Appendix W Acid Sulfate Soils Management Strategy

Public Transport Authority

Malaga to Ellenbrook Rail Works

Acid Sulfate Soils Management Strategy

June 2020

Assessment Number 2238

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Document Information

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Executive Summary

The Public Transport Authority of Western Australia (PTA) is proposing to develop the Malaga to Ellenbrook Rail Works (the Proposal) as part of the Western Australian Government's METRONET vision. The Proposal is located 12 to 22 kilometres (km) north-east of the Perth CBD, within the City of Swan. The Proposal connects to the proposed Bayswater to Malaga railway line at the eastern edge of the Tonkin Highway road reserve.

Most of the Proposed construction works will occur at or above grade and as such will avoid disturbing acid sulfate soils (ASS). However, deeper excavations and dewatering are likely to be required for construction of:

- Train stations. During the construction of deep infrastructure e.g. lift pits, underground services and pile caps.
- At the dive structure proposed to pass under the Tonkin Highway west of the proposed Malaga Station.
- During installation of foundations for major structures such as bridges and abutments at Beachboro Road, Bennett Brook, Whiteman Park and Gnangara Road.
- During the installation and/or relocation of underground services.

Given the Proposal requires temporary excavation and dewatering there is potential for construction activities to cause environmental impacts associated with the disturbance of ASS.

ASS management strategies will be determined once detailed design is complete and defined in an ASSMP that will be prepared and implemented by the Construction Contractor. It is anticipated that the key management strategies for ASS will include:

- Treatment of ASS excavated during earthworks.
- Treatment of effluent from dewatering and groundwater abstraction.

To detect potential impacts to the environment attributable to ASS disturbance the following monitoring will be implemented.

- Treated ASS will be tested and validated prior to reuse on site.
- Dewatering effluent will be tested before it is discharged to the environment.
- Groundwater and surface water quality will be monitored to detect potential impacts to the environment.

The ASSMP will include management actions and contingency measures that will be implemented to prevent significant environmental impacts attributable to the disturbance of ASS.

1. Introduction

1.1. Context and Scope

1.1.1. Description of Proposal

The Public Transport Authority of Western Australia (PTA) is proposing to develop the Malaga to Ellenbrook Rail Works (the Proposal) as part of the Western Australian Government's METRONET vision. The Proposal is located between 12 to 22 kilometres (km) north-east of the Perth CBD, within the City of Swan. The Proposal connects to the proposed Bayswater to Malaga railway line at the eastern edge of the Tonkin Highway road reserve.

1.1.2. Acid Sulfate Soils

Acid sulfate soils (ASS) are naturally occurring soils, sediments or organic substrates that contain iron sulfides, predominantly in the form of pyrites (DER 2015a). These soils commonly occur in environments prone to water logging or inundation. In Western Australia they often occur in sediments associated with fresh groundwater dependent wetlands and beneath the water table in podzolised sandy soil profiles.

In anoxic conditions ASS do not pose a significant risk to the environment, but when ASS are disturbed there is potential for iron sulfides in the soils to react with oxygen and produce sulfuric acid (DER 2015a). This can acidify the landscape and result in mobilisation of contaminants (commonly iron, aluminium and other metals) that can be transported to waterways, wetlands and groundwater. Construction activities with the greatest potential for disturbing ASS are excavation, temporary or permanent dewatering, compaction of saturated soils or sediments and lateral displacement of previously saturated sediments.

Most of the Proposed construction works will occur at or above grade and as such will avoid disturbing the ASS. However, significant excavations and dewatering are likely to be required for the dive structure at Tonkin Hwy and other infrastructure that requires deep foundations (e.g. piling structures) such as the stations and bridges. Given the Proposal requires temporary excavation and dewatering there is potential for construction activities to cause environmental impacts associated with the disturbance of ASS.

1.2. Purpose and Scope

The objective of this acid sulfate soils management strategy (ASSMS) is to outline the proposed approach for ASS management during implementation of the proposal. ASS management strategies proposed have been informed by DWER guidelines for the treatment and management of soil and water in acid sulfate soil landscapes (DER 2015b) and the Concept Design for the Proposal.

Once detailed design for the Proposal is complete, the Construction Contractor will prepare a more detailed ASSMP specific to construction activities required. The construction ASSMP will:

- be prepared in accordance with the DWER guidelines for treatment and management of soil and water in acid sulfate soil landscapes (DER 2015b)
- comply with the requirements of this strategic ASSMS.

2. Environmental Setting

The Development Envelope lies within the Swan Coastal Plain on the boundary between the Bassendean Dune System and the Pinjarra Plain. It is dominated by an undulating landscape of highly leached siliceous sand (Bassendean Sand) interspersed with poorly drained swamps in low lying depressions.

ASS in the Development Envelope were identified during a preliminary ASS investigation conducted late 2019 (Coffey 2020a). ASS risk in the region is attributed to wetland environments and ferruginous (iron rich) podzols associated with coffee rock in Bassendean Sands.

2.1. Surface Water

2.1.1. Surface Water

There are several wetlands and one watercourse that intersect the Development Envelope (Figure 1). The Department of Biodiversity, Conservation and Attractions (DBCA) Geomorphic Wetlands of the Swan Coastal Plain dataset shows the wetlands mapped in the Development Envelope include:

- A floodplain – a seasonally inundated alluvial plain associated with Bennett Brook
- Palusplains - seasonal waterlogged plains in low lying areas
- Sumplands – smaller patches of low land that form seasonally inundated basins

The DBCA has assigned management categories to these wetlands, which include:

- Multiple Use Wetlands (MUW) - wetlands with few important ecological attributes and functions remaining
- Resource Enhancement Wetlands (REW) - wetlands that may have been partially modified but still support substantial ecological attributes and functions
- Conservation Category Wetlands (CCW) - wetlands support a high level of ecological attributes and functions

CCWs are considered to have high existing conservation values. REWs are considered to be partially degraded and the focus of management is to restore their conservation value and hydrological/ hydrogeological regime. Three CCWs and four REWs occur within the Development Envelope (Table 1).

Table 1: Conservation Category and Resource Enhancement wetlands mapped within the Development Envelope

UFI	Management Category	Wetland Classification
15259	CCW	Floodplain
8728	CCW	Palusplain
8417	CCW	Palusplain
15752	REW	Palusplain
8806	REW	Palusplain
8678	REW	Sumpland
15757	REW	Sumpland

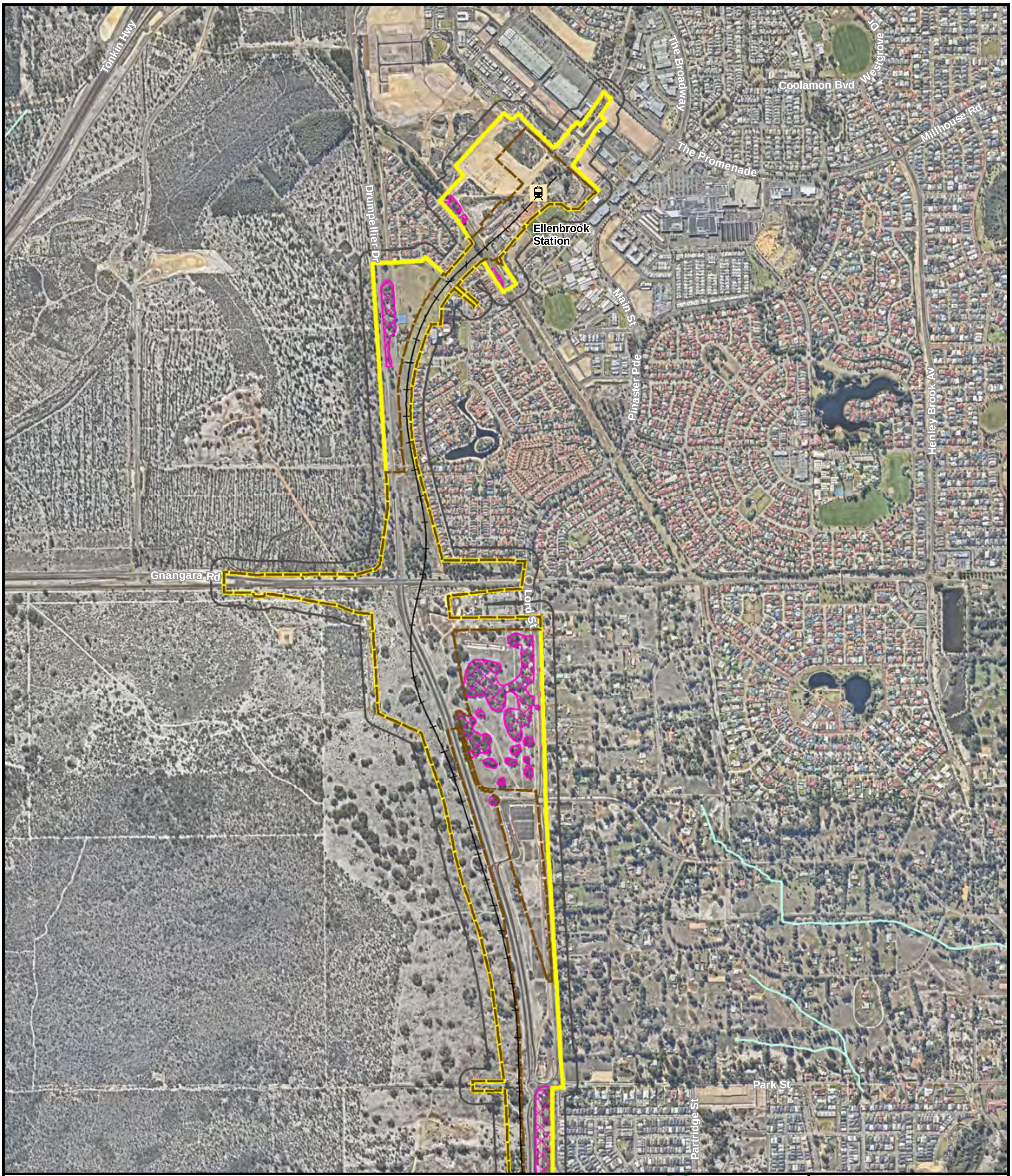

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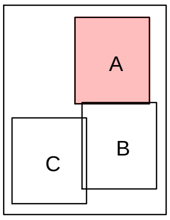
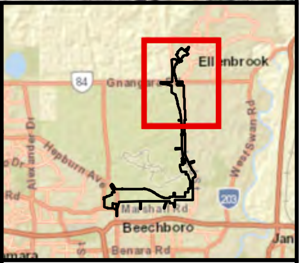
Figure 1A **Geomorphic Wetlands and Surface Water Features**

Public Transport Authority

Legend

- Development Envelope
- Development Envelope 50m buffer
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Indicative Railway Alignment
- Watercourse





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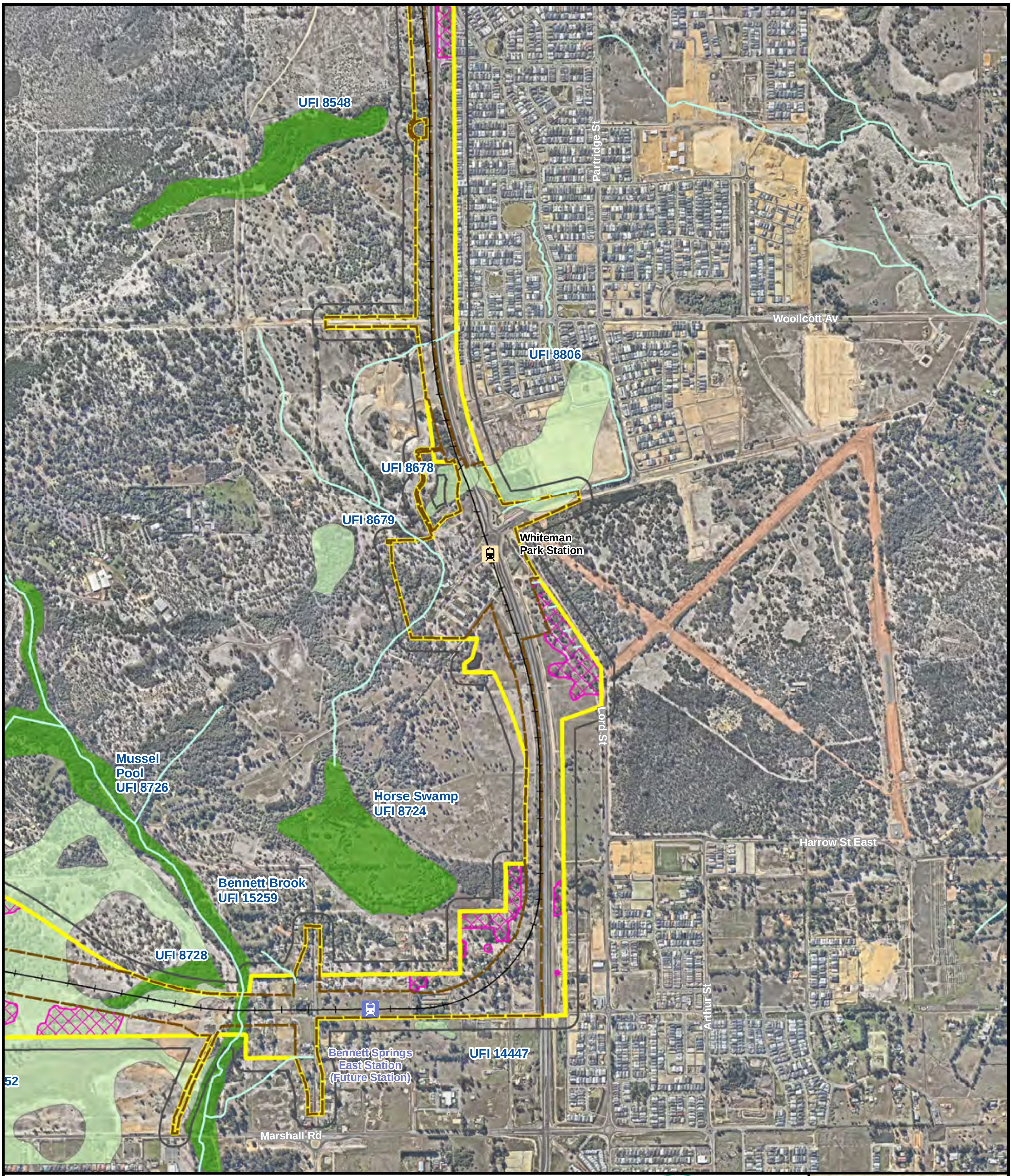

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Figure 1B **Geomorphic Wetlands and Surface Water Features**

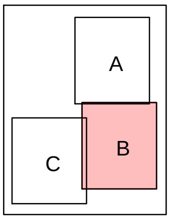
Public Transport Authority

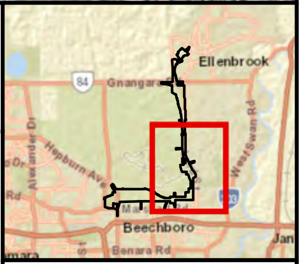
Legend

- Development Envelope
- Development Envelope 50m buffer
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment
- Watercourse

Geomorphic Wetlands

- Conservation
- Resource Enhancement





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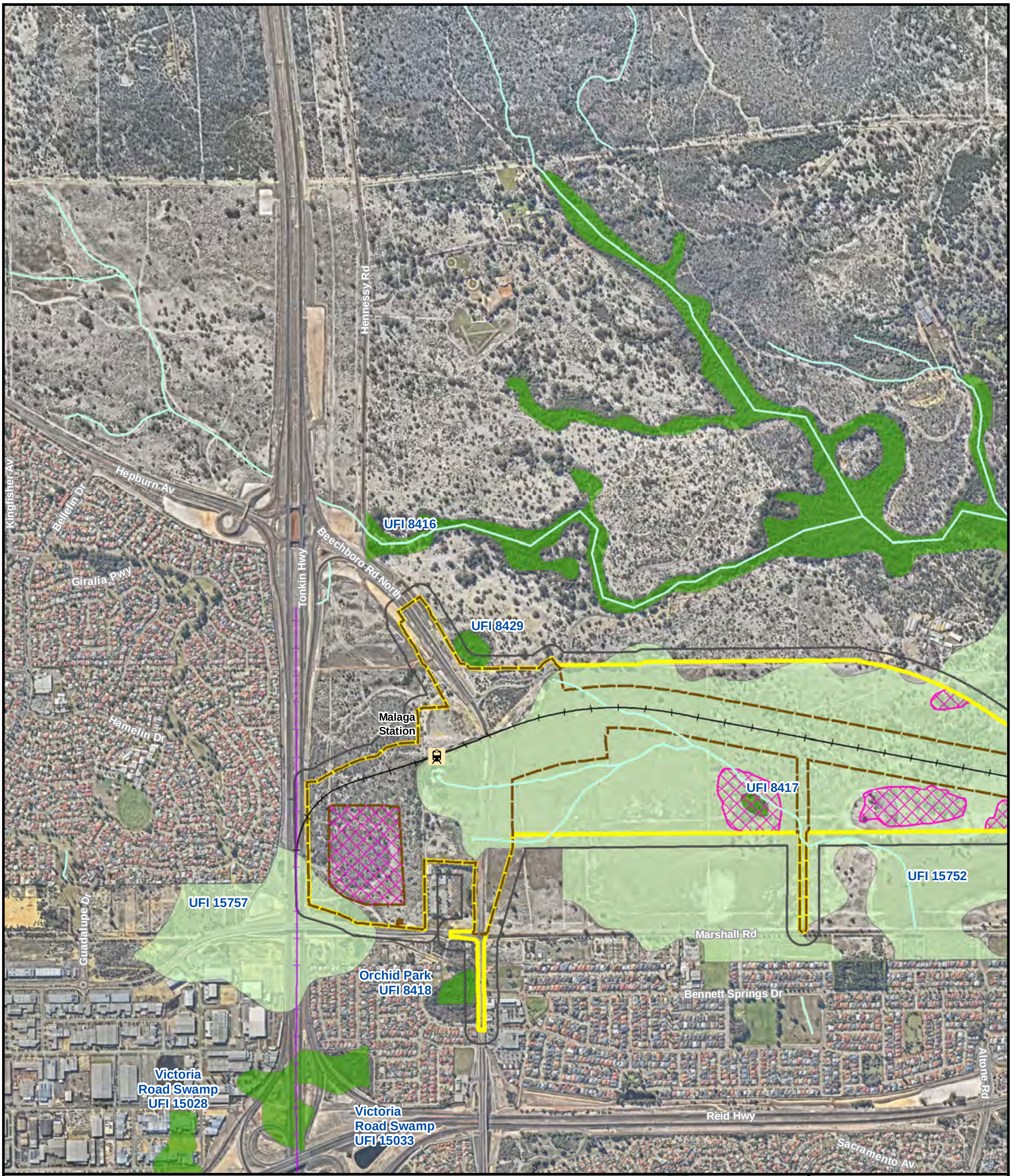

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Figure 1C **Geomorphic Wetlands and Surface Water Features**

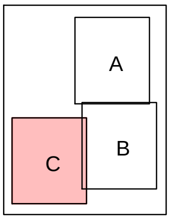
Public Transport Authority

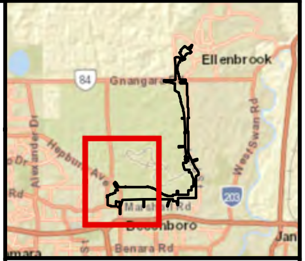
Legend

- Development Envelope
- Development Envelope 50m buffer
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Indicative Railway Alignment
- Watercourse

Geomorphic Wetlands

- Conservation
- Resource Enhancement





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The watercourse, Bennett Brook, is considered an ephemeral stream that only flows seasonally. In the drier months the water stops flowing, but typically continues to pool water in the river channel. There are some areas of localised drainage such as near Bennett Brook where surface water runoff drains towards the watercourse.

2.2. Groundwater

Hydrogeology underlying the Development Envelope comprises a shallow superficial aquifer that lies in transmissive Bassendean Sand deposits over the Mirrabooka, Leederville and Yarragadee aquifers. The thickness of the superficial aquifer ranges between 30 m and 55 m with an average of approximately 35 m (DWER 2019). The hydraulic conductivity of the Bassendean Sand ranges between 10 m/day and 50 m/day (Main Roads 2015).

Groundwater generally originates from the Gnangara Mound and flows across the Development Envelope in an easterly to southerly direction, discharging to Ellen Brook to the east or Swan River to the south (Coffey 2015).

2.2.1. Groundwater Levels

Results of recent groundwater monitoring conducted by Coffey (2020b) show that depth to groundwater within the Development Envelope ranges from 0.7 metres below ground level (mbgl) to 6 mbgl below ground level (Table 2). Given the unconfined nature of the superficial aquifer, groundwater levels change with seasonal rainfall patterns and recharge is rapid (Coffey 2015). Seasonally groundwater levels fluctuate by 0.72m to 1.25 (Coffey 2020b).

Table 2 Groundwater levels recorded along the Development Envelope

Proposal Location	Dry season (May 2019)		Wet season (Sep 2019)	
	m AHD	m bgl	m AHD	m bgl
Tonkin Highway Dive Structure Malaga Station Beechboro Road Bridge	29.1 to 30.1	2.1 to 3.3	29.8 to 30.9	1.2 to 2.6
Bennett Brook Crossing	12.5 to 16.6	0.9 to 2.1	12.6 to 16.9	0.7 to 2.0
Bennett Springs East Station (Future)	16.9 to 19.1	0.7 to 1.1	16.6 to 19.9	0.9 to 1.1
Whiteman Park Station	22.2 to 22.4	1.5 to 2.9	23.1 to 23.5	0.7 to 1.8
Gnangara Road Bridge	37.4 to 38.8	4.2 to 4.3	38.2 to 39.5	3.4 to 3.6
Ellenbrook Station	41.7 to 41.8	3.1 to 6.0	41.8 to 41.9	3.0 to 5.8

2.2.2. Groundwater Quality

Groundwater quality is influenced by existing and historic land uses, local geology, recharge and discharge zones and seasonal fluctuations in groundwater levels. Groundwater quality in the wider superficial aquifer is typically good, with salinity generally increasing, but remaining low, further from the crest of the Gnangara Mound, which is located approximately 15 km north of the Development Envelope (Coffey 2015).

A substantial amount of groundwater quality monitoring has been previously undertaken in the area, in particular for the NorthLink WA project. Nutrient levels have been found to vary and are influenced by land use (Coffey 2015). The NorthLink WA study found groundwater in the region is generally acidic with pH ranging from 4 to 6. Additional groundwater monitoring is currently underway to support planning and management of potential impacts of the Proposal.

2.2.3. Sensitive Groundwater Receptors

Sensitive groundwater receptors within the Development Envelope include:

- Priority 1, 2 and 3 Public Drinking Water Source Areas (PDWSA).
- Wetlands – CCWs and REWs
- Bennett Brook, a groundwater fed stream where groundwater levels are ultimately responsible for defining the hydrologic regime
- Banksia dominated woodlands of the Swan Coastal Plain TEC/PEC (Figure 9), where depths to groundwater are generally less than 5 m below ground level.

2.3. Geology

2.3.1. Regional Geology

The Development Envelope lies on the boundary between the Bassendean Dunes System and Pinjarra Plain. In this area deep Bassendean Sands are typically interfingered with Guildford Clays that are characteristic of the Pinjarra Plain (PPK 2002). The Bassendean Sands are commonly interspersed with wetlands that in dune swales and in Whiteman Park there is a small area where the Bassendean Sands are underlain by lacustrine sediments (lake deposits).

Bassendean Dunes

Bassendean Sand comprises basal conglomerate overlain by deep horizons of dune quartz sand with heavy mineral concentrations (Geological Survey of WA and Geoscience Australia 2008). These sands do not meet the traditional definition of ASS (DER 2015a). They are highly leached and contain no buffering capacity to neutralise the formation of acid and acid by-products.

In Bassendean Sand the amount of pyrite is generally low with chromium reducible sulfur levels commonly less than 0.02%S (DER 2015a). However, dewatering or other disturbance in these sands are known to result in acidification of the shallow groundwater aquifer and the mobilisation of iron, aluminium and other metals into the surrounding environment. Research suggests the primary source of this acidification is coffee rock, which forms by the precipitation of humates and iron from groundwater, mainly in the zone of watertable fluctuation.

Pinjarra Plains

Clayey sediments characteristic of the Guildford Formation are more common in the southeast towards Bennett Brook. Originally described as the Guildford Clays, the Guildford Formation comprises alluvial sand and clay with shallow-marine and estuarine lenses and local basal conglomerate (Geological Survey of WA and Geoscience Australia 2008). It consists mostly of grey and brown clays and silts that were deposited as coalescing alluvial fans at the foot of the Darling Scarp (Gozzard 2007). The Guildford Clays are known to be acid generating in nature. The clay forms a semi-confining layer within the superficial aquifer and is discontinuous in nature.

2.3.2. Local Geology

Soil sampling conducted throughout the Development Envelope has confirmed that the underlying geology is consistent with the regional geological setting (Coffey 2020). Underlying soils were dominated by Bassendean Sand, characterised by grey, brown and cream coloured silty sand and sand. Coffee rock was encountered at several locations and generally around the water table. Brown to pale brown clayey sands considered to be representative of Guildford Clays were identified at the base of some of the boreholes near Bennett Brook and Whiteman Park Station.

2.4. Soils

Soil landscape mapping by Purdie et al. (2004) shows the Development Envelope overlies the Bassendean and Pinjarra soil-landscape zones, which were described as:

- Bassendean Zone - mid-Pleistocene Bassendean sand, fixed dunes inland from the coastal dune zone, non-calcareous sands, podsolised soils with low lying wet areas.
- Pinjarra Zone - alluvial deposits (early Pleistocene to recent) between the Bassendean Dunes Zone and the Darling Scarp, colluvial and shelf deposits adjacent to the Darling Scarp. Clayey to sandy alluvial soils.

2.5. Acid Sulfate Soils

2.5.1. DWER Risk Mapping

DWER has published a series of ASS risk maps (Figure 2). ASS risk mapping shows that most of the Development Envelope has a ‘moderate to low risk of ASS occurring within 3 m of natural soil surface, but high to moderate risk of ASS beyond 3 m of natural soil surface’ (Class II ASS risk). Four areas are mapped as having a ‘high to moderate risk of ASS occurring within 3 m of natural soil surface’ (Class I ASS risk).

- north of the proposed Whiteman Park Station;
- north of the proposed Bennett Springs East Station (Future Station);
- two areas west of the proposed Bennett Springs East Station (Future Station); and
- the eastern most edge of the development envelope, in Malaga.

Areas with a high probability of ASS occurrence are generally limited to low lying areas that become seasonally water logged or inundated. Isolated peaty deposits associated with humic wetlands present a risk of net acid production from the oxidation of sulfide bearing minerals and organic materials, albeit the rate of generation is typically slower than that of the Bassendean Sand. Although the majority of Whiteman Park is classed as having a moderate to low risk of ASS being present, the likelihood of ASS being present may be higher given the presence of low-lying wetland areas and their associated sediments (Coffey 2020).

2.5.2. ASS Investigation

To ground-truth DWER ASS risk mapping and quantify ASS risk within the Development Envelope, a Preliminary ASS investigation was conducted in late 2019 (Coffey 2020). The ASS investigation included field sampling and analysis of soil from 28 boreholes to a maximum depth of 9 metres below ground level (mbgl). Sampling locations were designed to provide samples that were representative of soils throughout the Development Envelope and target areas that are either high risk (Class I ASS risk) or expected to require extensive disturbance (i.e. the dive structure at Tonkin Hwy and areas where stations and bridges need deep foundations).

Soil samples were submitted to an analytical laboratory for assessment of pH in deionised water as well as a peroxide solution to determine the presence of AASS and PASS. In accordance with DWER guidelines for the identification ASS, field pH (pH_F) and field peroxide pH (pH_{FOX}) results were used to identify samples where ASS may be present. Then selected samples were submitted for further analysis using the Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) suite and the Chromium Reducible Sulfur (CRS) suite to confirm if ASS were present.

ASS can be defined as actual ASS (AASS) or potential ASS (PASS) (DER 2015a). AASS are soils or sediments that contain iron sulfides or other sulfidic minerals that have undergone some oxidation. This results in low pH (less than 4) and often a yellow or red mottling. AASS contain existing acidity and unoxidised sulphide minerals that could acidify further (potential acidity). PASS are soils or sediments that contain iron sulfides and other sulfidic minerals that have not been oxidised. In their undisturbed state these soils have a higher pH that is above 4 and commonly neutral to alkaline (pH 7 to 9). These soils are commonly saturated with water.

The Proposal Development Envelope will take place in Bassendean Sands, which do not meet the traditional definition of ASS (DER 2015a). They are highly leached and contain no buffering capacity to neutralise the formation of acid and acid by-products. At the zone of groundwater fluctuation, the formation of ferruginous (iron rich) podzols known as coffee rock horizons are present and can be a major contributor to elevated iron concentrations in groundwater (Davidson 1995). The Department of Water and Environmental Regulation (DWER) recognises the Bassendean Sands as being of interest regarding ASS, due to being devoid of carbonate minerals and the potential to contain highly reactive pyrite (DER 2015a).

In Bassendean Sands the amount of pyrite is generally low with chromium reducible sulfur levels commonly less than 0.02%S (DER 2015a). However, dewatering or other disturbance in these sands are known to result in acidification of the shallow groundwater aquifer and the mobilisation of iron, aluminium and other metals into the surrounding environment. Research suggests the primary source of this acidification is coffee rock, which forms by the precipitation of humates and iron from groundwater, mainly in the zone of watertable fluctuation.

Results of laboratory analysis indicated that PASS was present in soils associated with coffee rock underlying Bassendean Sands throughout the majority of the Development Envelope. Coffey defined the extent of ASS occurrence as:

- Malaga Station (13,425 m) to Bennett Springs East Station (17,500 m) within coffee rock that may be encountered between 1.0 mbgl and 2.8 mbgl, dependant on topography. The maximum net acidity recorded was 0.393%S (Figure 3).
- North of Whiteman Park Station (17,800 m) to south of Ellenbrook Station (24,500m) within coffee rock that may be encountered between 1.25 mbgl to 2.1 mbgl dependant on topography. The maximum net acidity recorded was 0.073%S (
- Figure 4).

The underlying hydrogeological system has already undergone significant acidification. Groundwater pH indicated acidic to slightly acidic conditions and the presence of elevated concentrations of dissolved aluminium confirming that the system has been influenced by historical acidification. Groundwater beneath the Whiteman Park South and Lord Street sections possessed a low to moderate acid neutralising / buffering capacity. Concentrations of Titratable Alkalinity (TAlk) were generally greater in the vicinity of Ellenbrook, indicating some level of inherent buffering capacity.

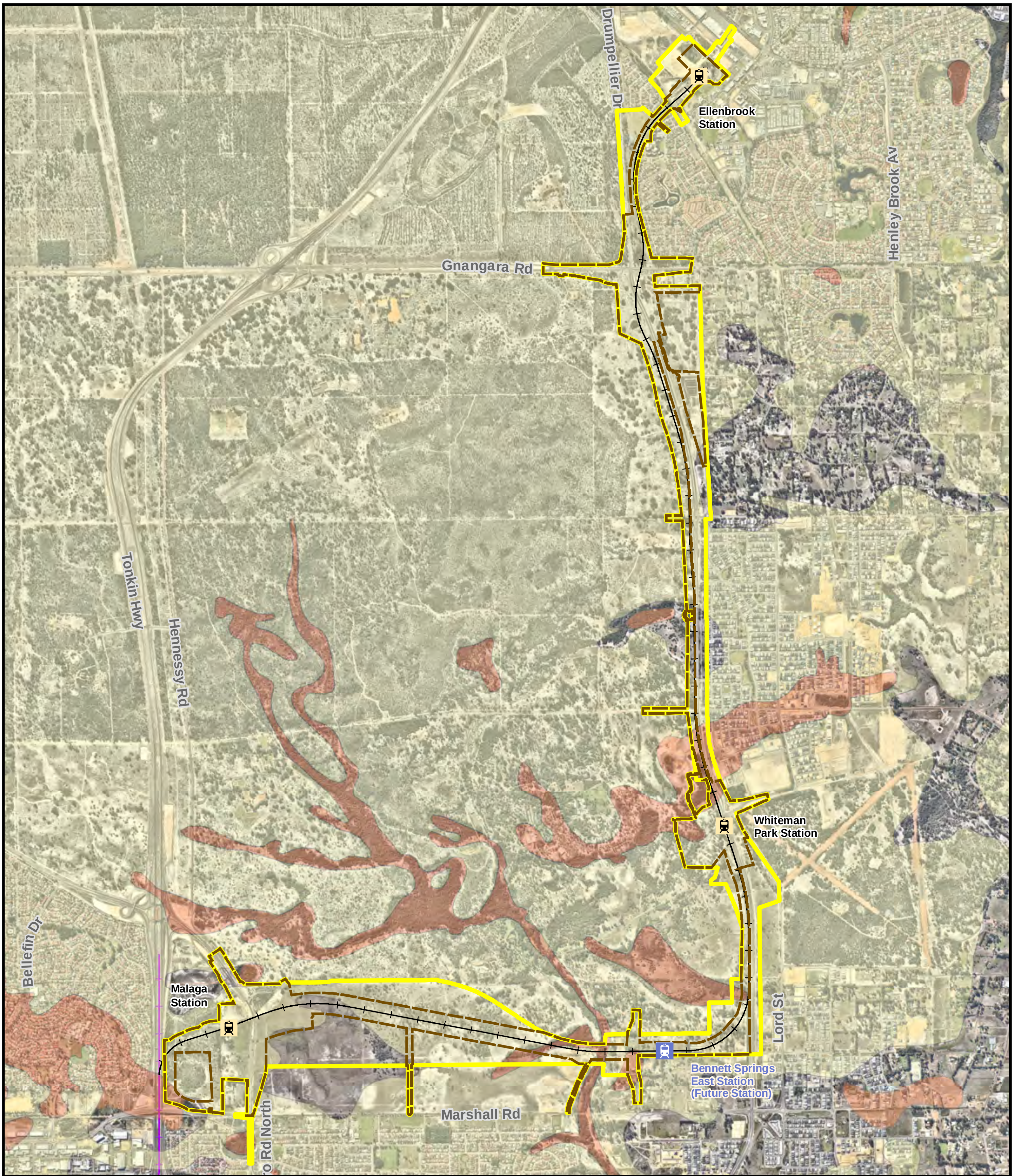

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Figure 2 **Acid Sulfate Soil Risk Map**

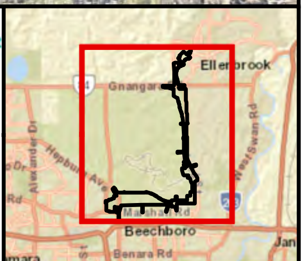
Public Transport Authority

Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

Acid Sulphate Soil Risk

- High to moderate risk
- Moderate to low risk



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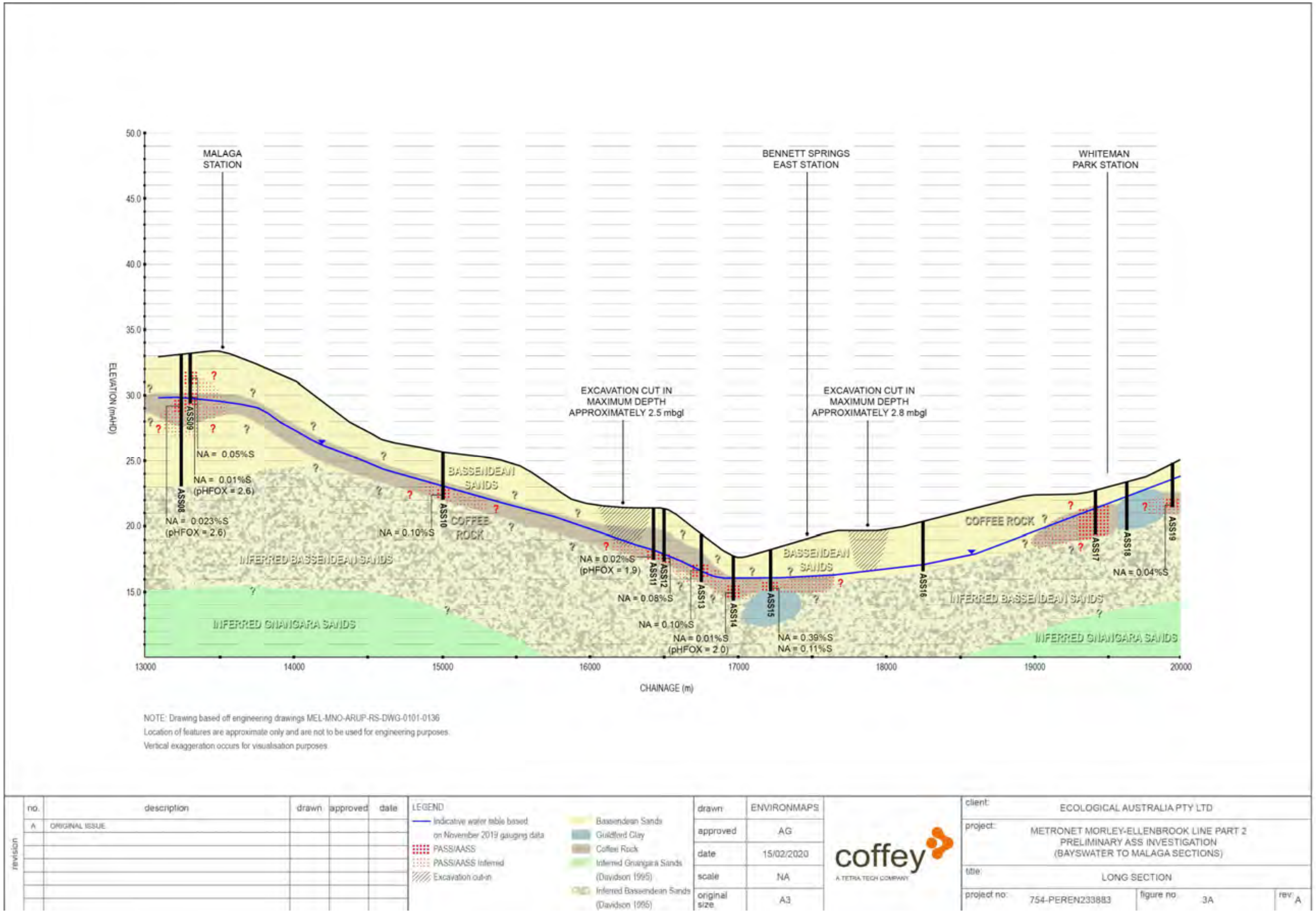

Figure 3 Inferred ASS profile and indicative ASS disturbance based on Concept Design between Malaga Station (13,425 m) and the future Bennett Springs East Station (17,500 m)

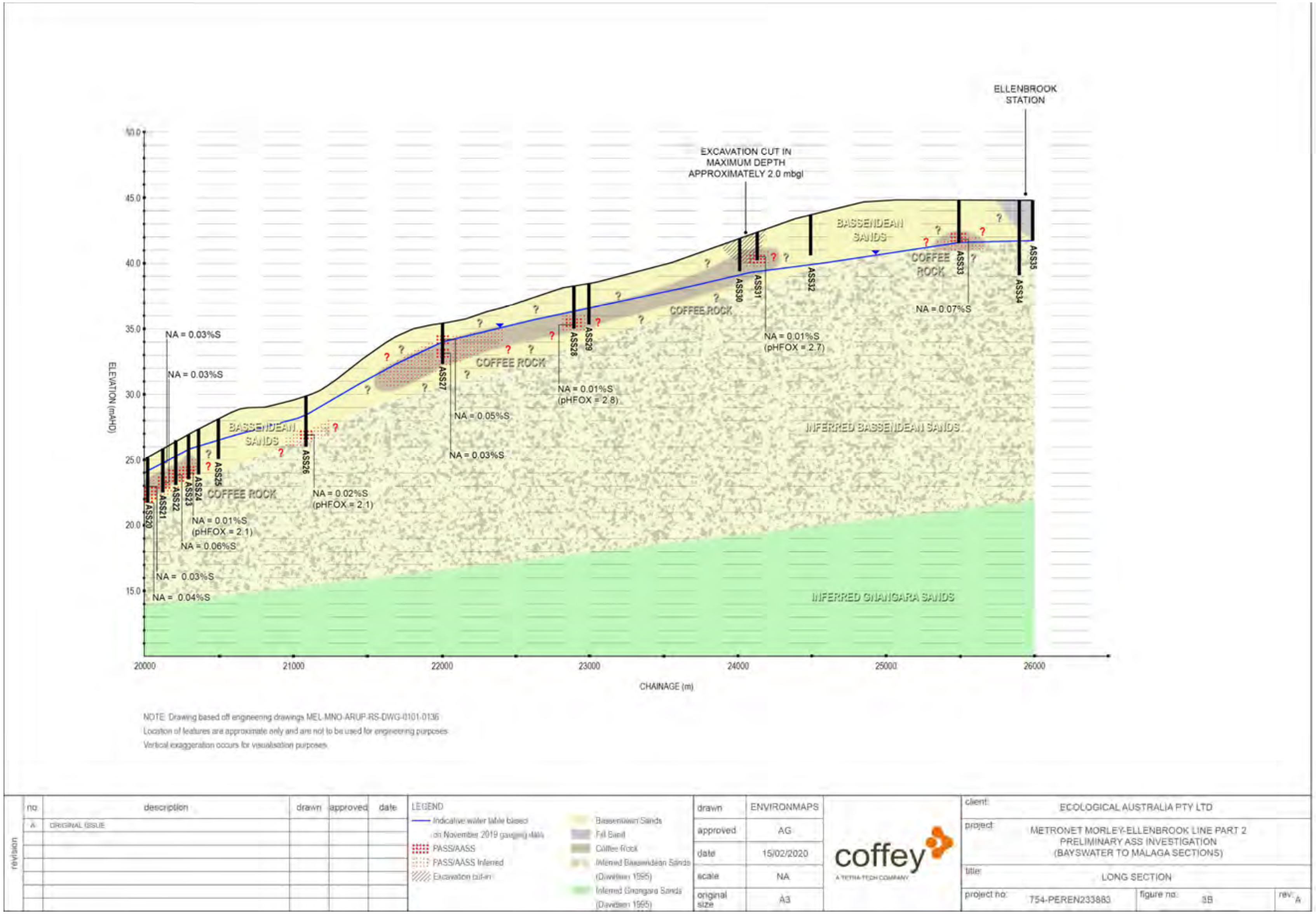

Figure 4 Inferred ASS profile and indicative ASS disturbance based on Concept Design from North of Whiteman Park Station (17,800 m) to south of Ellenbrook Station (24,500m)

3. Environmental Objectives and Targets

3.1. Environmental Objective

The objective for ASS management is to prevent significant acidification or release of contaminants to the surrounding environment.

3.2. Environmental Targets

The performance targets for ASS management include:

- Appropriate treatment of all excavated ASS prior to reuse on site.
- Appropriate treatment of dewatering effluent prior to discharge to the environment.
- No significant changes to surface water or groundwater quality attributable to disturbance of ASS during implementation of the Proposal.
- No unacceptable impacts to groundwater attributable to ASS disturbance i.e. deterioration of water quality.

4. Management

Management strategies required to adequately mitigate risks to the environment will be determined once detailed design is complete and defined in an ASSMP prepared and implemented by the Construction Contractor. The sections below identify key management strategies that are expected to be implemented as part of ASS management during earthworks and dewatering.

4.1. Earthworks

4.1.1. Identification of ASS

The Preliminary ASS investigation identified soil types that contain ASS as soils associated with coffee rock encountered:

- at 1.0 mbgl - 2.8 mbgl between Malaga Station (13,425 m) and the future Bennett Springs East Station (17,500 m)
- at 1.25 mbgl to 2.1 mbgl from north of Whiteman Park Station (17,800 m) to south of Ellenbrook Station (24,500 m)

These soils should be managed as ASS during earthworks. However, it is recognised that in Bassendean Sands dewatering or other disturbance of soils with low chromium reducible sulfur levels (i.e. less than 0.02%S) can also result in acidification of the shallow groundwater and mobilisation of iron, aluminium and other metals. Consequently, earthworks and dewatering will be minimised where practicable.

It has also been noted that the preliminary ASS investigation did not investigate potential ASS below 9 m from the soil surface. Further ASS investigations will be conducted prior to any earthworks deeper than 9 mbgl and management of any additional ASS identified will be managed using the Construction Contractor's ASSMP.

4.1.2. Excavation and Stockpiling of ASS

During excavation of ASS, management strategies implemented should include:

- Excavated soil not considered to be ASS should be segregated from ASS material.
- Excavated ASS should be segregated from non-ASS and stockpiled on a bunded pad constructed using limestone. DWER recommends a bund height of 300mm.
- The limestone pad and bund should be designed so that it is sufficient to hold anticipated ASS volumes.
- Where practicable, the limestone pad should be graded to direct and contain runoff within the bunded treatment pad area.
- Untreated coarse textured soils (sands to loamy sands) should not be stockpiled for more than 18 hours without treatment.

4.1.3. Treatment of ASS

All excavated ASS will be treated (neutralised) using a neutralising agent such as Aglime. All ASS should be adequately neutralised and validated prior to re-use or backfilling regardless, of the duration of stockpiling.

Neutralising material will be thoroughly mixed with the soil at a liming rate sufficient to neutralise potential acidity generated by ASS present. Based on the results of the ASS investigation, liming rates for ASS treatment are expected to be 8 or 45 kg/m3 depending on location (Table 3). Table 3 identifies indicative liming rates for the project, however specific liming rates will be revised in each project sub-area based on further investigation prior to commencement of construction. These liming rates assume a DWER safety factor of 1.5 and average soil density of 1.6 tonnes/m^3. Liming rates should be reviewed and updated once the source and specifications of the neutralising material are confirmed.

Table 3: Indicative liming rates

Location	Inferred Extent – Approx. Chainage (m)	Maximum Net Acidity (%S)	Liming Rate (kg/m^3)
Malaga Station to (future) Bennett Springs East Station	13,425 – 17,500	0.393	45
North of Whiteman Park Station to South of Ellenbrook Station	19,700 – 25,400	0.073	8

4.1.4. Disposal of ASS

Treated ASS can be reused on site or disposed of at a facility licenced to receive and treat ASS. It is preferable for these materials to be reused on-site where practicable, in line with PTA's waste management strategy. Soils to be reused on site should be tested to confirm the soils have been adequately treated prior to reuse.

Untreated ASS may be removed off-site to a licenced treatment facility as 'ASS special waste'.

4.2. Dewatering

During dewatering of ASS, management strategies to implemented should include:

- Where practicable, dewatering should be staged to minimise oxidation of ASS.
- Dewatering effluent should be monitored in accordance with Table 6 of DER (2015b), with appropriate contingencies in place to manage changes in effluent quality.
- No effluent should be discharged to adjacent water bodies or stormwater drainage without prior regulatory approval.
- The size of the dewatering settlement basin should be sufficient to hold the calculated volume of water and provide a minimum retention time of six hours.

  Effluent should be returned to the shallow aquifer where practicable, however alternative discharge strategies (e.g. discharge to sewer) may be utilised where approval is in place to do so. In the event that space constraints limit the use of shallow infiltration basins, or offsite disposal to sewer is inadequate to manage dewatering volumes, consideration of alternative methodologies (including aquifer recharge) will be made on a case by case basis.

- A groundwater (and if required, surface water) monitoring programme should be undertaken to detect changes in water level and quality related to the site works, and inform the deployment of contingency measures, if required.
- Prior to decommissioning settlement ponds used for treated effluent, sediments that accumulate in the pond should be tested to determine suitable disposal options.
- If sub-soil drainage is used to maintain a separation distance between rail infrastructure and the groundwater table then seepage produced by sub-soil drainage may require treatment and appropriate disposal or recharge into the aquifer.

5. Monitoring

5.1. Validation of ASS Treatment

Validation testing of treated ASS will be conducted to confirm ASS have been effectively treated to neutralise potential acidity prior to being reused on site for purposes such as backfilling. If soils fail validation, then additional neutralising material will be mixed through and the soils will be retested. This process will continue until soils meet performance criteria.

5.1.1. Sampling and Analysis

Validation testing will be undertaken using field testing at a sampling intensity consistent with the DWER Landfill Waste Classification and Waste Definitions (DWER 2019).

Analyses used for validation will include:

- Testing all samples for pHF and pHFOX.
- Confirmatory analysis of 25% of the field samples using the SPOCAS and / or the CRS suite.

5.1.2. Performance Criteria

Performance criteria for validation testing will be defined in the Construction Contractor's ASSMP and should be consistent with DWER guidelines that recommend:

- Neutralising capacity of treated soils exceeding the existing plus potential acidity of soil.
- Neutralising material has been thoroughly mixed through soil.
- Soil pH of 6.0 – 8.5.
- Excess neutralising material within the soil until all acid generation reactions are complete and soil has no further capacity to generate acid.

For Bassendean Sands it is also recommended that total potential acidity is less than limits of reporting.

5.2. Dewatering

5.2.1. Dewatering Effluent Monitoring

Dewatering effluent will be monitored to determine if it requires treatment. When dewatering effluent is treated it will be monitored before and after treatment to determine if treatment has effectively neutralised acidity in the water.

Trigger levels, management actions and associated monitoring recommended by DWER vary depending on whether or not the dewatering zone of influence (i.e. cone of depression) is less than or greater than 50 m. The dewatering zone of influence will be determined during detailed design conducted by the Construction Contractor. Once dewatering requirements have been defined the dewatering effluent monitoring programme will be developed and defined in the Construction Contractor's ASSMP.

To ensure acidic effluent is not being generated by the Proposal, it is expected that dewatering effluent monitoring will include daily monitoring for field parameters and fortnightly laboratory analysis of pH, EC and total titratable acidity. Results will be compared against DWER ASS criteria (DER 2015b).

5.2.2. Dewatering Basin Sediments

Settlement ponds used for dewatering have potential to accumulate sediments with elevated concentrations of contaminants such as metals (e.g. iron and aluminium) that precipitate in response to changes in pH caused by lime dosing. Prior to decommissioning settlement ponds, sediments will be tested to determine suitable uses for the materials. Where practicable these materials will be reused or buried on site. If required, these materials may be remediated for reuse on site or disposed of offsite at a licensed landfill.

5.3. Groundwater and Surface Water Monitoring

Groundwater (and if required, surface water) monitoring will be undertaken at the site to assess water level and quality against defined performance criteria for the protection of relevant receptors. The programme will include a baseline assessment to identify appropriate performance criteria, followed by monitoring during and post construction.

The water monitoring programme will be developed based on the detailed design to be completed by the Construction Contractor and defined in the Contractor's ASSMP. The Construction Contractor's ASSMP will include:

- Monitoring locations
- Frequency of monitoring
- Water quality parameters to be monitored – these are expected to be based on DWER ASS criteria defined in the guidelines (DER 2015b)
- Triggers, performance criteria and relevant management actions

5.3.1. Monitoring Before Construction

Water monitoring will be conducted prior to construction to establish a baseline for monitoring during ASS disturbance. It is expected that this will include at least one round of monitoring prior to dewatering to ensure baseline data is representative of conditions at the commencement of construction. Where practicable, this monitoring should be conducted within four weeks prior to construction.

5.3.2. Monitoring During Construction

Groundwater and surface water will be monitored during construction in accordance with DWER ASS guidelines (DER 2015b).

5.3.3. Monitoring After Construction

Following construction, six months of groundwater monitoring events will be undertaken to confirm there are no short-term or medium-term impacts on groundwater.

6. Contingency Actions

The Construction Contractor's ASSMP will include contingency that will be implemented if monitoring indicates that performance targets are not being achieved. Contingencies should be specific to performance criteria. For example, if soil validation or dewatering effluent monitoring indicates that ASS parameters are not sufficiently neutralised then liming / dosing rates should increase.

7. Roles and Responsibilities

The Construction Contractor's ASSMP will define roles and responsibilities for ASS management and monitoring during implementation of the Proposal. It is anticipated that the Construction Contractor will be responsible for all aspects of ASS management during construction. The PTA may be responsible for groundwater and surface water monitoring required before and after construction.

8. Review and Reporting

Accurate records will be kept for ASS management and monitoring conducted.

Compliance monitoring and reporting requirements will be defined in the Construction Contractor's ASSMP, which will be reviewed and revised as required to account for changes needed to achieve performance objectives (e.g. implementation of additional management actions).

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