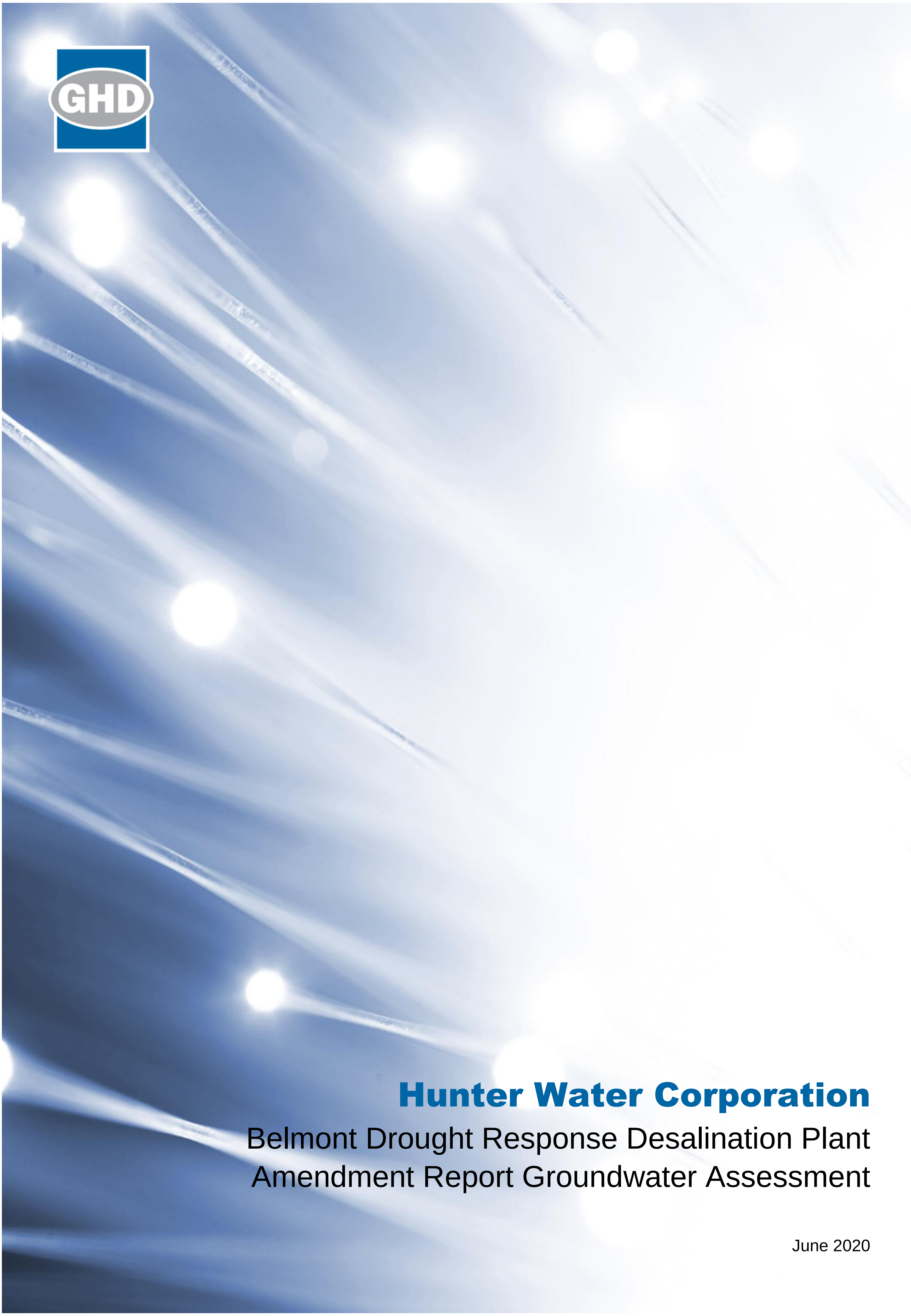
Appendix J – Groundwater Assessment



Hunter Water Corporation

Belmont Drought Response Desalination Plant Amendment Report Groundwater Assessment

June 2020

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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1. Introduction

1.1 Background

Hunter Water Corporation (Hunter Water) is seeking approval to construct and operate a drought response desalination plant (the 'Project'), adjacent to the Belmont Wastewater Treatment Works (WWTW) in Belmont South, a suburb of Lake Macquarie Local Government Area (LGA) of New South Wales (NSW) (the 'Project area'); (see Figure 1-1).

Like much of NSW, the Lower Hunter region continues to experience ongoing drought conditions. In response to the drought, Hunter Water is rolling out a program of drought response measures as outlined in the 2014 Lower Hunter Water Plan (LHWP). Measures include the staged introduction of water restrictions, implementation of a broad range of water conservation and water loss initiatives as well as various operational measures. The 2014 LHWP identified the implementation of emergency desalination as a measure of last resort in response to a severe drought, and would only be implemented if water storage levels reached a critical point and all other measures have been implemented.

GHD Pty Ltd (GHD) were engaged by Hunter Water to prepare an Environmental Impact Statement (EIS) (GHD, 2019a) to support a development application for the Project as State Significant Infrastructure (SSI) under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The EIS was prepared in accordance with the provisions of the EP&A Act and the EP&A Regulation and addresses the Secretary's Environmental Assessment Requirements (SEARs) issued by the Department of Planning, Industry and Environment (DPIE) for the Project on 12 December 2017 and revised on 24 January 2018. The EIS was publicly exhibited by DPIE for 28 days from 21 November 2019 to 19 December 2019.

The Project described in the EIS included the construction and operation of a desalination plant, designed to produce up to 15 megalitres per day (ML/day) of potable water, with two sub-surface intake structures.

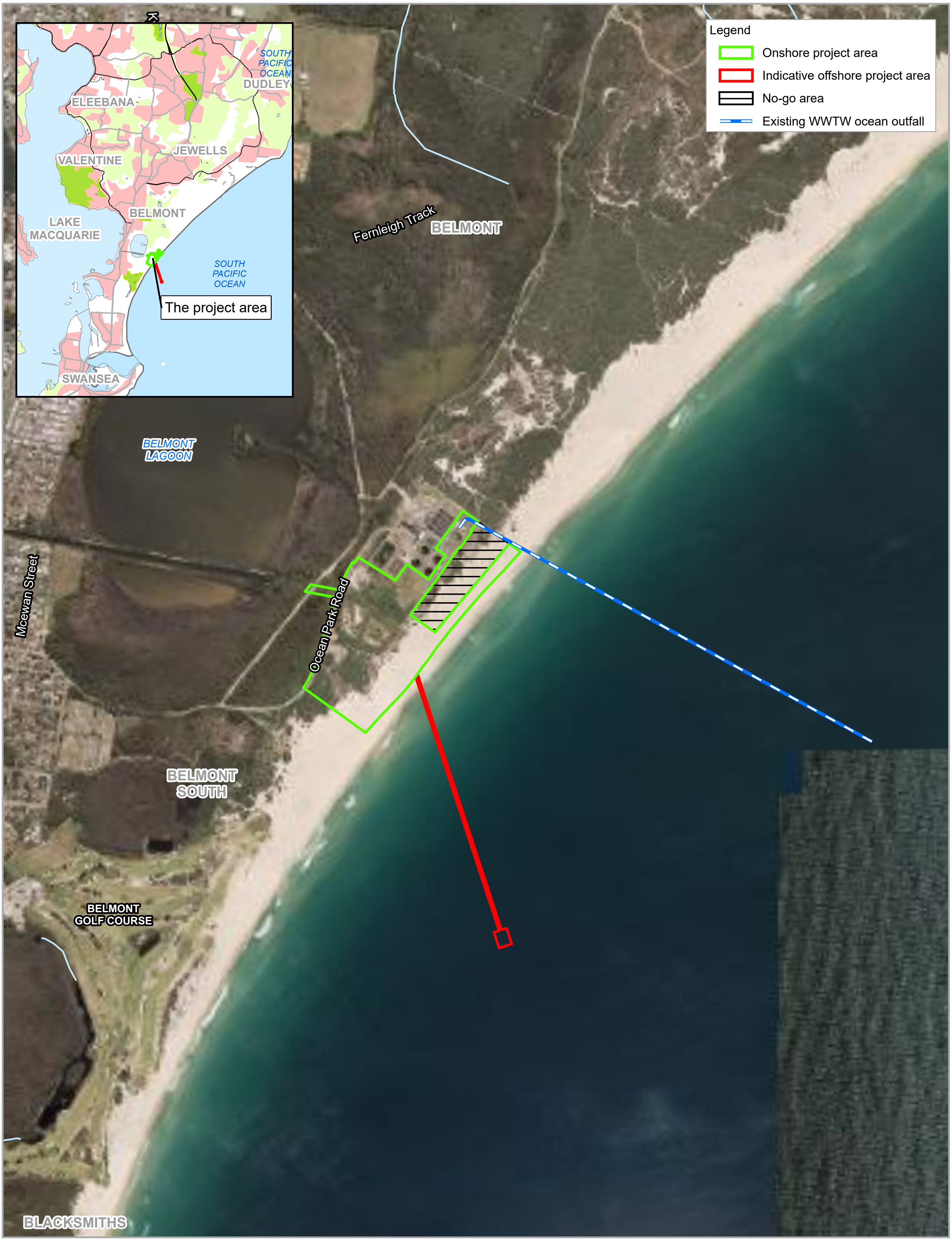
Since commencing this Project, Hunter Water has begun a major review of the 2014 LHWP, now referred to as the Lower Hunter Water Security Plan (LHWSP). The LHWSP seeks to determine the preferred portfolio of supply and demand side options to ensure a sustainable and resilient supply for the region, over the long term as well as during drought. This work indicates that a drought response portfolio including a desalination plant at Belmont with a nominal production capacity of up to 30 ML/day would provide the best balance of meeting the community's needs should a severe drought occur, while still providing value for money.

In addition to the proposed increase in plant capacity, further design development and assessment following completion of the EIS has identified that a direct ocean intake would perform considerably better than a sub-surface option across key criteria including, reliability, efficiency and scalability.

1.2 Purpose and structure of this report

This report has been prepared to support the Amendment Report and addresses the requirements for the SEARs in considering the revised impacts of the amended Project.

This report provides a brief overview of the amended Project, with a more detailed description of the Project provided in Appendix C of the Amendment Report. This assessment considers the impacts associated with the proposed amendments to the Project. Therefore, this report should be read in conjunction with GHD reports titled: Belmont Drought Response Desalination Plant – Environmental Impact Statement (GHD, November 2019) and Belmont Drought Response Desalination Plant – Groundwater Impact Assessment (GHD, November 2019).



Paper Size ISO A4

0 110 220 330 440

Metres

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

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Hunter Water Corporation
Belmont Drought Response Desalination Plant
Groundwater Assessment Report

Project No. 22-19573
Revision No. 0
Date 29/06/2020

Project Location

Figure 1-1

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Print date: 29 Jun 2020 - 07:57

Data source: LPI: DTDB / DCDB, 2017; public_NSW_Imagery: © Department of Customer Service 2020. Created by: fmackay

1.2.1 Consideration of design changes

The SEARs relevant to groundwater issues for the Project are summarised in Table 1-1 below, including identification of where in this report this requirement has been addressed with consideration to the Project, as amended (see Section 2).

Table 1-1 SEARs (SSI-8896) – Groundwater impacts

Requirement	Relevant section
An assessment of the impacts of the proposed development on the quantity and/or quality of surface and groundwater resources	Groundwater impacts addressed in Section 4.1 and 4.2
A description of the measures to minimise surface and groundwater impacts, including how works on steep gradient land or erodible soil types would be managed and any contingency requirements to address residual impacts.	Groundwater impact mitigation addressed in Section 5

2. Project changes

2.1 Overview

In addition to the proposed increase in plant capacity, the amended Project includes the following design changes:

- Seawater intake: Further design development and liaison with Hunter Water's construction partners following completion of the EIS identified reliability and construction risks with the proposed horizontal sub-surface intake system as described in the EIS. An assessment of the horizontal sub-surface intake system was undertaken against alternative intake options. This assessment found that a direct ocean intake would perform considerably better than a sub-surface option across key criteria including reliability, efficiency and scalability (see Section 2.2).
- Power supply: The EIS proposed to meet power requirements for the Project via a minor upgrade to the existing 11 kV power supply network in the vicinity of Hudson and Marriot Street. The amendment to the capacity of the water treatment process plant means this is now unfeasible, due to inability to meet energy requirements. Instead, the Project will connect to Ausgrid's 33 kV network in the vicinity of the Project (see Figure 2-1).

2.2 Key features of the amended Project

The amended Project for the construction and operation of a drought response desalination plant, designed to produce up to 30 ML/d of potable water, includes the following key components and as shown in Figure 2-1:

- **Direct ocean intake** – To ensure provision of sufficient quantities of raw feed water for the water treatment process plant, a direct ocean intake is proposed as part of the amended Project, as follows:
  - *Sea Water Pump Station (On-shore), including a central well, screening and pump housing, proposed to be a concrete structure (referred to as a wet well) of approximately nine to 11 m diameter, installed to a depth up to 20 m below existing surface levels.*
  - *Intake pipeline, the indicative pipeline alignment is approximately 1000 m in length, extending outwards from the central housing to the off-shore intake structure. Construction of the intake pipeline would be determined during detailed design; however, the following construction methodologies/ considered and assessed included Construction method 1 (CM1) Horizontal directional drilling (HDD) and (CM2) Pipejacking/micro-tunnelling.*
  - *Intake structure (Off-shore), the intake structure would be in the form of a horizontal intake with a velocity cap structure and low through-screen velocity to minimise impacts on marine species and habitat. The intake structure would be 5 m in diameter, have a minimum of 5 m clearance from the seabed and a depth of approximately 18 m of water.*

- **Water treatment process plant** – The water treatment process plant would not significantly change from that described in the EIS. The inclusion of buildings to house equipment rather than the installation of containerised equipment is the primary change. The buildings would be placed above ground level and located to allow incremental installation, if required. Services to and from the process equipment (e.g. power, communications, and raw feed water (seawater)) would comprise a mix of buried and overhead methods. The general components of the water treatment process would comprise:
  - *Pre-treatment: a pre-treatment system is required to remove micro-organisms, sediment, and organic material from the raw feed water.*
  - *Desalination: a reverse osmosis (RO) desalination system made up of pressurising pumps and membranes. These would be comprised of modular components. In addition, a number of tanks and internal pipework would be required.*
  - *Post treatment: desalinated water would be treated to drinking water standards and stored prior to pumping to the potable water supply network.*
- **Brine disposal system** – The desalination process would produce up to 56 ML/d of wastewater, comprising predominantly brine, as well as a small amount of pre-treatment and RO membrane cleaning waste. The waste brine from the desalination process would be transferred via a pipeline to a brine pump station at the Belmont WWTW for disposal via the existing ocean outfall pipe.
- **Power supply** – Power requirements of the amended water treatment process plant would require connection to Ausgrid's 33 kV line to the north-west of the water treatment process plant site, with new private power line connecting to a substation within the plant site.
- **Ancillary facilities** – including a tank farm, equipment housing buildings, chemical storage and dosing, hardstand areas, stormwater and cross drainage, access roads, parking areas, fencing, signage and lighting.

Each of these elements are described further in Appendix C of the Amendment Report.

The desalination plant would be connected to Hunter Water's potable water network via a potable water pipeline proposed to be constructed to augment the existing water network. The pipeline does not form part of the Project and would be part of a separate design and approvals process.

Paper Size ISO A4

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Metres

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

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GHD

Hunter Water Corporation
Belmont Drought Response Desalination Plant
Groundwater Assessment Report

The Amended Project

Project No. **22-19573**
Revision No. **0**
Date **29/06/2020**

Figure 2-1

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Print date: 29 Jun 2020 - 07:57

Data source: HWC: Aerial Imagery, Existing outfall: 2019; LPI: DTDB / DCDB, 2017; public_NSW_Imagery: © Department of Customer Service 2020. Created by: fmackay

3. Methodology

The groundwater impact assessment for the EIS, Belmont Drought Response Desalination Plant – Groundwater Impact Assessment (GHD, 2019), quantified changes to groundwater level and flow from the operation of the sub-surface seawater intakes. The assessment involved site investigations and the development of a groundwater model to predict groundwater yields and drawdown from the extraction of groundwater from the sand aquifer.

Groundwater impacts from the construction of the sub-surface seawater intakes were not assessed in detail in the EIS since they were expected to be substantially lower than the impacts from the operation of the sub-surface seawater intakes. Conversely, based on the proposed construction and operational activities it is not expected that the operation of the amended Project, including a direct ocean intake (DOI) in place of the sub-surface seawater intakes, would result in groundwater impact, or, if any impacts were to occur, these would be considerably reduced compared to the EIS Project. There is potential, however, for groundwater impacts from the construction of the DOI in the amended Project.

Therefore, this assessment considers potential groundwater impacts and mitigation measures associated with construction of the following:

- Two caissons and onshore sub-surface seawater intakes (EIS design).
- The DOI, including the transfer pipeline. The construction methodology for the intake pipeline would be determined during detailed design; however, the following construction methodologies have been considered and assessed:
  - *CM1: Horizontal directional drilling (HDD).*
  - *CM2: Microtunnelling/pipejacking.*

Construction impacts from the EIS design have been assessed in more detail in this report to provide a comparison to the proposed construction methods for the DOI.

Construction impacts from the DOI considers the construction of the sea water pump station and the intake pipeline. The assessment of groundwater impacts associated with the installation of the offshore intake structure was not considered necessary.

Potential groundwater impacts from construction of the DOI (as well as the construction of the sub-surface seawater intakes in the EIS design) are as follows:

- Take of groundwater from the Hawkesbury to Hunter Coastal Sands Groundwater Source, managed under the North Coast Coastal Sands Water Sharing Plan, resulting from dewatering of excavations.
- Groundwater drawdown within the coastal sand aquifer, resulting in impacts to groundwater receptors including groundwater dependent ecosystems (GDEs) and groundwater users.
- Deterioration in groundwater quality, resulting in impacts to groundwater receptors including GDEs and groundwater users.

Relevant data obtained from the site investigations undertaken as part of the EIS have been utilised in this assessment.

3.1 Dewatering calculations

Dewatering requirements for excavations associated with each construction methodology have been calculated. Due to the high permeability of the sand, shallow groundwater table and depth of excavations, it is assumed that sheet piling or similar will be necessary during construction in each case to support excavations and limit dewatering requirements.

The rate of dewatering of each excavation has been calculated using the method proposed by Kavvadas et al (1991). This is an analytical method that considers the influence of sheet piling installed around the walls of an excavation to a specified depth below the base of the excavation. The following assumptions apply to this method:

- The cut off walls or sheet piling are impermeable.
- The aquifer has an impermeable stratum at depth.

The input data required for these calculations are outlined below.

3.1.1 Input data

The dimensions of each excavation are defined in Table 3-1. These dimensions are based on the DOI Concept Design (WSP 2020). The pipe jacking entry shaft forms part of the pipe jacking construction methodology (CM2) for the intake pipeline. No excavations are required for the HDD construction methodology (CM1) for the intake pipeline.

Table 3-1 Excavation dimensions

Construction item	Depth (m)	Width (m)	Length (m)
2 x caissons (EIS)	20	10	10
1 x wet well (DOI sea water pump station) (Amended Project)	20	10	10
Pipe jacking entry shaft (CM2) (Amended Project)	24	10	20

The aquifer parameters used in the calculations are presented in Table 3-2. These parameters are based on field investigations conducted as part of the EIS Groundwater Impact Assessment (GHD, 2019) as well as the Geotechnical Investigation (GHD, 2018).

Groundwater depths are based on monitoring of standpipes installed in the vicinity of the proposed water treatment process plant (GW101 to GW108). The estimate of the sand hydraulic conductivity is based on particle size distribution analysis of samples collected during field investigations as well as a pump test (details reported in GHD, 2019). The depth of the sand aquifer is based on the geotechnical investigations (GHD, 2018), which found the sand/clay interface at depths of approximately 20 to 30 m below ground level in the area of the proposed desalination plant (specifically 31 m at GW103 and 20.4 m at GW106). The geophysical interpretation (reported in GHD, 2018) indicates sand depths of 25 to 30 m in the area between GW103 and GW105 where the majority of excavations are anticipated to occur.

Parameter ranges have been specified so that ‘high flow’ and ‘low flow’ estimations can be calculated for each excavation. For the depth of sand aquifer parameter, values of 25 m and 30 m have been adopted for the ‘low flow’ and ‘high flow’ cases respectively. In addition to the data in Table 3-2, the sheet pile depth below the base of excavations has been assumed to be 1 m for the ‘high flow’ case and 4 m for the ‘low flow’ case.

Table 3-2 Input parameters

Parameter	Units	Value (high flow)	Value (low flow)
Groundwater depth below ground level	m	0.3	1.2
Sand hydraulic conductivity	m/day	20	10
Depth of sand aquifer	m	30	25

3.2 Drawdown and groundwater quality

Groundwater drawdown outside each excavation would be minimal due to the cut off walls or sheet piling. The Kavvadas et al (1991) method is based on drawdown within the excavation rather than a drawdown of the groundwater external to the excavation.

Impacts of minor groundwater drawdown that may occur local to excavations and groundwater quality impacts have been assessed qualitatively by consideration of the location of the construction activities, construction methodology, surrounding hydrogeological environment and location of groundwater receptors.

Details regarding groundwater receptors in the vicinity of the Project area are provided in GHD (2019). The majority of registered bores are located to the southwest of the Project area throughout Belmont South and Swansea. The closest bore to the Project area (GW054897) is located approximately 1 km to the west on the western side of Belmont Lagoon.

An aquatic GDE (known as Belmont Lagoon Swamps) is mapped to the west of the Project area. An aquatic GDE relies on the surface expression of groundwater. Belmont Lagoon Swamps is listed as a High Priority GDE for the Hawkesbury to Hunter Coastal Sands Groundwater Source. The boundary of this High Priority GDE is located less than 400 m from the caissons (EIS design) and wet well for the seawater pumping station (DOI). It is noted that the High Priority GDE excludes the mangroves, saltmarsh, seagrass and saline waterway components of the Belmont Lagoon Swamps.

4. Impact assessment

Groundwater impacts have been predicted and assessed for the construction phase only, since the operation phase of the DOI will not impact groundwater. As outlined in Section 3, the assessment of groundwater impacts from the construction of the EIS design has been included in this report for comparison purposes.

4.1 Dewatering requirements and assessment

Calculated groundwater inflows for each excavation (in L/s) are presented in Table 4-1. Both ‘high flow’ and ‘low flow’ rates have been calculated, based on the input parameters presented in Table 3-2.

Table 4-1 Calculated groundwater inflows (L/s)

Construction item	Inflow (high)	Inflow (low)
2 x caissons (EIS)	117.2	8.2
1 x wet well (DOI on-shore pump station)	58.6	4.1
Pipe jacking entry shaft (CM2)	137.3	2.6

Total volumes of groundwater to be dewatered for each methodology are presented in Table 4-2. Volumes have been calculated for the ‘high flow’ (or worst case) only and have assumed a worst case construction time of six months (180 days) in each case.

Table 4-2 Total dewatering requirement

Scenario	Total groundwater inflow rate (high), L/s	Total groundwater volume, ML
EIS design (construction)	117.2	1,823
HDD* (CM1)	58.6	911
Pipe jacking**(CM2)	195.9	3,047

* Sea water pump station only

** Entry shaft and sea water pump station

The total groundwater volume to be dewatered during the construction of the EIS design has been calculated to be approximately 1,823 ML. This is likely to be higher than the volume to be dewatered for proposed CM1 (HDD) of the DOI, since two caissons were to be installed for the EIS design compared to one for the DOI. A higher dewatering volume is predicted for proposed CM2 (pipe jacking), since the entry shaft is assumed to be deeper than the other excavations. It is noted that a portion of the water that is extracted from each excavation during construction will be seawater rather than fresh groundwater. Overall, the groundwater take resulting from the construction and operation of the amended Project is less than the take predicted for the operation of the EIS design (up to 19.5 ML/day) due to the extraction of groundwater via the sub-surface seawater intakes.

All construction methods will require a Water Access Licence to cover the take of groundwater from excavations. The unassigned water within the Hawkesbury to Hunter Coastal Sands Groundwater Source of the North Coast Coastal Sands Water Sharing Plan is 12,740 ML/year (at commencement of the plan in 2016). Since this exceeds the predicted groundwater take for all scenarios, it is considered that there is sufficient groundwater available within the water source to enable Hunter Water to obtain a Water Access Licence for construction of the DOI.

Fresh groundwater extracted from the excavations during construction may be disposed by infiltration back to groundwater at a distance from the construction area. Based on a sand infiltration rate of 0.02 m/hr, an infiltration area of approximately 3.5 hectares would be required to manage the highest inflow rate of 196 L/s (CM2). It should be noted, however, that the maximum inflow would only be reached once the excavation is at maximum depth, at which time the water extracted would be seawater. As reported in the EIS Groundwater Impact Assessment (GHD, 2019), electrical conductivity (EC) profiling in monitoring wells identified fresher groundwater (0 – 10,000 µS/cm) generally up to a depth of 10 m below ground level with this depth becoming less towards the east. This suggests that seawater would be extracted in excavations beyond 10 m depth and require an alternative disposal method to infiltration. The saline groundwater (seawater) may be discharged to the ocean via the existing wastewater treatment works (WWTW) ocean outfall following appropriate treatment.

4.2 Comparison of potential groundwater impacts

The assessment of potential groundwater impacts from each construction method for the amended Project is based on the following:

- Groundwater model predictions from the Belmont Drought Response Desalination Plant – Groundwater Impact Assessment (GHD, 2019) indicate that the 3 m groundwater drawdown contour will not extend beyond 200 m from a sub-surface seawater intake during operation. No groundwater drawdown is expected at any registered groundwater bore (the closest being approximately 1 km from the seawater intakes) or at a high priority GDE (Belmont Lagoon), noting that the aquatic GDE between the site and Belmont Lagoon is not considered high priority since it is predominantly saltmarsh.
- With the use of sheet piles or similar, it is considered that there would be minimal drawdown of groundwater external to each excavation during construction (for each construction method) as stated in Section 3.2. The potential for groundwater drawdown during construction would be substantially less than the drawdown predicted during operation of a sub-surface seawater intake.
- Where excavations may expose Potential Acid Sulphate Soil (PASS), there is potential for the generation of acid and localised impacts on groundwater quality. Therefore, in order to mitigate this impact it is necessary to undertake an ASS investigation in the vicinity of each of these excavations as part of the detailed design phase to determine the risk of exposure of PASS and prepare and implement an Acid Sulphate Soil Management Plan (ASSMP) if necessary. This is a modification of the mitigation measure identified in the EIS Groundwater Impact Assessment (GHD, 2019) to undertake additional ASS sampling within the zone of groundwater drawdown resulting from the operation of the sub-surface seawater intakes, to confirm the risk of exposure of ASS due to drawdown and to reduce the groundwater drawdown if necessary.

4.2.1 EIS design (construction)

The closest registered groundwater bore is over 1 km from the location of the caissons (see Figure 4-3, GHD (2019)) and the closest high priority GDE (Belmont Lagoon) is approximately 400 m away (see Figure 4-4, GHD (2019)). Therefore, based on the groundwater drawdown predictions above, it is not considered that there would be groundwater drawdown at these groundwater receptors during construction.

The caissons are located within the 'low risk above 4 m' zone on the Acid Sulphate Soil Risk Map. Since excavations may extend up to 20 m below ground level, there is potential for exposure and oxidation of Potential Acid Sulphate Soil (PASS) and localised impacts on groundwater quality if the mitigation measure outlined above is not implemented.

4.2.2 Proposed construction method 1 (HDD)

The only excavation required as part of proposed CM 1 (HDD) is for the installation of the sea water pump station. This structure is proposed to be approximately 20 m deep and located in the vicinity of one of the caissons in the EIS design. Again, based on the groundwater drawdown predictions above, the potential for groundwater drawdown external to the excavation during construction by this method is considered to be low.

The closest registered groundwater bore is over 1 km from the location of the sea water pump station and the closest high priority GDE (Belmont Lagoon) is approximately 400 m away. Therefore it is not considered that there would be groundwater drawdown at these groundwater receptors during construction. Since there is only one excavation in this method (compared to two in the EIS design), there is less dewatering required during construction compared to the EIS design.

The sea water pump station is located within the 'low risk above 4 m' zone on the Acid Sulphate Soil Risk Map. Since excavations may extend beyond 20 m below ground level, there is potential for exposure and oxidation of PASS and localised impacts on groundwater quality if the mitigation measure outlined above is not implemented.

The HDD process will require the setup of a laydown area, which is proposed to be located approximately 200 m to the west of the sea water pump station towards Belmont Lagoon. A biodegradable drilling fluid will be used during drilling and is not expected to impact groundwater quality or flow in the long term. The use of a biodegradable drilling fluid is a new mitigation measure not included in the measures outlined in the EIS Groundwater Impact Assessment (GHD, 2019).

4.2.3 Proposed construction method 2

Proposed CM 2 (pipe jacking) requires excavations for the sea water pump station (same location as for HDD) and for the pipe jacking entry shaft. The entry shaft will be located to the west of the wet well in the vicinity of the proposed laydown area for the HDD method.

With the use of sheet piles or similar, there would be minimal drawdown of groundwater external to the excavations required for this method. The closest registered groundwater bore is approximately 800 m from the entry shaft and the closest high priority GDE (Belmont Lagoon) is approximately 200 m away (disregarding the saltmarsh which does not form part of the high priority GDE). Therefore it is not considered that there would be groundwater drawdown at these groundwater receptors during construction (based on the groundwater predictions outlined above), however it is noted that the excavation for this method is closer to Belmont Lagoon compared to the other proposed construction methods or EIS design. The largest volume of groundwater is predicted to be extracted for this construction method compared to the other DOI methods and construction of the EIS design since it is assumed that the entry shaft excavation will be deeper than the other excavations (refer Table 3-1).

The sea water pump station is located within the ‘low risk above 4 m’ zone on the Acid Sulphate Soil Risk Map while the entry shaft is located closer to higher risk zones. Since excavations may extend beyond 20 m below ground level, there is potential for exposure and oxidation of PASS and localised impacts on groundwater quality if the mitigation measure outlined above is not implemented.

5. Summary of revised mitigation measures

Potential impacts to groundwater from construction of the DOI have been identified and assessed for each of the proposed construction methodologies. Impacts have also been compared to those for the construction of the EIS design. In each case it is considered that the risk of impact to groundwater receptors is low when mitigation measures are implemented throughout construction. Overall, the potential for groundwater impact associated with the construction and operation of the amended Project is considered to be less than that for the construction and operation of the EIS design.

The operational phase mitigation measures for groundwater identified in the EIS Groundwater Impact Assessment (GHD, 2019) are no longer required. However, a number of additional mitigation measures are required as discussed in Section 5.1 and summarised in Table 5-1. The construction phase mitigation measures for groundwater identified in the EIS should be retained. These are:

- Develop and implement a groundwater monitoring program (refer Section 5.2).
- Adopt proper storage and handling practices for fuels (refer Section 5.1.3).

5.1 Mitigation measures

5.1.1 Dewatering volumes and groundwater disposal

The volume of groundwater that must be removed from excavations is less than the unassigned water within the Hawkesbury to Hunter Coastal Sands Groundwater Source of the North Coast Coastal Sands Water Sharing Plan for each construction method. However, reducing the volume that must be managed will reduce pumping infrastructure requirements and reduce the size of the infiltration area for groundwater disposal and treatment requirements.

As identified in Section 4.1, an infiltration area of up to 3.5 hectares may be required depending on the actual groundwater inflows to excavations during construction and the groundwater quality. Once groundwater EC of the extracted groundwater exceeds a level considered to exceed fresh water (say 1,500 µS/cm), it would be necessary to discharge this water to the existing ocean outfall.

Measures for reducing dewatering volumes and establishing an infiltration area for groundwater disposal are additional mitigation measures and are as follows:

- Use of sheet piling, or similar, to support excavations and reduce groundwater inflow is to be investigated during detailed design for each excavation in each construction method. The entry shaft for CM 2 (pipe jacking) is the priority excavation for extended sheet piling due to its closer proximity to Belmont Lagoon.
- Set up a cleared groundwater infiltration area with a suitable bund wall, or similar, around the entire perimeter to ensure that groundwater disposed within the area cannot flow off site and impact surface waterways or vegetation.
- Only fresh groundwater (EC less than 1,500 µS/cm) to be disposed within the infiltration area.

5.1.2 Groundwater drawdown

Groundwater drawdown external to excavations is expected to be minimal, particularly in comparison to the drawdown predicted for operation of the sub-surface seawater intakes (EIS design), if excavations are appropriately supported with sheet piling or similar. Further, in most cases there is sufficient distance between excavations and groundwater receptors (800 m to 1 km for the closest registered bore and 200 m to 400 m for Belmont Lagoon) for drawdown impacts on receptors to be very unlikely during construction (based on the drawdown analysis outlined in Section 4.2).

Under the amended Project, it is not necessary to retain the EIS mitigation measures for groundwater drawdown. It is not necessary to update the groundwater model to revise groundwater drawdown predictions since the groundwater impact assessment for the amended Project is not supported by a numerical groundwater model. Further, it is not necessary to retain the EIS mitigation measure to reduce groundwater drawdown by modifying the intake pumping schedule (i.e. allow periodic recovery by shutting off pumps) or by shutting off one of more horizontal arms since this measure is specific to the operation of the sub-surface seawater intakes which are not part of the amended Project.

5.1.3 Groundwater quality

Construction activities have the potential to introduce contaminants into the groundwater source, particularly hydrocarbons. The potential for groundwater contamination is the same for the amended Project and EIS and therefore the mitigation measure in the EIS to adopt proper storage, handling and usage practices for fuels is unchanged. The use of a biodegradable drilling fluid is a new mitigation measure required for CM 1 (HDD).

The mitigation measure in the EIS to detect and manage ASS should be retained, although modified to focus on areas of excavation (rather than the zone of drawdown for the operation of the sub-surface seawater intakes in the EIS design) and include the preparation of an ASSMP if necessary.

5.2 Groundwater monitoring

A construction groundwater monitoring program will be developed and implemented prior to the commencement of construction. The objective of the program is to detect impacts (should they occur) to groundwater level and quality in the vicinity of excavations and DOI construction activities.

The monitoring program design for the amended Project differs from the monitoring program proposed for the construction and operation phases of the EIS since groundwater impacts are predicted to be lower for the amended Project. It is proposed that groundwater monitoring be undertaken at existing sites GW105 and GW108. The monitoring program will include continuous monitoring of groundwater levels and routine sampling for groundwater quality. Groundwater level and quality triggers will be established based on baseline monitoring data.

Table 5-1 Summary of mitigation measures

Impact	Mitigation measure	Timing
Groundwater take	Metering of fresh groundwater removed from excavations for all construction methods. Use of sheet piling, or similar, to support excavations and reduce groundwater inflow for all construction methods will be investigated during detailed design. This applies to all construction methods. The infiltration area will be set up with bund walls, or similar, around the entire perimeter to ensure no discharge of groundwater outside the area. Only fresh groundwater (EC less than 1,500 µS/cm) to be send to the infiltration area.	Construction
Groundwater drawdown	Use of sheet piling, or similar, to support excavation and reduce groundwater inflow for all construction methods will be investigated during detailed design.	Construction
Groundwater quality	Biodegradable drilling fluids should be used during drilling works for CM 1 (HDD). Undertake an ASS investigation in the vicinity of each excavation as part of the detailed design phase to determine the risk of exposure of PASS and prepare and implement an ASSMP if necessary.	Detailed Design
Groundwater monitoring	Groundwater monitoring at sites GW105 and GW108. The monitoring program will include continuous monitoring of groundwater levels and routine sampling for groundwater quality in particular the change in EC associated with the fresh/ saline groundwater interface. Groundwater level and quality triggers will be established based on baseline monitoring data.	Construction

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6. Conclusion

Based on the proposed construction and operational activities it is not expected that the operation of the amended Project, including a direct ocean intake (DOI) in place of the sub-surface seawater intakes, would result in groundwater impact, or, if any impacts were to occur, these would be considerably reduced compared to the EIS Project.

Potential impacts to groundwater from construction of the DOI are groundwater take from the Hawkesbury to Hunter Coastal Sands Groundwater Source due to dewatering of excavations, groundwater drawdown impacting groundwater receptors and deterioration in groundwater quality impacting groundwater receptors. These potential impacts have been assessed for each proposed construction methodology and have been compared to construction impacts to groundwater from the original EIS design.

The volume of groundwater that will need to be extracted from excavations for each construction methodology has been calculated, assuming sheet piling is used to support excavations. The dewatering volume for CM 1 (HDD) was calculated to be less than for the construction of the EIS design. The volume for CM 2 (pipe jacking) was calculated to be higher than for the construction of the EIS design. In all cases, dewatering volumes were found to be less than the unallocated water available in the groundwater source.

Impacts to groundwater receptors were found to be minimal for each proposed construction methodology as well as for the construction of the EIS design.

Mitigation measures and groundwater monitoring requirements have been identified to ensure groundwater impacts are low.

7. References

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