Land-Based Effluent Disposal Assessment Report and MEDLI 2.0 Modelling

Lake Vermont Meadowbrook Project

M31991

Prepared for
AARC Environmental Solutions Pty Ltd

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1 Introduction

Cardno were commissioned by AARC Environmental Solutions Pty Ltd (AARC) to undertake land-based irrigation modelling using the Model for Effluent Disposal Using Land Irrigation (MEDLI 2.0) version 2.0 for the Lake Vermont Meadowbrook Project (the Project).

The proposed Meadowbrook Project is an extension of the Lake Vermont open cut coal mine located approximately 25km north of Dysart and 160km south-west of Mackay. The proposed Project includes:

> An underground and open cut pit mine with a workshop and Mine Infrastructure Area (MIA) including a Sewage Treatment Plant (STP);
  - On-site ablutions for daily workforce, including a bathhouse for the underground workforce;
> An operational workforce of 410 accommodated off-site;
  - Expected maximum workforce on site of 200 equivalent persons (EP) at any one time; and
  - Workforce wastewater generation of 200L/person/day.

The Project location is shown in Figure 1, **Appendix A**.

Workers will generate domestic wastewater from staff facilities. The wastewater will include that which is generated from the use of toilets (often classed as black water) as well as wastewater produced from showers, kitchen facilities and laundries (often classed as grey water). It is important to recognise that this domestic wastewater does not include mine affected water or sediment-laden water, which will be stored and handled in a separate manner.

1.1.1 Environmental Authority Requirements

Given that the wastewater systems at the Meadowbrook Project site will cater for more than 21 Equivalent Persons (EPs) (1 EP = 200 L/day), the activity triggers Environmental Relevant Activity (ERA) 63 for sewage treatment to be added as an ancillary activity to the resource activity Environmental Authority (EA) being sought from the Department of Environment and Science (DES).

An application for ERA 63 must provide supporting technical information in accordance with the DES *Guideline Application requirements for activities with impacts to land*. This guideline encourages the applicant to:

> Design a sustainable system in accordance with Australian New Zealand Standard *AS/NZS 1547:2012 On-site domestic wastewater management*; and
> Undertake validation modelling of the system based on local land and rainfall factors. The recommended model being the Model for Effluent Disposal using Land Irrigation (MEDLI 2.0) Version 2.0.

This report therefore centres around AS/NZS 1547:2012 and validation MEDLI 2.0 modelling of the irrigation site for the Meadowbrook Project.

2 Aim of the Assessment

2.1 Objectives

The principal objectives of this assessment are to:

> Characterise the estimated wastewater flow rates and treated wastewater quality in terms of Total Nitrogen, Total Phosphorus, Total Dissolved Salts, Electrical Conductivity, pH, E coli concentrations, Total Suspended Solids, and Biochemical Organic Demand (5 day);

> Use a suitable water balance model, specifically the Model for Effluent Disposal via Land Irrigation (MEDLI 2.0) to arrive at the appropriate sustainable wet weather storage volume and area to be irrigated with treated sewage based on the quantity and quality of the treated sewage to be irrigated; and

> Account for and manage potential impacts of treated sewage irrigation on surface and groundwater and other environmental values and describe how these impacts will be mitigated so as not to cause environmental harm or adversely affect relevant environmental values and water quality objectives.

2.2 Scope of Work

The scope of this assessment is limited to assessing the suitability of land areas within the Lake Vermont Meadowbrook Project site for effluent disposal via irrigation. The assessment consisted of:

> A desktop review of site topography, hydrology and soil type to select the most suitable effluent disposal area;

> Using AS1547: 2012 to estimate the irrigation rate using soil condition assumptions obtained during the review;

> Sampling and analysis of the soil profile within the intended effluent disposal area to assess soil characteristics;

> Calculating expected wastewater quality and generation rates for the Project;

> Obtaining site-specific climate data for the Lake Vermont region (particularly rainfall and evaporation rates);

> Determining the feasibility of using an irrigation system in accordance with AS/NZ 1547:2012;

> Verifying the suitability of the irrigation system using MEDLI 2.0; and

> Providing recommendations to improve the performance of the irrigation system.

This report does not include provision for a Site Based Management Plan applicable to the ongoing operation of a wastewater disposal system. Prior to commissioning, a management document detailing the ongoing maintenance, emergency response and contingency plans will be required.

2.3 Fundamentals of MEDLI 2.0

Irrigation modelling systems offer a way of validating and refining irrigation systems designed in accordance with AS 1547:2012. Daily time step simulation models such as MEDLI 2.0 are generally considered a requirement by DES in assessing ERA 63 applications. For this assessment, version 2.0 of MEDLI has been used.

2.3.1 MEDLI 2.0 Background

MEDLI 2.0 is a modelling program that simulates the complex dynamics of the effluent cycle on a daily time step using historical daily climatic data. MEDLI 2.0 simulates the behaviour of water and nutrients in the soil column and the growth of irrigated pastures or crops in response to climatic conditions and nutrient and salt loadings. MEDLI 2.0 can be used to determine the required irrigation area, the likely stresses on irrigated vegetation and the concentration of nutrients below the root zone. The model incorporates historic climate information (temperature, rainfall, evaporation, and solar radiation), estimates of effluent quality and quantity, and soil properties. Modelling provides a means of identifying the potential environmental impacts of the proposed effluent treatment system. Actual outcomes may depend on aspects of geology, soils and groundwater not able to be ascertained by this level of assessment as well as proposed irrigation methods and actual management practices in the field.

Effluent modelling allows the identification of anticipated weaknesses in the wastewater disposal scheme, providing the opportunity to explore alternative solutions until a suitable and robust design is found.

2.3.2 MEDLI 2.0 Modelling Objectives

An optimal effluent management system will have the following outcomes:

- Wet weather storage tank overflow events will be negligible in frequency and volume;
  - 95% reuse (irrigation) of effluent (99.5% re-use is ideal);
  - No overflow events shall be greater than 1mm worth of the tank volume (i.e. in this case the tank surface area is 55m^2 and therefore 1 mm of the tank volume equates to 55 L); and
  - Overflow should be experienced less than 10 days per year;
- No surface runoff of irrigated effluent;
- Less than 5kg/ha/year of nitrate is to be lost in deep drainage;
- Limit phosphorus in effluent irrigation such that soil adsorption capacity is not exceeded within the life of the Project;
- Build-up of salinity in the soil profile should not impede the growth of pasture; and
- Any pasture die-off events resulting from water stress, waterlogging, temperature stress or nitrogen stress are minimised to be as close as possible to zero.

3 Desktop Assessment

3.1 Preferred Irrigation Location

The STP and associated wet weather storage for the Project will be constructed within the MIA. Sewage which has been treated by the STP will be piped to the effluent disposal area.

The area being investigated for treated effluent disposal is located on Lot 102 Plan SP310393, close to the central western boundary of the lot, within the northern area of the MIA (borehole locations A, B, and C in Figure 2, **Appendix A**). This area has been proposed as an effluent treatment area because:

> It is within close proximity of the sewage treatment plant, the primary source of the wastewater; therefore, minimising pumping and pipe infrastructure requirements;

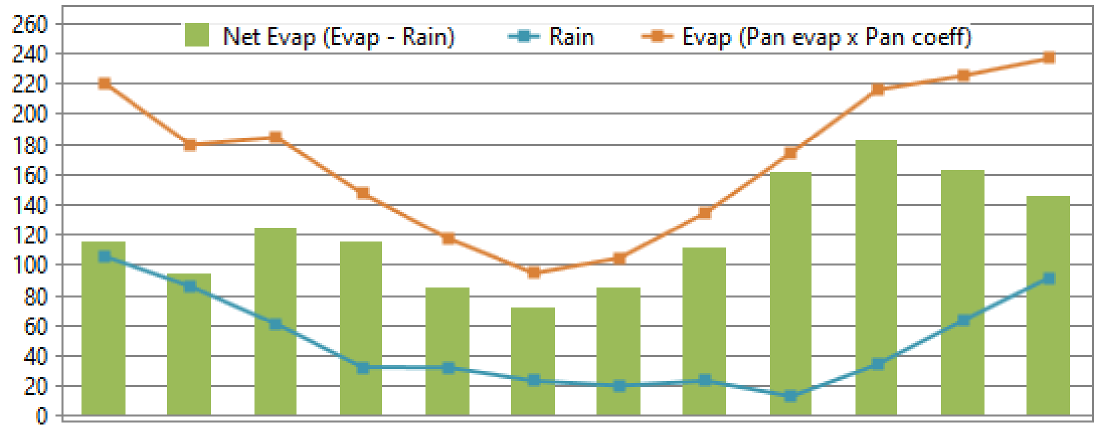
> There is sufficient space to allow for placement of the disposal area, maintaining large buffers from sensitive receptors such as One Mile Creek and other waterways, ecosystems and the public;

> Given the effluent disposal area will be located within the MIA, it will be contained within a bunded area which is protected from the 1% annual exceedance probability (AEP) rain event. The MIA will also already be subjected to disturbance and clearing therefore the project will not involve irrigation of regional ecosystems/communities/habitat.

3.2 Climate

Climate data was obtained from the Queensland Government Scientific Information for Land Owners (SILO). The data represents the nearest SILO grid point (latitude -22.40, longitude 148.40) and interpolates data from the nearest climate stations. The data includes evaporation rates, rainfall and maximum and minimum temperatures for a period of 48 years from 1970 to 2017.

Lake Vermont Mine has a relatively dry climate, with evaporation rates exceeding rainfall throughout the year. A distinctive dry/wet season pattern is observed, whereby the winter/spring period from April to October is traditionally dry, with monsoonal rainfall received over the summer months from November to February. During the wet season, the evaporation rates still exceed rainfall rates. Climate data has been summarised below in Figure 3-1.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	105.9	86.2	61.2	32.7	32.6	23.7	20.5	23.7	13.6	34.5	63.6	92.0	590.2
Evap	220.5	179.8	184.8	147.7	117.8	94.8	105.0	134.9	174.5	216.2	225.4	236.8	2038.2
Net Evap	114.6	93.6	123.6	115.0	85.2	71.1	84.5	111.1	160.9	181.7	161.8	144.8	1448.0
Net Evap/day	3.7	3.3	4.0	3.8	2.7	2.4	2.7	3.6	5.4	5.9	5.4	4.7	4.0

Figure 3-1 Climate Data interpolated for the site 1970– 2017. Source: Queensland Government climate data (SILO).

3.3 Topography, Drainage and Groundwater

Geology of the irrigation investigation area has been classified as 'TQa' i.e. Quaternary colluvium, comprising 'locally red-brown mottled, poorly consolidated sand, silt, clay, minor gravel; high-level alluvial deposits (generally related to present stream valleys but commonly dissected)' (source: Queensland Globe).

The investigation area slopes gently downgradient toward the east, with an elevation of approximately 175m Australian Height Datum (AHD). The investigation area does not contain any drainage lines of significance. One Mile Creek is located approximately 500m southeast of the investigation area. A minor, ephemeral tributary of One Mile Creek flows in an assumed north-easterly direction approximately 350m south of the investigation area. The topography and water courses surrounding Lake Vermont Mine is presented in Figure 3, **Appendix A.**

Queensland Globe mapping data does not indicate the presence of any Groundwater Dependent Ecosystems (GDEs) at the site. The nearest registered groundwater bores are located approximately 3.2km to the southwest and thus unlikely to reflect local conditions but based on the data from the closest bore's groundwater may be between 9 – 25m below ground level.

The site and surrounding regional area are classified as 'Isaac western upland tributaries' under the Queensland Environmental Protection Policy for water and wetland biodiversity. The Isaac River is located 12km to the northeast and downgradient of the site, and is fed by tributaries One Mile Creek and Hughes Creek. A wetland of high ecological significance is present approximately 10.3 km northeast and downgradient of the site, adjacent to a section of Hughes Creek.

3.4 Onsite Vegetation and Habitat

In order to construct the MIA, the vegetation/ecosystems it contains will be subject to disturbance and clearing, and the intent is to irrigate this disturbed land. However, it is still important to identify adjacent vegetation and habitat in order to protect it from impacts.

The vegetation which will remain around the proximity of the MIA is mapped in Figure 4, **Appendix A**. The mapping identifies the following Regional Ecosystems (REs):

- 11.4.9 (Endangered) – Acacia harpophylla shrubby woodland with Terminalia oblongata on Cainozoic clay plains;
- 11.5.3 (Least Concern) – Eucalyptus populnea, E. melanophloir and Corymbia clarksoniana woodland; and
- 11.4.8 (Endangered) – Eucalyptus cambageana woodland to open forest with Acacia harpophylla or A. argyrodendron.

REs 11.4.9 and 11.4.8 are also referred to as Brigalow Threatened Ecological Communities (TECs).

The area around the MIA is also mapped as having high amenity habitat value for the Ornamental Snake.

Accounting for the fact the vegetation within the MIA will be pre-cleared/disturbed the proposed effluent disposal area will be located at least 50 m from the closest terrestrial RE / TEC / habitat. A buffer zone of at least 50 m is considered to be suitable to protect residential properties from any adverse effects from spray drift in accordance with the QLD Government Technical Guideline for Disposal of Effluent via Irrigation, and therefore considered to be applicable to protection of terrestrial ecosystems.

3.5 Sensitive Receptors

No residential houses appear to be located within 1km of the proposed irrigation area and no onsite accommodation is proposed in the MIA. As such, the risk of exposure to aerosols generated by the operation of the irrigation area is low.

The irrigation scheme will need to be managed via an appropriate level of treatment and exposure reduction measures and controls (e.g. irrigation area restrictions, set back distances, personal protective equipment) to minimise any aerosol exposure risk to mining employees, operators or maintenance personnel.

4 Wastewater Characteristics

Given that the mine and associated infrastructure facilities have yet to be established, wastewater quantities and quality have been estimated as follows:

4.1 Wastewater Quantity

A total of 200 staff are expected to be on site at any one time. It is unlikely that all 200 workers will generate their entire volume of wastewater (i.e. showering, washing, toileting), for a day on site, as workers will utilise off site accommodation facilities. For modelling purposes, it has been conservatively estimated that all 200 workers will be on site, and each worker will generate their entire wastewater volume - equating to one equivalent person (EP). The *Environmental Protection Regulation 2019* states that 1 EP = 200 L/day of effluent. With a total of 200 Eps, the total daily wastewater volume is conservatively estimated at **40,000 L/day**.

4.2 Wastewater Quality

4.2.1 Key Contaminants

At the time of undertaking this assessment, final STP selection had not been completed. In the absence of a finalised design, conservative estimates of wastewater characteristics have been provided in Table 4-1. Expected effluent quality has been estimated based on the long-term limits established in the *Eligibility Criteria and Standard Conditions for Sewage Treatment Works (ERA 63) – Version 2*. These limit values also align with the quality which would be expected from a basic sewage treatment plant as per *Table A3.2 of the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)*. When comparing to the *Public Health Act 2005* classes of recycled water, the treated wastewater would equate to class C (<1000 cfu/100mL).

Table 4-1 Wastewater Quality Estimations: Source ERA 63 Eligibility Criteria Standard Conditions

Quality Characteristics	Release Limit	Limit Type
Total nitrogen*	60 mg/L	Maximum
Total phosphorus*	20 mg/L	Maximum
pH	5.0 – 8.5	Range
Total residual chlorine (if used for disinfection)	1 mg/L	Maximum
E. coli	<1000 cfu/100mL	Maximum

*note that these limits would typically correspond with long term average total nitrogen concentrations of 30 mg/L and phosphorus 10 mg/L (these long-term averages were modelled).

4.2.2 Operational Recommendations

In addition to the above parameters, AS 1547:2012 recommends that a secondary treated effluent is achieved for irrigation systems as per Table 4-2. These limits are primarily for operational purposes (e.g. to avoid clogging up pipes/fittings and soil pore spaces with solids and biofilms).

Table 4-2 Wastewater Quality Estimates – Secondary Treated Effluent

Quality Characteristics	Release Limit	Limit Type
5-day Biochemical Oxygen Demand (BOD5)	20 mg/L	Maximum

4.2.3 Toxins

There is potential for other contaminants to exist in domestic wastewater. These typically result from pharmaceuticals (present in human waste), cleaning products and pesticides which can be intentionally or unintentionally released into the sewerage system. Concentrations of these toxins are hard to predict but will generally be very low in concentration aside from pulse events, for example, should cleaning products be poured down a drain.

5 Irrigation Area Investigation

5.1 Sampling Procedure

A field investigation was undertaken on the 24th January 2022 to conduct soil sampling. The results have been used to evaluate the irrigation suitability of soils at the site, provide inputs to the irrigation model and to confirm the irrigation application rates. The data collected also provides a pre-irrigation baseline record of soil parameters.

Three (3) test pits were excavated within the area proposed for irrigation (denoted by test pits A, B and C in Figure 2, **Appendix A**). An additional three (3) reserve test pits were excavated in the event a backup irrigation location needed to be investigated (denoted by test pits D, E and F in Figure 2, **Appendix A**). The soils from test pits A, B and C were sent for immediate laboratory analysis with the soil from test pits D, E and F left on hold.

Soils were logged in accordance with AS1726: 2017 *Geotechnical site investigations.* A copy of the test pit logs is provided in **Appendix B**.

5.2 Hydraulic Conductivity Estimations

Owing to unfavourable soil sampling conditions encountered on the site (a dried hardened dense clay), it was not possible to carry out the hand augering required to carry out hydraulic conductivity measurements in the field. Cardno have adopted the default hydraulic conductivity parameters for the three upper layers of a "Grey Clay" within the MEDLI 2.0 model.

5.3 Laboratory Analysis

All chemical testing of the site soils was completed by environmental laboratories ALS Environmental, a NATA certified environmental testing laboratory, and Bio-Track Pty Ltd. Testing included:

- Soil pH, electrical conductivity and salinity;
- Calcium, magnesium and sodium adsorption rates;
- Total and exchangeable cation concentrations (K+, Na+, Ca+, Mg+);
- Total soluble salts;
- Emerson aggregate (dispersibility);
- Total nitrogen (TN), total Kjeldahl nitrogen (TKN), nitrates, nitrites and ammonia;
- Sodium adsorption ratio (SAR);
- Bulk density (measured in this case as Clod Density);
- Total phosphorus (TP) and orthophosphate;
- Saturated water content;
- Porosity;
- Field capacity; and
- Wilting point.

6 Irrigation Area Investigation Results

The soil profile in the primary (test pits A, B and C) and reserve irrigation area (test pits D, E and F) was similar in nature. The following sections describe the results specific to the primary irrigation area.

6.1 Irrigation Area Description

The investigation area was observed to be covered with very dry grasses, shrubs and juvenile trees scattered across the site. Site photographs are shown below, with additional photographs presented in **Appendix C**.

Figure 6-1 Vegetation at proposed effluent disposal area

Figure 6-2 Soil structure at proposed effluent disposal area

Site soils typically comprised dense dry brown sandy clays with medium to high plasticity to 0.3 mbgl overlying brown mottled grey very stiff medium to high plasticity sandy clays to the base of boreholes (1.2 mbgl). The clay soils were dried and condensed into "clods" which can be seen in Figure 6-2. Moisture or groundwater were not encountered. The test pit logs are attached in **Appendix B**.

As described in Section 5.2, field-based measurement of hydraulic conductivity was not possible. This was owing to the compacted dried clay nature of the soil which prevented penetration of a hand auger. In place of field-based measurements Cardno has adopted the default hydraulic conductivity measurements for a "Grey Clay" in MEDLI 2.0 (Table 6-1). The hydraulic conductivity values are reflective of a category 6 soil as described by AS1547:2012.

Table 6-1 Default Grey Clay Hydraulic Conductivities from MEDLI 2.0

Analyte	Unit	Surface (upper 100mm)	Upper subsoil (100-600mm)	Lower subsoil (600-1200mm)
Saturated Hydraulic Conductivity	mm/hour	10	1	0.5

6.2 Chemical and Physical Analysis

6.2.1 Soil Moisture and Nutrient Results

The soil moisture results are an indicator of the soil's ability to hold water and are used in the MEDLI 2.0 validation model. The figures represent the soil's plant-available water. The greater the difference between the field capacity and wilting point, the more plant-available water the soil can provide.

Nutrients such as nitrate and extractable phosphorus are also used in the MEDLI 2.0 model. The levels serve as a baseline platform upon which the model predicts how nitrate and phosphorus will be transported or accumulate in the soil profile.

The values utilised in the MEDLI 2.0 model for soil moisture, (field capacity, wilting point, porosity and bulk density) are presented in Table 6-2. The values utilised in the MEDLI 2.0 model for soil nutrients (phosphorus and nitrogen) are presented in Table 6-3.

Given that the soil profile consisted of a heavy clay which forms into “clods” it is challenging to undertake representative water holding tests. This is because the bulk density and porosity are most accurately measured from the clod, while the field capacity needs to be estimated from a larger “disturbed” soil sample. Given the two types of measurement, the field capacities generated in the lab results did not correlate with porosity. Based on advice from the laboratory the following field capacities were adopted instead:

> Surface soil field capacity assumed to be 3% lower than porosity.

> Sub soil field capacity assumed to be 1% lower than porosity.

Table 6-2 Physical Water Holding Capacity Parameters entered into MEDLI

Analyte	Unit	Surface Average (upper 100mm)	Upper subsoil Average (100-600mm)	Lower subsoil Average (600-1200mm)
Wilting Point (Lower Storage Limit)	%v/v	26.7	24.82	26.63
Field Capacity (Wilting Point)	%v/v	40.0	33.34	31.45
Available Water Capacity	mm	13.3	42.6	28.92
Saturated Water Content	%v/v	41.0	34.3	32.3
Bulk Density	%v/v	1.51	1.74	1.79
Porosity	%v/v	43.02	34.34	32.45

Table 6-3 Soil Nutrient Concentrations

Analyte	Unit	Surface Average (upper 100mm)	Upper subsoil Average (100-600mm)	Lower subsoil Average (600-1200mm)
Extractable Phosphorus	mg/kg	1.67	<5	<5
Nitrate	mg/kg	3	1.57	0.6

6.2.2 pH, Salinity and Sodicity

The soil pH, salinity and sodicity readings are presented in Table 6-4.

Table 6-4 Chemical Analysis Results

Analyte	Unit	Surface Average	Upper subsoil Average	Lower subsoil Average	Range
pH	pH unit	7.17	7.57	5.83	5.2-8.2
Sodium Adsorption Ratio	-	10.28	39.60	49.23	7.15-57.4
Exchangeable Sodium Percent	%	8.63	18.70	22.13	7.6-25.1
Electrical Conductivity	µS/cm	137	742	987	35-1290

Soil pH was close to neutral, with minor acidity in the subsurface samples and minor alkalinity in the surface samples. This tended to correlate with negligible levels of salt in the upper profile and slightly higher salt levels in the lower profile.

Overall, the level of salt within the soil was low. The former Department of Environment and Resource Management (DERM)'s Salinity Management Handbook provides a range of tolerance limits for soil salinity which has been adapted from Shaw et al. 1987. These limits have been reproduced in Table 6-5. At the maximum 1.290 dS/m recorded, the salt content of the soil would be well tolerated in all but the most sensitive crops.

Table 6-5 Soil salinity EC_{se}, and $EC_{1:5}$ for four ranges of soil clay content (adapted from Shaw et al. 1987).

Plant salt-tolerance grouping[1]	Corresponding ECse range[2] (dS/m)	Equivalent EC 1:5 reading, based on clay content of soil (dS/m)				Soil salinity rating
		10-20% clay	20-40% clay	40-60% clay	60-80% clay	
Sensitive crops	< 0.95	< 0.07	< 0.09	< 0.12	< 0.15	Very low
Moderately sensitive crops	0.95 – 1.9	0.07 – 0.15	0.09 – 0.19	0.12 – 0.24	0.15 – 0.3	Low
Moderately tolerant crops	1.9 – 4.5	0.15 – 0.34	0.19 – 0.45	0.24 – 0.56	0.3 – 0.7	Medium
Tolerant crops	4.5 – 7.7	0.34 – 0.63	0.45 – 0.76	0.56 – 0.96	0.7 – 1.18	High
Very tolerant crops	7.7 – 12.2	0.63 – 0.93	0.76 – 1.21	0.96 – 1.53	1.18 – 1.87	Very high
Generally too saline for crops	> 12.2	> 0.93	> 1.21	> 1.53	> 1.87	Extreme

Notes:

1. These groupings are statistically derived divisions based on families of linear curves representing the salt-tolerance ratings of the majority of crops reported by Maas and Hoffman (1977). The terminology of Maas and Hoffman has been modified and an additional group of sensitive crops incorporated.

2. EC_{se} given here is the boundary EC_{se} at which 10% yield reduction occurs for these plant salt tolerance groups. The $EC_{1:5}$ ranges have been determined from these EC_{se} ranges using the equations provided in Converting from $EC_{1:5}$ to EC_{se} (see page 30 of the Queensland Salinity Management Handbook).

Exchangeable Sodium Percentage (ESP) and the Sodium Absorption Ratio (SAR) measure the ratio of sodium in the soil with respect to other salts. A sodium ratio which is too high results in a sodic soil that readily dissolves and disperses in water (known as dispersive soils). Dispersive soils need to be managed carefully as they can be susceptible to erosion.

Table 6-4 was sourced from DERM's Salinity Management Handbook and shows sodicity classifications for soil. The samples tested showed ESP values ranging between 7.6% and 25.1% and are therefore considered to be sodic to strongly sodic soils. The sodicity of a soil also needs to be considered with respect to the salt content to determine how prone the soil could be to dispersion. This is discussed further in Section 6.2.3.

Table 6-6 Criteria for classifying sodicity in soils (from Northcote and Skene 1972).

Criteria	Description
ESP < 6	Non-sodic
ESP 6 – 14	Sodic
ESP > 15	Strongly sodic

6.2.3 Sodium Adsorption Ratio

The influence of sodicity on soil behaviour varies with clay content and clay mineralogy. Where clay content is higher, lower ESP levels significantly affect soil structure.

The three red crosses on the following graph indicate the stability for the three samples which had SAR values within the chartable range. The remaining soil samples had SARs >30. In summary all soil samples had a high SAR meaning they are prone to dispersion.

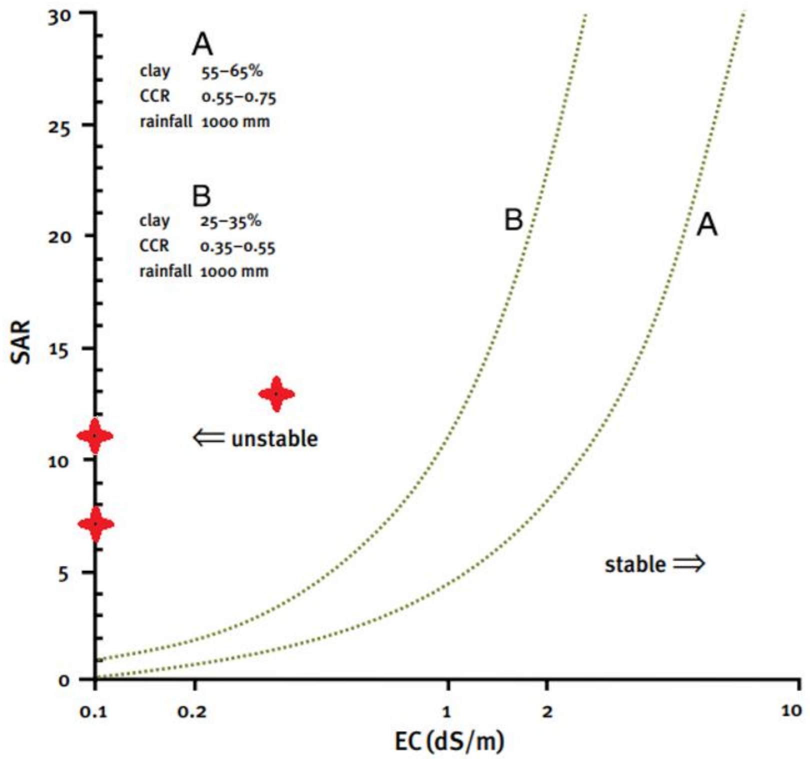


Figure 6-3 Reproduction of Figure 40 from the Salinity Management Handbook: The threshold lines for two soils of different clay content and mineralogy for an annual rainfall of 1000mm/yr.

The laboratory results are summarised in Table 6-5. Copies of the laboratory Chain of Custody, Sample Receipt Notification, Certificate of Analysis and quality control reports are provided in **Appendix D**.

7 Desktop AS1547 Assessment

7.1 Selection Criteria

To determine the suitability of a site/system for spray irrigation, a comparison against Appendix K of AS 1547:2012 has been presented in Table 7-1. Overall, results indicate that the nature of the soil and of the site is generally supportive of spray irrigation, although the dense clay soil profile does limit permeability.

Table 7-1 Selection Criteria for Irrigation Systems (Appendix K or AS/NZS 1547:2012)

	Slope Gradient	Soil Depth	Soil Category Number	Depth to seasonal water table	Duration of continuous seasonal soil saturation	Dispersive (sodic) soil	High content of stones, cobbles, or boulders	Climatic factors
Recommendation	Steep slopes can cause greater run-off during wet weather (< 10%).	A minimum of 0.6 m desirable.	Categories 1 and 2 may lead to nutrients reaching groundwater. Categories 4-6 may require large irrigation fields.	>1.2 m depth.	Prolonged saturation of upper soil impedes treatment and hinders adsorption.	Soil may lose permeability during life of system.	Unless extremely stony or covered in boulders, not relevant as delivery pipes need not be dug in soil in straight line.	Best in climates where intense rainfall events are uncommon and evapotranspiration exceeds rainfall in most months.
Conditions apparent on site	Gentle sloping site <10%.	Soil profile >1.2 m deep.	Soil profile category 6 (clay based). The medium/heavy clay does limit permeability.	Groundwater approx. 9-25 m below ground.	Saturation generally not an issue given the dry climate however medium/heavy clay soil profile will be prone to waterlogging following occasional heavy rainfall events.	Sodic soils present and therefore needs to be managed.	Gravel and stone not observed during investigation.	Climate suitable. Net evapotranspiration far exceeds rainfall for the whole of the year.

7.2 Design Criteria

The following sections provide design criteria for standard surface spray irrigation systems in accordance with Appendix L and Appendix M of AS 1547:2012.

7.2.1 Irrigation Trigger

Irrigation schemes can be scheduled using either a soil moisture deficit standard or a set daily irrigation rate.

A soil moisture trigger allows for large volumes to be irrigated in dry conditions (i.e. much of the winter dry season), but minimal or no irrigation can occur during wet conditions (i.e. frequent periods in the summer wet season). The use of a soil moisture trigger requires large wet weather storage volumes, but can lessen the irrigation area required.

A set daily irrigation rate will occur despite weather conditions. Given that irrigation will occur every day, minimal wet weather storage is required (it is generally reserved only for days when the irrigation field is waterlogged due to torrential rain). The disadvantage of a set daily irrigation rate is that the rate needs to be kept quite low, so as to not overload the soil profile in the wetter periods. This typically results in the need for a larger irrigation area than would be required for a soil moisture trigger scheme.

The site has a moisture deficit throughout the year (average evaporation exceeds average rainfall), therefore there is unlikely to be a significant difference in irrigation area required for a moisture deficit or a set irrigation scheme. Given that a set irrigation rate scheme requires minimal wet weather storage requirements and is simpler to operate, a set irrigation scheme was considered to be warranted for this site.

7.2.2 Design Irrigation Rate

AS 1547:2012 recommends a design irrigation rate (DIR) of no higher than 2mm/day in a medium to heavy clay (category 6 soil) for a secondary treated effluent. The 2 mm/day irrigation rate was set as a daily maximum within the MEDLI 2.0 model. The MEDLI 2.0 model was then used to predict the soil/plant response. Given that the clay was highly dense in nature it was encountering waterlogging issues even at 2mm/day. The model responded more positively to the application of effluent over 3.6 ha (equating to approximately 1.1mm/day)

8 MEDLI 2.0 Modelling – Mine Operational Period

The simulation was carried out using climate data for the period from 1970 to 2017. Given the wastewater will be sourced from a small new and confined network, the model assumed no wet weather infiltration into the network occurs.

The key model inputs used were as per Table 8-1. The model output file is provided in **Appendix E**.

Table 8-1 Mine Operational Period Extreme Impermeable MEDLI 2.0 Input Parameters

Parameter	Proposed System
Effluent quantity	40 m^3/day
Wet Weather Storage Tank Volume/Capacity	120 m^3 (3 days)
Tank System Sludge Accumulation	0.0 kg dwt/year
Average Rainfall	590.2 mm/yr
Soil Evaporation	2038.2 mm/yr
Effluent Irrigation Area	3.6 ha
Irrigation Application	Daily maximum of 2 mm depth (in practice only 1.1mm/day would be likely to occur over 3.6 ha).
Total Nitrogen entering the tank system	30 mg/L
Total Phosphorous entering the tank system	10 mg/L
Salinity	1,600 µs/cm
Pasture Type	Rhodes Grass
Soil Type	Default MEDLI 2.0 Grey Clay base Soil Hydrologic, Soil Phosphorus, Soil Nitrogen parameters amended to reflect site-based data.

8.1.2 Hydraulic Balance Results

The modelling outputs indicated that using the above irrigation scheme parameters, 100% of the treated effluent can be irrigated with no overflow events occurring.

8.1.3 Nutrient Balance Results

Nitrogen (N)

The nitrogen balance indicated that the average load of nitrogen added to the soil was 121.75 kg/ha/year. The average load of nitrogen removed by plant uptake was 194.52 kg/ha/year. This indicates there was a net average removal of nitrogen from the irrigation area. As is naturally expected, there are still a limited number of occasions when more nitrogen is added than removed (i.e. heavy rain periods), and during those occasions some nitrate is leached into the groundwater table. On average 5 kg/ha/year of nitrate is predicted to leach via deep drainage. This is equal to the accepted limit of 5 kg/ha/year.

Phosphorus (P)

The phosphorus balance indicated that the average load of phosphorus added to the soil was 40.58 kg/ha/year. The average load of phosphorus removed by plant uptake was 33.33 kg/ha/year. This indicates a slight net average addition of phosphorus to the irrigation area. This is typically expected as most plants have a demand for nitrogen which far exceeds the demand for phosphorus.

Given that a small net addition of phosphorus occurs in most land based effluent disposal systems, the soil phosphorus adsorption capacity is relied on. It is generally considered acceptable if the phosphorus adsorption capacity life reaches 30 years or more. The model confirmed that the above scenario can achieve 66.92 years life capacity.

Salinity

Modelling assuming a Rhodes Grass pasture (considered to be moderately salt-tolerant) indicated the resulting soil salinity would be too low to impact upon the health of the grass. Grass health is important to maintain to ensure that nitrogen and phosphorus uptake is maximised.

8.1.4 Waterlogging

Given the soil consisted of a dense clay it was prone to waterlogging and thus waterlogging was the limiting factor in the model. A waterlogged soil inhibits grass health/growth which then inhibits the grasses' ability to assimilate nitrate from the treated effluent which results in the nitrate leaching through the waterlogged soil profile.

To assist in visualising the impact of waterlogging throughout the year refer to Figure 8-2 (0 = no waterlogging, 1 = full waterlogging). In an ideal model, waterlogging can be easily maintained at 0 throughout the year, however in this case it is present throughout the year and only decreases slightly during spring. The decrease of waterlogging in spring likely coincides with when both the net evaporation is highest (before the wet season commences) and there is a surge in plant growth given the longer days and higher temperatures at this time of year.

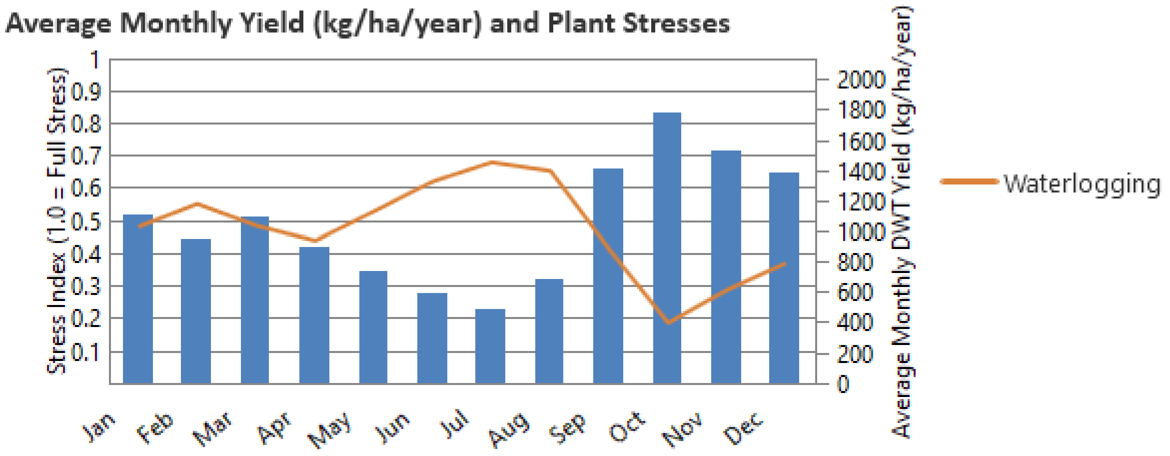


Figure 8-1 Grass Dry Weight Yield and Waterlogging Stress (extracted from MEDLI 2.0 output file)

8.1.5 Surface Runoff Water Quality

Given that the soil is prone to waterlogging, it is susceptible to effluent runoff. By restricting the effluent irrigation to an approximate of 1.1 mm/day over 3.6 ha the model did not detect runoff. It's important to note that during practice the irrigation area may be prone to pooling of water following rainfall events, and irrigation may need to be withheld on such days.

8.1.6 Pasture Health

Overall, the pasture maintains adequate health over the modelled period. No die off events were predicted and a satisfactory yield matter and coverage was maintained, however as described above in Section 8.1.4 plant health can be improved by reducing waterlogging.

8.1.7 Model Summary

The MEDLI 2.0 model supports the irrigation of effluent at the proposed location over an area of 3.6 ha at an irrigation rate that equates to approximately 1.1mm/day.

For further detail, the MEDLI 2.0 output report is provided in **Appendix E**.

9 Aerosols, Pathogens, Odours and Toxins

9.1 Aerosols and Pathogens

A spray irrigation system will likely be the most simple and practical method of irrigation for this site. Spray irrigation systems disperse effluent through the air, which can result in fine mist, otherwise termed as aerosols. The aerosols can contain pathogens which can be carried for some distance on the wind.

The *National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006* provide examples of how log reductions using treatment and exposure control can be achieved, where a log reduction corresponds to a 10-fold, or 90% reduction of a given pathogen. Three examples which are relative to municipal irrigation are provided below in Table 9-1. The options are presented in order of highest level of treatment to lowest level of treatment. The lower the level of treatment, the higher the level of exposure reductions measures are required.

Given that the site and available buffer area are not significantly constrained and are relatively isolated, it will be feasible to readily implement exposure reduction measures such as buffers, restriction of public access or spray drift control, if this is deemed to be necessary.

9.2 Odour

Both the sewage treatment plant and the irrigation field can be odour sources. Odour is spread in a similar manner to that of aerosols and can also be dealt with in a similar manner.

Odour can be reduced through increased treatment, set back distances and aerosol reduction measures (e.g. using aerosol limiting spray methods). Consideration to irrigation timing can reduce odour drift, for example avoiding irrigation when prevalent wind direction is towards nearby sensitive receivers.

9.3 Toxins

Aside from nutrients and pathogens, wastewater can contain other toxins as described in Section 4.2. These tend to only pose a direct risk to humans if the treated wastewater is intended for re-use to supplement a drinking water supply. In such cases the wastewater must be treated to an extremely high level to address these risks.

There is also some risk of exposure to toxins from dermal contact or inhalation, however, repeated continuous exposure would be required to result in any noticeable health effects. Health risks associated with aerosol exposure to toxins can be minimised by reducing the production of aerosols during irrigation, implementing access restrictions to the irrigation area, and ensuring buffer zones are implemented as per Section 11.2.

Table 9-1 Examples of how pathogen log reduction targets can be achieved for Municipal Irrigation systems (Source – National Guidelines for Water Recycling)

Log reduction targets (Virus, Protozoa, Bacteria) [a]	Indicative treatment process	Log reductions achievable by treatment (V, P, B)	On-site preventative measures	Exposure reduction [b]	Water quality objectives [c]
Municipal use – open use, sports grounds, golf courses, dust suppression, etc *or* unrestricted access and application					
5.0 3.5 4.0	Advanced treatment required; for example: Secondary, coagulation, filtration and disinfection Secondary, membrane filtration, UV light	5.0 3.5 4.0	No specific measures		To be determined on case-by-case basis depending on technologies Could include turbidity criteria for filtration, disinfectant Ct or dose (UV) *E. coli* < 1 per 100ml
Municipal use, with restricted access and application					
5.0 3.5 4.0	Secondary treatment with disinfection	2.0 - 3.0 1.0 >6.0	Restrict public access during irrigation **and one** of the following: No access after irrigation, until dry (1-4 hours) Minimum 25-30m buffer to nearest point of public access Spray drift control; for example, through low-throw sprinklers (180º inward throw), vegetation screening, or anemometer switching	2.0 1.0 1.0 1.0	▪ BOD < 20mg/L[d] ▪ SS < 30mg/L[d] ▪ Disinfectant residual (e.g. minimum chlorine residual) or UV dose[e] ▪ *E. coli* < 100cfu/100mL
Municipal use, with enhanced restrictions on access and application					
5.0 3.5 4.0	▪ Secondary treatment with > 25 days lagoon detention or primary treatment with > 50 days lagoon detention ▪ Secondary treatment	1.0 – 3.0 1.0 – 3.0 3.0 – 4.0 0.5 – 2.0 0.5 – 1.0 1.0 – 3.0	Restrict public access during irrigation **and combinations** of: ▪ No access after irrigation, until dry (1-4 hours) ▪ Minimum 25-30m buffer to nearest point of public access ▪ Spray drift control, e.g. through low throw sprinklers (180º inward throw), vegetation screening or anemometer switching	2.0 1.0 1.0 1.0	▪ BOD < 20mg/L[d] ▪ SS < 30mg/L[d] ▪ *E. coli* < 1000 cfu/100mL (disinfection may be required to achieve this concentration)

B = enteric bacteria; BOD = biochemical oxygen demand; cfu = colony forming unit; Ct = disinfectant concentration x time; P = enteric protozoa; SS = suspended solid; V = enteric virus; UV = ultraviolet.

a Log reduction targets are minimum reductions required from raw sewage based on 95^{th} percentiles from Table 3.7 of the guidelines.

b Exposure reductions are those achievable by on-site measures as listed in Table 3.3 of the guidelines.

c Water quality objectives represent medians for numbers of *E. coli* and means for other parameters.

d BOD and SS are an indication of secondary treatment effectiveness.

e Aim is to demonstrate reliability of disinfection and ability to consistently achieve microbial quality.

f Log reductions for public in the vicinity of commercial food crop irrigation areas should comply with total log reductions required for municipal use.

10 Wastewater Treatment Options

10.1 Standard of Wastewater Treatment

The MEDLI 2.0 model confirms that a standard secondary treated effluent as per Table 4-1 and Table 4-2 can be irrigated within the investigation area without overloading the modelled Rhodes Grass or soil with nutrients.

In terms of pathogen treatment capability, the classes of recycled water quality as per the *Queensland Public Health Regulation 2018* are as per Table 10-1. By utilising, for example, enhanced access restrictions (as per the last row of Table 9-1) a Class C recycled water quality would be acceptable standard of wastewater treatment.

If irrigation area restrictions need to be eased slightly (as per the middle row of Table 9-1) a Class B water quality may be required. If no restrictions are in place (as per the top row of Table 10-1), and staff/public can readily access the irrigation area then a Class A + quality may be required.

Table 10-1 Classes of Recycled Water

E.coli count	Class of Recycled Water
<1 cfu/100mL*	Class A+
<10 cfu/100mL	Class A
<100 cfu/100mL	Class B
<1000 cfu/100mL	Class C
<10,000 cfu/100mL	Class D

*to achieve A+ compliance other pathogens such as Clostridium perfringens, F-specific RNA coliphages, and somatic coliphages must also be tested for.

10.2 Package Treatment Plant Options

Many remote mining camps rely on package STPs which can be delivered in shipping containers and assembled on site. These are scaled down STPs having a small footprint and are generally highly efficient and of low maintenance requirements. Most package STPs come with standard Class C treatment capability and many come with upgrade options allowing them to readily achieve Class A treatment capability.

During detailed design the most applicable treatment plant type can be decided upon. At this stage, it is recommended that a low maintenance system with secondary treatment capability and ability to produce at least Class C effluent should be adopted pending irrigation area restrictions detailed in Table 9-1. If irrigation area restriction requirements for Class C effluent are not feasible, a low maintenance system with secondary treatment capacity should be selected with effluent quality capability of Class B or Class A in accordance with the management measures outlined in Table 9-1.

In addition to producing treated effluent, sewage treatment plants produce waste in the form of sludge. Waste sludge can be either be disposed of offsite, or where possible, recycled/reused.

11 Irrigation Area Management

11.1 Spray Irrigation Specifications

The irrigation system will adopt recommendations from AS/NZS 1547:2012 as determined to be appropriate. Key considerations are outlined in the following sections.

11.1.1 Designated Disposal Area

The designated irrigation area:

> Is not be used for purposes that compromise the effectiveness of the system or access for future maintenance purposes;

> Is to be used only for effluent application;

> Will have boundaries clearly delineated and not accessible to livestock to minimise damage;

> Will be constructed to capture run-off and seepage of effluent beyond the designated area; and

> Will have appropriate buffer areas maintained.

11.1.2 Irrigation System

The spray-irrigation system will be designed to:

> Distribute effluent evenly in the designated area;

> Control the droplet size, throw and plume height so that the risk of aerosol dispersion and the likelihood of wind draft distributing any effluent beyond the designated area is negligible;

> Have warnings complying with AS 1319 or AS/NZS 1319, at the boundaries of the designated area, clearly visible to property users, with wording such as “Recycled Water – Avoid Contact – DO NOT DRINK”; and

> Have a buffer area to ensure that any potential spray drift is adsorbed within appropriate setback distances.

11.2 Buffer Distances

The QLD Government Technical Guideline for Disposal of Effluent via Irrigation provide the following distances for reducing the risk associated with land disposal schemes using effluent irrigation:

> Natural waterways: >100 m

> Residential facility or public amenities: >50 m

> Domestic water bore: > 250 m

> Drinking water catchment and aquatic ecosystems with high ecological value: > 250 m

> Town water supply bore: > 1000m

> Groundwater bore used for potable water supply: >250 m; and

> Groundwater table at a depth: >3 m.

It is recognised that the public buffer of 50 m is greater than that suggested in Table 9-1. As a conservative measure, it is recommended to implement a 50 m buffer.

11.3 Maintaining Pasture

The MEDLI 2.0 model assumes that when the grass is mowed, that the grass clippings are removed from the area so that the nutrients within the grass clippings are removed with them. There are a couple of ways to achieve this, by either using a mower with a catcher, or by removing the grass clippings after mowing has been completed (e.g. mower grass catcher, leaf blower or raking).

The MEDLI 2.0 model indicates that mowing would only be required approximately 2 times per year to maintain sufficient growth and subsequent nutrient uptake. The grass can be mowed more frequently to maintain aesthetics if required.

11.4 Monitoring Program

Once detailed design progresses a risk assessment of the irrigation scheme will be undertaken to determine site-specific monitoring requirements. The monitoring program will be designed in accordance with the DES technical guideline *Disposal of Effluent using Irrigation* and can be adopted into the Irrigation Management Plan. The monitoring program may include periodic monitoring of soil, groundwater and any available surface water in close proximity to the irrigation area. Often such monitoring programs include 6 monthly or annual monitoring for nutrients, salts, sodicity and contaminants such as metals/metalloids and pesticides.

11.5 Managing Soil Permeability

The limited permeability of the soil may present waterlogging issues during operation, most likely following heavy rainfall. To improve permeability there are a couple of available options such as:

a. Deep ripping of the soil profile (to at least 500mm depth) to mechanically break up the compacted clay soil. During such an exercise it is recommended that gypsum be applied to the freshly exposed surface which will assist in breaking the clay and balancing the soil sodicity (discussed further in Section 11.6). By utilising this option, it may be possible to increase the irrigation rate closer to 2mm/day and therefore reduce the required irrigation area. OR

b. Import fill with greater levels of permeability (possibly from nearby mined locations) for irrigation purposes. If a deep enough layer of permeable fill (ideally 1000mm depth) could be sourced, it may be possible to increase the irrigation rate closer to 3 or 4 mm/day and therefore reduce the required irrigation area.

11.6 Managing Soil Sodicity

As discussed in Section 6.2 the soil is sodic. Sodic soils tend to disperse readily when in contact with water. Dispersion can become an issue because as the fine soil particles “dissolve” they tend to become deposited within the soil pore spaces, thereby causing the soil to become clogged and less permeable.

The MEDLI model does not have the ability to account for changes to the soil profile resulting from dispersion therefore additional measures need to be taken to prevent it from occurring. The Department of Environment and Resource Management - *Salinity Management Handbook Second Edition 2011* provides a range of management measures which can be used to manage salinity and sodicity in soils.

It is possible to balance the soil Sodium Adsorption Ratio (SAR) by addition of calcium (typically gypsum) into the soil profile. Application of gypsum works on the principle that the calcium added to the soil will counterbalance the sodium. The addition of gypsum can result in better surface soil aggregation and consequently reduced waterlogging and crusting, and can improve drainage.

Gypsum could be added to the upper soil profile with the aim of leaching the calcium into the underlying clay profile. Gypsum has a relatively low solubility, and it is estimated that on average only 1 tonne/ha/year of pure gypsum can be dissolved (Ayers & Westcot 1976). Due to the impurities in gypsum, unevenness of distribution and loss from surface runoff, the general recommendation is the application of 2-6 t/ha.

12 Conclusions

The model results presented are based on conservatively estimated wastewater volumes and treated water quality. These conclusions are therefore conservative and can likely be refined further during detailed design.

12.1 Disposal Area Size and Storage Requirements

During operation a conservative volume of **40m^3** per day of secondary treated effluent with a quality as per Table 4-1 and Table 4-2 is expected to be generated. This effluent can be irrigated over **3.6 ha** at no more than **1.1 mm/day** without nutrient leaching, runoff or overflow issues arising. The Queensland Government Technical Guideline for Disposal of Effluent via Irrigation recommends **120m^3** of wet weather storage (3 days) should be provided.

12.2 Location of Disposal Area

The irrigation disposal area can be located anywhere within the investigation area, using whichever shape is most practical. The investigation area is sufficiently large to accommodate the modelled irrigation area size. Any proposed structures within the MIA will need to take into consideration the operation of the irrigation system.

12.3 Managing Pathogen Exposure Risk

It will likely be reasonable and practical to restrict public/staff access to the irrigation area, and restrict the irrigation application method to that shown in the last row in Table 9-1. As a result, the risk of pathogen exposure to the public/staff is low enough justify a secondary treated Class C recycled water quality requirement.

12.4 Managing Soil Permeability

The limited permeability of the soil may present waterlogging issues during operation, most likely following heavy rain. Potential options to improve soil permeability are presented in Section 11.5.

12.5 Managing Soil Sodicity

The soil in the proposed effluent disposal area is sodic and therefore prone to dispersion. Dispersion can lead to further reduction in soil permeability. Management advice to reduce sodicity/dispersion is presented in Section 11.6.

12.6 Standard of Assessment and Limitations

This Land-Based Effluent Disposal Assessment Report has been undertaken in accordance with the current industry standard for wastewater management as set out in AS/NZS 1547:2012 *On-site Domestic Wastewater Management.*

13 References

- AS/NZS 1547: 2012 *On-site domestic wastewater management*.
- AS/NZS 1319: 1994 *Safety signs for the occupational environment.*
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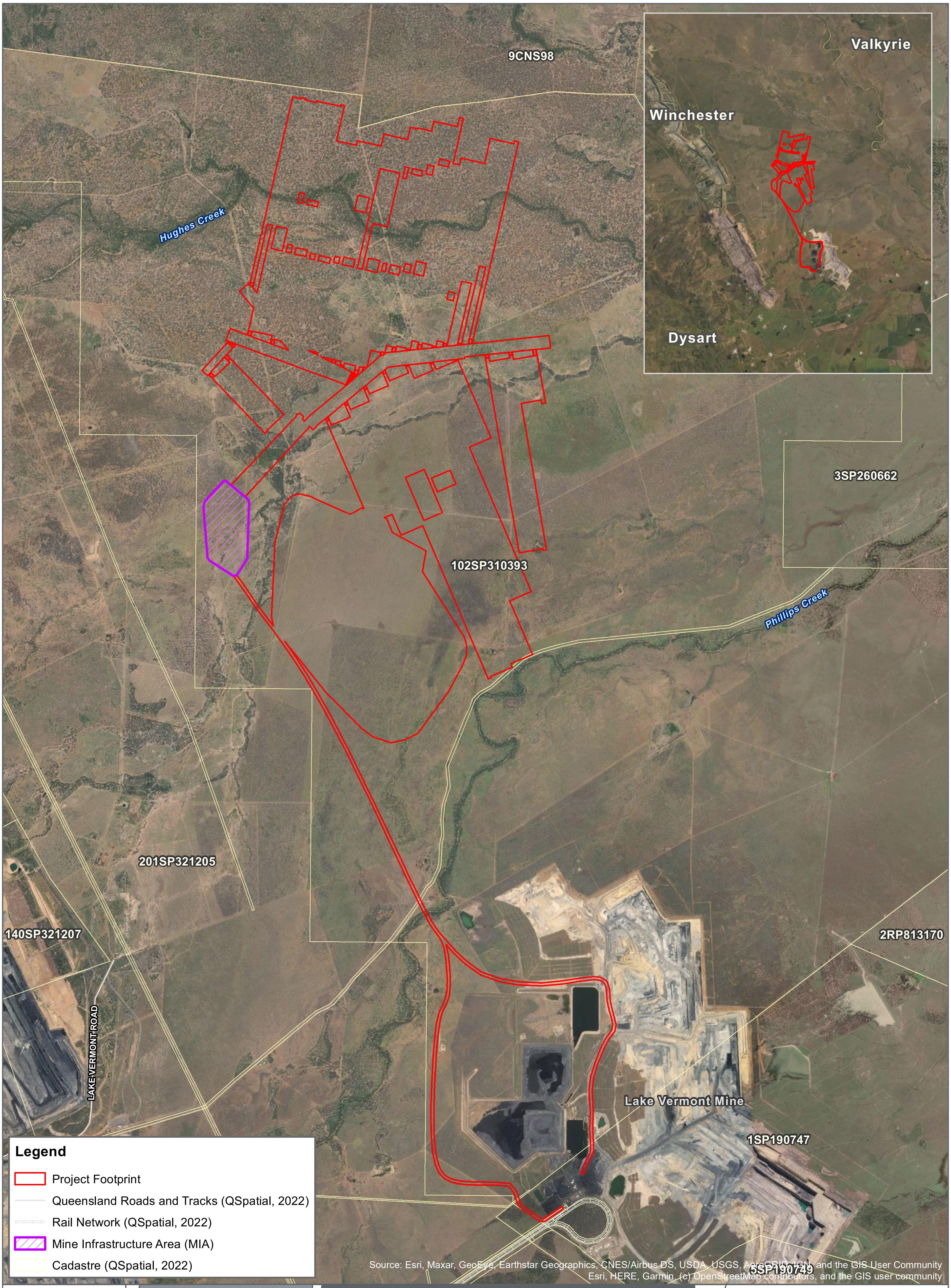
- Tennakoon. S, and Ramsay. I, 2020*. Technical Guideline for disposal of effluent via irrigation.* Brisbane: Queensland Department of Environment and Science*.*

APPENDIX

A

FIGURES



aarc ENVIRONMENTAL SOLUTIONS

FIGURE 1

1:50,000 Scale at A3

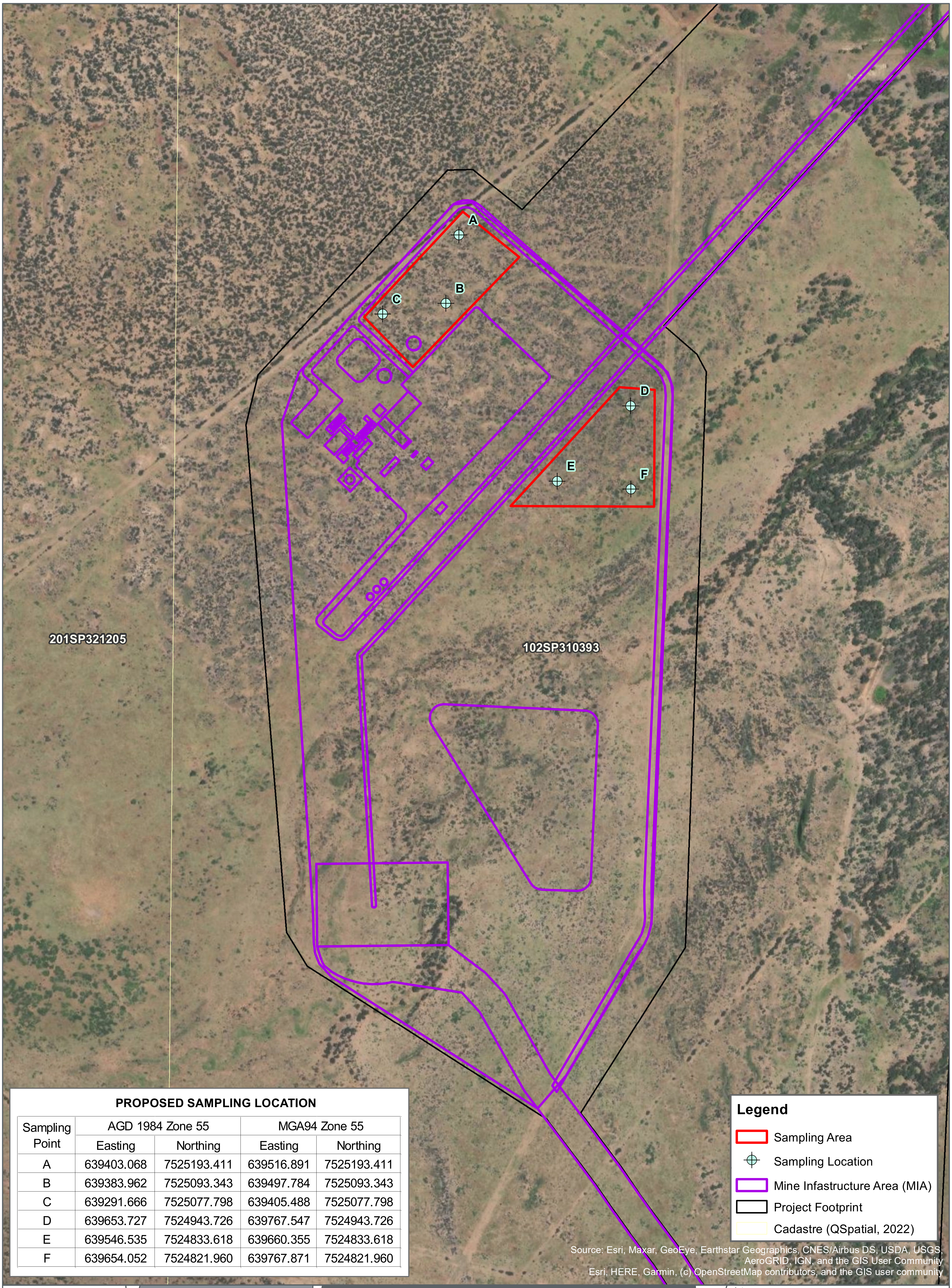
m
0 500 1,000 1,500 2,000

Lake Vermont Mine - Meadowbrook Project

LOCATION MAP

Cardno

Map Produced by Geosciences (9918)
Date: 2022-03-02 | Project: M31991
Coordinate System: GDA 1994 MGA Zone 55
Map: M31991-GS-001-SiteMap.mxd 01



PROPOSED SAMPLING LOCATION

Sampling Point	AGD 1984 Zone 55		MGA94 Zone 55	
	Easting	Northing	Easting	Northing
A	639403.068	7525193.411	639516.891	7525193.411
B	639383.962	7525093.343	639497.784	7525093.343
C	639291.666	7525077.798	639405.488	7525077.798
D	639653.727	7524943.726	639767.547	7524943.726
E	639546.535	7524833.618	639660.355	7524833.618
F	639654.052	7524821.960	639767.871	7524821.960

aarc ENVIRONMENTAL SOLUTIONS

FIGURE 2

1:5,000 Scale at A3

m 0 50 100 150 200

Lake Vermont Mine - Meadowbrook Project

SAMPLING LOCATION

Cardno

Map Produced by Geosciences (9918)
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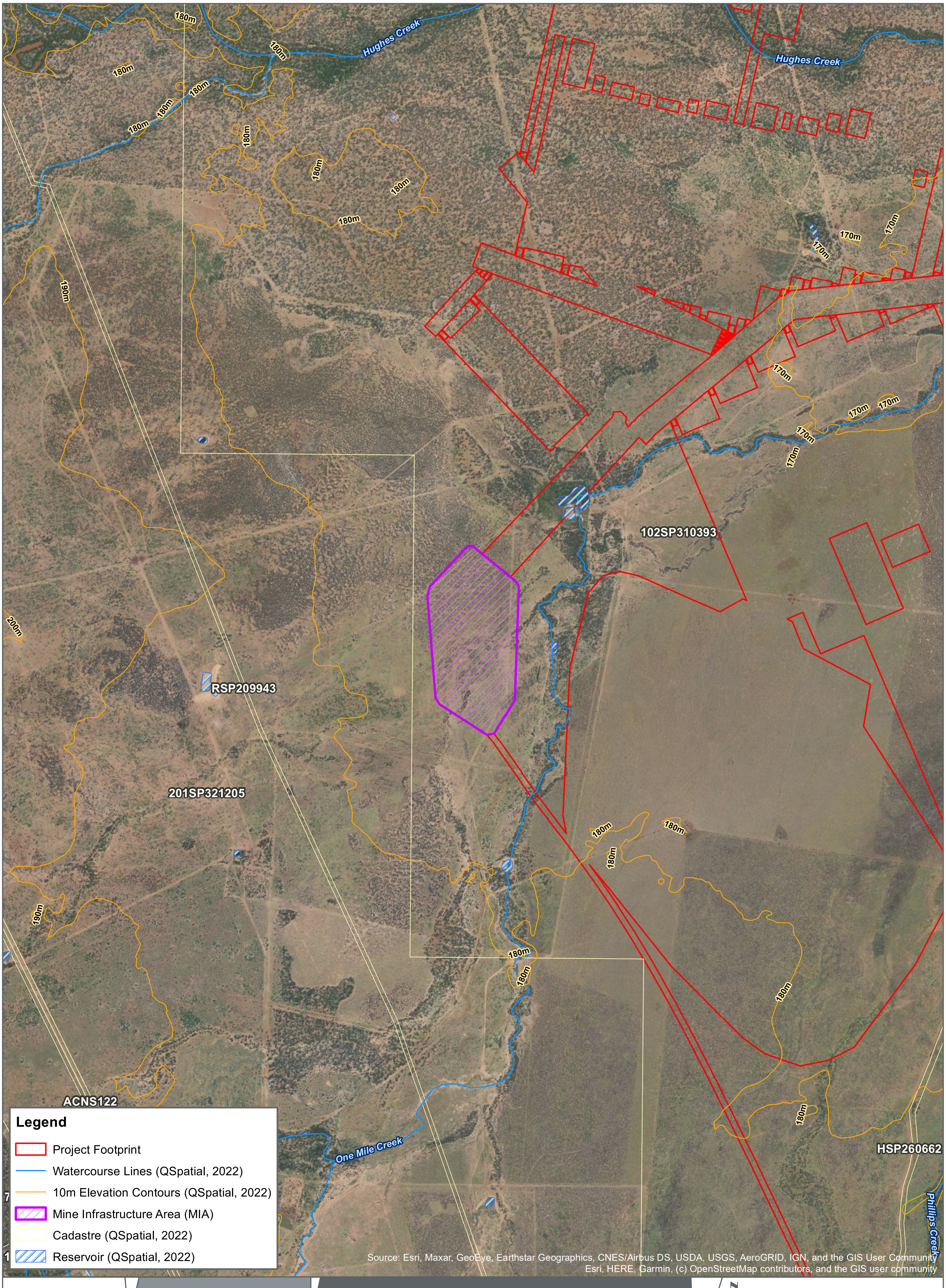
Coordinate System: GDA 1994 MGA Zone 55
Map: M31991-GS-006-SamplingLocation.mxd 01



aarc ENVIRONMENTAL SOLUTIONS

FIGURE 3

1:25,000 Scale at A3

m
0 200 400 600 800

Lake Vermont Mine - Meadowbrook Project

TOPOGRAPHY AND WATERCOURSES MAP

Cardno

Map Produced by Geosciences (9918)
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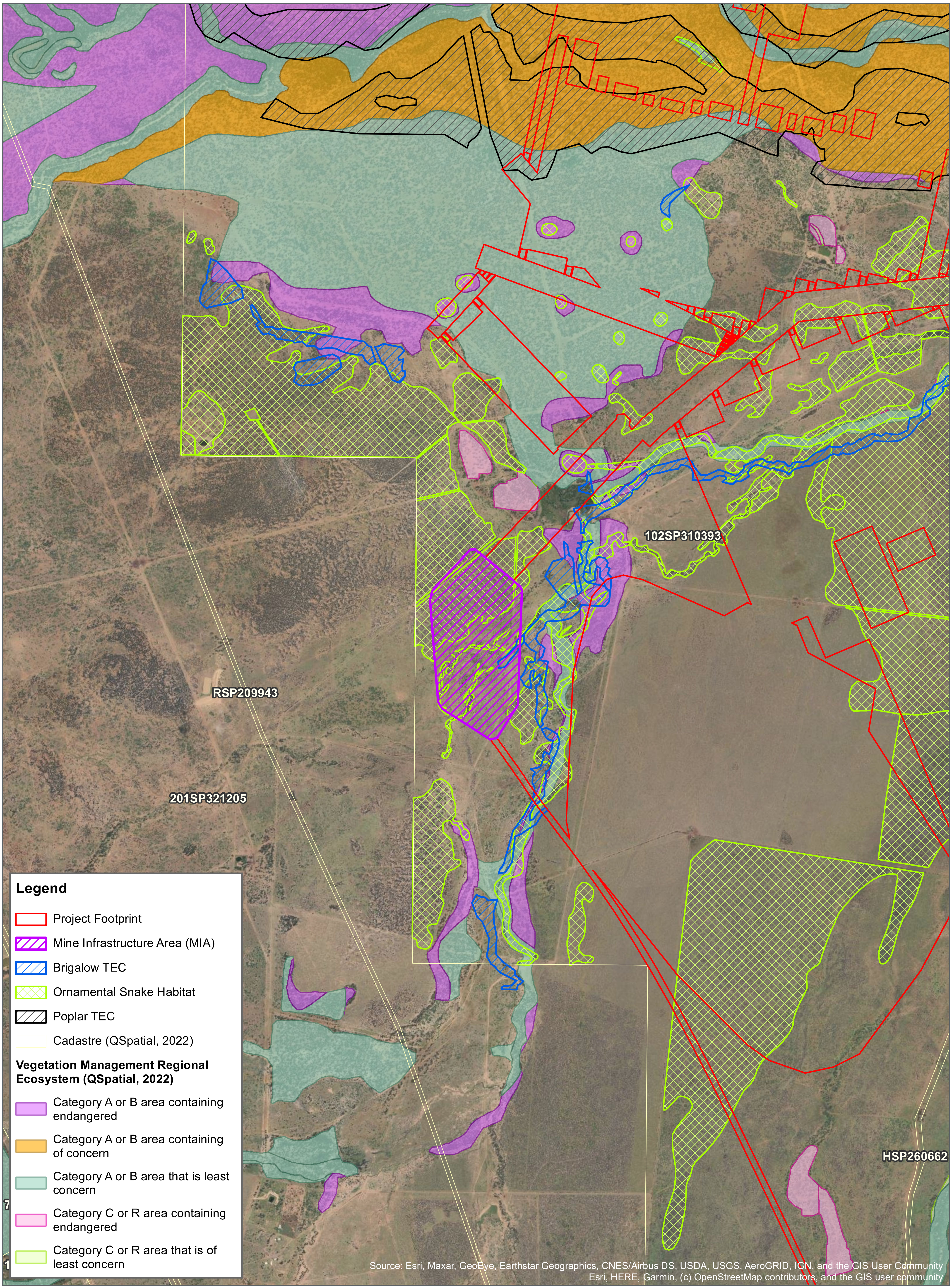
Coordinate System: GDA 1994 MGA Zone 55
Map: M31991-GS-003-Topo-Watercourse.mxd 01



aarc ENVIRONMENTAL SOLUTIONS

FIGURE 4

1:25,000 Scale at A3

m
0 200 400 600 800

Lake Vermont Mine - Meadowbrook Project

REGIONAL ECOSYSTEM MAP

Cardno

Map Produced by Geosciences (9918)
Date: 2022-03-02 | Project: M31991
Coordinate System: GDA 1994 MGA Zone 55
Map: M31991-GS-004-RegEco.mxd 01

APPENDIX

B

TEST PIT LOGS

Cardno now Stantec

TEST PIT LOG SHEET

Client: AARC Environmental Solutions
Project: Land Based Effluent Disposal - MEDLI Modeling
Location: Lake Vermont - Meadowbrook Project
Job No: M31991

Hole No: TP01

Sheet: 1 of 1

Position: E639506.000 N7525363.000 | **Angle from Horizontal:** 90° | **Surface Elevation:**
Machine Type: Backhoe | **Excavation Method:** 60mm toothed bucket
Excavation Dimensions: 1.60m LONG AND 0.80m WIDE | **Contractor:** N/A
Date Excavated: 24/1/22 | **Logged By:** GM | **Checked By:** MF

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Not Encountered	B 0.00 - 0.10 m			CI	Sandy CLAY: medium to high plasticity, brown, fine to coarse grained sand, no odour, no staining, roots. rootlets present, MPS 1 LL 50 P75 65	D	St	TOPSOIL
	H			B 0.10 - 0.60 m	0.30m					VSt	
				B 0.60 - 1.20 m	0.5		CI	Sandy CLAY: medium to high plasticity, brown mottled grey, fine to medium grained sand, no odour, no staining, MPS <1 LL 50 P75 70	D to M		ALLUVIUM
					1.0						
					1.20m			TERMINATED AT 1.20 m Target depth			
					1.5						

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
AD/T Solid flight auger: TC-Bit
WB Washbore drilling
RR Rock roller

RESISTANCE
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
Water Inflow
Water Outflow

SAMPLES
B Bulk disturbed sample
S Disturbed sample
ES Environmental sample
U50 Thin wall 50 mm diameter tube

FIELD TESTS
SPT Standard Penetration Test (Split Spoon)
SCSPT Standard Penetration Test (Solid Cone)
PP Hand/Pocket Penetrometer
PID Photoionisation Detector
VS Vane Shear; P=Peak R=Residual (uncorrected kPa)

Soil Descriptors
MPS - Maximum Particle Size (mm)
LL - Liquid Limit (%)
P75 - Passing 75 µm sieve (%)

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

Cardno now Stantec

TEST PIT LOG SHEET

Hole No: TP02

Client: AARC Environmental Solutions	
Project: Land Based Effluent Disposal - MEDLI Modeling	
Location: Lake Vermont - Meadowbrook Project	Job No: M31991 — Sheet: 1 of 1
Position: E639497.000 N7525270.000	Angle from Horizontal: 90° — Surface Elevation:
Machine Type: Backhoe	Excavation Method: 60mm toothed bucket
Excavation Dimensions: 1.60m LONG AND 0.80m WIDE	Contractor: N/A
Date Excavated: 24/1/22	Logged By: GM — Checked By: MF

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX (0.00 - 1.20 m)	F	Stable	Not Encountered	B 0.00 - 0.10 m	0.00 - 0.30		CI	Sandy CLAY: medium to high plasticity, brown, fine to coarse grained sand, no odour, no staining, roots. rootlets present, MPS 1 LL 50 P75 65	D	St	TOPSOIL
	H			B 0.10 - 0.60 m B 0.60 - 1.20 m	0.30 - 1.20		CI	Sandy CLAY: medium to high plasticity, brown mottled grey, fine to medium grained sand, no odour, no staining, MPS <1 LL 50 P75 70	D to M	VSt	ALLUVIUM
					1.20			TERMINATED AT 1.20 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
AD/T Solid flight auger: TC-Bit
WB Washbore drilling
RR Rock roller

RESISTANCE
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
Water Inflow
Water Outflow

SAMPLES
B Bulk disturbed sample
S Disturbed sample
ES Environmental sample
U50 Thin wall 50 mm diameter tube

FIELD TESTS
SPT Standard Penetration Test (Split Spoon)
SCSPT Standard Penetration Test (Solid Cone)
PP Hand/Pocket Penetrometer
PID Photoionisation Detector
VS Vane Shear; P=Peak R=Residual (uncorrected kPa)

Soil Descriptors
MPS - Maximum Particle Size (mm)
LL - Liquid Limit (%)
P75 - Passing 75 µm sieve (%)

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

Cardno (Qld) Pty Ltd

Cardno now Stantec

TEST PIT LOG SHEET

Client: AARC Environmental Solutions
Project: Land Based Effluent Disposal - MEDLI Modeling
Location: Lake Vermont - Meadowbrook Project

Hole No: TP03

Job No: M31991
Sheet: 1 of 1

Position: E639392.000 N7525246.000
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: Backhoe
Excavation Method: 60mm toothed bucket
Excavation Dimensions: 1.60m LONG AND 0.80m WIDE
Contractor: N/A
Date Excavated: 24/1/22
Logged By: GM
Checked By: MF

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Not Encountered	B 0.00 - 0.10 m	0.00		CI	Sandy CLAY: medium to high plasticity, brown, fine to coarse grained sand, no odour, no staining, roots. rootlets present, MPS 1 LL 50 P75 65	D	St	TOPSOIL
	H			B 0.10 - 0.60 m						VSt	
					0.30m		CI	Sandy CLAY: medium to high plasticity, brown mottled grey, fine to medium grained sand, no odour, no staining, MPS <1 LL 50 P75 70	D to M		ALLUVIUM
					0.5						
				B 0.60 - 1.20 m							
					1.0						
					1.20m			TERMINATED AT 1.20 m Target depth			
					1.5						

METHOD
- EX Excavator bucket
- R Ripper
- HA Hand auger
- AD/T Solid flight auger: TC-Bit
- WB Washbore drilling
- RR Rock roller

RESISTANCE
- VE Very Easy (No Resistance)
- E Easy
- F Firm
- H Hard
- VH Very Hard (Refusal)

WATER
- Water Level on Date shown
- Water Inflow
- Water Outflow

SAMPLES
- B Bulk disturbed sample
- S Disturbed sample
- ES Environmental sample
- U50 Thin wall 50 mm diameter tube

FIELD TESTS
- SPT Standard Penetration Test (Split Spoon)
- SCSPT Standard Penetration Test (Solid Cone)
- PP Hand/Pocket Penetrometer
- PID Photoionisation Detector
- VS Vane Shear; P=Peak R=Residual (uncorrected kPa)

Soil Descriptors
- MPS - Maximum Particle Size (mm)
- LL - Liquid Limit (%)
- P75 - Passing 75 µm sieve (%)

MOISTURE
- D - Dry
- M - Moist
- W - Wet
- PL - Plastic limit
- LL - Liquid limit
- *w* - Moisture content

SOIL CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

Cardno (Qld) Pty Ltd

Cardno now Stantec

TEST PIT LOG SHEET

Hole No: TP04

Client: AARC Environmental Solutions
Project: Land Based Effluent Disposal - MEDLI Modeling
Location: Lake Vermont - Meadowbrook Project
Job No: M31991
Sheet: 1 of 1

Position: E639774.000 N7525112.000 | **Angle from Horizontal:** 90° | **Surface Elevation:**
Machine Type: Backhoe | **Excavation Method:** 60mm toothed bucket
Excavation Dimensions: 1.60m LONG AND 0.80m WIDE | **Contractor:** N/A
Date Excavated: 24/1/22 | **Logged By:** GM | **Checked By:** MF

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	Material Description (SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components; ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure)	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F (0.00–0.10)	Stable	Not Encountered	B 0.00 - 0.10 m	0.00–0.30		CI	Sandy CLAY: medium to high plasticity, brown, fine to coarse grained sand, no odour, no staining, roots. rootlets present, MPS 1 LL 50 P75 65	D	St (0.00–0.10)	TOPSOIL
	H (0.10–1.20)			B 0.10 - 0.60 m	0.30–1.20		CI	Sandy CLAY: medium to high plasticity, brown mottled grey, fine to medium grained sand, no odour, no staining, MPS <1 LL 50 P75 70	D to M	VSt (0.10–1.20)	ALLUVIUM
				B 0.60 - 1.20 m							
					1.20			TERMINATED AT 1.20 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
AD/T Solid flight auger: TC-Bit
WB Washbore drilling
RR Rock roller

RESISTANCE
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
Water Inflow
Water Outflow

SAMPLES
B Bulk disturbed sample
S Disturbed sample
ES Environmental sample
U50 Thin wall 50 mm diameter tube

FIELD TESTS
SPT Standard Penetration Test (Split Spoon)
SCSPT Standard Penetration Test (Solid Cone)
PP Hand/Pocket Penetrometer
PID Photoionisation Detector
VS Vane Shear; P=Peak R=Residual (uncorrected kPa)

Soil Descriptors
MPS - Maximum Particle Size (mm)
LL - Liquid Limit (%)
P75 - Passing 75 µm sieve (%)

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

Cardno (Qld) Pty Ltd

Cardno now Stantec

TEST PIT LOG SHEET

Client: AARC Environmental Solutions
Project: Land Based Effluent Disposal - MEDLI Modeling
Location: Lake Vermont - Meadowbrook Project

Job No: M31991

Hole No: TP05

Sheet: 1 of 1

Position: E639663.000 N7525019.000 | **Angle from Horizontal:** 90° | **Surface Elevation:**

Machine Type: Backhoe | **Excavation Method:** 60mm toothed bucket

Excavation Dimensions: 1.60m LONG AND 0.80m WIDE | **Contractor:** N/A

Date Excavated: 24/1/22 | **Logged By:** GM | **Checked By:** MF

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Not Encountered	B 0.00 - 0.10 m; B 0.10 - 0.60 m	0.00 - 0.30		CI	Sandy CLAY: medium to high plasticity, brown, fine to coarse grained sand, no odour, no staining, roots. rootlets present, MPS 1 LL 50 P75 65	D	St	TOPSOIL
EX	H	Stable	Not Encountered	B 0.60 - 1.20 m	0.30 - 1.20		CI	Sandy CLAY: medium to high plasticity, brown mottled grey, fine to medium grained sand, no odour, no staining, MPS <1 LL 50 P75 70	D to M	VSt	ALLUVIUM
					1.20			TERMINATED AT 1.20 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
AD/T Solid flight auger: TC-Bit
WB Washbore drilling
RR Rock roller

RESISTANCE
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
Water Inflow
Water Outflow

SAMPLES
B Bulk disturbed sample
S Disturbed sample
ES Environmental sample
U50 Thin wall 50 mm diameter tube

FIELD TESTS
SPT Standard Penetration Test (Split Spoon)
SCSPT Standard Penetration Test (Solid Cone)
PP Hand/Pocket Penetrometer
PID Photoionisation Detector
VS Vane Shear; P=Peak R=Residual (uncorrected kPa)

Soil Descriptors
MPS - Maximum Particle Size (mm)
LL - Liquid Limit (%)
P75 - Passing 75 µm sieve (%)

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

Cardno (Qld) Pty Ltd

Cardno now Stantec

TEST PIT LOG SHEET

Client: AARC Environmental Solutions
Project: Land Based Effluent Disposal - MEDLI Modeling
Location: Lake Vermont - Meadowbrook Project

Hole No: TP06

Job No: M31991

Sheet: 1 of 1

Position: E639766.000 N7525001.000 | **Angle from Horizontal:** 90° | **Surface Elevation:**

Machine Type: Backhoe | **Excavation Method:** 60mm toothed bucket

Excavation Dimensions: 1.60m LONG AND 0.80m WIDE | **Contractor:** N/A

Date Excavated: 24/1/22 | **Logged By:** GM | **Checked By:** MF

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Not Encountered	B 0.00 - 0.10 m; B 0.10 - 0.60 m	0.00–0.30		CI	Sandy CLAY: medium to high plasticity, brown-yellow, fine to coarse grained sand, no odour, no staining, roots. rootlets present, MPS 1 LL 50 P75 60	D	St	TOPSOIL
	H			B 0.60 - 1.20 m	0.30–1.20 (0.5)		CI	0.30m Sandy CLAY: medium to high plasticity, brown-yellow, fine to coarse grained sand, no odour, no staining, MPS 1 LL 50 P75 65 0.50m fine to medium grain size	D to M	VSt	ALLUVIUM
					1.20 (1.0)			1.20m TERMINATED AT 1.20 m Target depth			
					1.5						

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
AD/T Solid flight auger: TC-Bit
WB Washbore drilling
RR Rock roller

RESISTANCE
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
Water Inflow
Water Outflow

SAMPLES
B Bulk disturbed sample
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U50 Thin wall 50 mm diameter tube

FIELD TESTS
SPT Standard Penetration Test (Split Spoon)
SCSPT Standard Penetration Test (Solid Cone)
PP Hand/Pocket Penetrometer
PID Photoionisation Detector
VS Vane Shear; P=Peak R=Residual (uncorrected kPa)

Soil Descriptors
MPS - Maximum Particle Size (mm)
LL - Liquid Limit (%)
P75 - Passing 75 µm sieve (%)

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
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SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

APPENDIX

C

SITE PHOTOGRAPHS

Photo 1: General Photo of Proposed Irrigation Area

Photo 2: Typical test pit profile. Note clay “lumps/clods” and the “streaks” the excavator has imprinted into the plastic clay on sides of test pit

Photo 3: “Lumps/Clods” of clay removed from test pit

Photo 4: Attempted Hand Auger. Note compaction of clay on the bottom/edges of the bore – resulting in auger refusal

APPENDIX

D

LABORATORY RESULTS

CHAIN OF CUSTODY

ALS

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph 07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: CARDNO (QLD) PTY LTD
OFFICE: Mackay
PROJECT: Lake Vermont Meadowbrook
ORDER NUMBER: M31991
PROJECT MANAGER: Mark Farrey — **CONTACT PH:** 07 3310 2309
SAMPLER: Gilson DeMello — **SAMPLER MOBILE:** 0408747095
COC emailed to ALS? (YES / NO) — **EDD FORMAT (or default):** NO
Email Reports to : soils@cardno.com.au/Mark. Farrey@cardno.com.au
Email Invoice to : soils@cardno.com.au/ Mark. Farrey@cardno.com.au

TURNAROUND REQUIREMENT ☑ Standard TAT (List due date):
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: EN/024/16 (Cardno blanket qoute)

COC SEQUENCE NUMBER (Circle)
COC: 1
OF: 1

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Gilson DeMello	[signature]	[signature]	P Taylor
DATE/TIME: 25/01/2022	DATE/TIME: 31/1/22 8:30	DATE/TIME: 31/1/22 16:00	DATE/TIME: 1.2.22 830

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price)
Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).

LAB ID (ALS USE ONLY)	SAMPLE ID	14/12/2021	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BAGS	HOLD	NT-1S	EN020-D40	EA058, EA006, EA014	EP004	EK080	AG-2	Water Holding Capacity (Wilton Point + Field Capacity) Bulk Density, Porosity		Additional Information
1	A 0.0 - 0.1	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
2	A 0.1 - 0.6	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
3	A 0.6 - 1.2	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
4	B 0.0 - 0.1	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
5	B 0.1 - 0.6	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
6	B 0.6 - 1.2	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
7	C 0.0 - 0.1	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
8	C 0.1 - 0.6	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
9	C 0.6 - 1.2	14/12/2021	Soil	Bag	1		x	x	x	x	x	x	x		
10	D 0.0 - 0.1	14/12/2021	Soil	Bag	1	x									
11	D 0.1 - 0.6	14/12/2021	Soil	Bag	1	x									
12	D 0.6 - 1.2	14/12/2021	Soil	Bag	1	x									
13	E 0.0 - 0.1	14/12/2021	Soil	Bag	1	x									
14	E 0.1 - 0.6	14/12/2021	Soil	Bag	1	x									
15	E 0.6 - 1.2	14/12/2021	Soil	Bag	1	x									
16	F 0.0 - 0.1	14/12/2021	Soil	Bag	1	x									
17	F 0.1 - 0.6	14/12/2021	Soil	Bag	1	x									
18	F 0.6 - 1.2	14/12/2021	Soil	Bag	1	x									
				TOTAL											

Environmental Division
Brisbane
Work Order Reference
EB2202397

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2202397**	Page	: 1 of 7
Client	: **CARDNO (QLD) PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MARK FARREY	Contact	: Nidhi Bhimani
Address	: 71 Maggiolo Drive Paget 4740	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 33102309	Telephone	: +61-7-3243 7222
Project	: Lake Vermont Meadowbrook	Date Samples Received	: 01-Feb-2022 08:30
Order number	: M31991	Date Analysis Commenced	: 01-Feb-2022
C-O-C number	: ----	Issue Date	: 14-Feb-2022 09:55
Sampler	: GILSON DE MELLO		
Site	: ----		
Quote number	: EN/024/18 (Primary work)		
No. of samples received	: 18		
No. of samples analysed	: 9		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- **Bulk Density analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- ED008-Exchangeable Cations with pre-treatement: Unable to calculate Magnesium/Potassium Ratio for sample 'A 0.1-0.6' (EB2202397-002) as required Exchangeable Magnesium and/or Potassium results are less than the limit of reporting.
- ED008-Exchangeable Cations with pre-treatement: Unable to calculate Magnesium/Potassium Ratio for sample 'C 0.6-1.2' (EB2202397-009) as required Exchangeable Magnesium and/or Potassium results are less than the limit of reporting.
- ED006 (Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio results for some samples as required Exchangeable Potassium results are less than the limit of reporting.
- ED008-Exchangeable Cations with pre-treatement: Unable to calculate Magnesium/Potassium Ratio for sample 'A 0.6-1.2' (EB2202397-003) as required Exchangeable Magnesium and/or Potassium results are less than the limit of reporting.
- ED008-Exchangeable Cations with pre-treatement: Unable to calculate Magnesium/Potassium Ratio for sample 'B 0.6-1.2' (EB2202397-006) as required Exchangeable Magnesium and/or Potassium results are less than the limit of reporting.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).
- ALS is not NATA accredited for the analysis of bulk density in a soil matrix.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Sample ID	A 0.0-0.1	A 0.1-0.6	A 0.6-1.2	B 0.0-0.1	B 0.1-0.6
			Sampling date / time	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00
Compound	CAS Number	LOR	Unit	EB2202397-001	EB2202397-002	EB2202397-003	EB2202397-004	EB2202397-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.1	6.7	5.2	6.2	7.9
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	10.8	35.8	44.3	7.15	35.4
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	68	715	1020	35	538
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	233	2430	3490	120	1830
EA051 : Bulk Density								
ø Bulk Density	BULK_DENSITY	1	kg/m3	1230	1370	1380	1150	1150
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	6.7	11.4	12.3	7.4	9.8
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Grayish Brown (10YR 4/2)	Dark Gray (10YR 4/1)	Dark Grayish Brown (10YR 4/2)	Very Dark Grayish Brown (10YR 3/2)	Dark Gray (10YR 4/1)
Texture	----	-	-	Medium Clay	Medium Heavy Clay	Medium Clay	Medium Clay	Medium Heavy Clay
Emerson Class Number	EC/TC	-	-	2	1	1	2	2
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	----	----	0.3	----	----
ø Exchangeable Aluminium	----	0.1	meq/100g	----	----	<0.1	----	----
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	7.3
ø Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	7.6
ø Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2
ø Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	2.8
ø Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	17.7
ø Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	16.0
ø Calcium/Magnesium Ratio	----	0.2	-	----	----	----	----	1.0
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	12.4	----	----	11.3	----
Exchangeable Magnesium	----	0.1	meq/100g	11.1	----	----	8.1	----
Exchangeable Potassium	----	0.1	meq/100g	0.2	----	----	0.1	----
Exchangeable Sodium	----	0.1	meq/100g	2.2	----	----	2.1	----
Cation Exchange Capacity	----	0.1	meq/100g	26.0	----	----	21.6	----
Exchangeable Sodium Percent	----	0.1	%	8.6	----	----	9.7	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	A 0.0-0.1	A 0.1-0.6	A 0.6-1.2	B 0.0-0.1	B 0.1-0.6
			Sampling date / time	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00
Compound	CAS Number	LOR	Unit	EB2202397-001	EB2202397-002	EB2202397-003	EB2202397-004	EB2202397-005
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Calcium/Magnesium Ratio	----	0.1	-	**1.1**	----	----	**1.4**	----
Magnesium/Potassium Ratio	----	0.1	-	**61.4**	----	----	**70.7**	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	**8.3**	**4.2**	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	**9.2**	**8.1**	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	<0.1	<0.1	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	**3.3**	**3.1**	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	**15.8**	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	**21.0**	----	----	----
Exchangeable Sodium Percent	----	0.1	%	----	**15.6**	**20.0**	----	----
Calcium/Magnesium Ratio	----	0.1	-	----	**0.9**	**0.5**	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	**10**	**10**	<10	<10
Magnesium	7439-95-4	10	mg/kg	<10	**10**	**20**	<10	<10
Sodium	7440-23-5	10	mg/kg	**80**	**620**	**870**	**50**	**490**
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	<10
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	**0.4**	**0.2**	<0.1	**0.4**	<0.1
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	**2.2**	**1.1**	<0.1	**2.7**	**1.0**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**2.6**	**1.3**	<0.1	**3.1**	**1.0**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**1260**	**530**	**190**	**890**	**600**
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	**1260**	**530**	**190**	**890**	**600**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**202**	**188**	**154**	**219**	**152**
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	**5**	<5	<5	<5	<5
EP004: Organic Matter								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	A 0.0-0.1	A 0.1-0.6	A 0.6-1.2	B 0.0-0.1	B 0.1-0.6
			Sampling date / time	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00
Compound	CAS Number	LOR	Unit	EB2202397-001	EB2202397-002	EB2202397-003	EB2202397-004	EB2202397-005
				Result	Result	Result	Result	Result
EP004: Organic Matter - Continued								
Organic Matter	----	0.5	%	**1.9**	**2.0**	**0.5**	**3.6**	**1.0**

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	B 0.6-1.2	C 0.0-0.1	C 0.1-0.6	C 0.6-1.2	----
Sampling date / time				14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	----
				EB2202397-006	EB2202397-007	EB2202397-008	EB2202397-009	--------
				Result	Result	Result	Result	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.7	8.2	8.1	6.6	----
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	57.4	12.9	47.6	46.0	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	652	308	973	1290	----
EA014 Total Soluble Salts								
Total Soluble Salts	----	5	mg/kg	2220	1050	3310	4400	----
EA051 : Bulk Density								
ø Bulk Density	BULK_DENSITY	1	kg/m3	1220	1170	1050	1440	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	8.4	6.9	9.9	9.6	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Grayish Brown (2.5Y 4/2)	Dark Grayish Brown (2.5Y 4/2)	Dark Grayish Brown (2.5Y 4/2)	Olive Brown (2.5Y 4/3)	----
Texture	----	-	-	Light Medium Clay	Medium Clay	Light Medium Clay	Medium Clay	----
Emerson Class Number	EC/TC	-	-	1	3	2	1	----
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	0.2	----	----	----	----
ø Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	----	10.6	6.7	----	----
ø Exchangeable Magnesium	----	0.2	meq/100g	----	9.1	9.2	----	----
ø Exchangeable Potassium	----	0.2	meq/100g	----	0.2	<0.2	----	----
ø Exchangeable Sodium	----	0.2	meq/100g	----	1.6	5.2	----	----
ø Cation Exchange Capacity	----	0.2	meq/100g	----	21.5	21.3	----	----
ø Exchangeable Sodium Percent	----	0.2	%	----	7.6	24.5	----	----
ø Calcium/Magnesium Ratio	----	0.2	-	----	1.2	0.7	----	----
ø Magnesium/Potassium Ratio	----	0.2	-	----	44.8	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.4	----	----	2.4	----
Exchangeable Magnesium	----	0.1	meq/100g	5.5	----	----	6.2	----
Exchangeable Potassium	----	0.1	meq/100g	<0.1	----	----	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	2.2	----	----	2.9	----
Cation Exchange Capacity	----	0.1	meq/100g	10.3	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	B 0.6-1.2	C 0.0-0.1	C 0.1-0.6	C 0.6-1.2	----
			Sampling date / time	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	14-Dec-2021 00:00	----
Compound	CAS Number	LOR	Unit	EB2202397-006	EB2202397-007	EB2202397-008	EB2202397-009	--------
				Result	Result	Result	Result	----
ED008: Exchangeable Cations - Continued								
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	11.6	----
Exchangeable Sodium Percent	----	0.1	%	21.3	----	----	25.1	----
Calcium/Magnesium Ratio	----	0.1	-	0.4	----	----	0.4	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	20	10	10	----
Magnesium	7439-95-4	10	mg/kg	20	20	10	20	----
Sodium	7440-23-5	10	mg/kg	570	280	820	1090	----
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	----
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.2	0.5	0.1	<0.1	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.2	4.1	2.6	1.6	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	4.6	2.7	1.6	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	150	820	300	130	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	150	820	300	130	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	103	194	156	102	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	1.9	0.7	0.8	----

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(SOIL) EA051 : Bulk Density

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Certificate of Analysis

Signatory: P. Eolunton

Phone: +617 3289 7179 Bio-Track Pty Ltd ABN 91 056 237 275

Test Code/Name	**[454] Clod Density - Soil**		
Lab Reference (LR)	**040222.377**	Client Name	ALS
SampleID	**(As Listed)**	Client Contact	SUB RESULTS
		Project Name	ALS Batch# EB2202397
Report Date	21/02/2022	Job Number	507454
Sample Received Date	3/02/2022	Order Number	
Sample Disposal Date	5/04/2022	Chain of Custody	
Sample Packaging	Plastic Bag	Client Email	subresults.briHi Jodi@alsglobal.com
Temperature	Ambient	Client Address	2 Byth St Stafford Brisbane Queensland
Particle Density g/cc	2.65	Assumed particle density	

Analytical Method: Density of soil clod dried at 40°C. Clod volume measured by displacement.
Clod density calculated as: Dry Mass (40°C)/Displacement Volume.
Particle density calculated as 1-Density/Particle Density

S#	SampleID	Clod Density g/cc	Porosity %
1	A 0-0.1	**1.32**	**50%**
2	A 0.1-0.6	**1.86**	**30%**
3	A 0.6-1.2	**1.84**	**31%**
4	B 0-0.1	**1.56**	**41%**
5	B 0.1-0.6	**1.65**	**38%**
6	B 0.6-1.2	**1.71**	**35%**
7	C 0-0.1	**1.65**	**38%**
8	C 0.1-0.6	**1.61**	**39%**
9	C 0.6-1.2	**1.81**	**32%**

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Certificate of Analysis

Signatory:

Phone: +617 3289 7179 Bio-Track Pty Ltd ABN 91 056 237 275

Test Code/Name	[75] Water Holding Capacity		
Lab Reference (LR)	**040222.376**	Client Name	ALS
SampleID(s)	**(As Listed)**	Client Contact	SUB RESULTS
		Project Name	ALS Batch# EB2202397
Report Date	11/02/2022	Job Number	
Sample Received Date	3/02/2022	Order Number	
Sample Disposal Date	5/04/2022	Chain of Custody	
Sample Packaging	Plastic Bag	Client Email	
Temperature	Ambient	Client Address	2 Byth St Stafford Brisbane Queensland

Moisture Content at Field Capacity and Wilting Point calculated using Moisture Tension Plate.

***NM = not measured**

S#	SampleID	MC% Grav. Field Capacity 30 kPa	MC% Grav. Wilting Point 1500 kPa	Available Water % Grav.
1	A 0-0.1	37.48	13.25	24.22
2	A 0.1-0.6	41.84	16.43	25.41
3	A 0.6-1.2	41.98	16.74	25.23
4	B 0-0.1	33.63	11.91	21.72
5	B 0.1-0.6	35.26	13.01	22.24
6	B 0.6-1.2	30.92	10.86	20.06
7	C 0-0.1	35.02	13.51	21.51
8	C 0.1-0.6	36.63	13.93	22.70
9	C 0.6-1.2	36.33	16.86	19.47

APPENDIX

E

MEDLI 2.0 OUTPUT FILE

MEDLI REPORT - FULL RUN

Enterprise: **Lake Vermont**

Description:
Meadowbrook Project

Client: **AARC**

MEDLI User: CARDNO\mark.farrey

Scenario Details:
Lake Vermont specific clay. 3 layers based on clod density.
3.6 ha at a maximum of 2mm/day (in practice 1.1mm/day would occur)

DESCRIPTION

Climate Data: Lake Vermont_-22.35_148.35 (2), -22.35°, 148.35°

Run Period: 01/01/1970 to 31/12/2017 48 years, 0 days

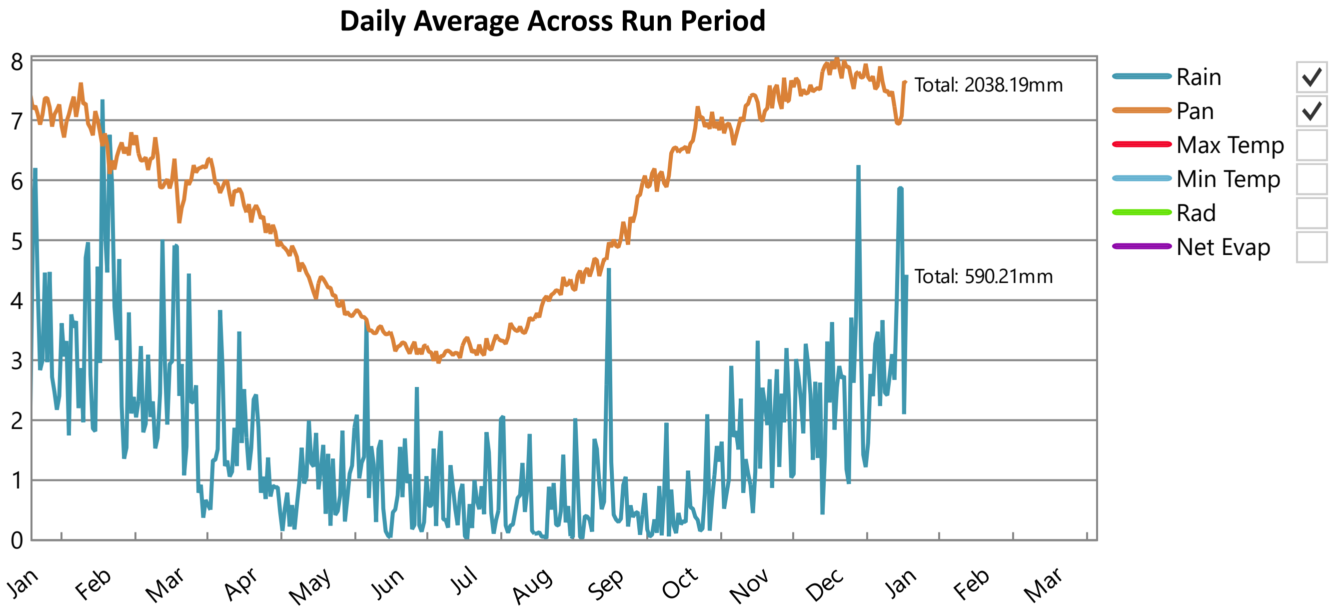
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	297	576	942
Pan Evaporation (mm/year)	1740	2062	2284

Climate Data:

■ Chart ☐ Table

☐ Monthly ■ Daily



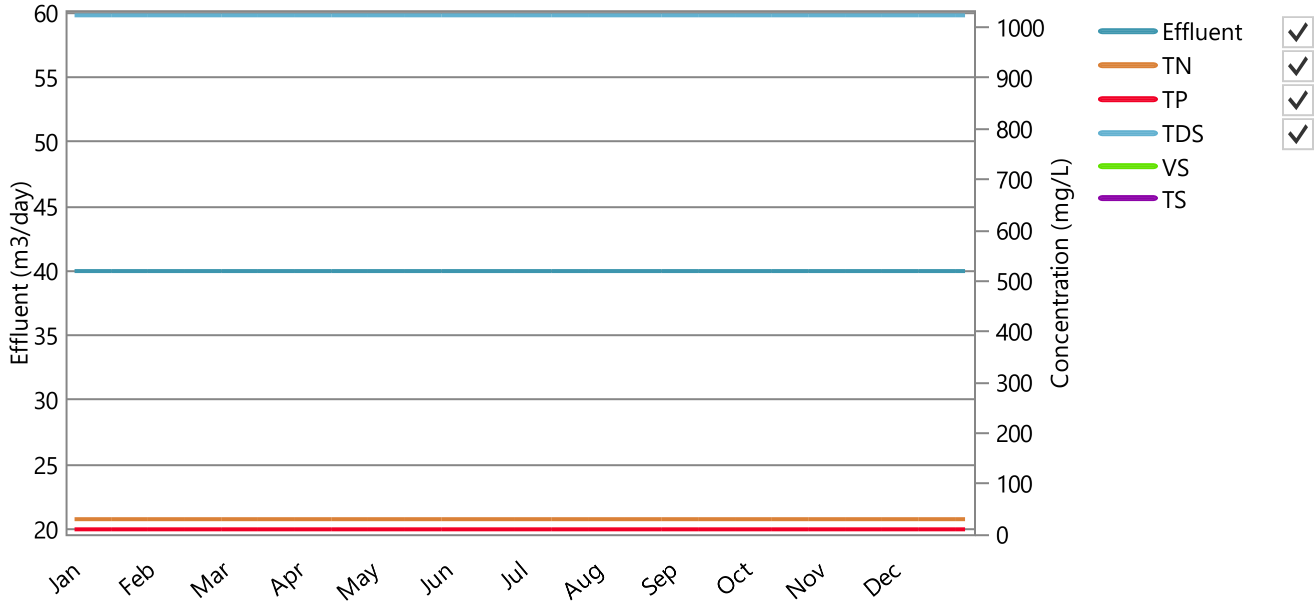
DESCRIPTION

Effluent type: New Sewage Treatment Plant

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:

■ Chart ☐ Table



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: 14610.00 m3/year or 40.00 m3/day (Min-Max: 40.00 - 40.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

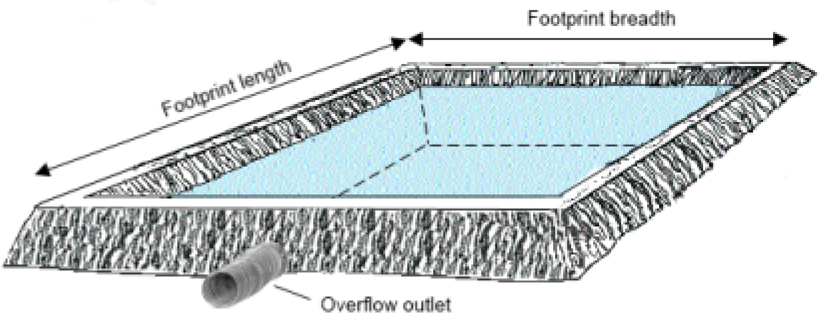
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	30.00 (30.00 - 30.00)	438.30 (438.00 - 439.20)
Total Phosphorus	10.00 (10.00 - 10.00)	146.10 (146.00 - 146.40)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	14960.64 (14950.40 - 14991.36)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

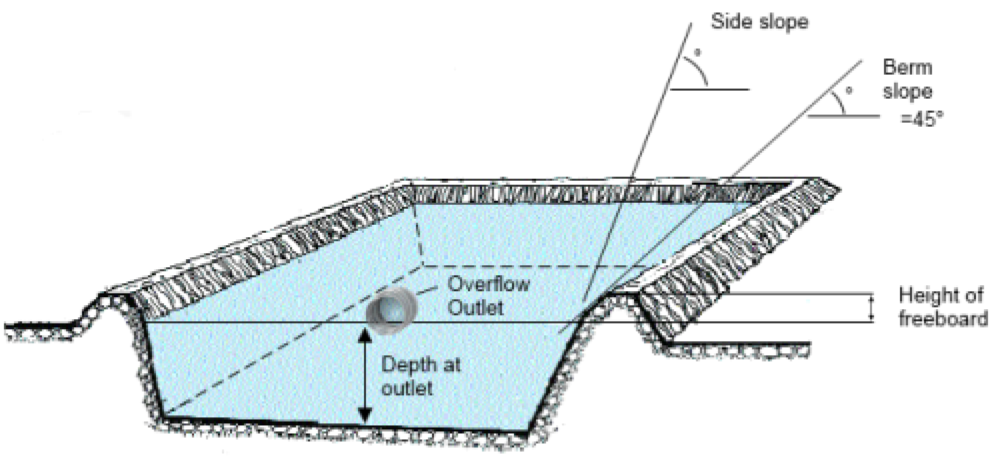
DESCRIPTION

Pond system: 1 closed storage tank

Pond system details:

	Pond 1
Maximum pond volume (m3)	120.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	3.00
Maximum water surface area (m2)	40.00
Pond footprint length (m)	6.32
Pond footprint width (m)	6.32
Pond catchment area (m2)	40.00
Average active volume (m3)	0.00





Irrigation pump limits:

Minimum pump rate limit (ML/day)	0.00
Maximum pump rate limit (ML/day)	9999999.00

Shandying water:

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

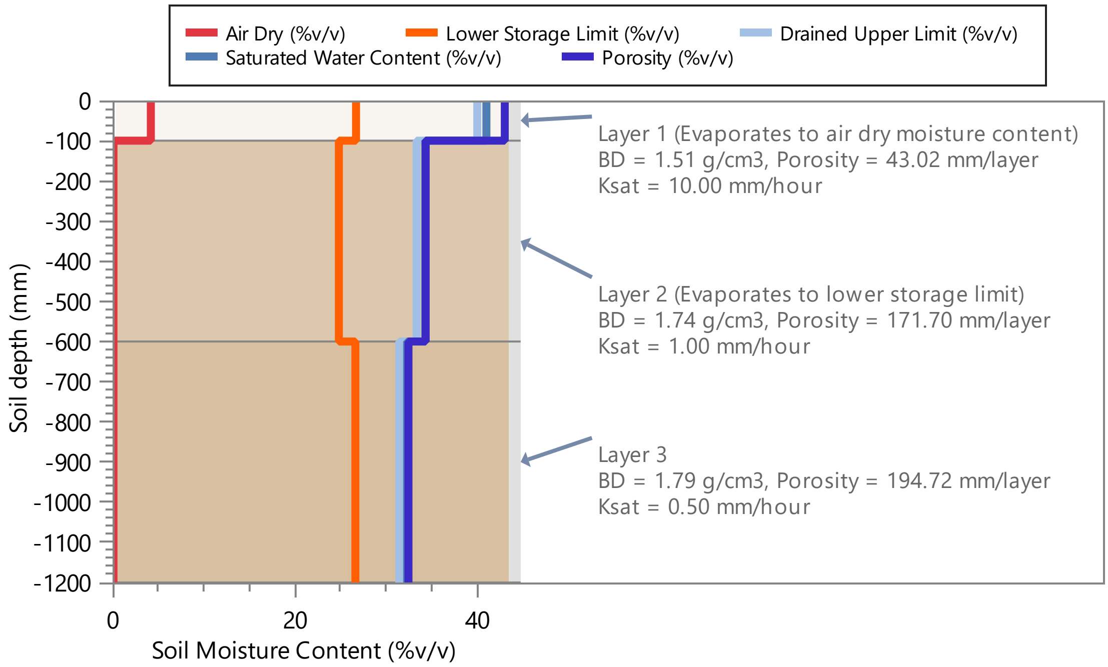
DESCRIPTION

Land: New Paddock

Area (ha): 3.60

Soil Type: Grey Clay - Lake Vermont, 1200.00 mm defined profile depth

Profile Porosity (mm)	409.43
Profile saturation water content (mm)	406.30
Profile drained upper limit (or field capacity) (mm)	395.40
Profile lower storage limit (or permanent wilting point) (mm)	310.58
Profile available water capacity (mm)	84.82
Profile limiting saturated hydraulic conductivity (mm/hour)	0.50
Surface saturated hydraulic conductivity (mm/hour)	10.00
Runoff curve number II (coefficient)	75.00
Soil evaporation U (mm)	6.00
Soil evaporation Cona (mm/sqrt day)	3.50



Plant Data: Continuous Rhodes Grass Pasture

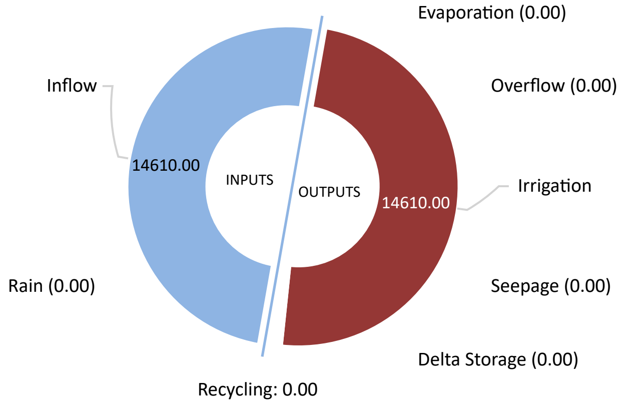
Average monthly cover (fraction) (minimum - maximum)	0.63 (0.58 - 0.70)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.9 x Pan coefficient 1)	0.90
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Maximum potential root depth in defined soil profile (mm)	1200.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03

PERFORMANCE

Pond System Water Performance - Overflow: 1 closed storage tank

Capacity of wet weather storage pond: **120 m3**

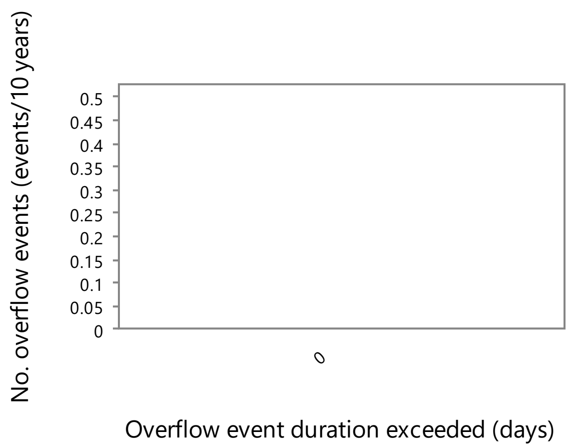
Pond System Water Balance (m3/year)

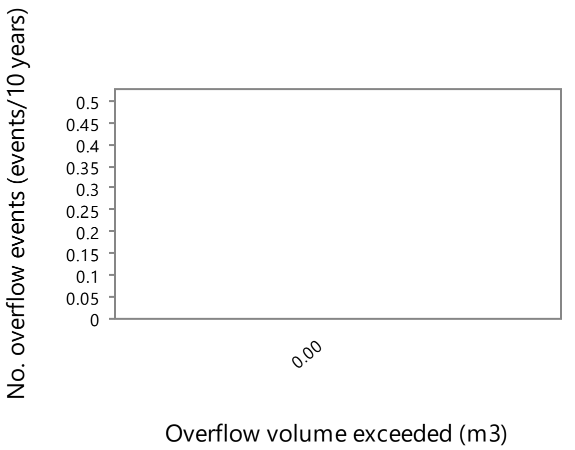


Name	Value
Rain	0.00
Inflow	14610.00
Recycling	0.00
Evaporation	0.00
Overflow	0.00
Irrigation	14610.00
Seepage	0.00
Delta Storage	0.00

Overflow Diagnostics

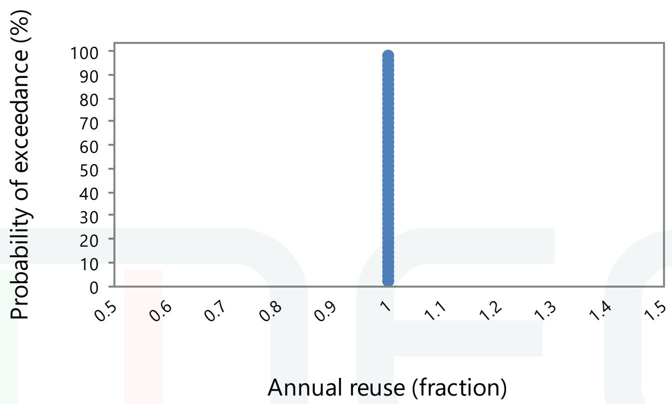
Volume of overflow (m3/year)	0.00
No. days pond overflows (days/year)	0.00
Average duration of overflow (days)	0.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% reuse (fraction)	1.00





Export plot

Export plot



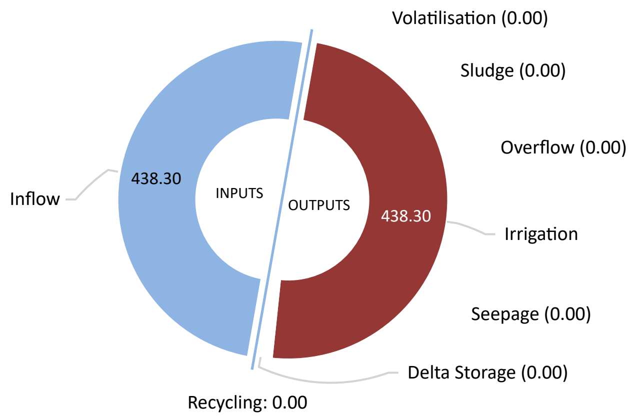
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

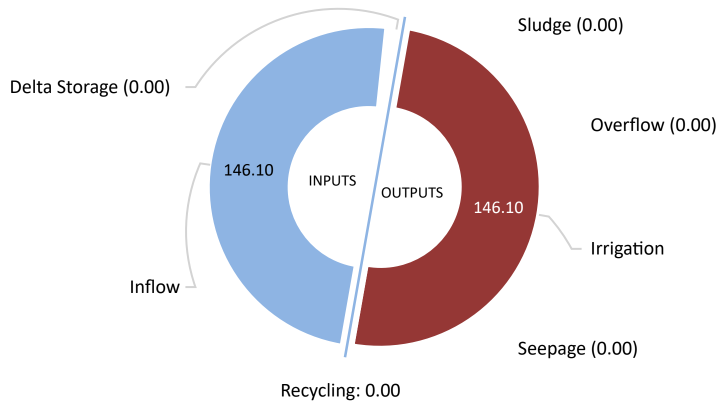
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



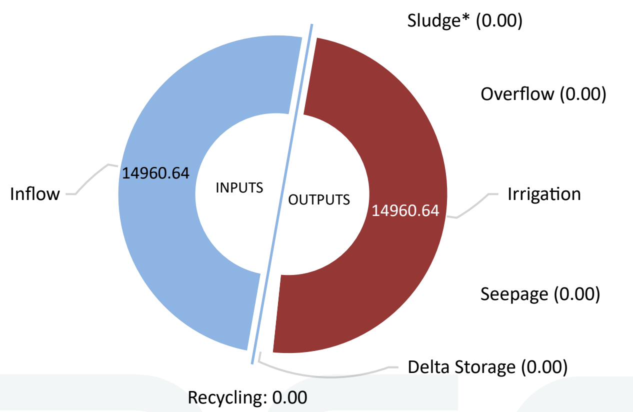
Name	Value
Inflow	438.30
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	0.00
Irrigation	438.30
Seepage	0.00
Delta Storage	0.00

Phosphorus Balance (kg/year)



Name	Value
Inflow	146.10
Recycling	0.00
Sludge	0.00
Overflow	0.00
Irrigation	146.10
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	14960.64
Recycling	0.00
Sludge*	0.00
Overflow	0.00
Irrigation	14960.64
Seepage	0.00
Delta Storage	0.00

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	30.00
Average phosphorus concentration of pond liquid (mg/L)	10.00
Average salinity of pond liquid (dS/m)	1.60

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	N.D.*
Final phosphorus concentration of pond liquid (mg/L)	N.D.*
Final salinity of pond liquid (dS/m)	N.D.*

* Not determined. Pond is empty.

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	14610.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	14610.00
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	30.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	30.00
Average phosphorus concentration of irrigation water (mg/L)	10.00
Average salinity of irrigation water (dS/m)	1.60

Irrigation Diagnostics:

Proportion of Days irrigation occurs (fraction)	1.00

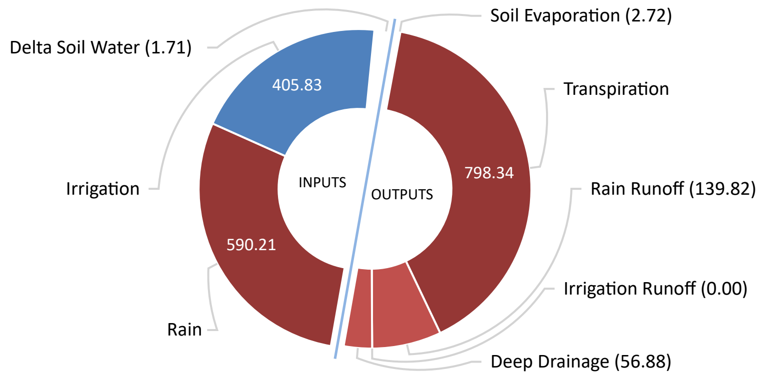
PERFORMANCE

Land Performance - Soil Water

Paddock: New Paddock, 3.6 ha
Soil Type: Grey Clay - Lake Vermont, 84.82 mm PAWC at maximum root depth

Land Water Balance (mm/year):

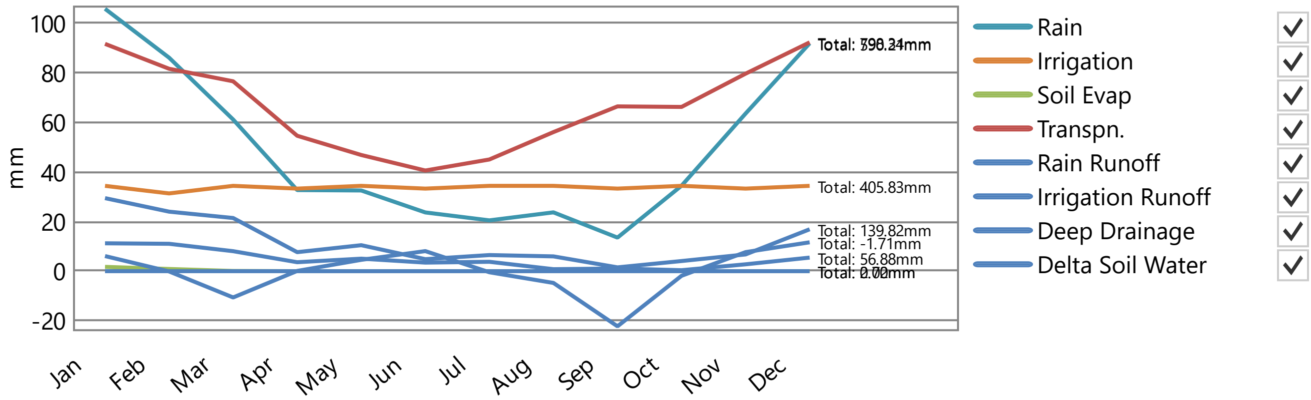
■ mm/year ☐ % Total inputs



Name	Value
Rain	590.21
Irrigation	405.83
Soil Evaporation	2.72
Transpiration	798.34
Rain Runoff	139.82
Irrigation Runoff	0.00
Deep Drainage	56.88
Delta Soil Water	-1.71

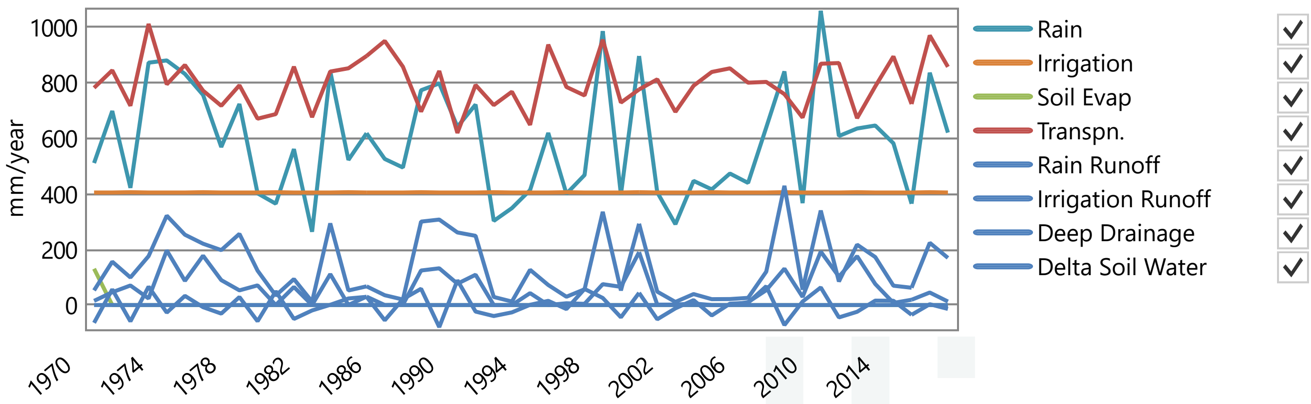
Average Monthly Totals (mm):

■ Chart ☐ Table



Average Annual Totals (mm/year):

■ Chart ☐ Table



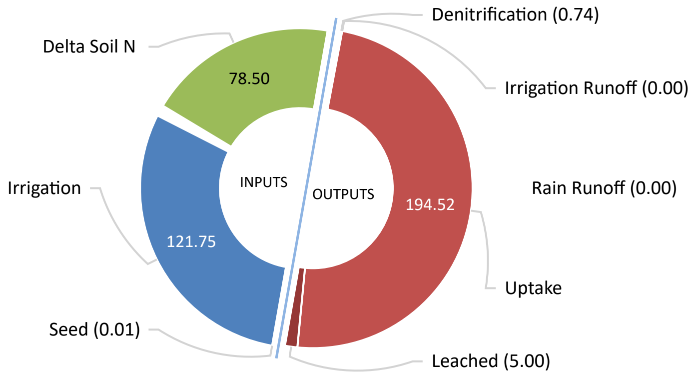
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: New Paddock, 3.6 ha **Soil Type**: Grey Clay - Lake Vermont

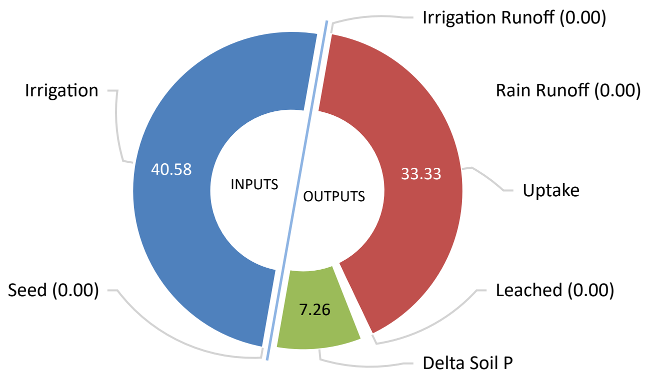
Irrigation ammonium volatilisation losses (kg/ha/year): 0.00
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.10

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.01
Irrigation	121.75
Denitrification	0.74
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	194.52
Leached	5.00
Delta Soil N	-78.50

Land Phosphorus Balance (kg/ha/year)



Name	Value
Seed	1.88E-03
Irrigation	40.58
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	33.33
Leached	1.77E-03
Delta Soil P	7.26

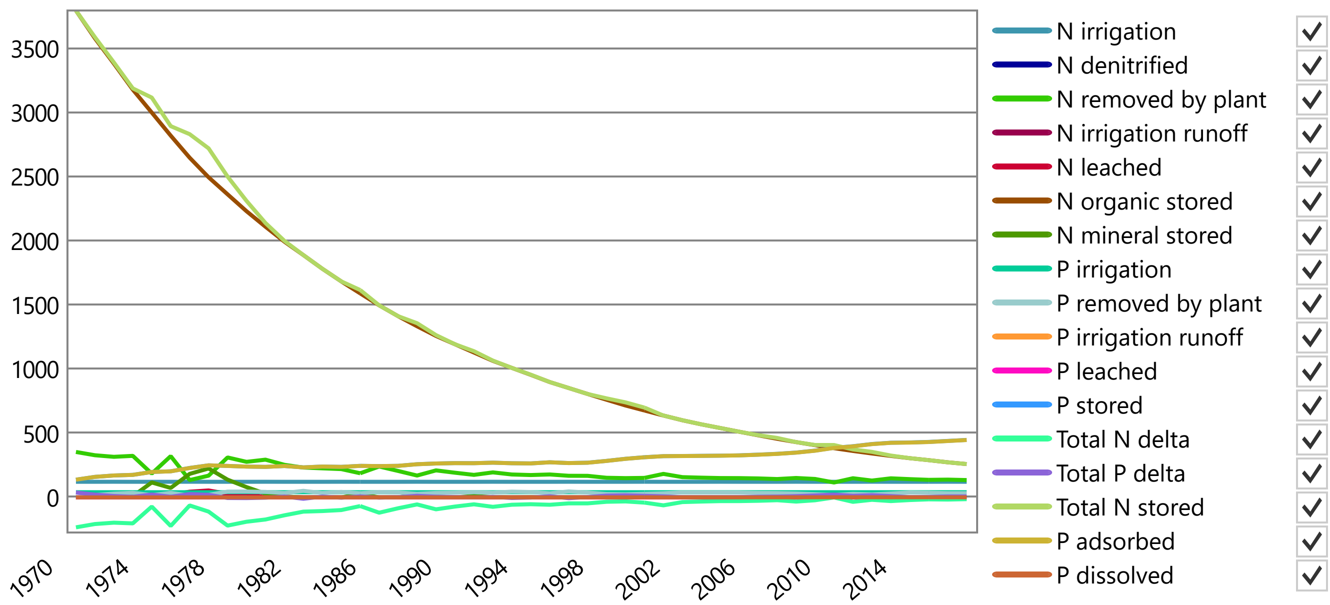
PERFORMANCE

Land Performance - Soil Nutrient

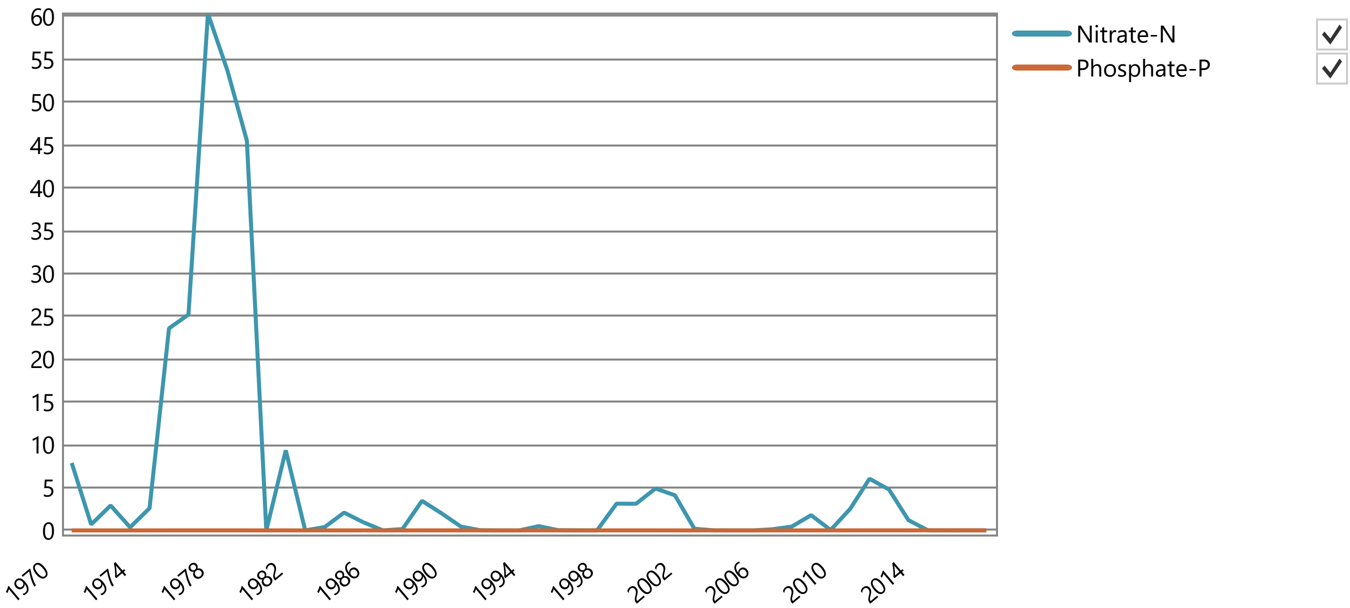
Paddock: New Paddock, 3.6 ha

Soil Type: Grey Clay - Lake Vermont

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: New Paddock, 3.6 ha **Soil Type**: Grey Clay - Lake Vermont

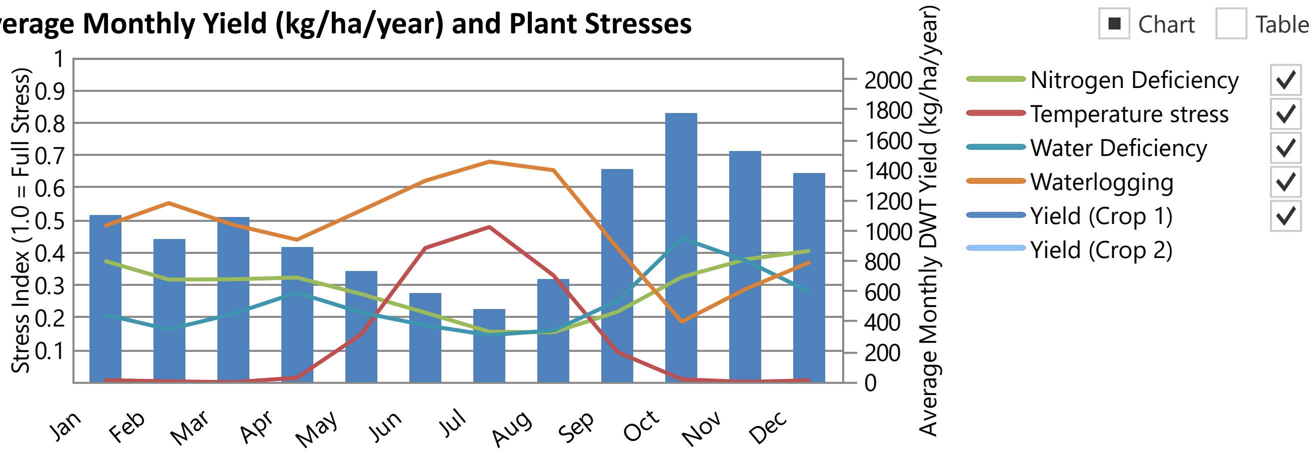
Plant: Continuous Rhodes Grass Pasture

Average annual shoot dry matter yield (kg/ha/year)	12621.81 (5585.36 - 23471.68)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.63 (0.58 - 0.70)
Average monthly root depth (mm) (minimum - maximum)	1198.02 (1185.06 - 1200.00)

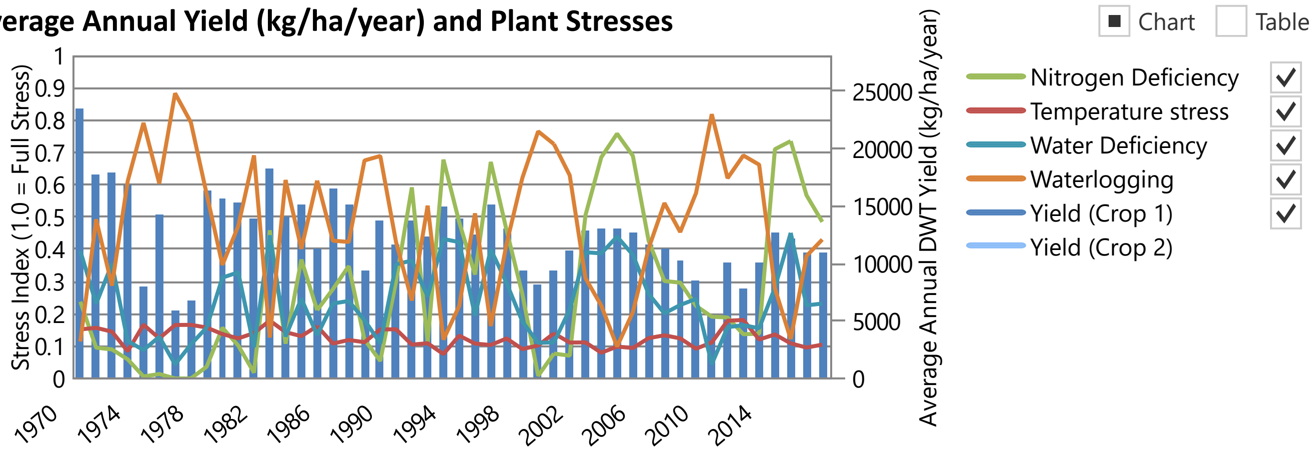
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	194.52 (116.14 - 354.31)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	33.33 (2.19 - 51.14)
Average annual shoot nitrogen concentration (fraction dwt)	0.02 (0.01 - 0.03)
Average annual shoot phosphorus concentration (fraction dwt)	0.003 (0.000 - 0.004)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 2.19 (normal)
No. days without crop/year (days/year): 0.00

PERFORMANCE

Land Performance

Paddock: New Paddock, 3.6 ha **Soil Type**: Grey Clay - Lake Vermont

Plant: Continuous Rhodes Grass Pasture

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03
No. years assumed for leaching to reach steady-state (years)	10.00

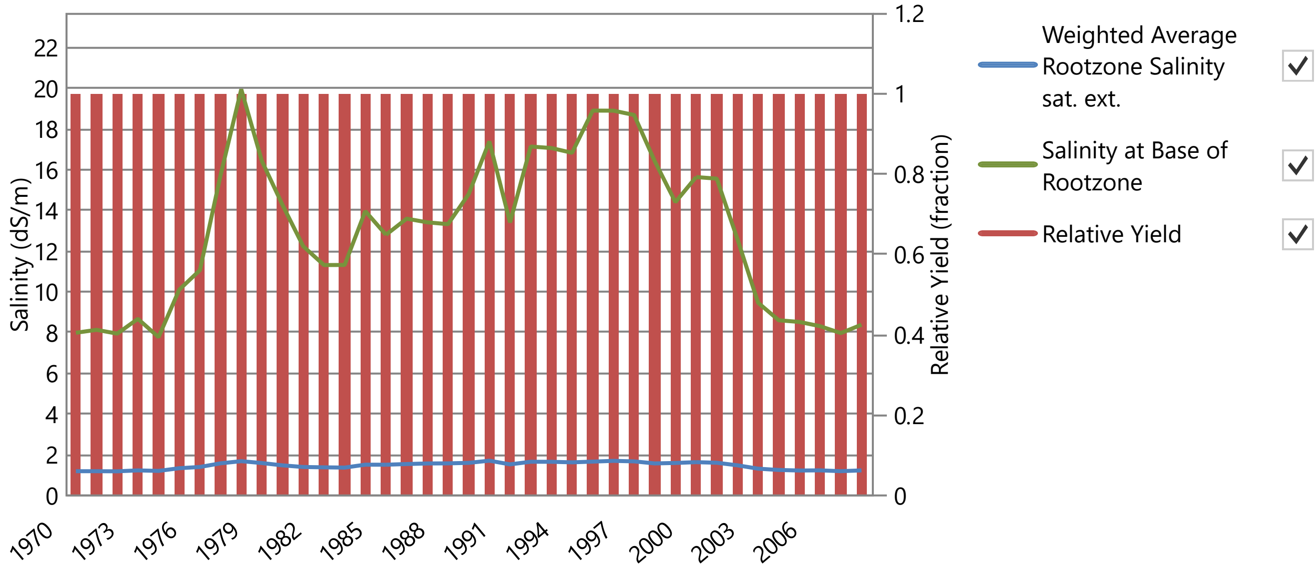
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.78
Salt added by rainfall (kg/ha/year)	86.48
Average annual effluent salt added & leached at steady state (kg/ha/year)	4242.21
Average leaching fraction based on 10 year running averages (fraction)	0.25
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.46
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	13.05
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average Annual Rootzone Salinity and Relative Yield:

■ Chart ☐ Table

All values based on 10 year running averages



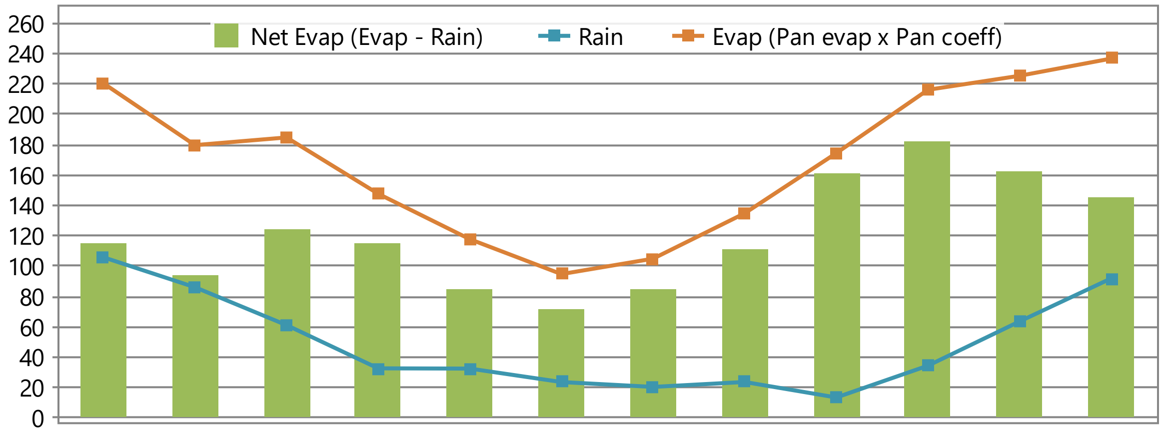
DIAGNOSTICS

Sustainability Diagnostics: Lake Vermont

Averaged Historical Climate Data Used in Simulation (mm)

Location: Lake Vermont_-22.35_148.35 (2), -22.35°, 148.35°

Run Period: 01/01/1970 to 31/12/2017 48 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	105.9	86.2	61.2	32.7	32.6	23.7	20.5	23.7	13.6	34.5	63.6	92.0	590.2
Evap	220.5	179.8	184.8	147.7	117.8	94.8	105.0	134.9	174.5	216.2	225.4	236.8	2038.2
Net Evap	114.6	93.6	123.6	115.0	85.2	71.1	84.5	111.1	160.9	181.7	161.8	144.8	1448.0
Net Evap/day	3.7	3.3	4.0	3.8	2.7	2.4	2.7	3.6	5.4	5.9	5.4	4.7	4.0

DIAGNOSTICS

Sustainability Diagnostics: Lake Vermont

Pond System: 1 closed storage tank

New Sewage Treatment Plant - 14610.00 m3/year or 40.00 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.25 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	30.00 (30.00 - 30.00)	438.30 (438.00 - 439.20)
Total Phosphorus	10.00 (10.00 - 10.00)	146.10 (146.00 - 146.40)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	14960.64 (14950.40 - 14991.36)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

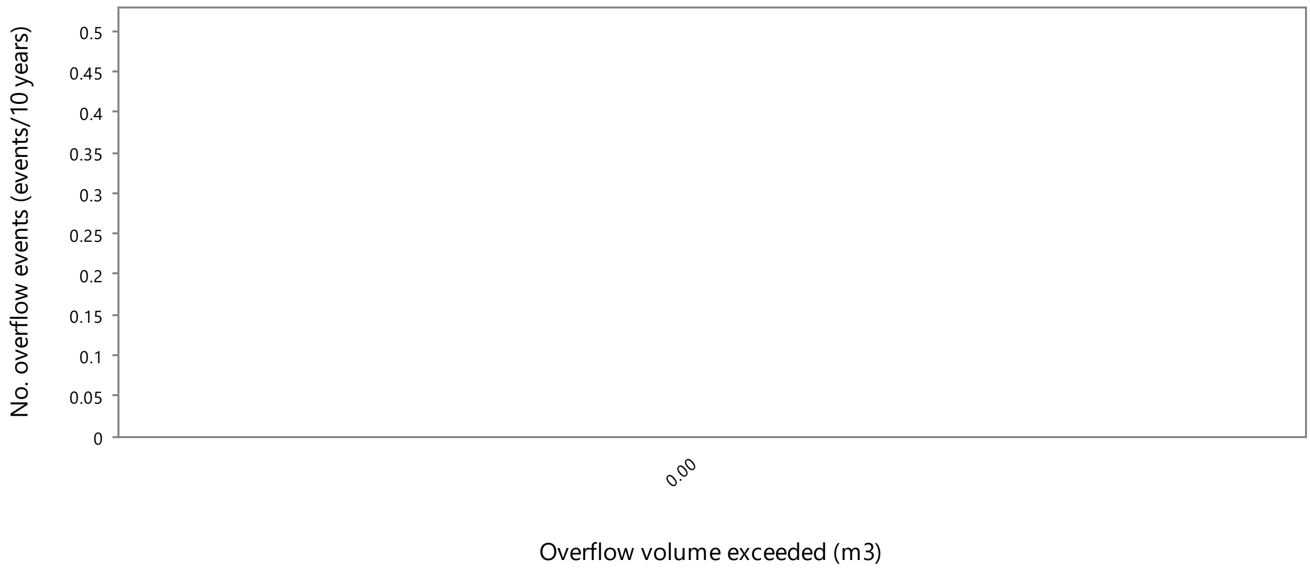
Last pond (Wet weather store): 120.00 m3

Theoretical hydraulic retention time (days)	3.00
Average volume of overflow (m3/year)	0.00
No. overflow events per year exceeding threshold* of 0.04 m3 (no./year)	0.00
Average duration of overflow (days)	0.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% effluent reuse (fraction)	1.00
Average salinity of last pond (dS/m)	1.60
Salinity of last pond on final day of simulation (dS/m)	1.60
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

■ Chart ☐ Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: Lake Vermont

Irrigation Information

Irrigation: 3.6 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	14610.00	4058.33
Total nitrogen applied (kg)	438.30	121.75
Total phosphorus applied (kg)	146.10	40.58
Total salts applied (kg)	14960.64	4155.73

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation occurs (fraction)	1.00

DIAGNOSTICS

Sustainability Diagnostics: Lake Vermont

Paddock Land: New Paddock: 3.6 ha

Irrigation: New Irrigation Method with 0% ammonium loss during irrigation

Irrigation triggered every 1 days
Irrigate a fixed amount of 2.00 mm each day
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Grey Clay - Lake Vermont, 84.82 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	105.9	86.2	61.2	32.7	32.6	23.7	20.5	23.7	13.6	34.5	63.6	92.0	590.2
Irrigation	34.4	31.4	34.4	33.3	34.4	33.3	34.4	34.4	33.3	34.4	33.3	34.4	405.8
Soil Evap	1.7	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
Transpn.	91.7	81.7	76.6	54.7	46.9	40.6	45.1	56.1	66.5	66.3	79.7	92.3	798.3
Rain Runoff	29.5	24.0	21.5	7.7	10.5	4.9	6.5	6.0	1.5	4.1	6.8	16.9	139.8
Irr. Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	11.3	11.1	8.1	3.6	5.1	3.5	3.8	0.8	1.1	0.4	2.8	5.5	56.9
Delta	6.1	-0.1	-10.6	0.1	4.6	8.1	-0.4	-4.7	-22.2	-1.9	7.7	11.7	-1.7

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	121.75
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	194.52
Average annual soil nitrogen removed by denitrification (kg/ha/year)	0.74
Average annual soil nitrogen leached (kg/ha/year)	5.00
Average annual nitrate-N loading to groundwater (kg/ha/year)	5.00
Soil organic-N kg/ha (Initial - Final)	3992.00 - 259.96
	36.03 - 0.03
Average nitrate-N concentration of deep drainage (mg/L)	8.79
Max. annual nitrate-N concentration of deep drainage (mg/L)	60.33

Soil Phosphorus Balance

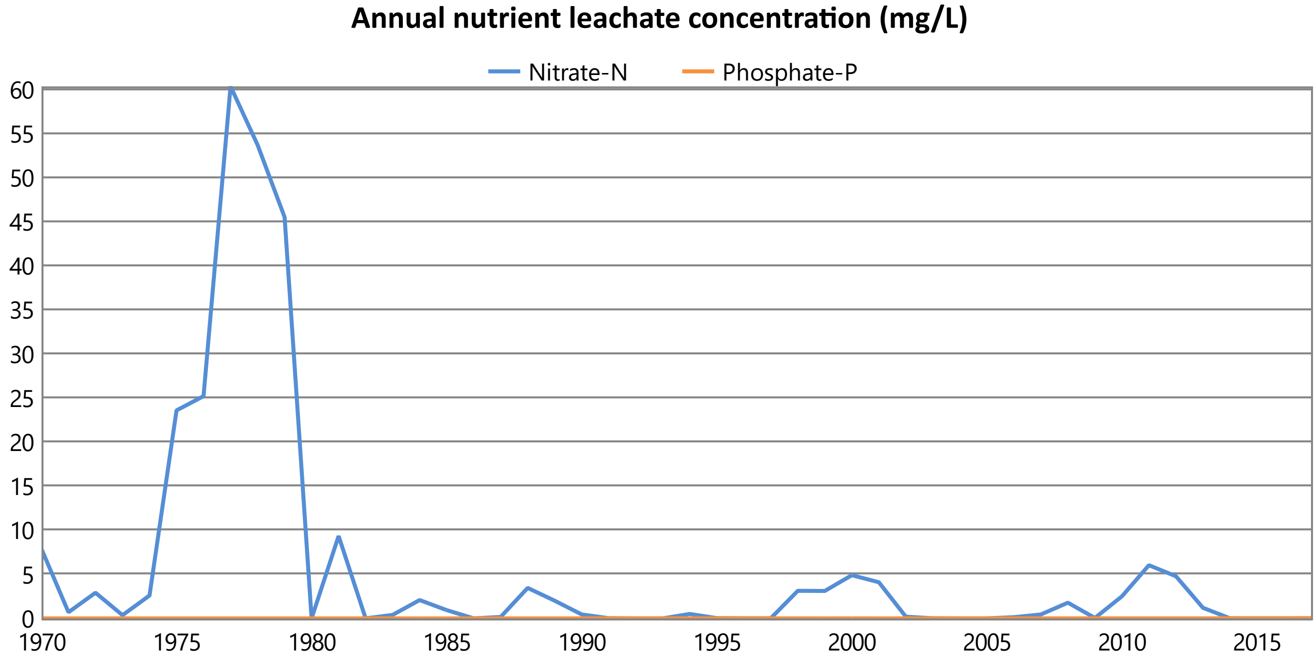
Average annual effluent phosphorus added (kg/ha/year)	40.58
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	33.33
Average annual soil phosphorus leached (kg/ha/year)	1.77E-03
Dissolved phosphorus (kg/ha) (Initial - Final)	3.70E-03 - 0.70
Adsorbed phosphorus (kg/ha) (Initial - Final)	99.72 - 447.31
Average phosphate-P concentration in rootzone (mg/L)	0.11
Average phosphate-P concentration of deep drainage (mg/L)	3.11E-03
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.01
Design soil profile storage life based on average infiltrated water phosphorus concn. of 4.74 mg/L (years)	66.92

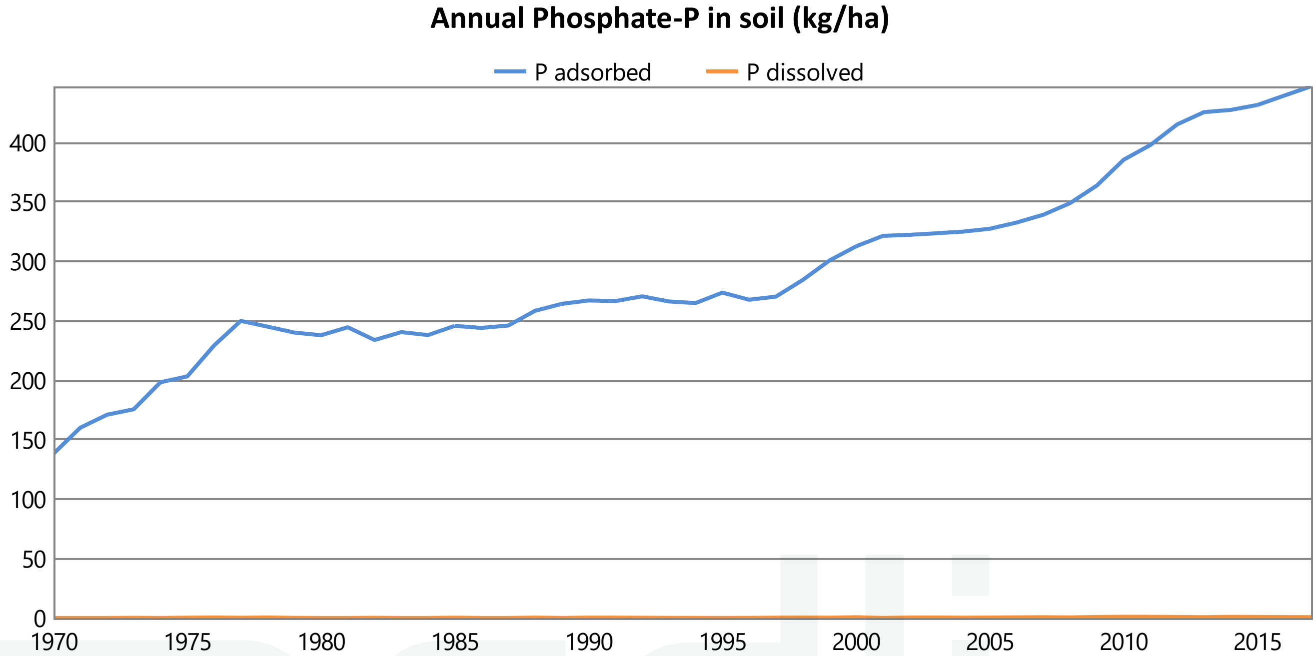
DIAGNOSTICS

Sustainability Diagnostics: Lake Vermont

Paddock Land: New Paddock: 3.6 ha

Irrigation: New Irrigation Method with 0% ammonium loss during irrigation





DIAGNOSTICS

Sustainability Diagnostics: Lake Vermont

Paddock Plant Performance: New Paddock: 3.6 ha

Average Plant Performance (Minimum - Maximum): Continuous Rhodes Grass Pasture

Average annual shoot dry matter yield (kg/ha/year)	12621.81 (5585.36 - 23471.68)
Average monthly plant (green) cover (fraction)	0.63 (0.58 - 0.70)
Average monthly crop factor (fraction)	0.57 (0.52 - 0.63)
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Average monthly root depth (mm)	1198.02 (1185.06 - 1200.00)
Average number of normal harvests per year (no./year)	2.19 (1.00 - 4.00)
Average number of normal harvests for last five years only (no./year)	2.00
Average number of crop deaths per year (no./year)	0.00 (0.00 - 0.00)
Average number of crop deaths for last five years only (no./year)	0.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.29 (0.00 - 0.76)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.01 (0.00 - 0.06)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.48 (0.19 - 0.71)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.24 (0.15 - 0.44)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.48 (0.19 - 0.68)
No. days without crop/year (days)	0.00

Soil Salinity - Plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts

All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.78
Salt added by rainfall (kg/ha/year)	86.48
Average annual effluent salt added & leached at steady state (kg/ha/year)	4242.21
Average leaching fraction based on 10 year running averages (fraction)	0.25
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.46
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	13.05
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

DIAGNOSTICS

Run Messages

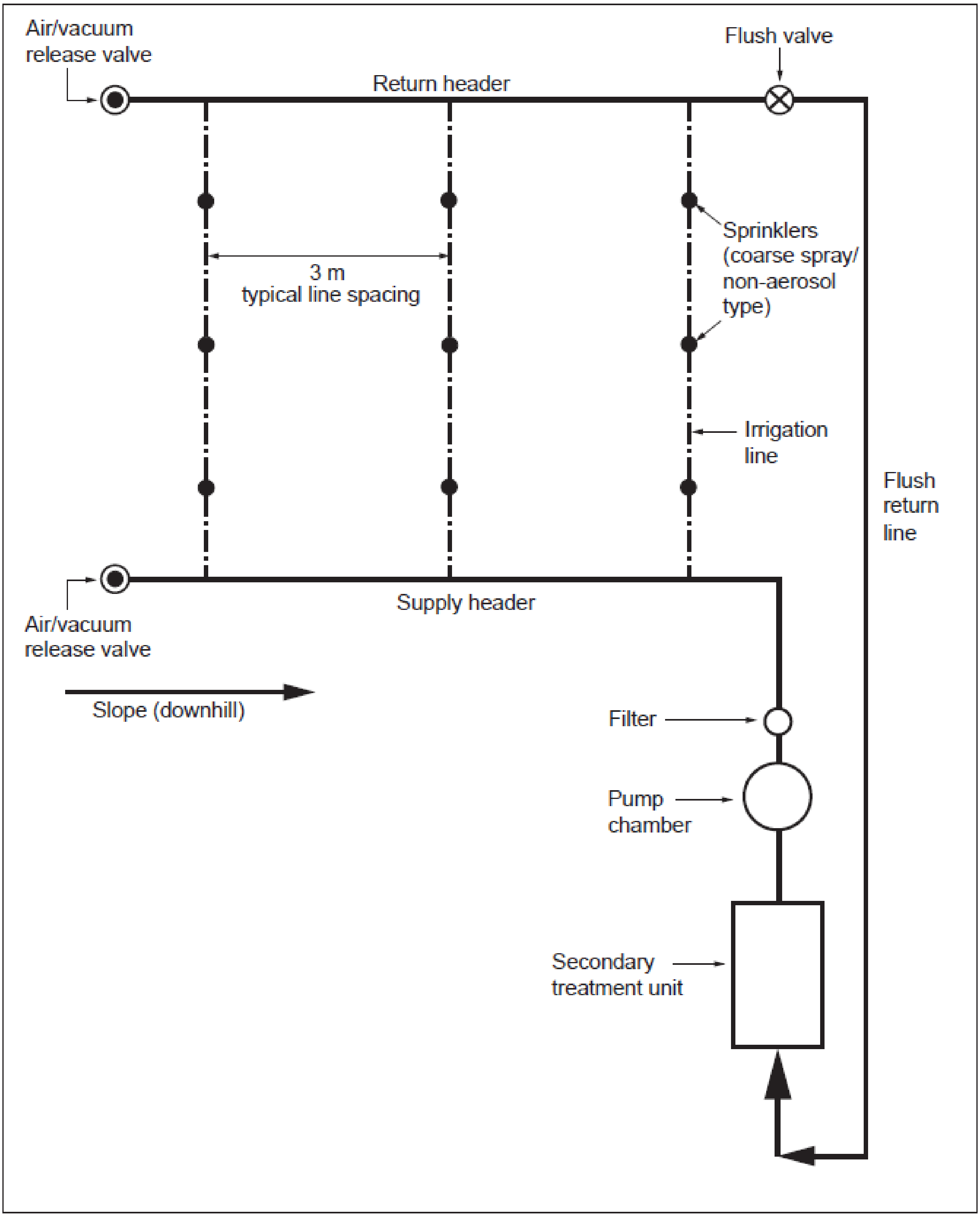
Messages generated when the scenario was run:

Full run chosen

APPENDIX

F

EXAMPLE OF SPRAY IRRIGATION SYSTEM



Source: AS/NZS 1547:2012