Douglas Partners
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Integrated Practical Solutions

Groundwater Monitoring Program

Proposed Industrial Subdivision
Stage 3, Lot 210 D.P.1174939, 2 Westrac Drive, Tomago

Prepared for
Northbank Enterprise Hub Pty Ltd

Project 39920.09
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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Groundwater Monitoring Program
Proposed Industrial Subdivision
Stage 3, Lot 210 D.P.1174939, 2 Westrac Drive, Tomago

1. Introduction

This Groundwater Monitoring Program (GMP) has been prepared for the proposed industrial subdivision at Stage 3, Lot 210 D.P.1174939, 2 Westrac Drive, Tomago. The investigation was undertaken for Northbank Enterprise Hub Pty Ltd (NEH) with reference to Douglas Partners Pty Ltd (DP) proposal 39920.09.P.001.Rev1 dated 31 October 2022.

The proposed development, which comprises an industrial subdivision, will consist of industrial lots with associated access roads and drainage reserves. To facilitate development, the site will require importation of fill for site raising, which is proposed to be undertaken in stages. This GMP is required for the assessment and management of groundwater levels and quality prior to, during and following development, given the site's close proximity to sensitive receptors.

It is understood that the proposed development represents Stage 3 of an existing conditional Project Approval granted by the NSW Department of Planning and Environment (DPE) (MP07_0086) as well as an existing conditional Environmental Protection and Biodiversity Conservation Act (EPBC) approval (2007/3343) granted by DCCEEW. The specific requirements of DPE Condition 13 and the relevant section of this report are shown in Table 1.

Table 1: Sections Addressing Condition 13 of DPE Approval

Requirements for Groundwater Monitoring Plan	Report Section
Be prepared in consultation with the DWE (Department of Water, now DPI) (completed for the overall plan)	9
Include details of a program to monitor groundwater levels and quality.	10.3 and 10.4
The groundwater levels and quality impact assessment criteria.	10.9
Procedures for reporting the monitoring results against the criteria.	10.10
Contingency measures to address exceedances.	10.11
A description of how the effectiveness of actions and measures would be monitored over time.	10.13

This Stage 3 GMP follows on from a previous *Groundwater Monitoring Plan* prepared by DP (2010a) for all stages of the development, although remains in place for Stage 1 which is established immediately east at Lot 212 D.P. 1174939.

The requirements in Table 1 have previously been completed prior to Stage 1 development, in the overall GMP that was for Stage 1 and the future industrial stages (Stages 2&3).

Relevant information from DP (2010a) has been incorporated herein.

This GMP includes the following information:

- Summary of the site condition, environmental setting and proposed development;
- Review of previous reports and groundwater level and quality data on the site and surrounding sites;
- Water quality data compilation, trend review and statistical assessment for site specific trigger levels;
- Development of a conceptual hydrogeological model (CHM);
- Identification of potential impacts to groundwater from the proposed development and identification of possible mitigation measures;
- Groundwater monitoring strategy including:
    - Requirements for continuous improvement and detailed design in line with data collection and staged development;
    - Summary of environmental standards for groundwater monitoring;
    - Recommendations for groundwater monitoring prior to, during and following construction;
    - Assessment criteria;
    - Contingency measures and reporting requirements;
    - Requirements for review of the monitoring plan and effectiveness of the program.

It is noted that the Stage 3/Lot 210 *Groundwater Management Plan* (GWMngtP) (DP, 2024), a separate document but overlapping with this GMP, was approved by DCCEEW (federal) 12 July 2024 to address the EPBC Approval 2007/3343. This GMP has been produced to meet both the Department of Planning, Housing and Infrastructure (DPHI) requirements (NSW state) and is consistent with the approved Stage 3 GWMngtP.

2. Site Description

The proposed industrial subdivision site is located south of Tomago Road, Tomago, in the local government area of Port Stephens Council.

The Stage 3 site details are summarised below and shown on Figure 1 and 2 below and on Drawing 1 in Appendix D.

Site Address	2 WesTrac Drive, Tomago
Legal Description	Lot 210 D.P.1174939
Area	50.13 hectares
Zoning	Zone IN1 General Industrial
Local Council Area	Port Stephens Council
Current Use	Vacant

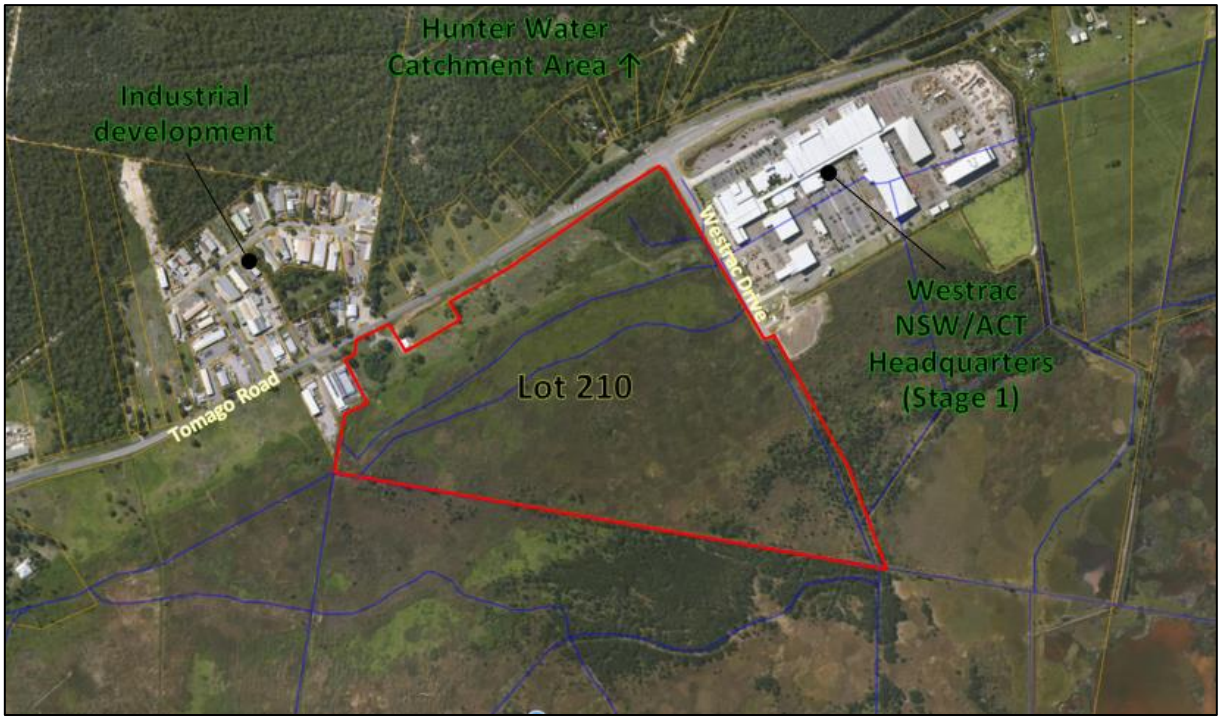

Figure 1: Approximate Lot 210 / Stage 3 boundary shown in red (Base Image source: MetroMap 2023)

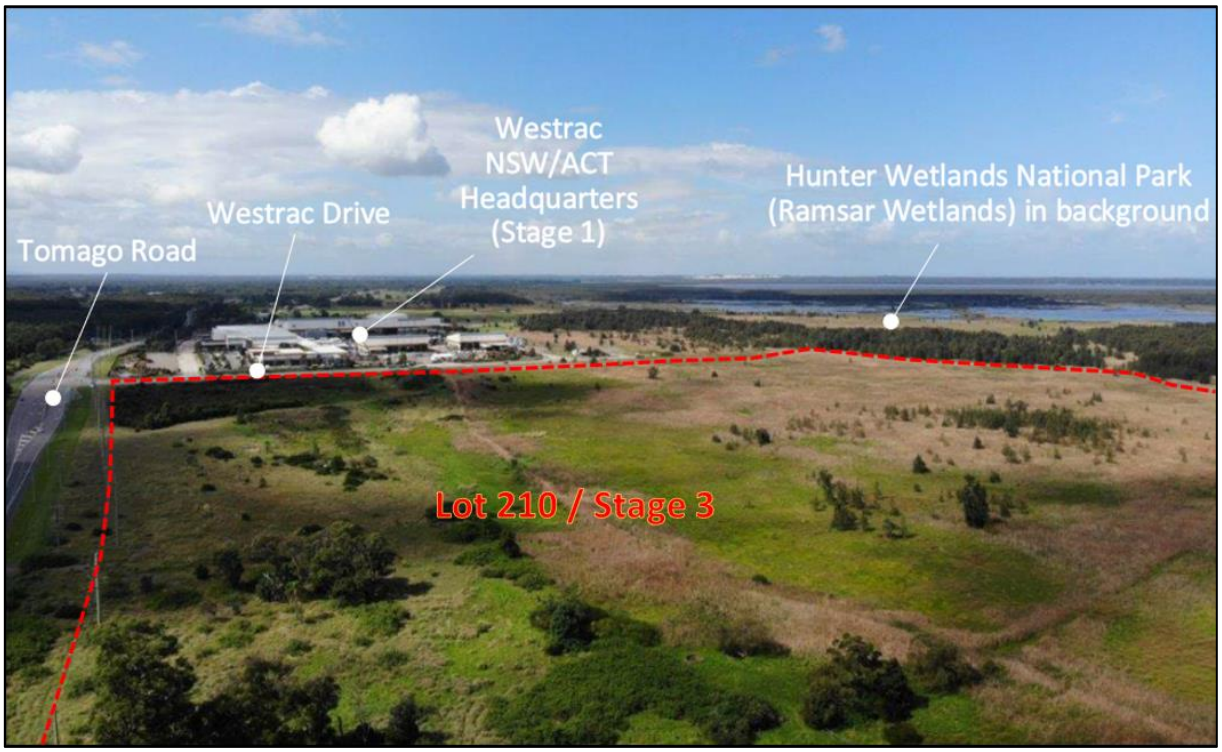

Figure 2: Approximate Lot 210 / Stage 3 boundary shown in red. Westrac NSW/ACT Headquarters (Stage 1) in background (Image Adapted from Torque Projects)

3. Environmental Setting

Site Topography	The majority of the site comprises generally flat water-logged terrain with typical elevations between RL 0.5 and 2.0 AHD. The northern part of the site adjacent to Tomago Road is elevated above this level, dominated by low sand dune formation with a maximum elevation of RL 4 AHD.
Site vegetation	Site vegetation includes dense reeds / scrubland, with reeds up to 3 m in height, mostly located in areas of water-logged terrain. Some mature trees are located on the site, mostly in the northern elevated parts.
Geology (Figure 3)	Reference to the 1:250,000 Newcastle Geology map indicates that the site is underlain by Quaternary alluvium, which typically comprises gravel, sand, silt and clay. The underlying bedrock comprises siltstone and sandstone of the Permian aged Tomago Coal Measures. Reference to the NSW Seamless Geology mapping indicates four mapped zones: • QP-bd: Coastal deposits of marine-deposited and aeolian-reworked coastal sand dunes; partially consolidated. • QP_brs: Coastal deposits comprising fine to medium-grained quartz-lithic-carbonate (marine-deposited) sand, organic-rich mud, peat. • QH-es: estuarine swamp comprising organic-rich mud, peat, clay, silt, very fine to fine-grained sand (marine-deposited), fine- to medium-grained sand (fluvially deposited). • QH_er: Estuarine shoreline ridge and dune deposits comprising fine- to medium-grained lithic-quartz sand (fluvially deposited), very fine- to fine-grained lithic-carbonate-quartz sand (marine deposited), polymictic gravel, silt, clay, shell material.
Acid Sulfate Soils (ASS) (Figure 4)	ASS typically occur at levels of approximately RL 5 AHD or below, but typically at elevations less than 1 AHD in coastal environments. Most of the site lies within an area of high risk of ASS conditions, most likely to be present between 1 m to 3 m below the ground surface, corresponding to lower-lying areas. The northern portion of the site fronting Tomago Road and on higher ground lies within an area of low probability of ASS conditions, which if present is mostly likely at greater than 3 m below the ground surface, corresponding to the Aeolian sandplain, elevation >4 m). Previous testing on the Stage 1 site (east) and site to the west indicated natural soils were potential ASS. DP (2023) has prepared an acid sulfate soil management plan (ASSMP) for the Lot 210 / Stage 3 development based on the previous testing with similar conditions expected for the subject site. The ASSMP noted that site based activities would predominantly comprise filling, with minimal disturbance of natural soils.

Aquifer	Two groundwater systems are present within the project area: • The aquifer within the Tomago Sandbeds which outcrop immediately north of the site and include an extensive water-extraction bore field operated by the HWC. The aquifer is unconfined north of Stage 3 area and semi-confined where clay soils overly the Tomago Sandbeds. As discussed below, groundwater flows away from the bore field and towards the Stage 3 site. • The aquitard within the Quaternary clay soils overlying the Tomago Sandbeds in most of the project area. The aquitard acts as a semi-confining layer.
Surface Water Bodies	The Hunter River (North Arm) is located to the south-west and south of the site, varying in distance from about 1.6 km to 2.4 km. Fullerton Cove is located about 2 km east-south-east of the site. The North South Drain is also distant from Lot 210 / Stage 3 in a separate catchment (i.e. surface water flows are not directed towards the Ramsar wetlands). The Stage 3 site includes a number of existing and manmade open channels (farm drains for previous land uses) and watercourses that direct flow in the low-lying areas. The approximate watercourse locations are shown on Figure 7 in Section 5.2. The existing open channels/drains to the south of the site (within Lot 1001) convey runoff from the southern development site boundary across Lot 1001 to the Hunter River North Arm. Vegetation in the existing drains can reduce surface water conveyance and lead to increased waterlogging across the site. Periodic maintenance is undertaken to reduce vegetation overgrowth to allow surface water to drain more freely.
Ramsar Wetlands	The Hunter Wetlands National Park is located southeast of the Stage 3 site and makes up part of the Hunter Estuary Wetlands Ramsar site which extends to the Hunter River (north Arm) and Fullerton Cove as shown in Figure 5. At its closest point, the wetlands are about 320 m from the Lot 210 boundary (measured from the south-eastern corner of Lot 210). The wetlands are important for a number of species including migratory birds. Surface water (comprising both surface water runoff and groundwater emanating as surface water) from Stage 3 overflows primarily south onto Lot 1001 (to the east) and distant from the Ramsar area and the North-South Drain.
Groundwater dependent ecosystems (GDEs)	Review of the Bureau of Meteorology GDE Atlas indicated no known or mapped GDEs on the Lot 210 / Stage 3 site. GDEs were mapped near the site as shown in Figure 5: • High probability of terrestrial GDEs south of the site and south-east of the site. Vegetation - Parramatta red gum/ Fern-leaved banksia/ Melaleuca sieberi swamp woodland. Ecological fieldwork mapping has this area to be Swamp Oak Forest; • High probability of terrestrial GDEs south of the fronting the Hunter River. Vegetation – salt marshes. Lot 1001, downstream of Lot 210, includes mapped GDEs. The majority of Lot 1001 is approved to be developed under EPBC Approval 2007/3343 and MP10_0185.

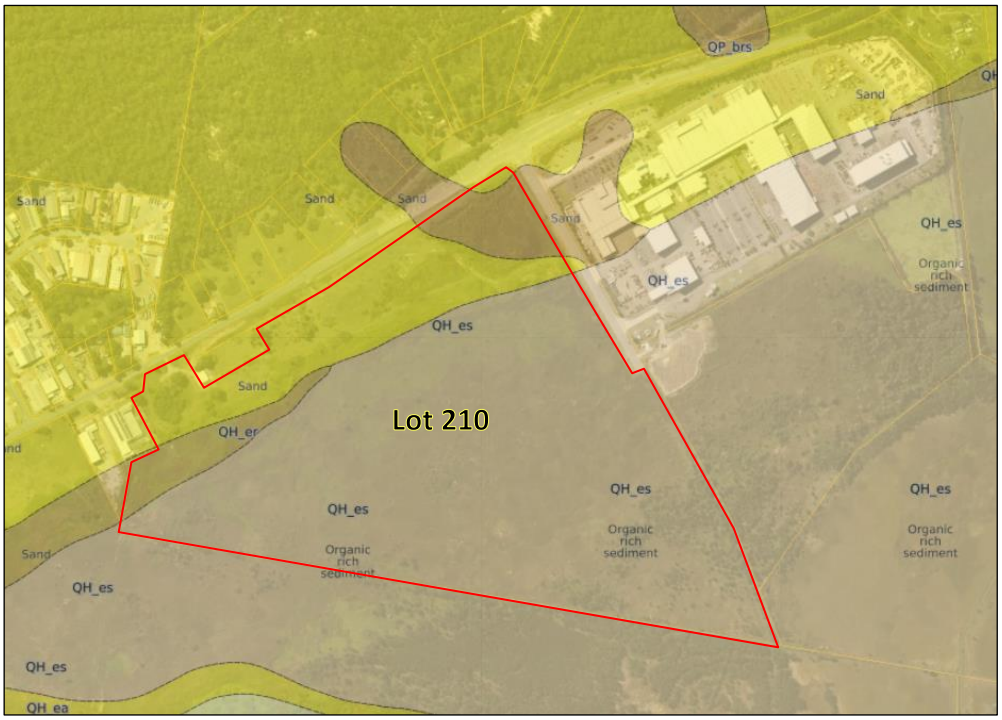

Figure 3: NSW Seamless Geology Map. Site boundary shown in red (Base Image source: MetroMap 2023)

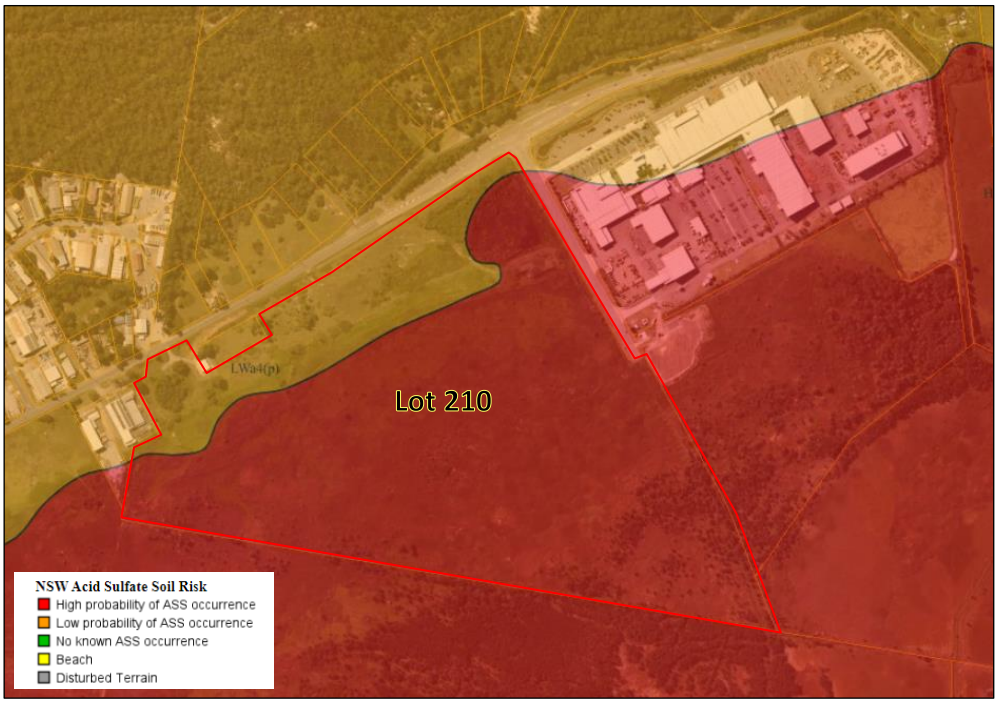

Figure 4: ASS Risk Map. Site boundary shown in red (Base Image source: MetroMap 2023)

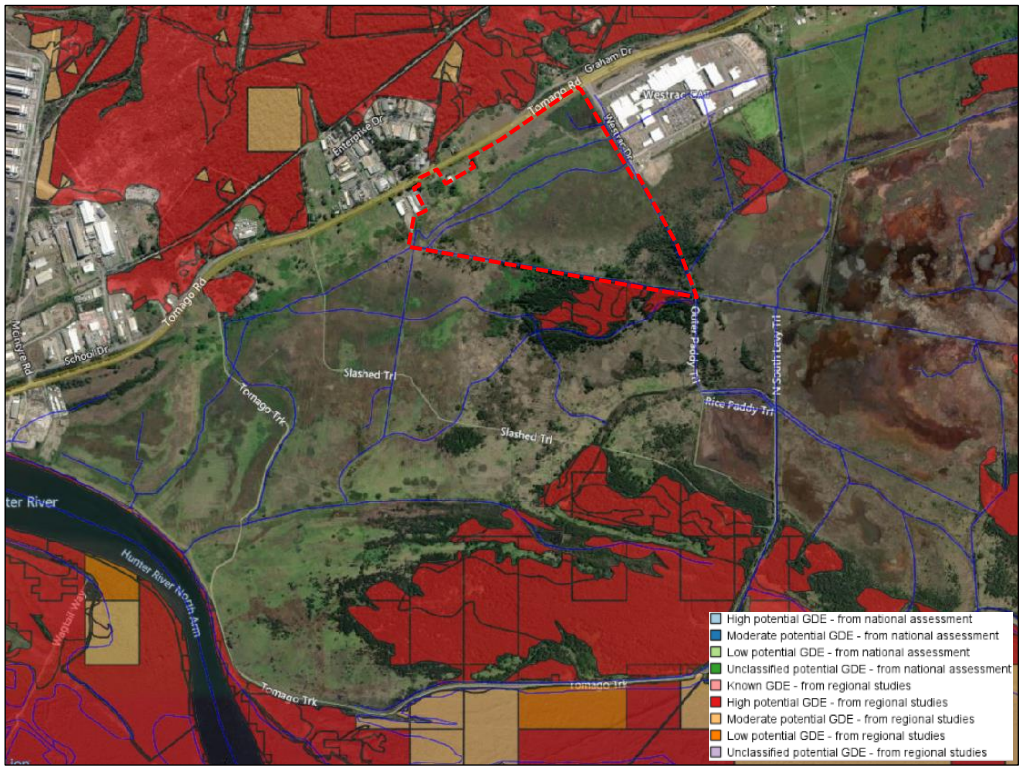

Figure 5: Mapped GDEs. Site boundary shown in red (Base Image source: MetroMap 2023)

The site hydrogeology and conceptual hydrogeological model is discussed in Section 6.

4. Proposed Development

It is understood the Stage 3 development will be staged and will comprise the following as shown on Figure 6:

- Bulk filling in the order of 2.5 m to 3 m above existing levels to reach flood planning levels/minimum floor levels. The finished levels of the lots will range from RL 3.5 to 4.0 AHD;
- Development of industrial lots and associated access roads, drainage reserves and water management ponds and drainage swales to be constructed above existing site levels;
- Water management ponds will be staged and include temporary basins as required with progression of bulk filling (located above existing ground levels);
- Excavation into natural soil is therefore likely to be minimal and for excavation of deeper service trenches only.

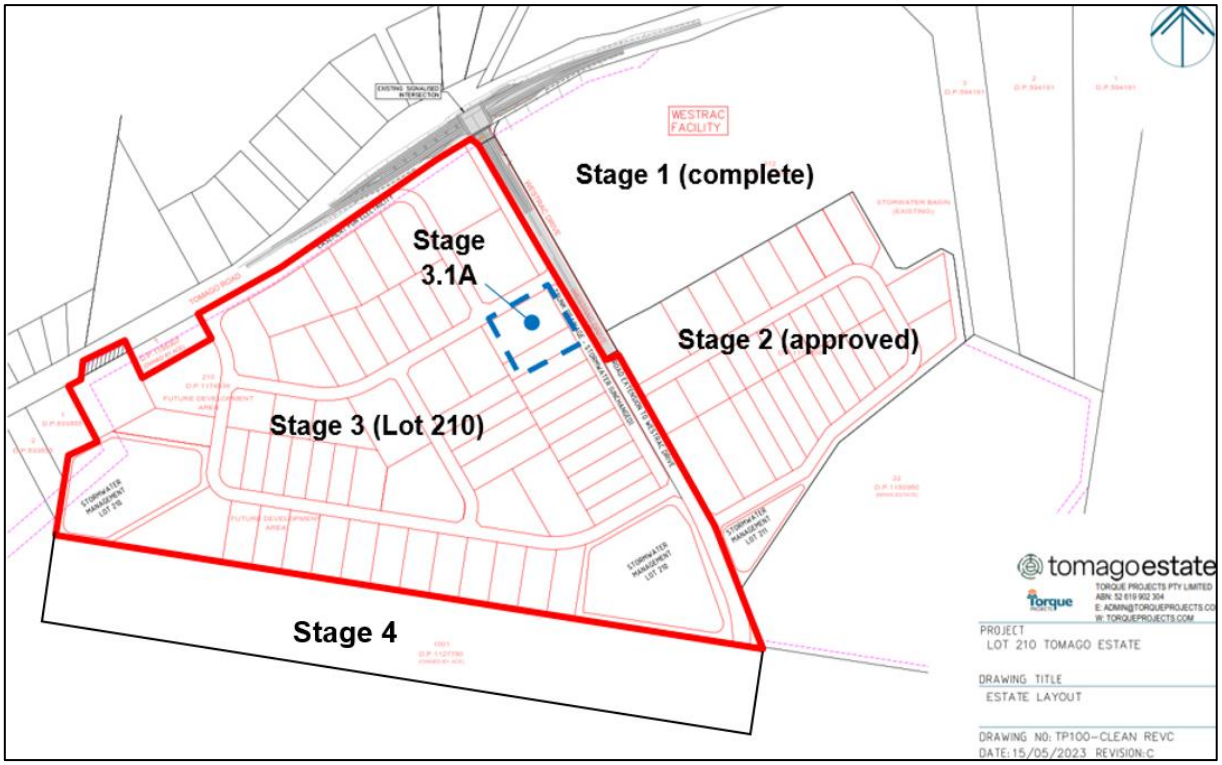

Figure 6: Proposed development layout. Lot 210/Stage3 boundary (red); Stage 3.1A (blue) (Adapted from Torque Projects, 2023)

It is understood that approval for partial filling for an area of about 1.2 hectares has been received as "Stage 3.1A", located midway down the eastern side of Lot 210 and adjoining Westrac Drive as shown in Figure 6.

Proposed surface water management ponds and drainage features are shown on WRM Figure 4.1 in Appendix D.

It is noted that Stage 2 of the development will be completed under separate cover by others.

5. Previous Assessments and Monitoring

5.1 Stage 1 Reports for Submission

DP has prepared a *Groundwater Monitoring Plan* (DP, 2010a) for Stage 1 of the development which has now been established immediately east at Lot 212 D.P. 1174939. The GMP was prepared in consultation with the Department of Water and Energy (DWE), which is now known as the Department of Planning and Environment (DPE). The relevant reports regarding geotechnical / hydrogeological conditions for the site and surrounding areas for the Stage 1 GMP are summarised in Table 2.

Table 2: Relevant Reports for the Stage 3 Site and Surrounds

Date	Title	Author
Jul 1990	Prediction of Maximum Water Levels at Tomago Aluminium	Douglas Partners Pty Ltd
1983 - 2000	Annual Reviews of Mineral Sands Mining at Tomago	Douglas Partners Pty Ltd
Jul 2001	Preliminary Geotechnical Investigation Proposed Steel Mill and Port Development, Tomago, New South Wales, Australia	Earth & Rock Engineering Pty Ltd
Dec 2001	Stage 2 Geotechnical Investigation Proposed Steel Mill, Tomago, New South Wales, Australia	Earth & Rock Engineering Pty Ltd
Aug 2006	Proposed Industrial Development, 197 - 325 Tomago Road, Tomago, NSW, Preliminary Geotechnical / Due Diligence Assessment	Coffey Geosciences Pty Ltd
Nov 2007	Proposed Westrac Industrial Development - Tomago - Geotechnical Assessment	Coffey Geotechnics Pty Ltd
Jul 2008	Geotechnical Review, Proposed Westrac Facility, Tomago Road, Tomago	Douglas Partners Pty Ltd
Aug 2008	Proposed Industrial Development - Tomago Hydrogeological Investigation	Coffey Geotechnics Pty Ltd
Jul 2009	Major Project Assessment: Red lake Enterprises Industrial Estate	NSW Department of Planning
Aug 2012	Modelling Shallow Groundwater - Lot 1001 Tomago, For Proposed Northbank Enterprise Hub Business and Industrial Park	Environ (now Ramboll)

Relevant information from DP (2010a), including previous advice from DWE, has been incorporated herein.

5.2 Long Term Monitoring and Trend Review

Groundwater and surface water monitoring for Stage 1 has been undertaken with reference to the initial *Groundwater Monitoring Plan* (DP, 2010a) which was aligned with:

- Annual Environmental Management Report (AEMR) requirements for the Major Project Approval 07_0086 (including Stages 1 to 3 area); and
- Annual Reports under Condition 9 of the EPBC Approval 2007/3343.

The monitoring undertaken for Stage 1 includes a number of well locations within and near the Stage 3 site. The borehole logs and a summary of monitoring well construction and screened strata/aquifer is included in Table A1 in Appendix A.

Monitoring on and near the Stage 3 site has broadly been undertaken as follows:

- Stage 1, incorporating the Stage 3 area:
  - 2007 – initial groundwater level and quality monitoring by Coffey Geotechnics;
  - 2010 to 2012 – groundwater level and quality monitoring during construction;

  - 2013 to present – typically undertaken annually between March-May, comprising sampling of groundwater monitoring wells and supplementary surface water monitoring locations. Monitoring has been undertaken by a number environmental consultants and most recently by DP;
- Lot 1001 located west of Stage 3:
  - 2007 and 2011 – groundwater level/quality and surface water monitoring by Douglas Partners;
- Hunter Wetlands National Park, southeast of the Stage 3 - monitoring from 2008 to 2011 engaged by National Parks and Wildlife Services (NPWS);
- Broader Tomago Sandbeds and drinking water aquifer extending to the north of the site and Tomago Aluminium to the north-west – routine monitoring of groundwater level and quality undertaken by HWC.

It is noted that most of the monitoring has been undertaken annually in March-May, and therefore may not show seasonal variability. However, the dataset is therefore normalised (controlled) for the set time of the year and assists in the assessment of long term trends. Monitoring has routinely been undertaken for the following locations shown on Drawing 1 in Appendix D:

- Monitoring wells MW2, MW4, MW6, MW10, MW11, MW8/8A;
- Surface water locations SW1, SW2, MW3/SW3a, Graham Drive.

The compiled groundwater level record us shown on Figure B1 in Appendix B. Time-series groundwater and surface water quality plots for key parameters are shown in Appendix C.

Key pertinent trends from the monitoring data capturing Stage 1 and Stage 3 are summarised in Table 3.

Table 3: Key pertinent observations from groundwater water level and groundwater / surface water quality plots

Item	Groundwater	Surface water
pH	pH in groundwater has varied widely between monitoring events. Wells screened in the clay aquifer have generally been at higher pH ranges and mostly within the 6.8-8.5 ANZG DGV. Wells screened in the Tomago Sandbeds generally indicated lower pH values. Low pH is common for the area regionally and could be due to a number of reasons including former sand mining within the broader Tomago Sandbeds (upgradient); podzol soils in coastal dunes; and acid sulfate soils. pH at the site would be affected by rainfall events. The range of values identified are not considered uncommon.	Similar to groundwater, pH in surface water has varied widely between monitoring events. This has included pH for upgradient monitoring locations along Tomago Road (SW3 and Graham Drive). Overall pH for surface water is slightly higher than groundwater. Fewer upgradient surface water monitoring locations were sampled due to dry conditions.
EC	EC has been relatively consistent between monitoring events. The notably low values reported in 2013 are considered likely to be erroneous as they are inconsistent with rainfall data. Similar to pH, higher EC is evident for wells screened in the clay aquitard. Wells screened in the Tomago Sandbeds were generally lower in EC and fresher owing to the freshwater catchment of the Tomago Sandbeds. The data suggests a reasonably consistent EC profile for each well, and a clear difference between well strata. The values are considered representative of the general site locality, and therefore exceedances of the ANZG and ADWG criteria are not of concern.	EC has been relatively consistent for between monitoring events and indicates low EC and fresh conditions which is consistent with rainfall and runoff.
Nutrients	Ammonia, nitrate, nitrite and total Kjeldahl nitrogen (TKN) are test methods to report forms of nitrogen. Concentrations have varied over the monitoring period. The nitrogen state can be dependent on pH and temperature and in mangrove / low lying areas can change with periods of wetting and drying. MW4 has indicated higher concentrations of ammonia which are typically greater than the ANZG criteria. MW6 was also elevated periodically and there was a single spike in MW2 in 2021 which subsequently returned to more typical concentrations. There is no ANZG (2022) criteria for total phosphorus (TP) and so the ANZECC (2000) value for NSW & Victorian east flowing coastal rivers in a marine setting has been adopted. TP is notably variable over the monitoring period, with similar variability to ammonia. Overall, higher nutrients are apparent for wells in the clay aquitard which is likely to be attributed to the organic rich clay soils rather than runoff impacts from site activities.	Lower ammonia, nitrate and TP concentrations were apparent for surface water. TKN concentrations in surface water concentrations were similar overall, but spikes in concentrations were typically higher. As noted for groundwater, nitrogen states can be dependent on pH and temperature and fluctuations may influenced by the variable pH for surface water. Nutrient concentrations may also be influenced by animal/bird populations that inhabit the basin. Overall, the nutrients indicate periodic spikes but do not suggest increasing trends during and following the Stage 1 development that could adversely affect downstream water quality.

Item	Groundwater	Surface water
Metals	Most metals concentrations were below the ANZG and NHRMC criteria for most events. Occasional exceedances occurred for dissolved arsenic and nickel, however, concentrations have typically been below the guideline value for the subsequent monitoring event. Monitoring during the initial period prior to 2013 suggest possible elevated results which may be due to sampling or filtration methods. Manganese, iron, copper, chromium, were regularly above the current ANZG criteria, with most exceedances for wells screened in the clay aquitard. Exceedance of ANZG criteria for such metals is a common occurrence in groundwater in the region and is often due to naturally occurring processes. Iron and manganese concentrations in the Tomago Sandbeds have been influenced by past sand mining activities. It is noted that metals are often more soluble in groundwater at lower pH. The variable pH in groundwater identified may therefore contribute to the variability of dissolved metals between monitoring events. Aluminium and iron have been tested from 2024 and therefore limited data is available to date. Overall, metals results do not suggest an increasing trend and appears to show values within a typical range of natural variability.	The metals testing has comprised dissolved metals (filtered) and total metals (non-filtered), however, this has not been consistent between monitoring events. Dissolved metals allow a comparison with groundwater results, whereas total metals concentrations are more representative of actual conditions reflecting metals which may be suspended in surface water due to soil-bound particulates. Monitoring would benefit from testing of both metal states. The variability in metals may be influenced by sample handling and the presence/absence of particulates for the particular sampling event. In most instances, metals concentrations were higher for downgradient locations (SW1, SW2) which are located in vegetated drains/basins and as such these results are not unexpected or significantly different to groundwater conditions.
Pesticides	The detection limits for pesticides have varied over the period of monitoring, and have been lower for recent monitoring. OCP and OPP pesticides have not been detected above the laboratory PQL.	Similar to groundwater, OCP and OPP pesticides have not been detected above the laboratory PQL for surface water.
Hydrocarbons, phenols	Hydrocarbon as TRH, fractions of BTEX and phenols have been identified at times. Phenols were identified in 2010 and 2021 at MW2 located in the Stage 1 area. Resampling was not recommended by the consultant, but subsequent well clean out was completed at the time. Subsequent annual events from 2016 to 2020 did not identify phenols. An elevated result in 2021 was re-tested and indicated concentrations below the laboratory PQL. Phenol has not been identified in subsequent annual monitoring. Low level hydrocarbons have been identified periodically. In most instances, silica gel clean up testing was undertaken which indicated the hydrocarbons were from a natural/organic source rather than a petroleum based source and were attributed to organics present in the clay aquitard. The monitoring has not indicated the presence of increasing hydrocarbon trends or a contaminant plume.	Similar to groundwater, hydrocarbons have been detected periodically above the laboratory PQL for surface water. Silica gel clean up testing has indicated the hydrocarbons were from a natural/organic source rather than a petroleum based source.

For the historical monitoring, it is noted that where quality results were suggested to be elevated above the default guideline value (DGV), or previous range of results, further assessment was generally undertaken and documented in each monitoring report. At times, elevated results were attributed to high suspended sediments, particularly in the instance of surface water monitoring locations.

It should be noted that groundwater levels are affected by climatic conditions and soil permeability and will vary with time. Similarly, surface water quality will be subject to variability and these influences.

5.3 Groundwater Statistical Assessment

Available groundwater quality data have been reviewed to analyse baseline conditions to determine site-specific trigger levels (refer Section 10.9.2). The full data set includes monitoring in 2007, 2010, 2011 and then annually from 2013. From 2015, field sampling methods, laboratory test methods and detection limits detailed in monitoring reports were reasonably consistent, which is aligned with a period of lesser variability between each monitoring event. Therefore the data available from 2015, including the Stage 3 baseline period to January 2025, is considered suitable for the adoption of trigger levels.

The monitoring bore field targets two different groundwater systems: the aquifer in the Tomago Sandbeds and the aquitard in the overlying clay soils, where present. Review of water quality data shows the two groundwater systems have different chemistry. For the purpose of the statistical analysis and trigger level determination, groundwater quality data were divided into two categories based on the profile screened by each well: sand and clay.

The 80th percentiles were assessed for each analyte to establish site-specific upper trigger levels, and the 20th percentiles were determined for analytes requiring lower trigger levels. The UCL95-mean was also calculated to be used as a tool to indicate when monitored values are above average background levels.

Graphs presenting historical groundwater quality results for the main parameters and analytes of interest are presented in Appendix C.

6. Conceptual Hydrogeological Model

6.1 Topography and Geology

Key features of the site include:

- The southern part of the site comprises flat water-logged terrain with a typical surface elevation of 0.5 to 1.0 AHD, with existing drains cut in lower than natural surface;
- The soil profile comprises alluvial / estuarine sediments (deposited under water), with some aeolian (wind-blown) sand deposits;
- The northern part of the site is dominated by a low sand dune formation with a maximum elevation of RL 4.0 AHD. This is underlain by estuarine sand deposits to depth;

- On the central and southern parts of the site the upper soil profile consists of very soft to stiff silty clay, clay and sandy clay soils, overlying very loose to medium dense clayey estuarine sand. These are subsequently underlain by dense sand and stiff to hard clay strata. The depth to bedrock has not been established, but exceeds 18 m.

6.2 Hydrogeology

The site is underlain by estuarine sands at depth associated with the Tomago Sandbeds. On the northern parts of the site, these are overlain by aeolian sands and on the southern parts of the site the sand is overlain with estuarine swamp deposits primarily clay (low permeability) soils.

The compiled groundwater level record is shown in Figure B1 in Appendix B and indicates the range of variability that has been captured to date. The monitoring has typically encountered groundwater at depths ranging from above ground surface in lower lying areas to slightly below ground level for the unconfined aquifer.

Groundwater levels are consistently higher levels for wells located in the northern elevated areas fronting Tomago Road (MW8A, MW101) compared to wells in the low-lying areas of Stage 1 and Stage 2 which were often similar to surface levels.

Groundwater flow on the site is to the south and south-east, with the main recharge coming from the Sandbeds to the north as evidenced by HWC monitoring bore SK3520 as well as surface infiltration on the site. Rainfall infiltration is expected to be limited on the southern lower lying parts of the site. This is partly due to the low permeability of the soil and partly due to the low-lying nature of the ground resulting in groundwater levels close to the surface and thereby inhibiting infiltration. As a result, groundwater is predominantly evident in the existing surface drains at the southern downstream boundary of the site. Evapotranspiration rates on the southern parts of the site are expected to be relatively high due the shallowness of the groundwater.

The observed limited variability of the groundwater level on the central and southern parts of the site is due to the low elevation of the natural ground surface which provides an upper limiting groundwater level for the shallow groundwater. Therefore, the groundwater level is kept lower than would occur for the same recharge conditions if a higher ground surface were present, for example across the northern parts of the site. The low natural surface and existing drains cut below natural levels limit the fluctuations which have been observed on the higher northern parts of the site from occurring on the low-lying parts downstream of the site.

Groundwater flow is expected to be split vertically by the presence of the estuarine swamp deposits, with some flowing up over the swamp deposits and discharging as seepage from the toe of the aeolian sands on the northern parts of the site. It is expected that the seepage discharge to surface flows will be subject to a combination of flow into surface drains, reinfiltration to groundwater within the swamp deposits and evapotranspiration, the relative proportions of which will vary depend on prevailing climatic conditions.

Shallow groundwater flows at the site are altered by the presence of the existing surface watercourses and drains excavated under previous land uses. These drains previously removed ponded surface water efficiently including near surface groundwater from the site draining the water in multiple directions including to the east and south-west towards the adjacent Lot 1001 and eventually discharge to the Hunter River.

A proportion of groundwater flows towards the south and south-east will occur within the estuarine sands below the swamp deposits and discharge downstream of the site, to various surface water bodies including most to the Hunter River and possibly Fullerton Cove. The estuarine sands below the site form a confined aquifer with limited interaction with the shallow groundwater conditions on most of the site. Previous investigations by DP at downstream sites indicated groundwater heads in the confined aquifer are typically lower and indicate flows towards the Hunter River.

It is noted that the downstream landscape of the wetlands has been altered by the introduction of tidal inundation via the North South Drain which is deeply incised below wetland ground levels.

Groundwater quality monitoring for the area has indicated dissolved metals that exceed ANZG (2018) ecological criteria which is not uncommon for groundwater quality in the Tomago locality (refer Section 5.2).

7. Potential Development Impacts

The management of groundwater at the site is highly dependent on the surface water management measures. To replicate natural conditions during and post development (as practicably as possible), integrated management groundwater and surface water strategies is therefore required and this will be refined as future detailed studies for design progress.

The proposed development has the potential to change the groundwater flow regime as follows:

- As typically anticipated with any development site, the distribution of recharge on the site will change, with recharge on impervious surface being transferred to drainage swales and basins, more concentrated infiltration will occur in these locations, the amount of which will depend on the permeability of the fill utilised for the bulk filling;
- Evaporative losses from the shallow groundwater will be less due to the impedance of the filling and impervious surfaces;
- Groundwater inflows into below water table excavations could result in drawdown in the intersected groundwater systems;
- Raising of the surface by filling allows the potential for groundwater levels to mound within the filling to higher levels than were previously possible;
- Placement of the filling without any assessment or design has the potential to impede groundwater seepage flows from the dune sands onto the flood plain which could lead to backing up of water upstream and possibly higher average groundwater levels in the Tomago Sandbeds upstream of the site;
- Flow in the deeper estuarine aquifer is not expected to be affected materially by the proposed development;
- If there were no controls, potential contamination of groundwater/surface water from site filling and activities during and post development.

A key element to replicating the natural groundwater conditions on the site is replicating the key role of the shallow ground surface in controlling the current groundwater flow regime. The drainage offered by the current ground surface is proposed to be replicated by installation of appropriately designed subsoil drainage within the fill platform at a level close to the existing ground level and/or the existing groundwater level. The subsurface drainage would be routed to the downstream toe of the fill and into the downstream surface water drains. The subsurface drainage would mitigate mounding within the fill and address potential damming of upstream flows from the Tomago Sand Beds. Similarly, lowering of groundwater water levels would be unlikely due to ongoing infiltration of water from the swales and basins and the removal of evaporative losses from the water table, which would have previously been a large component of the mass balance of the system. There may be some excess water from the overall site mass balance resulting in increased average flow in the surface drains downstream of the site. The proposed discharge point is to be approximately 700 m further west along the Lot 210 southern boundary onto Lot 1001 (owned by NEH). This approach was proposed by NEH and its consultants during the NSW state government consultation process with National Parks & Wildlife Service to be distant from the adjoining wetlands.

The potential risks and potential changes as a result of development are expected to be mitigated or controlled by groundwater management measures. Strategies will be confirmed at detailed analysis and review stages, however, may include the following:

- Design of surface water measures such as swales to allow infiltration to occur;
- Bulk earthworks geotechnical assessment, design and reporting for filling activities;
- Staging and selection of bulk fill for geotechnical / information properties;
- Provision of drainage blanket and subsoils drains within the near the existing ground surface and discharging into downstream surface drainage;
- Monitoring of groundwater levels during preloading for possible mounding effects;
- Detailed design of management measures for groundwater and surface water, including drainage blanket and subsoil drains to invert levels that replicates current groundwater levels;
- Routine maintenance of subsurface drainage system (where implemented);
- Implementation of the groundwater level and quality monitoring network (Section 10) to assist in detailed design of management measures for groundwater and surface water;
- Implementation of environmental management strategies during construction;
- Implementation of long-term development specific environmental measures and controls for each development lot post-development (e.g. bunding, leak detection devices, environmental management procedures and incident responses).

8. Regulatory Setting

The legislation and guidelines that are considered most relevant to the environmental management for the Stage 3 development are listed in Table 4.

Table 4: Environmental Legislation and Guidelines

Legislation / Guideline	Relevance / Applicability
Protection of the Environment Operations Act (1997) [POEO Act]	Key overarching legislation that enables the NSW Government to set out explicit policies for protection of the environment, including granting and administering Environmental Protection Licences (EPL).
Contaminated Land Management Act 1997 (as amended 2009) [CLM Act]	NSW Legislation for management of contaminated sites.
DECC Guidelines for the Assessment and Management of Groundwater (March 2007)	These guidelines are relevant for groundwater contamination in NSW. They stipulate the use of ANZECC groundwater investigation levels (GILs) for 95% protection of aquatic ecosystems.
National Environment Protection Council, National Environment Protection Measure 1999 (as amended 2013) [NEPM 2013]	The NEPMs outline *national* objectives for protecting or managing aspects of the environment. These may be a combination of goals, guidelines, standards, or protocols.
NSW EPA Guidelines for Consultants Reporting on Contaminated Land, 2020	These guidelines provide a reporting framework for consultant reporting on the management of contaminated land.
Water Management Act 2000	Framework for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations.
NSW Aquifer Interference Policy	Policy that covers requirements for obtaining water licences for aquifer interference activities.
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The Act and regulations provide guidance to protect and manage nationally and internationally 'matters of national environmental significance' including plants, animals, habitats and places.

9. Consultation with Government

DP has previously consulted with the Department of Water and Energy (DWE), now known as Department of Planning and Environment (DPE) as part of the initial approvals for the overall GMP, Stage 1 and future industrial stages under the Major Project Approval 07_0086. The outcomes and recommendations of 21 October 2009 meetings were adopted in the Stage 1 GMP and similarly have been incorporated into this Stage 3 GMP as follows:

- The general parameter types and the frequency of sampling and testing is generally commensurate with the Stage 1 GMP (DP, 2010);
- The use of statistical analysis of percentiles for setting trigger levels from background monitoring is appropriate where background concentrations are greater than ANGZ (2018) / ANZECC (2000) / ADWG (2018) criteria. If an exceedance occurs, re-testing to check if the exceedance was an aberration is a sensible approach as included in this plan;
- Review of the monitoring plan should be undertaken after 5 years and completion of construction, which may allow for revision / reduction of the monitoring parameters and frequency.

The Stage 3 GMP was referred for consultation to DCCEEW (NSW), formerly DPE Water. Response comments regarding monitoring well locations and monitoring requirements dated 4 October 2023 have also been addressed in the GMP.

As noted in Section 5.2, annual monitoring reports/returns have been submitted to DPE for review and assessment of compliance under the Major Project Approval 07_0086 and under Condition 9 of the EPBC Approval 2007/3343. The Stage 3 *Groundwater Management Plan* (DP, 2024) for development of Lot 210 was approved by DCCEEW (federal) on 12 July 2024

10. Monitoring Strategy

10.1 Continuous Improvement and Detailed Design

It is noted that the proposed development is at conceptual planning stages, and detailed design will be completed for each sub stage of Stage 3 to achieve appropriate management strategies for groundwater, surface water and geotechnical considerations as outlined in Section 7.

In addition to the requirements for on-going monitoring to achieve continuous improvement and as detailed in this Groundwater Management Strategy, detailed design will include the following:

- Details of fill materials, drainage blanket, and sizing of subsoil drains and possibly diversion trenches for the respective stage area;
- Geotechnical review of bulk fill, subject to identification of source materials;
- Confirm groundwater level ranges at specific locations based on historical data for determination of design invert levels for inflow and outflow points;
- Groundwater modelling of scenarios to confirm impacts can be mitigated;
- Continuing site wide integration of monitoring results for groundwater, surface water and geotechnical considerations as staging progresses;
- Monitoring equipment improvements to provide greater resolution for observing the water level responses to rainfall via equipment/technology which relay 'live' water levels.

In summary, detailed design of controls will be undertaken for respective stages to mitigate impacts and implement management strategies.

10.2 Standards

The following standards have been identified for groundwater monitoring.

Table 5: Summary of Monitoring Network

Item	Reference Standard
Groundwater monitoring well installation	• *Minimum Construction Requirements for Water Bores in Australia* (NUDLC, 2020).
Groundwater level and quality monitoring procedures	• Monitoring sampling, testing and assessment of groundwater shall be undertaken by appropriately qualified hydrogeologists or environmental scientists. • NEPC. (2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) [NEPM].* Australian Government Publishing Services Canberra: National Environment Protection Council. • Australian/New Zealand Standard (AS/NZS) 5667.1:1998 Water quality: sampling part 1 – guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples; • AS/NZS 5667.4 Water quality: sampling guidance on sampling from lakes, natural and manmade; • AS/NZS 5667.6 Water quality: sampling guidance on sampling of rivers and streams; • AS/NZS 5667.11 Water quality: sampling guidance on sampling of groundwaters.
Laboratory testing	• Environment Protection Authority Approved methods for the sampling and analysis of water pollutants in NSW, 2022. • NATA accredited laboratory to test methods.
Review of groundwater quality, level and hydrogeological trends	• Appropriately qualified hydrogeologists or environmental scientists.

10.3 Groundwater Monitoring Network

The groundwater quality should be monitored using a network of nine wells, comprising two existing wells and six new wells specifically for Lot 210 / Stage 3 as shown on Drawing 1 in Appendix D. Well locations have been selected with consideration of upgradient, mid site and downgradient locations which would be suitable for long term monitoring (before and during construction). It is noted that access for personnel and machinery was notably limited by site vegetation and wet ground conditions at the downgradient locations.

Monitoring wells MW4 and MW8-A (as replacement for MW8A) have been subject to long term annual monitoring since 2010.

Table 6: Summary of Monitoring Network

Well ID	New / Existing	Location within site	Rationale	Screened aquifer
MW04	Existing	South-eastern corner Near southern boundary	Downgradient location Adjacent to future basin (Basin 2)	Clay aquitard
MW08-A	New*	North-western corner Near northern boundary	Upgradient location Replacement / relocation of MW8 (damage and boundary adjustment)	Tomago Sandbeds / Aeolian Sands
MW101	New	Central northern boundary	Upgradient location	Tomago Sandbeds / Aeolian Sands
MW102	New	Central / northern part of the site	Downslope of elevated costal sand deposits	Tomago Sandbeds / Aeolian Sands
MW103	New	North-eastern corner	Accessible and suitable location for long term monitoring West and downgradient of proposed Stage 3.1 A fill area	Tomago Sandbeds / Aeolian Sands
MW104	New	Eastern portion	Mid site location Downgradient of proposed Stage 3.1 A fill area	Clay aquitard
MW105	New	Western corner	Accessible location on western part of site Downgradient of northern surface water flow path Near future western basin (Basin 3)	Tomago Sandbeds / Aeolian Sands
MW106	New	Central / southern boundary	Downslope of future fill area and industrial lots Downslope / adjacent to surface water	Clay aquitard
MW107	New	Southern/ south-western boundary	Downslope of future fill area and industrial lots and western discharge area	Clay aquitard

Notes:
* MW8-A replacement for MW8

The early installation of additional wells in Stage 3 and aim of upgradient locations is to further provide “background” water levels and quality with respect to groundwater flowing into the site. Similarly, downgradient locations provide water levels and quality for groundwater leaving the site. The wells near the initial Stage 3 fill area will allow for monitoring of groundwater responses and assist in detailed design of the remaining Stage 3 development.

The monitoring wells are screened to assess the upper water conditions in the unconfined aquifers.

The well locations are shown on the attached Drawing 1 in Appendix D. Well logs are included in Appendix A and should be read in conjunction with the preceding notes. A summary of the monitoring wells strata and installation depths is provided in Table A1, also in Appendix A.

10.4 Groundwater Quality Parameters

The parameters to be measured fall into three categories as shown in Table 7. The analytes comprise contaminants of concern based a typical suite of general water quality indicators and potential contaminants of concern considering future commercial/industrial use which has yet to be confirmed. The assessment criteria are shown on Table B1 and B2 in Appendix B.

Table 7: Groundwater Quality Parameters

Category 1 Parameters (Field parameters)	• Temperature (T) • pH • Electrical Conductivity (EC) • Dissolved oxygen; • Oxidation-reduction potential (ORP) • Turbidity.
Category 2 Parameters (laboratory)	• Total Suspended Solids (TSS) • Cations: – Calcium (Ca) – Potassium (K) – Magnesium (Mg) – Sodium (Na) – Iron (Fe) • Anions: – Chloride (Cl) – Sulphate (SO_4) – Ammonia (NH_3) – Bicarbonate (HCO_3) – Carbonate (CO_3) – Total alkalinity – Nitrite (NO_2) – Nitrate (NO_3) – Total Kjeldahl Nitrogen (TKN) – Total Phosphorous (PO_4) – Fluoride (F) • Heavy Metals: – Aluminium (Al) – Arsenic (As) – Cadmium (Cd) – Chromium (Cr) – Copper (Cu) – Iron (Fe) – Lead (Pb) – Manganese (Mn) – Mercury (Hg) – Molybdenum (Mo) – Nickel (Ni) – Zinc (Zn)
Category 3 Parameters (laboratory)	• Total recoverable hydrocarbons (TRH) • Polycyclic aromatic hydrocarbons (PAH) • Benzene, toluene, ethyl benzene, xylene (BTEX) • Polychlorinated biphenyl (PCB) • Phenols • Organochlorine pesticides (OCP) / organophosphorus pesticides (OPP) • Per- and polyfluoroalkyl substances (PFAS)

If the results of field observations or initial laboratory testing indicate exceedances of the adopted criteria or results which warrant further consideration, additional laboratory testing and further review may be required such as:

- Hydrocarbon detection:
  - Speciation testing via the total petroleum hydrocarbon (TPH) silica gel clean up method to assess for the presence of petroleum and/or non-petroleum based hydrocarbons;
  - Review of laboratory chromatograms for assessment of the possible hydrocarbon source/type.
- Metals:
  - Speciation testing to further assess the significance of the result e.g. Cr (III), Cr (VI);
- Re-testing of the sample where elevated suspended solids are present;
- Comparison of total and dissolved metals where elevated suspended solids may have influenced the result.

The assessment criteria are shown on Table B1 and B2 in Appendix B and discussed in Section 10.9.2. It is noted that not all parameters have an assigned criterion.

10.5 Sampling and Testing Protocols

The recommended sampling protocol is low-flow sampling which is consistent with the baseline monitoring and is in line with standard industry practice, including:

- Purging of at least three bore volumes or until T, pH, EC, DO, ORP and turbidity readings are steady;
- Filtering and preservation of samples specific to each test parameter;
- Chain of custody documentation;
- Duplicate samples on at least 10% of samples or one per monitoring event;
- Reporting (NSW EPA, 2020).

Laboratory testing should be undertaken at a NATA-accredited chemical laboratory and practical quantification limits (PQLs) which allow for comparison against the assessment criteria where possible. The assessment criteria are shown on Table E1 and E2 in Appendix E.

10.6 Baseline Monitoring (Prior to Construction of Stage 3)

Monitoring water quality for Stage 1 and the broader area of Lot 210 has been undertaken since 2010, therefore, groundwater quality has in part been established relevant to Lot 210/Stage 3. Stage 3.1A is already approved by NSW DPE and NPWS, and is located well within site boundaries and of small scale and therefore can be compared to baseline monitoring data.

Prior to commencement of further filling of Stage 3, beyond Stage 3.1A, the baseline monitoring program undertaken comprised:

- Quarterly groundwater quality sampling, including Category 1, 2 and 3 parameters (Table 7); and

- Continuous groundwater level monitoring at hourly intervals using dataloggers in at least five of the monitoring wells and manual level measurements taken at the time of the water quality sampling events in every well.

The three Baseline 2 monitoring events were undertaken in September 2023, January 2024 and April 2024. Baseline 2 monitoring for MW107 was undertaken in April 2024, August 2024, November 2024.

10.7 Post Baseline Monitoring (During and After Stage 3 Construction)

Following baseline monitoring (i.e. during and after construction of Stage 3), monitoring will continue on a 6 monthly basis. The exact number of wells and suite of analytes that need monitoring will be reviewed based on the outcome of the baseline monitoring program. Some initial advice is provided below.

Monitoring wells should be retained for as long as possible to assess for potential impacts, especially wells MW102 to MW104 which are located downgradient of initial fill areas. Monitoring wells in the northern and central areas of the site will be adjusted if required as staging of the development progresses. Reinstallation or replacement wells at suitable long term monitoring locations will be at the advice of the environmental/hydrogeological consultant. Monitoring wells will be replaced as soon as practicable and within three months. Alternative locations for long term monitoring will be at the advice of a suitably qualified groundwater consultant and will require revision and approval the GMP.

For example, post-baseline monitoring for Stage 3 could comprise the following:

- Monitoring of wells MW04, MW8A and MW101 to MW106 for as long as possible. Key / minimum monitoring wells to be retained long term are MW04, MW106, MW8-A and MW101;
- Monitoring well coverage will generally maintain monitoring locations of upstream and downstream of development staging. The interval and frequency of well installations will be confirmed by an environmental/hydrogeological consultant as staging progresses;
- Water quality sampling for the following parameters:
  - Category 1 and 2 Parameters on a 6 monthly basis during and after construction;
  - Category 3 Parameters on a 12 monthly basis;
- Groundwater level gauging on a 3 monthly basis if not subject to automated datalogger monitoring.

10.8 Monitoring Summary

The groundwater monitoring program is summarised in Table 8 with the nominated monitoring wells shown on Drawing 1 in Appendix D.

Table 8: Summary of Monitoring Program

Parameters	Baseline monitoring (Baseline 2) (Note 1)	During Stage 3 Construction
Wells to be Monitored	MW04, MW8A and MW101 to MW107 (all Stage 3 wells)	TBC (Note 2).
Water Levels	Continuous (dataloggers) 3 monthly (manual) (Note 3)	Continuous (dataloggers) 3 monthly (manual)
Category 1 and 2 Parameters	3 Monthly, min of 3 rounds	6 Monthly

Category 3 Parameters	3 Monthly, min of 3 rounds	12 Monthly
Reporting	On completion	12 Monthly
Monitoring Program Review	On Completion	3 Yearly

Notes to Table 8:
1. Baseline 1 was conducted as part of Stage 1 development and GMP (2009)
2. Exact wells that will be monitoring during and after construction will be determined based on the outcome of the baseline monitoring program. As a Minimum, we recommend monitoring of MW04, MW106, MW107, MW8A and MW101 be continued in addition to new wells installed for the project (if required).
3. Hourly water level monitoring by datalogger in wells MW04, MW8A and MW101 to MW106, 3 monthly manual measurements in all wells.

The three Baseline 2 monitoring events were undertaken in September 2023, January 2024 and April 2024. Following installation of MW107 in April 2024, baseline monitoring events were undertaken in May, August and November 2024.

10.9 Assessment Criteria

10.9.1 Groundwater Levels

Groundwater levels will fluctuate with variations in climatic conditions. Assessment of groundwater level trends during and following construction will therefore require:

- General comparison with the long term data set, as well as the baseline groundwater level information (via dataloggers) collected prior to construction for Stage 3;
- Consideration of climatic conditions measured at Williamtown Meteorological Station;
- Consideration of groundwater levels for upgradient wells which will influence groundwater levels and conditions flowing onto the site, including pumping and release of water as part of the HWC operations;
- Consideration of possible downstream influenced, such as changes to tidal inundation, flooding, levee bank failure etc which may affect regional groundwater levels and consequently drainage and surface water conveyance for Stage 3.

The results of monitoring should be reviewed for variations in groundwater levels which are inconsistent with rainfall trends (measured at Williamtown Meteorological Station) and/or outside the range of measured background fluctuations.

Groundwater level data should be used in detailed design of the earthworks, surface water and drainage measures.

10.9.2 Groundwater Quality

The ANZG (2018; 2023) guidelines recommend the use of site baseline data and relevant default guideline values (DGVs) to derive site-specific trigger levels, particularly where background concentrations naturally exceed DGVs. In this approach, *the natural range of values for key indicators at reference sites is used to provide a suitable baseline for comparison against values derived from similar aquatic ecosystems'* (ANZG, 2023). It is noted that adoption of site specific data, where lower than the DGV, would be an overconservative approach and not reflect the level of protection required.

Trigger levels do not guarantee a level of protection, rather, are defined as the 'concentration recorded by monitoring which would trigger further investigation to assess the potential for adverse impact on groundwater quality from a site. Periodic exceedances of the groundwater quality Trigger Levels can be expected to occur, particularly where values are based on the 20th/80th percentile calculations from the baseline data.

It is proposed that different criteria be used for monitoring bores screened in the Tomago Sandbeds aquifer and those in the overlying clay soils given the difference in water chemistry and beneficial uses of the two groundwater systems.

Typically, the guidelines (ANZG, 2018) recommend the 80th percentile of the available baseline data be used as criterion for each analyte. For stressors that cause problems at low levels, it is recommended that the lower criterion be the 20th percentile of the baseline data (i.e. pH which is expressed as an upper range by the 80th percentile and lower range by the 20th percentile to provide a trigger level range, commensurate with the generic ANZG pH criteria).

For PFAS, the relevant guidelines at the time of reporting is the *PFAS National Environmental Management Plan 3.0* (HEPA, 2025). The limited testing to date has indicated some wells, including upgradient wells, have identified PFAS above the 99% level of species protection (LOSP) criteria, present at concentrations indicative of urban the environment. Therefore the 95% LOSP is considered appropriate.

Statistical analysis of groundwater quality data was undertaken on the site baseline data from 2015-2025 (i.e. post Stage 1 construction) to determine the 80th percentile for each analyte to establish site specific upper trigger levels, and the 20th percentiles for analytes requiring lower trigger levels (Section 5.3).

The methodology used to select preliminary trigger levels in each groundwater system is described below. Proposed criteria for each analyte are provided in Table B1 and B2 in Appendix B.

The statistical analysis and associated trigger levels have been reviewed and refined following completion of the Stage 3 baseline monitoring program (refer Section 10.6). It is noted that it may be appropriate to undertake further statistical analysis and review of associated trigger levels regularly:

- As additional water quality data become available;
- As guidelines are updated;
- If it is deemed necessary to undertake site-specific modifications to criteria that can be made (e.g. adjustment for aquatic ecological DGVs based on hardness, pH, dissolved organic carbon, salinity etc).

It should be noted that the site specific trigger levels for groundwater are not applicable to surface water quality. However, the applicable values for surface water are the ANZG (2018) 95% marine water protection criteria which are indicated in Tables B1 and B2 as 'Note A', being the ultimate receiving environment. HEPA (2025) 95% LOSP is the appropriate guideline for PFAS for ecology.

10.9.2.1 Tomago Sandbeds Trigger Levels

Potential GDEs (GDE Atlas) in the Tomago Sandbeds are present upstream of the site. Risks of impacts from the project to these GDEs are currently considered to be low given their upstream location. Although the water from the Tomago Sandbeds aquifer is a fresh water source, the downgradient receiving environment and GDEs are considered to be an estuarine environment, receiving saline/marine tidal surface water flows which inundate the low-lying land areas of the Ramsar wetlands. The 95% level of species protection (LOSP) DGVs for marine water (ANZECC & ARMCANZ 2000) are therefore applicable in the establishment of trigger criteria for bores in the Tomago Sandbeds aquifer. The Drinking Water Guidelines (NHMRC, 2021) have also been considered due to the proximity to drinking water supply bores in the Tomago Sandbeds aquifer (excluding aesthetic-based criteria). The guideline value for the most sensitive beneficial use should be adopted for each analyte (i.e. the lower of ANZECC & ARMCANZ 2000 and NHMRC, 2021).

It is recognised, however, that groundwater in the region can have background levels (e.g. dissolved metals attributed to historical mining activities) with concentrations higher than the guideline values. Analytes for which the background 80th percentile is higher than the guideline value for the most sensitive beneficial use have been assigned the 80th percentile background concentration as a trigger level. Otherwise, the guideline value for the most sensitive beneficial use has been adopted (i.e. the lower of ANZECC & ARMCANZ 2000 and NHMRC, 2021). Where no criteria or site based data exists, the trigger level has generally been adopted as the laboratory limit of reporting (LOR). For general indicator water quality parameters that are not contaminants of concern, no criteria has been adopted. HEPA (2025) 95% LOSP is the appropriate guideline for PFAS for ecology.

The trigger level and basis for derivation of the value is highlighted in Table B1 in Appendix B.

10.9.2.2 Clay Aquitard Trigger Levels

Due to the presence of the potential estuarine / marine GDEs downgradient of the site, the 95% marine water species protection DGVs (ANZECC & ARMCANZ 2000) have been considered to establish trigger criteria for bores in the clay aquitard. The adopted trigger levels for bores in the clay have been taken as the higher of the 80th percentile background concentrations and 95% marine water species protection DGVs. Where no criteria or site based data exists, the trigger level have generally been adopted as the laboratory LOR. For general indicator water quality parameters that are not contaminants of concern, no criteria has been adopted. HEPA (2025) 95% LOSP is the appropriate guideline for PFAS for ecology.

The trigger level and basis for derivation of the value is highlighted in Table B2 in Appendix B.

10.10 Reporting Requirements

An annual report should be prepared which shall include the following:

- Time and date of sampling;

- Sampling methods, including well purging records;
- Sample Chain of Custody Documentation;
- Results of QA/QC protocols;
- Laboratory test methods and LOR;
- Tabulated results of current round of testing;
- Plot of results over time to allow assessment of trends;
- Groundwater levels plotted against rainfall records;
- Comparison with groundwater quality trigger levels and assessment of trends in groundwater levels noting any exceedances of criteria.

10.11 Assessment Process and Contingency Measures

10.11.1 Groundwater Levels

If a consistent trend in variations in groundwater level are recorded, then the potential implications of the long-term variation should be assessed. The management strategy will depend on the nature of the groundwater variation and its expected effects as outlined in Section 7.

10.11.2 Groundwater Quality

The trigger levels have been developed based on consideration of the baseline and long term data set (2015-2025) and assessment against relevant water quality guidelines as per Section 10.9.2 and these represent the main groundwater quality assessment criteria.

It is considered that the UCL95-mean values could be used to indicate when monitored values are above average background levels, prompting review and closer scrutiny if levels are consistently above average/mean. Exceedance of the adopted trigger levels would prompt further assessment. This procedure is summarised in Table 9.

Table 9: Actions Prompted by Monitoring Results

Event	Action
Consecutive results exceed UCL_{95}-mean value	• Review trend in parameter(s) concerned and note in monitoring report.
Result exceed adopted trigger level (Tables B1 and B2 in Appendix B)	• Assessment of the significance of the exceedance including, but not limited to: o Comparison with previous/historic site monitoring data used in preparation of trigger levels, full data series as shown on concentration vs time plots (i.e. is the result within data range for the historic data set for the well and/or all monitoring wells); o Review the basis for the trigger level criteria (i.e. reliability of the guideline value, or 20th / 80th percentile site derived); o Review of groundwater flow directions (i.e. representative of groundwater up-gradient, within site, and/or downgradient) and risk to receptors; o Review groundwater levels and preceding climatic conditions for possible influence (e.g. rainfall effects prior to event, abnormally dry/wet conditions etc); o Assess possible source of impacts such as potential impact from temporary activities, construction, site incidents of general activities; • Undertake additional speciation laboratory testing, if suitable (e.g. hydrocarbons or metals).
	• If the result is considered potentially significant in terms of potential impacts (on site or downgradient), undertake additional sampling at the relevant location(s) and analysis for parameter(s) concerned. A timeline of up to 28 days from confirmation of the initial results should be considered as a practicable timeframe for re-sampling; • Advise construction managers and/or Stage 3 lessees to review procedures, maintenance and incident records and notify consultant of relevant findings; • If the re-sampled result confirms the initial value, note the occurrence in the in monitoring report for additional review at next annual monitoring event. Additional actions would be prompted by further consecutive events as below; • If the re-sampled result is within the trigger level, suggesting the prior result was spurious or an aberration, then a note is to be made of the re-test in annual reporting.
Three consecutive results exceed the trigger level (including re-testing, if undertaken) and/or in the event two consecutive biannual sample results exceed the trigger value (Tables B1 and B2 in Appendix B)	• Investigate the possibility of adverse changes to the groundwater quality/flow regime and/or contaminant plume; • Implement appropriate actions to investigate and/or mitigate contamination risks. Actions may include: o A detailed site inspection of the site and adjacent sites to identify possible source(s); o The possible need to temporarily increase the frequency of monitoring until results have returned to below the trigger levels or within the historical range; o The possible need to for installation of additional monitoring wells or surface water locations; o Consideration of fate and transport mechanisms for potential impacts at receptors and/or specific risk assessment for GDEs; • The consent holder is to notify DCCEEW, DPH and NPWS within 7 days of receiving notification from the environmental consultant of the second or third consecutive exceedance and/or in the event two consecutive biannual (6 month) samples exceed the trigger value where the result is considered potentially related to site impacts.

The actions above represent contemporary practices and allow for considered investigation of potential exceedances and clarity with regards to timing of notifications.

It is noted that the laboratory results do not provide a direct indication of an exceedance, the determination of which requires data collation, quality control checking, data analyses and interpretation. The 7 day notification period is intended to apply once the site operator became aware of reportable exceedances.

10.12 Trigger Action Response Plan

A Trigger Action Response Plan (TARP) has been developed by Torque Projects to define the minimum set of corrective actions required in response to unpredicted impacts (i.e. contingency measures).

The TARP is included in Appendix E. The TARP defines different levels of impacts defined from 1 to 5. Level 1 applies to normal conditions (i.e. no noticeable impacts). Levels 2 to 5 refer to abnormal conditions with various degrees of impacts rated based on increased risk.

The TARP should be reviewed and updated following detailed design stages or as required.

10.13 Review and Continuous Improvement of the Monitoring Plan and Effectiveness

Improvements to the monitoring program or site practices should be included in the annual reports.

A revision of the monitoring program is an important aspect of continuous improvement. Review should be undertaken by a suitably qualified groundwater consultant:

- If there are additional monitoring requirements as a result of detailed design;
- Following completion of significant project work stages;
- Following significant environmental incidents;
- When material improvements to performance have been recommended by the consultant in annual reports or as directed by the environmental authority;
- When new stages of construction are proposed and have the potential to impact the site;
- Otherwise, every 3 years to:
    - Review changes in land uses within the site and for adjacent sites which may increase potential contamination sources and/or potential contaminants of concern (given the development is staged and future use is unknown);
    - Analyse trends in groundwater levels and quality for comparison against the long term data set;
    - Assess effectiveness of existing monitoring program and whether the objectives/intention of the monitoring program are being met;
    - Review trigger levels and update, if warranted;
    - Recommend any changes to provide an efficient and effective monitoring program such as changes to the monitoring well network, frequency of testing and nominated test parameters.

Parameters which have been established to be of minimal concern from the results of monitoring may be dropped from the program and others may be added, if warranted.

11. Conclusions

It is considered that implementation of this Groundwater Monitoring Plan for Stage 3 at Lot 210, in addition to future detailed design and identification of appropriate groundwater and surface water mitigation measures, can achieve the objectives of minimising potential groundwater and surface water impacts on Lot 210, and other adjacent properties.

12. References

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13. Limitations

Douglas Partners (DP) has prepared this report for this project at Lot 210 D.P.1174939, 2 Westrac Drive, Tomago with reference to DP's proposal 39920.09.P.001.Rev1 dated 31 October 2022 and acceptance received from Northbank Enterprise Hub Pty Ltd. The work was carried out under agreed terms between Douglas Partners Pty Ltd and Northbank Enterprise Hub Pty Ltd (Contract 20230206 ACE-LEG-005A executed 23 February 2023). This report is provided for the exclusive use of Northbank Enterprise Hub Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out, as reported by others. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences.

DP's advice is based upon the conditions encountered during previous investigations as reported by others. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the environmental / groundwater components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

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Appendix A

About This Report

Sampling Methods

Soil Descriptions

Symbols and Abbreviations

Borehole logs (Bores MW6 to MW11, MW8A, MW101 to MW107) – Douglas Partners

Borehole Logs (Bores MW1 to MW5) – Coffey

Table A1: Monitoring Well Summary

About this Report

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Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with ‘Mix of Soil and Cobbles/Boulders’ with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- ‘Moist, dry of plastic limit’ or ‘w <PL’ (i.e. hard and friable or powdery).
- ‘Moist, near plastic limit’ or ‘w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- ‘Moist, wet of plastic limit’ or ‘w >PL’ (i.e. soils usually weakened and free water forms on the hands when handling).
- ‘Wet’ or ‘w ≈LL’ (i.e. near the liquid limit).
- ‘Wet’ or ‘w >LL’ (i.e. wet of the liquid limit).

Rock Strength

Rock strength is defined by the Unconfined Compressive Strength and it refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects.

The Point Load Strength Index $Is_{(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

Strength Term	Abbreviation	Unconfined Compressive Strength MPa	Point Load Index * $Is_{(50)}$ MPa
Very low	VL	0.6 - 2	0.03 - 0.1
Low	L	2 - 6	0.1 - 0.3
Medium	M	6 - 20	0.3 - 1.0
High	H	20 - 60	1 - 3
Very high	VH	60 - 200	3 - 10
Extremely high	EH	>200	>10

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Residual Soil	RS	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely weathered	XW	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible
Highly weathered	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately weathered	MW	The whole of the rock material is discoloured , usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	No signs of decomposition or staining.
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.

Rock Descriptions

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections > 100 mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or stronger. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

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Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

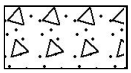
Symbols & Abbreviations

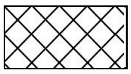
Graphic Symbols for Soil and Rock

General

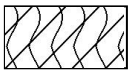

Asphalt

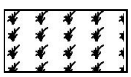

Road base

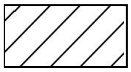

Concrete

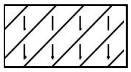

Filling

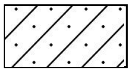
Soils


Topsoil

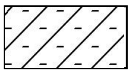

Peat

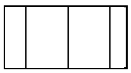

Clay

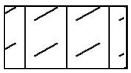

Silty clay

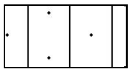

Sandy clay

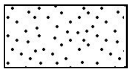

Gravelly clay

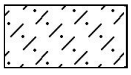

Shaly clay

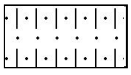

Silt


Clayey silt


Sandy silt

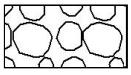

Sand

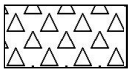

Clayey sand


Silty sand


Gravel

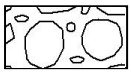

Sandy gravel


Cobbles, boulders

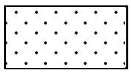

Talus

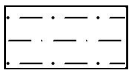
Sedimentary Rocks

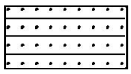

Boulder conglomerate

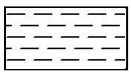

Conglomerate


Conglomeratic sandstone

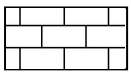

Sandstone


Siltstone

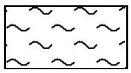

Laminite

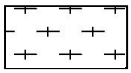

Mudstone, claystone, shale

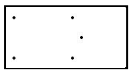

Coal


Limestone

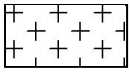
Metamorphic Rocks

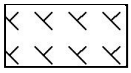

Slate, phyllite, schist

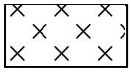

Gneiss

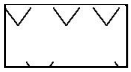

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

BOREHOLE LOG

CLIENT: WEPL Investments Pty Ltd
PROJECT: Tomago Industrial Estate
LOCATION: Tomago Road, Tomago

SURFACE LEVEL: --
EASTING: 383518
NORTHING: 6367336
DIP/AZIMUTH: 90°/--

BORE No: MW6
PROJECT No: 39920.03
DATE: 7/10/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
									Stickup = 0.7m
	0.23	SILTY CLAY - Dark grey silty clay, M>Wp							From 0m to 0.5m, Concrete
		SILTY CLAY - Grey silty clay, M>>Wp							From 0.5m to 2m, Backfill
	6.0	SAND - Grey/brown fine to medium grained sand with some silt and clay, trace shell fragments, saturated							From 2m to 4.5m, Bentonite plug From 4.5m to 6m, 2.5mm washed gravel screen From 6m to 9m, Collapsed strata From 6m to 9m, 50mm diameter Class 18 machine slotted PVC screen
	9.0	Bore discontinued at 9.0m, limit of investigation							End cap

RIG: 4WD Truck Mounted Drill Rig **DRILLER:** **LOGGED:** Prowse **CASING:** Nil
TYPE OF BORING: 130mm hollow flight auger
WATER OBSERVATIONS: Free groundwater encountered at 0.3m whilst augering
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: WEPL Investments Pty Ltd
PROJECT: Tomago Industrial Estate
LOCATION: Tomago Road, Tomago

SURFACE LEVEL: --
EASTING: 382801
NORTHING: 6366934
DIP/AZIMUTH: 90°/--

BORE No: MW7
PROJECT No: 39920.03
DATE: 26/10/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0	SILTY CLAY - Dark grey silty clay, M>Wp							Stickup = 0.85m From 0.0m to 0.2m, concrete From 0.0m to 0.6m, 50mm diameter Class 18 PVC blank From 0.2m to 0.5m, bentonite
	1	From 1.4m, trace sand and shell fragments							From 0.5m to 2.6m, 5/2mm gravel filter From 0.6m to 2.6m, 50mm diameter machine slotted Class 18 PVC screen End cap
	2	From 2.6m, collapsing							
	3	3.0 Bore discontinued at 3.0m, limit of investigation							
	4								
	5								
	6								
	7								
	8								
	9								

RIG: Hand Tools **DRILLER:** Parkinson **LOGGED:** Prowse **CASING:** Uncased
TYPE OF BORING: 75mm diameter Hand Auger
WATER OBSERVATIONS: Free groundwater observed at 1.2m during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▽	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: WEPL Investments Pty Ltd
PROJECT: Tomago Industrial Estate
LOCATION: Tomago Road, Tomago

SURFACE LEVEL: --
EASTING: 382353
NORTHING: 6367461
DIP/AZIMUTH: 90°/--

BORE No: MW8
PROJECT No: 39920.03
DATE: 4/8/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.2	FILLING - Brown fine to medium grained sand filling, with trace to some silt and abundant organics to 0.05m, moist							
	0.4	SAND - (Loose) light brown fine to medium grained sand, trace organics, moist		A	0.5				
		SAND (Loose) grey fine to medium grained sand, moist							From 0m to 1.8m, bentonite
	1	From 1.0m, loose		S	1.0		1,1,2 N = 3		
		From 1.3m, saturated			1.45				
	2								From 1.8m to 5.5m, gravel
		From 2.5m, brown, fine to coarse grained sand		S	2.5		1,2,4 N = 6		
	3				2.95				
	4	From 4.0m, medium dense		S	4.0		3,10,-		From 2.5m to 5.5m, machine slotted PVC screen
					4.3				
	5								End cap
				S	5.5		6,12,- (No Sample)		
	5.8	Bore discontinued at 5.8m, limit of investigation			5.8				
	6								
	7								
	8								
	9								

RIG: 4WD **DRILLER:** Atkins **LOGGED:** Harris **CASING:** Uncased

TYPE OF BORING: Hollow flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.3m during drilling

REMARKS: Class 18 piezometer PVC installed to 5.5m depth. Machine slotted from 2.5m to 5.5m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 3.1 AHD
EASTING: 382303.7
NORTHING: 6367395.9
DIP/AZIMUTH: 90°/--

BORE No: MW8A
PROJECT No: 39920.09
DATE: 12/4/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.25	SILTY SAND - fine to medium grained, dark grey, trace rootlets, moist		D	0.01				Stickup = 0.76 From 0m to 0.1m, concrete From 0.1m to 0.3m, bentonite From 0m to 0.5m, 50mm diameter Class 18 PVC Casing
		SAND - fine to medium grained, dark grey, trace rootlets, moist at 0.7m - colour change to brown		D	0.5				
	1.2	SAND - fine to medium grained, pale brown, trace sub-angular to sub-rounded gravel, moist at approximately 1.8m, wet		D	1.5				
				D	2.5				
				D	3.5				From 0.3m to 7.0m, 2mm sand From 0.5m to 7.0m, 50mm diameter Class 18 Machine Slotted PVC Screen
				D	4.5				
				D	5.5				
				D	6.5				
	7.0	Bore discontinued at 7.0m Limit of investigation							End cap

RIG: Geoprobe Dual Tube **DRILLER:** Tucker **LOGGED:** Krebs **CASING:** None

TYPE OF BORING: Push tube with disposable liners

WATER OBSERVATIONS: Free groundwater observed at 1.9m during drilling

REMARKS: Top of PVC casing level 3.86 AHD

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: WEPL Investments Pty Ltd
PROJECT: Tomago Industrial Estate
LOCATION: Tomago Road, Tomago

SURFACE LEVEL: 0.78 AHD
EASTING: 383467
NORTHING: 6367675
DIP/AZIMUTH: 90°/--

BORE No: MW9
PROJECT No: 39920.03
DATE: 2-3/8/10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	TOPSOIL - Grey silty clay/clayey silt with abundant organics, saturated							From 0.0m to 4.6m, bentonite
		SILTY CLAY - (soft to firm), grey silty clay, M>Wp		A	1.0				
		From 2.5m, (soft) with some fine to medium grained sand		S	2.5 2.95		0,0,0 N = 0 (No Sample)		
	4.0	SAND - Very loose, grey fine to medium grained sand, with trace to some clay and with trace organics, saturated		S	4.05 4.5		1,0,0 N = 0		
	5.75	SAND - Medium dense, grey, fine to medium grained gravel sand, saturated		S	5.75 6.2		1,1,2 N = 3		From 4.6m to 8.3m, machine slotted screen
		From 7.1m, loose		S	7.1 7.55		4,7,10 N = 17		
		From 9.8m, medium dense		S	9.8		4,12,13		From 8.3m to 10.6m, PVC damaged

RIG: 4WD **DRILLER:** Atkins **LOGGED:** Harris **CASING:** Uncased

TYPE OF BORING: Hollow flight auger

WATER OBSERVATIONS: Free groundwater obscured due to drilling water added

REMARKS: Class 18 piezometer PVC installed to 8.3m depth. Machine slotted from 4.6m to 8.3m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: WEPL Investments Pty Ltd
PROJECT: Tomago Industrial Estate
LOCATION: Tomago Road, Tomago

SURFACE LEVEL: 0.78 AHD
EASTING: 383467
NORTHING: 6367675
DIP/AZIMUTH: 90°/--

BORE No: MW10
PROJECT No: 39920.03
DATE: 2-3/8/10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	TOPSOIL - Grey silty clay/clayey silt with abundant organics, saturated							From 0.0m to 4.6m, bentonite
		SILTY CLAY - (soft to firm), grey silty clay, M>Wp		A	1.0				
		From 2.5m, (soft) with some fine to medium grained sand		S	2.5 2.95		0,0,0 N = 0 (No Sample)		
	4.0	SAND - Very loose, grey fine to medium grained sand, with trace to some clay and with trace organics, saturated		S	4.05 4.5		1,0,0 N = 0		
	5.75	SAND - Medium dense, grey, fine to medium grained gravel sand, saturated		S	5.75 6.2		1,1,2 N = 3		From 4.6m to 8.3m, machine slotted screen
		From 7.1m, loose		S	7.1 7.55		4,7,10 N = 17		
		From 9.8m, medium dense		S	9.8		4,12,13		From 8.3m to 10.6m, PVC damaged

RIG: 4WD **DRILLER:** Atkins **LOGGED:** Harris **CASING:** Uncased

TYPE OF BORING: Hollow flight auger

WATER OBSERVATIONS: Free groundwater obscured due to drilling water added

REMARKS: Class 18 piezometer PVC installed to 8.3m depth. Machine slotted from 4.6m to 8.3m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: WEPL Investments Pty Ltd
PROJECT: Tomago Industrial Estate
LOCATION: Tomago Road, Tomago

SURFACE LEVEL: 1.2 AHD
EASTING: 383294
NORTHING: 6367675
DIP/AZIMUTH: 90°/--

BORE No: MW11
PROJECT No: 39920.03
DATE: 4/8/2010
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
-9	11	SAND - Medium dense, grey fine to medium grained sand with trace shell fragments, saturated *(continued)*		S	11.5		6,17,0 N = 17		End cap
-10	11.8				11.8				
-11	12	Bore discontinued at 11.8m, limit of investigation							
-12	13								
-13	14								
-14	15								
-15	16								
-16	17								
-17	18								
-18	19								

RIG: 4WD **DRILLER:** Atkins **LOGGED:** Harris **CASING:** Uncased

TYPE OF BORING: Hollow flight auger to 11.5m depth

WATER OBSERVATIONS: Free groundwater obscured due to drilling fluids

REMARKS: Class 18 piezometer PVC installed to 10.6m depth. Machine slotted from 4.6m to 8.3m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 3.2 AHD
EASTING: 382656.6
NORTHING: 6367618.5
DIP/AZIMUTH: 90°/--

BORE No: MW101
PROJECT No: 39920.09
DATE: 12/4/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.15	SILTY SAND - fine to medium grained, dark brown, trace sub-angular to sub-rounded gravel, trace rootlets, moist		D	0.0 0.1				Stickup = 0.87 From 0m to 0.1m, concrete From 0.1m to 0.3m, bentonite From 0m to 0.5m, 50mm diameter Class 18 PVC Casing
		SAND - fine to medium grained, dark grey brown, moist		D	0.5				
		at 1.2m - light brown		D	1.5				
		at 2.75m - dark brown		D	2.5				
	3.2	SAND - fine to medium grained, dark brown, wet, (possibly indurated sand)		D	3.5				From 0.3m to 7.0m, 5/2mm graded gravel/sand From 0.5m to 7.0m, 50mm diameter Class 18 Machine Slotted PVC Screen
	4.35	SAND - fine to medium grained, brown, wet		D	4.5				
				D	5.5				
				D	6.5				
	7.0	Bore discontinued at 7.0m Limit of investigation							End cap

RIG: Geoprobe Dual Tube **DRILLER:** Tucker **LOGGED:** Krebs **CASING:** None

TYPE OF BORING: Push tube with disposable liners

WATER OBSERVATIONS: Free groundwater observed at 1.1m during drilling

REMARKS: Top of PVC casing level 4.09 AHD

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 1.8 AHD
EASTING: 382677.6
NORTHING: 6367505.9
DIP/AZIMUTH: 90°/--

BORE No: MW102
PROJECT No: 39920.09
DATE: 11/4/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		SANDY SILT - fine to medium grained, brown, trace rootlets, wet		D	0.0				Stickup = 0.76 From 0m to 0.15m, concrete From 0.15m to 0.3m, bentonite From 0m to 0.5m, 50mm diameter Class 18 PVC Casing
	0.3	SAND - fine to medium grained, brown, wet			0.2				
				D	0.6				
		at 0.8m - colour change to grey							
				D	1.5				
		at 1.95m - colour change to pale grey							From 0.3m to 4.0m, 2mm sand From 0.5m to 4.0m, 50mm diameter Class 18 Machine Slotted PVC Screen
				D	2.5				
				D	3.5				End cap
	4.0	Bore discontinued at 4.0m Limit of investigation							

RIG: Geoprobe Dual Tube **DRILLER:** Tucker **LOGGED:** Krebs **CASING:** None

TYPE OF BORING: Push tube with disposable liners

WATER OBSERVATIONS: Free groundwater observed at 0.2m during drilling

REMARKS: Top of PVC casing level 2.52 AHD

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 2.3 AHD
EASTING: 382853.1
NORTHING: 6367613.9
DIP/AZIMUTH: 90°/--

BORE No: MW103
PROJECT No: 39920.09
DATE: 12/4/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.0	SILTY SAND - fine to medium grained, dark brown, trace sub-angular to sub-rounded gravel, trace rootlets, moist		D	0.0				Stickup = 0.97
	0.3	SAND - fine to medium grained, brown, moist			0.2				From 0m to 0.1m, concrete
		at 0.7m - colour change to grey		D	0.8				From 0.1m to 0.3m, bentonite
				D	1.5				From 0m to 0.5m, 50mm diameter Class 18 PVC Casing
		at 2.4m - colour change to pale brown		D	2.5				
		at 3.2m - dark brown		D	3.5				From 0.3m to 7.0m, 5/2mm graded gravel/sand
				D	4.5				From 0.5m to 7.0m, 50mm diameter Class 18 Machine Slotted PVC Screen
				D	5.5				
				D	6.5				
	7.0	Bore discontinued at 7.0m Limit of investigation							End cap

RIG: Geoprobe Dual Tube **DRILLER:** Tucker **LOGGED:** Krebs **CASING:** None

TYPE OF BORING: Push tube with disposable liners

WATER OBSERVATIONS: Free groundwater observed at 1.2m during drilling

REMARKS: Top of PVC casing level 3.31 AHD

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 0.7 AHD
EASTING: 383147.6
NORTHING: 6367292
DIP/AZIMUTH: 90°/--

BORE No: MW104
PROJECT No: 39920.09
DATE: 17/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
0	0.0	SILTY CLAY (CH) - High plasticity, dark brown to brown with rootlets, W>PL		D	0.0				Stickup = 0.48m From 0m to 0.1m, concrete
	0.1				0.1				From 0.1m to 0.3m, bentonite From 0m to 0.5m, 50mm Class 18 blank PVC
				D	0.5				
	0.6	SILTY CLAY (CH) - High plasticity, grey, W=PL		D	0.7				
		From 0.9m, grey mottled brown							From 0.3m to 1.5m, 2mm sand
1				D	1.0				From 0.5m to 1.5m, 50mm diameter Class 18 machine slotted PVC screen
				D	1.4				End cap
	1.5	Bore discontinued at 1.5m Limit of investigation							
-1									
2									
-2									

RIG: Hand Tools **DRILLER:** Lambert/Krebs **LOGGED:** Lambert/Krebs **CASING:** None

TYPE OF BORING: 90mm diameter hand auger 0m to 1.5m

WATER OBSERVATIONS: Free groundwater observed at ground level during drilling

REMARKS: Top of PVC casing level 1.16 AHD

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 1.5 AHD
EASTING: 382360.3
NORTHING: 6367294.4
DIP/AZIMUTH: 90°/--

BORE No: MW105
PROJECT No: 39920.09
DATE: 11/4/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.2	SANDY SILT - fine to medium grained, dark brown, with rootlets, wet		D	0.0 0.1				Stickup = 0.55 From 0m to 0.1m, concrete From 0.1m to 0.3m, bentonite From 0m to 0.5m, 50mm diameter Class 18 PVC Casing
		SAND - fine to medium grained, brown, wet		D	0.5				
		at 1.4m - colour change to grey		D	1.5				
				D	2.5				
		at 3.0m - colour change to brown							From 0.3m to 6.0m, 2mm sand From 0.5m to 6.0m, 50mm diameter Class 18 Machine Slotted PVC Screen
				D	3.5				
				D	4.5				
				D	5.5				
	6.0	Bore discontinued at 6.0m Limit of investigation							End cap

RIG: Geoprobe Dual Tube **DRILLER:** Tucker **LOGGED:** Krebs **CASING:** None

TYPE OF BORING: Push tube with disposable liners

WATER OBSERVATIONS: Free groundwater observed at 0.2m during drilling

REMARKS: Top of PVC casing level 2.05 AHD

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 0.7 AHD
EASTING: 382929.3
NORTHING: 6367067
DIP/AZIMUTH: 90°/--

BORE No: MW106
PROJECT No: 39920.09
DATE: 17/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		SILTY CLAY (CH) - High plasticity, dark brown to brown with rootlets, fine to medium grained sand, W > PL		D	0.0				Stickup = 0.8m
					0.1				From 0m to 0.3m, bentonite
	0.3	SILTY CLAY (CH) - High plasticity, grey, W=PL							From 0m to 0.5m, 50mm Class 18 blank PVC
0		From 0.5m, grey mottled brown		D	0.4			▼	
	1			D	1.0				1
									From 0.3m to 2m, 2mm sand
									From 0.5m to 2m, 50mm diameter Class 18 machine slotted PVC screen
-1				D	1.5				
				D	1.9				End cap
	2	2.0 Bore discontinued at 2.0m Limit of investigation							2
-2									

RIG: Hand Tools **DRILLER:** Lambert/Krebs **LOGGED:** Lambert/Krebs **CASING:** None

TYPE OF BORING: 90mm hand auger 0m to 2m

WATER OBSERVATIONS: Free groundwater observed at 0.7m during drilling

REMARKS: Top of PVC casing level 1.49 AHD

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Northbank Enterprise Hub Pty Ltd
PROJECT: Stage 3 Northbank Enterprise Hub
LOCATION: Lot 210 Westrac Drive, Tomago

SURFACE LEVEL: 0.7 AHD
EASTING: 382380.6
NORTHING: 6367150
DIP/AZIMUTH: 90°/--

BORE No: MW107
PROJECT No: 39920.09
DATE: 29/4/2024
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		CLAY (CH) - High plasticity, dark grey brown with silt, very soft to soft, with rootlets, W>PL		A, D, E	0.1		PID<1		Stickup = 0.8m From 0m to 0.1m, concrete From 0.1m to 0.2m, bentonite From 0m to 0.5m, 50mm Class 18 blank PVC
	0.3	CLAY (CH) - High plasticity, dark grey, trace silt, very soft to soft, W>PL		A, D, E	0.5		PID<1		
0									
	1								1
									From 0.2m to 2.2m, 5/2mm gravel/sand From 0.5m to 2.2m, 50mm diameter Class 18 machine slotted PVC screen
				D, E	1.5		PID<1		
-1									
	2			D, E	2.0		PID<1		2
	2.2	Bore discontinued at 2.2m							End cap
-2									

RIG:
DRILLER: Krebs/Date
LOGGED: Krebs/Date
CASING: None
TYPE OF BORING: Hand Auger to 2.2m
WATER OBSERVATIONS: Groundwater observed at 0m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Engineering Log - Piezometer

Borehole No. MW 1

Sheet 1 of 1

Project No: GEOTSGTE20301AA

Client: ASQUITH & de WITT PTY LTD

Date started: 16.8.2007

Principal:

Date completed: 16.8.2007

Project: PROPOSED INDUSTRIAL DEVELOPMENT, TOMAGO

Logged by: CW

Borehole Location: REFER TO FIGURE 1

Checked by:

drill model & mounting: Truck Mounted | Easting: 383658 | slope: -90° | R.L. Surface: 2.31

hole diameter: 200mm | Northing: 6367969 | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	well details	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	structure and additional observations
HF		C	▼			2.0	0.5		SM	Silty SAND: fine to coarse grained, black.	D		ALLUVIAL
						1.5	1.0		SC	Clayey SAND: grey	M		
						1.0					W		
						0.5	1.5						
						0.0	2.0						
						-0.5	2.5						
						-1.0	3.0						
						-1.5	3.5						
							4.0			Borehole terminated at 3.85m			

PIEZOMETER 20301AA LOGS MW1-5 GPJ COFFEY GDT 1 7 08

Form GEO 5 10 Issue 3 Rev 0

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
DT	diatube
B	blank bit
V	V bit
T	TC bit
TBX	Tubex

*bit shown by suffix e.g ADT

support

C casing N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
P	pressure meter
Bs	bulk sample
R	refusal
E	environmental sample
PID	PID measurement
WS	water sample
PZ	piezometer
ALT	air lift test

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Piezometer

Borehole No. *MW 2*

Sheet 1 of 1

Project No: *GEOTSGTE20301AA*

Client: *ASQUITH & de WITT PTY LTD*

Date started: *17.8.2007*

Principal:

Date completed: *17.8.2007*

Project: *PROPOSED INDUSTRIAL DEVELOPMENT, TOMAGO*

Logged by: *CW*

Borehole Location: *REFER TO FIGURE 1*

Checked by:

drill model & mounting: Truck Mounted | Easting: 383725 | slope: -90° | R.L. Surface: 0.74

hole diameter: 200mm | Northing: 6367488 | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	well details	RL	depth metres	graphic log	classification symbol	material: soil type; plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	structure and additional observations
HF		C	10:30am			0.5	0.5		CI	Silty CLAY: medium plasticity, dark brown-black, with rootlets.	M>Wp		TOPSOIL Root affected
						0.0	1.0		Ci	CLAY: medium plasticity, grey.			ALLUVIAL / ESTUARINE
						-0.5	1.5						
						-1.0	2.0						
						-1.5	2.5						
						-2.0	3.0						
						-2.5	3.5			Borehole terminated at 3.5m			
						-3.0	4.0						

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
DT	diatube
B	blank bit
V	V bit
T	TC bit
TBX	Tubex

*bit shown by suffix e.g. ADT

support

C casing N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
P	pressure meter
Bs	bulk sample
R	refusal
E	environmental sample
PID	PID measurement
WS	water sample
PZ	piezometer
ALT	air lift test

classification symbols and soil description based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Piezometer

Borehole No.	MW 3
Sheet	1 of 1
Project No:	GEOTSGTE20301AA
Client:	ASQUITH & de WITT PTY LTD
Date started:	17.8.2007
Principal:	
Date completed:	17.8.2007
Project:	PROPOSED INDUSTRIAL DEVELOPMENT, TOMAGO
Logged by:	CW
Borehole Location:	REFER TO FIGURE 1
Checked by:	

drill model & mounting: Truck Mounted | Easting: 382895 | slope -90° | R.L. Surface: 2.91

hole diameter: 200mm | Northing: 6367789 | bearing | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	well details	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle charactenstics, colour, secondary and minor components	moisture condition	consistency/ density index	structure and additional observations
HF		C	11:55am			2.5	0.5		SM	**Silty SAND:** fine to coarse grained, black mottled white, with rootlets	M		TOPSOIL
						2.0	1.0		SM	**Silty SAND:** fine to coarse grained, dark grey	W		AEOLIAN
						1.5	1.5			Becoming dark brown			
						1.0	2.0			Trace of fine grained rounded gravel			Alluvial?
						0.5	2.5						
						0.0	3.0						
						-0.5	3.5						
						-1.0	4.0			Borehole terminated at 3 8m			

PIEZOMETER 20301AA LOGS MW1-5 GPJ COFFEY GDT 1 7 08

Form GEO 5.10 Issue 3 Rev 0

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
DT	diatube
B	blank bit
V	V bit
T	TC bit
TBX	Tubex

*bit shown by suffix e.g. ADT

support

C casing N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
P	pressure meter
Bs	bulk sample
R	refusal
E	environmental sample
PID	PID measurement
WS	water sample
PZ	piezometer
ALT	air lift test

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Piezometer

Borehole No.	MW 4
Sheet	1 of 1
Project No:	GEOTSGTE20301AA
Date started:	17.8.2007
Date completed:	17.8.2007
Logged by:	CW
Checked by:	

Client: ASQUITH & de WITT PTY LTD

Principal:

Project: PROPOSED INDUSTRIAL DEVELOPMENT, TOMAGO

Borehole Location: REFER TO FIGURE 1

drill model & mounting: Truck Mounted | Easting: 383345 | slope: -90° | R.L. Surface: 0 35

hole diameter: 200mm | Northing: 6366996 | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	well details	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
HF		C	1:51pm			0.0	0.5		CH	CLAY: high plasticity, grey-brown some orange mottled, with rootlets.	M>Wp		ALLUVIAL
						-0.5	1.0			Becoming grey.			
						-1.0	1.5						
						-1.5	2.0						
						-2.0	2.5						
						-2.5	3.0						
						-3.0	3.5						
						-3.5	4.0			Borehole terminated at 3.9m			

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
DT	diatube
B	blank bit
V	V bit
T	TC bit
TBX	Tubex

*bit shown by suffix e.g. ADT

support: C casing; N nil

penetration: 1 2 3 4 — no resistance ranging to refusal

water: 10/1/98 water level on date shown; water inflow; water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
P	pressure meter
Bs	bulk sample
R	refusal
E	environmental sample
PID	PID measurement
WS	water sample
PZ	piezometer
ALT	air lift test

classification symbols and soil description based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Piezometer

Borehole No. *MW 5*

Sheet 1 of 1

Project No: *GEOTSGTE20301AA*

Client: *ASQUITH & de WITT PTY LTD*

Date started: *18.8.2007*

Principal:

Date completed: *18.8.2007*

Project: *PROPOSED INDUSTRIAL DEVELOPMENT, TOMAGO*

Logged by: *CW*

Borehole Location: *REFER TO FIGURE 1*

Checked by:

drill model & mounting: Truck Mounted | Easting: 382251 | slope: -90° | R.L. Surface: 0.71

hole diameter: 200mm | Northing: 6367165 | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	well details	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	structure and additional observations
HF		C	8:15am			0.5	0.5		CI	Silty CLAY: medium plasticity, dark brown	M>Wp		ALLUVIAL
						0.0	1.0			Becoming dark grey-grey			
						-0.5	1.5						
						-1.0	2.0		SC	Clayey SAND / Sandy CLAY: fine to medium grained			
						-1.5	2.5						
						-2.0	3.0						
						-2.5	3.5						
						-3.0	4.0			Borehole terminated at 3.8m			

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
DT	diatube
B	blank bit
V	V bit
T	TC bit
TBX	Tubex

*bit shown by suffix e.g. ADT

support

C casing N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
P	pressure meter
Bs	bulk sample
R	refusal
E	environmental sample
PID	PID measurement
WS	water sample
PZ	piezometer
ALT	air lift test

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

PIEZOMETER 20301AA LOGS MW1-5.GPJ COFFEY.GDT 1.7.08

Form GEO 5.10 Issue 3 Rev 0

Douglas Partners
Geotechnics / Environment / Groundwater

Table A1: Monitoring Well Summary

Bore ID	Easting	Northing	Elevation Ground Level (AHD)	Elevation top of PVC Casing Level (AHD)	Depth (m bgl)	Screened interval (m bgl)	Target lithology	Comment	Proposed in monitoring program for Stage 3
MW1	383552	6368062	2.0	2.84	3.8	0.8-3.8	Sand, clayey		No
MW2	383721	6367483		1.25	3.5	0.5-3.5	Clay, silty		No
MW3	382900	6367780		3.56	3.0	0.5-3.0	Sand, fine to coarse, silty	Damaged/lost	No
MW4	383360	6367013	0.5	1.28	3.7	0.7-3.8	Clay	High EC readings assumed to be associated with elevated suspended solids (clay particles)	Yes
MW5	382225	6367156			3.8	0.8-3.8	Clay and sand	Damaged/lost	No
MW6	383516	6367333	0.6	1.26	9.0	6.0-9.0	Sand, fine to med		No
MW7	382804	6366932	0.4	1.41	2.6	0.6-2.6	Clay, silty	Collapsed strata 6-9m - no gravel pack High EC readings assumed to be associated with elevated suspended solids (fine sand due to absence of gravel pack)	No
MW8	382351	6367460	3.4	4.72	5.5	2.5-5.5	Sand, fine to med	Damaged/lost	No
MW8A	382304	6367396	3.1	3.86	7.0	0.5-7.0	Sand, fine to med	Replacement for MW8	Yes
MW9	383165	6367492	0.6	1.54	10.6	4.6-8.3	Sand, fine to med	Damaged/lost	No
MW10	383467	6367675	0.8	2.11	10.6	4.6-8.3	Sand, fine to med		No
MW11	383293	6367584	1.2	2.27	10.6		Sand, fine to med		No
MW101	382657	6367619	3.2	4.09	7.0	0.3-7.0	Sand, fine to med		Yes
MW102	382678	6367506	1.8	2.52	4.0	0.3-4.0	Sand, fine to med		Yes
MW103	382853	6367614	2.3	3.31	7.0	0.3-7.0	Sand, fine to med		Yes
MW104	383148	6367292	0.7	1.16	1.5	0.5-1.5	Clay	High EC readings assumed to be associated with elevated suspended solids (clay particles)	Yes
MW105	382360	6367294	1.5	2.05	6.0	0.3-6.0	Sand, fine to med		Yes
MW106	382929	6367067	0.7	1.35	2.0	0.5-2.0	Clay	High EC readings assumed to be associated with elevated suspended solids (clay particles)	Yes
MW107	382381	6367150	0.72	1.52	2.2	0.5-2.2	Clay		Yes

Notes:
AHD = metres Australian Height Datum
m bgl = metres below ground level
EC = electrical conductivity

Appendix B

Table B1: Groundwater Quality Assessment Criteria for bores in the Tomago Sandbeds (i.e. MW8A, MW101, MW102, MW103, MW105)

	Unit	LOR	Background monitoring data 2015-2025					Ecological Guidelines (Note A)			Human Health Guidelines (Note B)	Most sensitive beneficial use (lower of ANZG or ADWG)	Adopted Trigger level - Wells Screened in Sand aquifer	Comments
			No of readings	Minimum	Maximum	UCL_{95}-mean	80th Percentile	ANZG (2018) Marine Water Toxicant DGVs 95% LOSP	Notes to DGV	HEPA (2025) NEMP 3.0 Interim marine water 95% LOSP for protection of aquatic ecosystems	Australian Drinking Water Guidelines (ADWG, 2011, updated 2024)			
Physio chemical parameters (field)														
pH (Field)	pH	0.1	73	4.7	7.7	6.08	5.2 / 6.6 (20th/80th)	7.0-8.0	#14		Aesthetic only	ANZG (2018)	5.2-8.0	Lower bound based on 20th percentile, upper bound based on ANZG
Electrical Conductivity (field)	µS/cm	1	73	79	16140	4870	3780	125-2200	#15			ANZG (2018)	3780	General indicator water quality value for groundwater rather than contaminants of concern
DO (Field)	mg/L	0.1	72	0.01	5.5	2.3	3.47						-	
DO (Field)	%	1	-	-	-	-	-	80-110%	#14				-	
Turbidity (Field)	NTU	1	-	-	-	-	-	0.5-10	#14				-	
Temperature (Field)	°C	-	-	-	-	-	-						-	
Physio chemical parameters														
Total Suspended Solids	mg/L	5	42	2.5	1000	99.7	71.9						-	TSS in groundwater can vary per monitoring event and based on well condition. General indicator water quality value for groundwater rather than contaminants of concern
Anions														
Fluoride	mg/L	0.1	61	0.05	0.6	0.22	0.27				1.5	ANZG (2018)	0.27	
Chloride	mg/L	1	61	8	5960	1980	1390				Aesthetic only	ANZG (2018)	1390	General indicator water quality value for groundwater rather than contaminants of concern
Sulphate	mg/L	1	61	0.5	896	288	310				Aesthetic only	ANZG (2018)	310	
Alkalinity (Hydroxide) as CaCO3	mg/L	5	60	0.5	2.5	1.55	2.2						-	
Alkalinity (Carbonate as CaCO3)	mg/L	5	60	0.5	338	17.2	8.2						-	
Alkalinity (total) as CaCO3	mg/L	5	60	2.5	400	154	217						-	
Alkalinity (Bicarbonate as CaCO3)	mg/L	5	61	0.5	400	135	186						-	
Hardness (filtered)	mg/L	3	25	11	1000	336	204						-	
Nutrients														
Ammonia as N (filtered)	mg/L	0.005	61	<0.005	1.05	0.44	0.61	0.91	#1		Aesthetic only	ANZG (2018)	0.91	
Total Kjeldahl Nitrogen	mg/L	0.1	56	<0.1	1.8	0.817	1.05						1.05	TKN, nitrate, nitrite etc are all measures of nitrogen species. The trigger level for ammonia is generally considered most applicable to assessing nitrogen concentrations in groundwater.
Nitrate (as N) (filtered)	mg/L	0.005	40	<0.005	0.57	0.014	0.012				50	ANZG (2018)	0.012	
Nitrite (as N) (filtered)	mg/L	0.005	40	<0.005	0.68	0.038	0.022				3	ANZG (2018)	0.022	
Nitrogen (Total Oxidised)	mg/L	0.005	52	<0.005	1.7	0.10	0.059	0.015	#15				0.059	
Nitrogen (Total)	mg/L	0.1	24	0.3	1.8	0.95	1.1	0.3	#15				1.1	
Total Phosphorus (Organic Phosphate)	mg/L	0.05	60	<0.005	1.76	0.186	0.13	0.03	#15				0.13	
Reactive Phosphorus as P (Orthophosphate as P) (filtered)	mg/L	0.005	21	<0.005	0.064	0.004	0.005	0.005	#15				0.005	
Cations														
Calcium (filtered)	mg/L	0.5	61	<0.5	297	92.7	113						-	General indicator water quality value for groundwater rather than contaminants of concern
Magnesium (filtered)	mg/L	0.5	61	<0.5	439	141	102						-	
Potassium (filtered)	mg/L	0.5	61	<0.5	90	31.4	31.3						-	
Sodium (filtered)	mg/L	0.5	61	6.8	2790	955	733						-	
Metals (filtered)														
Aluminium (filtered)	mg/L	0.01	13	0.05	0.41	0.28	0.31	0.0005	#4				0.31	
Arsenic (filtered)	mg/L	0.001	57	<0.001	0.005	0.001	0.001	0.0023 (As V)	#16		0.01	ANZG (2018)	0.0023 (As V)	
Cadmium (filtered)	mg/L	0.0001	57	<0.0001	0.0005	N/A	N/A	0.0055	#2		0.002	ADWG (2011)	0.0055	
Chromium (III+VI) (filtered)	mg/L	0.001	57	<0.001	0.003	0.001	0.002	0.0044 (Cr VI)	#17		0.05	ANZG (2018)	0.0044 (Cr VI)	
Copper (filtered)	mg/L	0.001	57	<0.001	0.015	0.001	0.002	0.0013	#3		2	ANZG (2018)	0.002	
Iron (filtered)	mg/L	0.01	54	<0.01	7	2.2	2.8				Aesthetic only		2.8	
Lead (filtered)	mg/L	0.001	57	<0.001	0.007	0.001	0.001	0.0044	#4		0.01	ADWG (2011)	0.0044	
Manganese (filtered)	mg/L	0.005	56	<0.005	2.0	0.70	0.76	0.08	#9		0.5	ANZG (2018)	0.76	
Mercury (filtered)	mg/L	0.00005	57	<0.00005	<0.00005	N/A	N/A	0.0004	#3		0.001	ANZG (2018)	0.0004	
Molybdenum (filtered)	mg/L	0.001	56	<0.001	0.002	N/A	N/A	0.023	#18		0.05	ANZG (2018)	0.023	
Nickel (filtered)	mg/L	0.001	57	<0.001	0.006	0.001	0.001	0.07	#3		0.02	ADWG (2011)	0.02	
Zinc (filtered)	mg/L	0.001	57	<0.001	0.035	0.008	0.009	0.008	#6				0.009	
TRH														
C6-C10 Fraction (F1)	mg/L	0.01	56	<0.01	0.01	N/A	N/A						0.01	
C6-C10 (F1 minus BTEX)	mg/L	0.01	56	<0.01	0.01	N/A	N/A						0.01	
>C10-C16 Fraction (F2)	mg/L	0.05	56	<0.05	0.079	N/A	N/A						0.05	
>C10-C16 Fraction (F2 minus Naphthalene)	mg/L	0.05	48	<0.05	0.05	N/A	N/A						0.05	
>C16-C34 Fraction (F3)	mg/L	0.1	56	<0.1	0.5	N/A	N/A						0.1	
>C34-C40 Fraction (F4)	mg/L	0.1	56	<0.1	0.05	N/A	N/A						0.1	
>C10-C40 Fraction (Sum)	mg/L	0.05	56	<0.05	0.19	N/A	N/A						0.05	
C6-C9 Fraction	mg/L	0.01	53	<0.01	0.01	N/A	N/A						0.01	
C10-C14 Fraction	mg/L	0.05	53	<0.05	0.067	N/A	N/A						0.05	
C15-C28 Fraction	mg/L	0.1	53	<0.1	0.37	N/A	N/A						0.1	
C29-C36 Fraction	mg/L	0.1	53	<0.1	0.2	N/A	N/A						0.1	
C10-C36 Fraction (Sum)	mg/L	0.05	49	25	0.64	N/A	N/A						0.05	
TPH (Silica-Gel Cleanup)														
C10-C14 Fraction (SG)	mg/L	0.05	-	-	-	N/A	N/A						0.05	
C15-C28 Fraction (SG)	mg/L	0.1	-	-	-	N/A	N/A						0.1	
C29-C36 Fraction (SG)	mg/L	0.1	-	-	-	N/A	N/A						0.1	
>C10-C16 Fraction (SG)	mg/L	0.05	-	-	-	N/A	N/A						0.05	
>C16-C34 Fraction (SG)	mg/L	0.1	-	-	-	N/A	N/A						0.1	
>C34-C40 Fraction (SG)	mg/L	0.1	-	-	-	N/A	N/A						0.1	
BTEX														
Benzene	mg/L	0.001	56	<0.001	<0.001	N/A	N/A	0.7	#7		0.001	ADWG (2011)	0.7	
Toluene	mg/L	0.001	56	<0.001	<0.001	N/A	N/A	0.18	#8				0.18	
Ethylbenzene	mg/L	0.001	56	<0.001	<0.001	N/A	N/A	0.08	#8				0.08	
Xylene (m & p)	mg/L	0.001	56	<0.002	<0.002	N/A	N/A				0.6			
Xylene (m)	mg/L	0.001	56	<0.002	<0.002	N/A	N/A	0.075	#7				0.075	
Xylene (o)	mg/L	0.001	56	<0.002	<0.002	N/A	N/A	0.35	#8				0.35	
Xylene (p)	mg/L	0.001	56	<0.002	<0.002	N/A	N/A	0.2	#8				0.2	
PAH														
Acenaphthene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A							
Acenaphthylene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A							
Anthracene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A	0.0004	#9				0.0004	
Benzo(a)anthracene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A							
Benzo(b+j+k)fluoranthene	mg/L	0.0002	57	<0.0002	<0.0002	N/A	N/A							
Benzo(a) pyrene	mg/L	0.0001	57	<0.005	<0.005	N/A	N/A	0.0002	#9		0.00001	ANZG (2018)	0.0002	
Benzo(g,h,i)perylene	mg/L	0.0001	57	<0.0001	<0.001	N/A	N/A							
Chrysene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A							
Dibenz(a,h)anthracene	mg/L	0.0001	56	<0.0001	<0.0001	N/A	N/A							
Fluoranthene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A	0.0014	#9				0.0014	
Fluorene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A							
Indeno(1,2,3-c,d)pyrene	mg/L	0.0001	57	<0.0001	<0.0001	N/A	N/A							
Naphthalene	mg/L	0.0001	57	<0.0001	<0.005	N/A	N/A	0.07	#7				0.07	
Phenanthrene	mg/L	0.0001	57	<0.0001	<0.005	N/A	N/A	0.002	#9				0.002	
Pyrene	mg/L	0.0001	57	<0.0001	<0.005	N/A	N/A							
PAHs (Sum of positives)	mg/L	0.0001	56	<0.0001	<0.005	N/A	N/A							
PCBs														
Aroclor 1016	mg/L	0.00001	-	-	-	N/A	N/A							
Aroclor 1221	mg/L	0.00001	-	-	-	N/A	N/A							
Aroclor 1232	mg/L	0.00001	-	-	-	N/A	N/A							
Aroclor 1242	mg/L	0.00001	24	<0.0001	<0.0001	N/A	N/A	0.0003	#9				0.0003	
Aroclor 1248	mg/L	0.00001	-	-	-	N/A	N/A							
Aroclor 1254	mg/L	0.00001	24	<0.0001	<0.0001	N/A	N/A	0.00001	#9				0.00001	
Sum PCBs	mg/L	0.00001	51	<0.0001	<0.0001	N/A	N/A							
Phenols														
2,4,6-Trichlorophenol	mg/L	0.001	31	<0.001	<0.001	0.001	N/A				0.02			
2,4-Dichlorophenol	mg/L	0.001	31	<0.001	<0.001	0.001	N/A				0.2			
2-Chlorophenol	mg/L	0.001	31	<0.001	<0.001	0.001	N/A				0.3			
Pentachlorophenol	mg/L	0.005	31	<0.001	<0.005	0.002	0.002	0.022			0.01	ADWG (2011)	0.01	
Phenol	mg/L	0.001	16	<0.001	0.027	0.016	0.0142	0.4	#4				0.4	
PFAS														
Sum of PFHxS and PFOS	µg/L	0.0002	16	<0.0002	0.027	0.016	0.014				0.07			
Perfluorooctane sulfonic acid (PFOS)	µg/L	0.0002	16	<0.0002	0.013	0.0091	0.0073			0.00013			0.0002	
Perfluorooctanoic acid (PFOA)	µg/L	0.0002	16	<0.0002	0.005	0.0022	0.0028			0.22	0.56		0.22	
Sum of positive PFAS	µg/L	0.0001	16	<0.0001	0.12	0.059	0.070							

Refer notes following

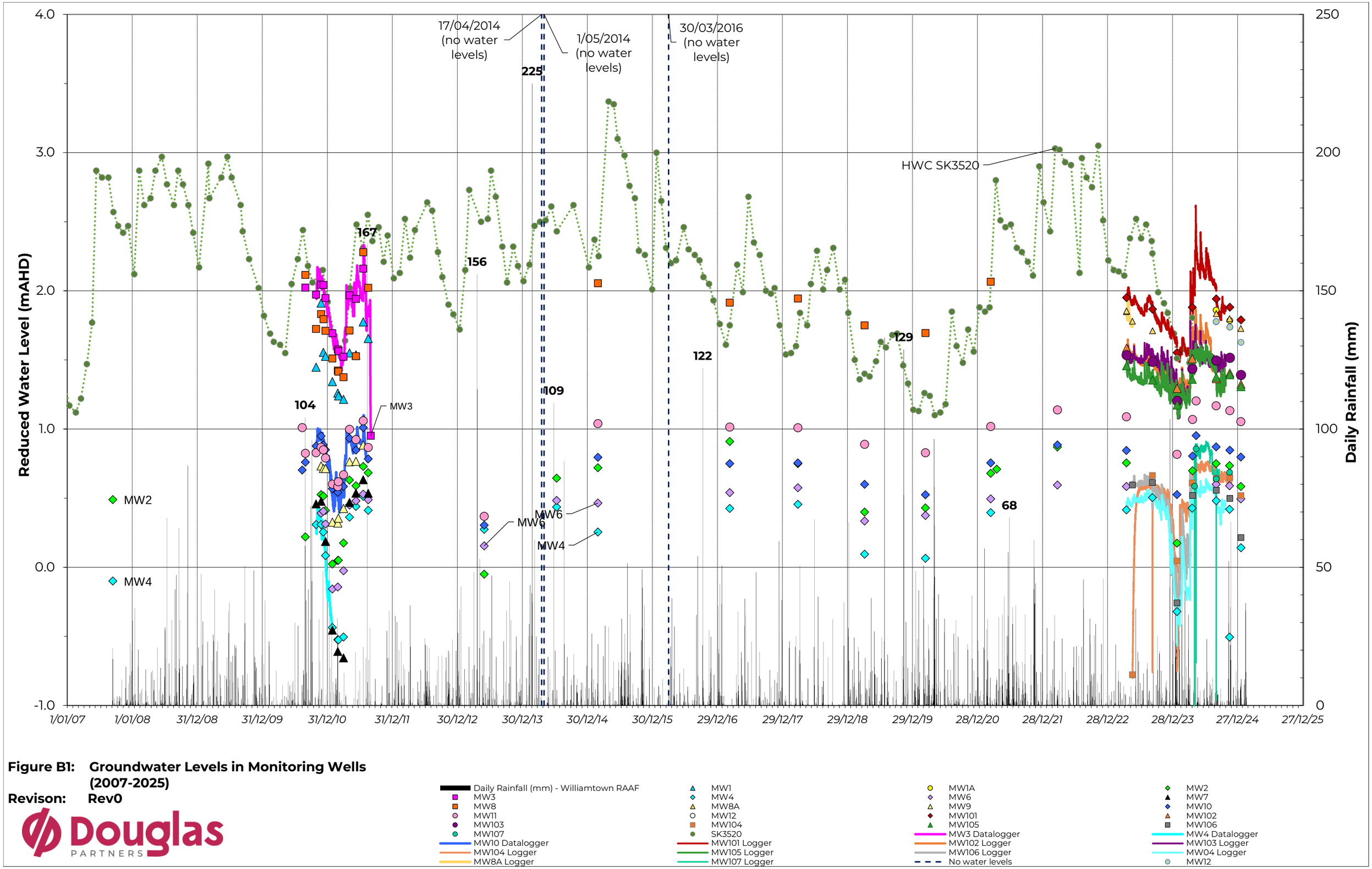


Figure B1: Groundwater Levels in Monitoring Wells (2007-2025)

Revison: Rev0

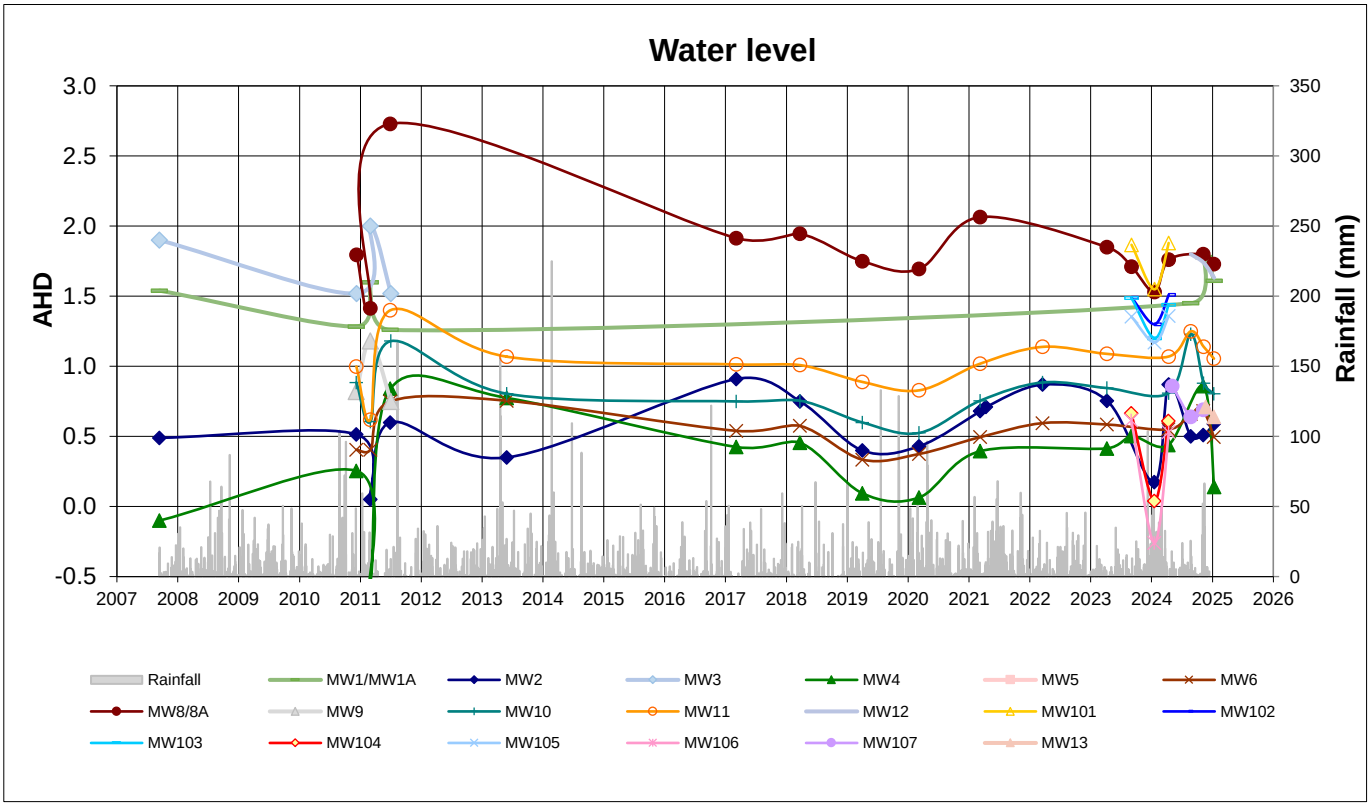
Douglas PARTNERS

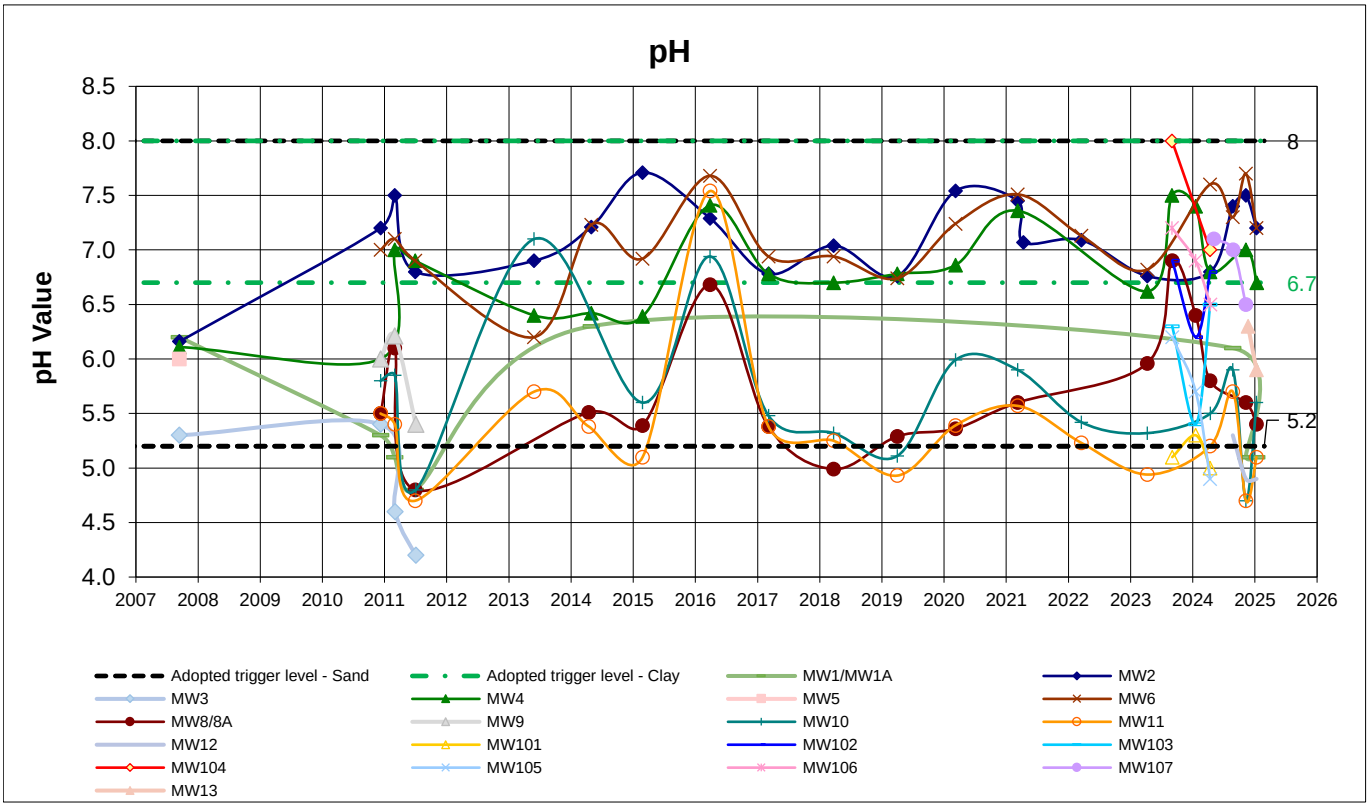
Appendix C

Groundwater Quality Plots
Surface Water Quality Plots

GROUNDWATER QUALITY MONITORING
Tomago Northbank Enterprise Hub
Data Period: 2007 to January 2025

Data set: All data **Project: 39920.09**

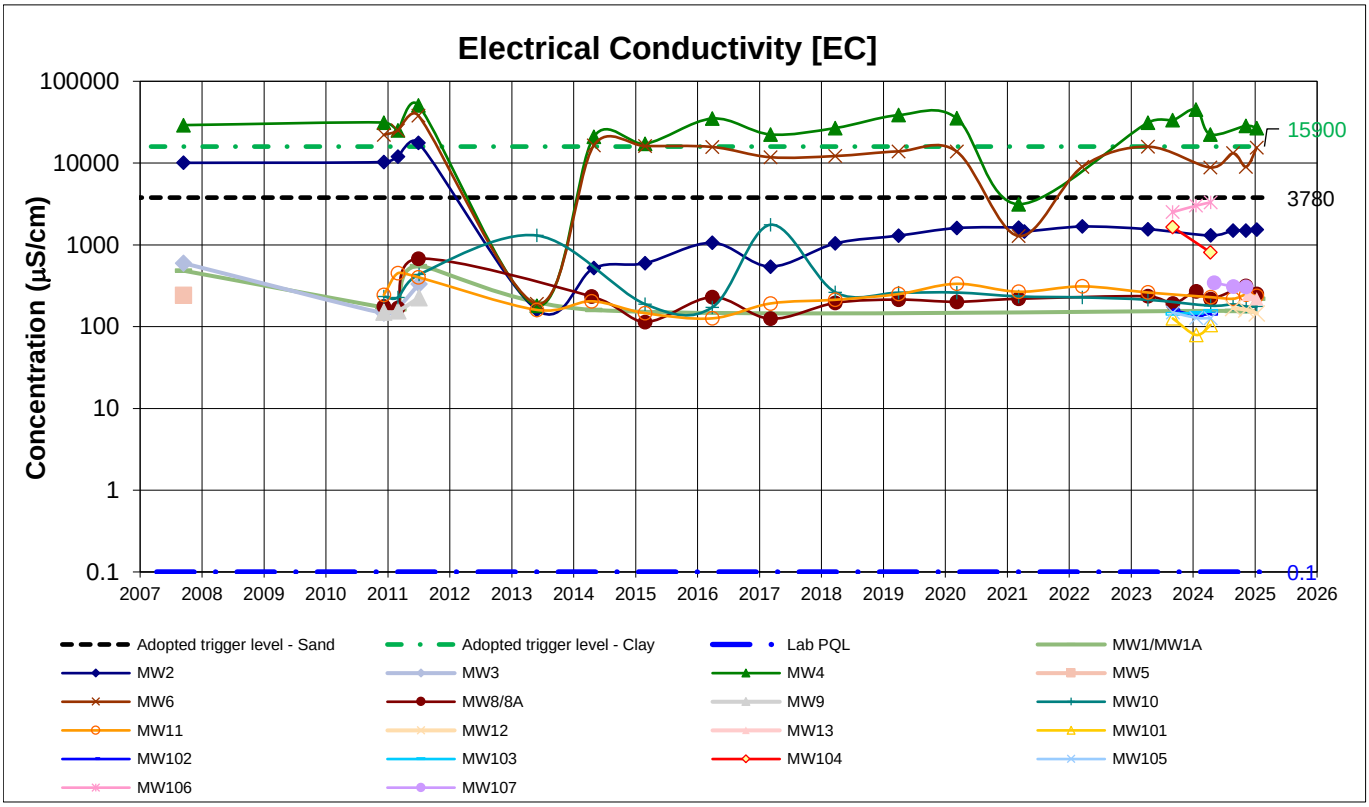


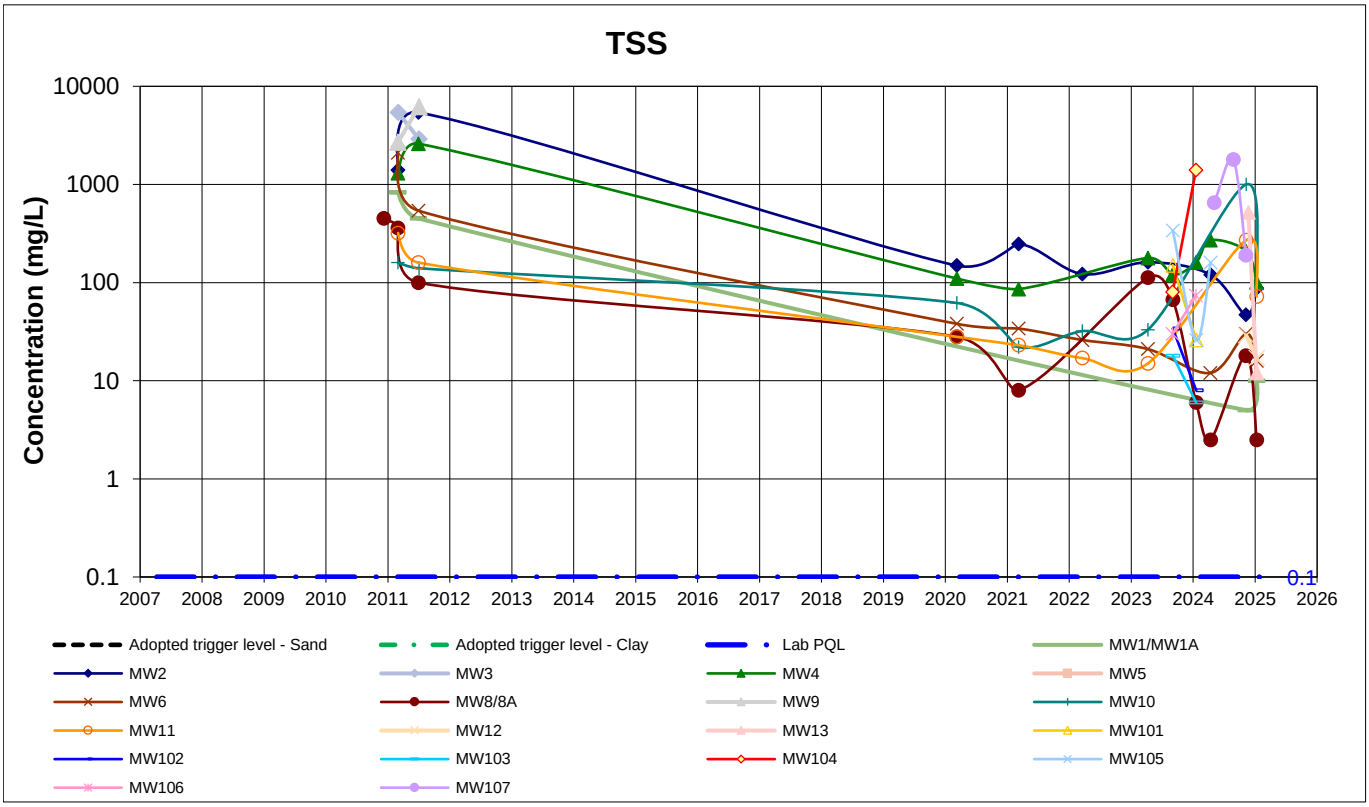


1. Values reported below PQL are plotted as half PQL
2. If a Criterion line is not plotted, there is no criteria

GROUNDWATER QUALITY MONITORING
Tomago Northbank Enterprise Hub
Data Period: 2007 to January 2025

Data set: All data **Project: 39920.09**

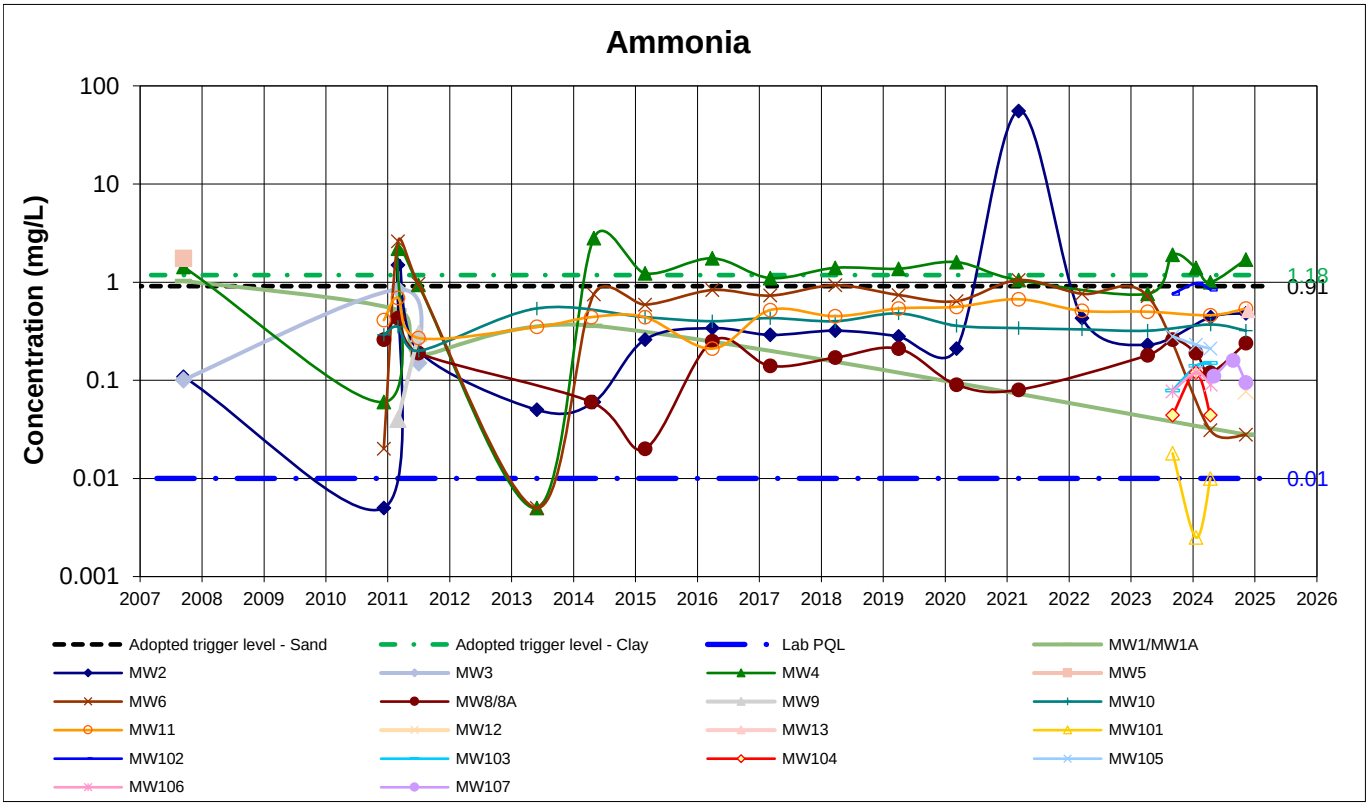


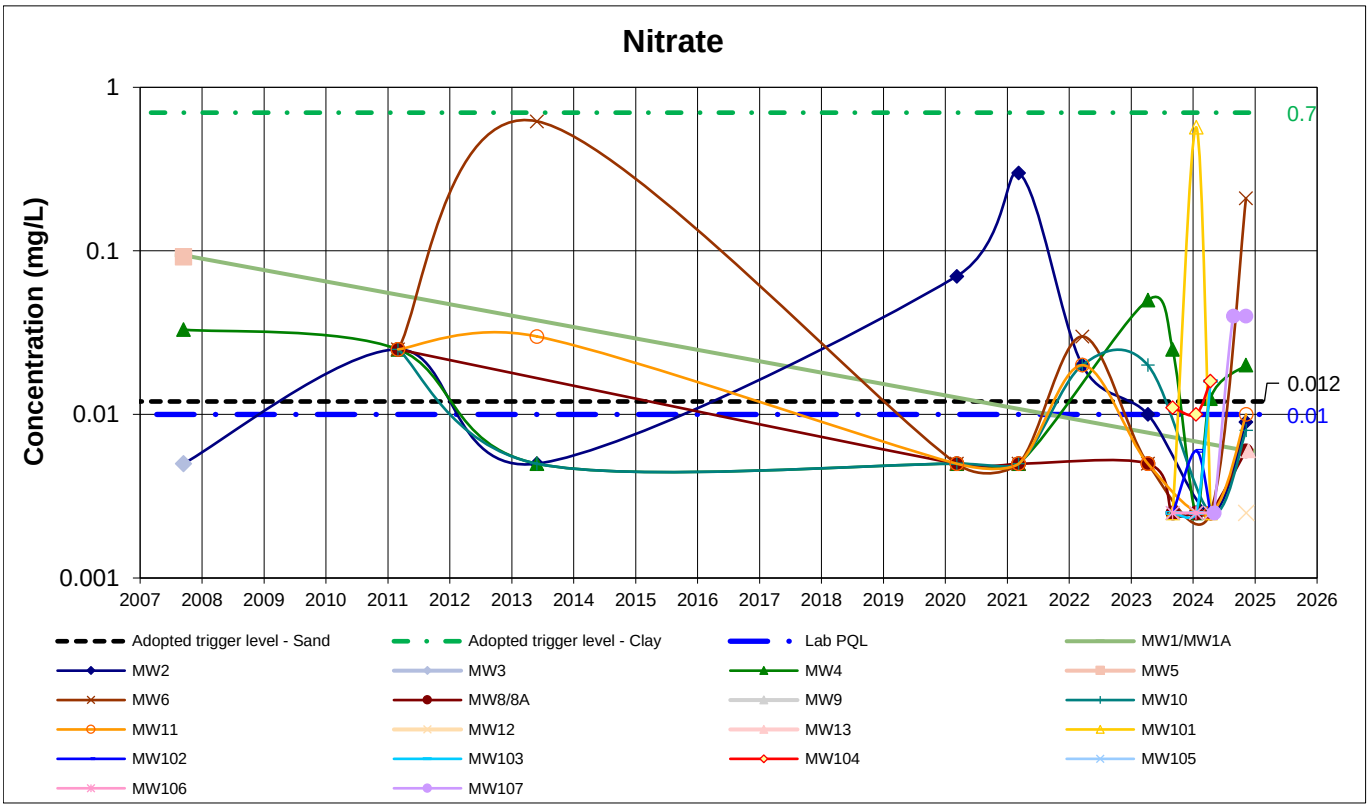


1. Values reported below PQL are plotted as half PQL
2. If a Criterion line is not plotted, there is no criteria

GROUNDWATER QUALITY MONITORING
Tomago Northbank Enterprise Hub
Data Period: 2007 to January 2025

Data set: All data **Project: 39920.09**

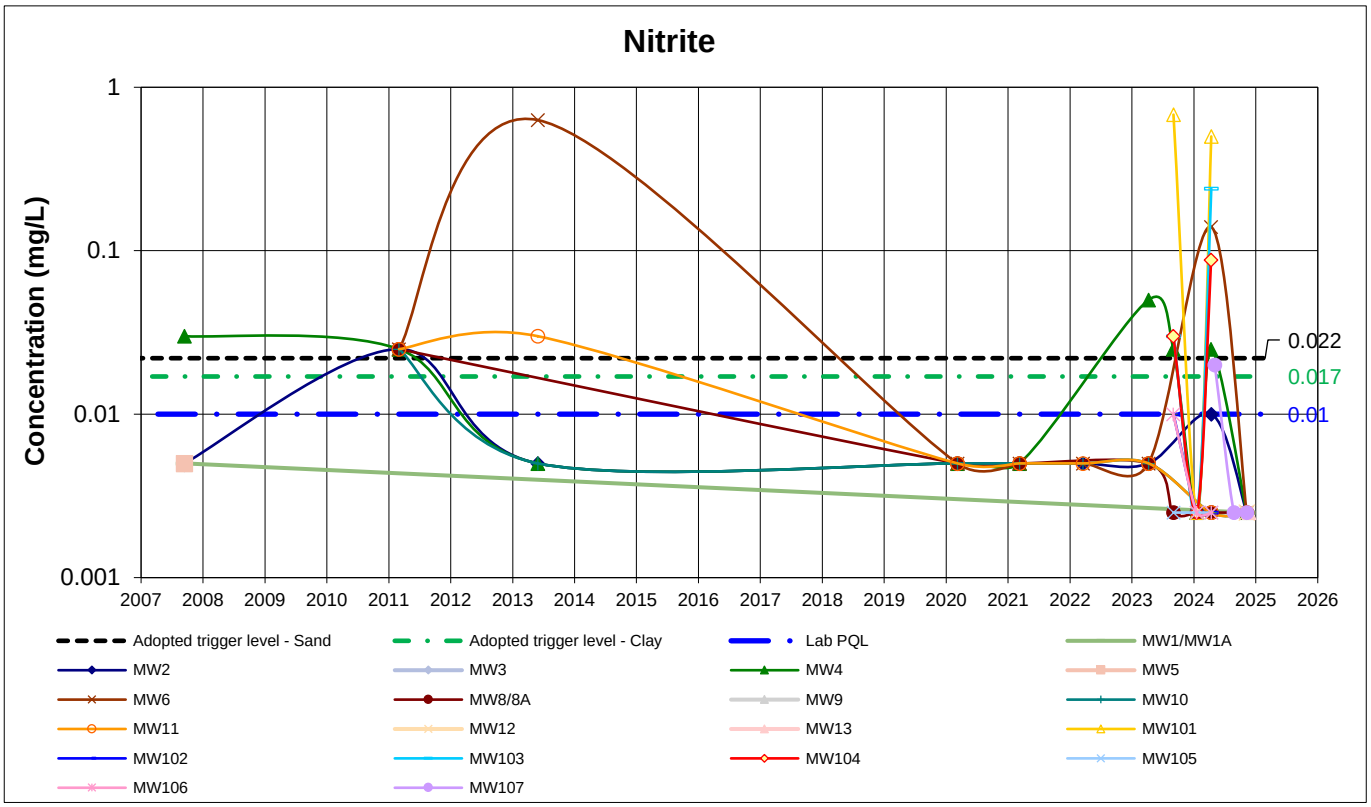


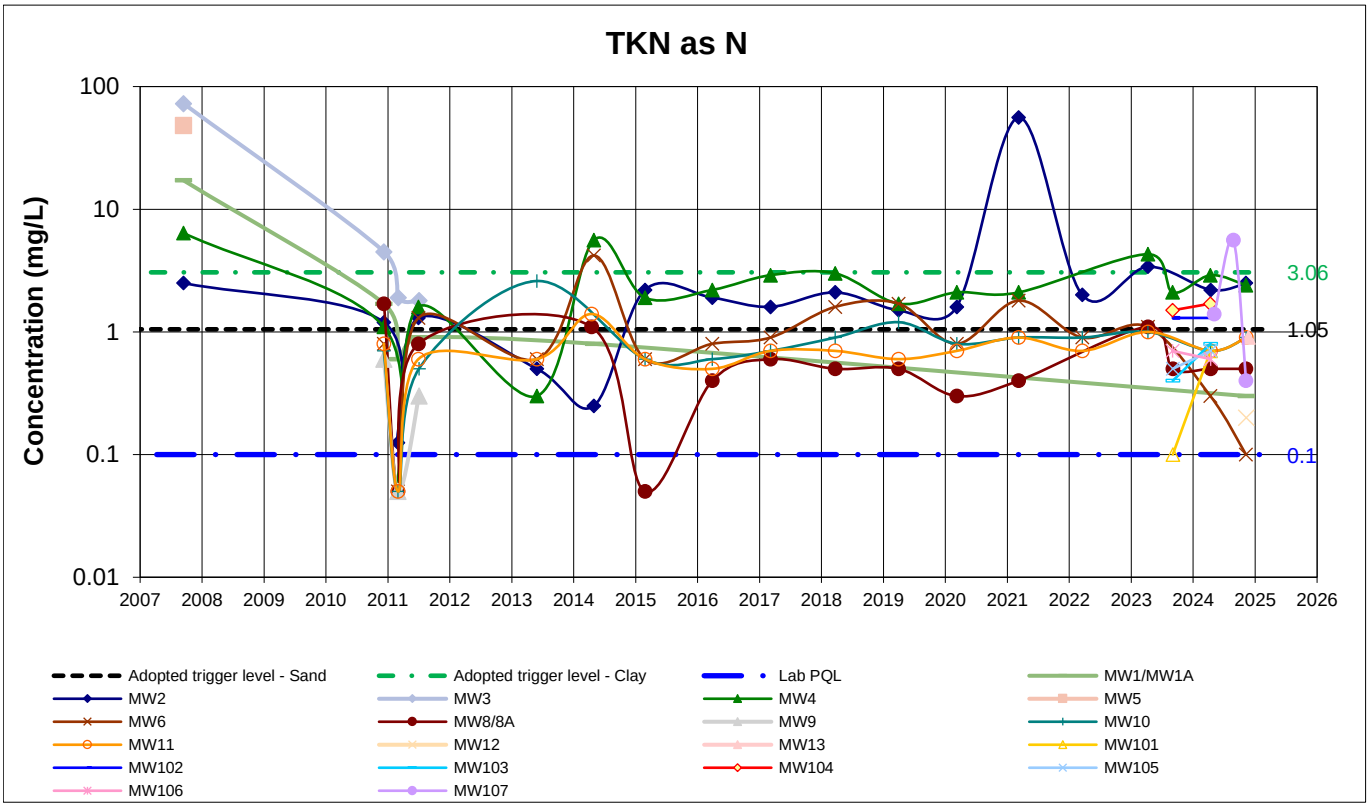


1. Values reported below PQL are plotted as half PQL
2. If a Criterion line is not plotted, there is no criteria

GROUNDWATER QUALITY MONITORING
Tomago Northbank Enterprise Hub
Data Period: 2007 to January 2025

Data set: All data **Project: 39920.09**

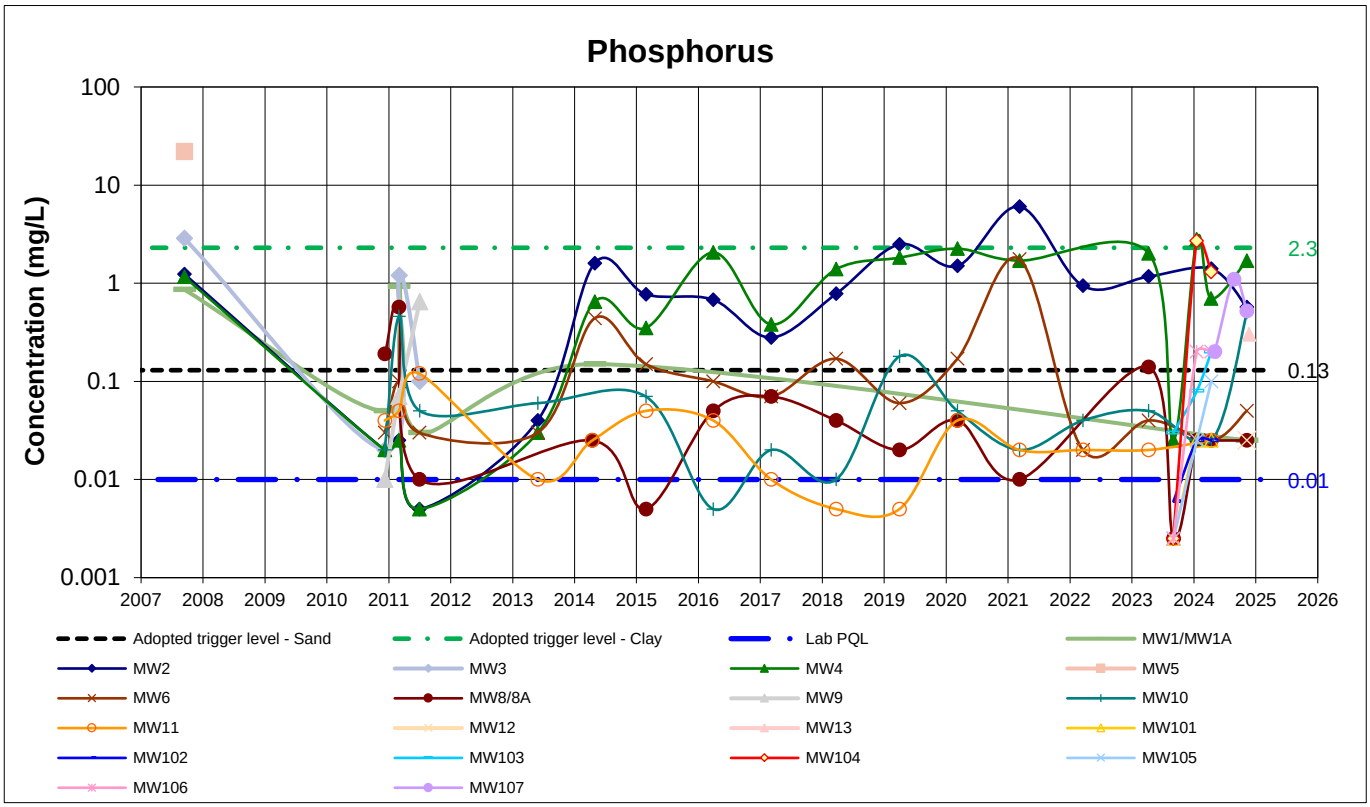


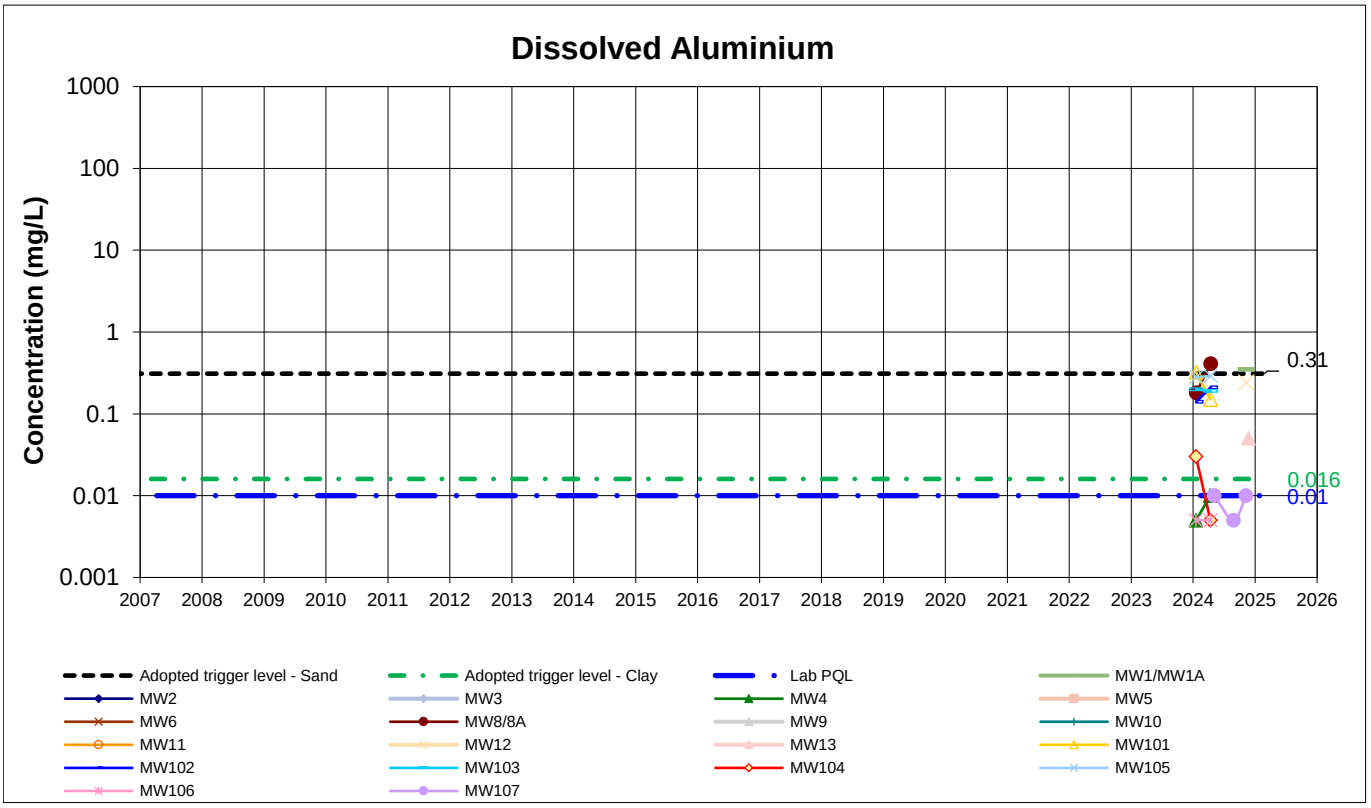


1. Values reported below PQL are plotted as half PQL
2. If a Criterion line is not plotted, there is no criteria

GROUNDWATER QUALITY MONITORING
Tomago Northbank Enterprise Hub
Data Period: 2007 to January 2025

Data set: All data **Project: 39920.09**

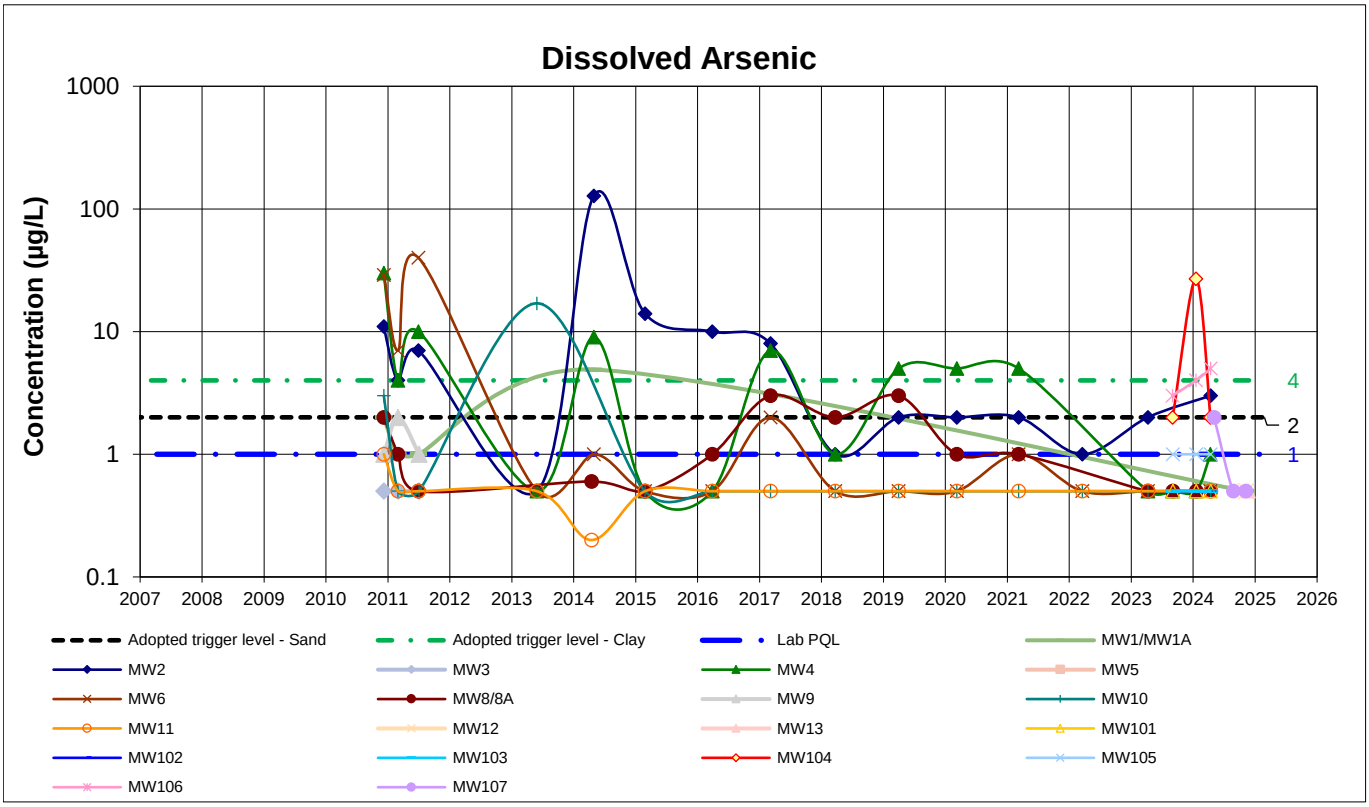


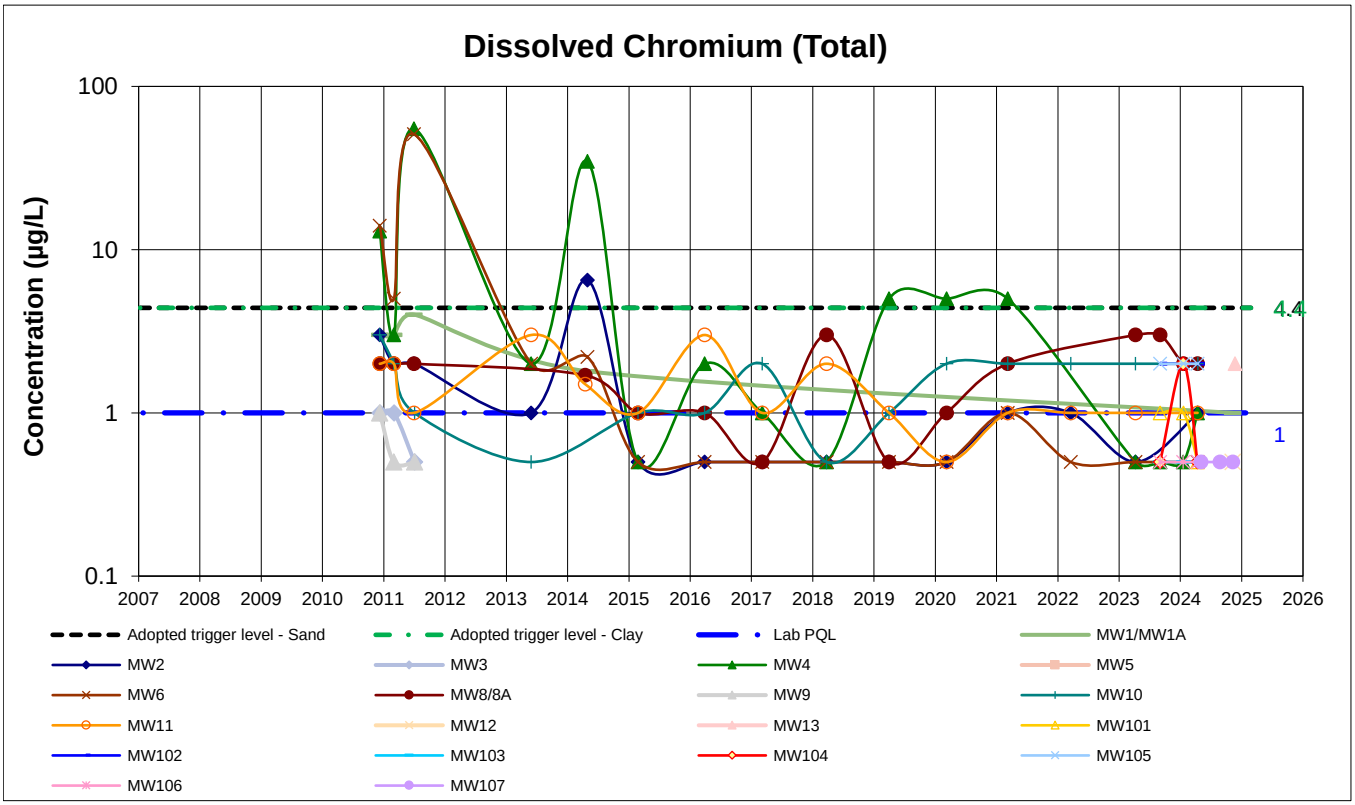


1. Values reported below PQL are plotted as half PQL
2. If a Criterion line is not plotted, there is no criteria

GROUNDWATER QUALITY MONITORING
Tomago Northbank Enterprise Hub
Data Period: 2007 to January 2025

Data set: All data **Project: 39920.09**





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GROUNDWATER QUALITY MONITORING
Tomago Northbank Enterprise Hub
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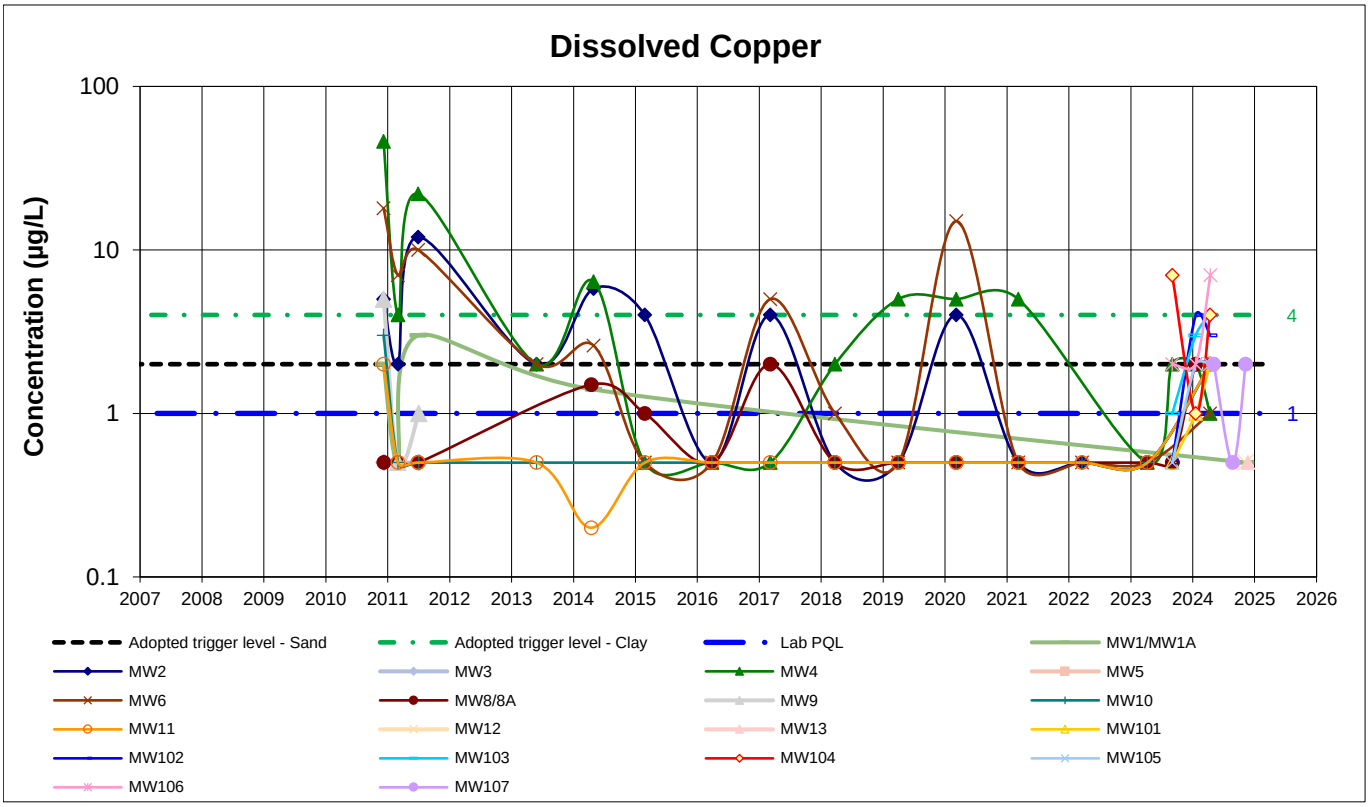

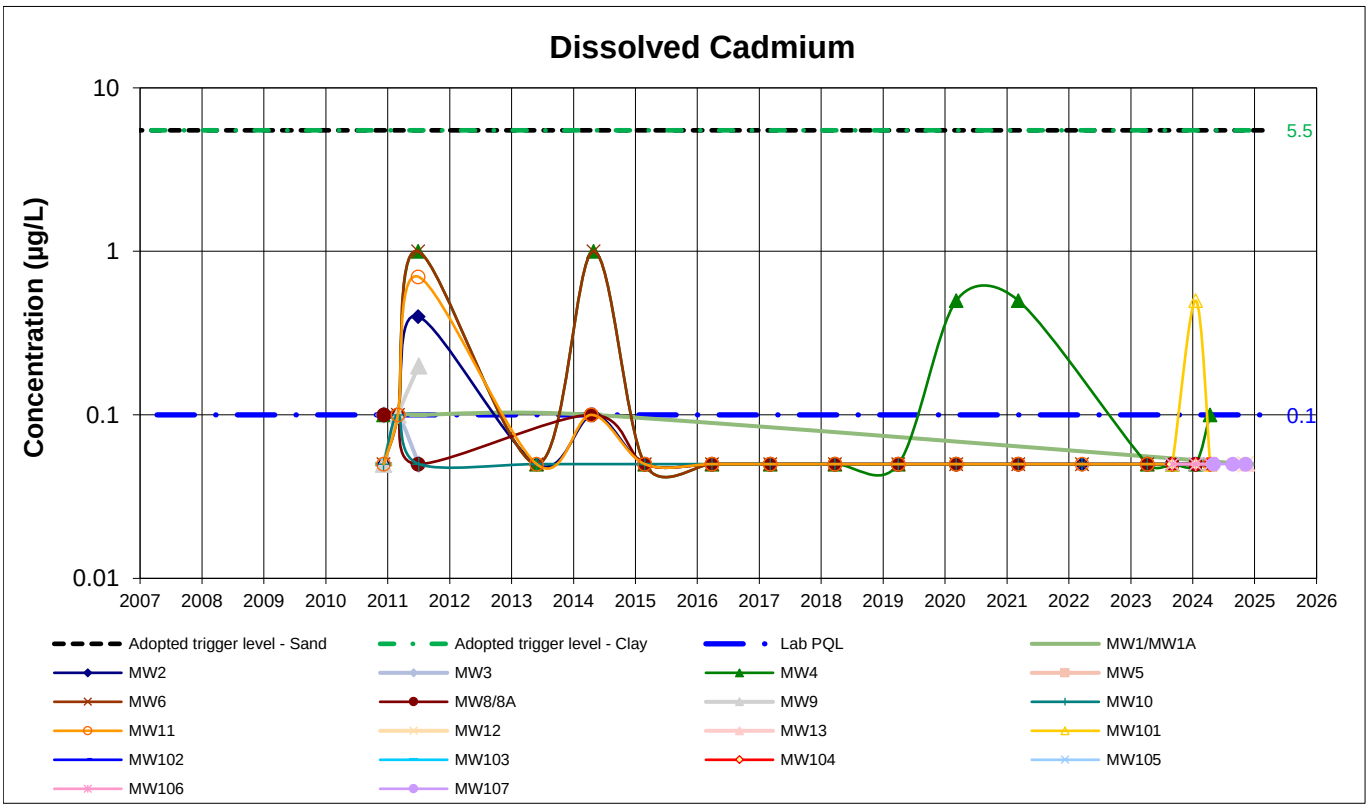

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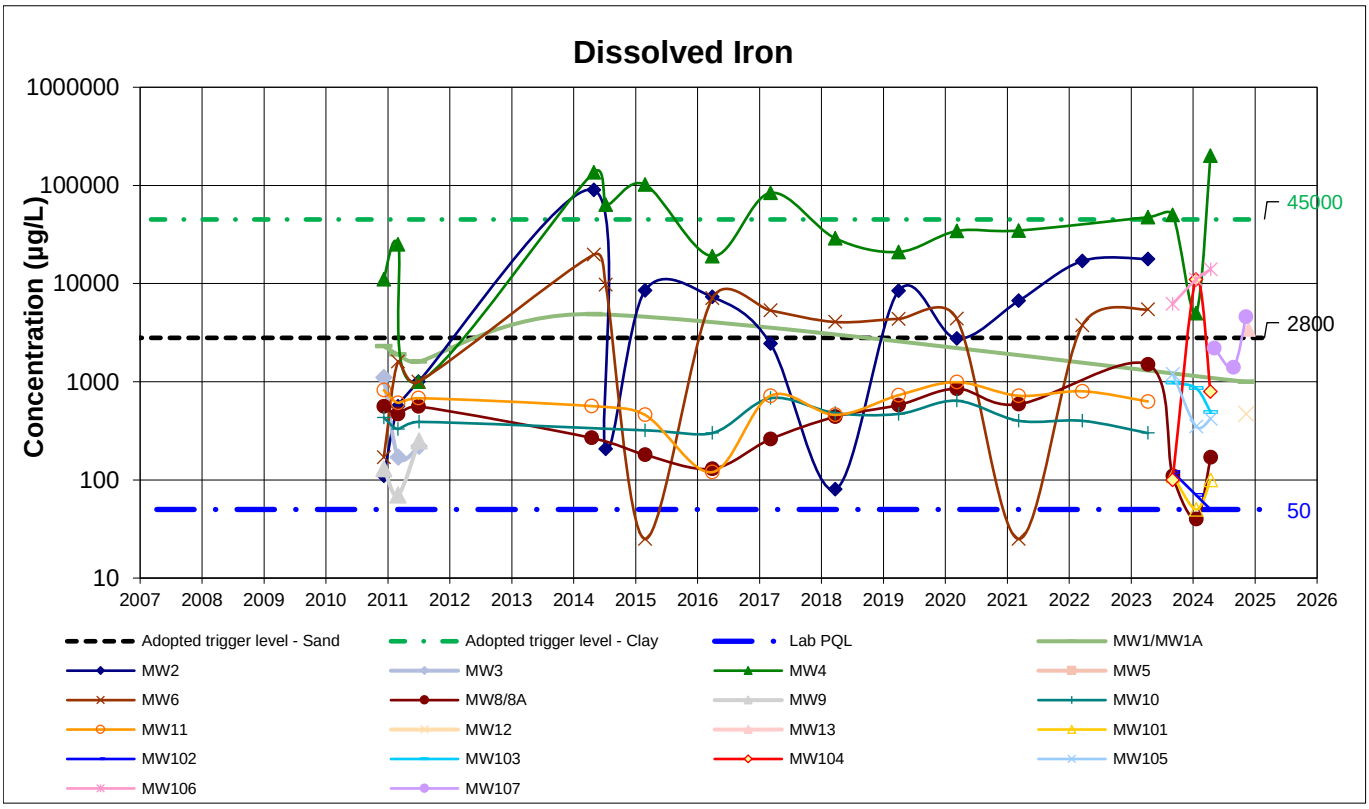

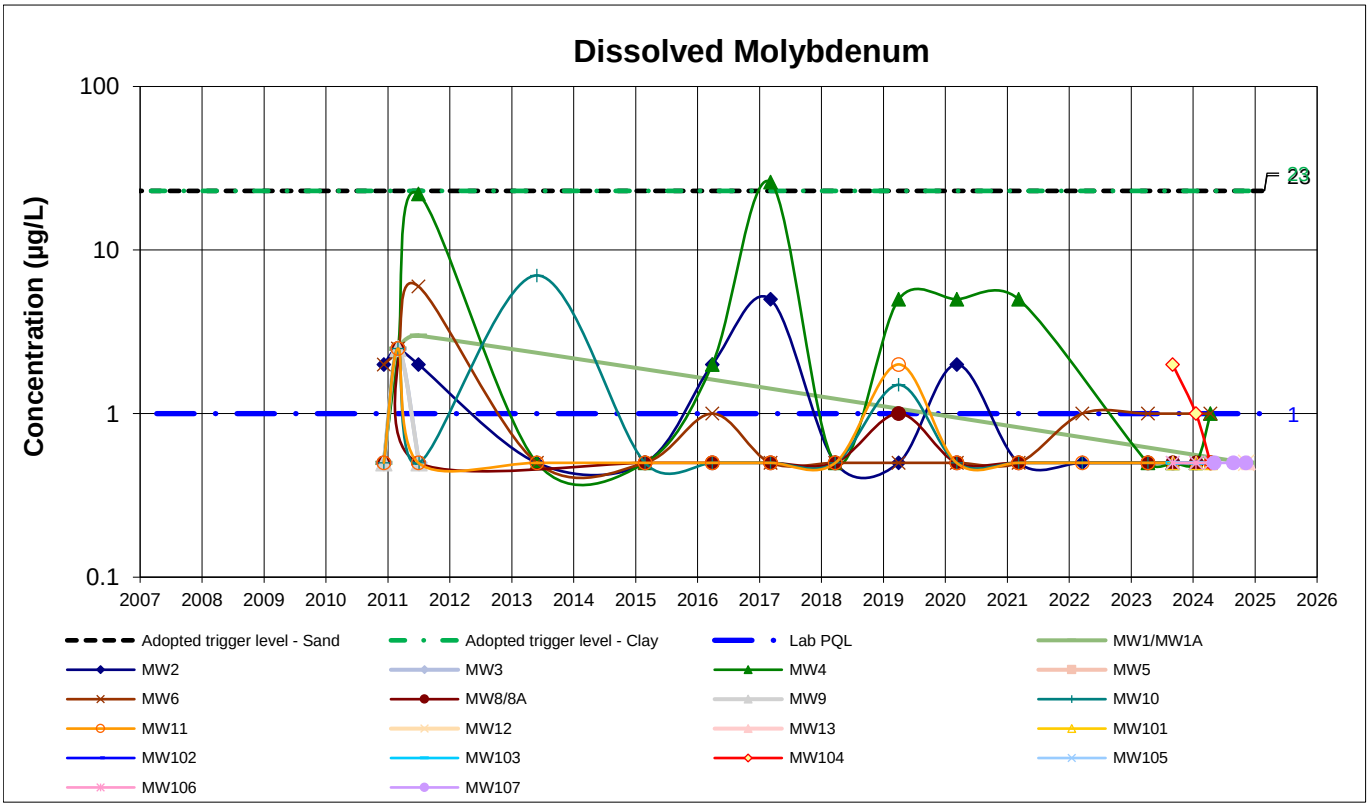

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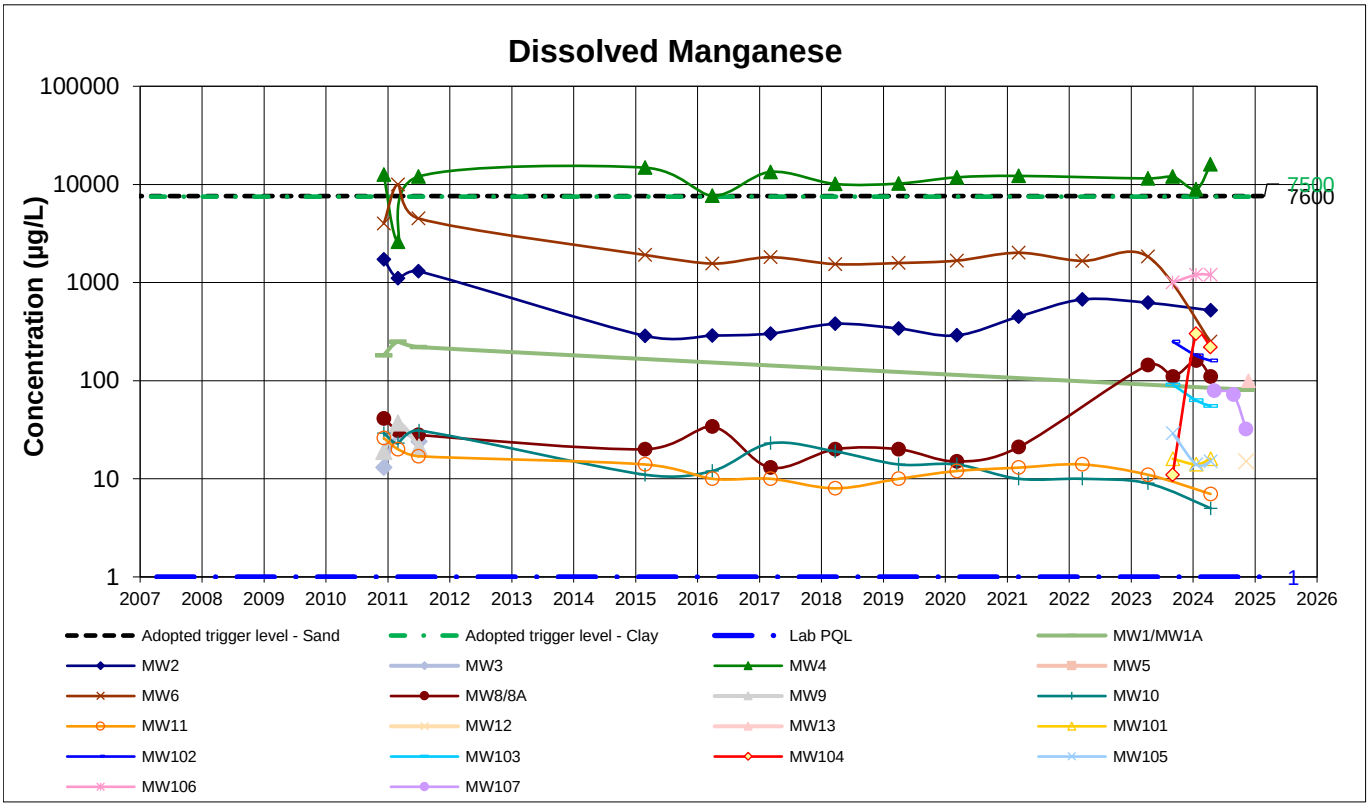

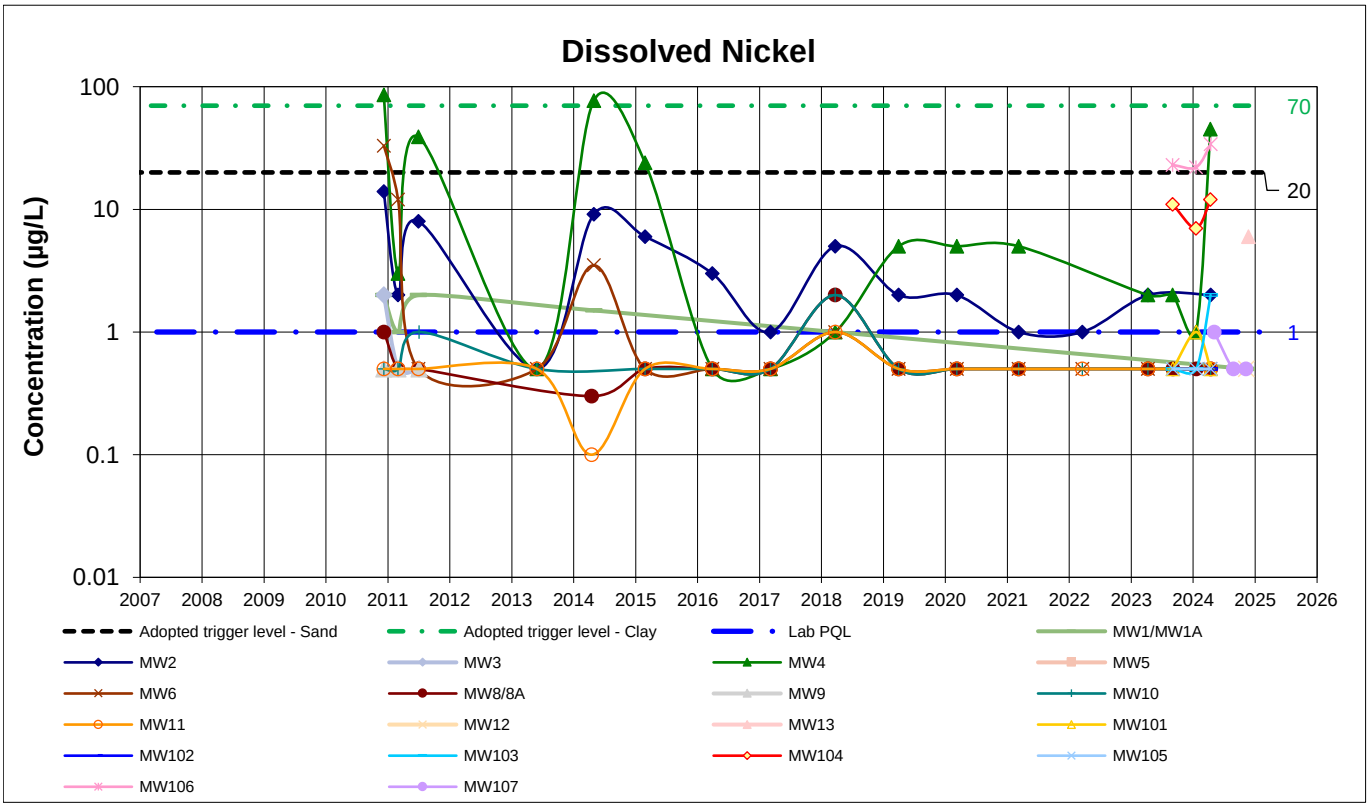

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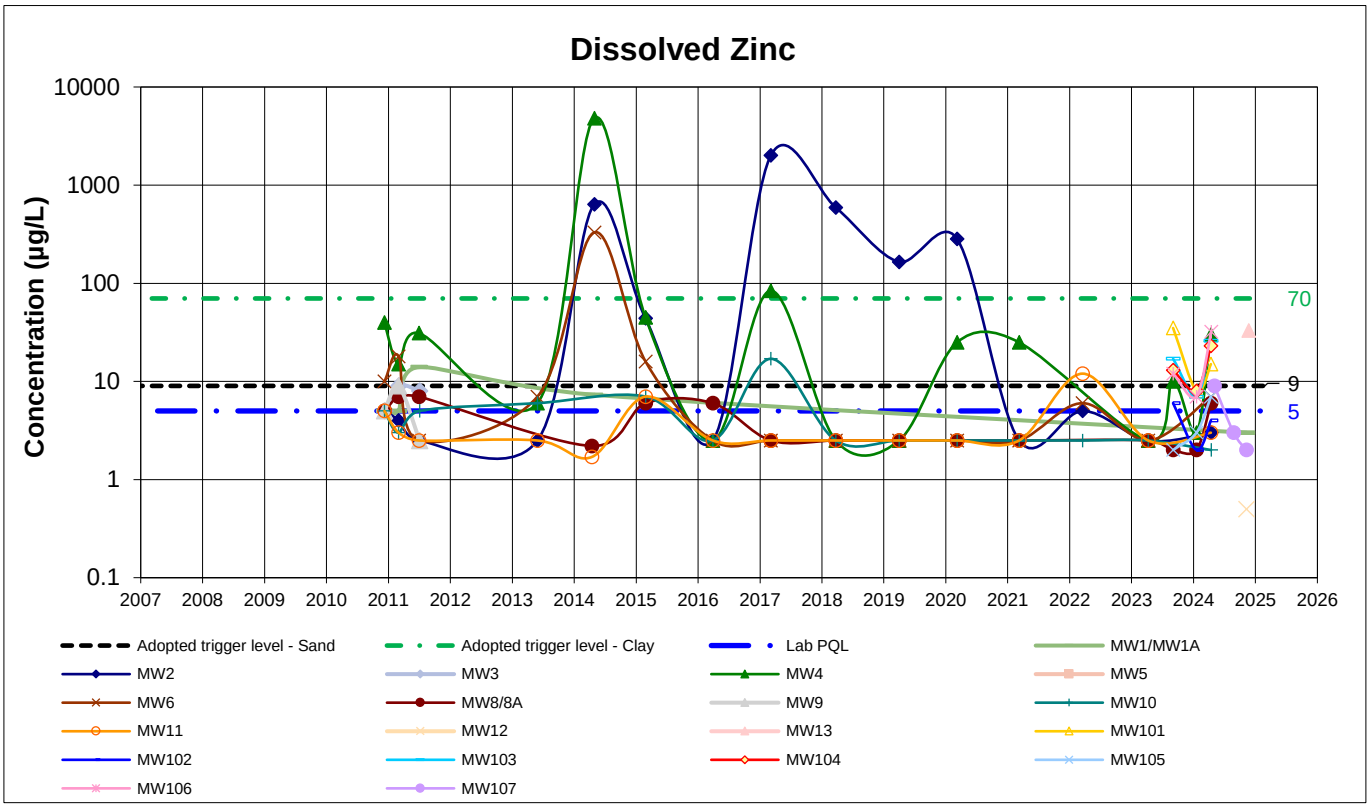

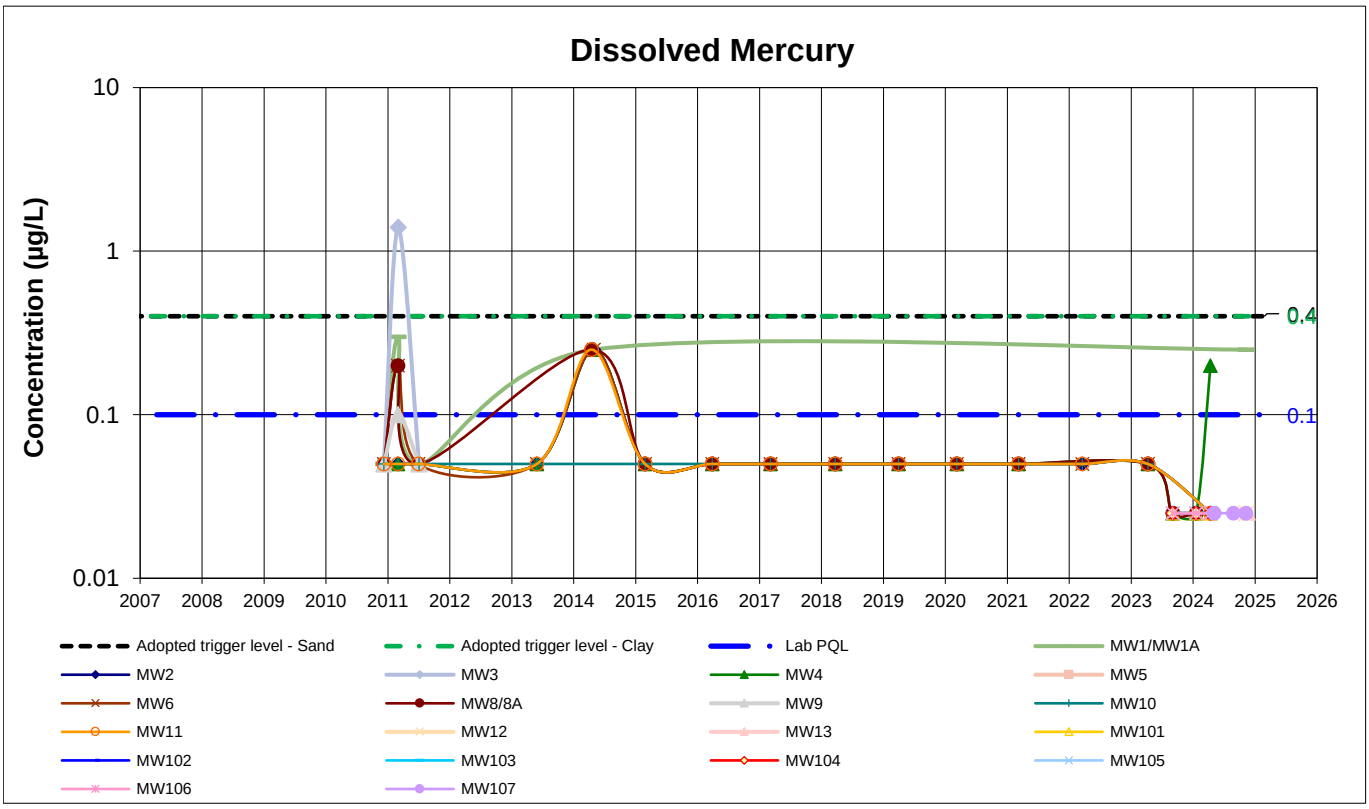

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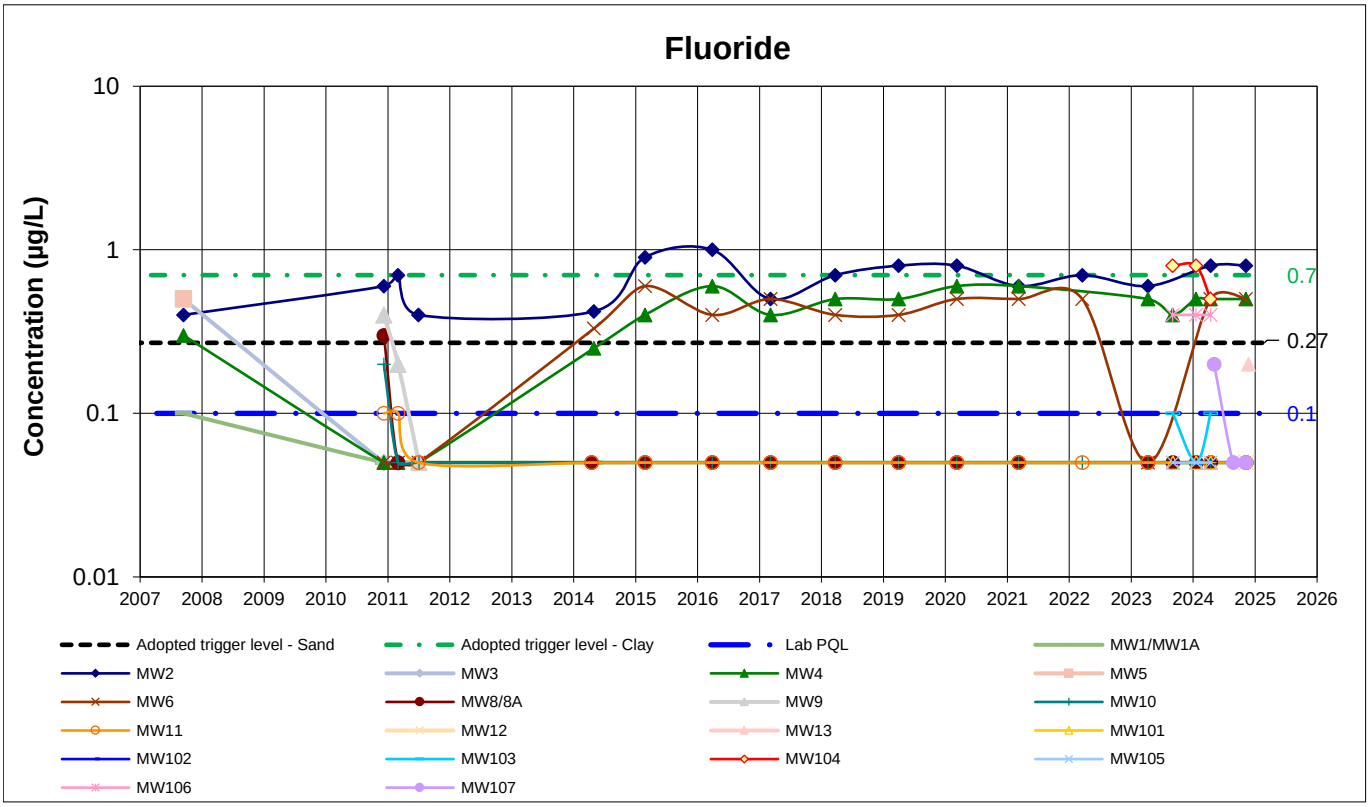

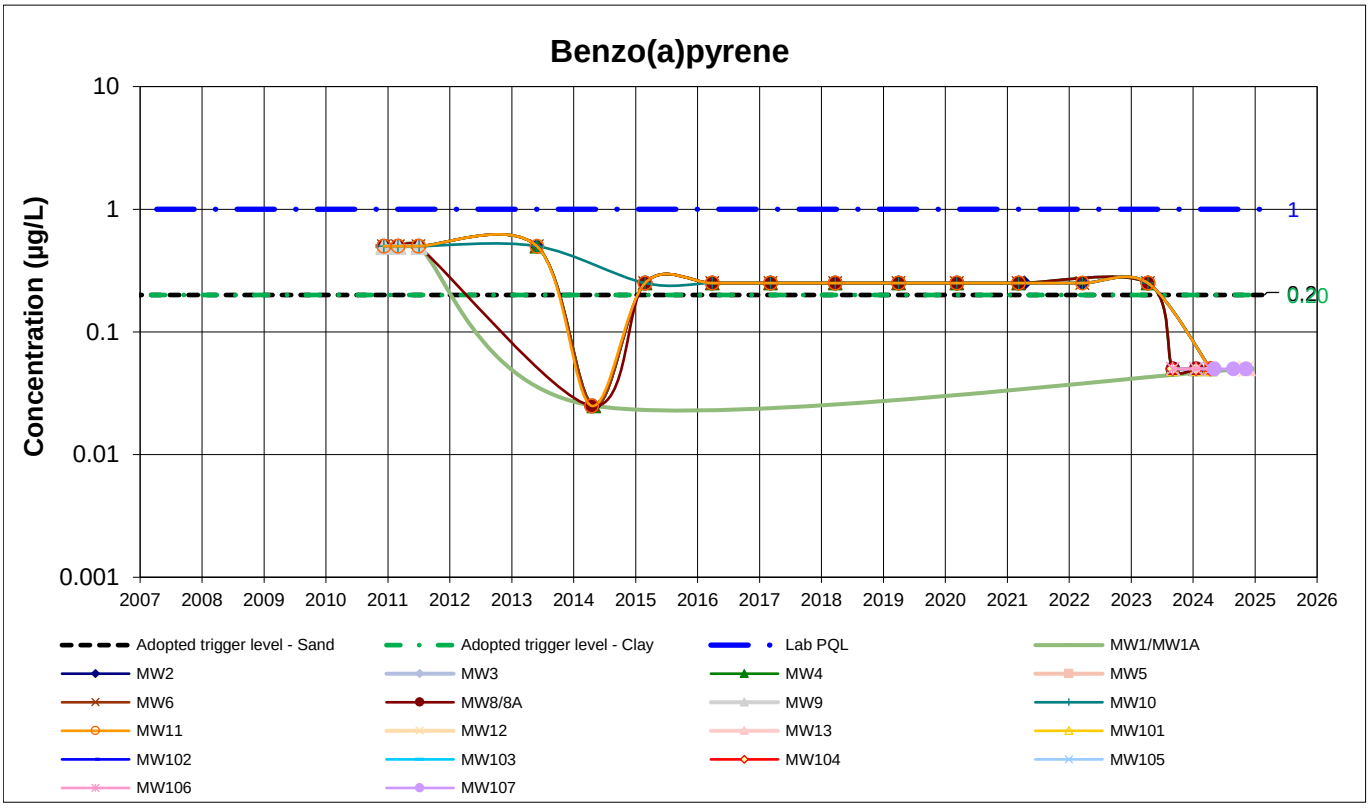

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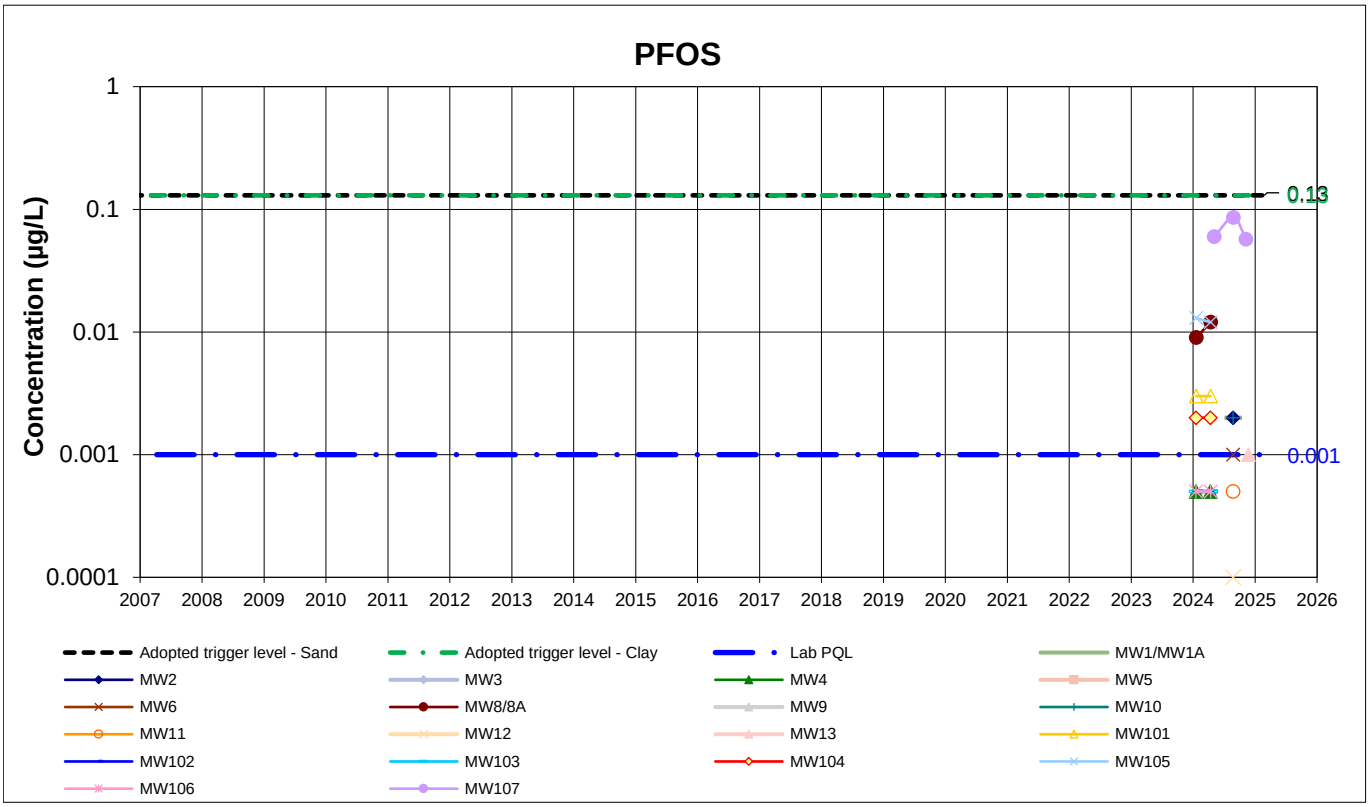

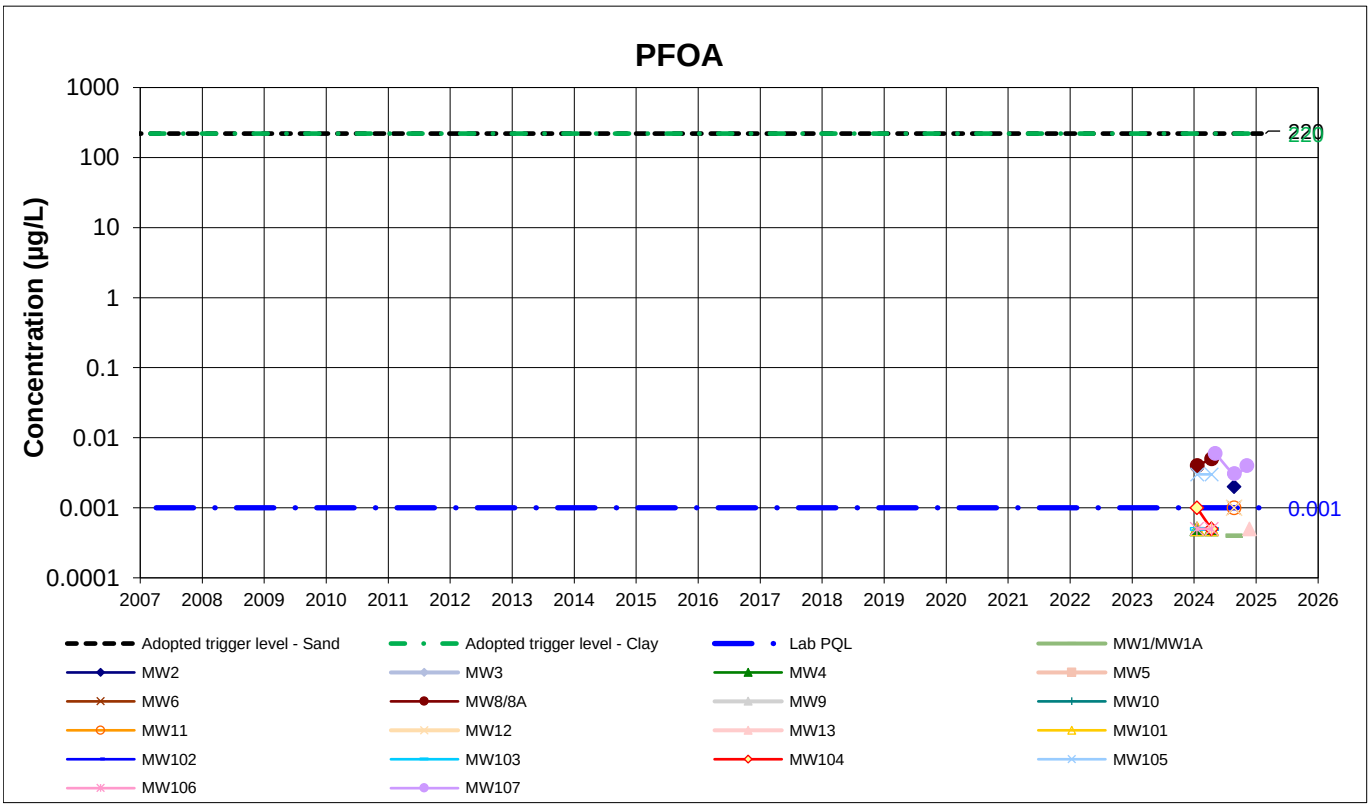

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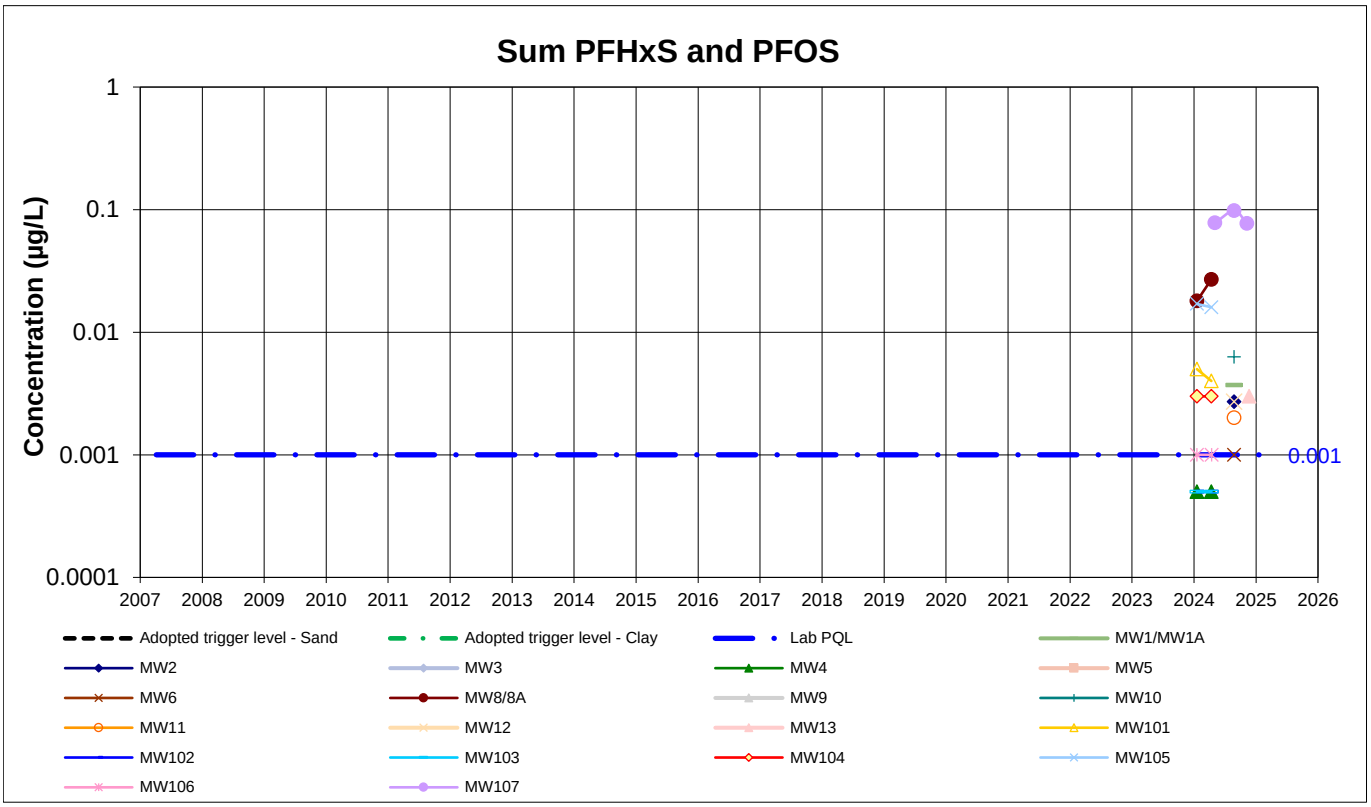

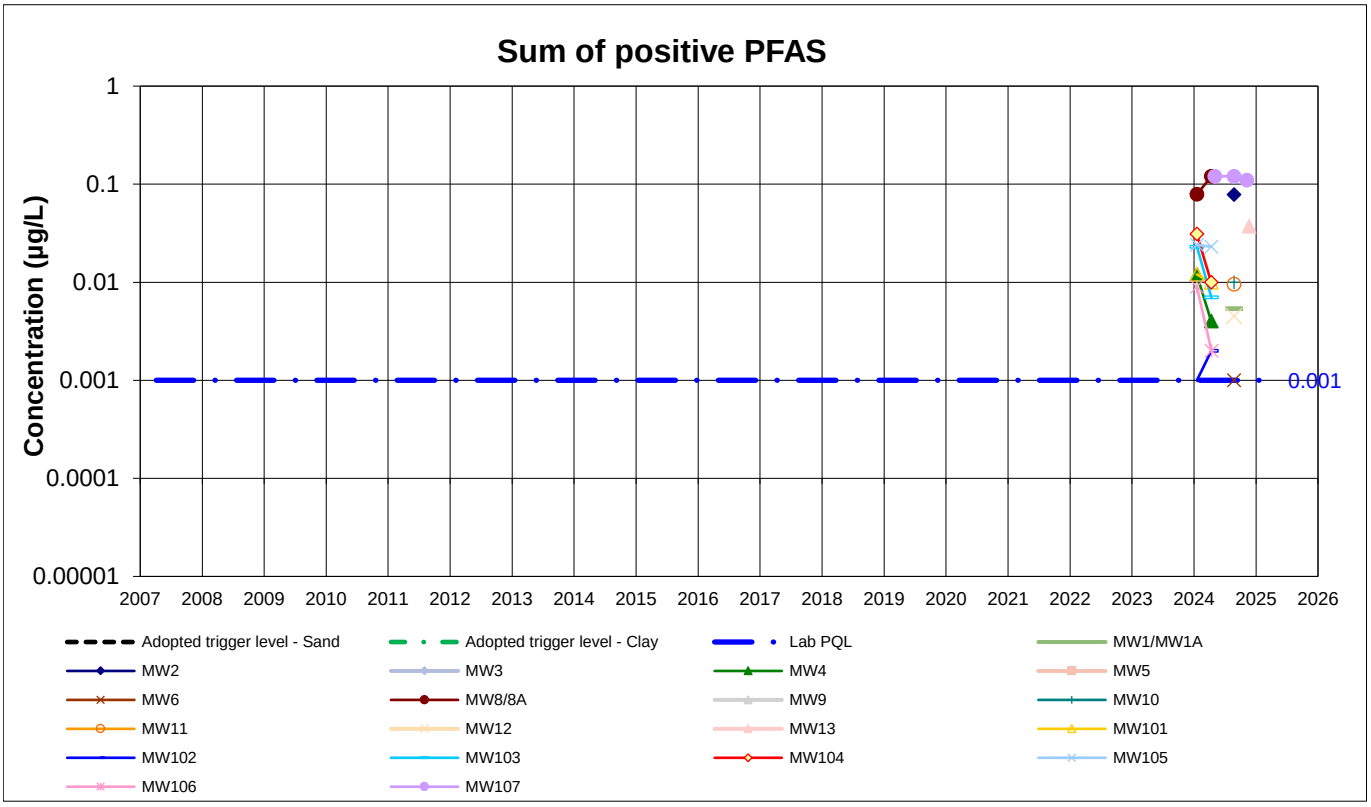

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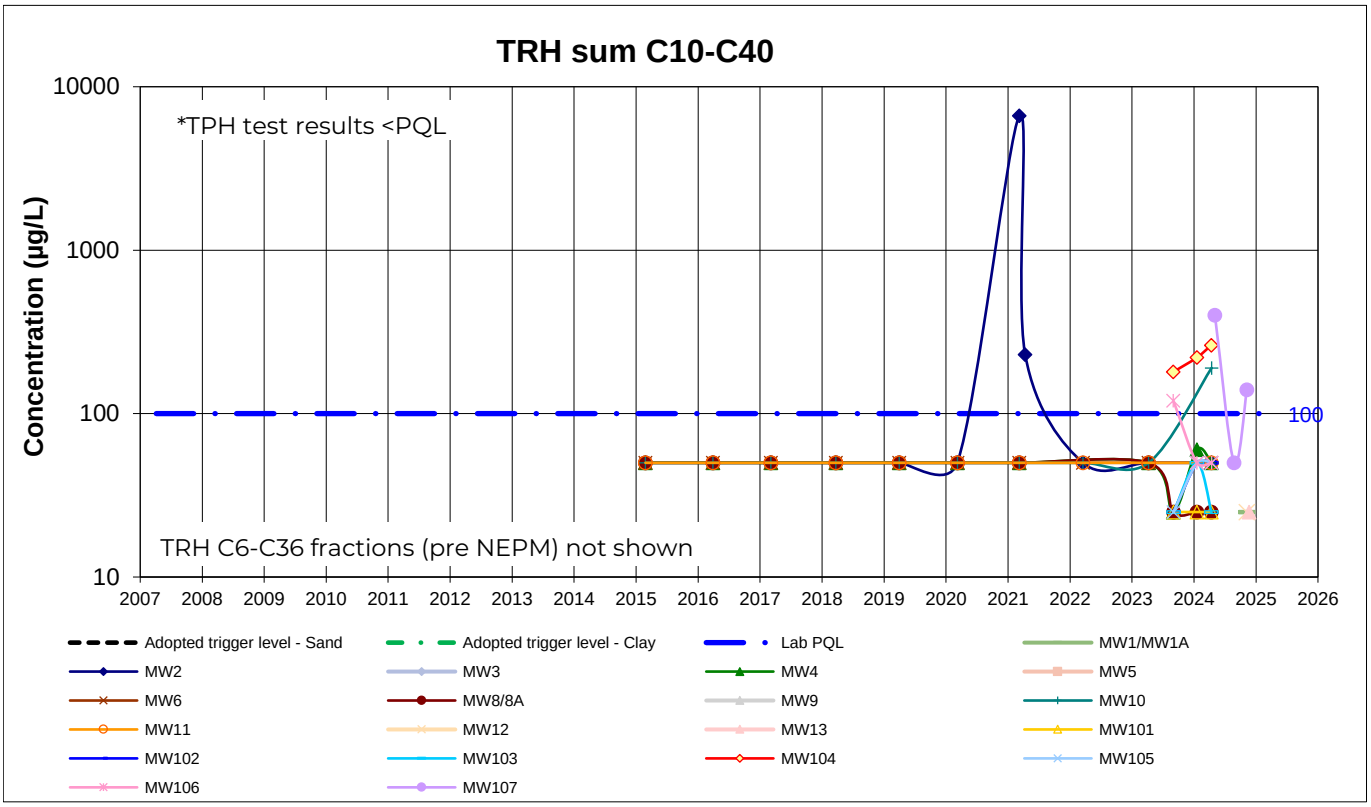

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SURFACE WATER QUALITY MONITORING
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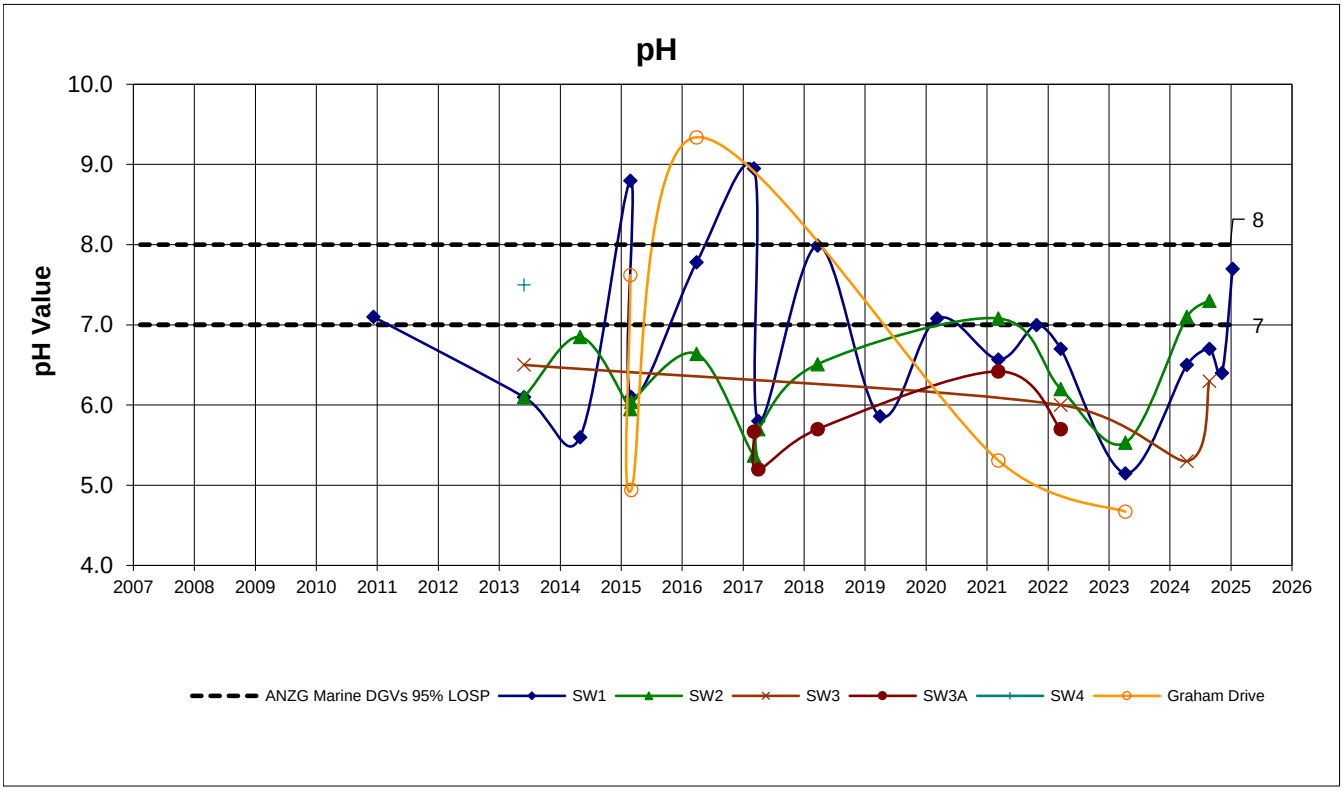

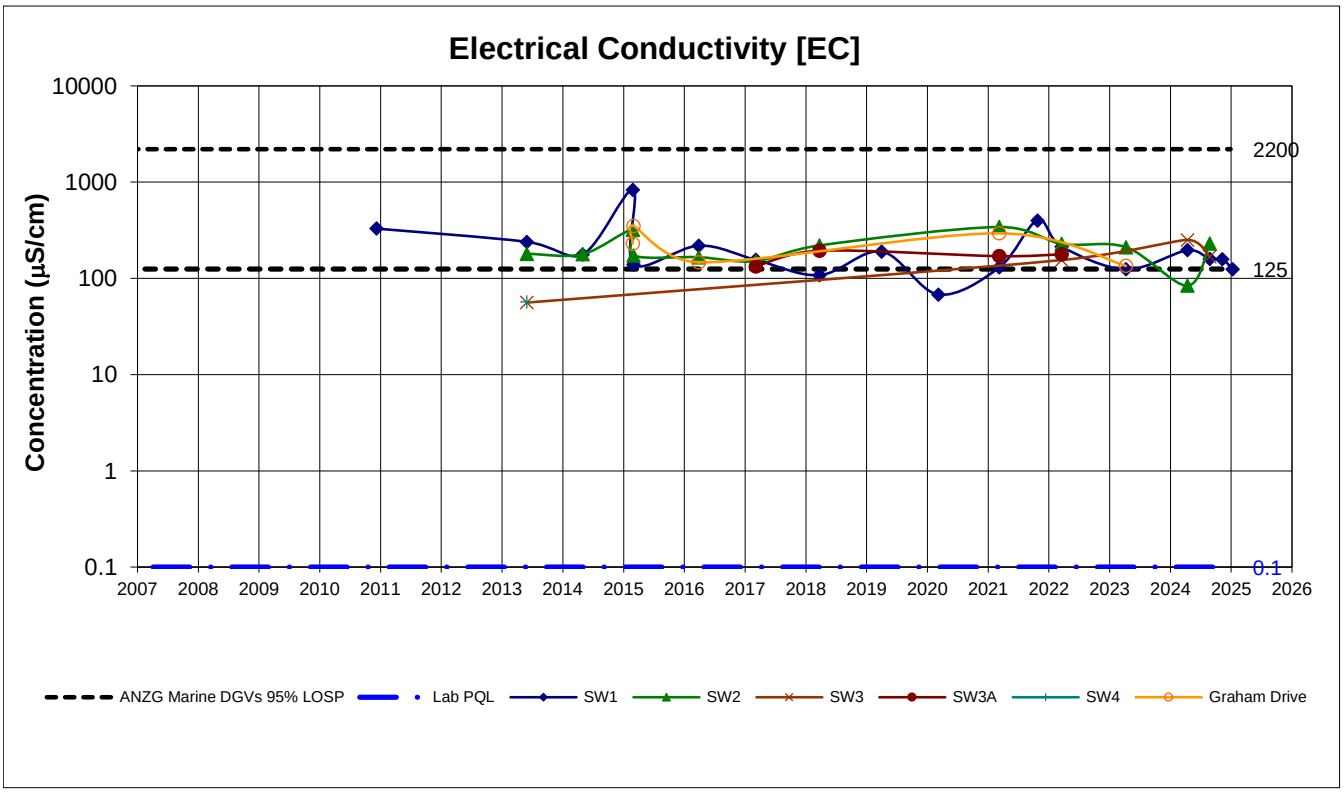

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Tomago Northbank Enterprise Hub
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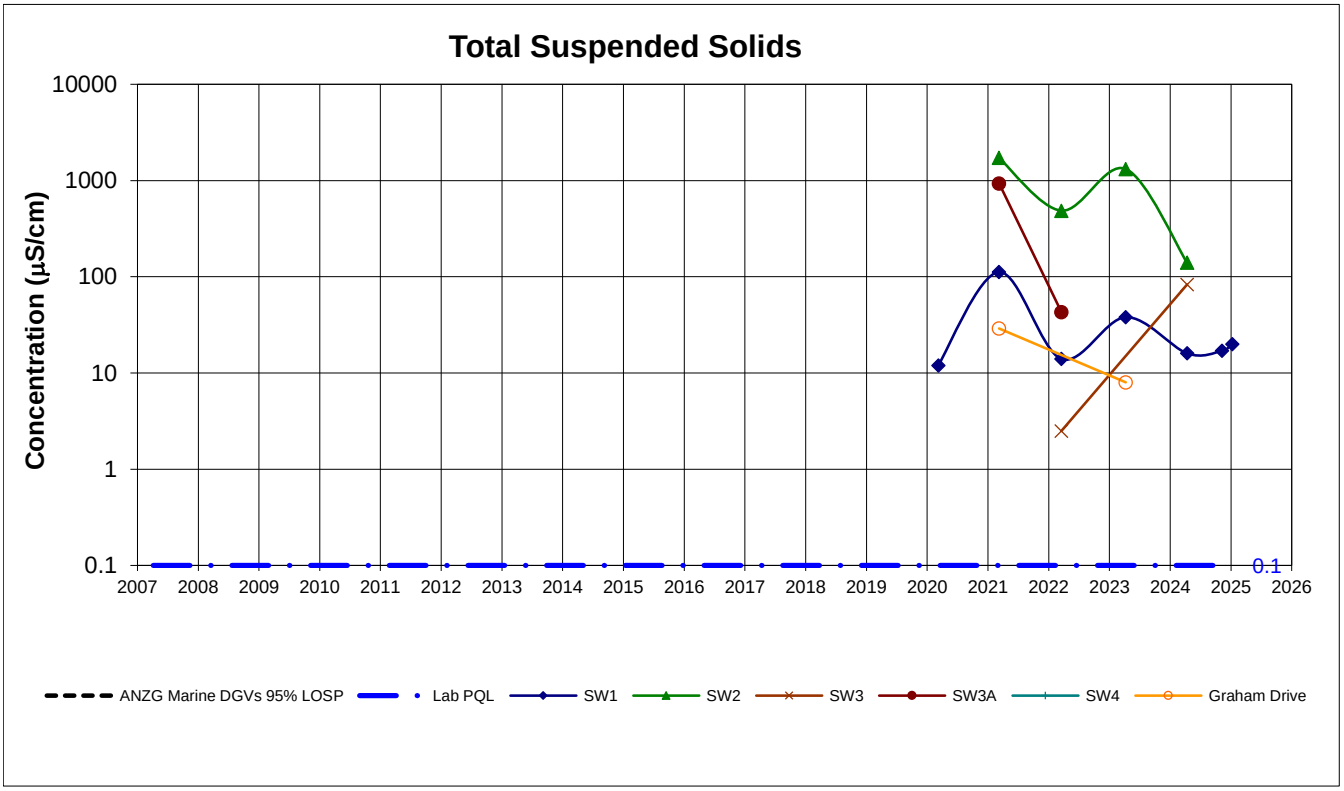

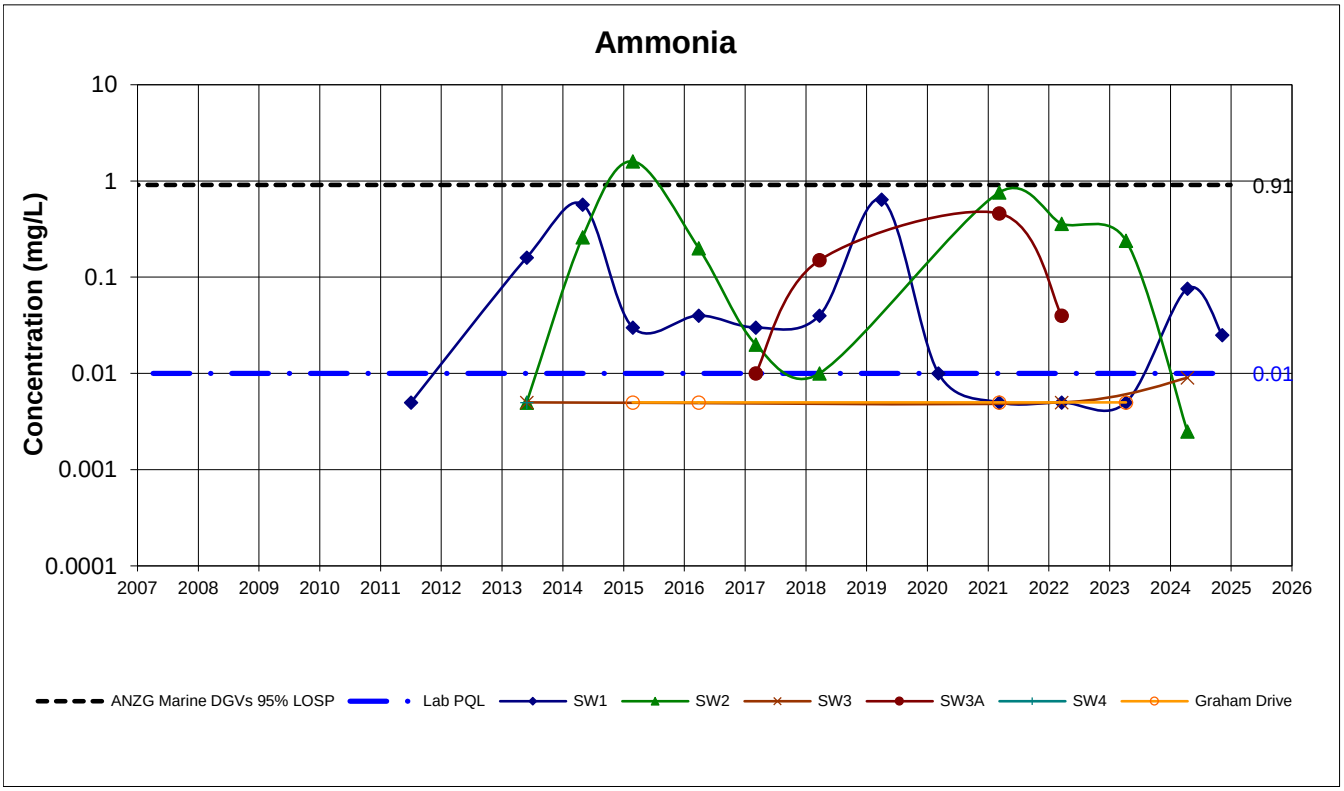

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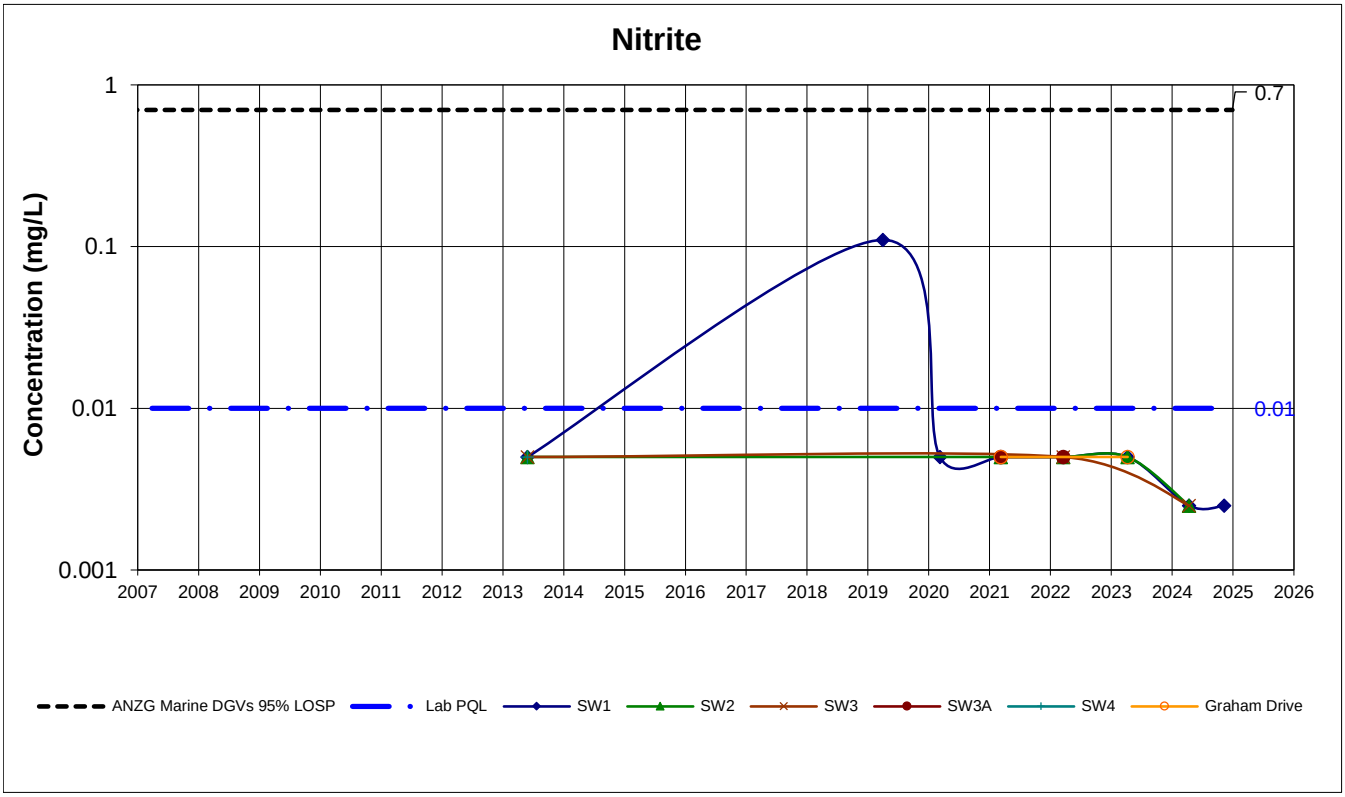

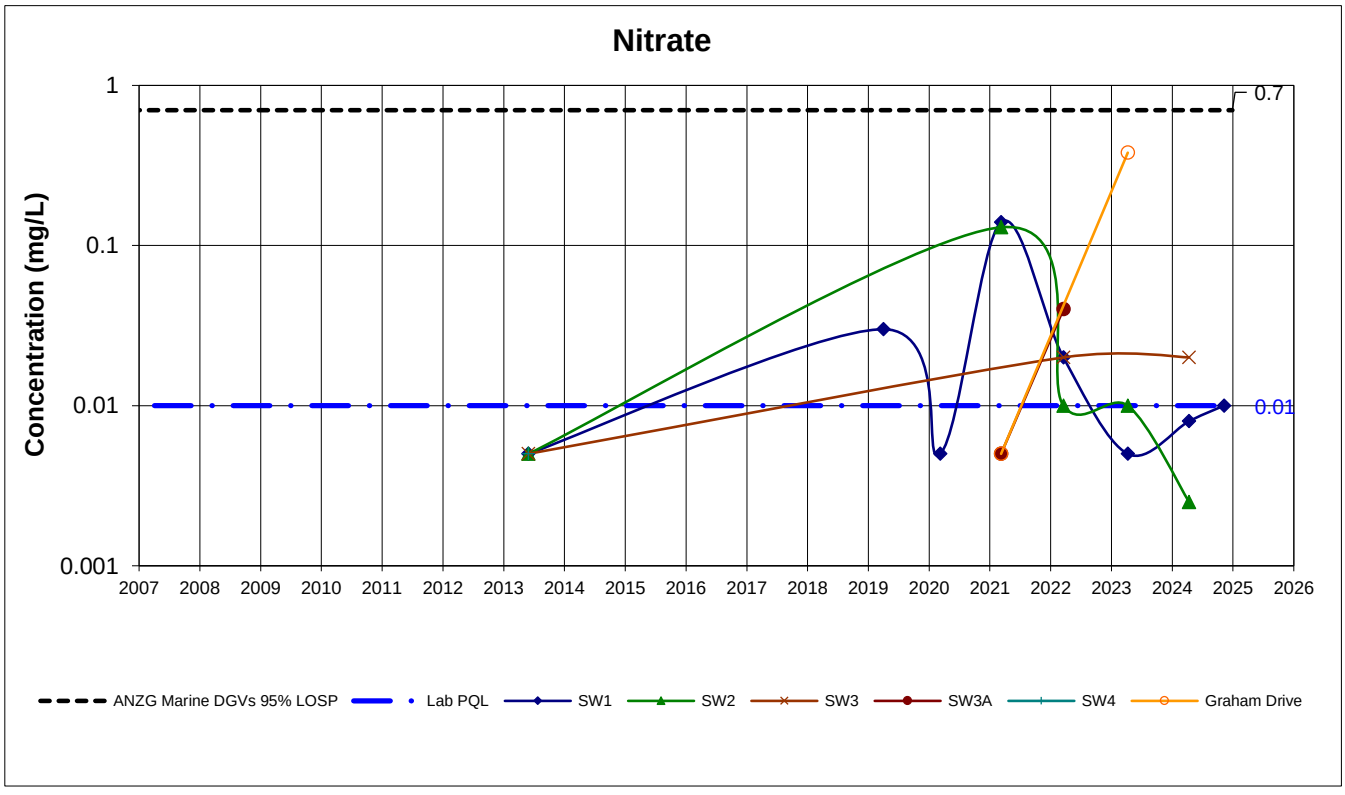

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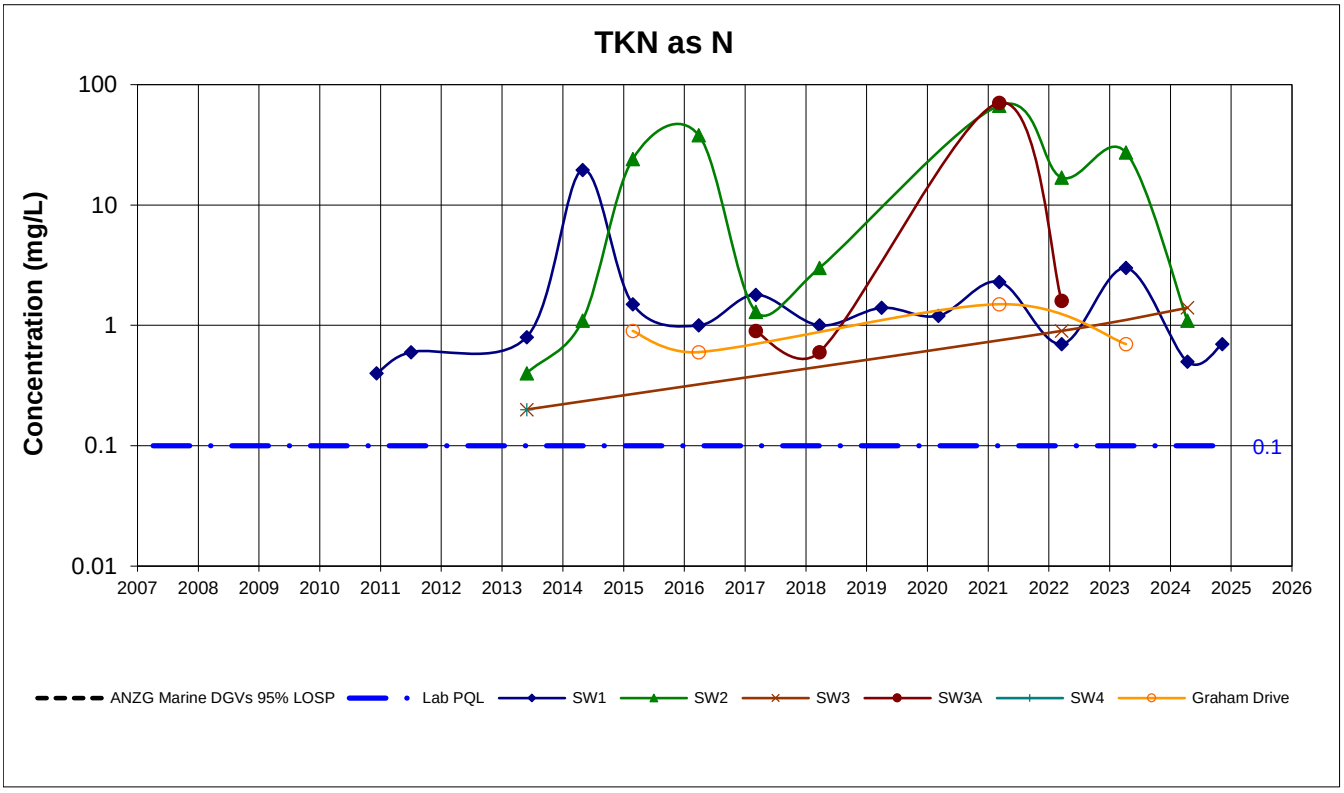

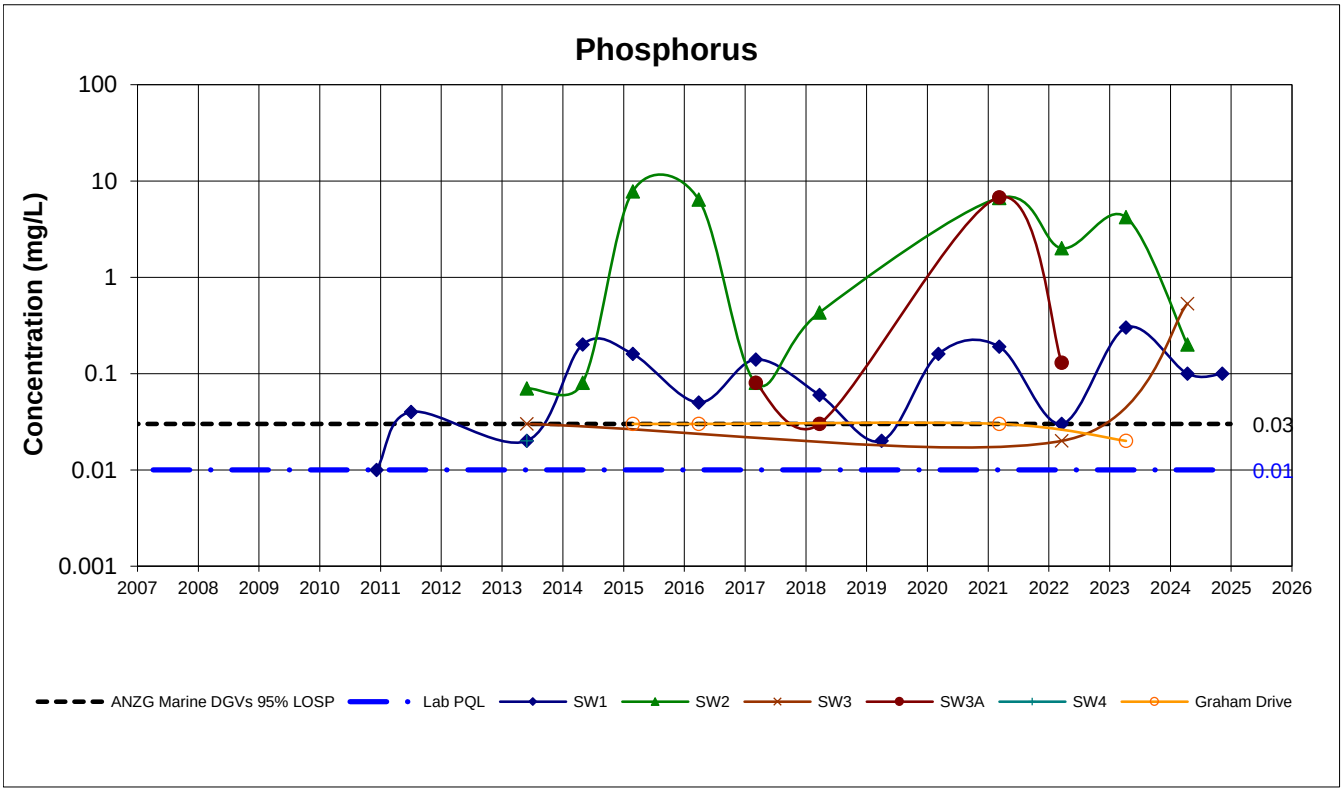

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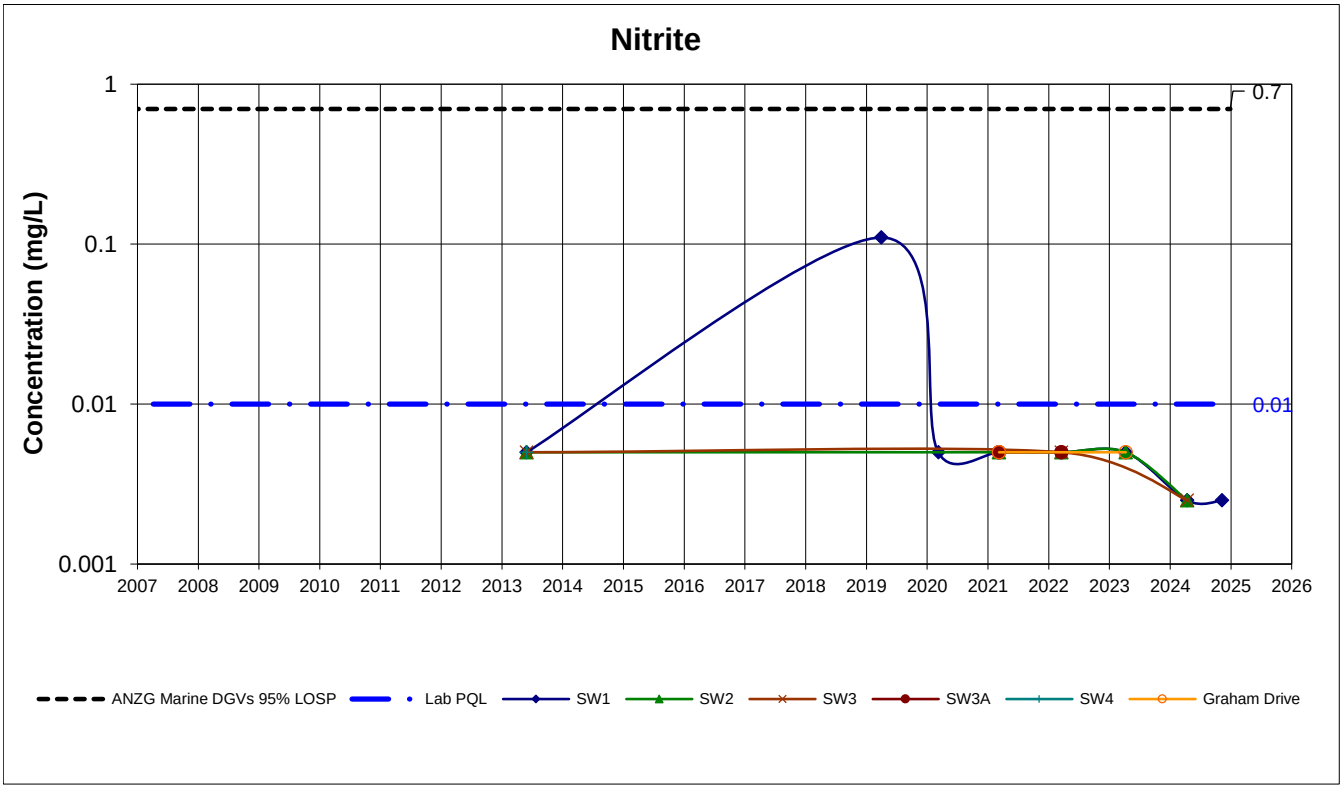

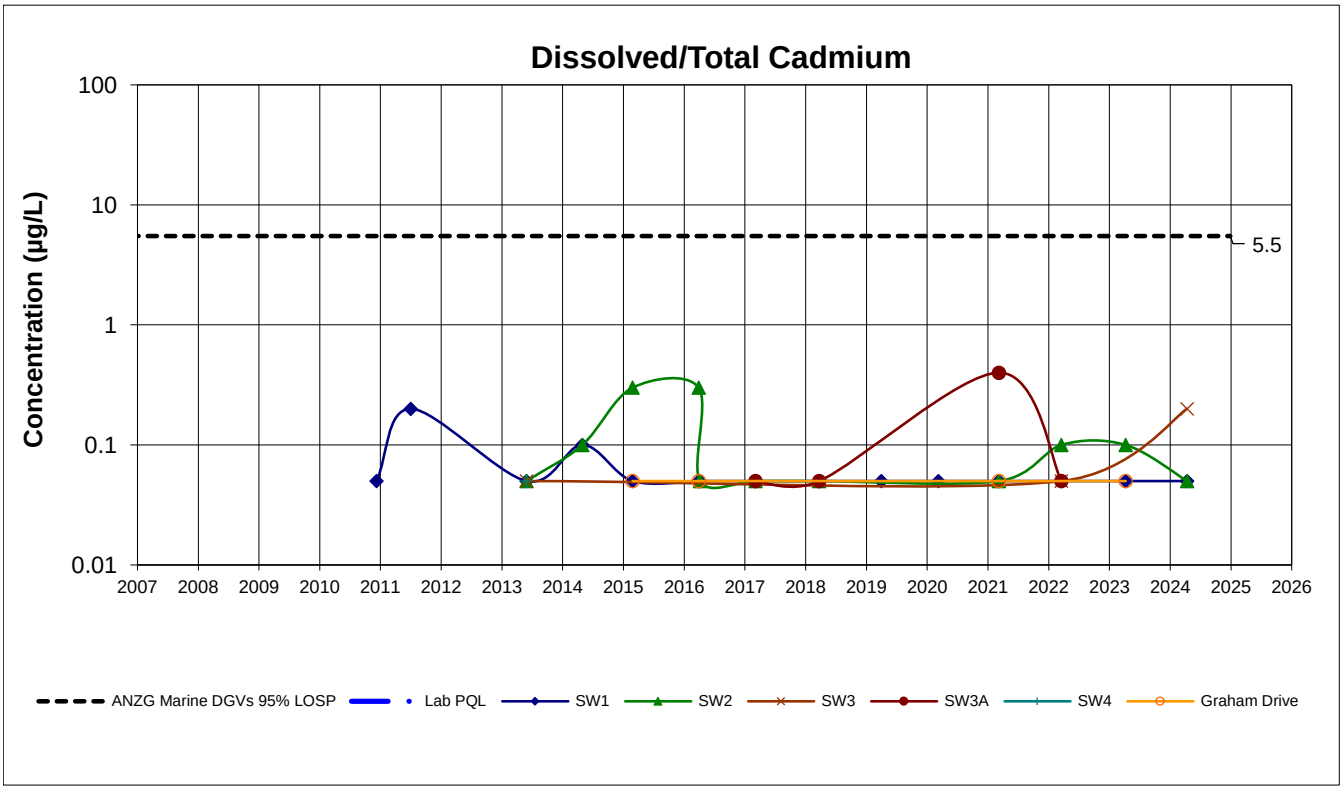

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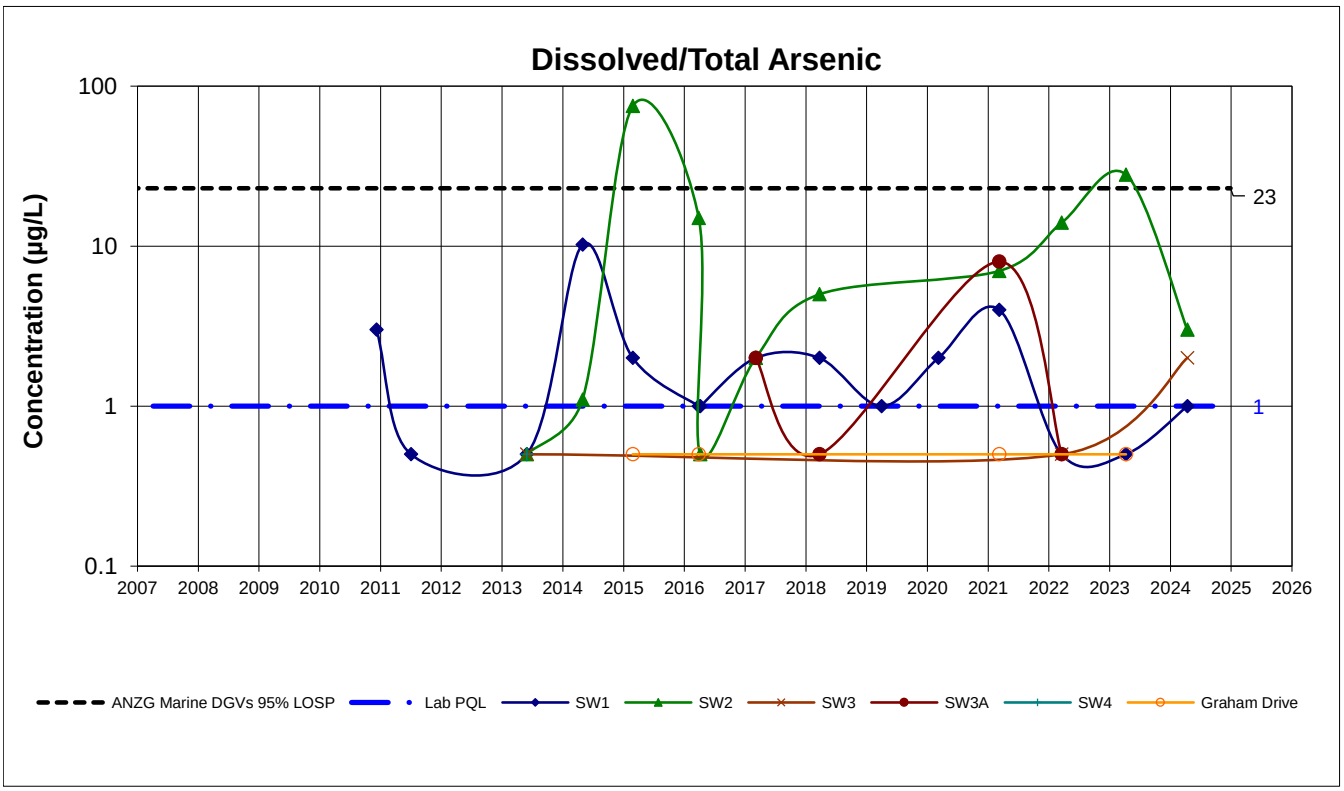

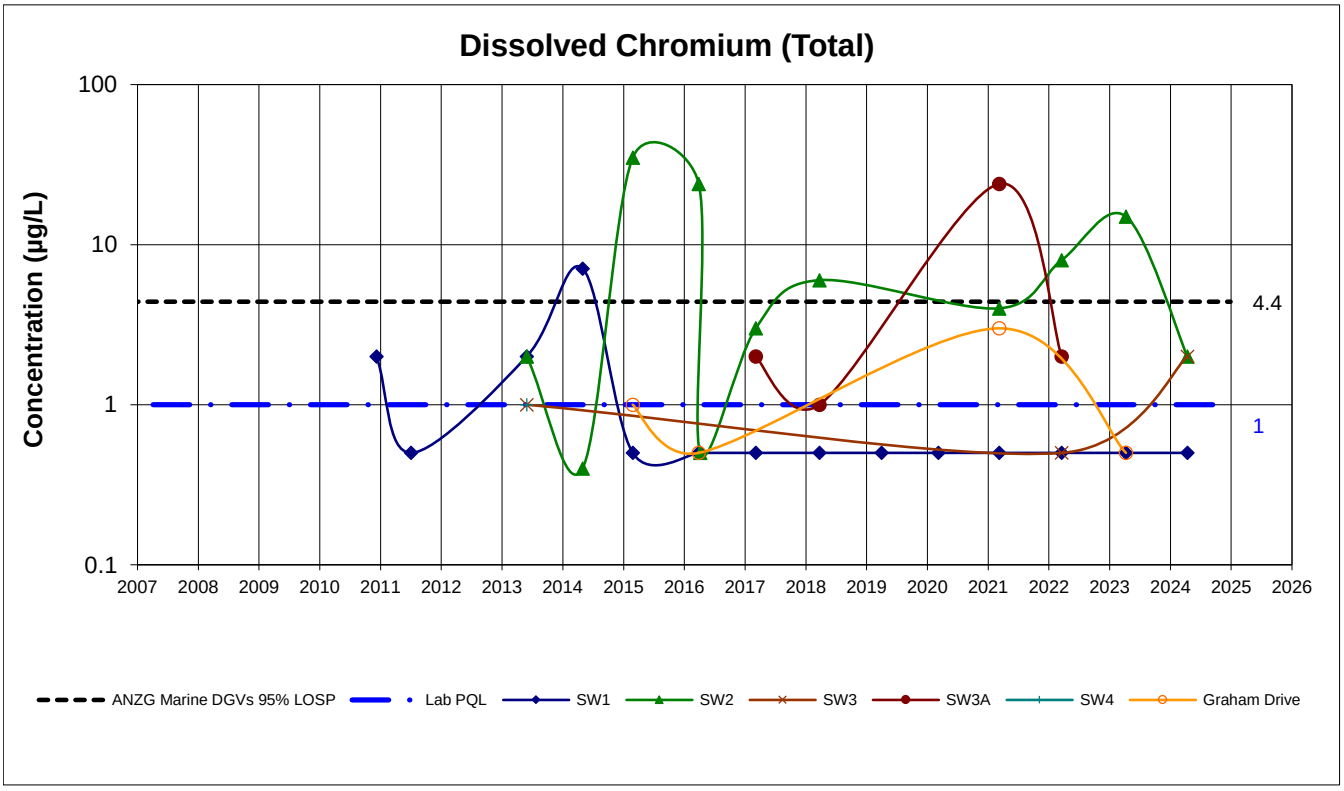

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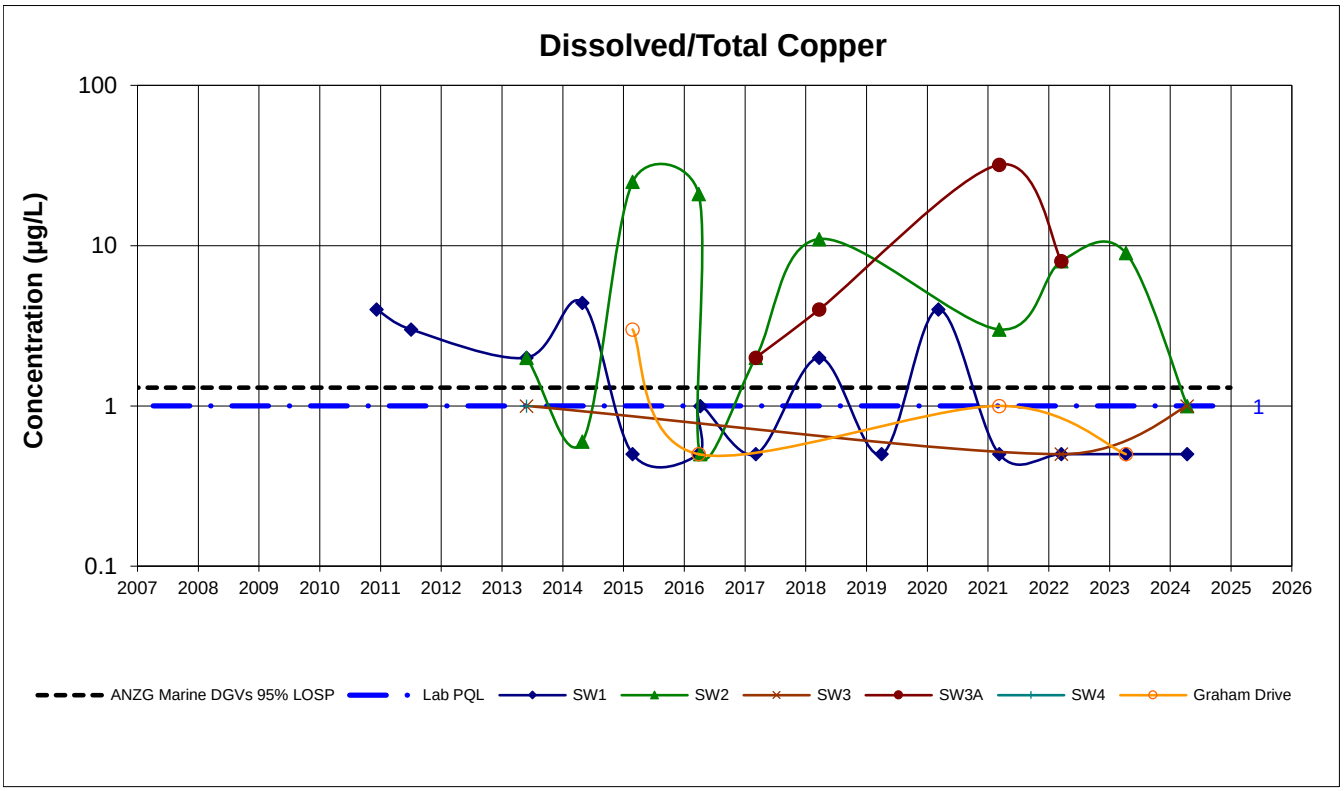

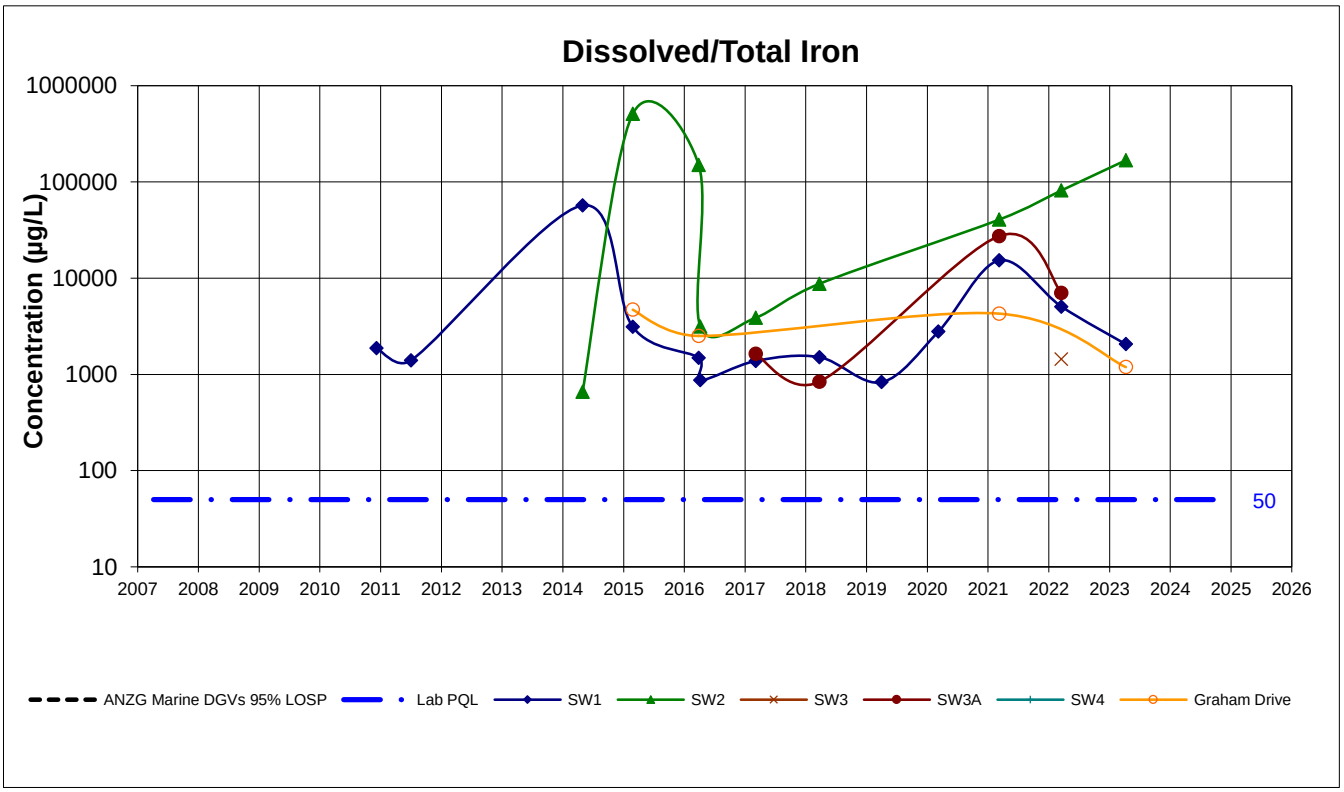

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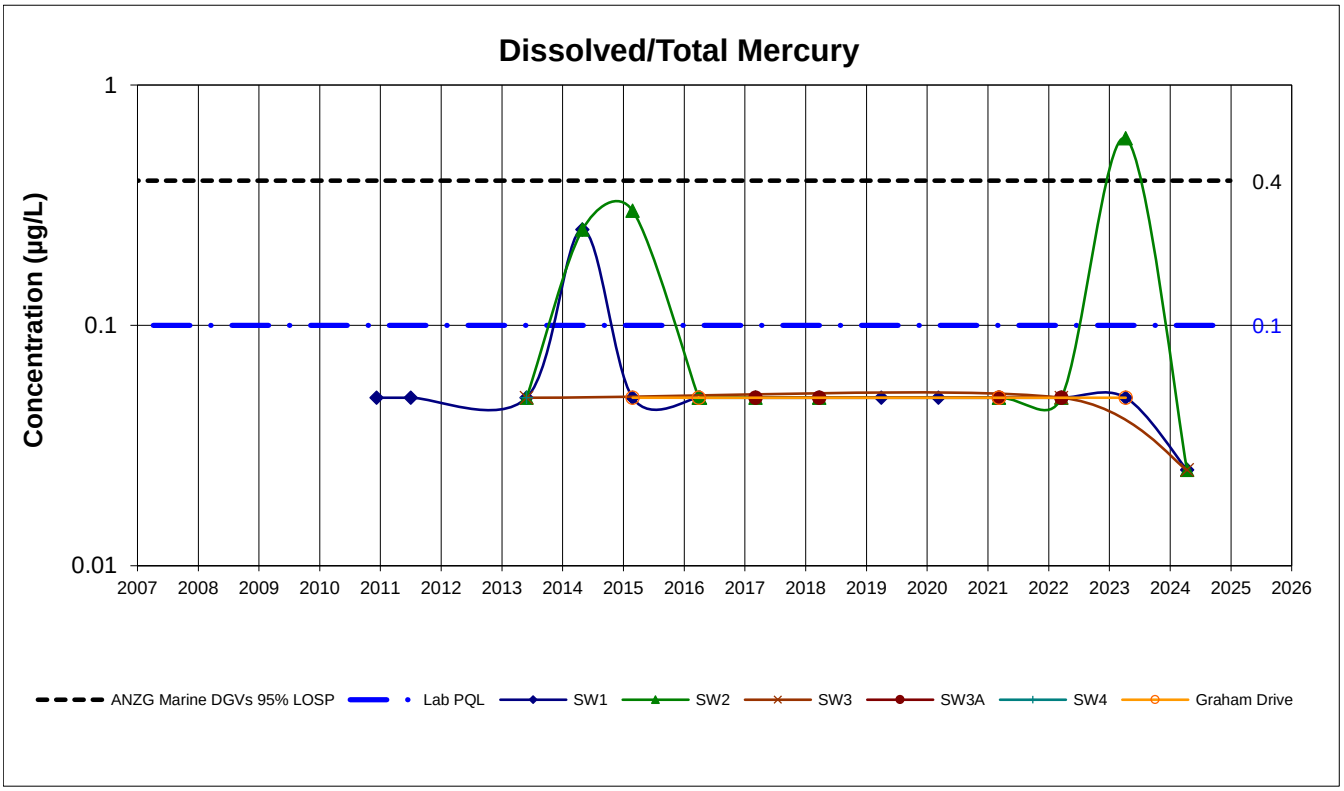

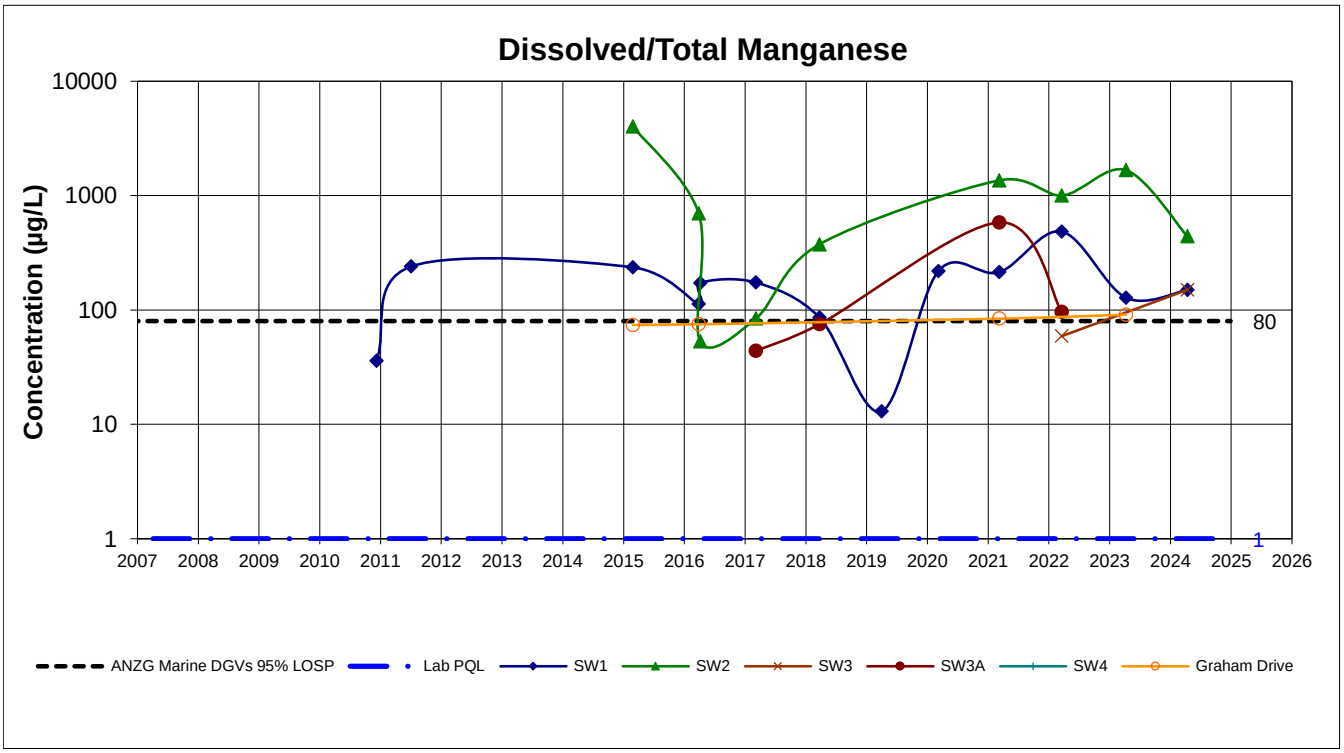

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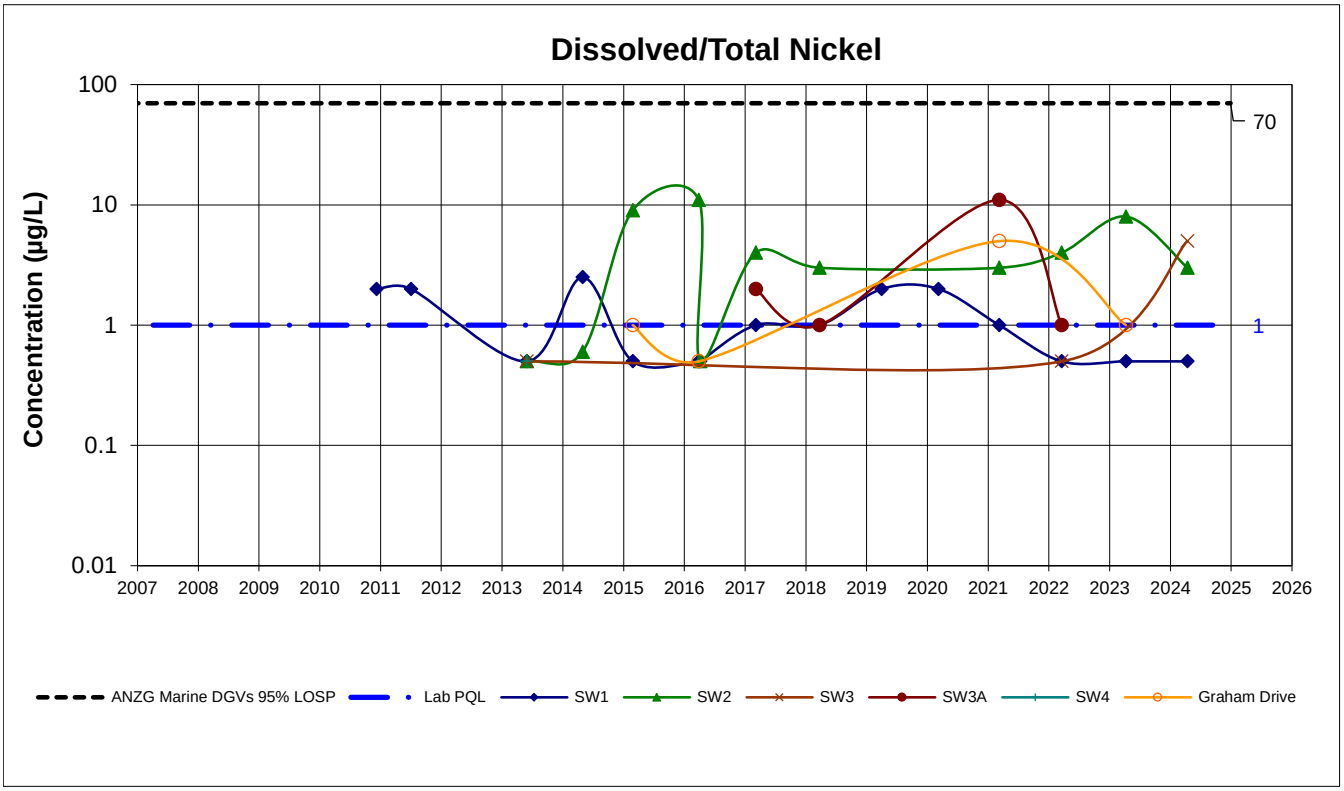

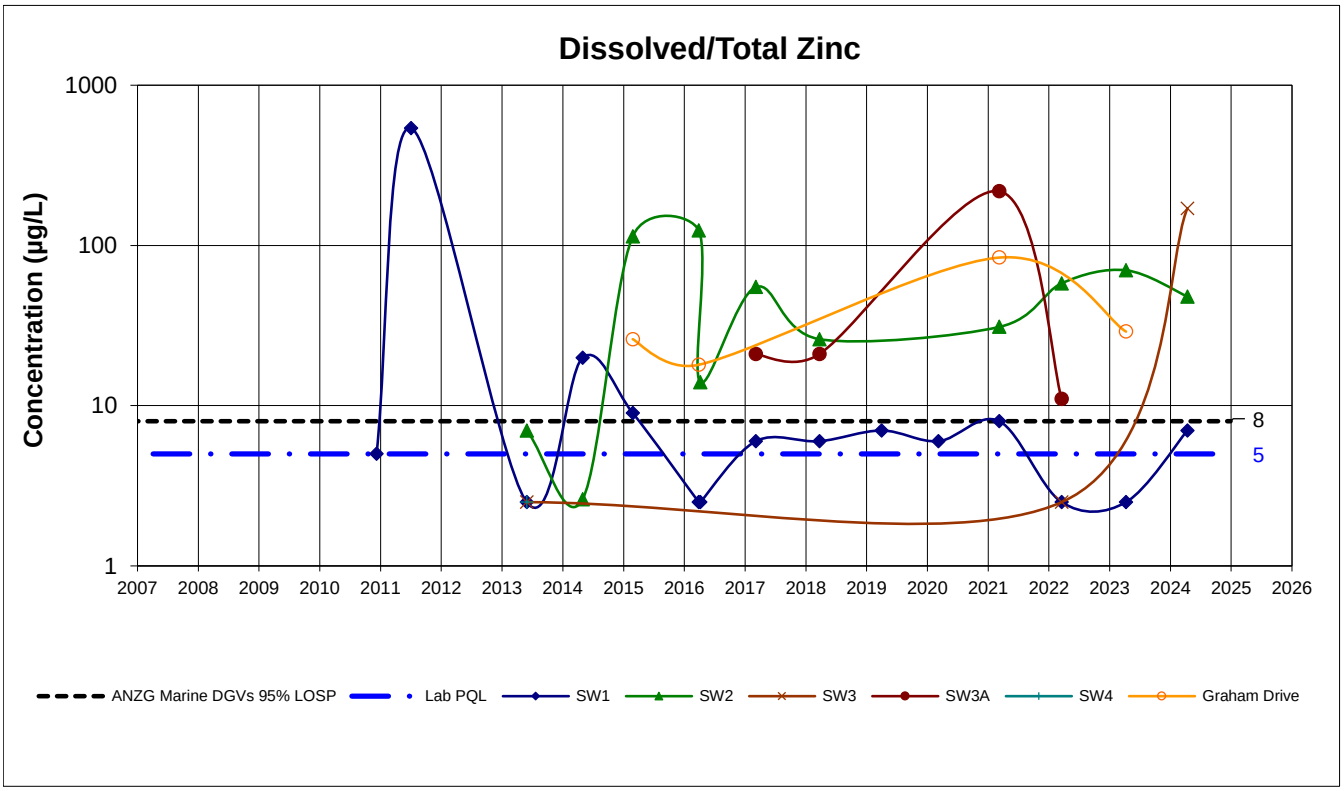

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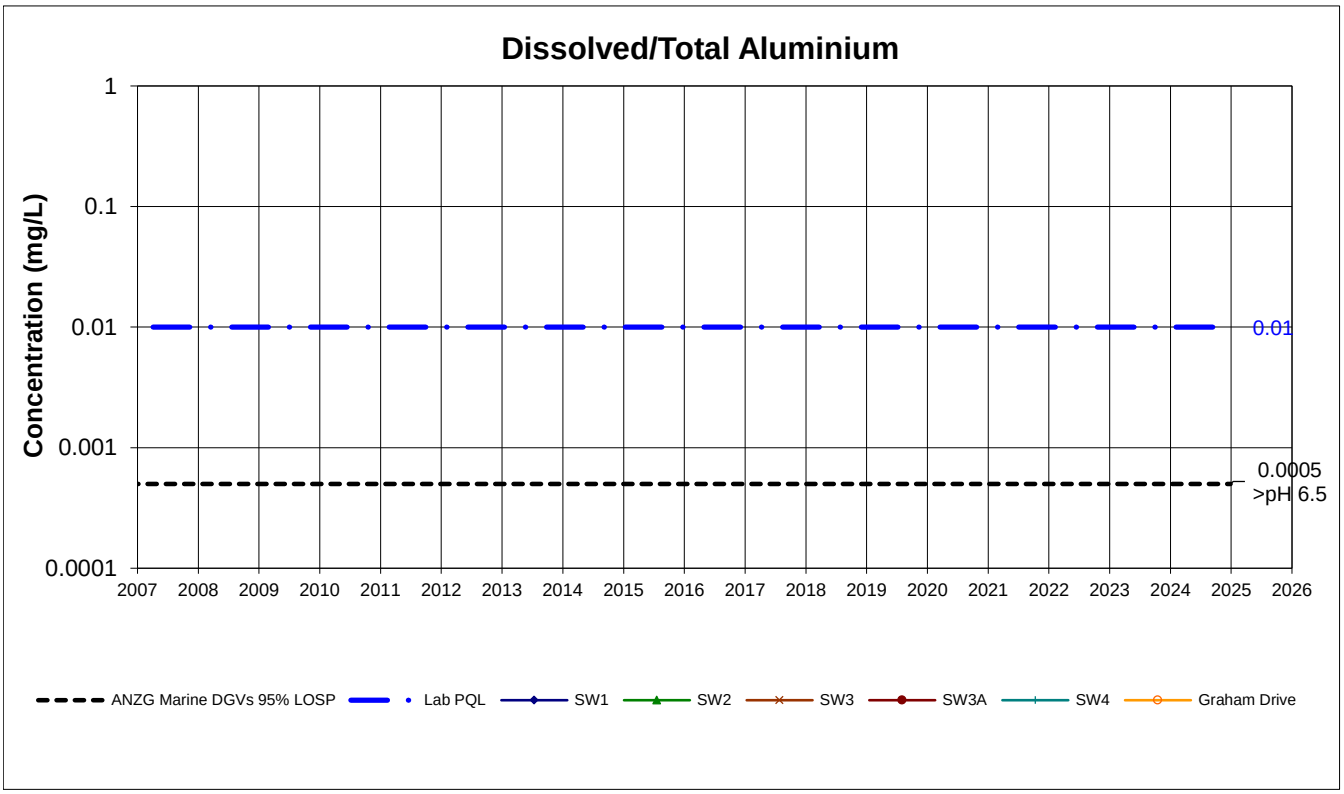

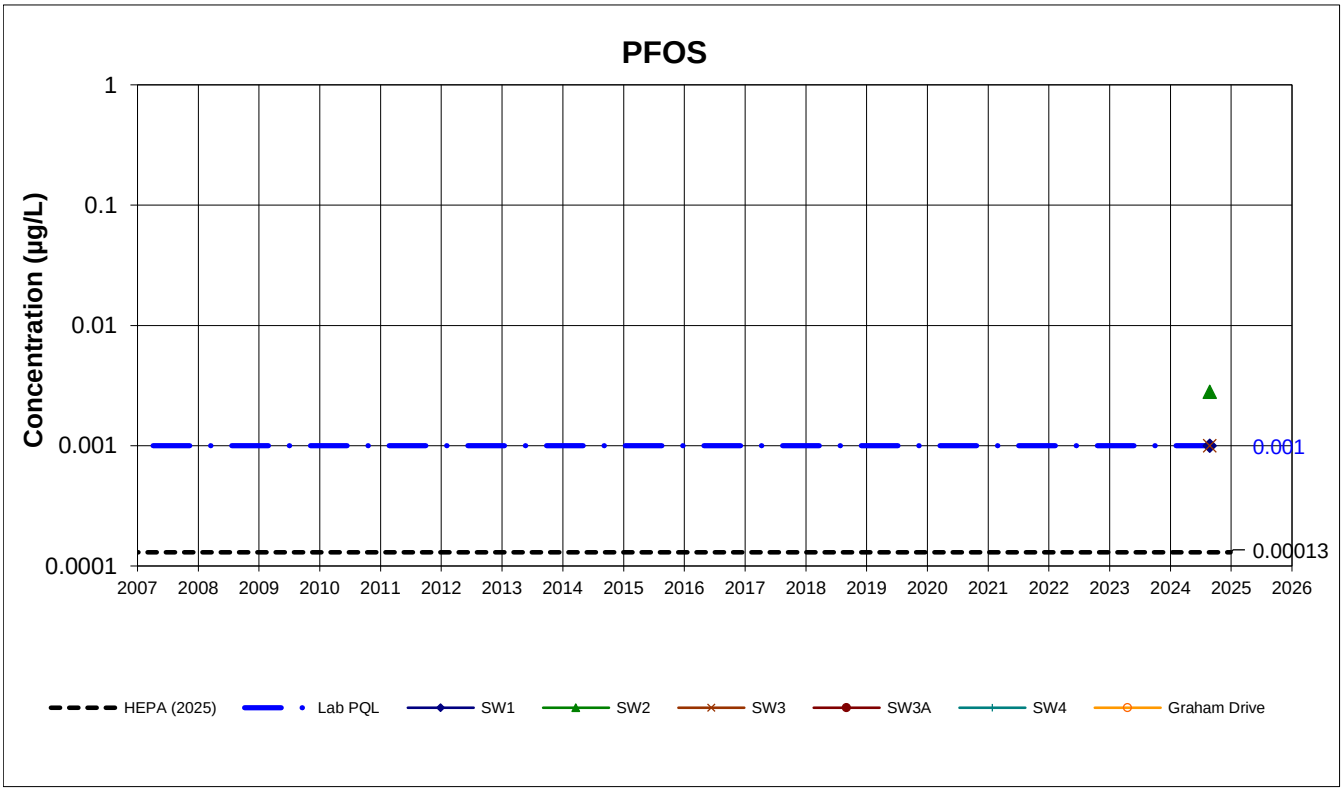

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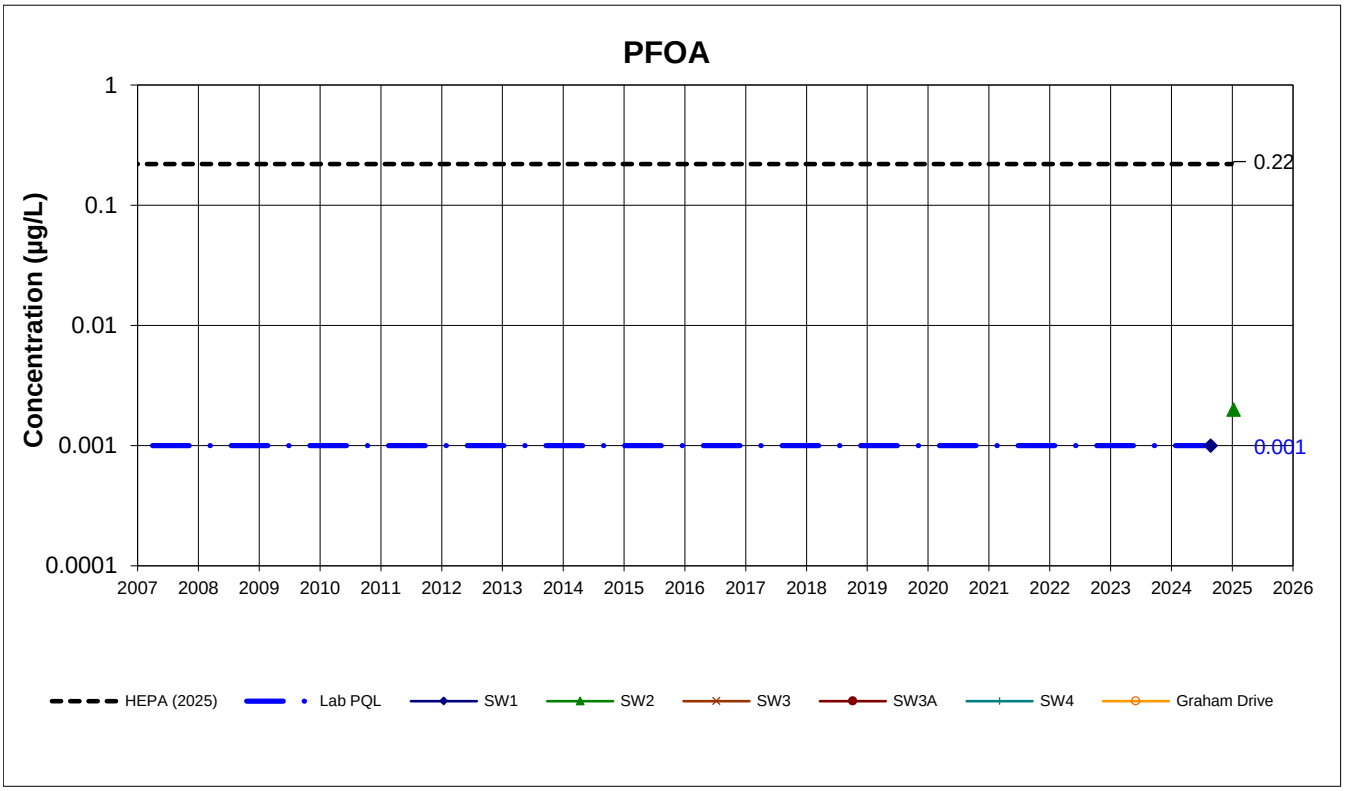

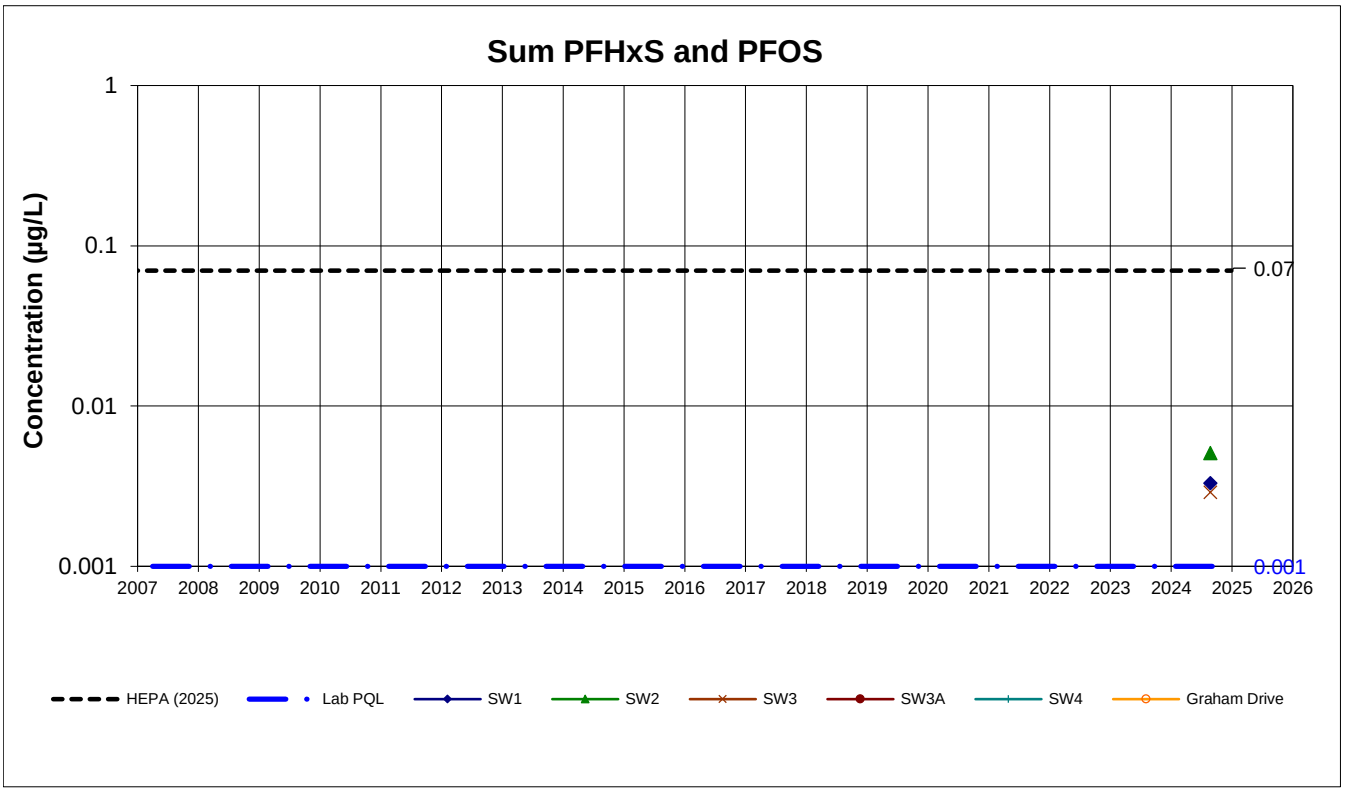

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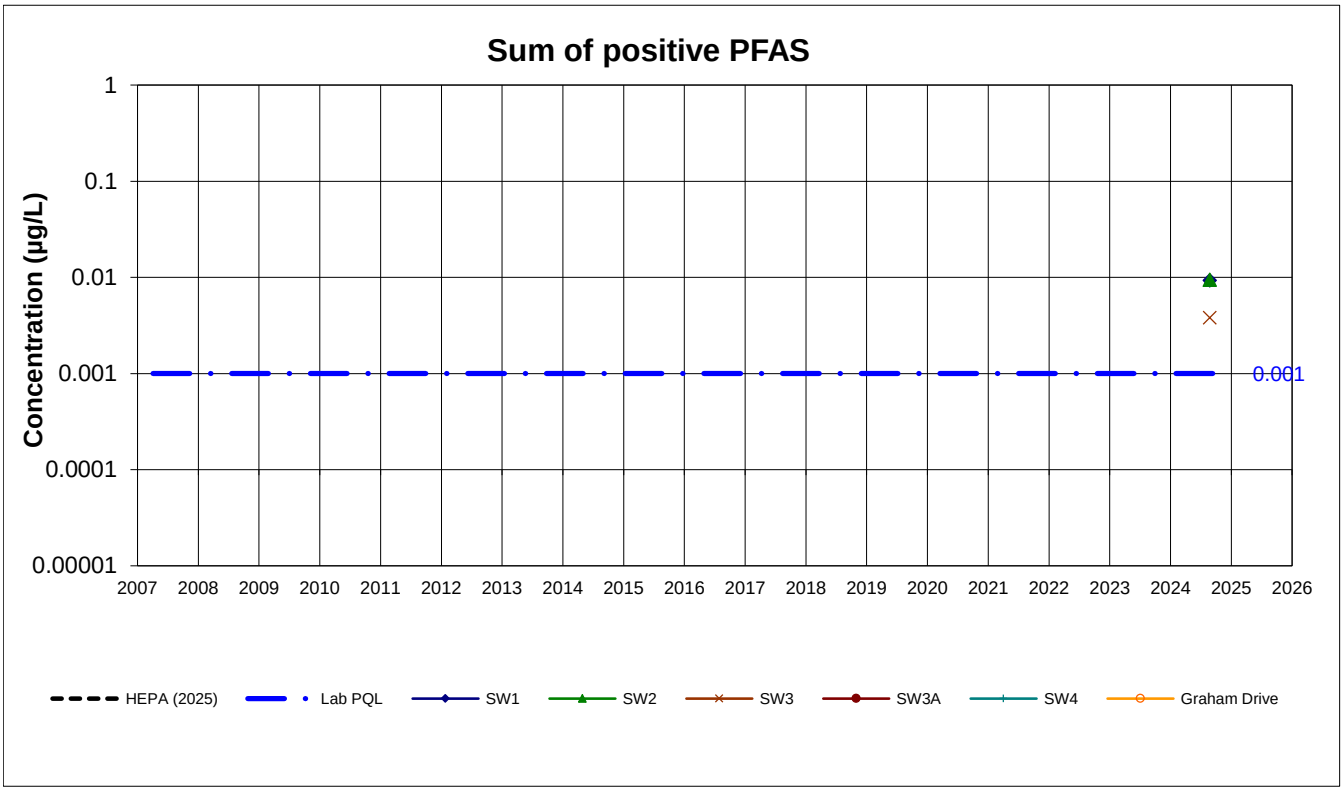

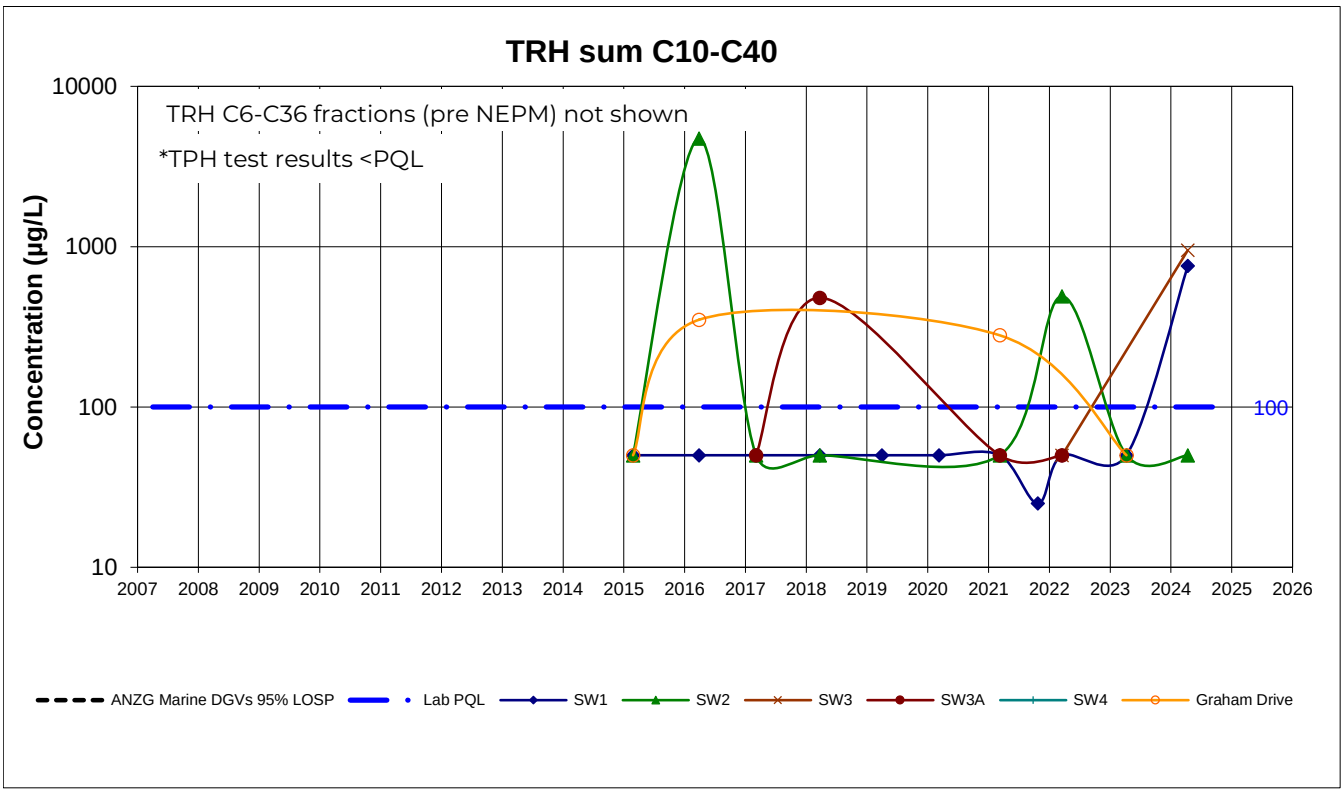

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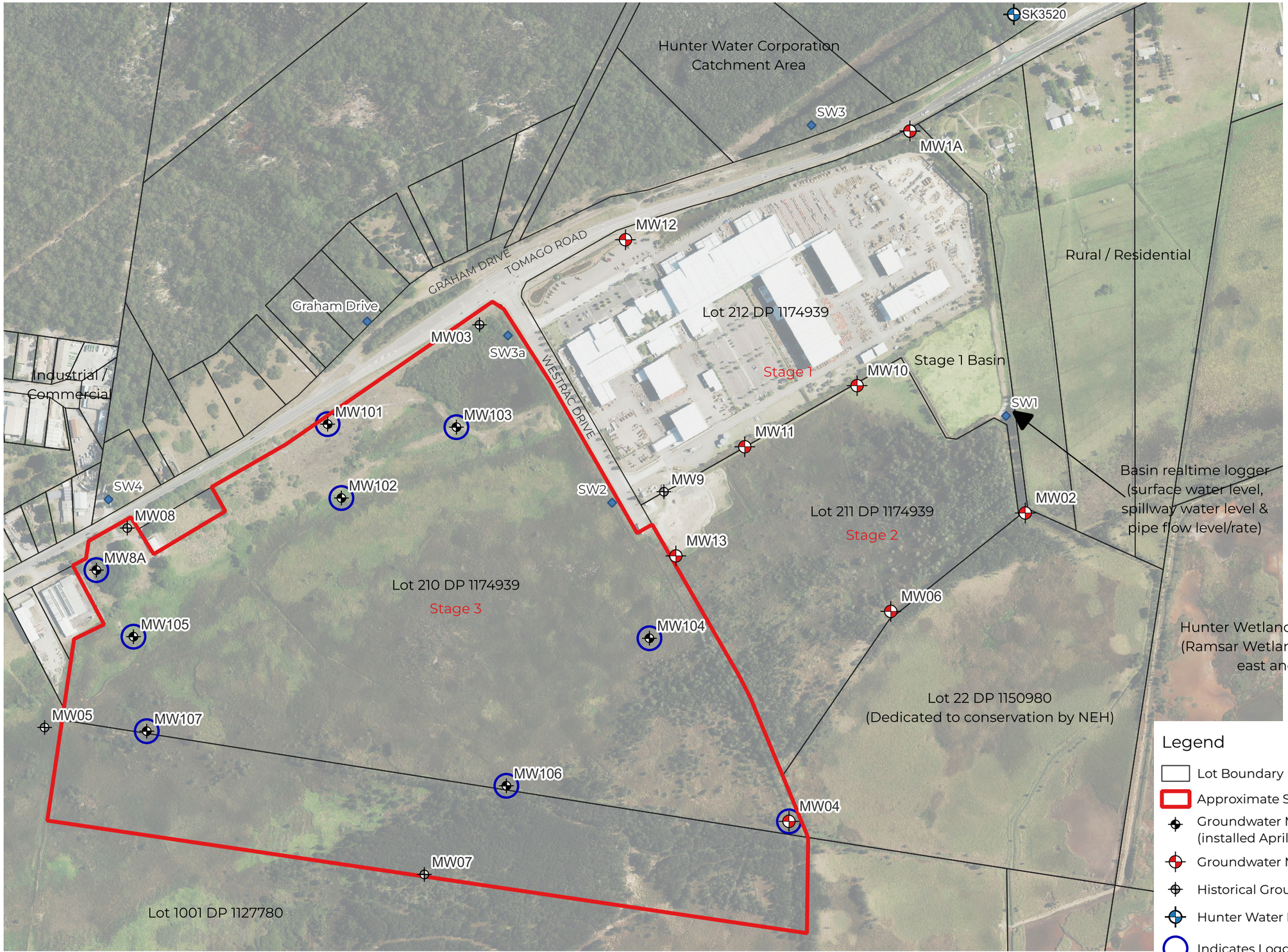
Appendix D

Drawing 1 – Monitoring Well Location Plan (Revision 3)

WRM – Figure 4.1: Proposed Development Site Layout, Bulk Earthworks Plan, Developed Catchments and Drainage Configuration



Site Location

Legend

- Lot Boundary
- Approximate Site Boundary
- Groundwater Monitoring Well (installed April/May 2023 and April 2024)
- Groundwater Monitoring Wells (2010 - existing)
- Historical Groundwater MonitoringWell (unserviceable)
- Hunter Water Monitoring Bore
- Indicates Logger Installed (Stage 3 Plan)
- Surface Water Monitoring Location (Stage 1-2 Plan)

0 100 200 m

Drawing adapted from Metromap Image dated 12.02.2023.
Test locations are approximate only. MW8A and MW100 series wells located using differential GPS.
MW1A & MW12 - Groundwater monitoring well (installed August 2024).

Douglas PARTNERS

CLIENT: Northbank Enterprise Hub Pty Ltd		TITLE: Groundwater Well Monitoring Location Plan Stage 3, Northbank Enterprise Hub Westrac Drive, Tomago
OFFICE: Newcastle	DRAWN BY: PLH	
SCALE: 1:6000 @ A3	DATE: 22.04.2025	

PROJECT No:	39920.09
DRAWING No:	1
REVISION:	4

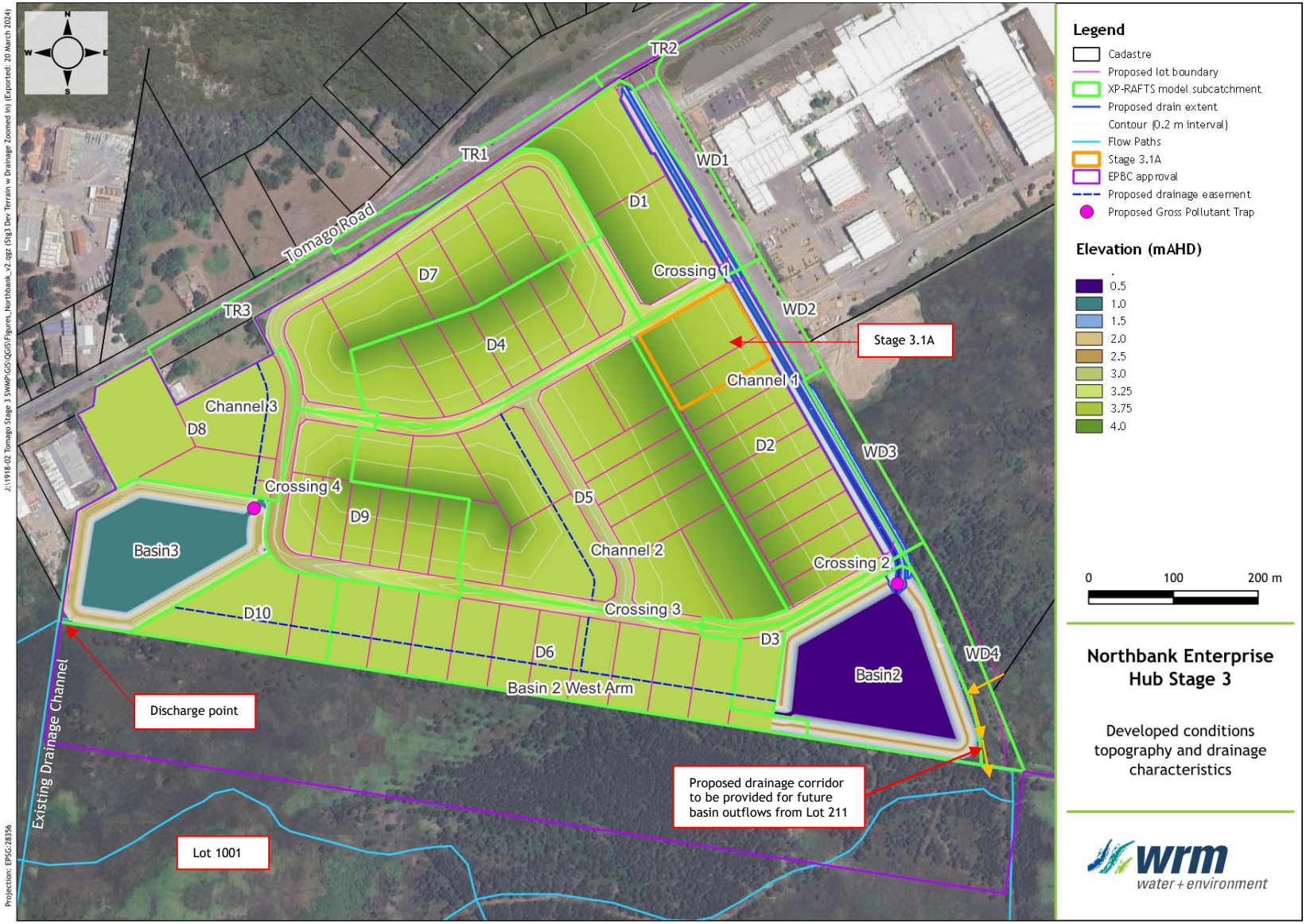


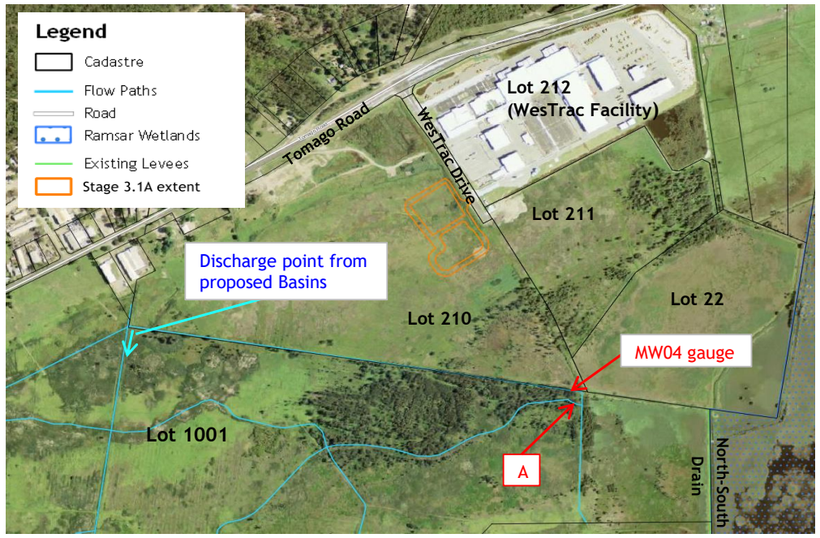
Figure 4.1 – Proposed development site layout, bulk earthworks plan, developed catchments and drainage configuration

Appendix E

Trigger Action Response Plan

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Locality and drainage map



Estate Layout Plan

Photo of Location "A"

Purpose of this TARP (TARP #1)

TARP #1 describes the adopted triggers, proposed actions and responses to identify and mitigate the potential impacts of the Project due to changes in groundwater quality and quantity downstream of the Project (i.e. the potential impact to the environmental receptors).

Commitments and monitoring

1) The following will be undertaken prior to the commencement of Stage 3 works:
- Existing drains will be cleared as per the drain clearing plan (refer to Figure 1 on Page 4).
- Assessment of water level data at MW04 and the downstream data provided by NPWS to establish baseline water level trends.
- Monitoring of observation areas to establish baseline site conditions (refer to Figure 2 on Page 5 for potential observation areas).
- Installation of live water level monitoring device at MW04 (telemetry).

2) The following will be undertaken during the first 3 months from the commencement of Stage 3 works:
- Continued monitoring and assessment of water level data at MW04 to establish baseline water level trends.
- Continued site observations on the ground and/or by drone.
- Continued observations of the cleared drains for integrity and function.

3) The following will be assessed and reported to NPWS every 6 months from the commencement of Stage 3 works:
- Observation area monitoring results.
- Water level monitoring results at MW04.
- Observations on the integrity and function of the cleared drains.

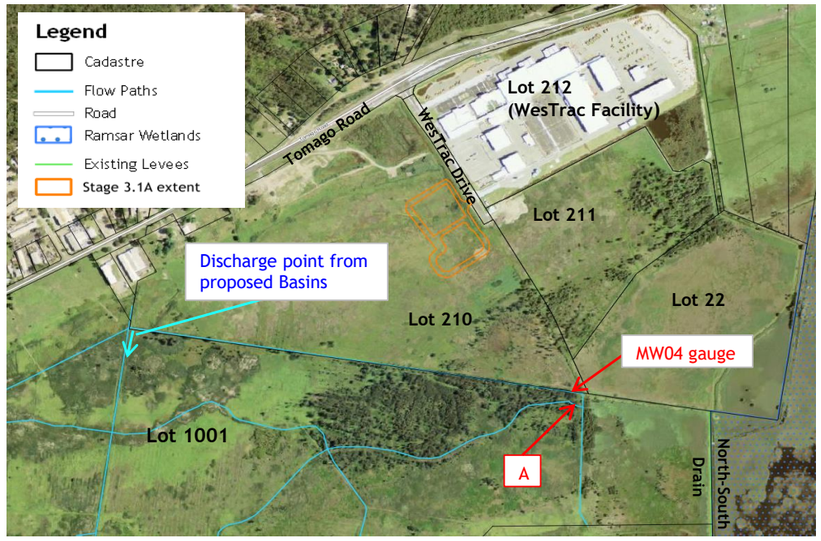
TARP

Level	Trigger (see note [a])	Action	Response
Level 1 (Normal)	• Trend in peak water levels at MW04 and Lot 1001 well are not adversely increased compared to the baseline.	• Continue to monitor water level at MW04, Lot 1001 well and NPWS Floodgate.	• No further response required.
Level 2 (Mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS Drains • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate.	• Response 1 - Undertake capping of the existing culvert at the southeastern corner of Lot 210 (refer to Figure 2 on Page 2).
Level 3 (Additional mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline. • Level 3 trigger applies if: o Culvert at the southeastern corner of Lot 210 has been capped in response to Level 2 trigger.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS Drains • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate.	• Response 2 - Grade fill layer for runoff control across Lot 210 to south and southwest corner of Lot 210 for overflow onto Lot 1001 DP1127780, including berms for control of runoff from any interim basins within Lot 210 (refer to Figure 3 on Page 2).
Level 4 (Additional mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline. • Level 4 trigger applies if: o Culvert at the southeastern corner of Lot 210 has been capped in response to Level 2 trigger; and o Existing graded fill layer across Lot 210 to the southwest corner of Lot 210 has been remediated in response to Level 3 trigger.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS Drains • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate.	• Response 3 - Undertake additional drain muck out of the existing drain within the drainage easement further south within Lot 1001 for extended length of the existing deeply incised drains within Lot 1001. Refer to Figure 4 on Page 2).
Level 5 (Additional mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline; or • Trend in peak water level at Lot 1001 monitoring well increases above bank • Level 5 trigger applies if: o Culvert at the southeastern corner of Lot 210 has been capped in response to Level 2 trigger; o Graded fill layer across Lot 210 in response to Level 3 trigger; and o Additional drain clearing on Lot 1001 in response to Level 4 trigger. o Muck out of the existing drain within Lot 1001.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS Drains • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate. • Review the observation area monitoring results and assess any correlations with the recorded water level data at MW04.	• Response 4 - Consider increased basin storage of Basin 3 within Lot 210. (refer to Figure 5 on Page 2) • Initiate an investigation on the reasons for increased water levels at MW04 and develop additional mitigation measures of further catchment diversions to the Hunter River.

[a] - The criteria for what would be considered an "adverse increase" in peak water level trends will be confirmed based on analysis of recorded water level data to date. This criteria will be reviewed on a quarterly basis and updated if required as additional monitoring data becomes available.

Worksheet title: Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Locality and drainage map



Estate Layout Plan

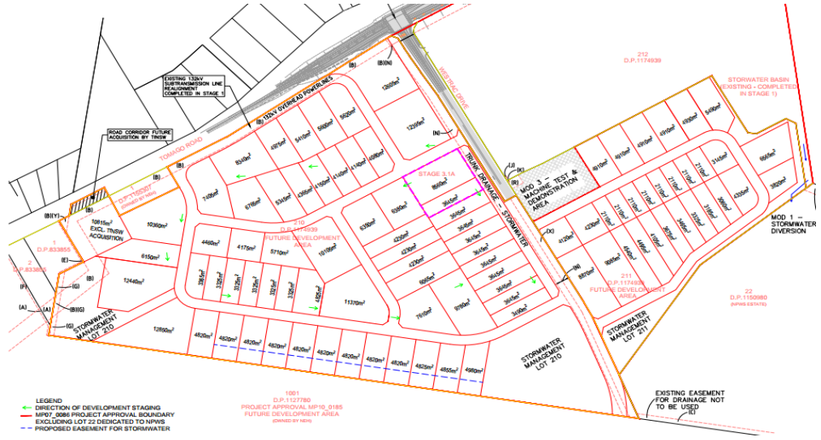


Photo of Location "A"

Purpose of this TARP (TARP #2)

TARP #2 describes the adopted triggers, proposed actions and responses to identify and mitigate the potential impacts of the Project on the drinking water supply (Hunter Water Corporation) due to changes in groundwater quantity in the Tomago Sandbeds.

Commitments and monitoring

1) The following will be undertaken prior to the commencement of Stage 3 works:
   - Installation of live water level monitoring device at MW101 and SK3520 (refer to Figure 5 on Page 8 for monitoring locations).
   - Assessment of baseline conditions at MW101 screened in the Tomago Sandbeds and located near the upstream boundary of the site.
   - Collection and review of monitoring data collected at the HWC bore (SK3520) screened in the Tomago Sandbeds and located about 1 km northeast of the project to assess baseline conditions at this location.

2) The following will be undertaken during the first 3 months from the commencement of Stage 3 works:
   - Continued monitoring and assessment of water level data at MW101 and SK3520 to establish baseline water level trends.

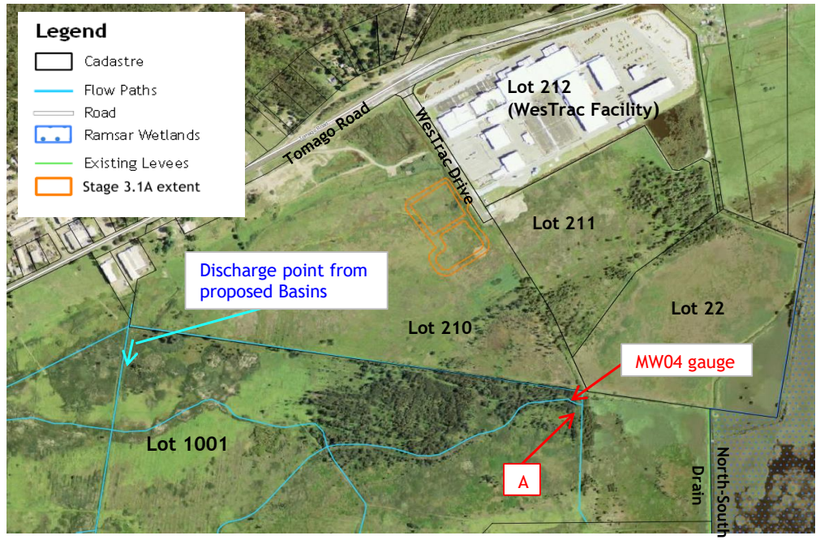
3) The following will be assessed and reported to NPWS every 6 months from the commencement of Stage 3 works:
   - Review of water level monitoring results at both MW101 and SK3520.

MW101 and SK3520 are both screened in the Tomago Sandbeds. The purpose of monitoring both MW101 located within the site and SK3520 located outside of the site is to assess whether any observed trends are attributable to the project or to regional stressors.

TARP

Level	Trigger	Action	Response
Level 1	• Groundwater levels at MW101 are within the baseline range; and • any noticeable trends are attributed to external stressors (e.g. climate, pumping).	• Continue to monitor as planned.	• No response required.
Level 2	• Groundwater levels at MW101 are outside baseline range; and • trends can be noticed that are not obviously attributable to external stressors.	• Review recorded data at SK3520 to check if trend is general. If so, trend would be considered not attributable to the project.	• Response 1 - investigate possible causes for the change.
Level 3	• Groundwater levels at MW101 are outside baseline range; • trends can be noticed that are not attributable to external stressors; • similar change is not observed at SK3520.	• If increase in water level (mounding): review drainage requirements in northern part of the site. • If decrease in water level (drawdown): review groundwater inflows in excavations.	• Response 2 (if mounding): installation of a drain at the northern boundary of the project to divert any runoff to Lot 210 (stormwater management basin area). • Response 2 (if drawdown): control and reduce inflows in excavation areas, discharge clean surplus water to the northern part of the site (on the sand beds) for infiltration and recharge.
Level 4	• Same as above; and • Response 2 was implemented but trends are still observed.	• Review performance of measures implemented as part of Response 2. • If increase in water level (mounding): review drainage system in northern part of the site. • If decrease in water level (drawdown): review groundwater inflows in excavations.	• Response 3 (if mounding): additional drain to divert water to Lot 210 (stormwater management basin area). • Response 3 (if drawdown): increased control to reduce inflows in excavation areas, discharge clean surplus water to the northern part of the site (on the sand beds) for infiltration and recharge.
Level 5	• Same as above; and • Response 3 was implemented but trends are still observed.	• Review performance of measures implemented as part of Response 3. • If increase in water level (mounding): review drainage system in northern part of the site • If decrease in water level (drawdown): review groundwater inflows in excavations.	• Response 4 - Stop work, initiate detailed investigations to understand the cause(s) of the changes in water levels, develop additional mitigation measures.

Locality and drainage map



Estate Layout Plan

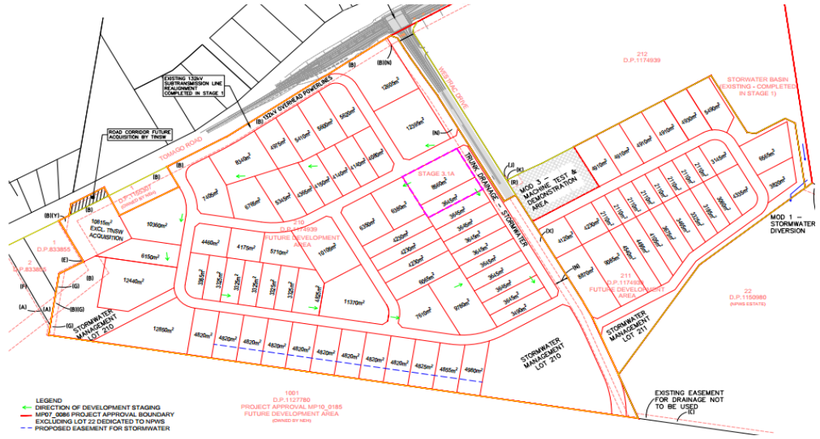


Photo of Location "A"

Purpose of this TARP (TARP #3)

TARP #3 describes the adopted triggers, proposed actions and responses to identify and mitigate the potential impacts of contamination/changes in groundwater and/or surface water quality as a result of the Project.

Commitments and monitoring

Monitoring of water quality will be implemented as outlined in the groundwater and surface water management plans.

TARP

Level	Trigger	Action	Response
Level 1	• Groundwater quality is within baseline range; and • any noticeable trends are attributed to external stressors (e.g. climate, pumping).	• Continue to monitor as planned.	• No response required.
Level 2	• Single exceedance for any one analyte and bore; or • Any noticeable trends / changes in water quality.	• Review water quality data for all analytes. • Organise additional monitoring rounds to confirm the exceedances / change in water quality	• Response 1 - keep monitoring water quality and assessing trends.
Level 3	• Three consecutive results exceeding trigger levels for any one bore and analyte.	• Advise and seek advice from DPE Water. • Review water quality data for all analytes. • Organise additional monitoring rounds to confirm the exceedances / change in water quality.	• Response 2 - investigate possible causes for the change.
Level 4	• Exceedances continue and cannot be attributed to external factors.	• Collect water quality data outside of the project area (e.g. at monitoring locations at other projects). • Compare site-specific data to those collected from surrounding areas. • If change in water quality appears to be caused by the project, advise relevant authorities, adjacent water users and conduct detailed investigations to plan for remediation.	• Response 3 (If change in water quality appears to be caused by the project) - Prepare remediation plan based on results of investigations. • Response 3 (if change is regional and not caused by project) - review and update trigger values.
Level 5	• Response 3 (if change is regional and not caused by project) - review and update trigger values; and • More analytes exceed their trigger levels.	• Review performance of measures implemented as part of Response 3.	• Response 4 - Stop work, develop additional remediation measures if consultation with experts.

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Figure 1: Drain clearing plan (for TARP#1 on Page 1)

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

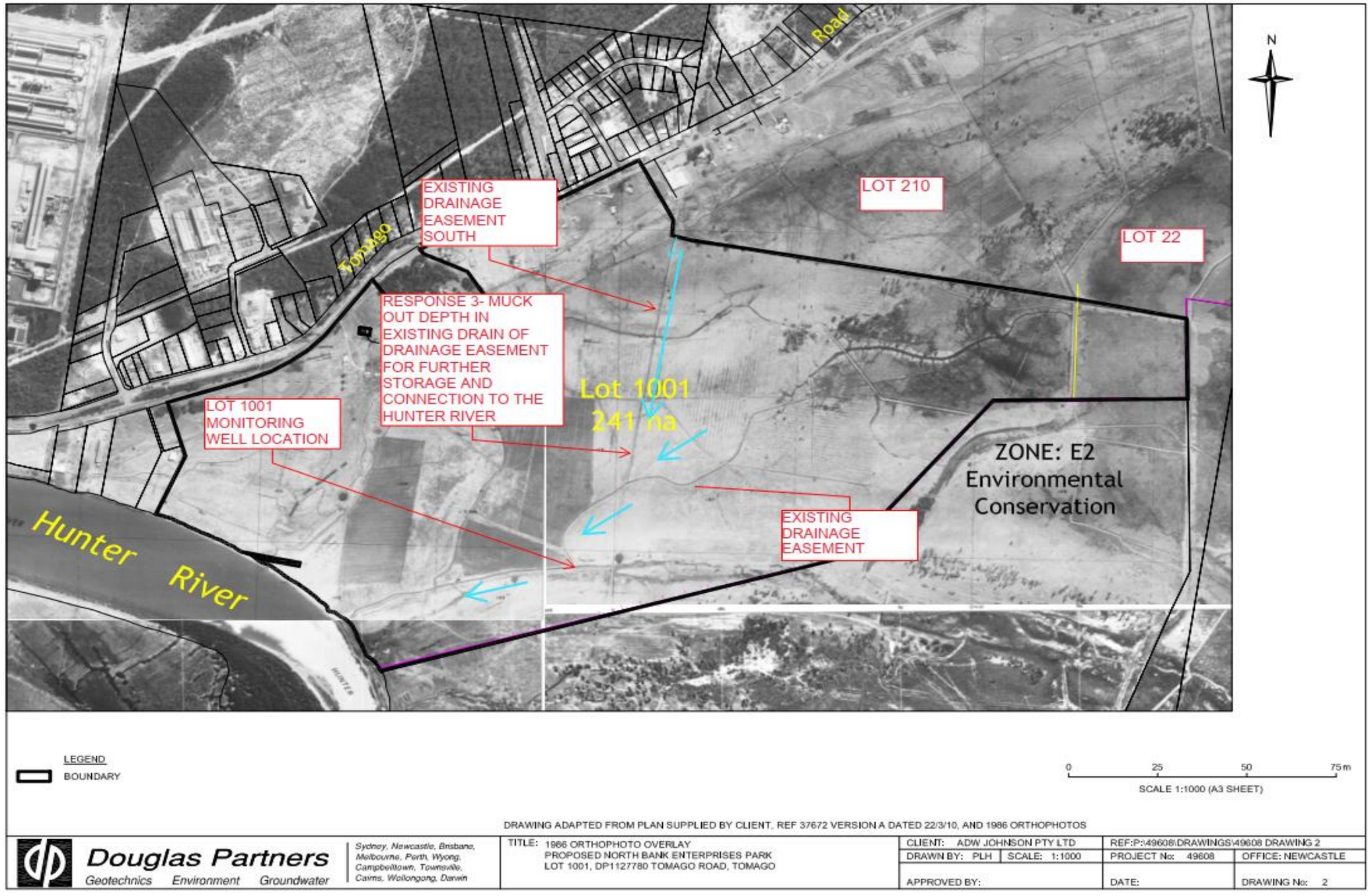
Figure 2: Response 1 (for TARP#1 on Page 1) - Capping of the existing culvert at the southeastern corner of Lot 210

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Figure 3: Response 2 (for TARP#1 on Page 1) - Extent of proposed initial fill layer, graded towards the south and southwestern boundaries of Lot 210

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Figure 4: Response 3 (for TARP#1 on Page 1) - Additional drain clearing along the existing drainage easement at Lot 1001



Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Figure 5: Groundwater monitoring well location plan