Regional Basin I

Groundwater Flow/Quality Assessment

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Contents

Groundwater Flow/Quality Assessment - Regional Basin I

1.1 Introduction

1.1.1 Background

This working report, prepared by Jacobs, documents the findings of a groundwater assessment for a proposed regional unlined stormwater basin, Basin I, which is located in the Regional Park to the south of Jordan Springs and to the north of the Central Precinct (Jordan Springs East). The report has been prepared to support an Environmental Impact Assessment. A separate groundwater report has been prepared for a second nearby regional basin, Basin B, which is proposed to be lined. Basin I and B are sufficiently separated (approximately 2.8km) from one another such that cumulative basin impacts to groundwater are not applicable.

The purpose of Basin I is to provide stormwater quality treatment and detention for peak flow mitigation.

The Basin I location includes an area of weedy Freshwater Wetlands, small patches of exotic grassland as well the Threatened Ecological Community (TEC) - River-flat Eucalypt Forest (in the form of Alluvial Woodland).

1.1.2 Objectives

The objectives of this assessment were formulated to address groundwater related content within the Secretary's Environmental Assessment Requirements (SEARS) developed for proposed Basin I and included:

1. Outline relevant Commonwealth and State legislation and policy, including groundwater related approvals and water licensing requirements.

2. Describe local soils, topography, drainage and landscapes.

3. Assess potential impacts of the proposed basin on quality and quantity of groundwater resources, including groundwater dependent ecosystems (GDEs), in accordance with the NSW Aquifer Interference Policy (NOW, 2012).

4. Where required, outline details of groundwater monitoring and measures to mitigate impacts to/from groundwater.

1.1.3 Assessment Methodology

Available hydrogeological site information (Section 1.3.2) including borehole/well logs, groundwater level/quality monitoring data and permeability test results were assessed in conjunction with a hydrogeological conceptualisation presented (JBS&G, 2018) for the broader region of the site to assist in formulation of a conceptual hydrogeological model for the area of Basin I.

Groundwater inflows and associated drawdown occurring during temporary dewatering required for the construction of Basin I were simulated using AnAqSim, an analytical element groundwater modelling program. Potential groundwater mounding during operation of the basin was also assessed using this model. The model was developed based on the conceptual hydrogeological model.

The conceptual and analytical models were used together with Basin I's key construction details to assess likely groundwater flow/quality impacts of the basin in accordance with the NSW Aquifer Interference Policy (NOW, 2012).

1.1.4 Basin I Key Construction Details

Key construction details for Basin I are summarised below:

- Maximum water surface length of approximately 350m.
- Maximum water surface width of approximately 142m.
- Permanent water level of 34mAHD.
- Base level of 32mAHD.
- Macrophytes to be established around perimeter.
- 1(v):4(h) bank batters.
- Box culvert inlet.
- Rock lined spillway outlet.
- On-line (i.e. basin length traverses a section of a drainage line which ultimately drains to South Creek).
- Overall footprint of approximately 5.73ha.
- Permanent water surface area of approximately 3.78ha.
- Indicative water quality comprising total nitrogen (TN) of 2mg/L, total phosphorus (TP) of 0.3mg/L, total suspended solids (TSS) of 50 to 100mg/L and low salinity (i.e. fresh).

For the purpose of assessing temporary construction dewatering impacts, we have assumed the duration of such dewatering would be 6 months.

1.2 Key Legislation & Policy

1.2.1 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prescribes the Commonwealth Government's role in environmental assessment, biodiversity conservation and the management of protected areas and species, population and communities and heritage items. Approval from the Commonwealth Minister for the Environment is required for projects likely to have a significant impact on 'matters of national environmental significance' (MNES).

The EPBC Act identifies MNES as:

- World heritage areas.
- National heritage areas.
- Wetlands of international importance (Ramsar wetlands).

- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).
- Great Barrier Reef Marine Park.
- A water resource in relation to coal seam gas development and large coal mining development.
- Water resources.

For the purpose of this assessment, Jacobs have assumed that the River-flat Eucalypt Forest TEC located north of the proposed basin constitutes a MNES.

1.2.2 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is the adopted national approach to protecting and improving water quality in Australia. It consists of a number of guideline documents, of which certain documents relate to protection of surface water resources and others relate to the protection of groundwater resources.

The primary document relevant to the assessment of groundwater risks for the project is the *Guidelines for Groundwater Quality Protection in Australia* (Australian Government, 2013). This document sets out a high-level risk-based approach to protecting or improving groundwater quality for a range of groundwater beneficial uses (called environmental values), including for aquatic ecosystem protection, primary industries, recreational use, drinking water, industrial water and cultural values.

Based on large offsets to surrounding licensed bores (Section 1.3.2) and low groundwater quality, including high salinity, the highest beneficial use category of groundwater in the vicinity of the project site is considered to be potential use for ‘industrial water’.

1.2.3 Water Act 1912 and Water Management Act 2000

Water resources in NSW are administered under the *Water Act 1912* and the *Water Management Act 2000* by the NSW Department of Industry (NSW DI). The *Water Management Act 2000* governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in NSW where Water Sharing Plans (WSP) have commenced. The WSP for the project area has commenced and the area is therefore generally governed under the *Water Management Act 2000.* The exception is temporary construction dewatering, which is currently licensed under the *Water Act 1912.*

The *Water Management Act 2000* requires approvals for activities that may impact an aquifer(s), including activities that intersect groundwater other than water supply bores. Part 2 of the *Water Management Act 2000* establishes access licences for the take of water within a particular water management area. Such licensing would apply in cases where Basin I leads to groundwater ‘take’ (or indirect ‘take’ from a surface water source) other than that which occurs during temporary construction dewatering.

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1.2.4 Water Sharing Plan (WSP)

The site is located within the Water Sharing Plan (WSP) for the Greater Metropolitan Region Groundwater Sources and within a management area called the Sydney Basin Central Groundwater Source (SBCGS).

Key applicable rules are summarised below.

- Granting of an access license may be considered for local water utility, major water utility, town water supply and a commercial access licence under a controlled allocation order made in relation to any unassigned water in this water source.
- Trading into the water source is not permitted.
- Trading within the water source is permitted, subject to local impact assessment.
- Conversion to another category of licence is not permitted.
- 1 ML/unit of share aquifer access licences.

1.2.5 NSW Aquifer Interference Policy (2012)

The NSW Aquifer Interference Policy (2012) outlines minimal impact considerations for water table and groundwater pressure drawdown at high priority GDEs (as identified in the WSP), high priority culturally significant sites (as identified in the WSP) and existing bores. Water quality impact considerations are also outlined.

The site has been interpreted as being within a 'less productive groundwater source' on the basis of low bore numbers, expected low yields and high salinity, for which the following impact considerations apply:

1. A maximum cumulative pressure head or water table decline of 2 m at any bore. If this condition cannot be met, then appropriate studies will need to demonstrate to the Minister's satisfaction that decline in head will not prevent the long-term viability of the affected water supply works unless make good provisions apply.

2. Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. If this condition cannot be met, then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem.

Impact limits to high priority GDEs and culturally significant sites are also outlined in the NSW Aquifer Interference Policy AIP (2012). However, these are not applicable at the site as such GDEs and sites are not mapped within approximately >20 km of the site (Appendix 2 of the WSP legislation).

1.2.6 Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems (GDEs) Policy (Department of Land and Water Conservation, 2002) implements the *Water Management Act 2000* by providing guidance on the protection and management of GDEs. It sets out management objectives and principles to:

- Ensure that the most vulnerable and valuable ecosystems are protected

- Manage groundwater extraction within defined limits thereby providing flow sufficient to sustain ecological processes and maintain biodiversity
- Ensure that sufficient groundwater of suitable quality is available to ecosystems when needed
- Ensure that the precautionary principle is applied to protect groundwater dependent ecosystems, particularly the dynamics of flow and availability and the species reliant on these attributes
- Ensure that land use activities aim to minimise adverse impacts on groundwater dependent ecosystems.

1.3 Hydrogeology

1.3.1 **Site Setting**

Basin I is proposed to be located towards the upper extent of an unnamed drainage line which flows in a general east north east to north east direction. As such, the basin is on-line. Elevation in the area of the proposed basin is of the order of 34 to 38mAHD. Land south of the basin slopes to the north north east and north east whilst land north and north west of the proposed basin slopes to the south east and east south east. Maximum land slopes are <5%.

1.3.2 **Data Set Overview**

<u>Public Domain Bore Records</u>

JBS&G's (2018) Environmental Site Assessment completed for Basin I concluded that review of NSW DI's online public domain bore records (NSW DI, accessed 26 February 2018, http://allwaterdata.water.nsw.gov.au/water.stm) indicated that there were no registered bores within 1.5km of the basin.

For the purposes of this assessment, data from bores >1.5km from the basin was considered to be of little value for characterisation of near-surface hydrogeology. Therefore, efforts were focused on review and interpretation of data and conclusions presented in site investigation reports.

<u>Site Investigation Reports</u>

Three site investigation reports and one set of raw field data were used to inform this assessment:

1. Douglas Partners (DP, 2016) Geotechnical Investigation:

    - This report included documentation of 7 test pits (TPs) which were extended as boreholes (BHs) and completed in the area of Basin I. Final borehole depths ranged between 2m and 5.3m below ground level (mBGL).

    - TPs/BHs generally encountered clays and silty clays and at 4 locations were stated to have possibly refused on shale at depths ranging from 3.6 to 4.0mBGL. At the remaining 3 locations, possible shale was not encountered to investigation depths which ranged from 2 to 5.3mBGL.

    - Groundwater was observed as minor seepage inflow in all test pits between 1.2 and 4mBGL, although typically between 1.5 and 2mBGL.

2. Cardno Bowler (2014) Geotechnical Investigation:

- This report documented 2 BHs with depths of 2mBGL in the area of Basin I. One BH encountered approximately 0.3m of topsoil underlain by silty clay whilst the other BH encountered approximately 0.3m of topsoil underlain by clayey sand to 1.0mBGL, which was underlain by silty clay.

- *Insitu* soil permeability was estimated by a falling head test in both BHs. The BH which encountered the clayey sand layer was reported to have a saturated hydraulic conductivity (K) value of 0.58m/d whilst the other borehole was reported to have a K value of 0.07m/d.

3. JBS&G (on behalf of Cardno Bowler) Groundwater Field & Laboratory Data

- On behalf of Cardno Bowler, JBS&G installed two groundwater monitoring wells (BI-MW-01 and BI-MW-02) in the vicinity of Basin I. The wells were installed on 01.05.18, developed on 10.05.18 and sampled for water quality (water quality probe and laboratory samples) on 14.05.18. Groundwater levels were measured at both wells on the dates of developing and sampling. The locations of the monitoring wells, borehole/well logs and field and water quality results were provided to Jacobs.

- Groundwater levels measured at the monitoring wells are provided in Table 1. For the purpose of this report, Jacobs have adopted the groundwater levels measured on 14.05.18 for assessment purposes, being that these groundwater levels were measured after well development.

- Based on the 14.05.18 groundwater levels, the monitoring wells being approximately 162m apart and the wells being inferred to be down groundwater gradient of one another, the groundwater hydraulic gradient in the area of Basin I is inferred to be 0.005m/m.

- BI-MW-01 material comprised clay from surface to 6mBGL, which was underlain by weathered shale with clay properties to 6.60mBGL (termination depth). Material was noted as either dry or damp.

- BI-MW-02 material comprised clay from surface to 5mBGL, which was underlain by shale to 6.60mBGL (termination depth). The shale was noted as being saturated between 6 and 6.60mBGL.

Table 1: Groundwater levels for monitoring wells in area of Basin I.

		Groundwater Level (mAHD)		
Location	Surface Level (mAHD) [1]	10.05.18 (well development date)	14.05.18 (water quality sampling date)	Adopted Representative Level
BI-MW-01	34.63	32.19	31.94	31.94
BI-MW-02	33.20	31.21	31.08	31.08

Notes:
1 Monitoring well not surveyed at time of this report. Estimated from contours/spot heights.

- The groundwater was slightly acidic to alkaline and highly saline with a peak field and laboratory tested EC of 27,677µS/cm and 34,000µS/cm respectively. Heavy metals and nutrients were low in concentration.

4 JBS&G (2018) Environmental Site Assessment

- This report documented 24 BHs in the vicinity of Basin I. BHs ranged from 0.8 to 1 mBGL and generally encountered silty clays and clays. No groundwater information was present on the BH logs.
- The report also documented hydrogeological conditions in the broader region of Basin I by summarising the findings of previous groundwater and Stage 2 investigations undertaken by Australian Defence Industries (ADI, 1996) and Kidd (1999), which were undertaken because Basin I is located within the former St Marys Australian Defence Industries site, where munition filling and storage activities were undertake up until 1994. The bore network associated with these investigations comprised 154 bores (JBS&G, 2018).

1.3.3 **Soils**

As outlined above in Section 1.3.2, soil in the area of Basin I generally comprises silty clays and clays.

1.3.4 **Geology**

The Penrith 1:100,000 Geological Series Sheet 9030 (Geological Survey of NSW, 1991) indicates the area of Basin I is generally underlain by quaternary alluvium, which is described as fine grained sand, silt and clay. The northern and north western extent of the proposed basin is mapped as Bringelly Shale, which is described as shale, carbonaceous claystone, claystone, laminate, fine to medium grained lithic sandstone, rare coal and tuff. The alluvium deposit overlies the shale unit.

As outlined above in Section 1.3.2, the depth to the top of the shale is inferred to be of the order of 4 to 5mBGL. The top of the shale unit is inferred to be weathered, with the degree of weathering decreasing with depth.

1.3.5 **Groundwater Levels**

For the purpose of this report, Jacobs have adopted the groundwater levels measured on 14.05.18 for assessment purposes, being that these groundwater levels were measured after well development. Therefore, groundwater level at the eastern extent of the basin is taken to be 31.94mAHD, the level from bore BI-MW-01, which is at the eastern extent of the basin. Based on the hydraulic gradient between groundwater monitoring wells BI-MW-01 and BI-MW-02 of 0.005m/m, groundwater level in the central and western extent of the basin is taken to be 32.82 and 33.69mAHD respectively.

1.3.6 **Creek Water Quality**

As reported in Jacob's surface water quality working paper, there is no water quality data for the unnamed creek in the area of Basin I. Sydney Water monitoring (39 sampling rounds at two sampling sites) at nearby South Creek indicates high nutrient concentrations, poor water quality and median EC values of the order of 1,000 to 1,100 µS/cm, which is markedly lower than the groundwater EC and suggests groundwater baseflow in the broader region of the site is not a significant process.

1.3.7 Groundwater Quality

As outlined in Section 1.3.2, groundwater in the area of Basin I is highly saline and therefore of low quality. In the context of potential water use, the groundwater's salinity is too high to make a viable resource for drinking water, stock and irrigation purposes.

1.3.8 Groundwater Dependent Ecosystems (GDEs)

Appendix 2 of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (NOW, 2011) contains a map of High Priority GDEs – Karst and Wetlands (HPGDE) located within the SBCGS. The nearest mapped HPGDE is located >20km from Basin I.

The BOM's online Atlas of GDEs was reviewed to assess the potential for aquatic, terrestrial and subterranean ecosystems which rely on the presence of groundwater. The mapping in this atlas is based on broad national scale GIS data and, where available, regional studies. Areas mapped as 'high potential GDEs (national assessment)' were mapped in the area of the proposed basin. No aquatic GDEs where mapped near the site. No mapping information was available for subterranean GDEs.

1.3.9 Hydraulic Conductivity

The K value for the falling head permeability test which was conducted in borehole 'Basin I-BH1', which encountered silty clay, was reported as 0.07m/d.

As the material in Basin I's areal and vertical footprint generally comprises clays and silty clays, K values are expected to be low and the tested K value of 0.07m/d has been adopted for assessment purposes.

1.3.10 Hydrogeological Conceptualisation

A conceptual hydrogeological model for the area of Basin I is summarised as follows:

- North easterly groundwater flow direction.
- Hydraulic gradient of approximately 0.005m/m.
- Unconfined.
- Low K (0.07m/d) silty clay and clay material, and weathered shale at deeper depths.
- Low specific yield (Sy) of the order of 0.01 to 0.04.
- Base at approximately 5 to 10mBGL with water table of the order of 2 to 3mBGL.
- Highly saline groundwater.
- Low recharge by rainfall.
- Underlain by a semi-confined fractured shale groundwater system.

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1.4 Groundwater Impact Assessment

1.4.1 Overview

Potential impacts to the groundwater system may occur due to temporary construction dewatering and associated drawdown, and/or due to changes to groundwater levels and flow directions which occur due to operation of the basin.

1.4.2 Temporary Dewatering Flows & Associated Drawdown

Temporary dewatering flows during construction and associated drawdown were assessed using AnAqSim, an analytical groundwater modelling program.

A transient single layer model was established to represent the hydrogeological conceptualisation outlined in Section 1.3.10. The model represented the basin excavation to 32mAHD over the basin's entire proposed surface water area as a constant head boundary. The boundary took effect from time 0 and continued for the entire model period of 180 days, the assumed time period required for temporary construction dewatering. Far-field constant head boundaries were used to generate a hydraulic gradient of 0.005m/m through the model and no recharge was applied. The initial head for the model, and therefore the basis for drawdown assessment, was created by doing a run of the model in steady state with the basin constant head boundary inactive. The model's 180 day runtime was simulated with 10 time steps and a step multiplier of 1.5.

Results are summarised in Table 2 and indicate a total dewatering discharge of approximately 1.2ML and average discharge rate of 6.6 m^3/d. The peak discharge rate, which occurs in the first period, was approximately 150 m^3/d. Based on the basin excavation being represented in the model as occurring at its full areal and vertical extent from time 0 onwards, and based on the assumed K value of 0.07m/d, which is considered somewhat high for clay, model discharge results are considered conservative.

Modelled drawdown results (Figure 1) indicate that at time 180 days, maximum drawdown of approximately 1.7m occurs at the very western extent of the basin. For this area of the basin, distance from the edge of the basin to the 1.0m, 0.5m and 0.1m drawdown contours was approximately 37m, 92m, 210m respectively.

Table 2: Modelled temporary construction dewatering inflows.

Day at End of Time Step	Step Duration (d)	Temporary Dewatering Discharge Rate (m^3/d) For Time Step	Temporary Dewatering Discharge (m^3/d) at End of Time Step
1.59	1.59	150.42	238.91
3.97	2.38	45.79	109.09
7.54	3.57	19.91	71.14
12.90	5.36	11.70	62.71
20.95	8.04	8.31	66.85
33.01	12.06	6.47	78.09
51.10	18.09	5.26	95.21
78.24	27.14	4.36	118.44
118.94	40.71	3.68	149.65
180.00	61.06	3.14	191.64
			Total Temporary Dewatering Discharge (m^3) = 1182
			Average Temporary Dewatering Discharge Rate (m^3/d) = 6.6

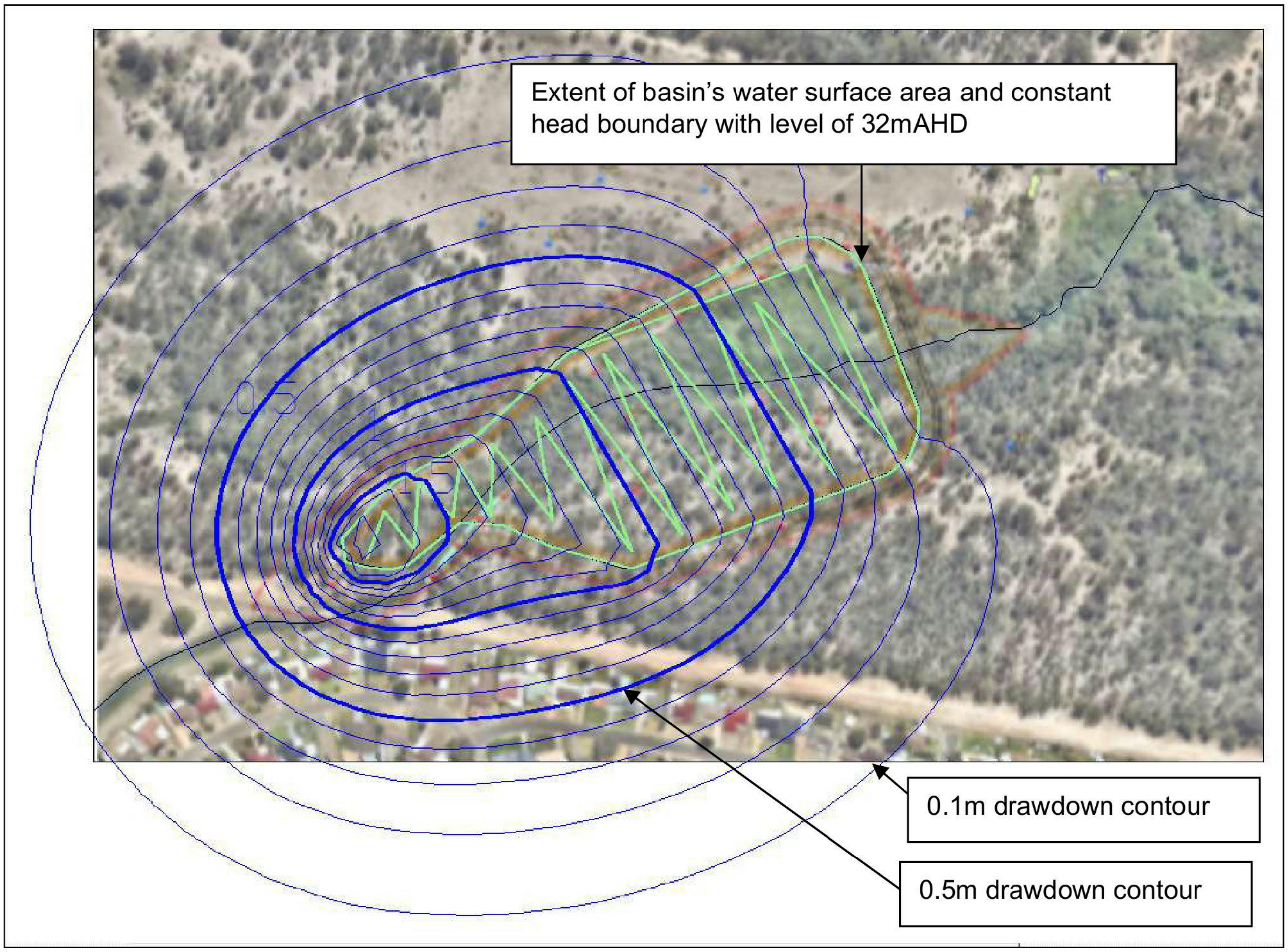

Figure 1: Modelled drawdown contours after 180 days of basin being represented with constant head boundary with level of 32mAHD.

1.4.3 Groundwater Levels & Changes to Flow Regime

To assess the long-term impact of the proposed basin on groundwater levels, an additional model run with the same duration of 180 days was completed with the basin's constant head boundary at a level of 34mAHD, the basin's stated 'permanent water level' on design plans.

The -1m drawdown contour (Figure 2) (i.e. 1m mounding contour) occurs at maximum distance from the basin water edge of approximately 73 m, indicating that localised water table mounding will likely occur surrounding the basin if the basin's water level is continually maintained above the pre-basin groundwater level. We note that as the model has no recharge, the mounding (and drawdown) extent is limited by the simulation time of 180 days. A longer simulation time would result in a more expansive mound, which would expand with time until the model's boundaries were met. Notwithstanding this, the nominal period of 180 days is considered suitable to gauge potential mounding extent/impacts.

Given the proposed basin bed/banks will comprise compacted clay, which is anticipated to be of lower permeability than surrounding material, in reality it is expected that the proposed basin will not be hydraulically well connected with the surrounding groundwater system. Therefore, mounding impacts are expected to remain localised and less than modelled.

With the exception of some semi-radial flow away from the eastern extent of the basin, the broader flow pattern remained unchanged. That is, the broader groundwater flow direction remained north east.

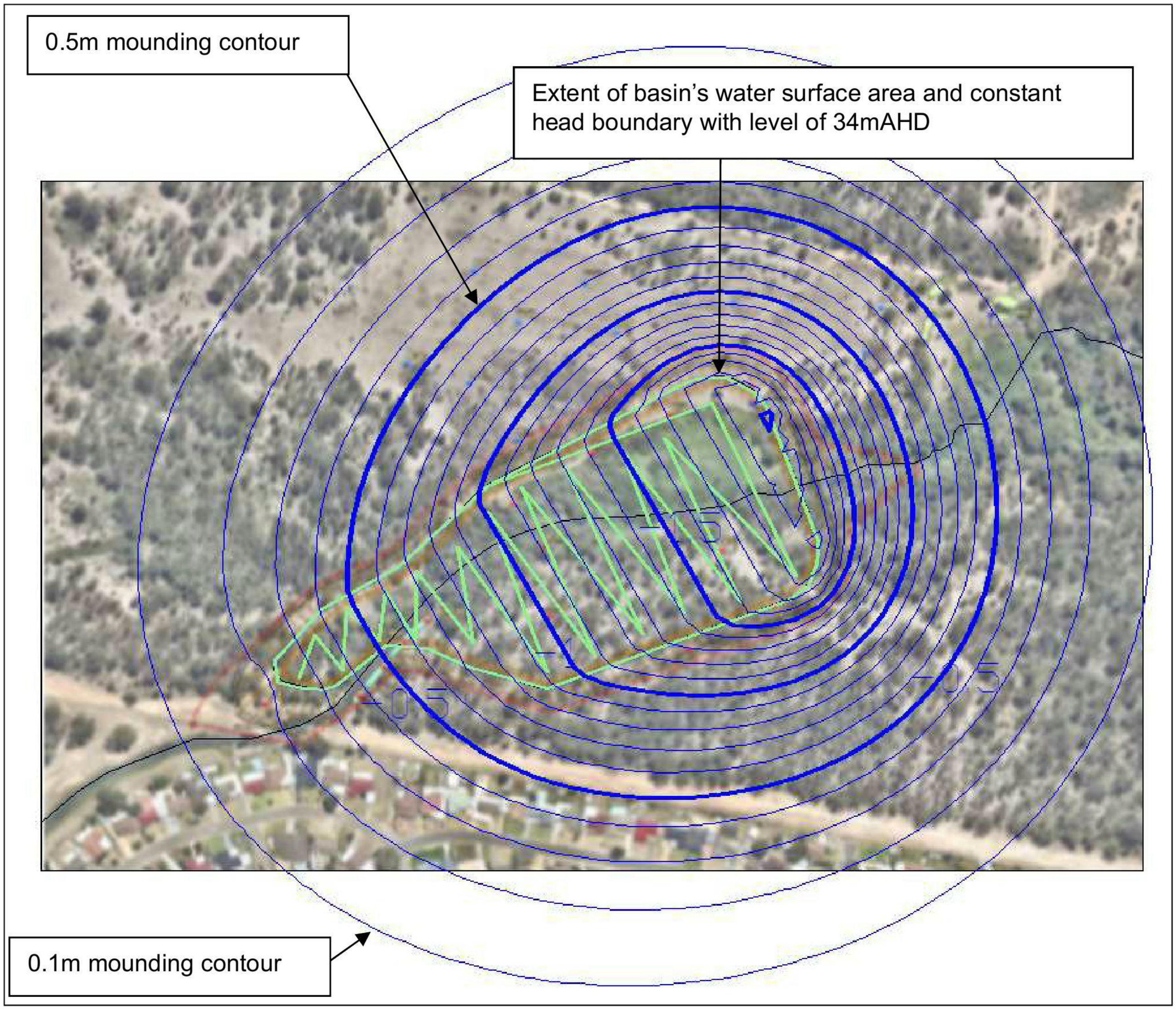

Figure 2: Modelled mounding contours after 180 days of basin being represented with constant head boundary with level of 34mAHD (the design permanent water level). The negative drawdown contours represent water table mounding from pre-development conditions.

1.4.4 Existing Bores

In accordance with the NSW Aquifer Interference Policy (2012), as temporary construction and long-term drawdown impacts are <2m, minimal impact considerations relating to surrounding bores will be met.

1.4.5 GDEs and TEC

In accordance with the NSW Aquifer Interference Policy (2012), as no high priority GDEs are mapped near the basin, minimal impact considerations relating to GDEs will be met.

The modelled water table changes presented in this report should be assessed by an ecologist such that potential impacts to the TEC and/or non-high priority GDEs (if present) in the vicinity of the basin can be evaluated. However, as the drawdown and mounding contours in the area surrounding the basin are for most areas considered likely within the range of natural groundwater level variation, and as the basin water and therefore mound water salinity will likely be relatively low, the water table changes are considered acceptable, subject to confirmation by an ecologist.

1.4.6 Creek & Groundwater Quality

With the exception of salinity, water quality of basin water is anticipated to be similar to that of background groundwater quality. The salinity of basin water is anticipated to be markedly lower than that of the groundwater system. As such, no significant long term adverse impacts to creek and groundwater quality are likely.

During construction, the temporary dewatering flows will likely be highly saline and therefore may not be readily suitable for discharge to the drainage line at the basin's outlet. As dewatering inflows are modelled to be low, we recommend the sump area of the excavation is maximised in order to achieve maximum evaporative losses. Therefore, the volume of water requiring discharge will be minimised. Alternatively, the salt concentration could be reduced through dilution with direct rainfall and catchment flows into the basin. Other options to manage the potential disposal requirement of saline water include dilution with fresh water sourced from off the site (i.e. trucked in), or offsite disposal to an appropriately licensed facility.

The proposed basin is not expected to lower the beneficial use category of the groundwater system.

1.4.7 Soil Salinity

Soil salinity is outside the scope of this report. However, impacts to soil salinity and subsequent impacts to receptors such as vegetation (e.g. the TEC) may occur locally due to water table mounding. We recommend this be assessed.

1.5 Water Licensing

Approval from NSW DI will be required for the temporary construction dewatering. Such an approval typically requires submission of an 'Application for approval for water supply works, and/or water use', complying with a dewatering checklist, preparation of a dewatering management plan and payment of a government fee of approximately $1.1K. We understand government processing time would be approximately 4 to 6 weeks. Jacobs can assist with lodging this application and preparing the dewatering management plan.

1.6 Conclusion

Assessment indicates proposed Basin I will result in minimal impacts to groundwater in accordance with the NSW Aquifer Interference Policy (2012). The proposed basin is not expected to lower the beneficial use category of the groundwater.

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Groundwater specific mitigation measures are not considered necessary for the proposed basin.

We recommend:

1. Modelled water table changes in this report are assessed by an ecologist to evaluate potential impacts to the Threatened Ecological Community (TEC) - River-flat Eucalypt Forest (in the form of Alluvial Woodland) and/or non-high priority GDEs (if present).

2. Soil salinity impacts to receptors such as vegetation arising due to water table mounding are assessed.

Monitoring well BI-MW-02 should be retained and maintained throughout construction and operation of the basin, to allow for groundwater quality sampling and/or groundwater level monitoring to be undertaken, should the need arise.

1.7 References

Australian Defence Industries (1996) – referenced in JBS&G (2018) text but full reference omitted

from report. Full reference is unknown.

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