Appendix 5

Void Water Irrigation Assessment by Strategic Environmental and Engineering Consulting (SEEC)

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Strategic Environmental & Engineering Consulting

Void Water Irrigation Assessment

for Werris Creek Coal Mine

Prepared by: Mark Passfield

SEEC Reference 14000171-R-02

2nd April 2015

SEEC

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Document Certification

This report has been developed based on agreed requirements as understood by SEEC at the time of investigation. It applies only to a specific task on the nominated lands. Other interpretations should not be made, including changes in scale or application to other projects.

Any recommendations contained in this report are based on an honest appraisal of the opportunities and constraints that existed at the site at the time of investigation, subject to the limited scope and resources available. Within the confines of the above statements and to the best of my knowledge, this report does not contain any incomplete or misleading information.

Mark Passfield
Director
SEEC

2nd April 2015

Document Table

Version	Date	Reviewer
DRAFT	12th December 2014	NL
DRAFT	29th January 2015	AI and Client
Draft	2nd February 2015	AI
Final	6th February 2015	Client
Rev 02	2nd April 2015	Client

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1 INTRODUCTION

SEEC have been commissioned by R.W. Corkery & Co. Pty Limited, on behalf of Werris Creek Coal Mine Pty Ltd (the Applicant), to investigate an option to apply (by irrigation) water which accumulates within the open cut void of the Werris Creek Coal Mine ("the Mine") to agricultural land surrounding the Mine Site. "Void water" is currently stored in five Void Water Dams with an approximate area of 27ha and a maximum capacity of 755 ML[1] (Figure 1). Two specific locations have been investigated as representative of agriculture land potentially available for irrigation in the local area:

- "Escott" property to the west; and
- "Cintra" property to the north.

Figure 1 identifies both properties as well as indicative locations for irrigation (assuming a centre pivot style irrigation system). The aim of this study is to determine whether void water can be sustainably used (irrigated) to promote pasture or crop growth and how much land is required to do so.

2 PROJECT DESCRIPTION

A combination of surface water runoff and groundwater seepage accumulates in the open cut void of the Mine. Currently, this water is pumped to the surface Void Water Dams where it is used for dust suppression across the Mine Site. Evaporating units are currently utilised to accelerate evaporation of water held in the Void Water Dams to maximise the available storage within these dams. In the event that the capacity of the Void Water Dams is reached, the water must be retained in-pit until available capacity becomes available.

In order to anticipate the likelihood that the capacity of the Void Water Dams will be reached over the remaining life of the Mine, the Applicant commissioned ENVIRON to complete a revised Water Balance Model (WBM) for the Mine (ENVIRON, 2015). **Table 1** presents a summary of the WBM output for a combination of predicted mining (in future years 2015, 2017 & 2020) and rainfall (15^{th} percentile, 90^{th} percentile & median) scenarios.

Considering the continued operation of evaporating units at the Mine, which are anticipated to provide additional evaporation of up to 300MLpa, **Table 2** provides a revised summary of the WBM output for each combination of mining and rainfall scenario.

[1] The operational capacity is slightly less (714 ML) which accounts for freeboard requirements within each dam.

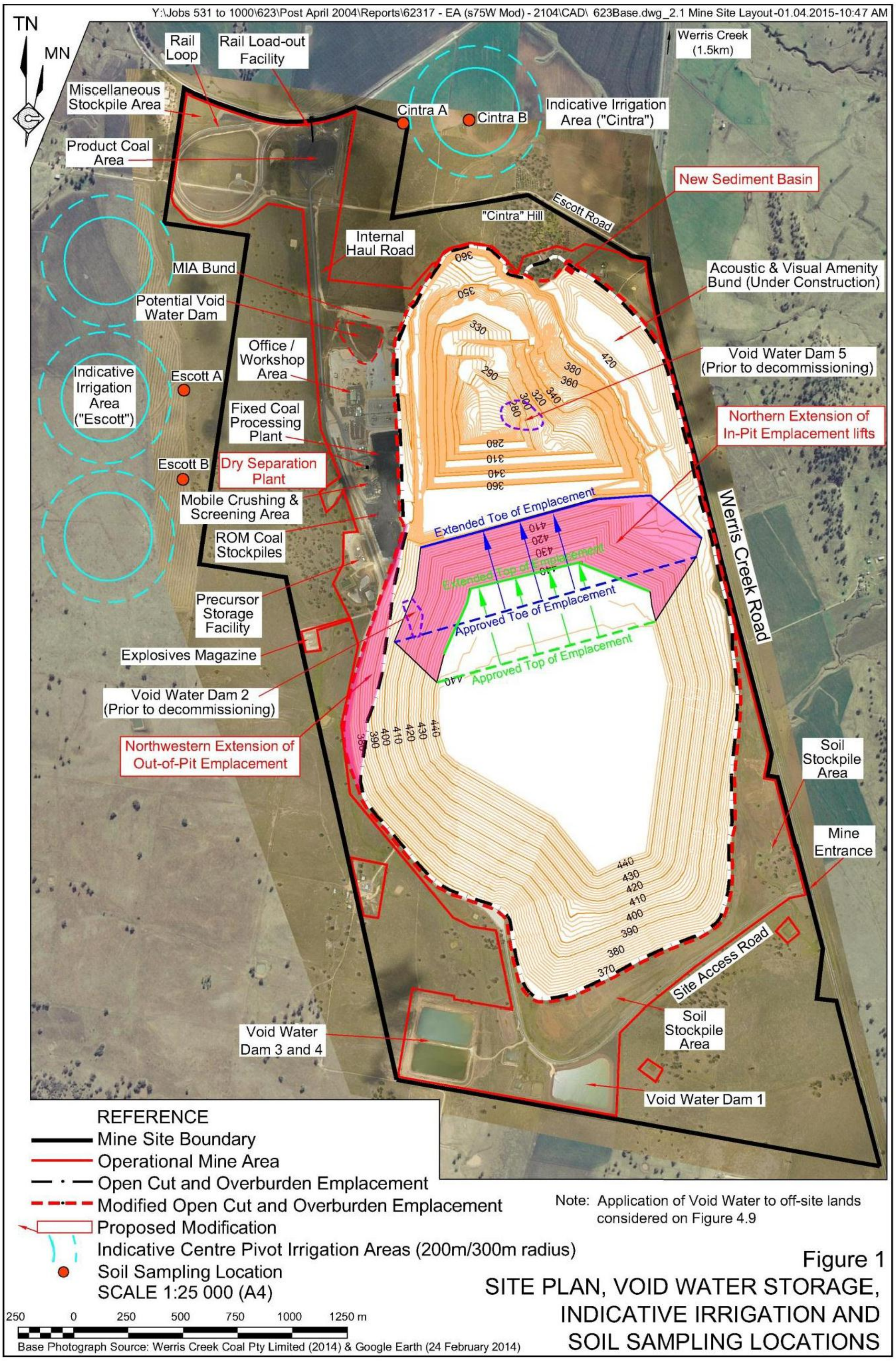

Figure 1
SITE PLAN, VOID WATER STORAGE, INDICATIVE IRRIGATION AND SOIL SAMPLING LOCATIONS

Table 1 – Void Water Balance

		Year 2015			Year 2017			Year 2020		
		Median	15th %ile	90th %ile	Median	15th %ile	90th %ile	Median	15th %ile	90th %ile
Inputs	Rainfall/runoff	737	570	1 043	835	643	1 192	792	605	1 130
	Groundwater Inflow	54	54	54	47	47	47	22	22	22
	Input (return) from Underground	67	67	67	-	-	-	-	-	-
	Total	**858**	**691**	**1 164**	**882**	**690**	**1 239**	**814**	**627**	**1 152**
Outputs	Evaporation[1]	408	381	329	428	408	374	409	328	358
	Water use	365	365	365	365	365	365	365	365	365
	Total	**773**	**746**	**694**	**793**	**773**	**739**	**774**	**693**	**723**
Balance		**85**	**-55**	**470**	**89**	**-83**	**500**	**40**	**-66**	**429**

Note 1: From surface of void water storages only (does not include additional evaporation from misting evaporator units)

Source: Modified after ENVIRON (2015) – Table 1

Table 2 – Void Water Balance (with Evaporating Units)

		Year 2015			Year 2017			Year 2020		
		Median	15th %ile	90th %ile	Median	15th %ile	90th %ile	Median	15th %ile	90th %ile
Inputs	Rainfall/runoff	737	570	1 043	835	643	1 192	792	605	1 130
	Groundwater Inflow	54	54	54	47	47	47	22	22	22
	Input (return) from Underground	67	67	67	-	-	-	-	-	-
	Total	**858**	**691**	**1 164**	**882**	**690**	**1 239**	**814**	**627**	**1 152**
Outputs	Evaporation (from VWD Surface)	408	381	329	428	408	374	409	328	358
	Evaporation (from Evaporator Units)	300	300	300	300	300	300	300	300	300
	Water use	365	365	365	365	365	365	365	365	365
	Total	**1 073**	**1 046**	**994**	**1 093**	**1 073**	**1 039**	**1 074**	**993**	**1 023**
Balance		**-215**	**-355**	**170**	**-211**	**-383**	**200**	**-260**	**-366**	**129**

Source: Modified after ENVIRON (2015) – Table 1

The WBM summary tables (**Tables 1** and **2**) indicate that a surplus of void water of up to 200MLpa or 500MLpa could occur depending on the status of mining, rainfall conditions and use of evaporators.

An option to irrigate any surplus void water, should it accumulate within the open cut void, has been proposed as a contingency by the Applicant. This study reviews the effect of irrigating either 200MLpa or 500MLpa of water on to the agricultural land adjacent to the mine site and the minimum wet-weather storage and area requirements for this activity.

3 WATER QUALITY

3.1 Void Water Quality

Void water was sampled by the Applicant and tested by ALS Laboratories for a suite of chemical parameters. Samples were taken on 10th November 2014 from four Void Water Dams (VWD). On 11th November 2014 water was sampled from the void itself, after 20 mm of rainfall (wet period). It was also sampled and analysed on the 18th November after a dry period. The full results of the laboratory analysis are presented in **Appendix 1** and a summary of the most applicable tests are given in **Table 3**.

Table 3 – Void Water Quality for Input to Irrigation Model

Sample Location	Electrical Conductivity µS/cm	pH	SAR	Nitrate mg/L	Nitrite mg/L	Total Nitrogen as N mg/L	Total Phosphorous mg/L	BOD mg/L
VWD1	1100	8.35	4.59	2.29	0.03	2.8	0	ND
VWD2	1070	8.41	-	4.86	0.05	5.6	0	-
VWD3	994	8.74	4.82	2.48	0.07	3.6	0.06	-
VWD4	1030	8.97	4.74	4.78	0.07	5.8	0	ND
Void (wet)	921	8.02	3.03	6.23	0.07	7.3	0.01	ND
Void (dry)	929	7.92	3.24	6.13	0.08	7.5	<0.01	<2
Mean	1023	-	4.3	4.1	0.05	5.0	0.01	ND
Median	-	8.41	-	-	-	-	-	-

In summary:

- Metals were generally undetectable or present at very low concentrations[2].
- Salinity (EC_i) ranged from 921 µS/cm to 1,100 µS/cm, the mean was 1,023 µS/cm (1.023 S/m).
- The pH ranged from 7.92 in the void to 8.97 in VWD4, the median was 8.41.
- The sodium absorption ratio (SAR) ranged from 3.03 in the void to 4.82 in VWD3, the mean value was 4.3.

2 Much lower than the short term trigger values given in ANZECC, 2000.

- The concentration of phosphorus ranged from non-detectable to 0.06 mg/L in VWD3. The mean was 0.01 mg/L.
- The concentration of nitrate ranged from 2.29 mg/L in VWD1 to 6.23 mg/L in the void. The mean was 4.1 mg/L.
- The concentration of nitrite ranged from 0.03 to 0.08 mg/L. The mean was 0.05 mg/L.
- The concentration of total nitrogen as N ranged from 2.8 mg/L in VWD1 to 7.5 mg/L in the void. The mean was 5 mg/L.
- There was no biological oxygen demand.

3.2 Stream Water Quality

Water quality in receiving waters was measured at three locations, two on Quipolly Creek (one upstream (QCU) and one downstream (QCD)) and one on Werris Creek (downstream) (WCD). The stream water quality is consistent and is very similar to the void water quality, although there is less nitrogen in the stream water and it is slightly more saline (**Table 4**).

Table 4 - Stream Water Quality Test Results

Sample Location	Electrical Conductivity µS/cm	pH	Nitrate mg/L	Nitrite mg/L	Total Nitrogen as N mg/L	Total Phosphorous mg/L
QCU	1420	7.89	0.02	0	3	0.26
QCD	1080	8	0	0	0.3	0.16
WCD	1400	8.34	0	0.05	0.6	0.24
Mean	1300		0	0	1.3	0.22
Median		7.95				

4 SOIL DESCRIPTION

4.1 Soil Landscape Mapping

A review of the soil landscape mapping of the Tamworth 1:100 000 map sheet (Banks, 2001) indicates that three soil landscapes are common on the land surrounding the Mine Site (see **Figure 2**), namely:

- 'The Siphon' Soil Landscape to the west;
- 'Escott' Soil Landscape to the north; and
- 'Duffs Gully' Soil Landscape to the north and south.

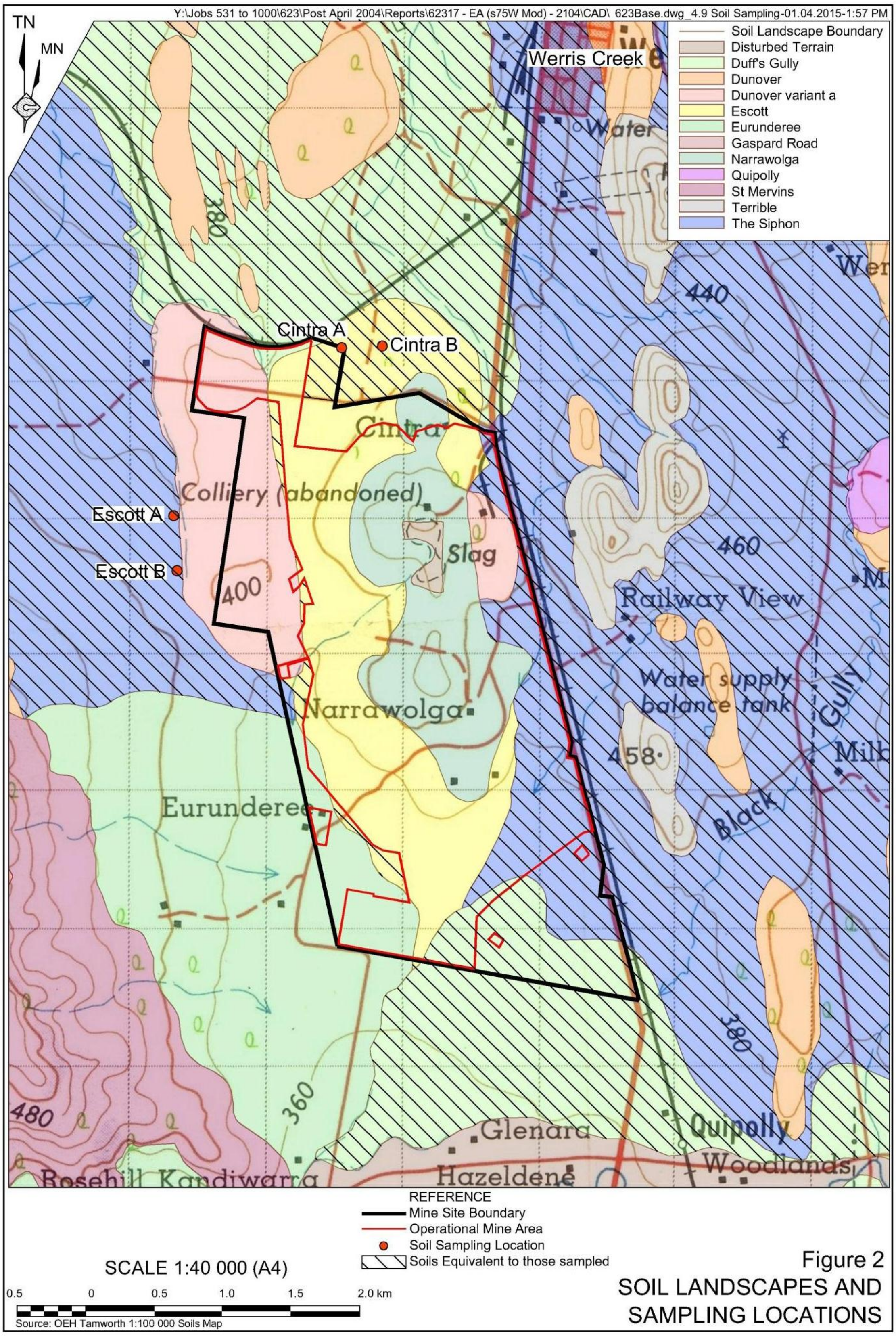

Figure 2
SOIL LANDSCAPES AND SAMPLING LOCATIONS

Banks (2001) notes that the 'Escott' Soil Landscape is derived from sandstone whilst 'The Siphon' and 'Duffs Gully' Soil Landscapes are of volcanic rock origin. Anecdotal evidence provided by the Applicant with respect to land use suggests that the soils of the "Cintra" property to the north of Escott Road are in fact derived from Werrie Basalt and therefore more indicative of 'Duffs Gully' Soil Landscape. However, in order to remain consistent with previous soil and land capability assessments conducted on the Mine Site reference to the Escott Soil Landscape is retained. In any event, soil sampling and analyses completed for this assessment provide a more accurate representation of soil characteristics.

4.2 Site Specific Soil Investigation

In order to identify the specific soil properties of the land of the local setting, for modelling and assessment purposes, soil samples from four locations were taken and analysed. Soils were samples at three depths at each location. **Figure 1** identifies the four soil sampling locations and **Table 5** presents the results of soil analyses.

Table 5 – Soil Laboratory Test Results

Sample Location and layer	Texture	pH	Electrical Conductivity (EC) µS/cm	Cation Exchange Capacity (CEC) meq/100g	Phosphorous Sorption mg/kg	Emerson Aggregate Test (EAT)	Total carbon %
Escott (or, possibly, Duffs Gully) Soil Landscape							
Cintra A1	Silty clay	6.6	55	30.7	1210	4	1.15
Cintra A2	Silty clay	7.9	40	43.4	1700	4	0.24
Cintra A3	Sandy clay	8.5	129	57.6	2480	4	0.25
Cintra B1	Silty clay	5.9	113	19.9	1400	4	0.9
Cintra B2	Silty clay	6.5	121	32.5	2410	4	0.46
Cintra B3	Sandy clay	7.2	73	36	1680	4	0.22
Mean		7.1	88.5	36.68	1813.33	4	1.03 (topsoil)0.54
Siphon Soil Landscape							
Escott A1	Silty clay	7.2	23	49.9	1340	4	1.09
Escott A2	Silty clay	7	46	54.1	1460	4	1.22
Escott A3	Silty clay	9.4	123	90.5	988	4	0.25
Escott B1	Silty clay	7.5	20	52.1	1660	4	0.94
Escott B2	Silty clay	8.1	26	48.7	2270	4	0.73
Escott B3	Clay loam	8	30	44.4	4670	4	0.4
Mean		7.9	41	56.6	2065	4	1.02 (topsoil)

In summary:

Escott Soil Landscape

- Soil texture is generally silty, sometimes sandy, clay.
- Soils are reasonably homogeneous.
- Soil pH varies from 5.9 to 7.9 but is generally neutral to slightly alkaline.
- Soils are not dispersive.
- Soils are not sodic.
- Cation Exchange Capacity (CEC) varies from 19.9 cmol/kg to 57.6 cmol/kg and averages 36 cmol/kg, which is high.
- Phosphorous sorption capacity varies between 1,210 mg/kg and 2,480 mg/kg and averages 1,813 mg/kg, which is high.
- Soil Conductivity varies from 40 µS/cm to 129 µS/cm and averages 88 µS/cm. After adjusting for soil texture[3] this gives soil salinity (ECe) between 280 µS/cm and 903 µS/cm, averaging 616 µS/cm (0.616 S/m). The soils are non-saline (Hazleton and Murphy, 2007).
- Topsoil has about 1% organic carbon (low to moderate).
- Based on their texture, soils have a water holding capacity of about 170 mm/m (Hazleton and Murphy, 2007).
- Based on their texture soils have a root zone leaching fraction (LF) of about 0.3 (ANZECC, 2000).

Siphon Soil Landscape

- Soil texture is generally silty clay.
- Soils are reasonably homogeneous.
- Soil pH varies from 7 to 9.4 but is generally alkaline.
- Soils are not dispersive.
- Soils are not sodic.
- Cation Exchange Capacity (CEC) varies from 44.4 cmol/kg to 90.5 cmol/kg and averages 56.6 cmol/kg, which is high.
- Phosphorous sorption capacity varies between 988 mg/kg and 4,670 mg/kg and averages 2,065 mg/kg, which is high.
- Soil Conductivity varies from 20 µS/cm to 123 µS/cm and averages 41 µS/cm. After adjusting for soil texture[4] this gives soil salinity (ECe) between 140 µS/cm and

[3] i.e. applying a factor of 7 for clay soils
[4] i.e. applying a factor of 7 for clay soils

861 µS/cm, averaging 287 µS/cm (0.287 S/m). The soils are non-saline (Hazleton and Murphy, 2007).

- Topsoil has about 1% organic carbon (low to moderate).
- Based on their texture, soils have a water holding capacity of about 170 mm/m (Hazleton and Murphy, 2007).
- Based on their texture soils have a root zone leaching fraction (LF) of about 0.3 (ANZECC, 2000).

5 Salinity and Sodicity

5.1 Introduction

The effects of salinity and sodicity in irrigation waters are situation-specific, making it inappropriate to set water quality trigger values for general application. Factors which need to be considered include:

- the type of crop being cultivated and its salt tolerance;
- the characteristics of the soil under irrigation;
- soil and water management practices; and
- climate and rainfall.

The above notwithstanding, an assessment can be made using the electrical conductivity (ECi) and concentrations of sodium (Na+), calcium (Ca2+) and magnesium (Mg2+) in the proposed irrigation water (ANZECC, 2000).

5.2 Salinity

Salinity is the presence of soluble salts in or on soils, or in waters. If elevated levels of salt are present in irrigation waters and/or the soil profile, their accumulation can lead to reduced crop yield and land degradation.

To determine the suitability of irrigation water for crops the average root zone salinity (EC_{se} in dS/m) is calculated as EC_i (salinity of the water) divided by (2.2 x LF), i.e. 1.02/(2.2X0.3) = 1.55. This result means the void water is suitable for *moderately sensitive crops* which represent most crops and all common pastures (ANZECC, 2000).

Some percolation is required to ensure salt does not build up in the topsoil. This is reflected by adopting a percolation rate of 10 mm/month in the irrigation modelling (Section 5.4.2).

The relatively low salinity of the water, and the low percolation rate adopted, mean salt should not build up in the soil so should not become entrained in surface runoff. Nor should it reach groundwater. Therefore, there should be no discernable impact on the overall salt load in the Namoi Catchment.

5.3 Sodicity

Sodicity is a condition that degrades soil properties by making the soil more dispersible and erodible, restricting water entry and reducing hydraulic conductivity (the ability of the soil to conduct water). These factors could limit leaching so that salt accumulates over long periods of time, giving rise to saline subsoils (ANZECC, 2000).

Figure 3 is used to assess the possible effect on soil structural stability. In this case, where SAR = 4.3 and EC_i = 1.02 dS/m, the soil should remain stable but ongoing monitoring of soil health should be undertaken annually.

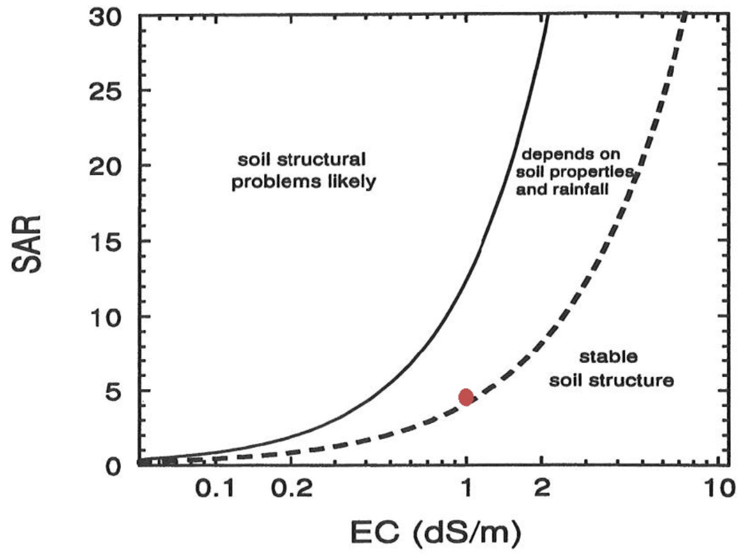

Figure 3 – Relationship between SAR and EC_i of irrigation water. Test result plotted as red dot.

5.4 Irrigation Balance

5.4.1 Background

While the Applicant would like the opportunity to use void water for beneficial reuse as possible there are limitations to its sustainable use.

- The water has low levels of salinity.
- The water is slightly alkaline.

- There is a potential for groundwater re-charge, which could trigger salinity.
- There is a potential for localised waterlogging.

Given these limitations it is appropriate to undertake water balance modelling to determine the combinations of wet weather storage and irrigation areas required to sustainably manage 200ML or 500ML of void water[5].

5.4.2 *Modelling*

5.2.2.1 Introduction

The void water is not *effluent* as described in the *Protection of the Environment Operations Act 1997* (POEO Act) but its salinity exceeds the relevant trigger for stream water quality for a NSW upland stream (350µS/cm) (ANZECC, 2000). Therefore, for the purpose of this study, it could be considered effluent and the Environmental Guidelines: *Use of Effluent by Irrigation* (DEC, 2004) has been applied.

DEC, 2004 is not mandatory or regulatory but it aims to ensure best management practice related to the use of effluent by irrigation. Water and nutrient balances are used via software known as ERIM (*Effluent Reuse Irrigation Model*) to calculate the amount of water and nutrients that should be applied, and at what times, to meet crop requirements whilst ensuring increases in runoff and percolation are minimised.

5.2.2.2 Inputs

Inputs to ERIM are as follows:

- Daily Rainfall Data. Data for Werris Creek Post Office is used and is in-built into ERIM.
- Daily potential evapotranspiration. Data for Tamworth Weather Station is used and is in-built into ERIM.
- Vegetation type (in this case it is pasture or moderately sensitive crop).
- Soil water holding capacity. Estimated from soil texture to be as 170 mm (Hazelton and Murphy, 2007).
- Soil percolation at 10mm per month (DEC, 2004)[6].
- Nutrient concentrations in void water:
  - Biological Oxygen Demand (BOD) = 0 mg/L;
  - Nitrate = 4.1 mg/L;

[5] Depending on whether spray evaporators are used.
[6] Some percolation is required to ensure salt does not build up in the topsoil. The maximum rate suggested by ERIM is 15mm/month but, in this case, as the site is a re-charge area, and there is a possibility of triggering salinity, 10 mm/month has been adopted.

  - Organic Nitrogen = 1 mg/L;
  - Ammonia = 0 mg/L;
  - Total phosphorous = 0.01 mg/L;
- Phosphorous sorption of the soil = 1,939 mg/kg.
- Soil density 1,300 kg/m^3.
- Soil depth available for phosphorous sorption = 1.0 m.
- Effluent strength = Low.
- Effluent loads = 200MLpa and 500MLpa.

5.2.2.3 Results

The deficit of rainfall over evapotranspiration (the irrigation demand) is used to define the potential irrigation pattern and the same data is used to calculate the required wet weather storage for each target irrigation depth. Ultimately graphs are produced that show storage size versus required irrigation land area (**Figures 4** and **5**). In terms of storage, the combined operating capacity of the void water dams is currently 714ML, although it is proposed to reduce that to 609 ML when VWD2 and VWD5 are decommissioned by 2017. This significantly exceeds the requirements of the modelling.

The graphs show results for the 50th percentile (median) of years, 75th percentile of years and 90th percentile of years. In this case, the 90th percentile is used as this relates to the same 90th percentile assumption in **Tables 1** and **2**. The land areas required for the 90th percentile of years are 32ha and 80ha for 200MLpa and 500MLpa respectively[7].

As nutrient concentrations in the water are very low, they do not match crop demand and so the model predicts they would not increase in the soil over time (**Figures 6** and **7**). Metals were generally undetectable or present in concentrations much lower than the trigger levels given in ANZECC (2000) and so these too would not accumulate in the soil.

5.5 Irrigation Scheduling

The ERIM model does not assume water is irrigated every day. Using historical daily rainfall and evaporation data it predicts the deficit of rainfall over evapotranspiration each day and this is used to calculate the irrigation demand. If there is no demand, the water is stored. In the future the same technique would be used on-site to calculate the daily irrigation demand.

[7] The graph lines do not extend to the Y-axis as there comes a point where the relationship between storage and area required becomes very sensitive and could be unreliable, particularly with regard to the permissible percolation rate. Therefore, the end points of the 90th percentile lines have been adopted.

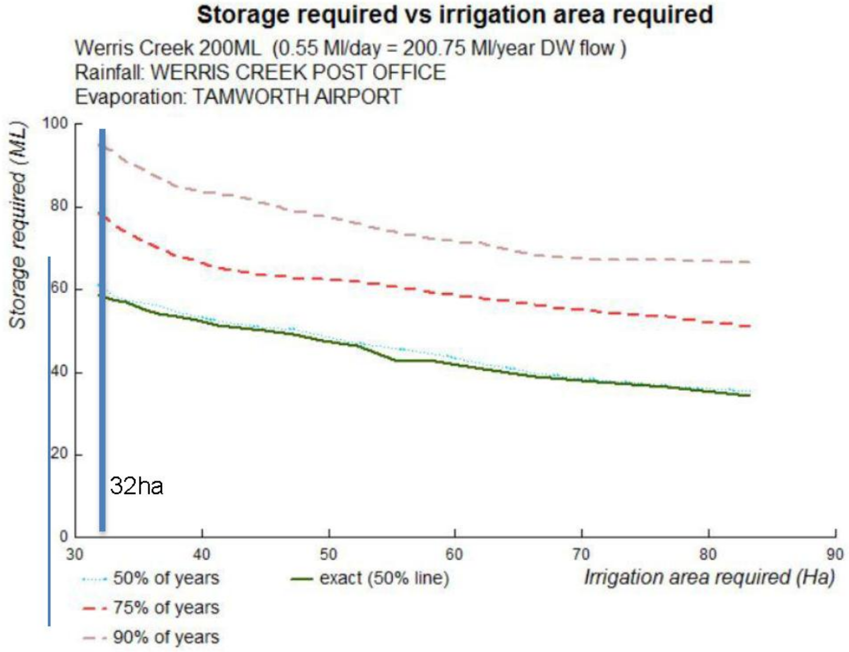

Figure 4 - Storage Versus Irrigation Area (200ML/y)

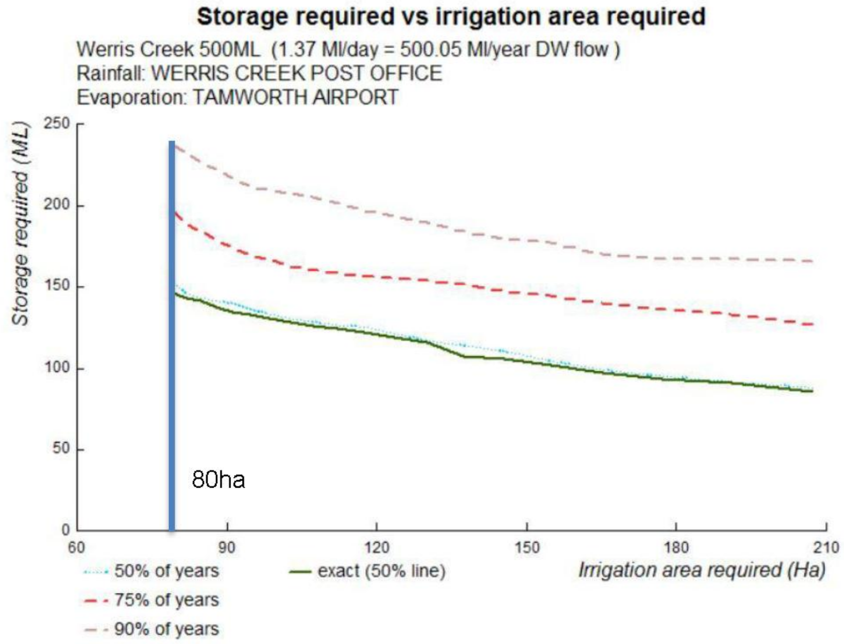

Figure 5 - Storage Versus Irrigation Area (500ML/y)

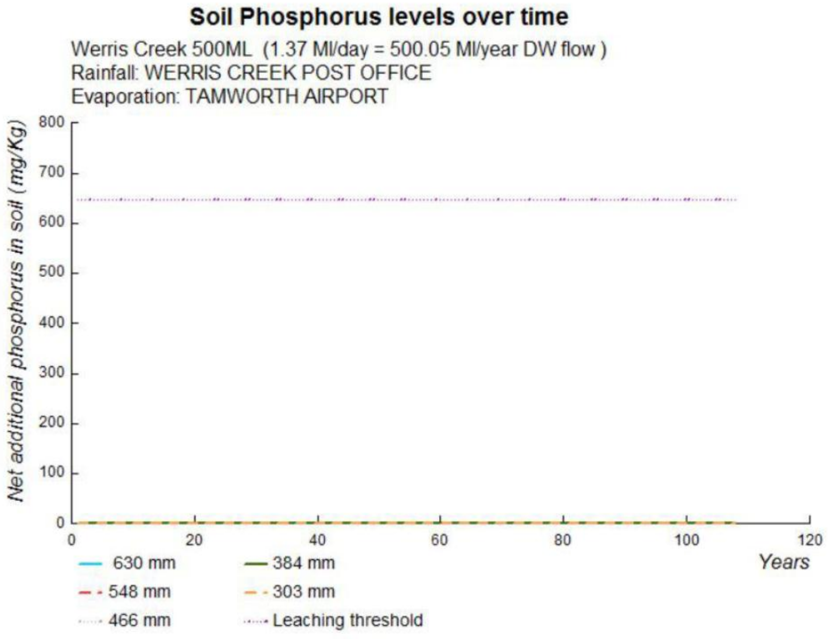

Figure 6 – Soil Phosphorous Levels with Time

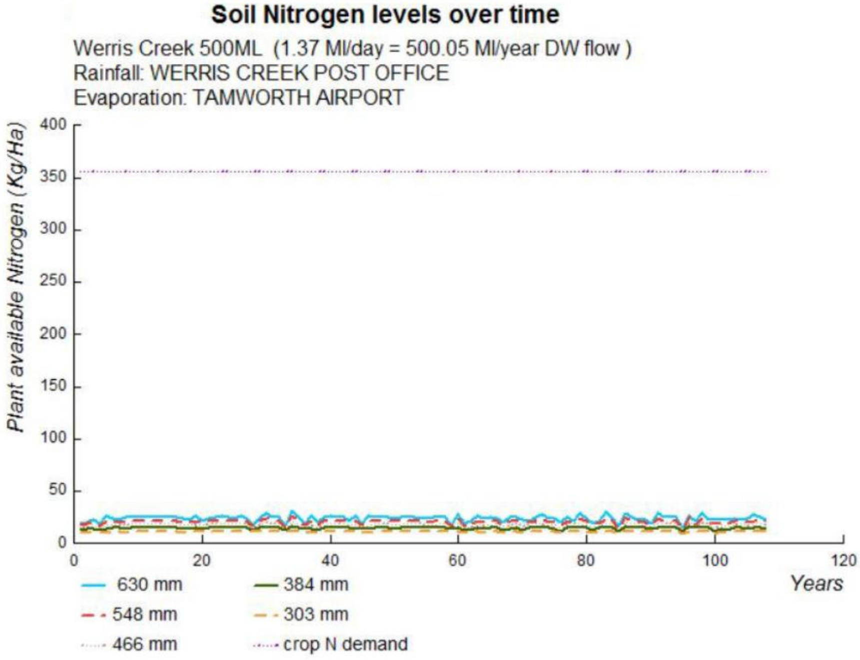

Figure 7 - Soil Nitrogen Levels with Time

The interval between irrigation, and the amount of water to apply when irrigating, depends on how much water is held in the root zone and how fast it is used by the crop. This is determined by:

- soil texture;
- soil structure/water penetration;
- depth of effective root zone of the soil;
- the crop grown; and
- the stage of development of the crop.

A simple spreadsheet tool would be used to enable appropriate scheduling to take place (e.g. **Table 6**). The irrigator would monitor the irrigation practices and make adjustments to the crop factor and allowable soil water storage in **Table 6** as necessary. If necessary, the irrigator would seek the advice of a professional agronomist.

Operation rules for the spreadsheet are summarised as follows.

- The spreadsheet is started following a rainfall that produces runoff or after irrigation (i.e. the soil is saturated). On this date the soil water storage is set to the maximum permissible (assumed to be 70 mm here).
- Evaporation and rainfall are recorded on a daily basis and entered into the relevant cells.
- When the soil water storage reaches zero, irrigation can commence to re-fill the soil. Alternatively, lighter irrigation amounts can be applied more often but would not over-fill the soil.
- The amount of water applied (mm/m^2) would be recorded.
- Periodic, slightly higher, irrigation rates would be used to flush salts from the topsoil.

Soil moisture monitoring (using tensiometers or equivalent) would allow the irrigator to calibrate the spreadsheet by adjusting the crop factor and effective rainfall parameters. An important consideration would be for the soil moisture monitoring to concentrate on the wetter areas to minimise waterlogging and accessions to the groundwater.

Table 6 – Example Irrigation Schedule Spreadsheet

Date	Evaporation[8] (mm)	Crop Factor[9]	Crop water Use (mm) = Evap x Crop factor	Effective Rainfall[10] (mm)	Soil Water Storage (mm)
				Irrigated	70[11]
Day 1	3	0.9	2.7	0	67.3
Day 2	2.3	0.9	2.07	0	65.23
Day 3	5	0.9	4.5	0	60.73
Day 4	8	0.9	7.2	0	53.53
Day 5	6	0.9	5.4	0	48.13
Day 6	5.5	0.9	4.95	0	43.18
Day 7	7.5	0.9	6.75	0	36.43
Day 8	8.5	0.9	7.65	0	28.78
Day 9	0	0.9	0	5	33.78
Day 10	0	0.9	0	5	38.78
Day 11	9	0.9	8.1	0	30.68
Day 12	5	0.9	4.5	0	26.18
Day 13	3	0.9	2.7	0	23.48
Day 14	0	0.9	0	5	28.48
Day 15	5	0.9	4.5	0	23.98
Day 16	8	0.9	7.2	0	16.78
Day 17	3	0.9	2.7	0	14.08
Day 18	2.3	0.9	2.07	0	12.01
Day 19	5	0.9	4.5	0	7.51
Day 20	8	0.9	7.2	0	0.31
Day 21	6	0.9	5.4	irrigate	

6 Conclusion

This assessment has determined that irrigation of void water to land adjacent to the mine could provide a viable method of reducing the volume of water stored within the Void Water Dams and that the void water is a valuable resource to encourage agricultural activities. A pre-agricultural void water use assessment will be prepared (including site specific soil testing and irrigation modelling) for the EPA and D&PE to review prior to any transfer and use of void water for irrigation or stock watering on land adjacent to the mine site.

8 Evaporation may be obtained for a nearby locality from the Bureau of meteorology.
9 This depends on the crop and time of year.
10 Daily rainfall would be measured on site. The effective rainfall is set assuming the first 5 mm of any rainfall event in spring, summer and autumn is ignored.
11 The estimated allowable water depletion (70 mm for silty clay).

Using the two example site as a basis for an indicative irrigation proposal, modelling predicts that 200MLpa of void water could be sustainably irrigated onto 32 ha of land. Irrigating 500MLpa of void water would require 80ha of land. These areas are readily achievable using a number of centre-pivot irrigators.

The irrigator would monitor the irrigation practices and make changes to the assumptions made herein as necessary. If necessary, the irrigator would seek the advice of a professional agronomist.

7 References

ANZECC (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council.

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8 Appendix 1 – Water Quality Results

Client - Matrix:	WATER	Sample Type:	REG
Workgroup:	ES1425485	ALS Sample number:	ES1425485001
Project name/number:	WERRIS CREEK NON-ROUTINE SURFACE-WATER	Sample date:	18/11/2014
		Client sample ID (Primary):	VOID NO RAIN
		Client sample ID (Secondary):	
		Sample Site:	
		Purchase Order:	9043

Analyte grouping/Analyte	CAS Numb	Units	LOR	
EA005P: pH by PC Titrator				
pH Value		pH Unit	0.01	7.92
EA006: Sodium Adsorption Ratio (SAR)				
Sodium Adsorption Ratio		-	0.01	3.24
EA010P: Conductivity by PC Titrator				
Electrical Conductivity @ 25°C		µS/cm	1	929
EA015: Total Dissolved Solids				
Total Dissolved Solids @180°C		mg/L	10	501
EA065: Total Hardness as CaCO3				
Total Hardness as CaCO3		mg/L	1	229
ED037P: Alkalinity by PC Titrator				
Hydroxide Alkalinity as Ca(	DMO-210-	mg/L	1	<1
Carbonate Alkalinity as Ca	3812-32-6	mg/L	1	<1
Bicarbonate Alkalinity as C	71-52-3	mg/L	1	160
Total Alkalinity as CaCO3		mg/L	1	160
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA				
Sulfate as SO4 - Turbidime	14808-79-8	mg/L	1	118
ED045G: Chloride Discrete analyser				
Chloride	16887-00-(	mg/L	1	117
ED093F: Dissolved Major Cations				
Calcium	7440-70-2	mg/L	1	77
Magnesium	7439-95-4	mg/L	1	9
Sodium	7440-23-5	mg/L	1	113
Potassium	########	mg/L	1	12
EG020F: Dissolved Metals by ICP-MS				
Aluminium	7429-90-5	mg/L	0.01	<0.01
Arsenic	7440-38-2	mg/L	0.001	0.004
Cadmium	7440-43-9	mg/L	0.0001	<0.0001
Chromium	7440-47-3	mg/L	0.001	<0.001
Copper	7440-50-8	mg/L	0.001	0.001
Nickel	7440-02-0	mg/L	0.001	0.005
Lead	7439-92-1	mg/L	0.001	<0.001
Zinc	7440-66-6	mg/L	0.005	0.011
Selenium	7782-49-2	mg/L	0.01	<0.01
Iron	7439-89-6	mg/L	0.05	<0.05

EG035F: Dissolved Mercury by FIMS				
Mercury	7439-97-6	mg/L	0.0001	<0.0001
EK040P: Fluoride by PC Titrator				
Fluoride	16984-48-8	mg/L	0.1	0.2
EK055G: Ammonia as N by Discrete Analyser				
Ammonia as N	7664-41-7	mg/L	0.01	0.23
EK057G: Nitrite as N by Discrete Analyser				
Nitrite as N		mg/L	0.01	0.08
EK058G: Nitrate as N by Discrete Analyser				
Nitrate as N	14797-55-8	mg/L	0.01	6.13
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser				
Nitrite + Nitrate as N		mg/L	0.01	6.21
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser				
Total Kjeldahl Nitrogen as N		mg/L	0.1	1.3
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser				
Total Nitrogen as N		mg/L	0.1	7.5
EK067G: Total Phosphorus as P by Discrete Analyser				
Total Phosphorus as P		mg/L	0.01	<0.01
EK071G: Reactive Phosphorus as P by discrete analyser				
Reactive Phosphorus as P	14265-44-2	mg/L	0.01	<0.01
EN055: Ionic Balance				
Total Anions		meq/L	0.01	9.53
Total Cations		meq/L	0.01	9.81
Ionic Balance		%	0.01	1.43
EP030: Biochemical Oxygen Demand (BOD)				
Biochemical Oxygen Demand		mg/L	2	<2

Client - Matrix:	WATER			Sample Type:	REG	REG	REG	REG	REG	REG	REG	REG	REG
Workgroup:	ES1424751			ALS Sample number:	ES1424751001	ES1424751002	ES1424751003	ES1424751004	ES1424751005	ES1424751006	ES1424751007	ES1424751008	ES1424751009
Project name/number:	WERRIS CREEK SURFACE-WATER WERRIS CREEK NON-ROUTINE SURFACE WATER			Sample date:	10/11/2014	10/11/2014	10/11/2014	10/11/2014	10/11/2014	10/11/2014	10/11/2014	10/11/2014	11/11/2014
				Client sample ID (Primary):	SD4	VWD1	VWD2	QCU	QCD	WCD	VWD3	VWD4	VOID WATER-AFTER RAIN
				Client sample ID (Secondary):									
				Sample Site:									
				Purchase Order:	8996/9003	8996/9003	8996/9003	8996/9003	8996/9003	8996/9003	8996/9003	8996/9003	8996/9003
Analyte grouping/Analyte	CAS Numb	Units	LOR										
AC03: Field Tests													
Electrical Conductivity (Non Compensa		µS/cm	1		390	1080	1050	1390	1050	1380	963	1010	935
pH		pH Unit	0.01		9.6	9	9	8.4	8	8.3	9.4	9.4	8.5
Temperature		°C	0.1		26	24.3	24.8	23	22.3	23.7	26.6	26.5	25.2
AC04: Field Observations													
Appearance		-			Slight turbid	Clear	Clear	Clear	Clear	Clear	Slight turbid	Clear	
Odour		-			Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Colour		-			Sandy	Clear	Clear	Greenish	Clear	Clear	Sandy	Clear	
EA005P: pH by PC Titrator													
pH Value		pH Unit	0.01		8.85	8.35	8.41	7.89	8	8.34	8.74	8.97	8.02
EA006: Sodium Adsorption Ratio (SAR)													
Sodium Adsorption Ratio		-	0.01			4.59					4.82	4.74	3.03
EA010P: Conductivity by PC Titrator													
Electrical Conductivity @ 25°C		µS/cm	1		373	1100	1070	1420	1080	1400	994	1030	921
EA015: Total Dissolved Solids													
Total Dissolved Solids @180°C		mg/L	10			602					546	561	512
EA025: Suspended Solids													
Suspended Solids (SS)		mg/L	5		71	6	38	76	17	38	119	16	
EA065: Total Hardness as CaCO3													
Total Hardness as CaCO3		mg/L	1			215					173	175	244
ED037P: Alkalinity by PC Titrator													
Hydroxide Alkalinity as CaC(	DMO-210-	mg/L	1			<1					<1	<1	<1
Carbonate Alkalinity as CaC(	3812-32-6	mg/L	1			7					18	17	<1
Bicarbonate Alkalinity as Ca	71-52-3	mg/L	1			144					110	104	159
Total Alkalinity as CaCO3		mg/L	1			150					129	121	159
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA													
Sulfate as SO4 - Turbidimet	14808-79-	mg/L	1			154					144	145	98
ED045G: Chloride Discrete analyser													
Chloride	16887-00-	mg/L	1			150					140	147	113
ED093F: Dissolved Major Cations													
Calcium	7440-70-2	mg/L	1			50					43	42	78
Magnesium	7439-95-4	mg/L	1			22					16	17	12
Sodium	7440-23-5	mg/L	1			155					146	144	109
Potassium	########	mg/L	1			10					10	10	9
EG020F: Dissolved Metals by ICP-MS													
Aluminium	7429-90-5	mg/L	0.01			0.02					0.03	0.06	<0.01
Arsenic	7440-38-2	mg/L	0.001			<0.001					0.002	0.001	0.006
Cadmium	7440-43-9	mg/L	0.0001			<0.0001					<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	mg/L	0.001			<0.001					0.012	0.001	<0.001
Copper	7440-50-8	mg/L	0.001			0.001					0.002	0.003	0.001
Lead	7439-92-1	mg/L	0.001			<0.001					<0.001	<0.001	<0.001
Nickel	7440-02-0	mg/L	0.001			<0.001					0.008	<0.001	0.006
Selenium	7782-49-2	mg/L	0.01			<0.01					<0.01	<0.01	<0.01
Zinc	7440-66-6	mg/L	0.005			0.051					0.006	0.146	0.024
Iron	7439-89-6	mg/L	0.05			<0.05					0.07	<0.05	<0.05

EG035F: Dissolved Mercury by FIMS												
Mercury	7439-97-6	mg/L	0.0001		<0.0001					<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator												
Fluoride	16984-48-	mg/L	0.1		0.2					0.2	0.1	0.1
EK055G: Ammonia as N by Discrete Analyser												
Ammonia as N	7664-41-7	mg/L	0.01		<0.01					0.01	<0.01	0.15
EK057G: Nitrite as N by Discrete Analyser												
Nitrite as N		mg/L	0.01	<0.01	0.03	0.05	<0.01	<0.01	<0.01	0.05	0.07	0.07
EK058G: Nitrate as N by Discrete Analyser												
Nitrate as N	14797-55-	mg/L	0.01	0.07	2.29	4.86	0.02	<0.01	<0.01	2.48	4.78	6.23
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser												
Nitrite + Nitrate as N		mg/L	0.01	0.07	2.29	4.91	0.02	<0.01	<0.01	2.48	4.78	6.3
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser												
Total Kjeldahl Nitrogen as N		mg/L	0.1	1.3	0.5	0.7	3	0.3	0.6	1.1	1	1
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser												
Total Nitrogen as N		mg/L	0.1	1.4	2.8	5.6	3	0.3	0.6	3.6	5.8	7.3
EK067G: Total Phosphorus as P by Discrete Analyser												
Total Phosphorus as P		mg/L	0.01	0.11	<0.01	<0.01	0.26	0.16	0.24	0.06	<0.01	0.01
EK071G: Reactive Phosphorus as P by discrete analyser												
Reactive Phosphorus as P	14265-44-	mg/L	0.01	0.01	<0.01	<0.01	<0.01	0.1	0.19	<0.01	<0.01	<0.01
EN055: Ionic Balance												
Total Anions		meq/L	0.01		10.4					9.81	10	8.94
Total Cations		meq/L	0.01		11.3					10.1	10	9.85
Ionic Balance		%	0.01		3.98					1.29	<0.01	4.85
EP020: Oil and Grease (O&G)												
Oil & Grease		mg/L	5	<5	<5	<5	<5	<5	<5	8	<5	
EP030: Biochemical Oxygen Demand (BOD)												
Biochemical Oxygen Demand		mg/L	2		<2					<2	<2	<2

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