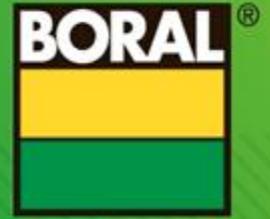


BORAL LAND AND PROPERTY GROUP

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Response to Submissions
Stockton Sand Quarry Dredging Project
Volume 2



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1 Introduction

Boral Resources (NSW) Pty Ltd (Boral) has submitted a State Significant Development, Development Application (SSD9690) proposing the establishment of a dredging operation at Boral's existing quarry site in Fullerton Cove. The Environmental Impact Statement (EIS) was exhibited for public consultation between March and April of 2020.

A total of 24 submissions were received in response to the exhibition, 11 from individuals and community groups and 13 from government agencies. Across all submissions a total of 15 key themes or areas of interest were identified. Of these areas of interest, the most prominent matter related to water with a particular focus on groundwater.

Volume 1 of the Response to Submissions (RtS), submitted in September 2020, provides responses to matters raised in relation to social impact assessment, biodiversity, traffic and transport, amenity (noise and air quality), economics, coastal processes and climate change, general planning matters, and strategic planning and policy matters.

This report forms Volume 2 of the RtS. This volume of the RtS focuses on responding to comments or requests for further information made in relation to groundwater and surface water and should be read in conjunction with volume 1.

1.1 Project overview

In January 2020, Boral lodged a Development Application with the Department of Planning, Industry and Environment (DPIE) for a new quarrying operation located on the inland dunes at Boral's established quarry site, on Coxs Lane Fullerton Cove.

The project seeks to access an approximate 9 million tonne reserve of sand over a period of 25 years for use in the production of construction materials. As Boral currently operates from the windblown sand dunes, located adjacent to Stockton Beach, a site wide transport limit of 750,000 tonnes per annum (tpa) is sought. It is anticipated the extraction on the windblown dunes will cease in 2028, at this time the transport limit will reduce to 500,000 tpa.

The proposed quarrying project will use a mix of dry and wet extraction methods, to progressively extract sand over six key stages. Wet extraction will use a suction dredge to remove sand to a depth of 15 metres below the ground water table (i.e. RL – 15 metres).

To access the sand resource, existing vegetation is required to be removed. The majority of this vegetation is rehabilitation vegetation planted and managed by Boral following the cessation of an earlier quarrying project in the same area in 2008. The removal of rehabilitation vegetation is considered to have reduced impact on biodiversity values as this area has not matured to reflect

the structural complexity of remnant vegetation areas thereby reducing the direct and indirect impacts on biodiversity.

1.2 Public exhibition and submissions

Between 13 March 2020 and 9 April 2020, the development application was publicly exhibited by notice placed in the locally circulating paper and by direct mail out to residents. The application was also referred to government agencies and departments for comment.

A total of 24 submissions were received during the exhibition period. 13 from government agencies and 11 from the public and local/community organisations and interest groups.

1.3 Response to Submissions

Boral's response to submissions has been made in two parts, with the first volume submitted to DPIE in September 2020. This document is known as the RtS Volume 1 and considered and responded to the following:

- Biodiversity;
- Socio-economics;
- Traffic and Transport;
- Amenity (acoustic and air quality);
- Coastal processes and climate change; and
- General planning and policy matters.

1.4 Purpose of this report

This RtS represents volume 2 and considers the following:

- Surface water;
- Groundwater;
- Groundwater Dependant Ecosystems;
- Water related management plans;
- All community submissions made in relation to matter extenuating from and related to groundwater including PFAS contamination, water quality, other water users, and the like.

1.5 Report structure

This report has been structured as follows:

- **Section 1** provides a high level summary of the project, process and the subject report;
- **Section 2** provides a summary of the project as exhibited and any changes that have been made in response to the exhibition and submission process, combined with any overview of volume 1 of the RtS;
- **Section 3** contains details of further information provided in the response to submission and clarifications to the project scope in response to matters raised or highlighted through the exhibition and submission process;
- **Section 4** response to State and Local government agencies
- **Section 5** response to public and community group submissions. Submissions have been grouped according to key themes or areas of concern.
- **Section 6** Conclusion

2 Project overview

Sand from the former inland extraction area was only extracted to 5 m AHD under the original 1996 development consent. The sand resource above 5 m AHD was exhausted in 2008 and in accordance with the conditions of consent the operations have ceased.

The project involves the extraction of sand from the former inland extraction area (inclusive of pits 1-6) from the existing ground level to a depth of -15 m AHD. As extraction will intercept the groundwater table (at 1-2 m AHD) the primary method of sand extraction will involve dredging.

There is an estimated 9 Mt of sand resource in the project site. The project seeks permission for a site wide increase on the dispatch limit to 750,000 tpa (i.e. the windblown sand extraction area and the project operations combined) up to 2028, after which the site wide limit will reduce to no more than 500,000 tpa.

The increase in the site wide dispatch limit is sought to permit maximum flexibility across the two sand extraction areas (on the same quarry site).

Mobile plant and equipment will operate across both project areas and a docket system at the weighbridge will monitor outgoing product as a quarry total.

To account for fluctuations in demand, Boral is seeking consent to operate the project for 25 years.

Figures 1 and **2** are replicated from the EIS and depict the project layout, existing and proposed site infrastructure. These figures should be read in conjunction with **Table 1** below.

Table 1: Project summary

Aspect	Exhibited application
Land use	Extractive industry
Hours of operation (standard operations)	<ul style="list-style-type: none"> ▪ Monday to Friday: 6:15 am to 5:00 pm; ▪ Saturday: 6:15 am to 12 noon; and ▪ Sunday and Public Holidays: Closed.
Hours of operation (major supply contracts)	<ul style="list-style-type: none"> ▪ Monday to Friday: 6:15 am to 6:00 pm; ▪ Saturday: 6:15 am to 3.00 pm; and ▪ Sunday and Public Holidays: Closed.
Consent period	25 years from commencement.
Production and transport limits	Up to 750,000 tonnes per annum
Extraction method	Stage 1 – dry extraction using front end loaders; and Stages 2 – 6 (inclusive) dredge.
Site infrastructure and plant	Dredge, bunded diesel generator, wash plant and radial stacker

Aspect	Exhibited application
Product transport	Truck via established road external network.
Waste management	Augmented waste management practices on site to meet an increased demand. A project specific waste management will be developed that compliments the existing site practices as necessary.
Material importation	70,000 Virgin Excavated Natural Material (VENM)
Employment	Six full time employees and three part time employees.
Rehabilitation and final landform	Open water body

Figure 1: Project area and general layout

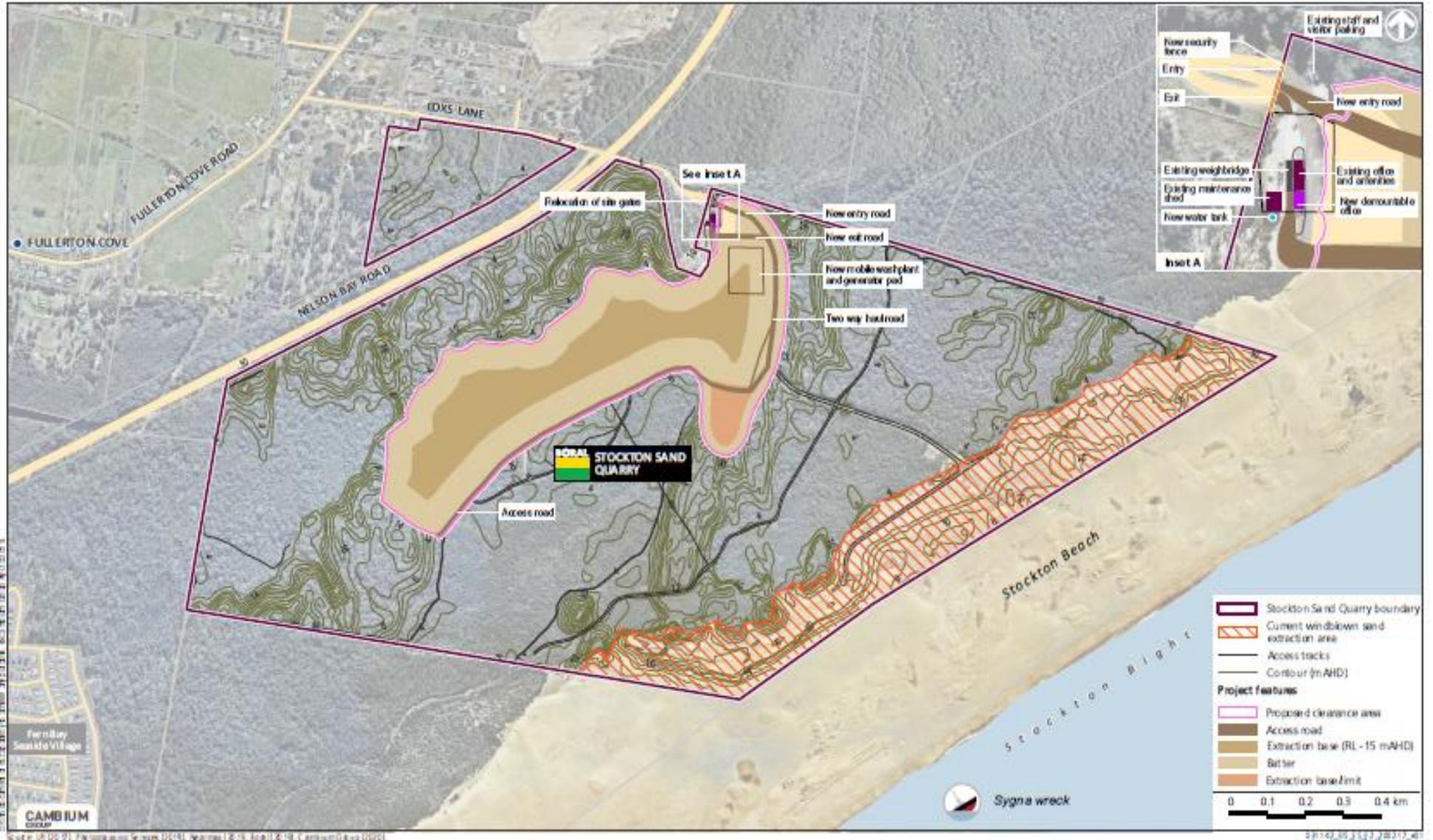
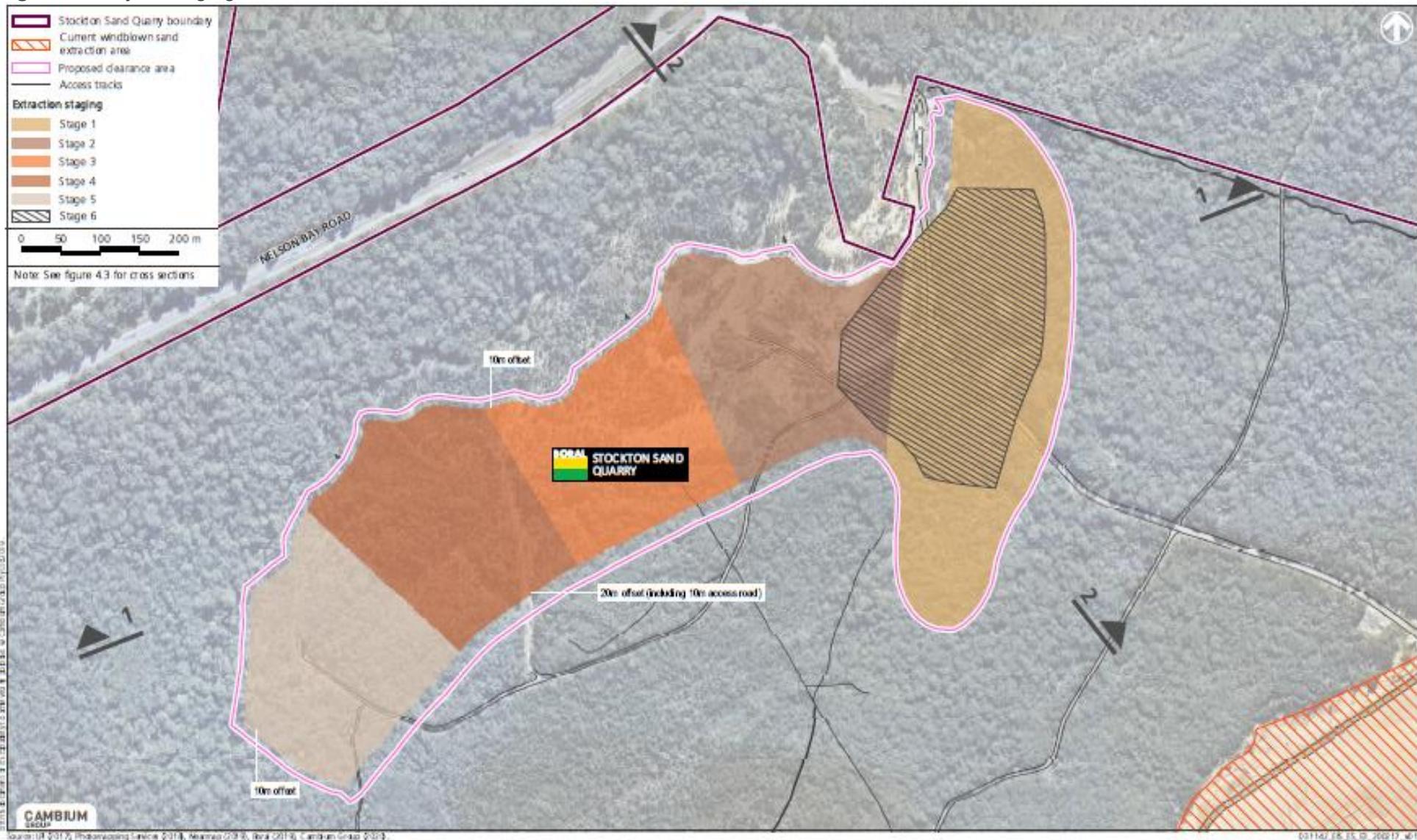


Figure 2: Project staging



3 Submissions overview

The application was notified and referred to government agencies by DPIE for a period of 28 days between 13 March 2020 and 4 April 2020.

A total of 24 submissions were made in response to exhibition of the application. Detailed analysis of the submissions received is contained in section 3 of Volume 1 of the RtS.

A high level summary of the submissions received is provided in **Table 2**. Government agency responses made up the majority of submissions received, however within this group four (4) submission made “no comment”. Removing these from consideration reduces this respondent group to nine submissions, or 36 per cent of all submissions made.

Table 2: Summary of submissions

Position	Community - Individuals	Community - Organisation	Agency	Total	Percentage of all submissions
Comment	0	0	12	12	50
Objection	6	5	0	11	46
Support	0	0	1	1	4
Total	6	5	13	24	100

3.1 Submissions themes

The 24 submissions made in response to the exhibition were analysed and identified 16 common themes identified (refer to **Table 3**). The dominant themes are groundwater, biodiversity, traffic and transport, quarrying methods and rehabilitation.

Due to the small number of submissions received community interest groups and individuals have been grouped together for the purposes of analysis. The common themes and the prevalence are set out in **Table 3** and **Figure 3**.

This report will focus on matters relating to and extenuating from water (groundwater and surface water). For all other responses relating to the other theme areas refer to Volume 1.

Table 3: Summary of key themes – community and government

Area of Concern	Community – Individuals & organisation	Government	Total	% of submissions raising key
Groundwater	6	4	10	42
Biodiversity	5	3	8	33
Rehabilitation	2	2	4	17
Traffic and Transport	7	2	9	37.5
Quarrying method	4	1	5	21
Archaeology and Heritage	0	1	1	4
Planning & policy	2	1	3	12
Environmental Impact Statement	2	2	4	17
Socio-Economic	4	2	6	25
Water (general)	1	1	2	8
Amenity	2	0	2	8
Greenhouse gas emissions & climate change	2	0	2	8
Coastal Processes	2	0	1	8
Post consent conditions	0	6	6	25
No comment	0	4	4	17

The detailed submissions matrix is provided in Appendix A of RtS Volume 1.

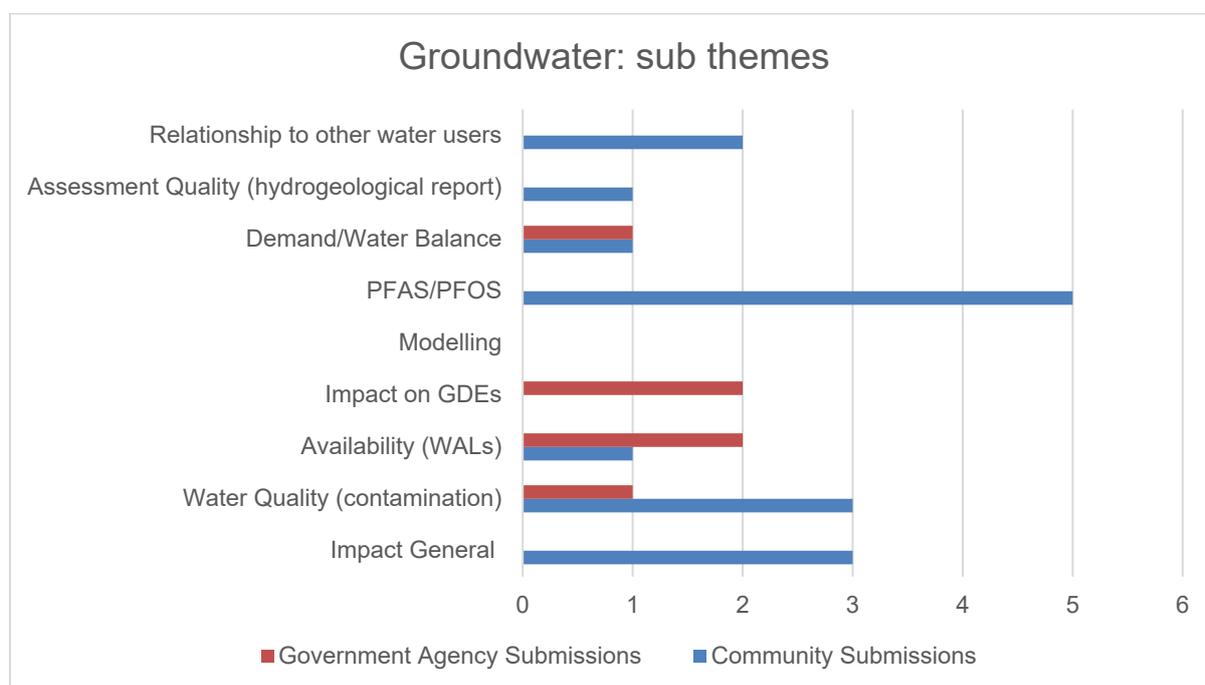
3.2 Theme: Water

A key theme identified across the majority of submissions related to water. These submissions predominantly raised matters relating to groundwater (11 submitters from both the community and government) with a smaller proportion of submissions also raising more general water matters (two submitters).

3.2.1 Groundwater

Within the key theme area of groundwater, nine key sub-themes were identified, the prominent of which was PFAS/PFOS followed by generalised concern of contamination. The distribution of submissions in relation to key subthemes is shown in **Figure 3**.

Figure 3: Distribution of key themes



It is evident that the key areas of focus for government and community are divergent. With the majority of concern for community members and groups focus on: PFAS/PFOS, generalised concerns, contamination, and the potential for the operation to impact on other water users.

The key areas of raised by government agencies included impact of groundwater dependant ecosystems, water availability, demand and quality.

4 Further Information

The following sections set out project clarification points or provide an overview of additional and further technical information obtained to support and inform responses to matters raised through the exhibition and submission process.

4.1 Correction

It is acknowledged in the submissions summary provided in Appendix B of the RtS volume 1 that the table contained an error in relation to the identification of sub themes, in particular the array of sub-themes related to groundwater with two entries relating to groundwater dependant ecosystems.

This error has now been corrected. Despite the double entry, the number of submissions was still counted and the distribution and priority of matters raised was not altered. An amended summary table is provided at **Appendix A** to this report.

4.2 Clarifications

As a result of the submissions received, no substantial changes have been necessary for the proposal to address specific comments, requests or concerns. Notwithstanding this, some aspects of the proposed project are clarified in the sections below in light of comments and questions received. Where suitable additional or expanded technical information has been provided by the project hydro-geologist, engineer and restoration ecologists.

4.2.1 Sand extraction and processing: methods

Following the receipt of the submissions further review of the sand extraction process, in particular the operation of the dredge and the washplant was undertaken. As part of this review the following additional information is provided in relation to the sand extraction and processing methodology:

Sand extraction

The primary method of sand extraction for the project, as set out in the exhibited EIS, is wet extraction using a suction dredge. The suction dredge will pipe a mix of sand and water from the ground to the washplant for processing.

Sand processing (washing)

Processing of sand through the wash plant could occur in two ways:

1. direct feed of dredge sand/water mix to the washplant; or
2. "loader feed" of dry sand into the washplant, with water pumped from the aquifer as part of the dredge processing captured and reused.

Source of water used in washplant

As set out above, water used in the processing of sand through the washplant will be taken from the groundwater source. Following processing, water will either be piped directly back to the aquifer to reduce water loss, or captured, stored and reused in the washplant as described above. As water taken from the aquifer is not “credited” on return, once extracted the water use will be optimised onsite.

4.3 Updated and additional technical reports (water)

In response to comments received from key agencies in the Biodiversity Conservation Division (BCD) and DPIE Water/Natural Resources Access Regulator (NRAR) the following additional work has been undertaken:

- A final landform plan (**Appendix B**) has been prepared by Cambium, showing the gradient/batters within the dredge pond, confirming the existing/finished ground levels of land surrounding the final dredge pond and the extent of the pond that will reach depths of –RL15 metres;
- The rehabilitation strategy prepared by Environmental Earth Sciences (EES) has been amended with a key focus on incorporating water quality management measures and stabilisation of the dredge pond/final landform including matters relating to achieving biological function (**Appendix C**);
- Detailed review of project water demand and water balance prepared by South East Engineering (**Appendix D**)
- A class 1 groundwater model prepared in accordance with the requirements of the Aquifer Interference Policy (**Appendix E**). Modelling also considered any geochemical changes that may arise in response to the project, these matters are also addressed in the modelling report.
- Technical responses prepared in relation to matters raised by agencies and the community concerning potential groundwater impacts (refer to **Appendix F**).

4.4 Updated and additional technical reports (biodiversity)

Following submission of the RtS Volume 1 report in September 2020. Further biodiversity surveys were undertaken by Niche to determine the presence of several key species. Following the completion of these surveys the Biodiversity Development Assessment Report has been updated and is now provided at **Appendix G**.

5 Response to State government agencies and Council

A total of 13 agency submissions were received, of these four provided comments of “no comment”, two (2) provided comments of “no objection” and sought conditions to be imposed

Four (4) agencies made comment in relation to matters concerning water, the prevalent themes among government submissions were groundwater quality, groundwater dependant ecosystems, rehabilitation and management.

All responses from agencies, government corporations and Council are addressed individually as follows.

5.1 Department of Planning, Industry and Environment: Assessments

The following sections respond to water matters raised by the DPIE Assessment Team. For the purposes of brevity, only matters relating to water excluded from Volume 1 of the RtS submitted in September 2020 are addressed in the following. For all other matters refer to volume 1.

5.1.1 Clarifications

The following project clarifications are relevant to the consideration of water related matters.

Use of evaporation barriers

The DPIE sought an indication on whether Boral had considered the use of evaporation barriers.

Boral investigated and considered a range of evaporation mitigation methods, including the use of surface barriers, throughout the project development phase. While Boral does not discount the potential to use such devices in the future, the efficacy of such devices would be informed by the availability of water entitlements and the final use of the site which is yet to be determined given the 25 year life span sought.

5.1.2 Water matters

Table 4 provides a cross reference of matters raised by agencies and the public, which DPIE’s lead assessing officers have specifically requested that Boral respond to as part of the RtS.

Table 4: Cross reference table

Agency	Matters raised	Section reference
DPIE Water/NRAR	Water quality, “incidental” water take and how these may influence groundwater dependant ecosystems, impact on beneficial use and other	Section 5.2 Appendix E Appendix F

Agency	Matters raised	Section reference
	water users. Concerns regarding earlier dredging operations impacting on groundwater quality in the Tomago catchment/aquifer	
Hunter Water	Final landform and requests to reduce the size of the final wetland (i.e. open lake) and how dredging operations will ensure the protection of the water source	Section 5.5
Biodiversity Conservation Division (BCD)	Further assessment of the final landform and rehabilitation strategy	Section 5.4 Appendix B Appendix C
Community	PFAS contamination risks	Section 6.1.3

5.2 DPIE Water Division & Natural Resources Access Regulator (NRAR)

DPIE Water/NRAR raised several matters requiring further investigation and resolution in relation to the water use of the project and the potential for impact on water take on the Stockton Groundwater Source.

A meeting was held with DPIE Water/NRAR representatives on 21 July 2020. DPIE Assessment Officers were also present at the meeting. As a consequence of the meeting further information was provided in relation to DPIE Water's focus areas in relation to the project. These predominantly related to discussion regarding the volumetric water demands of the project and the protection of groundwater quality.

Comments provided by DPIE Water/NRAR were split into two primary categories of matters requiring resolution prior to approval and matters to be considered post approval. The pre-approval matters are addressed in detail below. An overview of the post approval matters is set out in **Table 9, section 5.2.8** with relevant responses.

5.2.1 Project water demand

DPIE Water/NRAR have made two comments in relation to the project water demand, including:

- Determining the incidental take of groundwater associated with the dredging operation plus any additional take associated with the sand processing and other activities; and
- A prediction of the total amount of water.

Water Balance

A review of the project demand and operations was undertaken by Boral and South East Engineering.

A formal response prepared by South East Engineering is provided at **Appendix D** of this report, setting out those areas of water use considered to be “incidental”.

Table 5 contains a high level summary of the worst-case scenario for project water demand. This worst case is based on an operational upper limit of 750,000 tpa, no water reuse and maximum evaporation losses at completion of stage 6.

Table 5: Summary of water project demand

Project component	Water use requirement (ML/pa)
Dredge	873.2
Screen spray	262
Product (as a moisture content of sand)	3% of extracted material mass
Evaporation losses (vary dependant on stage)	0 – 191
Dust Suppression	15 (maximum)
Total (maximum)	1,341

Up to 65 per cent of the project water demand is related to the operation of the dredge. This water is returned almost immediately to the aquifer with negligible loss to the system. As a closed loop system, all water used by the dredge can be measured at the point of extraction and on return with minimal loss (or take) of water. Inequitably, under the current legislative provisions this “return of waters” to the aquifer is not recognised, creating a distortion in the volumetric take or put another way it does not distinguish between an “actual take” (i.e. a loss of water from the hydrological system) and a “paper take” (one that only exists in response to a policy construct). Allowing for return of waters, the actual volumetric demand of water would be reduced to 537 ML pa based on a conservative allowance for an 8% loss of water in processing and product moisture.

Taking into account the above, the actual loss (i.e. water taken and not returned) is minor in nature and will only peak in demand in the final year of Stage 6 after which point demand reduces further to a maximum of 200ML pa from evaporation (refer to **Table 6**).

Boral’s research into the potential for use of evaporation mitigation measures, principally the effective use of water barriers (other than chemical barriers which are inappropriate for the project based on sensitivity of the receiving system but also the local climatic/wind conditions) could reduce water demand associated with evaporation by up to 80 per cent. While the use of such devices does not form part of the current project demand it may be considered for use at later stages in the project.

Water availability

There is currently insufficient market available water to meet the demands of the project. However, the Stockton Groundwater Source is not fully allocated with respect to the available credits under the adopted Water Sharing Plan, with only 1,037ML of a possible 14,000ML allocated.

As the project has incremental water demands, it is feasible and practical that over time Boral will be able to build up the necessary credits to support the operation through a variety of water market products as set out above.

In the event that water is not available to operate at maximum capacity, the operation of the dredge can be scaled to respond to the volume of water held or permitted to be taken under the *Water Management Act 2000* (WM Act) for extractive purposes.

Prediction of annual water loss

The estimated annual water take of the project from commencement through to closure is set out in the response provided by South East Engineering provided at **Appendix D** of this report.

An overview of the annual water demand corresponding to project stage is set out in **Table 6**. The annual demand set out in **Table 6** is considered to be highly conservative including moisture content in sand above the water table to extracted in stage 1 (i.e. years one to three).

Table 6: Estimated annual water demand (source: South-East; September 2020).

Project Stage	Year of operation	Decile 1 rainfall	Decile 5 (median) rainfall	Decile 9 rainfall
1	1	-31.40	-31.40	-31.40
	2	-31.40	-31.40	-31.40
	3	-31.40	-31.40	-31.40
2	4	-1162.96	-1159.00	-1151.32
	5	-1175.78	-1167.86	-1152.50
	6	-1188.60	-1176.72	-1153.68

Project Stage	Year of operation	Decile 1 rainfall	Decile 5 (median) rainfall	Decile 9 rainfall
	7	-1188.60	-1176.72	-1153.68
3	8	-1200.41	-1184.88	-1154.77
	9	-1212.23	-1193.04	-1155.86
	10	-1224.04	-1201.21	-1156.94
	11	-1224.04	-1201.21	-1156.94
4	12	-1234.51	-1208.45	-1157.91
	13	-1244.99	-1215.68	-1158.87
	14	-1255.46	-1222.92	-1159.84
	15	-1265.93	-1230.16	-1160.80
	16	-1265.93	-1230.16	-1160.80
5	17	-1283.24	-1242.12	-1162.40
	18	-1300.56	-1254.08	-1163.99
	19	-1300.56	-1254.08	-1163.99
6	20	-1320.77	-1268.05	-1165.85
	21	-1340.98	-1282.02	-1167.71
Post closure		-190.84	-131.88	-17.57

5.2.2 Water entitlements and acquisition strategy

DPIE Water has requested that Boral demonstrate acquisition of, or an ability to acquire the necessary water licences to support the implementation of the project as required under the WM Act.

Boral understands that prior to undertaking any activity that requires the use of or taking of groundwater, the WM Act requires Boral to hold the necessary Water Access Licences (WAL) and share entitlements. It is, however, not a requirement under the WM Act that Boral hold these licences prior to obtaining development consent.

Notwithstanding this, Boral understands that some degree of demonstration is required to show acquisition of entitlements is plausible and/or that the project has the capacity to be scaled in response to the availability of water. In this regard, Boral's water strategy in relation to obtaining water to support the implementation of the project is as follows:

1. Use provisions under the WM Act that permit an exemption for water allocations to the maximum limit allowable (3ML pa);
2. Acquire allocations through controlled allocation releases (possible 9,492ML of unallocated water entitlements under the WSP - taking into account NSW Water policy to only allocate 80 per cent of the total 14,000 ML/pa entitlement). A total 672 water shares were released in 2020. Boral has acquired 100ML under the 2020 controlled allocation process and has registered for the 2021 allocation process; and
3. Acquire allocations through the market from existing entitlement holders (lease or purchase – possible current market available credits 1,037.5ML/pa).

Combined with the above, Boral will

- Commit to the use of a low water demand dredge. The selected dredge extracts sand at a ratio of 2 parts water to 1 part sand. Investigations into whether this could be reduced further are ongoing.
- If necessary, Boral will use evaporation barriers to reduce surface water loss from the dredge pond; and
- accept a condition of consent that no dredging activity will commence until Boral can demonstrate they have adequate water supply to support all stages of the development (as approved) or sufficient water to operate at a reduced scale to the satisfaction of the Secretary.

Boral is confident that the project can operate and achieve commercial viability whilst also responding to and allowing for restrictions in market available water. Over time as allocations are acquired through various water product options Boral can increase extraction volumes. As water can be metered at the point of take and return, it can be monitored with confidence. Similarly, extraction and transport volumes are reported to the government on an annual basis, which will provide the government with surety of the operations management.

As the extraction rate of both water and sand can be regulated and managed, it is feasible to scale the project operations within the approved extraction limit in response to available water shares.

5.2.3 Spatial and geochemical models

EES has prepared the requested spatial and temporal groundwater model together with a geochemical model of the Stockton Groundwater Source, taking into account the project scope and method. The modelling report is provided in **Appendix E**.

The modelling confirms that the project will not significantly reduce the height (level) of the groundwater table as a result of the activity or result in altered chemical profile.

5.2.4 Aquifer Interference Policy (AIP)

DPIE Water/NRAR requested that a complex groundwater model (i.e. a numerical model), in accordance with the “minimal impact provisions” of the AIP be undertaken to inform the prediction of effects on the Stockton Groundwater system including authorised users and GDEs.

As discussed in **section 5.2.3** above, a class 1 numerical model has been prepared based on groundwater modelling data collected from the site between 2018 – 2020 (inclusive). The Numerical Model report prepared by EES (**Appendix E**) provides a solid foundation for determining the base line environment and outlines the potential impacts that may arise as a consequence of the project.

Table 1 of the AIP contains matters for consideration and assessment aligned to a particular water source and three key criteria. The Stockton Groundwater Source is classified as a *coastal sands water source*. Each of the potential impact consideration criteria are considered in turn below.

Water table

Table 7: Consideration of water table – “minimal impact considerations’ of AIP

No.	Impact Consideration	Response
1	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” variations, 40m from any:	EES has developed a class 1 numerical model to consider the effect of the project on the aquifer. This report is provided in Appendix E .
(a)	high priority groundwater dependent ecosystem; or	EES has assessed the potential for the project to impact on GDEs. The modelling confirms that water taken from the aquifer will not contribute to a noticeable reduction in the water table level (refer to sections 4.1.1 and 4.1.3 of Appendix E to this report)
(b)	high priority culturally significant site;	There are no high priority culturally significant sites identified on the relevant maps adopted by the North Coast Coastal Sands Water Sharing Plan within the vicinity of the site. The site is acknowledged to adjoin the Worimi Conservation Land (WCL) that NPWS has indicated support important

No.	Impact Consideration	Response
		<p>GDE. The potential effect of the project on the GDE is considered in section 5.4.4</p> <p>The project area has also been assessed for potential cultural impacts in the exhibited Aboriginal Cultural Heritage Assessment Report provided at Appendix K of the EIS. This assessment resolved that there were no Aboriginal heritage constraints.</p>
	<p>listed in the schedule of the relevant water sharing plan. A maximum of a 2m decline cumulatively at any water supply work.</p>	<p>Given the project will not reduce the water table level it is considered unlikely to impact on the water level at any water supply work down gradient from the site.</p>
2.	<p>If more than 10% cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” variations, 40m from any:</p>	<p>Table 5 annexed to the Numerical Model report prepared by EES in relation to the Rts report demonstrates there will be a less than 10% cumulative variation in the groundwater table. Accordingly, the matters of subsection (2) are not required to be considered further.</p>
(a)	<p>high priority groundwater dependent ecosystem; or</p>	<p>Not applicable.</p>
(b)	<p>high priority culturally significant site;</p>	<p>Low probability of impact occurring. Refer to Aboriginal Cultural Heritage Assessment at Appendix K of the exhibited EIS.</p>
	<p>listed in the schedule of the relevant water sharing plan then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister’s satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site.</p> <p>If more than 2m decline cumulatively at any water supply work then make good provisions should apply.</p>	<p>Not applicable.</p>

Water Pressure

Table 8: Consideration of water table – “minimal impact considerations’ of AIP

No.	Impact Consideration	Response
1	A cumulative pressure head decline of not more than a 2m decline, at any water supply work.	Due to the size of Boral’s land holding, the closest water supply work is likely to be located in Fern Bay residential estate to the southwest of the site. Fern bay is down gradient of the site and based on the modelling work completed by EES it is unlikely that the project would result in the decline of head pressure.
2	If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister’s satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	Refer to the Appendix E.

Water Quality

Table 1 of the AIP requires consideration and demonstration that the proposed activity would not contribute to a change in the groundwater quality below the beneficial use category of the groundwater source.

DPIE Water/NRAR in the supplementary submission made on 20 August 2020 has identified the beneficial use categories applicable to the Stockton Groundwater Source are:

- Raw water for drinking water supply; and
- Ecosystem protection.

The use categories were identified in the *Water Sharing Plan for Tomago Tomaree Stockton Groundwater Sources 2003*. This regulatory instrument was repealed in 2016 and the current *North Coast Coastal Sands Water Sharing Plan 2016* contains no similar provision. It is likely that the beneficial use for drinking water was related to the Tomaree and Tomago aquifer which forms a backup drinking water supply source. The Stockton Groundwater Source does not form part of this system and under the adopted WSP there is no allocation of water to the local water provider, Hunter Water.

Notwithstanding the above, the potential for water quality to change as a consequence of the project is considered in the modelling report provided at **Appendix E**. The geochemical model resolves that adverse impact on groundwater quality is unlikely.

The project has a low likelihood of impacting reliant ecosystems, these matters are considered in further detail in addressed in **section 5.3.1** and **Appendix F**.

5.2.5 Water dependant assets

DPIE Water has raised concern that the proposed project will adversely impact on water dependant assets including:

- Groundwater Dependant Ecosystems within the Worimi Conservation Lands (WCL); and
- Water Rights held by Hunter Water Corporation (HWC) under their “Special Areas” provisions of the *Hunter Water Regulation 2015*

The relationship between the project and groundwater dependant ecosystems, including those located within the WCL are considered in detail in **Sections 5.3.1 and 5.4.4**.

In relation to the regulatory provisions that protect HWC interests we note the following:

- Boral’s land is located outside the North Stockton Catchment Area. As the boundaries of this area (and as such HWC’s interests) are established through a legislative instrument, it is beyond both HWC and DPIE Water to alter the reach of these provisions to prevent the project on the basis of impacting their rights;
- The provisions of the Hunter Water Regulation, specifically those under clause 15 limits HWC’s power to the extent that an extractive industry is located within the boundary of the North Stockton Catchment Area as mapped. As Boral’s land is located outside this area the provisions do not apply and cannot be extended to require HWC approval; and
- Under the North Coast Coastal Sands Water Sharing Plan, Hunter Water Corporation is not authorised to extract water from the Stockton Groundwater Source.

The proposed development does not result in a lowering of the groundwater table or significant alteration of the geochemical profile. As such the project is not anticipated to detrimentally impact on GDEs or HWC’s water rights.

5.2.6 Historical operations

DPIE Water/NRAR in the 20 August 2020 supplementary submission raised concern regarding a separate and unrelated historical operation located above the Tomago Water Source that resulted in unforeseen water quality impacts that remain “two decades post mining”.

DPIE Water/NRAR commented that the example is demonstrative of the risk for unforeseen long term water quality impacts to arise and that given the risk the proposal cannot be considered “compliant” with the Principles and Objects of the *WM Act*.

In order to address the above matters, impact investigation supported by a groundwater modelling platform was considered necessary to consider any potential changes to groundwater flow regimes and water volumes

A class 1 model has been prepared to consider the potential effects of the proposed development on the Stockton Groundwater Source, in terms of potential impacts on groundwater quality and levels. The investigations have concluded the potential for impact is minimal.

It is unreasonable to include in the assessment of merit, the impacts on unrelated mineral dredging operations that took place between 1970 and 1980. DPIE Water has provided no evidentiary basis for the linkages between the projects, that would suggest a similar event may occur in relation to the proposed dredging operation.

Geochemical modelling of the aquifer completed by EES indicates that the project has a low risk of altering the water chemistry and consequently the project is considered unlikely to adversely impact on water quality.

Key to the objects and principles of the *WM Act* is the need to recognise the efficient use and equitable sharing of water resources. The project achieves these objectives through

- appropriate selection and use of technology that optimises sand extraction while minimising water use and delivers a best practice outcome;
- effective management and monitoring of the groundwater table will ensure the protection of groundwater quality;
- facilitation of access to the natural resource that is intrinsic to the manufacture of high quality building products that directly benefits urban communities, industry, and recreation developments; and
- Maintaining access to resources for other water users nor diminishing the quality of water resources.

Boral is of the view that the project design including extraction method seeks to promote the purpose or object underlying the *WM Act*.

5.2.7 Remedial actions and bonds

A groundwater management plan (GMP) would be prepared prior to the commencement of works formalising a number of monitoring recommendations were made in the acid sulphate soil

management plan (ASSMP) and hydrogeological impact assessment (HIA). The GMP will describe the objectives of the groundwater management and monitoring and detail the proposed types and locations of monitoring. It will also describe the monitoring observations which would trigger actions and the proposed remedial actions and/ or mitigation measures to be deployed should triggers be exceeded.

The recommendations include:

- **Maintenance of the existing monitoring bore network** outside the proposed extraction area (MW_X1, MW_X2, MW_X5, MW_X6, MW7, GW2, GW4 and MW2) to provide early warning of the development of any environmental degradation or impact to surface water, groundwater and soils both during the project and for a period following completion.
- Once extraction progresses below the water table the dredge pond surface will need to be surveyed so that the relative height of water in the pond over time can be accurately measured.
- **Monthly measurement of standing water level (SWL)** and pond water level AHD heights during excavation, reinstatement and rehabilitation works (bores only). With all eight existing bores incorporated into the existing quarterly monitoring program for the wider quarrying site following rehabilitation.
- **Monthly measurement of pH** in all eight bores and the pond during excavation and rehabilitation works; and
- **Monthly sampling** of all monitoring bores for
 - field parameters (pH, EC, ORP, SWL, DO and temperature) and
 - laboratory analysis (full ionic balance suite: pH, TDS, cations, anions, nutrients and dissolved iron).

Boral is willing to accept a condition requiring of the payment of a security bond in the form of a bank guarantee prior to the commencement of dredging operations in stage 2 of the project.

5.2.8 Post-approval matters

DPIE Water/NRAR requested that several matters be addressed post approval. These matters are set out in **Table 9** with a corresponding Boral response.

Table 9: Consideration of post approval matters

DPIE Water Comment	Boral Response
<p>A water management plan that includes a project specific groundwater monitoring and management plan</p>	<p>Boral is will accept a condition that the relevant plan be prepared in consultation with the relevant agencies and approved prior to commencement of stage 2 (i.e. the commencement of dredging operations)</p>
<p>The proponent must comply with regulatory licensing requirements of the <i>Water Management Act 2000</i></p>	<p>Requirements of the <i>WM Act</i> are known and accepted.</p>
<p>Install metres on any pump extracting from open water bodies that intercepts the groundwater</p>	<p>This would typically be a condition of any water supply work sought and obtained under the <i>WM Act</i>.</p>
<p>Place composted mulch on hardstand areas with installation of a leachate treatment collection system</p>	<p>Mulch is used on site to support the growth of rehabilitation plantings. It is intended that this practice would continue under the proposed consent. In the event that material cannot be used on site, it is envisaged that the green waste material would be transported off site for reuse or disposal due to the proposed regulatory constraints.</p>
<p>Process for documenting imported material to ensure it is clean and inert without risk of generating contaminated leachate.</p>	<p>Boral would prepare and implement VENM/ENM receipt procedures to ensure that all material brought into the site and used for the purpose of stabilising the dredge pond and contributing to the final landform is suitable for use.</p>

5.3 Port Stephens Council

Port Stephens Council made four comments in relation to water matters. These are addressed in the following sections.

5.3.1 Groundwater Dependant Ecosystems

Port Stephens Council made two comments in relation to Groundwater Dependent Ecosystems:

- The SEARs required the preparation of a map showing the location of the terrestrial and aquatic GDEs relative to the project area; and
- The need for a detailed assessment of the GDEs in either the BDAR or the EIS.

Discussion of GDEs in the exhibited EIS

The exhibited EIS included a discussion of GDE's as follows:

- EIS section 2.5.7 Groundwater, subsections entitled Groundwater Dependent Ecosystems (p. 45) and Groundwater monitoring ((p. 46), describes and defines the identified GDEs within proximity to the site. It is acknowledged that the government established GDE Atlas published and managed by the Bureau of Meteorology identified no GDEs within proximity to the site/project area;
- EIS section 9.3 *Biodiversity*, subsection 9.3.3 *Indirect Impacts* (pp. 137 – 138) considers the potential for the project to impact GDES through reduce availability of water due to the dredging operation and exposure of the aquifer; and
- Hydrogeological Impact Assessment (Appendix D) section 6, subsection 6.2.4 describing the receiving environment including GDEs and section 8 impact assessment of the project.

Spatial relationship to the GDEs

In response to the comments received following exhibition of the EIS a further review of the GDE Atlas has been undertaken. The GDE Atlas was developed and is maintained by the Bureau of Meteorology to inform groundwater planning and management. The Atlas contains information about three types of ecosystems:

Aquatic ecosystems that rely on the surface expression of groundwater—this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs. Marine and estuarine ecosystems can also be groundwater dependent, but these are not mapped in the Atlas.

Terrestrial ecosystems that rely on the subsurface presence of groundwater—this includes all vegetation ecosystems.

Subterranean ecosystems including cave and aquifer ecosystems.

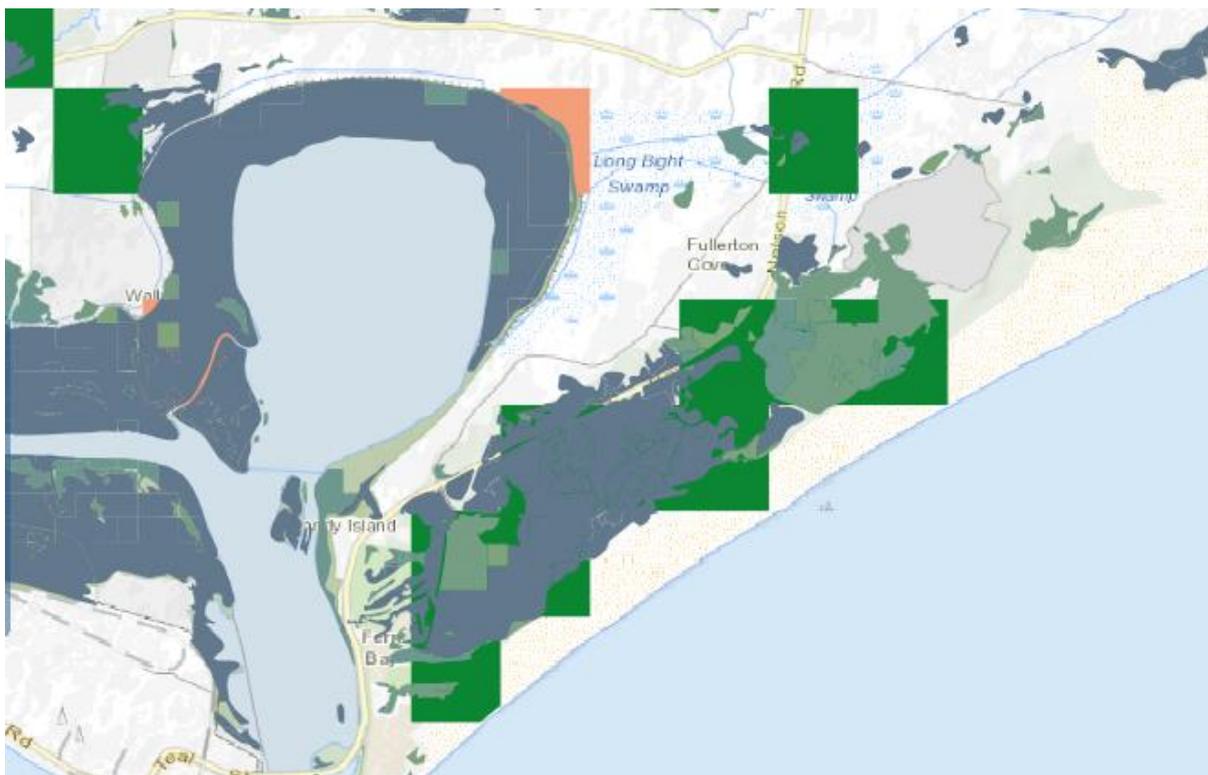
A search of the GDE Atlas undertaken in October 2020 confirmed the following:

- There are no analysed aquatic GDEs present within the site or on land immediately surrounding the site. The nearest aquatic GDE identified on the BOM managed site is located 7.17km north, north-east of the site. This GDE would be located up-gradient and outside the Stockton Groundwater Source;
- Within the site and immediately surrounding are moderate to high potential terrestrial GDE identified as *Coastal tea tree, old man Banksia coastal shrubland on foredunes of the central coast and lower north – South coastal sands dry sclerophyll forest*; and
- There are no analysed subterranean GDEs on the site or surrounding.

The identified terrestrial GDE, within the site and on land immediately surrounding, is “highly likely” to be reliant on groundwater including groundwater inflows as well as rainfall. The extent of this GDE is shown in **Figure 4**.

As the groundwater levels within the aquifer have been predicted to remain stable and close to current static conditions over the 25 year period of the project, it is unlikely that the identified GDEs would be impacted.

Figure 4: Distribution of GDEs and groundwater reliance

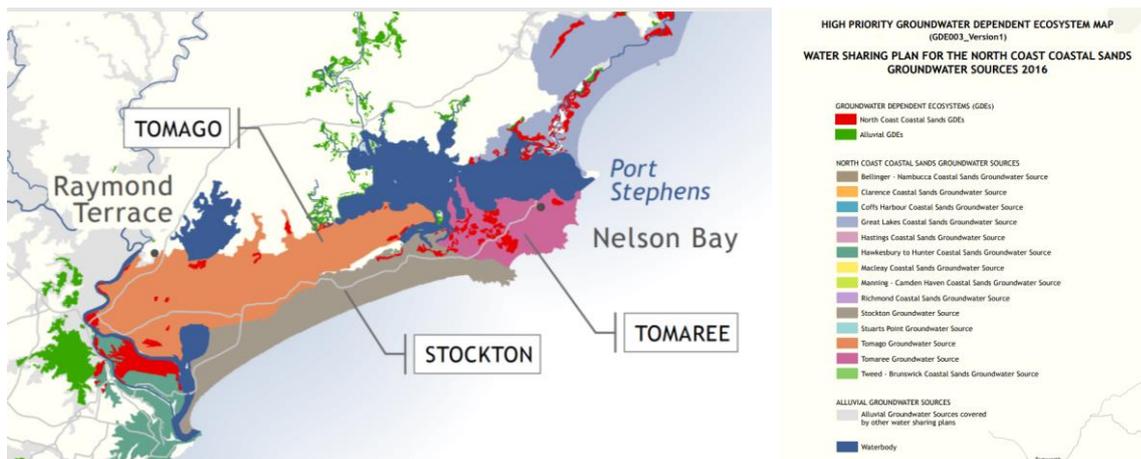


Proximity and relationship to high priority GDEs

The North Coast, Coastal Sands Water Sharing Plan (WSP) 2016 includes a map of “high priority” GDEs. The intent of the map and associated “rules” is to ensure that potentially impacting activities are separated from sensitive environments.

The adopted map is provided in **Figure 5** below with “high priority GDEs” coloured red and located to the west, north, and east of Boral’s site. The most proximate *high priority GDEs* identified by the WSP is in excess of 5 kilometres from Boral’s site and the proposed project.

Figure 5: Extract of *high priority GDE map from WSP*



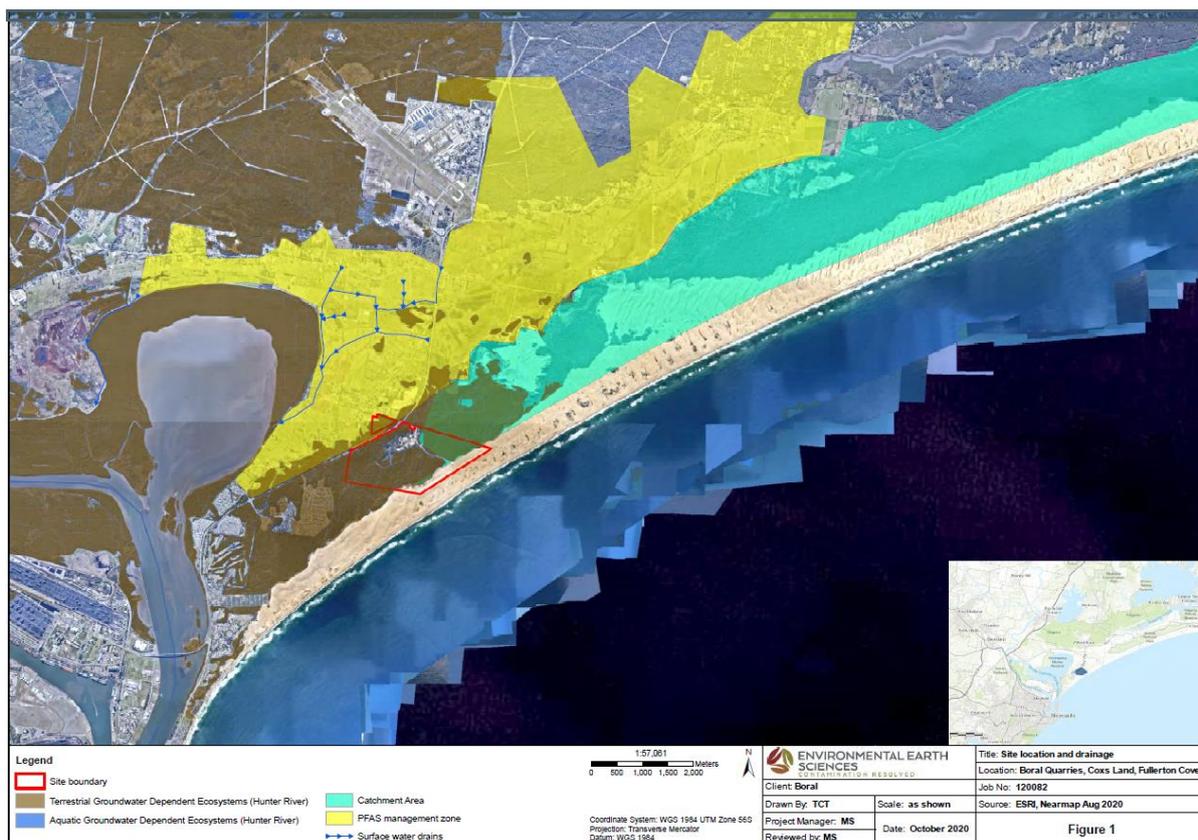
Project specific mapping and assessment

Figure 6 identifies the location GDEs relative to Boral’s site. The potential for these ecosystems to be impacted by the development was assessed as part of the aquifer model prepared by EES (**Appendix E**). The potential effect of the project on these GDEs is considered in detail in **Appendix F**.

The hydrogeological and geochemical model prepared by EES, predicted the creation of a dredge pond and end-point rehabilitation to a freshwater lake/ wetland would not alter the hydrogeological regime of natural movements of groundwater, nor groundwater chemistry, from current conditions. As such, it is concluded that the proposal has a low overall level of risk of impact on nearby groundwater dependent ecosystems (GDEs) and other potential receptors (e.g. recreation, fishing, stock-watering).

Modelling of the aquifer prior to and post project approval indicates that water levels will remain relatively static within and around the site indicating that the potential for GDEs to adversely affected is low.

Figure 6: Identification of GDE's in relation to the project site (source: modelling report, EES; 2020)



5.3.2 Groundwater monitoring program

Council made comment that a groundwater monitoring program should be implemented for the life of the project to monitor both groundwater levels, expected groundwater impacts (as described by the EIS) and the consequently the effects on GDEs.

Boral acknowledges the need to monitor the groundwater throughout the life of the project. In this regard Boral is willing to accept a condition of consent that a groundwater monitoring and management plan be prepared and approved by the relevant authorities prior to the commencement of any works on site.

5.3.3 Rehabilitation and landscape management

Council would like Boral to prepare and submit for approval an amended Rehabilitation and Landscape Management Plan prior to the commencement of any works on site.

As set out in section 5.2.1 Clarifications of the RtS Volume 1, the subject development application is a standalone consent. As such Boral, retracts comments relating to the amendment of existing management plans. Plans developed and implemented for the purposes of the project will be separate and standalone documents that reflect the terms of any future consent and the detail contained within the relevant sections of the EIS and the any amended or revised information submitted as part of the Report to Submissions.

Boral raises no objection to a condition of consent requiring that a final rehabilitation management plan be submitted and approved prior to commencement of work on site.

5.4 Biodiversity Conservation Division

The Biodiversity Conservation Division (BCD), including the National Parks and Wildlife Service (NPWS), made comment in respect to four key areas including the accuracy and extent of the final landform depicted in the exhibited EIS, the efficacy of exhibited rehabilitation strategy in achieving the appropriate biological function for a wetland environment, the need for groundwater management and monitoring and the potential effect of the project on GDEs located on the adjacent Worimi Conservation Lands (WCL).

Each of these matters is considered in turn in the following sections.

5.4.1 Final Landform

The BCD requested a final landform plan to be submitted detailing the expected footprint of the dredge pond including depths.

A final landform plan and cross sections has been prepared and is provided at **Appendix B**. The plan shows contours at 1 metre intervals within the pond.

Standing water height of groundwater is typically at 1.5 metres. The reference to a 4 metre water height was extracted from a historical report prepared by Umwelt in 1995 to support the establishment of the earlier inland extraction operation. Data collected to build the groundwater conceptual site model at this time was collated from a series of sources some of which was anecdotal. The 4 metres was a one off occurrence that is not representative of the standing water height.

Notwithstanding the above, in the event that the groundwater table rose to 4 metre AHD it would be unlikely to cause adverse impact on the immediately surrounding land or increase the sphere of influence of the project as the surrounding land levels immediately adjacent to the dredge pond are generally between RL 9 and RL 10. It is also likely that virgin excavated natural material brought into the site to stabilise the pond edges would serve as a crest edge around the pond.

5.4.2 Rehabilitation Strategy

The Rehabilitation Strategy has been amended to address the comments of the BCD, specifically:

- Methodology for rehabilitation and management aimed at addressing concerns relating to the deep water environment created through dredging operations;
- Preliminary water quality trigger levels and monitoring regimes; and

- The inclusion of performance and completion criteria

The amended rehabilitation strategy is provided at **Appendix C**.

The current rehabilitation strategy adopts the approach of retaining a 15 metre deep freshwater lake. The project has a 25 year operational life, and during this time if suitable virgin excavated natural material becomes available within the region, Boral would likely modify the strategy to partially fill the lake. Accordingly, the strategy has adopted an approach that is practical and achievable in the current conditions.

5.4.3 Groundwater management and monitoring

Boral acknowledges and agrees that prior to the commencement of operations (and subject to the granting of consent) a detailed groundwater management and monitoring plan will be required to be developed for the project area.

Boral raises no objection to this forming a condition of any future consent.

5.4.4 National Parks and Wildlife

The BCD has raised several matters in relation to NPWS and the potential impacts of the project on the adjacent WCL. The following section is focused on matters relating to the identified GDE, located on the beachfront adjoining Boral's larger landholding.

Groundwater dependant ecosystems

The NPWS has raised concern that the proposed operation may result in groundwater level changes impacting on the beach front wetlands in the WCL that has been assessed as broadly consistent with the endangered ecological community *Sydney Freshwater Wetlands in the Sydney Basin Bioregion*.

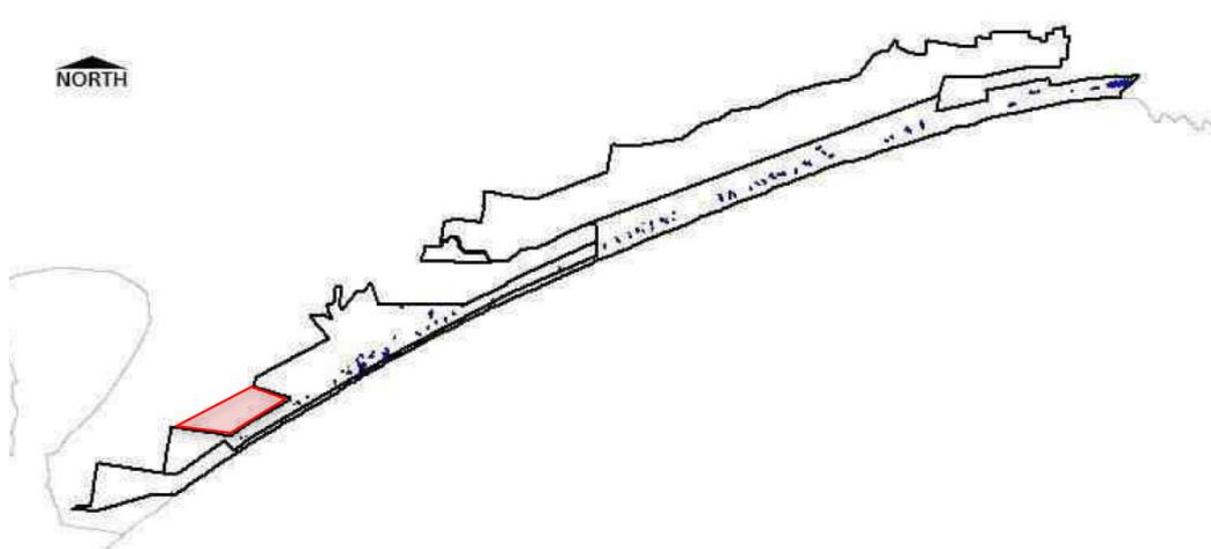
The subject GDE is identified and described in the *Vegetation of the Worimi Conservation Lands Port Stephens, New South Wales: Worimi NP, Worimi SCA and Worimi RP* prepared by Stephen Bell and Colin Driscoll (Eastcoast Flora Survey) November 2010 for the Department of Environment, Climate Change and Water Hunter Region, Parks and Wildlife Group (NPWS).

The location and distribution of the identified GDE is shown in **Figure 7** marked by small blue dots stretching along the dune system of Stockton Beach. Also identified below is the location of Boral's site relative to the identified GDE, identified by red outline.

A numerical model has been developed to determine the potential effect of water extraction from the aquifer (refer to **Appendix E**) with detailed consideration of the potential for the project to impact on GDEs in the context of the modelled results is provided in **Appendix F**.

The outcome of the model indicates that the groundwater levels are unlikely to be altered by the project. In this regard, it is considered unlikely that the project would impact on GDEs including those located southeast of the site on the frontal dune system.

Figure 7: Distribution of “Sydney Freshwater Wetlands” GDE (source: East Coast Flora Survey, 2010)



5.5 Hunter Water Corporation

Hunter Water Corporation (HWC) raised the following matters for consideration and response, including:

- project alternatives: final landform and project methodology (extraction limits);
- the need for groundwater management and monitoring; and
- confirmation for the water source and use for dust suppression.

The following sections respond to the focus areas of the remaining matters raised.

5.5.1 Final landform: alternatives

HWC considers that insufficient justification has been provided for the creation of a 23.3 ha open lake as the final landform.

Boral has considered multiple options for the potential final landform of the site, including partial filling of the lake to reduce the overall size and complete fill to return the site approximately to existing ground level.

Currently, there is insufficient material available within the region to achieve either of the above outcomes. However, if this changes in the future Boral would consider amending the final landform plan to achieve a reduce lake extent (size) or a complete return to existing conditions.

If the final landform remains as a large open lake, hydrogeological assessment of the project by EES concludes that removal of the aquifer matrix by excavation is likely to have very little physical and/or chemical impact upon groundwater at the site.

5.5.2 Limits to extraction depth

HWC has provided comment that extraction should be limited to the removal of sand above the water table.

This option was explored by Boral as part of the initial project development and is documented in the exhibited EIS as a project alternative. The option was not progressed due to the amenity impacts including noise, dust and visual intrusion combined with increased habitat and vegetation loss. The proposed extraction method seeks to minimise impacts by extracting within a predominantly disturbed environment providing extensive setbacks to adjoining uses.

5.5.3 Water source and use

HWC has requested that a condition of consent be imposed on any future consent requiring Boral to obtain a water allocation for the purposes of providing water for dust suppression activities.

Boral has recently obtained a 100ML share allocation for the Stockton Groundwater Source. Subject to sufficient water being available to meet the needs of the project operation, Boral intends, when feasible, to use allocated groundwater for dust suppression activities.

Boral objects to this being mandated through conditions of consent as it denies Boral the right to use a valued water commodity for its highest and best purpose, which in the hierarchy of demand relative to the project is processing and extraction.

HWC has made several recommendations relating to groundwater management and monitoring, these are noted to include comments numbered 4 – 6 (inclusive) in their submission.

- That the final groundwater management plan includes event based monitoring (with event triggers to be determined)
- That storage and management of fuels on site be undertaken to comply with the relevant standards to ensure the protection of the aquifer;
- The preparation and implementation of an Environmental Management Plan (EMP) that includes a spill management procedure;
- That importation of fill only be permitted in accordance with strict controls; and
- That a condition require independent audits of the operation be required at intervals through the operational life of the quarry.

All the matters set out above can be adequately addressed and managed through suitable management plans. The preparation, consultation and approval of these plans can be resolved through suitably worded conditions of any future consent.

Boral raises no objection to the above matters being resolved by way of condition.

5.5.5 Pollution risk and spill management

HWC has identified the need for suitable avoidance, mitigation, management practices and management plans to be implemented to avoid contamination associated with spill incidents and the importation of fill material.

The diesel generators used on site will be located within a bunded area built to comply with the relevant Australian Standards, similarly all fuels stored on site will continue to be stored in accordance with regulations.

A project specific EMP will be prepared in consultation with the relevant agency and need to be approved by DPIE prior to the commencement of operations. This plan will confirm all storage specifications and measures, combined with spill response measures and Virgin Excavated Natural Material (VENM) receipt procedures.

All matters raised in section 5 of the HWC submission are standard requirements for quarrying operations and can be resolved through suitable conditions on any future consent.

5.5.6 Independent Environmental Audit

HWC has requested that if the project is approved by DPIE that a condition be included requiring independent audits on specified intervals.

Boral notes that this is standard industry requirement and does not object to such a condition being imposed should the project be granted approval.

6 Response to public submissions and community groups

A total of 11 public submissions were received from six individual community members and five community groups.

Of the six community submissions, there was a 50 percent split between those living within the local area (Fullerton Cove and Fern Bay) and those located in the broader regional areas of Nelson Bay and Soldiers Point (each approximately 45 kilometres from the site). Three individuals elected to remain anonymous.

6.1 Groundwater

A total of seven community submissions raised concerns relating to groundwater. Of these three were community groups and four were individuals from within the community.

6.1.1 General impacts

Several submissions lacked sufficient detail for Boral to respond to adequately. Where this occurs, Boral acknowledges the comments but cannot provide any further response.

6.1.2 Water quality (contamination)

Two submissions raised concern regarding the potential for contamination of the groundwater table as a result of both the quarrying operation and the long term exposure of the aquifer.

The potential pathways for contamination are considered below:

Table 10: Contamination pathways and response measures

Source	Project phase	Avoidance response	Management response
Diesel Spill	Operational	Complete bunded area for the storage of fuels and points of use (i.e. around the washplant and dredge fuelling areas)	Spill kits retained on site and management plan developed to ensure clean up.
Turbidity – associated with dredging	Operational	Use of a suction dredge and in water booms.	Use of in water booms to control and limit migration of fines (where necessary and suitable) & periodic ongoing water quality monitoring.

Source	Project phase	Avoidance response	Management response
Change in water quality (chemical profile)	Operational and Ongoing	Implement an appropriate management plans and monitoring programs.	Geochemical modelling of the aquifer was undertaken by EES. The modelling confirmed that the project was unlikely to alter the profile of the aquifer.
Vandalism	Operational and ongoing	There are no practical avoidance options.	Improve site fencing and security measures including the installation of live feed 24 hour surveillance and alarms.

6.1.3 Poly-fluoroalkyl substances (PFAS)

Submitters have raised the following range of concerns in relation to PFAS:

- how and where PFAS has been addressed in the EIS and supporting technical reports;
- clarity on what is meant by the statement *'All analysis for PFAS compounds at bores MW_X1, MW_X2, MW_X7 and GW4 reported no concentrations above the laboratory limit or reporting between January and June 2018'*. (8.3.2);
- the source of PFAS contamination in Williamstown;
- the proximity of the project area/site to the "red zone"; and
- a lack of detail as to how the project would affect communities adversely impacted by PFAS contamination.

EIS and technical reports

Several submissions have made comments that PFAS was not discussed in the EIS or supporting technical reports.

PFAS was discussed within the context of the project site and the proposed development, in the exhibited EIS and the supporting technical reports in the following sections:

- section 8.3.2 of the EIS discusses Groundwater quality reporting and PFAS;

- PFAS levels and contamination was discussed in the *Executive Summary* of the Hydrogeological report in the context of the Conceptual Site Model that was developed to consider the flow of groundwater and hydraulic connectivity between groundwater sources;
- section 8.7.3 of the Hydrogeological report (Appendix H of the exhibited EIS) discusses comparison of data to water quality criteria (including discussion of PFAS);
- section 8.8 of the Hydrogeological report contains a discussion of Groundwater usage and receptors; and
- Table 18 of the Hydrogeological report contains laboratory results for PFAS concentrations in groundwater.

The discussion of PFAS is limited, as the Boral's land including the project area are located outside the PFAS Management zone. As established in Table 18 of the Hydrogeological report (and discussed in the section below) PFAS levels in the groundwater below the site are within appropriate limits and in fact below laboratory detection levels.

Laboratory limits of PFAS detection

One submission would like to understand what is meant by the following statement made in relation to outcome of PFAS concentrations detected in the groundwater:

All analysis for PFAS compounds at bores MW_X1, MW_X2, MW_X7 and GW4 reported no concentrations above the laboratory limit or reporting between January and June 2018'. (8.3.2)

The reference to the "laboratory limit" is taken from the hydrogeological report contained in Appendix H of the exhibited EIS. In the Hydrogeological report this statement reads as follows:

No per-or poly-fluoro-alkyl substances (PFAS) were recorded above the laboratory limit of reporting (LOR) for the monitoring period (January – June 2018), which supports the conceptual model (CSM) for the site that it [the Stockton quarry and Groundwater Source] lies in a separate groundwater (and surface water) catchment to the Williamstown RAAF Base.

The laboratory limit of reporting (LOR) refers to the minimum concentration at which an analyte may be reliably detected by a laboratory in any given sample. In this instance, Table 18 at the end of the Hydrogeological report contains details of the 22 samples collected and tested for PFAS in 2018. All samples tested returned concentration levels <0.01milligram/litre. As such, the LOR in this instance, would be below 0.01 mg/L.

For context, it is noted that the acceptable level of PFOA/PFOS in drinking water is 0.07 mg/L and 0.56 mg/L respectively. Accordingly, the detected PFAS levels in groundwater at the project site are within, and in fact well below, an acceptable range and do not present as a potential issue for human health within this area of the Stockton Groundwater Source.

Source of PFAS

One submission has commented on the source of PFAS (linked to the use of firefighting foam on Williamstown RAAF base) contamination in the groundwater was the result of exposure of the underlying aquifer through the establishment of “Lake Cochrane”.

The matter of PFAS contamination in the Tomago and Stockton Groundwater Sources associated with the Williamstown RAAF Base is not a matter for Boral to comment on. Boral notes Lake Cochrane was a secondary source (AECOM ESA (2017), p. 27) for the migration of PFAS into the underlying aquifer with contamination likely the result of the Lake being used for the purposes of a surface drain stormwater management and detention basin (DoD, July 2016; Lake Cochrane Fact Sheet). This is a markedly different situation to the exhibited project.

Unlike the RAAF Base, Boral has limited use of fuels and chemicals on site, and none of these materials contain PFAS. Where fuels are to be used, the areas will be bunded in accordance with industry standards to ensure suitable protection of the underlying sand bed and aquifer.

Boral has a network of groundwater monitoring bores located on site. Data from the bores is collected monthly and tested for a range of analytes aimed at ensuring on going water quality objectives are maintained. Monitoring of groundwater quality includes PFAS as a precautionary measure (noting that the project is outside the tiered management zones). To date there have no recordings of PFAS contamination.

Proximity to the PFAS Management Zones

Several submissions have raised the proximity of the project site to the “PFAS red zone”.

A risk management hierarchy has been established by the Department of Defence through a detailed Human Health Risk Assessment published in 2017. This report adopts four tiers of “risk zone” in relation to the PFAS contamination, exposure risk and management. Boral has interpreted references to the PFAS “red zone” as a reference to Risk Zone A.

The project site is located approximately 3.90 kilometres (km) from “Risk Zone A” and outside all mapped risk zones. The location of the site beyond the relevant management zones means that it is not subject to any restrictions.

Boral’s monthly monitoring of groundwater for PFOS/PFAS levels has consistently returned levels below laboratory detection, meaning that they are below levels associated with a potential to impact on human health.

Uncertainty and risk

Two submissions raised uncertainty and risk associated with the extraction and use of groundwater within the primary management zone of the PFAS impact. The submitters were concerned that the potential impacts cannot be accurately determined.

Boral's land is located outside all management zones in relation to the PFAS plume. Detailed modelling of the groundwater zone has been undertaken by EES. The modelling report is provided at **Appendix E** to this report. The outcome of detailed modelling indicates that there is low likelihood of project contributing to or exacerbating migration of the PFAS/PFOS plume due to the separation between the Tomago and Stockton Groundwater Sources. The potential effects of the project on the PFAS plume is considered in **Appendix F**.

6.1.4 Demand and water balance

Several submissions have raised questions regarding the project water and management combined with the total water demand associated with the project.

Water source and management

One submission asked how the sand is “washed” and the source of the water that may be used in the process.

Boral proposes a suction dredge that uses a suction tube to extract a sand/water mix. Water that is removed as part of the initial extraction is also used to “wash” sand through the plant prior to being returned to the aquifer by a constructed drainage and settling pond.

Water extracted by the dredge would also be used in the washing process, therefore there is no additional water demand.

As set out in **section 5.2.1** of this RtS, a further detailed review of the water balance has been undertaken to consider what “incidental” take may occur in the process of dredging and washing sand for dispatch.

Project water balance

The EIS provides a breakdown of the maximum water demand for the project associated with the dredge with respect to water lost to evaporation and as moisture content. This has been further reviewed and refined as part of the RtS process and following discussions with DPIE Water and the Natural Resource Access Regulator (NRAR) who have advised that in the absence of a “return of waters policy” adopted under Division 5, Sections 75 and 76 of the *Water Management Act 2000* all water extracted in the process of dredging must be considered as water “take”. The project water demand/balance is provided in section **5.2.1**.

Project water use

Questions were raised in the submission regarding how water will be used on the site.

Table 11 sets out the range of uses for water on the site and across the project, combined with the source of the water.

Table 11: Summary of water demand and use

Intended water source	Water use
Rainwater collection tanks	Amenities and ablutions Firefighting
Third party supplied water (tanked water and purified water)	Dust suppression*; and Drinking water (purified water bottle and dispensers in office and amenities building).
Groundwater	Dredge and processing operations including washplant. Evaporation and moisture content (3 -5 per cent) in product (i.e. extracted sand).

*subject to sufficient availability of water entitlements Boral may consider reusing water extracted for processing in dust suppression activities.

6.1.5 Relationship to other water users

Several submissions have raised concern regarding the potential impact of “wet extraction” methods on the other groundwater users in the area. One objection in particular raised concern regarding the use of water for the purposes of supporting an extractive industry over alternative land uses specifically the Newcastle Golf Course.

The project site is located above the Stockton Groundwater Source. Water extraction and use is regulated through the *Water Management Act* (WM Act) and subsidiary legislation including the North Coast Coastal Sand Water Sharing Plan (WSP).

Under the provisions of the WM Act and the WSP, water is “shared” between the environment and a hierarchy of uses including domestic and commercial users. As at October 2020, the NSW Water registry indicates that the Stockton Groundwater Source has issued licences or water supply work approvals for the permitted water users:

- 171 registered bores allowing associated with “basic rights” water use (i.e. domestic and stocking).

- 35 water access licences – allowing for use of water for commercial purposes. Notably three WALs (including Boral’s licence) are “zero share” licences. The remaining 32 licences have access to a total of 1,037.5 allocated water shares. **Table 12** provides an overview of water supply work and water purposes to which these WALs are linked; and
- No determinations of Native Title Rights have been made in relation to the Stockton Groundwater Source.

Table 12: Summary of registered bores: Stockton Groundwater Source

Authorised purpose	Water use
Basic Rights (Stock and Domestic)	171
Basic rights (Native Title)	0
Farming and Irrigation	8
Irrigation	8
Grape vines	1
Recreation	1
Dewatering	2
Not specified	10
Expired	2

Currently under the relevant WSP, a total of 14,000 unit shares are allocated for extraction and use. At present only 7.4 per cent of potential water shares are allocated and active within the water market. If Boral’s maximum water take is considered in this figure, only 16 per cent of the water source would be allocated. Leaving a considerable proportion of the groundwater source available for other users.

The release of unit shares is controlled by Water NSW and the current lack of availability has been driven by successive years where no controlled allocations orders have been made for the Stockton Groundwater Source. This action has effectively “locked up” the water entitlements and driven up the cost of market available water.

Boral has reviewed all known water access licences (WAL) and notes that Newcastle Golf Course does not appear to have a registered WAL or associated water supply work. Like Boral, the golf course can seek to purchase water shares from a current holder through the market

supply mechanisms including, water trades, water leasing or registering for notice of controlled allocations.

Fundamentally, increasing the availability of groundwater for commercial and industrial users, who are not entitled to basic user water rights, is subject to the relevant regulatory body making available the necessary credits through annual controlled allocations.

6.1.6 Quality of the assessment

One submitter is of the view that the hydrogeological report has not accurately reported the nature of the aquifer or the impacts of the project. Specifically, the submitter has raised concern that the report:

- states that the aquifer does not flow to Fern Bay and raises concern that the assessment is flawed;
- has relied on historical data from 1992 and 1995 inform the aquifer baseline profile; and
- presents opinions as opposed to a critical analysis of facts.

Each of the matters raised in considered in turn below.

Aquifer extent and groundwater flows

The directional flow of water within the aquifer is influenced by natural site characteristics including topography and geology. This natural directional flow of water will not be altered by the project and the rate of extraction will not alter the static water levels to affect the availability of water for other users accessing the groundwater source.

Use of historical data

The use of historical data in defining baseline environmental conditions is an accepted industry practice. Historical data provides the basis for establishing a trend series that allows current and recent data to be validated.

Boral has undertaken further and additional modelling of the aquifer to include the development of numeric class 1 model in accordance with the provisions of the NSW Aquifer Interference Policy (AIP). This model has incorporated data collected from the sites established bore network over the past 12 – 18 months. The modelling report is provided in **Appendix E**.

Opinion vs fact

The Hydrogeological Report was prepared by an appropriately qualified and experienced hydrogeologists. Boral notes but disagrees with the comments of the submitter.

6.1.7 Availability of water allocations

One submitter raised concern regarding the lack of available water allocations to support project. This availability of water entitlements is addressed in **Section 5.2.2**.

6.2 Planning Framework and Assessments

The following section responds to submissions that raised matters relating to the planning framework, including consistency with legislation, strategic planning directions, and planning instruments.

6.2.1 Consistency with Strategic Planning Directions

Several submissions have made comment that they do not believe the project is consistent with the directions of the Hunter Regional Plan, specifically:

- Direction 14: *Protect and connect natural areas*
- Direction 15: *Sustain water quality and security*

Direction 14 was considered in Volume 1 of the Response to Submissions lodged in September 2020.

Direction 15: Sustain water quality and security

Direction 15 is aimed at managing and protecting available water resources across the region. The project has been designed to ensure the protection and preservation of water quality. The use of an electric suction dredge, with low water demand, aiming to return 92 per cent of water extracted through dredging ensures minimal water loss from the environment.

Boral's site is located over the Stockton Sandbed Aquifer, water allocations for this source are guided by the rules set out in the North Coast Coastal Sands Water Sharing Plan (the WSP). The WSP identifies a possible total water share allocation of 14,000ML, of which just over a 1,000ML is currently available in the market. With the introduction of the *Water Management Act 2000* and the adoption of the WSP, the former moratorium on the release of entitlements implemented through the *Water Act 1912* is no longer valid. This enables the "reallocation" water shares to meet industry demand, in line with the *Strategy for the controlled allocation of groundwater* (Department of Primary Industries, Water; May 2017).

6.3 Rehabilitation and final landform

Two public and community group submissions raised matters relating to rehabilitation of the land. The issues raised within this category were largely matters requiring clarification or matters requiring a response from DPIE.

6.3.1 Rehabilitation commitments

One submission considers the following statement to be misleading:

The Stockton Transgressive Dune Quarry Rehabilitation and Landscape Management Plan will be updated to reflect biodiversity management measures to protect and manage biodiversity values.'

Boral notes the comment. The submission has elected to focus on only one dimension of biodiversity values and ecosystems. Aquatic environments and riparian fringes play a vital role in contributing to biodiversity and biological systems. The rehabilitation strategy has been expanded to consider and include these facets of the final landform, refer to **Appendix C**.

6.3.2 Rehabilitation/remediation assurances

One submission has raised concern regarding the reliability of “mining companies” in rehabilitating excavation voids and sites.

Boral would like to correct statements that refer to the project as a “mine”. The project does not involve the extraction or use minerals of any kind and as such is an “extractive industry” colloquially referred to as a “quarry”. The project does not involve mining of any kind.

Boral notes the comments. However, as the same submitter has also pointed out the site reflects a positive rehabilitation outcome demonstrated by the presence of established and thriving vegetation in the footprint of the former operation, we refute the inference that proponents and operators cannot be relied on to responsibly remediate, rehabilitate or manage land properly post consent.

6.3.3 Enforcement of rehabilitation

One submitter raised concern regarding enforcement of rehabilitation conditions. Boral is typically required to report annually to DPIE in relation to the compliance with conditions of a development consent. Matters relating to the perceived efficacy of enforcement is not a matter for Boral to comment on.

6.3.4 Practicality of the final landform

Several submissions have raised practical concerns regarding the final landform, as an open lake/pond. Principally these concerns

- How the lake would be filled with water and the duration of time this would take;
- The efficacy of achieving aquatic plant life in a deep water environment; and
- The attractiveness of the final landform to native fauna (i.e. birdlife that prefer shallow water environments).

The final landform will involve an open wetland environment. This wetland is the result of an exposed aquifer and will not require the pumping of additional water to backfill the “void”. Water extracted through the dredging process is not “removed” permanently from the aquifer but is returned with negligible loss to the system.

The edges of the pond will be battered at a gradient of 3:1, which is the natural angle of repose for sand material. This graduated embankment will allow for the establishment of edge planting with only a limited extent of the extraction area dredge to RL-15 metres.

A rehabilitation strategy has been prepared that considers terrestrial and aquatic outcomes and is provided at **Appendix C**.

6.3.5 Final landform: lake vs pond

One submitter expressed concerned that the EIS refers to the resultant wetlands as a “pond” due to its size and would rather it be referred to as a lake.

Boral acknowledges the comment. However, the term used to describe the final landform does not alter the veracity of the assessment documents.

7 Conclusion

The RtS (volume 2) report provides a comprehensive response to the Government Agency, Industry and community submissions received in response to the exhibition of the EIS relating to and extenuating from ground and surface water.

The process of review that has occurred because of the response to submissions process has not resulted in any substantial amendments or revision to the project approach or methodology requiring re-assessment of any matters.

A class 1 model in accordance with the requirements of the Aquifer Interference Policy has been developed to better understand and quantify and potential impacts that may arise as a consequence of the project. Modelling was undertaken to specifically identify any long term impacts of the proposed expansion activities on nearby sensitive receptors and confirm the risk status of the project with respect to impacts on ecosystems and groundwater resources.

The model indicates that the creation of a dredge pond and end-point rehabilitation to a freshwater lake/ wetland is not predicted to alter the hydrogeological regime of natural movements of groundwater, nor groundwater chemistry, from current conditions. As such, EES concluded that the proposal has a low overall level of risk of impact on nearby groundwater dependent ecosystems (GDEs) and other potential receptors (e.g. recreation, fishing, stock-watering).

Based on the outcome of the review and the additional technical work completed, the EIS where supplemented and revised by this report and its appendices are considered to demonstrate a high value project with a low likelihood of adverse environmental impact.

The development will secure an additional 9 million tonnes of sand resource for use in the building and construction sectors, locally and throughout the region and wider State. The continued and sustained demand for sand and sand related products is critical in supporting key industries in the recovery of the economy and in supporting the continued growth of the region.

APPENDIX A Submission matrix (amended)

APPENDIX B Final landform plans

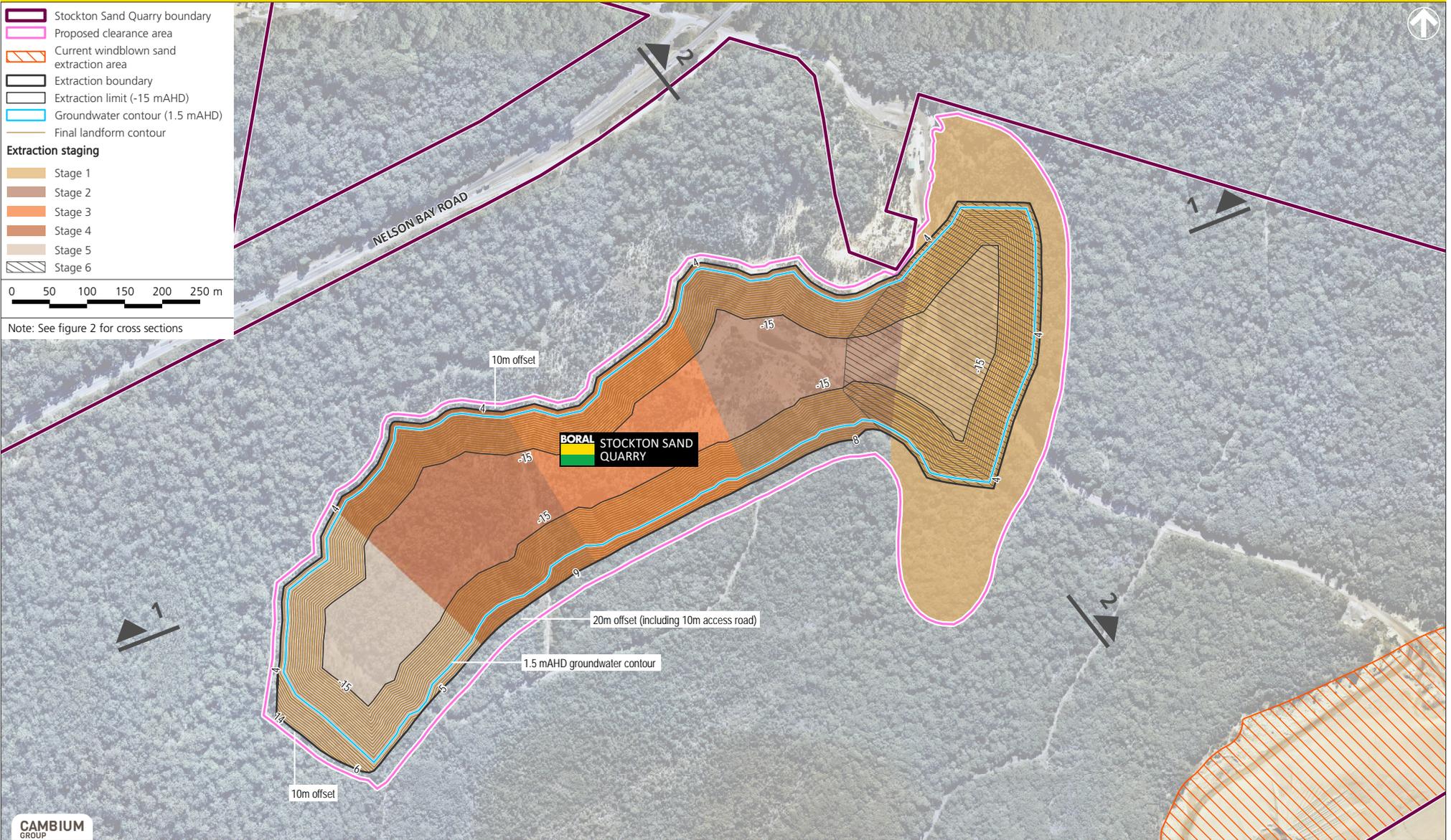
Figure 1
Final landform

Stockton Sand Quarry Dredging | Environmental Impact Statement

- Stockton Sand Quarry boundary
 - Proposed clearance area
 - Current windblown sand extraction area
 - Extraction boundary
 - Extraction limit (-15 mAHD)
 - Groundwater contour (1.5 mAHD)
 - Final landform contour
- Extraction staging**
- Stage 1
 - Stage 2
 - Stage 3
 - Stage 4
 - Stage 5
 - Stage 6

0 50 100 150 200 250 m

Note: See figure 2 for cross sections



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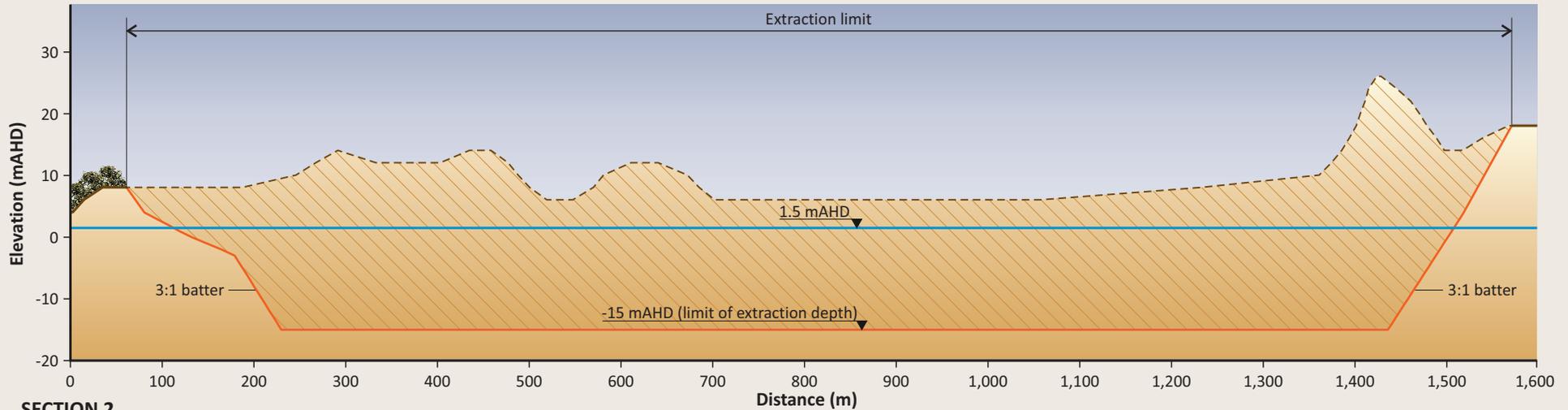
Figure 2
Sections

Stockton Sand Quarry Dredging | Environmental Impact Statement

SECTION 1

South west

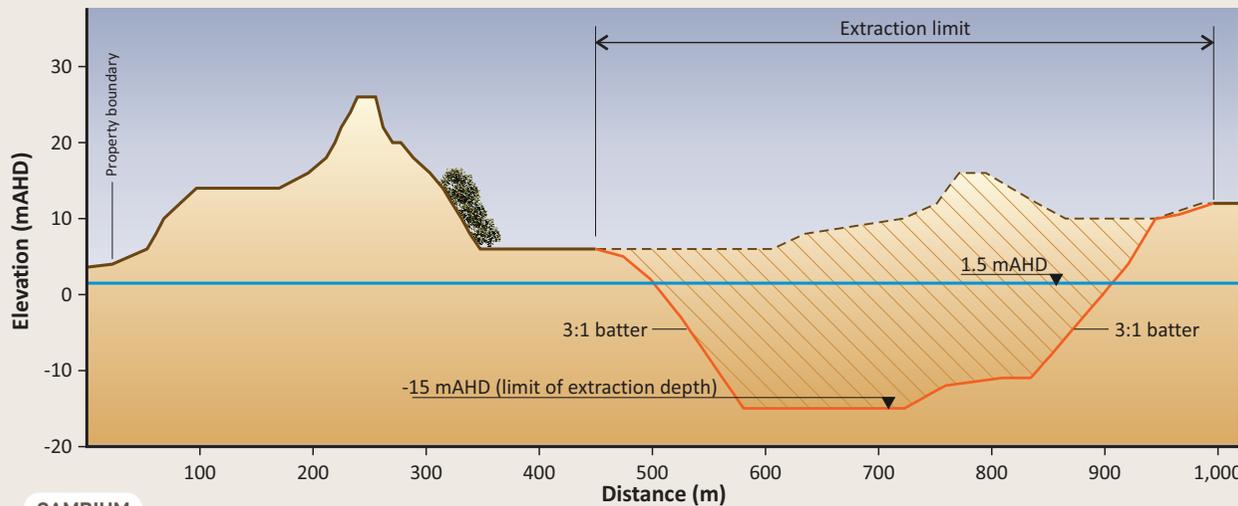
North east



SECTION 2

North west

South east



- 2018 surface
- - - Former 2018 surface
- Final pit design
- Groundwater level (average water table height)
- ▨ Extracted material

(Vertical exaggeration 1H:5V)

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APPENDIX C Rehabilitation strategy (amended)



**ENVIRONMENTAL EARTH
SCIENCES**
CONTAMINATION RESOLVED

**REHABILITATION STRATEGY FOR
STOCKTON SAND QUARRY
DREDGING, COXS LANE,
FULLERTON COVE, NSW
BORAL RESOURCES (NSW) PTY LTD**

24 NOVEMBER 2020
717041
VERSION 3



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1 INTRODUCTION

Boral Resources (NSW) Pty Ltd (Boral) owns and operates the Stockton Sand Quarry (hereafter referred to as the 'site' or the 'quarry'), a long standing operation that currently extracts sand from the windblown (transgressive) sand dunes of Stockton Bight and has consent to transport up to 500,000 tonnes of sand product per year for use in the building, landscaping and construction sectors.

Due to current and future demand for sand in the Hunter and Sydney regions, Boral is seeking approval for continued and expanded operations at the site through a State Significant Development (SSD) development application. The proposed development (hereafter referred to as the 'Project') involves the extraction of sand from the inland vegetated dunes by front-end loader/excavator to a depth of 4 metres (m) Australian Height Datum (AHD) in Stage 1 and subsequent dredging from 4 m AHD to 15 m below sea level (-15 m AHD) for Stages two to six (inclusive).

The Project would seek to permit a site wide increase on the dispatch limit to 750,000 tpa (i.e. the windblown sand extraction area and the Project operations combined) up until 2028 after which the site wide limit would reduce to no more than 500,000 tpa. The Project would be for a period of up to 25 years, subject to demand of sand resources.

Once sand extraction works have concluded, the Project will require rehabilitation and revegetation. In the initial phases of work, rehabilitation will primarily aim to stabilise the edge of the lake and where necessary to prevent wave action induced erosion at the lake edge. Stabilisation of the lake edge during active sand extraction is to be addressed in the erosion and sediment control plan and is outside the scope of this rehabilitation plan.

On completion, the Project site will be left as a freshwater lake and rehabilitation efforts will generally maintain and manage the lake and the immediate surrounds. This will minimise the potential for erosion and degradation of areas of exposed soils and maintain acceptable water quality. In particular, the management of dissolved oxygen and prevention and management of cyanobacterial blooms will be critical.

1.1 Objectives and scope of works

Environmental Earth Sciences was commissioned by Element Environment, on behalf of Boral, to undertake an assessment of the current rehabilitation works and propose a rehabilitation strategy for the Project (Version 1).

- The objective of Version 2 of the Rehabilitation Plan (Environmental Earth Sciences, 2020b) was to review the current rehabilitation efforts at the site and to formulate a rehabilitation strategy specific to the Project.

Following receipt of stakeholder comments on the original plan (refer Section 1.3), Environmental Earth Sciences was subsequently engaged directly by Boral to provide an update to the rehabilitation strategy (Version 3 – this document).

- The objective of this report is to consider the comments provided by key stakeholders and provide an updated rehabilitation strategy to ensure that specific concerns raised by stakeholders, particularly in relation to long term water quality are adequately addressed.

1.2 Secretary’s Environmental Assessment Requirements

This rehabilitation plan addresses the requirements of the Secretary’s Environmental Assessment Requirements (SEARs) for land rehabilitation for the Project. The SEARs are:

Rehabilitation – including the proposed rehabilitation strategy for the site having regard to the key principles in the Strategic Framework for Mine Closure, including:

- *rehabilitation objectives, methodology, monitoring programs, performance standards and proposed completion criteria;*
- *nominated final land use, having regard to any relevant strategic land use planning or resource management plans or policies; and*
- *the potential for integrating this strategy with any other rehabilitation and/or offset strategies in the region.*

The following Table (**Table 1**) lists the requirements of the SEARs against the locations in the rehabilitation plan.

Table 1: Requirement of the SEARs

SEARs	Location in rehabilitation plan
Rehabilitation objectives	Section 4 – Rehabilitation considerations
Rehabilitation methodology	Section 6 – Rehabilitation Management Plan Updates
Rehabilitation monitoring programs	Section 6.4 – Rehabilitation Inspection Schedule
Rehabilitation performance standards	Sections 3.4 and 6.5 – Rehabilitation Performance Criteria
Proposed completion criteria	Section 6.6 – Proposed Rehabilitation Completion Criteria
Nominated final land use	Section 2.2.4 – Proposed Final Land Use
Integration of rehabilitation strategy	Section 5 – Integration of Rehabilitation with Previous Works

1.3 Stakeholder comments

Environmental Earth Sciences previously prepared a rehabilitation plan in support of the Project application. During the public exhibition period, a number of submissions were received from key stakeholders including local council, government agencies and the local community, namely:

- Port Stephens Council (PSC);
- Department of Planning Industry and Environment (DPIE) – Planning Secretary;
- DPIE and Natural Resources Access Regulatory (NRAR) [combined response]; and

- DPIE Biodiversity and Conservation division (BCD) and NSW National Parks and Wildlife Service (NPWS) [combined response].

These responses raised specific concerns in relation to the project, specifically relating to the rehabilitation strategy proposed for the former dredge pond. A summary of these concerns cross-referenced to the section of the rehabilitation strategy where they are addressed, is provided as **Table 2** below.

Table 2: Stakeholder comments and responses.

Stakeholder	Comment		Location in rehabilitation plan
DPIE – BCD	1	The proponent should develop a final landform map, showing the expected footprint of the dredge pond, including different depths within the pond (such as the limit of the -15 m AHD extraction).	Figures 3 to 5
	2a	The proposed strategy to rehabilitate the dredge pond to a freshwater wetland should be reconsidered.	N/A
	2b	If the proponent decides to pursue this strategy, it should detail how wetland conditions can be established in such a deep environment and any rehabilitation activities required to achieve this.	Section 4 – wetland conditions Sections 5 to 6 – rehabilitation activities
	2c	The proponent should also detail any long-term management measures that will be implemented to ensure the pond is not degraded by pests, degrading water quality or other issues.	Section 4, Section 5 and Section 6
	3	The proponent should develop rehabilitation success criteria and objectives that are relevant to the dredge pond. This should cover the establishment of appropriate biological functions in the pond and the long-term management of issues such as aquatic pests and water quality.	Section 6
	4	The proponent should develop and implement a long-term water quality monitoring program for the dredge pond that includes a trigger action response plan if long term or immediate declining water quality is detected.	A long-term water quality monitoring and management strategy (incorporating a combined inspection, in-situ monitoring and laboratory analytical program) is to be developed as part of the post consent requirements following any approval. Specific details are not provided within this rehab plan.
DPIE	1	Please ensure that you carefully consider and respond to BCDs request to provide further assessment of the dredge pond final landform and rehabilitation strategy.	Refer Items 1 to 4 above
HWC	-	No specific reference to the rehabilitation strategy.	-
PSC	-	-	-

Notes:

NSW DPIE: New South Wales Department of Industry and the Environment,
BCD Biodiversity and conservation division
HWC: Hunter Water Corporation
PSC: Port Stephens Council

2 EXISTING ENVIRONMENT

2.1 General

The Stockton Sand Quarry is located in Fullerton Cove, approximately 9.8 kilometres (km) north north-east of the Newcastle Central Business District (CBD), within the Port Stephens Local Government Area (LGA) (**Figure 3**). Access to the site is via Nelson Bay Road and Coxs Lane.

The site owned and operated by Boral covers an approximate area of 246 hectares, comprising:

- Lot 1 DP 1006399, comprising 234 hectares and located predominantly on the eastern side of Nelson Bay Road;
- Lot 2 DP 1006399 comprising 10.4 hectares and located predominantly on the western side of Nelson Bay Road, with a small portion also positioned on the eastern side of Nelson Bay Road (formerly Part Lot 167, Part Portion 167); and
- Lot 3 DP 664552 comprising 1.619 hectares and located wholly on the eastern side of Nelson Bay Road, and within which the existing depot and weighbridge are located (formerly within Part Lot 3, Part Portion 3).

Under Boral's ownership there have been two primary development consents granted, these include:

- DA 2010/94: The 'inland extraction area' (also known as pits 1 – 6) granted by Port Stephens Council in May 1996; and
- DA 140-6-2005: The 'windblown sand extraction area' (also known as the "windblown project" or pit 7) located on the transgressive dunes adjoining Stockton Beach granted by the Department of Planning in 2006.

The inland extraction operation on the vegetated dunes occurred above 5 metres AHD and ceased in 2008 and rehabilitation has been ongoing. This former extraction area is generally consistent with the Project site and is the focus of this Development Application.

The windblown sand extraction area started operations in 2008 and in accordance with condition 5 of the development consent has a 20 year life, due to cease in 2028.

A site inspection of rehabilitated areas within the Project site identified that the majority had been revegetated with planted trees. Areas of more recent revegetation had established dense vegetation with young trees and shrubs. Where rehabilitation has been less successful, growth of trees and shrubs remains stunted and areas of open sand remain.

The surrounding natural woodland vegetation was identified to consist predominantly of Swamp Mahogany (*Eucalyptus robusta*) and Coastal Wattle (*Acacia sophorae*), with Beach Fescue (*Austrofestuca littoralis*) and Pig Face (*Carpobrotus glaucescens*) in open areas.

The Project site (identified as 'proposed clearance area' in **Figure 3**) contains all areas to be disturbed by Project operations and covers an area of approximately 37 ha. The area of the dredge pond specifically is approximately 29 ha, of this only 12 ha forms a deep-water pond. The remaining 12 ha will have a graduated embankment at the natural angle of repose of sand (i.e. a batter at a gradient of 3:1).

The Project site is generally consistent with the same disturbance footprint associated with the former inland extraction area approved and rehabilitated under the 1996 development consent, with the exception of areas to east and south east of Lot 3 and along the southern edge to allow for the construction of new haul roads.

2.2 Background

2.2.1 Sand extraction works

Sand from the former inland extraction area was only extracted to 5 m AHD under the original 1996 development consent. The sand resource above 5 m AHD was exhausted in 2007 and in accordance with the conditions of consent the operations have ceased. Progressive rehabilitation has occurred over the life of operations.

The following reports detail the existing and previous rehabilitation and landscape management plans (RLMP) for the site:

- RW Corkery & Co Pty Ltd (2018) *Rehabilitation and Landscape Management Plan for the Stockton Transgressive Dune Quarry*. Prepared for Boral Resources (NSW) Pty Ltd. September 2018.
- Environmental Compliance Services (2017) *Stockton Transgressive Dune Quarry, Rehabilitation and Landscape Management Plan*. Prepared for Boral Resources (Country) Pty Ltd. March 2017
- Environmental Resources Management Australia (ERM, 2010b), *Rehabilitation and Landscape Management Plan, Stockton Transgressive Dune Quarry*, Prepared for Boral Resources (NSW) Pty Ltd. August 2010.

Boral currently extracts sand from the transgressive dunes, referred to as the windblown sand extraction area. Sand extraction on the dunes commenced in 2008 in accordance with development consent DA 140-6-2005. The development consent permits transportation of up to 500,000 tpa of sand products over a 20-year period.

The Project is to be undertaken progressively in six stages, commencing with Stage 1. An overview of the extraction staging plan for the Project is presented in **Figure 4**.

Similar to previous operations of the inland extraction area, sand extraction will involve clearing and grubbing of established vegetation from previous rehabilitation and possible screening of accumulated leaf litter and organic matter. Vegetation will be cleared

progressively to limit the exposure of bare sand. Cleared vegetation will be mulched and reused during rehabilitation works. As vegetation clearance and reuse is progressive, it is anticipated that minimal excess, residual mulch will be generated during site activities and this excess will be taken off-site. Boral is currently in discussion with other business operators including landscaping suppliers to understand demand for mulch as a potential re-use option thereby minimising requirement for disposal as waste. Where no reuse options can be identified, excess material will be disposed offsite to landfill.

Any stripped topsoil will also be retained for use in rehabilitation efforts across the site.

Sand will first be removed via a front-end loader which pushes into the exposed sand face. As the sand is relatively free-flowing, material falls towards the front-end loader at the natural angle of repose.

The sand will then be screened and stockpiled before a front-end loader then loads road trucks in-pit with screened raw sand for transport off-site via the weighbridge.

Following initial extraction of sand above the water table to a depth of 4 m AHD in Stage 1, a pond will then be created in stage 2 large enough to float a dredge and accommodate freshwater pumping for the proposed wash plant.

The dredge will move progressively through the extraction area generally following the nominated stages. In most cases, the sand in each extraction stage is fully extracted unless constraints are encountered.

The dredge will move backwards and forwards across the active dredge pond. The sand / water mix will be pumped directly from the dredge via a pontoon-mounted pipeline to the wash plant in the processing area. The dredge manoeuvres around the pond and its position is stabilised by 'tie ropes connected to the banks around the active pond.

The dredge will then progressively extract sand in a south westerly direction in a staged process. Extraction will then move to the east and culminate with relocation of the proposed processing and stockpile area to a confined area in Stage 1 and subsequent dredging of the majority of the Stage 1 extraction area (to be known as Stage 6).

Sand will be extracted to a maximum depth of approximately 15 m below the sea level (0 m AHD).

2.2.2 Site hydrogeology

A hydrogeological report completed by Environmental Earth Sciences (2020a) details that the standing water level (SWL) rises from approximately 1 m AHD during low rainfall events to 2 m AHD at high rainfall events. Refer to Figures 4 and 5 in the following hydrogeological report:

- Environmental Earth Sciences (2020a), *Hydrogeological Impact Assessment, Stockton Sand Quarry, Cox's Lane, Fullerton Cove, NSW, Element Environment*, dated 19 February 2020 (reference: 717041_V4).

The Project site consists of an area to be disturbed of approximately 37 hectares. A component of the Project includes sand extraction from to a depth of 15 m below the water table (-15 m AHD).

The site is a groundwater recharge zone, and groundwater in the area is fresh. It is therefore expected that the open water body created from the dredge pond associated with the Project will in time form a deep freshwater wetland. The wetland will consist of a lake with a maximum depth of 15 m. There will be a batter of approximately 3:1 sloping up to a shallow area around the edge of the lake (**Figure 5**).

2.2.3 Vegetation management

It is proposed that a screen or buffer zone of native trees remains on site between the Project site and the quarry property boundaries to ensure minimal disruption to the greater community through visual amenity, noise, dust etc.

An offset zone of 10 m is proposed along the northern perimeter of the lake and a 20 m offset zone, including a 10 m haul road, is proposed to the east, south and south west of the lake. The two-way haul road would provide access for routine rehabilitation / maintenance works, and for safety purposes to provide access for fire services etc. The offset zones will require routine management and maintenance throughout the life of the Project.

2.2.4 Proposed final land use

The proposed final land use of the Project site once all operations cease is to create a freshwater wetland consisting of a freshwater lake, with a maximum depth of 15 m deep, with a shallow freshwater fringe colonised by wetland plants around the edge. The wetland will be surrounded by retained coastal woodland established with endemic species.

The edges of the lake would be adequately stabilised and revegetated with suitable groundcover species to minimise the potential for soil erosion.

Conceptual cross sections are provided in **Figure 5** and present approximate schematic drawings of the site following the completion of excavation works.

3 ASSESSMENT OF EXISTING REHABILITATION ACTIVITIES

3.1 General

In order to assess the efficacy of the rehabilitation activities completed (and currently ongoing) at the site, identify areas of potential improvement, and inform future rehabilitation strategies (proposed to be implemented to support site revegetation and establishment of a freshwater pond [wetland] ecosystem) Environmental Earth Sciences completed the following activities:

- Site inspection (7 June 2019) to assess the status of rehabilitation works undertaken in the former inland extraction area.

- The inspection aimed to assess the efficiency of rehabilitation strategies used to date, with consideration of time since rehabilitation and any localised site conditions which may have influenced vegetation establishment. The findings of the inspection were then used to inform recommendations for rehabilitation of the Project site.
- Review of existing, available rehabilitation and landscape management plans with respect to site observations and success (or otherwise) of rehabilitation activities completed at the site to date.
 - The review aimed to identify how the existing, proposed rehabilitation strategies could be improved, framed as recommendations for updates to existing rehabilitation/ landscape management plans.

Details of the site inspection and rehabilitation review findings are provided in Sections 3.2 and 3.3 below.

3.2 Site inspection observations

Environmental Earth sciences conducted a site inspection of rehabilitated areas on 7 June 2019. Rehabilitation activities have generally been successful at the quarry to date. The degree of vegetation establishment largely depends on the duration since sand extraction activities ceased, with the former Pit 1, 2 and 3 areas of the inland extraction area having well established tree cover, while Pits 4, 5 and 6 of the inland extraction area had smaller trees and shrubs. The following observations were made at the time of the site inspection:

- The successful species in rehabilitated areas consisted predominantly of:
 - Trees – Swamp Mahogany (*Eucalyptus robusta*);
 - Shrubs – Coastal Wattle (*Acacia sophorae*);
 - Grasses – Beach Fescue (*Austrofestuca littoralis*); and
 - Ground cover – Pig Face (*Carpobrotus glaucescens*).
- Poor vegetation establishment has occurred in some areas. This has been attributed to:
 - Areas exposed to high winds which disturb surface soil, particularly on elevated slopes;
 - Areas where nutrient deficiency limits plant growth – this has been observed due to utilisation of coal by-product (chitta) for construction of the haul road resulting in depletion the landscape of nitrogen and other nutrients. Areas of ‘pure’ sand are also subject to nutritional deficiencies; and
 - Limited water availability, observed on high exposed dunes, and potentially the cause of poor vegetation establishment over former haul roads due to soil compaction.

- Environmental Earth Sciences was advised by Boral that weed management has progressed from blanket treatment and now focuses on physical removal of re-grown weeds. The noxious weed Bitou bush was not observed during the site inspection.

A summary of the inspected areas is presented in **Table 3** below. Photographs are presented in **Appendix A**.

Table 3: Rehabilitation areas summary

Rehabilitation area Proposed (former)	Observations
Stage 1 Stage 6 (Pit 3)	Photograph 1. Successful revegetation across a large portion of the area, establishment of a variety of tree species and grass understory. Photograph 2. Small area of exposed sand east of haul road. Poor establishment due to windblown sand.
Stage 2 (Pit 6)	Photographs 3 & 4. Areas of poor tree establishment and patchy soil cover. Windblown sand. Rehabilitation more recent in this area.
Stage 3 / 4 (Pit 4)	Photograph 5. Large areas of successful revegetation with young trees and dense shrubs. Photographs 6 & 7. Successful revegetation across the majority of the area. Patchy regrowth in some areas, particularly along a former haul road – attributed to nitrogen deficiency related to use of coal by-product for road construction.
Stage 5 (Pit 2)	Photograph 8. Established trees with shrub understory. Leaf litter layer on ground surface. Photograph 9. Patchy understory and lack of soil cover in small areas within Stage 5.

3.3 Review of current rehabilitation methodology

Based on the findings of the rehabilitation review, and the rehabilitation requirements of the Project, the following recommendations have been made:

- Aspects of the existing rehabilitation process that are considered successful and should continue:
 - Species selection has facilitated establishment of a diverse and robust ecological environment which is representative of local native vegetation; and
 - Weed management has been successful in removing targeted species and preventing infestation.
- Aspects of the existing rehabilitation process that could be improved for future works:
 - Areas subject to high winds, such as elevated dunes, require additional stabilisation to allow vegetation establishment. These areas may also require use of more robust species, such as spinifex to stabilise soil;

- Areas subject to compaction and heavy impact, such as haul roads, may require deep ripping prior to rehabilitation to improve soil water availability and allow root penetration of soil; and
- Targeted application of suitable fertilizer, and/or use of nitrogen fixing plant species may improve plant establishment in some areas.
- Aspects where the intended final landform will change the rehabilitation requirements:
 - The final landform is dominated by a lake (the Lake), which will require bank stabilisation;
 - Suitable aquatic species may be required for revegetation within the aquatic zone; and
 - Species selection should facilitate development of understorey vegetation adjacent to retained coastal woodland community, with low ongoing maintenance.

To assist in the preparation of the rehabilitation strategy for the Project, the following guideline has been referred to:

- NSW Department of Trade and Investment (ESG3) *Mining Operations Plan (MOP) Guidelines*, September 2013.

It is noted, whilst the project does not involve mining, that is, the project is a quarrying operation, this guidance is considered to be a suitable guide to preparing an appropriate rehabilitation strategy.

3.4 Rehabilitation performance criteria

The current performance criteria for the rehabilitation of the final post sand extraction landform are:

- Stabilisation of the disturbed areas with re-established coverage of endemic species of vegetation; and
- Have a landscape function analysis (LFA) level of natural regeneration greater than 50% of the previously assessed National Bushland Control site, located within the quarry property.

4 REHABILITATION CONSIDERATIONS (DREDGE POND)

The proposed final land use of the Project site once all operations cease is to create a freshwater wetland consisting of a deep freshwater lake, with a shallow vegetated fringe. This rehabilitation option is proposed as it will return the site to a passive environment, whilst

maximising the potential for re-equilibration with the surrounding environment (flora and fauna).

Key considerations relevant to this proposed rehabilitation strategy include:

- **Type of wetland** that will establish;
- **Water Quality in the Lake** – acidification/ salinity;
- **Water Quality in the Lake** – nutrients (e.g. cyanobacterial blooms);
- **Flora** (what flora may establish and potential impacts, with particular regard to pest species); and
- **Fauna** (what fauna may colonise the Lake and potential impacts, with particular regard to pest species).

Each item is discussed in greater detail in Sections 4.1 to 4.5 below and summarised in the context of a likelihood risk matrix in **Table 4**.

4.1 Type of wetland

4.1.1 Definition of a wetland

Wetlands are defined under the Ramsar Convention and include a wide variety of natural and human-made habitats. Wetlands include swamps, marshes, billabongs, ponds, salt marshes, mudflats, mangroves, coral reefs, fens, peat bogs, or bodies of water – whether natural or artificial, permanent or temporary. Water within these areas can be static or flowing; fresh, brackish or saline; and can include inland rivers and coastal or marine water to a depth of six metres at low tide. The NSW wetland policy has a similar definition of wetlands (DECCW 2010).

The Ramsar Classification System of wetlands comprises 11 broad categories for marine or coastal wetlands, 20 for inland wetlands, and 9 for man-made wetlands (FAO 2020).

4.1.2 Wetland formation

At the conclusion of the dredging activities, as a result of sand extraction from below the water-table a freshwater wetland comprising a deep-water Lake landform will be formed. The Lake landform will occur naturally as sand materials are progressively removed from below the water-table, leaving behind an open excavation. However, rehabilitation processes including aquatic and emergent vegetation establishment will be required at the conclusion of dredging activities (refer Section 6).

The wetland that will establish will be a freshwater lake, with a surface area of approximately 29 ha and a maximum depth of 15 m. The Lake will be surrounded by a shallow fringe vegetated with native wetland species such as pigface (*Carpobrotus glaucescens*), beach fescue (*Austrofestuca littoralis*), beach spinifex (*Spinifex sericeus*), and common spike rush (*Eleocharis acuta*).

Using the Ramsar wetland classification system (DAWE, 2020) detailed above, it will be a man-made wetland resulting from excavation (type 7) that will have characteristics of a permanent fresh water lake over 8 ha (Type O), and a coastal freshwater lagoon (Type J).

The proposed Lake meets the International definition of a wetland (FRC Environmental, 2020)¹.

4.2 Water Quality – acidification/ salinity

Water quality in the Lake is likely to reflect the current characteristics of the groundwater underlying the site, slightly modified by rainfall and runoff from the surrounding catchment, although it is noted run-off is likely to be minimal due to the highly porous (sand) environment.

The dredging operation itself is deemed unlikely to significantly influence water quality at the site, merely increasing the potential for direct recharge via rainfall.

Based upon over 12 years' worth of data (Environmental Earth Sciences, 2020a) groundwater at the site has been demonstrated as relatively consistent with a pH varying between 6.0 to 8.0 and an average salinity of between 330 to 805 $\mu\text{S}/\text{cm}$ (seawater is approximately 55,000 $\mu\text{S}/\text{cm}$). Therefore, there is a low risk of adverse chemical changes associated with salinity and/or acidity (as a result of potential acid sulfate soils [PASS]).

Specifically:

- In most areas there was a low risk from Potential Acid Sulfate Soils (PASS). Further, there is high alkalinity and acid buffering capacity throughout the site (Environmental Earth Sciences, 2019), so the water in the lake is unlikely to be influenced by PASS; and
- While there are high spikes in salinity, this is associated with significant rainfall events and is likely due to rainwater flushing relict salinity out of the sediment above the water table (Environmental Earth Sciences, 2020a). Despite these spikes salinity is significantly below that of seawater, and the groundwater is predominantly fresh (Environmental Earth Sciences, 2020a).

4.3 Water Quality – nutrients and turbidity

While operation of the dredge may locally increase the turbidity of the water, the sediment to be disturbed is sand (Environmental Earth Sciences, 2020a), which will quickly settle out of the water column once the disturbance ceases. Impacts to turbidity due to dredging would be short term.

The sediment to be disturbed has very low fertility and is unlikely to have any contaminants (Environmental Earth Sciences, 2020a). Consequently, water quality is unlikely to be negatively impacted during dredge operations, other than short term impacts to turbidity.

¹Regardless of their depth, all lakes are considered to be wetlands (Ramsar 2016).

The concentration of nutrients (NH_4 , NO_3 , PO_3) in the groundwater (Environmental Earth Sciences, 2020) were above the Australian Water Quality Guidelines (AWQG) guideline values for freshwater lakes in south east Australia (ANZG, 2018) and the NSW guidelines for freshwater lakes in the Hunter catchment (DECCW, 2006).

The surrounding catchment is small, will be vegetated with native vegetation and the sediment is highly porous. Consequently, any runoff is likely to be low in volume compared to the capacity of the lake, and low in nutrient concentration. While water birds may use the lake, and increase nutrient input, there is limited habitat for water birds around the shoreline, and considering the large volume of the lake, this is not likely to result in a significant increase in nutrients.

Water clarity in the Lake is likely to be high (i.e. low turbidity) due to the coarse nature of the sediment, and the depth of the Lake. Any sediment that is disturbed is likely to settle quickly.

High concentrations of nutrients enhance the growth of primary producers, including phytoplankton, cyanobacteria and algae. If these populations bloom, the decay can lead to low dissolved oxygen concentrations and increased nutrient levels in the water. In extreme situations, this can result in fish kills.

Cyanobacterial blooms are a common issue in constructed lakes. Cyanobacteria often bloom because these lakes are:

- often stratified, with stratification increasing the availability of phosphorus and favouring cyanobacteria, which can float or adjust buoyancy levels
- often poorly mixed, with the growth of cyanobacteria inhibited by well mixed conditions
- have low ecological complexity and a paucity of zooplankton and fish that graze on the cyanobacteria
- nitrogen (as opposed to phosphorus) limited, with some species of cyanobacteria overcoming nitrogen limitations by fixing atmospheric nitrogen, and
- typically have high concentrations of nutrients and high turbidity.

The concentration of **chlorophyll a** is an indicator of the concentration of phytoplankton and cyanobacteria in the water.

The water in the lake is likely to be relatively fresh, slightly low pH, and with moderate concentrations of nutrients. While the concentration of dissolved oxygen in surface waters of the lake is likely to be high, the lake is relatively narrow and deep. As a consequence, wind mixing of the water is likely to be low and there is a risk water in the lake may stratify, with lower concentrations of dissolved oxygen at depth. Monthly water quality monitoring to at least 3 years after establishment of the final lake form will establish whether or not the lake is likely to stratify.

If the lake stratifies and the percent saturation of dissolved oxygen at depth falls below the trigger level, the lake will be destratified using a destratification pump or similar.

4.4 Lake flora

The lake is isolated, with no hydrological connectivity to other waterways. Consequently, the communities that establish in the lake are likely to be of low diversity.

The nearest freshwater ecosystems are groundwater dependent ecosystems (GDEs) are to south-east (seaward) and north-west (inland) of the proposed works. The seaward GDEs consist of small ephemeral and mobile shallow deflation basin ponds, vegetated with a variety of grasses, sedges and reeds, that provide ephemeral habitat for invertebrates and other species (ERM, 2005). The inland GDE's are primarily swamp forests in the dune swales and low-lying heath i.e. there is little standing water in these GDEs.

Freshwater aquatic plants can be divided into three broad groups:

- emergent vegetation with roots in the sediment and plant material emerging above the water surface;
- submerged vegetation; and
- floating vegetation.

The shallow surrounds of the Lake will be planted with a mixture of native emergent wetland species, that can tolerate inundation (**Table 5**). These plants, once established in the shallow water will spread to deeper water, with plants such as *Lepironia* able to colonise water up to approximately 2 m deep. Planting in shallow water and allowing colonisation to deeper water has a higher rate of success than planting seedlings directly into deeper water. Growth of these plants will stabilise the edge of the lake and assist in preventing erosion.

Weeds and other native species typical of coastal freshwater wetlands may also colonise from nearby areas, via airborne seeds or birds. However, given the distance to other similar waterbodies, this risk is considered to be low to moderate.

The deeper water of the lake will not be planted with vegetation, rather, native species will be allowed to colonise. It is unlikely rooted submerged aquatic plants will establish in the deeper section of the lake, however some, such as hornwort (*Ceratophyllum demersum*) and watermilfoil (*Myriophyllum* spp.), may establish in areas that are less than approximately 4 m deep. Some floating plants such as *Azolla* and duckweeds (*Lemna*, *Wolffia* and *Spirodella* spp.) are also likely to establish on the surface.

Aquatic weeds that may establish include water hyacinth (*Eichhornia crassipes*), Cape waterlily (*Nymphaea capensis*), and *Salvinia molesta* (Sainty and Jacobs 1981, after FRC Environmental 2020). Cape waterlily would be limited to water less than approximately 3 m deep, while water hyacinth and *Salvinia* float on top of the water. Weeds are unlikely to establish in water over 5 m deep, due to the distance from source material, and the limited number of species that grow in these conditions.

Weeds will be managed according to a project-specific Vegetation Management Plan.

Phytoplankton, cyanobacteria and potentially filamentous algae are likely to colonise the water body.

The Lake has a moderate to high risk of having phytoplankton or cyanobacterial blooms due to likely nutrient levels, likely poor mixing due to the depth of the Lake and as colonising faunal communities are likely to have low ecological complexity. Phytoplankton or cyanobacterial blooms will be monitored and managed accordingly (refer Section 6).

4.5 Lake fauna

Aquatic insects that have an adult terrestrial phase are likely to colonise relatively quickly (e.g. flies, mosquitoes, dragonflies). Microcrustaceans (e.g. cladocerans, ostracods, copepods) may slowly colonise, for example via water birds. Macrocrustaceans (e.g. freshwater prawns and yabbies) are unlikely to colonise the Lake.

Mosquitoes and biting midges may breed in shallow and intermittently wet areas around the foreshore of the Lake. However, as the Lake is distant from residential areas, these pest species are considered a low risk to human health and are not considered further in this management plan.

Zooplankton communities are likely to be relatively slow establishing in the Lake and of low species diversity.

Without hydrological connectivity, fish communities in the pond are also likely to be slow to establish, and of low diversity. Eggs of some species, such as Agassiz's glassfish (*Ambassis agassizii*), that lay eggs in freshwater vegetation, may be carried to the Lake by birds.

Other fish that could survive in the pond such as longfin eel (*Anguilla reinhardtii*), common jollytail (*Galaxias maculatus*), striped gudgeon (*Gobiomorphus australis*), and firetail gudgeon (*Hypseleporis galii*) (Morris *et al.* 2001, Allen *et al.* 2004, NSW BioNet Search 2020, after FRC Environmental 2020), are highly unlikely to be dispersed to the pond.

Common exotic fish species in the region include gambusia (*Gambusia holbrooki*), carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*). Given the lack of hydrological connectivity the risk of these species colonising is very low, however there is a risk that over time they may be introduced. For example, carp lay sticky eggs, sometimes in shallow water, that may be carried to the Lake by birds. However, as food sources within the Lake are likely to be low, it is unlikely they will proliferate.

Water birds are also likely to use the wetland, particularly the shallow vegetated edges. While they may contribute nutrients to the lake, no management of water birds is proposed. The concentrations of nutrients in the lake, along with the percent saturation of dissolved oxygen will be monitored and managed (refer Section 6 below).

Table 4: Key rehabilitation considerations freshwater Lake landform – Stage 6)

Risk	Risk description	Likelihood of impacts		Summary of monitoring/ management measures (refer Section 6.2 to 6.6)
		Likelihood	Rationale	
Salinisation	Significant increase in salinity beyond natural ranges	Low	>12 years of monitoring data indicates groundwater salinity is relatively stable. Minor peaks associated with significant rainfall events.	Ongoing monitoring (EC and TDS) and response actions as per long-term WQMP
Acidification	Acidification of lake as a result of oxidation of PASS	Low	>12 years of monitoring data indicates groundwater salinity is relatively stable and non-acidic. Minor risk associated with PASS identified. However, significant buffering capacity evidence therefore acidification unlikely.	Ongoing monitoring (pH) and response actions as per long-term WQMP
Stratification	Stratification of oxygen layers within deep pond landform due to inadequate vertical mixing	Moderate	Common issue in narrow, deep lakes that are poorly mixed by the wind.	Ongoing monitoring (DO) and response actions as per long-term WQMP, (including destratification as necessary)
Eutrophication	Nutrient concentration of the groundwater is above guideline levels for freshwater lakes. Increases in nutrient concentration could lead to eutrophication	Low	The surrounding catchment is small, will be vegetated with native vegetation, and the sediment is highly porous. Consequently, any runoff is likely to be low in volume compared to the capacity of the Lake, and low in nutrient concentration.	Ongoing monitoring (site inspections) Water quality sampling Erosion/ sediment control Destratification
Blooms of phytoplankton or cyanobacteria	Stratification of the water body and increase in nutrient concentrations may result in cyanobacterial blooms.	Moderate	Stratification, moderate nutrient concentration, low faunal abundance and complexity (specifically a lack of algal grazers) in the Lake may result in growth of cyanobacteria or phytoplankton	Ongoing monitoring (site inspections) Water quality sampling Physical removal, destratification
Pest flora (e.g. aquatic weeds)	Colonisation of lake by pest flora	Low-moderate	The lake is isolated and distant from other freshwater bodies; however some aquatic weeds can be dispersed over long distances by birds. Consequently, the risk of introduction of aquatic weeds is low to moderate.	Ongoing monitoring (site inspections) Physical intervention (as necessary)
Pest Fauna	Colonisation of lake by pest flora	Low	The lake will not be in hydrological connectivity with other water bodies, and consequently is unlikely to be colonised by pest species of fish and invertebrates.	

5 INTEGRATION OF FUTURE REHABILITATION WITH PREVIOUS WORKS

5.1 General

The post-quarrying landscapes associated with the earlier inland extraction project at Stockton Sand Quarry have been rehabilitated according to their respective rehabilitation plan (ERM, 2010b). While the rehabilitation of these areas has been largely successful (as discussed in Section 2 above), some aspects of the rehabilitation indicate areas where improvements and efficiencies can be made. These findings have been incorporated into the development of the updated rehabilitation strategy detailed below (refer Section 6).

This updated rehabilitation strategy aims not only to integrate the successful aspects of the previous strategies in the ongoing works to provide the benefit of consistency in approach for site operators, consistent use of rehabilitation species and continuity for site suppliers, but also to provide clear guidance with regard to specific rehabilitation strategies/ activities that will be required in relation to the post-dredging (freshwater Lake) landform to be formed at the conclusion of Stage 6 works.

5.2 Rehabilitation Timeline

Table 5 (below) sets out a summary and timeline for mitigation, rehabilitation, monitoring and maintenance works for the Project site.

These proposed rehabilitation activities are discussed further in the rehabilitation plan, Section 6 below.

Table 5: Proposed rehabilitation and management timeline

Site section	Mitigation/ Rehabilitation measure	Timeframe
Entire site	Topographical survey of current landform levels to inform rehabilitation, vegetation and monitoring.	Prior to site establishment
Site periphery	Maintain vegetative screen between project area and site boundaries	Ongoing
	Monitor vegetative screen to ensure it remains intact and sufficient to provide screening function for operations.	During sand extraction and ongoing
	Removal of undesirable weed species and vegetation not consistent with the local vegetative succession.	Ongoing maintenance
	Revegetation of any disturbed areas by way of selective planting with species native to the locality	Ongoing

Site section	Mitigation/ Rehabilitation measure	Timeframe
Dredge pond / excavation pit	Vegetate dredge pond / excavation pit embankments with native low growing shrubs and grasses to provide bank stability and reduce erosion (including water tolerant and salt tolerant species).	Stabilisation during sand extraction and revegetation at conclusion of site operations in each stage
	Monitor dredge pond / excavation pit embankments to ensure the area remains intact and sufficient for operations.	During sand extraction
	Encouragement of native vegetation establishment (edges of pond and surrounding area) through weed control and reduction.	Ongoing maintenance
Final Landform Option: Wetland / freshwater pond		
Wetland (open pit) / freshwater pond	Conversion of the dredge pond to a wetland comprising a deep Lake with a shallow vegetated fringe	At conclusion of Stage 6.
	Vegetate the shallow fringe of the Lake with native wetland plant species.	At conclusion of Stage 6.
	Encouragement of natural reforestation of surrounding land through weed control and reduction.	At conclusion of site operations in each stage Ongoing maintenance
	Monitoring and management of algal/ cyanobacteria blooms, invasive weed and pest species.	Ongoing maintenance

6 REHABILITATION MANAGEMENT PLAN (UPDATES)

6.1 General

The following sections detail proposed additions and/or updates to the existing rehabilitation management/ landscape management actions to ensure an appropriate strategy is maintained and managed for both the progressive rehabilitation of terrestrial areas of the site as well as the proposed wetland (freshwater Lake) landform at the conclusion of the proposed dredging activities.

Note: The following sections are not intended to detail the full, comprehensive rehabilitation strategy for the site. Rather, these sections are intended to provide succinct, summary information regarding how rehabilitation management plan/landscape management plan and long term water quality management plans specific to the proposed expanded sand extraction activities should be prepared to drive successful rehabilitation; including rehabilitation strategy considerations, method and implementation, monitoring, management and criteria for success.

The following steps are proposed to be implemented to facilitate effective remediation at the site.

6.2 Final landform – dredge pond/ freshwater lake

At the conclusion of the dredging activities, as a result of sand extraction from below the water-table, a freshwater wetland comprising a deep-water Lake landform will be formed. The Lake landform will occur naturally as sand materials are progressively removed from below the water-table leaving behind an open excavation. However, rehabilitation processes including aquatic vegetation establishment and bank stabilisation will be required at the conclusion of dredging activities (refer Section 6.3).

The freshwater lake will have a surface area of approximately 29 ha of which approximately 12 ha will form a deep water environment (maximum depth of 15 m) with the remaining 12 ha forming a graduated embankment at the natural angle of repose of sand (batter of 3:1).

The final landform of the Lake has been designed to maximise the opportunity for establishment of a functioning freshwater ecosystem. Specifically, the Lake will be battered to a gradient of 3:1 as the natural angle of repose of sand, providing a “natural” profile and facilitating the colonisation of the edges of the wetland by aquatic vegetation. This will minimise the total “deepwater” environment in favour of graduated slopes to encourage vegetation establishment along shallow wetland fringes environment.

It is envisaged the Lake will be surrounded by a shallow fringe vegetated with native wetland species such as pigface (*Carpobrotus glaucescens*), beach fescue (*Austrofestuca littoralis*), beach spinifex (*Spinifex sericeus*), and common spike rush (*Eleocharis acuta*).

6.3 Final landform – Terrestrial areas

While the freshwater Lake landform will dominate much of the Project Area requiring rehabilitation post-extraction (approximately 37 ha) it is noted that rehabilitation will also be required for terrestrial areas on completion of the proposed expanded extraction activities:

- along the fringes of the freshwater wetland, to establish slope stability; and
- where native vegetation has been cleared for project-specific infrastructure (e.g. haul road corridors/ accessways) will require rehabilitation on completion of the proposed Project activities.

Rehabilitation activities in these areas will comprise soil preparation (i.e. deep ripping haul road corridors) and establishment of native vegetation in disturbed areas to minimise soil erosion and establish slope stability.

6.4 Species selection for landscape position

Within the Project site, species selection should consider landscape position in relation to either the wetland or beach dune vegetation zones (**Figures 1 and 2**). The beach dune vegetation zones are specifically relevant to high exposed dunes, where wind impacts soil stabilisation. A summary of suitable revegetation species is presented in **Table 5**. Note that the list provides a wide range of potential species for use but is not exhaustive. Use of **all** species listed is not required.

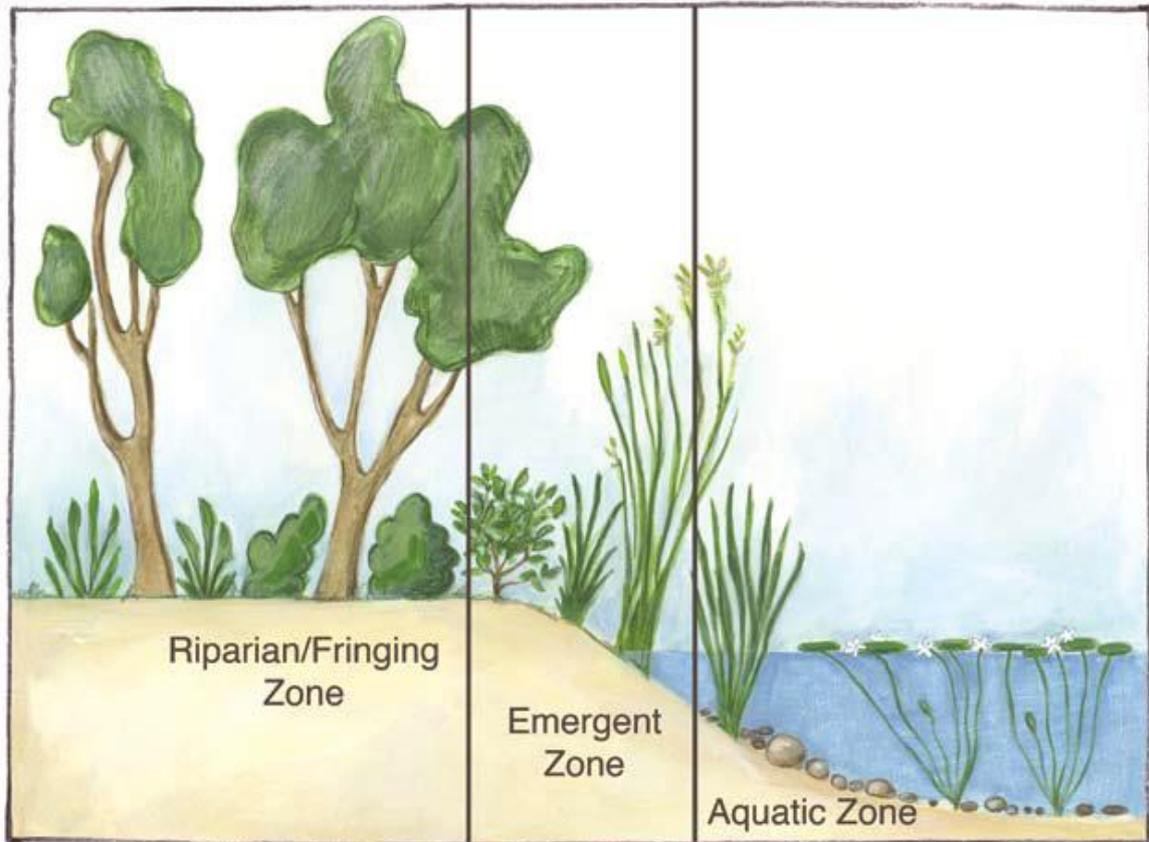


Figure 1: Identification of wetland vegetation zones (Australian Government 2008)

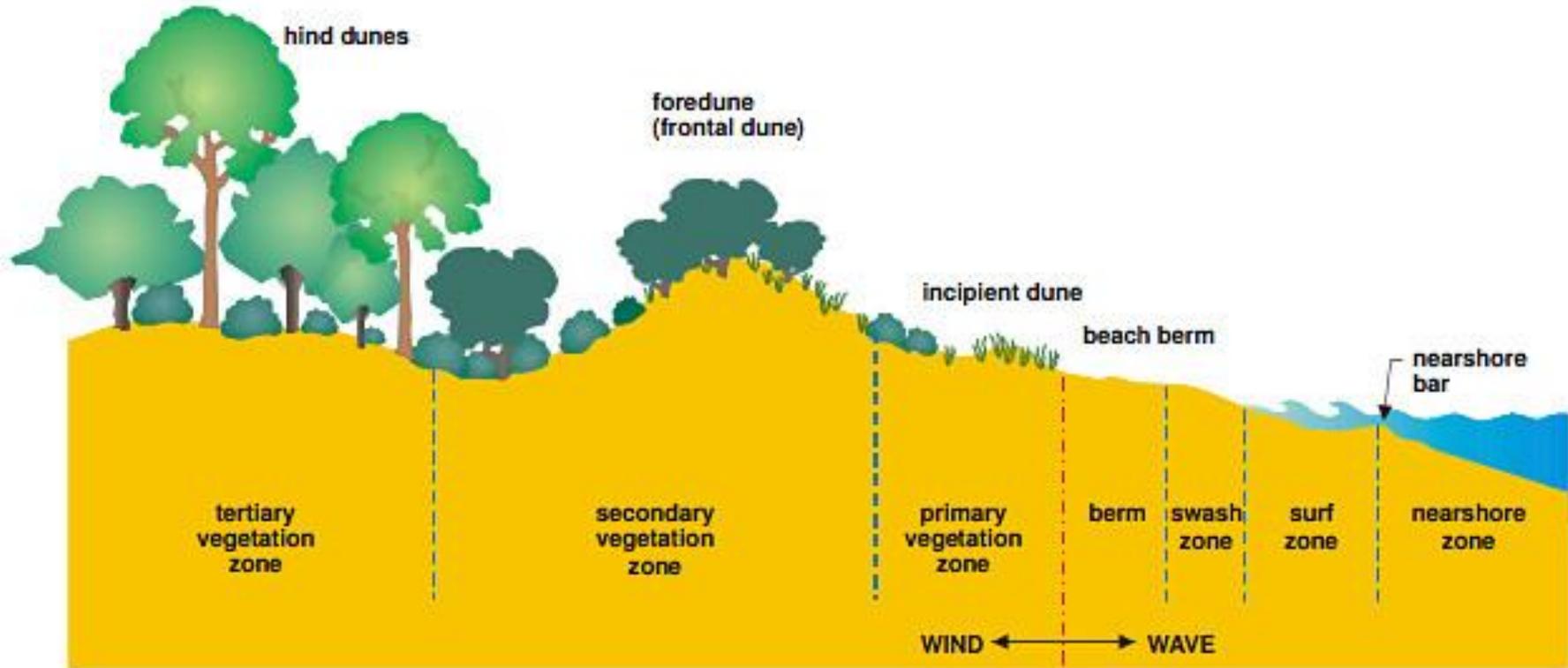


Figure 2: Identification of beach dune vegetation zones (NSW Department of Land and Water Conservation 2001)

Table 6: Revegetation species

Species	Vegetation class	Vegetation zone (Terrestrial)				Vegetation zone (aquatic)	Suitability notes	
		Riparian	Emergent	Fore Dune	Hind Dune		Commentary	Successful previous use on site?
Broad leaved Paperbark (<i>Melaleuca quinquenervia</i>)	Tree	✓	✓		✓		Grows in swampy conditions and can regenerate within weeks of a bushfire.	✓
Swamp Mahogany (<i>Eucalyptus robusta</i>)	Tree	✓			✓		Grows in swampy sandy conditions and is tolerant of waterlogging.	✓
Smooth-barked Apple (<i>Angophora costata</i>)	Tree				✓		Large tree, suitable for elevated, but not exposed locations.	
Blackbutt (<i>Eucalyptus pilularis</i>)	Tree	✓			✓		Large tree common in grassy coastal forests.	
Red bloodwood (<i>Corymbia gummifera</i>)	Tree	✓			✓		Common to coastal flats and low hills. Tolerant of poorer, sandy soils.	
Coastal Wattle (<i>Acacia sophorae</i>)	Shrub	✓		✓	✓		Has the capacity to capture wind blown sands resulting in the formation of hummocks. Beneficial for wind blown and exposed areas. Nitrogen fixing species. Wattles may have relatively short lifespan.	✓
Sydney Golden wattle (<i>Acacia longifolia</i>)	Shrub	✓		✓	✓		Has the capacity to capture wind blown sands resulting in the formation of hummocks. Beneficial for wind blown and exposed areas. Nitrogen fixing species. Subspecies of Coastal wattle. Wattles may have relatively short lifespan.	
Sweet wattle (<i>Acacia suaveolens</i>)	Shrub	✓		✓	✓		Has the capacity to capture wind blown sands resulting in the formation of hummocks. Beneficial for wind blown and exposed areas. Nitrogen fixing species. Wattles may have relatively short lifespan.	
Coastal Teatree (<i>Leptospermum laevigatum</i>)	Shrub			✓	✓		Salt and drought tolerant.	✓
Coastal Banksia (<i>Banksia integrifolia</i>)	Shrub			✓	✓		Thrives in sandy conditions and suitable for the stabilisation of sand and enables the solubilisation of nutrients.	✓
Old Man Banksia (<i>Banksia serrata</i>)	Shrub			✓	✓		Thrives in sandy conditions and suitable for the stabilisation of sand and enables the solubilisation of nutrients.	
Tree Broom Heath (<i>Monotoca elliptica</i>)	Shrub			✓	✓		Long lived and hardy dune species. May be difficult to propagate from seeds – cuttings may perform better.	
Common Bush Hop (<i>Dodonaea triquetra</i>)	Shrub	✓			✓		Forest understory.	

Species	Vegetation class	Vegetation zone (Terrestrial)				Vegetation zone (aquatic)	Suitability notes	
		Riparian	Emergent	Fore Dune	Hind Dune		Commentary	Successful previous use on site?
Pig Face (<i>Carpobrotus glaucescens</i>)	Ground cover			✓#	✓		Has the capacity to capture wind blown sands resulting in the formation of hummocks. Beneficial for wind blown and exposed areas.	✓
Beach Fescue (<i>Austrofestuca littoralis</i>)	Grass			✓#	✓		Endemic beach grass species.	✓
Blue Flax Lily (<i>Dianella caerulea</i>)	Understory	✓		✓	✓		Hardy and long-lived. Tolerant of a range of moisture conditions.	
Kangaroo Grass (<i>Themeda australis</i>)	Grass			✓#			Widespread native grass, tolerant of a range of conditions.	
Bracken Fern (<i>Pteridium esculentum</i>)	Understory			✓#	✓		Quick to colonise disturbed areas. Common in coastal woodlands. May be invasive.	
Spiny Headed Mat-Rush (<i>Lomandra longifolia</i>)	Rush	✓	✓				Tolerant of wet and drought conditions.	
Cogon Grass (<i>Imperata cylindrica</i>)	Grass			✓#			Tolerant grass used for ground cover and erosion control. May be invasive and difficult to control. Highly flammable.	
Beach Spinifex (<i>Spinifex sericeus</i>)	Grass			#			Deep roots to stabilise sand and prevent moisture loss. Recommended for locations where establishment of other vegetation has proven unsuccessful.	✓
Common Spike Rush (<i>Eleocharis acuta</i>)	Rush					Aquatic/ emergent zone	Grows to less than 1 m , in water up to about 45 cm deep	
Jointed Twig Rush (<i>Baumea articulata</i>)	Rush					Aquatic/ emergent zone	Grows to 2.5 m tall, in water up to 1 m deep	
Lepironia (<i>Lepironia articulata</i>)	Rush					Aquatic/ emergent zone	Robust plant, that can grow to 4 m tall, and in water to about 1.5 m deep.	
River club rush (<i>Schoenoplectus Validus</i>)	Rush					Aquatic/ emergent zone	Perennial wetland plant that grows to 3m, prevents erosion	
Frogsmouth (<i>Philydrum lanuginosum</i>)	Herb					Aquatic/ emergent zone	Wetland plant that can grow to 2 m high	
Persicaria (<i>Persicaria attenuatum</i>)	Herb					Aquatic/ emergent zone	Can grow in drying margins of wetland and in water to about 1 m deep	

Note(s):

- Information regarding collection of seed and runners, germination and planting, fertilisation and watering are provided in the Stockton Transgressive Dune Quarry Rehabilitation and Landscape Management Plan (2010).
- # Including exposed dune

6.4.1 Stabilisation and revegetation of disturbed areas

It is recommended that a project-specific Rehabilitation and Landscape Management Plan is prepared for the Project.

The updated management plan will address:

- the landscape units within each rehabilitation area;
- species and numbers of plants required for each rehabilitation area;
- site preparation requirements – including earthworks and deep ripping;
- soil stabilisation, erosion control and plant protection requirements for each stabilisation area; and
- watering and maintenance requirements until plants are established.

Species selection for each area should also address species diversity and succession over time. While some species, such as wattles, may perform well in the short term, they may result in a monoculture which inhibits establishment of other species. Wattles are also relatively short lived and may die out and create a bushfire hazard.

6.4.2 Pest and weed management

Regular inspections should be conducted to assess the presence of pests and weeds (both terrestrial and aquatic). Bitou Bush has previously been a problem at the quarry, however recent management strategies have substantially reduced occurrence. Manual removal has been successful in maintaining control over populations at the quarry. Targeted spraying or removal may be required during the Project.

Potential for animal or insect pest infestation should be monitored and managed as required.

6.5 Management and control measures

6.5.1 Erosion and sediment control

Due to the porous nature of sand at the project site, there is deemed a low likelihood of significant overland surface water movement and/or formation of drainage pathways. However, in the unlikely event such is observed within the Project lifespan, erosion and sediment controls are to be implemented and maintained. This will be undertaken on an “as needs” basis through the Project lifespan and until rehabilitated areas have adequately established.

Mechanisms for the control of surface water movement may include the following (as necessary):

- Diversion of ‘clean’ overland flow to the Project site away from ‘dirty’ areas;

- Vegetation and maintenance of drainage pathways to minimise erosion and sediment accumulation in flowing water;
- Corrective actions, relating specifically to:
 - maintaining, repairing and cleaning out sediment control structures in order to maintain compliance with the erosion and sediment control plan for the project (i.e. vegetated bund); and
 - repairing eroded areas.

Dust suppression methods are to be used on the existing and proposed haul roads for the Project and with the exception of Stage 1, progressive sand extraction within Stages 2 to 5 will seek to limit exposed ground surfaces to a maximum of 200-300 m at any one time to ensure that resource is not lost through exposure to prevailing winds.

6.5.2 Management of pest flora and fauna species (aquatic)

Algal and Cyanobacterial blooms

While there is a risk of cyanobacterial or phytoplankton blooms, the lake is not a recreational water body, and primary contact will be minimised. Consequently, the risk to human health is low.

The Rehabilitation Performance Objective for algal and cyanobacteria is to minimise the risk of blooms, and to prevent impacts to human health.

Nevertheless, it is recognised that the excessive growth of phytoplankton and/ or cyanobacteria can result in a range of problems, including impacts to public health and the environment due to the production of toxins, deterioration of the aesthetic quality of a water body, and operational issues of pumps and others equipment. Cyanobacterial blooms may also lead to ecological impacts, such as bird and fish kills in extreme cases.

The aims of managing phytoplankton/ cyanobacterial are to:

- minimise the risk of blooms occurring;
- implement a rapid response in the unlikely event of a blooms;
- prevent impacts to human health and environmental values; and
- maintain aesthetic value of the Lake.

The risk of blooms occurring will be minimised by reducing nutrient inputs into the Lake (e.g. areas that are revegetated should not be fertilized) and by monitoring the water quality in the Lake.

A long-term water quality monitoring and management strategy (incorporating a combined inspection, in-situ monitoring and laboratory analytical program) would be developed as part of the post consent requirements following any approval.

However, it is envisaged this program will comprise (at minimum) in the first year dredging operations commence, on a monthly basis:

- Visual monitoring of the Lake for the presence of phytoplankton and cyanobacteria including documentation of observations (algal scum, discolouration, unusual foaming on the surface, unusual water odours and/or fish kills);
- Measurement of water quality parameters (pH, electrical conductivity (EC), dissolved oxygen (DO) and temperature at 1 m depth intervals at three sites across the Lake; and
- Collection of representative surface water samples for analysis at a NATA accredited laboratory for parameters of concern in relation to freshwater Lake establishment, namely chlorophyll a and nutrients (total nitrogen, total phosphorus, ammonia, nitrate and nitrite);
 - Chlorophyll a is an indicator phytoplankton and cyanobacteria in the water. For constructed lakes, algal counts above 15,000 cells/mL (or chlorophyll a concentration >10.15 µg/L) represent a likely phytoplankton bloom where either aesthetics or health impacts may occur (Melbourne Water 2005, cited in FRC Environmental 2020).
 - Therefore, where the concentration of chlorophyll a is > 10.15 µg/L (or approximately 15 000 cells/mL) or a bloom is suspected (e.g. presence of algal scum or odours is observed), phytoplankton and cyanobacterial cells should be counted and identified.

The management of freshwater cyanobacteria and phytoplankton blooms will be in accordance with the *Guidelines for Managing Risk in Recreational Water* (NHMRC 2008)².

Trigger levels and management responses for water quality and cyanobacterial blooms are presented in **Table 7** and **Table 8** below. These preliminary trigger levels were developed following the protocols in ANZG (2018), targeting maintenance of dissolved oxygen levels and prevention of cyanobacterial blooms as the primary management aims.

As per the ANZG 2018, the trigger levels may be refined after regular monitoring.

Table 7: Preliminary trigger levels for water quality

Parameter (units)	WQO ¹	Current groundwater ²	Trigger	Proposed response
Total Phosphorous (µg/L)	10		10	Check DO. If nutrients exceed triggers and DO approaching trigger, monitor weekly. Note higher turbidity will suppress phytoplankton growth or may be indicative of high phytoplankton levels.
PO ₄ (µg/L)	5*	5 to 184	10	
Total Nitrogen (µg/L)	350		350	
NO ₃ (µg/L)	10*	<5 to 110	20	
Ammonia (µg/L)	10*	<5 to 420	20	

² Use of these standards is also appropriate to prevent impacts to fauna.

Parameter (units)	WQO ¹	Current groundwater ²	Trigger	Proposed response
Turbidity (NTU)	1-20			
Dissolved Oxygen (% saturation) below the surface ³	90-110		70 ³	Implement destratification
pH	6.5- 8.0		6.5	Investigate PASS discharges, implement management as required
Salinity (electrical conductivity µS/cm)	125- 220	200 to <1000	1000	Check condition of shallow water vegetation. Replace with more salt tolerant species if required.
Chlorophyll-a (µg/L)	5	> 10.15 g/L or a bloom is suspected		Count and identify phytoplankton and cyanobacterial cells - proceed according to table 7

Notes: WQO: Water Quality objectives

¹ WQO from NSW DECCW 2006 for protection of aquatic ecosystems for lakes and reservoirs in the Hunter catchment, which are the same as ANZG WQO for freshwater lakes in south eastern Australia* only ANZG

² Environmental Earth Sciences, 2020a

³ Percent saturation at the Lake surface is likely to remain over 90%, a drop with depth indicates stratification

Table 8: Trigger levels for freshwater cyanobacteria and algae

Alert Level	Trigger	Proposed response
Low alert	>500 and <5,000 cells/ml <i>Microcystis aeruginosa</i> OR 0.04 and <0.4 mm ³ /L biovolume of all cyanobacteria	Increase sampling to fortnightly (including species count and identification)
Medium alert	>500 and <50,000 cells/ml <i>Microcystis aeruginosa</i> OR 0.04 and <0.4 mm ³ /L biovolume of all cyanobacteria	Increase sampling to weekly (including species count and identification) Notify agencies of potential bloom and ongoing monitoring
High alert	>10 µg/L microcystins OR >50,000 cells mL ⁻¹ toxic <i>Microcystis-aeruginosa</i> OR Biovolume equivalent of >4mm ³ /L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume OR >10 mm ³ /L for total biovolume of all cyanobacterial material where known toxins are not present OR Cyanobacteria scums are consistently present	Increase sampling to twice weekly (including species count and identification, and cyanobacterial toxin concentrations) Place appropriate warning signs notifying the personnel/ public of potential health risks Contact relevant agencies for advice. Assess and implement treatment options (e.g. destratification, removal, algaecides, Phoslock) Note – due to continuity with groundwater resources, destratification and direct removal measures will be preferred to any chemical dosing.

Notes: Adapted from DERM 2010, NHMRC 2008, Water by Design, 2013, after FRC Environmental 2020.

Aquatic weeds

Emergent aquatic vegetation along the foreshores of the Lake will be managed in accordance with a project-specific Vegetation Management Plan. This plan will be prepared as part of the post consent requirements following any approval.

The risk of submerged and floating aquatic weeds colonising the lake is considered to be moderate to low, given the distance to other similar aquatic habitats (refer Section 4.4).

It is recommended visual monitoring for the presence and percent cover of floating aquatic weeds be undertaken concurrently with that proposed for algal and cyanobacteria blooms discussed above. Where aquatic weeds are observed, they will be removed and disposed of off-site.

The Rehabilitation Performance Objective for aquatic weeds is to prevent the colonisation of dense stands of aquatic weeds, with a Performance Criteria that less than 5% of the Lake is covered with aquatic weeds.

Pest fish species

The risk of pest fish establishing in the Pond is considered to be low. However, it is recognised that appropriate monitoring and management strategies must be in place in the unlikely event that this risk is realised.

The Rehabilitation Performance Objectives of managing pest fish are to:

- minimise pest fish entering and breeding in the Lake;
- implement a rapid response if a large biomass of pest fish is found in the Lake;
- prevent impacts to environmental values; and
- maintain aesthetic values of the Lake.

The Rehabilitation Performance Objective for pest fish is to prevent the colonisation of the Lake with pest species.

It is recommended visual assessment for pest fish populations is undertaken in monthly inspections concurrently with those proposed above and in response to any other issues influencing the amenity or environmental values that may be explained by excessive exotic fish populations (e.g. water quality issues).

Where risks are deemed unacceptable, rectification actions may include:

- stocking the Lake with native species, and/or
- selective fishing and destruction of exotic species³.

³ The capture, removal or destruction of exotic fish and the stocking of native fish is governed by strict ethical considerations and should only be undertaken by qualified staff, in accordance with NHMRC (2008) and with relevant permits.

The most appropriate rectification action will be selected as and when required.

6.6 Rehabilitation inspection schedule

As discussed above, the rehabilitation process should involve regular inspections to monitor the progress of rehabilitation activities, and proactively identify any problems with the remediation process.

Monthly and annual inspections are recommended as detailed in the sections below.

6.6.1 Monthly site monitoring

Monthly monitoring of areas relevant to progressive site rehabilitation should continue and be augmented by additional monitoring activities of the final Lake landform, as outlined in **Table 9**. Monitoring will focus on identification of any issues relating to terrestrial plant health or establishment, invasive species and water quality (dredge pond) to allow timely resolution.

Monthly monitoring should commence from the establishment of the Lake and continue for three years after establishment of the final Lake landform.

Table 9: Monthly monitoring areas

Area/ item	Monitoring requirements		
	Inspection	<i>In-situ</i> monitoring	Laboratory analysis
General site	Occurrence of weeds or pests. General health of vegetation.		
Established revegetation areas	Occurrence of weeds or pests. Health and growth of plants. Extent of vegetation cover. Suitability of plant stock for seed or runner collection.		
Trial plantings / Rehabilitation areas	Occurrence of weeds or pests. Health and growth of plants.		
Dredge pond/ freshwater lake	Occurrence of cyanobacteria/ algal blooms/ general water quality observations (see Tables 7 and 8) Occurrence of aquatic weeds or pests	In-situ water quality parameters (pH, EC, DO, temperature)	Water quality parameters relating to algal/ cyanobacteria blooms (chlorophyll a, nutrients)

6.6.2 Annual site inspection

An independent inspection of the rehabilitation process should be conducted by a suitably experienced ecologist or environmental restoration consultant annually, from the commencement of rehabilitation activities (conclusion of Stage 6).

It is recommended that a series of indicator sites a (minimum of 10 randomly distributed sites among the wetland plants around the lake edge) are monitored to assess the progress of

revegetation, with photographs taken to record site condition. The inspection should assess the site for compliance with the performance criteria, particularly the 50% LFA target. The inspection should also assess occurrence of any weed species that may be present to facilitate management.

6.6.3 Long term monitoring of water quality and aquatic vegetation (Wetland)

Long term monitoring should be undertaken from the establishment of the lake landform and the commencement of rehabilitation activities.

Where there has been no stratification, or algal or cyanobacterial blooms for 3 years post establishment of the final Lake form, water quality monitoring will continue on an as needs basis: i.e. when other regular monitoring indicates there has been an issue with water quality or there have been complaints (e.g. odour, visual).

Where there are issues with stratification or algal or cyanobacterial blooms, and/ or dieback of shallow water vegetation, monthly monitoring will continue until it can be demonstrated that management of the Lake has resolved these issues, with monitoring continuing for at least a year after the implementation of management strategies.

6.6.4 Long term monitoring of vegetation

It is anticipated that the management and monitoring of the rehabilitation process may extend to a period of up to 10 years from the commencement of rehabilitation of each section of the project area. The point of commencement is considered to be the site preparation and initial planting of those areas. The success of initial site preparation and vegetation establishment is likely to significantly reduce the management requirements for each area over time.

The duration of short to medium term management and monitoring period is estimated to require 1-5 years. This stage involves ensuring landscape stabilisation, vegetation establishment, erosion control and weed management.

If the short to medium term rehabilitation works are successful, monitoring can be substantially reduced over the long term. For the period between 5 and 10 years post rehabilitation monitoring frequency may be reduced. During this period the monitoring would focus on weed management, and species diversity and succession.

Annual site inspections by an ecologist should be maintained for 10 years post rehabilitation, or until the ecologist and administering authority advise that they are no longer required.

6.7 Updated rehabilitation performance criteria

The current performance criteria for the rehabilitation of the final post sand extraction landform are:

- Stabilisation of the disturbed areas with re-established coverage of endemic species of vegetation; and

- Have a landscape function analysis (LFA) level of natural regeneration greater than 50% of the previously assessed National Bushland Control site, located within the quarry property.

It is recommended, in consideration of the additional rehabilitation activities required to establish the former dredge pond landform as a functioning, freshwater wetland (deep water Lake environment), these are augmented with the following, additional performance objectives/ criteria (as per Section 6.4):

- Minimise the risk of algal and cyanobacterial blooms to prevent risks to human health with reference to recommended trigger levels and management responses;
- Prevent the colonisation of dense strands of aquatic weeds with less than 5% of the pond surface covered with aquatic weeds; and
- Prevent the colonisation of the pond with pest fish species.

6.8 Proposed rehabilitation completion criteria

The completion of the rehabilitation process will be assessed against the performance criteria for the rehabilitation of the final post sand extraction landform as detailed in Section 6.7 above.

Rehabilitation will be deemed to be complete when the criteria have been met, vegetation communities are mature and stable and stabilised freshwater wetland conditions free of significant weed and/or pest colonisation, requiring minimal to zero human intervention over a minimum period of 3 years, can be demonstrated.

It is anticipated that the majority of these criteria are likely to be fulfilled between 5 and 10 years post rehabilitation for each project stage. This will be assessed by the ecologist or environmental restoration consultant completing the annual inspections, who may then provide recommendation that ongoing inspections are no longer required.

7 LIMITATIONS

This report has been prepared by Environmental Earth Sciences NSW ACN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Boral;
2. The specific scope of works set out in Section 1.1 to 1.3 of this report;
3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);

4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works being located at Stockton Boral Quarry, Fullerton Cove, NSW (“the site”);
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
7. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
8. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill, excavated natural material (ENM) or virgin excavated natural material (VENM) if deposited off site; and
9. Our General Limitations set out at the back of the body of this report.

8 REFERENCES

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ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval

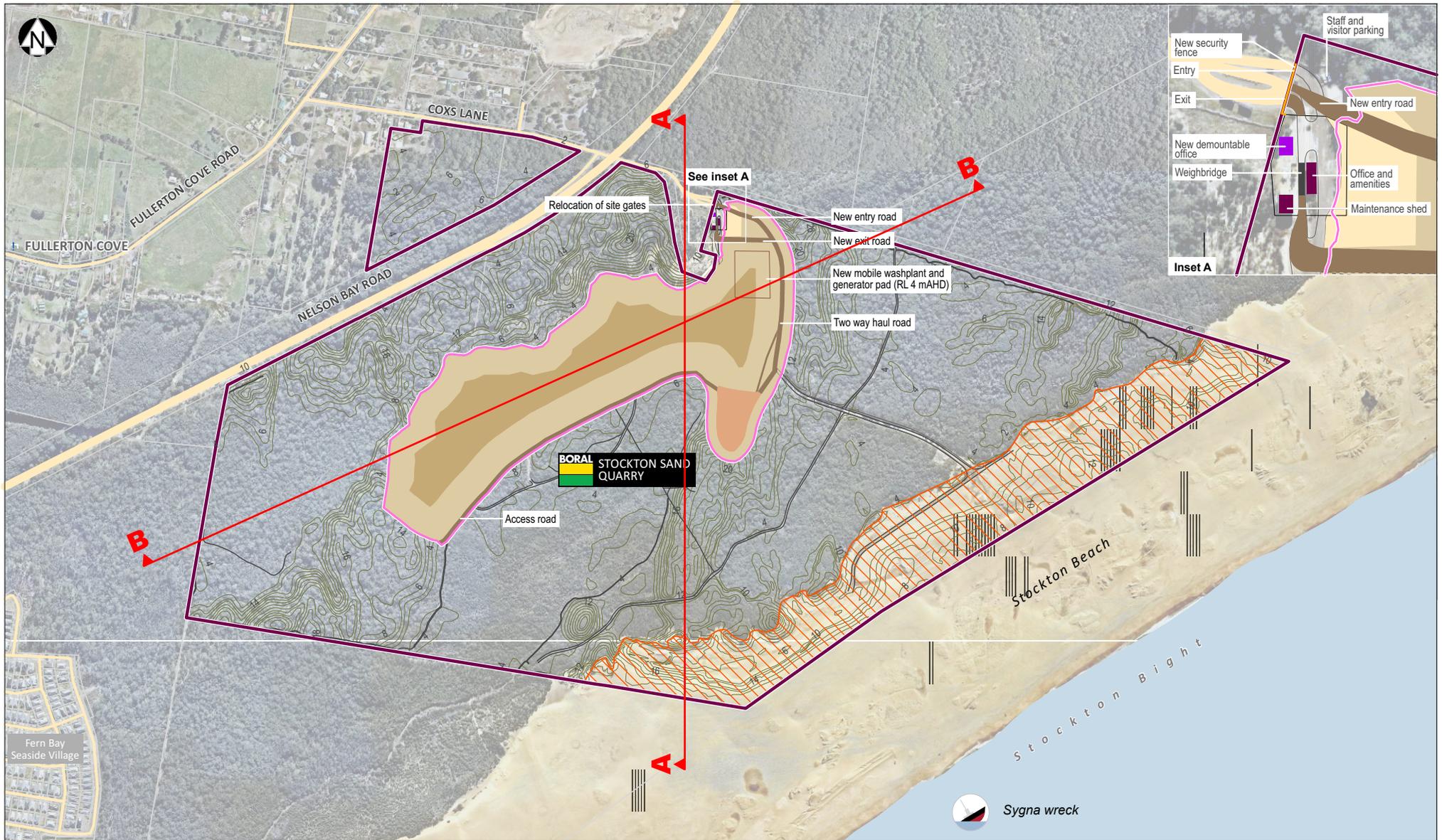
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

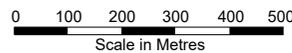
To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

FIGURES



Source: Element Environment

	Stockton Sand Quarry boundary	Project features	
	Current windblown sand extraction area		Proposed clearance area
	Contour (mAHd)		Access road
	Access tracks		Extraction base (RL -15 mAHd)
	Cross section location (refer Figures 3 and 4)		Batter
			Pad base (RL 4 mAHd)

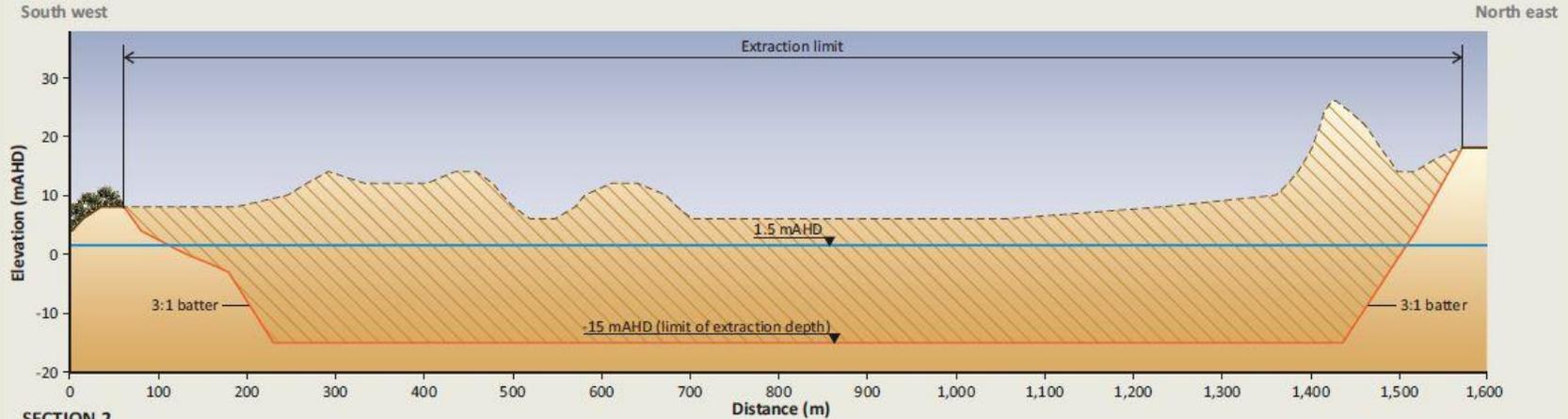


ENVIRONMENTAL EARTH SCIENCES CONTAMINATION RESOLVED	Title: Project Layout
	Location: Nelson Bay Road, Fullerton Cove, NSW
Client: Boral Quarries	Job No: 717041
Project Man: LL/AS	Scale: As shown
Drawn By: LB	Date: July 2019
Figure 3	

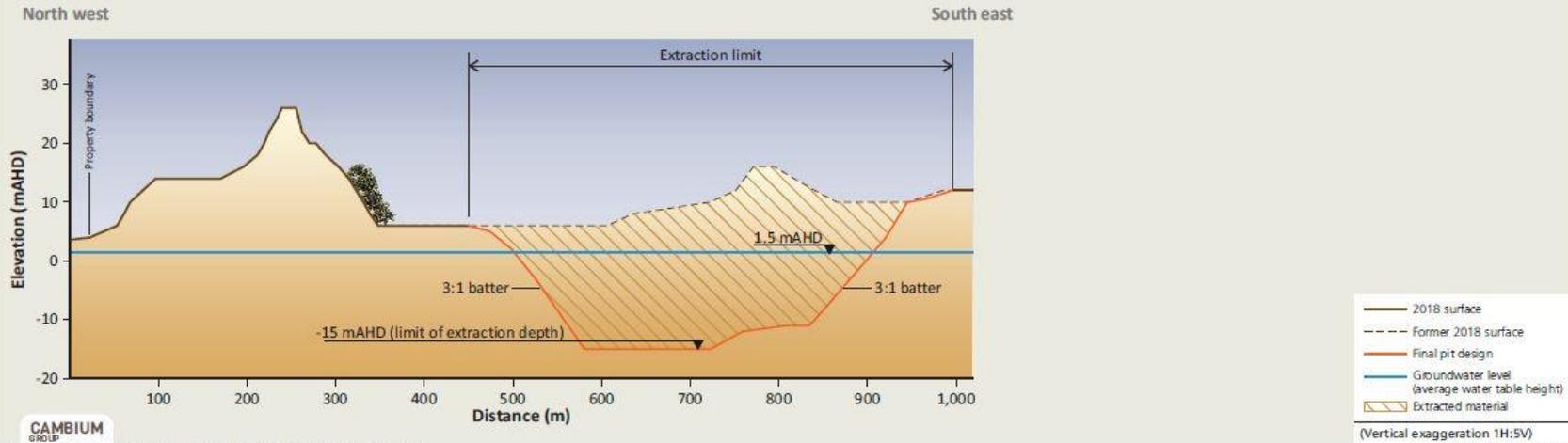
Figure 2
Sections

Stockton Sand Quarry Dredging | Environmental Impact Statement

SECTION 1
South west



SECTION 2
North west



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GAMBIUM GROUP

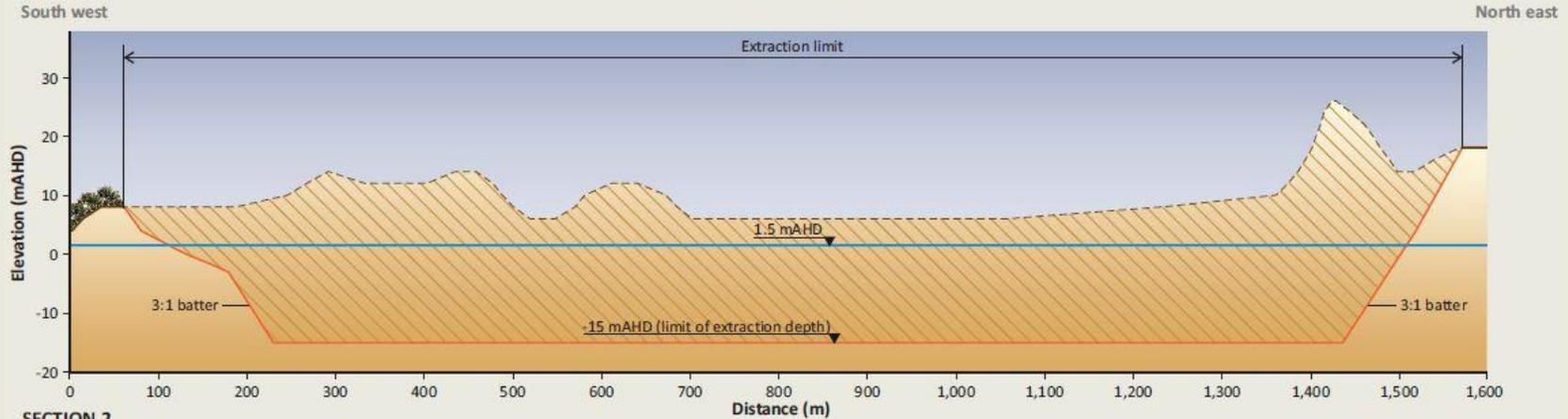
Source: Environmental Earth Sciences (2018), Photomapping (2018), Boral (2020), Gambium Group (2020).

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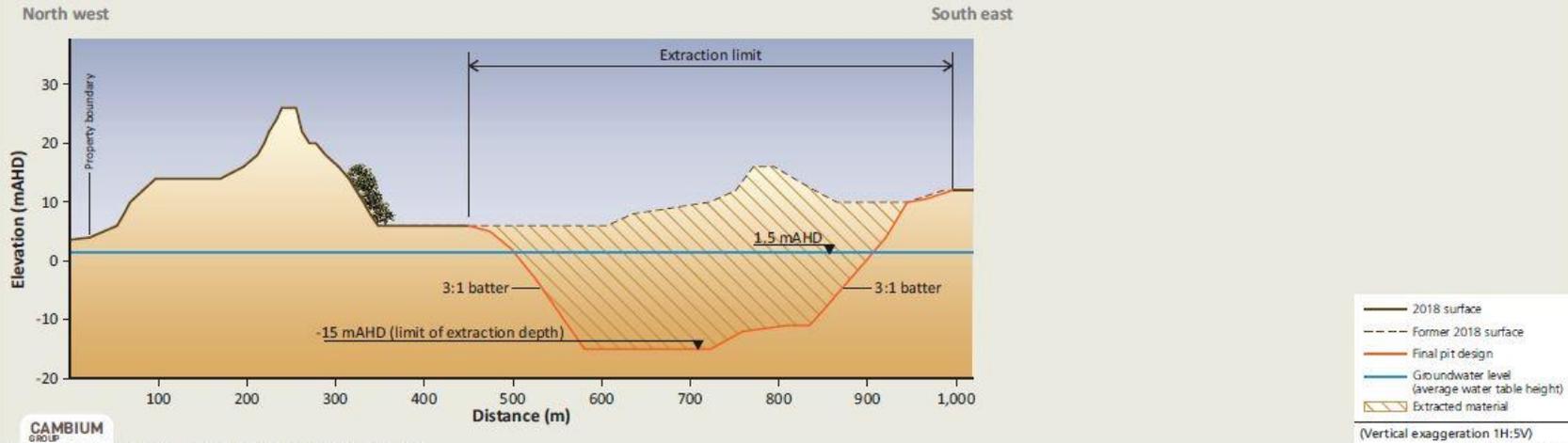
Figure 2
Sections

Stockton Sand Quarry Dredging | Environmental Impact Statement

SECTION 1
South west



SECTION 2
North west



DISCLAIMER: This document is for informational purposes only. It is not intended to be used as a basis for any legal or financial decisions. The user of this document is responsible for its use and any consequences thereof.

GAMBIUM GROUP

Source: Environmental Earth Sciences (2018), Photomapping (2018), Boral (2020), Gambium Group (2020).

031142_DRE_F2_5_200813_v02

APPENDIX A: PHOTOGRAPH PLATES



1. Successful rehabilitation in Stage 1 / Stage 6



2. Stage 1 / Stage 6 rehabilitation poor surface stabilisation in one small area - east of the haul road.



3. Areas of stunted growth in Stage 1 / Stage 6 and Stage 2



4. Areas of stunted growth in Stage 1 / Stage 6 and Stage 2



5. Successful rehabilitation in remaining areas of Stage 4



6. Northern boundary between Stage 3 and Stage 4



7. Northern boundary between Stage 3 and Stage 4



8. Successful rehabilitation of Stage 5



9. Slow growth in small area of Stage 5

APPENDIX D Project water balance: South East Engineering

30 September 2020

Rachel Snape
Boral Land & Property Group
Triniti T2 Level 5
39 Delhi Road, North Ryde NSW 2113

Dear Rachel,

Re: DPIE and NRAR submission for the Stockton Sand Quarry and incidental water take

Background

Southeast Engineering and Environmental prepared the Surface Water Assessment (SWA) for the Stockton Sand Quarry (SSD 9490) Environmental Impact Statement (EIS).

Subsequent to the submission of the EIS, the Department of Planning, Industry, and Environment (DPIE) Water Division/ Natural Resource Access Regulator (NRAR) have submitted a request for further information in relation to water management. This response to the submission addresses the pre-approval information requests:

- *Detailed assessment of incidental groundwater take, including losses from sand processes and operational activities.*
- *A prediction of the total amount of water that will be taken from the Stockton Groundwater Source on an annual basis as a result of the activity and after closure of the activity, as described in section 3.2.3 of the NSW Aquifer Interference Policy (AIP) (2012).*

Incidental water take refers to water taken “indirectly” from a groundwater source (or aquifer) by the proposed aquifer interference activity, in this the exposure of the aquifer, the dredging of sand and transport of sand with some water content off site.

The Surface Water Assessment (SWA) included a water balance model for the proposed dredge pond which included some incidental take and other assumptions:

- progressive exposure of the aquifer to the atmosphere as the dredge pond is created and expands
- evaporation from the exposed area, estimated using Morton’s Lake Evaporation (incidental take)
- direct rainfall recharge of the aquifer over the dredge pond area
- three rainfall scenarios were considered, a wet, average and dry period
- moisture content of material leaving the site is considered an extraction (incidental take)

The water balance did *not* consider all “incidental” groundwater take, that is, take associated with pumping from the dredge pond that returns to the aquifer either as:

1. Water from the dredge returned directly to the aquifer; and
2. Water drained from stockpiled sand.

In accordance with the provisions of the Aquifer Interference Policy (AIP) and in the absence of a “return of waters” policy framework, all water removed from the aquifer, irrespective of whether it is returned, is required to be considered as a “loss” from the system and quantified accordingly.

In light of the above, the water balance model and operation were reviewed in detail to determine the full extent of water use. In response to this review, the water balance model for the dredge pond has been updated to include the following:

- the incidental groundwater take which includes water extracted from the dredge slurry pump and pumping for screen sprayers and extraction for dust suppression; and
- the recharge that previously occurred over the dredge pond footprint, as 22% of rainfall, as outlined in the *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources Background document (DPIE, 2016)*.

This letter outlines the assumptions used in the updated model and the results.

Water balance model

The water balance mode from the SWA was updated to inform the assessment of the incidental water take associated with the proposed sand extraction and the prediction of the total amount of water likely to be taken from the Stockton Groundwater Source.

This model was prepared based on project and operational specific information combined with informed assumptions regarding key parameters/factors that affect water loss and demand associated with the proposed development, each of these are set out below.

Staging

Table 1 outlines the proposed progressive extraction of sand above the groundwater table (i.e. stage 1 of the project) and below the groundwater table using a dredge (i.e. stages 2 to 6, inclusive) and includes an estimate of dredge pond area over time based on the extraction staging plan. For the first two to three years of the project (dependant on customer demand), sand will progressively be removed by excavator to 4m AHD. Refer to section 1.3 of the SWA for a detailed description of this process.

Table 1 Proposed program for sand extraction

Stage	Reserve (tonnes)	Duration (years)	Approximate dates	Dredge pond water surface area (ha).
1	1,640,000	2 - 3	2020 - 2022	0
2	1,327,138	2 - 3 years	2022 - 2025	4.71
3	1,354,000	2 - 3 years	2025/2026 – 2028/2029	9.05
4	1,901,000	3 – 4 years	2030 – 2034	14.18
5	1,483,000	3 years	2037	18.42
6	1,326,000	3 years	2039/40	23.37
<i>Total</i>	<i>9,032,138</i>	<i>19 -20 years</i>		

Climactic assumptions

The following assumptions have been made regarding the climatic conditions over the operational life of the project. The climatic assumptions are used to determine the potential loss or take of water associated with evaporation from the dredge pond window to the aquifer, and to account for the direct recharge from rainfall onto the dredge pond surface.

Morton's Shallow Lake evaporation = 1382mm/y (SILO gridded data set). This is a derived value representative of evaporation from a large shallow waterbody. It assumes that sub surface heat storage in the lake is insignificant and that wind transition zone over the shoreline can be ignored. This value is likely conservative, that is, higher than reality, as the transition effects of the shoreline landscape and surrounds and the shape of the dredge pond will provide some protection from winds, and therefore lower evaporation in reality.

Three rainfall scenarios; Decile 1, 761mm/y, Decile 5 (median), 1,048mm/y, and Decile 9, 1,538mm/y (Newcastle Nobbys Signal Station, Station number 61055) to account for rainfall variability at the site.

Recharge

Prior to commencement of the dredge operation and exposure of the groundwater aquifer, recharge of the aquifer over the future dredge pond area has been assumed at 22% of rainfall, consistent with the rate outlined in the *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources Background document (DPIE, 2016)* for the Stockton groundwater source.

Once the dredge pond is commenced at Stage 2, recharge is assumed to be the balance between rainfall and evaporation, which is usually negative. The pre dredge pond recharge (22% of rainfall) is included in the water balance as a loss, as this will no longer occur over the dredge pond footprint.

Incidental groundwater take and return flows

As set out above, a review of the surface water model and the operational profile of the project has been undertaken based on the submission received from DPIE Water/NRAR in response to the exhibition of the EIS. The review focused on defining the incidental water taken through the operation of the dredge.

It is important to note that a significant proportion, assumed at 92% based on moisture content of material leaving the site and surface losses, of incidental take is returned to the aquifer either directly through the dredge pumping system and through the water leaching process from stockpiles as material dewatered prior to transport off site.

The following sections sets out operational characteristics that informed the calculation of this incidental groundwater take. Three pathways of incidental groundwater extraction have been identified:

Product moisture content

Water taken during this first stage prior to dredge pond creation will include moisture content of extracted material which is assumed at 3% by mass. When extracted from the dredge pond, product moisture content will be around 5% after dewatering on site.

Dredge slurry pump:

Pump rate: 150L/s (Slurry: 33.3% sand, 66.7% water by volume)
Average operational hours: 9h/d
Operational days: 5.5 days/wk
Operational weeks: 49wk/y
= 873.2ML/y, equivalent to 698.6T/y of sand

Screen spray pump:

Estimated at 20% of total dredge pump rate based on demand at similar dredge pond sand extraction process at Dunmore
= 262ML/y

Dust suppression:

Dust suppression estimates are based on recorded purchases of water supplied from a water cartage contractor. Water demand details are outlined in section 5.2.3 of the SWA. Estimated demands range from a maximum of 15ML/y whilst the wind-blown operation continues, to between 6.3 to 10.3ML/y during dredge pond operations. For the purpose of this updated water balance, it is assumed that 15ML/y is extracted from the dredge pond every year for dust suppression.

A water taken associated with dust suppression has been included as a discretionary element to reflect the maximum possible upper limit of extraction. Boral currently imports water to the site by tanker. It is currently anticipated that this process will continue for the foreseeable future. Subject to sufficient water entitlements being made available through the market or controlled allocations Boral may consider using groundwater for the purpose of dust suppression.

If water from the aquifer is used for dust suppression, this would be an additional take prior to the creation of the dredge pond at Stage 2, and once the dredge pond was created, would be a proportion siphoned off from the dredge slurry pump extraction, it would *not* be an additional extraction on top of the incidental take.

Model results

The following sections sets out the results of the revised groundwater model that includes the incidental water take and assumptions. Figure 1 outlines the annual water balance results.

Prior to exposing the groundwater table, demand from the aquifer are restricted to moisture content in material leaving the site extracted using dry methods (i.e. sand extracted above the groundwater table) and any water extracted from the aquifer for dust suppression. Based on estimated extraction and dust suppression assumptions, the water balance for Stage 1 is -31.4ML/y.

Subsequent to Stage 1 and as the dredge pond expands, the range of 'take' from the aquifer expands. Those linked to production (dredge pump, spray wash pump and dust suppression) are assumed to be constant as outlined above. Those linked to the dredge pond area and climate vary as the dredge pond expands in size. In the last year of operation, with the dredge pond at maximum size, the water balance ranges from -1,326ML/y for decile 1 rainfall to -1,153ML/y for decile 9 rainfall and -1,267ML/y for median rainfall.

Once extraction operations are ceased, the water balance for the dredge pond reverts to impacts associated with the climate only, and ranges from -191ML/y (decile 1 rainfall) to -17.6ML/y (decile 9 rainfall) with a median of -132ML/y.

Figure 1 also includes the results for the water balance if the water that returns to the aquifer is incorporated.

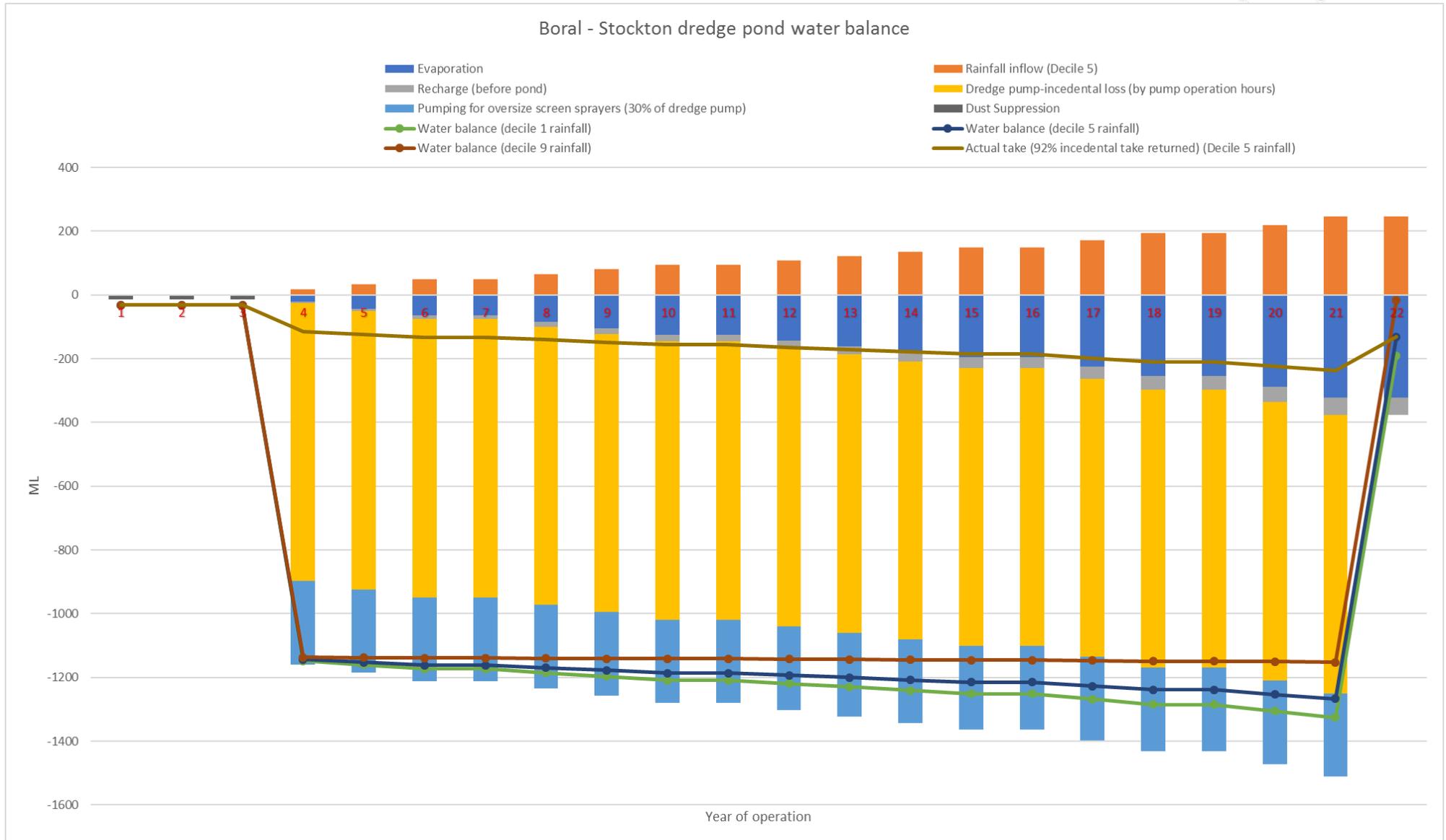


Figure 1 Water balance results

Conclusion

As Figure 1 shows, the water balance is dominated by the incidental extractions associated with the dredge pump and screen sprays, with the next greatest take being evaporation from the pond surface. Rainfall variation does not have a large impact on total water extraction, only influencing the water balance significantly as the dredge pond increases in size.

When the water balance factors in the return of 92% of water associated with the “incidental” take, that is to say that the “loss” of water from the system is a symptom of a policy framework (i.e. it is a take on paper) not a tangible loss or take of water, the actual removal of water from the aquifer is significantly reduced. Table 2 outlines estimated total extraction from the aquifer over the life of the dredge pond and post closure. This includes a column showing the water balance if the actual 92% returns are accounted for.

Table 2 Water balance results over the life of the dredge pond (ML/y)

Year of operation	Decile 1 rainfall	Decile 5 (median) rainfall	Decile 9 rainfall	Actual take estimate (Decile 5 rainfall)
1	-31.40	-31.40	-31.40	-31.40
2	-31.40	-31.40	-31.40	-31.40
3	-31.40	-31.40	-31.40	-31.40
4	-1162.96	-1159.00	-1151.32	-114.67
5	-1175.78	-1167.86	-1152.50	-123.53
6	-1188.60	-1176.72	-1153.68	-132.39
7	-1188.60	-1176.72	-1153.68	-132.39
8	-1200.41	-1184.88	-1154.77	-140.55
9	-1212.23	-1193.04	-1155.86	-148.72
10	-1224.04	-1201.21	-1156.94	-156.88
11	-1224.04	-1201.21	-1156.94	-156.88
12	-1234.51	-1208.45	-1157.91	-164.12
13	-1244.99	-1215.68	-1158.87	-171.35
14	-1255.46	-1222.92	-1159.84	-178.59
15	-1265.93	-1230.16	-1160.80	-185.83
16	-1265.93	-1230.16	-1160.80	-185.83
17	-1283.24	-1242.12	-1162.40	-197.79
18	-1300.56	-1254.08	-1163.99	-209.75
19	-1300.56	-1254.08	-1163.99	-209.75
20	-1320.77	-1268.05	-1165.85	-223.72
21	-1340.98	-1282.02	-1167.71	-237.69
Post closure	-190.84	-131.88	-17.57	-131.88

Please contact the undersigned if you have any questions.

Yours sincerely,



Lachlan Bain

Environmental Engineer BEng (Env) MEnvMgt

APPENDIX E Groundwater modelling report



**ENVIRONMENTAL EARTH
SCIENCES**
CONTAMINATION RESOLVED

**GROUNDWATER NUMERICAL
MODELLING REPORT, STOCKTON
SAND QUARRY DREDGING
PROJECT, COXS LANE,
FULLERTON COVE, NSW
BORAL RESOURCES (NSW) LTD**

26 NOVEMBER 2020

120082

VERSION 2

26 November 2020

Boral Resources (NSW) Ltd

Trinity T2, Level 5
39 Delhi Road
North Ryde NSW 2113

Attention: **Rachael Snape**
Planning and Development Manager NSW/ ACT

Dear Rachael,

**Boral Stockton Sand Quarry Dredging Project Supplementary Works – Groundwater
Numerical Model**

Please find enclosed a copy of our report entitled as above. Thank you for the opportunity to undertake this work.

Should you have any queries, please do not hesitate to contact us on (02) 9922 1777 or (07) 3852 6666.

For and on behalf of
Environmental Earth Sciences NSW

Modeller
Geordie McMillan
Principal Hydrogeologist

Internal Reviewer
Mark Stuckey
Senior Principal Hydrogeologist

120082_Stockton numerical model_v2

EXECUTIVE SUMMARY

Introduction and objectives

Boral owns and operates the Stockton Sand Quarry and is currently seeking approval for continued and expanded operations for sand extraction from the inland vegetated dunes along the Stockton Bight coastline. During the public exhibition period a number of submissions were received from key stakeholders including local council, government agencies and the local community. This report has been prepared to detail the supplementary works required to address specific comments provided by DPIE relating to the provision of groundwater modelling in support of the proposed development.

The objectives of the works are therefore to address the DPIE exhibition comments pertaining to groundwater modelling, to the satisfaction of all identified stakeholders.

The modelling objectives are to identify the potential for any long-term impacts of the proposed expansion activities on nearby sensitive receptors and provide further confidence to stakeholders of the low-risk status of the project, with regards to impacts on ecosystems and local groundwater resources.

Findings

The model has predicted that groundwater levels in the aquifer surrounding the lake, and in particular between the lake and the ocean, will remain stable and close to current static conditions over the period of creation of the lake (assumed to be 22 years).

The model has also predicted that seawater intrusion and other potential chemical impacts associated with increased concentrations of dissolved salts that can result from dredging of the proposed project are not expected to be a risk. Due to the increased recharge associated with the creation of the lake, the aquifer at and surrounding the site is expected to reduce in salinity as a result of dredging operations.

Based on a review of numerical and solute transport modelling performed for per- and polyfluoroalkyl substances (PFAS) emanating from RAAF Base Williamtown, there is no risk of PFAS impacts from this source to the site (including as a result of the proposed dredging operations). This is supported by groundwater chemical data collected from the site over 2018 (five events) and 2020 (six events) exhibiting PFAS concentrations less than the laboratory limit of reporting (LOR), and the regional conceptual site model (CSM) confirming that the site is in a separate groundwater catchment to RAAF Base Williamtown.

Conclusion and recommendations

Based on the above findings, which have validated those of the analytical modelling performed as part of the HIA report, the recommendations of that report can now be confirmed. This includes the preparation and implementation of a project specific acid sulfate soil management plan (ASSMP) and groundwater monitoring and management plan (GMMP).

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Figure 8: Heads at time T1

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Figure 10: Heads at time year 10

Figure 11: Heads at time year 21

Figure 12: Drawdown at time T1

Figure 13: Drawdown at time year 5

Figure 14: Drawdown at time year 10

Figure 15: Drawdown at time year 21

Figure 16: Water-table elevation year 1

Figure 17: Water-table elevation year 5

Figure 18: Water-table elevation Year 10

Figure 19: Water-table elevation Year 21

Figure 20: Seawater intrusion year 1

Figure 21: Seawater intrusion year 5

Figure 22: Seawater intrusion year 10

Figure 23: Seawater intrusion year 21

Figure 24: Seawater intrusion year 21 (zoomed in)

Figure 25: Predicted groundwater salinity (mg/L as TDS) Year 1

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Figure 28: Predicted groundwater salinity (mg/L as TDS) Year 21

Figure 29: Schoeller Diagram for Bore MWX1 (July 2017 – June 2019)

Figure 30: Schoeller Diagram for Bore MWX2 (July 2017 – June 2019)

Figure 31: Schoeller Diagram for Bore MWX3D (July 2017 – June 2019)

Figure 32: Schoeller Diagram for Bore MWX3S (July 2017 – June 2019)

Figure 33: Schoeller Diagram for Bore MWX4D (July 2017 – June 2019)

Figure 34: Schoeller Diagram for Bore MWX4S (July 2017 – June 2019)

Figure 35: Schoeller Diagram for Bore MWX5 (July 2017 – June 2019)

Figure 36: Schoeller Diagram for Bore MWX6 (July 2017 – June 2019)

Tables

Table 1: Calibrated HSUs (after HydroSimulations 2017)

Table 2: Maximum annual groundwater extraction estimates

Table 3: Model values for hydraulic conductivity and storage parameters

Table 4: Simulated Steady-State Site Water Balance (21 years)

Table 5: Cumulative water balance and volumetric budget after 21 years

Appendices

APPENDIX A: GROUNDWATER CHEMICAL CHARACTERISATION (SCHOELLER PLOTS FOR MX SERIES BORES)

APPENDIX B: GROUNDWATER DEPENDENT ECOSYSTEM MAPPING (AFTER BOM, 2020)

1 INTRODUCTION

Boral Resources (NSW) Ltd (Boral) owns and operates the Stockton Sand Quarry (hereafter referred to as the 'site' or the 'quarry') and is currently seeking approval for continued and expanded operations for sand extraction from the inland vegetated dunes along the Stockton Bight coastline, through a State Significant Development (SSD). It is understood that initial extraction is proposed by front-end loader/ excavator, followed by dredging. The proposal (hereafter referred to as the 'Project') seeks a site wide transportation limit of 750,000 tpa per year until the windblown sand extraction project lapses in 2028, after which the transportation limits will then reduce back to 500,000 tpa.

The regional location of the site is provided on **Figure 1** and site layout on **Figure 2**.

Environmental Earth Sciences previously prepared the following reports for Boral as part of an environmental impact statement (EIS) in support of the above application:

- Acid Sulfate Soil Impact Assessment (AASIA, reference 717041_ASS_v2, dated 8 August 2019);
- Hydrogeological Impact Assessment (HIA, reference 717041_HIA_v4, dated 19 February 2020); and
- Rehabilitation Strategy (RS, reference 717041_RS_V3, dated 19 November 2020).

During the public exhibition period (now closed) a number of submissions were received from key stakeholders including local council, government agencies and the local community, namely:

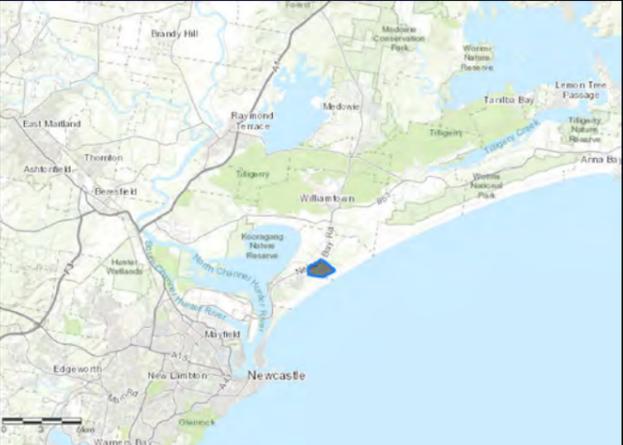
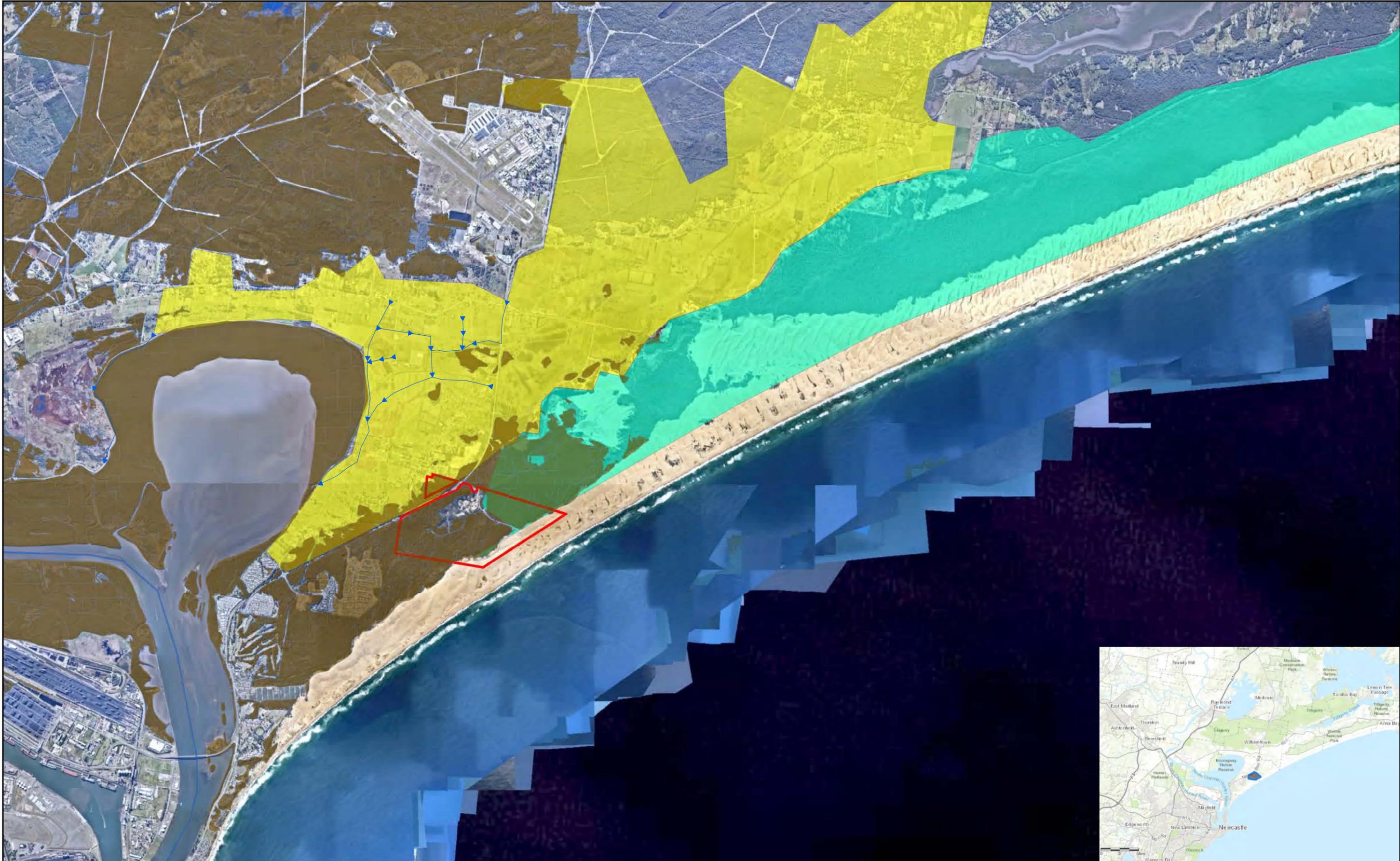
- Port Stephens Council (PSC);
- Department of Planning Industry and Environment (DPIE) – Planning Secretary;
- DPIE and Natural Resources Access Regulatory (NRAR) [combined response]; and
- DPIE Biodiversity and Conservation division (BCD) and NSW National Parks and Wildlife Service (NPWS) [combined response].

These responses raised specific concerns in relation to the project/ identified apparent data gaps in the information received that require further assessment to the satisfaction of each stakeholder, before approval for the expansion project may be granted.

This report has been prepared to detail the supplementary works required to address specific comments provided by DPIE relating to the provision of groundwater modelling in support of the proposed development.

1.1 Objectives

The objectives of the works are to address the DPIE exhibition comments pertaining to groundwater modelling, to the satisfaction of all identified stakeholders.



Legend

- Site boundary
- Terrestrial Groundwater Dependent Ecosystems (Hunter River)
- Aquatic Groundwater Dependent Ecosystems (Hunter River)
- Catchment Area
- PFAS management zone
- ↔ Surface water drains

1:57,061
 0 500 1,000 1,500 2,000 Meters

N

Coordinate System: WGS 1984 UTM Zone 56S
 Projection: Transverse Mercator
 Datum: WGS 1984

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Client: Boral	
Drawn By: TCT	Scale: as shown
Project Manager: MS	Date: October 2020
Reviewed by: MS	

Title: Site location and drainage	
Location: Boral Quarries, Coxs Land, Fullerton Cove	
Job No: 120082	
Source: ESRI, Nearmap Aug 2020	
Figure 1	



Legend

- Groundwater Bores
- Dredge Stages
- Site boundary
- Terrestrial Groundwater Dependent Ecosystems (Hunter River)
- Aquatic Groundwater Dependent Ecosystems (Hunter River)

Scale: 1:7,084
 0 50 100 150 200 Meters

Coordinate System: WGS 1984 UTM Zone 56S
 Projection: Transverse Mercator
 Datum: WGS 1984

		Title: Site layout	
		Location: Boral Quarries, Coxs Land, Fullerton Cove	
Client: Boral		Job No: 120082	
Drawn By: TCT	Scale: as shown	Source: ESRI, Nearmap Aug 2020	
Project Manager: MS	Date: November 2020	Figure 2	
Reviewed by: MS			

The modelling objectives are to:

- Assist in refinement of the hydrogeological conceptual site model (CSM) for the site and surrounds, including groundwater flow, and surface water-groundwater interaction.
- Provide input for decision-making for management.

This model will aim to identify any long-term impacts of the proposed expansion activities on nearby sensitive receptors and provide further confidence to stakeholders (beyond the narrative provided in the HIA) of the low-risk status of the project, with regards to impacts on ecosystems and local groundwater resources.

1.2 Scope of works

The scope of works has been developed to address the additional groundwater modelling work required by DPIE in support of the development. Specifically, the requirement for “*complex groundwater modelling conducted in accordance with the Australian Groundwater Modelling Guidelines, as described in section 3.2.3 of the AIP (2012)*”.

Based on the data available (both temporal and spatial), a Class 1 groundwater model has been developed for the site to predict potential impacts on sensitive receptors (aquatic and terrestrial groundwater dependent ecosystems [GDEs] and drinking water supplies).

DPIE have raised concerns in relation to the potential for aqueous geochemical reactions to detrimentally impact/ alter the water quality of the final dredge pond (acidify/ become an anoxic environment) which is intended to be rehabilitated as a natural, freshwater ecosystem at the conclusion of the proposed dredging activities. The intent of this geochemical modelling is therefore to provide further confidence to stakeholders that detrimental geochemical reactions are unlikely to occur within the final lake, and allow for appropriate mitigation and measures to be designed and incorporated into relevant management documents following approval of the Proposal.

2 CONCEPTUAL SITE MODEL (CSM) REFINEMENT

The CSM aims to inform an exposure assessment of any impact (or potential for impact) identified by demarcating sources, pathways and receptors of the groundwater flow system. The CSM is one of the primary planning tools used to support decision making processes, organising available information about a site or issue in a clear structure that facilitates the identification of data and information gaps.

The hydrogeological CSM has been developed as part of the HIA report, including text, maps, cross sections, graphics, tables and other visual representations (including Piper and Schoeller Plots to classify groundwaters on the basis of chemistry). This report has been provided to further develop and refine the CSM, in particular in the context of groundwater flow and surface water-groundwater interaction. Therefore, this report should be read with reference to Environmental Earth Sciences (2020a).

2.1 Physical setting

The physical setting at the site and surrounds has been described in detail in numerous previous reports, including the HIA report (which should be referred to for further detail). Some key parameters relating to modelling inputs have been summarised below.

2.1.1 Climate

Mean annual rainfall of 1,118 mm taken from Newcastle weather station (BOM)¹ at Nobby's Head, which is considered to have comparable on-ground conditions to site, rather than the closer Williamstown weather station.

2.1.2 Evaporation

Mean annual (Morton's Shallow Lake) evaporation of 1,382 mm/year was utilised (Southeast Engineering and Environmental, advice to Boral 30 September 2020).

2.1.3 Evapotranspiration

Evapotranspiration data was not available from the Williamstown RAAF BOM site. A local annual evapotranspiration estimate of 800 mm was derived from the average annual and monthly evapotranspiration maps from the BOM².

2.1.4 Topography

Topography within the project area forms the shape of a basin, reflective of former sand extraction in this area. Topography ranges from approximately 2.0 – 5.5 m AHD in the centre of the Project area and is encircled by higher topography ranging from a maximum of 29 m AHD (north), 8.8 m AHD (south), 27 m AHD (east) and 12 m AHD (west).

2.1.5 Surface water and site catchment

The site comprises the Stockton sand dunes, with no surface water features present within the Site. There are no established drainage lines within the site due to the very high rate of infiltration to the sand substrate. Any runoff during high intensity rainfall would typically collect in interdunal swales, where infiltration would be dependent on the antecedent groundwater conditions. The Pacific Ocean (Tasman Sea) lies directly to the south of the Stockton dunes. Tidally influenced Fullerton Cove and lower Hunter River are situated to the west of the project site and Port Stephens and Tilligerry Creek are tidal water bodies to the north-east.

The surface water catchment area encompassing the site is included on **Figure 1**, which indicates that the Stockton Sandbeds is a longitudinal network of sand dunes extending along the coastline.

¹ http://www.bom.gov.au/climate/averages/tables/cw_061055_All.shtml

² http://www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp?maptypes=1&period=an#maps

2.2 Geology

The site's geology is Quaternary Holocene barrier dune (Qhbd) described as unconsolidated aeolian deposits of marine sand estimated to have formed between 6,500 – 9,500 years ago. This deposit ranges from 10 – 30 m thick and it is commonly referred to as the Stockton Sandbeds or the Stockton Sand Member. **Figure 1** shows the longitudinal nature of the unit.

The Tomago Sandbeds are Pleistocene-aged (circa 30,000 years) deposits that underlie the Stockton Sandbeds. Finally, the Stockton and Tomago Sandbeds are underlain by the Medowie Clay Member. A geological cross section of the area through the Tomago-Stockton Sandbeds, based on Thom *et al.* (1992) and Roy and Boyd (1996), after Woolley *et al.* (1995) is presented as **Figure 3**.

2.3 Hydrogeology

2.3.1 Aquifers

The Stockton Sandbeds and transgressive sand dunes are the main aquifer at the site and comprise the Stockton Groundwater Source of the Water Sharing Plan (WSP) for the North Coast Coastal Sands Groundwater sources. Underlying these are the Tomago Sandbeds of the Tomago Groundwater Source. The Stockton Sandbeds Aquifer is a shallow unconfined aquifer which overlies the south, south-eastern extremity of the deeper Tomago Sandbeds Aquifer. The sand extraction proposed for the project area is intended to be contained within the Stockton Sandbeds Aquifer.

2.3.2 Local recharge-discharge and flow patterns

The recharge zone for the Stockton Sandbeds Aquifer is along the Stockton transgressive sand dunes (HydroSimulations, 2017).

Groundwater flow at the site and along the Stockton Sandbeds and transgressive sand dunes, as well underlying Tomago Sandbeds (after HydroSimulations 2017, Environmental Earth Sciences 2020 and Woolley *et al.* 1995) is to the:

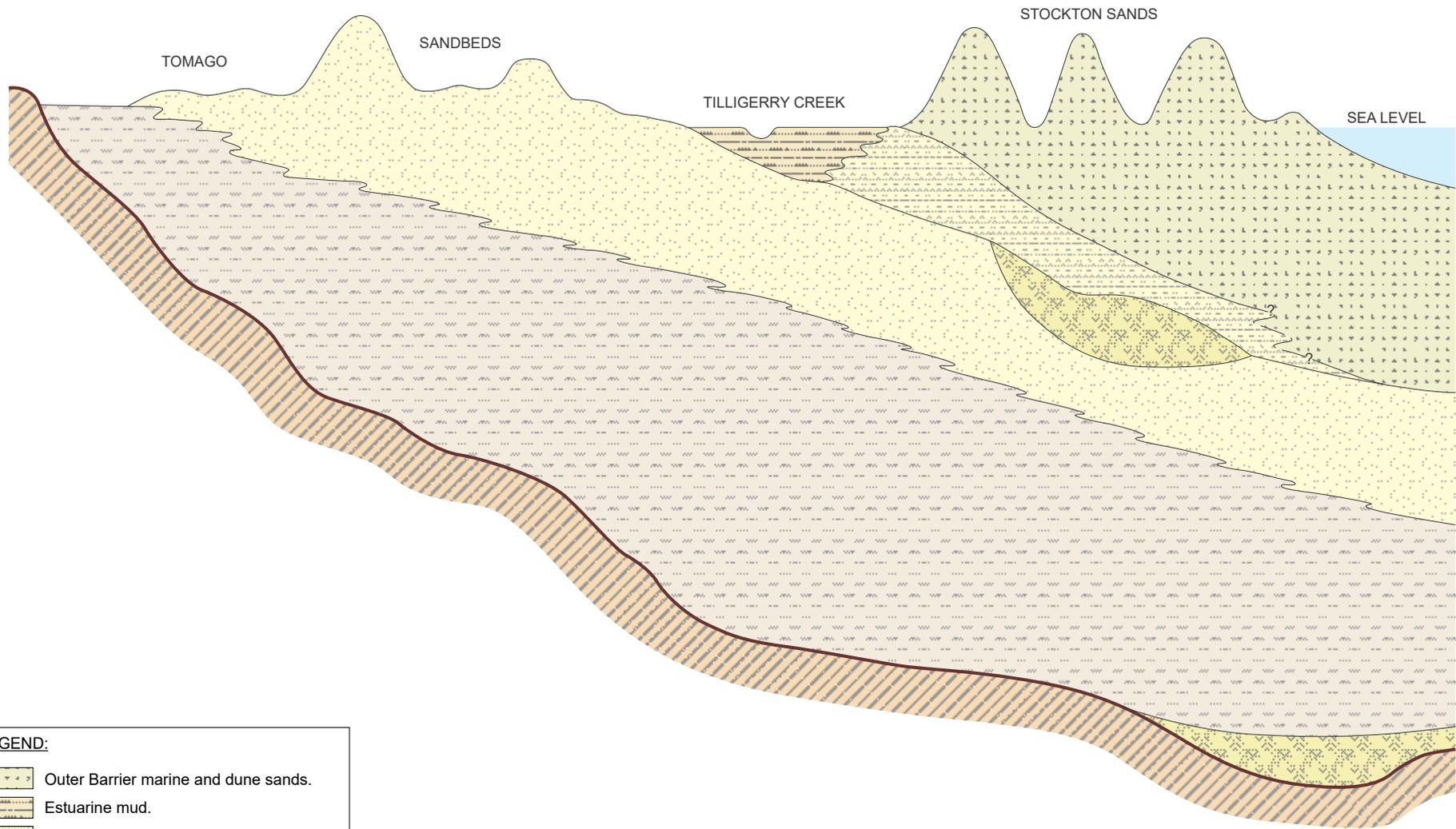
- Pacific Ocean to the immediate south, south-east of the site; and
- north, north-east towards Fullerton Cove and Tilligery Creek estuaries (including Long Bight Swamp, and Fourteen Foot Drain and other man-made drainage structures, which are generally at or below sea-level – see **Figure 1** and **Appendix B**).

2.3.3 Hydrostratigraphic units (HSUs)

The following HSUs have been identified at the site, with their physical parameters calibrated as part of the most recent numerical modelling report performed on these units (HydroSimulations 2017, Section 4.6.3 Table 4-4).

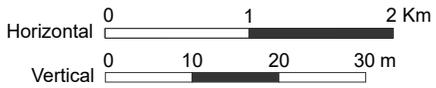
North West

South East



LEGEND:

-  Outer Barrier marine and dune sands.
-  Estuarine mud.
-  Marine and estuarine sands and muds.
-  Fluvial sand and gravel.
-  Inner Barrier marine and dune sands.
-  Estuarine-lagoonal mud; sand lenses.
-  Unconformity.
-  Bedrock.



 ENVIRONMENTAL EARTH SCIENCES CONTAMINATION RESOLVED	Title: General Geological Cross Section
	Location: Nelson Bay Road, Fullerton Cove, NSW
Client: Boral Resources (NSW) Pty Ltd	Job No: 120082
Project Man: MS	Scale: As shown
Drawn By: LB	Date: November 2018
Figure 3	

Table 1: Calibrated HSUs (after HydroSimulations 2017)

Layer	HSU	Kh (m/d)	Kv (m/d)	Kv/Kh	Ss (m ⁻¹)	Sy
1	Stockton Sandbeds	20	0.2	0.01	0.0001	0.18
2	Medowie Clay/ Tilligerry Mud	0.5	0.03	0.06	0.0001	0.05

Note(s): Kh – hydraulic conductivity (horizontal); Kv – hydraulic conductivity (vertical); Ss – specific storage; Sy – specific yield

2.3.4 Chemical conditions (hydro-geochemistry)

According to the HIA (Environmental Earth Sciences 2020a, Figures 4 and 5) the site is located atop a groundwater divide, which has been corroborated by both the historic and more recent data collected at the site and summarised below.

Groundwater at the site can be chemically classified as follows:

- west of the groundwater divide (towards Fullerton Cove) the shallow Stockton Sands aquifer is predominantly sodium-chloride (Na-Cl) dominated (as represented by bores MW_X1, MW_X2, MW_X3S and MW_X4S), whilst the deeper portion of the Stockton Sandbeds aquifer is calcium-bicarbonate (Ca-HCO₃) dominated (as represented by bores MW_X3D and MW_X4D), likely reflective of an increasing marine (carbonaceous material such as shells and marine exoskeletons) influence with depth; whereas
- east of the divide (towards the coast) the groundwater is Ca-HCO₃ dominated (Na-Cl sub-dominant) in bores MW_X5 and MW_X6, also likely reflective of an increasing marine influence.

Updated Schoeller plots demonstrating the ionic composition for groundwater for key monitoring bores (MX series bores) are provided in **Appendix A (Figures 29-36)**. All bores have a data range of July 2017 to June 2019 for most ions. These charts show the consistency of groundwater chemistry over time at each sampling location providing an excellent background water chemistry signature.

2.3.5 Per- and polyfluoroalkyl substances (PFAS)

Based on a review of numerical and solute transport modelling performed for per- and polyfluoroalkyl substances (PFAS) emanating from RAAF Base Williamstown (HydroSimulations 2017 and URS 2015), it can be concluded that there is no risk of PFAS impacts from the RAAF source to the site. This is demonstrated in **Figure 4** below, which shows the predicted extent of the PFAS plume emanating from the RAAF Base in 2050, after HydroSimulations (2017, Figure 24).

This prediction is supported by the fact that the site sits in a different groundwater catchment to the RAAF Base, with a groundwater discharge zone for both the Stockton Sandbed aquifer (to the south) and Tomago Sandbed aquifer (to the north) being present in the locality of Fullerton Cove, Long Bight Swamp, Fourteen Foot Drain and Tillgerry Creek (north of the site and south of the RAAF Base).

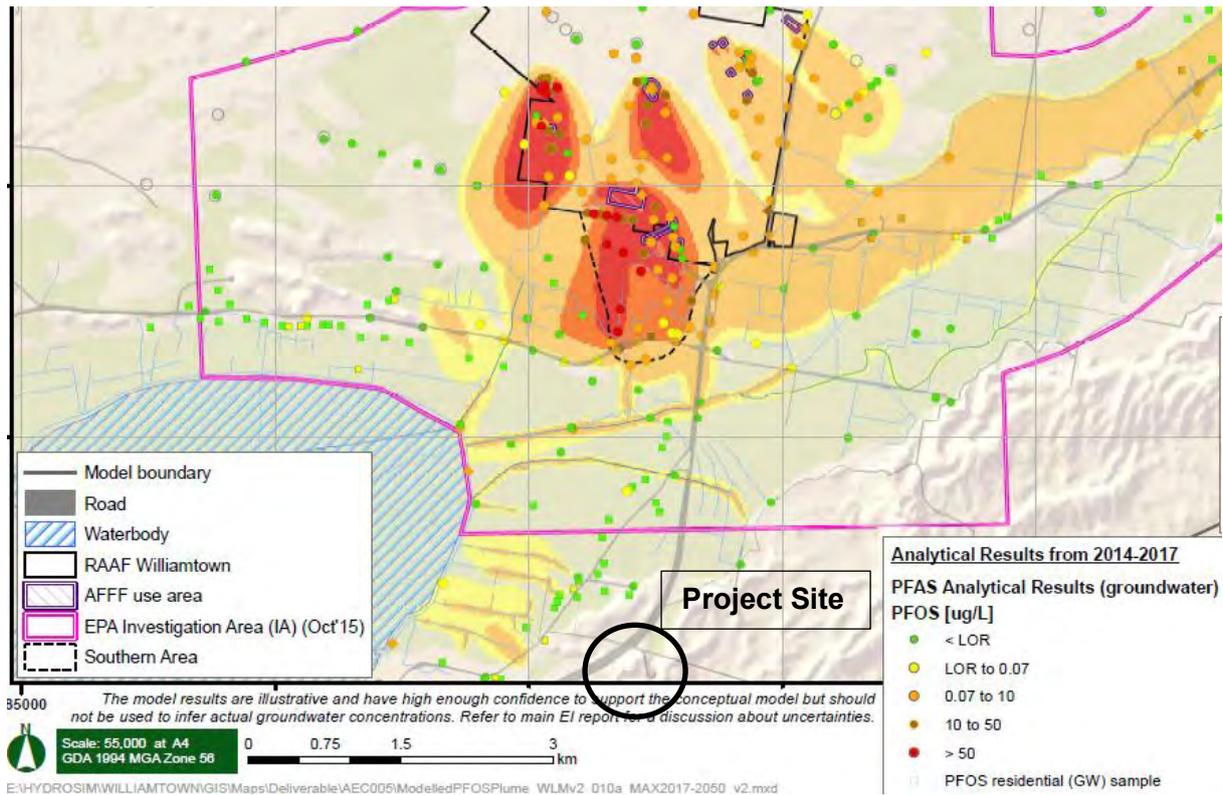


Figure 4: Modelled maximum PFOS distribution in groundwater 2017-2050 (HydroSimulations, 2017)

This finding is also supported by groundwater chemical data collected from the site over 2018 (five events) and 2020 (six events) exhibiting PFAS concentrations less than the laboratory limit of reporting (LOR) (Environmental Earth Sciences 2020a and 2020b).

The potential effect of dredging on the RAAF PFAS plume is discussed in Section 4.2.2.

2.3.6 Groundwater dependent ecosystems (GDEs)

As part of the HIA, investigations into the potential for the presence of GDEs in the vicinity of the site were undertaken. The closest potential GDEs are terrestrial and located to the south-east (seaward) and north-west (inland) of the extraction area, as indicated on **Figures 1** and **2**. GDE maps (after BOM, 2020) are also provided in **Appendix B**.

The seaward GDEs comprise small ephemeral and mobile shallow deflation basin lakes vegetated with a variety of grasses, sedges and reeds. These lakes provide an ephemeral habitat for a number of invertebrates and other species (ERM, 2005).

The inland GDEs are primarily the swamp forests in the dune swales and the low-lying heath. These systems are up-gradient (inland) of the extraction area.

Based on the HIA dataset, Environmental Earth Sciences determined that the risks posed to GDEs in the vicinity of the project site (groundwater, surface water and aquatic ecosystems) are low. This is because the sand extraction activities (primarily creation of a dredge pond) and end-point rehabilitation to a freshwater lake/ wetland is not predicted to alter the hydrogeological regime of natural movements of groundwater (including static water levels

[SWLs]), nor result in adverse chemical reactions (e.g. acidification, salinisation) or groundwater contamination.

However, in response to DPIEs request for additional information (to provide further support to the conclusions drawn above), further consideration of potential impacts to local GDEs in this manner has been undertaken (refer to Sections 3 and 4 below). This will identify any long-term impacts of the proposed extraction activities on nearby sensitive receptors.

2.3.7 Surface water and groundwater connectivity

The HIA report confirmed that (based on study of hydrographs) the Stockton Sandbeds Aquifer responds rapidly to rainfall, with observations indicating that events >40 mm could raise static water levels (SWLs) by approximately 0.5m. The catchment soil type (Podosols) is expected to recharge around 30-45% of rainfall (Crosbie *et al.*, 2010a and 2010b).

3 GROUNDWATER MODELLING

The potential impacts of the Stockton dredge sand quarry on groundwater have been further assessed with the conversion of the initial HIA (Environmental Earth Sciences, 2020a) into a conceptualised model in Visual MODFLOW Flex 6.1. From conceptualisation, the model was converted to a numerical model to simulate sand quarrying and associated impacts over a 20-year period.

3.1 Conceptual model establishment

The key features of the conceptual model of the Stockton sand dredge quarry include:

- An unconfined (water-table) aquifer in the Stockton Sand Member to approximately -25 mAHD depth, underlain by an aquiclude in the Medowie Clay Member of approximate 5 m thickness;
- The Medowie Clay Member forms a no-flow barrier and is relatively flat with a gentle dip to the east and south-east;
- The unconfined Stockton Sand Member's recharge is dominated by rainfall infiltration, with recharge estimated at 43% of average annual precipitation (Crosbie *et al.*, 2010a);
- Groundwater flows mostly to the east and south-east towards the ocean, although the presence of the southwest-northeast trending topographic divide along the dunes also indicates groundwater to the north-west of the proposed dredge stages may flow in a west, north-westerly direction toward Fullerton Cove.

Figure 5 has been provided to show the key features of the conceptual model, including:

- The model boundary;
- The site boundary;

- Proposed stages of dredging (Stages 2-6). Note that Stage 1 is considered a 'dry' extraction process above the water table; and
- Current monitoring bore network.

Figure 6 shows the model refined grid mesh, also showing the model boundary conditions, including a constant head boundary along the coast.

3.2 Model layout and parameters

The model was developed with two layers:

- Stockton Sand Member (Layer 1); and
- Medowie Clay Member (Layer 2).

Ground surface elevation was digitised in ArcGIS using survey data provided by Boral. A three-dimensional representation of the model is presented in **Figure 7**.

3.2.1 Model domain and boundary conditions

The grid size used in the model was refined from approximately 25 m by 25 m to ~11 m by 11 m across the sand dredge areas (refer to **Figure 6**). Layer 1 (Stockton Sand Member) surface ranged from ~19 mAHD in the highest surveyed point of the dune system on site to -30 mAHD. Layer 2 was defined as approximately 5 m thick and is a no-flow barrier boundary.

Other boundary conditions:

- Constant head boundary (ocean) fixed at 0 mAHD;
- General head boundary of 1 mAHD along the north-western model boundary (Nelson Bay Road) – Layer 1;
- General head boundaries of 1.5 mAHD along the south-western and north-eastern model boundaries – Layer 1 to allow for water-table seasonal fluctuations;
- Constant head boundary of -25 mAHD (allowing for semi-confined conditions) in Layer 2;
- Constant seawater concentration of 32,000 mg/L TDS at the ocean constant head boundary;
- Initial heads of 1.5 mAHD in Layer 1, and -25 mAHD in Layer 2; and
- Initial salinity concentrations of 400 mg/L TDS in Layer 1, and 5,000 mg/L in Layer 2.

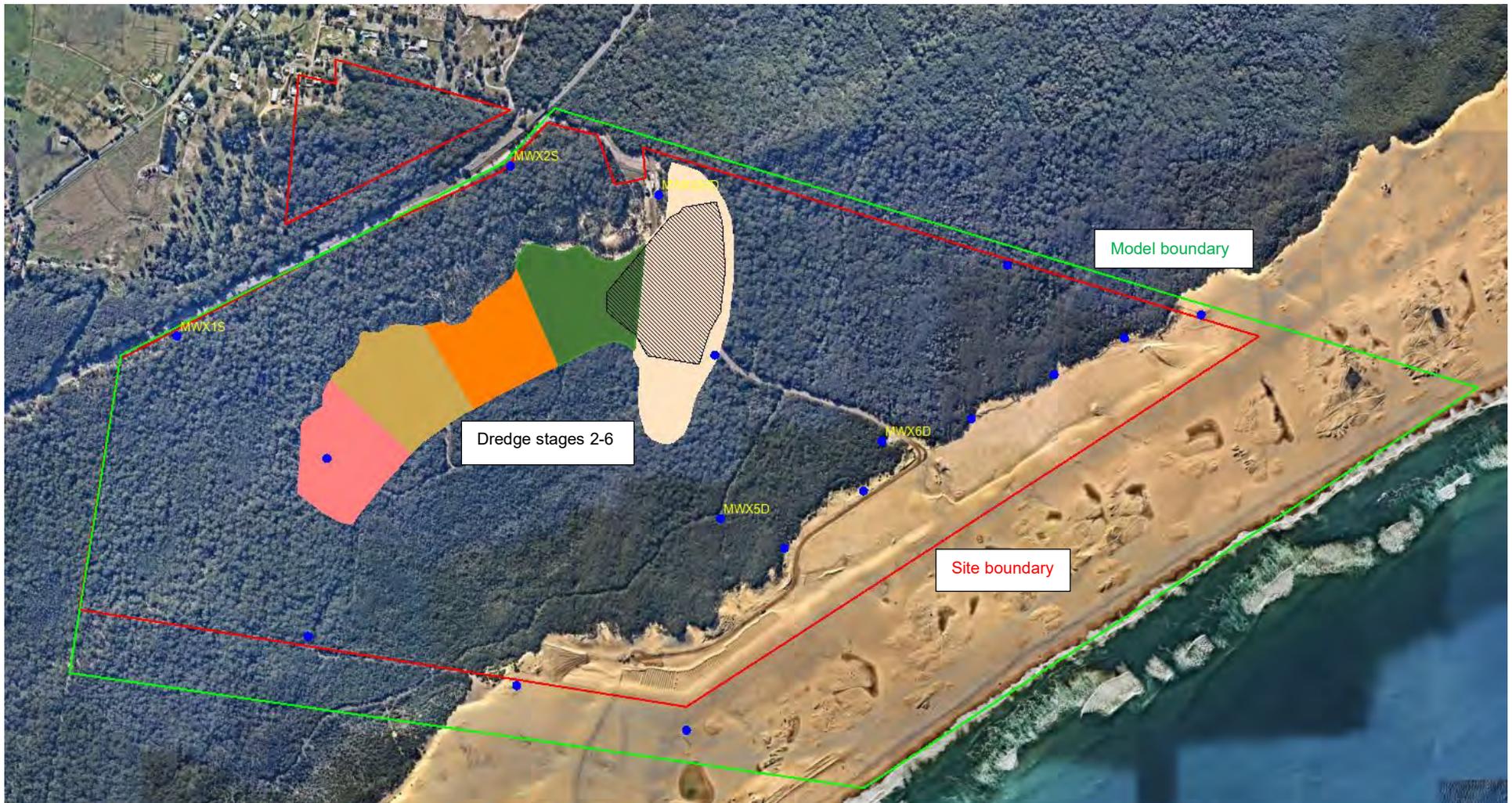


Figure 5: Groundwater conceptual model features

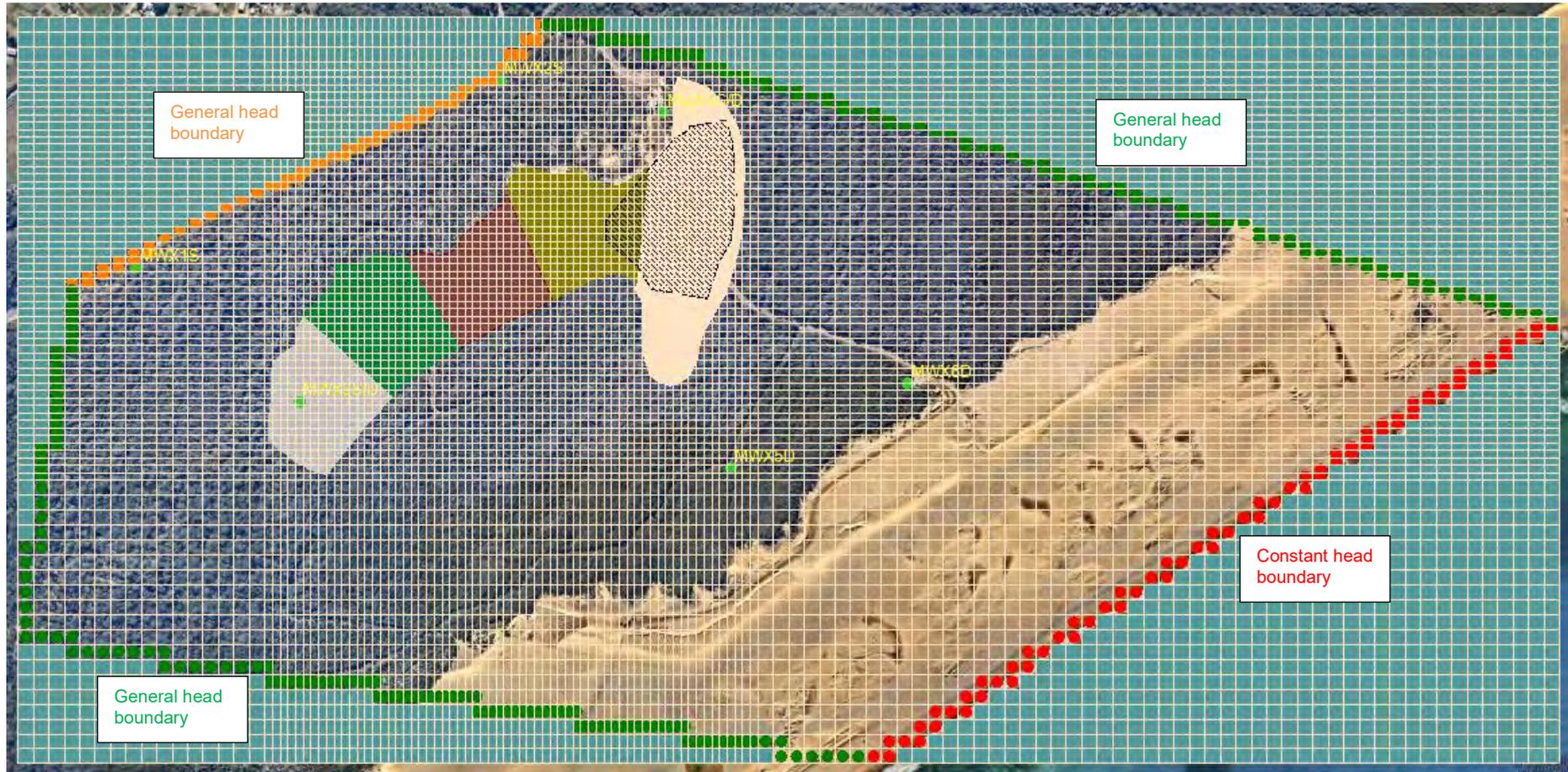


Figure 6: Numerical model – refined grid

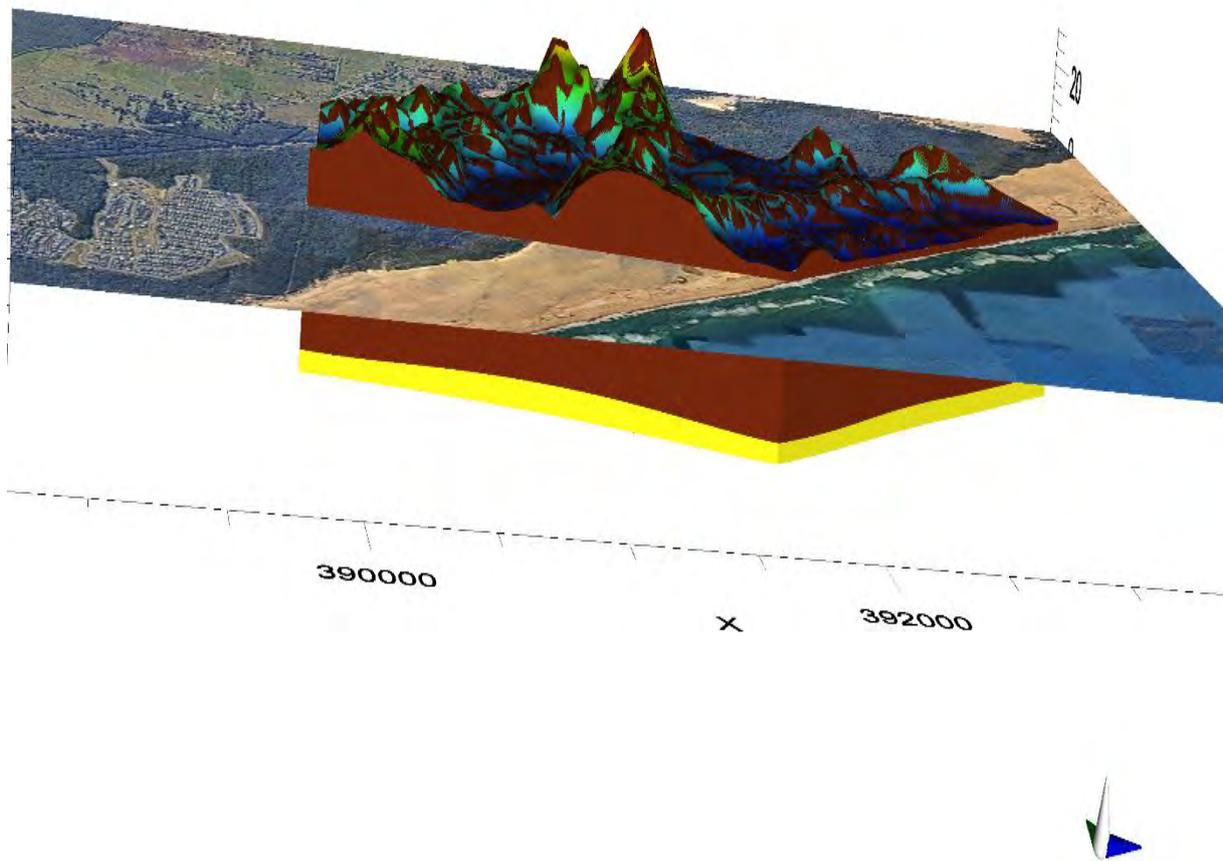


Figure 7: 3-dimensional representation of model (10 x vertical exaggeration)

The LAKE function was used to represent the six stages of sand extraction (Stage 1 being “dry” extraction process and Stages 2 to 6 being staged dredging activities). Each dredge stage was defined according to the proposed development schedule, with the top of each lake (stage) set at 1 mAHD and the base at -15 mAHD.

3.2.2 Lake extraction

Extraction estimates were adopted from the surface water impact assessment report (Southeast, 2020) using the actual take estimates, presented in **Table 2**.

3.2.3 Hydraulic conductivity and aquifer storage parameters

Estimates of hydraulic conductivity (K) and storage parameters were derived from Environmental Earth Sciences (2020) and HydroSimulations (2017), and are presented in **Table 3**.

Table 2: Maximum annual groundwater extraction estimates

Stage	Operation year	Maximum annual extraction for the periods modelled	
		ML/year	m ³ /day
1	1	31.4	86
	2	31.4	86
	3	31.4	86
2	4	114.67	315
	5	123.53	339
	6	132.39	364
3	7	132.39	364
	8	140.55	386
	9	148.72	409
4	10	156.88	431
	11	156.88	431
	12	164.12	451
	13	171.35	471
5	14	178.59	491
	15	185.83	511
	16	185.83	511
6	17	197.79	543
	18	209.75	576
	19	209.75	576
	20	223.72	615
	21	237.69	653

3.2.4 Recharge and evaporation

An extinction depth of evapotranspiration of 2 m was adopted. As indicated in Section 2.1.3 above, a local annual evapotranspiration estimate of 800 mm was derived from the average annual and monthly evapotranspiration maps from the BOM.

Table 3: Model values for hydraulic conductivity and storage parameters

Parameter (units)	Layer 1	Layer 2
Horizontal <i>K</i> (m/sec)	0.00029	2.9 x 10 ⁻⁵
Horizontal <i>K</i> (m/day)	25	2.5
Vertical <i>K</i> (m/sec)	10 ⁻⁷	10 ⁻⁸
Vertical <i>K</i> (m/day)	0.01	0.001
Specific storage (<i>Ss</i>)	10 ⁻⁵	10 ⁻⁵
Specific yield (<i>Sy</i> , %)	15	15
Effective porosity (<i>n_e</i> , %)	14	5
Total porosity (%)	30	15

3.2.5 Interaction with seawater

Based on desk-top assessment, the risk of seawater intrusion is considered minimal, as evidence of this in the local area has indicated the saline interface is “within 60m of the high-water mark” and saltwater intrusion “is minimal below the high-water mark” and “generally within 100m of the shore” (Woolley *et al.* 1995, s6.3). **Figure 2** demonstrates that the proposed lake that will be formed by sand dredging is over a kilometre from the shore.

Previous numerical modelling has indicated that even considering zero recharge and drought conditions, a safe extraction rate (i.e. total loss of water) of 20 ML/day would prevent saltwater intrusion in the Stockton Sandbeds (Woolley *et al.* 1995, s6.3).

4 MODELLING RESULTS AND IMPACT ASSESSMENT

4.1 Predicted physical impacts

4.1.1 Groundwater levels

Figures 8 to 11 (in the Figures section at the rear of this report) have been presented to show the model output of predicted groundwater levels between Year 0 (commencement of “dry” sand extraction Stage 1) and year 21 (completion of dredging stage 6). This output demonstrates that the model predicts (based on the inputs presented above) that there will be negligible to no change in groundwater levels as a result of the creation of the dredge pond over a 21-year period, and suitable for a 25-year consent.

4.1.2 Site modelled water balance

A water balance has been presented in **Table 4**. The cumulative water-balance, and water balance for year 21 and the final model time step has been provided in **Table 5** in the Tables section at the rear of this report.

Table 4: Simulated Steady-State Site Water Balance (21 years)

Parameter	Inflow			Outflow			
	Units	L/sec	m ³ /d	ML/a	L/sec	m ³ /d	ML/a
Recharge		24.1	2,079	760			
Storage		0.4	30.4	13	0.0	1.1	0.4
Constant Head		2.7	234	85	142.0	12,272.5	4,479.5
Groundwater inflow		259.4	22,415.5	8,180			
Lake Seepage (Dredge Stages)		1.8	159.5	58.2	15.4	1329.3	485.2
Evapotranspiration					0.0	0.9	0.3
Groundwater outflow					148.9	12866.2	4,696.2
TOTAL		288.4	24,918.4	9,096.2	298.2	25,766.4	9,404.7

4.1.3 Water level drawdowns

Figures 12 to 15 (in the Figures section at the rear of this report) have been presented to show the model output of predicted water-table drawdown levels between year 0 (commencement of “dry” sand extraction Stage 1) and year 21 (completion of dredging stage 6). **Figures 16 to 19** (in the Figures section at the rear of this report) have also been presented to show the model output of predicted water-table elevations between year 0 (commencement of dredging stage 1) and year 21 (completion of dredging stage 6).

This output demonstrates that the model predicts (based on the inputs presented above) that the level of drawdown in the water-table at the site will decline as the size of the lake increases over a 21-year dredging period, with water-table elevations remaining consistent over time.

4.2 Predicted chemical impacts

4.2.1 Seawater intrusion

Figures 20 to 24 (in the Figures section at the rear of this report) have been presented to show the model output of predicted seawater intrusion between year 0 (commencement of “dry” sand extraction Stage 1) and year 21 (completion of dredging stage 6). This output

demonstrates that the model predicts that there will effectively be no seawater intrusion over a 20-year dredging period.

4.2.2 PFAS impacts following dredging

The modelled drawdown and water-table levels of the project duration indicate no appreciable impact on groundwater outside the site boundary, including to the north, in the direction of the RAAF Base Williamstown PFAS plume (which accords with HydroSimulations' findings from 2017, see **Figure 4** above). Therefore, based on the predicted water-table elevations as a result of dredging shown in **Figures 16 to 19** below, it can be concluded that dredging activities will not influence or exacerbate the migration of the PFAS plume that is present to the north of Fourteen Foot Drain.

4.2.3 Solute transport assessment of dredge pond

In the unlikely event that chemical reactions occur as a result of the creation of the dredge pond (such as sulfide oxidation), an assessment of the potential impacts has been performed. This was undertaken through the following step-wise process for the Stockton Sandbeds aquifer.

Firstly, Darcy's law ($V_g = K_h \cdot i / n_e$, where K_h is reported in **Table 3** above [25 m/day], i is hydraulic gradient [0.0015 m/m] and n_e [effective porosity] is also reported in **Table 3** [0.14]), was used to estimate the groundwater attenuation rate between the pond (groundwater divide pre-dredging) and the ocean (0.3 m/day or 98 m/year).

Secondly, the potential for dissolved salts created as a result of the dredging operations (such as evapo-concentration or sulfide oxidation) to migrate towards the nearest receptor (the ocean or nearby terrestrial GDEs) was assessed using a solute transport approach (after Domenico 1987 and Carey *et al.*, 2006).

Based on a flow-path length of close to 1,000 m, longitudinal dispersivity (α_x) was calculated as 12m, transverse dispersivity (α_y) as 1.2m and vertical dispersivity (α_z) as 0.12 (after Carey *et al.* 2006 and Fetter 2001, based on Xu and Eckstein 1995). From the α_x value, longitudinal hydrodynamic dispersion (D_x or D_L) and the Peclet (Pe) number can be calculated. As Pe for the calculations ranges from 12-85 along the flow-path (i.e. are >6 after Guyonnet and Neville 2004 and Newell *et al.* 2002), the potential for errors associated with use of the Domenico solute transport solution can be considered low.

Figures 25 to 28 (in the Figures section at the rear of this report) have been presented to show the solute transport model output of predicted groundwater salinity as total dissolved salts (TDS) between year 0 (commencement of "dry" sand extraction Stage 1) and year 20 (completion of dredging stage 6).

The output indicates that the model predicts the salinity of groundwater will gradually decline as freshwater recharge from the lake increases over time.

This outcome demonstrates that the potential for increased dissolved salts (such as sulfate and TDS) within the surrounding aquifer as a result of any changes in chemistry in the lake over time are predicted by the model to be low and acceptable. It can be therefore predicted that the consistent chemistry of groundwater observed to date, as shown on **Figures 29 to 36** in **Appendix A**, will continue throughout the operation of the proposed dredging project.

5 CONCLUSION AND RECOMMENDATIONS

The supplementary works reported herein have been performed to address a request from DPIE to provide a Class 1 groundwater numerical model (after Barnett *et al.* 2012, s2.5 and Table 2-1) in support of the proposed development, to support the analytical approach provided in the HIA report (Environmental Earth Sciences, 2020a).

The model has predicted that groundwater levels in the aquifer surrounding the lake, and in particular between the lake and the ocean, will remain stable and close to current static conditions over the period of creation of the lake (assumed to be 21 years, and the consent period of 25 years).

The model has also predicted that seawater intrusion and other potential chemical impacts associated with increased concentrations of dissolved salts as a result of dredging operations are not expected to be a risk. Due to the increased recharge associated with the creation of the lake, the aquifer at and surrounding the site is expected to reduce in salinity as a result of dredging operations.

As such, given groundwater levels in the aquifer are anticipated to remain stable, and seawater, PFAS and other potential chemical impacts are not expected to occur, no adverse impacts to local GDEs are predicted.

Based on the above findings, which have validated those of the analytical modelling performed as part of the HIA report (Environmental Earth Sciences, 2020a), the acid sulfate soil management plan (ASSMP, after Environmental Earth Sciences 2019) and groundwater monitoring and management plan (GMMP, after Jacobs 2017) for the site can be implemented.

As part of the GMMP recommendations for analytical suites, no further assessment for PFAS is necessary (after Environmental Earth Sciences 2020a and 2020b, HydroSimulations 2017 and URS 2015).

6 LIMITATIONS

This report has been prepared by Environmental Earth Sciences NSW ACN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Boral;
2. The specific scope of works set out in 120082_VAR01 and included in Section 1.2 (Scope of Work) of this report;
3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);

4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works being located at Cox's Lane, Fullerton Cove, NSW ("the site");
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
7. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
8. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill, excavated natural material (ENM) or virgin excavated natural material (VENM) if deposited off site;
9. This report is not a geotechnical or planning report suitable for planning or zoning purposes; and
10. Our General Limitations set out at the back of the body of this report.

7 REFERENCES

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ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval

The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

FIGURES

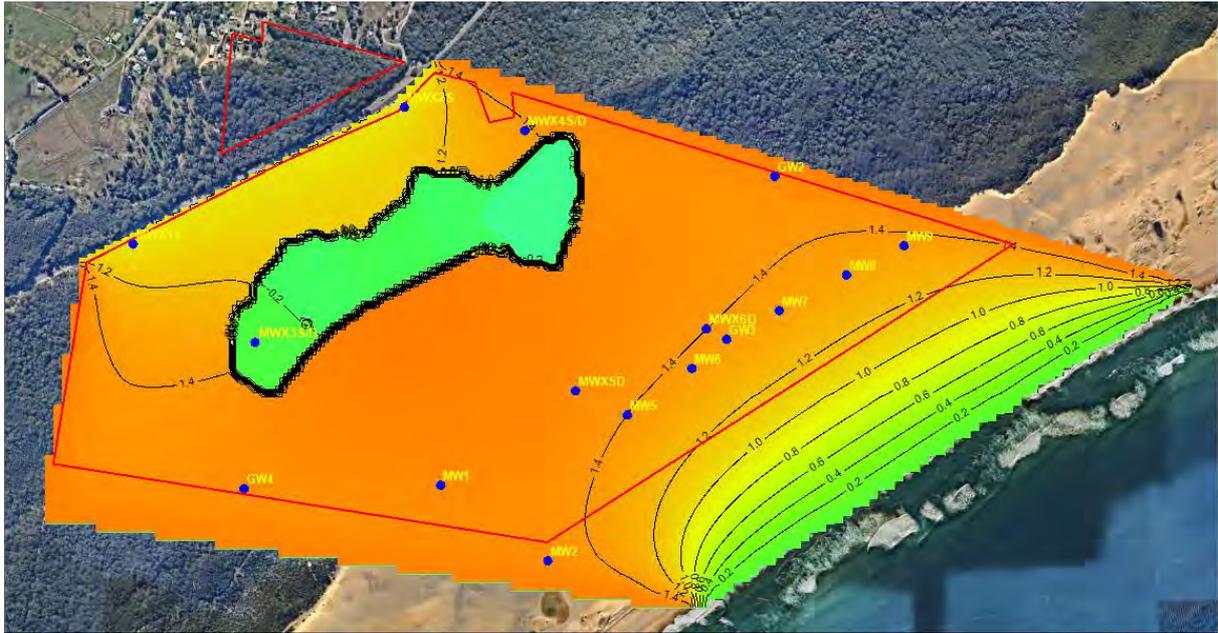


Figure 8: Heads at time T1

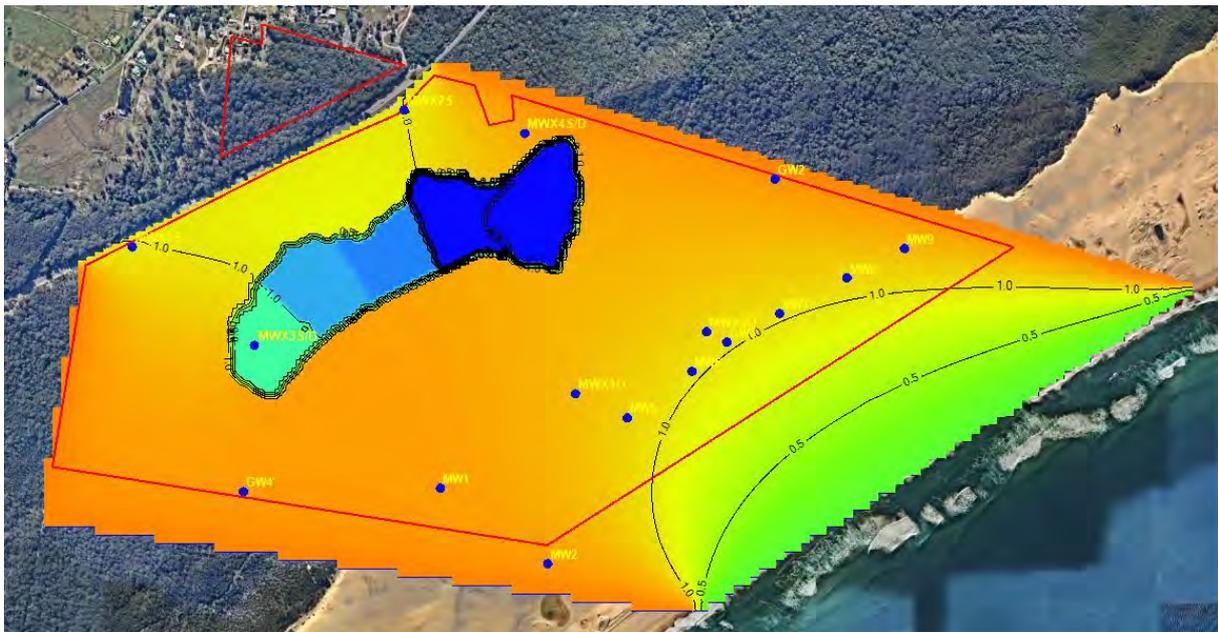


Figure 9: Heads at time year 5

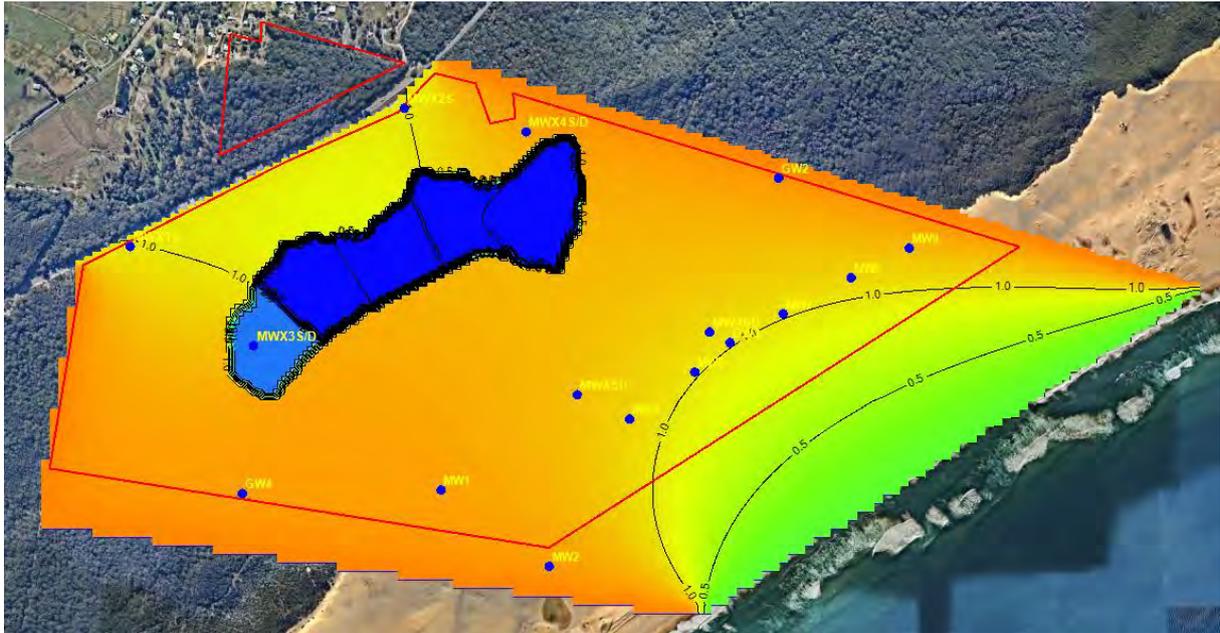


Figure 10: Heads at time year 10

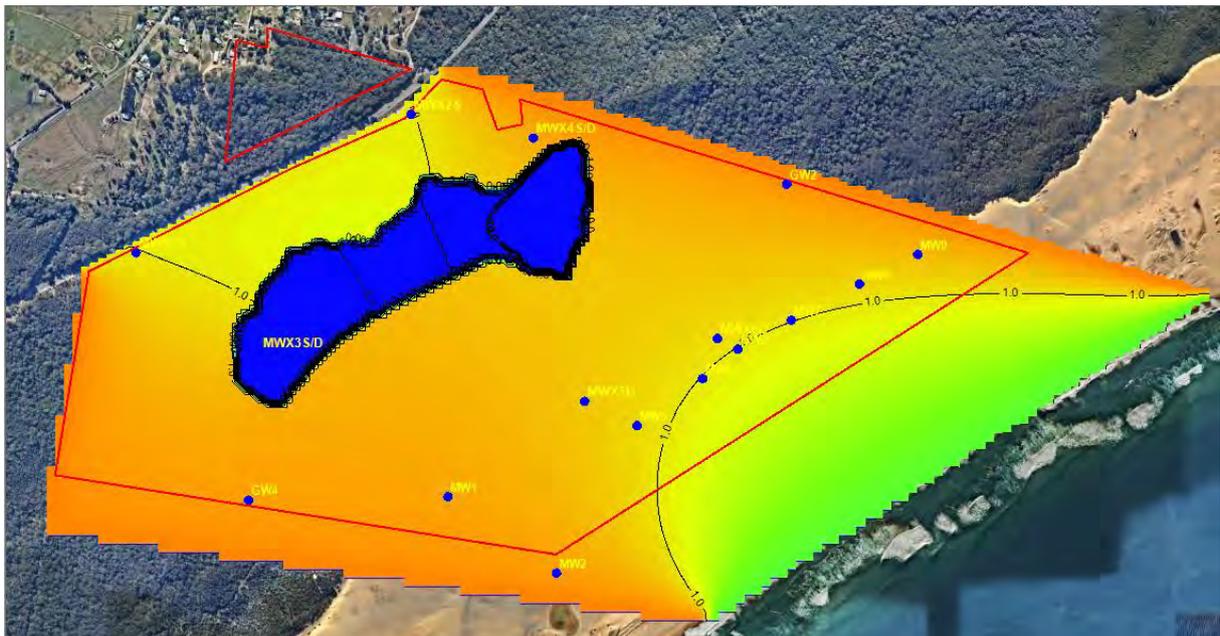


Figure 11: Heads at time year 21

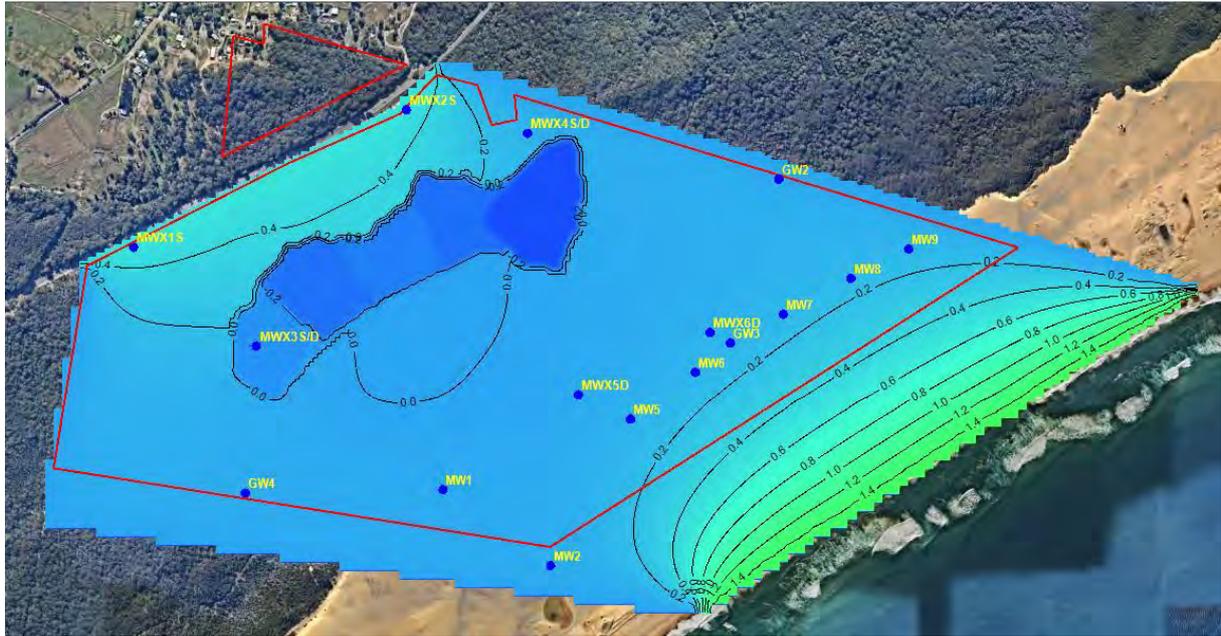


Figure 12: Drawdown at time T1

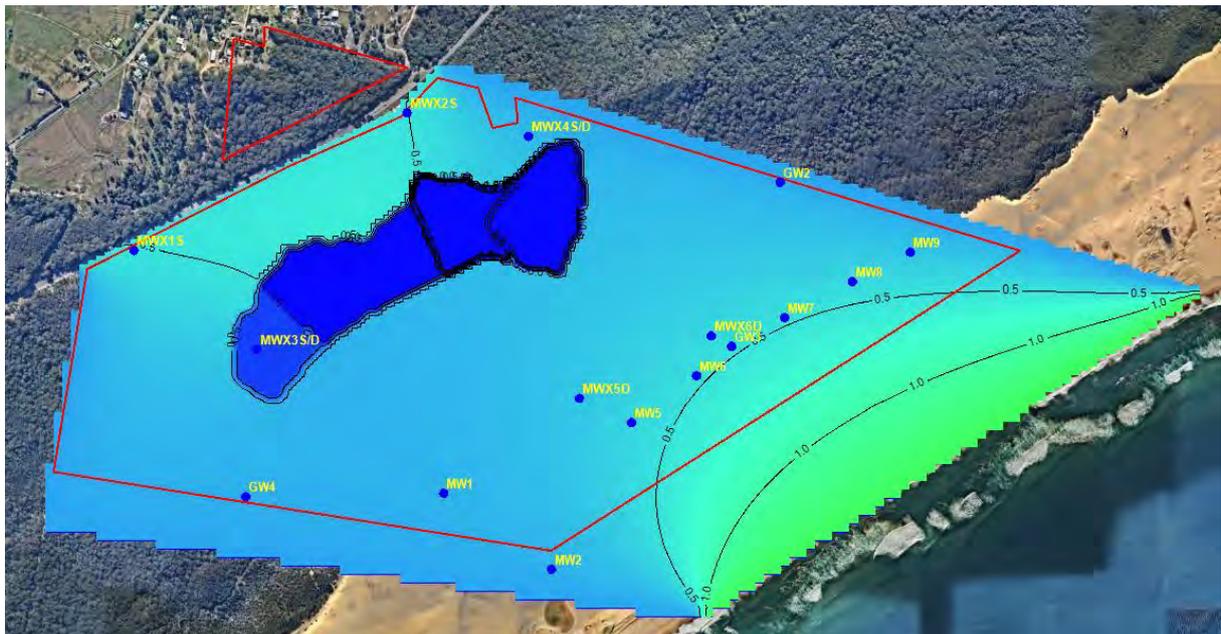


Figure 13: Drawdown at time year 5

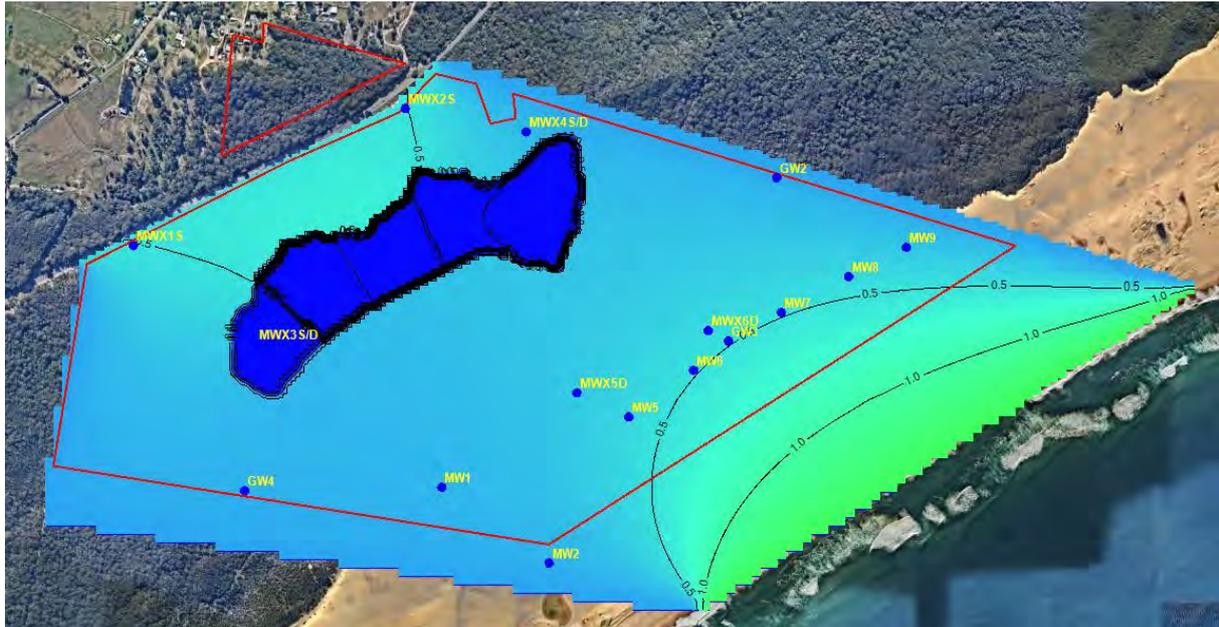


Figure 14: Drawdown at time year 10

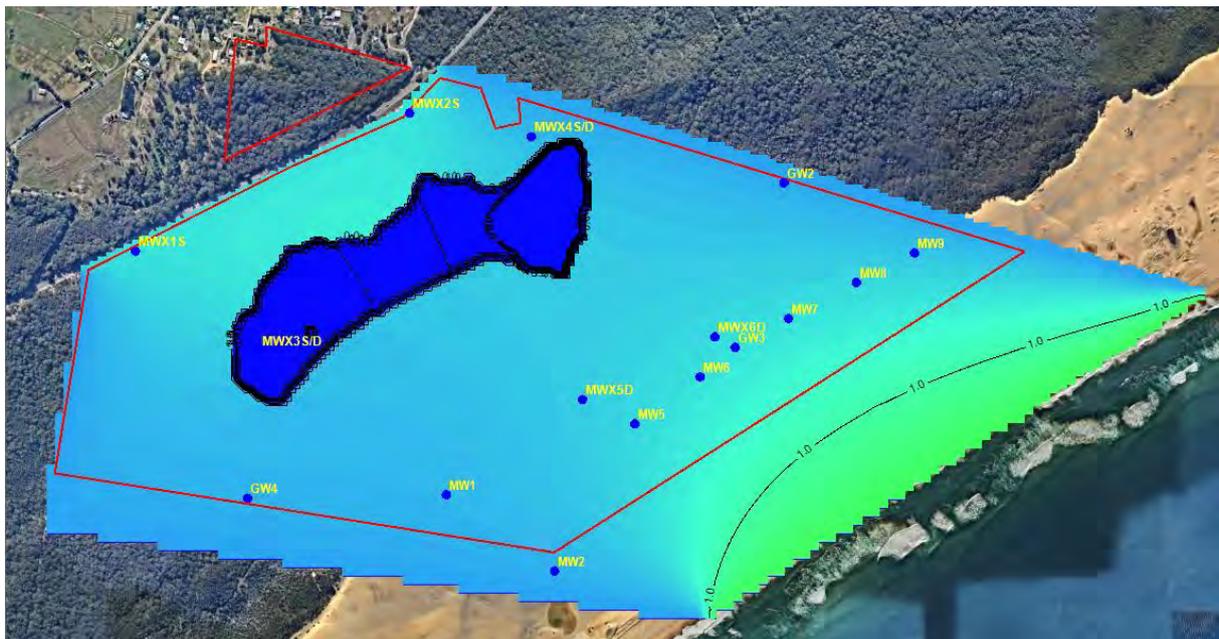


Figure 15: Drawdown at time year 21

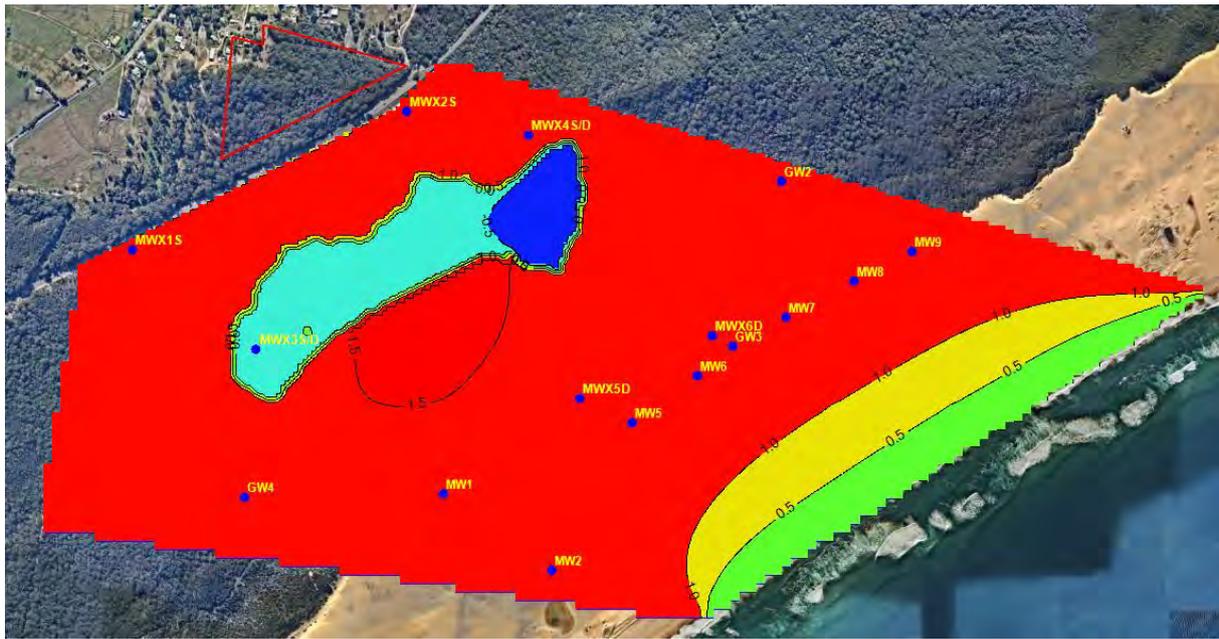


Figure 16: Water-table elevation year 1

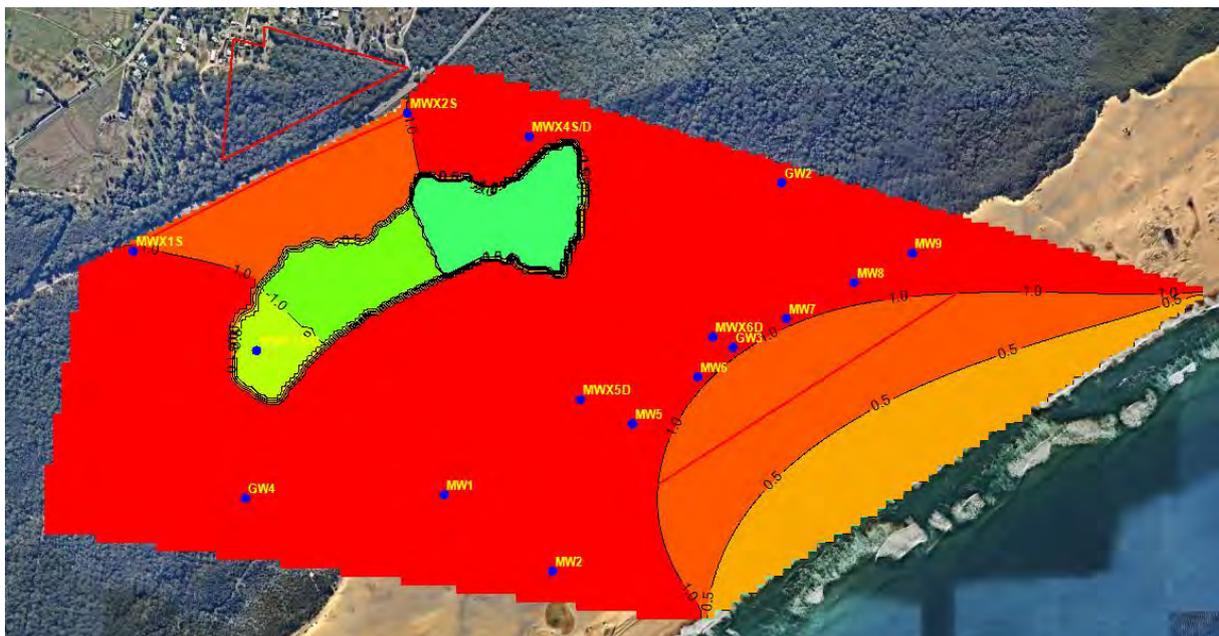


Figure 17: Water-table elevation year 5

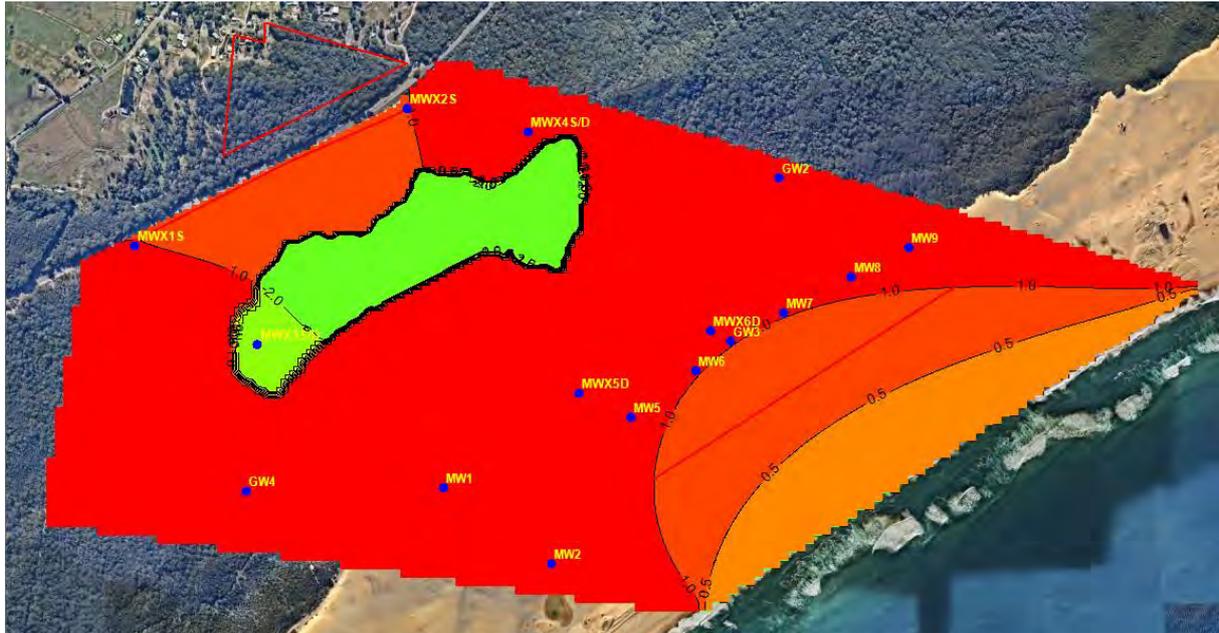


Figure 18: Water-table elevation Year 10

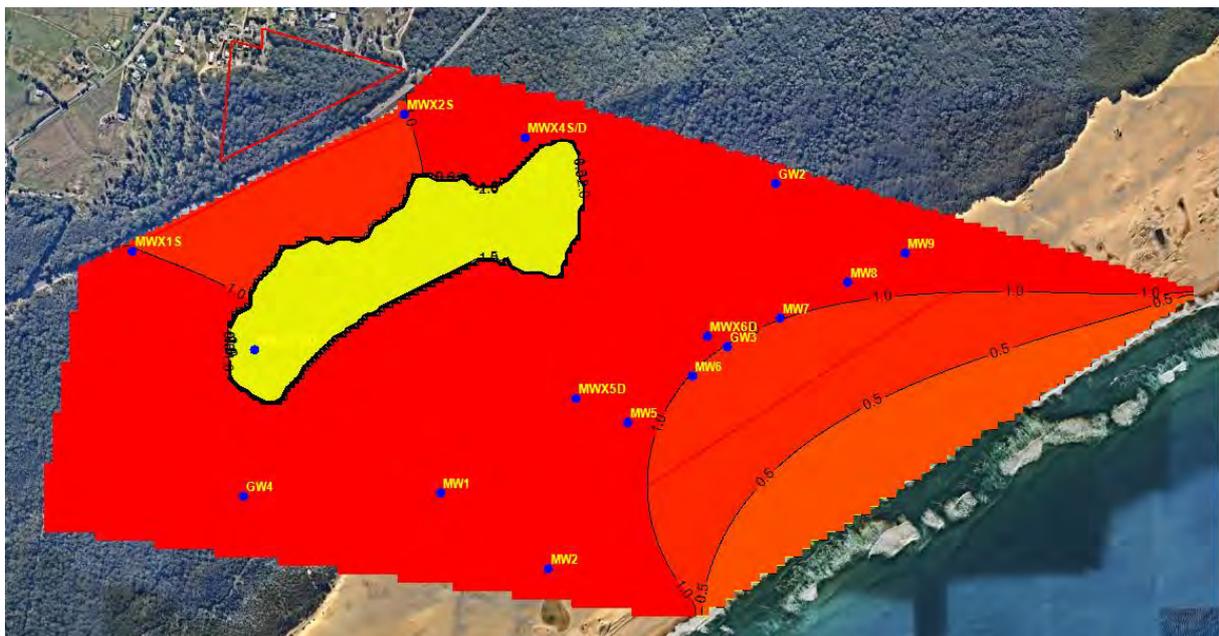


Figure 19: Water-table elevation Year 21

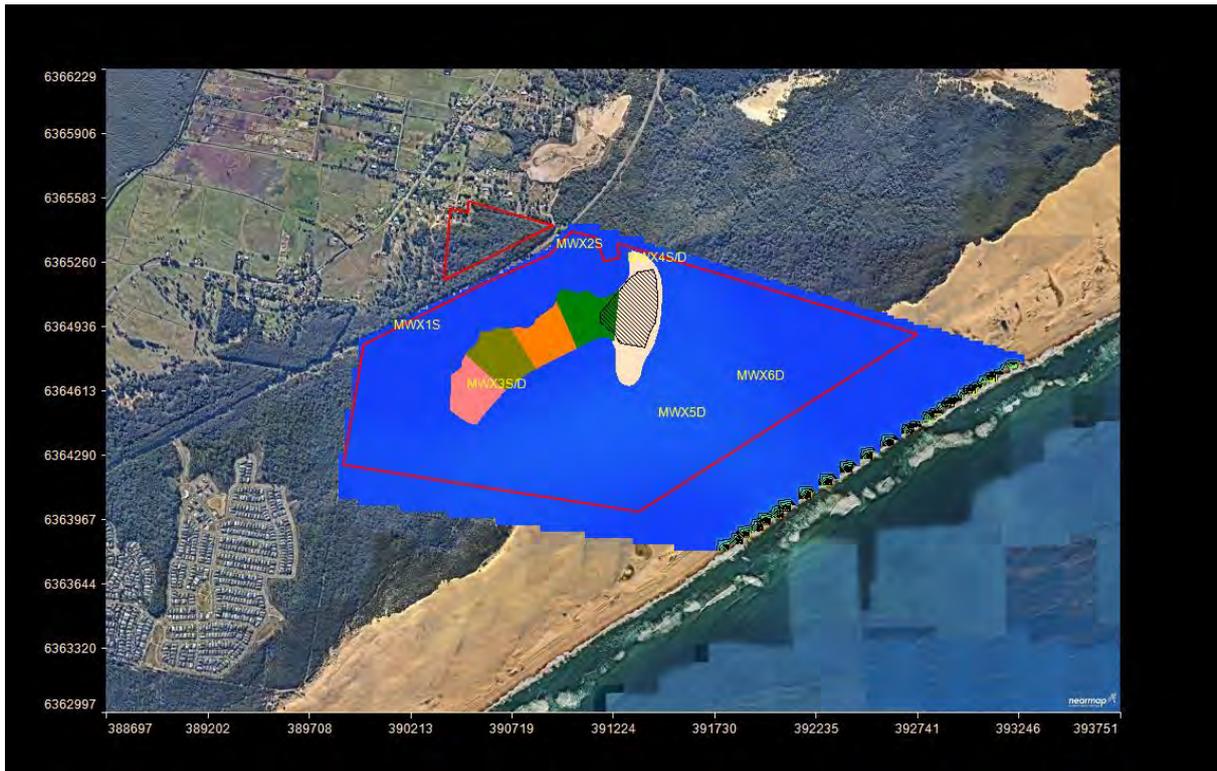


Figure 20: Seawater intrusion year 1

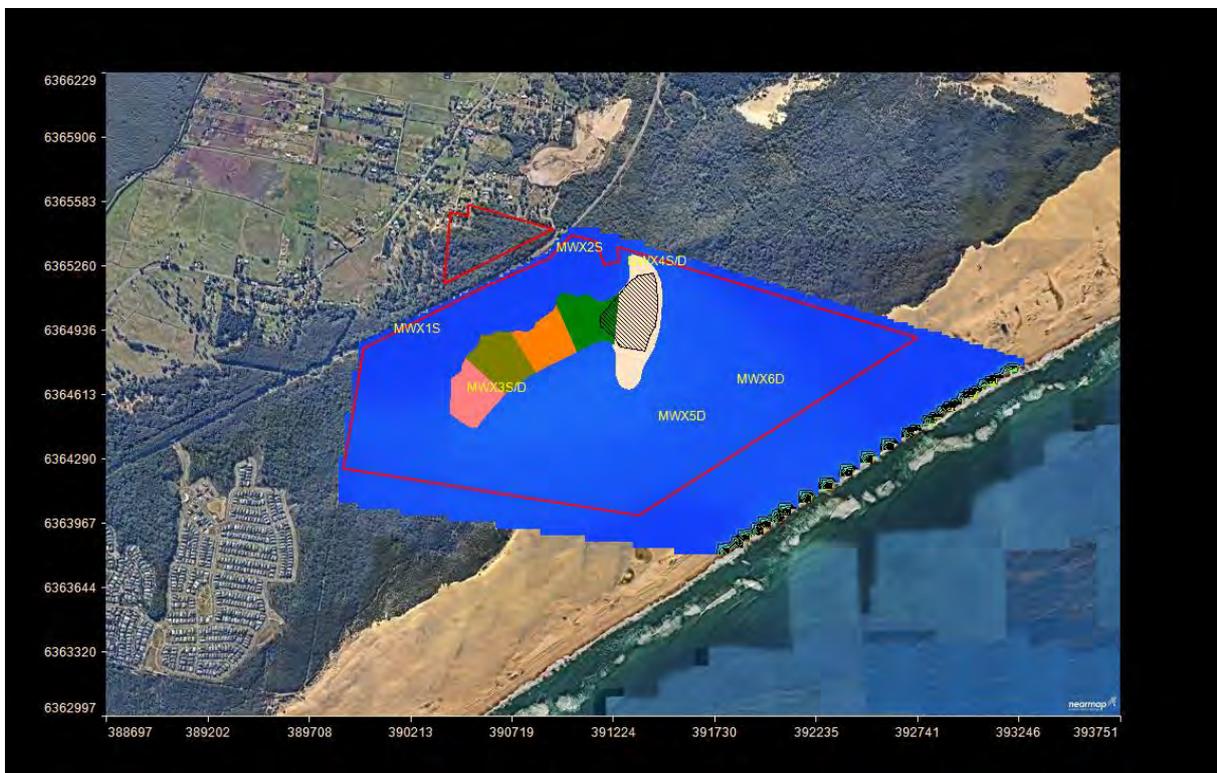


Figure 21: Seawater intrusion year 5

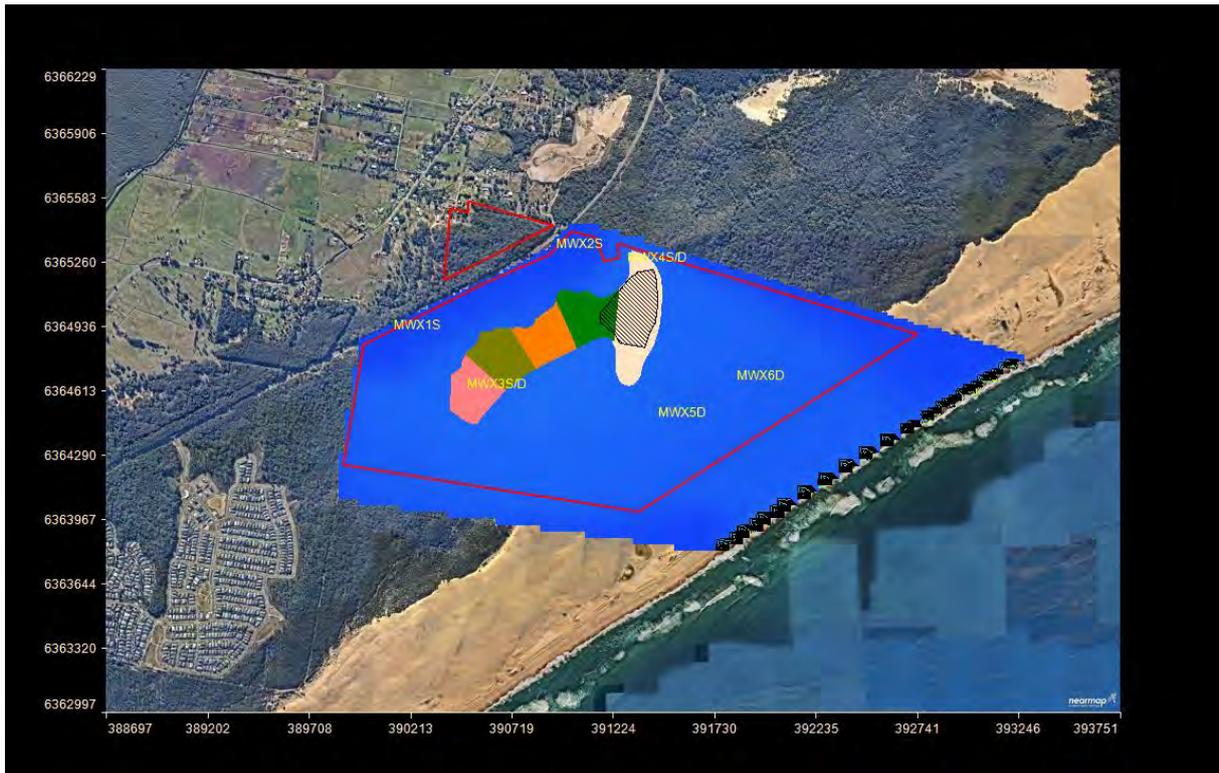


Figure 22: Seawater intrusion year 10

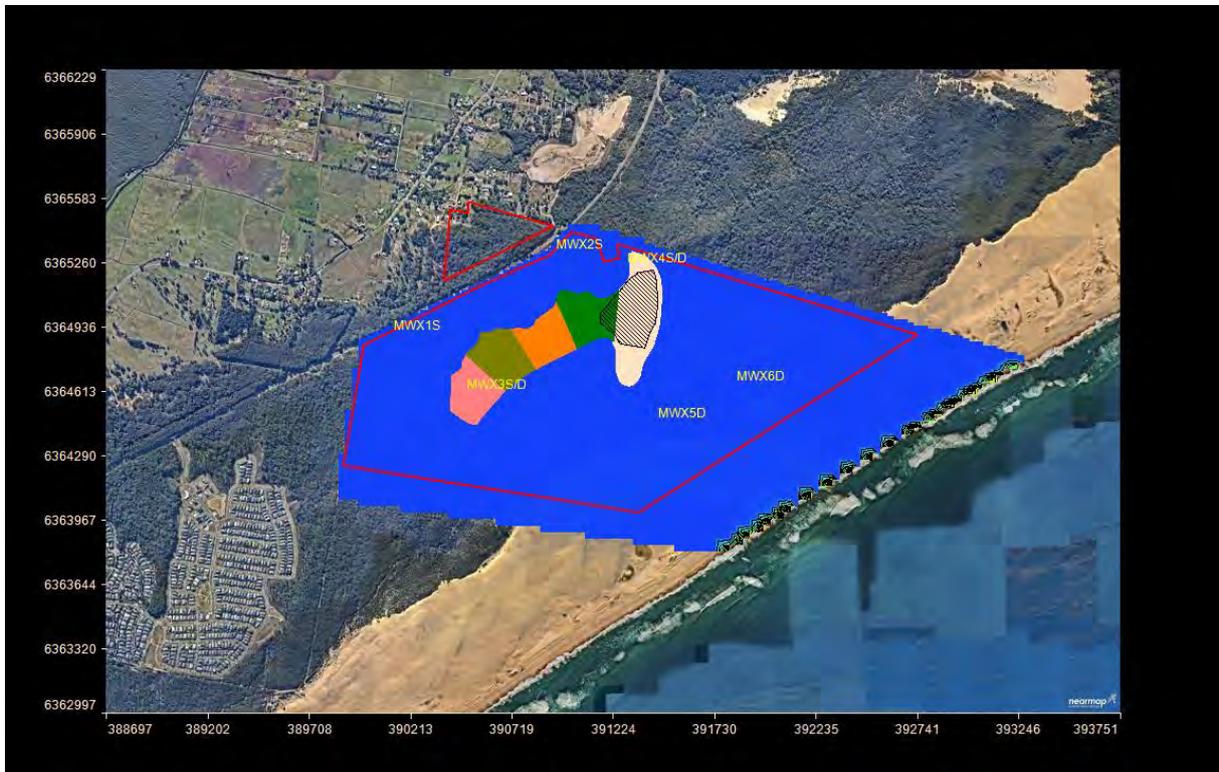


Figure 23: Seawater intrusion year 21

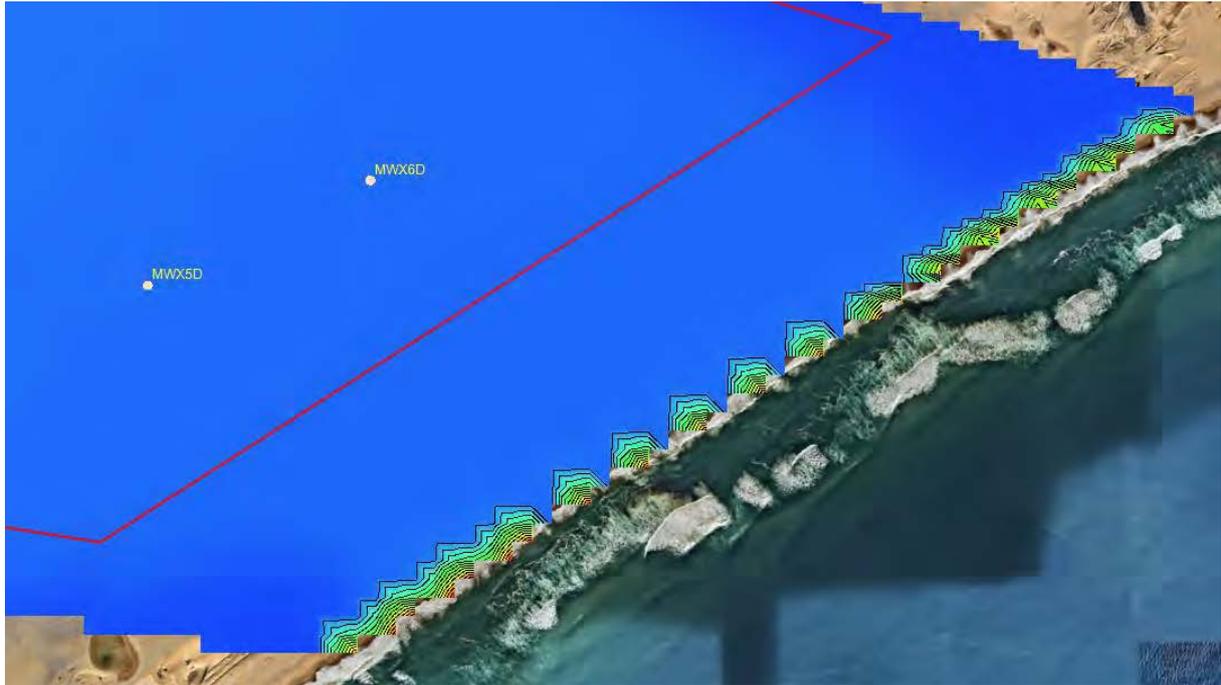


Figure 24: Seawater intrusion year 21 (zoomed in)

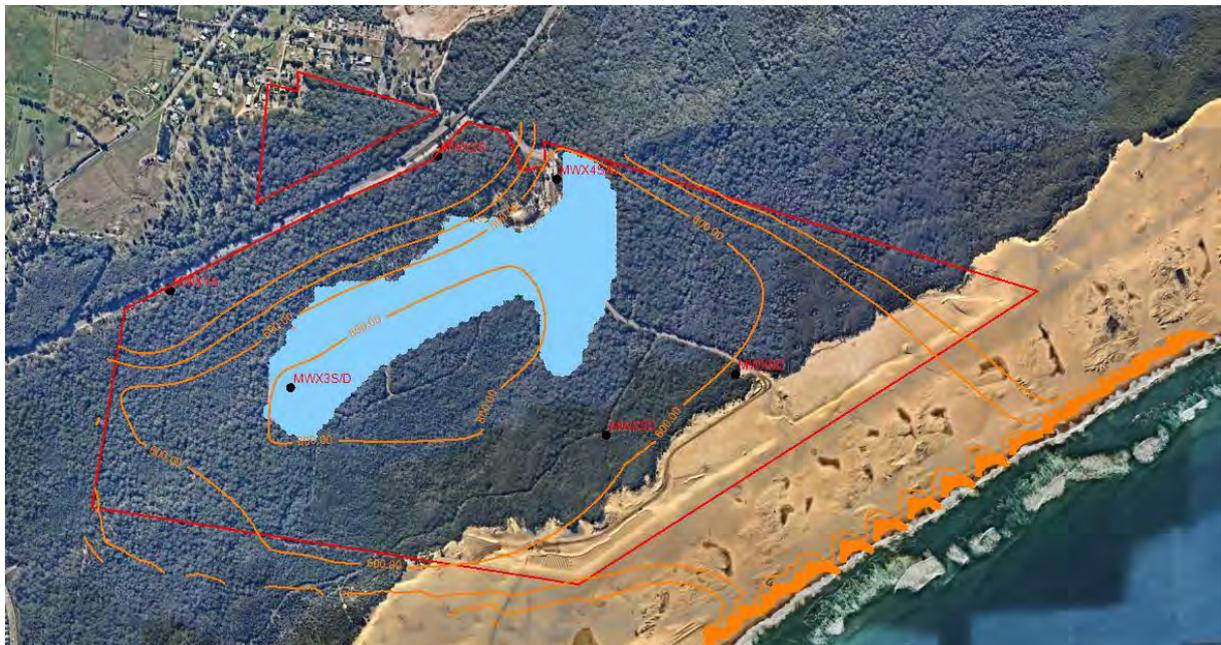


Figure 25: Predicted groundwater salinity (mg/L as TDS) Year 1

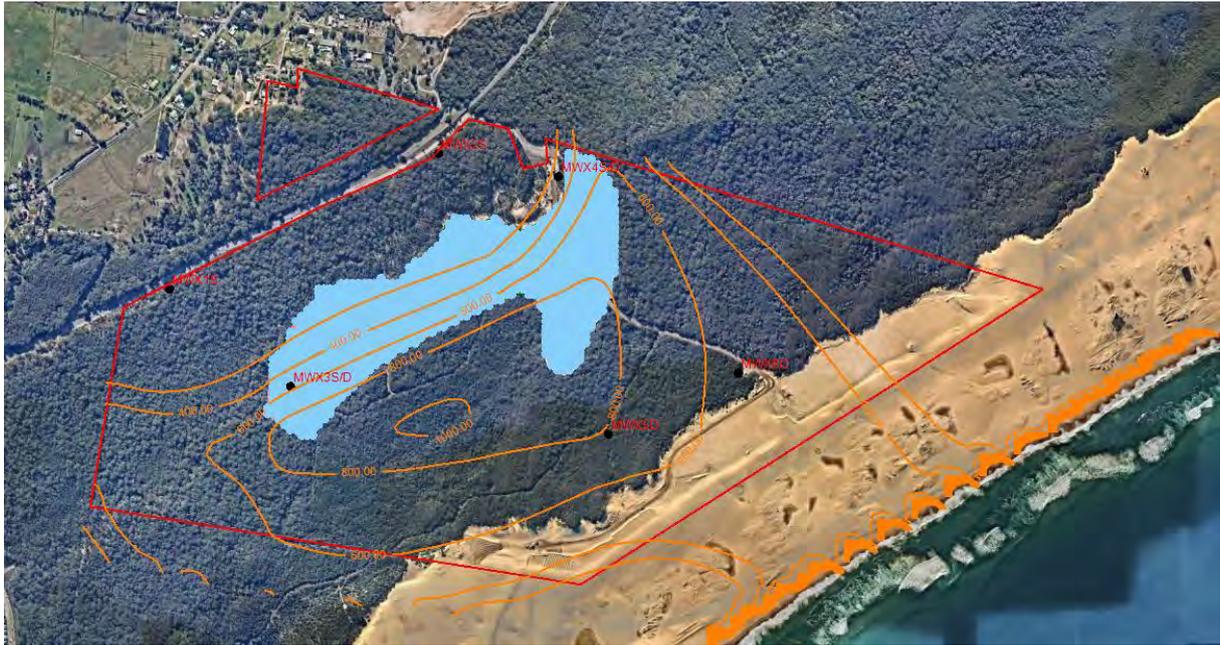


Figure 26: Predicted groundwater salinity (mg/L as TDS) Year 5

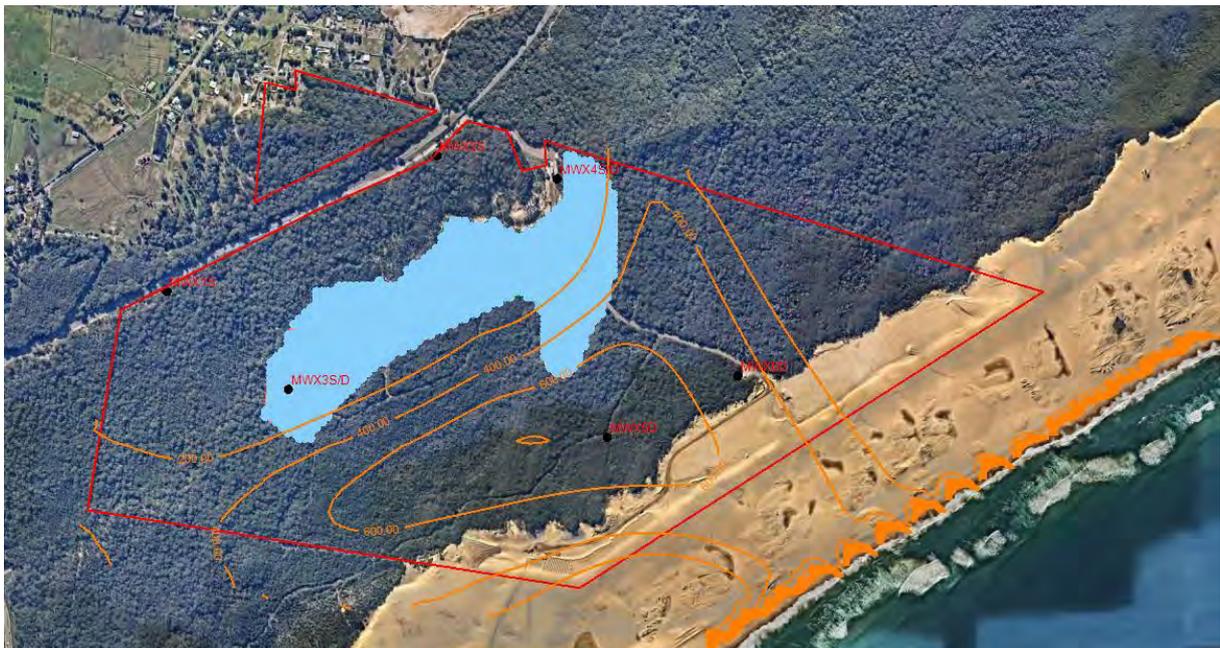


Figure 27: Predicted groundwater salinity (mg/L as TDS) Year 10



Figure 28: Predicted groundwater salinity (mg/L as TDS) Year 21

TABLES

Table 5: Cumulative water balance and volumetric budget after 21 years

Cumulative	M ³	M ³ /D	ML	ML/annum	Time step 10 (21y)	M ³ / time period
IN					IN	
Storage	233014	30.4	233.0	11.1	Storage	4.5229
Constant Head	1793517	234.0	1793.5	85.4	Constant Head	233.9383
Lake Seepage	1222264	159.5	1222.3	58.2	Lake Seepage	112.4132
ET	0	0	0.0	0.0	ET	0
GW Inflow	171815056	22415.5	171815.1	8181.7	GW Inflow	23170.6816
Recharge	15935658	2079.0	15935.7	758.8	Recharge	2077.6602
Total IN	190999520	24918.4	190999.5	9095.2	Total IN	25599.2168
OUT					OUT	
Storage	8210	1.1	8.2	0.4	Storage	1.4701
Constant Head	94068920	12272.5	94068.9	4479.5	Constant Head	11935.3105
Lake Seepage	10188856	1329.3	10188.9	485.2	Lake Seepage	791.6307
ET	7160.7217	0.9	7.2	0.3	ET	126.3544
GW Outflow	98619648	12866.2	98619.6	4696.2	GW Outflow	12750.7568
Recharge	0	0.0	0.0	0.0	Recharge	0
Total OUT	197499664	25766.4	197499.7	9404.7	Total OUT	25605.5215
IN-OUT	-6500144	-848.0	-6500.1	-309.5	IN-OUT	-6.3047
%DIFF			-3.35%		%DIFF	-0.02%

APPENDIX A: GROUNDWATER CHEMICAL CHARACTERISATION (SCHOELLER PLOTS FOR MX SERIES BORES)

Figure 29: Schoeller Diagram for Bore MWX1 (July 2017 – June 2019)

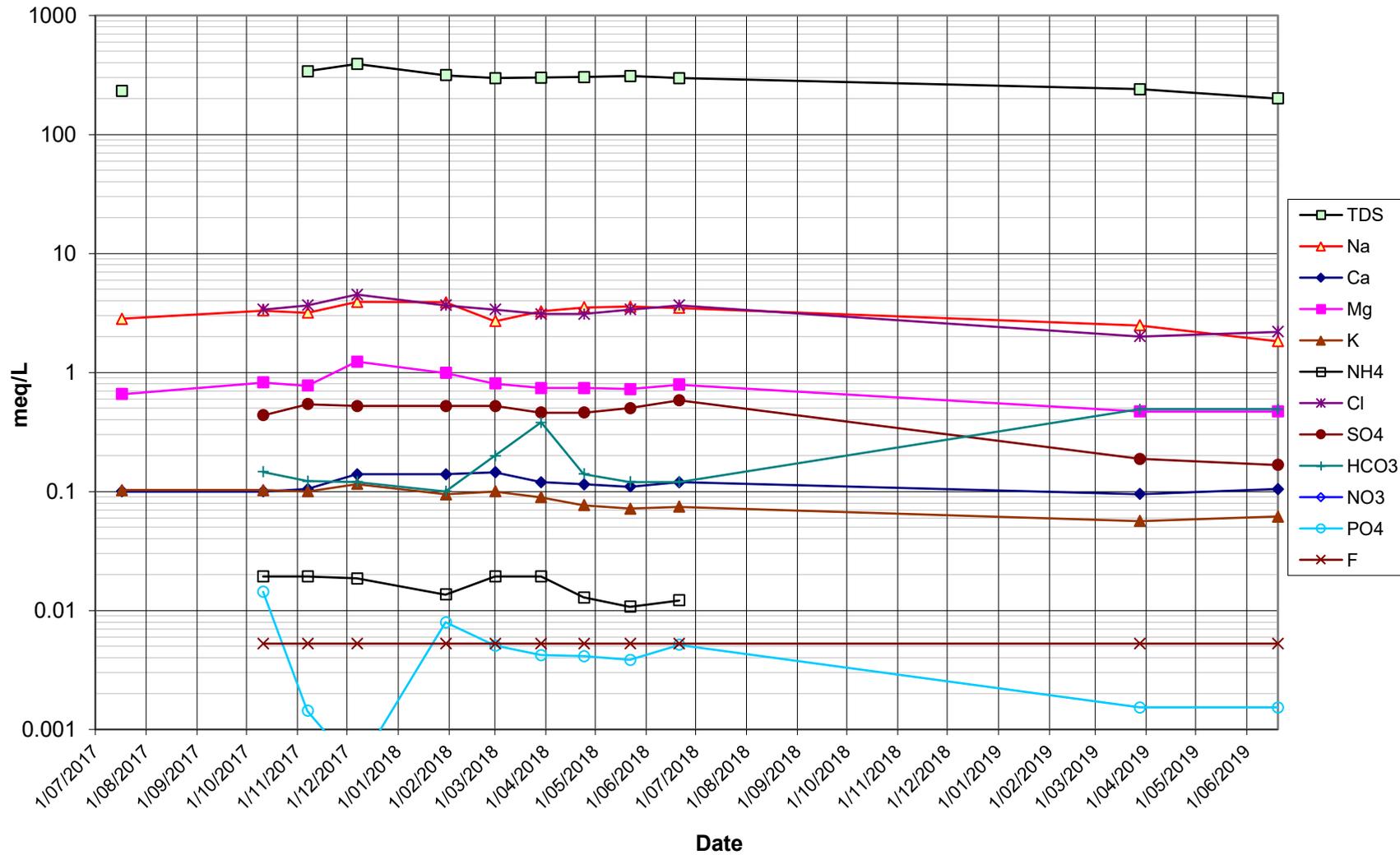


Figure 30: Schoeller Diagram for Bore MWX2 (July 2017 – June 2019)

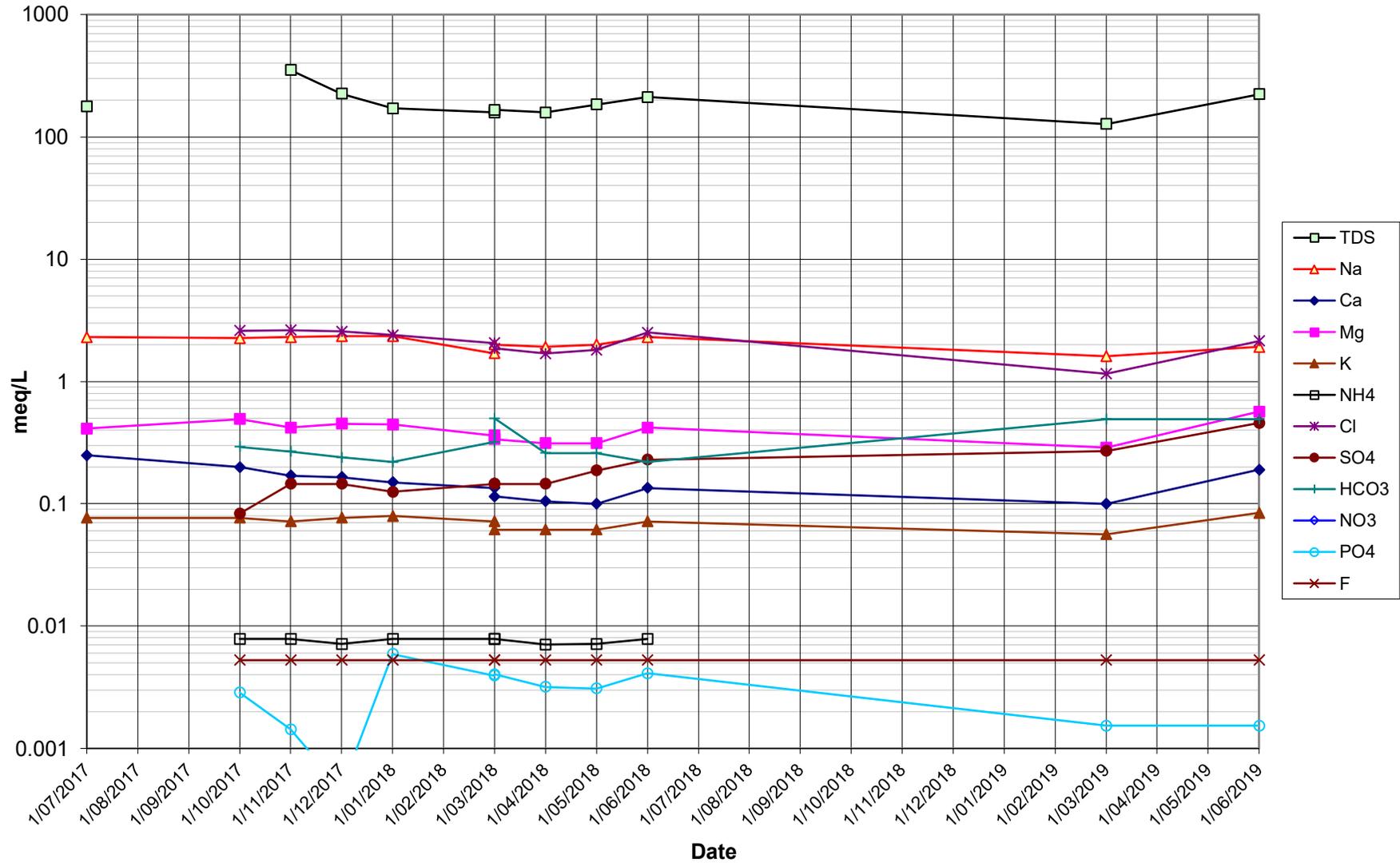


Figure 31: Schoeller Diagram for Bore MWX3D (July 2017 – June 2019)

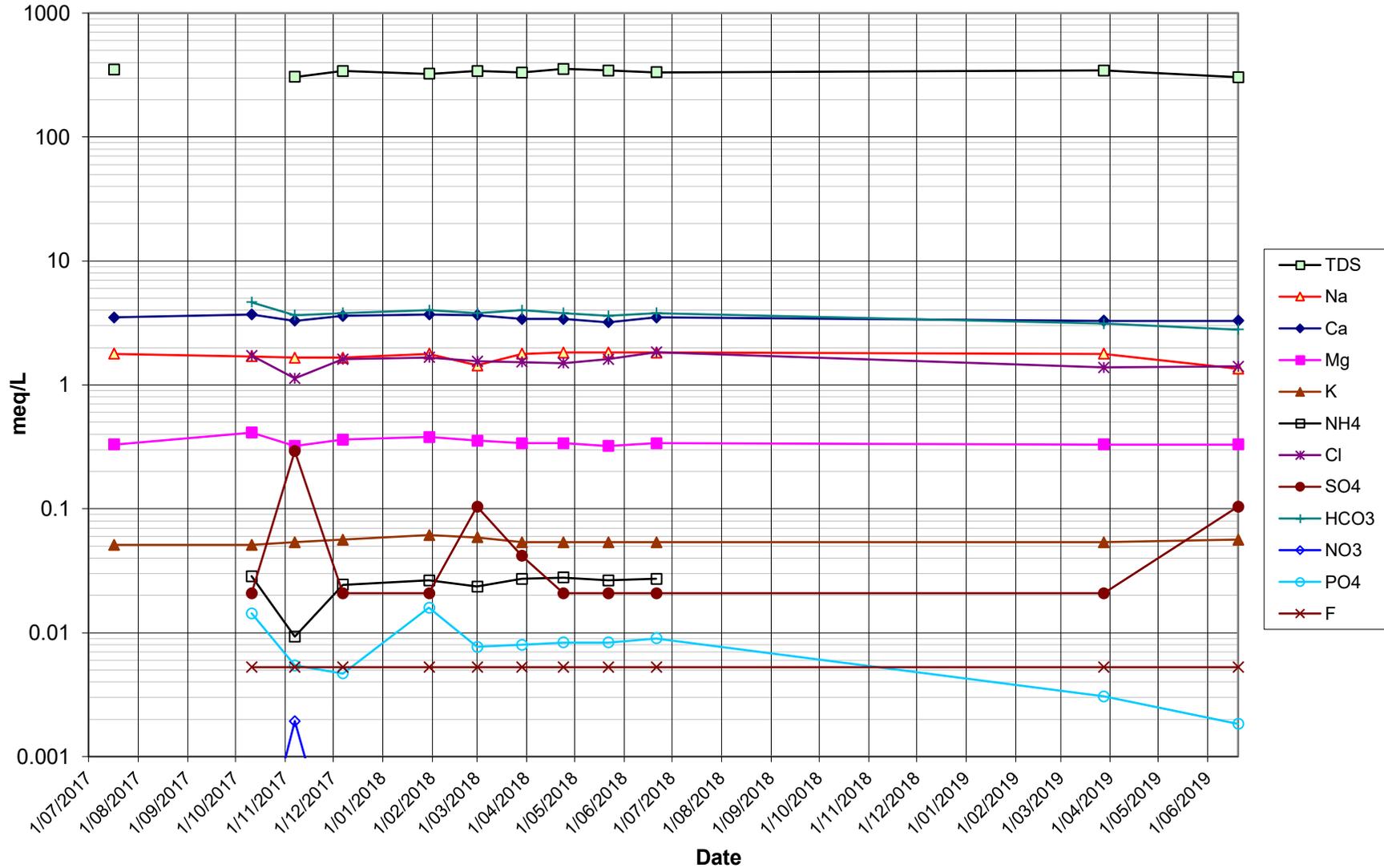


Figure 32: Schoeller Diagram for Bore MWX3S (July 2017 – June 2019)

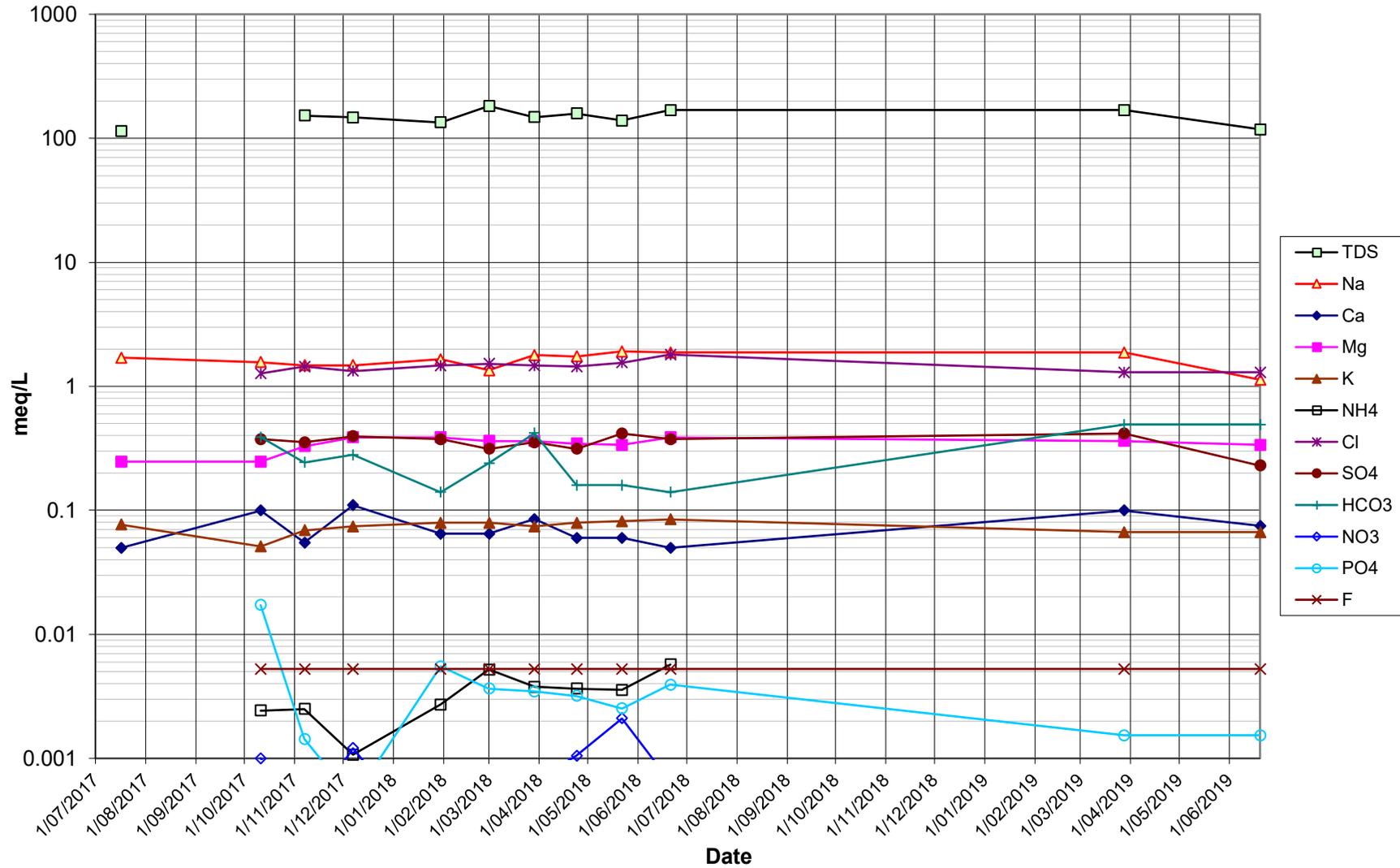


Figure 33: Schoeller Diagram for Bore MWX4D (July 2017 – June 2019)

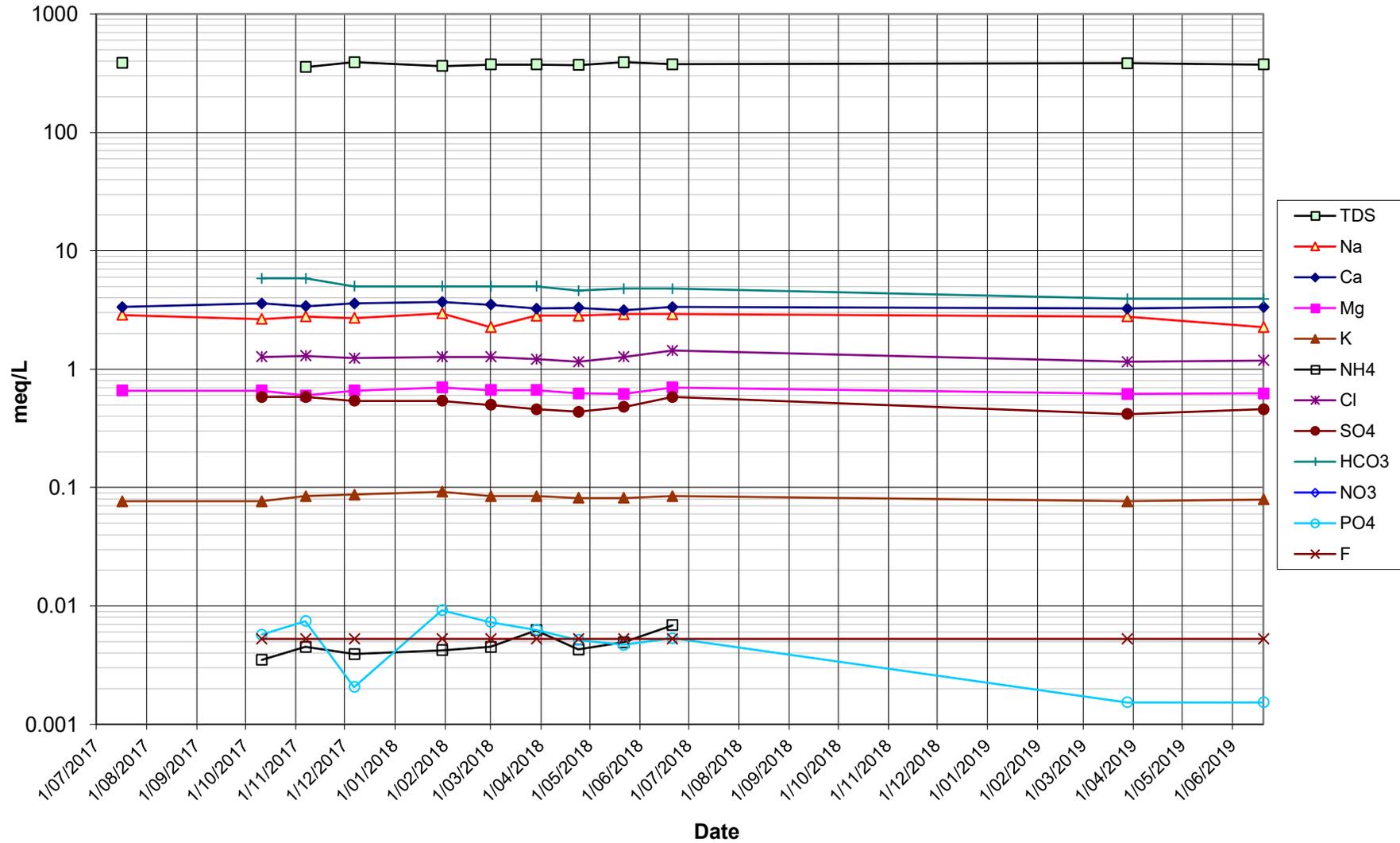


Figure 34: Schoeller Diagram for Bore MWX4S (July 2017 – June 2019)

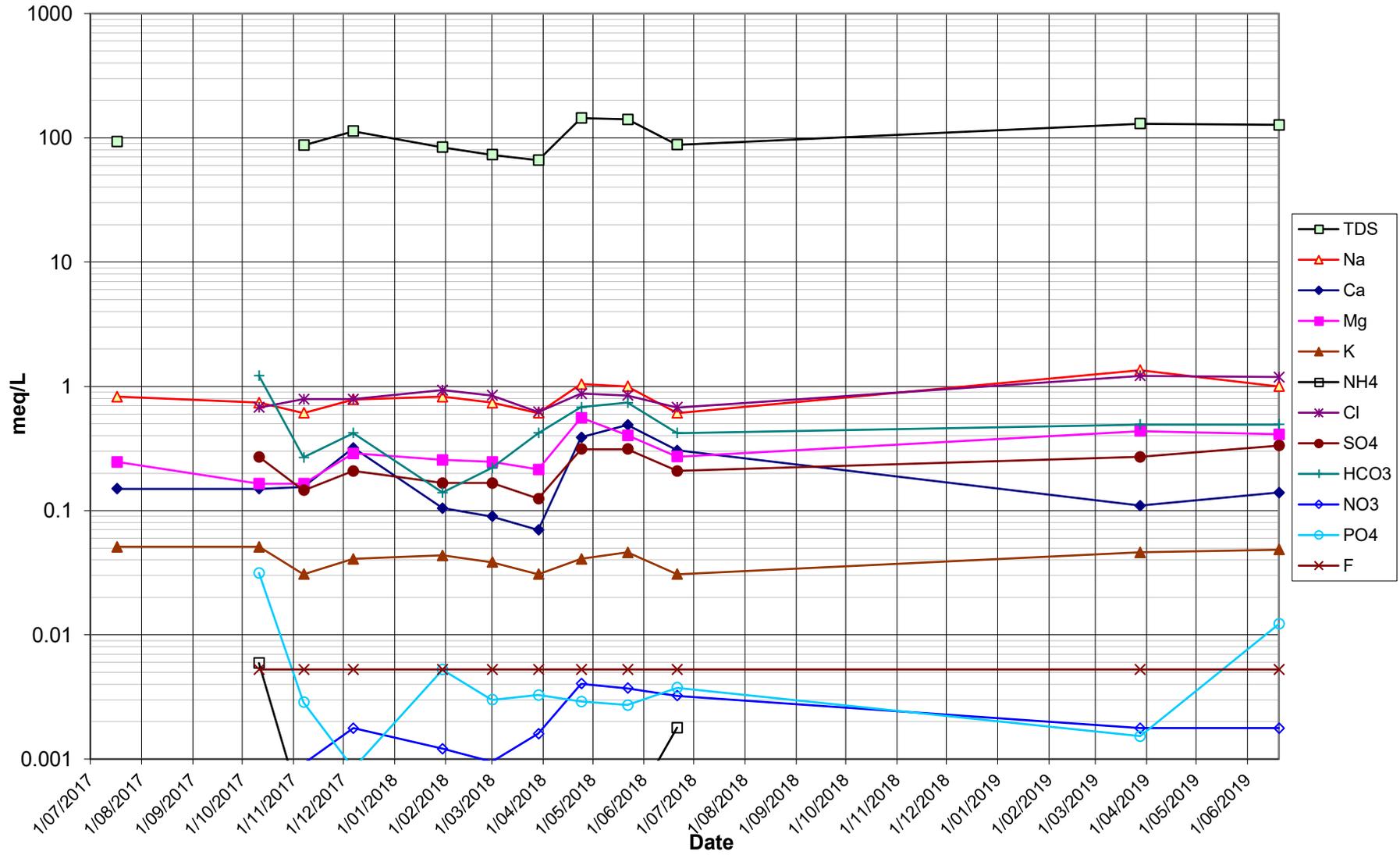


Figure 35: Schoeller Diagram for Bore MWX5 (July 2017 – June 2019)

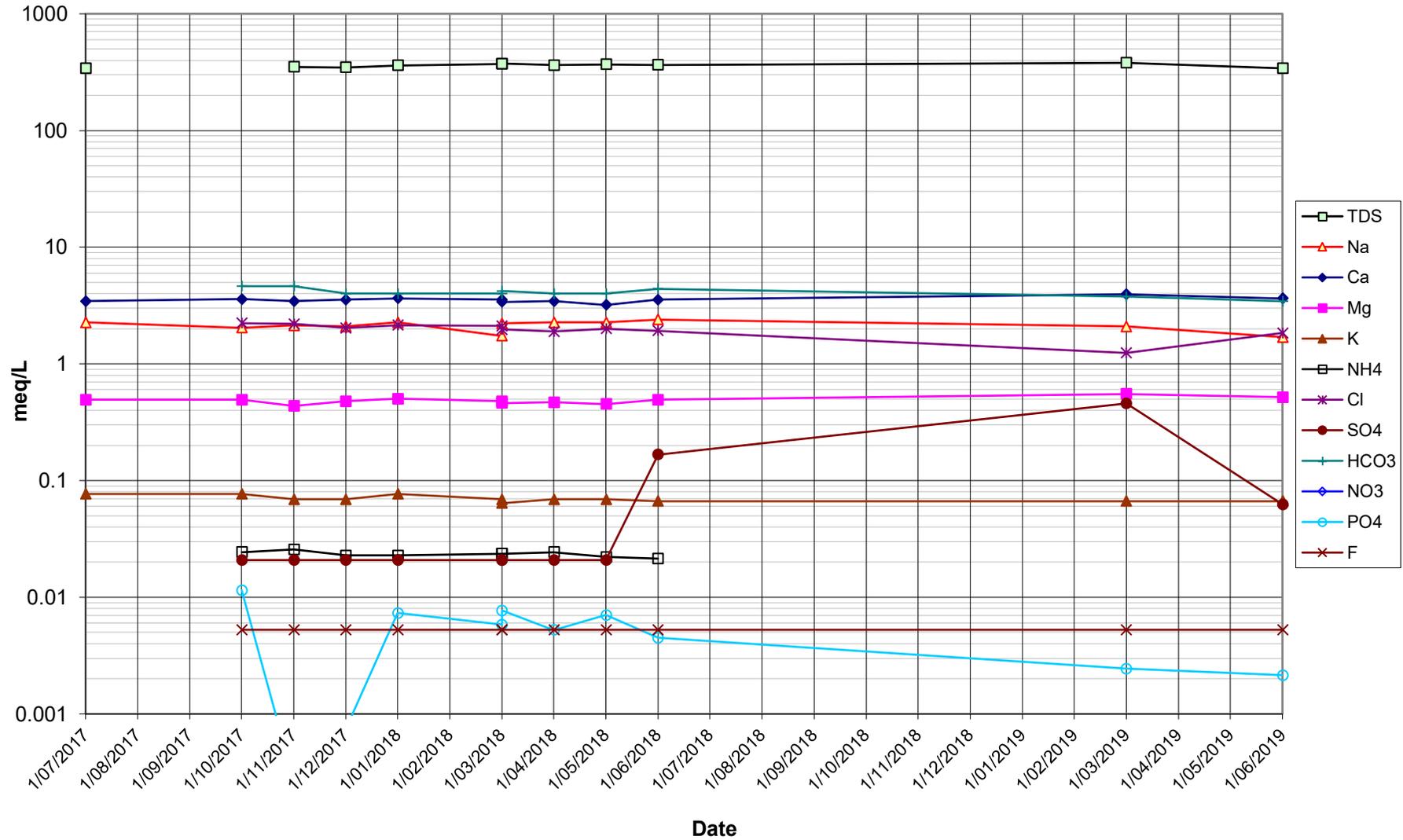
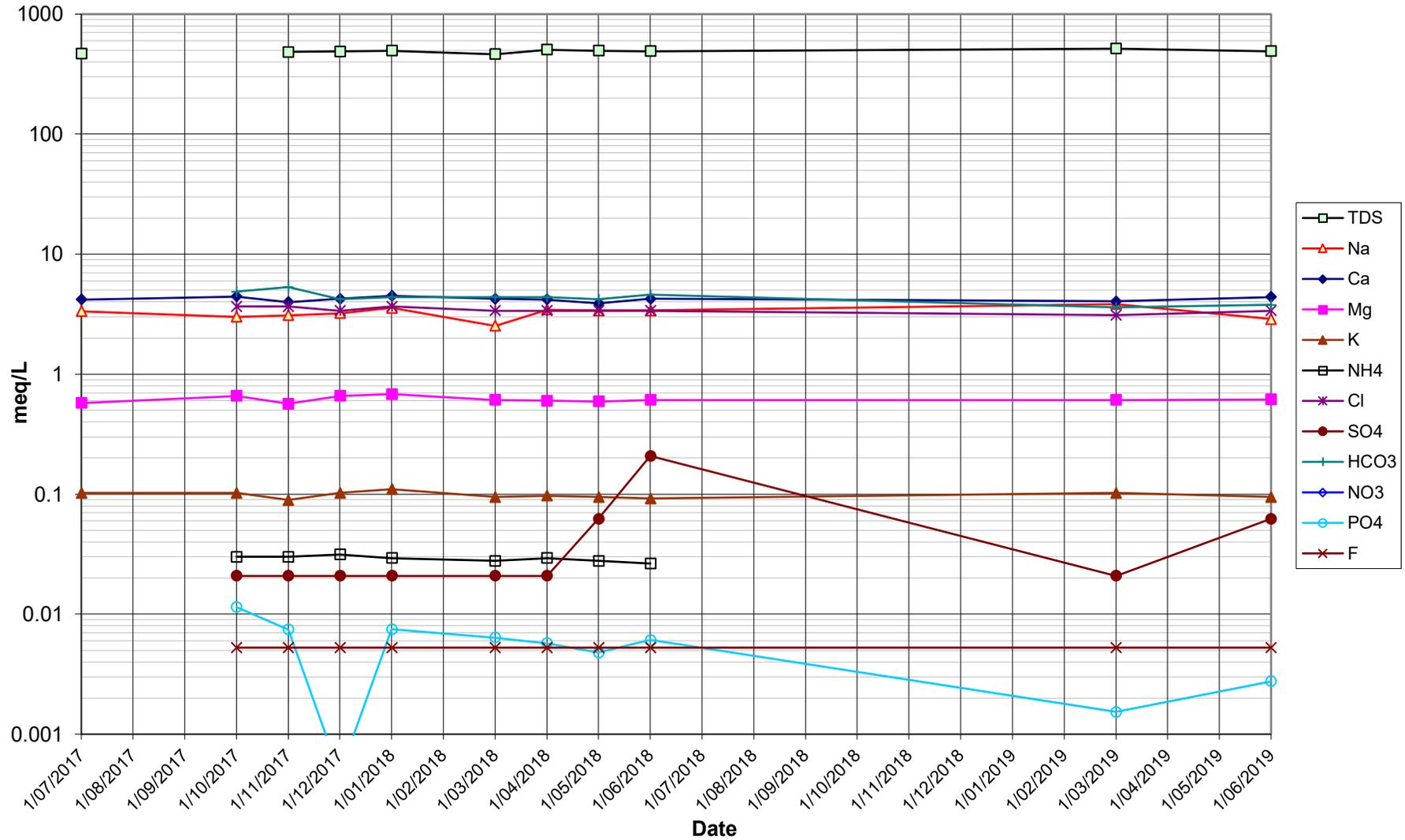


Figure 36: Schoeller Diagram for Bore MWX6 (July 2017 – June 2019)



APPENDIX B: GROUNDWATER DEPENDENT ECOSYSTEM MAPPING (AFTER BOM, 2020)



Terrestrial GDE (no data)

No ecosystems analysed

Terrestrial GDE

- Known GDE (regional study)
- High potential GDE (regional study)
- Moderate potential GDE (regional study)
- Low potential GDE (regional study)
- Unclassified potential GDE (regional study)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)
- Unclassified potential GDE (national assessment)

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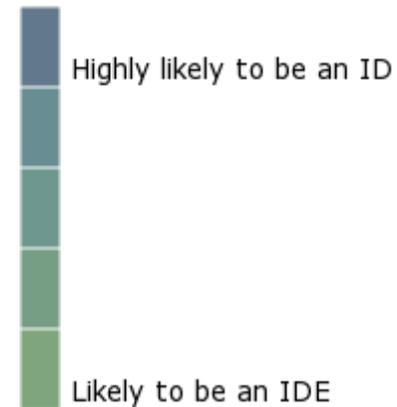
Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: [Click here](#)

Australian Albers GDA94

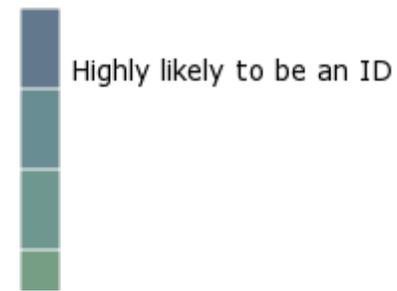




Terrestrial Inflow Dependent Ecosystem (IDE), reliant on water in addition to rainfall



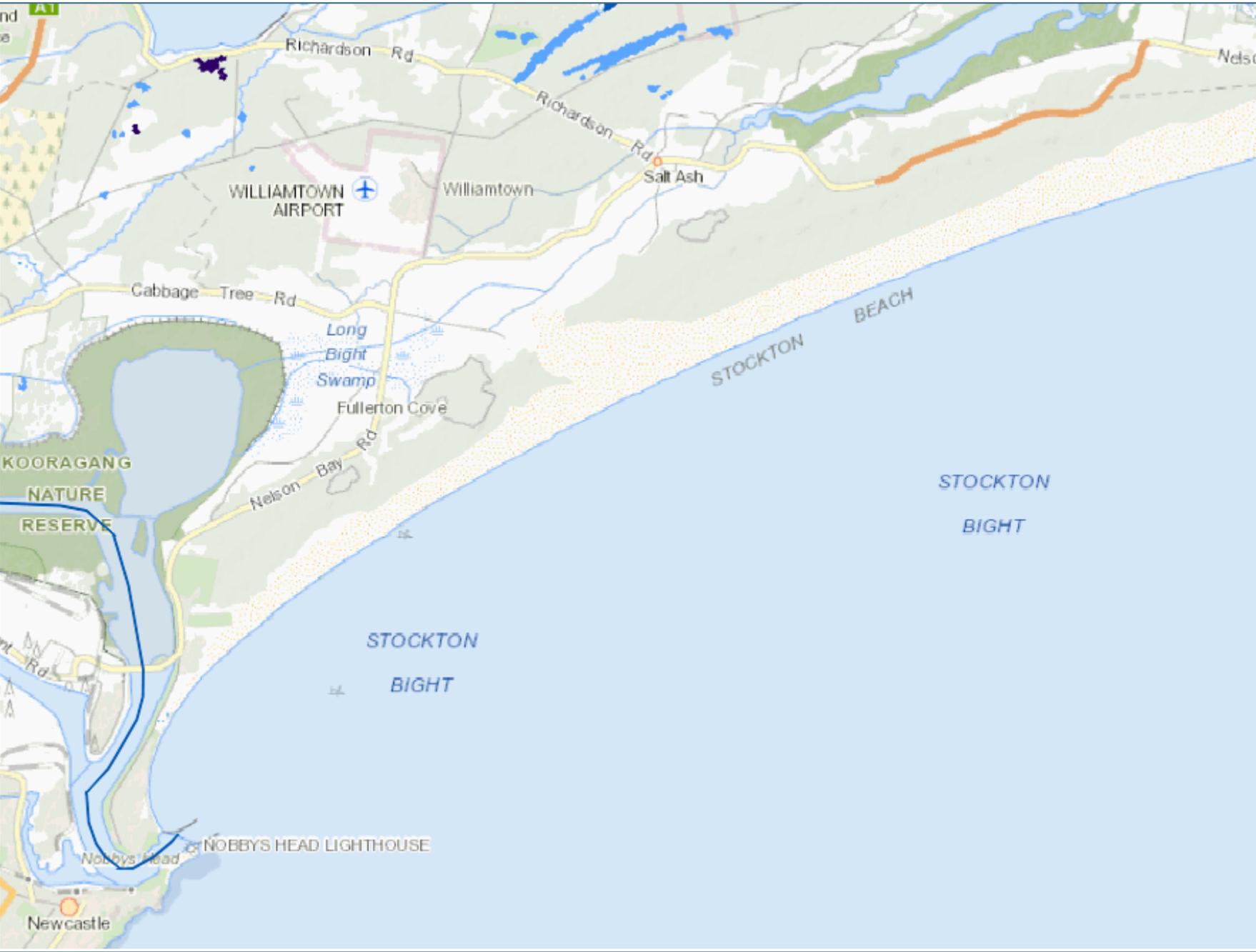
Terrestrial Inflow Dependent Ecosystem (IDE), reliant on water in addition to rainfall



Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: [Click here](#)

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Aquatic GDE

- Known GDE (regional study)
- High potential GDE (regional study)
- Moderate potential GDE (regional study)
- Low potential GDE (regional study)
- Unclassified potential GDE (regional study)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)
- Unclassified potential GDE (national assessment)

N

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Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: [Click here](#)

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APPENDIX F Submission responses (Environmental Earth Sciences)

30 November 2020

Boral Land and Property Group

Trinity T2, Level 5
39 Dehli Road
North Ryde NSW 2113

Attention: **Rachael Snape**
Planning and Development Manager (NSW & ACT)

Dear Rachael,

**Boral Stockton Sand Quarry Dredging Project: Response to Submissions (DPIE –
Water and the NSW Natural Resources Access Regulator, NRAR)**

1 Introduction

Environmental Earth Sciences was commissioned by Boral Land and Property Group on behalf of Boral Resources (NSW) Pty Ltd (Boral) to respond to submissions received from the various stakeholders regarding the Environmental Impact Statement (EIS) for the proposed sand quarry expansion at Boral Stockton, Coxs Lane, Fullerton Cove, NSW (the “site”).

1.1 Background

Boral owns and operates the Stockton Sand Quarry and is seeking approval to expand their sand extraction operations into the inland vegetated dunes along the Stockton Bight coastline, which forms part of a State Significant Development (SSD). The final excavated area will cover approximately 37 hectares and it is understood that initial extraction will utilise dry extraction methods using a front-end loader/ excavator, followed by dredging. The proposal seeks a site wide transportation limit of 750,000 tonnes per annum (tpa) until the windblown sand extraction project will lapse in 2028, after which the transportation limits will then reduce to 500,000 tpa.

Environmental Earth Sciences previously prepared the following reports for Boral as part of an EIS in support of the above application:

- Acid Sulfate Soil Impact Assessment (reference 717041_ASS_v2, dated 8 August 2019);
- Hydrogeological Impact Assessment (717041_HIA_v4, dated 19 February 2020); and
- Rehabilitation Strategy (717041_V2, dated 20 November 2020).



During the public exhibition period, a number of submissions were received from key stakeholders including local council, government agencies and the local community, namely:

- Port Stephens Council (PSC);
- Department of Planning Industry and Environment (DPIE) – Planning Assessments;
- The Hunter Water Corporation (HWC);
- DPIE Water and Natural Resources Access Regulatory (NRAR) [combined response]; and
- DPIE Biodiversity and Conservation division (BCD) and NSW National Parks and Wildlife Service (NPWS) [combined response].

These responses identified specific matters for which further detail is required to be provided, in relation to the project and identified apparent data gaps that require further attention, in order to satisfy each stakeholder, before approval for the expansion project may be granted.

The response provided herein has been prepared to address the specific concerns that fall within Environmental Earth Sciences areas of expertise pertaining to the hydrogeological assessment/ monitoring for the project.

2 Objective

The objective of this report is to provide a direct, structured response to those comments received from key stakeholders in relation to the perceived environmental risks (namely hydrogeological) associated with the establishment, operation and decommissioning of the Stockton Sand Quarry Dredging Project.

3 Additional data acquisition and interpretation (December 2018 – June 2020)

Since the completion of the acid sulfate soil (ASS) and hydrogeological impact assessments (ASSIA and HIA) reports in August 2019 and February 2020 respectively (Environmental Earth Sciences, 2019 and 2020a), further information has been acquired in the form of pressure transducer logger data, for static water levels (SWLs) and groundwater sampling from existing bores for chemical analysis (specifically with regards to per and polyfluoro-alkyl substances [PFAS]). This data has been presented and summarised below in order to assist the response to DPIE – Water comments provided in Section 4 (**Table 1**), particularly with regards to the provision of a more comprehensive spatial and/or temporal groundwater monitoring dataset.

3.1 Static water levels (SWLs)

SWLs were measured monthly using data loggers between December 2019 and July 2020. Not all data was available in metres Australian Height Datum (mAHD), therefore SWLs have

been provided as Depth to Water (DTW) in metres from the top of casing (mTOC) for consistency.

Chart 1 shows the DTW data for bores GW2 – GW4 and MWX1 – MWX6 from September 2017 – July 2020. This hydrograph confirms that SWLs at the site remain relatively consistent over time at each location. Chart 1 shows patterns in seasonal fluctuation, which supports the hypothesis that the aquifer is highly responsive to seasonal variation (i.e. rainfall), confirming recharge to the aquifer is primarily via direct infiltration from the surface.

Groundwater flow is inferred to flow towards the coast to the southeast and to Fullerton Cove, to the west of the site. **Chart 1** supports this inference, showing that groundwater is consistently closer to the surface to the east of the site (bore GW2).

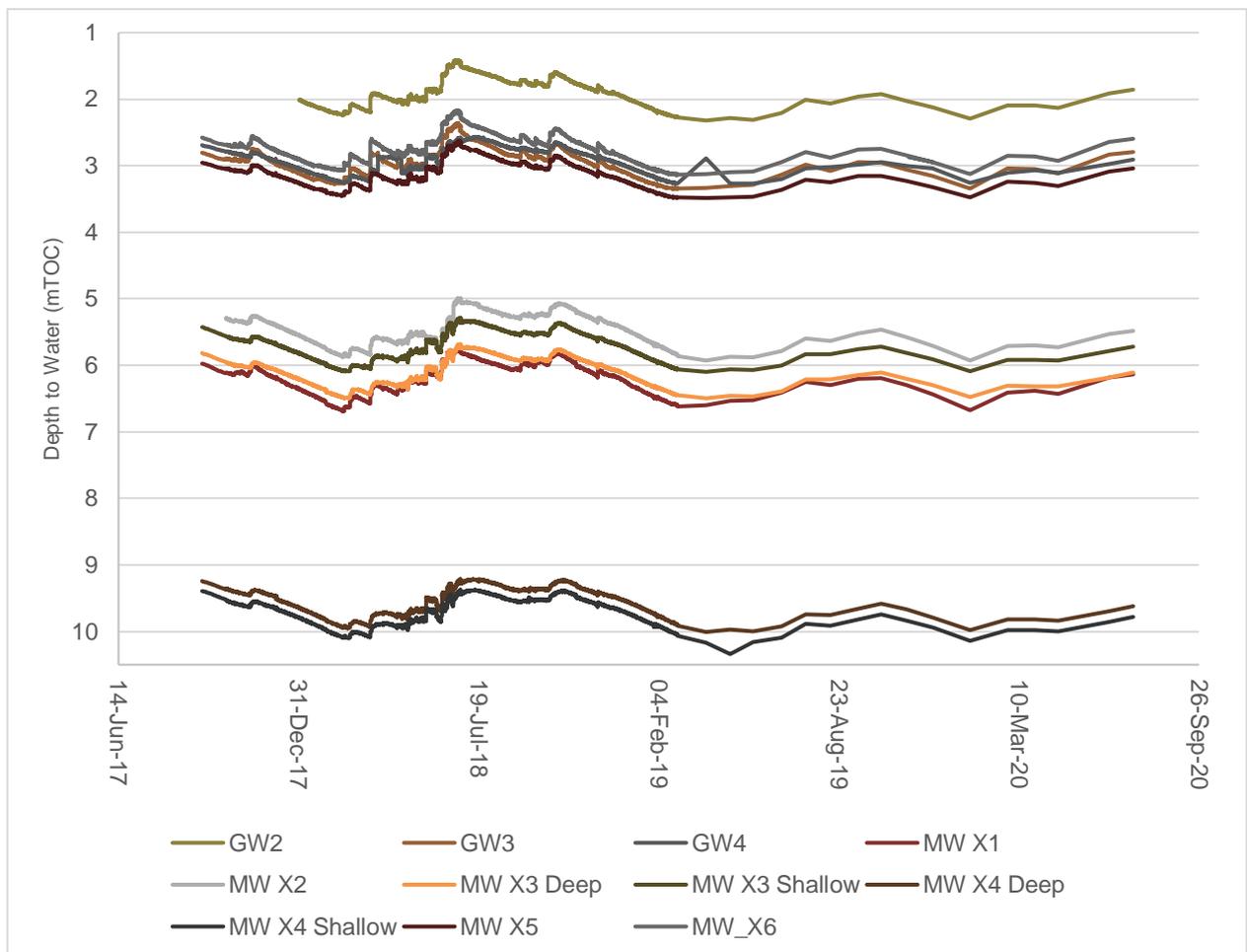


Chart 1: Hydrograph for wells GW2 – GW6 and MW X1 – MW X6, September 2017 – July 2020

3.2 Groundwater quality – Hydrochemistry

According to the HIA (Environmental Earth Sciences 2020a, Figures 4 and 5) the site is located atop a groundwater divide, which has been corroborated by both the historic and more recent data collected at the site and summarised below.

3.2.1 Groundwater type

Groundwater at the site can be classified as follows:

- west of the groundwater divide (towards Fullerton Cove) the shallow Stockton Sands aquifer is predominantly sodium-chloride (Na-Cl) dominated (as represented by bores MW_X1, MW_X2, MW_X3S and MW_X4S), whilst the deep Tomago Sandbeds aquifer is calcium-bicarbonate (Ca-HCO_3) dominated (as represented by bores MW_X3D and MW_X4D), likely reflective of an increasing marine (carbonaceous material such as shells and marine exoskeletons) influence with depth; whereas
- east of the divide (towards the coast) the groundwater is Ca-HCO_3 dominated (Na-Cl sub-dominant) in bores MW_X5 and MW_X6, also likely reflective of an increasing marine influence.
 - A relationship between pH and salinity (EC) exists due to the presence of carbonate material (marine shells and other exoskeletons) in the aquifer matrix, resulting in the more alkaline pHs to the south east and deeper aquifer and subsequent higher dissolution rates of bicarbonate ($\text{HCO}_{3(\text{aq})}$) rather than venting as $\text{CO}_{2(\text{g})}$ in more acidic conditions. The higher HCO_3 results in higher Ca in equilibrium and slightly higher salinity.

Updated Schoeller plots demonstrating the ionic composition for groundwater for key monitoring bores (MX series bores) are provided in **Appendix A**. All bores have a data range of July 2017 to June 2019 for most ions. These charts show the consistency of groundwater chemistry over time at each sampling location providing an excellent background water chemistry signature.

3.2.2 pH and salinity (EC)

The additional analytical data confirms the chemistry of groundwater reported during the most recent monitoring period (December 2019 to June 2020) is consistent with that previously observed (generally stable and within typical ranges).

Specifically (see **Chart 2**):

- Shallower bores to the north-west of the site¹ (west of the groundwater divide) demonstrating higher acidity (ranging from pH 4.8 to 6.3 between September 2017 and June 2019); and
- Deeper bores to the south-east of the site² (east of the groundwater divide and towards the coast) demonstrating neutral to slightly alkaline conditions (ranging from pH 6.8 to 7.8 between September 2017 and June 2019).

¹ Bores GW1, GW2, GW4, MW_X1, MW_X2, MW_X3S and MW_X4S

² Bores MW_X3D, MW_X4D, MW_X5 and MW_X6 (this also includes bores MW1, MW2 and MW5 to MW11, however the data for these bores has not been presented herein).

Furthermore, consistent with the observations made in the HIA, salinity (as EC) typically ranges from 120 to 822 $\mu\text{S}/\text{cm}$ (see **Chart 3**) with:

- the highest ECs (ranging from 368 to 822 $\mu\text{S}/\text{cm}$ between September 2017 and June 2019) consistently reported in the deep bores located east of the divide (indicative of marine influence); and
- the lowest ECs (ranging from 120 to 594 $\mu\text{S}/\text{cm}$ between September 2017 and June 2019) consistently reported in the shallower bores located to the west of the divide; while
- salinity can vary significantly over time in specific locations, with bore MWX5 showing the greatest range of 216 $\mu\text{S}/\text{cm}$ over the past 4 years (maximum-minimum); and
- the largest spikes in salinity occur following significant rainfall events and are inferred to be due to recharge flushing relict salt from above the water table.

3.3 Groundwater quality – PFAS

Monthly PFAS monitoring was undertaken between January and June 2020. The results from the 2020 monitoring period show that concentrations of PFAS were consistently below the laboratory limit of reporting (LOR), confirming the **absence of PFAS** in groundwater at the site.

These results are in line with the analytical results from the 2018 monitoring period (Environmental Earth Sciences 2020a, Table 18), during which PFAS compounds were not detected in any of the groundwater bores at the site supporting the conceptual site model (CSM) that the site lies in a separate groundwater (and surface water) catchment to the Williamstown RAAF Base.

A summary of the 2020 PFAS results is provided in **Table 2**, appended to the rear of this report.

4 Response to Comments

Environmental Earth Sciences has prepared a direct response to the submissions received from DPIE – Water and NRAR. This response is presented in tabulated format in relation to individual submission comments/ requests for clarification in **Table 1** below.

In addition, Environmental Earth Sciences determination is that based on the data obtained, and methodology of extraction proposed, it can be concluded that water sources and their dependent ecosystems or authorised water users (for example, the Hunter Water Corporation North Stockton Catchment Area and/or anyone who holds a water access licence (WAL) will be protected from any impacts associated with the proposed expansion.

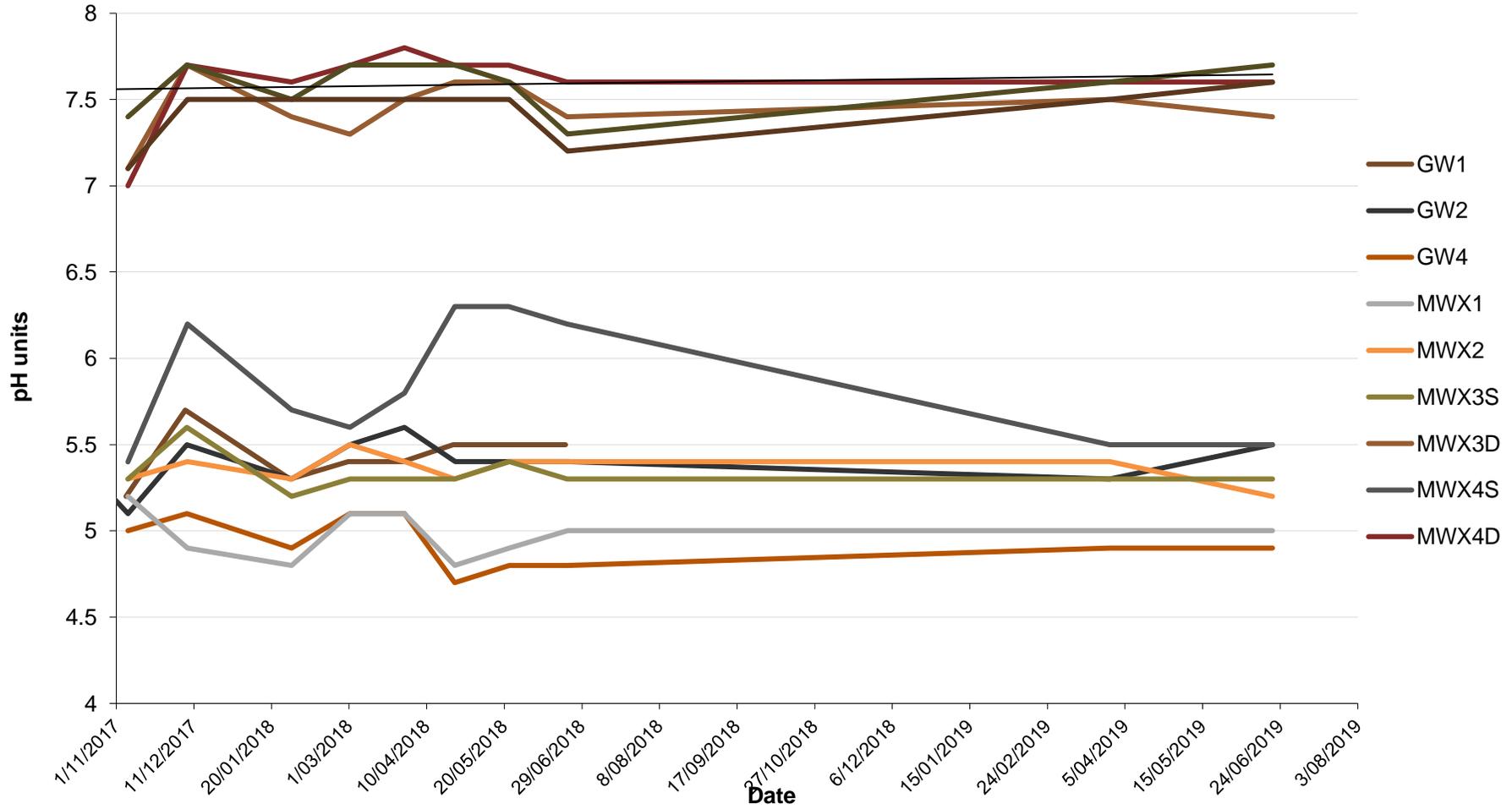


Chart 2: Groundwater pH variation (September 2017 – June 2019)

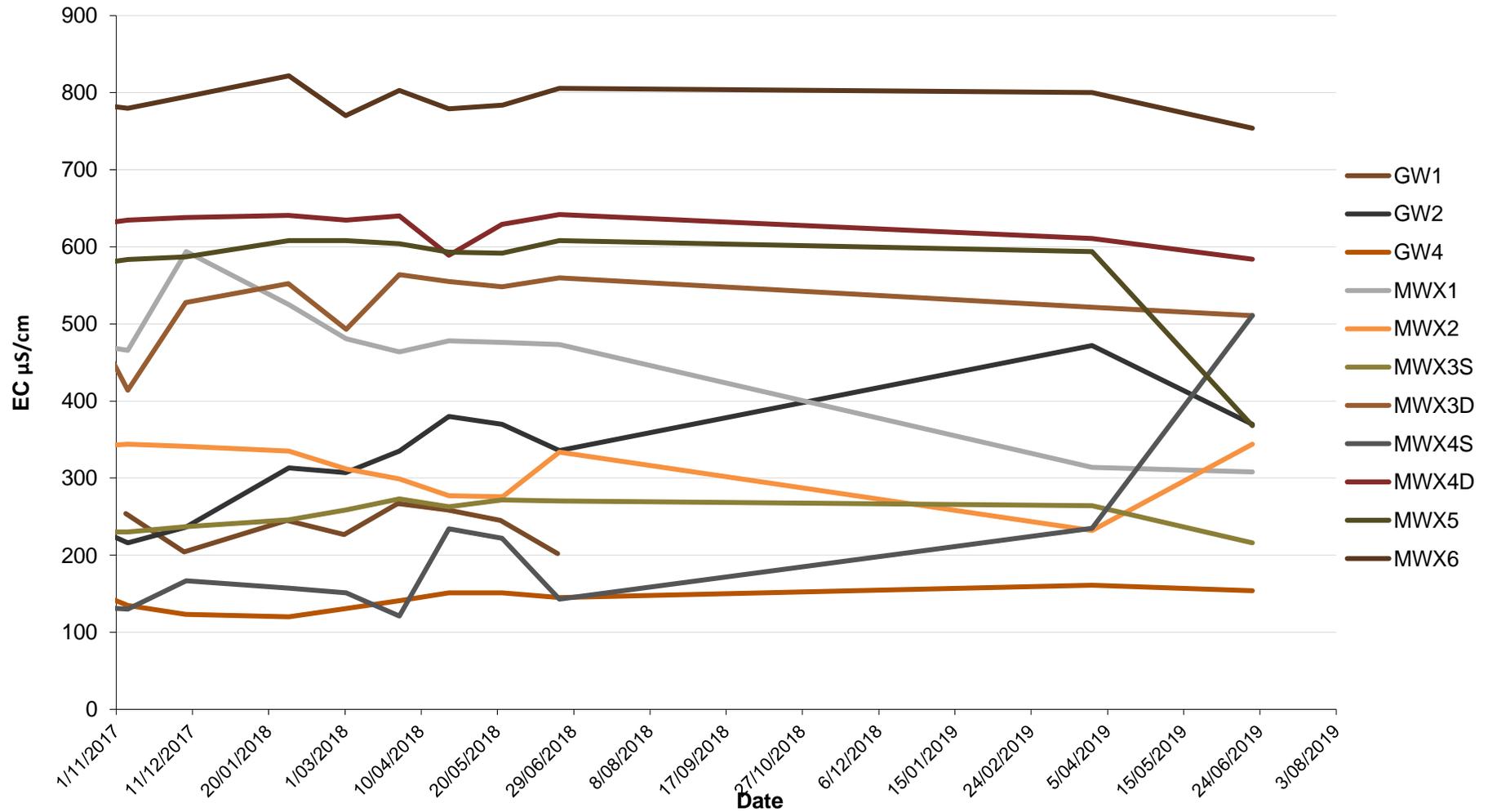


Chart 3: Groundwater salinity (as EC) variation (September 2017 – June 2019)

The creation of a dredge pond and end-point rehabilitation to a freshwater lake/ wetland is not predicted to alter the hydrogeological regime of natural movements of groundwater, nor groundwater chemistry, from current conditions. As such, it is concluded that the proposal has a low overall level of risk of impact on nearby groundwater dependent ecosystems (GDEs) and other potential receptors (e.g. recreation, fishing, stock-watering).

A qualitative assessment of the key environmental risks posed by the proposed development (groundwater, surface water and aquatic ecosystems) is provided in **Appendix B**. The risk assessment provides both initial risk ratings as assessed based on current site conditions and residual risk ratings, following the implementation of the recommended monitoring and management strategies detailed within the HIA.

It should be noted that this “low risk rating” is also supported by the outcomes of the recent groundwater modelling exercise (Environmental Earth Sciences, 2020c) which was specifically undertaken to identify any long term impacts of the proposed expansion activities on nearby sensitive receptors and confirm the risk status of the project with respect to impacts on ecosystems and groundwater resources.

The model predicted that:

- groundwater levels in the aquifer surrounding the lake, and in particular between the lake and the ocean, will remain stable and close to current static conditions over the period of creation of the lake (assumed to be 25 years); and
- seawater intrusion and other potential chemical impacts associated with increased concentrations of dissolved salts as a result of dredging operations are not expected to be a risk. Due to the increased recharge associated with the creation of the lake, the aquifer at and surrounding the site is expected to reduce in salinity as a result of dredging operations.

5 Conclusions

In summary, in relation to the tabulated response provided in **Table 1** below, the risk posed to nearby GDEs and/or the Hunter Water Corporation North Stockton Catchment Area (associated with negligible anticipated changes to the local hydrogeological regime and/or salinization/ acidification of the final dredge pond landform) is deemed to be low. This is based primarily on the extraction methodologies proposed and the physical environmental conditions at the site. As per the findings of both the HIA and ASSIA, any potential impacts are unlikely to be realised (particularly with management and mitigation measures in place, as per the recommendations of these reports).

Environmental Earth Sciences considers that any residual environmental risk can be further mitigated and/ or managed provided appropriate monitoring and management regimes are established at the site prior to the commencement of extraction activities, and that these are continued during extraction and for a specified period post closure.

The management and mitigation measures proposed have been summarised in Section 6 below.

Table 1: Responses to Stakeholder Comments

#No	Department Review Comment/ Request for Clarification	Environmental Earth Science Response
DPIE Water and NRAR (30 April 2020) and (20 August 2020)		
Prior to approval, the following information needs to be provided by the proponent:		
1	<p><i>Detailed assessment of the incidental take of groundwater from dredging activities plus loss from sand for processing and operational activities.</i></p>	<p>A detailed hydrogeological desktop review and field assessment was undertaken as part of the Hydrogeological Impact Assessment (HIA) between March 2018 and February 2019 to obtain sufficient, data from which to derive a representative site water balance for the sand extraction scenario. The field study comprised:</p> <ul style="list-style-type: none"> Continual measurement of standing water levels (SWL) across the existing groundwater monitoring bore network (MW_X1 to MW_X6) via submersible data loggers between May 2017 and July 2018; Measurement of <i>in-situ</i> physio-chemical parameters (pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), electrical conductivity (EC)); and temperature during well purging, prior to sampling; and Collection and submission of a representative groundwater sample from MW_X3 for water characterisation parameters including: <ul style="list-style-type: none"> pH, TDS, cations (Na, Ca, Mg, K), anions (Cl, SO₄, HCO₃, PO₄, F) and nutrients (NH₃, NO₃ and NO₂); and dissolved metals / metalloids including aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni) and zinc (Zn); and Hydraulic parameter testing (falling head slug tests) at one nested bore location (MW_3X shallow) to determine <i>in-situ</i> hydraulic conductivity (K). Using the results from these tests the values for K, transmissivity (KD) and groundwater velocity (v) were determined for the unconfined Quaternary aquifer. <p>In addition to the above, Environmental Earth Sciences were supplied with an extensive groundwater chemical dataset to review for the MX bore series, collected on a monthly basis from October 2017 – June 2018. This data was collected by VGT and scheduled for laboratory analysis for:</p> <ul style="list-style-type: none"> Full ionic balance: pH, EC, TDS, cations (Na, Ca, Mg, K), anions (Cl, SO₄, HCO₃, PO₄, F) total alkalinity as CaCO₃ and nutrients (NH₃, NO₃ and NO₂); and dissolved metals / metalloids including Al, As, boron (B), Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni and Zn; and Perfluorinated compounds including perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) monthly from January – June 2018 at limited locations (ID: MW_X1, MW_X2, MW_X7 and GW4). <p>A site water balance for the sand extraction scenario, based on the findings of a detailed hydrogeological desktop review and field assessment was completed for the site as part of the HIA and pertinent details reproduced below.</p> <ul style="list-style-type: none"> Sand extraction within the project area is conservatively estimated at 750,000 tpa for up to 25 years, with the product expected to contain a moisture content of between 3% (dry product) and 5% (saturated materials from below the water table). For the purposes of the water balance calculations, moisture content has been conservatively estimated as 5% for the duration of excavation activities. <p>This will result in approximately 37.5 MLpa of water being “taken” equating to approximately only 102 m³/day or 1.2 L/sec. This amount is expected to be less than the natural aquifer recharge onto and discharge off the site towards the Pacific Ocean to the south and Fullerton Cove/ Long Bight Swamp/ Tilligerry Creek to the north (estimated to be around 600 m³/day).</p> <ul style="list-style-type: none"> Crosbie <i>et al.</i> (2010b) state that, for the dominant soil type of the catchment (Podosols), recharge would be expected to be in the range of 100-1,000 mm/year, with a line of best fit of 386 mm (337 mm) for an annual rainfall of 1,100 mm on perennial (all) vegetation and Podsol soil types. This equates to 31% of rainfall recharging the aquifer, which is at the lower range of estimates for coastal alluvium provided by Crosbie <i>et al.</i> (2010a). The Water Sharing Plan (NSW DPI, 2016) for the area indicates total recharge for the Stockton Groundwater Area as 21,000 ML/yr, with an estimated infiltration rate of 22%. The dominant recharge to the aquifer is via direct infiltration of rainfall. Recharge from rainfall is estimated at around 30% of total rainfall (taking into account evapotranspiration). However, localised recharge rates in dune environments with predominantly endoheric (i.e. closed basin) drainage likely to be higher. Total rainfall input to the site is estimated at 1.12 ML/d (407 MLpa). For the project area, recharge for the 37 ha site equates to 0.34 mpa x 370,000 m² = 126,170 m³/y (126 MLpa) or 346 m³/day or 4.0 L/sec. Evapotranspiration is estimated at 70% of recharge (88 MLpa, 242m³/day or 2.8 L/sec). Under the lake scenario (which is expected to be 23.3 ha), recharge to the 137,000 m² nonlake area will be 47 MLpa, 128 m³/day or 1.5 L/sec, and to the 233,000 m² lake will be 256 MLpa, 702 m³/day or 8.1 L/sec, for a combined lake scenario recharge of 303 MLpa, 830 m³/day or 9.6 L/sec. Evaporation from the lake is estimated at 1,382 mm, or 322 MLpa (882 m³/day and 10.2 L/sec), and evapotranspiration from the non-lake area 33 MLpa, 90 m³/day or 1.1 L/sec. Discharge will be via through flow to the ocean to the south-east and also inland towards Fullerton Cove (north-west) and its drained estuarine flats. Calculations indicate that the water take with the sand product contributes 4% of total groundwater outflows, which is being ‘won’ from natural groundwater discharge (outflow) from the site towards either the north or south. As half of this discharge is to the ocean, it is hard to see this as ‘take’ when it is recharging

#No	Department Review Comment/ Request for Clarification	Environmental Earth Science Response
		<p>a marine water body. As the sand extraction proceeds, the above is expected to be altered gradually over time as recharge increases due to direct rainfall onto the dredge pond that is created, off-set by increased direct evaporation from the surface water body.</p> <ul style="list-style-type: none"> Refer to Environmental Earth Sciences (2020c) for updated information on the site water balance following numerical modelling.
2	<p><i>Prediction of the total amount of water that will be taken from the Stockton Groundwater Source on an annual basis as a result of the activity and after closure of the activity, as described in section 3.2.3 of the NSW Aquifer Interference Policy (AIP) (2012).</i></p>	<p>Sand extraction within the project area is conservatively estimated at 750,000 tpa for up to 25 years, with the product expected to have a moisture content of between 3% (dry product) and 5% (saturated materials from below the water table). For the purposes of the water balance calculations, moisture content has been conservatively estimated as 5% for the duration of excavation activities. This will result in approximately only 102 m³/day of water being used (37.5 ML per annum). This amount is expected to be less than the natural aquifer recharge onto and discharge off the site towards the Pacific Ocean to the south and Fullerton Cove/ Long Bight Swamp/ Tilligerry Creek to the north (estimated to be ~600 m³/day).</p> <p>Further detail is provided in response to Item 1.</p>
3	<p><i>Assessment of impacts against the 'minimal impact considerations' of the AIP (2012). As the take of water might have potentially significant impacts on water sources or their dependent ecosystems or authorised water users e.g. Hunter Water Corporation North Stockton Catchment Area gazetted under the Hunter Water Regulation 2015, the predictions should be based on complex groundwater modelling conducted in accordance with the Australian Groundwater Modelling Guidelines, as described in section 3.2.3 of the AIP (2012).</i></p>	<p>Environmental Earth Sciences NSW prepared a detailed HIA for the site and proposed expansion (ref: 717041_v4, 19 February 2020). The HIA was based upon the local hydrogeological setting (i.e. development of a Conceptual Site Model (CSM), collection and interpretation of field data and relevant legislation and guidelines).</p> <p>The available dataset was considered to be sufficient to effectively conclude that significant change in the hydrogeological flow regime at the site (including static water levels [SWLs]) and/or other impacts to beneficial users (including groundwater dependent ecosystems [GDEs]/ local water supply) were unlikely given the proposed excavation methodology. Furthermore groundwater flow or transport modelling (a complex groundwater model in accordance with the Australian Groundwater Modelling Guidelines (as described in Section 3.2.3 of the AIP [2012])) was not considered necessary given that neither dewatering or drawdown were to result from the proposed extraction activities. However, in response to DPIEs concerns and at Boral's request, a Class I Groundwater Model for the site has been prepared – this will be submitted for consideration, in support of the proposed expansion, under separate cover.</p> <p>Summary of HIA Findings: Conceptual Site Model</p> <ul style="list-style-type: none"> The site is located on the Stockton Sandbeds (SS) Aquifer; a shallow aquifer (10 – 30 m thick) that overlies the eastern extremity of the deeper Tomago Sandbeds Aquifer. There is a groundwater divide which runs in a northeast to southwest direction to the southeast of the windblown sand extraction area. Groundwater is inferred to flow towards the coast to the southeast and to Fullerton Cove to the northwest of the site. The proposed sand extraction is intended to be limited to the SS Aquifer, with the expected final depth being 15m below the water level. Aquifer testing confirmed that the SS Aquifer beneath the site is very permeable (hydraulic conductivity (K) values between 6 and 55 m per day and transmissivity (KD) values up to between 50 and 4,627 m²/day), but that due to the low hydraulic gradients (0.002 metres per metre (m/m) or 0.2%), groundwater velocities are relatively low (12.6 – 116 m per year). Groundwater flux through the area of the proposed extraction area has been estimated at 600 m³/day (219 megalitres (ML) per annum). This equates to a groundwater flux of approximately 18 ML/month. Sand extraction within the project area is conservatively estimated at 750,000 tpa for up to 25 years, with the product expected to contain a moisture content of between 3% (dry product) and 5% (saturated materials from below the water table). For the purposes of the water balance calculations, moisture content has been conservatively estimated as 5% for the duration of excavation activities. <p>This will result in approximately only 102 m³/day of water being used (37.5 ML per annum). This amount is expected to be less than the natural aquifer recharge onto and discharge off the site towards the Pacific Ocean to the south and Fullerton Cove/ Long Bight Swamp/ Tilligerry Creek to the north (estimated to be around 600 m³/day).</p> <ul style="list-style-type: none"> Mean annual rainfall recorded at the site exceeds average monthly evaporation rates, suggesting high groundwater recharge rates of up to 70 – 80% of total rainfall for this system. This equates to a minimum of 31% of rainfall recharging the aquifer. The water balance from the HIA is replicated in the Item 1 response above. Groundwater movement accounts for less than 0.5% of catchment drainage even in the driest recorded years, excavation of the aquifer sediments are predicted to have no discernible potential effect on catchment hydrology other than increasing the area available for water storage and direct recharge to the Stockton Sandbeds Aquifer on the site. <p>Further details with regards to estimated recharge rates and water balance at the site are provided in Item 1.</p>
4	<p><i>The proponent must demonstrate acquisition of, or ability to acquire licensable groundwater entitlement as required under the Water Management Act 2000.</i></p>	<p>It is understood Boral will respond to these matters under separate cover.</p>
5	<p><i>As required under the Water Management Act 2000, the proponent should provide additional information on how it plans to obtain the required WALs for the project prior to approval. The WAL shares must be obtained and evidence provided to DPIE Water & NRAR prior to commencement of works.</i></p>	<p>As per Item 4 above.</p>

#No	Department Review Comment/ Request for Clarification	Environmental Earth Science Response
6	Comprehensive spatial and temporal groundwater level and water quality baseline data set.	Boral completed monthly groundwater monitoring between May 2017 and July 2018, which is presented and discussed in Environmental Earth Sciences' Hydrogeological Impact Assessment (HIA) report for the project (reference 717041_V4, 19 February 2020). Additional groundwater monitoring was undertaken between December 2018 and June 2020 as summarised in Section 3 above.
7	<p>(a) Proposed remedial actions for impacts greater than those predicted as part of the relevant approval. The requirement for remedial actions may occur where modelled predictions were inaccurate or where planned mitigation, prevention or avoidance strategies have failed.</p> <p>(b) It is recommended a security bond specifically to manage groundwater impacts apply. DPIE-Water should be consulted in the remediation plan to be costed.</p>	<p>(a) A number of monitoring recommendations were made in the ASSMP and HIA which are to be formalised in project-specific GMMP to be prepared on determination of the Stockton expansion proposal.</p> <ul style="list-style-type: none"> The GMMP will form a subplan to the Water Management Plan (WMP) prepared in accordance with Condition 3 (12) of Development Consent DA 140-6-2005 (2004). The GMMP will describe the objectives of the groundwater management and monitoring and detail the proposed types and locations of monitoring. It will also describe the monitoring observations which would trigger actions and the proposed remedial actions and/ or mitigation measures to be deployed should triggers be exceeded. <p>The recommendations include:</p> <ul style="list-style-type: none"> Maintenance of the existing monitoring bore network outside the proposed extraction area (MW_X1, MW_X2, MW_X5, MW_X6, MW7, GW2, GW4 and MW2) to provide early warning of the development of any environmental degradation or impact to surface water, groundwater and soils both during the project and for a period following completion. <ul style="list-style-type: none"> Once extraction progresses below the water table the dredge pond surface will need to be surveyed so that the relative height of water in the pond over time can be accurately measured. Monthly measurement of SWL and pond water level AHD heights during excavation, reinstatement and rehabilitation works (bores only). With all eight existing bores incorporated into the existing quarterly monitoring program for the wider quarrying site following rehabilitation; Monthly measurement of pH in all eight bores and the pond during excavation and rehabilitation works; and Monthly sampling of all monitoring bores for <ul style="list-style-type: none"> field parameters (pH, EC, ORP, SWL, DO and temperature) and laboratory analysis (full ionic balance suite: pH, TDS, cations, anions, nutrients and dissolved iron). <p>The GMMP will be reviewed and revised (as necessary) to ensure all comments are adequately addressed prior to final submission, subsequent to approval of this modification.</p> <p>(b) Environmental Earth Sciences can make no comment with regards to security bonds to be lodged and understands this will be considered and responded to separately by Boral. However, it is noted remedial/ management actions to be implemented should trigger exceedances be identified, will be supplied within the updated GMMP.</p>
8	<p>The DPIE Water Division and the Natural Resources Access Regulator (NRAR) submission requests further information on several matters, which are supported by the Department. Please ensure the Submissions Report addresses all matters raised.</p> <p>Please provide further clarification and assessment on how potential water quality changes and incidental take of groundwater from the Project may have a potential impact on water sources, their dependent ecosystems and authorised water users surrounding the Project.</p>	<p>The groundwater resource beneath the site is of relatively useful yield and quality and is therefore suitable for a number of potential beneficial uses (it is understood approximately 171 domestic and stock watering [basic rights] bores have been approved as of October 2020).</p> <p>Based on the current/ baseline groundwater assessment for the site, the beneficial uses to be protected are (in order of priority and importance): drinking water, freshwater and marine ecosystems of local surface water features and nearby ephemeral creek systems; stock watering; recreational, direct contact and aesthetic use; possible irrigation; and dust suppression.</p> <p>The potential for impacts to these beneficial uses as a result of changes to the existing hydrogeological regime at the site (groundwater quality/ SWLs/ flow direction) was assessed in detail as part of the HIA (Environmental Earth Sciences, 2020a) and is summarised below.</p> <p>SWLs: Significant change in groundwater levels and/or impacts to adjacent and downstream environments is not anticipated given the proposed excavation methodology is not expected to cause significant changes to either the hydrogeological flow regime (flow direction) or SWLs.</p> <ul style="list-style-type: none"> Minimal to no dewatering is required during the proposed sand extraction activities. Sand will be extracted via suction dredge that will operate from a barge on the lake that is to be created by the extraction excavation extending below the water-table; The majority of water removed during dredging will drain back into the dredge pond thus preventing a lowering of the water-table; and Recharge is rapid in this lithology (infiltration anticipated at around 30%) therefore, rainfall will rapidly recharge the aquifer, further preventing impacts to the groundwater table across the site. <p>Acidity and salinization:</p> <p>Acidity: The risk of acidification of groundwater associated with the expansion activities is deemed low given (with reference to the ASSIA):</p> <ul style="list-style-type: none"> Desktop assessment of the site reported a low probability for the occurrence of acid sulfate soils (ASS) at the site; Twenty-three of 25 samples analysed reported a risk level of "no risk – no sulfur" (NRNS) and, as such, are considered "Not Acid Sulfate Soils [NASS]" and one sample was designated "no risk – non reactive" (NRNR);

#No	Department Review Comment/ Request for Clarification	Environmental Earth Science Response
		<ul style="list-style-type: none"> • High alkalinity and high buffering capacity was reported throughout the lithological profile of boreholes drilled at the site; • Excavation activities are considered unlikely to change the groundwater level due to high recharge rates and draining water back into the dredge pond; • Proposed dredging activities include the sieving of material so that fines (materials finer than sand) and/or oversize material (outside the appropriate grading envelope) are separated on site and are immediately returned below the water table. This reduces the potential for acid generation and safeguards the final sand product for commercial sale; and • One location reported a moderate risk for potential acid sulfate soil (PASS) but this was a localised occurrence and only marginally exceeding Tier 1 thresholds for management. <p>Note – In order to facilitate proactive management of any PASS/ ASS risk (albeit considered low on the basis of PASS detection in a single sample), a draft ASSMP will be prepared on determination of the Stockton expansion proposal. The ASSMP will include information on the proposed monitoring and management actions to be implemented at the site, prior to, during and on completion of the proposed extraction activities. This ASSMP will be reviewed and revised (as necessary) to ensure these comments are adequately addressed prior to final submission, and subject to further consultation with relevant agencies.</p> <p>According to DPIE Water (August 2020), the ASS investigation was insufficient to rule out the interception of acid sulfate material and organic layers at depth across the project area as the assessment was limited to 4 test holes. However, Environmental Earth Sciences considers the information presented is sufficient and appropriate to classify the site as low risk for the reasons specified above – low probability of occurrence, high alkalinity and buffering capacity throughout the soil profile and maintenance of groundwater levels. It should be noted that PASS cannot oxidise and cause adverse chemical reactions while materials remain saturated.</p> <p>As indicated, an ASSMP will be prepared, site activities monitored and in the unlikely event PASS are encountered at the site during the project activities materials will be managed accordingly.</p> <p>Salinization: The risk of land and aquifer salinization is deemed low in consideration of the following:</p> <ul style="list-style-type: none"> • Groundwater level and chemistry monitoring has been undertaken at the project site for over 12 years as part of the existing Boral quarrying operation and associated with the proposed expansion area. The historical (and ongoing) assessment undertaken has indicated: <ul style="list-style-type: none"> • Little to no impact on groundwater levels associated with sand extraction activities completed to date. Levels have remained stable including from bores located directly adjacent to and down gradient of mining activities; and • No significant changes in groundwater chemistry (including salinity) have been observed with groundwater chemistry remaining relatively consistent over the past >12 years. <p>The proposed extraction activities in the initial stages (above the water table) are similar to those currently undertaken at the site, and dredging activities to be undertaken below the water-table are not anticipated to significantly alter the hydrogeological regime (dewatering is not required), Hence, only minimal fluctuations in water levels and groundwater chemistry are expected to occur as a result of the proposed expansion activities.</p> <p>Groundwater chemistry:</p> <p>The risk of significant contamination of groundwater associated with the proposed expansion activities is deemed low:</p> <ul style="list-style-type: none"> • Increases in dissolved metals content (as a result of increased acidity following exposure and oxidation of PASS, for example – increased soluble iron) is considered low given the water-table will not be lowered, there is a low likelihood of PASS occurrence at the site (as discussed above), and there is an excess of alkalinity in the soil profile; • There is a low likelihood of impacts to groundwater associated with PFAS sourced from RAAF Base Williamtown (refer to Item 10 below for detailed discussion); and • Operational risks at the site (e.g. leaks/ spillages associated with chemical storage such as hydrocarbons) can be readily managed and mitigated in accordance with a site operational environmental management plan, thus significant impacts to groundwater are unlikely. <p>According to DPIE Water (August 2020), “<i>material rejected back to the pond will contain concentrated heavy metals, waste products and organic sludge waste and even potentially radioactive material. Chemical reactions with the extracted and returned material or within the oxygenated pond itself has the potential to release soluble metals</i>”. No evidence has been identified during the ongoing assessment and monitoring program at the site, to support this. Rather, based on available site information (refer information above), the likelihood of adverse chemical reactions at the site is deemed low.</p> <p>Monitoring/ Management actions proposed</p> <p>Given excessive sedimentation, and that chemical impacts are considered to pose the highest risk to receiving waters/ habitats, the following management and/or monitoring actions will be employed prior to, during and post operations:</p> <p>Construction/ Design:</p> <ul style="list-style-type: none"> • Sedimentation from construction will be managed in accordance with a construction soil and water management plan.

#No	Department Review Comment/ Request for Clarification	Environmental Earth Science Response
		<ul style="list-style-type: none"> Although clearing and grubbing will generate areas of exposed materials, increasing the potential for erosion and transfer of sediment to receiving waters, all flood protection bunding and slopes will be stabilised with vegetation to limit erosion and sedimentation. <p>Operations:</p> <ul style="list-style-type: none"> The nominated excavation methodology will minimise any potential for PASS exposure and oxidation (although it is acknowledged that there is a low likelihood of PASS materials being encountered on site). During ongoing operations systematic monitoring and maintenance will be incorporated into operational procedures to limit the possibility of failures of any sediment retention structures/ sediment transfer pipelines. This will allow rapid response and repair to be achieved in the unlikely event of a leak or failure. Ongoing monitoring (see below) will be undertaken in relation to groundwater physical parameters (SWL) and chemistry to provide early indications of any potential changes to the groundwater flow and/or chemical regime during operations. In the unlikely event chemical changes to groundwater (increased acidity), with the potential to subsequently impact on down-gradient ecosystems is identified, appropriate mitigation strategies will be employed. Noting a ready supply of Ag-lime will be kept, as a precautionary measure, on site, at all times. <p>All:</p> <ul style="list-style-type: none"> Ongoing monitoring (see below) will be undertaken in relation to groundwater physical parameters (SWL) and groundwater chemistry from construction through operational and rehabilitation phases as a precautionary measure, to provide early indications of any potential changes to the groundwater flow and/or chemical regime during operations. <p>Ongoing Monitoring:</p> <p>Boral currently undertakes ongoing monitoring of SWLs and groundwater chemistry at the site in accordance with an existing GMMP to proactively monitor any potential risks to groundwater (and beneficial uses) and allow for implementation of remedial actions/ mitigation measures.</p> <p>A project specific GMMP will be developed in relation to the project area and will include recommendations made in both the ASSIA (Environmental Earth Sciences, 2019) and HIA (Environmental Earth Sciences, 2020a) to be formalised following determination of the Stockton expansion proposal.</p> <p>This GMMP will include details of appropriate remedial measures to adequately address salinity and acidity. This plan will be prepared in consultation with relevant agencies subsequent to any approval of this application and approved prior to commencement of any works within the project area. The major remedial measure to ensure the salinity and acidity of the lake is maintained at acceptable levels is to allow continued recharge of fresh rainwater to the excavation, whilst a ready supply of AgLime (CaCO₃) can be maintained on site to dose the pond in the unlikely event of increased acidity. Such measures can be readily included in future iterations of the ASSMP and GMMP.</p> <p>Further, assessment of each potential impact, associated risk and, residual risk rating following implementation of proposed monitoring and/or management measures is provided in Table 3, Appendix B.</p>
DPIE BCD (17 April 2020)		
9	<i>The proponent should develop a final landform map, showing the expected footprint of the dredge pond, including different depths within the pond (such as the limit of the -15 m AHD extraction)</i>	A final landform map has been prepared and is supplied as part of the Rehabilitation Plan, provided under separate cover.
10	<i>The proposed strategy to rehabilitate the dredge pond to a freshwater wetland should be reconsidered. If the proponent decides to pursue this strategy it should detail how wetland conditions can be achieved in such a deep environment and any rehabilitation activities required to achieve this. The proponent should also detail any long-term management measures that will be implemented to ensure the pond is not degraded by pests, degrading water quality or other issues.</i>	<p>The rehabilitation strategy for the site has been reviewed and updated with additional information to address BCDs concerns. The rehabilitation strategy is supplied under separate cover.</p> <p>A project specific long-term water quality monitoring program and other management plans (as required) will be developed for the project area following determination of the Stockton Expansion Proposal.</p>
11	<i>The proponent should develop rehabilitation success criteria and objectives that are relevant to the dredge pond. This should cover the establishment of appropriate biological functions in the pond and the long-term management of issues such as aquatic pests and water management.</i>	
12	<i>The proponent should develop and implement a long-term water quality monitoring program for the dredge pond that includes a trigger action response plan inf long term or immediate declining water quality is detected.</i>	

#No	Department Review Comment/ Request for Clarification	Environmental Earth Science Response
13	<p>The potential impact on beach wetlands in the Worimi Conservation Lands (which have been assessed as broadly consistent with endangered ecological community Sydney Freshwater Wetlands in the Sydney Basin Bioregion) due to possible changes to groundwater levels from the project, need to be assessed.</p>	<p>Please refer to Item 8 above. No adverse impact to groundwater ecosystems due to changes in groundwater levels caused by the project are anticipated, primarily because no significant groundwater level changes will occur. There is therefore considered to be a negligible to low potential for impacts upon beach wetlands in the Worimi Conservation Lands.</p>
DPIE Water (6 May 2020)		
14	<p>The DPIE Water Division and the Natural Resources Access Regulator (NRAR) submission requests further information on several matters which are supported by the Department. Please ensure the Submissions Report addresses all matters raised.</p> <p>Please provide further clarification and assessment on how potential water quality changes and incidental take of groundwater from the Project may have a potential impact on water sources, their dependent ecosystems and authorised water users surrounding the project.</p>	<p>Please refer items 1 to 8 above.</p>
15	<p>Please ensure all matters listed by the Hunter Water Corporation (HWC) are addressed in your Submissions Report, including HWC's proposal of a final landform that is at least one metre above the predicted maximum groundwater elevation. <u>Please provide further justification as to how the extractive operations (particularly stages two to six of the Project) will be designed to avoid impacts to, and preserve, the water table. This response should include any additional measures to reduce the size of the final landform design of the proposed 23.3 ha open lake identified in the Hydrogeological Impact Assessment.</u></p>	<p>Removal of the aquifer matrix by excavation is likely to have very little physical and/or chemical impact upon groundwater at the site.</p> <p>Please refer to Items 1 and 8 above.</p>
16	<p>A few community submissions have raised concerns regarding excavations below the water table (Project stages two to six) and associated issues with PFAS contamination near the RAAF Williamstown Base. Please provide a response to these submissions and include further clarification and assessment on the PFAS contamination risks associated with excavating below the water table. This includes consideration to assessing potential future PFAS migration risks.</p>	<p>Regional groundwater within the Tomago Sandbeds Aquifer has been historically impacted by PFAS and PFOA associated with the RAAF Base, Williamstown. As a result, a NSW EPA Investigation Area has been nominated in the vicinity of the RAAF Base. The Risk Zone C boundary is drawn along the low-lying drainage area that both the Tomago and Stockton Sandbed aquifers drain into.</p> <p>Given the proximity of known PFAS-impacted groundwater to the Boral project site, it is recognised that a number of community concerns have been raised regarding excavations below the water table and potential issues with PFAS contamination when excavating below the water-table. However, based on the available data, PFAS is not, nor is considered likely to be of concern in the future at the site as:</p> <ul style="list-style-type: none"> • The Stockton Sandbeds Aquifer underlying the site is different to that underlying RAAF Williamstown (the Tomago Sandbeds). The Tomago Sandbeds Aquifer is situated to the west of the Stockton Sandbeds Aquifer and is separated by Tilligerry Creek and associated drainage network in this low-lying estuarine region. Groundwater from both the Tomago Sandbeds Aquifer and the Stockton Sandbeds Aquifer discharge into this low-lying region, that ultimately directs discharge on to Fullerton Cove. • The site is located in a separate groundwater and surface water catchment to RAAF Base Williamstown. • PFAS has not been detected above laboratory LOR in any samples collected at the site within the overall monitoring period (January 2018 – June 2020); and • As neither drawdown nor dewatering will occur as a result of the extraction activities proposed, it is unlikely that the overall groundwater flow regime (potentially extenuating migration of the off-base PFAS plume) will occur. <p>In addition to the above, it is noted once extraction is complete, the creation of an enhanced groundwater recharge zone (former dredge pond/ freshwater lake), in addition to the regional groundwater discharge zone of Tilligerry Creek/ Fourteen Foot Drain means groundwater will continue to migrate away from the pond (including to the north towards Fullerton Cove, Cabbage Tree Road and the RAAF base).</p>
17	<p>Please ensure that you carefully consider and respond to BCD's request to provide further assessment of the dredge pond final landform and rehabilitation strategy.</p>	<p>The rehabilitation strategy for the site has been reviewed and updated with additional information to address BCDs concerns. The rehabilitation strategy is supplied under separate cover.</p>
Hunter Water Corporation (15 August 2019)		
18	<p>Hunter Water recommends that all extractive operations should be designed and undertaken in a way that ensures protection of water sources and facilitates sustainable future land use. If the proponent maintains the intention to dredge sand, the EIS must demonstrate why this particular development should be allowed to undertake activities not permitted at other local mines and how such works would be sustainable and not have any adverse effect on the aquifer.</p>	<p>Removal of the aquifer matrix by excavation is likely to have very little physical and/or chemical impact upon groundwater at the site and therefore will not impact upon water sources/have an adverse effect on the aquifer.</p> <p>A project specific GMMP and other management plans (as required) will be developed for the project area following determination of the Stockton Expansion Proposal.</p>

#No	Department Review Comment/ Request for Clarification	Environmental Earth Science Response
	<p><i>This should include the development of a monitoring and management program to assess and mitigate any effects on groundwater levels and quality.</i></p> <p><i>Further, the EIS should address site operations and management practices and how these will be undertaken to ensure that site activities do not result in contamination of the sandbeds, including management of wastewater and stormwater.</i></p>	<p>Please refer to Items 1 and 8 above.</p>
19	<p><i>Rehabilitation and future use of the site to protect the sandbeds as a potential source of drinking water in the future should also be addressed,</i></p>	<p>The rehabilitation strategy for the site has been reviewed and updated with additional information to address all stakeholder concerns. The rehabilitation strategy is supplied under separate cover.</p>
<p>Port Stephens Council (9 April 2020)</p>		
<p>No hydrogeological comments provided</p>		

6 Specific recommendations

Specifically, to minimise the residual risk, it is recommended that:

- PASS management options to ensure sediments below the site surface remain saturated, and related management measures to ensure that acid leachate is not produced, be implemented through an ASS management plan (ASSMP), requiring that:
 - excavation works commence by quarrying the shallow sand material (above the water-table) and work to depth;
 - once the excavation extends in depth greater than 1-2m below the ground surface some groundwater ingress may commence;
 - manage the on-going excavation of sand materials (containing PASS) by sieving the fines out of the excavated material and returning fines to the excavation (under the water-table) immediately;
- all ongoing environmental monitoring recommendations made with respect to surface water and groundwater are formalised in project-specific GMMP.

This will allow a proactive monitoring regime to be established so that in the event of unforeseen circumstances (i.e. early indications of salinization/ acid generation) appropriate management actions will be triggered before environmental impacts are realised.

7 Limitations

This report has been prepared by Environmental Earth Sciences NSW ACN 109 404 006 in response to and subject to the following limitations:

1. The specific scope of works, requested by Rachael Snape of Boral Land and Property Group, has been undertaken in accordance with PO120122_v3;
2. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);
3. This report comprises the formal report, documentation sections, tables and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
4. The report only relates to the site referred to in the scope of works, Boral Stockton Sand Quarry, being located on Coxs Lane, Fullerton Cove, NSW within a portion of land within Lot 1 DP1006399 and Lot 3 DP664552 ('the project site').
5. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;

6. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
7. This report is not a geotechnical or planning report suitable for planning or zoning purposes; and
8. Our General Limitations set out at the back of the body of this report.

Should you have any queries, please do not hesitate to contact us on (02) 9922 1777 or (07) 3852 6666.

For and on behalf of
Environmental Earth Sciences NSW

Author
Laura Halliday
Environmental Scientist

Project Director / Internal Reviewer
Mark Stuckey
Senior Principal Hydrogeologist and Soil Scientist

120082_Boral Stockton_L01_V2

8 References

Environmental Earth Sciences (2019). *Acid Sulfate Soil Impact Assessment, Stockton Sand Quarry Dredging, Coxs Lane, Fullerton, NSW*. Report reference 717041-ASS, 8 August 2019.

Environmental Earth Sciences (2020a). *Hydrogeological impact assessment (HIA), Stockton Sand Quarry Dredging, Coxs Lane, Fullerton, NSW*. Report reference 717041_v4, 19 February 2020a.

Environmental Earth Sciences (2020b). *Rehabilitation strategy for Stockton Sand Quarry Dredging, Coxs Lane, Fullerton, NSW*. Report reference 717041_v3, 19 November 2020b.

Environmental Earth Sciences (2020c). *Groundwater numerical modelling report, Stockton Sand Quarry Dredging, Coxs Lane, Fullerton, NSW*. Report reference 120082_v2, 20 November 2020.

Jacobs (2017). Stockton Sand Quarry Groundwater Management Plan. Ref. IA147700_001b/B. Prepared for Boral Pty Ltd.

ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval

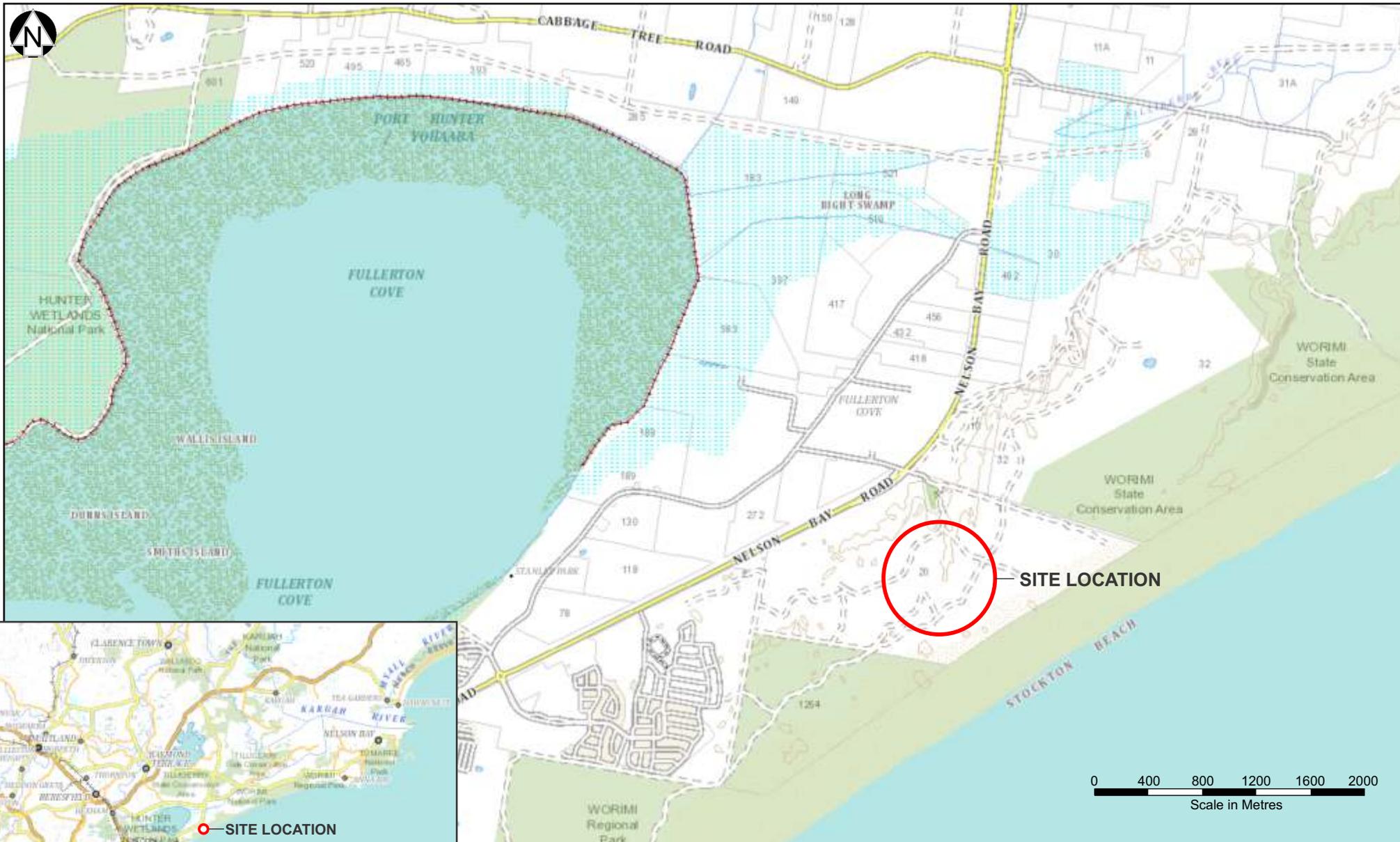
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

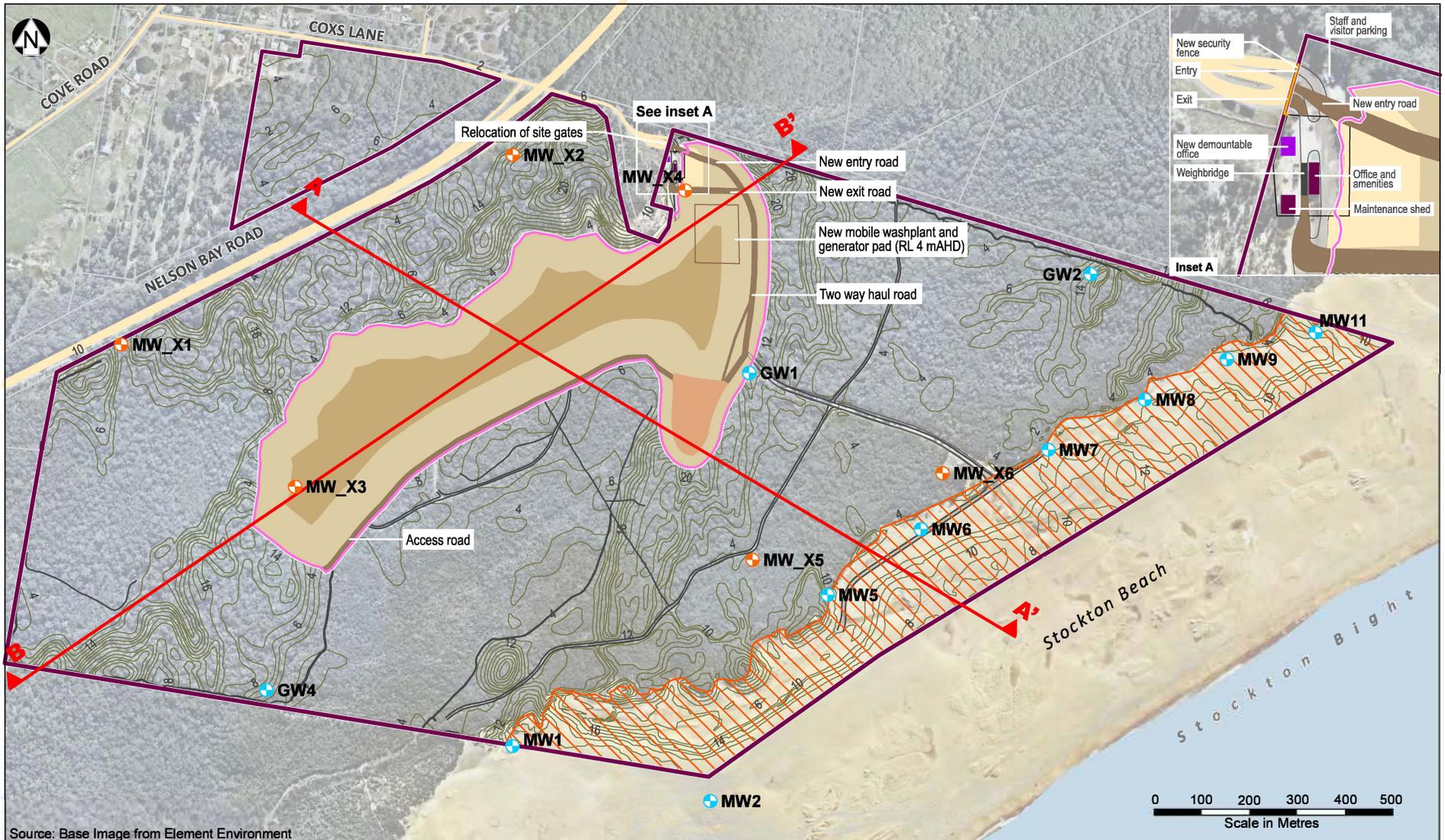
FIGURES



Source: © NSW Govt. SIX Maps



 ENVIRONMENTAL EARTH SCIENCES CONTAMINATION RESOLVED	Title: Site Location
	Location: Nelson Bay Road, Fullerton Cove, NSW
Client: Boral Resources (NSW) Pty Ltd	Job No: 717041
Project Man: EG	Scale: As shown
Drawn By: LB	Date: November 2018
Figure 1	



Source: Base Image from Element Environment

LEGEND:

- Stockton Sand Quarry boundary
- Current windblown sand extraction area
- Contour (mAHD)
- Access tracks
- Additional groundwater monitoring location - installed April 2017
- Current groundwater monitoring location
- Cross section location (refer Figures 10 and 11)

PROJECT FEATURES:

- Proposed clearance area
- Access road
- Extraction base (RL -15mAHD)
- Batter
- Pad base (RL 4mAHD)



Title: **Borehole and Groundwater Monitoring Well Locations**

Location: **Nelson Bay Road, Fullerton Cove, NSW**

Client: **Boral Quarries**

Job No: **717041**

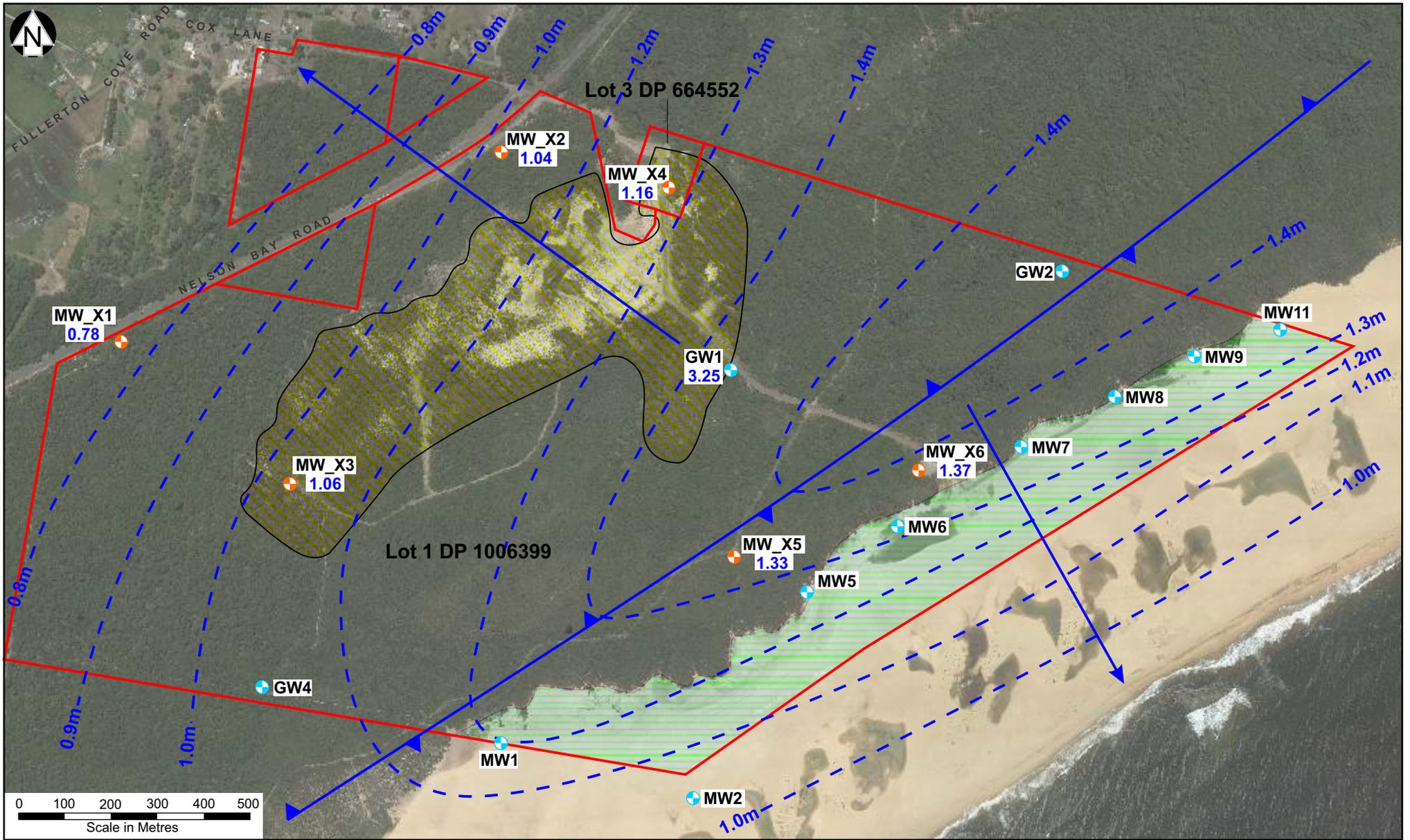
Project Man: **EG**

Scale: **As shown**

Drawn By: **LB**

Date: **September 2019**

Figure 2

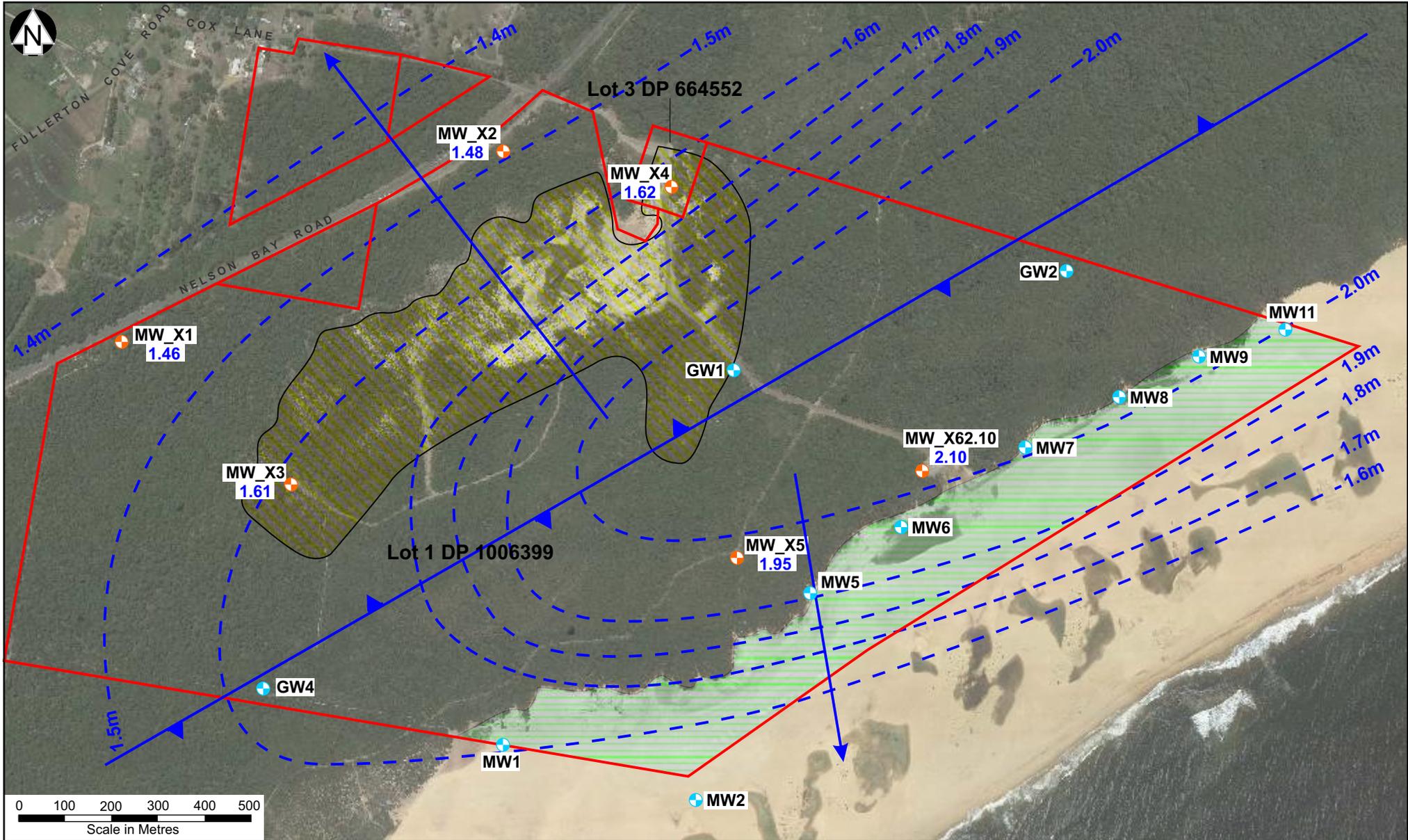


Source: Map data © 2016 Google Earth Pro

LEGEND:

- Lot area
- Windblown sand extraction area
- Inland extraction area
- + Additional groundwater monitoring location - installed April 2017
- + Current groundwater monitoring location
- Inferred groundwater level (mAHD)
- ▲ Inferred groundwater flow divide
- Inferred groundwater flow direction
- 1.33 Standing water level (mAHD)

ENVIRONMENTAL EARTH SCIENCES <small>CONTAMINATION RESOLVED</small>	Title: Groundwater Levels Low Rainfall (14 March 2018)	
	Location: Nelson Bay Road, Fullerton Cove, NSW	
Client: Boral Resources (NSW) Pty Ltd	Job No: 717041	
Project Man: EG	Scale: As shown	Figure 3
Drawn By: LB	Date: November 2018	



Source: Map data © 2016 Google Earth Pro

LEGEND:

- Lot area
- Windblown sand extraction area
- Inland extraction area
- Additional groundwater monitoring location - installed April 2017
- Current groundwater monitoring location
- Inferred groundwater level (mAHD)
- ▲ Inferred groundwater flow divide
- Inferred groundwater flow direction
- 1.95 Standing water level (mAHD)

ENVIRONMENTAL EARTH SCIENCES <small>CONTAMINATION RESOLVED</small>	Title: Groundwater Levels High Rainfall (20 June 2018)	
	Location: Nelson Bay Road, Fullerton Cove, NSW	
Client: Boral Resources (NSW) Pty Ltd	Job No: 717041	
Project Man: EG	Scale: As shown	Figure 4
Drawn By: LB	Date: November 2018	

TABLES

Table 2: PFAS Results, January - June 2020

	Perfluorohexane sulfonic acid	Perfluorooctane sulfonic acid	Perfluorooctanoic acid	6:2 Fluorotelomer sulfonate	8:2 Fluorotelomer sulfonate	Total Positive PFHxS & PFOS	Total Positive PFOA & PFOS	Total Positive PFAS
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
PQL	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Sample ID	Date	Perfluorohexane sulfonic acid	Perfluorooctane sulfonic acid	Perfluorooctanoic acid	6:2 Fluorotelomer sulfonate	8:2 Fluorotelomer sulfonate	Total Positive PFHxS & PFOS	Total Positive PFOA & PFOS	Total Positive PFAS
GW4	16-Jan-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	26-Feb-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	27-Mar-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	22-Apr-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	20-May-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
GW4	18-Jun-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	16-Jan-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	26-Feb-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	27-Mar-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	22-Apr-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	20-May-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X1	18-Jun-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	16-Jan-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	26-Feb-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	27-Mar-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	22-Apr-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	20-May-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X2	18-Jun-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	16-Jan-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	26-Feb-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	27-Mar-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	22-Apr-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	20-May-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MW X7	18-Jun-20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

APPENDIX A: SCHOELLER PLOTS (MX SERIES BORES)

Figure 5: Schoeller Diagram for Bore MWX1 (July 2017 – June 2019)

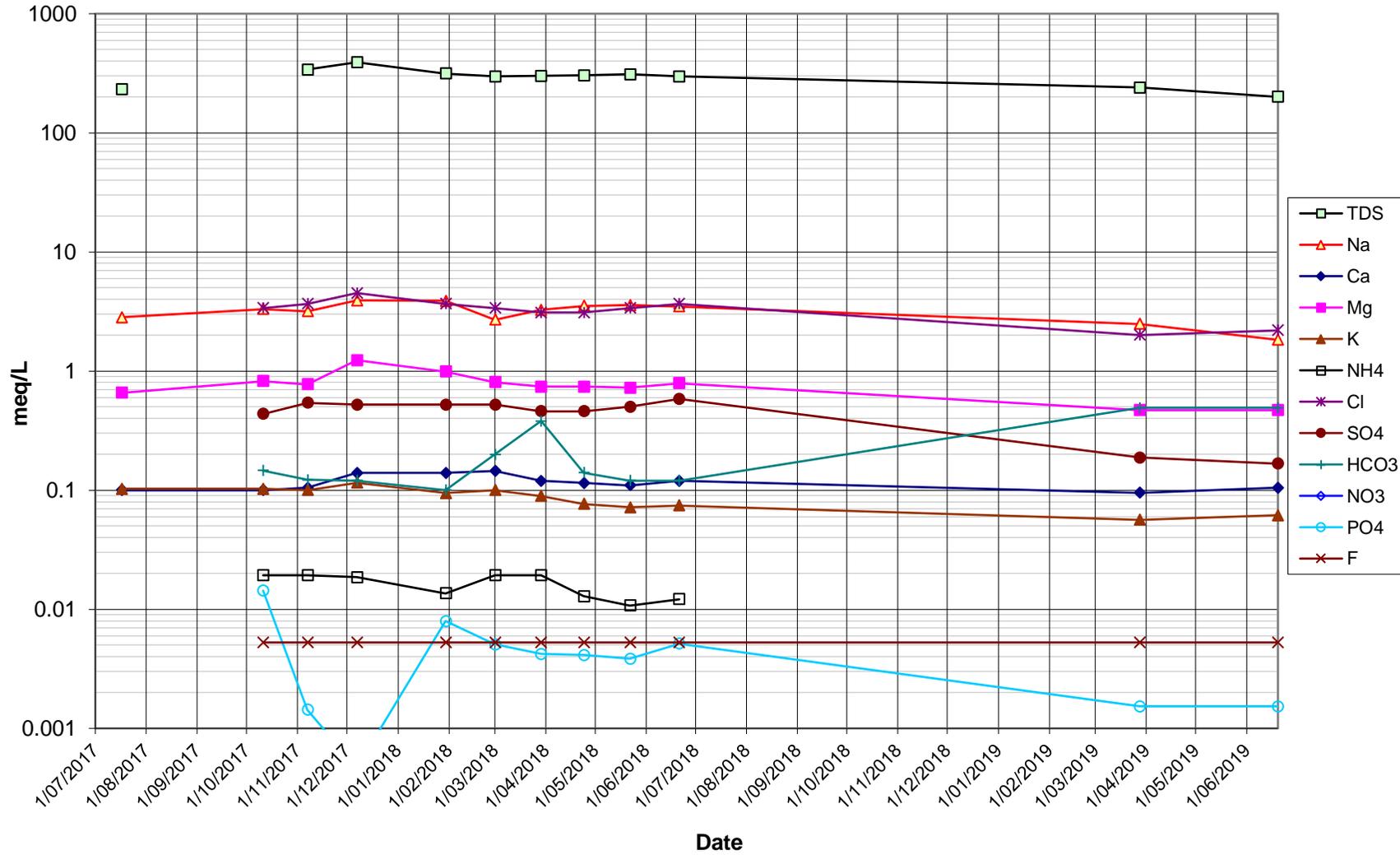


Figure 6: Schoeller Diagram for Bore MWX2 (July 2017 – June 2019)

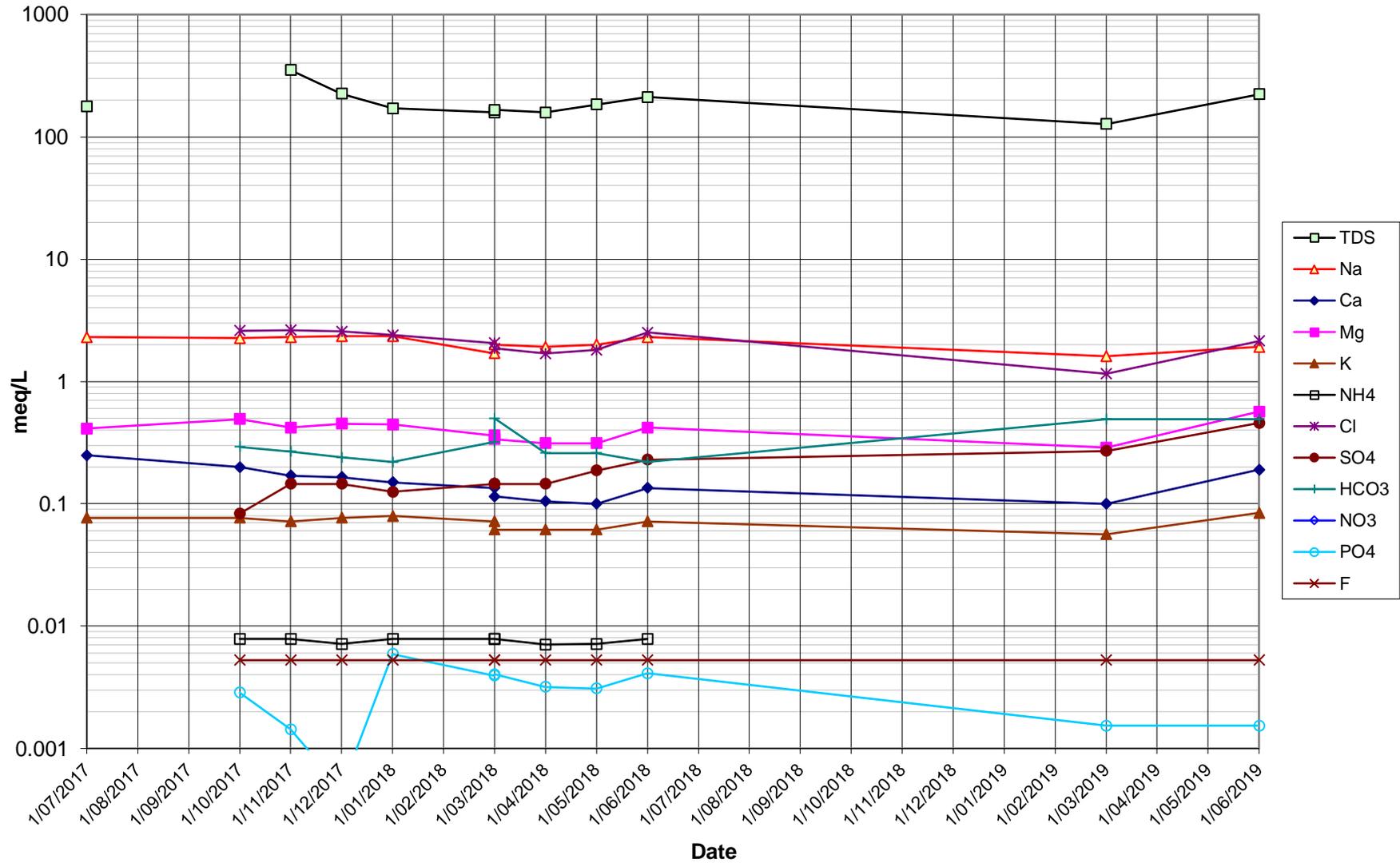


Figure 7: Schoeller Diagram for Bore MWX3D (July 2017 – June 2019)

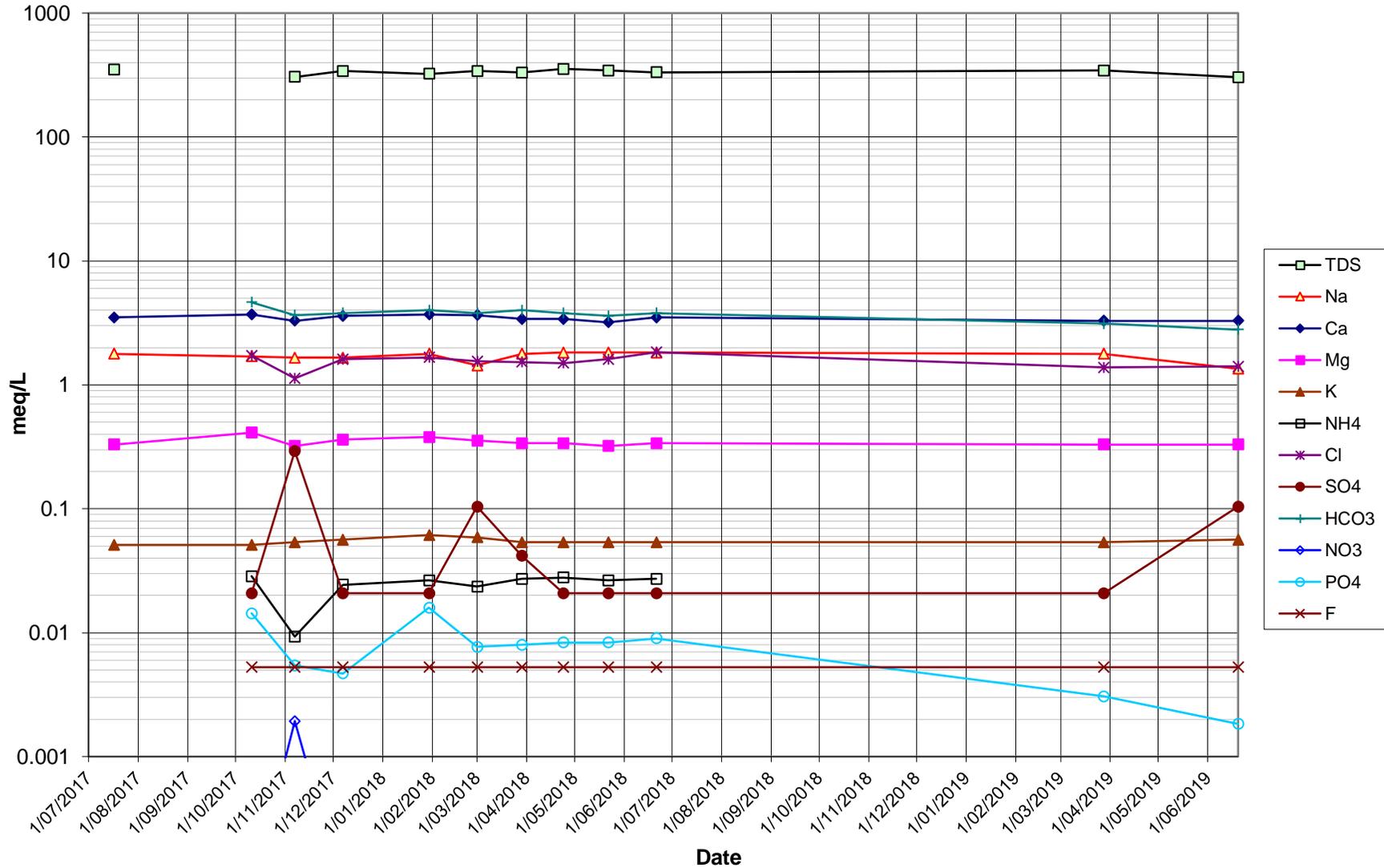


Figure 8: Schoeller Diagram for Bore MWX3S (July 2017 – June 2019)

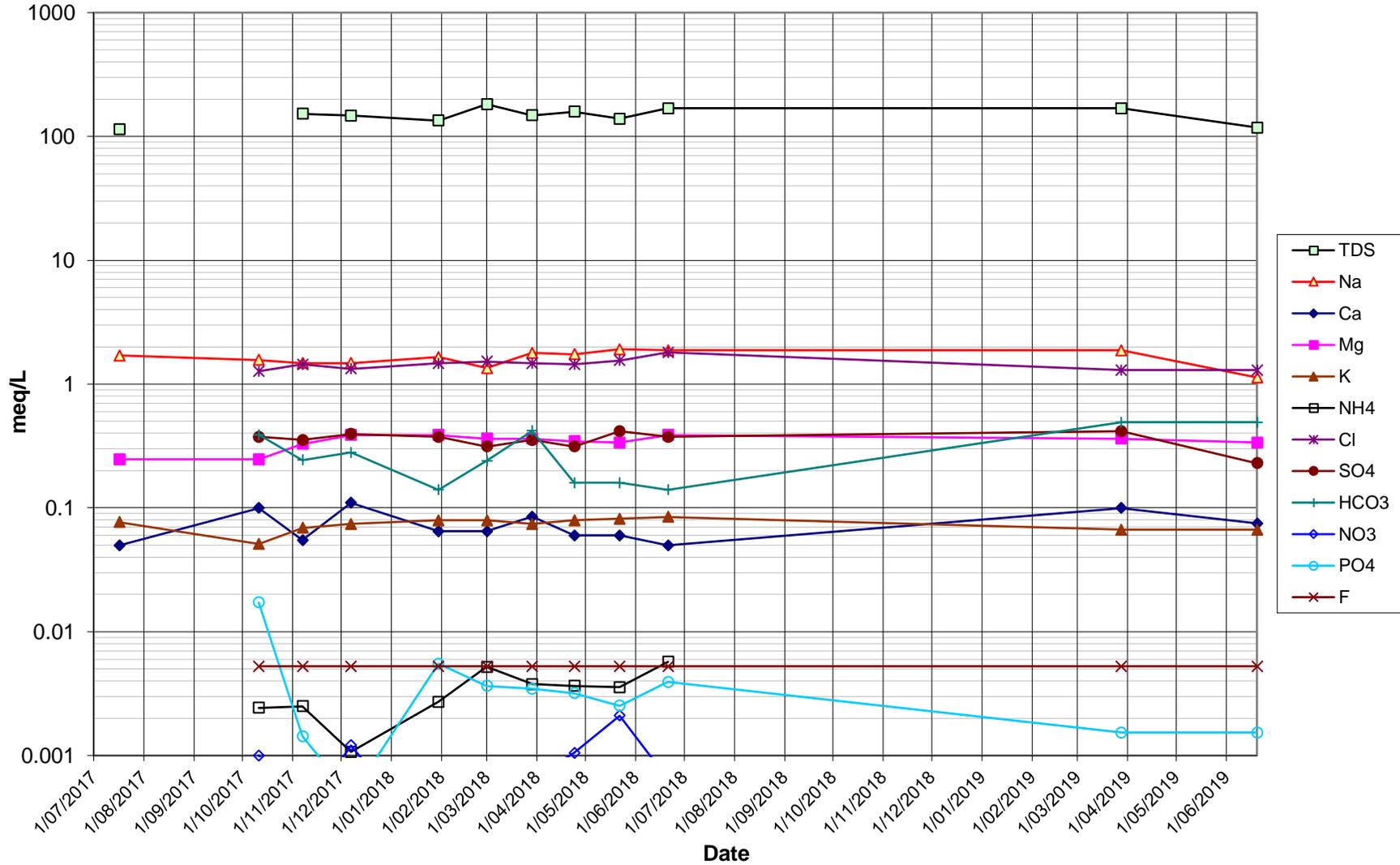


Figure 9: Schoeller Diagram for Bore MWX4D (July 2017 – June 2019)

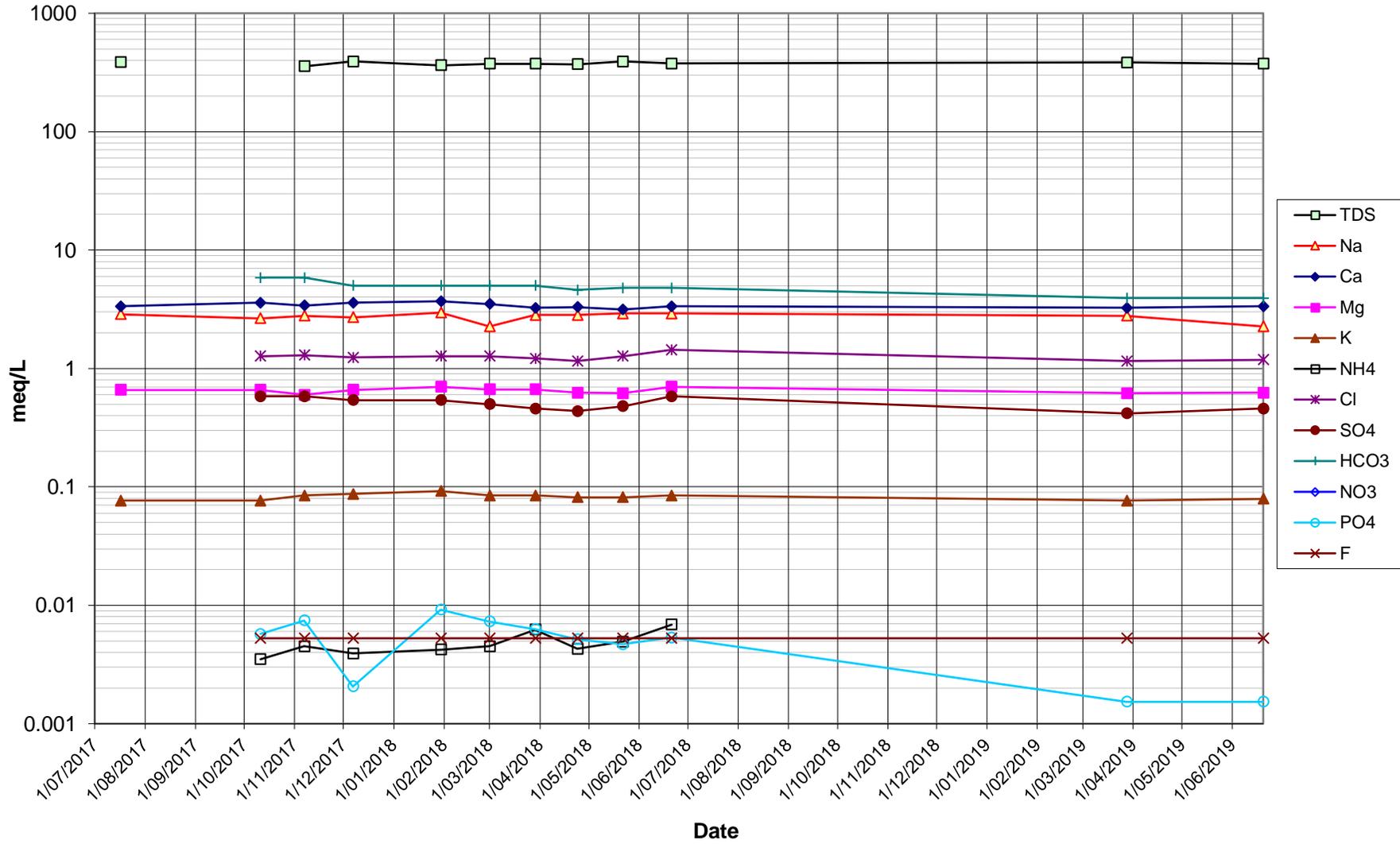


Figure 10: Schoeller Diagram for Bore MWX4S (July 2017 – June 2019)

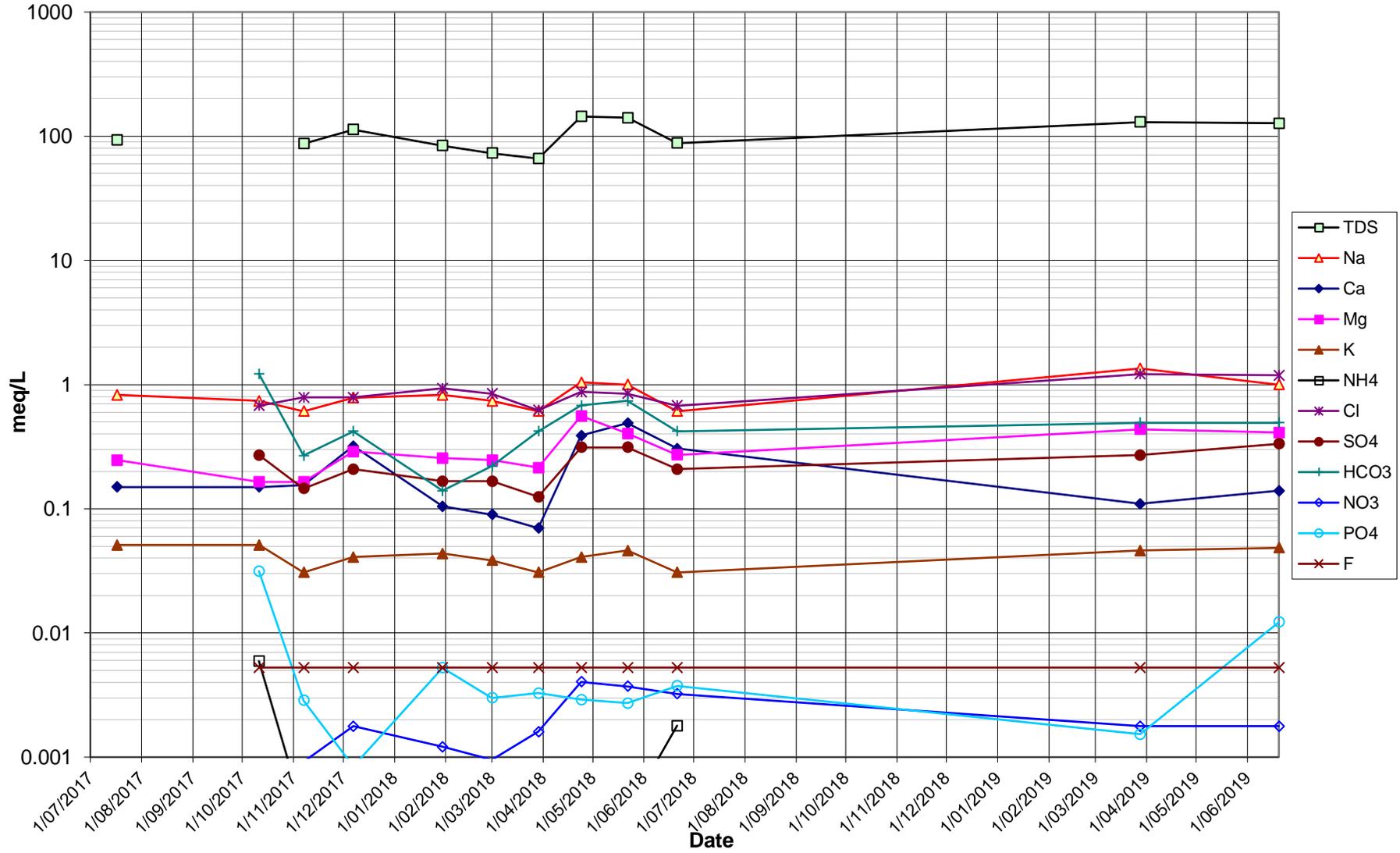


Figure 11: Schoeller Diagram for Bore MWX5 (July 2017 – June 2019)

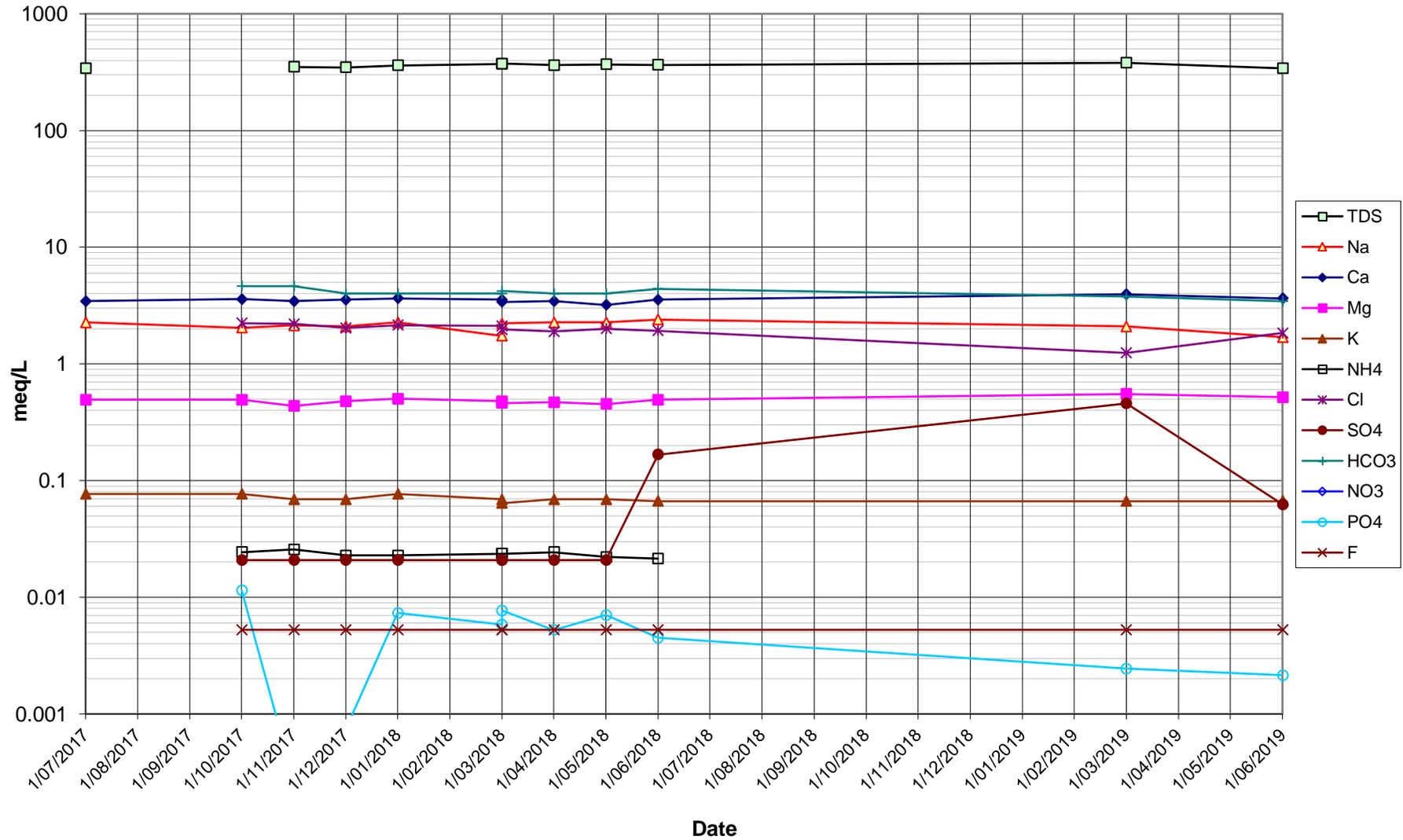
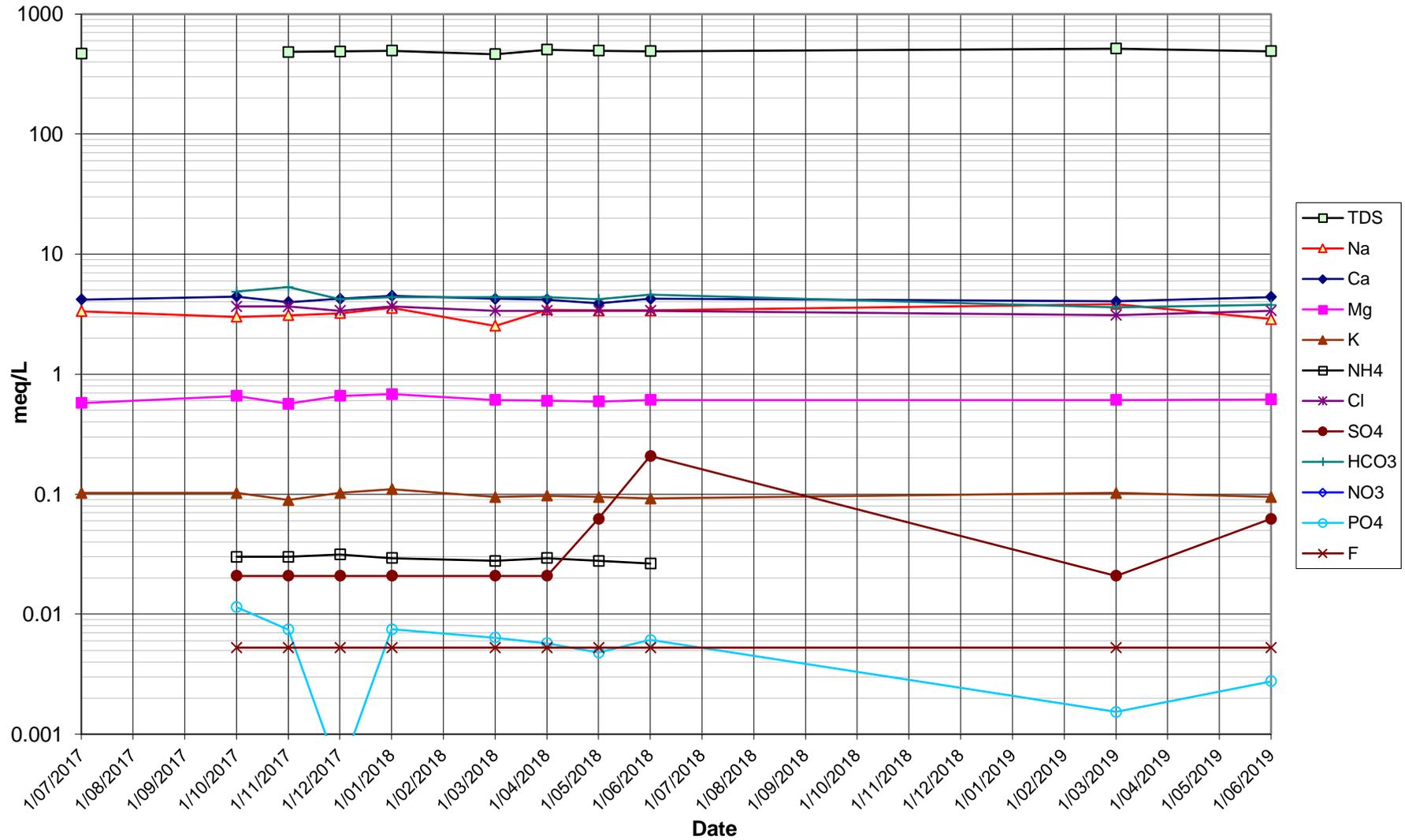


Figure 12: Schoeller Diagram for Bore MWX6 (July 2017 – June 2019)



APPENDIX B IMPACT ASSESSMENT

Table 3: Qualitative impact assessment

Proposal Component	Aspect	Potential Impacts	Likelihood of Impact	Consequence of Impact	Initial Risk Rating	Comments	Mitigation, monitoring or management strategies proposed	Residual Risk Rating	
Site Preparation	Vegetation Clearing	Physical Impact to Groundwater: -Increased recharge, run-on, run-off and erosion	Unlikely (4)	Minor (4)	Low (8)	The implementation of erosion and sediment controls will minimise erosion while improving water-table recharge (direct infiltration of ponded surface water). Combined with reduced evapo-transportation, this may result in localised water-table elevation beneath the site.	Monitoring: Ongoing physical assessment of standing water levels (SWL), pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)	
		Chemical Impact to Groundwater	Very Unlikely (5)	Moderate (3)	Low (8)	No mechanism for impact		Low (8)	
		Ensuing Physical Impact to Ecosystems (coastal wetlands/ estuary/ aquatic habitats) or Groundwater Users	Unlikely (4)	Moderate (3)	Low (8)	Ecosystem not heavily reliant on groundwater.		Low (10)	
		Ensuing Chemical Impact to Ecosystems (coastal wetlands/ estuary/ aquatic habitats) or Groundwater Users	Very Unlikely (5)	Moderate (3)	Low (8)	No mechanism for impact other than potential increases in freshwater recharge to the aquifer which can be considered a "beneficial" impact.		Low (8)	
Excavation/ dredging	Removal of Aquifer matrix	Physical Impact to Groundwater: Lowering of water-table	Unlikely (4)	Minor (4)	Low (8)	Removal of the aquifer matrix by excavation is likely to have little impact on the groundwater resource given the disturbance footprint of the Stage 5 extraction area is so small (0.1 % of the Minnamurra River Catchment). Mechanisms for lowering the water-table will be limited to increased evaporation and reduced run-on to pond areas which are likely to be partially offset by vegetation removal (reduced evapo-transpiration) and surface water and erosion controls which will improve the mechanism for water-table recharge (direct infiltration of ponded water). Ultimately any water-table variations will not have a physical consequence for the aquifer or potential receptors.	Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)	
		Chemical Impact to Groundwater: Exposure and oxidation of PASS (Stage 5A only)	Unlikely (4)	Moderate (3)	Low (8)	Although localised pockets of PASS are present within the Stage 5A area, the proposed extraction methodologies have been selected to avoid or minimise exposure of PASS. Furthermore there is an excess of alkalinity in the soil profile. Minimal water-table changes are anticipated based on existing water balance calculations.		Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters. Management/ Mitigation: A supply of Ag-lime will be kept on-site for soil treatment as a precautionary measure in the unlikely event acidity is identified.	Low (8)
		Chemical Impact to Groundwater: Salinisation	Unlikely (4)	Minor (4)	Low (8)	Given the distance of the dredge area from the coast (Figure 2) and assessment completed to date for confirming no significant changes to groundwater chemistry over 12 years (including salinity) has occurred, salinisation is deemed unlikely.		Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters. Management/Mitigation: The footprint of the proposed dredging area, is located greater than 50 m distance from tidal zone. Freshwater inflow to the dredge pond will be maintained.	Low (8)
		Ensuing Physical Impact to Ecosystems Ecosystems (coastal wetlands/ estuary/ aquatic habitats) or Groundwater Users	Unlikely (4)	Minor (4)	Low (8)	Ecosystem not heavily reliant on groundwater		Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)
		Ensuing Chemical Impact to Ecosystems (coastal wetlands/ estuary/ aquatic habitats) or Groundwater Users	Unlikely (4)	Minor (4)	Low (8)	No mechanism for impact.		Monitoring: Ongoing physical assessment SWL, pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)

Proposal Component	Aspect	Potential Impacts	Likelihood of Impact	Consequence of Impact	Initial Risk Rating	Comments	Mitigation, monitoring or management strategies proposed	Residual Risk Rating
							Mitigation & Management: A supply of Ag-lime will be kept on site for soil treatment as a precautionary measure in the unlikely event acidity is identified.	
		Drawdown of water increasing plume of PFAS from RAAF Base Williamtown	Very Unlikely (5)	Moderate (3)	Low (8)	The site is located in a separate groundwater and surface water catchment to the identified sources of PFAS in groundwater. Detectable concentrations of PFAS have not been reported in site groundwaters during monitoring program completed, to date.	Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)
Rehabilitation (wetland and lake)	Wetland and lake formation	Physical Impact to Groundwater: Reduction in aquifer porosity, possible lowering of water-table	Very unlikely (5)	Negligible (5)	Low (10)	Risk decreasing over time.	Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)
		Chemical Impact to Groundwater	Unlikely (4)	Minor (4)	Low (6)	Risk decreasing over time.	Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)
		Ensuing Physical Impact to Ecosystems (coastal wetlands/ estuary/ aquatic habitats) or Groundwater Users	Unlikely (4)	Negligible (5)	Low (9)	Ecosystem not heavily reliant on groundwater	Monitoring: Ongoing physical assessment of SWL, pond water level (AHD) and quarterly monitoring of chemical parameters.	Low (8)
		Ensuing Chemical Impact to Ecosystems (coastal wetlands/ estuary/ aquatic habitats) or Groundwater Users.	Unlikely (4)	Minor (4)	Low (8)	Regional groundwater flow to the north-west and south-east		Low (8)