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Hydrogeological Assessment

Googong Foreshore Interface Management Strategy - Neighbourhood 4 and 5

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List of Abbreviations and Acronyms

Abbreviation/	Description
ACT	Australian Capital Territory
BOM	Bureau of Meteorology
COA	Conditions of Approval
CRD	Cumulative Rainfall Departure – calculated in the method described by Ferdowsian et al (2001)
CEMP	Construction Environmental Management Plan - A site or project specific plan
DO	Dissolved Oxygen
DEC	Department of Environment and Conservation
EC	Electrical Conductivity
EP	Equivalent Population - Term used to describe sewage generation based on
EP&A Act	Environmental Planning and Assessment Act
GFIMS	Googong Foreshore Interface Management Strategy
GWMP	Groundwater Monitoring Program
IWC	Integrated Water Cycle
ha	hectares
ID	Identification – refers to name of element
L/sec	Litres per second (flow)
m	Metres
mAHD	Meters (Above) Australian Height Datum
mBGL	Meters Below Ground Level
m/day	Meters per day (hydraulic conductivity unit)
mg/L	Milligrams per litre
mTOC	Meters below Top of Casing
NA	Not Assessed / Not Applicable
NH	Neighbourhood (of Googong Township)
NR	Not recorded
NS	No Sample – refers to not enough for sample collection
PTWL	Pink Tailed Wormed Lizard

Abbreviation/	Description
PVC	polymerization of vinyl chloride – a type of pipe
QPRC	Queanbeyan-Palerang Regional Council
RAB	Rotary Air Blast
RL	Relative Level, generally referenced to mAHD
SOC	Statement of Commitments
SMEC	Snowy Mountains Engineering Company – SMEC Australia Pty Ltd
SPS	Sewage Pumping Station
STP	Sewage Treatment Plant
SWL	Standing Water Level
UTM	Universal Transverse Mercator – coordinate system
WMP	Water Management Plan (RPS, 2018)
WRP	Water Recycling Plant
WSG	World Survey Grid 1984

1 Introduction

Googong Township is located approximately 8 km south of Queanbeyan and 14 km south-east of Canberra, near the Googong Reservoir in New South Wales (Figure 1-1 and Figure 1-2). The Googong Township is a planned housing development for about 18,850 people or Equivalent Population (EP) and is being developed over the next 25 years. The township is designed around an integrated water cycle (IWC), with a dedicated Water Recycling Plant (WRP) that will reduce the consumption of potable water in the community by around 60 per cent and recycle the township's water for non-potable use. The Googong IWC Project is being constructed and operated in stages to ensure the infrastructure is appropriately sized to meet the incremental level of demand as development of the Googong township progresses.

The stages of development are summarised as:

- Stage 1A and 1B, which was completed in Late 2016 for WRP and designed for 4,700 EP;
- Stage C which was completed in November 2019 and included the Stage C WRP for 9,400 EP; and
- Stage D the ultimate capacity of the project which is planned for 18,850 EP.

Concept Approval for the ultimate development subject to future environmental assessment requirements, was granted by the Minister for Planning under Part 3A (now repealed) of the Environment Planning and Assessment Act 1979 (EP&A Act). The township's Water Management Plan (WMP) prepared by RPS (2018) outlines the baseline and operational phase monitoring requirements for groundwater. The two-year operational phase monitoring is currently conducted by SMEC Australia Pty Ltd (SMEC), on behalf of Queanbeyan Palerang Regional Council (QPRC).

Stage D required a hydrogeological assessment to address the requirements of the Part 3A Concept Approval and requirements for project approval under the EP&A Act. It incorporated all neighbourhoods, sporting grounds and open spaces for irrigation, both current and planned.

SMEC Australia Pty Ltd (SMEC) was engaged by Eight Mile Planning on behalf of Googong Township Priority Limited (GTPL) to prepare this Hydrogeological Assessment (HA) to support a development application for a variation to the approved Stage D in the dam catchment protection zone of Neighbourhood 4 and 5 (NH45).

1.1 Part 3A Concept Plan Approval Requirement

Section 2.1 of the Part 3A Concept Plan Approval outlines:

Pursuant to section 75P(2)(c) of the EP&A Act, the following environmental assessment requirements apply with respect to any future development that is subject to Part 4 or Part 5 of the EP&A Act (which are not exempt or complying development), for the subsequent project stages:

- h)** assessment of the following key issues considering all components of the project (including temporary construction facilities) and cumulative impacts from other projects associated with the Concept Plan:
 - **Groundwater** – including potential impacts on local recharge levels, contamination risks, groundwater mounding, isolated waterlogging of soils and impacts on groundwater quality
- j)** the environmental assessment of the project must take into account relevant State Government guidelines, policies and plans; and
- k)** the assessment of the subsequent project stages shall take into account, but not limited to the following guidelines as relevant;
 - *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000);*
 - *National Water Quality Management Strategy – Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (NRMMC, 2006) and*
 - *Environmental Guidelines: Use of Effluent by Irrigation (DEC, 2004).*

1.2 Scope of Work

The scope of work for this HA consisted of:

- comparison of Stage D HA masterplan with the GFIMS planning proposal for NH 4 and 5;
- desktop assessment of groundwater in the GFIMS planning proposal area; and
- summary of potential impacts of the development to groundwater.

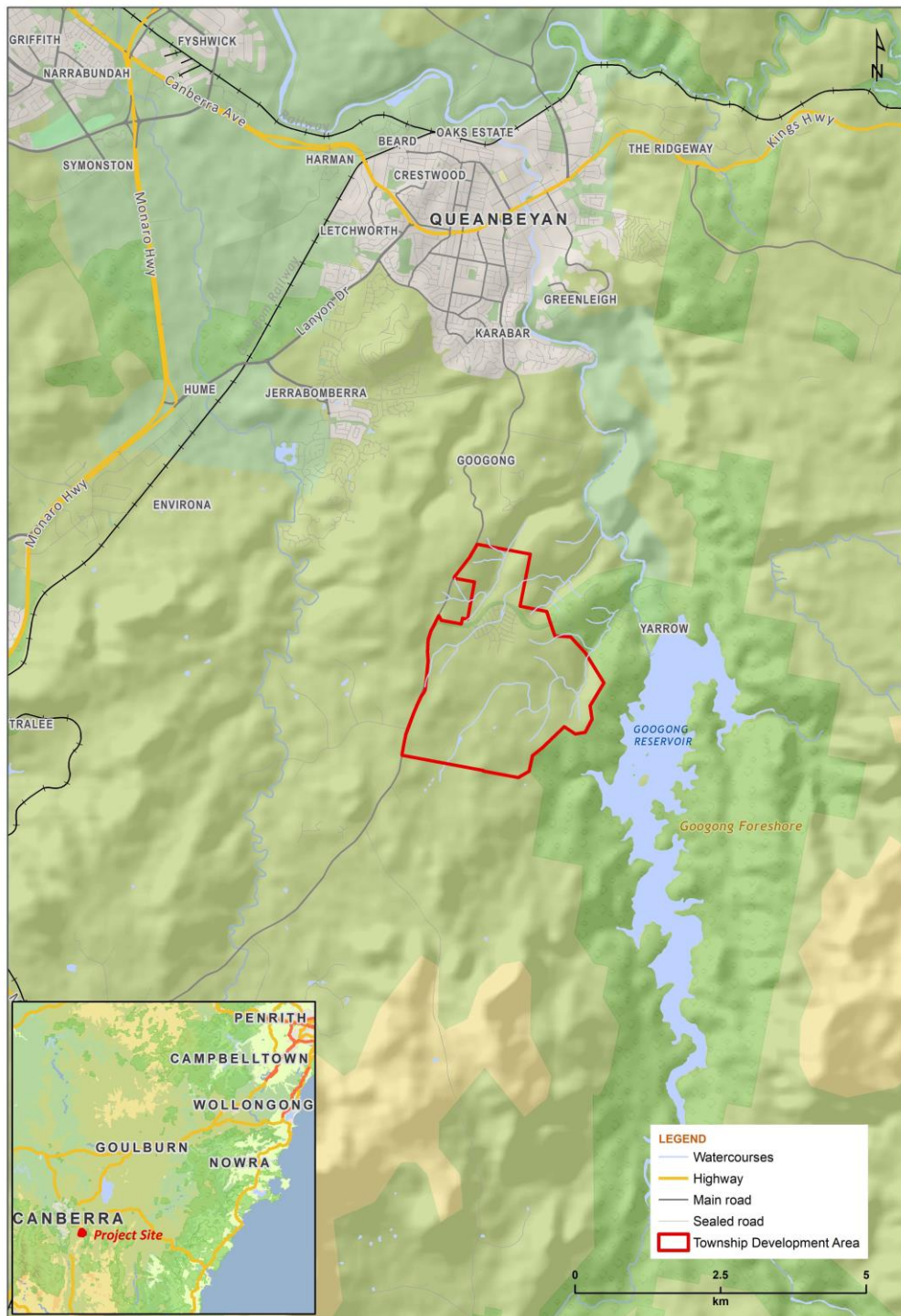


Figure 1-1 Googong township regional location

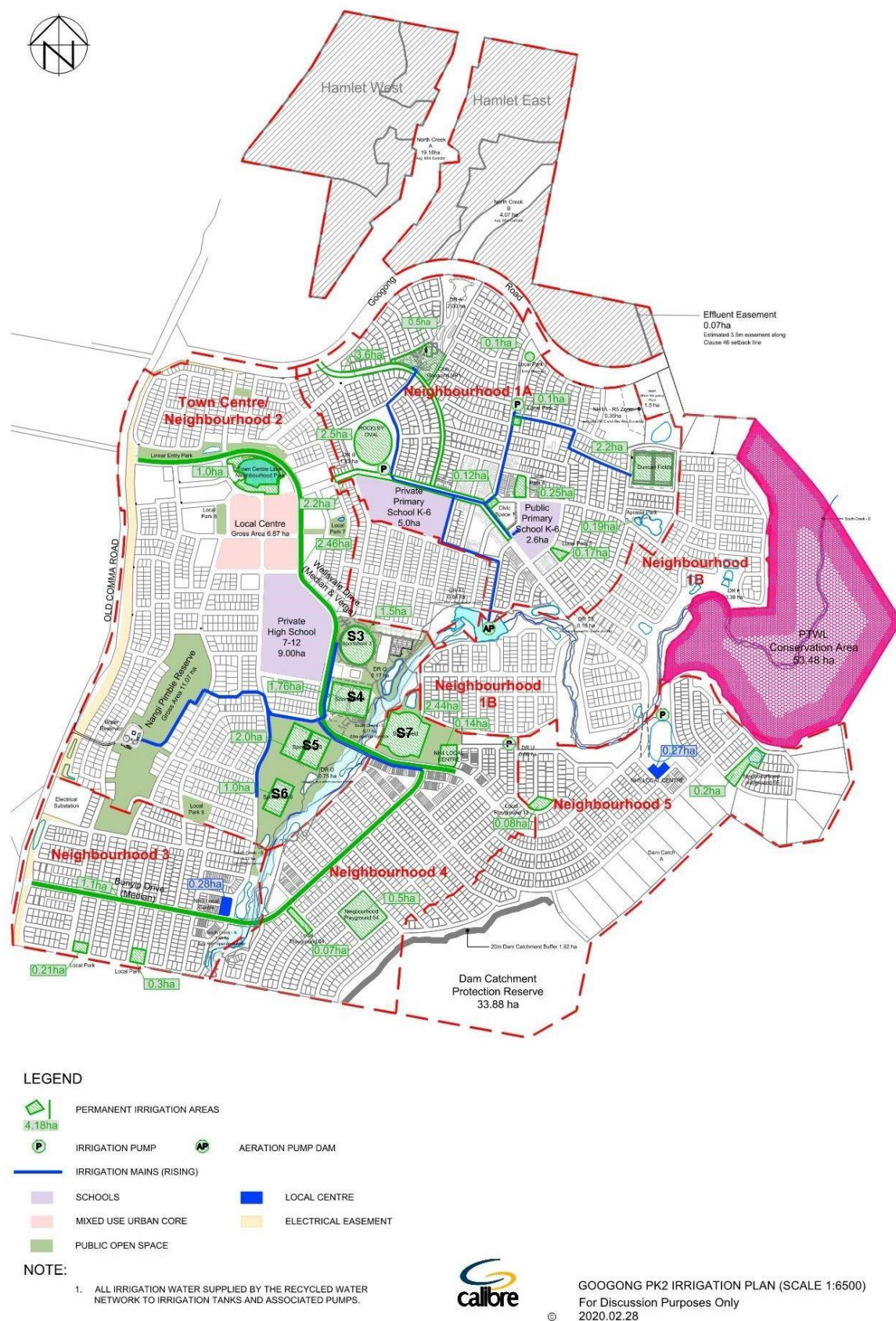


Figure 1-2 Stage D Googong township masterplan with neighbourhood developments, open spaces and protection areas

1.3 Googong Foreshore Interface Management Strategy

A Planning Proposal is being prepared seeking minor amendments to the Queanbeyan Local Environmental Plan 2012 (QLEP 2012) as it applies to certain land in Googong (the Site) within the Queanbeyan-Palerang Local Government Area (LGA).

The proposed amendments to the QLEP 2012 aim to rationalise the development boundary in response to the Biodiversity Certification of land that is currently zoned for urban uses to ensure that planning controls are aligned with the conservation objectives of Googong. Certain areas of residentially zoned land will be zoned conservation and a small area of land within the Googong Foreshore Interface Management Strategy (GFIMS) area to the south and east of Neighbourhood 1B and Neighbourhoods 3-5 of the Site is proposed to be rezoned for residential uses. The proposed changes will facilitate the delivery of development yield identified for the Site in the Googong Masterplan.

The Planning Proposal seeks to amend the Land Use Zoning and Minimum Lot Size controls and maps under the QLEP 2012 as detailed below.

Land Use Zoning maps:

- Rezone the Pink Tail Worm Lizard (PTWL) conservation area located to the east of the Site to C2 Environmental Conservation, currently zoned R5, to better align the intended use of the subject land with the objectives and the purpose of the conservation area; and
- Adjust the boundaries between C2 and R1 zoned land along the south-east side and eastern corner of the Site to follow the amended Site boundaries as a result of the recent approvals and applications under assessment by the Queanbeyan Palerang Regional Council.

Minimum Lot Size map:

- Adjust the boundaries and area of land within the minimum lot size requirements of 80 Ha and 1.5 Ha along the south-east side and eastern corner of the Site to follow the amended Site boundaries as a result of the recent approvals and applications under assessment by the Queanbeyan Palerang Regional Council.
- Change the minimum lot size requirement for R5 zoned land along the south-east side of the Site from 1.5 Ha to 600 sqm.

The proposed changes under this application will facilitate the realignment of the dam catchment boundary, subject of a separate application, to increase the area of the developable land within the Site. In seeking approval for the development of Neighbourhoods 3, 4 and 5 GTPL lodged a Biodiversity Certification Assessment Report (BCAR) with the NSW Department of Planning and Environment (DPE). As part of the approval process GTPL has been required to set aside as reserve a significant area of land previously identified for residential development in order to avoid impacts on the BC Act listed Box-Gum Woodland threatened ecological community. The additional developable land that will be released as a result of the realignment of the dam catchment boundary is to compensate the yield loss that previously occurred to protect areas of high environmental value. The area previously identified as high environmental value is now subject to BCAR and as such can be used for development purposes.

The regained development yield is consistent with the development yield planned for the Site under the Googong Masterplan.

The proposal is consistent with and gives effect to the Queanbeyan-Palerang Local Strategic Planning Statement (LSPS). It delivers on Planning Priority 6 and Action 4.6.3 of the LSPS that require opportunities for high quality environmental vegetation in Queanbeyan Palerang Regional Council (QPRC) area to be proactively conserved as part of recent biodiversity reforms. The proposal will support the potential redevelopment of land that does not contain any identified environmental attributes to meet the social, economic, and residential needs of the community. The expected outcomes of the proposal represent a more efficient use of available land within the LGA.

2 Regional Setting

2.1 Googong Township

Googong Township is located approximately 8 km south of Queanbeyan, in NSW at the intersection of Old Cooma Road and Googong Road (Figure 1-1). Googong Reservoir is located approximately 600 m to the east of the eastern boundary of the township.

2.2 Climate

Climatic data is available from:

- Queanbeyan Bowling Club for rainfall from station number 070072 to 31 October 2015;
- Wickerslack Gauge for rainfall station number 570983 from August 1973 on the Queanbeyan River;
- Googong Township Weather station from September 2013 to December 2020; and
- Canberra Airport (in the ACT) evaporation from station number. 070014.

These are the closest stations with long term records held by the Bureau of Meteorology. On-site a weather station records data which is available between September 2013 and December 2020 for rainfall, wind speed, wind direction, minimum and maximum temperature, solar radiation and minimum and maximum relative humidity. There is no on-site evaporation data and some months have incomplete records. The baseline hydrogeological data (collected between 2013 and 2016) was collected during a period of average to below average rainfall conditions and subsequent monitoring data has been collected during both above average and below average rainfall conditions. This should be considered during any interpretation of results and trends.

The Googong climate is temperate and characterised by warm dry summers and cold winters. Average annual rainfall at the Googong Township, from the township weather station between 2014 and 2020 is approximately 612 mm compared to 597mm at Wickerslack and the 620 mm annual average for the region. Rainfall is variable and can be subject to prolonged periods of above or below average rainfall with the winter months generally being slightly drier. Figure 2-1 presents the mean, median and monthly total in 2020 from the Googong Weather Station and rain gauge at the Wickerslack location on the Queanbeyan River to the north of the site and at the Wickerslack gauge for 2021. Rainfall is generally higher in the spring and summer months. It should be noted that the Googong Township weather station has a limited dataset for statistical analysis, and this should be considered when comparing results.

Climate statistics from Canberra Airport show the mean temperatures range from -0.1°C to 12°C in winter to 13 °C to 34.5°C. Mean temperatures at Queanbeyan are within the range of 13-27°C during summer and 0.5-12° C in winter. The Googong township weather station shows between September 2019 and December 2020 the mean temperature ranges from 6-30°C in summer and 0.4-20°C in winter.

The cumulative rainfall departure (CRD) compares the cumulative monthly rainfall with the long-term average. The CRD is calculated for Wickerslack, Tuggeranong and Queanbeyan weather stations (Figure 2-2). Wickerslack is the the closest rainfall station with a long record of data and shown where practical on figures within this report. It was not calculated for Canberra Airport or Googong Township weather station as they have only been in operation for a shorter period. The CRD is most effective where more than 50 years of continuous records exist. On Figure 2-2 and other figures within this report showing the CRD it is the slope of the line that is important not the numerical value.

Figure 2-2 shows generally the same trends for periods of above or below average rainfall, with a prolonged period of below average conditions occurring between 2002 and 2010 at all three locations. From 2010 to 2020, the trend at Wickerslack is generally average rainfall conditions, with short periods of below average conditions before the start of another period of above average rainfall from mid-2020 to present. The baseline groundwater data was collected during a period of below average rainfall conditions and subsequent monitoring data has been collected

during both above average and below average rainfall conditions. This should be considered during any interpretation of results and trends.

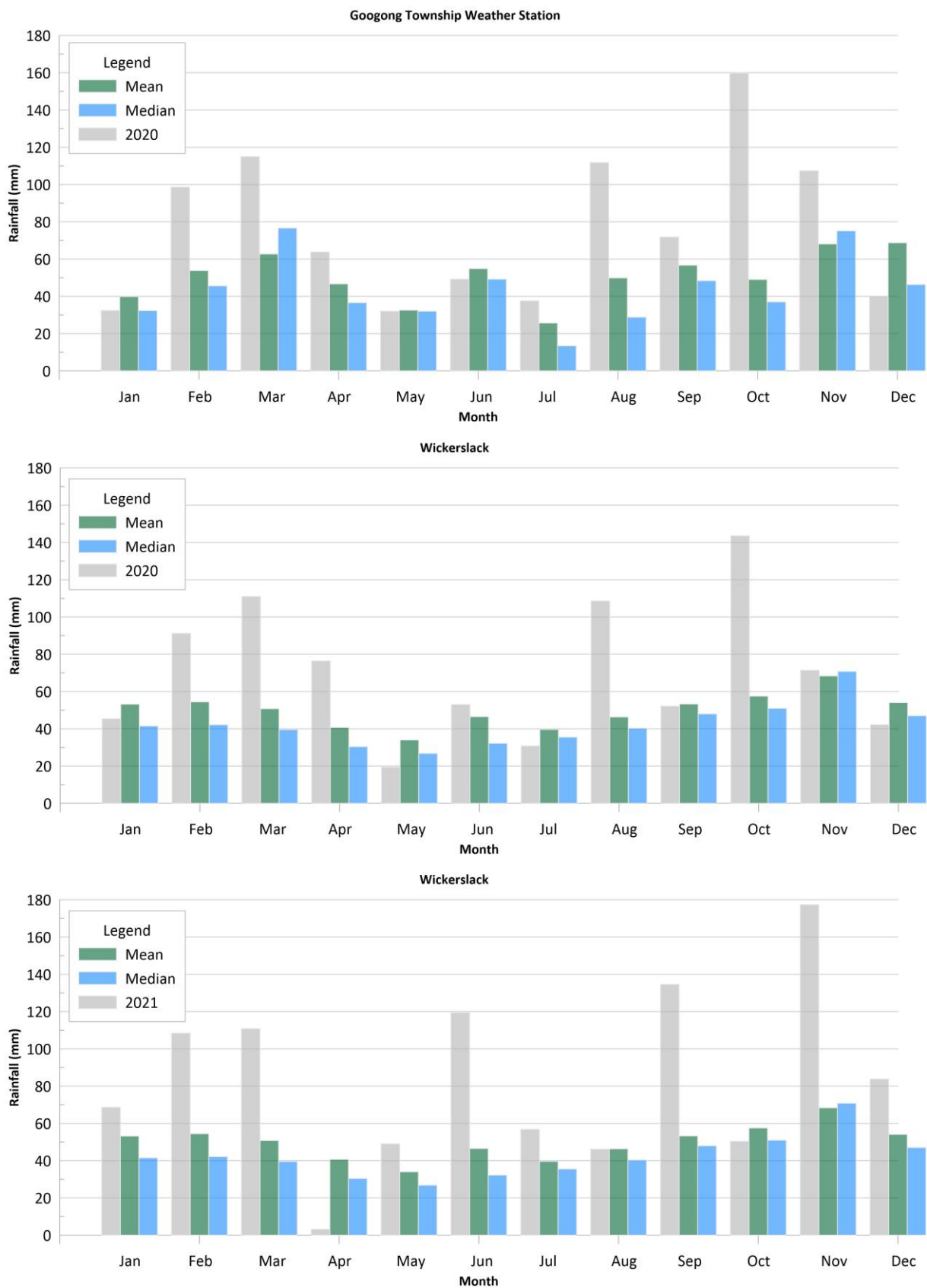


Figure 2-1 Monthly rainfall distribution at Googong township weather station for 2020 for monthly rainfall summary with mean and median results

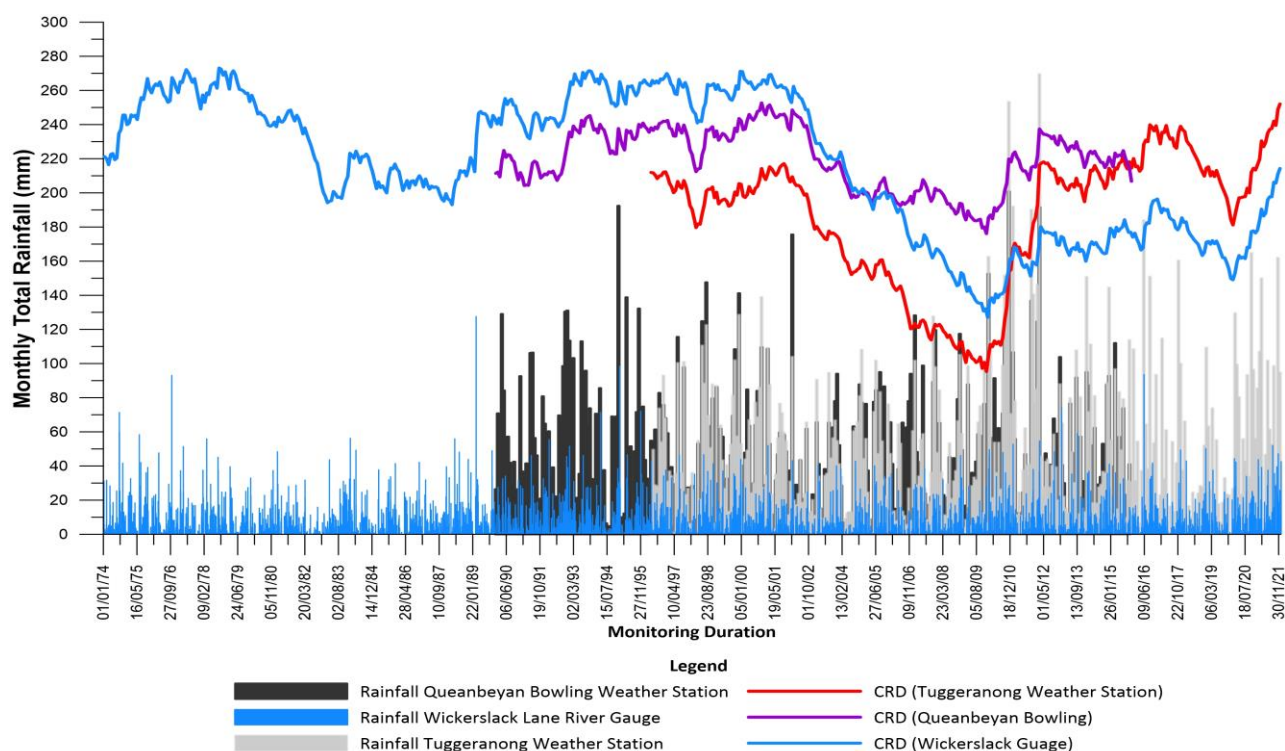


Figure 2-2 Monthly rainfall and cumulative rainfall departure from 1990 to July 2021

2.3 Topography and Drainage

The township of Googong is located on a highland plateau with elevations ranging from 650 mAH to 800 mAH. The area is characterised by the ongoing Googong Township development and low-intensity grazing land, natural bushland, and rural residential land uses. The surface water drainage for the developed neighbourhoods is controlled by the township design and contained within the IWC. Within the developed open spaces, such as Beltana Pond the surface run-off is towards the drainage creek and pond. For areas yet to be constructed the current surface water flow and drainage is controlled by the existing topography and drainage creeks.

Part of the township is located within the Googong Reservoir water supply catchment. Topographically the township's surface water catchment is bounded by Old Cooma Road to the west, Googong Dam to the east and elevated land between Wells Place and Burra Road to the south of the site as shown on Figure 2-3. Within the township catchment area are three named water courses:

- South Creek / Montgomery Creek;
- North Creek (located between Hamlet West and Hamlet East); and
- Googong Creek.

These water courses join the Queanbeyan River north of the township and their catchment boundaries are shown on Figure 2-3 with the townships surface water monitoring locations. Within NH5 and within the Dam Catchment protection zone there is a small surface water catchment and drainage line that drains east to Googong Reservoir.

2.4 Regional Geological Setting

General information sourced from the Geological Survey of New South Wales and Bureau of Mineral Resources shows the region is underlain by the Colinton Volcanics, a late Silurian aged volcanic unit within the Canberra block, part of the Lachlan Fold Belt. The Lachlan Fold Belt (LFB) is a 700-kilometre-wide belt of deformed, Palaeozoic, deep and shallow marine sedimentary rocks, cherts and mafic volcanic rocks. Surface structural elements suggest that it was formed by massive telescoping and strike-slip translation within a continental margin sediment prism along the former eastern margin of Gondwanaland during the mid-Palaeozoic.

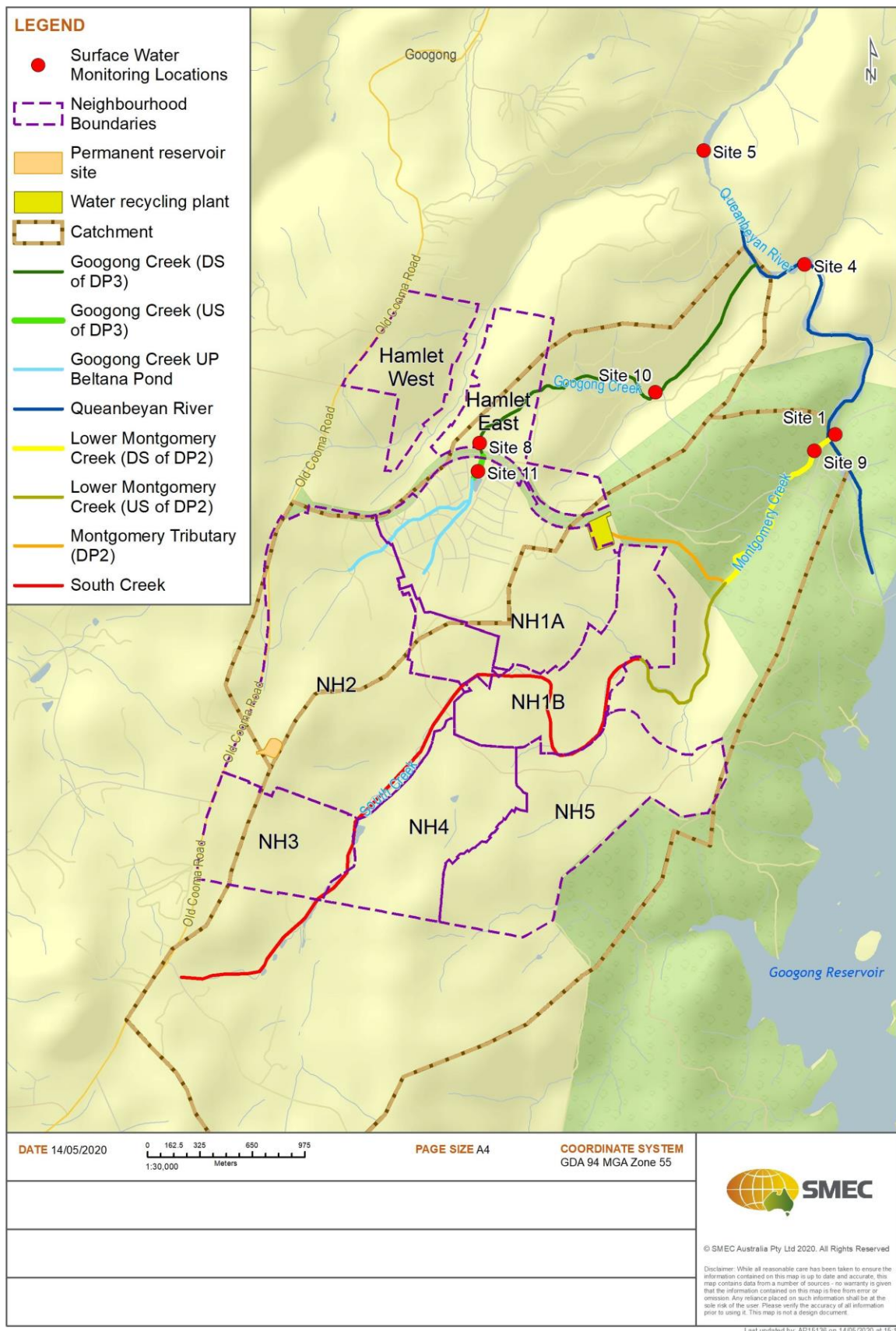


Figure 2-3 Googong IWC Project Stage D works and neighbourhood boundaries with surface water catchment boundaries and surface water monitoring locations

During the Devonian (and to a lesser degree the Carboniferous) the introduction of granites and associated batholiths – such as the Ellenden, Gibraltar and Rossi Granites of the Bega Batholith to the east and south-east of the study area – marked the LFB's transition from an immature depositional basin comprising poorly sorted volcanoclastic sediments and airfall tuffs, towards a mature continental margin with the development of complex sedimentary deposits and explosive volcanic events. As a result of the numerous tectonic movements throughout the LFB's 'active' duration, the geological units throughout most of the fold belt have undergone multiple deformation events. In general, a strong regional tectonic inclination – from north-north-west to south-south-east – dominates the alignment of structures and geological units, particularly in the central and northern portions of the fold belt. In the Googong–Queanbeyan districts, however, the dominant tectonic inclination is north north-east–south-south-west (Figure 2-4).

The township (Figure 2-5) is underlain by the Colinton Volcanics, a unit of Silurian age. The Colinton Volcanics typically comprise limestone and dolomitic limestone, dark green dacitic ignimbrite and minor volcanoclastic sediments. The Stage AB field investigation encountered shale and dacite during the monitoring bore drilling program. A reef of igneous rock is exposed at the surface outside the south-eastern corner of the site and runs on about the line of the north-eastern boundary of the site. The north-eastern corner of the township, where the WRP is situated, is underlain by the Googong Adamellite, a locally significant intrusive body that is described as a medium to coarse-grained, moderately weathered, buff-coloured porphyritic adamellite. It is the youngest unit in the area, having been intruded into the surrounding Colinton Volcanics, and appears to have faulted boundaries. Hill 800 reservoirs are located on the Colinton Volcanics in the south-west of the site. Drilling of GGW6, located nearby, encountered a thin layer of shale over dacite.

2.5 Hydrogeology

Review of hydrogeological datasets within the Geoscience Australia Portal and SMEC experience from hydrogeological investigations at the township shows groundwater is hosted in regionally extensive fractured-rock aquifers. The fractured rock aquifers are classed as non-saline with hydraulic conductivity ranging from 0.5 to 5 m/day.

Minor alluvial aquifers are located along the alignments of locally significant waterways such as the Queanbeyan River, Googong Creek and Montgomery Creek, and they are expected to have minimal storage and not to be of significance to this assessment. The depth to bedrock across much of the Googong Township is between 0.5 m and 2 m, with fresh bedrock encountered at shallower depths at higher elevations, commonly marked by changes in slope. Shallow groundwater migrates along the interface between the soil horizons and relatively fresh bedrock, and discharges to surface water drainage lines and creeks. The regional groundwater flow direction is north-east towards the Queanbeyan River. Shallow groundwater flow direction is towards local drainage lines and creeks.

2.5.1 Aquifer Types

An assessment of private borehole summary worksheets, township monitoring bore logs and Geoscience Australia Portal indicate that groundwater, in the vicinity of the township, is hosted in a regionally extensive, unconfined to semi confined fractured rock aquifer. On the site these are associated with limestone, granite intrusions and volcanics. Structural features thought to be significant to groundwater flow at the site include local and regional faults, joints, fractures and cleavage.

2.5.2 Groundwater Recharge

Rainfall recharge of fractured-rock aquifers occurs through areas of open fracturing, either at the surface or through superficial unconsolidated material. In the latter case, there may be a delay between a rainfall event and the entry of water into the aquifer, due to storage in the unconsolidated material of the recharge zone. Recharge of the aquifers would occur mainly via infiltration of rainfall, infiltration of slope runoff, and outflow from the Queanbeyan River and Jerrabomberra Creek (and other watercourses) during periods of high flow and flooding events. Overall, recharge in the area is expected to be limited by the generally low rainfall, particularly during winter months.

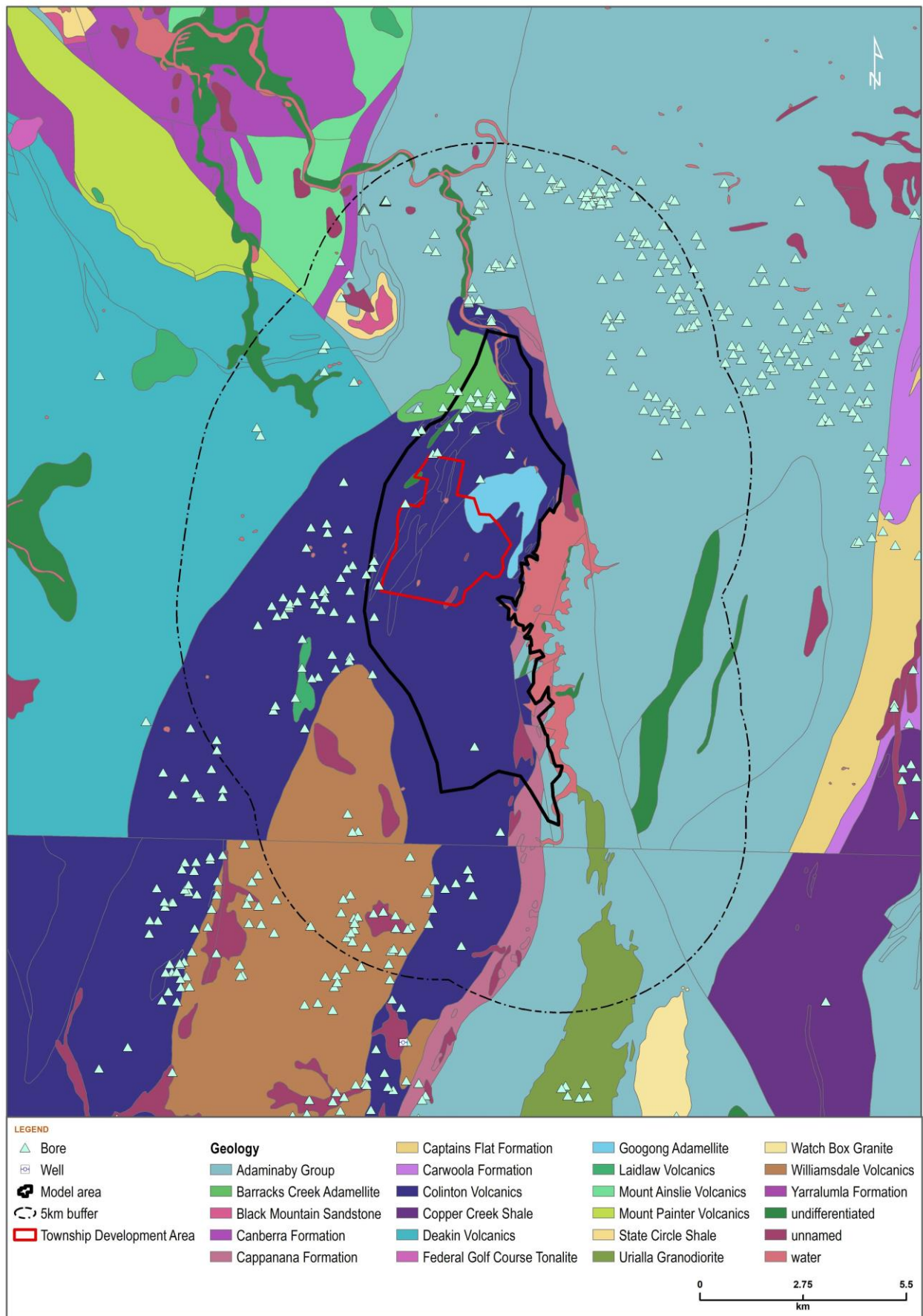


Figure 2-4 Regional geology map showing Googong Township and registered private bores

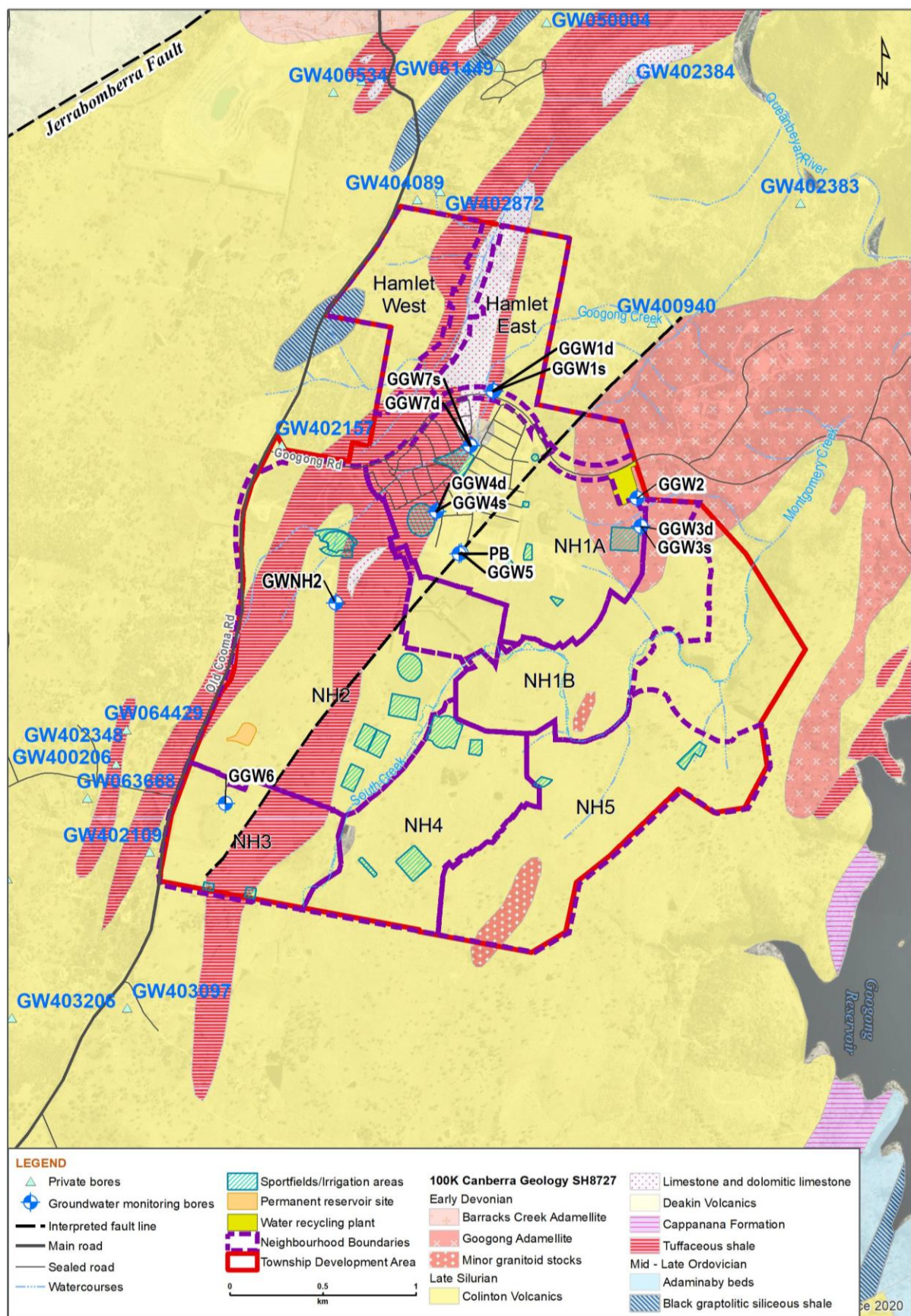


FIGURE TITLE Location of Groundwater Monitoring Bores, Googong Township

Figure 2-5 Googong Township geological map with township groundwater monitoring bore locations and registered private bores

2.5.3 Groundwater Discharge

Discharge from the fractured rock aquifer is primarily through natural flow from springs, both perennial and ephemeral, and from baseflow into perennial watercourses. Other discharges from the aquifer include bore pumping for domestic and stock purposes, whilst some localised irrigation is also possible. A potential spring was observed at the site in the vicinity of the WRP during the baseline groundwater monitoring program and during construction of Rockley Oval found the old dam at the site may have been associated with a groundwater spring. The original assessment for Stage 1 works did not note any springs or 'soaks' but it is noted that the assessment was carried out in a relatively dry period. Commonly in rural farmland springs are often converted into dams.

2.5.4 Groundwater Utilisation / Abstraction

Groundwater is anticipated to be of sufficient quality for general water supply purposes, and it may be suitable for potable use. Groundwater in the area is predominantly used for a combination of domestic and stock purposes. Of the 272 bores located within a 5 km buffer of the township, all but a few are registered for such use, and only a few appear to have achieved yields that would satisfy all the water requirements of a property without some form of reliance on surface water supplies. There are no private bores located within the township. There are five private bores located north of the township (within 1.5 km of the boundary) and three located to the west (within 500 m of the boundary) (Figure 2-4).

2.5.5 Bore Yields and Aquifer Hydraulic Properties

Yields for the registered bore drilled in the Late Silurian aged Colinton Volcanics throughout the Googong region vary from less than 0.1 L/s to up to about 10 L/s, including some into the margins of the Barracks Creek Adamellite. Most of the private bores are in the Colinton Volcanics where yields are more modest and typically range between 0.5 L/s and 1.0 L/s. The higher-yielding bores were drilled in the ignimbrite and metasedimentary units of the Colinton Volcanics, although a few higher-yielding bores have also been drilled along the southern margin of the Barracks Creek Adamellite where natural fracturing and deeper weathering profiles are thought to exist.

Boreholes that have encountered multiple water-bearing zones appear to have markedly higher yields, and in most instances yields appear to increase with depth. The highest-yielding water-bearing zones throughout the area were typically identified at depths of between 20 m and 50 m, beyond which the degree of fracturing is thought to decline markedly, particularly in the Silurian intrusions.

2.5.6 Googong Township Groundwater Monitoring Network

The dedicated groundwater monitoring network (Figure 2-5) has been established at the township since August 2013. The groundwater monitoring network consists of 11 monitoring bores at seven different locations. At four locations nested shallow and deep monitoring bores have been installed. A test production bore was established and tested adjacent to GGW5 before it was decommissioned, and surface works destroyed. GGW2 was decommissioned and surface works destroyed when the WRP expanded its footprint and was replaced with GGW2A. In 2021 a groundwater monitoring bore was found in NH2 and incorporated into the Stage D operational phase monitoring program.

The groundwater monitoring bore completion, construction and survey details are provided in Table 2-1 to Table 2-3. Groundwater bore completion logs are provided in Appendix A.

Table 2-1 Drilling details summary

Bore ID	Date Completed	Total Depth Drilled (m)	Borehole Diameter (mm)	Method	Final Airlift Yield (L/sec)	Screened Lithology	Status
GGW1S	14/08/2013	10.5	120	RAH	NA	Limestone /	Active
GGW1D	13/08/2013	19.0	120	RAH	0.14	Shale /	Active

Bore ID	Date Completed	Total Depth Drilled (m)	Borehole Diameter (mm)	Method	Final Airlift Yield (L/sec)	Screened Lithology	Status
GGW2	20/08/2013	8.0	120	RAB	NA	Adamellite/	Destroyed
GGW2A	20/10/2015	19.2	120	RAB	<0.1	Adamellite/	Active
GGW3S	19/08/2013	7.0	120	RAB	NA	Adamellite	Active
GGW3D	19/08/2013	25.6	120	RAB	0.03	Dacite	Active
GGW4S	27/08/2013	7.0	120	RAB	NA	Shale / Phyllite	Active
GGW4D	26/08/2013	55.0	120	RAB	0.05	Shale / Phyllite	Active
GGW5	20/08/2013	43.0	120	RAB	0.02	Dacite	Active
GGW6	29/08/2013	43.0	120	RAB	0.16	Dacite	Active
GGW7S	5/09/2013	3.0	120	RAB	NA	Fill – sandy clay	Active
GGW7D	5/09/2013	19.0	120	RAB	NS	Shale / Phyllite	Active
PB	12/09/2013	66.0	250	RAB	0.07	Dacite	Destroyed
GWNH2	15/02/2017	14.5	95	NR	NA	Slate	Active

RAB – rotary air blast, NR- not recorded, NA – not assessed

Table 2-2 Bore construction details

Bore ID	Casing Stickup (m)	Screen Interval (mbgl)	Gravel Pack Interval (mbgl)	Bentonite Seal (mbgl)	Backfill (mbgl)	Casing / Screen Size / Type
GGW1S	0.58	7.5 to 10.5	4.9 to 10.5	4 to 4.9	0 to 4	50mm / PVC
GGW1D	0.55	13 to 19	12 to 19	11 to 12	0 to 11	50mm / PVC
GGW2*	0.9	5 to 8	2.7 to 8	1.7	0 to 1.7	50mm / PVC
GGW2A	0.8	7.2 to 19.2	3.5 to 19.2	2.2 to 3.5	0 to 2.2	50mm / PVC
GGW3S	0.48	4.5 to 7	1.8 to 7	1 to 1.8	0 to 1	50mm / PVC
GGW3D	1.03	18.5 to 25.6	16 to 25.6	15 to 16	0 to 15	50mm / PVC
GGW4S	0.79	4 to 7	1.5 to 7	0.5 to 1.5	0 to 0.5	50mm / PVC
GGW4D	0.6	44 to 55	43 to 55	42 to 43	0 to 42	50mm / PVC
GGW5	3.83	32 to 43	27 to 43	26 to 27	0 to 26	50mm / PVC
GGW6	0.68	25 to 43	12 to 43	11 to 12	0 to 11	50mm / PVC
GGW7S	1.052	1 to 3	0.5 to 3	0 to 0.5		50mm / PVC

Bore ID	Casing Stickup (m)	Screen Interval (mbgl)	Gravel Pack Interval (mbgl)	Bentonite Seal (mbgl)	Backfill (mbgl)	Casing / Screen Size / Type
GGW7D	0.7	7 to 19	5 to 19	4 to 5	0 to 4	50mm / PVC
PB	0.5	30 to 66	23 to 66	22 to 23	9 to 22	125mm / PVC
GWNH2	0.74	8.5 to 14.2	7.4 to 14.5	7 to 7.4	0 to 7	50mm / PVC

PVC- polyvinyl chloride pipe

Table 2-3 Bore survey details

Bore ID	Easting (UTM WSG84)	Northing (UTM WSG84)	RL Ground (mAHD)	RL Concrete Base (mAHD)	RL Top Monument (mAHD)	RL Top PVC Casing* (mAHD)
GGW1S	702954.6	6078765.1	723.43	723.54	724.22	724.12
GGW1D	702951.99	6078765.8	723.26	723.33	724.02	723.88
GGW2	703722.77	6078189.8	719.78	719.87	720.97	720.77
GGW2A	703767.12	6078212.2	714.60			715.475
GGW3S	703745.88	6078039.8				723.12 [#]
GGW3D	703745.03	6078037.5				723.20 [#]
GGW4S	702646.37	6078120.3	738.53	738.61	739.62	739.4
GGW4D	702648.54	6078117.95	738.58	738.66	739.38	739.26
GGW5	702779.39	6077894.9				744.60 [#]
GGW6	701513.5	6076548.2	789.04	789.19	789.95	789.87
GGW7S	702830.23	6078473.9	725.66	725.71	726.77	726.712
GGW7D	702828.67	6078472.3	725.97	726	726.84	726.67
GWNH2	702107.01	6077626.1				753.00

Note: the survey details are from September 2014 and for NH2 in My 2020. UTM – Universal Trans Mercator, WSG84 – World Survey Grid 84, RL – Relative Level, mAHD – metres Australian Height Datum, *casing is measuring point RL, # approximate following extension of PVC and to be confirmed by survey

2.5.7 Groundwater Level and Flow

Groundwater is generally present between 4 and 10 m below the ground surface and ranges in elevation from 712.7 mAHD to 787 mAHD. At the nested groundwater locations there is a small separation between the shallow and deep screened aquifer groundwater levels. Within each of these monitoring bores an electronic transducer with data logging capabilities has been installed for monitoring of the groundwater levels and their response to rainfall and long-term weather patterns (Figure 2-6). Groundwater levels generally follow the long-term weather trends with declines in groundwater level during periods of below average rainfall and increases in groundwater level in response to rainfall events and periods of above average rainfall. Table 2-4 presents a summary of the measured groundwater levels for the monitoring bores within the township for January 2020 and June 2021 and Table 2-5 presents a summary groundwater levels for December 2021 and June 2022.

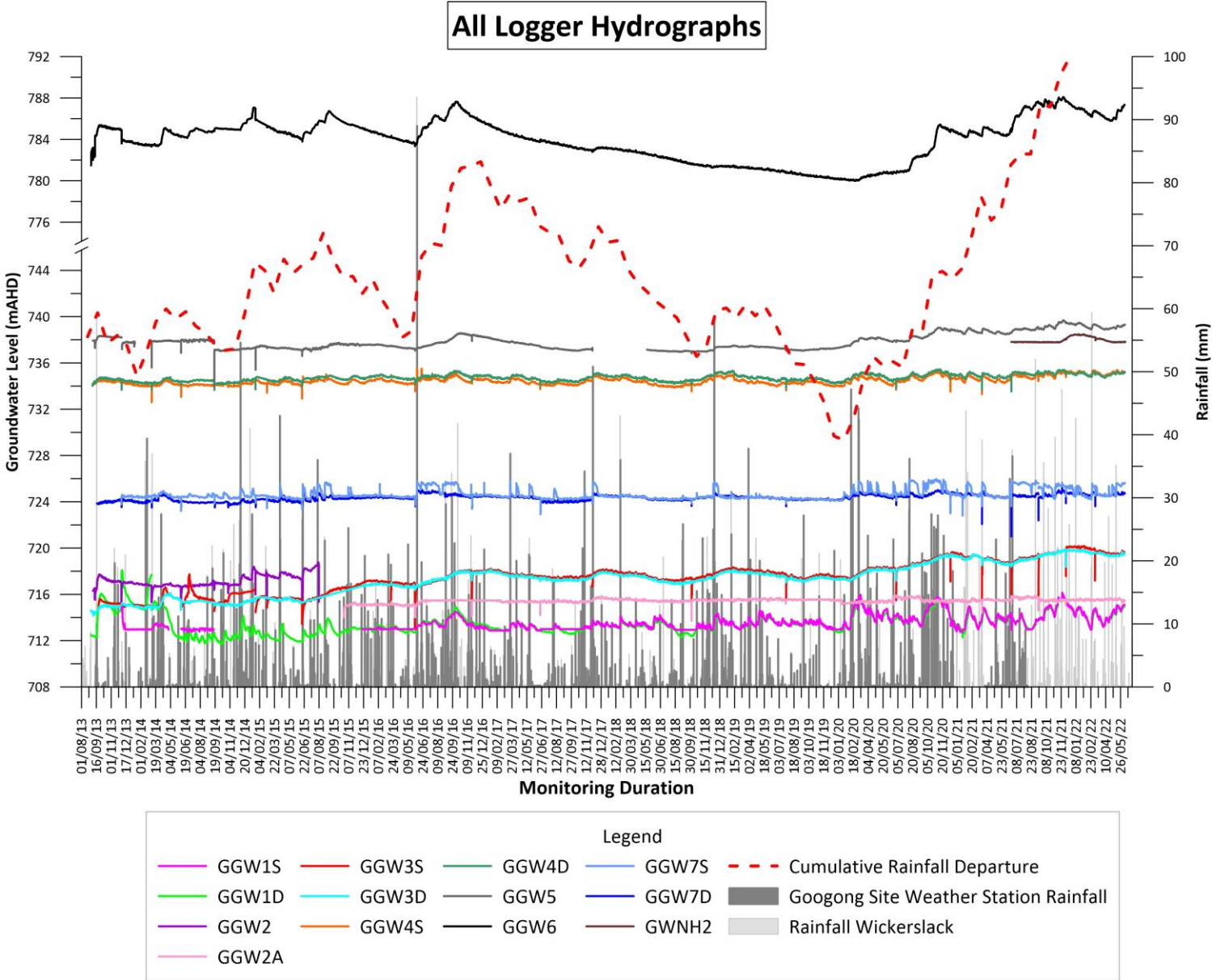


Figure 2-6 Googong Township monitoring bore groundwater level hydrographs

Table 2-4 Groundwater level for January 2020 and June 2021

Bore ID	Date	Manual Measurement (mBGL)	Manual Measurement (mAHD)	Date	Manual Measurement (mBGL)	Manual Measurement (mAHD)
GGW1S	14/01/2020	11.14	712.98	21/06/2021	10.17	713.94
GGW1D	14/01/2020	11.09	712.79	21/06/2021	9.97	713.91
GGW2A	14/01/2020	0.02	715.45	21/06/2021	0.00	715.47
GGW3S	14/01/2020	5.67	717.45	21/06/2021	4.58	718.54
GGW3D	14/01/2020	5.99	717.30	21/06/2021	4.81	718.48
GGW4S	14/01/2020	5.40	734.00	21/06/2021	4.73	734.67
GGW4D	14/01/2020	4.99	734.27	21/06/2021	4.34	734.92
GGW5	14/01/2020	6.50	737.37	21/06/2021	5.26	738.61
GGW6	14/01/2020	9.75	780.12	21/06/2021	4.80	785.07
GGW7S	14/01/2020	2.61	724.10	21/06/2021	1.32	725.39
GGW7D	14/01/2020	2.51	724.16	21/06/2021	2.30	724.37
GWNH2	28/05/2021	dry	-	21/06/2021	dry	-

Table 2-5 Groundwater level for December 2021 and June 2022

Bore ID	Date	Manual Measurement (mBGL)	Manual Measurement (mAHD)	Date	Manual Measurement (mBGL)	Manual Measurement (mAHD)
GGW1S	7/12/2021	8.92	715.20	7/06/2022	9.01	715.11
GGW1D	7/12/2021	8.60	715.28	7/06/2022	8.91	714.97
GGW2A	7/12/2021	0.00	715.47	7/06/2022	0.00	715.47
GGW3S	7/12/2021	3.26	719.86	7/06/2022	3.48	719.64
GGW3D	7/12/2021	3.44	719.85	7/06/2022	3.81	719.48
GGW4S	7/12/2021	4.36	735.04	7/06/2022	4.15	735.25
GGW4D	7/12/2021	4.03	735.23	7/06/2022	4.14	735.12
GGW5	7/12/2021	4.35	739.52	7/06/2022	4.55	739.32
GGW6	7/12/2021	2.12	787.75	7/06/2022	2.53	787.34
GGW7S	7/12/2021	1.50	725.21	7/06/2022	1.09	725.61
GGW7D	7/12/2021	1.88	724.79	7/06/2022	1.97	724.7
GWNH2	7/12/2021	14.90	738.10	7/06/2022	dry	dry

The interpreted regional groundwater contours and regional flow direction is shown on Figure 2-7. Regional groundwater flow direction is north-east towards the Queanbeyan River. Localised shallow 'perched' groundwater flows towards the main drainage lines in the surface water sub-catchments e.g. north towards Googong Creek and east towards Googong Reservoir in NH5 as shown on Figure 2-8 as the shallow groundwater flow path is a subdued version of topography.

2.5.8 Groundwater Quality

Groundwater quality is monitored as part of the township's WMP. The groundwater monitoring parameters are described in the Groundwater Management Plan of the WMP and include:

- Field measurements of pH, electrical conductivity, temperature;
- Laboratory analysis of major ions, total and suspended solids, ammonia, nitrate, total nitrogen, total Kjeldahl nitrogen, alkalinity; and
- Laboratory measurement of dissolved heavy metals: cadmium, chromium, copper, lead, nickel, zinc and total iron and manganese.

Groundwater monitoring has been undertaken at 11 locations as part of the pre-construction phase of Stage 1AB, the results of which are discussed in the SMEC 2014 Annual Groundwater Monitoring Report and subsequent monitoring is in accordance with the WMP and presented in the SMEC 2017, 2019 and 2020 Annual Factual Monitoring Reports. Monitoring data has been provided by QPRC for the period May 2020 and June 2022.

Monitoring data shows the following field groundwater quality ranges:

- Field EC (shallow): 425 $\mu\text{S}/\text{cm}$ to 2168 $\mu\text{S}/\text{cm}$;
- Field EC (deep): 425 $\mu\text{S}/\text{cm}$ to 2887 $\mu\text{S}/\text{cm}$;
- Field pH (shallow): 6.23 to 8.83; and
- Field pH (deep): 5.81 to 8.3.

The groundwater chemistry results indicate the water type is generally bicarbonate dominate, sulphate type with variable metals. Changes in the water type likely reflect natural variations or the act of sampling. Within each monitoring location the groundwater chemistry plots show a general cluster of consistent results each monitoring round (Figure 2-9 and Figure 2-10) with minor variations likely reflecting seasonal influences and the prolonged period of below average rainfall. From June 2020 monitoring of the groundwater spring discharge at the WRP commenced. The spring chemistry results are similar to GGW2 which was located near that spring. GGW4S and GGW4D plot as two distinct clusters of points, reflecting the difference between the weathered shale and fresh shale. Nutrients observed in the groundwater likely reflect the rural land use history of the site and up-gradient land use.

2.6 Surrounding Land Use and Potential Receptors

The land use surrounding the township of Googong is rural farmland to the north, west and south and Googong Reservoir to the east. The receiving surface water environments consist of the ephemeral creeks which flow into the Queanbeyan River and Googong Reservoir.

2.7 Geophysics

In 2009 Agsol undertook surface geophysical mapping using EM-31 and EM-38 ground conductivity meters. The conductivity results reflect the soil composition (e.g. clays), soil moisture, soil salinity and shallow groundwater. Moderate to high conductivity (green to yellow colours on Figure 2-11) values do not necessarily indicate high soil salinity. Higher values along waterways and drainage lines may indicate shallow groundwater and mobile salt discharge in these areas. The ground electromagnetic survey showed in general moderate conductivity values (greens to yellow) in the areas reflecting the surface water drainage pathways of South Creek and the upper reaches of Googong Creek. It is important to note that these results will not be comparable with post-construction results within the township due to the significant landform changes, paving, buried services and buildings.

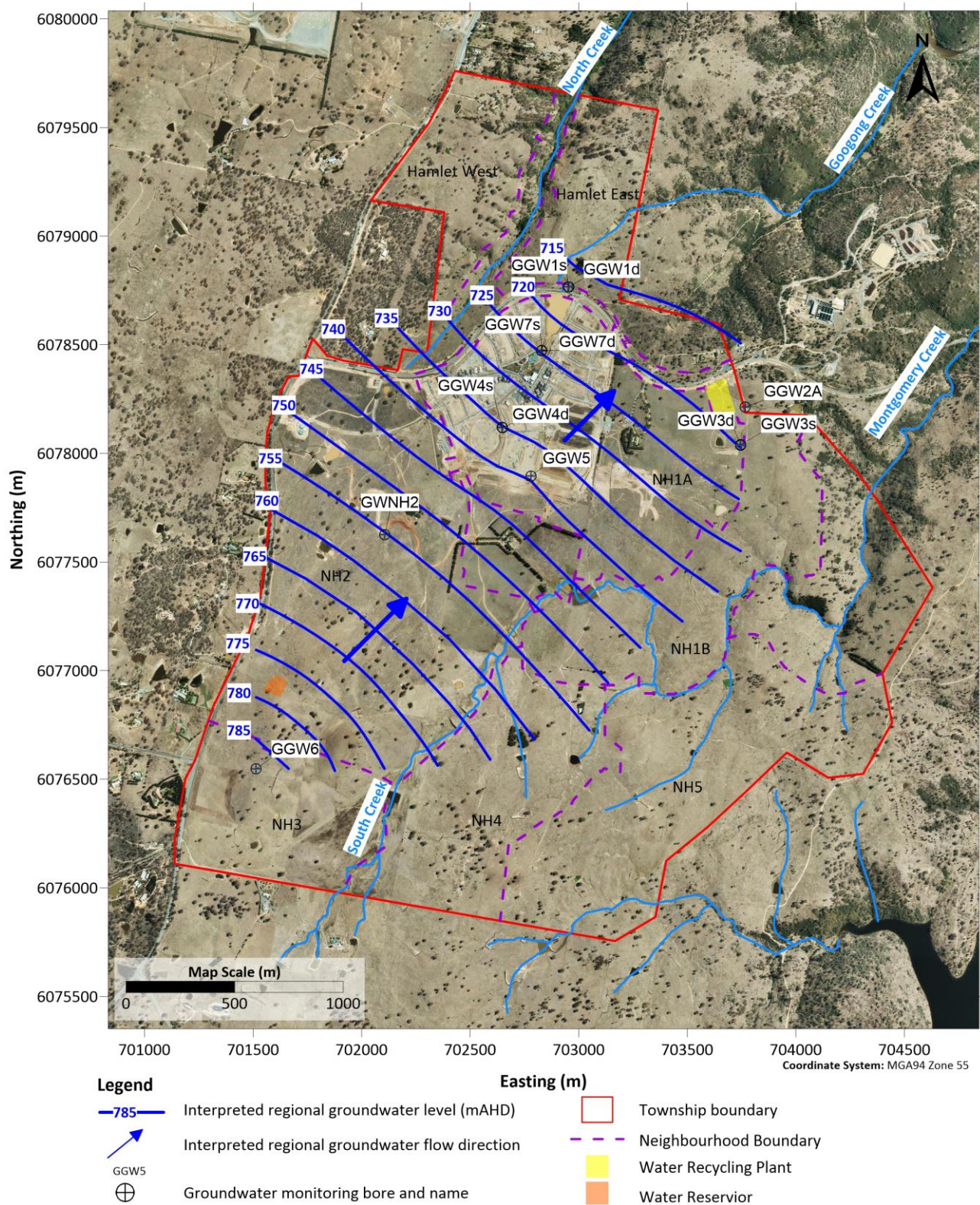


Figure 2-7 Googong Township and interpreted regional groundwater contours and flow direction

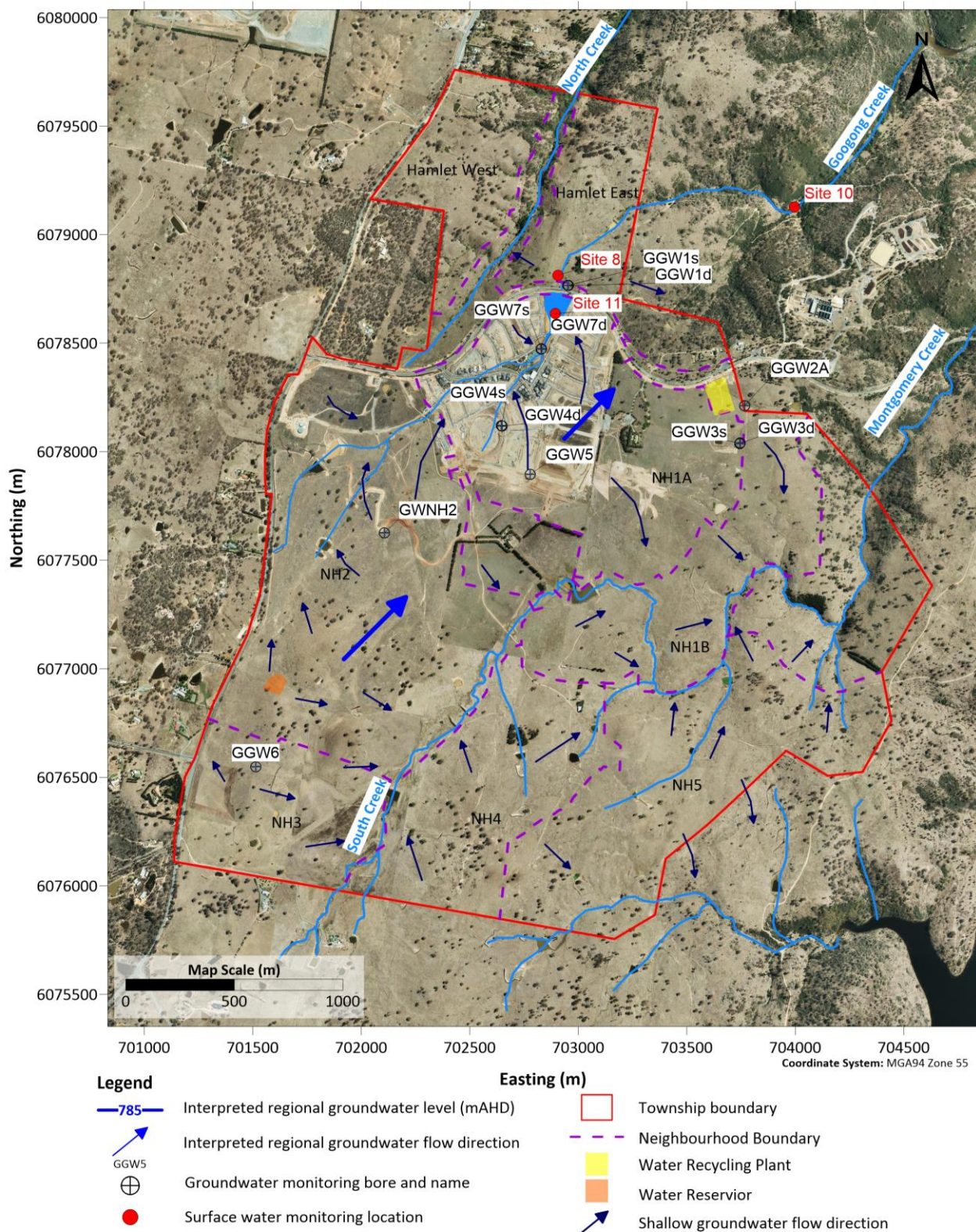


Figure 2-8 Googong Township surface water and interpreted shallow groundwater flow direction with regional groundwater flow direction

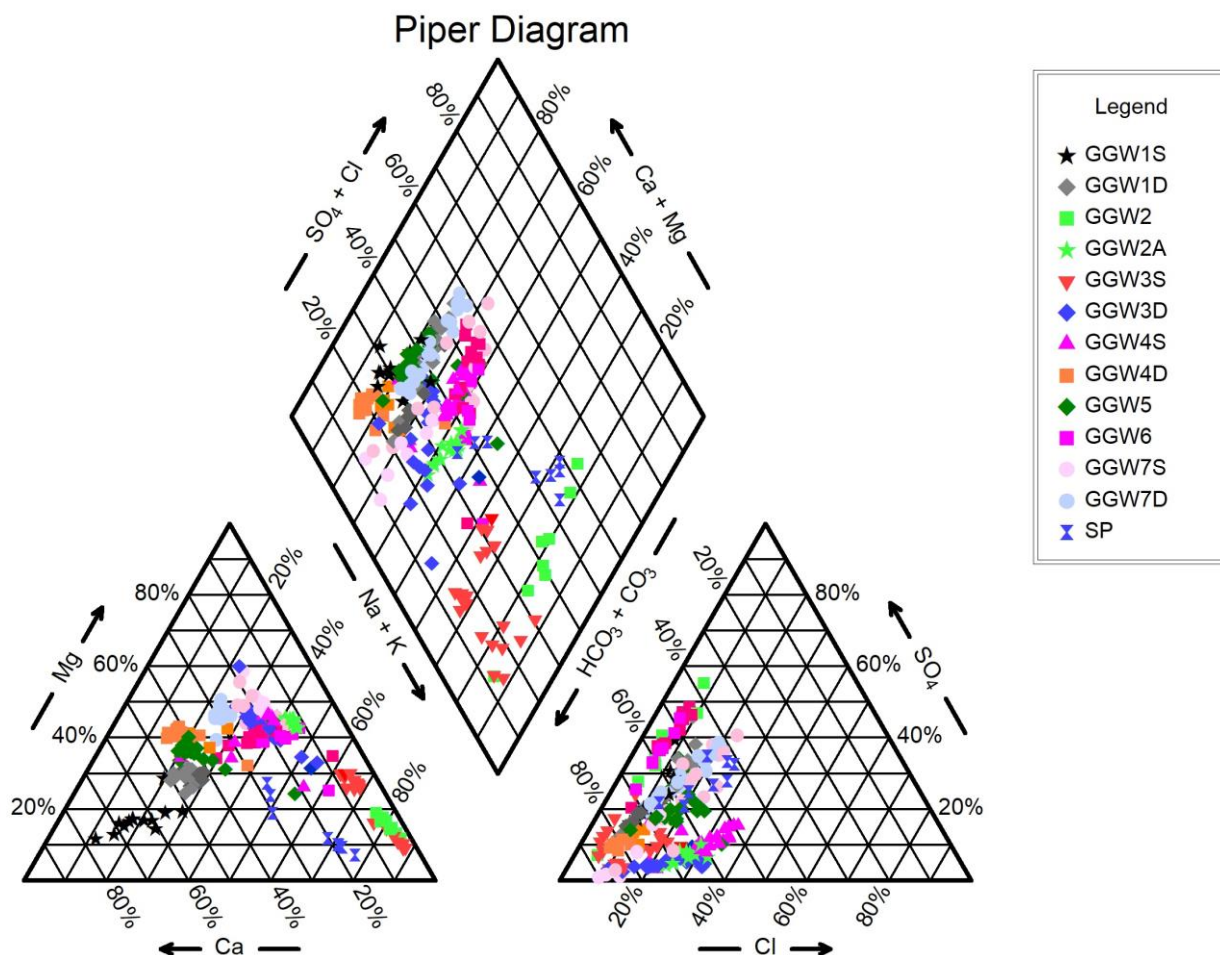


Figure 2-9 Piper diagram of groundwater monitoring data from 2013 to June 2022

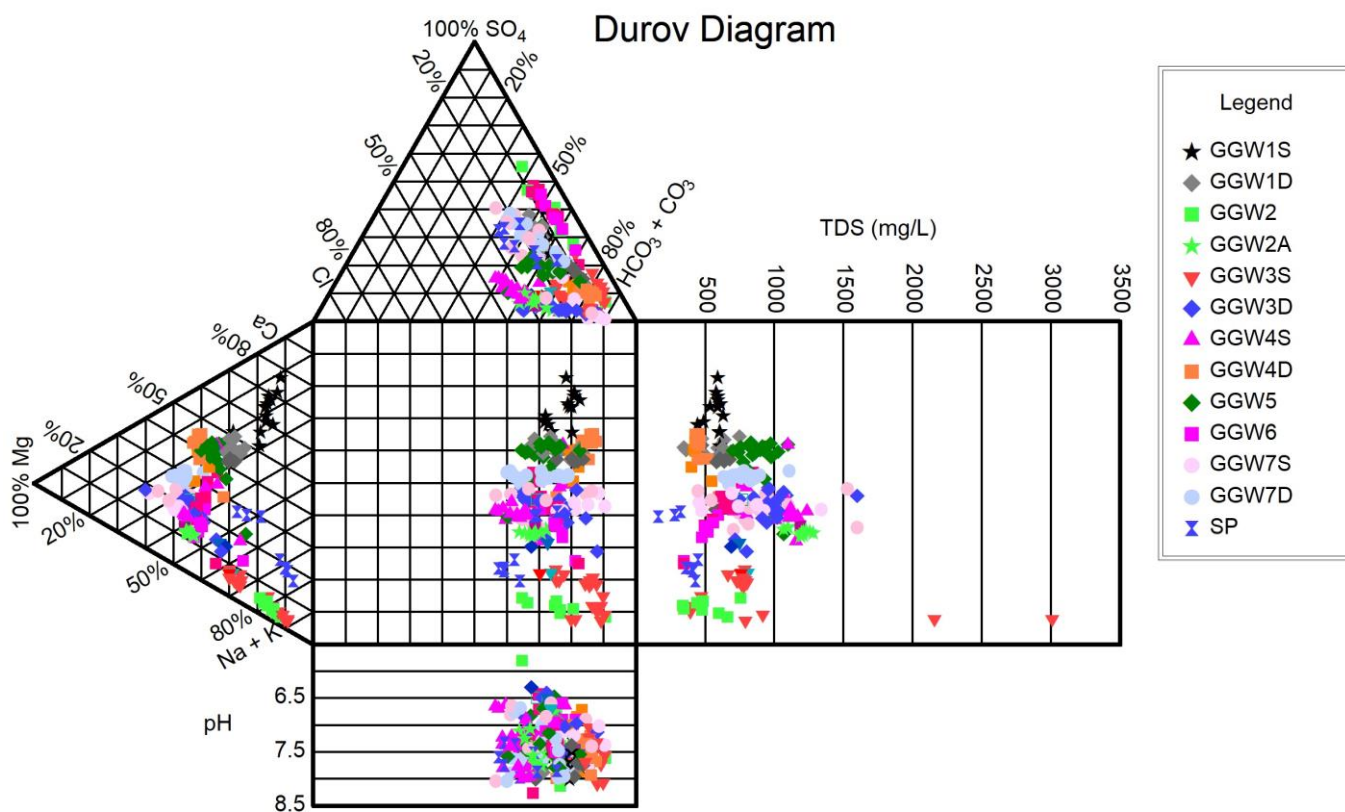


Figure 2-10 Durov diagram of groundwater monitoring data from 2013 to June 2022

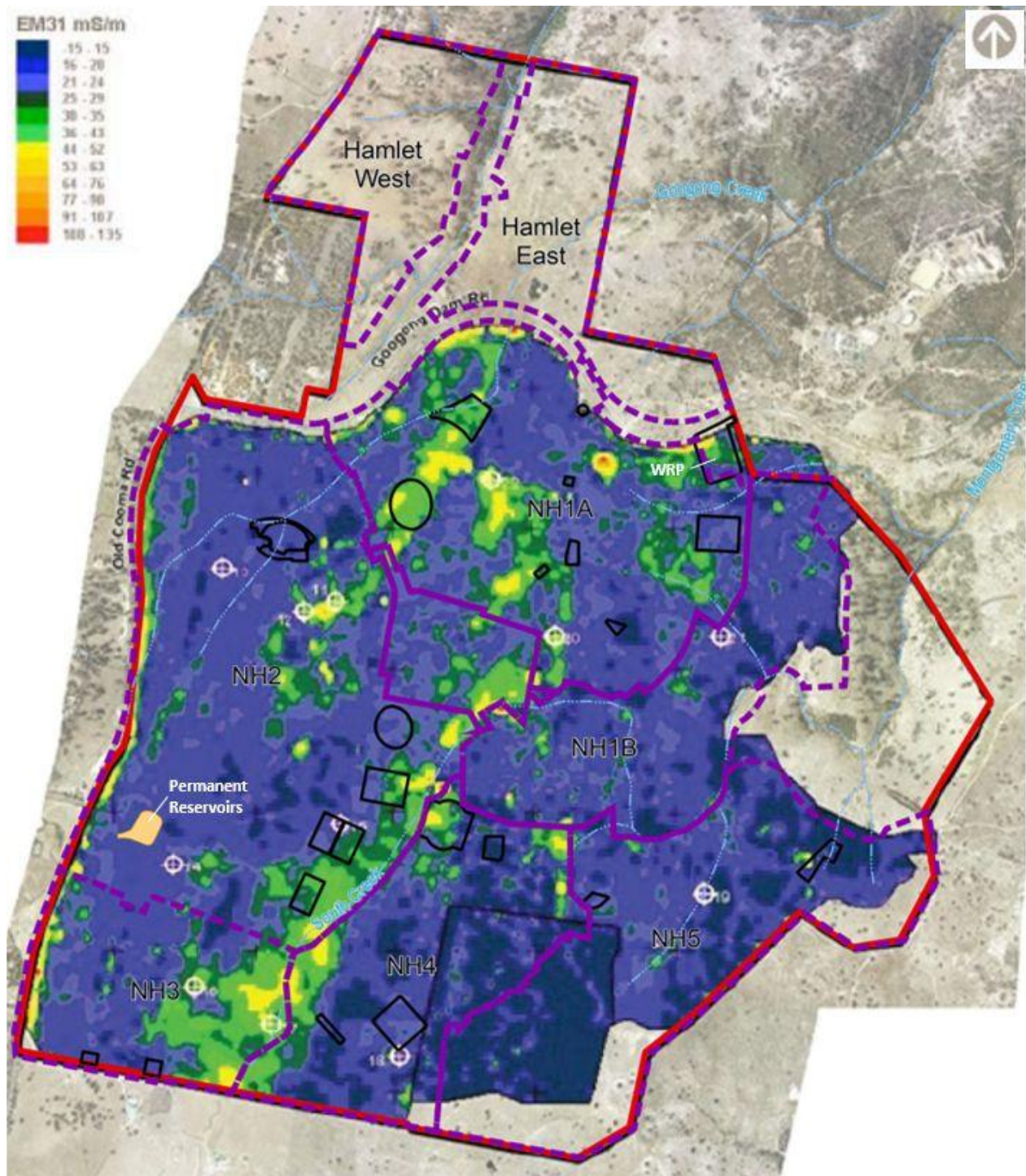


Figure 2-11 Agsol electromagnetic survey conductivity map (adapted from the WMP) with current and proposed sporting fields and irrigated open space outlined in black, permanent reservoirs (pale orange) and WRP location

3 Proposed Works and Existing Environment

This section of the hydrogeological assessment details the existing environment and proposed changes. There are two proposed changes which are shown on Figure 3-1 and are outlined as follows:

1. Two areas within the dam catchment protection reserve of NH5 are proposed to change from open space to residential dwellings; and
2. One area of developable land for residential dwellings in NH4 will be changed to open space.

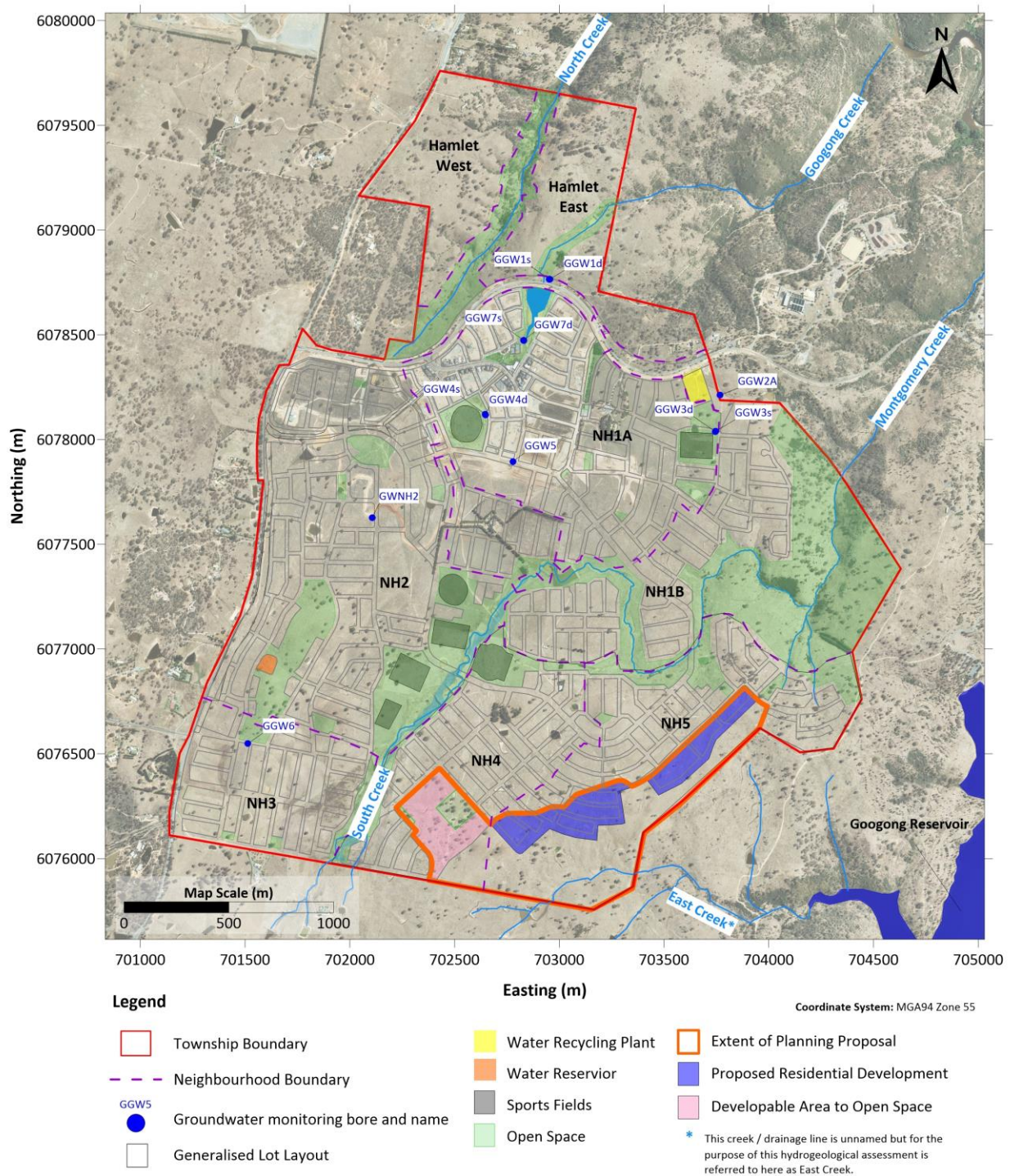


Figure 3-1 Planning proposal changes in the Googong Township Masterplan

3.1 Site Location

NH4 and NH5 are located within the south-eastern portion of the Googong Township development and covers an area of approximately of 185 ha of which approximately 123 ha is to be developed. In the southern part of the neighbourhood is the dam protection zone where the proposed development is planned (the site).

3.2 Surface Drainage

The site is situated on a surface water divide. Part of the site drains north towards South Creek and part drains south-east towards an unnamed creek. For the purpose of this assessment the creek has been named East Creek and it flows to Googong Reservoir.

3.3 Soils

The neighbourhood will be constructed on residual ground and reworked soil. No fill will be imported to the site.

3.4 Surrounding Land Use and Potential Receptors

The area around the site is currently undeveloped farmland. The neighbourhood boundary shows to the north is existing dwellings of NB1B and to the west is farmland yet to be developed with some development of sporting grounds in NH2. The southern boundary of the site is the edge of the township and consists of farmland and to the east is the township boundary and Googong Reservoir.

South Creek and East Creek are the nearest receiving surface water environments. Within the Township South Creek flows into Montgomery Creek which flows into the Queanbeyan River. East Creek flows into Googong Reservoir. There are no registered groundwater bores within 2 km radius of the site area.

3.5 Geophysics

The 2009 Agsol surface mapping of the site in the areas of the proposed development shows generally low conductivity soils with a small moderate conductivity response associated with farm dams.

3.6 Local Geology and Hydrogeology

The site is underlain by the Colinton Volcanics. Granitic intrusions are indicated to the south of the site. The site is not covered by the townships existing groundwater monitoring program and as such there is no site-specific information for depth to groundwater, groundwater quality and groundwater flow direction and gradients.

Shallow groundwater is anticipated to be within 4 m to 10 m below ground surface with the flow direction a subdued version of the topography. The site is situated on a groundwater divide that separates the majority of the township, for which the flow direction is to the north, with a small catchment area with a flow direction anticipated to be towards the east. Groundwater quality is anticipated to be similar to monitoring bores GGW5 and GGW6 of the townships monitoring program.

3.7 Surface Water Quality

There are no surface water sampling sites established in South Creek or East Creek. The township's WMP monitoring program has one surface water monitoring location on Montgomery Creek. This location is at times dry, reflecting the ephemeral nature of the system. East Creek is likely ephemeral.

3.8 Identification of Impacts

The proposed development in the dam catchment protection zone of NH5 will result in a change in land use and likely a reduction in rainfall recharge to groundwater.

4 Impact Assessment

The planning proposal has two potential impact periods, those during construction and the long-term (operational) impact of the development. Potential construction impacts are generally short term in nature and managed through the Construction Environmental Management Plan (CEMP). Long-term potential impacts are generally the result of a change in environment from the predevelopment state.

The proposed residential development area in the planning proposal covers an area of around 16.7 ha and lies on the groundwater divide between Catchment 1, Catchment 3, Catchment 4 and Catchment 5 as shown on Figure 4-1. The developable land returning to open space covers an area of around 8.6 ha and is predominantly within Catchment 2 (Figure 4-1).

Shallow groundwater flow, which follows a subdued version of topography, is towards the catchment drainage lines. In Catchment 2, 3 and 5 groundwater flow north towards the Queanbeyan River whilst in Catchment 1 and 5 groundwater flows east towards Googong Reservoir.

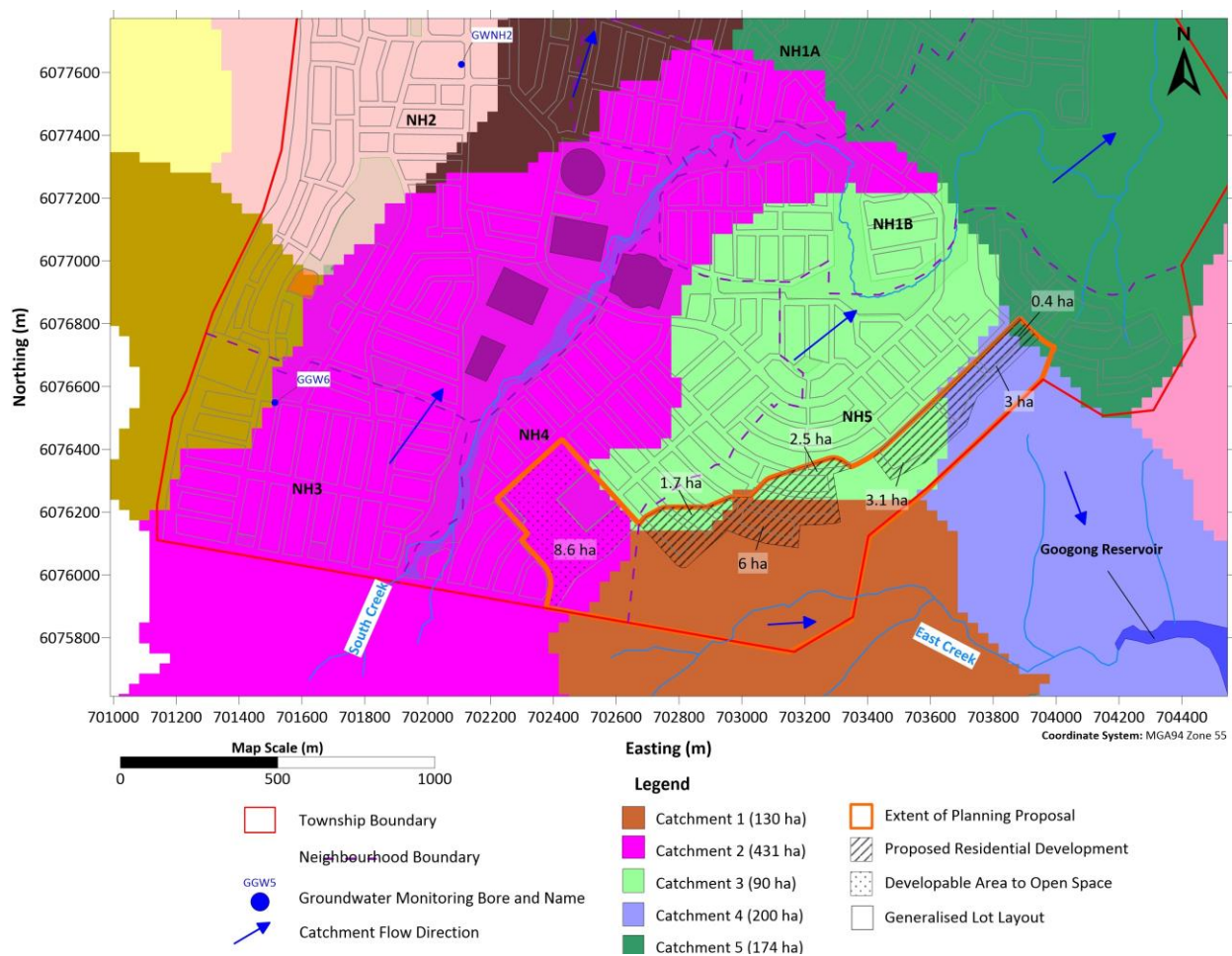


Figure 4-1 Catchments and planning proposal area.

4.1 Construction Activities and Potential Impacts

Construction activities include bulk earthworks and excavation, which expose and disturb the soil and shallow rock profile, road and lot development, dwelling construction and landscaping. During construction activities the potential impacts to groundwater include:

- Increased direct rainfall recharge from disturbed ground and open trenches to the shallow groundwater aquifer; and
- Mobilisation of nutrients and metals during rainfall infiltration from the disturbed soil and shallow rock to the shallow groundwater aquifer.

The potential increase in volume of recharge to the shallow groundwater is likely to be relatively small relative to the volume of recharge of the overall catchment area. Construction activities occurring within Catchment 1 and Catchment 4 have the potential to impact the Googong Reservoir catchment because they are within the Dam Catchment Protection Zone and the shallow groundwater flow in these catchments is towards the Reservoir. It is understood that under the CEMP, surface water control measures would be in place to manage potential sediment and surface water run-off to East Creek from construction.

4.2 Operational Activities and Potential Impacts

The unavoidable impact of the proposed development is a reduction in rainfall recharge to groundwater from increased impermeable surfaces. Under pre-development conditions recharge is approximately 1% of annual rainfall (i.e. 0.16 m³/day per hectare) and evenly distributed across a catchment. Once developed, water that falls on impervious surfaces is transferred to the IWC stormwater system. The overall township results in an average 75 % reduction (SMEC 2014) in recharge to groundwater in urbanised areas. This reduction takes into account the additional recharge from irrigation of open spaces and sporting grounds and domestic garden watering.

The reduction in recharge to groundwater within the planning proposal area will result in a reduction in the volume of flow within the catchments (Figure 4-1) and, as a result, a reduction in base flow to the ephemeral creeks / drainage lines and discharge to Googong Reservoir. The planning proposal site is assessed using 75 % average reduction and a 95% reduction to account for this particular development having no large open ground or sporting fields. Assessment of areas within Catchment

In Catchment 1:

- the catchment size of 130 ha contributes 20.8 m³/day when undeveloped;
- the site (developed) footprint covers an area of 6 ha;
- a 75% reduction in recharge over the site area is 0.72m³/day which is 3.4 % of catchment recharge; and
- a 95% reduction in recharge over the site is 0.9 m³/day which is 4.3% of the catchment recharge.

In Catchment 3:

- the catchment size of 90 ha contributes 14.4 m³/day when undeveloped;
- the site (developed) footprint covers an area of 7.3 ha;
- a 75% reduction in recharge over the site area is 0.87 m³/day which is 6 % of catchment recharge; and
- a 95% reduction in recharge over the site is 1.1 m³/day which is 7.7 % of the catchment recharge.

In Catchment 4:

- The catchment size of 200 ha contributes 32 m³/day when undeveloped;
- The site (developed) footprint covers an area of 3 ha;
- a 75% reduction in recharge over the site area is 0.36 m³/day which is 1.1 % of catchment recharge; and

- a 95% reduction in recharge over the site is 0.45 m³/day which is 1.4 % of the catchment recharge.

In Catchment 5:

- The catchment size of 174 ha contributes 27.8 m³/day when undeveloped;
- The site (developed) footprint covers an area of 0.4 ha;
- a 75% reduction in recharge over the site area is 0.04 m³/day which is 0.1 % of catchment recharge; and
- a 95% reduction in recharge over the site is 0.06 m³/day which is 0.2 % of the catchment recharge.

In Catchment 2, 8.6 ha of developable land that was previously proposed to be developed is to remain as open space in NH4.

The development in the planning proposal area is assessed to have a reduction in recharge of less than 5 % for the undeveloped catchment recharge in Catchment 1 and Catchment 4, which are within the dam catchment protection zone, and less than 1 % of the total Googong Township development area recharge.

4.3 Monitoring and Mitigation of Construction and Operation Impacts

The site does not have any established groundwater locations or baseline data. It may be difficult to establish a groundwater monitoring network due to the steep terrain and limited space within the proposed development footprint. Contributions to shallow groundwater come from outside of the township development boundary over a more significant area than the proposed development in the dam catchment zone.

Construction impacts will be short lived, with the potential discharge of sediment to East Creek considered the main potential impact to the receiving environment. This can be managed with appropriate sediment fencing and monitoring in the CEMP. Further reducing the length of time large excavations remain open will reduce the amount of direct rainfall recharge that has the potential to mobilise metals and nutrients into the shallow groundwater.

The CEMP should consider controls to:

- manage the areas being stripped to avoid large areas of disturbance;
- covering of soil stockpiles and or placement stockpiles outside of Catchment 1 and 4;
- minimise the ponding of water within trenches and excavations in Catchment 1 and Catchment 4; and
- direct and collect surface water to areas not in Catchment 1 and Catchment 4.

The long-term operational impacts from the reduction of groundwater recharge may be more pronounced during drier periods. Observational monitoring may be considered for the slopes below the site and within East Creek's channel for vegetation changes and potential groundwater discharge.

Groundwater quality changes will likely be related to general long-term changes in catchment use and long-term weather trends and therefore difficult to associate with this specific site development considering the volume of groundwater relative to the catchment is relatively low.

5 Discussion, Conclusions and Recommendations

5.1 Discussion

Reductions in groundwater recharge from rainfall, as a result of increased impervious surfaces in the catchment compared to an undeveloped catchment, have the potential to impact groundwater levels and groundwater quality. Changes in quality may include changes in the concentrations of salts, metals and nutrients. It may be more pronounced in the shallow groundwater aquifer, which contributes to flow in the creeks and recharge to Googong Reservoir.

The reduction in recharge is assessed to be less than 5 % of the total catchment recharge, assuming an average 75 % reduction, in Catchment 1, Catchment 4 and Catchment 5. This reduction does not take into account additional sources of recharge such as irrigation / garden watering and leaking pipes (water supply and stormwater). At a 95 % reduction of recharge, representing considerable impervious areas, the reduction in recharge is still below 5 % of the total catchment contribution. Catchment 3 has a reduction in groundwater recharge of less than 10 %, though the catchment size is considerably smaller than the others that were assessed. The receiving environments potentially impacted from the reduction in groundwater recharge are East Creek and Googong Reservoir and Montgomery Creek and the Queanbeyan River but it is noted that the volume of groundwater will be small relative to the overall groundwater contribution from the rest of the catchment.

An approximate change of less than 5 % in the average recharge is highly unlikely to be easily observed through monitoring data without very long time series data sets which are continuous (i.e. since 2013) and extend into the development (i.e. post construction). Contribution to changes in level and quality from areas of the Catchment outside of the township would also need to be considered. It is debatable as to whether these changes (i.e. to level and quality) would be observed in such data sets outside of the natural variation of the data resulting from long-term weather trends. Potentially the changes may be manifested in the surface environment and monitoring of vegetation and surface flows in Catchment 1 and Catchment 4 could be considered.

Short term potential changes in groundwater quality from the development of the site have the potential to impact to Googong Reservoir but the volume of groundwater relative to the contribution from the rest of the catchment (of both groundwater and surface water) is considerably small and the risk may be managed with adequate CEMP controls. It is considered there is a low risk of a negative impact to Googong Reservoir and the Queanbeyan River from groundwater from the construction activities.

Following construction, in the operation of the proposed development, the groundwater quality would return to an equilibrium and it would not be anticipated that the use of recycled water, which meets the quality requirements of the IWC of the Township under the WMP, for irrigation / garden watering, would contribute to significant localised changes in groundwater quality. It is understood the recycled water is treated to a quality that is near comparable with potable water. The volume of groundwater contribution from the catchments is very small relative to the overall catchment contribution of groundwater (and surface water) and it is considered there is a low risk of a negative impact to Googong Reservoir and the Queanbeyan River.

Therefore, groundwater level and quality monitoring within these catchments is not considered to be of benefit during construction and operation of the planning proposal development.

5.2 Conclusions

This hydrogeological assessment concludes that the reduction of groundwater recharge from the proposed development is less than 5 % and potential changes in groundwater level and quality are likely to be within the range associated with natural variation. During construction of the planning proposal area, management and mitigation of groundwater potential impacts should be undertaken through the site CEMP and include minimising wide spread stripping within the catchment, avoiding open trenches for water ponding, diverting stormwater and surface run off to Catchment 3 and placing soil stockpiles outside of the dam catchment zone.

5.3 Recommendations

Groundwater monitoring is not recommended. The potential change in recharge is considered negligible and unlikely to be observable. During construction, visual observations of East Creek may be considered.

6 References

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SMEC 2014. Annual Groundwater Monitoring Report – January 2015 (Document Reference 30011252)

SMEC 2017. Annual Monitoring Report – October 2017 (Document Reference 30012126-AR01)

SMEC 2019. Annual Factual Monitoring Report – May 2019 (Document Reference 30012126-AR02)

SMEC 2020. Annual Factual Monitoring Report for 2019 – May 2020 (Document Reference 30012126-AR03)

Appendix A

Groundwater Monitoring Bore Logs



Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW1D

Sheet No: 1 of 1

Project No: 30011525

Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Location: Googong, NSW /

Co-ordinates System: E 702951.99

MGA N 6078765.86

Ground Level: 723.26 m.AHD

RL (Top of Casing): m.AHD

Angle from Horiz: -90

Drilling		Depth		Well Construction		SUBSTANCE				Testing		OTHER OBSERVATIONS						
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)					
RR 110 mm	RAB 125 mm		1		Backfill 0.5m to 11m		TOPSOIL: silty clay, red brown with minor sand and gravel	D										
		722		SHALE: yellow brown extremely weathered														
2																		
3		720																
4							SHALE: yellow grey to grey brown, highly weathered to moderately weathered	M										
5		718	▶															
6																		
7		716						D										
8																		
9		714																
10			◀▶ 14/08/2013															
11		712	▶	Bentonite seal 11m to 12m		LIMESTONE: dark grey, fresh with minor veins of pyrite	M											
12								D										
13		710		Filter pack 12m to 19m														
14				Screen interval 13m to 19m		SHALE: brown grey moderately weathered, minor quartz vein												
15		708						M										
16							SHALE: grey brown with minor fractures, some quartz veins											
17		706						W										
18																		
19		704						Bore discontinued at 19.00m						ALT	0.2			
20																		

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense Inflow Standing Water Level

Contractor: Ultradrilling

Commenced: 13/08/2013

Logged By: ARP

Equipment: Mayhew1000

Completed: 13/08/2013

Checked By:



Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW1S

Sheet No: 1 of 1

Project No: 30011525

Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Location: Googong, NSW /

Co-ordinates System: E 702954.6

MGA N 6078765.14

Ground Level: 723.43 m.AHD

RL (Top of Casing): m.AHD

Angle from Horz: -90

Drilling		Depth		Well Construction		SUBSTANCE			Testing		OTHER OBSERVATIONS										
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)								
RR 110 mm			1		Backfill 0.5m to 4m		TOPSOIL: silty clay, red brown with minor sand and gravel														
			2				LIMESTONE: brown grey to white, highly weathered to moderately weathered														
RAB 125 mm			3				LIMESTONE: dark grey, fine grained, frish with thin high plasticity clay bands og green brown to red. Becoming more laminated at 7.5m						Colinton Volcanics								
			4																		
			5																		
			6		Bentonite seal 4m to 5m																
			7											Filter pack 5m to 10.5m							
			8																		
			9		Screen interval 7.5m to 10.5m		SHALE: interbedded high plasticity clay and calcarious shale, moderately weathered														
			10																		
			11				Bore discontinued at 10.50m														
			12																		

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense ▶ Inflow ▼ Standing Water Level

Contractor: Ultradrilling

Commenced: 14/08/2013

Logged By: ARP

Equipment: Mayhew1000

Completed: 14/08/2013

Checked By:



Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW2A

Sheet No: 1 of 1

Project No: 30011525

Ground Level: 714.605 m.AHD

RL (Top of Casing): m.AHD

Angle from Horz: -90

Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Co-ordinates System: E 703767.125

Location: Googong, NSW /

MGA N 6078212.245

Drilling		Depth	Well Construction		SUBSTANCE					Testing		OTHER OBSERVATIONS	
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)
RAB 141 mm		714	1		Backfill 0.5m to 2.2m		TOPSOIL: red brown, sandy silt, fine to coarse sand	D			ALT	0.1	Googong Granite
			2		Bentonite seal 2.2m to 3.5m		ADAMELITE: pink, medium grained, highly weathered to moderately weathered						
		712	3				ADAMELITE: green gray, medium grained, moderately to slightly weathered, fracture 5.5m to 6m						
			4		Filter pack 3.5m to 19.2m								
		710	5										
			6										
		708	7		Screen interval 7.2m to 19.2m		DACITE: dark green grey, fine to medium grained, fresh, fracture at 8.7m and 15.2m	W			ALT	0.05	Colinton Volcanics
			8										
		706	9										
			10										
		704	11										
			12										
		702	13										
			14										
		700	15										
			16										
		698	17										
			18										
		696	19										
			20										
		694	21										
							Bore discontinued at 19.20m						

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense ▶ Inflow ▼ Standing Water Level

Contractor: Ultradrilling

Commenced: 20/10/2015

Logged By: ARP

Equipment: Gardner Devner

Completed: 20/10/2015

Checked By:





Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW3S

Sheet No: 1 of 1

Project No: 30011525

Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Location: Googong, NSW /

Co-ordinates System: E 703745.03

MGA N 6078037.55

Ground Level: 720.02 m.AHD

RL (Top of Casing): m.AHD

Angle from Horz: -90

Drilling		Depth		Well Construction		SUBSTANCE				Testing		OTHER OBSERVATIONS	
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)
RAB 125 mm					Backfill 0.5m to 0.5m Bentonite seal 0.5m to 1.8m		TOPSOIL: clayey sand, tan to brown with rock fragments						Googong Granite
							ADAMELLITE: extremely weather tan to white, quartz rich and foliated						
			1										
													
			2		Filter pack 1.8m to 7m								
													
			3										
													
			4		Screen interval 4.5m to 7m								
													
		5											
													
		6											
													
		7											
						Bore discontinued at 7.00m							

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense ▶ Inflow ▼ Standing Water Level

Contractor: Ultradrilling

Commenced: 19/08/2013

Logged By: CJ

Equipment: Mayhew1000

Completed: 19/08/2013

Checked By:

Checked By:



Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW5

Sheet No: 1 of 1

Project No: 30011525

Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Location: Googong, NSW /

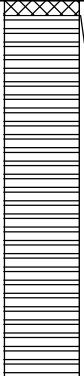
Co-ordinates System: E 702779.39

MGA N 6077894.96

Ground Level: 741.33 m.AHD

RL (Top of Casing): m.AHD

Angle from Horiz: -90

Drilling		Depth		Well Construction		SUBSTANCE				Testing		OTHER OBSERVATIONS	
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)
RR 125 mm			1		Backfill 0.5m to 20m		FILL: gravelly sandy clay, red brown with rock fragments	D					
	740	2	SHALE: extremely weathered yellow brown and foliated, becoming blue / grey / brown and moderately weathered at 7m and yellow / brown and extremely to moderately weathered at 10m				Dm						
	738	3					M						
		4					W						
		5											
	736	6											
		7											
	734	8											
		9											
	732	10											
		11											
	730	12											
		13			DACITE: blue grey, moderately weathered								
	728	14											
		15											
	726	16											
		17											
	724	18											
		19											
	722	20											
		21											
	720	22											
		23											
	718	24											
		25											
	716	26											
		27			Bentonite seal 20m to 27m								
	714	28			Filter pack 16m to 26m								
		29											
	712	30											
		31											
	710	32											
		33			Screen interval 43m to 49m								
	708	34											
		35											
	706	36											
		37											
	704	38											
		39											
	702	40											
		41											
	700	42											
		43											
	698	44											
		45											
	696	46											
		47											

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense Inflow Standing Water Level

Contractor: Ultradrilling

Commenced: 20/08/2013

Logged By: CJ

Equipment: Mayhew1000

Completed: 20/08/2013

Checked By:



Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW6

Sheet No: 1 of 1

Project No: 30011525

Ground Level: 789.04 m.AHD

RL (Top of Casing): m.AHD

Angle from Horiz: -90

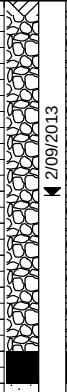
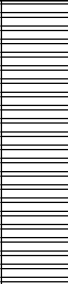
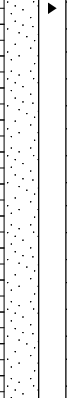
Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Co-ordinates System: E 701513.5

Location: Googong, NSW /

MGA N 6076548.21

Drilling		Depth		Well Construction		SUBSTANCE				Testing		OTHER OBSERVATIONS	
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)
RAB 125 mm		788	1		Backfill 0.5m to 11m		SHALE: tan to red / yellow, foliated with quartz and weathered at the surface and becoming blue gray and hard at 3m	D			ALT	0.1	Colinton Volcanics
	786	2											
	786	3											
	784	4											
	784	5											
	782	6											
	782	7											
	780	8											
	780	9											
	780	10											
	778	11					Bentonite seal 11m to 12m Filter pack 12m to 43m						
	778	12											
	776	13											
	776	14											
	774	15											
	774	16											
	772	17											
	772	18											
	770	19											
	770	20											
	768	21											
	768	22											
	766	23											
	766	24											
	764	25											
	764	26											
	762	27											
	762	28											
	760	29											
	760	30											
	758	31											
	758	32											
	756	33											
	756	34											
	754	35											
	754	36											
	752	37											
	752	38											
	750	39											
	750	40											
	748	41											
	748	42											
	746	43											
	746	44											
	744	45											
	744	46											
	742	47											
							Bore discontinued at 43.00m				ALT	0.2	

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense Inflow Standing Water Level

Contractor: Ultradrilling

Commenced: 29/08/2013

Logged By: CJ

Equipment: Mayhew1000

Completed: 29/08/2013

Checked By:



Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW7D

Sheet No: 1 of 1

Project No: 30011525

Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Location: Googong, NSW /

Co-ordinates System: E 702828.67

MGA N 6078472.34

Ground Level: 725.97 m.AHD

RL (Top of Casing): m.AHD

Angle from Horz: -90

Drilling		Depth		Well Construction		SUBSTANCE				Testing		OTHER OBSERVATIONS	
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)
RR 125 mm			1		Backfill 0.5m to 3m		FILL: grey brown, gravelly sandy clay with angular to cobble size pieced of dacite	D					Colinton Volcanics
		724	2				Dm						
			3		Bentonite seal 3m to 5m		SHALE: tan to brown, laminated and foliated with orange / red weathering at 5m then becoming blue / grey from 6m						
		722	4										
			5		Filter pack 5m to 19m		D						
		720	6										
			7		Screen interval 7m to 9m								
		718	8										
			9										
		716	10										
			11										
		714	12										
			13		Screen interval 13m to 16m								
		712	14			Dm							
			15										
		710	16										
			17										
		708	18										
			19					Bore discontinued at 19.00m					
			706	20									

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense Inflow Standing Water Level

Contractor: Ultradrilling

Commenced: 5/09/2013

Logged By: CJ

Equipment: Mayhew1000

Completed: 5/09/2013

Checked By:



Geological Log of Groundwater Bore Hole

on behalf of
Googong Township Pty Ltd

HOLE NO: GGW7S

Sheet No: 1 of 1

Project No: 30011525

Project: Googong Hydrogeological Study

Purpose: Groundwater Investigation

Location: Googong, NSW /

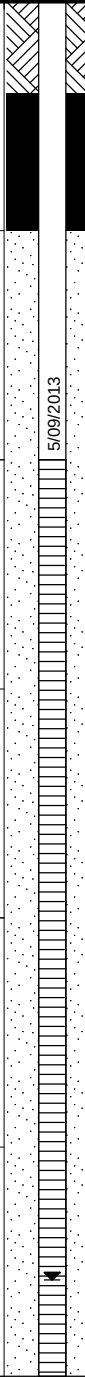
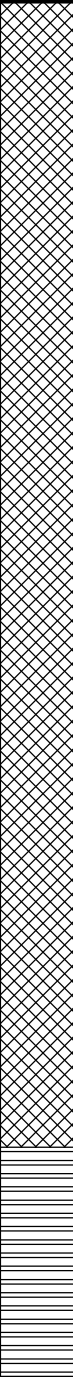
Co-ordinates System: E 702830.23

MGA N 6078473.95

Ground Level: 725.66 m.AHD

RL (Top of Casing): m.AHD

Angle from Horz: -90

Drilling		Depth		Well Construction		SUBSTANCE				Testing		OTHER OBSERVATIONS	
Method	Support	Elev. (RL m)	Depth (mbgl)	Well Construction Details	Construction notes	Graphic Log	Description NAME: grain size / plasticity, color, structure, minor components	Moisture	Density	Weathering	Type	Result (L/sec)	Notes (Structure, origin, etc)
RAB 125 mm					Bentonite seal 0.2m to 0.5m Filter pack 0.5m to 3m Screen interval 1m to 3m		FILL: gravelly sandy clay with dacite and shale fragments, tan to brown						Colinton Volcanics
			1										
			724										
			2										
							SHALE: extremely weathered tan to brown						
			3				Bore discontinued at 3.00m						

Notes: mbgl = metre below ground level; m.a.s.l. = metre above sea level, RL m = Relative Level in metre (here m.a.s.l.), HW=Highly Weathered, EW=Extremely Weathered, MW=Moderately Weathered, SW=Slightly Weathered, FR=Fresh, D=Dry (moisture), M=Moist, W=Wet, ALT=Air Lift Test, D=Dense (density), MD=medium dense Inflow Standing Water Level

Contractor: Ultradrilling

Commenced: 5/09/2013

Logged By: CJ

Equipment: Mayhew1000

Completed: 5/09/2013

Checked By:

Checked By:

engineering log - monitoring well

Client : PEET						Job No. : 12675/4	
Project : Proposed Residential Subdivison						Borehole No. : GW 1	
Location : Neighbourhood 1A, Stage 7 & Neighbourhood 2 Googong Road Googong						Date : 15/02/2017 Logged/Checked by: JH	
drill rig : Geoprobe 7822DT						R.L. surface : AHD	
groundwater 15/02/2017 : DRY (m)							

groundwater	samples	PID Reading (ppm)	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	MONITORING WELL	
							Graphic Log	Description
								700mm Lockable Monument
			0		CI	TOPSOIL: Silt Clay, low to medium plasticity, brown, trace of root fibres Silty CLAY, medium plasticity, red-brown, with inclusion of ironstone gravel		Concrete capping/ soil cuttings
			1		CI	Shaley CLAY, medium plasticity, yellow- brown-grey, with shale and ironstone fragments		Bentonite Grout Casing
	DS		2			SHALE, distinctly weathered		
	DS		3					
	DS		4					
	DS		5					
	DS		6					
	DS		7			SLATE, distinctly weathered		Bentonite plug/pellets
								Sand
	DS		8					Screening

engineering log - monitoring well

Client : PEET						Job No. : 12675/4	
Project : Proposed Residential Subdivison						Borehole No. : GW 1	
Location : Neighbourhood 1A, Stage 7 & Neighbourhood 2 Googong Road Googong						Date : 15/02/2017 Logged/Checked by: JH	
drill rig : Geoprobe 7822DT						R.L. surface : AHD	
groundwater 15/02/2017 : DRY (m)							

groundwater	samples	PID Reading (ppm)	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	MONITORING WELL		
							Graphic Log	Description	
	DS		9						
	DS		10						
	DS		11						
	DS		12						
	DS		13						
			14						
			15			Monitoring well terminated at 14.5m			
			16						
			17						
			18						

KEY TO SYMBOLS

Symbol Description

Symbol Description

Strata symbols



Topsoil



Silty Clay
medium plasticity



Shaley Clay
medium plasticity



Shale



Limestone

Monitor Well Details



Locked Cap



concrete seal



bentonite slurry



bentonite pellets



silica sand, blank PVC



slotted pipe w/ sand



endcap on pipe
packed in sand

Descriptions of various line types (solid, dotted, etc.)

_____ Profile change

Notes:

1. Exploratory borings were drilled between 15/02/2017 and 15/02/2017 using a 50, 100 and 125mm diameter continuous flight power auger.
2. These logs are subject to the limitations, conclusions and recommendations in this report.
3. Results of tests conducted on samples recovered are reported on the logs.

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