



Remondis Australia Pty Ltd

Swanbank Hardfill

Sampling, Analysis and Quality Plan

January 2021

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1. Introduction

GHD Pty Ltd (GHD) was engaged by Remondis Australia Pty Ltd (Remondis) to undertake a number of assessments of the hardfill located in Stage 2 of the Swanbank Renewable Energy and Waste Management Facility (REWMF). The objectives of the assessments were to understand the potential impact of the high leachate levels within the hardfill on the receiving environment and determine a suitable way forward for the management of the leachate within the hardfill. To date the following assessments have been undertaken (a summary of the investigation findings is outlined in Section 3.2):

- Swanbank Hardfill Investigations, Environmental monitoring review and hardfill risk assessment (February 2018)
- Swanbank Renewable Energy and Waste Management Facility Updated Hardfill Assessment (December 2019)
- Swanbank Hardfill Hydrogeological assessment, Groundwater Modelling Report (July 2020)
- Swanbank Hardfill Hydrogeological Assessment, Water Quality Assessment (December 2020)

This Sampling Analysis and Quality Plan (SAQP) has been prepared to address gaps in the current undertaking of conditions surrounding the hardfill and address comments provided by the Department of Environment and Science (DES) in the following correspondence:

- 2020131 Technical Services Review – Dec 2019 GHD report
- 2020131 Water Sciences Review – Dec 2019 GHD report
- WRNB ID 2596, Review of the Transitional Environmental Program for Remondis Australia Pty Ltd, Water Sciences, Environmental Monitoring and Assessment, Science Delivery, Department of Environment and Science – 28/08/2020

The works have been scoped, and will be completed, with consideration of the National Environmental Protection Measures (NEPM).

2. Site information

The following information is taken from the previous investigation reports listed in Section 1.

2.1 Site description

The hardfill is located in the south western portion of Stage 2 of the Swanbank REWMF, outlined on Figure 1, Appendix A.

Filling of the hardfill was undertaken between 2004 and 2018, and accepted inert construction and demolition waste, commercial and industrial waste and low-level contaminated soil.

The hardfill was constructed within a former open cut coal mine with high walls to the south, east and west that extended to an elevation of approximately 10 to 15 mAHD. It is understood that the eastern high wall is located along the Palmer Fault. Prior to landfilling a 600 mm-thick compacted clay layer was placed at the base of the landfill and progressively constructed up the walls in line with progressive filling.

There is one constructed leachate sump (LSH1) and two leachate monitoring points (LSH2 and LSH3) present in the hardfill, as identified on Figure 2, Appendix A.

LSH1 is located within the south eastern portion of the hardfill and has an approximate base of 10.54 mAHD. LSH1 was included in the initial design of the hardfill and was constructed from the base of the hardfill before filling commenced. LSH1 was subsequently extended vertically as waste placement was undertaken.

LSH2 is located on the northern batter of the landfill and has a depth of 12.05 m from the top of the concrete pipe to the base at 49.506 mAHD. The base of LSH2 does not extend to the lowest base level of the hardfill, but rather it extends to the base of the clay liner mid-way up the side wall. A clay sump (bund) was formed on top of the clay liner to allow the rise pipe placement.

LSH3 is located within the south eastern portion of the hardfill, close to LSH1, and has a depth of approximately 25 meters (the practicable extent of drilling ability into the waste), which is above the clay liner base of the hardfill. LSH3 was installed after filling for the purposes of conducting a pumping trial.

Landfilling has temporarily ceased in the hardfill. Areas to the north and central section remain unfilled. The landfill keys into the existing ground level to the east / north east at elevations ranging between 79 mAHD to 84 mAHD. The hardfill then batters down to approximately 55 mAHD to the western and southern hardfill boundaries.

Table 2-1 Summary of site details

Item	Description
Registered lot and plans	The site is located on: <ul style="list-style-type: none">Lot 102 of RP839072
Landowners	Remondis
Local government authority	Ipswich City Council
Land zoning	The <i>Ipswich City Planning Scheme</i> interactive map ¹ indicates the following zoning applies to Lot 102:

¹ Ipswich City Planning Scheme Interactive Map, <https://maps.ipswich.qld.gov.au/weave/planscheme.html>, accessed 14 December 2020

Item	Description
	<ul style="list-style-type: none"> Regional Business and Industry Investigation (RB1A02) Regional Business and Industry (RB05M) Regional Business and Industry Buffer (RBB01)
Surrounding land use	<p>The Swanbank REWMF is located within a greater commercial and industrial precinct. The site and surrounding land were formerly used for underground and open cut mining, which have resulted in legacy contamination, geotechnical and hydrogeological issues at the site.</p> <p>General land use surrounding the hardfill is summarised as follows:</p> <ul style="list-style-type: none"> North: Stage 2 of the REWMF including disposal of demolition and construction wastes, screening and crushing area, beyond which is the Stage 1 lined persuasible landfill. Northwest: NuGrow composting facility and Lantrak non-putrescible landfill East: Stage 2 of the REWMF beyond which is Wood Muleching Industries facility South: Vacant bushland, surface water body SW11 to the southeast West: Property boundary beyond which is the NuGrow composting facility and Lantrak non-putrescible landfill

2.2 Environmental setting

2.2.1 Geology

Bedrock at the site is characterised as Bundamba Group of Middle Jurassic to Late Triassic Age and the Ipswich Coal Measures of the Triassic Age. Sedimentary bedrock geology at the site includes The Raceview Formation and Aberdare Conglomerate of the Bundamba Group and Blackstone formation of the Coonaena Formation of the Ipswich Coal Measures in descending order and increasing age (CDM Smith, 2012).

Historical mining activities in the area immediately surrounding the hardfill are summarised as follows:

- North – Open cut mining, plus level 1 and level 2 underground mining.
- East – Open cut mining, plus level 1 and level 2 underground mining.
- South – No evidence of mining – natural ground / undeveloped bushland.
- West – unknown.

As a result of mining activities, much of the site contains fill materials derived from over burden. This fill material was used to backfill or partially backfill open cut mining voids or was stockpiled in some areas of the site at the completion of mining. Based on review of borelogs from the site, the depth of fill material across the Swanbank REWMF generally varies in thickness from 6 m to 58 m and is described as sand and gravel with various amounts of silt and clay, debris, cobble/boulder zones, and occasional coal pieces.

Fill material is underlined by natural soils described as clay or sand that is mottled with mixtures of orange, brown, red, brown, grey, and black. Natural soils grade into bedrock of siltstone, sandstone and mudstone with coal present in some areas.

Bedrock beneath the area comprises the Ipswich Coal Measures, which is generally formed by interbedded sandstone, mudstone, shale and coal seams.

2.2.2 Hydrogeology

The regional groundwater aquifer is located within the bedrock. Previous permeability tests of monitoring wells located within bedrock reported an average hydraulic conductivity of 4.6×10^{-2} m/day. It is noted that rock defects and structural features, as well as old mine workings, may contribute to variation and possible slight increases in the flow regime in isolated areas (CMD Smith, 2012).

Open cut mining extended into the bedrock and therefore, in some areas the aquifer also intersects fill material, over burden and mine workings. Previous permeability tests of monitoring wells located within fill reported an average hydraulic conductivity of 2.5×10^{-1} m/day (CDM Smith, 2012).

A review of hydrographs and modelled groundwater contours does not identify an obvious difference in groundwater levels between those screened in bedrock and those in fill and mine workings.

The inferred groundwater contours developed by Golder (2018), based on standing water levels across the Swanbank REWMF recorded in February and March 2018, are included as Figure 3, Appendix A. The groundwater contours indicate that groundwater surrounding the hardfill generally flows to the north / north westerly direction, while the groundwater surrounding the landfill (north of the hardfill) generally flows towards the central western boundary of the site, away from the hardfill area. It is noted that all groundwater wells on site are located on the western and southern boundaries, which has the potential to influence the inferred groundwater contours. Previous attempts to install groundwater wells on the eastern portion of the site have been restricted due to the presence of mine voids.

All available groundwater standing water level records over time are presented in Figure 2-1 and Figure 2-2 below. The groundwater standing water level in the area surrounding the hardfill area has fluctuated between 45 and 60 mAHD from 2013 to present. Standing water levels at GMB15, to the southeast of the hardfill, showed a notable increase between 2010 and 2013, rising approximately 21 m over the three-year period. Where data is available for this period, the majority of groundwater monitoring wells across the site reported a significant increase in standing water level during this time.

The rise in standing water levels is considered to be attributed to the gradual recharge of natural groundwater levels following a cease in groundwater dewatering that occurred as part of mining operations in the wider area. Mining operations in the area are understood to have finished in the late 1990's. Between approximately 2000 and 2008, South East Queensland experienced drought conditions. This was followed by a number of peak rainfall years between 2008 and 2011, as outlined in Figure 2-1 below.

After these peak rainfall events, there have been a series of above average rainfall years and a number of floods and cyclones. This extended wet period, in conjunction with the completion of mining in the area (circa 1998) has resulted in an increase in the average groundwater standing water levels at the site. It is expected that the current groundwater standing water levels have now stabilised and are representative of pre-mining conditions.

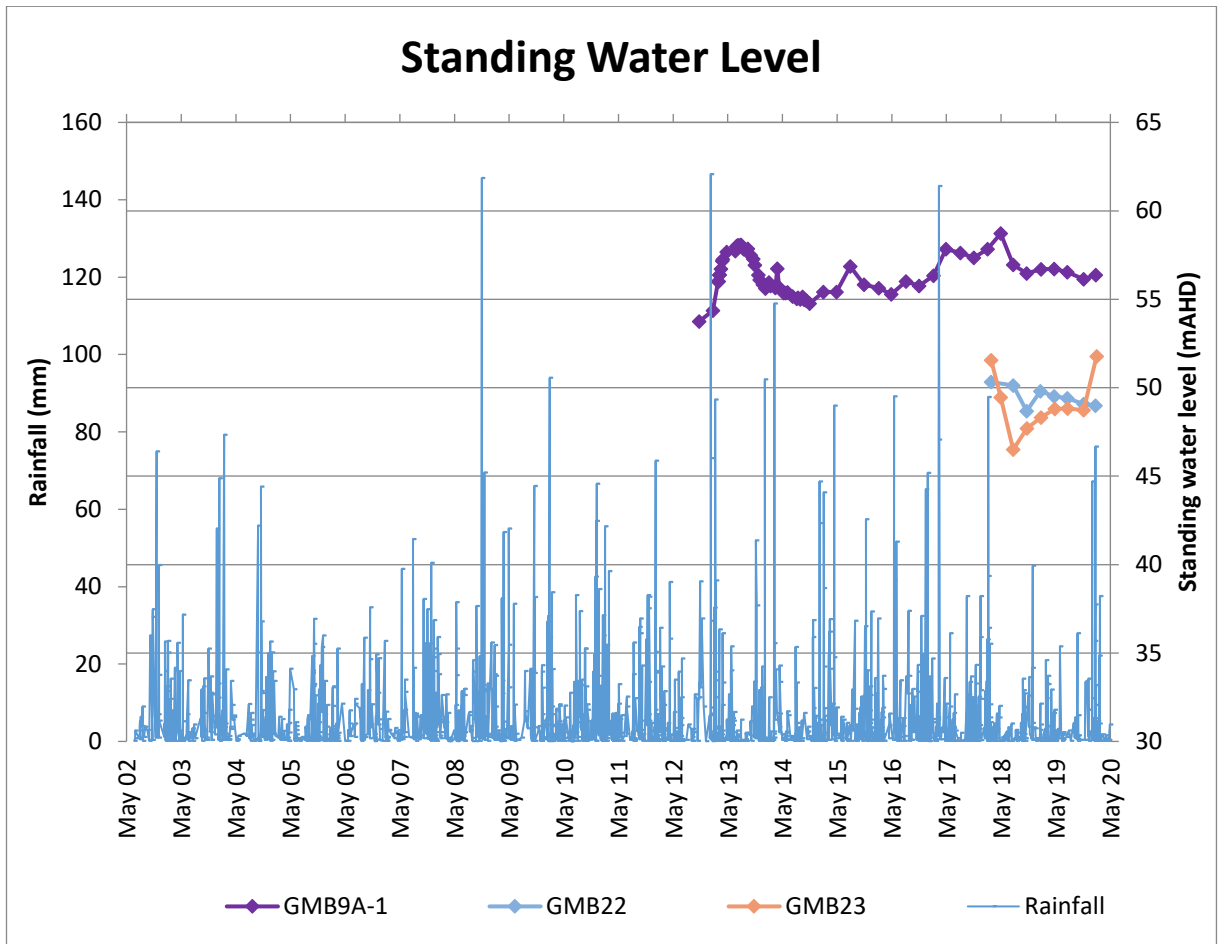


Figure 2-1 Swanbank REWMF hardfill groundwater levels against rainfall

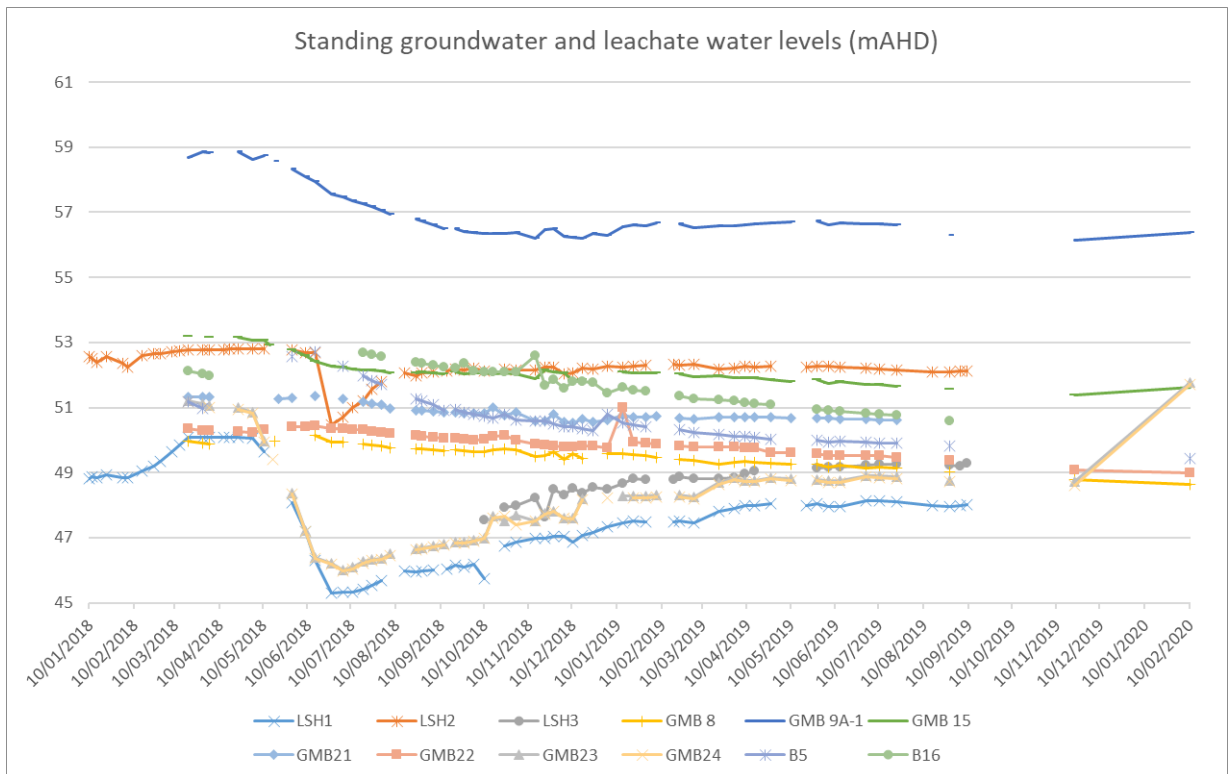


Figure 2-2 Swanbank REWMF hardfill groundwater and leachate levels (2018 to 2020)

2.2.3 Hydrology

Surface water at the site is characterised by a series of open cut mine voids (SW6, SW10 and SW11) and shallow surface water bodies (DW1 and SW7), as identified in Figure 2, Appendix A. The former mine voids are significantly deep and extend into the bedrock and they are hydraulically connected to groundwater. It is understood that the base of SW10 and SW11 are located at approximately 31.4 mAHD and 23.3 mAHD, respectively.

Water from the onsite ponds does not typically discharge from the site.

DW1 is a shallow, dammed natural water body to the west of the site that collects surface water runoff from a portion of the site, as well as upstream surface water from off-site wood mulching operations. DW1 is not considered to be hydraulically connected to groundwater and is not reported to overflow further downstream.

SW7 is an off-site dammed area that collects upstream surface water from off-site wood mulching operations. GHD understands that SW7 is upstream of the site and during periods of heavy rainfall, flows into SW11 via overland flow then through a pipe which runs beneath a road between the two ponds.

There is no direct surface water discharge from Stage 2 of the Swanbank REWMF. Surface water flow is instead directed into on site ponds, SW8, SW10 and SW11.

Any surface water discharge from the site is only likely to occur in Stage 1 and is via controlled release into the off-site Swanbank Power Station cooling pond, SW5, to the northwest of the site. The cooling pond is located approximately ultimately 1.3 km to the northwest of the hardfill, which is connected to Oaky Creek followed by Bundamba Creek, which ultimately discharges into Bremer River located 7 km to the north east.

2.2.4 Environmental values

Environmental values (EVs) are established to protect the quality of natural waters as prescribed in the Environmental Protection (Water) Policy 2009. EVs are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. EVs should be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. EVs identify for surface and groundwater at the site are described in the *Bremer River environmental values and water quality objectives*, July 2010² and summarised in Table 2-2.

Table 2-2 Summary of environmental values for the site

Water type	Bremer River catchment waters	Environmental values
Surface Water & Groundwater	Bremer River (7 km to the norther east)	<ul style="list-style-type: none">• Aquatic ecosystems• Human consumer• Primary, Secondary and Visual Recreation• Industrial Use• Cultural and spiritual values

² Environmental Protection (Water) Policy 2009, July 2010. Bremer River environmental values and water quality objectives. Basin No.143 (part), including all tributaries of the creek.

Water type	Bremer River catchment waters	Environmental values
Surface Water & Groundwater	Bundamba Creek - estuary	<ul style="list-style-type: none"> • Aquatic ecosystems • Secondary and Visual Recreation • Cultural and spiritual values
	Bundamba Creek – freshwater (connected Swanbank Power Station Pond)	<ul style="list-style-type: none"> • Aquatic ecosystems • Irrigation • Stock Watering • Secondary and Visual Recreation • Industrial Use • Cultural and spiritual values
	Other freshwater tributaries (applied to Oaky Creek)	<ul style="list-style-type: none"> • Aquatic ecosystems • Secondary and Visual Recreation • Cultural and spiritual values

3. Site history

3.1 Historical use

Underground mining occurred at the site from the early 1900s to 1988 and open cut mining began in 1972 and ceased in 1998.

Within the hardfill area, mining included open cut mining and level 1 underground mining (CDM Smith, 2012).

There is evidence in the Golder 2004 report that prior to commencement of hardfill operations, the area was characterised as former open pit mine with high walls to the south, east and west. The eastern high wall is understood to align with the Palmer Fault.

Filling of the hardfill was undertaken between 2004 and 2018.

3.2 Summary of previous investigations

Swanbank Hardfill Investigations, Environmental monitoring review and hardfill risk assessment (May 2018)

The desktop assessment indicated that leachate was hydraulically contained within the hardfill (by surrounding groundwater) at the time of assessment. Based on the conceptual cross sections produced, the hydraulic containment was noted to be marginal in some areas (i.e. less than 10 cm difference between the level of leachate at LSH1 and groundwater at GMB22).

Swanbank Renewable Energy and Waste Management Facility Updated Hardfill Assessment (December 2019)

The updated cross section for the hardfill, based on consideration of additional information of groundwater and leachate standing water levels indicated:

The leachate level in LSH2 (52.116 mAHD on 9 September 2019) is approximately 4 metres higher than the leachate level at LSH1 (48.03 mAHD on 9 September 2019) and is also higher than that reported in the surrounding groundwater wells. Following discussion with Remondis it is understood that LSH2 is a perched leachate sump / monitoring point that was installed in a corner of the hardfill where the base elevation is higher than that of the remainder of the hardfill. The sump is surrounded by a clay bund that allows leachate from a portion of the hardfill to be contained within LSH2, creating a perched leachate containment area that is not hydraulically connected to the remainder of the hardfill and therefore not representative of leachate levels within the landfill.

Groundwater levels around the hardfill (i.e. GMB22, GMB23 and GMB15) range between 48.77 mAHD (GMB23) and 51.559 mAHD (GMB15). This is approximately 0.7 – 3.5 metres higher than that at leachate sump LSH1 (48.03 mAHD).

The leachate in the hardfill appears to remain hydraulically contained (albeit only slightly in some areas).

Swanbank hardfill hydrogeological assessment, Groundwater modelling report (July 2020)

A groundwater modelling exercise was completed to assess potential hydraulic containment options for leachate within the hardfill at Remondis' Swanbank REWMF. The study was a high-level assessment of the *potential* to achieve hydraulic containment to assist with the development of the hardfill management plan.

Modelling suggests that in the absence of a drainage layer at the base of the hardfill, it would not be possible to achieve a water level of 300 mm or less above the liner. Furthermore, the volume of water required to be extracted to achieve and sustain a leachate level of 300 mm above the liner is significant and management of the extracted water would further prohibit this as a viable option.

Modelling did indicate that leachate in the hardfill can be hydraulically contained within one month of proposed operation of four new sumps within the hardfill. Model predicted total flow rate from the four sumps is approximately 360 m³/d for the first year, which reduces to 170 m³/d in the second year and then stabilises to approximately 140 m³/d in the third year. This equates to a significant volume of water, which will require management on an ongoing basis. The volume of water is estimated between approximately 365,000,000 litres and 182,500,000 litres in the first year and approximately 47,450,000 litres each year after.

It was also noted as part of the assessment that hydraulic containment is likely to result in drawdown of groundwater in the surrounding region, which may present complications to the surrounding industry and the environment. Reducing the regional groundwater level does not present the best environmental outcome for the region and could impact surrounding surface water bodies. This level of drawdown may also draw in impacted groundwater from surrounding developments onto the Remondis site, altering the groundwater contamination profile of the area.

Therefore, while hydraulic containment is possible within the hardfill, it is possible that the environmental impacts associated with management of the extracted water and regional drawdown impacts would be greater than the potential impact of the leachate within the hardfill on the receiving environment (should it eventually migrate outside the hardfill footprint).

Swanbank hardfill hydrogeological assessment, water quality assessment (December 2020)

There are a number of potential sources of contamination in the area, in addition to the hardfill, that have the potential to impact groundwater and surface water quality both on and off the site.

The surrounding industrial sites uses, in addition to the geological setting (fill materials and mine backfill) have resulted in changes to groundwater chemistry at the site associated with a significant increase in the groundwater standing water level between 2010 and 2013. This increase in standing water level also resulted in an increase in the water level within the hardfill and groundwater in the region returning to pre-mining levels.

Based on the findings of this water quality assessment, it is noted that key hardfill contaminants (bicarbonate alkalinity (as CaCO₃), COD, TOC, ammonia (as N) and AOX) are present in down gradient groundwater and downstream surface water monitoring locations. However, the concentrations are well below the results reported within the hardfill leachate sumps (LSH1 and LSH2) and results reported at all three up gradient groundwater wells.

Water quality data available to date does not indicate a measurable impact from the hardfill on the downstream surface water (SW5 and SW10) or on site downstream groundwater (GMB9A-1, GMB22 and GMB8). In the absence of measured impacts on the site, the hardfill is currently not considered to present an unacceptable impact to the receiving environment.

4. Preliminary conceptual site model

A conceptual site model (CSM) is a qualitative analysis tool, which identifies the contamination sources, transport mechanisms, exposure pathways and receptors. It uses information on the environmental setting of the site and surrounding area in order to identify potentially significant source-pathway-receptor (SPR) linkages in respect of risks to human health and ecological receptors.

Without a complete linkage between a source of contamination and a receptor via a plausible pathway, a risk cannot exist. Even where a complete linkage is identified, for a potential risk to exist there should be contaminants at concentrations that exceed scientifically based risk threshold criteria.

When developing the CSM for the hardfill, GHD prepared two conceptual cross sections of the hardfill (see Figure 5 and Figure 6, Appendix A) to illustrate the potential hydraulic linkage between the hardfill and surrounding groundwater and surface water bodies. The conceptual cross sections were prepared based on the following information:

- The hardfill surface contour was sourced from the *Stage 2 Landfill – Contour Survey, Drawing 3595/010-2 Rev 0* (Terramap, 2017)
- Surface contours surrounding the hardfill were based off a whole site survey undertaken in 2001
- Water levels within the surface water bodies were based off levels collected in April 2018, with the exception of SW10, which was obtained from Taylor mining services Drawing No. 2017.03.11_01
- The base of surface water body SW11 was sourced from CDM Smith, 2012
- Groundwater standing water levels were based off levels recorded in May 2018. The details of the surface water and groundwater standing water levels and when they were recorded are outlined in Table 4-1

Table 4-1 CSM water levels

Monitoring location	Monitoring date	Standing water level (mAHD)
Groundwater		
GMB8	21 May 2018	49.97
GMB9A-1	21 May 2018	58.67
GMB15	21 May 2018	53.173
GMB22	21 May 2018	50.36
GMB23	21 May 2018	51.21
GMB24	21 May 2018	51.18
Surface water		
SW7	24 April 2018	65.1
SW10	11 March 2017	50.04
SW11	24 April 2018	52.18

Monitoring location	Monitoring date	Standing water level (mAHD)
Leachate		
LSH1	23 April 2018	50.07
LSH2	23 April 2018	52.81

4.1.1 Source of contamination

The hardfill itself is a potential source of chemical contamination. Contamination typically associated with hardfill depends on the source of the material used to form the hardfill, which in this case includes inert construction and demolition waste, commercial and industrial waste and low-level contaminated soil. Potential contamination associated with this type of waste that could be present within the hardfill generally includes:

- Leachate with elevated concentrations of contaminants associated with construction and demolition wastes, such as heavy metals, hydrocarbons, and nutrients
- Leachate with elevated concentrations of contaminants associated with commercial and industrial wastes, such as heavy metals, bicarbonates, and nutrients
- Leachate with elevated concentrations of contaminants associated with low level contaminated soil, such as heavy metals and bicarbonates

Other potential sources of contamination in the area surrounding the hardfill are illustrated in Figure 4, Appendix A and summarised in Table 4-2. It is noted that PFAS has been identified in groundwater at the site as part of a site-wide assessment undertaken by Golder (2020a, b).

Table 4-2 Potential contamination sources

Source	Location	Contaminants of potential concern
Stage 2 of the Swanbank REWMF	Directly north of the hardfill	Nutrients, heavy metals, hydrocarbons and PFAS
Stockpile of inert wastes for reuse	Directly north of the hardfill	Heavy metals and nutrients
Screening and crushing of concrete	Directly north of the hardfill	Heavy metals and bicarbonates
Biosolids treatment pads and ponds	Directly north of the hardfill	Heavy metals, nutrients
Surface water body SW11 (receives intermittent overflow from upstream location SW7)	Directly east of the hardfill	Heavy metals, nutrients, organics
Wood Mulching Industries	East of the site	
NuGrow Composting Facility	North west of the site	Heavy metals, nutrients, organics, pesticides, herbicides and PFAS
Lantrak landfill and resource recovery facility	North west of the site	Heavy metals, nutrients, organics, hydrocarbons and PFAS

4.1.2 Potential exposure pathways

For an exposure to occur, a complete pathway must exist between the source of contamination and the receptor. Where the exposure pathway is incomplete, there is no exposure, and hence no risk. Where the pathway for a contaminant from the source to the receptor is incomplete, there is no incremental risk due to the presence of the contamination.

Possible exposure pathways identified associated with the hardfill include:

- Mobilisation and/or leaching of contaminants from the hardfill into groundwater and surface waters

The main potential transport pathways for leachate leaving the hardfill include:

- Lateral migration in groundwater
- Migration in surface water runoff

Surface water runoff from the hardfill area is directed to the hardfill pond to the north east (SW10). It is understood that no direct off-site discharge of surface water from this on-site water body occurs.

4.1.3 Potential receptors

When evaluating potential adverse effects to people or the environment from exposure to contamination, all potentially exposed populations should be considered. For the site, the populations or receptors of interest include:

- Aquatic ecology of down gradient surface water receptors including:
 - Mining void SW10 located approximately 200 m to the north of the hardfill.
 - Water cooling pond (SW5) for the Swanbank Power Station located approximately 1.3 km to the northwest of the hardfill, which is connected to Oaky Creek and Bundamba Creek, and which ultimately discharges into Bremer River located 7 km to the northeast.

Given the historical mining activities and current waste management use of the area, the site is considered to be highly disturbed and the aquatic ecology is unlikely to be highly sensitive.

The closest possible sensitive aquatic receptor down gradient of the hardfill is the Power Station cooling pond. It is important to note that the cooling pond also receives surface water runoff from the surrounding area, which includes a number of industrial / commercial sites.

In addition, it is important to consider the environmental value (EV) of groundwater within and down gradient of the site. An EV is a particular value or use of groundwater that is important for the maintenance of a healthy ecosystem or for public benefit, welfare, safety or health, and which requires protection from the effects of contamination. EVs are listed Section 2.2.4. The most sensitive EV identified in relation to groundwater migrating from the hardfill is the aquatic ecology of the Power Station cooling pond.

5. Data quality objectives

Development of data quality objectives (DQOs) for the investigation is based on guidance presented in ASC NEPM (NEPC 2013).

The DQO process comprises the following seven steps and is presented in detail in Table 5-1:

- Step 1: State the problem
- Step 2: Identify the principal study question
- Step 3: Inputs to the decision
- Step 4: Boundaries of the study
- Step 5: Decision rules
- Step 6: Tolerable limits on decision errors
- Step 7: Optimisation of the data collection process

Table 5-1 Data quality objectives

Step	Description
Step 1: State the problem	Contaminants of potential concern have been identified in leachate associated with the hardfill. Based on this, the overarching objective for the investigation is to evaluate whether contaminants in the leachate are likely to pose a risk to groundwater and surface waters (including consideration of the Environmental Value of the receiving environment).
Step 2: Identify the decision / goal of the study	The key questions to be answered: <ul style="list-style-type: none"> • Do contaminants in leachate pose a risk to health and the environment? • Are further leachate management measures required at the site?
Step 3: Identify information inputs	Sources of information will include: <ul style="list-style-type: none"> • Historical investigation reports made available to GHD • Groundwater level and quality parameters • Sampling of groundwater and surface waters • An updated Conceptual Site Model with an evaluation of source-pathway-receptor linkages
Step 4: Define study boundaries	The lateral boundary of the study area is shown in Figure 1, Appendix A and is limited to the extent of the hardfill, groundwater and surface water sampling locations. The vertical boundary will be the maximum depth of groundwater sampling.
Step 5: Develop the analytical approach (or decision rule)	Sample analytical data will be compared to assessment levels considered to be relevant to the receiving environment and protective of health and the environment. If contamination is identified at concentrations exceeding the adopted assessment criteria and a potentially complete exposure linkage is identified, then further investigations will be undertaken to assess the nature and extent.
Step 6: Specify the	Two types of decision errors are possible:

Step	Description
performance or acceptance criteria (tolerable decision errors)	<ul style="list-style-type: none"> Sampling errors, which occur when the sampling program does not adequately detect the variability of a contaminant from point to point across the site (i.e. the samples collected are not representative of site conditions) Measurement errors, which occur during sample collection, handing preparation, analysis and data reduction. <p>To minimise the potential for decision errors, data quality indicators (DQIs) have been determined, for completeness, comparability, representativeness, precision and accuracy.</p> <p>The DQIs for sampling techniques and laboratory analysis of collected samples defines the acceptable level of error required for this investigation. The data quality objectives should be assessed by reference to data quality indicators as follows:</p> <ul style="list-style-type: none"> Data Representativeness - expresses the degree which sample data accurately and precisely represents a characteristic of a population or an environmental condition. Representativeness is achieved by collecting samples in an appropriate pattern across the site, and by using an adequate number of sample locations to characterise the site. Consistent and repeatable sampling techniques and methods are utilised throughout the sampling. Completeness - defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is set at there being sufficient valid data generated during the study. If there is insufficient valid data, then additional data are required to be collected. Comparability - is a qualitative parameter expressing the confidence with which one data set can be compared with another. This is achieved through maintaining a level of consistency in techniques used to collect samples and ensuring analysing laboratories use consistent analysis techniques and reporting methods. Precision - measures the reproducibility of measurements under a given set of conditions. The precision of the data is assessed by calculating the Relative Percent Difference (RPD) between duplicate sample pairs. $RPD(\%) = \frac{ C_o - C_d }{C_o + C_d} \times 200$ <p>Where Co = Analyte concentration of the original sample Cd = Analyte concentration of the duplicate sample</p> <p>A nominal acceptance criteria of +/- 30% RPD for field duplicates and splits for inorganics and a nominal acceptance criteria of +/- 50% RPD for field duplicates and splits for organics should be adopted, however it is noted that this will not always be achieved, particularly at low analyte concentrations.</p> <ul style="list-style-type: none"> Accuracy - measures the bias in a measurement system. Accuracy can be undermined by such factors as field contamination of samples,

Step	Description
	<p>poor preservation of samples, poor sample preparation techniques and poor selection of analysis techniques by the analysing laboratory. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes and analyses against reference standards. Accuracy of field works is assessed by examining the level of contamination detected in equipment blanks.</p>
<p>Step 7: Optimise the design for obtaining data</p>	<ul style="list-style-type: none"> • To optimise the design of the investigation, the following measures will be adopted: • Use of the latest and most relevant industry guidelines and regulations. • Ongoing consultation with DES • use of robust field and laboratory quality assurance/quality control protocols • use of suitable laboratory limits of reporting

6. Assessment criteria

Guidelines that form the framework for the investigation are presented below with the appropriate groundwater and surface water assessment levels.

6.1 Assessment framework

The relevant legislation and guidelines that outline the appropriate framework for this investigation include:

- Australian Standard (AS) AS44482.1 – 2005 Guide to the investigation and sampling of sites with potentially contaminated soil, Part 1: Non-volatile and semi-volatile compounds (Standards Australia, 2005)
- Australian Standard, (AS4482.2-1999) Guide to the sampling and investigation of potentially contaminated soil, Part 2: Volatile substances
- Australian and New Zealand Governments and Australian state and territory governments (ANZG), 2018 *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*
- Australian and New Zealand Environment Conservation Council (ANZECC) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000)
- Department of Environment and Resource Management, 2010, *Environmental Protection (Water) Policy 2009* Bremer River environmental values and water quality objectives Basin No. 143 (part), including all tributaries of the creek
- Department of Environment and Science 2018 Queensland Auditor Handbook for Contaminated Land: Module 6: Content requirements for contaminated land investigation documents certifications and audit reports
- Department of Science, Information Technology and Innovation (DSITI), 2017, Using monitoring data to assess groundwater quality and potential environmental impacts.
- National Environmental Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)* (ASC NEPM; NEPC 1999) (NEPC, 2013)
- Heads of EPAs (HEPA) Australia and New Zealand and the Australian Government Department of the Environment and Energy (DoEE), *PFAS National Environmental Management Plan*, January 2018 (NEMP, 2018)

6.2 Adopted assessment criteria

When selecting appropriate screening criteria for analytical results, we have considered the follow key factors:

- The most sensitive downstream receiving environment is the aquatic ecology of a former mining void (SW10) and the Power Station cooling pond.
- The environmental value of Oaky Creek and/or Bundamba Creeks, which are connected to the Power Station cooling, pond includes:
 - Aquatic ecosystems
 - Irrigation and stock watering
 - Secondary and Visual Recreation

- Industrial use
- Cultural and spiritual values
- There are no domestic groundwater abstraction bores within the vicinity of the site and given the industrial nature of the site and surrounding area, it is unlikely that groundwater would be used for potable purposes.

The adopted assessment criteria to be used for evaluating analytical results for surface water and groundwater samples, are as follows:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)
 - Toxicant default guideline values for protecting aquatic ecosystems (freshwater, 95% level of species protection). These values are considered to be sufficient to provide a suitable level of protection for slightly to moderately disturbed ecosystems.
- Heads of EPAs (HEPA) Australia and New Zealand and the Australian Government Department of the Environment and Energy (DoEE), PFAS National Environmental Management Plan, January 2018 (NEMP, 2018)
- Department of Environment and Resource Management (2009) Environmental Protection (Water and Wetland Biodiversity) Policy, Bremer River environmental values and water quality objectives, Basin No 143 (part) including all tributaries of the Bremer River:
 - Lowland Freshwater

In accordance with the methodologies outlined in the ANZG 2018 guidelines and the provisions of the state policy and guideline, where multiple trigger values for a parameter exist they have been adopted in the following order of preference, such that where a local trigger value exists it is used in preference to a regional, state or national value:

1. Bremer River Water Quality Objectives
2. Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Assessment of the groundwater and surface water results collected from the site against these guidelines consistently report a number of exceedances (for electrical conductivity, total suspended solids, sulfate, nutrient and metals), indicating that the aquifer characteristics on site may not completely align with the regional aquifer of Bremer River or conditions representative of slightly to moderately disturbed ecosystems, as outlined in the adopted guidelines.

6.3 Statistical assessment

The current method of assessing groundwater quality is adopted from *Using monitoring data to assess groundwater quality and potential environmental impacts* (Department of Science, Information Technology and Innovation [DSITI] 2017).

The development of site-specific groundwater trigger values to interpret and analyse monitoring results for the site is not feasible due to a number of factors including:

- The regional water quality guideline, EPP (Water and Wetland Biodiversity), does not represent the water quality reported on site.
- The presence of multiple aquifers with large variability in aquifer characteristics at the site.
- Differing aquifer characteristics between inferred up and down gradient monitoring locations.

Therefore, it is proposed that a two-tiered nonparametric trigger system be adopted for each groundwater monitoring location to assess statistically significance and monitor the magnitude of change of results above background results.

As outlined in DSITI, 'the two tiered trigger nonparametric approach proposed compares a rolling median against triggers that are calculated based on the long-term 80th percentile (Tier 1 trigger) and three consecutive individual exceedances of the long-term 95th percentile (Tier 2 trigger)' (DSITI 2017).

Controls charts have been developed for each parameter for each groundwater monitoring location. The control charts include a time series plot, the rolling median (most recent eight monitoring results) and the Trigger 1 (80th percentile) and Trigger 2 (95th percentile) levels. The trigger levels (80th percentile and 95th percentile) have been derived based on the entire data set up to 2019, with outliers removed. These derived trigger levels are fixed triggers and will be reviewed on an annual basis, as required.

The following observations were noted during the derivation of location specific trigger levels at up gradient groundwater monitoring well GMB15:

- Given the considerable increase in standing water levels at the site between 2010 and 2013, trigger values for groundwater wells GMB8, GMB9A-1 and GMB15 have been calculated off results reported between 2014 and 2019.
- TOC and lead results at groundwater monitoring well GMB15, reported a considerable change in results from November 2014. As parameters have remained generally consistent from November 2014 onwards, the associated trigger levels for these parameters were calculated off results reported between November 2014 and December 2019.
- COD, zinc, AOX, ammonia (as N) at GMB15 have experienced fluctuations and variations of results since monitoring began in December 2003. Due to ongoing fluctuations in results, it is difficult to determine which values that are most representative of the groundwater quality. Therefore, all data between 2014 and 2019 has been used to derive the trigger levels and regular scrutiny of these trigger levels and future results is required.

Groundwater monitoring wells GMB22, GMB23 and GMB25 will likely require an annual review of trigger levels as they only have two years' worth of quarterly monitoring data available.

6.3.1 Groundwater general assessment

The rationale and methodology for the assessment of groundwater quality is summarised as follows:

- Assessment of statistically significant fluctuations in groundwater quality.
- Identification of variations in indicator parameter concentrations between up gradient and down gradient locations, where aquifer connectivity is present
- Identification of variations in indicator parameter concentrations between groundwater and nearby surface water bodies
- Trends in parameter concentrations at specific monitoring locations

6.3.2 Surface water assessment

The rationale and methodology for the assessment of surface water quality is summarised as follows:

- Assessment of surface water quality against the water quality guidelines detailed in Section 6.2.
- Identification of variations in indicator parameter concentrations between upstream and downstream locations, where connectivity is present

- Identification of variations in indicator parameter concentrations between surface water and nearby groundwater
- Trends in parameter concentrations at specific monitoring locations

6.3.3 Leachate assessment

The rationale and methodology for the assessment of leachate quality is summarised as follows:

- Trends in parameter concentrations at specific monitoring locations

Identification of variations in indicator parameter concentrations between leachate, downstream surface water bodies and down gradient groundwater to assess potential impact.

7. Sampling and analytical program

7.1 Objectives

Update the water quality assessment to address current data gaps in the understanding of water quality associated with the hardfill. The scope of the additional sampling also includes consideration of the comments provided by DES on the water quality assessment and site wide PFAS assessment. Comments provided by DES and GHD response to comments are included in Appendix B.

7.2 Scope

The scope of proposed works for the additional assessment includes:

- Review of available information on water quality monitoring of the surrounding area in order to develop a regional groundwater contour of the area surrounding the hardfill, which extends beyond the Remondis site boundaries.
- Undertake one water quality sampling round that includes collection of groundwater, surface water and leachate samples from the monitoring locations outlined in Table 7-1 and the analytical suite outlined in Section 7.9.
- Update the current CSM in consideration of the additional investigation findings.
- Update the water quality assessment report with the inclusion of the additional assessment results and the following additional items:
 - Further assessment of potential metal bioaccumulation
 - PFAS assessment
 - Assessment of water chemistry in SW10

7.3 Proposed sample locations

The groundwater and surface water monitoring locations surrounding the Swanbank REWMF hardfill and included in the additional assessment are identified on Figure 1, Appendix A and detailed below in Table 7-1.

Table 7-1 Proposed sampling locations

Sampling location	Location (with respect to the hardfill)	Description
Groundwater monitoring locations		
GMB8	Down gradient	On the western border of Stage 2, inferred down gradient of the hardfill, former biosolids pads and SW10. Drilled in: <ul style="list-style-type: none">• Fill surface to 6.5 mbgl• Mudstone/sandstone 6.5 to 36 mbgl, with coal inclusions 18 to 33 mbgl Screened in: <ul style="list-style-type: none">• 24.5 to 36 mbgl in coal and mudstone/sandstone
GMB22	Down gradient	In the western portion of Stage 2, inferred down gradient of the hardfill. Drilled in:

Sampling location	Location (with respect to the hardfill)	Description
		<ul style="list-style-type: none"> • Siltstone/sandstone 1 to 40 mbgl Screened in: <ul style="list-style-type: none"> • Siltstone/sandstone 28 to 40 mbgl
GMB26	Down gradient	<p>North of the hardfill. Inferred perched water</p> Screened in: <ul style="list-style-type: none"> • 4 to 8 mbgl in coal and siltstone
GMB9A-1	Cross gradient	<p>Located within the highwall in natural geology on the western border of Stage 2, inferred cross gradient of the hardfill.</p> <p>The groundwater standing water level at this location is not consistent with surrounding levels and appears to be located within a different aquifer.</p> Drilled in: <ul style="list-style-type: none"> • Sandstone/mudstone 1 to 70 mbgl Screened in: <ul style="list-style-type: none"> • Sandstone/mudstone 39 to 70 mbgl
GMB23	Cross gradient	<p>Located on the western boundary of Stage 2, inferred up gradient of the hardfill.</p> Drilled in: <ul style="list-style-type: none"> • Fill Surface to 3 mbgl • Sandstone/siltstone 3 to 36 mbgl, with coal inclusions 14 to 15 mbgl Screened in: <ul style="list-style-type: none"> • Sandstone/siltstone 26 to 36 mbgl
GMB24	Up gradient	<p>Located on the south western boundary of Stage 2, inferred up gradient of the hardfill.</p> Drilled in: <ul style="list-style-type: none"> • Fill 0 to 5 mbgl • Siltstone/sandstone 5 to 32.5 mbgl • Coal 32.5 to 41 mbgl Screened in: <ul style="list-style-type: none"> • Siltstone/sandstone and coal 21 to 41 mbgl
GMB25		<p>North east side of the hardfill</p> Screened in: <ul style="list-style-type: none"> • Silty gravel fill 20.1 to 35.1 mbgl
GMB15	Up gradient	<p>Located between the hardfill and surface water body SW11 on the south eastern boundary of Stage 2, inferred up gradient of the hardfill.</p> Drilled in: <ul style="list-style-type: none"> • Fill Surface to 7 mbgl • Sandstone/mudstone 7 to 35 mbgl • Shale/coal 35 to 36 mbgl Screened in: <ul style="list-style-type: none"> • Sandstone/mudstone and shale/coal 33 to 36 mbgl
GMB27	Upgradient	South west of boundary of the site.

Sampling location	Location (with respect to the hardfill)	Description
		Screened in: Sandstone and siltstone 25 to 34 mbgl
GMB28	Upgradient	South east boundary of the site Screened in: Siltstone and sandstone 47 to 53 mbgl
Surface water monitoring locations		
SW5	Downstream	Licensed discharge point to the off-site Swanbank Power Station cooling pond. Located approximately 1.3 km north west of the hardfill footprint.
SW6	Downstream	Former mine void that is significantly deep and extends into the bedrock and is hydraulically connected to groundwater. Captures surface water runoff from Stage 2 landfill area (on site).
SW7	Upstream	Off-site upstream monitoring location located on the adjacent wood mulching facility property. Captures off-site surface water runoff and overflow from this pond discharges onto the site into SW11.
SW10	Downstream	Former mine void that is significantly deep and extends into the bedrock and is hydraulically connected to groundwater. Captures surface water runoff from Stage 2 operational areas, including the hardfill.
SW11	Upstream	Former mine void that is significantly deep and extends into the bedrock and is hydraulically connected to groundwater. Captures surface water runoff from a portion of the hardfill and overflow from upstream location SW7.
Leachate monitoring locations		
LSH1	Hardfill leachate	Located within the south western portion of the hardfill, collecting leachate from within the hardfill in Stage 2. The base of the sump is understood to be at 10.540 mAHD.
LSH2	Hardfill leachate	Located on the southern batter of the Stage 2 landfill and is understood to extend into the base of waste in this area, which is higher than that in LSH1. The sump collects perched leachate from a portion of the hardfill in Stage 2. The base of the sump is unknown.

7.4 Field work preparations

Health safety and environmental management

Prior to the commencement of field works, a job safety and environmental assessment (JSEA) will be prepared, in accordance with GHD's health safety and environmental management policies and procedures, to identify the hazards, risks and mitigations measures specific to our sampling work.

7.5 Groundwater sampling

7.5.1 Groundwater sampling

Groundwater sampling will be undertaken with consideration of with Section 18 of the PFAS NEMP and Schedule B2 of the ASC NEPM.

All wells will be purged and sampled using low-flow sampling techniques with dedicated (disposable, PFAS-free) HDPE tubing. Using this approach, only dedicated disposal equipment will come into contact with the sample. The collection point will be placed within the screen interval and the flow rate reduced to achieve a low flow sampling effect whereby water is preferentially drawn in through the well screen.

The following general sampling methods and procedures will be implemented:

- Prior to groundwater sampling, all equipment will be decontaminated and rinsed to prevent cross-contamination between wells and / or equipment. This will involve the use of a nutrient-free and PFAS-free decontaminating agent to clean the equipment followed by double rinsing of the equipment with demineralised water (as detailed in Section 8.6).
- Field parameters measured during purging and sampling will be recorded at regular intervals (i.e. every 2 to 5 minutes or every 2 to 5 litres) using flow through cell or similar device. This will include temperature, pH, EC, DO and redox potential on a calibrated measuring instrument.
- Descriptions of the visual and olfactory characteristics of the groundwater will be recorded each time a measurement is made and include details such as elapsed time, volume purged, colour, turbidity, odour, sheen etc.
- All measured stabilisation parameters and field observations will be recorded on a purging and sampling field sheet.
- The parameters will be considered stable when three consecutive readings are within the following:
 - 0.05 for pH;
 - $\pm 3\%$ for EC;
 - $\pm 10\%$ for DO;
 - ± 0.2 °C for temperature; and
 - ± 10 mV for Eh.
- A groundwater sample will be collected after the measured parameters have stabilised.
- If parameters do not fully stabilise, sampling will commence once at least one-well volume has been purged from the well. If the well is purged dry, it will be left to recover overnight and sampled the next day.
- All sampling for PFAS will be undertaken with Teflon-free equipment, including sampling bottles and tubing (where possible). The sampling will also be undertaken with reference to groundwater sampling requirements listed in Section 18 of the PFAS NEMP, to reduce the potential for cross contamination from equipment containing PFAS to avoid false positive results in samples.
- Samples scheduled for dissolved metals will be filtered in the field using a 0.45 μm filter (prior to being placed in the nominated sampling container).
- Samples will be placed in laboratory supplied bottles appropriate for the particular analyte and filled to the top to eliminate headspace and potential for volatilisation of samples. The bottles will be immediately stored in chilled insulated containers.

7.6 Surface water sampling

Surface water sampling will be undertaken as follows:

- Surface water samples will be collected by grab sampling with a dedicated sample bottle attached to an extendable arm. Where possible, samples will be collected from approximately 30 cm below the surface of the water and disturbance of sediments will be minimised.
- Samples scheduled for dissolved metals will be filtered in the field using a 0.45 µm filter (prior to being placed in the nominated sampling container).
- Surface water samples will be placed in laboratory supplied bottles appropriate for the particular analyte and filled to full to reduce headspace. The bottles will be immediately stored in chilled insulated containers.
- Dedicated sample bottles will be used to collect surface water samples, eliminating the need for decontamination of equipment and rinsate samples.

7.7 PFAS considerations

Section 18 of the PFAS NEMP and the Western Australian Department of Environment Regulation *Interim Guideline of the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances* Version 2.1 (January 2017) provide information regarding commonly suspected sources of environmental sample contamination during PFAS investigations and mitigation practices and alternatives.

PFAS sampling will be undertaken with consideration of the field procedures presented in Table 7-2.

Table 7-2 PFAS sampling considerations and procedures to minimise sample contamination

Item / product	Field procedures
Clothing and food	
New clothing	Not to be used by sampling personnel. All field clothing will be washed a minimum of six times after purchase to remove surface coatings before being used at the site.
Clothing with stain resistant, rain resistant or waterproof coatings / treated fabric (for example GORTEX®)	Not to be used by sampling personnel. Polyethylene rain gear (for example disposable LDPE), vinyl or polyvinyl chloride (PVC) clothing are acceptable. Sampling will not occur in the rain, if possible.
Tyvek® clothing	Not to be used by sampling personnel.
Fast food wrappers and containers	Not to be consumed by sampling personnel during field works. Rigid plastic containers or bags or stainless-steel containers are to be used for all food brought to site.
Pre-wrapped foods and snacks (for example chocolate bars, energy bars, granola bars and potato chips)	
Sampling equipment and containers	

Item / product	Field procedures
Teflon® containing or coated field equipment (tubing, bailers, tape and plumbing paste)	Not to be used at site. HDPE or silicone tubing will be used.
Teflon® lined lids on containers (for example sample containers, rinsate water storage containers)	Polypropylene lids are to be used for sample containers and polypropylene or HDPE containers for rinsate containers.
Glass sample containers with lined lids	Use polypropylene or HDPE for sample containers for samples collected for PFAS analysis (PFAS adsorb strongly to glass).
Other products	
Aluminium foil	Not to be used at site.
Self-sticking notes and similar office products (for example 3M Post-It notes)	Not to be used at site.
Waterproof paper, notebooks, and labels	Not to be used at site.
Detergents and decontamination solutions (for example Decon 90® Decontamination Solution)	Certified PFAS free decontamination solution to be used only.
Reusable chemical or gel ice packs (for example BlueIcel®)	Not to be used. Ice contained in plastic (polyethylene) bags will be used.
Sunscreen	<p>To mitigate the potential for cross contamination of samples due to the use of sunscreens, the following steps to apply sunscreen should be undertaken by field staff:</p> <ul style="list-style-type: none"> • Before applying sunscreen, put on a pair of disposable nitrile gloves. • Apply sunscreen to your skin when wearing the nitrile gloves. • Once application of sunscreen is completed, remove the nitrile gloves carefully and in a manner that prevents any sunscreen coming into direct contact with the hands. • During the day, avoid having your hands come into contact with parts of your body or skin where sunscreen has been applied.

7.8 Waste handling

Potentially contaminated purge and development water generated from the sampling of groundwater wells will remain on site.

7.9 Laboratory analysis

Water samples collected will be analysed at two commercial laboratories (primary and secondary labs) that are National Association of Testing Authorities (NATA) accredited for the analysis in Table 7-2.

Selected samples from each location will be submitted for laboratory analysis for contaminants of concern identified in Section Table 4-2. The laboratory analytical schedule will be dependent on the field observations made during sampling.

Table 7-3 Indicative laboratory analytical program

Media	Analysis	LOR	No of primary samples
Groundwater, surface water and leachate	Nutrients	0.1 mg/L	5 groundwater
	Heavy metals (total and dissolved)	0.005 – 0.1 mg/L	9 surface water
	BTEXN	1 – 5 µg/L	
	PAH	0.5 – 1 µg/L	
	TRH	20 – 100 µg/L	
	Phenols	1 – 2 µg/L	
	PCB	1 µg/L	
	OCP/ OPP	0.05 – 0.2 mg/kg	
	PFAS	0.0002 – 0.001 mg/kg	

Notes:

Nutrients: Total nitrogen, total kjeldahl nitrogen, nitrate, nitrite, ammonia, total phosphorous, reactive phosphorous

Heavy metals: As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg

PFAS: A suite of 28 PFAS compounds has been selected as this is in line with the standard national laboratory capabilities on PFAS analysis. PFAS analysis on groundwater and surface water will be undertaken to super ultra-trace level which is currently the lowest available standard national laboratory capabilities.

8. Sample preservation, handing, transport and documentation

Samples collected at the site are appropriately, preserved, handled and transported to maintain sample integrity with consideration of the following procedures.

8.1 Sample labelling

Sample containers will be supplied pre-prepared by the laboratory and will be labelled with the container preservative and the analytes it is suitable for. Samples will be labelled with the following information:

- Project identification number.
- Sample identification number.
- Date of sampling.
- Initials of sample collector.
- Container type / preservative (from laboratory).

All details on the sample label will be completed on site with indelible PFAS-free ink. The sample identification number will also be written with indelible ink on the cap of the sample bottle where possible in case the sample label is lost or destroyed.

QA/QC samples will be labelled differently so that where required, the samples are delivered 'blind' to the laboratories. The same information as for a normal sample will be recorded excluding the time of sampling and the sample identification number. The sample identification system used will indicate only the type of verification sample along with a unique number. The number will correspond to a predetermined location (and sampling interval) in the case of a duplicate or split; or predetermined location only for an equipment rinsate blank on a particular day, etc.

8.2 Chain of custody forms

The Chain of Custody (CoC) form will be completed on completion of field sampling. An individual CoC will be completed for each discrete batch of samples. Chain of Custody procedures are used to track samples, discourage tampering and provide a sampling summary.

The following information is included on the CoC form:

- Project identification number.
- Sample number;
- Date and time of collection;
- Type of sample;
- Number and type of container (if required);
- Analysis required;
- Comments;
- Signature of sampler; and
- Signature of receiver (laboratory).

Each sample sent to the laboratory will be included on a CoC form. When the sample is relinquished (by GHD) and received (by the laboratory or courier), the party involved signs the form and indicates the time and date. The original copy will accompany the samples to the laboratory in the sample cooler. The original will be signed by the laboratory and sent back to GHD for filing. The laboratory and GHD will retain a copy as a record of samples sent and analyses requested.

8.3 Sample handling and packing

Once a sample has been collected in the field the container will be wiped to avoid spreading contamination. All details on the sample label will be completed. During field work and sample preparation activities samples should be stored in a chilled cooler (esky with ice).

At the end of work for that day, the CoC form will then be placed in a separate bag and sealed. All glassware will be packed in bubble wrap / foam if necessary, to avoid breakage. The samples will then be placed in a cooler containing ice. No gel ice packs will be used. If ice is used it should be contained in sealed bags to avoid leakage. Samples will be kept at around 4°C. The CoC form shall be placed in the cooler with the samples and the cooler will be sealed with tape / security seals and collected by or couriered to the testing laboratory.

8.4 Sample storage and disposal

Storage and disposal protocols will be undertaken with consideration of relevant National Association of Testing Authorities (NATA) guidelines and protocols.

The laboratory will be responsible for ensuring samples are correctly stored and disposed of once submitted for analyses. The laboratory will also ensure the correct sample containers are supplied for the analyses required as requested by GHD.

GHD personnel will ensure the correct sample containers are used and any preservation / sample preparation methods specified by the laboratory (i.e. field filtering) are followed.

8.5 Sample receipt notification

Sample receipt notification (SRN) will be issued by the laboratory on the same day samples are received. The SRN shall be forwarded in digital (pdf) format.

The SRN shall clearly highlight any discrepancies between the chain of custody forms and the samples received in addition to any breakages or inadequacies in sample preservation, preparation or containers.

8.6 Equipment decontamination

Cross contamination of samples from sampling equipment will be prevented by decontaminating equipment prior to taking samples. Equipment used to collect samples for chemical analyses will be decontaminated before field use, between each sample collection and on leaving site.

The following procedure will be used where appropriate to clean groundwater and surface water sampling equipment prior to obtaining each sample that is to be submitted for chemical analysis:

- Initial rinse and scrub with tap water;
- Scrub with a certified PFAS free, nutrient free and fluorine free detergent (Liquinox) with a known chemical composition;
- Double rinsing equipment with deionised water.

The above method has been adopted for consistency with Section 18 of the PFAS NEMP.

Submersible pumps and low-flow sampling equipment used for purging or sampling will be decontaminated to remove trace-level contamination from the pump housing, bowls, and discharge line. The pump will be submerged in a bath of detergent and water. The exterior of the pump and hose will be scrubbed with brushes. The pump bowls will be cleaned by activating the pump and allowing the detergent to pass through the pump and discharge line. The pump will then be placed in deionised water and flushed by pumping to remove the detergent solution.

Monitoring equipment, such as field water quality meter and interface probe, will be decontaminated between each measurement location as per manufacturer's instructions.

9. Sample quality assurance / quality control

To ensure the field investigations and analyses are undertaken in a way that enables the collection and reporting of reliable data on which to base the site assessment, the following quality assurance / quality control (QA/QC) procedures should be followed.

9.1 Field quality control

As part of the investigation program the following QAQC samples will be collected for water samples:

- Blind duplicates – collected at a rate of 1 in 20 primary samples (and 1 in 10 for PFAS analysis), but evenly divided between split duplicates.
- Split duplicates - collected at a rate of 1 in 20 primary samples (and 1 in 10 for PFAS analysis), but evenly divided between blind duplicates.
- Rinsate blanks – collected at a rate of 1 for each piece of non-disposable equipment used per day of sampling.
- Trip blanks – One trip blank will be included within each esky containing samples for volatile analysis

Blind duplicates

Field quality control procedures used during the project will comprise blind duplicates: these are prepared in the field by duplicating the original sample and placing two equivalent portions into two separate containers. The blind duplicate sample is sent anonymously to the primary laboratory. Blind duplicates provide an indication of the analytical precision of the primary laboratory but may also be affected by factors such as sampling methodology or inherent heterogeneity of the sample medium.

Blind duplicates are to be collected for groundwater, surface water and soil samples at a rate of 1 in 20 primary samples, but evenly divided between split duplicates (below).

Blind duplicates will be collected for groundwater and surface water analysis for PFAS at a rate of 1 in 10 primary samples.

Split duplicates

Split duplicates: these are field duplicates analysed by a secondary laboratory. Split duplicates provide an indication of the analytical precision of the primary laboratory.

Split duplicates will be collected for groundwater and surface water samples at a rate of 1 in 20 samples, but evenly divided between blind duplicates.

Split duplicates will be collected for groundwater and surface water analysed for PFAS at a rate of 1 in 10 primary samples.

Rinsate blanks

Rinsate Blank: is deionised / distilled water provided by the laboratory which is poured over the sampling equipment (e.g. IP Probe), and re-collected in another appropriate sample bottle as a sample to be analysed for the contaminant(s) of concern. This provides an indication as to the suitability of the decontamination methods utilised.

Rinsate blanks will be collected and analysed at a rate of 1 for each piece of equipment used per day of sampling where required. Rinsate blanks will not be collected where non-disposable sampling equipment is used.

A sample of the deionised water used to in the field decontamination process will also be collected and analysed (for PFAS).

Transport blanks

Transport blanks are laboratory prepared samples which are used to determine whether contamination of samples have occurred as a result of ambient exposures during transport. One trip blank will be included within each esky containing samples for volatile analysis

9.2 Calibration requirements

Instruments expected to be used on the project and associated tasks include:

- Interface Probe (IP).
- Water Quality Meter.
- Low flow groundwater sampling equipment.

All equipment used on site is to have been recently calibrated as per manufacturer's instructions with evidence of calibration retained.

10. Reporting

The findings of the additional sampling round will be used to update the Water Quality Assessment report, that includes the following general headings:

- Introduction
- Hardfill description
- Summary of the works and methodology
- Environmental setting
- Preliminary site model
- Results and findings of the assessment
- Updated conceptual site model
- Conclusions and recommendations

11. Limitations

This report has been prepared by GHD for Remondis Australia Pty Ltd (Remondis) and may only be used and relied on by Remondis for the purpose agreed between GHD and Remondis as set out in Section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Remondis arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Remondis and others (in addition to that obtained by GHD) who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

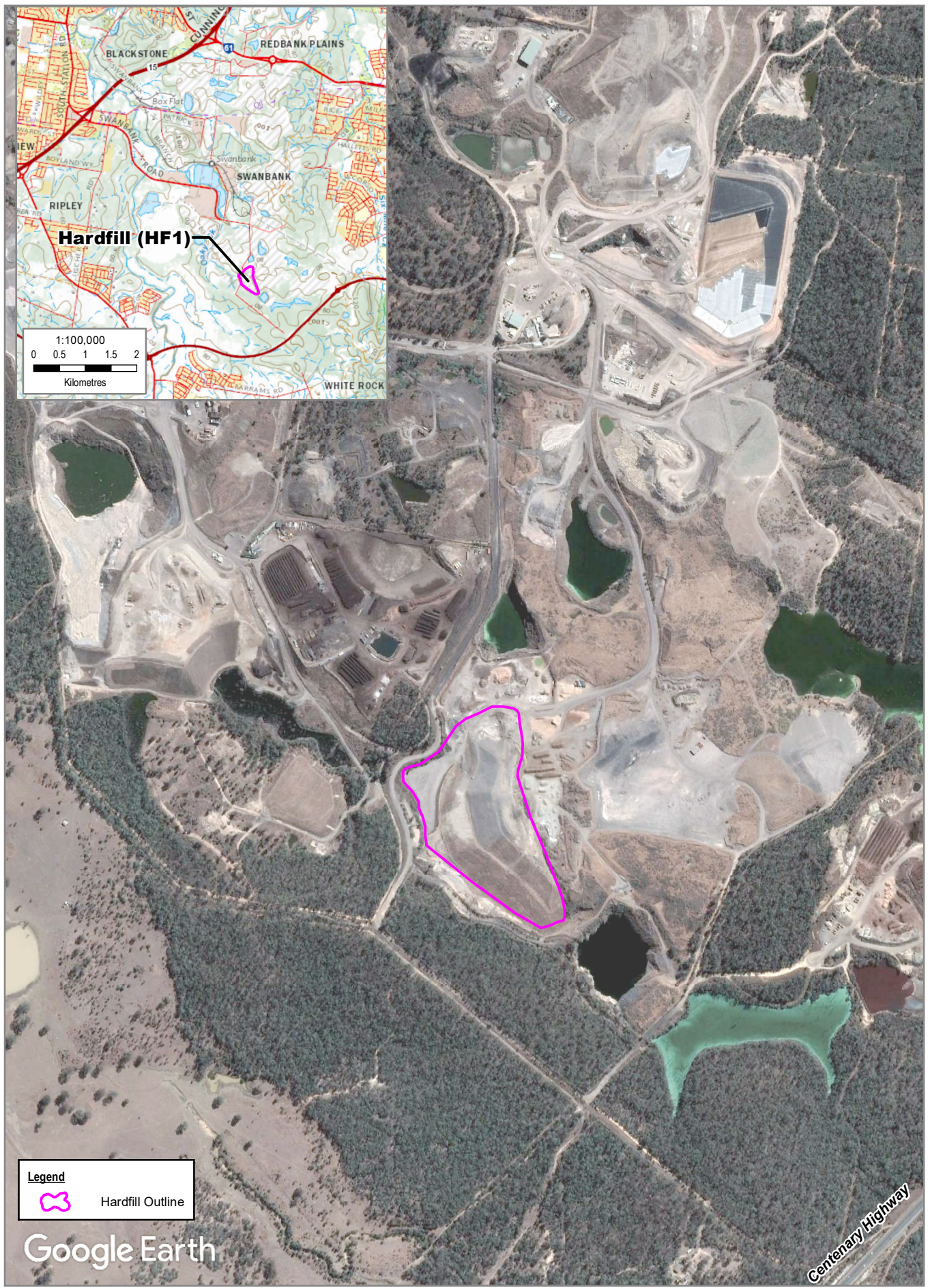
Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

12. References


- *Geotechnical and hydrogeological review, Proposed Stage II Landfill, Swanbank, Golder Associates, March 1998.*
- *Geotechnical and Hydrogeological Studies, Swanbank C&D/C&I Landfill, Swanbank, Queensland, Golder Associates, August 2004.*
- *Thiess Services, Swanbank Landfill Stage 2, Preliminary Geotechnical Report, CDM Smith, October 2012.*
- *Thiess Services, Swanbank Design Study – Hydrogeology Report, CDM Smith, October 2012.*
- *Operations 1 Assessment, South East Queensland Facility, Golder Associates Pty Ltd, 24 July 2020, 24 July 2020 (Assessment 1) (2020a)*
- *Operations 2 Assessment, South East Queensland Facility, Golder Associates Pty Ltd, 24 July 2020 (Assessment 2) (2020b)*

Appendices

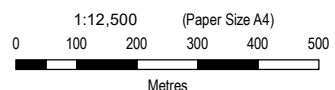
Appendix A – Figures



Legend

 Hardfill Outline

Google Earth



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

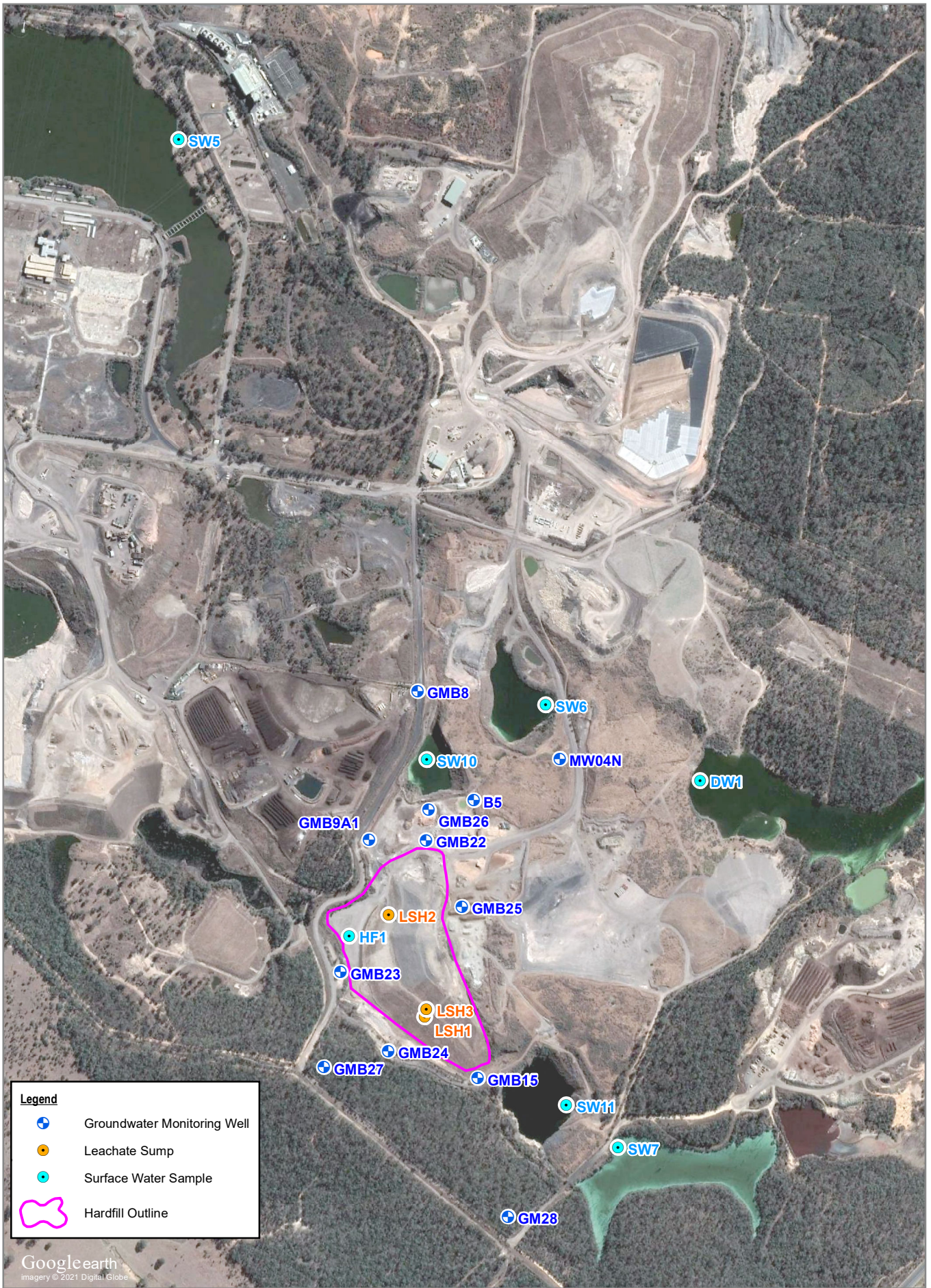


**Remondis
 Swanbank Hardfill Cell
 Hydrogeological Assessment**

Project No. 12524528
 Revision No. B
 Date 13/01/2021

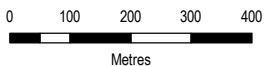
Site Location

FIGURE 1



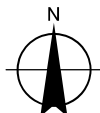
Google Earth
imagery © 2021 Digital Globe

1:12,500 (Paper Size A4)



Metres

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



Remondis
Swanbank Hardfill Cell
Hydrogeological Assessment

Project No. 12524528
Revision No. B
Date 14/01/2021

Hardfill Monitoring Locations

FIGURE 2



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- LEGEND**
- Bore location 15 Feb 2018 (Water level m AHD)
 - Bore location 19 March 2018 (Water level m AHD)
 - HF1 Sampling location (m AHD)
 - Interpreted contours-Feb and March 2018 (m AHD)
 - Drainage Pathways
 - Surface Water Feature (m AHD)
 - Stage 2 Landfill
 - Stage 1 and 1B Landfill

Coordinate System: GDA 1994 MGA Zone 56
 Projection: Transverse Mercator
 Datum: GDA 1994



- NOTE(S)**
1. PRESUMED BEDROCK FAULTS FROM GOLDER, 1998.
 2. DEM AND AERIAL IMAGERY FOR 2018 SUPPLIED BY REMONDIS.
 3. LINE NOTES
 4. SURFACE WATER SUPPLIED BY REMONDIS ON 6 SEPT 2017. DOCUMENTS REFERENCE: SEP 2017 GROUNDWATER LEVELS, 2017.09.05_01_RMONDIS_SWANBANK_WATER_VLS.VIEW.PDF
 5. GROUNDWATER LEVELS SUPPLIED BY REMONDIS ON 9 MAY 2018. DOCUMENTS REFERENCE: SWANBANK GROUNDWATER RLS MASTER 2017












- REFERENCE(S)**
1. AECOM AUSTRALIA PTY LTD (2014A) "SWANBANK LANDFILL STAGE 2 CONCEPT DESIGN - DRAWINGS", DRAWING REF: 60304301-CO-001 TO 60304301-CO-016 REV'S
 2. GOLDER ASSOCIATES PTY LTD (1998) "REPORT ON GEO-TECHNICAL AND HYDROGEOLOGICAL REVIEW PROPOSED STAGE II LANDFILL SWANBANK", DOCUMENT REF: 98833004(C).
 3. REFERENCE 3

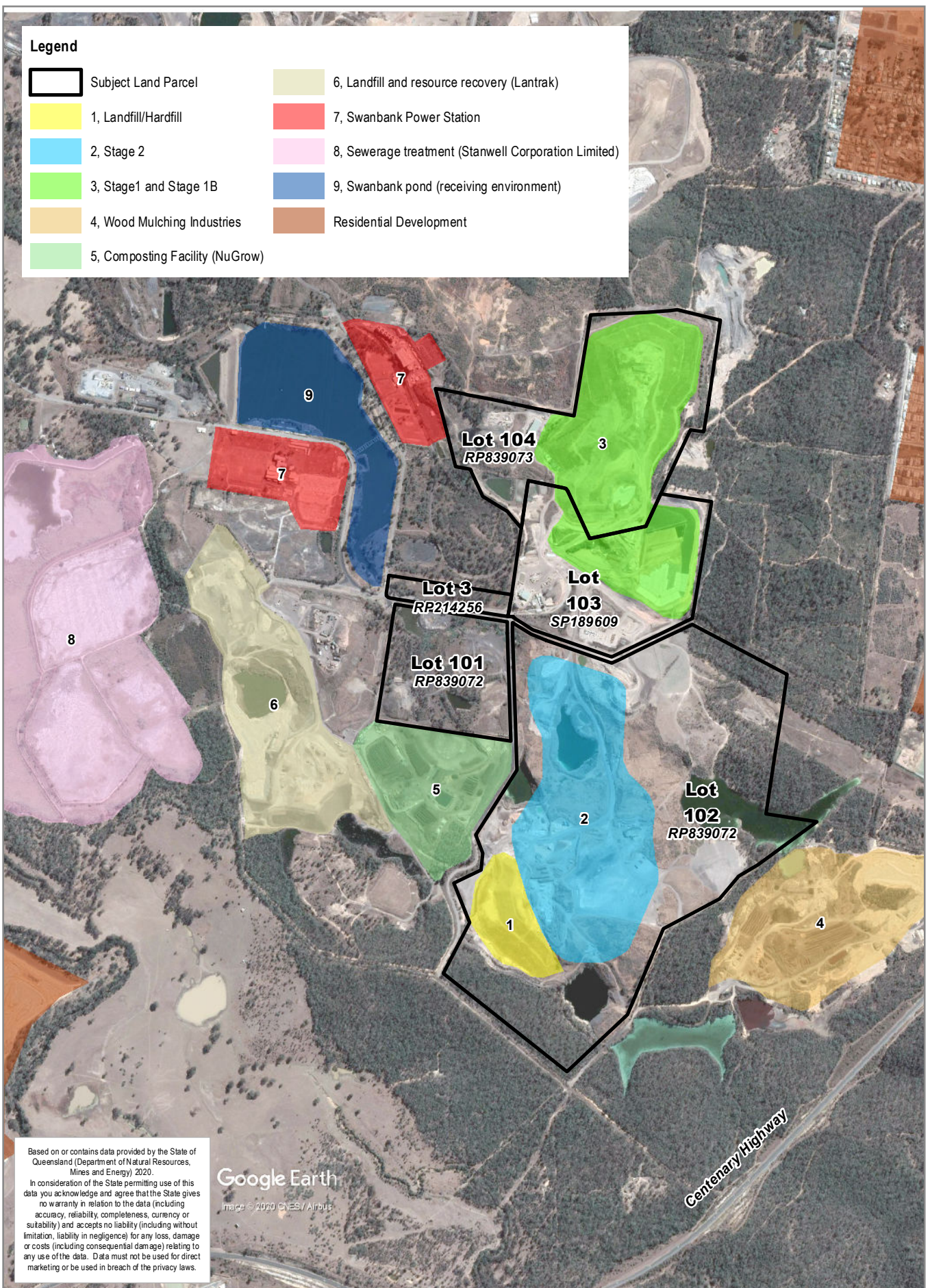
CLIENT		REMONDIS	
PROJECT		SWANBANK LANDFILL	
TITLE			
INFERRED GROUNDWATER FLOW DIRECTION - GROUNDWATER ELEVATIONS FEBRUARY AND MARCH 2018			
CONSULTANT		YYYY-MM-DD	24/05/2018
		DESIGNED	JL
		PREPARED	JL
		REVIEWED	SRF
		APPROVED	SRF
PROJECT NO.	CONTROL	REV.	FIGURE
1543998	015	1	01



IF THIS DRAWING OR PART THEREOF IS SHOWN TO BE A REVISION, THE SHEET NUMBER WILL BE INDICATED BY A RED CIRCLE WITH A WHITE BACKGROUND AND A BLACK BORDER.

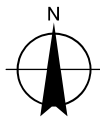
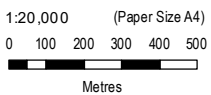
Legend

	Subject Land Parcel		6, Landfill and resource recovery (Lantrak)
	1, Landfill/Hardfill		7, Swanbank Power Station
	2, Stage 2		8, Sewerage treatment (Stanwell Corporation Limited)
	3, Stage1 and Stage 1B		9, Swanbank pond (receiving environment)
	4, Wood Mulching Industries		Residential Development
	5, Composting Facility (NuGrow)		



Based on or contains data provided by the State of Queensland (Department of Natural Resources, Mines and Energy) 2020.
 In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

Google Earth
 Image © 2020 CNES/Airbus



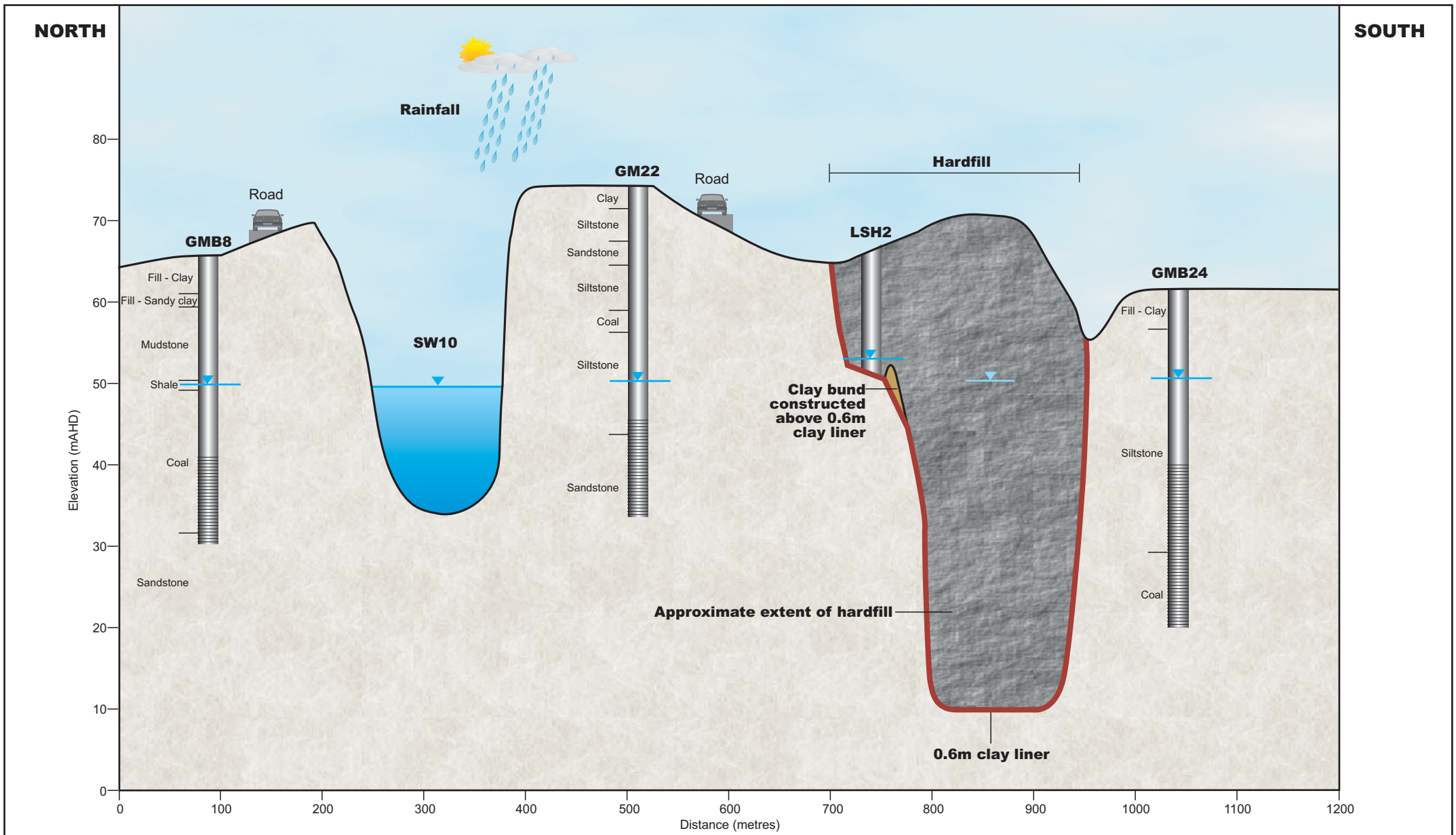
Map Projection: Universal Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 56

Remondis
 Swanbank Hardfill Cell
 Hydrogeological Assessment

Project No. 41-12524528
 Revision No. B
 Date 20/05/2020

Surrounding land uses

FIGURE 4



LEGEND

- Fill
- Groundwater level

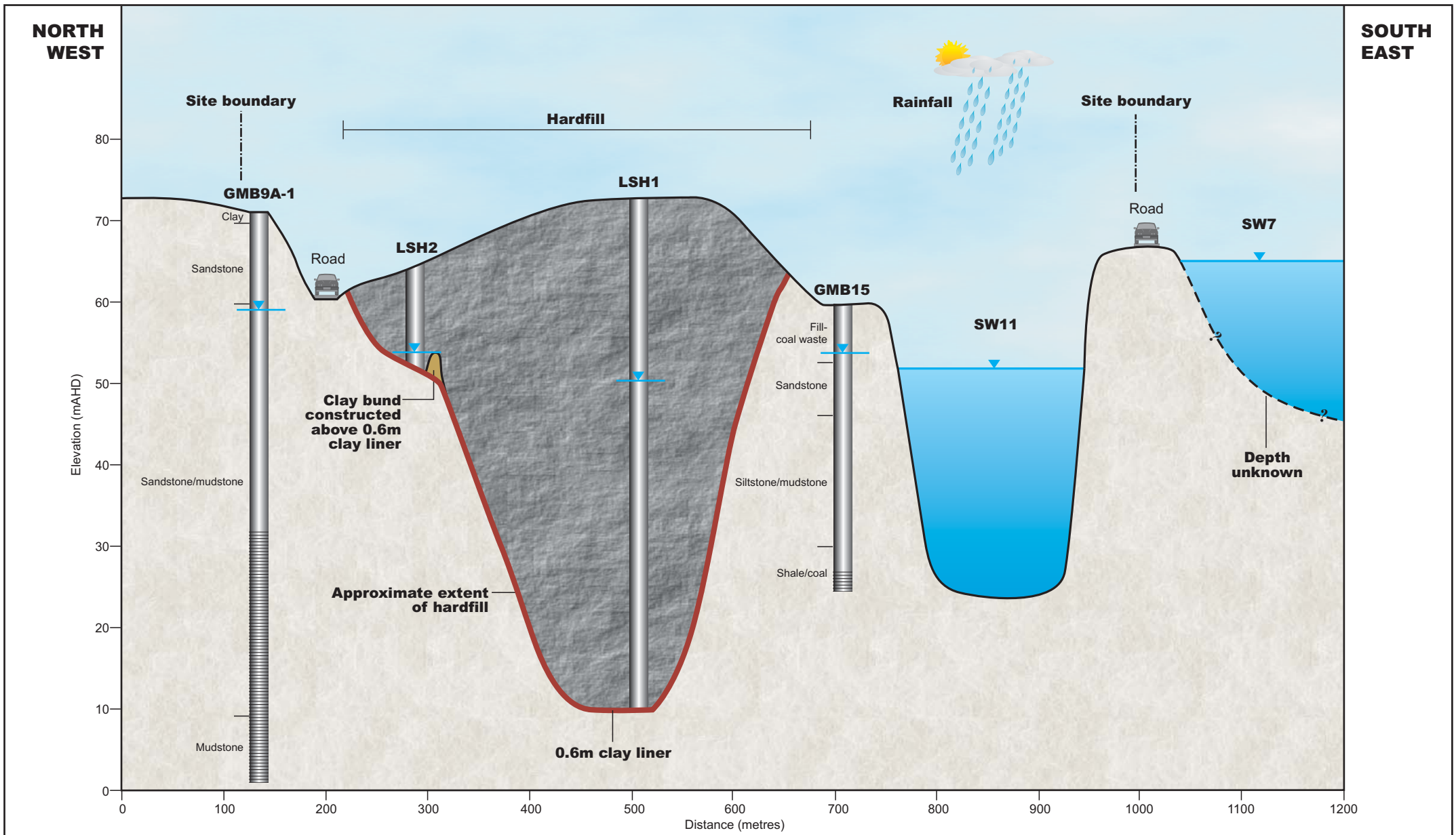


Remondis
Swanbank Hardfill Investigation

Conceptualised Cross Section (North-South)

Job Number | 12-524528
Revision | 0
Date | 3 June 2020

Figure 5



LEGEND

- Fill
- Groundwater level



Remondis
Swanbank Hardfill Investigation

Conceptualised Cross Section (North West-South East)

Job Number | 12-524528
Revision | 0
Date | 8 June 2020

Figure 6

Appendix B – DES comments and actions

Comment	Action
2020131 Water Sciences Review – Dec 2019 GHD report	
Need to identify triggers that can be used to benchmark changes in water quality.	<p>A detailed waste quality assessment in line with the DSITI guidelines has been undertaken (GHD December 2020) to determine suitable benchmarks for the assessment of water quality trends.</p> <p>This will be used as the basis for the additional assessment outlined in this SAQP.</p>
Need to define spatial extent of impacts and assess environmental risk	<p>Assessment to date suggests no measurable impact on the receiving environment.</p> <p>However, a detailed water quality assessment in line with DSITI (GHD 2020) and the additional scope for work outlined in this SAQP is proposed to further demonstrate this conclusion.</p>
Comparison of up and down gradient wells is not sufficient based on the complex geology and other statistical assessment methods in line with DSITI should be considered.	<p>As part of the detailed water quality assessment (GHD 2020) a review of the DSITI guidelines was undertaken which identified suitable statistical assessment techniques for the hardfill. This approach will also be adopted as part of this assessment.</p>
Need to define local water quality guidelines	<p>As part of the water quality assessment (GHD 2020) an assessment of water quality was undertaken with reference to <i>Using monitoring data to assess groundwater quality and potential environmental impacts</i> (Department of Science, Information Technology and Innovation [DSITI] 2017). This assessment concluded that the development of site-specific groundwater trigger values to interpret and analyse monitoring results for the site was not feasible due to several factors. Therefore, a two-tiered trigger system was instead adopted for the assessment of water quality. This assessment will continue as part of the additional assessment</p>
Will increasing the SWL at GMB15 (and more generally) increase connectivity.	<p>Overall, it is considered that the increase in the groundwater level represents a return to post mining conditions and the current standing water level trends are expected to remain generally consistent (within seasonal variation). This return to pre-mining groundwater levels has resulted in more connectivity between leachate in the hardfill and the groundwater table, which is discussed further below.</p>

Comment	Action
Further assessment of groundwater and surface water nutrient results is required to determine if they are a result of impact from the landfill or other sources.	Given the highly disturbed nature of the surrounding environment, it is expected that the hardfill is not a major source of nutrients in groundwater and surface water up and down gradient of the hardfill. However, nutrients were included in the water quality assessment (GHD 2020) and will be included in this additional scope for works.
Include PFAS in the assessment	<p>A site wide assessment of PFAS in groundwater and surface water was undertaken in 2019/2020 (Golder 2020a, b). A summary these results is included in the water quality assessment (GHD 2020).</p> <p>PFAS will also be included in this additional scope of work.</p>
The location and coordinate of all monitoring bores overlaid on a map of the site with classification of the bores as reference/control or test bores.	All proposed and existing monitoring locations will be included in the additional water quality assessment report.
A description of the hydrogeological features of the site and aquifers that includes soil and rock types (including porosity, permeability) and stratigraphy (including faulting and fracture propensity).	Available information on the monitoring locations is included in Section 2.2 of this document.
Identify the location of potentials surface-ground interactions, such as where there is a groundwater expression to the surface (e.g. seeps and springs) and other groundwater dependent ecosystems.	<p>As outlined in the summary of geology and hydrology in Section 2, it is expected that groundwater is hydraulically connected to the former open cut mine voids that extend down to the bedrock and now operate as surface water bodies. In Stage 2 this includes SW10, SW11 and SW6. There are no other known surface water expressions of groundwater within Stage 2 of the Swanbank REWMF.</p> <p>Modelled groundwater contours indicate that groundwater from the area around the hardfill flows towards the north west. The closest receiving water body from Swanbank REWMF is Swanbank Lake, approximately 1.7 km to the north east of the hardfill.</p> <p>SW7, located up stream of the hardfill on the adjacent property, is a dammed natural, shallow water body not connected to groundwater. However, it does overflow into SW11 during periods of high rainfall.</p>

Comment	Action
<p>Identify the direction(s) of any surface water runoff and drainage lines that pass through or near the site and any surface waters potentially impacted by the activity (including rivers, creeks, lakes, wetlands or drainage lines) that are within or adjacent to the site.</p>	<p>A discussion of surface water in the vicinity of the hardfill is outlined in Section 2.</p>
<p>The standing water level and an indication of the movement (including direction and rate of flow) of groundwater across the site.</p>	<p>Groundwater is discussed in Section 2.</p> <p>Modelled groundwater contours, included in the annual groundwater monitoring report indicate that groundwater from Stage 2 of the Swanbank REWMF flows in a north westerly direction, towards Swanbank Lake.</p> <p>Previous permeability tests of monitoring wells at the site reported an average hydraulic conductivity between 4.6×10^{-2} m/day (in bedrock) and 2.5×10^{-1} m/day (in fill) (CDM Smith, 2012).</p>
<p>Identify and describe any geological barriers that are overlying and underlying aquifers.</p>	<p>There are no known geological barriers overlying or underlying the regional aquifer located in bedrock.</p>
<p>Any existing (registered and unregistered) or proposed water bores or groundwater monitoring wells within the site or on land adjacent to the site, including bore log information.</p>	<p>A figure outlining possible sources of contamination and sensitive receptors will be included as part of a detailed water quality assessment.</p> <p>A figure with existing and proposed monitoring locations will also be provided.</p>
<p>Identify any environmentally sensitive places and environmental values within or adjacent to the site.</p> <p>Identify the location of current and historic activities that may adversely impact water quality such as pits, dams, waste rock dumps, tailing storage facilities and leachate ponds.</p>	<p>Detailed site history, including this information, where possible, is included in Section 3 of this SAQP and the subsequent additional assessment report.</p> <p>Environmental Values identified for the site and receiving environment are listed in Section 2 of this SAQP.</p>

Comment	Action
The location of waste storage, processing, treatment and disposal locations. Include details for both raw and treated wastes and details for the relevant storage facilities. Plans must show any proposed point source discharges to waters from water management processes onsite.	
Minimum groundwater quality monitoring data requirements satisfied. Check data integrity including QA/QC of data;	QAQC is outlined in Section 5, Section 8 and Section 9.
Table of descriptive statistics provided for each bore (i.e. date range, count, minimum, maximum, median 80 th and 95 th percentiles).	This has been included in the water quality assessment (GHD 2020) and will be included in the additional assessment.
Time series plots of all available groundwater and surface water quality data.	This is included in the quarterly monitoring reports. Charts from the 2019 annual report from Stage 2 that are relevant to the hardfill assessment have been included in the water quality assessment (GHD 2020). This will be revised as part of a detailed water quality assessment.
Distribution of major anions and cations in each bore and surface water site (i.e. piper diagram).	Major ions piper plots, for monitoring locations within Stage 2, relevant to the hardfill assessment have been included in the water quality assessment (GHD 2020) and the be included in the additional assessment.
Box plots for all bores for each indicator showing as a minimum, the median, 20 th & 80 th percentiles and the relevant water quality guidelines or limits.	This has been included in the water quality assessment (GHD 2020) and will be included in the additional assessment.
2020131 Technical Services Review – Dec 2019 GHD report	
Review all existing monitoring bore construction logs, confirming well appropriate construction to monitor the profile (i.e. 40 m of leachate being contained), the monitored geological units are appropriate to detect potential impacts from the hard-cell landfill, (e.g. given the depth of leachate are nested wells required to monitor additional	<p>Leachate monitoring locations</p> <p>It is acknowledged that the existing leachate monitoring locations within the hardfill are not consistent with typical monitoring well construction specification. This is because the leachate monitoring to date has been opportunistic within existing leachate sumps and monitoring locations. Given the depth of the waste profiled (greater than 40 metres) it is</p>

Comment	Action
<p>lithology?). Provide recommendations to upgrade the monitoring bores in the network if required.</p>	<p>unlikely that a monitoring well in accordance with standard well construction guidelines would be able to be successfully installed within the waste profile. It is therefore considered that, for the purposes of this assessment, the existing leachate monitoring locations are sufficient to gain an understanding of leachate levels and quality within the site. Noting that there would be value in the installation of additional leachate monitoring locations in the northern portion of the hardfill.</p> <p>Groundwater monitoring locations</p> <p>The Swanbank REWMF includes a robust groundwater monitoring network within both Stage 1 and Stage 2 that is monitored on a quarterly basis in accordance with the current Environmental Authority for the site. It is acknowledged that much of the Swanbank area is located on old mine workings and over burden backfill and as a result, the geology in which the groundwater monitoring wells are installed varies across the site. However, the existing groundwater monitoring network is considered sufficient for the purpose of the hardfill assessment based on a review of borelogs, geology and screen depths.</p> <p>A copy of the borelogs relevant to the hardfill are included in Attachment B. Further assessment of the impact that geology has on the local water quality has been undertaken as part of the water quality assessment (GHD 2020)</p>
<p>Confirm wells have been appropriately surveyed in mAHD and the surveying has been conducted by a suitably qualified person, to ensure that groundwater level and leachate level reporting is accurate.</p>	<p>A recent survey of monitoring locations was included the waste quality assessment (GHD 2020).</p>
<p>Provide an assessment of the appropriateness of the sampling methodologies utilised, including an assessment as to whether they are compliant with the relevant EA, which requires that the sampling manual is followed.</p>	<p>Historical sampling has been undertaken in accordance with the methodology outlined in the annual water quality monitoring report.</p> <p>Sampling procedure for the additional investigation outlined in this report is outlined in Section 7 and Section 8.</p>

Comment	Action
<p>Review of all existing analytical results including quality assurance/quality control data to confirm the reliability of the data.</p>	<p>The data used in the hardfill assessment was obtained from the routine water quality monitoring program and in accordance with the sampling methodology outlined above. While a quality assurance and quality control assessment of the data is not undertaken as part of the routine monitoring program it is considered that the robust data set, going back to as early as the 1990s is valuable in helping to identify outliers in results (which is consistent with the objective of laboratory blind duplicate and blind blank samples). The sampling is also undertaken by the same person, which has been the case for over 15 years. This consistency provides reliability and repeatability of the dataset, which is demonstrated in the field notes.</p> <p>To confirm this, a quality assurance and quality control assessment will be undertaken as part of the detailed water quality assessment.</p>
<p>Conduct a comprehensive assessment of the chemistry of the leachate for the purpose of modifying the regulatory analytical suite to monitor contaminants that can detect potential leakages from the landfill, as intended when the EA was drafted. The assessment for chemical constituents should be extensive and undertaken for the purpose of identifying a potential element or contaminant that can be used to monitor potential releases from the landfill to groundwater/surface water.</p>	<p>The water quality assessment (GHD 2020) statistical assessment review was undertaken in line with DSITI to identify the most suitable statistical assessment to assess groundwater and surface water quality up and down gradient of the hardfill site.</p> <p>It is considered that the current analytical suite is sufficient to identify potential leachate impacts from the landfill on the downstream surface water and adown gradient groundwater quality.</p> <p>It is noted that the additional assessment will also include analysis of PFAS, in addition to the existing suite.</p>
<p>Confirm that the landfill liner (given that leachate levels do not appear to have been managed as required) are capable from a design perspective to contain the contaminants within the Cell.</p>	<p>Cell design drawings prepared by Mausell in 2004 for the southern portion of the landfill indicate that the base of the landfill was to be graded to a low point in the south east where the leachate sump (LS01) was to be located. The elevation of the clay liner at the based on the south eastern portion of the landfill is to be at an elevation between 11 and 15 mAHD. The clay liner was designed to be 600 mm in thickness and overlaid by a 300 mm gravel leachate collection layer.</p>

Comment	Action
	<p>Remondis indicate that this design was adopted for the base of the entire hardfill. Remondis also indicated that the walls of the hardfill were progressively lined with 600 mm compacted clay that was applied in lifts as the landfill progressed.</p> <p>At the time the hardfill was constructed, the groundwater level in this area was below the base of the excavation. However, the local groundwater standing water level has now recovered to pre-mining levels.</p> <p>The suitability of the liner to contain leachate within the hardfill has been considered as part of the hydrological modelling recently undertaken by GHD.</p>
<p>Review and/or implement all recommendations made by GHD regarding the installation of additional monitoring wells and leachate wells, plus undertaking pump tests and the recommended detailed hydrogeological assessment to gain a better understanding of the site hydrogeology.</p>	<p>The hydrological modelling and water quality assessment have been undertaken by GHD.</p> <p>The next phase of assessment includes an additional water quality assessment to close data gaps in the current understanding of the hardfill impact on the receiving environment (specifically water quality).</p>
<p>Require that a suitably qualified and experienced person complete a detailed assessment of leachate management options for the site, clearly outlining why various options are or are not suitable or able to be considered.</p>	<p>It is proposed that a leachate management options assessment is undertaken. This will be undertaken following completion of the pumping tests and additional water quality assessment, as it is expected that the outcomes of this assessment will help inform suitable leachate management options.</p> <p>The leachate management options assessment will be undertaken by people with significant experience in groundwater modelling and landfill and leachate management.</p>
<p>Water Sciences Technical Report 28/08/2020</p>	
<p>Not all possible groundwater migration pathways from the hardfill to the receiving environment have been considered in the Water Quality Report. Possibility of groundwater migration from the northwest side of the site towards discharge point at cooling pond SW5 should be considered.</p>	<p>Groundwater contours suggest that it is unlikely groundwater from the hardfill will migrate to the north west towards SW5. However, as part of the additional water quality assessment, further investigation of regional groundwater contours will be undertaken (where data can be obtained) to better understand regional groundwater flow directions in the area surrounding the hardfill.</p>

Comment	Action
<p>Moreover, the suitability of the up-gradient bores like GMB24 to profile background water quality of the site is questioned, given the chances of leachate movement to these bores. Furthermore, we recommend that new monitoring bores like GMB27 and GMB28 should be included in the monitoring program during TEP for a better spatial resolution of the groundwater quality at the site.</p>	<p>It is noted that PFAS groundwater data reported PFAS concentrations at GMB27 and GMB28 below the LOR and GMB24 was not sampled for PFAS. On this basis GMB27 and GMB28 will be included in the additional assessment and considered as 'background' wells.</p>
<p>Though the Modelling Report assesses two scenarios for the leachate management, practical aspects associated with the proposed hydraulic containment of the leachate, its implementation strategies, subsequent leachate management, treatment, disposal options and monitoring potential impacts on the surrounding groundwater quantity and quality have not been explicitly outlined in the TEP.</p> <p>The proponent indicates that further details would be provided within eight weeks of approval of the TEP. It is unclear whether the scenarios outlined in the modelling report are the only preferred management option for leachate management or whether additional options will be discussed in the leachate management options assessment. Further details may be required regarding the scope of the leachate management options assessment.</p>	<p>A leachate management options assessment will consider all of the elements outlined.</p> <p>However, prior to the completion of a leachate management options assessment, pump tests are required to calibrate the hydrogeological modelling and better quantity leachate volumes requiring management.</p>
<p>Given the risks presented by the migration of leachate to the surrounding ground and surface water, we highly recommend a monitoring design document which outlines the appropriate monitoring regime and key performance indicators to measure the status of the ground and surface water quality overtime should be included as an action in the TEP and provided to the department for approval before its on-site implementation.</p>	<p>This additional assessment will outline the investigation required to address data gaps and outlined the monitoring program moving forward.</p>

Comment	Action
<p>Need of PFAS monitoring at-least during the period of TEP of three years according to the NEMP guidelines should be considered. Even though high levels of PFAS signatures are noted in the hardfill leachate, a plan for monitoring it in the surface and groundwater was not outlined in the draft TEP.</p>	<p>PFAS will be included in the additional assessment.</p>
<p>The status of the bioaccumulative metals/metalloids and phenols which is required to monitor according to their EA should be clarified. This is not discussed in the current leachate, ground and surface water assessment.</p>	<p>Assessment of bioaccumulative metals/metalloids and phenols will be included in the additional assessment.</p>
<p>The proponent argues that aquatic ecology values of the cooling pond SW5 which receives landfill affected water are the only environmental value relevant to the activities. It is difficult to agree with such an assertion. Since the site discharges to the Oakey Creek via the pond SW5 there might be a need to consider the protection of a broader set of environmental values of the lower Bremer River receiving environment.</p>	<p>Consideration will be given to the lower Bremer River as part of the receiving environment in the additional assessment.</p>
<p>Monitoring of dissolved metals/metalloids concentrations in the ground and surface water is required for the protection of aquatic ecosystems and should be considered in the water quality monitoring program. If monitored in future, dissolved metals should be assessed in accordance with the national guidelines (AWG, 2018). Currently only total metals concentrations are monitored at the site.</p>	<p>Dissolved metals will be included in the additional assessment. The outcomes of the assessment will also include consideration of dissolved metals in accordance with AWG 2018.</p>
<p>Reasons for elevated levels and an increasing trend of electrical conductivity (EC), total dissolved solids, chloride, magnesium, sulphate and sodium at the SW10 and further possibility of it reporting to the receiving waters via discharges from the SW5 should</p>	<p>There is no surface water discharge from SW10 to the receiving environment (SW5). There is potential for water with SW10 to interact with groundwater and the migration pathway from Stage 2 is considered to be via groundwater only.</p>

Comment	Action
<p>be investigated. This is important, given the ground-surface water interactions at the site.</p>	<p>It is noted that groundwater, on the down gradient boundary of Stage 2 (B17) has reported PFAS concentrations below the LOR to date.</p> <p>Surface water flow paths will be made clear on the additional assessment.</p>
<p>The Water Quality Report has classified surface water and groundwater monitoring locations as either up or downgradient. From these classifications it is assumed that the groundwater migration pathway under investigation is from the hardfill towards SW10. However, based on the topographic contours provided in the Assessment 2 Report (Figure 3), it is suggested that all possible groundwater migration pathways from the hardfill to the receiving environment, in particular, to the final discharge point SW5 from the north-west side of the landfill should be considered. An additional groundwater migration pathway to the west of the hardfill following Oakey Creek towards SW5 is suggested (Figure 4). Further detail is required regarding the groundwater flow direction across the site.</p>	<p>Groundwater flow direction at the site is complex and will be revised as part of the water quality monitoring program. As highlighted in previous reports, it is difficult to install representative groundwater monitoring wells across the site due to underground mine workings and backfill from open cut mining. As a result, the modelled groundwater contours are skewed based on the location of the monitoring wells. Based on information available to date, it is considered that groundwater from the hardfill will discharge into SW10, but a portion may also migrate further down gradient towards SW5.</p> <p>The additional assessment will seek to provide further detail on regional groundwater flows (based on available information) and also make it clear where surface water flow paths currently exist.</p>
<p>It is also suggested that the monitoring locations do not adequately monitor all potential groundwater migration pathways. GMB24 has been classified in the Water Quality Report as upgradient and GMB9A-1 and GMB23 as cross gradient. It is suggested that GMB24 is not upgradient and is likely to be influenced by leachate from the hardfill.</p>	<p>This is possible. New wells GMB27 and GMB28 are located further up gradient of the hardfill and may be more representative of up gradient groundwater quality. One of these new wells can be used in place of GMB24. This will be reviewed as part of the additional assessment.</p>
<p>We recommend a revision of the groundwater migration pathway conceptualisation and inclusion of all the relevant ground and surface water monitoring locations including SW5. Furthermore, suitable upgradient bores should be nominated after assessing all the potential groundwater migration pathways and topographical contours of the site.</p>	<p>A revised groundwater contour can be modelled based on the additional information and monitoring wells. The additional assessment will also seek to provide further detail on regional groundwater flows (based on available information) and also make it clear where surface water flow paths currently exist.</p>

Comment	Action
<p>Water Sciences suggests that the risk of migration of contaminants from the leachate to the groundwater is high especially when a hydraulic connectivity between leachate and groundwater has been already established. Moreover, ground-surface water interactions in mining voids like SW6 and SW10 downstream (see Table 3.-1, Water Quality Report) are an additional concern. Potentially contaminated waters from the onsite surface water bodies through the discharge points SW5 during wet season increases the risks to the environmental values downstream of the site. These issues are not sufficiently addressed in the documents provided to date. One objective of the TEP should be minimise the risks presented by the leachate to ground and surface water bodies at the site. After considering the overall risks, we highly recommend inclusion of monitoring of PFAS in the routine quarterly water quality monitoring at least for the three-year period of TEP to ensure the improvements in the site water quality.</p> <p>PFAS can be included in the routine monitoring program at selected location.</p>	<p>Noted. It is however important to note that there is currently no surface water flow path from Stage 2 to SW5. Migration from Stage 2 to SW5 is via groundwater only.</p>
<p>The NEMP (2018) indicates that, “monitoring of landfill leachate and groundwater, surface water and land receptors should include PFAS in accordance with the regulatory requirements, specifically, conditions imposed for landfills approved to accept solid PFAS-contaminated materials. If regulatory requirements do not exist, monitoring programs should include PFAS”.</p> <p>Currently, a strategy to monitor PFAS in the waters bodies related to the site has not been included in the routine quarterly monitoring plans. In contrast, the Assessment 1 and Assessment 2 reports indicate the possibility of winding up PFAS monitoring at the site after</p>	<p>The additional assessment will include PFAS sampling at selected locations.</p>

Comment	Action
<p>one additional round of sampling from the leachate, groundwater and surface water (Section 13, Assessment 2). A detailed assessment of the yearly PFAS monitoring results in the ground and surface water is presented in the Assessment 2. However, it is suggested that time-series graphs at each monitoring location might be a better option to study the overall trends.</p> <p>It is suggested that a monitoring program design document, which provides surface and ground water quality and groundwater level monitoring locations, indicators, limits and reporting requirements should be developed and provided to the DES for review.</p>	
<p>A number of potential contaminants of concern needs to be monitored in the groundwater according to the Condition 1-C7 of the EA. Though monitoring outcomes of few contaminants (mainly cations and anions) are presented in the Appendix C of the Water Quality Report. Monitoring data for important bio-accumulative heavy metals of landfill-origin like arsenic, mercury, cadmium and selenium is not presented in the Water Quality Report. Similarly, phenols are also considered as potential contaminates of concern from landfilling activities and should be monitored in accordance with the EA. If these indicators are currently monitored as per EA, the reason for not reporting on these indicators during TEP was not discussed.</p>	<p>Dissolved metals including arsenic, mercury, cadmium and selenium and phenols will be included in the additional assessment.</p>
<p>Even though the site is outside the boundaries of Bremer River water quality objectives as per the Environmental Protection (Water) Policy 2009, appropriate identification of site related environmental values is highly recommended. Aquatic ecosystems, irrigation, farm supply, stock watering, human consumer recreation, drinking water, industrial use, cultural and spiritual values are the environmental values of the Lower Bremer River near to which the site is located. However, only</p>	<p>Lower Bremer River environmental values will be considered in the additional assessment.</p>

Comment	Action
<p>aquatic ecology has been considered potential receptors in the Section 2.7.3 of the Water Quality Report.</p> <p><i>“Aquatic ecology of down gradient surface water receptors including:</i></p> <ul style="list-style-type: none"> <i>– Mining void SW10 located approximately 200 m to the north of the hardfill.</i> <i>– Water cooling pond (SW5) for the Swanbank Power Station located approximately</i> <p><i>1.3 km to the northwest of the hardfill, which is connected to Oakey Creek and ultimately discharges into Bremer River.”</i></p> <p>Source: Section 2.7.3 Potential Receptors, Water Quality Report</p> <p>It is further stated in the Water Quality Report that, the Power Station cooling pond is the only possible sensitive aquatic receptor down gradient of the hardfill. This assertion is not supported given the possibility that hardfill-influenced water could be discharged offsite and could flow to the lower Bremer River. We note that the PFAS assessment of the site does include the drinking water, recreation and aquatic ecosystem protection guideline values in the course of their assessment (see Section 8, Assessment 1 and Section 10, Assessment 2). However, the GHD Water Quality Report does attribute these environmental values to the site.</p> <p>Protection of the Lower Bremer River environmental values should be considered during quarterly ground and surface water quality assessment in the course of TEP, given the ground-surface water interactions at the site.</p>	

Comment	Action
<p>At least five surface water bodies are present at the site (SW5, SW6, SW7, SW10 and SW11). Among these, SW6, SW10 and SW11 are deep mine voids hydraulically connected to the groundwater (see Table 3-1, Water Quality Report). For the purpose of assessment, SW7 and SW11 has been envisaged as upstream while three other surface water SW5, SW6, and SW10 to be downstream. SW10 is positioned in-between the two down-gradient monitoring bores GMB22 and GMB8 (see Figure 2-1, Report).</p> <p>A comparison between the upstream and downstream surface water bodies as presented in the Water Quality Report may not be useful. Potential sources of contaminants to these confined surface water bodies might be highly varying depending upon the geophysical location in relation to each other and the hardfill. Therefore, reasons for elevated levels and an increasing trend of electrical conductivity (EC), total dissolved solids, chloride, magnesium, sulphate and sodium at the SW10 should be investigated further given the ground-surface water interactions at the site.</p>	<p>The additional assessment will include consideration of groundwater and surface water interactions.</p>

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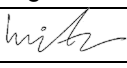

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Rev 0	I Bird	V Wilton		I Bird		14/01/21

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