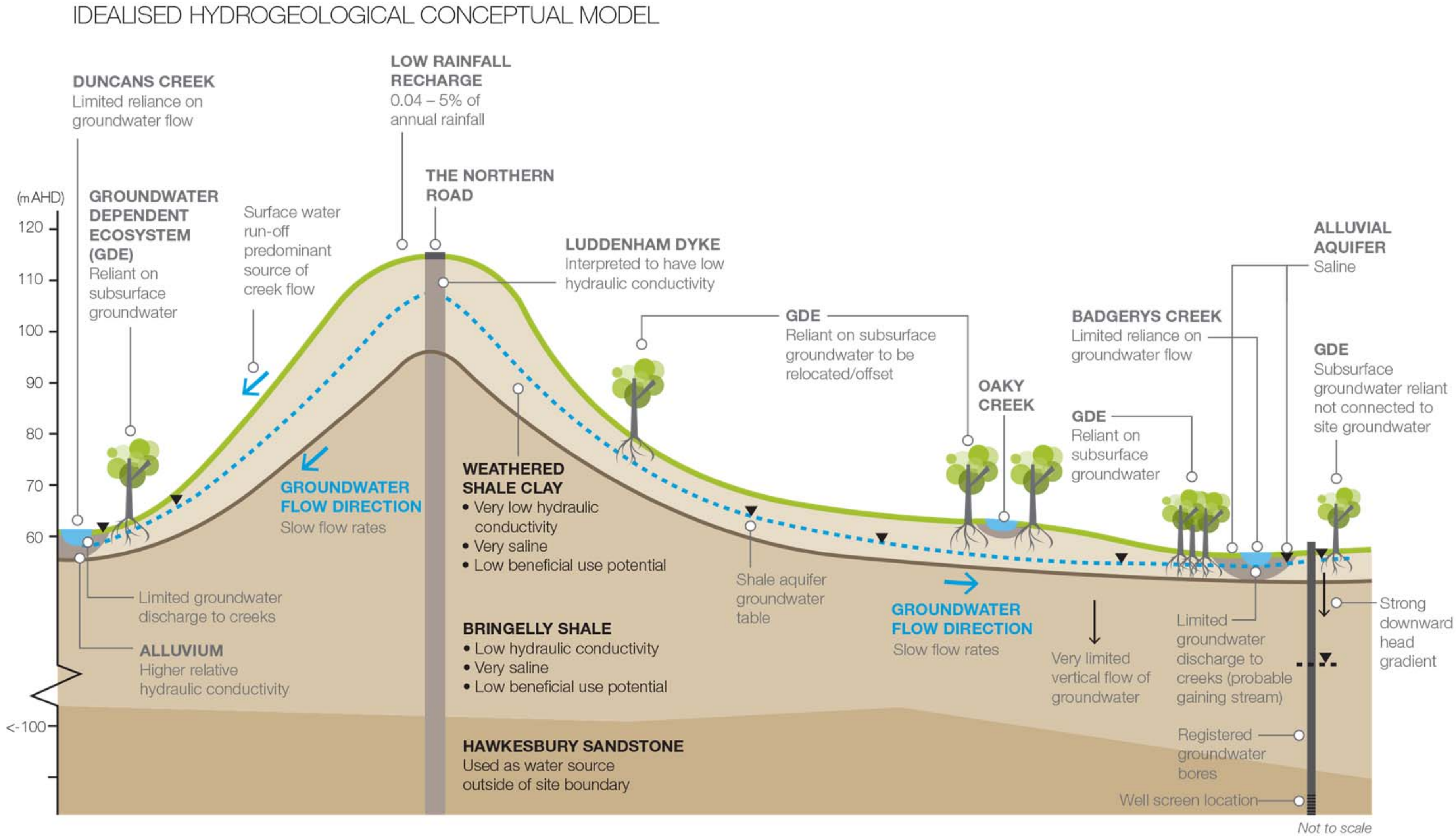

Figure 6 – Conceptual Hydrogeological Model

4. Assessment of Impacts

4.1 Introduction

The aim of this assessment is to consider the potential for development of the proposed Western Sydney Airport to alter the existing groundwater conditions at the site and associated risks to the range of beneficial uses or values of the receiving environment identified in Section 3.

The impact assessment includes a discussion of the key project features/sources that could affect groundwater conditions. These include:

- changes in groundwater recharge;
- groundwater drawdown from subsurface infrastructure and cuttings intersecting the groundwater table; and
- groundwater quality risks.

These sources of impacts have been assessed relative to the surrounding sensitive environmental features/systems identified in Section 3.

The risk/impact to groundwater resources would differ significantly between construction and operation and therefore each of these sources of impact are discussed separately.

The proposed airport would be developed in stages based upon aviation demand. The initial airport development would include a single 3,700 metre runway on a north-east/south-west orientation and aviation support facilities to provide an operational capacity of approximately 10 million annual passengers. The airport may subsequently expand to include two parallel runways and supporting facilities to achieve a capacity of approximately 82 million annual passengers. For the purposes of this assessment, potential impacts associated with the initial and longer term development have been considered together because the potential groundwater impacts are broadly similar and the mitigation and monitoring measures can also be applied to both stages of development.

4.2 Groundwater Recharge

4.2.1 Sources of Recharge Reduction

Construction

A conceptual outline of construction based on the current understanding of construction activities is presented in Figure 7. The key aspects of the airport construction that may limit recharge are listed below.

- The construction of access roads, tracks and the isolation of areas for the stockpiling of construction materials (i.e. the laydown and maintenance areas) could alter groundwater recharge conditions. Compaction of shallow soils associated with construction works in areas of unconsolidated alluvial sediments may also result in reduced groundwater recharge.
- Re-profiling of the land surface would alter the hydraulic properties of the environment as excavated material used for fill is expected to have higher overall permeability and porosity. This may lead to a temporary increase in the potential for rainfall recharge during the bulk earthworks phase of the development.

- As construction progresses, there would be an increasing amount of paved concrete surface and site facilities that would reduce recharge below existing conditions.
- Sedimentation basins may also act as a source of recharge, although the natural clays and shales in this area currently limit recharge. Any additional sediment basins would be constructed by similar methods, limiting the recharge that would occur.
- All existing farm dams would ultimately be removed, which subsequently would eliminate any potential recharge from these sources. The present recharge from these sources is expected to be small.

Overall, minimal change to local groundwater recharge would be expected as the existing shale derived clay soils have low permeability resulting in the majority of rainfall falling at the site being released as stormwater run-off rather than infiltrating to groundwater. It is not expected that existing farm dams at the site contribute a large amount to groundwater and the removal of these during construction would likely have a negligible effect on groundwater recharge.

Operation

A conceptual outline of operation based on the current understanding of proposed construction activities is presented in Figure 8. During operation, the primary cause of recharge reduction would be sealed areas. The estimated sealed areas that would be taken up by the Stage 1 and longer term developments are summarised as follows:

- Stage 1 development – 345 Ha of the total site area of 1,775 Ha (i.e.19 per cent of the total site area); and
- Longer term development – 1,008 Ha of a total site area of 1,775 Ha (i.e. 57 per cent of the total site area).

It is understood that there would be a swale system put in place to receive tarmac run-off and direct water to bio-retention basins. In areas of exposed shales and existing residual clays, there would be limited migration to the underlying groundwater systems, similar to the limited migration to groundwater systems from the existing farm dams on the site. In re-profiled areas that have been infilled, the swales would be clay lined to prevent infiltration to groundwater and hence the potential generation of groundwater quality impacts.

The surface water collected from buildings and other site facilities would be directed into a surface water collection system that includes clay lined swales and a number of bio-retention basins. It is expected that the bio-retention basins would also be lined and that recharge from these systems would be minimal.

Based on the sealed areas for the Stage 1 and longer term Development outlined above, it can be expected that the net reduction in recharge will approximate:

- 19 per cent of existing conditions for the Stage 1 Development; and
- 57 per cent of existing conditions for the longer term development (this is inclusive of the Stage 1 project).

As noted in Section 3, the underlying shale aquifer is of negligible beneficial use and this reduction is not expected to result in substantive impacts to resource volumes. Additionally, impacts to groundwater bores are expected to be negligible as there are no bores located within the saline shale aquifer underlying the site.

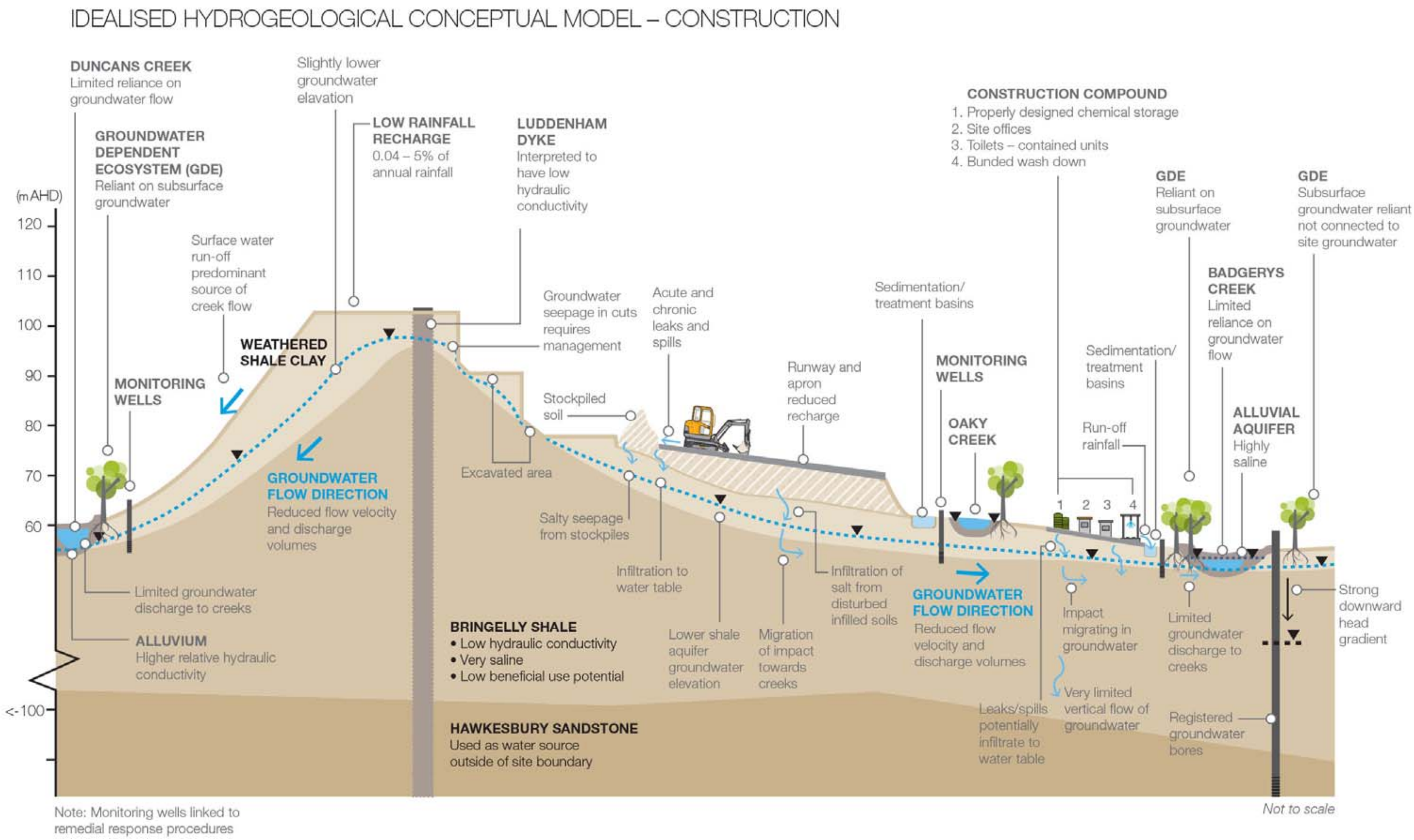

Figure 7 – Conceptualisation of Construction Interactions with Groundwater

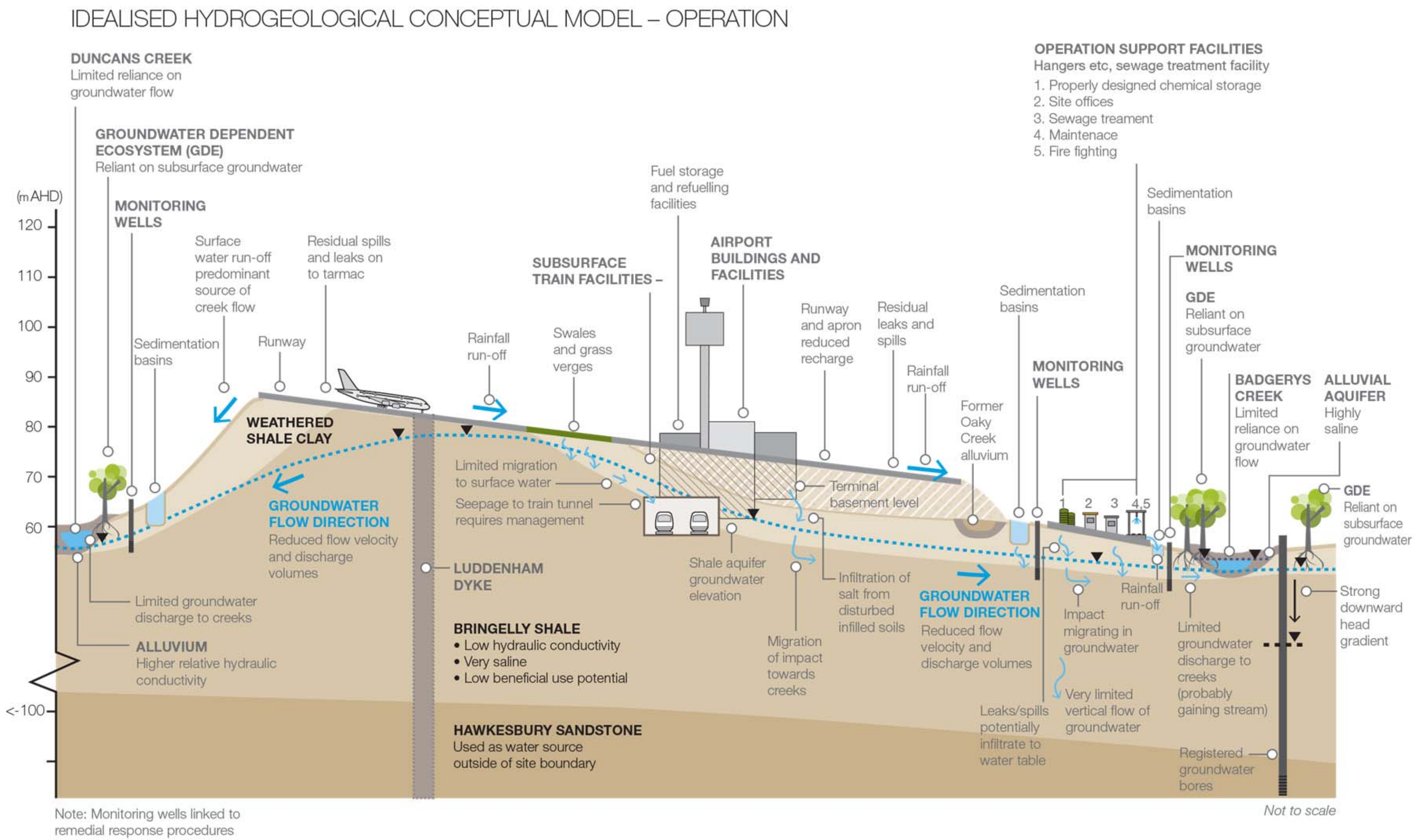

Figure 8 – Conceptualisation of Operational Interactions with Groundwater

4.2.2 Impacts of Recharge Reduction

Artificial wetlands in farm dams are not expected to be in hydraulic connection with groundwater and as such impacts are expected to be negligible. The majority of these features would also be removed as development progresses.

Changes in groundwater elevations from re-profiling the airport site and from reduced recharge beneath paved areas may have a minor impact on vegetation located along the riparian zones of the surface water systems. The impacts to these systems are expected to be minor for the reasons outlined below.

- Groundwater in the alluvial aquifer systems appear to have limited contact with groundwater in the shale aquifers impacted by site works. Historical data also suggest that the alluvial aquifer systems do not rely on the shale aquifer for water supply.
- Rainfall recharge in the alluvial aquifer areas is not expected to change as these areas would not be impacted by site works and changing land use.
- Site works would not result in a significant lowering of surface elevations such that alluvium and the shale aquifers would be drained. There may be a reduction in groundwater flow rates; however the overall changes in level would be expected to be small.
- There would be localised impacts around excavations for the rail connection. This is not however expected to result in significant dewatering of riparian areas. Additional modelling at detailed design may be required to confirm this conclusion.

Changes in groundwater levels may result in a small reduction in discharge to surface water features. The impacts to these systems are expected to be minor for the following reasons.

- Historical water quality data and hydrogeological data (hydraulic testing data) suggest overall groundwater inputs to surface water are small (for example there is a significant difference between the TDS of surface water and the TDS of groundwater aquifers). Therefore the overall recharge reductions of between 19 per cent and 57 per cent are not expected to create adverse impacts. Further, groundwater across the site is highly saline and a small reduction in flows may actually reduce salt loads to surface water features and improve overall water quality.
- While recharge to groundwater might change, it is unlikely that groundwater elevations at discharge points would fall significantly (as they would still be a point of discharge). As such, it is not expected that stagnant pools present in surface waters during dry periods would be prone to drying up as a result of the proposed development.

While the impacts are expected to be minor, a monitoring regime should be implemented. This monitoring would be able to identify and characterise any emergent impacts outside of those expected and would make links to necessary response procedures.

There is a potential risk for settlement of soft sediments associated with reduced rainfall recharge beneath the proposed airport, and dewatering around areas of subsurface infrastructure and up-gradient of cuttings where seepage is occurring. Existing groundwater data suggest that aquifers in residual clay and weathered shales are intermittent and perched and as such, the potential for settlement is expected to be low. The potential for settlement in re-profiled material is being assessed as part of ongoing geotechnical investigations. The design phase should consider potential impacts of further dewatering of soft sediments to characterise the level of risk involved in the process.

4.3 Groundwater Drawdown

4.3.1 Sources of Groundwater Drawdown

Construction

Extensive re-profiling of the site would be undertaken to create a flatter surface for the development of the proposed runway and associated facilities. The works would include excavating areas of higher topography and using the material to infill areas of lower topography. This would result in an expected elevation at the south western end of the northern runway of approximately 93 m AHD and an expected elevation at the north eastern end of the runway of 73 m AHD. These elevations will be higher than the surrounding creeks.

The re-profiling would result in a decrease in groundwater elevations in areas that currently have higher topographical elevation. This is expected to result in reduced groundwater flow rates and hence reduced discharge to surrounding surface features. The re-profiling would not result in dewatering of the groundwater system below the level of the surrounding creeks and there would be no potential for drying up of the creeks.

Establishment of basements in the terminal complex and creation of a station cavern for a future rail connection during the initial construction would likely intercept the underlying shale aquifers and require dewatering and management throughout construction.

Due to low inherent hydraulic conductivities of the geology in these areas, it can be expected that seepage volumes would be relatively small.

The installation of services would generally be shallow and would only intersect very shallow groundwater if at all.

The peripheral sections of the re-profiled area would likely have exposed cuttings that would seep and reduce groundwater levels in the elevated areas around the cuttings.

Operation

The same sources of impact present during construction would be present during operation. Nevertheless, the manifestation of seepage would be different as the construction excavations would be replaced by infrastructure that would change seepage conditions. For example, subsurface infrastructure wall linings could be designed to limit seepage.

4.3.2 Groundwater Drawdown Impacts

Groundwater drawdown and flow risks to surrounding groundwater users and artificial wetlands would be negligible as there would be no hydraulic connection between these features and any subsurface infrastructure.

Due to the hydrogeological conditions, there is expected to be minor potential for impacts to groundwater elevations beneath vegetation along creek riparian zones and for reduction in discharge into creeks. It is recommended that additional modelling should be completed at the detailed design phase to confirm any drawdown impacts, when the nature and design of subsurface structures intersecting groundwater is understood.

There are a number of methods available for reducing seepage and drawdown impacts that could be adopted which include the installation of temporary linings (such as sheet-piling and shotcreting excavations) during construction and permanent linings or grouting during operation.

As drawdown impacts are expected to be minor, a groundwater monitoring programme at potential sensitive receptors (such as creeks with riparian vegetation) is considered to be sufficient to assess for the emergence of any impacts.

4.4 Groundwater Quality

4.4.1 Sources of Groundwater Quality Impact

Construction

Potential groundwater quality risks include isolated spills and incidents occurring during construction and diffuse impacts associated with general construction activities such as use of machinery. Contaminants of primary concern are usually hydrocarbons, however other chemicals such as herbicides, pesticides and fertiliser may also be used during construction. Impact is likely to occur through the infiltration of pollutants into the ground surface or through dirty water retention facilities (such as temporary sediment basins) to the underlying groundwater systems.

Groundwater seepage into excavations for building basements or station cavities would need to be managed by pumping any seepage to stormwater management facilities and/or other suitable treatment systems. Given the background groundwater quality data and the expected chemicals that would be used during construction, the following primary chemicals of concern have been identified:

- pH;
- Total dissolved solids (TDS);
- Metals;
- Total nitrogen;
- Phosphorus;
- Sulphate;
- Petroleum hydrocarbons; and
- Polynuclear aromatic hydrocarbons.

There would be small seeps from cuttings that would also require appropriate management prior to discharge offsite.

Sewage generated during construction would be contained in storage facilitates and removed offsite by an appropriately licensed waste contractor.

Groundwater present in the shallow geology has been identified to have high salinity values. The excavation and use of this material for infilling could permit the release of additional salts into groundwater. This would only occur where increased recharge occurs to fill areas and where a shallow groundwater table develops in the fill material.

Operation

It is expected that the stormwater management system would include a mixture of stormwater drains that would re-direct surface water from the proposed aviation and commercial development areas to the stormwater capture systems, swales and site bio-retention basins.

All chemicals located on-site would be handled and stored in accordance with appropriate standards and would include appropriate bunding, spill management capacity and emergency response systems and procedures.

Run-off from sealed surfaces could potentially contain pollutants associated with normal site activities, acute and diffuse leaks and spills, and accidents from aircraft support vehicles and aircraft.

The surface water system implemented to capture and treat surface water could potentially act as a diffuse source of groundwater quality impacts. The stormwater treatment systems (treatment/bio-retention basins) would be designed to prevent leakage and infiltration to groundwater. This would include the lining of swales where they intersect higher permeability re-profiled material rather than the lower permeability clays and shales that currently exist.

Based on the current understanding of aquifer properties and likely groundwater migration rates, it is expected that any potential impacts would emerge slowly as any groundwater impacted by site activities migrates down the hydraulic gradient.

The primary chemicals of concern associated with site activities are expected to arise from metals and petroleum hydrocarbons (including poly aromatic hydrocarbons). There would also be a risk from fire retardants and other chemicals associated with managing accidents and spills, and solvents used in maintenance facilities.

The potential future subsurface rail connection is anticipated to intersect groundwater. In the instance of a free draining rail alignment, seepage would require collection and management before discharge to any receiving environment.

4.4.2 Groundwater Quality Impacts

As the underlying aquifer system is of low beneficial use, adverse impacts may only potentially emerge when impacted groundwater migrates beneath areas of groundwater reliant vegetation (located in creek riparian areas) and/or discharges into creeks.

Impacts to surrounding registered water bores would be negligible as they are expected to be hydraulically separated from the site by the saline, low hydraulic conductivity shale aquifer.

Groundwater flow velocities are expected to be slow and as such the emergence of any impacts would be slow. A groundwater monitoring approach is considered to be suitable to manage the identification of groundwater quality impacts.

Site management procedures and the operational design of the proposed airport would further limit the potential for groundwater quality impacts and are discussed below with regard to construction and operation.

Construction

The risk posed by construction activities would be low due to stringent management measures imposed during construction as part of a construction environmental management plan (CEMP) that would be developed in accordance with Australian Standards. The CEMP would include methods and procedures for:

- separating clean and dirty water and preventing infiltration of impacted surface water into the underlying groundwater system;
- preventing groundwater seepage from contacting potentially contaminating site activities by minimising ponding of water in active areas and making storage facilities impermeable;
- adequately storing and handling site chemicals;
- identifying and responding to chemical spills and managing their clean-up; and
- monitoring for the emergence of diffuse water quality impacts with subsequent response procedures to remediate any impact.

Proposed monitoring procedures are outlined further in Section 5.

Groundwater seepage would be either transported away from active construction areas and discharged back to the environment and/or removed/discharged offsite to an appropriately licensed treatment facility. While seepage volumes to the subsurface rail corridor, caverns, and at cuttings are expected to be small, seepage minimisation methods may also be adopted to either eliminate or minimise the amount of groundwater seepage generated. These methods could include:

- installing temporary walls (such as shotcrete liners or sheet piling) during construction behind the progressing work area (at cuttings and in any building basements or sub-surface rail corridor); and
- installing liners (if selected) as soon as possible behind the working face.

Based on the water quality conditions discussed in Section 3.8, groundwater seepage into cuttings and the subsurface rail corridor would require some form of treatment (for total dissolved solids, sulphate, metals and nitrogen) before it could be discharged to surface water. The type of treatment system developed would be determined at the detailed design phase, but may include discharge to the surface water treatment system.

Operation

The detailed design and procedures at the proposed airport would facilitate efficient vehicular movements that would be controlled by regimented airport control systems. This would reduce the potential for accidents and also the potential of a spill of hazardous substances.

The system would be designed to minimise infiltration of contaminants to groundwater by redirecting any rainfall and run-off from the airport through a treatment system that would prevent connection to the underlying groundwater systems. The design would include drainage systems and storage systems that are impermeable or minimise leakage.

In the event that any spills did occur, the spill would be directed to surface water capture systems, which would have the capacity to receive a spill with a volume corresponding to that of the expected source. Any surface water capture systems installed would have potential for spillage control or containment. Maintenance areas where solvents are used would be within isolated areas with appropriate storage. Any waste generated would be managed and transported offsite to an appropriately licensed facility.

Surface water quality treatment measures would be implemented to provide capacity to treat first flush from pavement surfaces and reduce the risk of spills discharging onto adjacent land or watercourses. The potential for spillage control or containment would be based on the hydrologic conditions prevailing at the time of the spill. Structures would be designed to limit the potential for infiltration to the underlying groundwater system (i.e. they would be appropriately lined).

Groundwater seepage into cuts, the subsurface rail corridor and station caverns would be treated before being discharged back to the environment and/or removed/discharged offsite to an appropriately licensed treatment facility. Treatment may include discharge to the surface water treatment system if suitable; however, the design of the treatment system would be determined at the detailed design phase. Monitoring would be required to test the effectiveness of the treatment system implemented.

While seepage volumes in subsurface rail corridor areas, and particularly at cuttings, are expected to be small, seepage minimisation methods such as the adoption of impermeable liners may be considered at the detailed design phase.

4.5 Cumulative Impacts

Cumulative impacts to groundwater are expected to be localised to the low value shale aquifer systems beneath the site that discharges to surrounding surface water features.

There would be an ongoing risk to surface water quality from groundwater discharge that would require monitoring and management. If impacts emerge, response procedures would be implemented to mitigate the impacts.

Based on the above, it is considered that cumulative impacts can be effectively managed.

5. Mitigation and Management Measures

5.1 Construction

5.1.1 Groundwater Drawdown

Drawdown impacts are expected to be minor and any mitigation measures would be linked to groundwater elevation monitoring at key sites. If changes are found to be creating adverse impacts to either groundwater reliant vegetation or instream water availability, mitigation measures would be imposed to supplement groundwater supplies. Such measures may include the recharge of treated seepage water or other clean surface water derived on-site to key areas where issues have been identified. Given the low discharge nature of the aquifer systems in these areas, it is expected that required volumes could easily be obtained from surface water run-off supplies.

It is noted that the likelihood of occurrence of groundwater drawdown impacts is expected to be minimal and therefore a reactive approach based on monitoring is considered to be acceptable.

5.1.2 Water Quality

It is expected that the risk posed by construction activities would be low due to stringent management measures imposed during construction as part of the CEMP. The CEMP would include methods and procedures for:

- separating clean and dirty water and preventing infiltration of impacted surface water into the underlying groundwater system. Measures adopted should be in accordance with relevant NSW and Australian guidelines;
- preventing groundwater seepage from contacting potentially contaminating site activities by minimising ponding of water in active areas and making storage facilities impermeable;
- preventing impacted groundwater from entering the surface water management system unless it represents a credible treatment option;
- adequately storing and handling site chemicals;
- identifying and responding to chemical spills and managing their clean-up; and
- monitoring for the emergence of diffuse water quality impacts and implementing response procedures to remediate any impact.

5.2 Operation

5.2.1 Groundwater Drawdown

Drawdown impact mitigation would be the same as that presented for the construction phase.

5.2.2 Water Quality

The design and operation procedures at the proposed airport would facilitate efficient vehicular movements that would be controlled by regulated airport control systems. This would reduce the potential for accidents and spills at the airport including hazardous substances.

The system would be designed to minimise infiltration of contaminants to groundwater by redirecting any rainfall and run-off from the airport through a surface water system that would prevent connection to the underlying groundwater systems. The design would include drainage systems and storage systems that are impermeable or that minimise leakage.

In the event that any spills did occur, the spill would be directed to surface water capture systems, which would have the capacity to receive a spill with a volume corresponding to that of the expected source (e.g. an aircraft refuelling spill). Any surface water capture systems installed would have spillage control or containment systems. Maintenance areas where solvents are used and other facilities such as fire training areas would be within isolated bunded areas with appropriate storage. Any waste generated would be transported offsite to appropriately licensed facilities.

Surface water quality treatment measures would be implemented to provide capacity to treat first flush from pavement surfaces and reduce the risk of spills discharging onto adjacent land or watercourses. Spillage control or containment systems would be based on the hydrologic conditions prevailing at the time of the spill. Containment systems would be designed to limit the potential for infiltration to the underlying groundwater system (i.e. they would be appropriately lined).

There will be a residual risk of diffuse impacts from run-off from the proposed runway and apron areas being directed to and infiltrating through swale systems. The risk of groundwater quality impacts are expected to be low as the swales would collect water from areas that are away from more intensive site activities (which would have additional operational controls in place). As such, a monitoring approach is proposed for managing this risk with subsequent remedial investigations and clean-up responses linked to the emergence of groundwater quality impacts.

5.3 Monitoring

The proposed monitoring to assess impacts from construction and operation activities is presented below.

An airport lessee company would be required to undertake water quality monitoring in accordance with the Airports (Environmental Protection) Regulations 1997.

5.3.1 Groundwater Drawdown

Ongoing monitoring of the groundwater elevations on a quarterly basis should be undertaken to identify changes in groundwater elevations in and around areas near creeks and areas with groundwater dependent ecosystems.

Groundwater monitoring around areas of subsurface infrastructure and cuttings where seepage could occur would also be undertaken to characterise potential groundwater impacts.

Impacts would be considered to exist when groundwater elevation changes fall below expected root zones for sensitive vegetation and below seasonal variations near to creeks. This would instigate additional biodiversity investigations to assess the impact on biodiversity at these sensitive receptors.

Baseline monitoring is recommended for determining existing conditions on which the emergence of impacts could be identified.

Baseline and construction (including earthworks) monitoring would be essential for identifying conditions on which the emergence of impacts during operation could be identified. Quarterly monitoring would be undertaken and continue until such time that data suggest that any identified impacts stabilise or for a minimum period of:

- three years after completion of the Stage 1 Development; and
- three years after completion of the longer term development of the airport (i.e. construction of a potential second parallel runway and associated earthworks).

5.3.2 Water Quality Monitoring

The proposed locations for groundwater monitoring should focus on the early detection of impacts and the protection of sensitive environmental receptors. As such monitoring would occur:

- around and down-gradient of major infrastructure and at depths equivalent to the depth of construction and operation impacts. It is noted that the key sources of groundwater quality impacts would be different during construction and during operation and as such, the monitoring network would need to change also; and
- within areas of identified sensitive vegetation in creek riparian areas and around creeks.

Groundwater monitoring of both the alluvial aquifer and shale aquifers should be undertaken. Some monitoring of fill material should also be undertaken to assess the potential generation of a separate water table within the fill and intensified movement of salt.

Surface water quality monitoring would be down-gradient of key site works and focus on dry periods when groundwater seepage has greater potential to impact on instream conditions.

As the emergence of groundwater quality impacts is expected to be slow, a quarterly monitoring frequency is considered to be suitable. This may be expanded to yearly subject to the findings of a suitable period of preceding monitoring events.

It is expected that the analytical suite used for water quality monitoring would focus on key contaminants expected to be associated with construction activities and the surrounding land use and chemicals that are indicative of overall instream condition. As a minimum the analytical suite should include:

- total dissolved solids;
- suspended solids;
- pH;
- metals concentrations in groundwater for cadmium, iron, lead, nickel, manganese and zinc;
- chloride, sodium and sulphate;
- nitrogen and phosphorus;
- total recoverable hydrocarbons, BTEX and polycyclic aromatic hydrocarbons (PAHs);
- pesticides; and
- aqueous film forming foam substances (during operation only).

Water quality monitoring results exceeding background water quality criteria and/or ANZECC (2000) would instigate further investigations and/or the remediation requirements outlined in the CEMP during construction. During operation the method of response to exceedances would be detailed in a groundwater monitoring plan for the site.

The available surface water and groundwater quality data suggest that there may be potential impacts from discharging collected groundwater seepage back to surface water, and that treatment may be required prior to discharge.

Regardless of the method of treatment proposed, monitoring would be required of the treated water prior to disposal. The frequency for monitoring would depend on the treatment system. Based on the hydraulic properties of the geology in which the subsurface rail corridor is proposed to be located, groundwater seepage volumes are expected to be low. As such, treatment within the surface water management system, or transport off-site to an appropriately licensed treatment facility, may be feasible. This would be determined at the detailed design phase.

It is expected that the criteria to be used for determining the acceptability of water quality for discharge or for the characterisation of 'no impact' would be background groundwater and surface water quality data (using ANZECC 2000 statistical methods), and the ANZECC (2000) freshwater criteria for the protection of 95% of freshwater species.

6. Summary and Conclusions

6.1 Groundwater Flow and Drawdown

Registered Groundwater Bores

Registered groundwater bores are located off-site at significant depth in the Hawkesbury Sandstones that are hydraulically disconnected from the saline Bringelly Shale aquifer located beneath the site. As such, the impacts to registered groundwater bores are expected to be negligible during construction and operation of the proposed airport.

Groundwater Dependent Ecosystems

Impacts to artificial wetlands within the airport site are expected to be negligible as they are located in low permeability clays with limited groundwater interactions and have historically been developed as farm dams to capture surface water run-off.

There are vegetation stands that may be opportunistically reliant on subsurface groundwater. Stands of remnant and regrowth vegetation would be progressively cleared with the ongoing development of the airport site. However, sensitive vegetation would remain along the riparian corridors of Duncans, Oaky and Badgerys Creeks. This vegetation is expected to intersect alluvial deposits which historical data suggest has limited hydraulic connection to the shale aquifers potentially impacted by the establishment of the proposed airport. While there may be minor changes to groundwater flow within the shale aquifers, the overall groundwater fluctuation would be small and any drawdown impacts in areas of sensitive vegetation are expected to be minor.

Further, in riparian areas near to discharge points it can be expected that, while discharge rates would change, overall groundwater fluctuations would be small. Consequently, groundwater drawdown impacts in areas of sensitive vegetation are expected to be minor. There may be enhanced drawdown in localised areas where cuttings or building basements are present. Due to the hydraulic characteristics of the intersected geology, this impact is expected to be very localised. A groundwater monitoring regime would be required to characterise the emergence of these impacts.

It is expected that construction and development of the proposed airport would reduce rainfall recharge and hence reduce groundwater discharge to surrounding creek systems. Historical water quality data and the existing hydrogeological conditions suggest that groundwater discharge forms a very low component of creek flow. This implies that the overall reliance on groundwater discharge is low and that groundwater discharge changes would have minor impacts.

During no-flow periods stagnant pool levels may be linked to surrounding groundwater elevations. While the construction of the proposed airport may reduce overall groundwater discharge rates, it is not expected that groundwater elevations would change significantly at discharge points, such that stagnant pools will drain. Because of this, it is expected that impacts would be negligible.

6.2 Groundwater Quality

Construction

There would be an inherent risk to groundwater quality associated with site activities during construction. The key sources of potential impact would be:

- acute and diffuse spill and leaks from site activities;
- diffuse leakage from site water treatment systems such as sediment dams;
- preferential leakage of salts from the disturbed shale derived material used as fill for re-profiling, although this is not expected to pose a significant additional risk given that groundwater is already very saline; and
- discharge of seepage water into excavations (such as the sub-surface rail corridor), cuttings and surface water if not treated suitably.

The underlying aquifer system is of low beneficial use potential and localised impacts within the aquifers are not expected to represent a potential adverse impact. There is a risk presented by the migration of impact within the saline aquifer beneath shallow sensitive vegetation located along creek riparian areas with discharge to creeks and artificial wetlands in farm dams. The risks are expected to be minor for the following reasons.

- The hydraulic connection between artificial wetlands and underlying groundwater is expected to be limited by low hydraulic conductivity of surficial materials. Historically the farm dams (in which the artificial wetlands are located) have been designed to intercept surface water rather than the saline groundwater.
- The alluvial aquifer systems in the riparian areas of creeks appear to have some hydraulic separation from the underlying shale aquifer (sometimes with higher groundwater elevations). As such, water quality impacts to the alluvial aquifers (on which riparian vegetation may rely) are expected to be minimal.
- Existing water quality data and hydrogeological conditions (low hydraulic conductivity and groundwater flow rates) suggest that overall groundwater discharge comprises a small component of creek flow and therefore instream water quality.

Despite the low risk, a residual risk is present and the construction and operation phases of the proposed airport development would include a number of features to further reduce the potential for impacts. These measures are summarised below in Section 5.1.

Any seepage water generated would need to be treated and managed before discharge to surface water. Recommended mitigation and monitoring measures are outlined Sections 5.1 and 5.3 of this report.

Operation

While the sources of groundwater quality impacts would be slightly different to those present during construction, the overall migration pathways and risk to sensitive receptors would be similar. As noted for construction, there will always be an inherent risk (albeit very low) to water quality at surrounding surface water features and sensitive groundwater reliant vegetation. Recommended mitigation and monitoring measures are outlined in Sections 5.2 and 5.3 of this report.

6.3 Conclusions

The groundwater assessment suggests that the inherent hydrogeological conditions result in a low risk of adverse groundwater impacts from construction and operation of the proposed airport.

There would be minor residual risks present which could be effectively managed using standard onsite procedural controls, engineered solutions and monitoring techniques.

Mitigation and monitoring measures have been recommended to address the identified issues and potential emergent issues that might arise during the construction and development stages of the proposed airport.

Appendices

Appendix A – Site Groundwater Monitoring Well Data

Table A–1 – Site Groundwater Monitoring Well Data

Well ID	Easting	Northing	Easting	Northing	Consultant	RL (m AHD)	Date of installation	Well depth (m bmp)	Screen Top (m bmp)	Screen Bottom (m bmp)	Water elevation (m bmp)	Water elevation (m AHD)	Date of GWL observation	Interpreted Aquifer	Hydraulic conductivity (m/day)
D1	271752.1	1246954	286840	6245879	Coffey	104.2	5/07/1990	15.20			7.9	96.3	18/07/1990	Bringelly Shale	
D2	271995.5	1247904	287065	6246834	Coffey	97.6	4/07/1990	9.85			3.7	93.9	18/07/1990	Bringelly Shale	
D3	272232.7	1248255	287295	6247189	Coffey	105.7	27/06/1990	10.00			3.35	102.35	18/07/1990	Bringelly Shale	
D4	272063	1248870	287114	6247801	Coffey	98.8	5/07/1990	15.10			2.98	95.82	18/07/1990	Shallow unconsolidated/ Bringelly Shale	
D5	273082.2	1248529	288139	6247480	Coffey	102.5	9/07/1990	20.15			3.9	98.6	18/07/1990	Bringelly Shale	
D6	272714.5	1247595	287790	6246539	Coffey	112.9	2/07/1990	25.10			7.4	105.5	18/07/1990	Bringelly Shale	
D6	272714.5	1247595	287790	6246539	Coffey	112.9	2/07/1990	25.10			9.65	103.25	28/08/1990	Bringelly Shale	
D7	273069.5	1246943	288158	6245894	Coffey	79.4	6/07/1990	10.35			3.95	75.45	18/07/1990	Bringelly Shale	
D8	274012.3	1247535	289089	6246504	Coffey	92.1	27/06/1990	10.05			7.9	84.2	14/09/1990	Bringelly Shale	
D9	274422	1248172	289486	6247149	Coffey	87.5	26/06/1990	10.25			4.2	83.3	18/07/1990	Bringelly Shale	
D9	274422	1248172	289486	6247149	Coffey	87.5	26/06/1990	10.25			4.6	82.9	14/09/1990	Bringelly Shale	
D10	274722	1248891	289772	6247874	Coffey	88	10/07/1990	10.00			4.7	83.3	18/07/1990	Bringelly Shale	
D10	274722	1248891	289772	6247874	Coffey	88	10/07/1990	10.00			6.9	81.1	14/09/1990	Bringelly Shale	
D11	274432.2	1249505	289470	6248482	Coffey	74.1	25/06/1990	10.05			4	70.1	14/09/1990	Shallow unconsolidated/ Bringelly Shale	
D12	276140.9	1250354	291163	6249365	Coffey	59	24/06/1990	10.50			3.2	55.8	18/07/1990	Bringelly Shale	
D12	276140.9	1250354	291163	6249365	Coffey	59	24/06/1990	10.50			3.5	55.5	18/07/1990	Bringelly Shale	
D13	275667.4	1248896	290718	6247897	Coffey	73.5	24/06/1990	10.35			3	70.5	18/07/1990	Shallow unconsolidated/ Bringelly Shale	

Well ID	Easting	Northing	Easting	Northing	Consultant	RL (m AHD)	Date of installation	Well depth (m bmp)	Screen Top (m bmp)	Screen Bottom (m bmp)	Water elevation (m bmp)	Water elevation (m AHD)	Date of GWL observation	Interpreted Aquifer	Hydraulic conductivity (m/day)
D13	275667.4	1248896	290718	6247897	Coffey	73.5	24/06/1990	10.35			3.05	70.45	14/09/1990	Shallow unconsolidated/ Bringelly Shale	
D14	277093.4	1249619	292129	6248648	Coffey	55.2	21/08/1990	10.10			3.8	51.4	-	Shallow unconsolidated/ Bringelly Shale	
D19	273350.7	1249173	288395	6248129	Coffey	88.9	14/08/1990	15.00			5.5	83.4	-	Bringelly Shale	
D22	272171.1	1247389	287250	6246322	Coffey	103.2	15/08/1990	20.00			9.1	94.1		Bringelly Shale	
D23	272062	1248586	287118	6247517	Coffey	105.6	22/08/1990	20.7			9.6	96		Bringelly Shale	
D29	273321.5	1248075	288388	6247031	Coffey	95.1	15/08/1990	10.05			7.6	87.5		Bringelly Shale	
A	273027.8	1244999			PPK Environment	92.91		27.30	24.3	27.3	11.66	81.25		Bringelly Shale	0.0186
B	274549.3	1250139			PPK Environment	71.18		38.50	35.5	38.5	9.39	61.79		Bringelly Shale	0.0518
C	270472.7	1248025			PPK Environment	66.52		26.00	23	26	8.17	58.35		Bringelly Shale	0.022
D	271769.3	1247228			PPK Environment			25.00						Dry	
E Deep	272676	1245812			PPK Environment	78.21		11.30	8.3	11.3	2.85	75.36		Siltstone	0.026
E Shallow	272676.3	1245813			PPK Environment	78.23		5.00	2	5	0.69	77.54		Alluvial	0.536
E Creek Bed	272702.2	1245804			PPK Environment	76.06		0.00			-0.11	76.17		Creek Bed	
F Deep	273675.4	1246712			PPK Environment	69.87		30.30	27.3	30.3	3.9	65.97		Bringelly Shale	0.0162
F Shallow	273675.2	1246710			PPK Environment	69.92		6.00	3	6	2.51	67.41		Alluvial	0.00499

Well ID	Easting	Northing	Easting	Northing	Consultant	RL (m AHD)	Date of installation	Well depth (m bmp)	Screen Top (m bmp)	Screen Bottom (m bmp)	Water elevation (m bmp)	Water elevation (m AHD)	Date of GWL observation	Interpreted Aquifer	Hydraulic conductivity (m/day)
F Creek Bed	273651.5	1246808			PPK Environment	66.2		0.00			-0.11	66.31		Creek Bed	
G Deep	275625.6	1247625			PPK Environment	59.64		24.30	21.3	24.3	5.005	54.635		Bringelly Shale	0.0374
G Shallow	275627	1247625			PPK Environment	59.71		5.00	2	5	4.7	55.01		Alluvial	0.00496
G Creek Bed	275684.1	1247554				55.07		0.00			-0.1	55.17		Creek Bed	
H Deep	273982.6	1245295			PPK Environment	84.06		12.30	9.3	12.3	2.98	81.08		Bringelly Shale	0.0924
H Shallow	273981.3	1245296			PPK Environment	84.03		4.50	1.5	4.5	2.41	81.62		Weathered Shale	0.00269
I	275067.1	1246075			PPK Environment			45.30						Dry	
J Deep	274824.6	1243803			PPK Environment	70.86		42.30	39.3	42.3	5.64	65.22		Bringelly Shale	0.0355
J Shallow	274824.8	1243805			PPK Environment	70.86		4.50	1.5	4.5	3.63	67.23		Alluvial	0.00544
F Creek Bed	274823.3	1243678				68.13		0.00			-0.17	68.3		Creek Bed	
K	274455.5	1249145			PPK Environment	72.01		32.30	29.3	32.3	3.5	68.51		Bringelly Shale	0.00291

Table B–1 – Registered Groundwater Bores

Bore ID	Final Depth (m)	Standing Water Level (m)	Licence Status	Easting	Northing	Distance from Site Centre (approx. m)	Authorised purpose	Intended Purpose
GW112174			ACTIVE	292977	6250986	4972	MONITORING BORE	MONITORING BORE
GW112170			ACTIVE	292657	6251029	4774	MONITORING BORE	MONITORING BORE
GW112169			ACTIVE	292250	6251042	4511	MONITORING BORE	MONITORING BORE
GW112166			ACTIVE	292203	6250844	4331	MONITORING BORE	MONITORING BORE
GW112168			ACTIVE	292271	6251087	4559	MONITORING BORE	MONITORING BORE
GW112167			ACTIVE	292226	6250791	4306	MONITORING BORE	MONITORING BORE
GW112172			ACTIVE	292885	6250097	4339	MONITORING BORE	MONITORING BORE
GW112116			ACTIVE	292252	6250395	4040	MONITORING BORE	MONITORING BORE
GW112173			ACTIVE	292686	6250365	4344	MONITORING BORE	MONITORING BORE
GW072774	30.00 m		ACTIVE	292654	6250124	4168		G/WATER XPLORE
GW112171			ACTIVE	292112	6250198	3802	MONITORING BORE	MONITORING BORE
GW112165			ACTIVE	292922	6250269	4470	MONITORING BORE	MONITORING BORE
GW100136	110.70 m	23.80	CONVERTED	288609	6250514	3012	STOCK	STOCK
GW106198			CONVERTED	286732	6250544	3940	STOCK, DOMESTIC	
GW102305	61.00 m	12.00	CANCELLED	285664	6250741	4841	STOCK	STOCK
GW111840	30.70 m		ACTIVE	289231	6249454	1864	MONITORING BORE	MONITORING BORE
GW111839	30.40 m		ACTIVE	289217	6249289	1701	MONITORING BORE	MONITORING BORE
GW111838	30.00 m		ACTIVE	288816	6249274	1761	MONITORING BORE	MONITORING BORE
GW108933	268.00 m		CANCELLED	285491	6248644	3992	TEST BORE	IRRIGATION
GW104979	180.00 m	42	CONVERTED	285687	6247137	3683	STOCK, DOMESTIC	STOCK, DOMESTIC
GW104215	222.50 m	40	CANCELLED	286513	6244862	3932	STOCK, DOMESTIC	STOCK, DOMESTIC
GW105959	337.00 m	70	CANCELLED	286738	6244446	4085	IRRIGATION, STOCK, FARMING	STOCK, FARMING, IRRIGATION

Bore ID	Final Depth (m)	Standing Water Level (m)	Licence Status	Easting	Northing	Distance from Site Centre (approx. m)	Authorised purpose	Intended Purpose
GW106829	249.00 m	85	CONVERTED	287457	6243826	4212	STOCK, DOMESTIC	STOCK, DOMESTIC
GW113439			ACTIVE	290854	6243885	4004	MONITORING BORE	MONITORING BORE
GW113438			ACTIVE	290755	6243883	3970	MONITORING BORE	MONITORING BORE
GW113440			ACTIVE	290807	6243793	4073	MONITORING BORE	MONITORING BORE
GW113442			ACTIVE	291198	6244233	3839	MONITORING BORE	MONITORING BORE
GW113441			ACTIVE	290919	6244429	3535	MONITORING BORE	MONITORING BORE
GW063062	151.00 m		CONVERTED	289671	6243201	4404	STOCK, INDUSTRIAL, DOMESTIC	STOCK, INDUSTRIAL, DOMESTIC
GW073533	330.00 m			289618	6243139	4463		DOMESTIC
GW101062	220.00 m	45	CONVERTED	289934	6242958	4673	STOCK, DOMESTIC	STOCK, DOMESTIC
GW111604	20.00 m		ACTIVE	290071	6242820	4828	MONITORING BORE	MONITORING BORE
GW106636				292223	6247047	2932		
GW103739	32.98 m		ACTIVE	292339	6246890	3078	MONITORING BORE	TEST BORE
GW106735			CONVERTED	292192	6247030	2905	INDUSTRIAL	INDUSTRIAL
GW103743	27.25 m		ACTIVE	292339	6246890	3078	MONITORING BORE	TEST BORE
GW103741	27.15 m		ACTIVE	292339	6246890	3078	MONITORING BORE	TEST BORE
GW112649	30.12 m	6.8	ACTIVE	290253	6246317	1568	MONITORING BORE	MONITORING BORE
GW112650	30.70 m	8.5	ACTIVE	290509	6246300	1742	MONITORING BORE	MONITORING BORE
GW105016	252.50 m	53	CONVERTED	292895	6248599	3693	STOCK, DOMESTIC	STOCK, DOMESTIC
GW103742	23.93 m		ACTIVE	292339	6246890	3078	MONITORING BORE	TEST BORE
GW103740	32.00 m		ACTIVE	292339	6246890	3078	MONITORING BORE	TEST BORE

Appendix C – Historical Water Quality Data

Table C–1 – Historical Surface Water Data

Appendix C
Table 1
Historical Surface Water Quality

Department of Infrastructure and Regional Development
Western Sydney Airport

		NA	Surfactants	Field		Inorganics				Metals								TRH - NEPM 1999				BTEX & MAH				PAH	Phenols	VOCs	Nutrients					
		Fraction Organic Carbon	Soxhlet Grease	MBAS	Dissolved Oxygen (% saturated) (Field) (Filtered)	Dissolved Oxygen (Lab) (Filtered)	Electrical conductivity (lab)	pH (Lab)	Total Suspended Solids	Turbidity	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Mercury	Nickel	Zinc	C6 - C9 Fraction	C10 - C14 Fraction	C15 - C28 Fraction	C29 - C36 Fraction	Benzene	Toluene	Ethylbenzene	Xylene Total	PAHs (Sum of total) - Lab calc	Phenols	1,2-dichlorobenzene	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total)	Phosphorus
		%	mg/L	µg/L	%S	mg/L	µS/cm	pH Units	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lowland rivers (ANZECC 2000, South East Australia)																																		0.5	0.05
NHMRC 2008 Recreation Waters - Health Criteria								6.5-8.5			0.002	0.05	2	0.3	0.01	0.001	0.02	3					1	25	3	20			1						
ANZECC 2000 FW 95%											0.0002	0.001#1	0.0014		0.0034	0.0006	0.011	0.008					950						160	0.9		0.158#2			
ANZECC 2000 FW Med-Low Reliability											0.0002		0.0014	0.3	0.0034		0.011	0.008					950	180	80				160			0.7			
ANZECC 2000 Recreational Purposes Guidelines								6.5-8.5			0.005	0.05	1	0.3	0.05	0.001	0.1	5					10							0.01		10	1		
ANZECC 2000 Primary Contact Recreation																																			
ANZECC 2000 Secondary Contact Recreation																																			
ANZECC 2000 Irrigation - Short-term Trigger Values											0.05	1	5	10	10	0.002	2	5																25#3	
ANZECC 2000 Irrigation - Long-term Trigger Values											0.01	0.1	0.2	0.2	0.2	0.002	0.2	2																5	0.05
ANZECC 2000 Stock Watering											0.01	1	0.5#4		0.1	0.002	1	20														90	9.1		
Location Code	**Sampled Date Time**																																		
Badgerys Creek B1	4/12/1996	10	<5	<20	63	4.5	1170	6.9	2	1.1	<0.005	<0.005	0.005	0.22	<0.005	<0.001	<0.005	0.013	<20	<40	<200	<200	<1	<1	<1	<1	<1	<10	<1	0.054	5	<0.02	<0.02	-	<0.02
Badgerys Creek B2	4/12/1996	25	<5	220	150	12.2	2900	7.3	33	7	<0.005	0.01	<0.005	1.8	<0.005	<0.001	<0.005	<0.01	<20	<40	<200	<200	<1	<1	<1	<1	<1	<10	<1	0.38	2.9	<0.02	<0.02	-	1.2
Badgerys Creek B3	4/12/1996	<0.01	<5	14,000	24	2.2	1080	6.7	14	5.1	<0.001	<0.01	0.005	<0.005	<0.005	<0.02	<0.005	<0.005	<40	<200	<200	<1	<1	<1	<1	<1	<1	1100	<1	0.21	0.7	<0.02	<0.02	0.12	0.26
Badgerys Creek B3	17/09/1998	9	<5	130	107	11.3	1530	6.9	9	46	0.001	<0.005	<0.005	1.93	<0.005	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.14	1.1	1.16	0.03	2.3	0.35
Badgerys Creek B3	8/10/1998	11	<5	160	13	1.4	1895	7	15	19	<0.001	<0.005	<0.005	1.51	<0.005	<0.001	<0.005	0.02	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.16	1.3	0.01	<0.01	1.31	0.47
Badgerys Creek B3	15/12/1998	17	8	<50	35	2.9	2250	7.2	24	19	<0.0005	<0.005	<0.005	3.02	<0.002	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.13	1.4	0.02	<0.01	1.42	0.32
Cosgroves Creek C1	10/12/1996	<0.01	<5	16,000	25	2.2	1500	6.7	5	2.9	<0.001	0.018	<0.005	<0.005	<0.005	<0.02	<0.005	<0.005	<40	<200	<200	<1	<1	<1	<1	<1	<1	<50	<1	0.12	0.9	<0.02	<0.02	-	<0.02
Cosgroves Creek C3	10/12/1996	<0.01	<5	16,000	25	2.2	1500	6.7	5	2.9	<0.001	0.018	<0.005	<0.005	<0.005	<0.02	<0.005	<0.005	<40	<200	<200	<1	<1	<1	<1	<1	<1	<50	<1	0.12	0.9	<0.02	<0.02	<0.02	<0.02
Cosgroves Creek C3	16/09/1998	12	<5	190	65	6.6	1220	6.9	12	16	0.001	<0.005	<0.005	1.76	<0.005	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	30	<1	0.11	1.2	0.13	0.01	1.3	0.07
Cosgroves Creek C3	7/10/1998	15	<5	120	53	4.9	1820	7	8	10	<0.001	<0.005	<0.005	2.28	<0.005	<0.001	<0.005	0.03	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.06	1.2	0.03	<0.01	1.23	0.07
Cosgroves Creek C3	14/12/1998	18	9	100	2	0.2	2150	7.4	6	16	<0.0005	<0.005	<0.005	3.17	<0.002	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.7	1.7	<0.01	<0.01	1.7	0.05
Duncans Creek D1	10/12/1996	<0.01	<5	12,000	15	1.3	1750	6.7	13	5.2	<0.001	0.01	<0.005	<0.005	<0.005	<0.02	<0.005	<0.005	<40	<200	<200	<1	<1	<1	<1	<1	<1	530	<1	0.025	0.2	<0.02	<0.02	<0.02	<0.02
Duncans Creek D1	17/09/1998	10	<5	170	28	2.7	1330	7	10	12	0.001	<0.005	<0.005	1.26	<0.005	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.02	1.1	0.2	<0.01	1.3	0.03
Duncans Creek D1	8/10/1998	8	<5	60	24	2.2	1950	7	8	10	0.001	<0.005	<0.005	1.29	0.003	<0.001	<0.005	0.04	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	<0.01	0.8	<0.01	<0.01	0.8	0.04
Duncans Creek D1	15/12/1998	10	<5	90	50	4.1	2590	7.1	9	6.2	<0.0005	<0.005	<0.005	0.58	<0.002	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	<0.01	0.5	<0.01	<0.01	0.5	0.02
South Creek S1	16/09/1998	12	<5	90	105	10.1	673	7.2	12	65	0.001	<0.005	0.006	1.5	<0.005	<0.001	<0.005	0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.04	0.9	0.67	0.02	1.6	0.14
South Creek S1	7/10/1998	10	<5	200	83	7.4	1000	7.1	8	15	<0.001	<0.005	<0.005	1.41	0.002	<0.001	<0.005	0.03	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.08	1.2	0.14	<0.01	1.34	0.12
South Creek S1	14/12/1998	5	<5	50	100	7.7	1600	7	56	38	<0.0005	<0.005	<0.005	0.81	<0.002	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.24	0.3	0.19	<0.01	0.49	0.01
South Creek S2	16/09/1998	11	<5	120	66	6.6	727	6.9	11	82	0.001	<0.005	0.006	1.81	<0.005	<0.001	0.012	0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.04	1	0.5	0.02	1.5	0.11
South Creek S2	7/10/1998	9	<5	160	60	5.5	989	7	19	32	<0.001	<0.005	<0.005	1.5	<0.005	<0.001	<0.005	0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.03	0.7	<0.01	<0.01	0.7	0.07
South Creek S2	14/12/1998	7	<5	<50	87	6.8	1420	6.8	5	7	<0.0005	<0.005	<0.005	0.35	<0.002	<0.001	<0.005	0.16	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	<0.01	0.4	0.04	<0.01	0.44	0.01
South Creek S3	16/09/1998	12	<5	130	79	7.5	690	6.9	12	40	0.001	<0.005	<0.005	2.03	<0.005	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	120	<1	0.09	1.1	0.24	0.02	1.4	0.47
South Creek S3	7/10/1998	11	<5	210	44	4.1	645	6.9	14	23	0.001	<0.005	<0.005	3.06	0.003	<0.001	<0.005	0.02	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.21	1.3	0.18	0.04	1.52	0.5
South Creek S3	14/12/1998	12	<5	<50	39	3.1	850	7.4	4	12	<0.0005	<0.005	<0.005	0.66	<0.002	<0.001	<0.005	0.03	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.03	0.8	<0.01	<0.01	0.8	0.05
Thompson Creek T1	10/12/1996	<0.01	<5	16,000	23	2.2	4960	6.4	5	4.9	0.01	0.018	0.006	<0.005	<0.005	<0.02	<0.005	<0.005	<40	<200	<200	<1	<1	<1	<1	<1	<1	4900	<1	0.13	0.5	<0.02	0.026	<0.02	<0.02
Thompson Creek T1	17/09/1998	11	<5	140	50	5.5	2400	7	11	10	0.001	<0.005	<0.005	1.21	<0.005	<0.001	<0.005	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.18	1	0.1	0.01	1.1	0.01
Thompson Creek T1	9/10/1998	13	<5	210	15	1.5	4240	7	8	11	<0.001	<0.005	<0.005	1.39	<0.005	0.01	<0.005	0.03	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.29	1.1	0.02	<0.01	1.12	0.04
Thompson Creek T1	15/12/1998	18	<5	170	46	4.2	9550	7.3	11	14	<0.0005	<0.005	<0.005	1.16	<0.002	<0.001	0.006	<0.01	<20	<20	<100	<100	<1	<1	<1	<1	<1	<10	<1	0.04	1.1	0.04	<0.01	1.14	0.04
Statistical Summary																																			
Number of Results		28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	25	28
Number of Detects		23	2	24	28	28	28	28	28	28	10	5	5	23	3	1	2	11	0	0	0	0	0	0	0	0	0	5	0	25	28	16	8	22	23
Minimum Concentration		<0.01	<5	<20	2	0.2	645	6.4	2	1.1	<0.0005	<0.005	<0.005	<0.005	<0.002	<0.001	<0.005	<0.005	<20	<20	<100	<1	<1	<1	<1	<1	<1	<10	<1	<0.01	0.2	<0.01	<0.01	<0.02	0.01
Minimum Detect		5	8	50	2	0.2	645	6.4	2	1.1	0.001	0.01	0.005	0.22	0.002	0.01	0.006	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	ND	0.02	0.2	0.01	0.01	0.12	0.01
Maximum Concentration		25	9	16000	150	12.2	9550	7.4	56	82	0.01	0.018	0.006	3.17	<0.005	<0.02	0.012	0.16	<40	<200	<200	<200	<1	<1	<1	<1	<1	4900	<1	0.7	5	1.16	0.04	2.3	1.2
Maximum Detect		25	9	16000	150	12.2	9550	7.4	56	82	0.01	0.018	0.006	3.17	0.003	0.01	0.012	0.16	ND	ND	ND	ND	ND	ND	ND	ND	ND	4900	ND	0.7	5	1.16	0.04	2.3	1.2
Average Concentration		9.9	2.9	2743	53	4.8	2014	7	12	19	0.0011	0.0048	0.003	1.3	0.0021	0.0025	0.003	0.016	12	27	63	45	0.5	0.5	0.5	0.5	0.5	244	0.5	0.13	1.2	0.13	0.011	1	0.16
Median Concentration		10.5	2.5	150	48	4.15	1515	7	10.5	12	0.0005	0.0025	0.0025	1.34	0.0025	0.0005	0.0025	0.005	10	10	50	50	0.5	0.5	0.5	0.5	0.5	5	0.5	0.1	1.05	0.02	0.0075	1.14	0.05
Standard Deviation		6.1	1.6	5766	35	3.1	1789	0.23	11	19	0.0018	0.0051	0.0012	0.94	0.00069	0.004	0.0019	0.03	3.9	35	22	25	0	0	0	0	0	940	0	0.15	0.91	0.26	0.009	0.6	0.26
Number of Guideline Exceedances		0	0	0	0	0	0	1	0	0	28	28	28	23	18	28	1	23	0	0	0	0	0	0	0	0	0	0	0	25	0	7	0	18	13
Number of Guideline Exceedances(Detects Only)		0	0	0	0	0	0	1	0	0	10	5	5	23	0	1	1	11	0	0	0	0	0	0	0	0	0	0	0	25	0	7	0	18	13

Env Stds Comments
#1:Cr(VI) guideline has been adopted
#2:Nitrate (as NO3) value divided by 4.427
#3:25-125 mg/L - requires a site specific assessment
#4:Guideline value for sheep

Monitoring_Zone = 'surface'
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Table C–2 – Historical Ground Water Data

Department of Infrastructure and Regional Development
Western Sydney Airport

Appendix C
Table 2
Historical Groundwater Results

		Inorganics				Metals						Alkalinity	Major Ions						Nutrients			
		Nitrite + Nitrate as N	Bicarbonate as CaCO3	Electrical conductivity (lab)	pH (Lab)	Aluminium	Cadmium	Copper	Iron	Lead	Zinc	Alkalinity (Carbonate as CaCO3)	Calcium	Chloride	Magnesium	Potassium	Sodium	Sulphate	Total Kjeldahl Nitrogen	Nitrate (as N)	Nitrogen (Total)	Phosphorus
		mg/L	mg/L	µS/cm	pH Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ADWG 2011 Aesthetic					6.5-8.5	0.2		1	0.3		3			250			180	250				
ADWG 2011 Health							0.002	2		0.01								500				
Lowland rivers (ANZECC 2000, South East Australia)																					0.5	0.05
NHMRC 2008 Recreation Waters - Health Criteria					6.5-8.5		0.002	2	0.3	0.01	3			250#1			180	250				
ANZECC 2000 FW 95%						0.055	0.0002	0.0014		0.0034	0.008									0.158#2		
ANZECC 2000 Irrigation - Short-term Trigger Values						20	0.05	5	10	10	5										25#4	
ANZECC 2000 Irrigation - Long-term Trigger Values						5	0.01	0.2	0.2	0.2	2										5	0.05
Location Code	**Sampled Date Time**																					
GW A	29/09/1998	0.06	188	29,700	7.43	<0.01	<0.001	0.013	<1	0.004	0.039	<1	518	9660	186	56	5440	4	11.9	0.06	12	0.06
GW B	29/09/1998	0.03	921	28,500	6.72	<0.01	<0.001	0.02	<1	0.005	0.042	<1	650	9450	573	96	4600	4	12.4	0.03	12.4	0.02
GW C	29/09/1998	0.03	866	5,520	7.65	0.06	<0.001	0.002	<0.1	0.022	0.014	<1	42	1120	51	15	935	9	2.5	0.03	2.5	0.42
GW E Deep	29/09/1998	0.06	1140	7,900	7.42	<0.01	<0.001	0.002	<0.1	0.006	0.012	<1	62	1670	163	11	1260	152	0.5	0.06	0.6	0.08
GW E Shallow	29/09/1998	9.78	777	3,990	7.21	0.04	<0.001	0.002	<0.1	0.001	0.008	<1	106	648	113	7	488	93	3.9	9.75	13.7	1.2
GW F Deep	29/09/1998	0.03	621	20,970	7.08	<0.001	<0.001	0.003	<0.1	0.003	0.009	<1	291	6560	516	36	3260	85	5	0.03	5	0.08
GW F Shallow	29/09/1998	0.03	1060	40,800	7.02	0.01	<0.001	0.004	<0.1	0.003	0.017	<1	181	13,800	1500	13	6560	390	0.8	0.03	0.8	0.53
GW G Deep	29/09/1998	0.02	687	23,900	6.94	<0.01	<0.001	0.008	<1	0.004	0.018	<1	446	7740	464	53	3970	1	6.6	0.02	6.6	0.04
GW G Shallow	29/09/1998	0.02	630	14,390	7.5	0.02	<0.001	0.003	<0.1	0.001	0.006	<1	145	4070	364	6	2160	249	1	0.02	1	0.11
GW G4a	15/06/1905	-	-	36,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW G5	15/06/1905	-	-	31,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW G6	15/06/1905	-	-	28,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW G7	15/06/1905	-	-	28,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW H Deep	29/09/1998	0.02	862	33,600	6.98	<0.01	<0.001	0.006	<1	0.007	0.014	<1	237	10,600	1080	31	5370	1080	1.8	0.02	1.8	0.09
GW H Duplicate	29/09/1998	0.06	157	-	-	0.04	<0.001	0.004	<1	<0.001	0.025	<1	23	8410	799	12	4280	677	1	0.06	1.1	0.46
GW H Shallow	29/09/1998	0.06	155	26,450	7.07	0.04	<0.001	0.004	<1	<0.001	0.024	<1	25	8380	812	12	4270	667	1	0.06	1.1	0.47
GW J Deep	29/09/1998	0.05	549	26,300	6.72	<0.01	<0.001	0.014	1.8	0.002	0.037	<1	605	8300	217	62	4560	1	11.7	0.05	11.8	0.07
GW J Shallow	29/09/1998	0.4	255	28,000	7.51	0.03	<0.001	0.004	<1	<0.001	0.009	<1	54	8810	744	13	4580	494	1.3	0.4	1.7	0.54
GW K	29/09/1998	0.03	939	27,400	7.03	<0.01	<0.001	0.005	<1	0.015	0.018	<1	282	8160	825	59	4180	977	4.5	0.03	4.5	0.06
GW Well D11	13/06/1905	-	-	14,810	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW Well D13	13/06/1905	-	-	1350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW Well D8	13/06/1905	-	-	3010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW Well D9	13/06/1905	-	-	14,290	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW Well G1a	15/06/1905	-	-	17,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW Well G3a	15/06/1905	-	-	22,190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW2D	29/09/1998	0.04	907	-	-	<0.01	<0.001	0.019	<1	0.005	0.038	<1	633	9290	574	91	4530	3	13.7	0.04	13.7	0.11
MW2D Duplicate	29/09/1998	0.03	893	-	-	<0.01	<0.001	0.019	<1	0.005	0.041	<1	675	9290	611	92	4400	3	13.3	0.03	13.3	0.06
Statistical Summary																						
Number of Results		17	17	24	14	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
Number of Detects		17	17	24	14	7	0	17	1	14	17	0	17	17	17	17	17	17	17	17	17	17
Minimum Concentration		0.02	155	1350	6.72	<0.001	<0.001	0.002	<0.1	<0.001	0.006	<1	23	648	51	6	488	1	0.5	0.02	0.6	0.02
Minimum Detect		0.02	155	1350	6.72	0.01	ND	0.002	1.8	0.001	0.006	ND	23	648	51	6	488	1	0.5	0.02	0.6	0.02
Maximum Concentration		9.78	1140	40800	7.65	0.06	<0.001	0.02	1.8	0.022	0.042	<1	675	13800	1500	96	6560	1080	13.7	9.75	13.7	1.2
Maximum Detect		9.78	1140	40800	7.65	0.06	ND	0.02	1.8	0.022	0.042	ND	675	13800	1500	96	6560	1080	13.7	9.75	13.7	1.2
Average Concentration		0.63	683	21474	7.2	0.017	0.0005	0.0078	0.42	0.005	0.022	0.5	293	7409	564	39	3814	287	5.5	0.63	6.1	0.26
Median Concentration		0.03	777	25100	7.075	0.005	0.0005	0.004	0.5	0.004	0.018	0.5	237	8380	573	31	4280	93	3.9	0.03	4.5	0.09
Standard Deviation		2.4	321	11113	0.3	0.018	0	0.0065	0.42	0.0056	0.013	0	244	3560	380	32	1672	363	5.1	2.4	5.4	0.31
Number of Guideline Exceedances		0	0	0	0	1	17	17	11	9	15	0	0	17	0	0	17	6	0	2	17	15
Number of Guideline Exceedances(Detects Only)		0	0	0	0	1	0	17	1	9	15	0	0	17	0	0	17	6	0	2	17	15

Env Stds Comments
#1:Adopted from Aesthetics
#2:Nitrate (as NO3) value divided by 4.427
#3:pH<6.5. GL for pH>6.5 = 55 ug/L
#4:25-125 mg/L - requires a site specific assessment
#5:Guideline value for sheep

Data Comments
#1 ESDAT Combined. Some analytes are reported multiple times; the lowest non-detect or the highest detect is used.
#2 ESDAT Combined with Non-Detect Multiplier of 0.5.
#3 ESDAT Combined.

Monitoring_Zone = 'groundwater'
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