Appendix B **Site and Soil Evaluation**

VA & MP Wright & Son

LOT 564 GARVEY ROAD

SUBDIVISION SITE-AND-SOIL EVALUATION (SSE)

June 2024

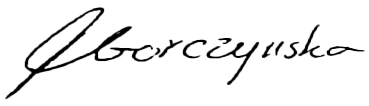
11207-G-R-003 Rev1

WML

Consulting Engineers

Document History and Status				
Revision	**Prepared By**	**Reviewed By**	**Purpose of Issue**	**Date**
0	Bidhan B	Raphael H	For issue	12/03/2024
1	Aleks G	Raphael H	Issued to Client	19/06/2024

Issued to:	Ross Wright, Ashlee Rose, Kylie Shaw
WML Project Number:	11207
Document Name:	11207-G-R-003 Rev1



Aleksandra Gorczynska
Senior Geotechnical Engineer
Author
For and on behalf of WML Consultants Pty Ltd

Raphael Hyde
Senior Geotechnical Engineer
Reviewer

CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

WML Consultants has undertaken a Site-and-Soil Evaluation (SSE) for the proposed subdivision and residential development at Lot 564 Garvey Road.

The Site-and-Soil evaluation has been prepared to assess the suitability of the subject land for on-site effluent disposal, provide recommendations for the site and soil improvement as well as recommend setback distances to ensure effluent disposal is managed in accordance with the Government Sewerage Policy 2019 and the Australian and New Zealand Standard AS/NZS 1547:2017.

Generally, the site in its current condition is unsuitable for on-site effluent disposal and will require significant site improvement to ensure that the risk of environmental contamination is reduced as far as practicable. The main constraining factors for the subject land are the site's location within a sewerage-sensitive area and the high recorded peak groundwater levels.

Based on the assessment within this report, WML recommends the following to support on-site treatment and disposal of effluent in accordance with GSP 2019 and AS/NZS 1547:2017:

1 Ensure proposed Lots have a minimum size of 1 ha.
2 Elevate the land application area (LAA) using imported sandy loam, or site-won sand, to provide a minimum 1.5 m vertical separation between the peak groundwater level and the invert level of the application system.
3 Treat wastewater to a secondary level using a Secondary Treatment System (STS) with nutrient removal utilising a subsurface application system.
4 Position on-site effluent disposal as far as practicable from inundation areas and drainage channels, along with the above measures, to minimise the environmental impact.

Three zones have been identified within the site (Zones 1-3) based on the subsoil profile and thickness of sand overlying sandy CLAY/ CLAY. Setback distances and land application areas (LAA) have been assessed based on site-won materials or imported sandy loam to elevate the land application system with a soil classification of Category 1 for Zone 1 and Category 3 for Zones 2 and 3 as per GSP 2019. Therefore, setbacks should be considered minimum requirements for each identified land area.

Preferred land application areas (LAAs) have been included for each lot based on the subsurface profile, restrictions due to setbacks and the presence of waterlogged areas. The size and position of the preferred LAAs have been recommended assuming site and soil recommendations within this document are adhered to. It should be noted that alternative LAAs are appropriate; however, specific assessments will be required for the nominated area.

The findings of this Site-and-Soil evaluation are based on groundwater data collected from monitoring wells, historical data and site images and the contour survey provided by Harley Dykstra.

There are ongoing landowner obligations to ensure that the operation and management of the treatment and disposal systems are regularly maintained in accordance with relevant health regulations and manufacturer’s recommendations.

1 INTRODUCTION

WML Consultants Pty Ltd (WML) has been engaged by VA and MP Wright and Son (the Client) to undertake a Site-and-Soil Evaluation (SSE) for Lot 564 Garvey Road, Crooked Brook (the site). This report summarises the two stages of fieldwork investigation (May 2023 and November 2023), testing, and groundwater monitoring of the WML installed monitoring wells. This data is used to assess the sub-surface and surrounding site conditions and provide recommendations for on-site wastewater management systems and relevant setback distances in accordance with the Government Sewerage Policy 2019 and the Australian and New Zealand Standard AS/NZS 1547:2017.

The recommendations within this report are based on the approved lot locations and sizes on the 'survey map drawing '23585-02C CONCEPT PLAN OPTION C' by Harley Dykstra.

During the geotechnical investigation, several distinct areas were noted based on differences in landform, subsurface profile (soil category), depth to peak groundwater levels and, therefore, the constraints on on-site effluent disposals and treatment systems. General information has been provided on Drawings 11207-G1-DG-002 and 11207-G1-DG-003, detailing the distinct areas across the site, non-development areas for on-site disposal and the location of investigation boreholes. As the proposed lot layout is confirmed, or if the layout is changed, recommendations within this report will need to be reassessed.

1.1 Background

The two stages of investigation aimed to characterise the sub-surface profile of Lot 564 Garvey Road and provide a geotechnical assessment and recommendations for site classification and suitability for development. The first investigation primarily included the installation of 10 groundwater monitoring wells across the site to inform geotechnical and environmental design. The investigation results are presented in the report titled *"Lot 564 Garvey Road – Geotechnical Investigation, "* located in Appendix B. In addition, the data from this investigation, including the soil logs, encountered groundwater levels, and laboratory testing, have been summarised in Section 3, and have been used to undertake the suitability assessment of the in-situ soils for on-site effluent disposal.

1.2 Site description and proposed development

The proposed subdivision is between Garvey Road and Holland Loop, west of Dardanup, WA. The site is approximately 12 km southeast of Bunbury and has a total area of 40.52 ha. The subdivision plan encompasses the entire lot and consists of twenty (20) residential lots ranging in size from 1.008 ha to 3.97 ha. The differences across the site have divided the subject land into three (3) areas, with a slight variation in site remediations, soil improvement and setback distances. Each proposed lot has been assigned to an area requiring different remediation measures based on the site constraints present.

The landform can generally be described as flat with a slope gradient of <1% with some sand dunes/ridges across the site. These sand dunes/ridges are gently sloping with an approximate 3-5% gradient. The sand ridge is elevated approximately 1.0 – 3.0 m above the surrounding land with approximately a 5% slope. The lowest and highest elevation points on site, based on the desktop study, are 24 m AHD and 30 m AHD. Generally, the site has a higher elevation towards the north, closer to Garvey Road. A man-made pond approximately 50 m x 20 m has been constructed in the centre of the site (on Lot 14), and historical images reveal some alluvial channels within the site leading to the pond. An open drain runs through the western boundary on Lot 13 and diagonally runs mid-way through Lots 15 and 16.

Seasonal inundation has been noted across most of the site, with groundwater expected to be at the surface or ponding above the ground at some locations. Most of the lot comprises grass-covered paddocks and cleared land with some medium to large trees located mostly along the NW on Lot 10-12 and Lot 19-20.

1.3 Supporting documentation

The Client has made the following information available to assist in preparing this report.

- ‘23585-02C CONCEPT PLAN OPTION C’ drawing by Harley Dykstra
- Landgate Map of Lot 564
- ‘23858-01A Contour Survey’ by Harley Dykstra

1.4 Report objectives

The objectives of the site-and-soil evaluation were to:

- Review the available geotechnical and geo-environmental historical information for the subject land.
- Assess the features of the site in relation to effluent disposal.
- Assess the soil of the site in relation to effluent disposal.
- Assess the overall suitability of the site for effluent disposal according to the Government Sewerage Policy 2019 and AS/NZS 1547:2012.
- Provide land application area (LAA) and setback distances in accordance with the above policies.
- Provide recommendations for soil and site remediation if required.

2 SITE ASSESSMENT

2.1 Site key features

The site's key features in relation to the effluent management for subdivision lots are summarised in Table 1 below. The assessment has been based on several distinct areas with different subsurface soil conditions and is to be applied to the relevant lots. These are shown on Drawing 11207-G1-DG-002. Additionally:

- Most of the site can be considered flat, with an approximate gradient of 1-3%. Sand dunes/ridges have an approximate slope of 3-5%.
- The entire site is located **within a sewerage-sensitive area**, the estuary catchments on the Swan and Scott Coastal plains.
    - All lots requiring on-site effluent disposal must have a minimum lot size of 1 ha.
    - A minimum vertical groundwater separation of 1.5 m from the base of any on-site effluent disposal is required for all lots in accordance with GSP 2019.
    - Effluent must be treated to a secondary level using a secondary treatment system with nutrient removal.
- There is no published information regarding the FPM Extent of Flooding. However, based on the nearest data, the site is not within a 1-100 AEP floodplain area. The closest floodplain area is approximately 2.5 km northwest of the Lot boundary (DWER-WAWA DI99/AN59: Preston River Flood Study 1% AEP).
- No public drinking water sources are located on-site or within 100 m of the site. The nearest public drinking water source is approximately 700 m east of the subdivision (Public Drinking Water Source Areas Boundaries: Dardanup Water Reserve).
- The Lot 564 is not within 1 km of significant wetlands.

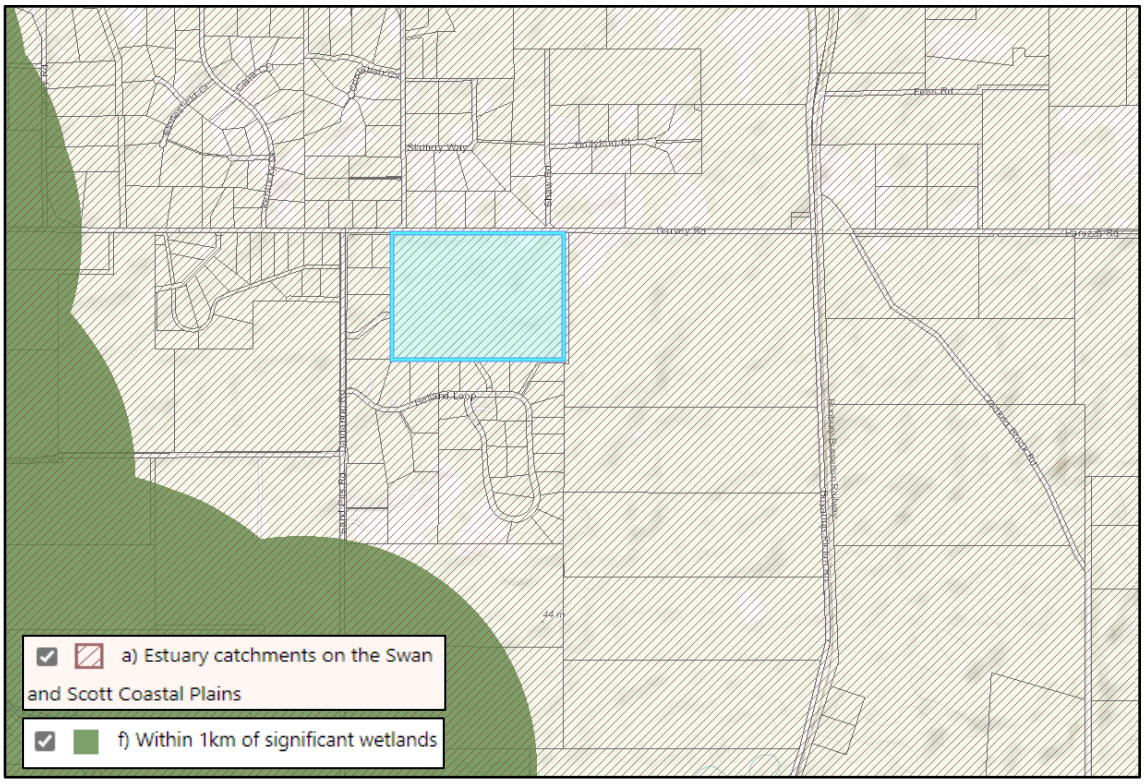


Figure 1: Local wetland and sewerage sensitive areas (Extract from Natural Resource Information, DPIRD)

Table 1: Site assessment

Feature	Description	Level of Constraint	Mitigation Measures
Sewerage Sensitive Areas	All lots are within the Swan and Scott Coastal Plain estuary catchment, a sewerage-sensitive area.	High	A minimum vertical separation of 1.5 m to groundwater is required (GSP, 2019). The land application area should be elevated using suitable site-won/imported fill material. Any imported fill material should be loamy sand (sand with a clay content between 5-10%) and achieve a minimum PRI of 20. Implementation of secondary treatment systems with nutrient removal is required. In accordance with GSP 2019, any lot requiring on-site effluent disposal must have a minimum lot size of 1 ha.
Climate	The average annual rainfall is 888.7 mm (BOM Marriwood Climate Station No 009629). The estimated average annual pan evaporation is 1500 mm (BOM pan evaporation maps).	Low	NN
Drainage	The subject land is typically defined as low, flat areas prone to inundation during the wet season. Sand dunes/ridges are typically comprised of moderately draining materials. The general subsurface materials are sand topsoils with trace fines, underlain by sandy clays. Sandy clays (below the sand) create a semi-impermeable layer. Permeability testing of shallow soils (sands with trace to some fines) indicate the soils to be moderately-high free-draining (0.17 – 2.2 m per day). Due to the underlying clay materials, it is expected that perched groundwater will be present during most of the year.	Moderate	NN, the elevation of LAA to satisfy 'Sewerage Sensitive Area' requirements to address this feature.
Watercourses	A drainage channel runs diagonally along between the southern and western boundary, then along the majority of the western boundary. A watercourse/river is located approximately 2.5 km west of the Lot boundary.	Low	Appropriate setbacks should be implemented as described within this report.
Surface waters	Surface water has been noted within the site. The existing artificial pond is located in the centre of the site located in Lot 13.	High	Appropriate setbacks should be implemented as described within this report. In addition, secondary treatment to

Feature	Description	Level of Constraint	Mitigation Measures
	Standing water is expected across 50-75% of the site during the wet season and following high rainfall events.		reduce nutrient output is recommended to mitigate contamination. A non-development area within 40 m of the pond is required. Lot build-up using imported material is likely required to provide adequate separation between surface water and the treatment system. See Section 4 for detailed recommendations. Where possible, position LAA outside of expected inundation areas.
Erosion & Landslip	No signs of erosion or landslips were noted.	Low	NN
Exposure & Aspect	Most sites have no physical structure to impede wind exposure and typically have no distinct aspect direction.	Low	NN
Flooding	The area is not located within a 1:100 AEP flood plain area (no published data for nearby watercourses).	Moderate	Lot build-up using imported material is likely required to provide adequate separation between surface water and the treatment system. See Section 4 for detailed recommendations. Where possible, position LAA outside of expected inundation areas. Where not possible, position LAA furthest distance from open drains and, where possible, should drain away from open channels and drains.
Groundwater	Groundwater is expected to be within 0.9 m bgl or above the natural ground surface for approximately 80-90% of the site during the wet season. Peak groundwater levels exist in some areas above the natural ground level (approximately 0.2 m). In the areas where existing sand dunes/ridges are located (BH7), groundwater wasn't noted to the depths of 2.5 m from the ground surface during peak wet weather.	High	Most of the development areas (residential construction and land application area) will need to be elevated to provide a minimum groundwater separation of 1.5 m from the base of the effluent treatment systems.
Imported Fill	No imported fill was identified on-site.	Low	NN

Feature	Description	Level of Constraint	Mitigation Measures
Landform	The proposed development area is considered relatively flat for most of the subject land area with some high points (sand dunes) mostly on the northern part of site, with typical elevation range from 24.0 m AHD to 30 m AHD.	Low	NN
Rocky Outcrops	No rocky outcrops were noted on site.	Low	NN
Run-on & Runoff	Some surface run-on and run-off would be expected towards the onsite pond located on proposed lot 14.	Low	Sub-surface application of effluent is recommended.
Slope	The proposed development area is typically based on a < 1% slope, with 3-5% slopes at the elevated sand dunes/ridges.	Low	Sub-surface application of effluent is recommended.
Vegetation	The site is typically covered in grass with some of medium to large mature trees on Lot 10-12 and Lot 19-20.	Low	NN

Note: NN – Not Needed

2.2 Site Assessment Results

Based on the observed site features, the overall land capability of the subdivision to suitably manage effluent is not satisfactory in its current condition. Therefore, bulk earthworks are likely required to ensure the lots provide a minimum vertical separation of 1.5 m from the base of any subsurface effluent disposal treatment system to peak groundwater levels. The following mitigation measures are a summary of Table 1 above and are recommended for all proposed lots to ensure that the risk of environmental contamination is reduced as far as practicable in accordance with the GSP19 and AS 1547:

1. A minimum of 1 ha lot size will be required for all on-site effluent disposal (currently met based on the provided lot layout).
2. Treatment of the generated wastewater to a secondary level with a Department of Health approved secondary treatment system (STS) with nutrient removal is required. However, the client's final selection of the system should be undertaken from the list of approved Department of Health Secondary Treatment Systems. It should achieve a minimum nutrient output of:
    a. 20 mg/L of Biochemical Oxygen Demand (BOD)
    b. 30 mg/L of Total Suspended Soils (TSS)
    c. 10 cfu/100mL of Escherichia (E) coli
3. Site build-up (elevation of the entire lot or LAA) will be required for most of the proposed lots (potentially not required for lots proposed on sand dunes/ridges where groundwater separation is greater than 1.5 m) to ensure a minimum 1.5 m vertical separation between the base of the disposal system and peak groundwater during the wet season. The material used to elevate LAAs can be sourced from on-site or imported materials. The following criteria and material recommendations should be adopted.
    a. For site-won materials (SANDS with trace fines sourced from dunes/ridges), additional amelioration of soils is required to improve the nutrient retention ability of the soils (to achieve a minimum PRI of 20). This would involve mixing the soil with 5-10% of clay
    b. Imported fill material should be loamy SAND (SAND with a clay content between 5-10%) and achieve a minimum PRI of 20.
4. For Lot 13, the Land Application Areas (LAAs) should be placed so that effluent disposal drains away from the surface water (existing pond) and at the highest elevation where possible.
5. Due to the moderately draining sub-soils, sub-surface application of the effluent once the LAA is built up is recommended for all lots. No application areas should be installed on a slope greater than 30%.

3 SOIL ASSESSMENT

WML Consultants undertook a geotechnical investigation for the entire subject land in May and November 2023. The investigation results are presented in the report titled *"Lot 564 Garvey Road – Geotechnical Investigation"* (document number 11207-G-R-002 Rev1), which is attached to this report in Appendix B. The following sections summarise the geotechnical information and laboratory testing within the report. The findings of this investigation have been assessed to inform the site and soil evaluation and provide recommendations and setback distances for the design and implementation of effluent disposal systems in accordance with the Government Sewerage Policy 2019 (GSP19) and the Australian Standard 1547:2018 "On-site domestic Wastewater Management" (AS 1547).

3.1 Fieldwork

WML Consultants undertook two stages of the fieldwork in May and November 2023. The work consisted of a total of 15 machine-augured boreholes to a maximum depth of 5.5 m using an ute-mounted drill rig and installing groundwater monitoring wells. Test locations were positioned to provide a broad spread of information for the subject land. Three (3) in-situ permeability tests (Talsma-Hallam method) were undertaken across the site. In addition, representative materials were sampled to confirm the visual geotechnical assessment of soils and undergo environmental testing for nutrient retention.

The approximate location of boreholes has been plotted on Drawing 11207-G1-DG-002, located in Appendix A.

3.2 In-situ sub-surface profile

The subsurface profile identified by WML is generally consistent across the site, with slight variations noted with respect to layer composition (increase/decrease of secondary materials) and thicknesses of layers. Therefore, three profiles have been identified across the site to account for these differences and have been labelled Zone 1, Zone 2 and Zone 3.

The three subsurface profiles are summarised below in Table 2, Table 3 and

Table 4. In addition, logs of the boreholes can be found within the geotechnical report, 11207-G-R-002 Rev1, attached in Appendix B.

- Zone 1 – low dunes and undulating sandplain with shallow pale grey sands, and deep (generally than 1.5 m) brown-orange sand with fines.
- Zone 2/3 – Flat to very gently undulating plain with varying depth of sand over sandy clay/clay.
- The top 100 mm across the site is typical topsoil consisting of:
  Silty SAND, fine to medium-grained, dark grey; silt is low plasticity; trace roots; moist; loose.

Table 2: Generalised Sub-surface soil profile for Zone 1

Depth (m)	Description
0.1 – 2.5	**SAND**/silty **SAND:** fine to medium-grained, moist, pale grey to dark orange, and loose to medium dense.

Table 3: Generalised Sub-surface soil profile for Zone 2

Depth (m)	Description
0.1 – 1.0	**SAND**/silty **SAND:** fine to medium-grained, varying colour including pale to dark grey and brown-orange, moist, loose to medium dense. Some areas have slightly cemented lateritic sand.
1.0 – 2.6	Sandy **CLAY/CLAY**: medium to high plasticity, varying colour including yellow and brown/grey mottled red, trace medium-grained subrounded to subangular gravel, trace to some slightly cemented lateritic gravel, moist to wet, generally stiff to very stiff.

Table 4: Generalised Sub-surface soil profile for Zone 3

Depth (m)	Description
0.1– 0.7	**SAND**/silty **SAND**: fine to medium-grained, pale grey to brown, with silt/clay, moist, loose to medium-dense. BH12 had shallow sands to the depths of 0.25 m. BH14 consisted of silty SAND with low to medium plastic clay to depths of 1.25 m.
0.7 – 5.5	Sandy **CLAY/CLAY:** medium plasticity, varying colour including orange-brown and grey mottled orange; sand is fine to medium-grained, moist, generally stiff. Traces of lateritic orange sand clumps are occasionally present. BH3 and BH6 drilled from 2.6-5.5 m identified some gravel was identified within the stiff sandy clays.

3.3 In-situ permeability

The in-situ permeability test results are summarised in Table 5. The permeability results indicate that the material encountered across the site may be considered moderately free draining.

Table 5: In-situ permeability test results

Location ID	Test soil	In-situ Permeability Test	
		m/s	m/day
BH11	SAND with clay (SP)	2.54×10^{-5}	2.20
BH14	Silty SAND (SM)	1.92×10^{-6}	0.17
BH15	SAND trace silt (SP)	7.30×10^{-5}	4.50[1]

Note: 1- conservative conversion

3.4 Geotechnical and geo-environmental soil testing

Samples of representative soils collected by WML were submitted to Construction Science and Environmental and Agricultural Testing Services (EATS) for geotechnical and environmental testing. The laboratory certificates are appended to the geotechnical report in Appendix B. Table 6 and

Table 7 below summarise the laboratory testing.

Table 6: Summary of the geotechnical laboratory testing

Location ID	Depth (m)	PSD			Atterberg Limits				[1]Soil Classification (USCS)
		Fines (%)	Sand (%)	Gravel (%)	LL (%)	PL (%)	PI (%)	LS (%)	
BH11	1.25	43	47	10	50	17	33	12	CL
BH12	0.30	17	87	5	NO	NP	NP	0	SP
BH14	0.30	13	87	0	NO	NP	NP	1	SP
BH11	0.50	18	80	2	NO	NP	NP	0.5	SP

Notes:

Terminology - PSD = Particle Size Distribution; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; LS = Linear Shrinkage; NO = Not Obtainable; NP = Non-Plastic

[1]Soil classifications based on the classification of fine and coarse-grained soils presented in Table 9 and Table 10 of AS1726:2017

Table 7: Summary of the geo-environmental laboratory testing

Location ID	Depth (m)	Emersion Class	Description	PRI (mL/g)	Classification	USCS
BH13	0.5	3	Slakes. Dispersion after remoulding	611	Very Strongly Absorbing	SP
BH11	1.25	5	Slakes. Flocculation in soil/water suspension	108	Very Strongly Absorbing	CL
BH14	0.75	6	Slakes. Flocculation in soil/water suspension	1225	Very Strongly Absorbing	SC
BH15	1.5	3	Slakes. Dispersion after remoulding	33	Moderate to Strongly Absorbing	SP

Note: PRI – Phosphorous Retention Index

The phosphorous retention index (PRI) can be defined as the ratio of phosphorus absorbed to the phosphorus remaining when the soil is left in contact with a standard phosphorus solution under standard conditions. It is generally used to measure a soil's ability to strip an applied effluent of phosphorus and hence prevent leaching or contamination into the groundwater. In sandy soils, the phosphorus retention index is usually less than 5. Very strongly absorbing soils include lateritic loams, iron-rich peats, and Karri loams with PRI >70. A negative value indicates the soil can no longer absorb any more phosphorus and, as such, would leach through the layer easily.

3.5 Groundwater

Peak groundwater levels were typically identified within 0.0-0.8 m of the existing ground level, with some low-lying areas having water ponding as high as 200 mm above the ground level. Based on provided survey data, peak groundwater elevation is expected to be between 23.43-25.78 m AHD.

The biggest differences were noted where sand dunes/ridges were present (BH7) and where groundwater was not identified to the depths of 2.5 m.
The measured groundwater depths and the expected peak groundwater levels have been summarised in Table 8 below for each investigation area.

Table 8: Groundwater levels

Test ID	Depth of Groundwater (m)				[2]Expected peak groundwater level (m ADH)
	Observed 1/06/2023	Observed 10/8/2023	Observed 15/9/2023	Observed 31/10/2023	
BH1	1.4	0.76	0.71	1.3	23.43
BH2	GNE	0.18	0.04	1.05	24.73
BH3	3.8	-0.10	-0.20	GNE	23.47
BH4	1.2	0.63	0.63	1.22	24.29
BH5	1.8	0.80	0.89	1.29	24.21
BH6	GNE	0.00[1]	0.00[1]	GNE	25.78
BH7	GNE	GNE	GNE	GNE	-
BH8	1.0	0.00	0.00	GNE	26.12
BH9	GNE	0.00	0.00	1.19	24.70
BH10	2.3	0.60	0.35	0.99	24.16

Notes: All depths are relative to the existing ground surface
GNE = Groundwater not encountered, [1]Groundwater not encountered in borehole, but ponding present in the area around the monitoring well.
[2] Based off RL of well location picked up by Thompson surveyor minus observed peak water table.

3.6 Soil survey and analysis

A soil survey and analysis have been performed based on the distinct subsurface soil profiles present within the land development area and other constraining features, such as the proximity to groundwater/surface waters. As a result, the land development area can be divided into three (3) distinct areas and is used to inform the assessment of setbacks and mitigation control measures. The area boundaries are based on the subsurface profile across the lot and are detailed in Drawing 11207-G1-DG-002, attached in Appendix A. The tables below (

Table 9 - Table 11) assesses the physical and chemical characteristics of the subsurface profile for the identified three zones.

The soil category has been considered for in-situ soil conditions. Due to high groundwater and the site being classified as a sewerage sensitive area, fill placement to ensure a minimum groundwater separation of 1.5 m is required for Zone 2 and 3. It should be noted that the land application area (LAA) and setback distances for Zone 2 and 3 have been assessed with the assumption that suitable thickness of suitable fill have been placed as detailed within this report.

The site has been divided into three zones, which apply to the following lots (Refer to Drawing 11207-G1-DG-002):

- Zone 1 – Part of Lots 9, 10, 11, 12, 19 and 20
- Zone 2 – Lot 8. Part of Lots 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20
- Zone 3 – Part of 1, 2, 3, 4, 5, 6, 7, 13, 14, 15, 16, 17, 18, 19 and 20.

Table 9: Soil Assessment for Zone 1

Shown on Drawing 11207-G1-DG-002			
Feature	**Assessment**	**Level of Constraint**	**Mitigation Measures**
Phosphorous Retention Index	SAND with fines (5-12%): Estimated PRI up to 33	Low	NN
Rock Fragments	Cobble and boulder-sized rock fragments were not observed across the site.	Low	NN
Soil Depth	SAND (with fines): 0.0-2.5 m	Low	NN
Soil Permeability	Sand (with fines): Saturated hydraulic conductivity (k_{sat}) approx. 2 m/day. Underlain by a permeable sandy layer.	Low	Distribute treated effluent over a large application area.
Soil Category	SAND (with fines, 5-12%) (Category 1).	Low	Employ appropriate horizontal and vertical setbacks. Mounds, beds/trenches or irrigation systems are considered suitable for Category 1 soils.
Water Table Depth	Groundwater was not encountered to the depths of 2.5m. Peak expected to be below 2.5 m below ground level. Exact depths will vary between specific Lots.	Low	NN

Note: NN – Not Needed

Table 10: Soil Assessment for Zone 2

Shown on Drawing 11207-G1-DG-002			
Feature	**Assessment**	**Level of Constraint**	**Mitigation Measures**
Phosphorous Retention Index	SAND with fines (5-12%): PRI up to 611.	Low	NN
Rock Fragments	Cobble and boulder-sized rock fragments were not observed across the site.	Low	NN
Soil Depth	SAND (with fines): 0.0-1.1 m Sandy CLAY/ CLAY: 1.1 – 2.6m	Low	NN
Soil Permeability	Sand (with fines): Saturated hydraulic conductivity (k_{sat}) approx. 0.5- 2 m/day Underlain by a relatively impermeable sandy CLAY (>1.1 m).	Low	NN
Soil Category	SAND (with fines, 5-12%) overlaying Sandy CLAY/ CLAY (Category 3).	Medium	Employ appropriate horizontal and vertical setbacks.

Water Table Depth	Groundwater was encountered at varying depths, with peak expected levels around 0.9 m below ground level. Exact depths will vary between specific Lots.	High	All lots will require elevation of LAA to ensure a minimum groundwater separation of 1.5 m. As the base of typical effluent disposal systems is 0.5 m below ground level, a minimum import of 2.0 m of suitable fill material is likely needed. Suitable fill material requirements are outlined in Section 4.

Note: NN – Not Needed

Table 11: Soil Assessment for Zone 3

Area shown on Drawing 11207-G1-DG-002			
Feature	**Assessment**	**Level of Constraint**	**Mitigation Measures**
Phosphorous Retention Index	SAND and sandy CLAY: High PRI up to 1225	Low	Strongly absorbing. NN
Rock Fragments	Cobble and boulder-sized rock fragments were not observed across the site.	Low	NN
Soil Depth	SAND (with fines): 0.0 – 0.7m Sandy CLAY/ CLAY: 0.7 – 2.6m Sandy CLAY trace gravel – 2.6-5.5 m	Low	At BH12, the depth to impermeable clay is only 0.25 m below ground level. Increased soil depth through elevation of LAA is expected to address groundwater constraints; therefore, specific mitigation measures for soil depth are not required.
Soil Permeability	Silty SAND: Saturated hydraulic conductivity (k_{sat}) approx. 0.17 m/day Underlain by a relatively impermeable sandy CLAY (>0.7 m).	Low	NN
Soil Category	SAND (with fines, 5-12%) overlaying Sandy CLAY/ CLAY (Category 4).	Low	Employ appropriate horizontal and vertical setbacks.
Water Table Depth	Peak groundwater expected on surface levels to 0.2 m <u>above</u> ground level. Some slightly higher sections may have groundwater up to 0.5m below the surface level. Exact depths will vary between specific Lots.	High	All lots will require elevation of LAA to ensure a minimum groundwater separation of 1.5 m is achieved. As the base of typical effluent disposal systems is 0.5 m below ground level, a minimum import of 2.0 m of suitable fill material is likely needed. Suitable fill material requirements are outlined in Section 4.

Note: NN – Not Needed

3.7 Soil assessment results

Based on the soil encountered during the investigation, the overall capability of the soil and groundwater conditions to suitably manage effluent in its current condition is unsatisfactory. The following mitigation measures are a summary of

Table 9 to Table 11 above and should be considered minimum recommendations to ensure that the risk of environmental contamination is reduced as far as practicable in accordance with the GSP19 for lots utilising on-site effluent disposal systems:

1. The minimum lot size for all proposed lots is one (1) hectare due to the sewerage-sensitive area, in accordance with GSP 2019.
2. Each LAA must provide a minimum vertical setback of 1.5 m between groundwater levels and the invert level of the application system, in accordance with GSP 2019. The vertical setback can be achieved by elevating the LAA using site-won or imported fill material, which will be required for most of the site.
    a) Any imported fill material should be loamy sand (sand with a clay content between 5-15%) and achieve a minimum PRI of 20. In addition, any imported fill should not prevent the effective drainage ability of the layer.
    b) Site-won material from sand dunes/ridges may be used as fill material.
3. Secondary treatment systems are required for all lots due to the subject land lying within a sewerage-sensitive area, in accordance with GSP 2019.

Recommendations for horizontal and vertical setbacks in Section 4 of this report have been made considering the minimum constraints mentioned above to ensure compliance with GSP 2019 requirements.

The Government Sewerage Policy, 2019 states the following with respect to addressing the groundwater separation from the invert level of the application area using drains:

> *'The use of drains to achieve groundwater separation will only be considered for land that is already zoned for urban development and where drainage management plan is provided to the satisfaction of the responsible authority in consideration of advice from referral agencies to demonstrate:*
>
> - *How separation from groundwater will be achieved.*
> - *Adequate separation between sewage disposal areas and drains in accordance with GSP 2019 Section 5.2.2; and*
> - *That redirected water will not impact upon surrounding properties or receiving water bodies."*

Assessment of a suitable drainage management plan falls outside the scope of this site and soil evaluation. It, therefore, has not been considered when assessing the required vertical setbacks or recommendations for site suitability. However, a suitable drainage management plan should be provided if the above vertical setback recommendations are not adopted using imported fill material to elevate the LAA.

4 RECOMMENDATIONS

4.1 Wastewater management system

A detailed design of the lots' wastewater management system is beyond this report's scope. However, based on the results of the Site-and-Soil Evaluation, on-site treatment, and disposal of the generated wastewater for the subject development land can be considered achievable, as long as the following recommendations are followed and there is adherence to the minimum requirements detailed in Section 3.7.

4.1.1 Zone 1

- The following lots may have land application areas positioned within assessment Zone 1.
    - Part of Lots 9, 10, 11, 12, 19 and 20
- All lots are located within an estuary catchment of the Swan and Scott coastal plain and are therefore considered within a sewerage-sensitive area.
- All potential lots are required to have a minimum area of 1 ha.
- The general landform of the potential lots is that of a flat to gently sloping plateau with a typical gradient of 1-3%.
- Groundwater is expected to be 2.5 m below ground level, based on the monitoring well data recorded at BH7. Ongoing groundwater level measurements should be conducted throughout the wet season to monitor the peak levels and seasonal fluctuations.
- Considering the requirement for the minimum lot size and a secondary treatment system, the subject land can be expected to support the minimum land application area while meeting the recommended horizontal and vertical setback distances.
- The land application areas should be placed on each lot's highest, flattest parts where practicable.
- Based on the results of the SSE investigation, treatment of the generated wastewater to a secondary level with a Department of Health approved secondary treatment system (STS) with nutrient removal utilising a sub-surface application system can be considered satisfactory. However, the client's final selection of the system should be undertaken from the list of approved Department of Health Secondary Treatment Systems. It should achieve a minimum nutrient output of:
    - 20 mg/L of Biochemical Oxygen Demand (BOD)
    - 30 mg/L of Total Suspended Soils (TSS)
    - 10 cfu/100mL of Escherichia (E) coli
- For a typical 6-person residential household with a design loading rate of 120 L/person/day, a land application area of 144 m^2 is required based on the in-situ Category 1 soil. This calculation is based on the conversion factors provided in Section 2 of Schedule 2 of the GSP19.
- If land application areas are placed outside of the preferred location (Zone 1) selected within this report and within a different zoned area (See Drawing 11207-G1-DG-002), then the recommendations for the Wastewater Management system should be in accordance with Zone 2/3 in Section 4.1.2 below.

4.1.2 Zone 2 and Zone 3

- The following lots may have Land Application Areas positioned within assessment Zone 2/3.
    - Zone 2 – Lot 8. Part of Lots 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20
    - Zone 3 – Part of 1, 2, 3, 4, 5, 6, 7, 13, 14, 15, 16, 17, 18, 19 and 20.
- All lots are located within an estuary catchment of the Swan and Scott coastal plain and are therefore considered within a sewerage-sensitive area.
- All potential lots are required to have a minimum area of 1 ha.
- The general landform of the potential lots is that of a flat to gently sloping plateau with a typical gradient of 1-3%.
- Groundwater is expected to be within 0.9 m below ground level to 0.2 m above ground level for most of the site, based on the monitoring well data installed by WML.

- The land application area should be elevated for all lots to provide a minimum 1.5 m vertical separation to groundwater.
- Considering the requirement for the minimum lot size and the use of a secondary treatment system, it can be expected that lots can support the minimum land application area while meeting the recommended horizontal and vertical setback distances.
- The land application areas should be placed on each lot's highest, flattest parts where practicable.
- Based on the results of the SSE investigation, treatment of the generated wastewater to a secondary level with a Department of Health approved Secondary Treatment System (STS) with nutrient removal utilising a sub-surface application system can be considered satisfactory. The client should undertake the final selection of the system from the list of approved Department of Health Secondary Treatment Systems. It should achieve a minimum nutrient output of:
    - 20 mg/L of Biochemical Oxygen Demand (BOD)
    - 30 mg/L of Total Suspended Soils (TSS)
    - 10 cfu/100mL of Escherichia (E) coli
- For a typical 6-person residential household with a design loading rate of 120 L/person/day, a land application area of 180 m^2 is required based on Category 3 imported sandy loam soil/ site won fill material. This calculation is based on the conversion factors provided in Section 2 of Schedule 2 of the GSP19. It should be noted that the Land Application Area (LAA) and setback distances for Zones 2 and 3 have been assessed with the assumption that suitable thickness of suitable fill have been placed as detailed within this report.
- Special consideration should be given to avoid effluent discharge into the surface water, which includes the existing pond in Lot 13, and the open drain on the western boundary/southwestern corner of the site. All nearby effluent systems must have a minimum horizontal setback distance of 50 m from the surface water. In addition, the nearby build-up area for the effluent system should be sloped to drain the surface water and effluent away from the pond.

It is recommended that the design and installation of the effluent management system are carried out by a suitably qualified, licensed plumber or drainer experienced with on-site wastewater disposal systems and an irrigation expert familiar with effluent irrigation equipment to provide further design advice if required. The irrigation plan must ensure the even application of effluent throughout the entire application area. The primary constraint influencing detailed design is the proximity to surface waters (requiring vertical separation).

4.2 Setback distances

The minimum required setback distances have been based on imported materials used to achieve vertical groundwater separation. As a result, the setback distances are generally consistent across the entire subject development land. However, setback distances should be reassessed following confirmation of proposed lot locations, allowing the preferred LAA area to be included in subsequent drawings.

Setback buffer distances from effluent land application areas and treatment systems are required to help prevent human contact, maintain public amenities, and protect sensitive environments. The following recommendations have been made in general accordance with GSP 2019 and AS / NZS 1547:2012.

4.2.1 Zone 1

The recommended minimum setback distances have been based on a sub-surface application system disposing of a secondary treated effluent through Category 1 soil.

Table 12: Relevant setback distances for Zone 1

Feature	Minimum Setback distance
Private bore for household/drinking water purposes	35 m
A drainage system that discharges directly into a waterway or wetland without treatment	100 m
Waterway/watercourse (measured from the edge of the wetland vegetation)	100 m
Vertical distance to peak groundwater levels	1.5 m
Property boundary	4.5 m
Buildings/houses	2.5 m
Surface water	35 m
Recreational areas (children's play areas, swimming pools and so on)	5.5 m
In-ground water tank	6 m
Retaining walls and embankments, escarpments, cuttings	3 m or 45° angle from the toe of the wall (whichever is greatest)

4.2.2 Zone 2 and 3

The recommended minimum setback distances have been based on a sub-surface application system disposing of a secondary treated effluent through Category 3 soil.

Table 13: Relevant setback distances for Zones 2 and 3

Feature	Minimum Setback distance
Private bore for household/drinking water purposes	38 m
A drainage system that discharges directly into a waterway or wetland without treatment	100 m
Waterway/watercourse (measured from the edge of the wetland vegetation)	100 m
Vertical distance to peak groundwater levels	1.5 m
Property boundary	6 m
Buildings/houses	3 m
Surface water	50 m
Recreational areas (children's play areas, swimming pools and so on)	6 m
In-ground water tank	6.5 m
Retaining walls and Embankments, escarpments, cuttings	3 m or 45° angle from the toe of the wall (whichever is greatest)

4.3 Preferred land application areas

WML have prepared drawing 11207-G1-DG-003, detailing the available land for land application areas, along with the preferred location of the effluent treatment within this LAA. These locations have been selected to ensure the greatest mitigation of contamination is achieved, including excluding areas of inundation where possible, elevated areas of the

lots, and positioned to promote drainage away from open channels and drains. The preferred LAA drawing is attached in Appendix A.

4.4 Monitoring, operation and maintenance

Maintenance is to be carried out in accordance with the DOH Approval of the selected primary or secondary treatment system and the manufacturer's recommendations. The treatment system will only function adequately if appropriately and regularly maintained.

To ensure the treatment system functions adequately, residents must:

- Have a suitably qualified maintenance service technician for the primary or secondary treatment system at the frequency required by the manufacturer under the local government permit to use.
- Use household cleaning products that are suitable for septic tanks or ATUs.
- Keep as much fat and oil out of the system as possible; and
- Conserve water (AAA-rated fixtures and appliances are recommended).

To ensure the land application system functions adequately, residents must:

- Regularly harvest (mow) vegetation within the application area and remove this to maximise uptake of water and nutrients.
- Monitor and maintain the application system following the manufacturer's recommendations, including flushing the drainage lines; and
- Regularly clean in-line filters.

5 CLOSURE

As a result of our assessment, we recommend that sustainable on-site sewage management and disposal systems be installed to meet the needs of the proposed residential lots of 564 Garvey Road Subdivision, WA. We trust that the information provided satisfies your present requirements and meets your approval. Should you have any queries, please do not hesitate to contact the author.

We draw your attention to the attached “Report Limitations” included with this report. This information sheet is intended to provide additional information about this report and its information. This information is provided not to reduce the level of responsibility accepted by WML but to ensure that all parties that rely on this report and the information contained herein are aware of the responsibilities that each assumes in so doing.

6 REFERENCES

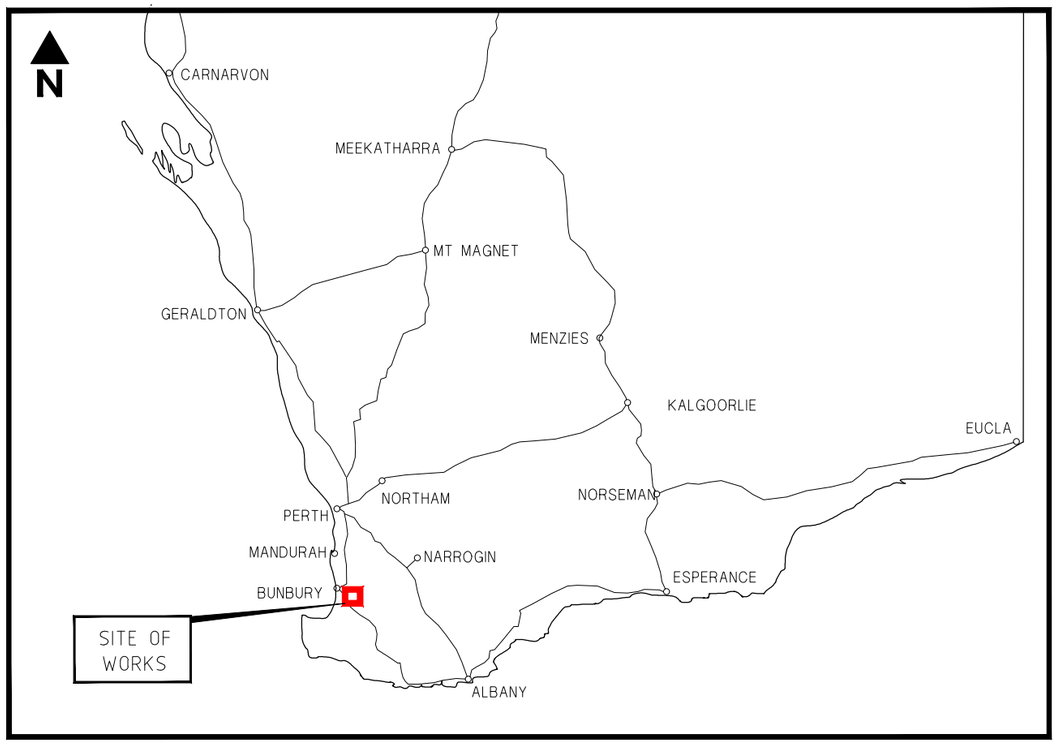
1. Department of Primary Industries and Regional Development (DPIRD), 'Natural Resource Information (NRInfo) – digital mapping', (Accessed March 2022), Natural Resource Information (WA) (agric.wa.gov.au)
2. Department of Health (DoH), '*Approved Secondary Treatment Systems*' 14 November 2019, (Accessed March 2022), https://ww2.health.wa.gov.au/Articles/A_E/Approved-aerobic-treatment-unit
3. Bureau of Meteorology (BoM), Climate Data Online, '*Monthly rainfall for BOM Marriwood Climate Station No 009629*', (Accessed March 2022),
4. Government of Western Australia (2019) '*Government Sewerage Policy*'
5. Standard Australia / Standards New Zealand (2012). AS/NZS 1547:2012 '*On-site domestic-wastewater management.*'

APPENDIX A

DRAWINGS

[illegible] [illegible] AR[illegible] R[illegible] A[illegible]

[illegible] [illegible]H[illegible] [illegible]A[illegible] [illegible] [illegible]S[illegible] A[illegible] [illegible]



MAP
NOT TO SCALE

LOCALITY PLAN
NOT TO SCALE

SITE PLAN
NOT TO SCALE

PRELIMINARY DRAWING
NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE NOT TO SCALE
A1

WML
Consulting Engineers
Civil & Geotechnical & Structural
[illegible]
CONSULTANT DRAWING NUMBER 11207-G1-DG-001

REVISIONS				
B	ISSUED FOR APPROVAL	A G	18.06.24	C H
A	ISSUED FOR REVIEW	B B	28.02.24	C H
N°.	DESCRIPTION	APPROVED	DATE	DRAWN

NOTE * INDICATES SIGNATURES ON ORIGINAL ISSUE OF DRAWING OR LAST REVISION OF DRAWING

NAMES PRINTED IN FULL		DATE
DESIGNED	B. BAJGAIN	FEB 2024
DRAWN	C. HICK	FEB 2024
VERIFIED		
APPROVED		

CLIENT
VA & MP WRIGHT & SON

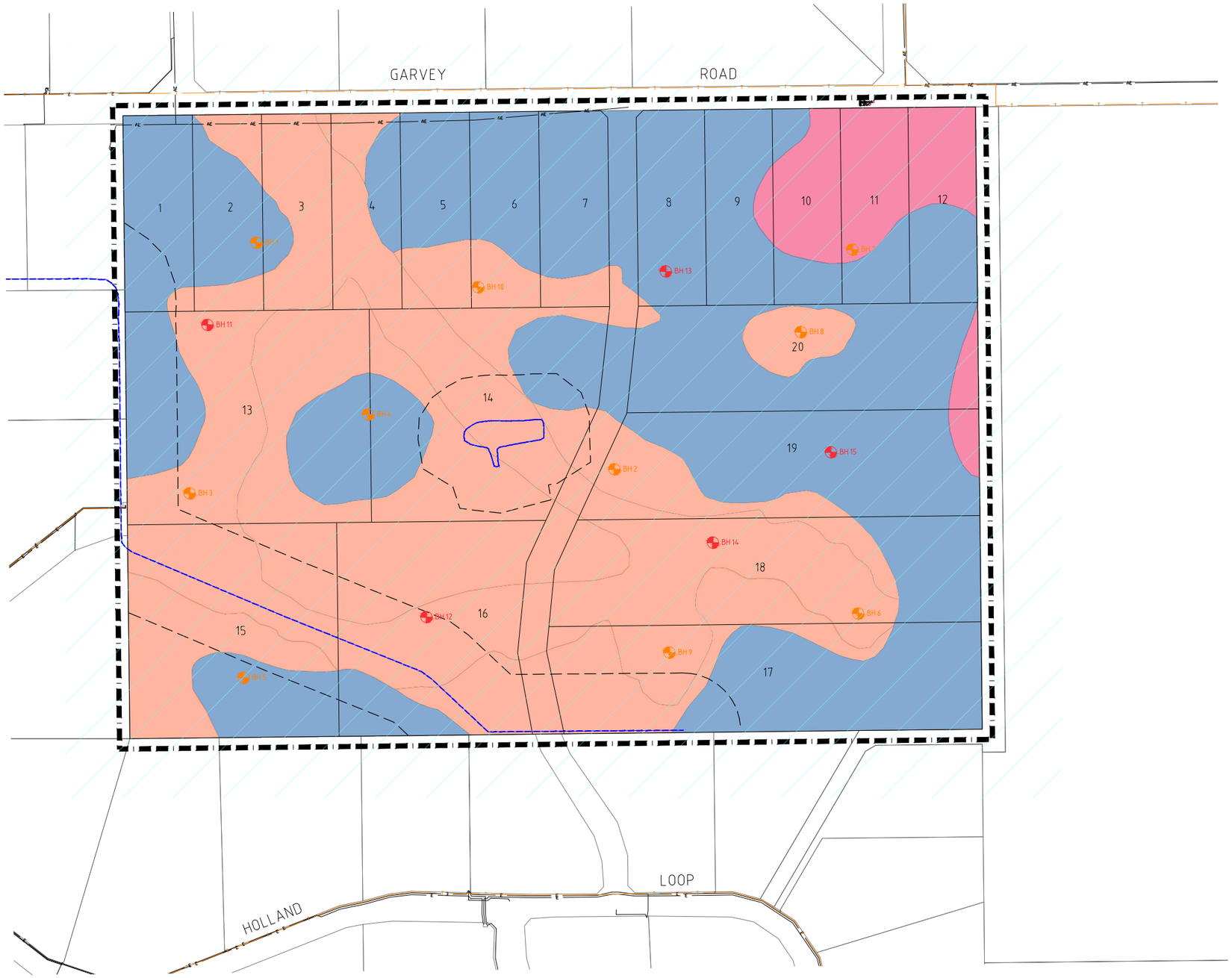
PROJECT
LOT 564 GARVEY ROAD
GEOTECHNICAL INVESTIGATION

DRAWING TITLE
LOT 564 GARVEY ROAD
SUBDIVISION
LOCALITY PLAN

THIS DRAWING SHALL BE TREATED AS PRELIMINARY AND IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED.

DRAWING NUMBER 11207-G1-DG-001 REVISION B

N



LEGEND

- BH 11 — WML BOREHOLE (JANUARY 2024)
- BH 4 — WML BOREHOLE (MAY 2023)
- ZONE 1
- ZONE 2
- ZONE 3
- SCOTT COASTAL PLAIN
- SITE BOUNDARY
- 50m SETBACK TO SURFACE WATER
- EXISTING OPEN DRAIN

PLAN

NOT TO SCALE

PRELIMINARY DRAWING

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE NOT TO SCALE

A1

WML Consulting Engineers

Civil | Geotechnical | Structural

CONSULTANT DRAWING NUMBER 11207-G1-DG-002

REVISIONS				
N°	DESCRIPTION	APPROVED	DATE	DRAWN
B	ISSUED FOR APPROVAL	A G	18 06 24	C H
A	ISSUED FOR REVIEW	B B	28 02 24	C H

NOTE * INDICATES SIGNATURES ON ORIGINAL ISSUE OF DRAWING OR LAST REVISION OF DRAWING

NAMES PRINTED IN FULL		DATE
DESIGNED	B. BAJGAIN	FEB 2024
DRAWN	C. HICK	FEB 2024
VERIFIED		
APPROVED		

CLIENT: VA & MP WRIGHT & SON

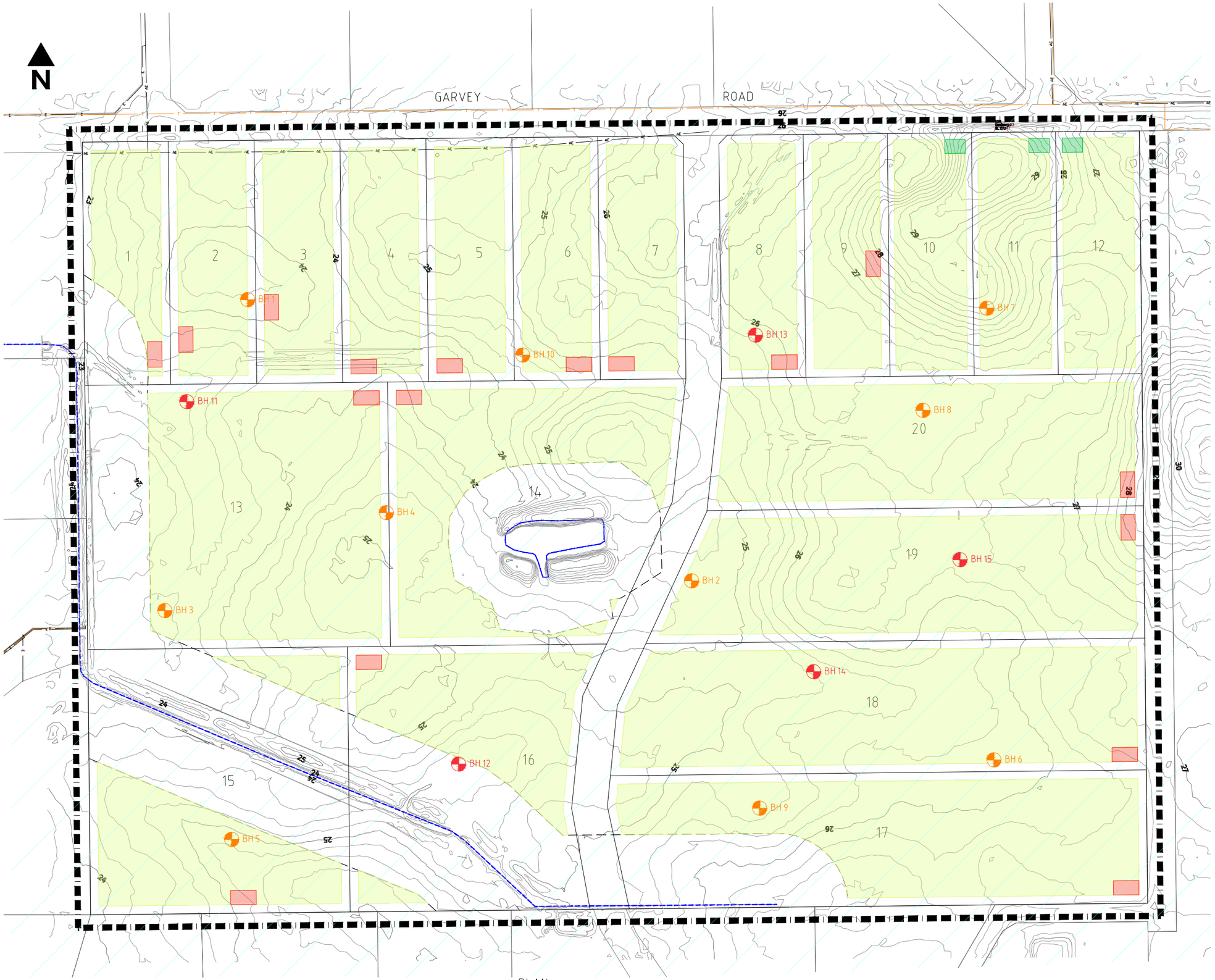
PROJECT: LOT 564 GARVEY ROAD GEOTECHNICAL INVESTIGATION

DRAWING TITLE: LOT 564 GARVEY ROAD SUBDIVISION SOIL SURVEY AND ANALYSIS AREAS

THIS DRAWING SHALL BE TREATED AS PRELIMINARY AND IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED.

DRAWING NUMBER: 11207-G1-DG-002 B

REVISION



PLAN
NOT TO SCALE

PRELIMINARY DRAWING
NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE NOT TO SCALE
A1

WML Consulting Engineers
Civil | Geotechnical | Structural
CONSULTANT DRAWING NUMBER 11207-G1-DG-003

REVISIONS					
B	ISSUED FOR APPROVAL		A G	18 06 24	C H
A	ISSUED FOR REVIEW		B B	28 02 24	C H
N°	DESCRIPTION		APPROVED	DATE	DRAWN

NOTE * INDICATES SIGNATURES ON ORIGINAL ISSUE OF DRAWING OR LAST REVISION OF DRAWING

NAMES PRINTED IN FULL		DATE
DESIGNED	B. BAJGAIN	FEB 2024
DRAWN	C. HICK	FEB 2024
VERIFIED		
APPROVED		

CLIENT
VA & MP WRIGHT & SON

PROJECT
LOT 564 GARVEY ROAD
GEOTECHNICAL INVESTIGATION

DRAWING TITLE
LOT 564 GARVEY ROAD
SUBDIVISION
PREFERRED LAND APPLICATION AREAS

THIS DRAWING SHALL BE TREATED AS PRELIMINARY AND IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED.

DRAWING NUMBER 11207-G1-DG-003
REVISION B

APPENDIX B

WML GEOTECHNICAL REPORT