

The logo consists of the text "Energy in action.™" in a blue, sans-serif font, positioned within a large, light-brown rounded rectangle. Below this rectangle are three smaller, light-brown rounded rectangles of varying sizes, arranged in a descending staircase pattern from left to right. At the bottom right of these shapes is the AGL logo, which features a blue square with a white sunburst icon and the letters "AGL" in white.The AGL logo is a blue square containing a white sunburst icon and the letters "AGL" in white.

AGL UPSTREAM INVESTMENTS PTY LTD

GLOUCESTER GAS PROJECT

**December 2015 Monitoring Report:  
Tiedman Irrigation Program  
EPL 20358**

Reporting Period: November 2015

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## Foreword

<b>PREMISES</b>	Gloucester Coal Seam Gas Project Bucketts Way Gloucester NSW 2422
<b>LICENCE DETAILS</b>	<a href="#"><u>Environment Protection Licence 20358</u></a>
<b>LICENCEE</b>	AGL Upstream Investments Pty Limited (AGL)
<b>LICENCEE'S ADDRESS</b>	Locked Bag 1837, North Sydney, NSW 2060
<b>MONITORING DATE</b>	17 November 2015
<b>MONITORING BY</b>	Jacobs, on behalf of AGL
<b>ANALYSIS BY</b>	East West, Tamworth (Work order number: EW150936)
<b>DATE AGL OBTAINED DATA</b>	18 December 2015
<b>REPORT DATE</b>	22 December 2015
<b>REPORT PREPARED BY</b>	Nicola Fry, Hydrogeologist

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## Introduction

AGL is proposing to build the Gloucester Gas Project (GGP) which comprises several stages of development facilitating the extraction of coal seam gas (CSG) from the Gloucester Basin. Concept plan and project approval (Part 3A Approval) for the Stage 1 Gas Field Development Area (GFDA) was granted on 22 February 2011 under Part 3A of the Environmental Planning and Assessment Act (1979) (EP&A Act). In addition the project received approval under the Environment Protection and Biodiversity Conservation Act (1999) (EPBC Act) (EPBC Approval) on 11 February 2013.

The GGP will involve depressurising of deep groundwater and the extraction of gas from multiple coal seams within the Gloucester coal measures. Target coal seam depths will vary from site to site but are expected to range between 250 and 1,000m below ground level (mbgl). The current GGP includes the construction, operation, and decommissioning of not more than 110 coal seam gas wells and associated infrastructure, including gas and water gathering lines within the Stage 1 GFDA.

Conditional approval was granted to AGL by the Division of Resources and Energy (DRE) in 2012 to implement a program (the Tiedman Irrigation Program) for produced water storage, blending, and irrigation activities on AGL's Tiedman property at Stratford in New South Wales (NSW). Approval was extended to 30 April 2015 by the Office of Coal Seam Gas (OCSG) on 4 July 2014; following which, AGL did not seek further extension and on 30 April 2015 the irrigation approval expired. On 6 August 2014, the NSW Environment Protection Authority (EPA) issued Environment Protection Licence (EPL) 20358 that covers the CSG exploration, assessment and production activities in the GGP (EPA, 2014).

The Tiedman Irrigation Program is divided into two areas, being Stage 1A and 1B (Figure 1):

- > Stage 1A is serviced by a lateral move irrigator which irrigated a maximum area of 18.2 ha, including 16 plots, two crop systems (annuals and perennials), and four soil treatment depths.
- > Stage 1B comprises an area of 8.6 ha (of which approximately 4ha is currently under irrigation), including four plots and a mix of annual and perennial pasture.

This Monitoring Report relates to the monitoring activities specified in Part 5, Monitoring and Recording Conditions, of Environment Protection Licence 20358 (the Licence). This report relates specifically to the monitoring surrounding the Tiedman Irrigation Program, and details:

1. Monitoring results from the 6-monthly soil sampling event at the Tiedman Irrigation Program (17 November 2015).

As per the Licence, the monitoring encompasses the monitoring points at the locations as shown in Table 1 and Figure 1.

The specific analytes and sample frequency are shown in Table 2. The monitoring results for this reporting period are shown in Table 3.

The monitoring points that are the subject of this report are part of the GGP soil monitoring network, as described in AGL's Soil Quality Monitoring and Management Program (FK, 2012). Soil monitoring results for the Irrigation program are presented in a baseline water monitoring report (FK, 2013a) and six-monthly compliance reports (FK, 2013b, 2014a and 2014b; and Jacobs, 2015a, and 2015b) up to May 2015.

For monitoring points 53 – 68 (Stage 1A), samples were taken manually using a hand auger at 20 cm intervals down to the base of the respective treatment depth of 120 cm or until refusal on rock, and each depth interval from each soil sample location was be sampled and analysed.

For monitoring points 69 -81 (Stage 1B), samples were taken manually using a hand auger at 20 cm intervals down to the base of the respective treatment depth of 120 cm or until refusal on rock at 20 cm, and a lateral composite sample was formed from the different sample locations from the same depth profile located in the Stage 1B area and analysed.

The soil samples were analysed by East West Enviroag Pty Ltd, Tamworth, NSW, a National Association of Testing Authorities (NATA) and the Australasian Soil and Plant Analysis Council (ASPAC) accredited laboratory.

This report is prepared in accordance with the *Requirements for Publishing Pollution Monitoring Data* (EPA, 2012) (Publication Requirements).

Water monitoring data collected in November for the Tiedman Irrigation Program (monitoring points 27 – 52) will be published in a separate report in accordance with the *Requirements for Publishing Pollution Monitoring Data* (EPA, 2012) (Publication Requirements).

The remaining water and land monitoring points in EPL 20358 will be reported in subsequent reports when the requirement for monitoring is triggered.

More information on the groundwater monitoring of the GGP is available on the project website: [agl.com.au/Gloucester](http://agl.com.au/Gloucester)

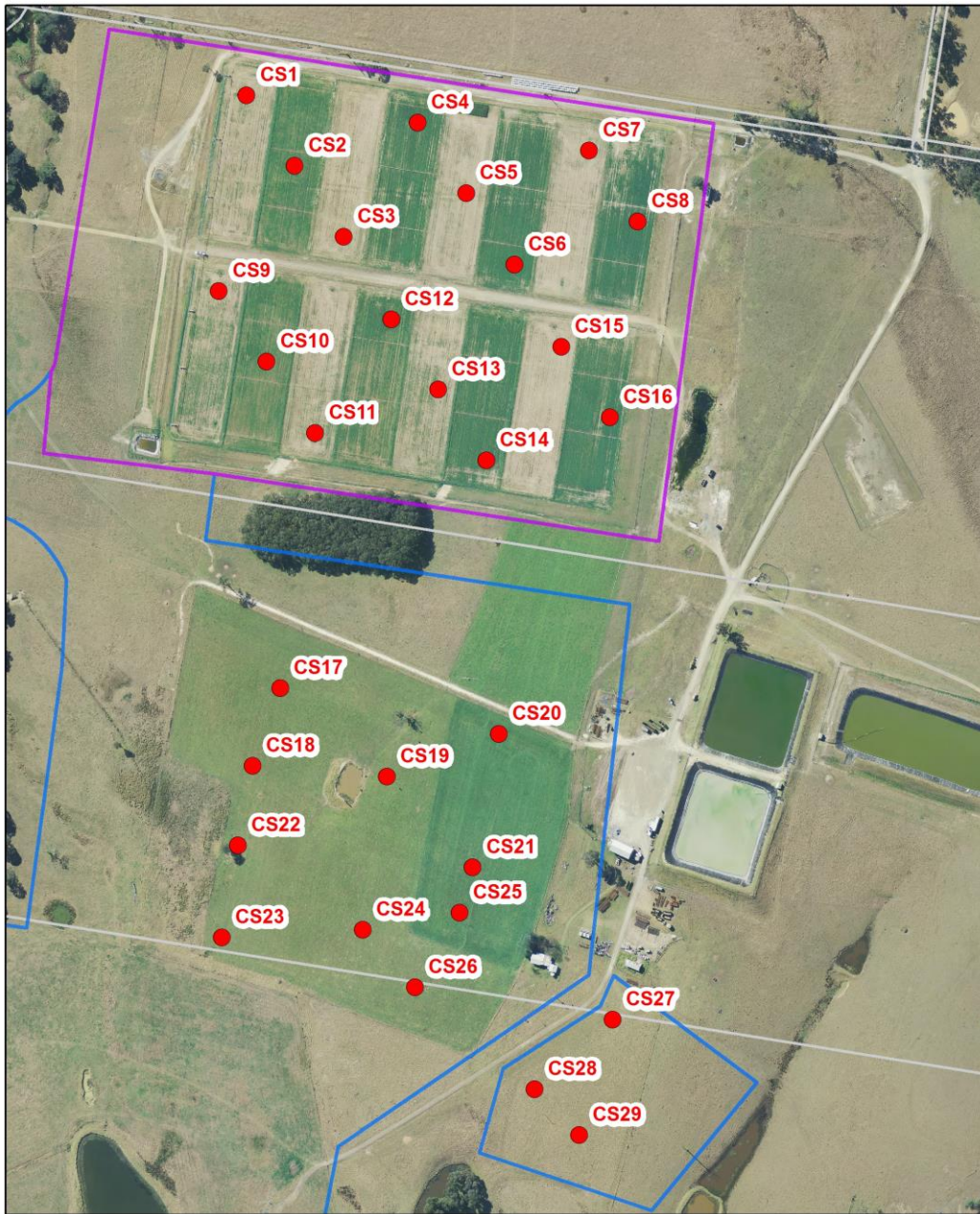


**Table 1: Soil monitoring points, Irrigation Program (as per EPL 20358)**

EPA ID no.	AGL ID	Location (Irrigation Area)	Type of monitoring point	Easting	Northing
53	CS1	Stage 1A	Soil quality	402197.4	6449446.6
54	CS2	Stage 1A	Soil quality	402238.8	6449386.7
55	CS3	Stage 1A	Soil quality	402280.6	6449326.7
56	CS4	Stage 1A	Soil quality	402343.7	6449423.3
57	CS5	Stage 1A	Soil quality	402385.2	6449363.4
58	CS6	Stage 1A	Soil quality	402426.6	6449302.9
59	CS7	Stage 1A	Soil quality	402490.2	6449399.8
60	CS8	Stage 1A	Soil quality	402531.7	6449339.6
61	CS9	Stage 1A	Soil quality	402173.9	6449280.2
62	CS10	Stage 1A	Soil quality	402214.8	6449220.5
63	CS11	Stage 1A	Soil quality	402256.4	6449160.1
64	CS12	Stage 1A	Soil quality	402321.4	6449256.5
65	CS13	Stage 1A	Soil quality	402361.5	6449197.0
66	CS14	Stage 1A	Soil quality	402402.4	6449136.6
67	CS15	Stage 1A	Soil quality	402466.6	6449233.2
68	CS16	Stage 1A	Soil quality	402508.1	6449173.2
69	CS17	Stage 1B	Soil quality	402226.4	6448943.4
70	CS18	Stage 1B	Soil quality	402202.8	6448877.5
71	CS19	Stage 1B	Soil quality	402317.4	6448868.3
72	CS20	Stage 1B	Soil quality	402413.1	6448904.5
73	CS21	Stage 1B	Soil quality	402390.9	6448791.5
74	CS23	Stage 1B	Soil quality	402176.6	6448732.1
75	CS22	Stage 1B	Soil quality	402190.3	6448810.1
76	CS24	Stage 1B	Soil quality	402297.1	6448738.4
77	CS25	Stage 1B	Soil quality	402379.8	6448753.0
78	CS26	Stage 1B	Soil quality	402341.7	6448689.7
79	CS27	Stage 1B	Soil quality	402510.5	6448662.0
80	CS28	Stage 1B	Soil quality	402443.7	6448603.1
81	CS29	Stage 1B	Soil quality	402481.8	6448564.1

Coordinate reference system: Map Grid of Australia 1994, Zone 56

# Gloucester Gas Project – Tiedman Irrigation Program Soil Monitoring Sites



	Author: Upstream Gas	<p>Kilometres 0 0.05 0.1</p> <p>Scale 1:3,000 @A3</p> <p>Geocentric Datum of Australia 1994</p>	<p><b>Legend</b></p> <ul style="list-style-type: none"> <li>● Soil Monitoring Sites</li> <li>□ Property Boundaries</li> <li>□ Irrigation Areas</li> <li>    ■ Stage 1A</li> <li>    ■ Stage 1B</li> </ul>
	Date: 02/02/2015		
	Ref: 3190r1		

Disclaimer: While AGL has taken great care and attention to ensure the accuracy of the data represented on this map, no liability shall be accepted for any errors or omissions. No part of this map may be reproduced without prior permission of AGL.

Sources: AGL Energy Limited, MapData Sciences, SKM

**Figure 1: Location of soil monitoring points: Irrigation Program (as per EPL 20358)**

**Table 2: Analytes monitored and frequency (as per EPL 20358) – monitoring points 53 – 81 (soil monitoring points)**

Analyte	Units of measure	Monitoring points		Monitoring points	
		53 - 68		69 - 81	
		Frequency	sampling method	Frequency	sampling method
<b>Aluminium</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Available phosphorus</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Boron</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Calcium</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Cation Exchange Capacity</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Chloride</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Copper</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Electrical conductivity</b>	microsiemens per metre	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Exchangeable sodium percentage</b>	percent	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Iron</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Magnesium</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Manganese</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Nitrogen (nitrate)</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Organic carbon</b>	percent	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>pH</b>	pH	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Phosphorus</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Potassium</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Sodium</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Soil texture</b>	Visible	Every 6 months	In situ	Every 6 months	In situ
<b>Sulfate</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6
<b>Zinc</b>	milligrams per kilogram	Every 6 months	Special Method 2	Every 6 months	Special Method 6

Notes:

- > Special Method 2 – Samples will be taken at 20 cm intervals down to the base of the respective treatment depth of 120 cm (or until refusal on rock). For each of the four treatments, each depth interval from each soil sample location will be sampled and analysed.
- > Special Method 6 - Samples will be taken at 20 cm intervals down to the base of the respective treatment depth of 120 cm (or until refusal on rock). A lateral composite sample will be formed from the different sample locations from the same depth profile located in the Stage 1B area and analysed.
- > Depth increments (cm below ground):
  - » 0 – 20
  - » 20 – 40
  - » 40 – 60
  - » 60 – 80
  - » 80 – 100
  - » 100 – 120

**Soil monitoring results**  
**Table 3: November 2015 soil monitoring results for monitoring points 53 - 81 (soil monitoring points)**

Analyte	Units of measure	Lowest obtainable reading	53						54						55						56						57						58					
			CS-1						CS-2						CS-3						CS-4						CS-5						CS-6					
			Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)					
			0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120
Aluminium	mg/kg	0.5	0.62	456	516	383	171	3.47	641	701	615	394	266	3.7	128	109	32	24	456	6.87	404	350	181	58.7	1.18	234	52.4	1.25	0.51	41.6	76.7	78.1						
Available phosphorus	mg/kg	1	90.2	11.2	7.3	11.1	8.8	42.8	10.2	7.5	3.5	5.2	10.1	104	139	8.9	13.7	15.8	12.3	64.3	10.8	10.4	11.9	14.7	58.8	12.2	21.1	70.6	29.7	24	19.2	8.5						
Boron	mg/kg	0.2	2.4	1.38	0.82	0.59	0.56	1.84	1.3	0.62	0.65	0.49	1.19	1.18	0.86	0.37	0.34	0.41	0.96	1.59	1.56	0.57	0.37	0.25	0.63	0.47	0.27	0.6	0.37	0.26	0.24	<0.2						
Calcium	mg/kg	20	2930	894	414	171	96.7	1320	330	135	128	90.5	72.7	923	291	142	202	189	791	1905	490	244	317	495	1640	607	375	2655	1474	963	640	168						
Cation Exchange Capacity	Cmol/kg <sup>a</sup>	na	21.6	25.5	27.9	26.2	18.4	14	23.3	24.3	26.4	25.6	25.7	10.7	14.5	15.2	13.2	12.1	19.8	17.4	19.1	19.7	17.6	14.6	14.8	15.5	16.4	23.7	22	24	24.9	23.2						
Chloride	mg/kg	5	22.7	161	221	264	184	90.5	207	218	202	177	188	34.1	106	135	77	55.5	79	37.2	123	151	127	76.8	61.5	162	135	53	123	261	366	268						
Copper	mg/kg	0.2	0.27	0.21	0.27	0.3	0.65	0.51	0.23	0.24	0.25	0.41	1.71	0.47	0.32	0.36	0.37	0.44	0.33	0.53	<0.2	0.6	0.95	0.76	0.34	0.29	0.4	0.41	0.34	0.38	0.45	0.57						
Electrical conductivity	µS/m	1000	19000	32000	31000	27000	19000	30000	33000	29000	26000	24000	25000	16000	21000	21000	11000	12000	24000	17000	23000	24000	21000	16000	21000	30000	19000	20000	29000	40000	46000	29000						
Exchangeable sodium percentage	%	na	6.87	9.73	11.2	14.5	16.9	12	12.7	12.6	14.3	15.3	16.6	11.9	12.2	13.6	14.4	15.4	8.1	7.06	10.6	91.2	61.0	46.0	163	161	101	10.3	15.7	16.6	19.9	21.8						
Iron	mg/kg	0.5	108	56.2	42.4	33.6	32.5	144	44.5	27.8	27.8	38.5	41.9	65.4	198	84.8	59.1	35.3	58.3	134	22.2	51.2	61.0	46.0	163	161	101	76.0	115	110	101	38.7						
Magnesium	mg/kg	10	620	1567	1975	2019	1510	598	1345	1492	1759	1949	2027	540	1145	1319	1164	1050	1054	735	1153	1375	1310	1108	525	830	1366	890	1292	1702	1850	1912						
Manganese	mg/kg	0.5	12.5	1.87	0.67	<0.5	0.64	8.37	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.05	<0.5	<0.5	1.33	1.54	8.11	<0.5	0.65	0.57	1.19	7.26	3.58	1.01	9.92	10.5	10.4	8.24	0.96						
Nitrogen (nitrate)	mg/kg	0.5	10.1	2.9	4	3.8	2.7	65.5	18.9	6.76	3.8	1.9	2.9	11.5	2.9	5.2	3.5	2.8	3.6	7	5.49	3	1.8	<0.5	2.3	2.9	<0.5	6.9	2.9	0.98	2.8	<0.5						
Organic carbon	%	0.05	2.56	0.73	0.48	0.27	0.11	1.41	0.55	0.38	0.33	0.21	0.21	1.4	0.38	0.23	0.14	0.18	0.77	1.68	0.49	0.24	0.14	0.2	1.48	0.83	0.33	1.68	0.92	0.98	0.59	0.14						
pH <sup>b</sup>	pH units	na	6.41	4.14	4.11	4.1	4.17	5.02	4.14	4.02	3.99	3.98	3.97	5.08	4.31	4.33	4.48	4.58	4.03	5.42	3.98	3.92	4.01	4.32	5.22	4.2	4.64	6.52	6.11	4.72	4.76	4.44						
Phosphorus	mg/kg	37	432	68.5	48.1	31.5	37.4	187	62.9	42	41.2	33.8	32.5	188	44.7	32.6	51.4	68.7	77.1	259	63.1	34.7	30.6	69.8	250	65.4	88.8	351	126	86.1	89.5	33.4						
Potassium	mg/kg	10	120	166	197	190	139	303	174	165	218	279	364	33	9.12	115	108	116	214	209	197	227	238	169	295	318	250	281	278	276	444	266						
Sodium	mg/kg	10	341	571	721	876	715	387	679	704	868	902	1098	292	406	474	438	429	370	282	467	593	507	438	403	575	527	564	794	913	1140	1161						
Soil texture <sup>c</sup>	Class	na	CL	LMC	LMC	MC	MC	CL	LMC	MC	MC	MC	MC	CL	LMC	MC	FSC	SC	CL	CL	LMC	LMC	MC	MC	CL	LMC	LMC	CL	LMC	LMC	LMC	LMC						
Sulfate	mg/kg	3	57.6	169	96.9	53.1	17.5	138	113	90.3	84.9	61.5	67.8	148	149	132	60.6	51.9	191	108	163	158	167	116	255	182	82.5	116	243	265	257	84.6						
Zinc	mg/kg	0.2	2.37	0.21	0.23	0.36	0.71	1.18	0.20	0.29	0.26	0.39	0.71	0.76	0.21	0.35	0.56	0.38	0.43	1.94	0.21	0.55	0.54	0.60	1.23	0.45	0.47	2.39	0.67	0.76	0.77	0.88						

Analyte	Units of measure	Lowest obtainable reading	59						60						61						62						63						64					
			CS-7						CS-8						CS-9						CS-10						CS-11						CS-12					
			Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)						Depth increment (cm bal)					
			0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120	0-20	20-40	40-60	60-80	80-100	100-120
Aluminium	mg/kg	0.5	<0.5	152	257	91	1.14	193	152	30.9	25.1	<0.5	180	250	160	0.9	84.3	40.5	1.5	<0.5	<0.5	8.4	10.6	<0.5	<0.5	8.4	10.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5				
Available phosphorus	mg/kg	1	120	14.4	8.9	9.8	19.6	7.3	13.9	17.3	11.4	66.4	24	16.8	13	37	22.7	11.6	7.4	9.5	82.3	11.2	7.1	6.2	184	60.9	79.5	115	60.2	39.6								
Boron	mg/kg	0.2	0.45	0.27	<0.2	<0.2	0.35	0.21	0.22	<0.2	<0.2	0.57	0.36	0.23	0.13	0.42	0.33	<0.2	<0.2	<0.2	0.46	0.38	<0.2	<0.2	1.02	0.25	0.23	0.26	0.23	0.24								
Calcium	mg/kg	20	2545	784	293	107	662	450	294	390	114	1938	863	305	132	969	626	184	148	139	1719	946	380	211	241	1826	1780	2368	2008	1719								
Cation Exchange Capacity	Cmol/kg <sup>a</sup>	na	22.5	16.2	16.6	12.2	9.02	23.6	22.3	21.1	19.1	17.7	17.3	18.3	17.1	13	15.5	17.5	21.5	20.5	14.4	26.2	28.6	21.5	23.1	24.6	24.4	24.9	25	24.5								
Chloride	mg/kg	5	81	141	146	120	51	168	220	269	201	29.2	29	121	86.5	71.5	138	287	324	283	204	122	212	150	50.5	341	335	357	309	316								
Copper	mg/kg	0.2	0.52	0.23	0.2	0.31	0.34	<0.2	0.34	0.52	0.48	0.47	0.35	<0.2	0.76	0.32	0.34	0.24	0.37	0.49	0.37	<0.2	0.29	0.49	1.3	0.30	0.55	0.77	0.37	0.84								
Electrical conductivity	µS/m	1000	28000	25000	20000	15000	13000	27000	32000	35000	33000	16000	21000	21000	15000	21000	24000	33000	38000	28000	13000	34000	28000	21000	29000	57000	58000	74000	83000	76000								
Exchangeable sodium percentage	%	na	10.7	13.2	14.3	18.9	17.6	15	15.9	19.2	22.3	8.54	12.3	11.1	13.5	15.4	16.1	19.4	21.9	22.4	6.67	12.6	11.2	14.4	13.2	12.4	12.2	11.9	13.7	14.2								
Iron	mg/kg	0.5	109	89.5	69	36.3	179	51.1	100	91.5	62.8	270	161	99.1	56.5	178	153	77.2	23.1	18.6	86.9	29.2	42.5	25	98.4	61.1	82.5	109	80.1	97.2								
Magnesium	mg/kg	10	792	942	1117	939	465	1831	1818	1715	1626	683	1080	1398	1446	999	1028	1496	1885	1798	547	2126	2756	2037	2234	1400	1434	1129	1311	1420								
Manganese	mg/kg	0.5	13	12.6	1.38	<0.5	10.4	8.86	0.95	1.36	0.58	7.14	2.74	1.6	0.64	3.51	1.52	<0.5	<0.5	<0.5	7.46	<0.5	<0.5	1.53	0.81	2.5	2.93	4.08	3.21	6.29								
Nitrogen (nitrate)	mg/kg	0.5	5.8	<0.5	<0.5	<0.5	8	3.4	1.8	4.4	2.7	7.1	4	1.6	1.7	6.2	4.64	2.6	3.2	3.4	5.1	2.8	2.1	1.8	14.4	6.1	6.0	9.1	7.4	5.7								
Organic carbon	%	0.05	1.82	0.73	0.3	0.13	1.27	0.46	0.43	0.37	0.18	2.33	0.87	0.37	0.2	1.12	0.69	0.35	0.24	0.19	1.33	0.81	0.46	0.23	3.7	0.72	0.67	0.96	0.67	0.73								
pH <sup>b</sup>	pH units	na	6.62	4.42	4.2	4.14	5.77	4.34	4.24	4.56	4.44	5.77	4.36	4.24	4.24	5.53	4.59	4.7	5.54	6.28	6.82	5.19	5.1	6.19	7.1	6.42	6.78	7.04	6.51	6.57								
Phosphorus	mg/kg	37	434	107	50.6	63	171	42.9	34.5	45.6	33	350	110	54.2	50.8	179	86.1	57.2	49.1	64.7	301	78.7	53.8	69.2	1873	211	220	260	229	247								
Potassium	mg/kg	10	471	256	552	317	108	177	253																													



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