Land Capability Assessment and Literature Summary for the Harrietville Tailings Site

Prepared for Alpine Shire Council

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Document Control Sheet

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Acknowledgement

DWA acknowledges the Traditional Custodians throughout Australia and their continuing connection to land, water, culture and community, and pays respect to their Elders past, present and future.

Limitations Statement

This report and the associated services performed by Decentralised Water Australia (DWA) relate solely to the scope, budget, time and access constraints as set out in the engagement agreement and quotation between DWA and the Client. DWA accept no liability for any use or reliance on this Report for any purpose not documented in this agreement and quotation by the Client. It has been prepared for the exclusive use of the Client and DWA accepts no liability for any use of or reliance upon this report by any third party.

The outcomes and recommendations contained in this report may have relied upon a range of information and data sources including information and discussions with the client, field investigations (limited to those described in this report), publicly available information and other sources. DWA have not verified the accuracy of third party data and any inaccuracies or inadequacies may influence the accuracy of our findings. Similarly, both the inherent variability of environmental and ground conditions and the passage of time can lead to changes in ground conditions and other factors which may affect the accuracy of our findings. The Client should seek advice from DWA on the accuracy of findings after more than six months has passed or where changes in relevant conditions are known to have occurred. Data and information collected during field investigations should not be taken as accurate and complete for all depths and locations across the site.

The report and services have been completed in accordance with relevant industry standards, guidelines and government legislation as of the date of publication unless stated otherwise. Where an engineering design is included, this design has been based on site and construction plans as provided by the Client and/or their representative and documented in the report. DWA accepts no liability for the impact of any changes to site conditions and / or building layout and extents on our design where DWA were not notified of the changes prior to completing our services. Additional costs may be incurred where work has already been completed.

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1 Introduction

Alpine Shire is located in the Hume region of Victoria approximately 300km northeast of Melbourne. The shire which covers an area of approximately 4800km^2 includes the townships of Bright, Dinner Plains, Mount Beauty, Myrtleford, and Harrietville along with several other smaller townships. The Alpine Council administrative building is located in Bright. The population as at the 2016 Census was 12,337.

The township of Harrietville is located on the Great Alpine Road 22km southeast of Bright. At the 2016 Census, the town and surrounds had a population of 338 and 255 private dwellings. Harrietville is located within the greater area of the Alpine National Park, an area containing a range of environmentally sensitive eco-systems, unique landforms and characterised by high rainfall, pristine waterways, and unique soil and groundwater conditions.

Alpine Shire Council are currently assessing development opportunities associated with a 12Ha '*township*' zoned allotment in Harrietville known as the '*Tailings Site*'. The zoning permits residential development and other uses consistent with the zoning subject to planning and regulatory processes.

The village of Harrietville does not have a reticulated sewer with existing allotments serviced by individual on-site wastewater management systems. The future development of the site is, in part, dependent on the successful development of a cost-effective wastewater solution that can achieve a very high level of environmental protection while meeting the expectations of the Harrietville community and regulatory authorities and requirements.

This report documents the outcomes from the projects scope of works and objectives:

- To understand the different technical solutions available within the cluster system paradigm against site characteristics and potential scope development and identify technical solutions(s) that could be applied to the site.
- In parallel with item 1, undertake a full land capability assessment of the site and make a judgement on the best technical solution available,
- To develop a concept design and location(s) for the identified technical solution,
- To assess whether the cluster system approach could be applied to other clusters of properties in Harrietville from a technical perspective.

An optional separable component of the project will involve working with Council and Council's development consultants to identify financial requirements, critical timeframes, and ownership and maintenance parameters necessary to ensure successful development and operation of the wastewater management site solution in perpetuity.

2 Background

In 2015, Council undertook a community resilience project seeking, in part, to enhance resilience in Harrietville through increased development opportunities. Community resilience is synonymous with facing day-to-day shocks and stress; however, it is also about building future resilience into the community. Increasing development and infrastructure is one method of achieving this.

The Harrietville Tailings site, which is owned by Council, was identified through the project as a potential development site and a project that aligns with the 2015 resilience project objectives. DWA understands that the community supported the development concept as it could attract new residents with subsequent future economic benefit to the local businesses of Harrietville. The subdivision of land in Harrietville is however reliant on the development of an appropriate, cost effective and sustainable method of managing sewage. As mentioned in the introduction, Harrietville is reliant on onsite wastewater management systems with development of the site, in part, dependent on the successful development of a cost-effective wastewater solution that can achieve a very high level of environmental protection while meeting the expectations of the Harrietville community and regulatory authorities and requirements.

Council is responsible under the *Environment Protection Act (2017)* for the approval of on-site wastewater management systems. This includes the approval of alterations to existing systems and consideration of wastewater management risks associated with new unsewered development. The Alpine Planning Scheme includes reference to the relevant provisions of the *Environment Protection Act* and requires consideration of the capability to contain wastewater within property boundaries when approving new development.

Council is required to ensure existing on-site systems do not adversely impact on human health or the environment under the *Health and Wellbeing Act (2008)*. This has historically proven to be a challenging outcome for local councils to achieve due to constraints in the ability to resource oversight and enforce upgrades to failing or inappropriate systems.

2.1 Property Details

The subject site is identified as 147A Great Alpine Road, Harrietville Victoria 3741.

Property, site and planning information is detailed below.

Table 1 Property Details

Property Information	
Property owner / applicant	Alpine Shire Council
Council property number	6564
Allotment size	11.88ha
Parcel Details	Lot D LP200281 SPI D\LP200281
	Lot 1 PS322667 SPI 1\PS322667
Planning Zone	Township (TZ)
Utilities	
Rural Water Corporation	Goulburn-Murray Water
Urban Water Corporation	North East Water
Power distributor	AUSNET

2.2 Legislative Context

The following legislation that is relevant to Wastewater Management in Victoria has been included for regulatory context.

Local Government Act 1989

The Local Government Act (1989) provides a framework for the establishment and operation of Councils. This includes planning and providing services and facilities to local communities (including domestic wastewater management), making and enforcing local laws and exercising, performing and discharging the duties, functions and powers of Councils under this Act and other Acts.

Environment Protection Act 2017

From 1 July 2021 the Environment Protection Act 2017 (Act) came into effect through the Environment Protection (Amendment) Act 2018. The amendment act made significant changes to the Environment Protection Act 2017 and repealed the Environment Protection Act 1970.

The new legislation introduces a preventative approach to environmental protection and a focus on the duty of an individual or company rather than the historical reactive approach. The Act introduces the concept of '*General Environmental Duty*' or GED that applies to all Victorian individuals and companies that engage in an activity with the potential to cause harm to the environment or human health.

Historically, the management of septic tank systems was managed under the Environment Protection Act 1970. While various Statutory Rules addressed environmental protection, (domestic) wastewater systems were not predominantly captured under any specific subordinate legislation.

The permit system for approving the installation of on-site wastewater management systems has been retained. Municipal Councils continue to be responsible for managing permission applications (i.e. permits) for systems with flow rates less than 5000L/day. Permits for wastewater systems are categorised as '*medium risk prescribed activities*' in the hierarchy of risk.

The EPA have retained responsibility for managing all other activities including on-site wastewater management systems with flows greater than 5000L/day.

In general, the Act prescribes the higher-level framework governing permissions and permits with the Statutory Rule prescribing the operational details.

New subordinate legislation comprising the Environment Protection Regulations 2021 and Environmental Reference Standards came into effect on 1 July 2021. The Regulations support the Environmental legislation by providing further details and clarification on matters pertaining to on-site wastewater management systems.

Water Act 1989

This Act provides a formal means to protection and enhancement of the environmental qualities of waterways and catchments and aims to eliminate inconsistencies in the treatment of surface and groundwater resources and waterways. Part 3 (Assessment of and Accounting for Water) of the Act identifies that the water resources assessment program must include an analysis the disposal of wastewater. This includes the collection, collation, analysis and publication of information about on-site wastewater management systems.

Planning and Environment Act 1987

The key legislation relating to land development in Victoria is the Planning and Environment Act 1987. The two objectives of the planning framework under the Act are;

- To enable land use development and planning and policy to be easily integrated with environmental conservation and resource management policies; and
- To ensure that the effects on the environment are considered when decisions are made about the use and development of land.

Public Health and Wellbeing Act 2008

The objective of this Act is to achieve the highest attainable standard of public health and wellbeing by:

- Protecting public health and preventing disease, illness, injury, disability or premature death;
- Promoting conditions in which persons can be health; and

Reducing inequalities in the state of public health and wellbeing. Under Division 1, Part 6 of the Act, Councils have a duty to remedy as reasonably possible all existing nuisances, whereby nuisances are (or a liable to be) dangerous to health or offensive. As such, if an on-site wastewater system is or has the ability to cause/become a nuisance, Council has a duty to rectify the existing / possibly threat to human health.

State Environmental Protection Policy (Waters)

The amended legislation has resulted in the deconstruction of State Environmental Planning Policies (SEPP's) and development and implementation of Environmental Reference Standards (ERS). DWA understands that the SEPP's will cease to have any legal status from July 2021 however they will continue to provide a state of knowledge around environmental management. Transitional savings legislation in the form of the *Environment Protection Transitional Regulations 2021* has been introduced that will permit specific clauses within SEPP (Waters) to remain in-force for a period of 2 years unless revoked sooner. The clauses relevant to domestic wastewater management systems, sewerage planning and DWMP's include 28(1), 28(2), 29 and 30.

The Environment Protection Authorities Code of Practice for Onsite Wastewater Management provides standards and guidance to ensure the management of on-site wastewater protects public health and the environment for wastewater flows up to 5,000L/day. This code is the Victorian guideline for best practice management of on-site wastewater systems and land capability assessments. The code states that Councils need to assess the suitability of land for on-site wastewater management to ensure that permits are consistent with the guidelines of the code and outlines key obligations for Councils and occupiers of premises.

2.3 Environmental Reference Standards

The new legislation will result in the introduction of the Environment Reference Standard (ERS). The ERS identifies environmental values including a procedure to assess the values. The ERS consists of multiple reference standards that will apply to ambient air, ambient sound, land and water environments. Each reference standard identifies environmental values unique to each theme.

The ERS does not assign compliance limits. It is a tool that has been designed to assist in decision making.

2.4 Other relevant legislation

- Safe Drinking Water Act 2003 and Regulation 2005
- Catchment and Land Protection Act 1994
- Victorian Building Regulations 2006

The design, operation and management of on-site systems are supported by a number of standards and guidelines. Namely:

- EPA Code of Practice – Onsite Wastewater Management, Publication 891.4 (2016)
- MAV Land Capability Assessment Framework (2014) – replacing EPA Publication 746.1
- AS/NZS 1547:2012 Onsite Domestic Wastewater Management (updated since last DWMP)
- AS/NZS 3500:2003 Plumbing and Drainage
- Guidelines – Planning Permit Applications in Open, Potable Water Supply Catchment Areas (DSE, 2012)

Note: Since July 2016 EPA no longer award a Certificate of Approval to individual on-site wastewater systems. The *Environment Protection Act 2017* relies upon certification of four system types in line with the following Australian Standards:

- AS/NZS 1546.1 Septic tanks
- AS/NZS 1546.2 Waterless composting toilets

- AS/NZS 1546.3 Aerated wastewater treatment systems
- AS/NZS 1546.4 Domestic greywater treatment systems (draft)

Council Officers can only approve the installation of an on-site wastewater system that is certified to comply with the relevant Australian Standard by an accredited conformity assessment body (CAB). As part of a permit application to council, the applicant will need to include a copy of the certificate of conformity from a CAB.

3 Status of Domestic Wastewater Management in Harrietville

3.1 Approval of New Unsewered Development / On-site Systems

Currently, on-site systems that manage or are designed to manage flow rates of more than 5,000 litres per day are regulated by EPA through works approvals and, in some cases, operating licences.

Systems with flow rates less than 5,000 litres a day are the responsibility of Council which issue permits for the construction, installation, and alteration of on-site systems. Council may refuse a permit if the site of the proposed system or proposed effluent land application is considered unsuitable and must refuse if the type of treatment system is not certified by a CAB against one of the nominated Australian Standards.

Land use planning context is discussed below.

3.2 Existing On-site Systems

To assist in understanding the local wastewater context, DWA was provided a spatial layer of existing onsite wastewater management systems for Harrietville. The data was extracted, collated and key statistics determined. The information is presented in Table 2, Table 3 and Table 4.

The data indicates that primary septic tank treatment systems disposing to in-ground absorption trenches is the predominant system type operating throughout Harrietville. This is likely a reflection of the historical nature of onsite wastewater in the township where septic tank/trench systems were the traditional method and, in some instances, the only method for the management of human waste. The installation of secondary treatment systems is likely to have occurred more recently and is likely to have been driven by new technology, a better understanding of environmental constraints, community expectations and regulatory change.

Table 2 Treatment System Level

Treatment System Type	Number	Percentage of total
Primary	125	60
Secondary	70	33.7
Other	1	0.5
Unknown	12	5.8
Total	208	100

Table 3 Treatment and Land Application by Type

Treatment System Type	Number	Percentage of total %
Composting Toilet and Greywater Treatment System to Unknown Land Application Area	1	0.5
Secondary Treatment (Trickling Filter) and Trenches	1	0.5
Secondary Treatment System (AWTS) and Sub-surface Irrigation	19	9.1
Secondary Treatment System (AWTS) and Trenches	10	4.8
Secondary Treatment System (AWTS) and Unknown Land Application Area	28	13.4
Secondary Treatment System (AWTS) and Wisconsin Mound	1	0.5
Secondary Treatment System (Reed Bed) and Sub-surface Irrigation	1	0.5
Secondary Treatment System (Reed Bed) and Trenches	2	1.0
Secondary Treatment System (Reed Bed) and Unknown Land Application Area	7	3.4
Secondary Treatment System (Sand Filter) and Unknown Land Application Area	1	0.5
Septic Tank and Trenches	125	60
Septic Tank and Unknown Land Application Area	0	0
Unknown	10	4.8
Unknown Treatment System to Trenches	2	1.0
Total	208	100

Table 4 Land Application by Method

Land Application Method	Number	Percentage of total %
Trenches	140	67.3
Subsurface Irrigation	20	9.6
Wisconsin Mound	1	0.5
Unknown	47	22.6
Total	208	100

3.3 Land Use Planning Context

The Alpine Planning Scheme has been considered in the context of this project with a focus on areas identified for current and future residential development.

For subdivision in the Township Zone (TZ), each proposed lot must be provided with reticulated sewerage, if available. If reticulated sewerage is not available, the planning permit application must be accompanied by:

- A land capability assessment which demonstrates that each lot is capable of treating and retaining all wastewater in accordance with applicable state policy, regulation and legislation, and
- A plan which shows the building envelope and effluent disposal area for each lot.

The Bushfire Management Overlay (BMO) is applicable to the site with the key purpose to ensure the development of land prioritises the protection of human life and strengthens community resilience to bush fire. It has potential impacts for on-site wastewater management systems on unsewered properties.

There is no Erosion Management Overlay (EMO) for the Shire, however slope and landslip risk (assessed on a site-specific basis) is also a recognised constraint to development that can have a significant influence on the ability to contain on-site.

The Environmental Significance Overlay (ESO) applies to land across the Shire identifying land where the development of land may be affected by environmental constraints such as proximity to waterways. The ESO ensures that development is compatible with identified environmental values. The site is not identified within the ESO.

3.4 Integrated Water Management

Integrated Water Management (IWM) aims to provide a holistic and forward-thinking approach to all elements of the water cycle (movement of water through its various phases) including wastewater in addition to stormwater, potable / non-potable water supply and local watercourses. The intention is for this approach to be adaptive to temporal changes over the long-term and designed in conjunction with end users (community) with a place-based element to design.

The recently developed IWM Framework (DELWP, 2017) is aimed at assisting government agencies and the community in planning and implementation of these IWM concepts / options in the future. This includes the establishment of several new Victorian IWM Forums. This project was included in the North East IWM Forum Strategic Directions Statement (2019) as a "Ready to Advance" IWM Project.

4 Land Capability Assessment

A Land Capability Assessment (LCA) has been undertaken for the Tailings Site by DWA staff on 16 June 2021 comprising site and soil assessment, soil analysis, and detailed analysis of the observations and results.

A total of three soil test pits were excavated across the site using an excavator. Additionally, the soils within two existing exposed cuttings were also assessed. The locations for the 5 test pits are presented in Figure 1 with the soil bore logs presented in Appendix B.

A composite soil sample was analysed by Sydney Environment and Soil Sciences Laboratory (SESL). The results are included in Appendix B.

The collected site and soil data in conjunction with the laboratory results were utilised to finalise the LCA for potential Land Application Area locations in accordance with the EPA Code of Practice and MAV Land Capability Framework (in addition to *AS1547:2012*).

The key outcomes of the land capability assessments are presented in Table 5 and Table 6 with the Site and Soil Characteristic Risk Assessments presented in Appendix A.

Photos for the test pits are presented in Figure 2, Figure 3, Figure 4, Figure 5 and Figure 6.

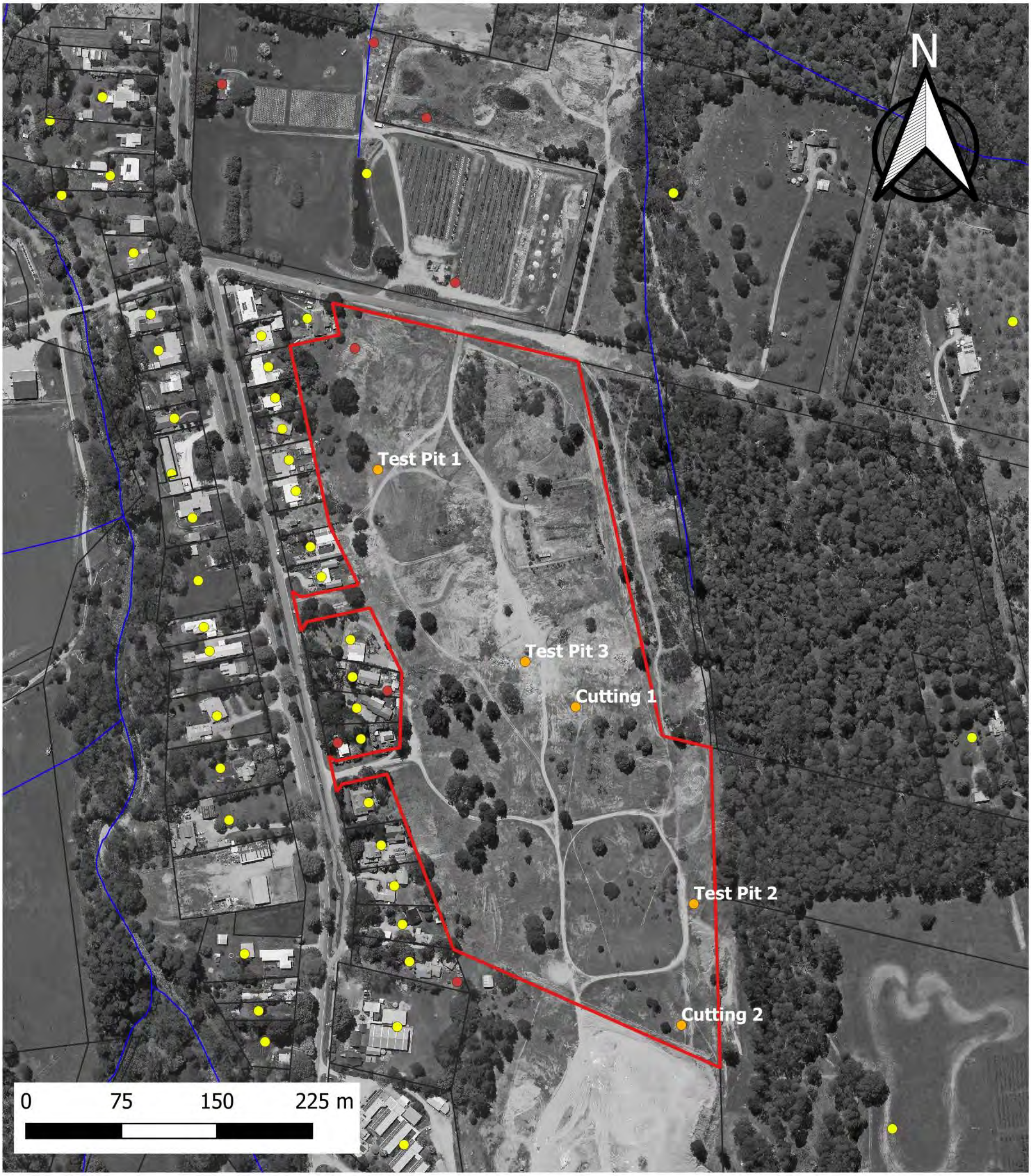

Figure 1: Harrietville Tailings Site - Soil Test Pit Locations

Legend

Lot boundary
Groundwater bores
Watercourses
Soil Test Pits
Onsite Wastewater systems (existing)

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Table 5 Land Capability Assessment – Site Characteristics

LCA Assessment Tables			
Property Id	Harrietville Tailings Site	Lot/Plan	SPI
Property Address	147A Great Alpine Road, Harrietville Victoria	Lot D LP200281	D\LP200281
		Lot 1 PS322667	1\PS322667
Date Completed	16/5/2021		
Overall Land Capability Class Rating	Based on the results of the site and soil assessment tabled below and provided in the Appendices, the overall land capability of the proposed effluent management area is constrained. However, the effluent management system will be designed, installed and maintained in ways which will mitigate these factors.		

Site Characteristics				
Land Feature	Observation and Description	Assessed Criteria	LCA Rating	Mitigation Measures
Aspect (affects solar radiation received)	North / North-East / North-West	North / North-East / North-West	Minor	No impact on design.
Exposure	High exposure	Full sun and/or high wind or minimal shading	Minor	No impact on design.
Climate	Harrietville, VIC (BOM site 083085 Mt Hotham - 10.3km)	Excess of rainfall over evaporation in the wettest months	Major	Beneficial reuse by irrigation is largely unfeasible due to a lack of water demand. Constraint can be managed by adopting a conservative Design Loading Rate (DLR) in a land application configuration.
Erosion potential	Minor erosion observed.	Nil or minor	Minor	No impact on design.

Site Characteristics				
Land Feature	Observation and Description	Assessed Criteria	LCA Rating	Mitigation Measures
Fill	Site is largely comprised on mining tailings.	Extensive poor-quality fill and variable quality fill	Major	Import good quality fill to adequate depth to ensure all land application areas operate efficiently. Install a raised land application system.
Flood inundation frequency (ARI)	Site is located outside the Floodway located to the east (adjacent to Ovens River).	Less than 1 in 100 year	Minor	No impact on design.
Groundwater bores and Hydrogeology	The aquifers within Harrietville have good water quality and are of high ecological value and are considered the most sensitive receiving environment to the site. The unconfined aquifer underlying the Tailings site and broader valley floor will be the primary receiving water for treated effluent generated by whichever wastewater solution is deemed preferred. There is one (1) groundwater bore located on the site. The closest groundwater bores outside of the property boundary include two (2) on properties located directly west, one (1) at the Primary School to the southwest and three (3) on the property located directly north. These range in distance from ~10-190m from the site boundary.	Setback distance from bore does not comply with requirements in EPA Code of Practice 891.3 (as amended)	Major	Adopt a high level of wastewater treatment. Undertake an aquifer impact assessment for the proposed wastewater treatment method.
Landslip (or landslip potential)	The site is not prone to landslip	Minor to moderate	Minor	No impact on design.
Rock outcrops (% coverage)	Large cobbles / boulders were present at the soil surface across the site (due to the area being a remnant tailings site).	>20%	Major	Install a raised LAA with appropriate imported fill material to ensure adequate construction and operability. Adopt a conservative Design Loading Rate (DLR).

Site Characteristics				
Land Feature	Observation and Description	Assessed Criteria	LCA Rating	Mitigation Measures
Slope form	The site is primarily divergent across the site, with a straight west north west slope present in the south eastern corner of the site (which gradually converges).	Convex or divergent side-slopes	Minor	No impact on design.
Slope gradient (%)	General slopes across the site range ~0-5% with the exception of tailings stockpiles. It is expected that the site will be heavily landscaped as part of any development works.	<10%	Minor	The site should be landscaped to have slopes <10% in all proposed Land Application Areas (slopes of <5% are preferred).
Soil drainage (qualitative)	All soil profiles examined were comprised of a gravel with some silt content which had been significantly disturbed. As such the soil is relatively free draining. Inspection was undertaken In Winter during wet weather and there was minimal surface ponding in low lying points.	No visible signs or likelihood of dampness, even in wet season	Minor	Inspection undertaken in winter during wet weather. Adequate surface and subsurface diversion drainage should be installed where necessary.
Soil drainage class		Well drained. Water removed from the soil readily, excess flows downward. Some horizons may remain wet for several days after addition	Minor	
Stormwater run-on	Due to the relatively free draining nature of the soil, there is only a minor potential for upslope stormwater run-on under the current site conditions. However, this should be re-evaluated as the project develops (due to landscape changes etc).	Low likelihood of stormwater run-on.	Minor	Re-evaluate the need for upslope stormwater diversion drainage once the site layout and landscaping has been confirmed.
Surface waters - setback distances	The closest surface water receiving environment is the drainage line located along the eastern site boundary (as a result of the site being cut for mine tailings operations). This is not considered to have a high ecological value. This then joins to Hit or Miss Creek located ~50m east of the north eastern portion of the site. Ovens River (Permanent Watercourse) and Ovens River East Branch (Intermittent Watercourse) are	Setback distance complies with requirements in EPA Code of Practice 891.3 (as amended), with the exception of the man-made drainage line located along the	Moderate	Setbacks to high value ecological environments is achieved. Performance modelling is to be undertaken to demonstrate impacts to all waterways can be managed. It is noted that the dominant pathway for pollutant migration to surface waterways will be via

Site Characteristics				
Land Feature	Observation and Description	Assessed Criteria	LCA Rating	Mitigation Measures
	located a minimum of ~126m west of the property boundary.	southeastern property boundary.		groundwater flow in the unconfined aquifer.
Vegetation	Mixed grasses and some mature trees.	Limited variety of vegetation.	Moderate	The site will need to be relandscaped and vegetated as part of the development. This will include planting adequate and appropriate vegetation within any effluent land application or reuse areas.

Table 6 Land Capability Assessment – Soil Characteristics

Soil Characteristics				
Soil Feature	Observation and Description	Assessed Criteria	LCA Rating	Mitigation Measures
Electrical conductivity (dS/m)	0.02	<0.8	Minor	Laboratory result
Emerson aggregate class (in context of sodicity)	Gravel soils observed - EAT not possible	-	-	It is accepted that the development site would include significant civil and site works which would include landscaping
Gleying	None observed	Nil	Minor	No impact on design
Mottling	The soil is classified as a gravel with some silts - no mottling	Nil	Minor	No impact on design
pH (H2O 1:5)	6.5 which is slightly acidic	5.5 - 8 is the optimum range for a wide range of plants	Minor	While the pH is within the optimum range, it is accepted that the development site would include significant landscaping and soil amelioration
Rock fragments (%)	The soil is classified as a gravel with some silts. As such, gravels take up the majority of the soil profile.	>20%	Major	Install a raised LAA with appropriate imported fill material (sandy loam / loam) to ensure adequate construction and operability. This may be incorporated into a broader site re-landscaping and fill plan. Adopt a conservative Design Loading Rate (DLR).
Sodicity (ESP%)	<0.1%	<6%	Minor	Soils (gravels) are non-sodic

Soil Characteristics				
Soil Feature	Observation and Description	Assessed Criteria	LCA Rating	Mitigation Measures
Depth to rock (m)	Bedrock was not encountered during the assessment (test pits progressed from 1.5 - 2m below ground level). Information from historical mining activities indicates a significant depth to bedrock (approx. 40 metres).	>1.5m	Minor	No impact on design
Soil structure (pedality)	Massive soil structure throughout	Structureless, Massive or hardpan	Major	Adopt a conservative DLR to minimise off-site export risk.
Soil texture, indicative permeability	Massive gravel with some silt present and high permeability.	Category 1 soils from *AS1547*	Major	Conservative DLR to be adopted to minimise off-site export risk. Install a raised LAA and import good quality fill (sandy loam / loam). Consider amended soil systems. Undertake a cumulative impact assessment to show the proposed development is sustainable.
Watertable depth below base of LAA (m)	No watertable was encountered during this assessment.	>2m	Minor	No impact on design
Phosphorus sorption capacity	97 mg/kg (at 70%)	Low	Major	Low P-sorption capacity

Figure 2: Harrietville Tailings Site - Soil Test Pit Photos, TP1

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Figure 3: Harrietville Tailings Site - Soil Test Pit Photos, TP2

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Figure 4: Harrietville Tailings Site - Soil Test Pit Photos, TP3

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Figure 5: Harrietville Tailings Site - Soil Test Pit Photos, Cutting 1

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Figure 6: Harrietville Tailings Site - Soil Test Pit Photos, Cutting 2

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Figure 7: Harrietville Tailings Site - General Overview Photos

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4.1 Discussion of Major Constraints

4.1.1 Characteristics of Tailings Material

The siting of the development area on historical mine tailings presents a unique set of challenges for the management of wastewater. Notwithstanding, it also offers opportunities for the design and engineering of effluent management solutions that are not always possible on less disturbed sites.

The tailings are highly permeable due to the prevalence of gravels and cobbles throughout the profile. The limited soil present is predominantly a silt to silty loam with no structure or profile development due to the historical disturbance. The capacity for retention of phosphorus and other pollutants within this material is limited. The tailings also pose a constraint to the establishment of a healthy vegetation cover in some areas.

The tailings are however, very consistent in their properties and deep in the context of the management of treated effluent. In addition, the significant degree of site disturbance means any development of the site will require a significant recontouring and rehabilitation which offers an opportunity to incorporate measures to improve the capability of the site for receiving and attenuating pollutants from domestic wastewater. There will inevitably be financial and practical constraints to this.

As such it will be necessary for any wastewater management solution to provide a high level of treatment and pollutant reduction prior to percolation into the tailings material.

4.1.2 Groundwater

4.1.2.1 Summary of Groundwater Catchments

The groundwater hydrology within the Upper Ovens catchment is complex, with groundwater being present in the fractured rock and the unconsolidated sediments, forming two separate groundwater flow systems. The aquifers present within the unconsolidated sediments are porous and are the major groundwater resource for users. The fractured rock aquifers are drawn from less frequently, and are mainly used for domestic, stock and small-scale developments (D. Lovell, 2006).

A summary of the Upper Ovens Catchment Geology is outlined in Table 7.

A significant number of mapped groundwater bores are scattered across the township. These are presented in Figure 8.

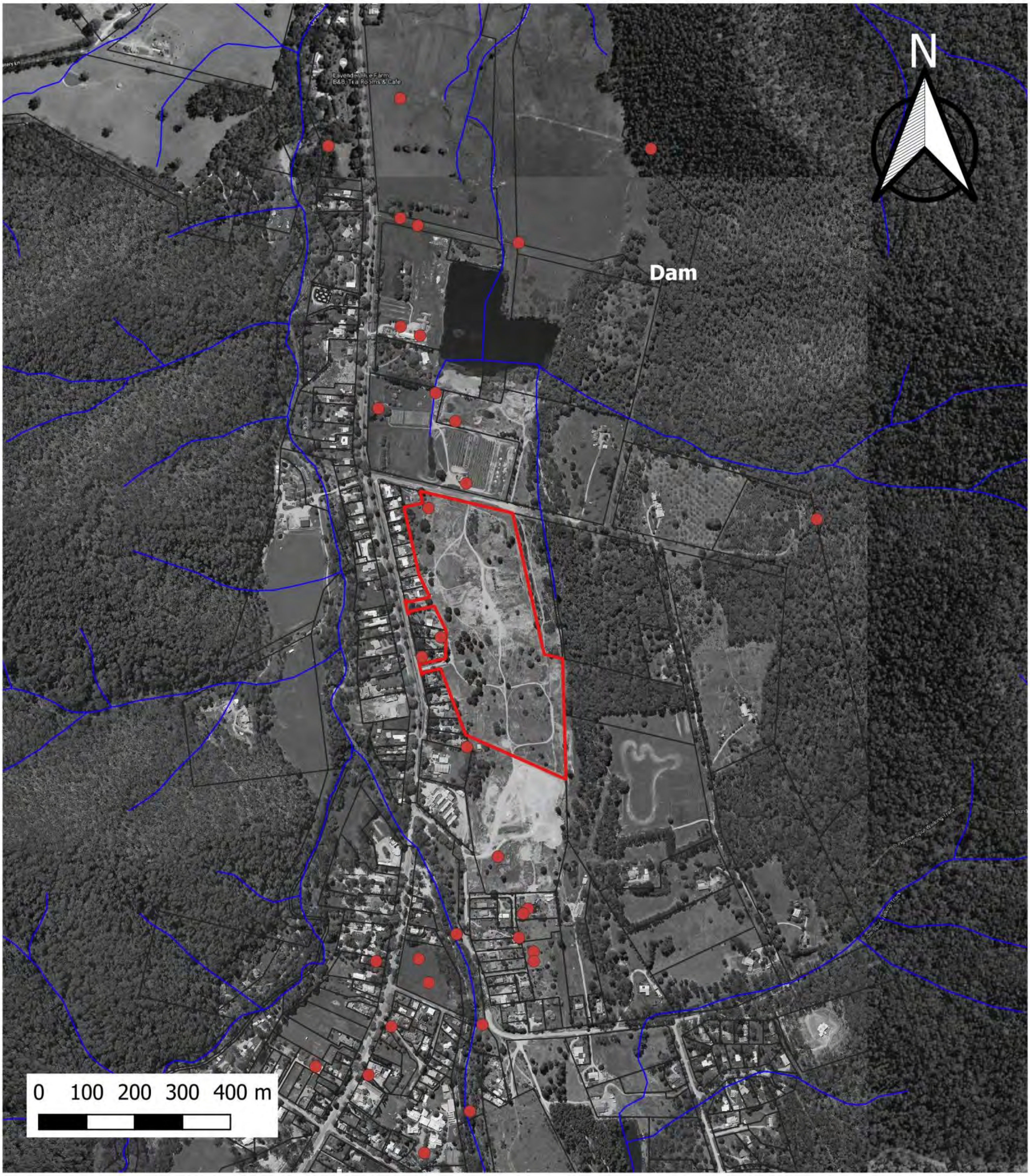

Figure 8: Groundwater Bore Locations

Legend

Lot boundary   Groundwater bores   Watercourses

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Table 7 Summary of the Upper Ovens catchment Geology (SKM, 2006)

Groundwater System	Age	Formation	Description	Thickness
Unconsolidated Sediment Deposits	Quaternary	Coonambidgal Formation	Alluvial flats with clay to gravel deposits	<100m
		Shapparton Formation	Fine to coarse sand and gravel deposits (in a shoestring form)	
		Calivil Formation	Coarse sand and gravels	
Fractured Rocks	Tertiary	Older Volcanics	Olivine Basalt	100m
	Devonian	Granite	Granite and granodiorite	>2km
	Ordovician	Gneiss and schists	Metamorphosed sediments (sandstone, shale, siltstone)	>2km

Fractured Rock Aquifers

The majority of the fractured rock aquifer is within the Ordovician sandstone, however there are minimal areas of granite intrusion (Devonian age) and some basalt in the Older Volcanics Formation (Tertiary age). Rainfall enters via a weathered zone and through rapid and direct infiltration through rock fractures of upper layers. Discharge from these aquifers is primary via seeps (at breaks in slopes) and springs, connecting this aquifer with the Ovens River and surface water generally (SKM, 2006). The fractured rock aquifer is of good quality, with Total Dissolved Solids (TDS) generally being less than 200-300 mg/L (D Lovell, 2009).

Unconsolidated Sediments Aquifers

The unconsolidated alluvial and colluvial sediments have a complex depositional process, with different formations being present as thin heterogenous layers and discrete units as opposed to larger layers extending across the valley. Due to the complex nature of this aquifer system, individual aquifer units have not yet been determined and the interconnectivity between these aquifers is difficult to define (D. Lovell, 2009).

Aquifers in the unconsolidated alluvial sediments are recharged primarily from rainfall and irrigation channel seepage, with additional (minor) recharge occurring via spill from elevated bedrock, terraces and colluvial deposits. Discharge from these aquifers occurs through evapotranspiration, seepage to the Ovens River, vertical movement to underlying aquifers (including the fractured rock aquifers), downward valley flow and via extraction bores (SKM, 2006).

The alluvial aquifer has a high water quality and the water can be utilised for all water uses. This water generally has low salinity and generally less than 200 mg/L Total Dissolved Solids (TDS). However, some areas are high in iron which could require aeration depending on the end use (D. Lovell, 2009).

It is also worth noting that significant dredging of the top 40m of the alluvial sediments in search for gold. This work had involved disturbance of the shallow sediments by excavation, mixing, re-constitution and re-deposition. As such, the natural depositional formation and hydraulic conductivity of these sediments has been changed (Lovell, 2009).

4.1.2.2 Groundwater Flow

The groundwater flow within the Upper Ovens catchment generally follows the topographic contours and associated gradients. The greatest volumetric groundwater flow of the alluvial aquifer is horizontally towards the river, with only a small portion travelling downwards through the colluvial aquifer and to the fractured rock aquifer.

Figure 9 conceptually shows the groundwater flow characteristics of the alluvial aquifers.

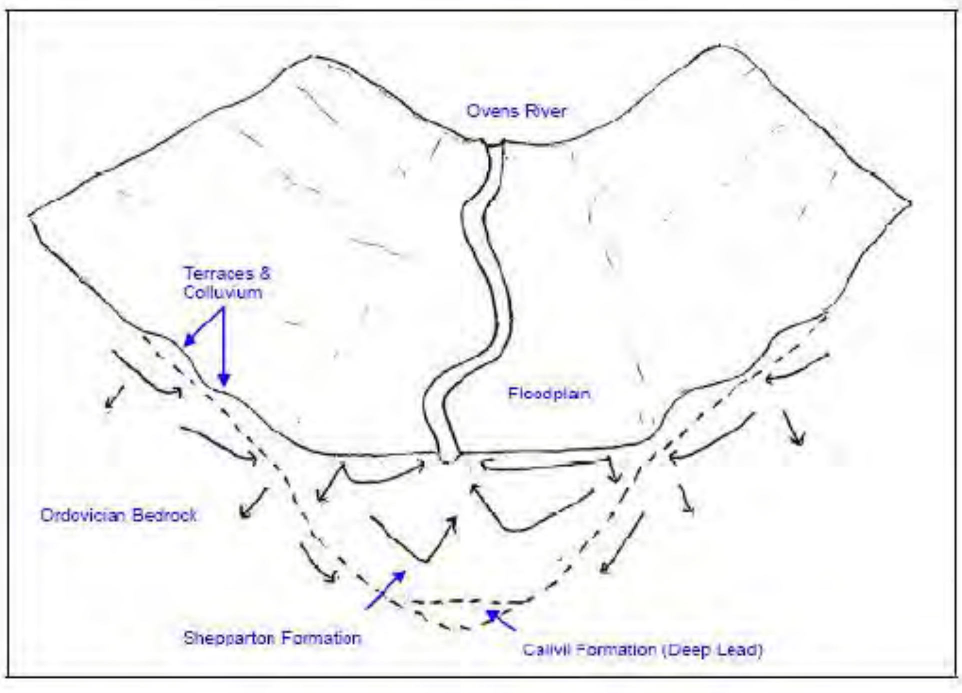


Figure 9 Conceptualisation of Groundwater Flows of Alluvial Aquifers within the Upper Ovens Catchment (Sinclair Knight Merz 2007)

4.1.3 Surface Water Quality

The East Ovens and West Ovens streams are the two main streams present in the Upper Ovens River catchment, and these steams join in the Harrietville Township. The major tributaries of the Ovens River include the Buckland River, Buffalo Creek, Morses Creek, Barwidgee Creek and Happy Valley Creek. The catchment receives significant volumes of snow melt during Spring, and alluvial groundwater aquifers contribute to baseflows to rivers as detailed above (North East Water, 2016).

A Waterway Monitoring Program was completed in Harrietville in 2016 by North East Water to determine if on-site wastewater treatment was impacting water quality of the Ovens River. This information would be used to support any proposed future sewer options in the future.

The water sampling was carried out at 10 representative locations within the Harrietville Township, and samples were collected on 15 occasions (2014-2016). Samples were analysed at a NATA accredited laboratory for parameters which are indicators of on-site wastewater pollution. Field measurements for dissolved oxygen and temperature were also completed. The water quality sampling results showed that all SEPP WoV objectives were achieved, with the exception of dissolved oxygen (North East Water, 2016). A summary of the Ovens River water quality results and the SEPP WoV objectives is outlined in Table 8.

Table 8 Summary of the Ovens River Water Quality Against WoV Objectives

Parameter	SEPP WoV Objective[1]	Were Objectives Achieved?
Total Phosphorus	≤25 µg/L	Yes
Total Nitrogen	≤350 µg/L	Yes
Dissolved Oxygen (DO)Saturation	25th -≥90%	No
Turbidity	≤5 NTU	Yes
Electrical Conductivity	≤100 µs/cm	Yes
pH	25th -≥6.4 75th -≤7.7	Yes
E. Coli	≤150 org/100mL	Yes

Note 1: The concentrations are median unless specified otherwise.

As can be seen from the above information, the Ovens River has good quality water and does not appear to be negatively impacted by on-site wastewater treatment systems. Whilst DO concentrations were marginally below the SEPP WoV guidelines, there was no decreasing trend in DO concentrations during the study period, which could be an indicator of impact from on-site wastewater pollution. This result is also comparable to a DELWP monitoring site, providing further evidence that no contamination is occurring (North East Water, 2016).

Whilst the E.coli concentrations at each monitoring site achieved the SEPP WoV targets, an upward trend in concentrations was identified during the study. Additionally, E.coli concentrations were generally higher during Summer months when stream flows were lower (reducing the total water volume whilst on-site wastewater volumes remain reasonably constant). It has also been hypothesised that these increased concentrations are due to the increased water activity within the river during Summer months, including swimming (North East Water, 2016).

The Department of Environment, Land, Water & Planning (DELWP) have a Ovens River monitoring site (403244) located within the Harrietville Township. An analysis of the 2018 monthly water quality sampling further showed that the water within the Ovens River if of a high quality and did not show high concentrations of on-site wastewater pollutants or any other parameters including sodium, potassium, magnesium or sulphate. A summary of the key statistics from the 2018 monthly sampling is shown in Table 9.

Table 9 DELWP Ovens River Water Quality Sampling Outcomes (Site 403244) (DELWP, 2018)

Parameter	50th %ile	90th %ile	Maximum
pH	7.2	7.4	7.5
DO (mg/L)	10.6	11.5	11.8
Turbidity (NTU)	1.1	2.6	3
Conductivity (µs/cm)	35.9	42	43
Total Suspended Solids (mg/L)	2	4	6
Total Nitrogen (mg/L)	0.009	0.047	0.064
Total Phosphorus (mg/L)	0.014	0.019	0.029
Sodium (mg/L)	2.5	3.0	3.3
Potassium (mg/L)	0.3	0.39	0.4
Magnesium (mg/L)	1.8	2.09	2.1
Sulphate as SO_4 (mg/L)	1	1	5

4.1.4 Climate

Bureau of Meteorology (BOM) climate data was obtained to determine the long-term climate conditions for the Harrietville Township. Average monthly rainfall data was obtained from Mount Hotham and Bright weather stations, and the average monthly evaporation data was obtained from the Dartmouth Reservoir weather station. A summary of the average monthly rainfall and evaporation is presented in Figure 10.

The average monthly data shows that evaporation is equal to or less than rainfall for seven to eight months of the year (from April until October/November). Average rainfall exceeds evaporation by ~50-100 mm/month during the months from May to September, and beneficial reuse of effluent is estimated to only be possible for two to four months of the year (November through to February). As such, the climate presents a high risk from an on-site wastewater management perspective as evapotranspiration can only remove low volumes of water from the soil and beneficial reuse is likely not viable as the only wastewater management solution.

Any considered on-site wastewater management options are recommended to adopt conservative Design Loading Rate (DLR) to accommodate the low evaporative rates (compared to high rainfall). This will result in larger Land Application Areas (LAAs) compared to areas with more desirable climatic conditions.

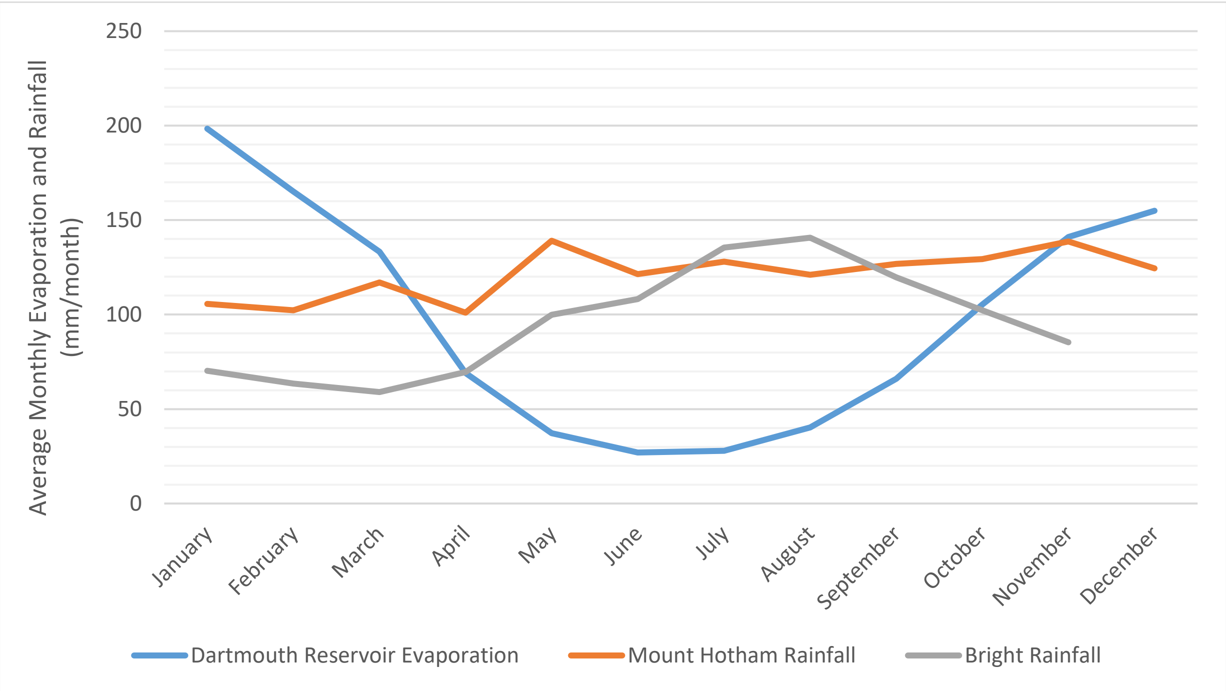


Figure 10. Average Monthly Rainfall and Evaporation (BOM)

4.2 Outcomes of Land Capability Assessment

The Tailings site is subject to a number of major to moderate constraints to wastewater management including gravelly, high permeability, disturbed soils, proximity and sensitivity of groundwater use and a climate that almost eliminates beneficial reuse by irrigation as an effluent management option. These constraints are relevant for individual on-site wastewater management systems and cluster or multi-lot solutions. Notwithstanding, some of the more conventional land capability constraints and considerations included in the EPA CoP and MAV (2014) are not directly applicable to an Alpine environment or need to be approached from a different perspective. The following sections summarise the key outcomes of the LCA process that will be incorporated into both the development and assessment of wastewater management options for the Tailings site.

4.2.1 Consideration of Effluent Management Options

Beneficial reuse of effluent by land irrigation is not a viable option for the Tailings development or Harrietville more broadly. Rainfall exceeds evaporation for approximately 8 months of an average year and evapo-transpiration is noticeably lower than most other areas of Victoria. In addition to this, there are ample, low-cost water supplies available that do not require treatment and are arguably a more sustainable water source.

Recycling of effluent by indoor uses such as toilet flushing, and laundry cold water supply will be considered. However, it is noted that this is typically cost prohibitive at this scale as 'third pipe' scheme.

Land application or land treatment (a concept widely recognised in other colder climate countries such as New Zealand and the USA – USEPA Process Design Manual for Land Treatment) is another option that should legitimately be considered for this project. A typical on-site wastewater effluent Land Application Area (LAA) is a simple example of this. However, it is possible to develop highly engineered and managed land treatment systems that can provide a very high level of ecosystem and human health protection. This may include individual advanced on-site LAAs or cluster or multi-lot land treatment systems.

Land treatment involves the utilisation of the assimilative and attenuative capacity of soil, plant, groundwater environments to provide a level of treatment of contaminants. At small scales such as this, it can provide a much lower cost and lower risk approach to tertiary treatment. In the context of the Tailings site (and Harrietville more broadly), land treatment might include recharge of the local unconfined aquifer following adequate treatment and in consideration of proximity to groundwater bores.

The alpine hydrology of the Ovens River also means consideration should be given to discharge to surface waters for some or potentially all the treated effluent from the development. Subject to adequate treatment, the long-term nutrient loads that the proposed development could contribute to the catchment can be considered very low. Control of discharge frequency, timing and volume can ensure adequate dilution so as to not result in toxicity impacts on the local ecology. Whilst not an ideal sustainability outcome, the relative risk of surface water discharge is considered comparable to other options in the context of the Tailings development.

4.2.2 Recommended Impact Assessment Approach

Given the wide variety of effluent management options that will need to be considered an overall water and pollutant mass balance will be developed for the site that will provide a relative indicator of the level of performance of each option. In addition, the following may be required at varying stages in project development and implementation.

- Long-term continuous daily water and nutrient balance modelling of effluent irrigation and land application areas to enable more accurate estimates of pollutant retention and export to receiving environments (e.g. using MEDLI).
- Steady state groundwater models to examine risk to nearby bores, pathogen die-off, nutrient attenuation and medium to long term watertable changes.
- Quantitative and semi-quantitative risk assessments (e.g. using the Australian Drinking and Water Recycling methodologies) for key pollutants such as human viruses and nutrients.
- Potential establishment of a baseline groundwater monitoring program (quality and water levels).

Preliminary versions of these tools will be developed and discussed as part of the options analysis and any concept design process.

Depending on the preferred effluent management strategy, there may be a need to develop a dynamic groundwater model for the Tailings that also incorporates adequate representation of the interaction of the unconfined aquifer with surface waters (e.g. as part of final impact assessment for regulatory approval).

4.2.3 Management Controls Arising from LCA

In addition to the above recommended impact assessment methodology, the following management controls are likely to be worth considering for the Tailings site.

- Provision of secondary and possibly advanced secondary treatment for any on-site wastewater management systems considered is likely to be recommended due to the limited attenuative capacity of the receiving environment.
- Advanced treatment / pollutant removal may be achieved through the use of amended soil materials as part of either on-site land application areas or cluster land treatment systems. This can include materials with high phosphorus sorption capacity, zeolite for more general pollutant adsorption or carbon to encourage denitrification.

- Importation of topsoil with good organic matter content to improve vegetation growth and pollutant retention.
- Implementation of remote monitoring to notify Council and/or the designated system manager / operator of high tank levels and other potential operational issues.

5 Literature Summary

As part of this assessment, a review has been undertaken of studies related to alternative wastewater management options for multi-lot developments in unsewered towns. The project scope of work for this element was provision of '*a literature summary, where literature includes industry knowledge as well as written material, that allows us to understand whether a multi-lot management model has precedence and whether the risks can be ameliorated, and where this has worked well'.*

It can be seen from this summary that there have been very few documented examples of multi-lot wastewater management models that have not been delivered as a public sewerage scheme. DWA are aware of a small number of private schemes, managed via a body corporate arrangement in Victoria however no information is publicly available for them. It is the understanding of DWA that these systems have suffered from issues relating to governance disagreements between strata members and ensuring appropriately trained persons are conducting maintenance of assets.

The Blackwood Septic Upgrade project, Park Orchards On-site Containment Trial and the Mount Macedon Wastewater Project are examples of collaborative projects between water authorities and local councils to fund and manage the improvement of on-site systems in constrained areas where appropriate. This is an option that will be explored as part of the Harrietville project and may include both ensuring a high level of design and construction quality in addition to increased oversight of the on-going operation of the systems.

The Project Brief indicated that the intention of the project was for any multi-lot solution to be managed privately and not by council or North East Water. Our literature review and an examination of relevant legislative instruments would suggest the only available option at this time would be establishment of a body corporate who would be the holder of an EPA Licence to operate wastewater management infrastructure. Feedback from the Project Control Group (PCG) indicated there may be reservations associated with this approach also due to historical experience where privately managed schemes fall into a state of poor operation and/or condition. There have been examples in the region where the local water authority is then directed by the Victorian government to assume ownership of these assets which can carry a significant financial, compliance and operational risks depending on the circumstances.

The Options Investigation phase of this project will involve testing of several management and technological models that considers these constraints.

5.1 Review of Similar Studies

As part of this assessment, a review has been undertaken of studies related to alternative wastewater management options for multi-lot developments in unsewered towns and other relevant documents, studies and guidelines.

A list of the studies reviewed is provided in Table 10 below with a comprehensive table with key information, constraints, and lessons learnt provided in Appendix C.

Note: The table of information in Appendix B has been adapted from the report prepared by KBR titled '*Place Based Small Town Wastewater Management Project (KBR, 28 June 2021)*'.

Table 10 Literature Review Studies and Documents

Category	Details	Author
Water Authority Report	North East Strategic Directions Statement, May 2019	North East Integrated Water Management Forum
Council Report	Blackwood Localised Septic Program (2013)	Central Highlands Water, Moorabool Shire Council
Council Report	Forest Wastewater Investigation Project (2019)	Barwon Water, Colac Otway Shire Council
Council Report	Park Orchards On-Site Containment Trial Project (2015-2018)	Yarra Valley Water, Manningham City Council
Council Report	Integrated Water Cycle Planning for Community Sewerage Areas Case Study (2015) - Monbulk Community Sewerage Area	Yarra Valley Water, Yarra Ranges Council
Council Report	Mt Macedon Wastewater Project	Western Water, Macedon Ranges Shire Council
Water Authority Report	Moyhu Wastewater Business Risk Assessment Moyhu Wastewater Report - Sewerage and Water Supply Program - Assessment of Septic Tank Impact Assessment of Septic Tank Impacts Moyhu Wastewater Business Case Moyhu Options Analysis	North East Water

Category	Details	Author
Council Report	Parts 1 & 2 - Domestic Wastewater Management Plan - Pilot Project Background Report Approaches for Risk Analysis of Development with On-Site Wastewater Disposal in Open Potable Water Catchments Domestic Wastewater Management Plan Pilot Project: Assessing the Efficacy of the EDIS-White Risk Assessment Algorithm - Using Data from Howes Creek Road & Goughs Bay Sub-Catchments Executive Summary of Goughs Bay Scoping Study	Mansfield Shire Council
Water Authority Report	Lake Eildon Catchment Septic Tank Risk Assessment (2009)	Ecos Environmental Consulting for Goulburn Valley Water
State Government Report	Managing the Environmental Impacts of Domestic Wastewater (2018)	Victorian Auditor-General's Office
Water Authority Report	Wye River and Separation Creek Sewerage Scheme Options Report (2011)	Sinclair Knight Merz (SKM)
International Report	Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems	United States Office of Water
State Government Report	Onsite Wastewater Management - Code of Practice (2016)	VIC EPA

Category	Details	Author
Research Organisation Report	Overcoming Barriers to Evaluation and Use of Decentralized Wastewater Technologies and Management (2007)	Water Environment Research Foundation (WERF)

6 Review of Available Data and Information

A review of available data necessary for the successful completion of the project has been undertaken with the outcomes summarised in the following table.

Table 11 Summary of Available Data and Sources

Data	Description	Source
Topographic / Elevation Data	A 1m Digital Elevation Model (DEM) was provided by Council and was available for the majority of the site, with the exception of the south eastern portion of the site. Additionally, a 2m DEM is available for the Harrietville Township (ELVIS). Contours and site slopes were created / determined within QGIS using this information. A 10m DEM is also available for Harrietville (Data Vic).	Alpine Shire Council Anzlic Committee on Surveying and Mapping Victorian Government
Ortho-photography	High resolution ortho-photography tiles for the Harrietville Township	Alpine Shire Council
Soil type (landscape) data	Land Resource Assessment for the North East Catchment Management Authority Victorian Soil Type data set layer for Victoria. Geomorphology (GMU) layer for Victoria	The State of Victoria, Department of Natural Resources & Environment Vic Gov data portal Department of Economic Development, Jobs, Transport and Resources (previously DEPI)
Watercourses (All)	State-wide watercourse (hydroline) layer – 1:25,000 scale trimmed to the Harrietville township. Used to define both partially vegetated / rehabilitated intermittent drainage lines and permanent watercourses.	Victorian Government data portal
Hydro areas (waterbodies)	State-wide waterbodies layer trimmed to Harrietville Township. Used to define farm dams and other larger waterbodies.	
Groundwater bores	Groundwater bore locations and available data (potable / non-potable).	BoM Australian Groundwater Explorer online mapping (http://www.bom.gov.au/water/groundwater/explorer/map.shtml)
Planning Overlay	Planning overlay used to isolate Environmental Significant Overlay (ESO), Floodways / Land Subject to Inundation and Bushfire Management Overlay (BMO).	Victorian Government data portal

Data	Description	Source
Bio Region Conservation Areas	Bio-conservation vegetation layer used to define environmentally significant vegetation (in combination with ESO layer). *Native Vegetation - Modelled 2005 Ecological Vegetation Classes (with Bioregional Conservation Status)* - NV2005_EVCBCS layer utilised.	Victorian Government data portal
Property boundaries	Cadastral boundaries for current properties within the Harrietville Township.	Victorian Government data portal

Key guidelines and sources of criteria for the current and future mapping are summarised in Table 12.

Table 12 Guidelines / Standards: On-site Wastewater Risk Framework

Organisation	Resource	Purpose
Victorian government	SEPP (Waters)	Historical context only resulting from recent legislative changes. The following clauses of the SEPP however remain in-force: - 28(1) and (2): Consideration of applications for subdivision and onsite domestic wastewater management systems - 29: Councils to develop a domestic wastewater management plan - 30: Sewerage Planning
EPA Victoria	EPA Code of Practice (CoP) – On-site Wastewater Management (2016)	Sets out specific means of compliance recognised as "deemed to comply" with the SEPP. Setback distances adopted for risk classification Framework.
MAV	Victorian Land Capability Framework (2014)	Documents the state government endorsed land capability hazard framework for on-site wastewater management in Victoria. Used as the basis for the land capability elements of the risk classification.
Standards Australia	ASNZS1547:2012 On-site domestic wastewater management	Provides additional design, siting and operational guidance that has been applied within the risk classification Framework.

7 References

BMT WBM (2012) *Assessment of On-site Containment: Park Orchards Case Study*. Yarra Valley Water.

BMT WBM (2015a) *Park Orchards Trial Project: Preliminary Design Package Volume 1*. Yarra Valley Water.

BMT WBM (2015b) *Integrated Water Cycle Planning for Community Sewerage Areas Case Study – Monbulk*. Yarra Valley Water.

BMT WBM (2016) *Park Orchards Trial Project: Baseline Monitoring Program Technical Review*. Yarra Valley Water.

DELWP (2017) Integrated Water Management Framework for Victoria.

EPA Victoria (2016) *Code of Practice for Onsite Wastewater Management*. Publication 891.4.

Municipal Association of Victoria (2014) Victorian Land Capability Assessment Framework.

Standards Australia (2012) *AS/NZS1547:2012 On-site domestic wastewater management.* Standards Australia.

Victorian Auditor-General's Office (2018) *Managing the Environmental Impacts of Domestic Wastewater.*

Department of Environment, Land, Water and Planning (2018), *403244 Ovens River @ Harrietville: WQ 2018 Percentiles Report*.

Lovell, D.M. (2009), *Conjunctive Management of Groundwater and Surface Water Resources in the Upper Ovens River Valley*. The Department of Civil and Environmental Engineering, The University of Melbourne.

North East Water (2016). *Harrietville Waterway Monitoring Program*.

Sinclair Knight Merz (2006). *Upper Ovens River Environmental FLOWS Assessment – ISSUES PAPER* North East CMA.

Sinclair Knight Merz (2007). *Upper Ovens Conceptual Hydrogeological Model. Melbourne, Goulburn Murray Water Unpublished Report DOCS# 2400986:78.*

Queensland Government (2021), *SILO Point Climate Data*.

Kellogg Brown and Root (2021). *Place Based Small Town Wastewater Management Project*, Goulburn Valley Water.

Appendix A Risk Assessment of Site and Soil Constraints

Risk Assessment of Site Characteristics				
Characteristic	Level of Constraint			Assessed Level of Constraint for Site
	Nil or Minor	Moderate	Major	
Aspect (affects solar radiation received)	North / North-East / North-West	East / West / South-East / South-West	South	North/North-West/North-East
Climate (difference between rainfall and pan evaporation)	Excess of evaporation over rainfall in the wettest months	Rainfall approximates to evaporation	Excess of rainfall over evaporation in the wettest months	Excess of rainfall over evaporation
Erosion [1] (or potential erosion)	Nil or minor	Moderate	Severe	Minor erosion observed
Exposure to sun and wind	Full sun and/or high wind or minimal shading	Dappled light	Limited patches of light and little wind to heavily shaded all day	High exposure to both sun and wind
Fill [2] (imported)	No fill or minimal fill, or fill is good quality topsoil	Moderate coverage and fill is good quality	Extensive poor-quality fill and variable quality fill	Legacy mining site
Flood frequency (ARI) [3]	Less than 1 in 100 years	Between 100 and 20 years	More than 1 in 20 years	Not flood prone
Groundwater bores [4]	No bores onsite or on neighbouring properties	Setback distance from bore complies with requirements in EPA Code of Practice 891.3 (as amended)	Setback distance from bore does not comply with requirements in EPA Code of Practice 891.3 (as amended)	Setbacks to bores not in compliance with CoP
Land area available for LAA	Exceeds LAA and duplicate LAA and buffer distance requirements	Meets LAA and duplicate LAA and buffer distance requirements	Insufficient area for LAA	Land area will be determined through project
Landslip (or landslip potential) [5]	Nil	Minor to moderate	High or Severe	Not prone to landslip
Rock outcrops (% of surface)	<10%	10-20%	>20%	Large cobbles and boulders present >20%
Slope Form (affects water shedding ability)	Convex or divergent side-slopes	Straight side-slopes	Concave or convergent side-slopes	Primarily divergent
Slope gradient [6] (%)				
(a) for absorption trenches and beds	<6%	6-15%	>15%	0 – 5%
(b) for surface irrigation	<6%	6-10%	>10%	0 – 5%
(c) for subsurface irrigation	<10%	10-30%	>30%	

Risk Assessment of Site Characteristics

Characteristic	Level of Constraint: Nil or Minor	Level of Constraint: Moderate	Level of Constraint: Major	Assessed Level of Constraint for Site
Soil Drainage [7] (qualitative)	No visible signs or likelihood of dampness, even in wet season	Some signs or likelihood of dampness	Wet soil, moisture-loving plants, standing water in pit; water ponding on surface, soil pit fills with water	Free draining
Stormwater run-on	Low likelihood of stormwater run-on		High likelihood of inundation by stormwater run-on	Low likelihood
Surface waters - setback distance (m) [9]	Setback distance complies with requirements in EPA Code of Practice 891.3 (as amended)		Setback distance does not comply with requirements in EPA Code of Practice 891.3 (as amended)	Generally comply with CoP setbacks except man-made drainage line on south-eastern boundary
Vegetation coverage over the site	Plentiful vegetation with healthy growth and good potential for nutrient uptake	Limited variety of vegetation	Sparse vegetation or no vegetation	Sparse however landscaping would be a component of any future development

Characteristic	Level of Constraint: Nil or Minor	Level of Constraint: Nil or Minor	Level of Constraint: Moderate	Level of Constraint: Major	Level of Constraint: Major	Assessed Level of Constraint for Site
Soil Drainage [8] (Field Handbook definitions)	Rapidly drained. Water removed from soil rapidly in relation to supply, excess water flows downward rapidly. No horizon remains wet for more than a few hours after addition	Well drained. Water removed from the soil readily, excess flows downward. Some horizons may remain wet for several days after addition	Moderately well drained. Water removed somewhat slowly in relation to supply, some horizons may remain wet for a week or more after addition	Imperfectly drained. Water removed very slowly in relation to supply, seasonal ponding, all horizons wet for periods of several months, some mottling	Poorly/Very poorly drained. Water remains at or near the surface for most of the year, strong gleying. All horizons wet for several months	

Risk Assessment of Soil Characteristics				
Characteristic	Level of Constraint			Assessed level of constraint
	Nil or Minor	Moderate	Major	
Electrical Conductivity (ECe) (dS/m) as a measure of soil salinity [1]	<0.8	0.8 - 2	>2	0.02
Emerson Aggregate Class (consider in context of sodicity)	4, 5, 6, 8	7	1, 2, 3	N/A -gravel
Gleying [2] (see Munsell Soil Colour Chart)	Nil	Some evidence of greenish grey / black or bluish grey / black soil colours	Predominant greenish grey / black, bluish grey / black colours	Nil
Mottling (see Munsell Soil Colour Chart)	Very well to well-drained soils generally have uniform brownish or reddish colour	Moderately well to imperfectly drained soils have grey and/or yellow brown mottles and in the mottled areas occur higher in the profile the less well-drained the soil	Poorly drained soils have predominant grey colours with yellow brown or reddish brown mottles located along root channels, large pores and cracks	Gravel - no mottling
pH [3] (favoured range for plants)	5.5 - 8 is the optimum range for a wide range of plants; 4.5 - 5.5 suitable for many acid-loving plants		<4.5, >8	6.5
Characteristic	Level of Constraint			Assessed level of constraint
	Nil or Minor	Moderate	Major	
Rock Fragments (size & volume %)	0 – 10%	10 – 20 %	>20%	>20%
Sodicity [4] (ESP %)	<6%	6 – 8%	>8%	<0.1
Soil Depth to Rock or other impermeable layer (m) [5]	>1.5 m	1.5 – 1 m	<1 m	1.5 - 2.0m
Soil Structure (pedality)	Highly or Moderately structured	Weakly-structured	Structureless, Massive or hardpan	Massive
Soil Texture, [6] Indicative Permeability	Cat. 2b, 3a, 3b, 4a	Cat. 4b, 4c, 5a	Cat. 1, 2a, 5b, 5c, 6	Gravel - 1
Watertable Depth (m) below the base of the LAA	>2 m	2 – 1.5 m	<1.5 m	Not encountered

Appendix B Soil Test Pit Logs and Laboratory Results

Results of External Laboratory Analysis																					
Site Name	**Sample Name**	**CEC** (cmol/kg))	Rating	**Ca** (mg/kg)	Rating	**Mg** (mg/kg)	Rating	**Na** (mg/kg)	Rating	**K** (mg/kg)	Rating	**ESP** (%)	Rating	**P-sorp.** (mg/kg)	Rating	**Bray P** (mg/kg)	Rating	**Total Nitrogen** (%)	Rating	**Organic Carbon** (%)	Rating
Harrietville Soil Sample	TP Composite	2.8	VL	190	VL	198	M	21	VL	47	VL	0.03	NS	97	L	-	n/a	-	n/a	-	n/a

Interpretation Sheet 1 - pH, EC & Emerson Aggregate Class

Interpretation of Soil pH (1:5 Soil:Water) (rating based on Hazelton & Murphy (1992))	
pH	**Rating**
0.00 to 4.50	Extremely acid
4.51 to 5.00	Very strongly acid
5.01 to 5.50	Strongly acid
5.51 to 6.00	Moderately acid
6.01 to 6.50	Slightly acid
6.51 to 7.30	Neutral
7.31 to 7.80	Mildly alkaline
7.81 to 8.40	Moderately alkaline
8.41 to 9.00	Strongly alkaline
9.01 to 14.00	Very strongly alkaline

preferred range

Multiplier Factors for Calculating ECe (taken from Hazelton & Murphy (1992))		
Texture Class	**Applicable Soil Textures**	**MF**
S	Sand, loamy sand, clayey sand	17
SL	sandy loam, fine sandy loam	11
L	loam, loam fine sandy, silty loam	10
CL	clay loam, sandy clay loam	9
LC	light clay	8
MC	medium clay	7
HC	heavy clay	6

Interpretation of ECe (1:5 Soil:Water) (rating based on Hazelton & Murphy (1992))	
Ece (dS/m)	**Rating**
0.00 to 2.00	Non-saline
2.01 to 4.00	Slightly saline
4.01 to 8.00	Moderately saline
8.01 to 16.00	Highly saline
16.00 up	Extremely saline

increasing hazard

Interpretation of Emerson Aggregate Class (rating describes likelihood of dispersion)	
EAT Class	**Rating**
1	High
2(1)	Mod
2(2)	Mod
2(3)	High
2(4)	High
3(1)	Low
3(2)	Low
3(3)	Mod
3(4)	Mod
4	Low
5	Low
6	Low
7	Low
8	Low

Interpretation Sheet 2 - CEC, P-Sorption, Bray P, Organic carbon, Total nitrogen

Interpretation of CEC

(rating based on Hazelton & Murphy (1992))

Rating	CEC (me/100g)			Ca (mg/kg)			Mg (mg/kg)			Na (mg/kg)			K (mg/kg)		
VL	0.00	to	6.00	0.00	to	400.00	0.00	to	36.50	0.00	to	23.00	0.00	to	78.20
L	6.01	to	12.00	400.01	to	1000.00	36.51	to	121.50	23.01	to	69.00	78.21	to	117.00
M	12.01	to	25.00	1000.01	to	2000.00	121.51	to	365.00	69.01	to	161.00	117.01	to	274.00
H	25.01	to	40.00	2000.01	to	4000.00	365.01	to	972.00	161.01	to	460.00	274.01	to	782.00
VH	40.01	up		4000.01	up		972.01	up		460.01	up		782.01	up	

VL=very low, L=low, M=medium, H=high, VH=very high

Interpretation of ESP

(rating based on Hazelton & Murphy (1992))

Rating	ESP (%)			Description
NS	0.00	to	6.00	Non-sodic
S	6.01	to	15.00	Sodic
SS	15.01	to	25.00	Strongly sodic
VSS	25.01	up		Very strongly sodic

↓ increasing hazard

Interpretation of Phosphorus Sorption Capacity

(rating based on Hazelton & Murphy (1992))

Rating	P-sorption (mg/kg)			Description
L	0.00	to	125.00	Low
M	125.01	to	250.00	Medium
MH	250.01	to	400.00	Medium-High
H	400.01	to	600.00	High
VH	600.01	up		Very high

↑ increasing hazard

Interpretation of Bray Phosphorus

(rating based on Hazelton & Murphy (1992))

Rating	Bray P (mg/kg)			Description
VL	0.00	to	5.00	Very Low
L	5.01	to	10.00	Low
M	10.01	to	17.00	Moderate
H	17.01	to	25.00	High
VH	25.01	up		Very high

Interpretation of Soil Nitrogen (TN)

(rating based on Hazelton & Murphy (1992))

Rating	TN (%)			Description
VL	0.000	to	0.050	Very Low
L	0.051	to	0.150	Low
M	0.151	to	0.250	Medium
H	0.251	to	0.500	High
VH	0.501	up		Very high

Interpretation of Soil Organic Carbon (OC)

(rating based on Hazelton & Murphy (1992))

Rating	OC (%)			Description
VL	0.00	to	1.50	Very Low
L	1.51	to	2.00	Low
M	2.01	to	3.00	Medium
H	3.01	to	5.00	High
VH	5.01	up		Very high

Soil Bore Log

DECENTRALISED WATER CONSULTING

Client:	Alpine Shire Council	**Test Pit No:**	**TP1**		
Locality:	Harrietville Tailings Site	**Topography:**	Disturbed tailings site with gently undulating terrain comprised of tailings stockpiles		
Site Address:	147A Great Alpine Road, Harrietville	**Geology:**	Ordovician Sandstone, Shale and Siltstone		
Logged by:	DH	**Soil Type:**	Red Dermosol		
Date:	16-June-2021	**Slope:**	0-5%	**Aspect:**	North West
Project:	0495	**Drainage:**	Free Draining	**Exposure:**	High
Excavation type:	Hand Auger and shovel	**Surface condition:**	Disturbed	**Surface:**	Mixed grass with gravels / cobbles

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1										Minor silt present.
0.2										
0.3										
0.4										
0.5		TP1/1								The top 600mm is comprised of ~30% cobbles. This is reduced to ~10% beyond this depth.
0.6										
0.7										
0.8										
0.9			A	Gravel	Massive	Light Brown	-	Soil is primarily gravels with coarse sand and cobbles present	Moist	
1.0		TP1/2								
1.1										
1.2										
1.3										
1.4										
1.5		TP1/3								
1.6										
1.7										
1.8										
1.9		Test Pit Terminated at 1.8m								
2.0										

Soil Bore Log

DECENTRALISED WATER CONSULTING

Client:	Alpine Shire Council	**Test Pit No:**	**TP2**		
Locality:	Harrietville Tailings Site	**Topography:**	Disturbed tailings site with gently undulating terrain comprised of tailings stockpiles		
Site Address:	147A Great Alpine Road, Harrietville	**Geology:**	Alluvium Palaeozoic Sediments, Metasediments and Igneous Rocks		
Logged by:	DH	**Soil Type:**	Brown Dermosol		
Date:	16-June-2021	**Slope:**	0-5%	**Aspect:**	West North West
Project:	0495	**Drainage:**	Free Draining	**Exposure:**	High
Excavation type:	Hand Auger and shovel	**Surface condition:**	Disturbed	**Surface:**	Mixed grass with gravels / cobbles

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1			A							Minor silt present.
0.2										
0.3										Veins of alluvial gravels are present throughout the test pit (depicted by the dark colouring).
0.4										
0.5		TP2/1								
0.6										
0.7										
0.8										
0.9										
1.0		TP2/2		Gravel	Massive	Light Brown	-	Soil is primarily gravels with coarse sand and cobbles present	Moist	
1.1										
1.2										
1.3										
1.4										
1.5		TP2/3								
1.6										
1.7										
1.8										
1.9										
2.0				Test pit terminated at 2m						

Soil Bore Log

DECENTRALISED WATER CONSULTING

Client:	Alpine Shire Council	**Test Pit No:**	**TP3**		
Locality:	Harrietville Tailings Site	**Topography:**	Disturbed tailings site with gently undulating terrain comprised of tailings stockpiles		
Site Address:	147A Great Alpine Road, Harrietville	**Geology:**	Ordovician Sandstone, Shale and Siltstone		
Logged by:	DH	**Soil Type:**	Red Dermosol		
Date:	16-June-2021	**Slope:**	0-5%	**Aspect:**	North East
Project:	0495	**Drainage:**	Free Draining	**Exposure:**	High
Excavation type:	Hand Auger and shovel	**Surface condition:**	Disturbed	**Surface:**	Mixed grass with gravels / cobbles

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1 – 1.5		TP3/1 (0.5); TP3 (1.0)	A	Gravel	Massive	Light Brown	-	Soil is primarily gravels with coarse sand and cobbles present	Moist	Minor silt present. Significant cobbles and boulders present throughout the soil profile. ~50mm sily clay loam soil vein present at ~500mm
1.6 – 2.0			Test pit terminated at 1.5m							

Soil Bore Log

Client:	Alpine Shire Council	**Test Pit No:**	**Cutting 1**
Locality:	Harrietville Tailings Site	**Topography:**	Disturbed tailings site with gently undulating terrain comprised of tailings stockpiles
Site Address:	147A Great Alpine Road, Harrietville	**Geology:**	Ordovician Sandstone, Shale and Siltstone
Logged by:	DH	**Soil Type:**	Red Dermosol

Date:	16-June-2021	**Slope:**	0-5%	**Aspect:**	North East
Project:	0495	**Drainage:**	Free Draining	**Exposure:**	High
Excavation type:	Hand Auger and shovel	**Surface condition:**	Disturbed	**Surface:**	Mixed grass with gravels / cobbles

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1 – 1.6 (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6)		Cutting 1	A	Gravel	Massive	Light Brown	-	Soil is primarily gravels with coarse sand and cobbles present	Moist	Minor silt present.
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Client:	Alpine Shire Council	**Test Pit No:**	**Cutting 2**		
Locality:	Harrietville Tailings Site	**Topography:**	Disturbed tailings site with gently undulating terrain comprised of tailings stockpiles		
Site Address:	147A Great Alpine Road, Harrietville	**Geology:**	Alluvium Palaeozoic Sediments, Metasediments and Igneous Rocks		
Logged by:	DH	**Soil Type:**	Brown Dermosol		
Date:	16-June-2021	**Slope:**	0-5%	**Aspect:**	West North West
Project:	0495	**Drainage:**	Free Draining	**Exposure:**	High
Excavation type:	Hand Auger and shovel	**Surface condition:**	Disturbed	**Surface:**	Mixed grass with gravels / cobbles

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1										
0.2										
0.3										
0.4										
0.5										
0.6			A	Gravel	Massive	Light Brown	-	Soil is primarily gravels with coarse sand and cobbles present	Moist	Minor silt present.
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

DECENTRALISED WATER CONSULTING

Key to Soil Borelogs

Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

Moisture conditions

D	Dry	**VM**	Very moist
SM	Slightly moist	**W**	Wet / saturated
M	Moist		

Graphic Log and Textures

S - Sand LS - Loamy sand CS - Clayey sand	CL - Clay loam SCL - Sandy clay loam SiCL - Silty clay loam	Gravel (G)
SL - Sandy loam	LC - Light clay SC - Sandy clay	Parent material (stiff)
L - Loam LFS - Loam fine sandy SiL - Silty loam	MC - Medium clay HC - Heavy clay	Parent material (weathered)

SESL AUSTRALIA
Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road, Thornleigh NSW 2120
Mailing Address: PO Box 357, Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 60558	Sample N°: 3	Date Received: 28/6/21	Report Status: Final

Client Name:	**Decentralised Water Consulting**	Project Name:	**DWC**
		SESL Quote N°:	
Client Contact:	**Andrew Weekes**	Sample Name:	**0495**
Client Order N°:	**N/A**	Description:	**soil**
Address:	**2/ 12 Channel Rd Mayfield West NSW 2304**	Test Type:	**PSI_Curve_5, ECEC_M3**

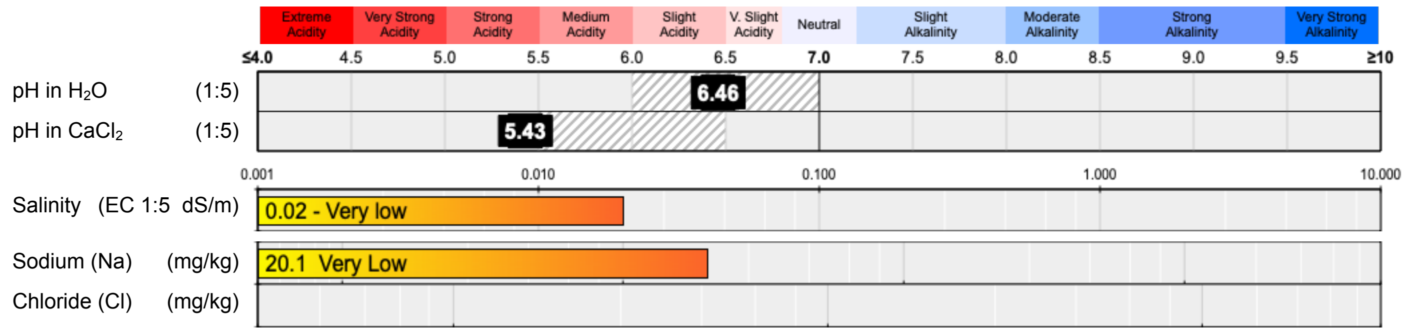
RECOMMENDATIONS

Analysed by SESL Australia Pty Ltd, NATA # 15633

Results only requested.

Recommendations by SESL Australia not requested.

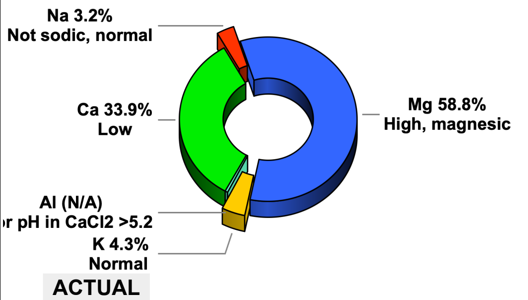
pH and ELECTRICAL CONDUCTIVITY

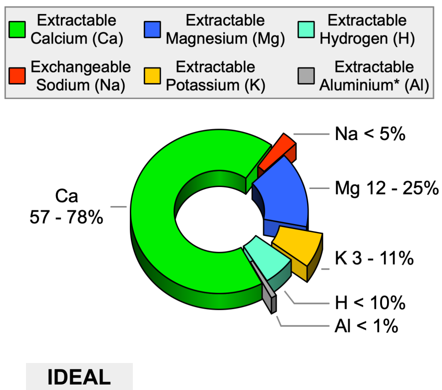


CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in $CaCl_2$ ≤ 5.5
Al only determined if pH in $CaCl_2$ is ≤ 5.2





EFFECTIVE CATION EXCHANGE CAPACITY (eCEC) (cmol(+)/kg)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	0.6	4.1 – 6.0
Comment: Potential Calcium deficiency		
Mg:K	13.7	2.6 – 5.0
Comment: Potential Potassium deficiency		
K/(Ca+Mg)	0.05	< 0.07
Comment: Acceptable		
K:Na	1.3	N/A

EXCHANGEABLE CATIONS (cmol(+)/kg)

Na:	K:	Ca:	Mg:	H:	Al:
0.09	0.12	0.95	1.65	0	-

eCEC does not include correction for soluble salts as standard. Where exchangeable calcium exceeds 80 % of eCEC and/or salinity exceeds 0.75 dS/m, alternative methods are recommended to determine true eCEC.

The units of eCEC *cmol(+)/kg* are the SI unit and are equivalent to *meq/100g*.

SESL AUSTRALIA
Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road, Thornleigh NSW 2120
Mailing Address: PO Box 357, Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 60558 | **Sample N°: 3** | **Date Received: 28/6/21** | **Report Status: Final**

PLANT AVAILABLE NUTRIENTS

EFFECTIVE AMELIORATION DEPTH (mm): ◉ 100 ○ 150 ○ 200 **DESIRED FERTILITY CLASS:** ○ Low ◉ Moderate ○ High

Major Nutrients	Unit	Result	Very Low / Low / Marginal / Adequate / High	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	mg N/kg	-		-	4	Did not test
Phosphorus (P)	mg P/kg	-		-	8.4	Did not test
Potassium (K)	mg/kg	45.6		6.1	23.7	17.6
Sulfur (S)	mg S/kg	-		-	9	9
Calcium (Ca)	mg/kg	191		25.4	168.5	143.1
Magnesium (Mg)	mg/kg	200		26.6	17.8	Drawdown
Iron (Fe)	mg/kg	-		-	73.4	Did not test
Manganese (Mn)	mg/kg	-		-	5.9	Did not test
Zinc (Zn)	mg/kg	-		-	0.7	Did not test
Copper (Cu)	mg/kg	-		-	0.8	Did not test
Boron (B)	mg/kg	-		-	0.4	Did not test

Explanation of graph ranges:

Very Low Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90 %.

Low Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90 %.

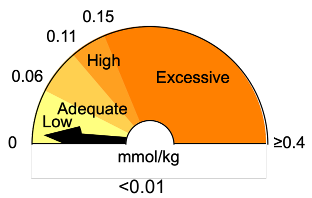
Marginal Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60 %.

Adequate Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30 %.

High The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2 %.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.
Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.
• g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and effective amelioration depth.

Phosphorus Saturation Index



Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH):	**8.1**
Sum of Base Cations (cmol(+)/kg):	**2.8**
Eff. Cation Exch. Capacity (eCEC):	**2.8**
Base Saturation (%):	**100**
Exchangeable Acidity (cmol(+)/kg):	**-**
Exchangeable Acidity (%):	**-**

Lime Application Rate (g/sqm)

– to achieve pH 6.0: **0**

– to neutralise Al: **-**

Calculated Gypsum Application Rate (CGAR)

(g/sqm) to achieve 67.5 % exch. Ca: **108**

The CGAR is corrected for the selected effective amelioration depth (100 mm) and any Lime addition to achieve pH 6.0.

PHYSICAL DESCRIPTION

Texture:	-
Estimated clay content:	-
Tactually gravelly:	-
Tactually organic:	-
Calculated EC_{SE} (dS/m):	-

Requires EC and Soil Texture result.

Munsell Colour:	-
Structure Size:	-
Structural Organisation:	-
Structural Unit:	-
Potential infiltration rate:	-
Est. Permeability Class (mm/hr):	-

Additional comments:

Organic Carbon (OC %):	-
Organic Matter (OM %):	-
Est. Field Capacity (% water):	-
Est. Permanent Wilting Point (% water):	-
Est. Plant Available Water (% water):	-
Est. Plant Available Water (mm/m):	-

Date Report Generated 12/07/2021

Consultant: Neena Goundar

Authorised Signatory: Simon Leake

METHOD REFERENCES:
pH (1:5 H_2O) - SESL CM0002; Rayment & Lyons 4A1-2011
pH (1:5 $CaCl_2$) - SESL CM0002; Rayment & Lyons 4B4-2011
EC (1:5) - SESL CM0001; Rayment & Lyons 3A1-2011
Chloride - Rayment & Lyons 5A2a-2011
Nitrate - Rayment & Lyons 7B1a-2011
Aluminium - SESL CM0007; Rayment & Lyons 15A1-2011
P, K, S, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - SESL CM0007; Rayment & Lyons 18F1-2011
Buffer pH and Hydrogen - SSSA Methods of Soil Analysis 2007, Pt 3, Ch 17; Adams-Evans (1962)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure* - "Murphy" (1991), Colour- "Munsell" (2000))

*Structure analysed in the laboratory is conducted on a disturbed sample, therefore is only a representation of the macro-structures that may be present in the field, which provide an indication of the soil physical characteristics and behaviours that may exist.

Appendix C Literature Summary Detail

Study Name Study Author	Study Overview	Relevance to Study	Key Constraints / Lessons
North East Strategic Directions Statement, May 2019 North East Water	The 2019 North East Water Strategic Directions Statement is a collaborative document bringing together the principles of Integrated Water Management (IWM), regional stakeholders and a shared strategic direction for water related objectives for the North East region of Victoria. The statement lists IWM Ready to Advance projects within which the Harrietville Tailings project is included.	Provides the framework, direction and funding for the current study	The key constraints will primarily be environmental, land capability, regulatory and economic. Study in progress
Blackwood Localised Septic Program (2013) Central Highlands Water, Moorabool Shire Council	The Blackwood Localised Septic Program (BLSP) was established as part of a $2.6m funding announcement in 2015 and has two main objectives: 1. To renew or upgrade existing septic tank systems in the Blackwood Township that were identified in the Moorabool Shire Council's Septic Tank Auditing Program as being faulty or presenting a risk to public health or the environment; and 2. To implement a planning assistance program for owners wishing to build a new dwelling on unsewered vacant land within the Blackwood Township At the end of Part 1 of the project the outcomes were: - 70 residential installations were completed - New systems at the public toilets, recreation reserve, and the post office/general store were installed - The Caravan Park was upgraded, eliminating >1 million Litres of wastewater per year from entering the Lerderderg River - Property use is changing with new families investing in properties in the township Part 2 of the program was a major success with: - 32 lots receiving advice. - 4 Planning Permits granted - In principal support from all agencies for 31 developments. - 1 development deemed unsuitable.	The BLSP is a project for the upgrade and implementation of wastewater systems in small towns reliant on septic tank systems.	The key constraints for the BLSP were primarily environmental and land capability including: - Steep slopes - Limited depth of soils - High rainfall - Lots of rock - Heavy clay soils - Dense vegetation As well as to do with the properties in the towns involving: - Very small lots - Intermittent and seasonal use of the dwellings The lessons learnt from the project were based on what worked and what didn't: What worked: - Breaking the upgrades into sizeable rounds - Managing the homeowner's expectations - On-site inception meetings with homeowners - Good working relationship with the Environmental Health Officer - Retention of payments of contractors - Having a project manager with a sound knowledge of domestic wastewater management undertaking the project design - Maintaining a good working relationship with the Department of Environment Land, Water and Planning (DELWP) What didn't: - The BSLP only addressed 24% of the issues in the township - During the program, and additional 42 properties were found to have failing systems. There was not enough money to fix them. - The project manager underestimated the cost of upgrading the underfloor plumbing in properties - Subsidence of soils - The consolidation and re-alignment of boundaries
Forest Wastewater Investigation Project (2019) Barwon Water, Colac Otway Shire Council	The objective of the study was to investigate wastewater management upgrade options for the Forrest Community. The investigation was undertaken in order to assess and support Barwon Water and Colac Otway Shire Council to assist the community in developing a long-term solution that can support the growth and liveability of Forrest as well as taking advantage of the opportunity to achieve multiple benefits from the improved management of wastewater. The project was undertaken in four stages: 1. Project Review, Definition and Justification 2. Option Development 3. Solutions Package Assessment 4. Business Case Development and Reporting Four solutions packages were developed as part of stage 2 of the project using a Multi-Criteria Analysis (MCA) based on each of the measures of success previously developed from community feedback. These comprised of a range of factors (i.e. environmental, social, economic, etc) that were considered most important to the community regarding the wastewater solution for Forrest.	The investigation of upgrade options for wastewater management in Forrest is highly applicable to the current study being undertaken on behalf of Goulburn Valley Water (GVW). The investigation of Forrest wastewater systems provides a framework for investigation for a range of solutions to upgrading the wastewater systems based on town-specific criteria (land capability, cost, constructability, etc) which is what the tool being developed will incorporate into its decision-making framework.	The key constraints of the project was primarily related to cost. A major problem during community consultation was there were no details on the potential cost per lot/resident and hence it was very challenging to explain the uncertainty about cost and who will manage the system. In addition, most residents did not want to have to fund improvements, and with no mechanism currently available to fund the project Barwon Water are still trying to find options to get the project off the ground. Barwon Water is hopeful that an economic assessment which considered the benefits from tourism and economic development may provide impetus for some additional funding of the scheme. It was found that the desire for development was varied, and that different socio-economic groups have different aims, politics, etc, which all affect the perceptions and drivers for upgrades. In addition, with significant tourist influxes, and the lack of operational and maintained on-site wastewater infrastructure, odours, and high levels of off-site discharge of black- and grey-water to the drainage network inhibits tourism and growth of the area.

Study Name Study Author	Study Overview	Relevance to Study	Key Constraints / Lessons
	Partial On-site Containment with Central Irrigation / Reuse was determined to be the preferred option for Forrest (Solution Package 3). This package has been taken forward to the next stage of the project (Business Case development and reporting). This stage investigates potential funding sources and implementation strategies for appropriate agencies. This will include refinement of costing estimates and potential funding and management structures for the preferred solution.		Findings were that effective community engagement was almost as big as the technical solution component. Approaches used included website, letters, face to face, workshops and drop-in centers to allow residents to come when it suited them. This allowed Barwon Water to show details to residents and get feedback and comments. The options selected provided a clear division in terms of the types of systems that could be installed. People needed some information on potential costs as well as technical details of schemes, so they could understand why there are different approaches rather than just traditional reticulated sewerage Surveys and direct engagement provided good range of feedback.
Park Orchards On-Site Containment Trial Project (2015-2018) Yarra Valley Water, Manningham City Council	Unsewered properties in Park Orchards and Ringwood North currently manage their wastewater using various septic systems. Manningham City Council (MCC) has identified that approximately 1,250 properties within Park Orchards and some sections of Ringwood North are either unable to contain their wastewater on-site all year round or do not, due to the performance of their current septic systems. However, due to uncertainties surrounding the feasibility of an onsite servicing approach, the planning for a trial commenced in 2013. The trial was divided into four stages: Stage 1: Identification of the Trial Area Stage 2: On-Site Design Stage 3: Tendering Stage 3B: Construction Stage 4: Trial Monitoring & Evaluation The objectives of the Park Orchards trial project are to: - Evaluate the potential to maximise on-site containment in a community sewerage area - Evaluate the performance of alternative sewerage technologies in comparison to conventional sewerage services - Evaluate the potential to retain existing on-site systems and integrate these into YVW's sewerage service - Explore the social, environmental, health and fiscal considerations involved in utilising on-site containment as a sustainable servicing solution - Identify regulatory, policy and role uncertainties in relation to water authority use of on-site containment systems The trial seeks to provide all relevant information required to inform the discussion in regards to the preferred servicing approach to Park Orchards, along with the potential to incorporate on-site containment technologies into YVW's sewerage service offerings.	The Park Orchards Trial project applicable to the current study being undertaken on behalf of Goulburn Valley Water (GVW). The trial involving the onsite containment of wastewater systems provides an understanding of key constraints from the community as well as land capability in implementing such systems.	The key constraints associated with the trial were: - Conflicting views relating to development - Extended Project Timeline resulting in fatigue - Not all YVW stakeholders were engaged in the project - the YVW Community - Sewerage Projects Vision has become more complex - Loss of focus on the Project - Reinstatement commitments to customers were unrealistic - L35 Irrigation Areas Lessons learnt from the project: - Executive Support is essential for Trial Projects - Lack of clarity with respect to YVW CSP obligations - Trial Projects require greater stakeholder engagement - YVW lacked technical understanding of on-site sewerage systems Things that went well: - Customer Sentiment - Developing an understanding of the Land Capability Assessment Framework - Waterway Quality Monitoring - Project Team Continuity - Engaging the on-site system supplier for installations - Community Engagement - Use of Social Research tools Establishing a Memorandum of Understanding with the Environment Protection Agency, Council, DELWP and Melbourne Water
Integrated Water Cycle Planning for Community Sewerage Areas Case Study (2015) - Monbulk Community Sewerage Area Yarra Valley Water, Yarra Ranges Council	Yarra Valley Water worked with BMT WBM to evaluate and identify opportunities to incorporate Integrated Water Cycle (IWC) management principles and practices into the long-term management of sewerage as part of their Community Sewerage program; and whether they can deliver acceptable health and ecosystem protection outcomes with respect to sewerage impacts for an equivalent or less cost. The study involved the development of a range of possible alternative water management approaches for Monbulk, in collaboration with stakeholders and the community in order to establish objectives, confirm strategic direction, and define the measures of success for the project. The options assessed included: - Partial Contain On-site - Contain On-site - Cluster systems - Community WRP	The Monbulk Community Sewerage project is applicable to the current study being undertaken on behalf of Goulburn Valley Water (GVW). The project involved the assessment and consideration of multiple options on a cost-benefit criteria for the potential upgrade of sewerage systems in Monbulk. This provides an understanding for the assessment of key considerations for managing wastewater systems in small towns and the options for upgrades based on site constraints and capabilities.	Slope and climate are the predominant hazards that limit the capacity for sustainable management of effluent on-site in Monbulk

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	- Municipal Irrigation - Private (Irrigation) Reuse - Reticulated Sewerage (ETP) - Distributed WSUD - EOL Stormwater Measures - 30% Rainwater Tanks - Do Nothing Outcomes from this study present an integrated evaluation of the costs and benefits associated with delivery of a range of alternative water cycle scenarios in comparison with a Do Nothing and Conventional Sewerage approach. Long-term, dynamic environmental and economic modelling has informed the assessment of scenarios against stakeholder developed measures of success. The assessment supports the general opinion of stakeholders that the existing situation is unsatisfactory and unsustainable.		
Mt Macedon Wastewater Project Western Water, Macedon Ranges Shire Council	In 2010 – 2015 Macedon Ranges Shire Council and Western Water worked on a collaborative project that involved the following. - Audit of ~430 existing on-site systems in Mt Macedon to determine performance against EPA standards - Land Capability Assessment to confirm the capability for sustainable on-site containment - Identification of areas in need of an alternative, off-site wastewater management service. - Design and delivery of a pressure sewer system for the non-containment properties by Western Water - Provision of 70% funding to owners for the design, approval and upgrade of older on-site systems on properties able to sustainably contain on-site. - This included local council oversight of the LCA, approval and installation process to ensure an adequate standard of upgrade was achieved on what were constrained sites.	An example of a collaborative project between a local council and water authority where an adaptive, fit for purpose solution was developed and delivered through a cost sharing structure between agencies and property owners. This may be an option for the Tailings development if governance constraints for multi-lot servicing approaches cannot be overcome.	Not Applicable
Moyhu Wastewater Business Risk Assessment Moyhu Wastewater Report - Sewerage and Water Supply Program - Assessment of Septic Tank Impact Assessment of Septic Tank Impacts Moyhu Wastewater Business Case Moyhu Options Analysis North East Water	Moyhu is a small township located in the King Valley in North Eastern Victoria. It has a population of just over 200. The typical challenges exist with developing a more sustainable wastewater management system for this community including affordability, gaining community support, meeting stakeholder expectations, return on investment for the service provider, expectations for innovation and the development of a model for other towns. Wastewater services in Moyhu are currently provided by septic tanks, a high proportion of which do not treat sullage or are undersized for compliant onsite treatment. Discharges from the township's sullage to stormwater drains pose public health and environmental risks and have a negative impact (visual, odour) on the amenity of the township. The objectives of the Moyhu Wastewater Scheme project were: - Elimination of public health risks and amenity concerns - Elimination of adverse environmental impacts - Provision of services that facilitate economic development in the township - Provision of a cost-effective, 'best fit', innovative system - Utilization of reclaimed water in a beneficial way - Effective community ownership via a proactive partnership with the Moyhu Action Group After extensive community consultation and support to inform the assessment criteria, a Septic Tank Effluent Drainage (STED) reticulation system, mechanical type treatment and a landscaped infiltration area located at the Recreational Reserve was selected as the preferred solution. This innovative system fulfils all project objectives and was developed in consultation with key stakeholders.	The investigation of upgrade options for wastewater management as part of the Moyhu Sewerage Scheme is highly applicable to the current study being undertaken on behalf of Goulburn Valley Water (GVW). The investigation and undertaking of wastewater system upgrades provide a framework for investigation for a range of solutions to upgrading the wastewater systems based on town-specific criteria (land capability, cost, constructability, etc) which is what the tool being developed will incorporate into its decision making framework.	The key identified constraints for the scheme were: - Land capability (generally comprised of clay with poor drainage characteristics, small lot size of 800-1000m2) Affordability of options for the householder / landowner The key lessons learnt from the project were: - Community involvement in the process is imperative in providing feasible options - The undertaking of a Multi-Criteria Assessment (MCA) was effective in determining the best options for the town Engaging with relevant stakeholders was key
Parts 1 & 2 - Domestic Wastewater Management Plan - Pilot Project Background Report	This Background Document provides the basis for the development of the Domestic Wastewater Management Plan by identifying the wastewater management issues at play within Mansfield Shire, along with catchment management/water quality considerations for declared potable water catchments (some of which extend beyond municipal boundaries).	The DWMP for Mansfield Shire Council addresses key considerations such as development pressure, land zoning, proximity to waterways and the management of unsewered land, similar to the GVW study for upgrading septic tank reliant	The key constraints within the Shire as part of the DWMP were found to be: - An increasing population within the townships and rural living areas, calls for development pressures - Management strategies for unsewered vacant land, residential, and camping ground, and tourism facility areas

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	The Pilot Project does not differ from the objectives of any DWMP, which are to: - Provide strategic direction for the development of management practices, tools and strategies for wastewater management across Mansfield Shire - Identify, clarify and detail the roles and responsibilities of all stakeholders including Council, abutting municipalities, water corporations, government departments and authorities and landowners - Specify what actions are to be implemented by stakeholders over the next 5 years to mitigate any adverse impacts of wastewater on the environment and public health - Identify where settlements / townships require larger scale public and private infrastructure investment to ensure domestic wastewater is treated to an acceptable level - Provide guidance to, and minimum standards for, those preparing land capability statements - Develop a decision-making framework for the assessment of applications to install a new wastewater management system; Mansfield Shire DWMPPP Background Report Page 5 - Develop a comprehensive compliance and enforcement regime as a quality assurance tool for existing wastewater management systems Specify action plans to achieve these objectives, including the identification of resources that Council and other stakeholders need to allocate to ensure the DWMP delivers tangible results.	towns. However the DWMP is primarily related to the overall management of wastewater within Mansfield Shire and not particularly relevant to the development of a decision making tool for upgrading septic tank reliant wastewater systems.	Townships/settlements such as Jamieson, McMillan Point, Kevington, Gaffneys Creek, Woods Point and Howqua have limited opportunities for future development due to a lack of vacant land and constraints including zoning, lot size, bushfire risk and proximity to waterways
Approaches for Risk Analysis of Development with On-Site Wastewater Disposal in Open Potable Water Catchments	Mansfield Shire Council engaged Robert van de Graaff of van de Graaff & Associates Pty Ltd to review the Discussion Paper by Mr Larry White and Dr Robert Edis entitled "Approaches for risk analysis of development with on-site wastewater disposal in open potable water catchments" dated November 2013. The objective of Mansfield Shire is to draw together the most recent science, studies and information available to develop a more sophisticated and scientifically based approach to analysing the risk of domestic wastewater treatment within a given area.	The report aims to assess and review the EDIS-White Risk Assessment Algorithm for land capability risk, and soil risk classifications.	Not Applicable
Domestic Wastewater Management Plan Pilot Project: Assessing the Efficacy of the EDIS-White Risk Assessment Algorithm - Using Data from Howes Creek Road & Goughs Bay Sub-Catchments	The investigation's primary objective was to assess the efficacy of the risk assessment algorithm as presented in *Approaches for Risk Analysis of Development with On-Site Wastewaster Disposal in Potable Water Catchments* by Dr Edis and Larry White (2014). The assessment involved the mapping of unique land-soil units which were defined in terms of salient attributes including; geology (parent material), slope, soil profile characteristics (including colloid stability) and hydraulic conductivity.	The report aims to assess and review the EDIS-White Risk Assessment Algorithm for land capability risk, and soil risk classifications.	Not Applicable
Executive Summary of Goughs Bay Scoping Study Mansfield Shire Council	Goughs Bay is a township of some 263 properties located on the shores of Lake Eildon. The township does not have reticulated wastewater services (or reticulated water) and existing wastewater management arrangements associated principally with earlier development have been raised as potential and likely environmental, public health and amenity risks requiring further investigation. Of particular concern is the discharge of greywater to stormwater drains, which is prevalent due to the installation of 'blackwater'- toilet only septic systems up to the late 70's or early 1980's (representing some 50% of systems). Concern is also raised in relation to the capacity of sites to retain wastewater within on-site septic trench drainage lines. To practicably achieve an acceptable level of long-term protection of the environment a wastewater upgrade based on some form of reticulated sewerage is recommended for Goughs Bay. Three options were put forth: Option 1: Reticulation to a local treatment plant and local irrigation for agriculture Option 2: Reticulation to a local treatment plant and discharge to the environment Option 3: Reticulation and pumping to Mansfield	The project provides options for the management and upgrade of septic tank wastewater systems in small towns in Victoria. However, the provided report does not have much information in relation to the implementation and assessment of each option for the towns that is relevant to the GVW study. The executive summary primarily addresses management of long- and short-term options for implementation with little detail relevant to land capability constraints, etc.	Not Applicable/Provided

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Lake Eildon Catchment Septic Tank Risk Assessment (2009) Ecos Environmental Consulting for Goulburn Valley Water	Goulburn-Murray Water and Goulburn Valley Water commissioned Ecos Environmental Consulting to undertake an assessment of the risks associated with the proliferation of on-site sewage treatment systems (i.e. septic tanks) in the catchments of the Eildon, Thornton and Alexandra Water Supply Systems and to determine the extent of appropriate setback distances for septic tanks from water bodies. Ecos's findings are set out in this report and are based on quantitative microbial risk modelling using spreadsheets and proprietary statistical software coupled with a GIS based hydrological model. Two models were developed and are described as follows: 1. Subsurface Flow Model 2. A Surface Flow Model The objectives of this study were to assess the level of risk associated with the current number of on-site treatment systems on public health, investigate appropriate setback distances for the siting of new systems and investigate the implications of increasing numbers of systems within the Lake's catchment and environs.	The report assesses the risk of contamination by viruses arising from septic tank effluent in the catchment area. As such, it provides insight into potential issues arising from the mismanagement of septic tanks that are failing and the potential harm to the community and environment. However, it does not provide information in relation to the upgrade of septic tank dependent residences/towns and the implementation of alternative domestic wastewater management strategies.	Not Applicable
Managing the Environmental Impacts of Domestic Wastewater (2018) Victorian Auditor-General's Office	The Victorian Auditor General's office (VAGO) conducted a review of council and water authority performance against the legislative elements (SEPP and EPA Act) pertaining to domestic wastewater management in Victoria in 2018. VAGO examines whether the environmental and public health impacts of domestic wastewater are being effectively managed. They examined South East Water Ltd (SEW) and Yarra Valley Water Ltd (YVW), Yarra Ranges Council (YRC) and Mornington Peninsula Shire Council (MPSC), and the Department of Environment, Land, Water and Planning (DELWP) and the Environment Protection Authority (EPA). VAGO looked at the efficiency, economy and effectiveness of water authorities' sewer backlog programs, the extent to which councils are managing the risks on onsite domestic wastewater and the regulatory system and whether its implementation supports water authorities and councils in protecting the environment and public health. The environmental and public health risks from poorly performing onsite systems are not being adequately managed due to below reasons: 1. Regulatory issues, poor leadership and limited collaboration between DELWP and EPA 2 Audited councils are not effectively managing poorly performing onsite systems 3. Property owners are slow to connect to sewer	This report holds relevance to the current study being undertaken by GVW as it provides the governance framework for: - The identification and assessment of risks in unsewered towns - Monitoring and compliance of onsite systems - The effectiveness of the regulatory framework in managing risks from onsite systems Water authority programs to sewer high-risk unsewered areas	The key constraints found were: - Regulatory framework has significant gaps - Onerous requirements to force sewer connection - Approval processes lengthy and unwanted The report found the following positives and negatives of the Councils and management of systems: <u>Positive</u>: - Approving and installing of new domestic wastewater systems <u>Negative</u>: - Identification of risks posed by onsite systems, and the need for ongoing performance monitoring - Legacy system risks have not been adequately addressed - Inadequate compliance inspections and follow up procedures
Wye River and Separation Creek Sewerage Scheme Options Report (2011) Sinclair Knight Merz (SKM)	Only the executive summary for the Wye River and Separation Creek Sewerage Scheme Options report was provided. Wye River and Separation Creek were identified in Colac Otway Shire's DWMP as the equal highest priority for improved wastewater management out of all the unsewered towns within the shire. As such a high-level investigation of the options for improvement of wastewater systems was conducted. The investigations concluded that the recommended solution comprised a centralised wastewater collection system and a treatment plant with recycled water to be irrigated on land west of the Wye River Township. Further investigations determined that the sewerage scheme concept was not technically viable, as the area was found to be within a landslip zone and therefore not suitable. It was found that alternative options for managing excess recycled water have been considered and include: - Discharge to Separation Creek - Discharge to Wye River Discharge to the ocean	Based on the executive summary of the report that has been provided, this study has a small amount of relevance the GVW study. The executive summary for Wye River and Separation Creek provides details of an assessment into the feasibility of wastewater system upgrades based on constraints to small towns in Victoria. However, due to the report only containing the executive summary there is little detail of the assessment provided and does not provide much information for the study at hand.	The primary constraints were found to be: - Land capability (landslip zones) - Substantial additional field investigations are required - Community/stakeholder consultations are necessary if these are options to be considered further The potential solutions are significantly more costly than the initial Concept Design

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Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems United States Office of Water	The Voluntary National Guidelines for Management of Onsite and Clustered Wastewater Treatment Systems is a document produced by the United States Office of Water. The guidelines outline five management models in order to enhance the performance and reliability of decentralised wastewater treatment systems and improve water quality and public health goals at state, tribal, and local government level.	As this document is United States specific guidelines document it is not particularly relevant to the current study. It is only relevant in the consideration of management options for domestic wastewater in order to improve water quality and public health.	Not Applicable
Onsite Wastewater Management - Code of Practice (2016) VIC EPA	This Code of Practice for Onsite Wastewater Management developed by the Victorian EPA provides the standards and guidance to ensure the management of onsite wastewater protects public health and the environment and uses resources efficiently. This Code includes guidance on: 1. Wastewater treatment systems that may be permitted in new subdivisions and on single allotments or for upgrading or retrofitting existing premises 2. Effluent recycling/disposal system options that may be permitted in new subdivisions and on single allotments or for upgrading or retrofitting existing onsite systems, including design requirements for land application systems 3. Calculating the appropriate size of onsite systems The effective management of the systems.	This code of practice is relevant the GVW study as it outlines the requirements and procedures for sewered and unsewered areas including: - Site assessment - System selection - Permitting - Installation Sustainable Management	Not Applicable to the document as it is not a study. The code of practice however outlines certain constraints for the management of wastewater such as land zoning, land capability, and other site-specific constraints.
Overcoming Barriers to Evaluation and Use of Decentralized Wastewater Technologies and Management (2007) Water Environment Research Foundation (WERF)	The study identifies important factors that affect whether engineers equitably consider decentralised wastewater treatment options, and the how the barriers associated with decentralised water can be solved. The report primarily focuses on what engineers can do to create an environment where all wastewater treatment solutions are considered equitably and where fair decisions are made for clients and communities.	This study is marginally relevant to the study. It provides information on identified barriers to the implementation of decentralised wastewater systems through a conceptual case study that is United States-centric. It provides information, but little insight into issues that would be relevant to the GVW study at hand.	The five man barriers were characteriszed as: - Engineer's financial reward for using centralised systems - Engineer's lack of knowledge of decentralised systems - Engineer's unfavourable perception of decentralised systems - Unfavourability of the regulatory system for decentralised systems Lack of systems thinking applied to wastewater issues

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