1. INTRODUCTION

Forest Hill has operated the winery in Denmark for 20 years, with production volumes varying over time. As a business committed to premium winemaking, we focus on crafting high-quality wines from smaller parcels. To support this approach, we are seeking a license for 350kL of production—an increase from our current output but still below both the facility's capacity and its historical licensing limits.

The proposed changes under the VAIG will not affect the winery's wastewater management, as we already handle on-site bottling through a mobile contractor. Our plan is to streamline this process by bringing bottling in-house with our own production line. Additionally, the installation of a new cool room will enhance operational efficiency while also enabling greater opportunities for barrel fermentation and future growth.

Forest Hill is deeply committed to minimizing our environmental footprint and preserving the health of the land we operate on. Over the past 20 years, we have consistently demonstrated this commitment through various sustainability initiatives. In partnership with the Wilson Inlet Catchment Committee, we have fenced off creek lines on our Denmark properties to protect them from cattle, followed by extensive replanting of native species along the creek lines and pastures. Similarly, at our Mount Barker vineyard, we undertook a large-scale restoration effort after acquiring the property in 1995, replanting over 10 hectares with native, non-commercial species to enhance biodiversity and land conservation.

This commitment extends to the management of our winery wastewater and working to ensure our compliance with the Western Australia Department of Water and Environmental Regulation (DWER) guidelines.

2. APPROVALS AND ACCREDITATION

2.1 Planning Approval

Planning approval for the proposed infrastructure upgrades was granted by the Shire of Denmark on 4th February 2025

Planning approval was also granted prior to the initial construction and for all subsequent expansions of the existing winery site.

2.2 Licence

In accordance with Part V of the Environmental Protection Act 1986, a License from the Department of Water and Environmental Regulation is required to operate a winery with a production capacity of >350kL. This application forms part of the License Application.

3. ENVIRONMENT

3.1 Location and Planning

The site is located approximately 4km west of the Denmark townsite, within the Shire of Denmark's boundary. Under the Shire of Denmark's Local Planning Scheme No. 3, the property is zoned as Rural, with part of the property also falling within the Shire's district heritage boundary.

This site is suitable for waste irrigation given adequate separation to sensitive receptors, adequate separation to groundwater and not falling within a Public Drinking Water Source Area (PDWSA). Relevant suitability factors are discussed below.

The property comprises broad crests and flanking slopes. The site selected for irrigation comprises a hill crest, peaking at 85m ADH and is aligned centrally along the northern boundary of the eastern half of the area. The slopes have a south-easterly and south-westerly aspect with a gradient of 1:8 and 1:9 respectively. The slope of the irrigation area is between 8 and 9%.

Given the location of a minor intermittent creek line >150m to the west of the irrigation area, a buffer zone > 50m has been established and planted with rainfed Karri Trees and grass.

3.2 Zoning and surrounding land uses

The property is zoned rural and the adjoining properties consist of special rural farming property to the north, farming properties to the south and east, and a chalet development to the west.

3.3 Climate

Denmark has a Mediterranean climate with warm, dry summers and mild, wet winters. The following rainfall data is taken from SILO Patched Point data for station: 9523 ILLALANGI

Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean (mm)	30	26	54	84	127	163	178	159	126	91	62	39
Median (mm)	22	18	47	80	114	155	168	157	117	86	52	32
9th decile (mm)	50	58	98	133	194	235	242	204	198	138	109	79
1st decile (mm)	10	6	21	29	69	93	124	111	71	49	30	9
Mean rain days	5	4	7	9	12	15	17	17	14	12	8	6

The following evaporation data is taken from SILO Patched Point data for station: 9523 ILLALANGI

Evaporation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean (mm)	208	174	145	92	62	48	50	62	82	113	148	192
Mean Daily (mm)	6.7	6.2	4.7	3.1	2.0	1.6	1.6	2.0	2.7	3.6	4.9	6.2

3.4 Geology and Soils

Soils of the proposed irrigation area comprise a sandy loam sub-soil overlying mottled sandy clays. The surface soils of the proposed irrigation area are/have:

- Slightly acidic, varying between pH 4.5 and pH 5.4;
- Low electrical conductivity which varies between 1.9 and 6.3;
- Medium to high water holding capacity;

A 2002 study of soils within the irrigation area concluded the following: "the soils of the study area are generally grey- brown sandy loams overlying mottled yellow-brown and red-brown sandy clays. The surface soils of the areas tested are of low salinity and pH, have relatively strong phosphorus absorption, high moisture absorption and a low potential for sodicity (structural decline once under irrigation). Therefore, the disposal of treated winery effluent to land should not adversely effect neither onsite or offsite environmental receptors."

Furthermore, "a disposal area of 2ha would adequately assimilate hydraulic and nutrient loads produced by a winery with a 3000 tonne throughput capacity providing wastewater is treated to the quality as expected by DEWCP."

3.5 Surface Water

A minor intermittent creek line runs north/south across the property, over 150 metres from the nearest boundary of the irrigation area. There is no licensed use of surface water on this property.

The map below shows the location of the irrigation area in relation to the creek line, with an approximately 80m buffer of rain fed trees planted.

3.6 Environmentally Sensitive Areas

The irrigation area is an existing site, and no clearing or land use change is intended. The table below provides a summary of sensitive receptors.

Environmental Constraint	Site Detail
Groundwater Separation	14m (Figure 1)
Public Drinking Water Source Area	No (Figure 2)
Separation to wetland/estuary	>200 m (Figure 3)
Watercourse	>700 m (Figure 3)
Coastal Plain	No (Figure 4)
Environmental Protection Policy Area	No (EPA, 2024)
Land Slope	<10 % - (Figure 5)
Soil	>6.0 m

3.7 Ground Water Separation

Sits within the Karri groundwater area. Info from: WRIMS – Groundwater Areas (DWER-085), https://catalogue.data.wa.gov.au/dataset/wrims-groundwater-areas

Doesn't sit within a proclaimed groundwater area(as defined by the Rights in Water Irrigation (RIWI) Act, 1914). Map layer: RIWI Act, Groundwater Areas (DWER-034), https://catalogue.data.wa.gov.au/dataset/riwi-act-groundwater-areas

Info from: WRIMS – Groundwater Resources (DWER-084), https://catalogue.data.wa.gov.au/dataset/wrims-groundwater-resources

Aquifer	Level
Combined - Fractured Rock West - Alluvium	1
Combined - Fractured Rock West - Calcrete	2
Combined - Fractured Rock West - Palaeochannel	3
Combined - Fractured Rock West - Fractured Rock	4

A production bore is located below the irrigation area and will be used for water quality monitoring. Previous reports indicate that bore log data showed underlying granite to be at depths of 6-15m with water struck at a depth of 15m below the granite layer.

Bore logs for a second location drilled in March 2024, 50m away from the first, show water at 6m. The elevation of the bore is 65 mAHD, with the irrigation area having an elevation range of 85 - 78 mAHD, therefore assuming the groundwater table is relatively flat, the likely groundwater separation under the irrigation areas at this time was likely to be around 13 mBGL.

Figure 1 Map showing location of groundwater sample location and second bore location

Figure 2 Map of PDWSA compared to site. (DPIRD, 2024)

Figure 3 Map showing site and distance to closest wetland/estuary/watercourse (DPIRD, 2024).

Figure 4 Map of location in relation to the coastal plain (ABD Guidelines).

Figure 5 Topographic map of the site (Landgate, 2024).

3.8 Threatened Fauna, Flora and Ecological Communities

No threatened Fauna, Flora and Ecological Communities have been identified

3.9 Culturally significant sites

According to the ACHIS database, there are no cultural heritage areas on the site.

3.10 Access & impact to traffic

The Main entrance is located some 800 metres away from the winery off South Coast Highway. A secondary driveway and entrance is located on Myers Road for Emergency Services vehicles, and staff movements during public opening hours. However truck access will always be from the South Coast Highway entrance as this provides the safest entrance and exit for slow moving vehicles. Truck movements are generally outside public opening hours, particularly during vintage time when grape receivals will occur in the cooler early morning hours prior to 10 am.

There are no proposed changes to traffic/road usage.

3.11 Fresh water supply

Water is sourced entirely from rainwater. The winery roofs are sheeted with Colourbond Spandek sheeting which run into large 250 mm eave gutters and are connected to numerous 150 mm diameter downpipes. These run into concrete clean-out drains and are connected via buried conduits to an underground lined (Food Grade) concrete collection sump.

The water is then automatically transferred by submersible pumps through a rising main to the high point of the site where a series of storage tanks are located. The storage facility consists of 4 x 173 KL lined (Food Grade) tanks. Excess large stainless steel wine tanks are also used for additional rainwater storage winter rainfall.

3.12 Separation distances

The nearest sensitive receptor is a residence located approximately 200m from the premises.

4. PROPOSED OPERATIONS

Forest Hill winery was initially constructed in 2002, with wine making operations commencing in 2004 and the winery undergoing an expansion in 2005. In 2024 approximately 369 tonnes of grapes were processed on the premise, which is below the production capacity of the premise. Since 2014, the average production of the facility has been 317 tonnes of grapes per year, or approximately 220kL in wine production.

Our vineyard is located in Mount Barker. At approximately 60ha (which includes 7.6ha new vines), producing between 100 to 200 tonnes of fruit each year.

Grapes are harvested between February to April, depending on the variety and ripeness and then transported to the winery in Denmark temperature-controlled bins to avoid oxidation or fermentation starting prematurely.

Grapes are processed on-site, where they are destemmed and crushed or gently whole-bunch pressed, depending on the desired wine style. Fermentation takes place in temperature-controlled tanks, barrels, or other specialized vessels to develop distinct flavour profiles. Wines are matured in a combination of oak barrels, stainless steel tanks, or other vessels for a period tailored to each wine, enhancing complexity and structure. After maturation, wines are blended, fined, and filtered to achieve consistency, clarity, and stability before bottling.

Capacity

The current total storage capacity of stainless steel tanks is 757kL. However over half of this capacity is from large 30kL and 40kL stainless steel tanks, designed for high-volume production and have essentially been 'decommissioned' given the winery's focus on small, high-quality batches.

As part of a project, to be partially funded through the DPIRD Value Add Grant, we will be removing 390kL of redundant storage capacity (7 x 30kL and 4x45kL tanks), providing space for us to build a cold storage room and relocate dry and finished goods storage from Mount Barker to Denmark.

Total storage capacity following completion of the project will be:

- 367kL of tank storage
- 100kL of barrel storage

Also as part of the project, we intend to install a new bottling line, allowing us to bottle when required, providing flexibility. The proposed line will also service our existing contract clients and provide an opportunity to grow our contract winemaking offer while remaining within our wastewater capacity. The new bottling line will be positioned in the same location that the existing mobile line inhabits when it is on-site. A new canopy will extend over this area which will house the line, reducing the stormwater run-off going into our drain system during rain events and winter months.

5. DIVERSION OF STORM WATER

An over flow is connected to the stormwater drain which allows excess water to run down to the existing creek line.

Since the process areas are roofed only wind blown stormwater enters the effluent treatment system, therefore reducing the amount liquid waste.

Additional canopy area is being introduced over the crush pad as part of the proposed winery amendments. This will reduce the amount of stormwater entering our wastewater system, particularly over winter.

6. WASTEWATER MANAGEMENT

6.1 Wastewater infrastructure

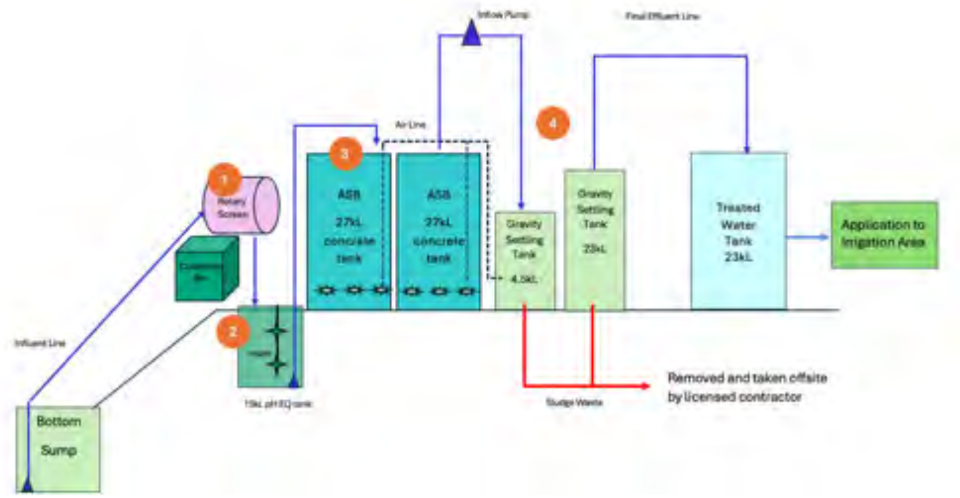
The following outlines the key existing and proposed infrastructure relating to the prescribed premises

Existing Wastewater Infrastructure:

Rotary screen + Collection bin
1x 15kL pH EQ Tank
2 x 27kL concrete tanks (aeration tanks) with blower
2 x Gravity Settling Tanks (4.5kL and 23kL)
1 x 23kL Treated Water Tank

Proposed Wastewater Infrastructure

2 x 50kL Poly Tanks for Storage



6.2 Wastewater Treatment

Winery liquid waste is collected in a system of open drains which are located under the roofed area of the winery and conveyed to an underground lined concrete collection sump through a network of buried conduits. It is then transferred automatically to the Effluent Treatment Area by a pair of submersible pumps connected by a buried rising main.

At the treatment area the effluent has the gross solids removed by a rotary screen (which is more suitable for the areas climate in lieu of evaporation). Following solids removal the supernatant is pumped to storage tanks where it is held for up to 24 hours. During storage aeration and oxidation are used to provide initial aerobic decomposition of the BOD. The waste liquid then has the remaining solid settled out within the treatment unit by the use of flocculent. The resulting water then also undergoes pH adjustment by an automatic dosing pump and liquid lime.

Following this, the wastewater is gravity fed into a series of three settling tanks and then into a final holding tank. Following this short detention the waste is filtered and pumped to the tree lot for disposal using low trajectory bubblers to minimise aerosol generation and drift during irrigation.

A flow meter has been fitted to the outlet of the wastewater treatment plant to continuously measure the volume of water discharged from the system in cubic meters.

The settled solids that result from the flocculation process form a sludge which is further dried in a hopper which drains the remaining liquid and returns this to the treatment system, leaving a dry spadable substance that can be mixed with the other solid waste.

Since 2014, the following improvements have been made to the wastewater system:

- Installed new blower unit (5.5kw) to provide better and more consistent oxygen delivery to the aeration basin, improving the efficiency of biological treatment processes such as nitrification and organic matter breakdown.

- Installed new automatic pH dosing which will ensure the pH level of wastewater stays within the desired range, enhancing biological and chemical treatment processes.
- Use of bacterial supplement for system seeding and repopulation of the healthy bacteria for more efficient waste breakdown

These improvements were made to significantly reduce the BOD loading rates of wastewater to align with industry standard. Sampling will be undertaken during vintage to confirm.

6.3 Wastewater Disposal

Disposal of treated liquid waste is irrigated onto a 1.13ha tree lot. The tree lot has been planted on the area adjacent to the northern boundary of the property and is also used as a visual screen of the winery from the neighbouring property on that boundary.

The irrigation system is automatically activated by wastewater levels within the storage tanks.

Irrigation is via a three-station drip irrigation system using 8L/hr emitters at 0.3m spacings.

The estimated monthly irrigation amounts are shown in the table below:

Waste Water	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Waste Production (kL)	57	132	189	170	38	38	38	38	38	76	76	57	945
Irrigation (mm)	5	12	17	15	3	3	3	3	3	7	7	5	84

6.4 Irrigation Area

The tree lot contains over 200 Karri trees, planted from 2005, which now stand between 20 - 30m tall. Tree rows are interplanted with kikuyu to aid nutrient uptake.

Key benefits of using Karri Trees for the wastewater irrigation area include the following:

- Karri trees, native to southwestern Western Australia, are among the tallest hardwoods globally and can reach up to 90 meters in height. Endemic species generally tolerate the soils and climate best and thus make for the most effective disposal

- Karri trees have high transpiration rates due to their tall structure and extensive canopy. This allows them to efficiently uptake and transpire large amounts of water, making them ideal for wastewater irrigation to reduce waterlogging and manage excess water. (Florence, 2004)

- Karri trees grow rapidly under high-nutrient conditions, which makes them ideal for wastewater irrigation where nutrient loading is significant. (Grove, 1988)

- Biomass produced can be harvested for timber or biofuel, providing additional economic benefits. (Grove, 1988)
- The extensive root systems of Karri trees help stabilize soil structure, reducing erosion risks in areas with wastewater application. Their root activity can improve soil aeration and nutrient cycling. (Florence, 2004)
- Trees, deep-rooted perennials and native vegetation help lower water tables in areas with excessive irrigation, reducing risks of salinization and waterlogging. They act as natural biofilters, extracting salts and improving soil health over time. (Water Quality Australia, 2019)
- Karri trees sequester significant amounts of carbon dioxide, contributing to climate change mitigation (Florence, 2004)

An assessment of the irrigation area in 2002 by ATA Environmental concluded that the initially proposed disposal area of 2ha would be suitable for an average 3000 tonne winery. Therefore, an irrigation area of 1.13ha is more than 3 times the requirement for effluent disposal of a 500-tonne winery.

The area to the west of the irrigation area has also been planted with both Karri trees and Kikuyu, which are entirely rainfed and provide a 50m buffer to mitigate surface or subsurface migration of nutrient rich wastewater

Location of irrigation area and storage tanks.

The growth of the tree lot over the past 20 years supports the fact that the soil in the area is deep, fertile, well-drained, and retains adequate moisture.

6.5 Waste Water Analysis

Trade waste during vintage (when loading rates are highest) was last sampled back in May 2014 (Appendix D). The wastewater characteristics can be seen in the table below.

Laboratory results of trade waste.

Parameter	
pH	5.1
BOD (mg/L)	8,460
Total Nitrogen (TN) (mg/L)	59
Total Phosphorus (TP) (mg/L)	20.3

Since 2014, significant improvements have been made to the wastewater system to reduce the BOD loading rates of wastewater, in line with industry standard:

- Installed new blower unit (5.5kw) to provide better and more consistent oxygen delivery to the aeration basin, improving the efficiency of biological treatment processes such as nitrification, and organic matter breakdown.
- Installed new automatic pH dosing which will ensure the pH level of wastewater stays within the desired range, enhancing biological and chemical treatment processes.
- Use of bacterial supplement for system seeding and repopulation of the healthy bacteria for more efficient waste breakdown

Sampling will be undertaken during vintage (when peak loading occurs) to confirm.

pH

The allowable pH range for irrigation is 6.5-8.5. Where the pH is outside of this rate, pH correction will be required via an automatic dosing pump with pH probe in mixing tank.

Salinity

Salinity was calculated to determine yield loss based on an EC reading of 1450 uS/cm (maximum level recorded in 2015). The EC reading is converted to salinity using a conversion factor of 0.64.

$$1450\ [\mu S/cm] \times 0.64\ = 928\ [mg/L]$$

Using the values provided in the DPRID suitability of liquid waste guideline, the salinity is considered within suitable limits (<2500 mg/L). Consideration of leaching fraction is not required as salinity is less than 2500mg/L

Nutrients

N and P mass loading (kg/ha/year) are addressed under the nutrient balance section below.

Sodium Adsorption Ratio (SAR)

Monitoring of the sodium absorption in soil is not required due to use of liquid lime for pH adjustment

6.6 Waste Water Volume

In 2024 the winery produced 276kL of wine. A new flow meter was installed at the beginning of 2023 and the reading in mid-December 2024 was 1461kL. With wine production over the same 2 year period as 539kL, this gives a trade waste ration of 2.7.

A production capacity of 350kL will be considered to ensure that both current and future anticipated production volumes can be accommodated.

$$350\left[\frac{kL\ wine\ produced}{yr}\right] \times 2.7\left[\frac{L\ trade\ waste}{L\ wine\ produced}\right] = 945\ [\frac{kL\ of\ trade\ waste}{yr}]$$

Monthly trade waste production has been modelled using historical monthly data from 2008 to 2014 with adjustments to reflect the following changes over the past 10 years:

- Lower production of Cabernet means less wastewater produced in May
- Earlier ripening along with new contract clients from warmer climate regions means vintage is now commencing in early February to late January, bringing peak periods of wastewater production forward by two months.
- Higher % of production is Chardonnay which ripens in February or early March
- Wine filtration method has changed to cross flow filtration resulting in considerably less wastewater production
- Winemaking processes have changed, requiring less wine movement operations with associated cleaning
- Significant guttering repairs and improvements in 2024, reducing the amount of rainwater entering the wastewater system

Waste Water	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
% Annual Production	6%	14%	20%	18%	4%	4%	4%	4%	4%	8%	8%	6%	**100%**
Waste Production (kL)	57	132	189	170	38	38	38	38	38	76	76	57	**945**

6.7 Nutrient Balance

Nutrient balancing will be achieved through the combined off-take from both Kikuyu grass and Karri Trees.

Nutrient Offtake by Kikuyu Grass

Pastures from Space was used to determine pasture yields for the site. The cumulative pasture growth rate (PGR) was 11,279 kilograms of dry matter per hectare (kg DM/ha) for the location. This data is for a rain fed system, and yields are likely to be higher under irrigation. An additional 60mm of irrigation during the summer months of November – April will likely result in an additional 1,200 kg-DM/ha pasture yield, assuming a water use efficiency of 20 kg/ha/mm for pasture (ABD Guidelines – Sizing a Waste Irrigation Area, 2024). This gives an estimated pasture yield of 12,479 kg-DM/ha.

The area of grass is estimated to cover 50% of the irrigation area (Appendix E), which gives 6,240 kilograms of dry matter per hectare (kg-DM/ha).

Harvesting will be performed mechanically, harvest efficiency is 80% for mechanical harvesting, leaving 20% of the crop remaining (Hancock, 2009).

$$6\,240\left[\frac{kg\ of\ dry\ matter}{ha}\right] \times 80\%\ harvest\ efficiency\ = 4992\ crop\ offtake\ \left[\frac{kg\ of\ dry\ matter}{ha}\right]$$

As an irrigated pasture the crop has a dry basis nutrient content of 20kg/t-DM for nitrogen and 3kg/t-DM for phosphorus (Tucker, 2018).

$$Nutrients\ out = crop\ nutrient\ content\ \times crop\ yield\ per\ hectare$$

$$3 \left[\frac{kg\ of\ phosphorus}{t}\right] \times 4.992 \left[\frac{t\ of\ dry\ matter}{ha}\right] = 14.98 \left[\frac{kg\ of\ phosphorus}{ha}\right]$$

$$20 \left[\frac{kg\ of\ nitrogen}{t}\right] \times 4.992 \left[\frac{t\ of\ dry\ matter}{ha}\right] = 99.84 \left[\frac{kg\ of\ nitrogen}{ha}\right]$$

Nutrient Load

Total Nutrient Load was calculated using concentrations from tested samples between 2013-2014, and has been calculated on a monthly basis.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
WW Volume (kL)	57	132	189	170	38	38	38	38	38	76	76	57	**945**
Nitrogen mg/L	30	47	43	24	59	30	37	17	51	11	14	41	**404**
Phosphorus mg/L	17	16	10	5	20	10	10	7	17	6	7	15	**140**
Total Nitrogen kg	1.7	6.2	8.1	4.1	2.2	1.1	1.4	0.6	1.9	0.8	1.1	2.3	**32**
Total Phosphorus kg	0.9	2.2	1.8	0.9	0.8	0.4	0.4	0.3	0.6	0.4	0.6	0.9	**10**

Nutrient Balance

The below nutrient balance shows that expected nutrient offtake from Kikuyu pasture exceeds nutrient application in wastewater.

	Nutrients IN (irrigation)	Nutrients OUT (Kikuyu harvest)	Nutrient Balance
Nitrogen (kg/ha/year)	28.32	99.84	-72.52
Phosphorus (kg/ha/year)	8.85	14.98	-6.13

Additional uptake by Karri trees is shown below but not included in the long-term nutrient balance as offtake of Karri tree biomass has not been predicted. Instead it shows an additional nutrient uptake measure.

Nutrient Uptake by Karri Trees

An estimate of nutrient uptake rates by Karri Trees has been determined using the average of various rates found in various literature.

Source	**N kg/ha/year**	**P kg/ha/year**
Eucalyptus (Ali, 2017)	127	13
Eucalyptus (Gardner, 2003)	175	91[1]
Eucalyptus Globulus (Kinhill, 1992)	106	10
Average Uptake	**136**	**12**

[1] Excluded from average

Combined Potential Nutrient Balance (kg/ha/year)

Based on these estimated uptake rates, we have calculated the nutrient assimilation by Kikuyu Grass and Karri Trees within the irrigation areas. This demonstrates there will be a nutrient deficit at 350kL production, and no excess nutrient accumulation will result.

Nutrients	In	Karri Uptake	Pasture Offtake	Net	Balance
N	28	(136)	(100)	(208)	Potential uptake/off-take far exceeds what is applied
P	9	(12)	(15)	(18)	

6.8 Biological Oxygen Demand (BOD)

Appropriate BOD loading rates for soil are highly variable given soil type, climate, land use and biological activity. A maximum BOD rate of 1500 kg/ha/month (or 50 kg/ha/day) is suggested for 'Slow Rate' land treatment methods (US EPA, 2006).

As per the water balance in section 5.6, peak irrigation rates from February to April may be as high as 243 m^3/month, or 0.243 ML/month. This peak irrigation rate at a BOD concentration of 6500 mg/L requires a minimum area of 1.053ha to not exceed the BOD maximum rate.

$$Area\ (ha) = \frac{BOD\ concentration\ of\ wastewater\ \left(\frac{mg}{L}\right) \times Volume\ of\ wastewater\ irrigated\ (\frac{ML}{month})}{1{,}500\ (\frac{kg}{ha * month})}$$

$$Area = \frac{6500\ \left(\frac{mg}{L}\right) \times 0.243\ (\frac{ML}{month})}{1{,}500\ (\frac{kg}{ha * month})} = 1.053\ ha$$

One-off testing of wastewater BOD levels will be conducted during the upcoming vintage (where levels are highest) to ensure levels are well below 6500mg/L and are not likely to result in clogging.

The risk of clogging is managed through use of an inline filter and monthly flushing and weekly dripper line checks.

6.9 Hydraulic Loading

A soil assessment of the irrigation area in 2002 by ATA Environmental concluded that the disposal area (initially proposed as 2ha) would adequately assimilate hydraulic and nutrient loads produced by a winery with a 3000 tonne (2100kL) throughput capacity. The current irrigation area being 1.13ha (56% of the proposed area), would therefore adequately assimilate hydraulic and nutrient loads produced by a winery with a 1680 tonne (1176kL) throughput capacity. This is more than 3 times what is required for 350kL production.

Furthermore, a soil water balance model has been developed based on a combination of the modelling approach outlined in Victorian guideline for irrigation with recycled water (EPA Victoria, 2022) and the FAO Irrigation and Drainage Paper 56 (FAO, 1998). The model, including key parameters and assumptions is detailed in Appendix B.

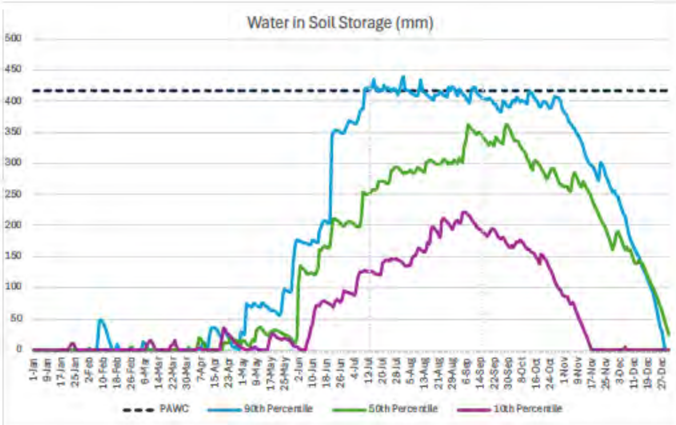
The table below shows monthly water balances for Median, 10th and 90th Percentile rainfall years. Key Inputs include:

- Daily rainfall and evapotranspiration data obtained from the Australian Bureau of Meteorology (station 9523 ILLALANGI)
- A daily time-step water balance model developed and reported monthly.
- Plant available water storage capacity calculated based on soil profile layers, total soil water storage to 2.5m is 417mm.
- Deep percolation modelled at 2.5m of soil depth
- Commencement value for water storage is set at 0% of PAW storage capacity
- Key parameters and assumptions are detailed in Appendix B.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
90th Percentile (2021)	Rainfall (mm)	15	100	31	114	235	275	243	155	114	134	53	17	1486
	Effective Rainfall (mm)	11	88	26	99	208	240	209	132	96	112	45	13	1279
	Irrigation (mm)	5	12	17	15	3	3	3	4	3	7	8	4	84
	Evapotranspiration (mm)	262	168	142	97	57	40	54	61	85	96	150	229	1441
	Crop Evapotranspiration (mm)	327	209	177	122	71	50	67	76	107	120	188	287	1801
	Water Deficit	311	171	148	96	43	22	14	35	73	74	165	270	1423
	Rainfall Percolation (mm)	0	61	14	88	184	216	160	95	65	72	31	0	985
	Soil Storage [PAW_{max}] (mm)	417	417	417	417	417	417	417	417	417	417	417	417	
	Water in Soil Storage (mm)	0	0	0	30	170	363	417	414	391	390	256	0	
	Deep Percolation (mm)	**0**	**0**	**0**	**0**	**0**	**0**	**92**	**62**	**15**	**0**	**0**	**0**	**169**
50th Percentile (2012)	Rainfall (mm)	12	22	21	75	84	297	157	107	189	79	87	77	1207
	Effective Rainfall (mm)	8	17	16	62	71	262	133	89	164	67	74	64	1026
	Irrigation (mm)	5	12	17	15	3	3	3	4	3	7	8	4	84
	Total Water (mm)	13	28	33	77	74	265	136	93	166	73	82	68	1111
	Evapotranspiration (mm)	208	150	175	95	58	56	45	61	88	134	142	172	1383
	Kc	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	
	Crop Evapotranspiration (mm)	260	187	219	119	73	70	56	76	110	167	177	215	1729
	Water Deficit	246	167	191	86	51	34	26	37	68	128	145	178	1358
	RF Percolation (mm)	0	8	4	44	52	229	107	54	124	35	51	32	740
	Soil Storage [PAW_{max}] (mm)	417	417	417	417	417	417	417	417	417	417	417	417	
	Water in Soil Storage (mm)	0	0	4	9	10	206	286	303	359	266	171	24	
	Deep Percolation (mm)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
90th Percentile (2019)	Rainfall (mm)	33	7	59	69	63	156	115	168	83	85	46	33	917
	Effective Rainfall (mm)	27	5	47	58	53	135	96	145	70	70	36	26	768
	Irrigation (mm)	5	12	17	15	3	3	3	4	3	7	8	4	84
	Evapotranspiration (mm)	215	185	139	99	58	54	39	68	88	123	168	241	1477
	Kc	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	
	Crop Evapotranspiration (mm)	269	231	174	124	73	67	49	85	110	153	210	301	1846
	Water Deficit	247	214	140	90	55	42	24	54	74	111	169	277	1498
	RF Percolation (mm)	10	0	31	39	39	113	74	118	37	34	3	6	505
	Soil Storage [PAW_{max}] (mm)	417	417	417	417	417	417	417	417	417	417	417	417	
	Water in Soil Storage (mm)	0	0	0	4	6	92	142	206	168	91	0	0	
	Deep Percolation (mm)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

For all three years, rainfall exceeds evapotranspiration in winter. However, when considering soil water storage capacity, the water balance model shows that the excess rainfall, along with limited irrigation in these months can be sustainably managed within the soil profile for most years. So although water inputs exceed losses, the plant water demand is greater that the surplus.

However, modelling of a 90th percentile wet year, showed deep percolation below the root zone occurring between mid July to mid September, where rainfall is >2mm.



To prevent seepage of wastewater below the root zone, no irrigation should occur during this period in high rainfall years.

The estimated maximum wastewater to be produced over these months is 38kL/month (the equivalent of 3mm of irrigation per month) requiring at least 76kL in storage capacity.

The proposed installation of 2x50kL poly tanks, in addition to the existing 23kL storage tank, would provide adequate storage for wastewater in high rainfall years.

To ensure a low risk of drainage during an average rainfall year, the following measures will be taken:

- Reduced wastewater production and maximum irrigation of 3mm per month between June to September
- No irrigation during and 24 hours after a rainfall event greater than 3 mm
- Maintenance of a rainfall log to identify high rainfall years (>85th percentile year)

Furthermore, the risk of infiltration past the root zone into groundwater should be considered low given the following:

- Rooting depths for Karri Trees can be between 3-10m, and play a major role in supplying the tree water demand during dry periods
- It has been demonstrated that in Eucalyptus plantations, the soil layer below the rooting zone functions as a secondary storage "reservoir" of water for the roots. An upward flux is established from that layer, driven by water depletion in the first layer causing a water potential gradient inversion (Soares 2001)

6.10 Storage

Storage requirements were determined based on the water balance for a 90th percentile rainfall year, where drainage below the root zone occurred between mid-July to mid-September. In order to prevent seepage of waste water below the rootzone, irrigation should cease over this period and wastewater stored. Given estimated wastewater volumes of ~38kL/month over winter, this requires 76kL of storage.

The installation of 2x50kL poly tanks, in addition to the existing 23kL of storage, should be more than adequate to allow for storage of wastewater in high rainfall years.

For most years however, soil water capacity can adequately accommodate both rainfall and wastewater irrigation.

6.11 Off-take Strategy

Pasture

Kikuyu grass will be mechanically harvested. Due to the small area, harvesting will be done by a lawn mower and clippings collected. The annual removal of clippings will further support the balancing of nutrients.

In the event that pasture yields are insufficient, tree lot thinning will take place to allow more light in for pasture growth.

Trees

Collection of litterfall and harvesting of timber for firewood takes place each year and aids in preventing the accumulation of nutrients

6.12 Monitoring

Wastewater discharge will be measured with a flow meter, and volumes recorded monthly. Wastewater and groundwater samples will be taken twice a year (one during peak vintage period and one post vintage) and sent to a lab for analysis. Estimated maximum total nitrogen and phosphorus applied via wastewater irrigation will be calculated for each year by applying nutrient concentrations recorded during vintage to actual wastewater discharge volumes.

7. SOLID WASTE MANAGEMENT

Solid waste comprises grape marc, stalks, solids from the liquid waste treatment and filter earth.

Generation of solid waste is about 20% of the tonnage of crush. For a 500 tonne winery this represents around 100 tonnes of solid waste.

Marc waste, produced during the wine-making process is output directly into a trailer, which sits atop a covered concrete hardstand and is then immediately transported offsite to open farmland outside the premise boundary on an adjacent property. No solid waste is stored onsite.

8. OTHER EMISSIONS

8.1 Dust

All roads on the premises have been sealed such that the risk of impacts from dust emissions is considered to be very low.

8.2 Odours

Possible odour sources at the winery are solid waste storage areas, effluent drainage areas, liquid waste storage areas and the irrigation area.

The effluent treatment system is a sealed unit with internal aeration provided by an external blower. This is to reduce any odour emitted by reducing effluent water BOD.

Water is distributed onto wood lot by ground located drip system, reducing mist and drift of treated wastewater.

All effluent drains are treated regularly with “Ecozyme B+” which is an enzymatic deodorant designed to work in conjunction with the effluent treatment system’s live predatory bacteria population.

Marc is removed immediately from site

Irrigation loading of BOD less than 30kg/ha/day, the risk of odour is very low

8.3 Noise

Winery noise emanates from various sources such as refrigeration plant, pumps and motors (year round operations), and from wine crushing and processing equipment such as receival bin loading, crushers/de-stemmers, conveyors and small pumps (vintage time operations).

Most of this equipment is located inside the winery buildings and the winery has been located centrally on the lot to maximise the distances from all existing and future neighbours.

Both the Barrel Hall and Planted Tree Lot provide excellent noise screening. It is also worth noting that the construction of the buildings required significant excavation into the hillside, therefore providing an earth barrier to the northern side of the winery development.

The most constant noise source in the winery is the refrigeration plant, and to reduce this source the plant has been located within block work plant room complete with insulated roof, and baffles, and ventilation vertically through the roof and not directed horizontally across the ground.

9. CONCLUSION

The nutrient and irrigation plan outlined above ensures that nutrients from both 945kL/year of trade waste will be utilised to continue the growth of our tree lot, as well as grow pasture which is then removed and taken offsite. This conservative approach, along with twice yearly monitoring of groundwater and surface water will ensure the plans objectives are met.

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APPENDIX A Wastewater Discharge Volumes - Historical

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ocr	Nov	Dec	Total
2008	485	270	600	200	200	271	128	105	288	79	81	163	2870
2009	130	181	115	565	308	178	263	161	128	215	65	5	2315
2010	89	110	116	531	12	494	205	197	116	72	102	82	2126
2011	30	217	212	373	340	99	58	91	182	11	0	378	1991
2014	21	88	86	531	465	171	104	142	78	278	155	146	2266
2015	15	5	6	345	143	106	85	48	92	123	89	14	1069

Appendix B Water Balance Model Parameters & Assumptions

Soil water balance

Per FAO (1998), the root zone can be presented by means of a container in which the water content may fluctuate. It makes the adding and subtracting of losses and gains straightforward as the various parameters of the soil water budget are usually expressed in terms of water depth. Rainfall, irrigation and capillary rise of groundwater towards the root zone add water to the root zone and decrease the root zone depletion. Soil evaporation, crop transpiration and percolation losses remove water from the root zone and increase the depletion. The daily water balance, expressed in terms of depletion at the end of the day is:

$$D_{r,i} = D_{r,i-1} - (P - RO)_i - I_i - CR_i + ET_{c,i} + DP_i$$

Where

$D_{r,i}$	root zone depletion at the end of day i (mm) *where* $0 \leq D_{r,i} \leq PAW_{max}$
$D_{r,i-1}$	water content in the root zone at the end of the previous day (mm)
P_i	precipitation on day i (mm)
RO_i	runoff from the soil surface on day i (mm)
I_i	net irrigation depth on day i that infiltrates the soil (mm)
CR_i	capillary rise from the groundwater table on day i (mm)
$ET_{c,i}$	crop evapotranspiration on day i (mm)
DP_i	water loss out of the root zone by deep percolation on day i [mm] i.e. water surplus when $D_{r,i} = 0$

The daily water balance model has been summarised into a monthly table, and includes the following components :

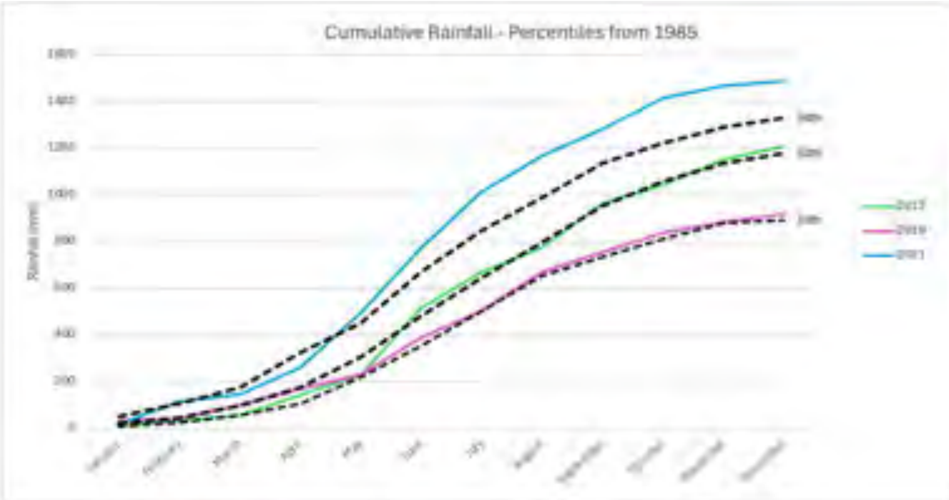
Soil Water Storage	$PAW_{max} - D_{r,i}$
Water Deficit	$ET_{c,i} - (P_i + I_i)$ where >0
Rainfall Percolation	$(P_i + I_i) - ET_{c,i}$ where >0

Rainfall

Median, 10th percentile, 85th Percentile and 90th percentile wet years were calculated using 50 years of historical daily rainfall data from Denmark station (Bureau of Meteorology station number: 9531).

The following years were selected as representative of each:

- 90th percentile: 2021
- 50th percentile: 2012
- 10th percentile: 2019



Effective Rainfall

Per EPA Guidelines (EPA Victoria 1991) Effective rainfall is the amount of rain that is available to the plant. It is the rainfall that remains in the root zone after evaporation, runoff and percolation. The use of effective rainfall is valid due to canopy interception of rainfall.

Rainfall interception refers to the amount of rain that is caught by the tree canopies and evaporates before reaching the ground. In a closed-canopy Karri forest, interception can be significant due to the large leaf area and dense canopy.

Effective rainfall is assumed to be 70 % of rainfall (P) for P < 5 mm, 85 % of P for 5 to 15 mm, and 90% for P> 15 mm. These figures are based on studies of interception by trees in WA (Schofield,1984).

Irrigation / Wastewater Volume

Daily irrigation amounts were calculated based on the following parameters:

- Wastewater / Wine ratio: 2.7[2]
- Annual Wine Production Capacity: 350kL
- Irrigation Area: 1.13ha
- Estimated monthly wastewater volumes

WW	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
% of Annual Total	6%	14%	20%	18%	4%	4%	4%	4%	4%	8%	8%	6%	100%
Waste Production (kL)	57	132	189	170	38	38	38	38	38	76	76	57	945

Evapotranspiration

Evapotranspiration (ET_c) is a combination of the amount of water used by plants and water evaporated from the surface. Evapotranspiration is determined by applying a crop coefficient (K_c) to evaporation data measured from a Class A Pan (ET_o) as follows:

$$ET_c = K_c \times ET_o$$

A crop coefficient of Kc = 1.25 was used based on the following:

Crop Coefficient	**Species**	**Source**
1.27	E. globulus	Macfarlane, 2002)
1.2 to 1.5	Full cover of eucalyptus trees	(Stribbe, 1975; Sharma, 1984).

However, this could be considered conservative given that:

Sharma (1984) found monthly evapotranspiration rates up to 3 x Class A pan in Eucalypt-dominated forest in Western Australia during rainy winter periods. He argued that these high values were the result of canopy interception and direct evaporation from the leaf surface. During the hot, dry summer months, much lower evapotranspiration rates of 0.1-0.5 x Class A pan were found, reflecting the low water availability during that period.

According to Bradshaw (2015) it's estimated that in high rainfall karri forest, the vegetation intercepts an estimated 10-20 per cent of rainfall and transpires about 60-70 per cent. (Bradshaw, 2015).

[2] based on 2023 and 2024 production and wastewater discharge volumes which includes storm water run-off

Root Zone Depth

An effective root zone of 2.5m was used for water budget modelling of a Eucalyptus forest (Soares et al, 2001).

The following table shows a root depth of 2.5m for 20 year old Eucalyptus globulus trees (Knight, 1999)

Parameters	Age of trees (years) 1	3	10	20
Lateral extension (m)	3.12	5.12	6.40	9.52
Depth of root system (m)	1.02	2.21	3.08	2.46
Total volume (m^3)	7.80	47.16	99.03	160.78
Length of tap root (m)	1.49	2.31	3.94	5.52

Soil Profile/Plant Available Water

Soil profile was determined from soil sampling results by ATA Environmental in 2002 (Appendix F)

0-150mm	brown sandy loam with organic matter
150-700mm	brown gravelly sandy loam
700-2000mm	mottled brown-red and yellow-brown sandy (gritty) clay

The soil profile was matched to DPIRD MySoil data for soil type “Brown deep loamy duplex” (Appendix C). The upper water limit and lower water limit for each soil layer were used to calculate the Plant available water (PAW) storage capacity.

	Depth	Upper water limit (mm/m)	Lower water limit (mm/m)	Depth (mm)	PAW (mm/m)	PAW Root Zone (mm)
Layer 1	0-15 cm	214	109	150	105	16
Layer 2	15-70 cm	279	126	550	153	84
Layer 3	70-250 cm	299	123	1800	176	317
Total Plant Available Water Capacity (PAWC)						417

Run Off and Capillary Rise

Given that there has been no run-off observed on the tree lot over the past 20 years the model assumes no surface runoff.

Per FAO (1998), Capillary Rise can normally be assumed to be zero when the water table is more than about 1 m below the bottom of the root zone.

Appendix C Soil Profile Data Estimate

WA SOIL GROUP*: Brown deep loamy duplex

SOIL QUALIFIER*: permeable acid to neutral subsoil

Soil-landscape Zone: 254 - Warren-Denmark Southland Zone

Broad soil type - (AG SOIL):** Deep loamy duplexes & earths

PREDICTED SOIL QUALITIES*:**

PRD - Physical rooting depth (cm)	200	**Water storage to 100cm or CRD (mm)**	148	**Profile permeability**	Moderately slow
Water storage 100cm or PRD (mm)	148	**Surface condition**	Firm	**Permeability to 50cm**	Moderate
pH at 20cm	5.7	**Water repellence susceptibility**	Nil	**Subsoil acidity susceptibility**	High
Surface salinity (mSm)	100	**Subsoil compaction susceptibility**	High		
CRD - Chemical rooting depth (cm)	200	**Structure degradation susceptibility**	Low		

PREDICTED SOIL LAYER VALUES**:**

Typical horizon	Depth	Typical texture and arrangement	Soil pH (water)	OC (%)	ECE (mSm)	Clay (%)	LSL (mm/m)	USL (mm/m)	PRI	Coarse Frag (%)	ESP (%)	Ksat (mm/hr)	Bulk Density	Ero-dibility	Stability	Dispersion	Slaking
A1	0 - 10 cm	Sandy loam; Earthy	6.5	4.9	100	14	109.2	213.8	20	5	2	110	1.45	Moderate	Good	Nil	Partial
A21	10 - 35 cm	Sandy loam; Earthy	5.7	2.2	50	14	109.2	213.8	70	5	3	110	1.45	Low	Fair	Nil	Nil
A22	35 - 50 cm	Loam; Earthy	6.3	0.6	50	18	126	279	70	10	4	100	1.35	Low	Fair	Nil	Nil
B2	50 - 100 cm	Clay; Strong structure	6.5	0.6	50	40	123.2	299.2	50	12	12	25	1.35	Moderate	Very poor	Partial	Complete
B3	100 - 200 cm	Clay; Earthy	6.5	0.6	100	40	138	239.2	50	8	20	15	1.55			Partial	Complete

*** WA SOIL GROUP and QUALIFIER:**	Schoknecht, N R, and Pathan, S. (2013), Soil groups of Western Australia : a simple guide to the main soils of Western Australia (4th ed)
**** AG SOIL:**	Ag Soils are amalgamations of WA Soil Groups and the equivalent of MySoils on the DAFWA web site
***** PREDICTED SOIL QUALITIES:**	These are based on the predicted soil layer values and are an indicative guide
****** PREDICTED SOIL LAYER VALUES:**	The soil information represents a modelled mean value for a soil-landscape zone and real values can vary significantly

VINTESSENTIAL

[redacted]

LABORATORY REPORT NUMBER: B1405028

Forest Hill Wines (Passchendaele Ridge t/as)		**Purchase Order**	ZB0329051
cnr South Coast Highway & Meyers Road		**Sample(s) Received**	8/05/2014
Denmark WA 6333		**Report Type**	Final
Phone	[redacted]	**Issue Preferences**	michael@foresthillwines.com.au;liam@foresth

Sample Number	**Sample Details**
B1405028/01	Winery Effluent

Test	**Result**	**Unit**
*Biochemical Oxygen Demand (H07)	8460	mg/L
*Electrical Conductivity (H01)	188.3	mS/m
*pH (H02)	5.1	
*Total Dissolved Solids (H04)	2400	mg/L
*Total Kjeldahl Nitrogen (H05)	59	mg/L
*Total Phosphorous (H06)	20.29	mg/L
*Total Suspended Solids (H03)	430	mg/L

[redacted]

Date Report Issued

13/05/2014

The above results relate only to the samples as received.

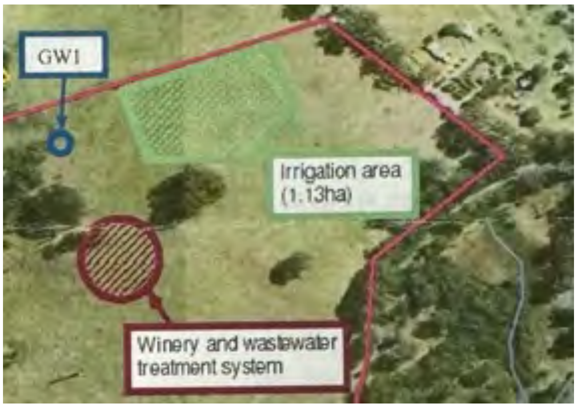
***Indicates determination by NATA accredited method.**

Accreditation No. 11587
Site No. 11580 (Vic) 14527 (WA)
This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025

Page 1 of 1

Appendix E Tree Lot Photographs

Aerial photographs showing the establishment and growth of the planted tree lot and buffer area over 20 years



Recent photographs taken of the tree lot

Appendix F ATA Soil Assessment

MICRO DESIGN ARCHITECTS

0 5 APR 2002

SOIL ASSESSMENT OF PROPOSED EFFLUENT IRRIGATION AREA, FOREST HILL WINERY SITE

VERSION 1

APRIL 20002

REPORT NO: 2002/39

ATA Environmental
environmental scientists

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

1.1 Purpose

ATA Environmental were commissioned by Micro Design Architects to conduct a soil assessment of a proposed effluent disposal area at the proposed Forest Hill winery site, Denmark. This report details the findings of the soil assessment and provides a brief discussion on the capability of the area to manage effluent disposal loads.

1.2 Background and Scope of Works

The objective of the assessment was to provide lithological descriptions and physiochemical characterisation of soils within a proposed site (study area) for the disposal of treated winery effluent. It was understood that the findings of this assessment will be used to delineation the most appropriate disposal area to adequately assimilate effluent loadings whilst adhering to regulatory authority guidelines and policies.

The sampling methodology adopted by ATA Environmental facilitated the compilation of an adequate data set, not only to meet the objectives of the assessment, but to satisfactorily comply with the baseline soil assessment condition as set by Department of Environmental, Water and Catchment Protection's (DEWCP) through the Works Approval process. A Works Approval is required prior to the construction of any winery with a throughput capacity in exceedance of 500tonne/annum as prescribed under Part V of the *Environmental Protection Act, 1998.*

Consequently, the scope of works for the soil assessment included a site visit (conducted 8 March 2002) to log soils and to collect representative soil samples for laboratory analysis to characterise the properties/capabilities of the soils of the study area.

2. PHYSICAL SETTING OF STUDY AREA

2.1 Site Location and Study Area Description

The proposed Forest Hill winery site is located at Part Lot 421, Denmark and is bounded by Myers Road to the east and South Coast Highway to the south. The study area is located in the northern portion of the north-eastern quarter of the site (Figure 1) and comprises approximately 3.1ha of cleared pastoral land.

2.2 Topography

The topography of the study area comprises a hill crest and flanking slopes. The crest which peaks at an elevation of 85mAHD is aligned centrally along the northern boundary of the eastern half of the study area. The slopes have a south-easterly and south-westerly aspect with a gradient of 1:8 and 1:10, respectively.

2.3 Geomorphology and Geology

The proposed Forest Hill winery site is located within the southern fringe of the Great Plateau of Western Australia. The geomorphology of the site is mapped by Churchward *et al.*, (1988) as comprising the Keystone map unit. The unit describes the landform as comprising broad crests and flanking slopes.

The geology is described by Churchward *et al.*, (1988) as comprising Precambium crystalline basement, including granites, gneisses and migmatites. Granite outcrops on the upper slopes may occur as prominent domes or pinnacles however, granite and gneiss is generally deeply weathered on mid and lower slopes. There is often sporadic thin cover of sand and lateritic duricrust may be present on the crests and the upper slopes.

2.4 Soils

Churchward *et al.*, 1988 describe the soils of the site and study area as comprising the Keystone (b) map unit. The soils of this unit are duplex soils with brown gravelly surface horizons, yellow brown and red brown clay subsoil and red or yellow earths.

Lithological descriptions of soils within the study area as recorded by ATA Environmental field staff are provided in Section 3.3.

3. SOIL ASSESSMENT

3.1 Sample Location Selection Rationale

The soil sample locations were selected to facilitate adequate compilation of physiochemical and lithological descriptions of the study area, in the first instance, as well as to provide the data as generally required by DEWCP during the Works Approval application process. As a general rule, DEWCP require that at least four sample locations are selected within the proposed irrigation area, as well as one offsite and downgradient of the disposal area (control site). Therefore, four representative soil sampling locations were chosen within the study area (FH A, FH B, FHC and FH D) and a control located downgradient and in close proximity to the native stand of vegetation (FH E). The soil sample locations are shown in Figure 1.

In anticipation of the requirements of the baseline soil assessment as required under DEWCP Works Approval, soil samples were collected from the depth intervals 100mm and 200mm at each location and analysed for pH, Electrical Conductivity, Total Nitrogen, Total Phosphorus, Orthophosphate, Phosphorus Retention Index, Calcium, Magnesium, Sodium, Sodium Adsorption Ratio, soil moisture and water holding capacity.

3.2 Study Area Filed Description

A number of field observations were noted, once on site, that should also be considered in conjunction with the findings of this report when finalising the siting of the disposal area. These are summarised below:

- A small portion of the western half of the proposed irrigation area is remnant vegetation.

- A small portion of this western half also appears to support a perched water table.

- A 50m buffer is required between disposal areas and intermittent water courses including sumplands (identified as a perched water table).

- Consolidated pisolitic (gravel) strata was noted in the heavily ripped areas coinciding with soil sample locations, FH C and FH D indicating the potential for shallow impermeable lateritic subsoils.

As DEWCP requires that the disposal area must have at least 1m of permeable soils and no less than a 2m depth to groundwater; and, that the disposal of treated effluent to native vegetation is not permitted, the finalised disposal area may be considerably smaller than that delineated in this assessment.

3.3 Sample Site Lithology

Lithological descriptions were recorded for all sample locations to a maximum depth of two meters or until lateritic (impenetrable by hand auger) were encountered. The following descriptions were recorded for each of the five sampling locations:

FH A	0-300mm	grey- brown sandy loam with organic matter
	300-500mm	grey-brown sandy loam
	500-800mm	yellowish-brown sandy clay
	800-2000mm	mottled brown-red and yellow-brown sandy (gritty) clay
FH B	0-200mm	grey sand with organic matter
	300-500mm	grey-brown gravelly sandy loam
	500-800mm	yellowish-brown gravelly sandy clay
	800-2000mm	mottled brown-red and yellow-brown sandy (gritty) clay
FH C	0-150mm	brown sandy loam with organic matter
	150-700mm	brown gravelly sandy loam
	500-2000mm	mottled brown-red and yellow-brown sandy (gritty) clay
FH D	0-100mm	light grey-brown gravelly loamy sand with organic matter
	100-500mm	light grey-brown gravelly loamy sand
	500mm	auger rejection due to suspected lateritic duricrust (impenetrable by hand auger).
FH E	0-250mm	grey-brown sands with organic matter
	250mm	auger rejection due to suspected granite basement (impenetrable by hand auger).

In summary, the soils of the study area comprise a sandy loam sub-soil overlying mottles sandy clays. Shallow lateritic strata (consolidated gravel) was evident in soils of the midslope of the southwestern aspect of the study area.

3.4 Physiochemical Characteristics of Surface Soils

Soil samples collected from the depth intervals 100mm and 200mm at each were analysed for pH, Electrical Conductivity, Total Nitrogen, Total Phosphorus, Orthophosphate, Phosphorus Retention Index, Calcium, Magnesium, Sodium, Sodium Adsorption Ratio, soil moisture and water holding capacity.

All analytical results were compared to the Agriculture Western Australia (AgWA) soil ratings (Moore *et al.*, 1998). A results summary table comparing analyte concentrations to the AgWA ratings is provided in Appendix 1. A Graphical comparison of the soil characteristics at each sampling location as compared to AgWA guidelines is provided in Appendix 2.

In summary, the surface soils of the proposed effluent irrigation area are/have:

- Slightly acidic.
- Low salinity.
- Medium to high water holding capacity (currently unsaturated).
- Medium to high stored nitrogen levels (except for low stored nitrogen levels at FH C and FH D).
- Low stored phosphorus levels with medium to high phosphorus retention capacity (except at location FH D which have low phosphorus retention capabilities).
- High sodium absorption ratio.

On the basis of the analytical results, the surface soils of the irrigation area (once vegetated) appear to have the capacity to adequately assimilate treated winery effluent without promoting adverse environmental (soil or water) impacts.

4. CONCLUSIONS AND RECOMMENDATIONS

ATA Environmental conducted a site visit at the proposed Forest Hill winery site in order to assess the capability of soils within the designated effluent disposal area to assimilate treated effluent loads. In doing so, lithological descriptions and physiochemical characteristics of five sample locations were determined.

The methodology of the sampling and analysis plan of the disposal area was based on the anticipated requirements for the baseline soils assessment as required under the DEWCP Works Approval application process. DEWCP Works Approval is required prior to the construction of the winery as prescribed under Part V of the *Environmental Protection Act (1986)*.

The study concludes that the soils of the study area are generally grey- brown sandy loams overlying mottled yellow-brown and red-brown sandy clays. The surface soils of the areas tested are of low salinity and pH, have relatively strong phosphorus absorption, high moisture absorption and a low potential for sodicity (structural decline once under irrigation). Therefore, the disposal of treated winery effluent to land should not adversely effect neither onsite or offsite environmental receptors.

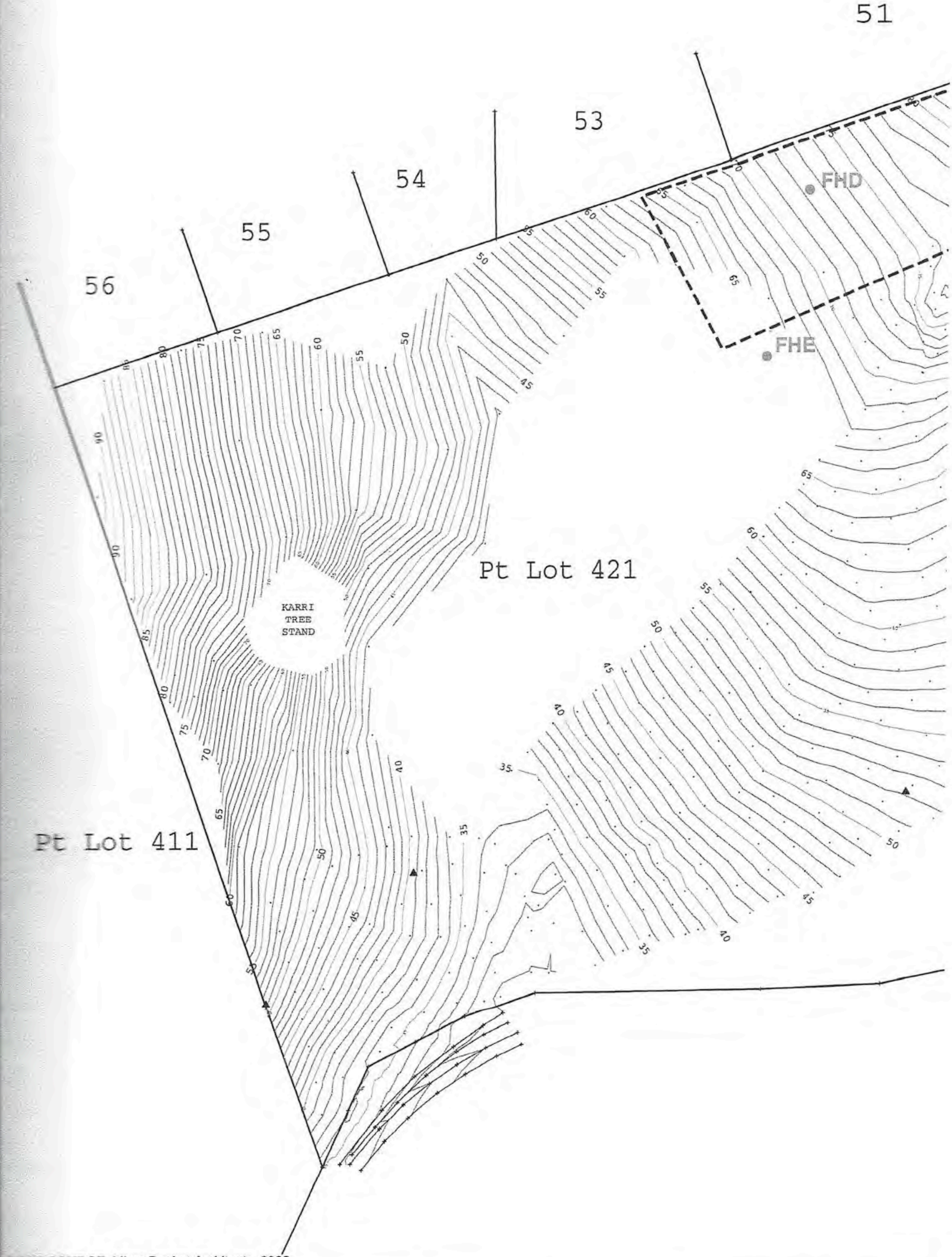
Notwithstanding, the presence of native vegetation, the potential for a perched water table at the foot of the proposed irrigation area, as well as the presence of shallow lateritic sub-strata in the viscinity of FH D, may constrain the total area available for disposal. It is therefore recommended that the irrigation area comprise areas associated with FH A, FH B, FH C (and potentially FH D if laterite is only localised). The remaining of the study area could be planted with a rainfed buffer planted from location FH D and downgradient. This will enable the objectives of the revegetation program to be met as well as to provide the required 50m buffer to mitigate surface or subsurface migration of nutrient rich wastewater to the areas associated with the perched water table should such an event occur.

Nevertheless, it is ATA Environmental's experience that a disposal area of 2ha would adequately assimilate hydraulic and nutrient loads produced by a winery with a 3000 tonne throughput capacity providing wastewater is treated to the quality as expected by DEWCP. ATA Environmental can conduct the appropriate modelling study to determine the required disposal area should Micro Design Architects require such information.

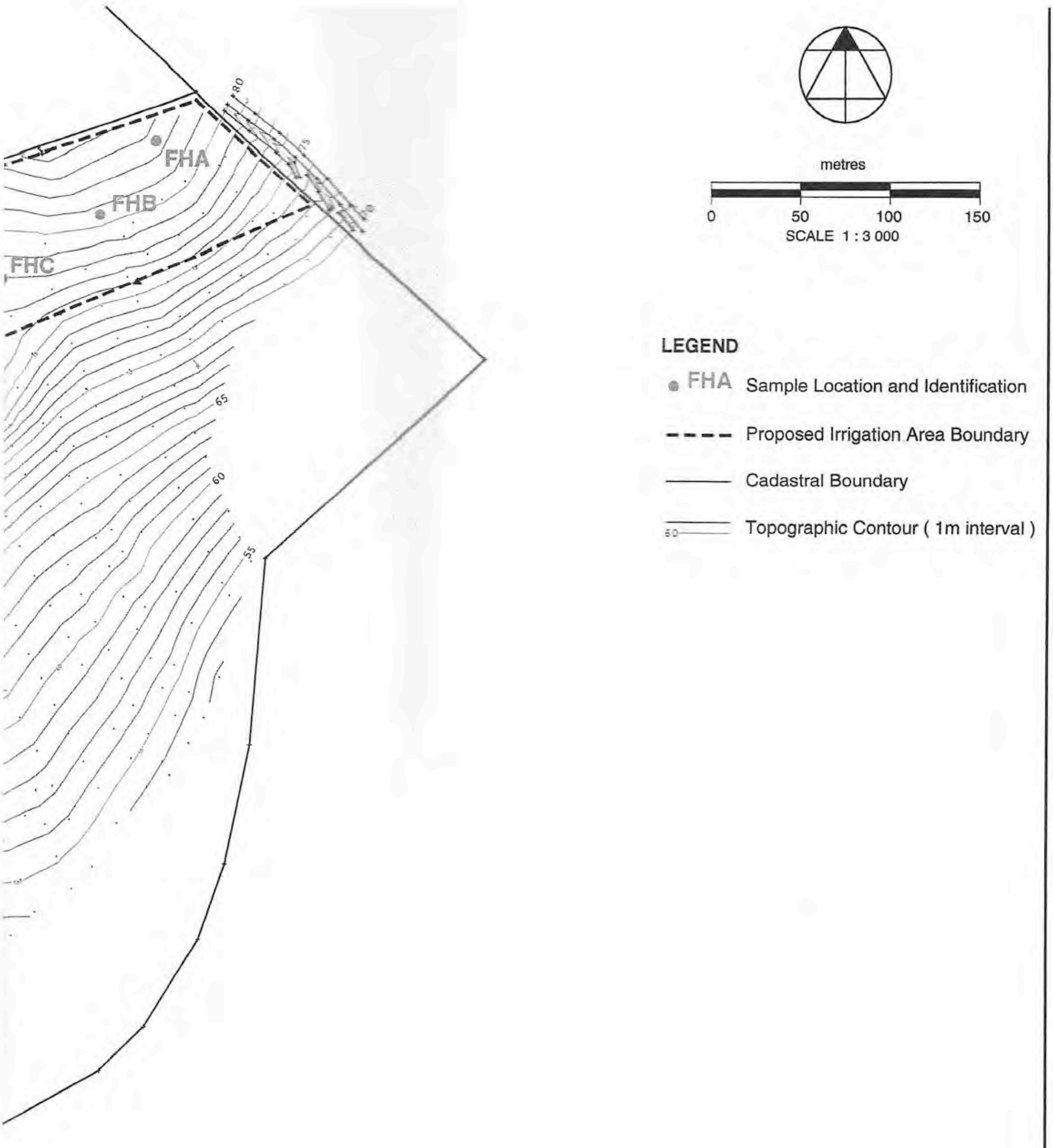
REFERENCES

Churchward, H.M., W.M. McArthur, P.L. Sewell and G.A. Bartle (1988). *"Landforms and Soils of the South Coast and Hinterland, Western Australia, Northcliffe to Manypeaks"*, Divisional report 88/1, Division of Water Resources, CSIRO Australia.

Moore, G (1998). "*Soil Guide, A Handbook for Understanding and Managing Agricultural Soils*" Bulletin 4343, Agriculture Western Australia.



BASE SOURCE: Micro Design Architects, 2002



ATA Environmental
environmental scientists

SOIL ASSESSMENT OF PROPOSED
EFFLUENT IRRIGATION AREA
FOREST HILL WINERY SITE, DENMARK

SOIL SAMPLING LOCATIONS

FIGURE 1

APPENDIX 1

ANALYTICAL RESULTS SUMMARY

ANALYTICAL RESULTS

BASELINE SOIL CONDITIONS FOR PROPOSED TREATED EFFLUENT DISPOSAL AREA

Sample Description	Physiochemical					Nutrients			Sodicity			
	pH	EC (mS/m)	Moisture content (%)	Water Holding Capacity (%w/w)	PRI	Total N (mg/kg)	Ortho P (mg/kg)	Total P (mg/kg)	Na (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	SAR (me/L)
FH A 100	4.7	3.4	2.7	40	149	1200	33	192	102	399	43	21.3
FH A 200	5.0	4.0	8.8	36	488	1900	14	311	97	716	98	20.2
FH B 100	4.6	2.3	1.6	35	17	1000	23	130	83	408	46	23.1
FH B 200	4.8	4.7	2.3	34	21	2400	27	119	108	849	150	21.1
FH C 100	5.4	1.9	3.4	30	33	800	5	100	73	1593	112	19.8
FH C 200	5.6	2.0	2.3	26	21	700	9	48	96	1976	109	20.1
FH D 100	4.5	5.0	0.1	26	9	700	7	64	54	359	52	21.6
FH D 200	4.5	2.4	0.1	28	11	500	5	85	94	467	58	22.5
FH E 100	5.0	6.3	9.9	50	115	2800	28	186	191	2336	651	15.7
FH E 200	5.0	7.7	5.4	38	87	1200	15	137	183	1137	353	19.6
AgWA Ratings												
low	<4.5	<50	nr	nr	<2	<1500	<10	<200	nr	nr	nr	<5
medium	nr	50-200	nr	nr	2-20	1500-2500	10-30	200-800	nr	nr	nr	5-25
high	>9	>200	nr	nr	>20	>2500	>30	>800	nr	nr	nr	>25

nr - no recommendation