Report

Christmas Creek Triennial Groundwater Monitoring Review

July 2013

Hydrogeology

30 July 2014

CC-RP-HY-0039

Fortescue

The New Force in Iron Ore

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	Christmas Creek Triennial Groundwater Monitoring Review **July 2013**		**CC-RP-HY-0039**
Revision Number	**2**		**30/07/2014**
Status	**IFU - ISSUED FOR USE**		
Author	Michael Carroll	Signature	30/07/2014
Checked	Paul Ricketts	Signature	30/07/2014
Approved	Bobak Willis-Jones	Signature	30/07/2014
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☒ No
Review Date	Click here to enter a date.		

Revision History *(to be completed for each version retained by Document Control)*

Author	Checker	Approver	Rev No.	Status	Issued Date
Timothy Wilkinson	**Jordin A. Barclay**	**Bobak Willis Jones**	0	**IFU**	14/10/2013
Timothy Wilkinson	**Jordin Barclay**	**Bobak Willis Jones**	1	**IFU**	6/06/2014
Michael Carroll	**Paul Ricketts**	**Bobak Willis Jones**	2	**IFU**	30/07/2014

EXECUTIVE SUMMARY

This report presents the Triennial Aquifer Review for Fortescue's Christmas Creek groundwater abstraction scheme. Groundwater abstraction at Christmas Creek is managed under Groundwater Licences (GWL) 167593(5) and the *Christmas Creek Groundwater Operating Strategy*. The reporting period for this review is from 18 December 2009 to 31 July 2013.

This document provides a summary of the groundwater abstraction, injection and monitoring data collected over the reporting period and describes groundwater system responses to both climatic events and groundwater management activities. This document has been drafted in accordance with the Department of Water guideline documents and the Christmas Creek Groundwater Operating Strategy.

Mining below water table has progressed in two mine pits spanning approximately 8km of the mineralised Marra Mamba Formation (MMF). Water quality permitting, this groundwater is used for ore processing and dust suppression. Excess brackish water has been injected to the east and west of the below water table mining area (but within the same aquifer) and saline groundwater has been injected to the Oakover Formation (OF) located between the mining area and the Fortescue Marsh. In the reporting period, some brackish groundwater was abstracted from previous brackish injection areas to supplement brackish supply for the mine site.

A total of 0.3, 0.9GL, 9.2GL, and 36.3 GL were abstracted for the 2009/2010, 2010/2011, 2011/2012 and 2012/2013 licence periods respectively. Of the total abstraction, mine site water use and injection comprised 100% and 0% respectively for 2010/2011; 78% and 22% respectively for 2011/2012; and 52% and 48% for 2012/2013.

The dewatering, injection and abstraction activities have been carried out in compliance with relevant revisions of the Christmas Creek Groundwater Operating Strategy, and have succeeded in meeting the stated objectives for each management zone. Groundwater level changes due to dewatering and injection activities follow expected trends, and there have been no impacts to the environment or other groundwater users as a result of Fortescue's operations.

Recommendations have been made for revision of Near Marsh trigger levels to align with absolute ranges for measured and inferred Near Marsh water levels.

Monitoring will continue in accordance with the Groundwater Operating Strategy during the next water year and the next quarterly monitoring summary will be issued to the Department of Water by 31 December 2013.

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1. INTRODUCTION

Groundwater data recorded from the Christmas Creek mine site (Christmas Creek) is presented for the period from the commencement of the first 5C licence for the project, 18 December 2009, to 31 July 2013 (the reporting period). This triennial aquifer review includes analysis of the data to assess the impact of groundwater abstraction from local aquifers. The review has been written in accordance with *Operating Policy no. 5.12 - Hydrogeological reporting associated with a groundwater well licence* (Department of Water, 2009).

Christmas Creek is an iron ore mine operated by Fortescue Metals Group (Fortescue) and has been in operation since April 2009. It is located in the Pilbara region of Western Australia, approximately 270 km south-east of Port Hedland and approximately 30 km east of Fortescue's Cloudbreak mine site (Cloudbreak), operational since May 2008. The location of Christmas Creek is presented in Appendix 1.

Groundwater is abstracted to facilitate the progression of mining as well as for mine site use including dust suppression, construction, camp supply and ore processing. Prior to 14 October 2011, these demands were met through supplementary groundwater abstraction and conveyance from Cloudbreak.

1.1 Licence History

1.1.1 Licence to Construct Well (26D)

A summary of 26D licences, and the number of bores constructed against each are summarised in Table 1. Site wide dewatering and injection bores are currently being drilled under 26D Licence CAW175334 (1).

1.1.2 Licence to Abstract Water (5C)

Groundwater abstraction at Christmas Creek is governed by GWL167593, issued by the DoW in accordance with the *Rights in water and irrigation act 1914* (Government of Western Australia, 2010). There have been four revisions of the licence issued (see Table 2) during the reporting period due to adjustments of the abstraction and water use requirements of the site.

Abstraction for dewatering purposes has only been licenced since 11 September 2011 (GWL167593 (2)). Copies of the licence revisions are presented in Appendix 2.

Table 1: Summary of 26D licences during reporting period

Instrument No	Issue Date	Expiry Date	No. of Bores	Purpose
CAW169550(1)	30/07/2009	30/07/2010	52	Site Wide injection and abstraction bores
CAW171574(1)	09/06/2010	08/06/2011	110	Site Wide injection and abstraction bores
CAW173614(1)	23/05/2011	22/05/2013	110	Site Wide injection and abstraction bores
CAW175334(1)	04/04/2012	03/04/2014	227	Site Wide injection and abstraction bores

Table 2: Summary of 5C licences during reporting period

Instrument No.	Water Resource	Duration of Licence	Annual Water Entitlement	Water Use	Licence Operational within Reporting Period
GWL167593(1)	Pilbara – Hamersley Fractured Rock	18 Dec 09 - 31 Jul 11	1,150,000 kL	• Dust suppression for earthworks and construction purposes. • Earthworks and construction purposes. • General campsite purposes. • Railway construction and maintenance.	18 Dec 09- 12 May 11
GWL167593(2)*	Pilbara – Hamersley Fractured Rock	12 May 11 - 11 May 13	1,150,000 kL	• Dust suppression for earthworks and construction purposes. • Earthworks and construction purposes. • General campsite purposes. • Railway construction and maintenance.	12 May 11 - 10 Sep 11
GWL167593(3)	Pilbara – Hamersley Fractured Rock	11 Sep 11 – 20 Sep 12	18,000,000 kL	• Dewatering for mining purposes. • Dust suppression for earthworks and construction purposes. • Earthworks and construction purposes. • General campsite purposes. • Mineral ore processing and mining purposes. • Railway construction and maintenance.	11 Sep 11 – 08 Feb 12
GWL167593(4)	Pilbara – Hamersley Fractured Rock	09 Feb 12 – 08 Feb 13	23,000,000 kL		09 Feb 12 – 11 Jul 12
GWL167593(5)	Pilbara – Hamersley Fractured Rock	12 Jul 12 – 11 Jul 13[1]	48,000,000 kL		12 Jul 12 – 30 Jul 13

**continued to be active until 21 September 2011*

[1] GWL167593(5) renewal submitted prior to expiry on 11th July 2013. Licence currently under review by DoW and will continue to be utilised until a decision is made.

2. CHRISTMAS CREEK WATER MANAGEMENT SCHEME SUMMARY

Groundwater is abstracted from dewatering borefields to enable dry pits, to provide water for mine dust suppression, ore processing, civil works and potable water supply for the Mine Village. Excess groundwater abstracted from the dewatering operation is injected into suitable aquifers (managed aquifer recharge (MAR)), in accordance with the *Operational Policy 1.01 Managed Aquifer Recharge in Western Australia* (DoW, 2011).

A high level description of the system is provided below with locations shown in Appendix 3. Water infrastructure has been and will be developed to meet the needs of the business, the environment and stakeholders whilst aiming to maximise flexibility in operations. Planned expansion of the dewatering and injection system over the next 12-18 months is outlined in the Christmas Creek Water Management Scheme (FMG, 2013a).

2.1 Dewatering System

The dewatering system includes up to three water streams: the brackish, the saline and sump water. Separate systems exist for both brackish and saline dewatering systems. Dewatering bores and interconnecting pipelines are located along mine pit perimeters and in some cases within mine pits.

2.2 Disposal System

The disposal system is designed to move water across the site from areas of abstraction (dewatering system) to areas of injection. Water is conveyed through separate brackish, saline and sump pipelines via ponds.

2.2.1 Transfer and Settlement Ponds

Transfer ponds and settlement ponds consist of water storage facilities for the purpose of facilitating bulk flow transfer and/or settlement of suspended material. Separate facilities exist for handling of brackish, saline and sump water.

2.2.2 Bulk Flow and Conveyance Pipelines

Pipeline sizes and routes have been designed to:

- optimise hydraulic performance in combination with pump duties
- meet connectivity requirements
- comply with relevant regulatory approvals and licence requirements.

2.2.3 Injection System

Excess groundwater abstracted from the dewatering operation is returned to compatible aquifers by injection methods in accordance with the DoW's Managed Aquifer Recharge policy (DoW, 2011). Injection systems consist of networks of injection bores and interconnected pipelines. Water is injected to the bore via a downhole flow control valve, which eliminates air from entering the bore.

Brackish Injection

Managed aquifer recharge is undertaken with brackish water in areas east and west of the active mining area and typically targets the mineralised MMF. Brackish injection occurs at two separate borefields:

- Spinifex Pigeon
- Hillside East.

The Spinifex Pigeon (Spinifex) injection borefield is located to the west of the Mine and covers a distance of approximately 1.5 km. The Hillside East borefield is located to the west of the Mine and covers a distance of approximately 9 km.

Saline Injection

Saline injection commenced in July 2012 into the Oakover Formation, between the southern limit of the resource area and the northern limit of the Fortescue Marsh. The injection borefield spans approximately 30 km east – west and is located roughly halfway between the active mine site and the perimeter of the Fortescue Marsh. The borefield was first operated as gravity fed and gradually retrofitted to pressurised injection. Pressurised injection flow into individual units is regulated by the pressure in the Oakover Formation (measured in adjacent piezometer approximately 50 m away) and the system adjusts flow so that the local piezometric head does not mound above 2 m bgl.

At each injection location there is generally a flow meter and a down-hole water level sensor. The down-hole and flow sensors can be supplemented by regular visual inspections of the pipework and fittings and manual recordings of meter readings.

2.3 Water Supply System

Brackish water abstracted from active dewatering, brackish managed aquifer recharge areas and future mining areas are supplied to the mine for ore processing, dust suppression and potable supply purposes.

Ore Processing and Tailings

A bulk flow conveyance line delivers water to process water ponds adjacent to the OPF for use in ore processing operations. The transfer ponds receive raw water from the brackish conveyance system and from the tails decant water.

Supernatant water from tailings is collected using decant systems such as decant towers and returned to the system via water infrastructure for reuse across the site.

Dust Suppression

For dust suppression, water cart fill points are maintained across the mine area. These systems are supplied by the water conveyance system. A pump and standpipe assembly is used to fill the water trucks.

Potable Supply System

Potable water is made available to the two camps at Christmas Creek, and in the mine administrative building.

Potable water supply is sourced from four bores in proximity to the camp; CCCP01, CCCP02, CCCAP03 and CCCAP04. Abstracted water is treated at the camp RO plant, stored and fed to the camps and mine buildings via an independent distribution network.

3. CLIMATE AND RAINFALL

The climate of the Pilbara is arid tropical, characterised by low and variable rainfall, high daily temperatures, high diurnal temperature variability and high evaporation rates. Summer months extend from October to April, when maximum daily temperatures can exceed 35°C. The winter months extend from May to September, with temperatures ranging from approximately 7°C to 23°C. Average annual rainfall is approximately 300 mm at nearby Newman and is characterised by frequent, low-intensity events related to localised thunderstorms. Variability in annual rainfall is influenced by tropical cyclone systems which occasionally develop between December and April.

Rainfall measurement was initiated at Cloudbreak prior to 2008 and at Christmas Creek in 2011, although there have been periods without record at each site. Figure 1 displays the monthly rainfall totals and cumulative annual rainfall (by water year), averaged for all the Fortescue rain gauges across the Chichester Range. This is considered the most complete record for the combined operational area. The data illustrates the annual variation discussed above, with annual rainfall varying between 180 mm and 720 mm for the data on record. The final three years of the reporting period have had well above the regional average rainfall, with an average of almost 600 mm per year. The following major events occurred within the reporting period:

- 28 Feb 2009, unnamed tropical low,105 mm in 24 hours;
- 11 to 17 Feb 2011, low pressure system, 103 mm in 7 days;
- 09 to 15 Jan 2012, Tropical Cyclone Heidi, 410 mm in 7 days, including 170 mm in a 24 period; and
- 26 Feb to 01 Mar 2013, Tropical Cyclone Rusty, 109 mm in 4 days

Total annual rainfall, a 5 year moving average, and a cumulative deviation from the mean plot for the Bureau of Meteorology's Bonney Downs station are shown in Figure 2. These data show the rainfall pattern in Figure 1 is part of a period of higher than average rainfall occurring since 1995, with peak rainfall occurring in 2000 and 2002. This period was preceded by 15 years of near average rainfall and a longer term drying trend which commenced at the start of the data record in 1909. This assessment is consistent with the findings of the CSIRO report into Pilbara climate (Charles, et al., 2013).

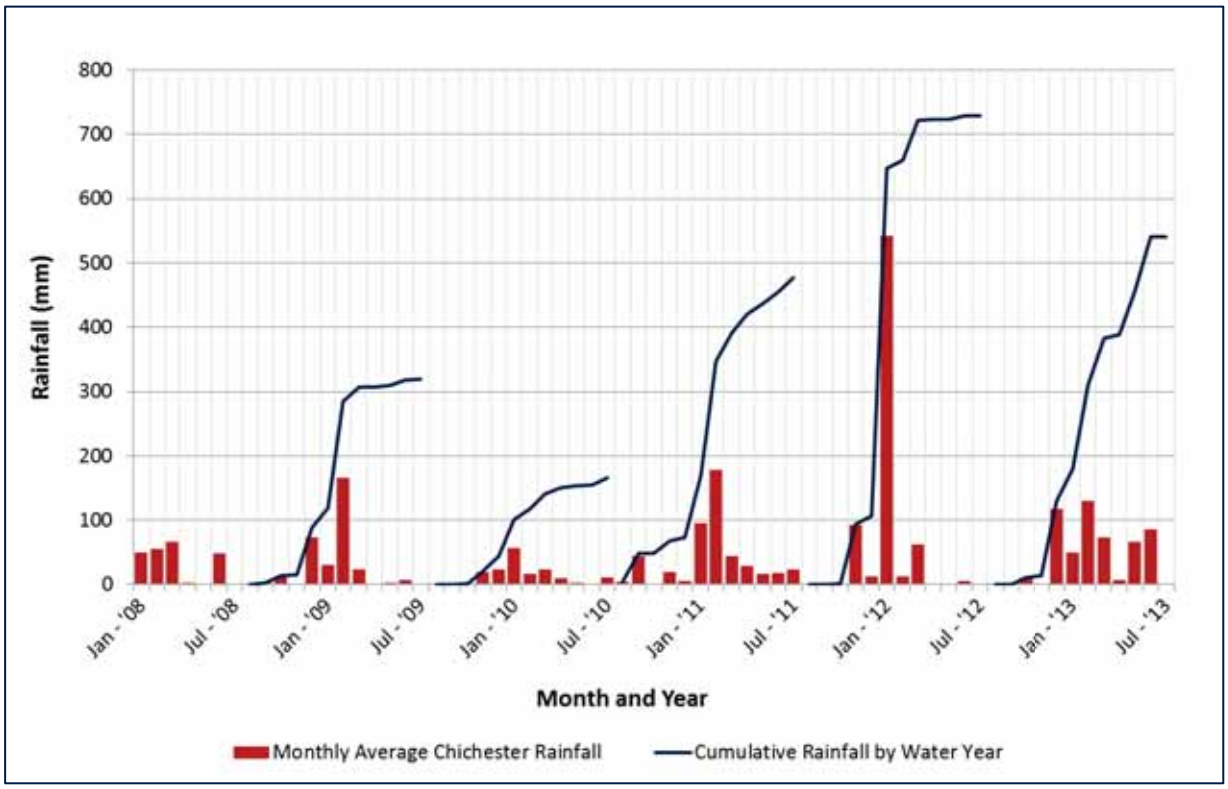

Figure 1: Annual rainfall measured at Fortescue's Chichester Range gauges

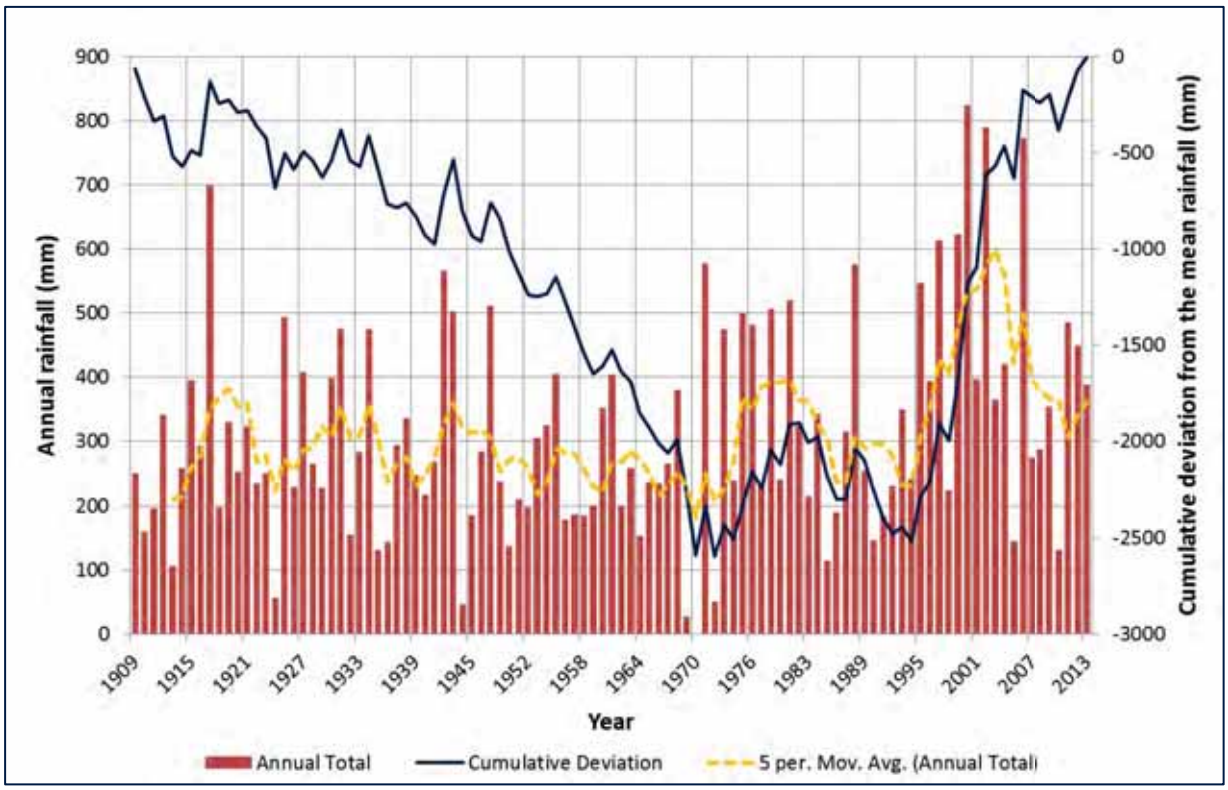

Figure 2: Long term regional rainfall and cumulative deviation from the mean from Bonney Downs (BoM station 4006)

4. PHYSICAL ENVIRONMENT

The following sections describe key aspects of the regional and local physical environment: physiography, hydrology, geology and hydrogeology. This information provides a basis for the conceptual hydrogeological model against which the groundwater monitoring data has been reviewed.

4.1 Physiography

The eastern Pilbara regional topography is dominated by the Hamersley Plateau in the south and the Chichester Ranges in the north with the two features separated by the Fortescue Valley. The Fortescue Marsh forms an extensive intermittent wetland on the valley floor. The eastern section of the Chichester Range immediately adjacent to the Christmas Creek operation mine occupies an area about 100 km long by typically 10 km wide, at an elevation of around 400 to 405 m Australian height datum (AHD). Between the raised relief of the Chichester ranges and the Fortescue Marsh Basin a transitional zone exists, characterised by fluvial deposition and formation of a series of alluvial fans, which for the most part overlie the Christmas Creek mine mineralisation.

Christmas Creek has an elevation range of around 415 to 480 mAHD, which is well above any potential flood storage level in the Fortescue marsh. Topographic mapping indicates that there are no springs or pools located in the project area.

4.2 Hydrology

The regional and local hydrology, in particular with respect to controls on the Fortescue Marsh and associated groundwater regime, is a highly dynamic seasonally variable system with the ability to cause significant and rapid fluctuations in shallow groundwater observations. Flooding events have been noted to have significantly more influence on shallow groundwater levels adjacent to the Fortescue Marsh than either dewatering or injection activities.

4.2.1 Regional Hydrology

The Goodiadarrie Hills, about 60 km east from the town of Wittenoom, effectively cut the Fortescue River into two separate river systems. West from the Goodiadarrie Hills, the Lower Fortescue River Catchment drains to the coast, whereas east from the hills the endorheic Fortescue Marsh receives drainage from the upper Fortescue River catchment. The alluvial outwash fan from the Weeli Wolli Creek system abutting the Goodiadarrie Hills is believed to be partially responsible for obstructing the Fortescue River and forming the Fortescue Marsh.

The Fortescue Marsh forms an extensive intermittent wetland (located on the floor of the Fortescue Valley) occupying an area around 100 km long by typically 10 km wide. The Fortescue Marsh is listed in the directory of Important Wetlands (Env, 2001) and is listed by the

Department of Environment and Regulation (DER) as a Priority 1 Ecological Community. The Fortescue Marsh has an elevation of around 400 m AHD.

Following significant rainfall events, runoff from the upper Fortescue River catchment (approximately 31,000 km^2) drains to the Fortescue Marsh. Rainfall runoff drains down gradient concentrating in defined flow channels. In this process, surface retention, vegetation, infiltration and other mechanisms absorb water from the runoff stream. In steep areas, the runoff processes are rapid with relatively low losses, and defined drainage channels are typically in close proximity. In the lower slope areas, the runoff processes are slow with relatively higher losses and greater distances between defined drainage channels.

Where defined drainage channels from the steeper slopes enter the lower slope areas, the channels typically have a reduced discharge capacity and in many instances become less defined, braided, or may even completely disperse in flat areas. In these reducing slope channels, runoff tends to overspill the main channel flow zones and spread over a wider front. In some of the lower slope areas, vegetation communities (scrub and Mulga woodlands) have developed. These are dependent on seepage water provided by the overland flow process. In these areas, the overland flow process has been termed sheet-flow. Conversely, the Fortescue River, Weeli Wolli Creek, and other main channels entering the Marsh typically support Eucalyptus woodlands on their banks and floodplains.

For the smaller runoff events, isolated pools form on the Marsh at the main drainage inlets, whereas for the larger events the whole marsh area may flood. Following a significant event that floods the whole marsh area, the ponded water may be over 4 m deep in the lower elevation marsh areas.

Water stored on the Fortescue Marsh slowly dissipates through the processes of infiltration and evaporation. During the evaporation process, the water salinity levels increase and as the ponded areas recede, traces of surface salt can be seen. During the infiltration process, as the ponds evaporate, increasingly more saline water is believed to seep into the valley floor alluvial deposits.

4.2.2 Local Hydrology

Rainfall runoff from the Chichester Range flows in a southerly direction towards the Fortescue Marsh. Surface water flows at the Chichester Operations have previously been characterised as one of several modes (Worley Parsons, 2012a), summarised as follows:

- Hillslope Runoff: Majority of runoff contained within small creeks, broad swales or gullies. Naturally, flows are generally convergent which concentrate flows, increases velocities, promotes scour and enhances channel formation.
- Channel Flow: Associated with large catchments that predominantly drain the steep areas of the Chichester Range. Large convergent flows, high velocities and large, well defined channels are typical of these creeks. Smaller, more frequent flows are mostly confined to the channel while larger and less frequent flood flows break out onto the

adjacent floodplain. Channels are usually devoid of vegetation due to bed load movement during flood events. Vegetation on the adjacent floodplains is maintained either by periodic inundation or has rooting depths sufficient to access the superficial fresh aquifer replenished by more frequent smaller flows.

- Diverging Flow: Channel flow becomes dispersed, leading to a loss of channel form. The transition from channel flow to diverging flow normally occurs on the low relief terrain after large rivers have discharged from the Chichester Ranges. Banded grove-intergrove vegetation patterns typical of sheet flow areas are not normally found downstream of areas where diverging flows intersect with sheet flow zones. Sheet flow zones form in 'fan' like terrain.
- Sheet flow. Sheet flow zones form in areas where overland flow moves down slope while maintaining a broad shallow front. This is the initial hillslope response to infiltration excess prior to channel initiation. The banded Mulga (*Acacia aneura*) formations common throughout the study area are part of an ecological response to the sheet flow patterns.

Some areas, including those closer to the fringe of the Marsh, may exhibit one or more of these characteristics. The Christmas Creek mining footprint is typically located in the channel flow and diverging flow zone, with injection activities towards the Sheetflow zone.

4.2.3 Fortescue Marsh Surface Water Balance

In June 2012 Worley Parsons prepared the Fortescue Marsh Catchment Water Balance Study (Worley Parsons, 2012b). As part of this study a water balance model was constructed to assess:

- Rainfall directly on the water surface of the Fortescue Marsh
- Runoff inflows to the Fortescue Marsh
- Evaporation losses from the water surface of the Fortescue Marsh.

The water balance model was run for the period from 1/12/1984 to 30/04/2011 for the natural pre-development scenario with no mines at Cloudbreak, Christmas Creek or Roy Hill and with the remainder of the catchment in current conditions in place. Figure 3, shows the annual volume of water entering the Fortescue Marsh for this scenario. Total annual flows into the Fortescue Marsh have been predicted to range between <50 GL/a to 1400 GL/a depending on climatic variation (Worley Parsons, 2012b).

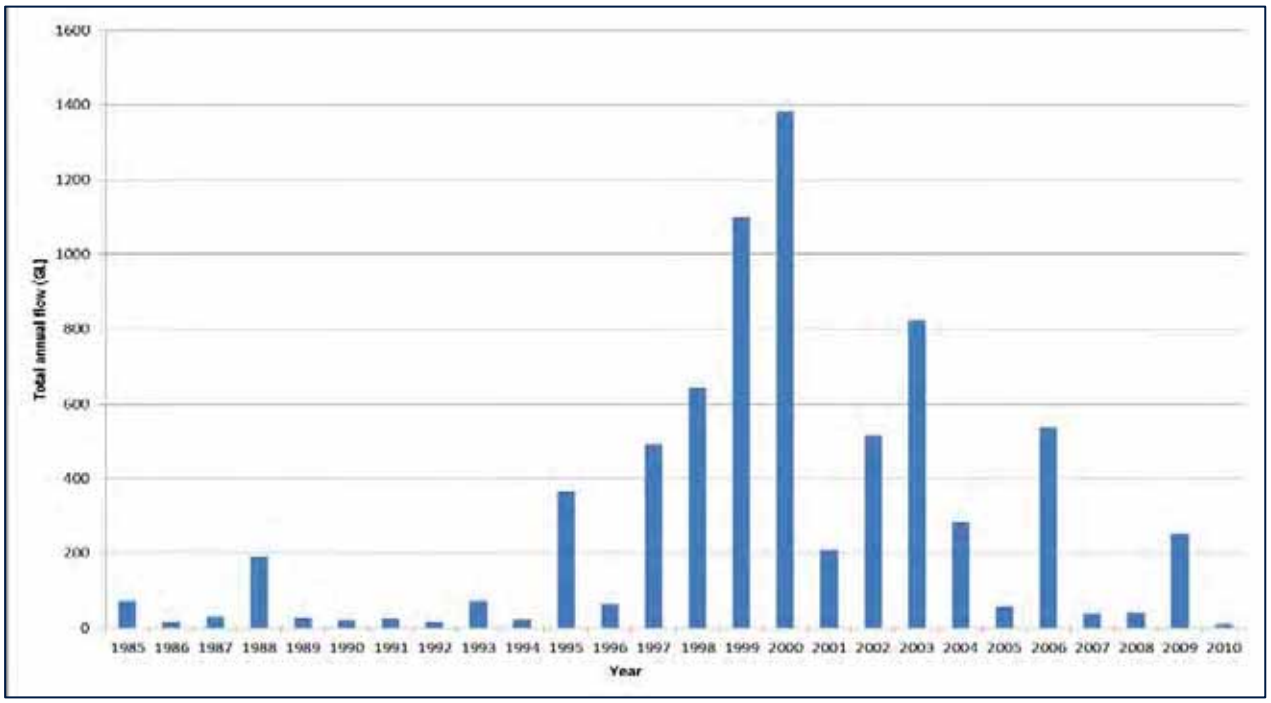

Figure 3: Fortescue Marsh – Water Balance Model results (1985-2010)

4.3 Geology

The Christmas Creek deposits lie within the Hamersley Basin where sedimentary groups overlie the granitoid rocks of the Archean Pilbara Craton. The Pilbara Craton granitoid rocks are overlain by the Archean Fortescue Group, which is overlain by the Archean-Proterozoic Hamersley Group. Table 3 summarises the following description of the geological sequence relevant to the Chichester Ranges.

Mineralisation at Christmas Creek is confined to the Marra Mamba Formation (MMF), the lowermost formation of the Hamersley Group, which occurs along the strike of the Chichester Range. Christmas Creek mineralisation occurs in the Nammuldi Member; lowermost member of the MMF. Underlying the MMF is the Roy Hill Shale Member (RHS) of the Jeerinah Formation, the uppermost formation of the Fortescue Group.

The Wittenoom Formation (WF) overlies the MMF; however, the WF is only present south of the resource area, towards the Fortescue Marsh. On the lower slopes of the Chichester Range, outcropping MMF is partially concealed by colluvial deposits. Further south, the MMF (and even further south the WF) is overlain by a sequence of Quaternary and Tertiary deposits. This sequence comprises highly variable valley fill materials (Lower Tertiary Detritals, LTD) underlying an extensive calcrete deposit termed the Oakover Formation (OF). Overlying the OF is a lacustrine clay deposit (Tertiary Clay, TC) which is in turn overlain by an upper detrital unit and mixed alluvium/colluvium, collectively termed the Upper Tertiary Detrital (UTD).

4.4 Hydrogeology

A summary of the regional and local hydrogeology is presented in this following section. A more comprehensive assessment and interpretation of available data is presented as part of the Christmas Creek LOM hydrogeological assessment (FMG, 2013a).

Groundwater flow in the Christmas Creek area is strongly controlled by stratigraphy, topography, density, mineralisation and structure. Aspects of the hydrogeology, including; hydraulic characteristics, groundwater recharge, through flow, storage, discharge and quality are summarised below. A conceptual hydrogeological cross section is provided in Figure 4.

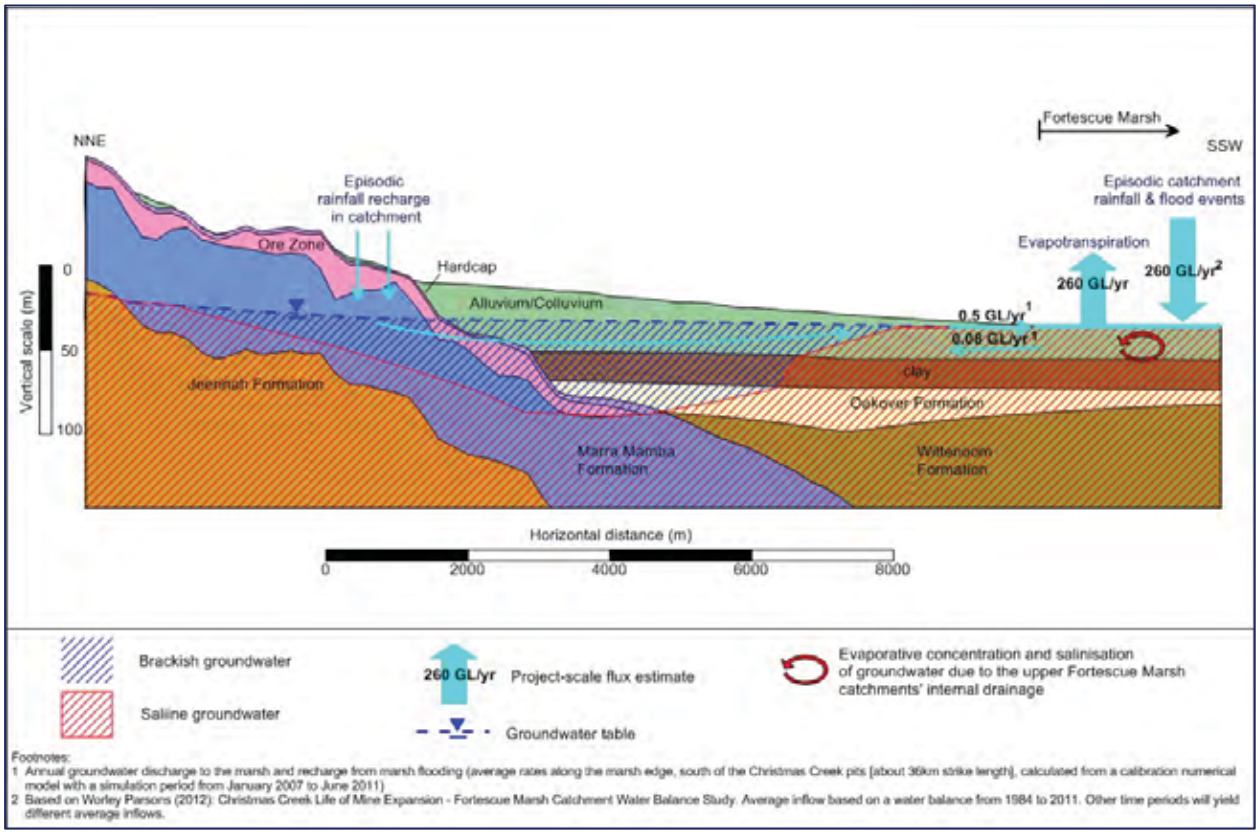

Figure 4: Christmas Creek Hydrogeological Cross Section

4.4.1 Regional Hydrogeology

In a regional sense, groundwater movement within the Christmas Creek area is driven by rainfall recharge on the elevated flanks of the Fortescue Valley and surrounding plateau. The topographically driven groundwater moves southwards towards the valley. Southward flow of the topographically driven fresh groundwater is opposed by a northward pressure gradient associated with density driven saline groundwater. This saline groundwater has evolved through evapo-concentration and outward convection beneath the Fortescue Marsh. As a result, a saline interface develops with fresh/brackish water overlying saline/hypersaline water.

Groundwater flow in the Fortescue Valley and Chichester Range is strongly controlled by local scale and regional scale stratigraphy and topography and is often enhanced along faults and discontinuities. While variable, aquifer units and hydraulic properties can generally be ascribed to coincident stratigraphic horizons. The hydrostratigraphic units typically encountered in the Fortescue Valley and Chichester Range, and their relationship to the geology described in section 4.3, are included in Table 3.

Recharge in the Chichester Range occurs via episodic rainfall infiltration over outcrop regions of MMF, RHS and UTD. The general recharge component is estimated to be about three percent of rainfall but this will vary depending on the intensity and duration of the rainfall events and season.

Groundwater discharge from topographically driven flow (in both the UTD and MMF systems) is low, due to the strong pressure gradient associated with hypersaline groundwater beneath the Fortescue Marsh impeding flow into this regime. Additionally, low hydraulic connection between topographic discharge areas and underlying aquifers impedes discharge. The MMF aquifer becomes increasingly confined down-dip (southwards) and, therefore, the potential discharge via leakage through the overlying Tertiary sediments are expected to be limited by the low vertical permeability of clay zones in those sediments. Leakage through the Tertiary sediments is likely removed from the system by evapo-transpirational processes.

4.4.2 Local Hydrogeology

A local hydrogeological; cross section from water bore drilling at Christmas Creek has been drawn along the section line presented on Figure 5. The section takes in the dewatering area around Flinders pit area in the north, the saline injection borefield in the centre and the northern edge of the Fortescue Marsh to the south. Key features of the hydrogeological cross section are described below, and summarised in Table 3. Water levels represent water level conditions at April 2013 and are not corrected to a fresh water equivalent level.

Hydrostratigraphy

- The shale dominated lithology of the RHS results in relatively low permeability conditions. The shale is likely anisotropic, with low vertical permeability relative to the horizontal permeability. Fault systems and lithological variation can create zones of enhanced permeability.

- Mineralisation of the MMF forms a laterally extensive aquifer along strike of the Chichester Range. This ore body is characterised by high permeability and high storage properties related to secondary alteration. Below the orebody the occurrence of high permeability is constrained to discrete fracture zones. The MMF is unsaturated to the north where the aquifer outcrops on the flanks of the Chichester Range and dips southward where diminishing mineralisation corresponds with less secondary alteration at around 4 to 8 km north of the Fortescue Marsh.

- The WF occurs to the south of Christmas Creek, subcropping at a depth of approximately 60 - 80 m. Drilling results indicate the WF consists of crystalline dolomite, with no evidence of the karstic conditions found in regional investigations to the south of the Marsh. Groundwater in the WF is considered to be a function of secondary permeability associated with fractures and limited weathering profiles.

- The MMF and the WF are unconformably overlain by a sequence of Tertiary colluvial, alluvial and chemical sediments that thicken towards the south.

    - The presence of the LTD in the Christmas Creek area has only recently been identified from drilling results. It is conceptualised as a highly variable aquifer, consisting of goethitic colluvium and isolated channelized deposits along palaeodrainage features and topographical depressions in the upper surface of the MMF and WF.

    - The OF consists of calcrete and silcrete with high permeability and storage through the development of interconnected voids. It is a sub-horizontal chemical deposit, onlapping and pinching out against the Chichester Range immediately to the south of the mining area. Drilling data suggests a more clay rich facies to the OF as it thins in the north.

    - The TC aquitard overlies the OF, creating confining conditions in the OF. It consists primarily of clay and silt, with the proportion of coarser grains increasing in proximity to the hillslopes where the clay until is considered to pinch out.

    - Silts, sands and gravels of the UTD are generally of low permeability, with the exception of creek bed material and isolated palaeodrainage features. It is therefore not considered a major aquifer but may be potentially environmentally important as a source of water supply for vegetation uptake.

Groundwater Flow and Connectivity

Groundwater flow conditions in the Christmas Creek area is consistent with the regional description provided in section 4.2.1, and is a function of the connectivity of hydrostratigraphic units, hydraulic gradients (both topographic and density driven) and aquifer properties. Operations at Christmas Creek have also modified hydraulic gradients through abstraction and injection. Analysis of changes to the groundwater flow regime is a key objective of this triennial report, and is discussed in more detail through sections 0, 10, and 12. A local overview of groundwater flow and connectivity prior to mining activity is presented here:

- Through-flow from the RHS to the MMF is generally thought to be low, due to the low vertical (across bedding) hydraulic conductivity of the RHS and potential impedance by less mineralised basal conditions of the MMF. However, the flux may be locally enhanced along (SW-NE) cross cutting fault zones which have enhanced transmissivity.
- Groundwater flow within the MMF is greatest in the direction of dip and along strike, following bedding planes. Connectivity with overlying units is naturally limited, apart from

fault zones, areas where mineralisation extends to the surface of the MMF or where incision of the bedrock surface has taken place.

- Groundwater flow within the WF is considered to be limited to any upper weathering profile and fracture zones. There is likely to be a direct connection with overlying units (OF and LTD) and natural throughflow will be a function of density gradients.
- Although not indicated in Figure 6, the LTD is possibly connected to the MMF where deep incision has occurred, although these occurrences have not been mapped from drilling data. The LTD is considered to be in direct connection with the OF, and groundwater exchange may occur depending on the balance of density driven and topographic gradients.
- The OF is confined by the overlying TC, and northwards groundwater flow is limited by southwards topographic flow and decreasing aquifer transmissivity to the north. Drilling data has not indicated southerly limits to the OF, and the unit is conceptually considered to occur beneath and to the south of the Marsh.

Recharge and Discharge

Local recharge and discharge reflects the regional patterns described in section 4.2.1. Groundwater model calibration suggests that the average annual catchment recharge to the Chichester Range and flanking areas is approximately 8 GL/a. Periodic ponding of water on the Fortescue Marsh imposes a hydraulic head on the regional groundwater regime.

Table 3: Cloudbreak Hydrostratigraphy

Formation							Aquifer			
Age	Supergroup	Group & Division[1]		Name	Thickness	Lithology	Name	Type	Groundwater quality	Bore yield
Cenozoic	n/a	Tertiary and Quaternary Sequence	TD3	Tertiary Alluvium	10-40 m	Poorly-sorted, angular to sub-angular, polymictic gravel of chert, goethite and hematite in a silt or clay matrix; predominantly brown. Lower	Upper Tertiary Detritals (UTD)	Unconsolidated sedimentary	Fresh[2] to brackish[3] (although saline[4] to hypersaline[5] near the Fortescue Marsh).	Up to 900 kL/day
				Upper Detritals	Up to 15 m	Goethite and maghemite pisoids and ooids in a clay matrix; predominantly brown.				
			TD2	Tertiary Clay	Up to 30 m	Clay stained brown, red, white or yellow.	Tertiary Clay (TC)	n/a	n/a	n/a
				Oakover Formation	Up to 40 m	Calcrete; predominantly grey or white; characterised by secondary porosity developed through partial dissolution of calcrete via percolating surface water and moving groundwater.	Oakover Formation (OF)	Chemically deposited	Saline to hypersaline.	Up to 5,000 kL/day
			TD1	Lower Detritals	Up to 100 m	Highly variable but mainly goethite and maghemite pisoids and ooids in a clay matrix; predominantly brown.	Lower Tertiary Detritals (LTD)	Unconsolidated sedimentary	Saline to hypersaline.	unknown
UNCONFORMITY										
Early Proterozoic	Mount Bruce Supergroup	Hamersley Group		Wittenoom Formation	Up to 10 m has been observed but it may be thicker	Dolomite with goethite and hematite alteration and chert inclusions; predominantly grey.	Wittenoom Formation (WF)	Fractured-rock	Fresh to hypersaline (salinity increasing with proximity to Fortescue Marsh).	Up to 2,500 kL/day
				Marra Mamba Formation	Up to 50 m	Only the lowermost member (Nammuldi Member) has been observed. Interbedded goethite, hematite and chert with minor magnetite, maghemite and jaspilite; predominantly grey, mustard yellow, and dark purple.	Marra Mamba Formation (MMF)	Fractured-rock[6]	Fresh to hypersaline (salinity increasing with proximity to Fortescue Marsh).	Up to 2,500 kL/day
		Fortescue Group		Jeerinah Formation	Up to 40 m has been observed but it may be thicker	Only the uppermost member (Roy Hill Shale Member) has been observed. Soft, carbonaceous shale; dark grey to black.	Roy Hill Shale (RHS)	Inferred to be fractured-rock	Fresh to hypersaline (salinity increasing with proximity to Fortescue Marsh).	n/a

[1]After Kepert (2001); [2]Fresh ≤ 800 µS/cm; [3]brackish = 800 – 50,000 µS/cm; [4]saline = 50,000 – 80,000 µS/cm; [5]hypersaline ≥ 80,000 µS/cm; [6]With further secondary porosity due to alteration processes.

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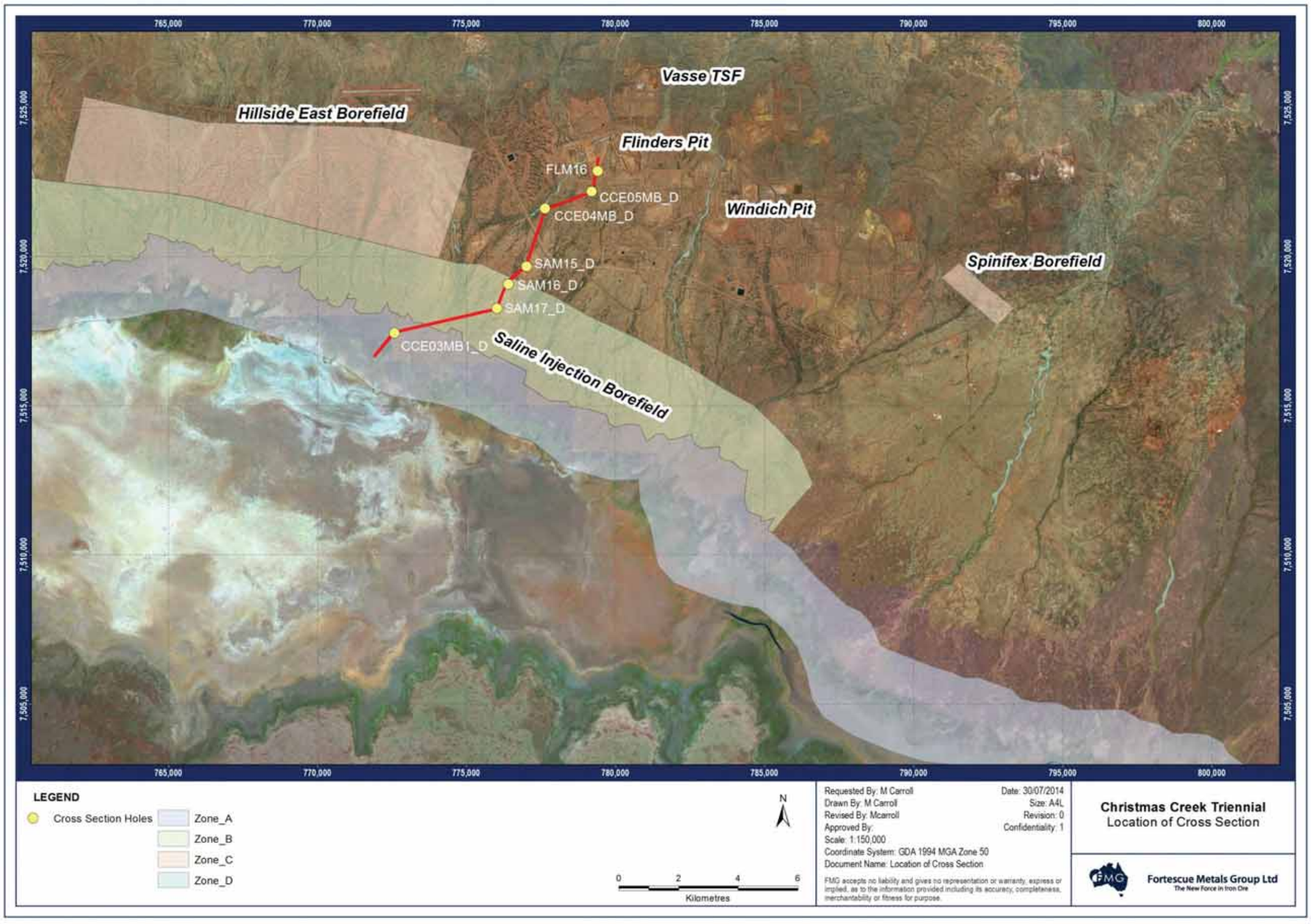

Figure 5: **Location of cross section trace**

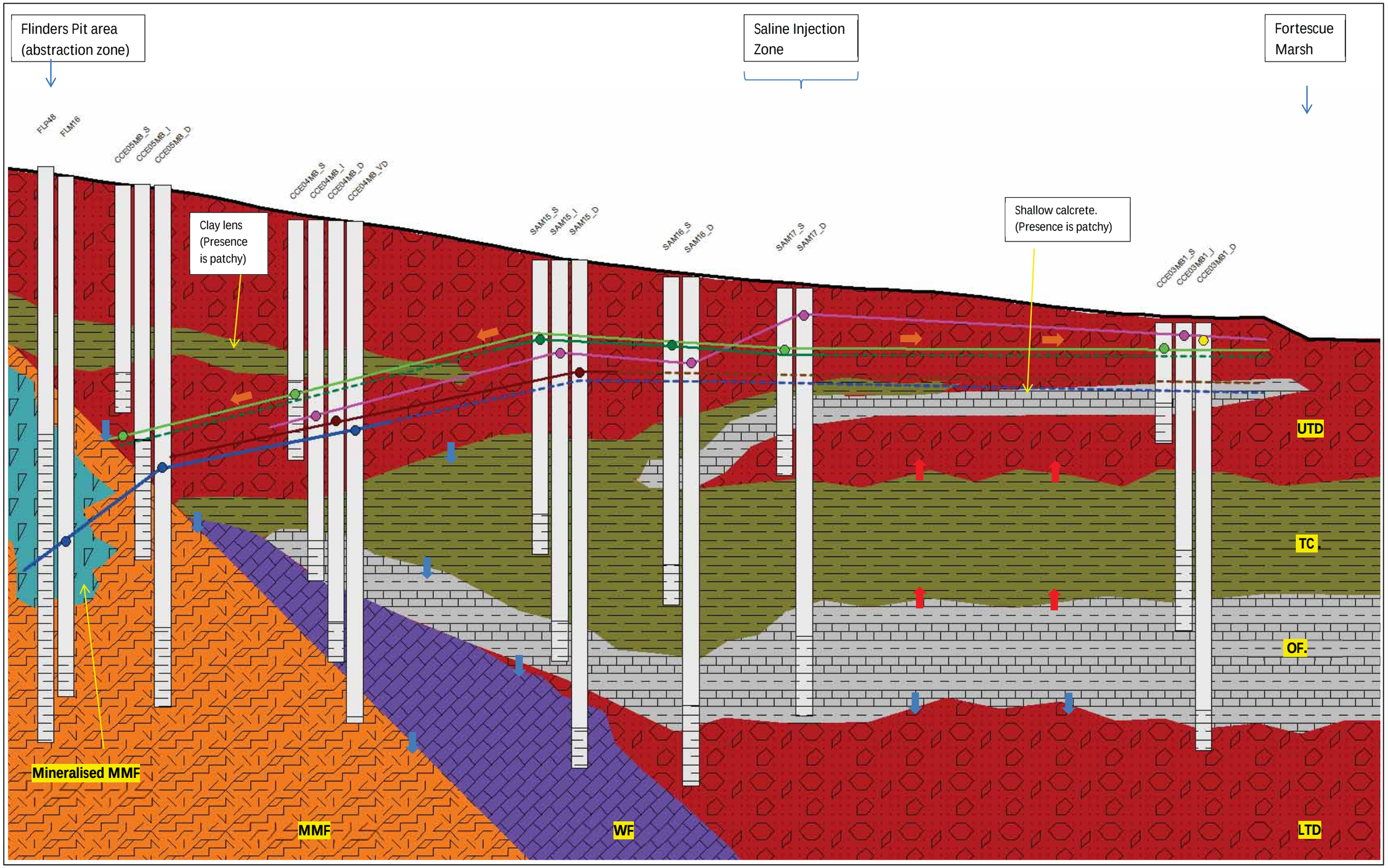

Figure 6: Christmas Creek Hydrogeological Cross section

5. BOREFIELD DESCRIPTION

The Christmas Creek borefield is comprised of monitoring, production, saline and brackish injection bores. Before the operation began a groundwater exploration program was conducted. This program consisted of a number of production and monitoring bores constructed across the future mine area and also in regional locations. The Hillside east brackish injection area was utilised by Cloudbreak to dispose of the initial surplus in brackish water prior to abstraction beginning at Christmas Creek (April 2011). The quantity of each type of bore and local location is presented in Table 4. A map showing the locations of active abstraction bores is presented in Appendix 4; a map showing the locations of active injection bores is presented in Appendix 5; and a map showing the locations of active monitoring bores is presented in Appendix 6, with trigger bores highlighted.

Details of bores at Christmas Creek have been provided to the DoW in the form of standard Bore Completion Reports. New monitoring and abstraction bores at Young and Cathedral pit area are yet to be reported (bores were drilled outside the reporting period). The Bore Completion Reports include full construction details, including screened intervals, aquifer test and groundwater chemistry results. The FMG document numbers for each of the Bore Completion Reports that have been submitted are provided in Table 6.

It is important to note that in November 2012, the monitoring bore names in the saline injection area were modified. Thus these will differ to the monitoring bore numbers in the current Operating Strategy (FMG, 2013c). This change of monitoring bore names was reported on page 13 of the 2012 annual monitoring review (FMG – CC-RP-HY-0031). A detailed memo outlining the name changes is presented in Appendix 7.

Table 4: Number of existing and new bores constructed in reporting period

Location	Type	Total
Camp Supply	Production	4
Cathedral	Monitoring	10
	Production	5
Christmas Creek Regional	Production	8
Exploration	Monitoring	62
	Production	24
Flinders	Monitoring	38
	Production	99
Hillside east	CB Brackish Injection	22
Hillside east extension	Brackish Injection	5
	Monitoring	10
Pastoral	Monitoring	1
Saline Injection	Monitoring	101
	Saline Injection	37
Spinifex	Brackish Injection	6
	Monitoring	17
Vasse	Monitoring	5
Windich	Monitoring	14
	Production	45
Young	Monitoring	5
	Production	15
Grand Total		533

Table 5: Submitted bore completion reports

Fortescue Document number	Title	Reference
CC-RP-HY-0001	Christmas Creek, Stage 1	FMG (2009)
CC-RP-HY-0003	Christmas Creek Borefield Assessment	FMG (2010a)
CC-RP-HY-0007	Christmas Creek 2009 Bore Completion Report	FMG (2010b)
CC-RP-HY-0020	Flinders Abstraction Borefield	FMG (2011a)
CC-RP-HY-0021	Hillside East Extension Brackish Injection Borefield	FMG (2011b)
CC-RP-HY-0026	Windich Abstraction Borefield	FMG (2012a)
CC-RP-HY-0028	Fortescue Marsh Northern Boundary Monitoring Bores	FMG (2012b)
CC-RP-HY-0029	Saline injection Phase 1 borefield	FMG (2012c)
CC-RP-HY-0032	Saline Injection Borefield Part 2 – Eastern Spur	FMG (2012d)
CC-RP-HY-0019	Spinifex Pigeon Injection Area	FMG (2012c)
CC-RP-HY-0033	Flinders Abstraction Borefield - Stage 2	FMG (2013d)

Fortescue Document number	Title	Reference
CC-RP-HY-0035	Vasse Tailings facility monitoring bores Bore completion report	FMG (2013e)
CC-RP-HY-0036	Windich tailings facility monitoring bores	FMG (2013f)
CC-RP-HY-0040	Flinders Abstraction Bore Field Stage 3	FMG (2013g)
CC-RP-HY-0041	Windich Abstraction Bore Field Strips 27 to 29	FMG (2013h)
CC-RP-HY-0042	Windich strip 13 borefield	FMG (2013i)
CC-RP-HY-0043	Saline Injection	FMG (2013j)

6. WATER BALANCE

Groundwater abstraction, injection and usage volumes (ML) for the 2010 – 2013 monitoring period are presented in Table 6. In the 2013 water year, over 50% of total outputs from the water balance was the return of groundwater through injection.

Table 6: Annual water balance

	Water Balance Input and Output		Annual Water Year volume (ML)			
			2010	2011	2012	2013
Inputs	Dewatering	Flinders dewatering	-	-	8,697	25,602
		Windich dewatering	-	-	-	9,431
		Sump dewatering	-	-	65	15
	Supply	Hillside East	-	-	-	94
		Spinifex	-	-	-	382
		Camp water supply bores	133	324	354	438
		Brackish water supply	184	601	54	323
	Misc.	Site transfer in from C'Break	-	-	1,162	0
Water Balance Input Total			**317**	**925**	**10,332**	**36,285**
Outputs	Injection	Hillside East Brackish injection	-	-	1,344	261
		Spinifex Brackish Injection			625	603
		Saline injection	-	-	289	16,674
	Use	OPF supply	-	-	2,655	6,375
		Dust suppression – Brackish	184	601	1,707	4,643
		Dust suppression – Saline	-	-	-	-
		Construction	-	-	78	-
		Camp supply	133	324	354	438
	Misc.	Evaporation	16	56	68	253
		Changed storage, & seepage			768	1,796
		Site transfer out to C'Break	-	-	11	307
Water Balance Output Total			**333**	**981**	**7,899**	**31,351**
Water Balance Error	**ML**		**-16**	**-56**	**2,433**	**4,934**
	% of Input		**5%**	**6%**	**24%**	**14%**

The error in the water balance can be qualitatively attributed to a number of factors:

a) Small inaccuracies compounded in the large number of individual flow meters. There are approximately 100 individual flow meters at the abstraction and injection bore headworks. During the initial year of dewatering, regular maintenance had not been implemented across the borefield. During water year 2012/13 and currently, a regular maintenance program has been implemented.

b) Substantial measurement and systemic errors that are not corrected in the QA/QC process. A large amount of data is collected and reviewed, and some errors are likely to be missed in this process. This is particularly noticeable where meters are replaced and no ‘signal’ is entered into the database to trigger a change in calculation methods.

c) System inaccuracy. In some cases a bore meter may be incorrectly allocated to the wrong borefield or an injection volume recorded as abstraction.

Revision of the water balance inaccuracy triggers a follow up QA/QC process or review of systems and procedures. For example, the implementation of water meter maintenance is believed to have resulted in the decreased error in the 2012/13 water year.

7. MONITORING OBJECTIVES

The monitoring objectives for Christmas Creek, as defined in the *Groundwater Operating Strategy CC-PH-HY-0002* (FMG 2013), have been developed in response to environmental management objectives, regulatory requirements/conditions and a system of trigger levels for water level and electrical conductivity (Table 7). Monitoring also provides data for ongoing hydrogeological analysis.

7.1 Environmental Management Objectives

Environmental management objectives, which aim to protect key flora and fauna species and habitats from potential impact as a result of dewatering and injection activities, have been defined for the following discrete management zones, depicted in Figure 5:

- Mining Region;
- Near Marsh Region (Zone A);
- Saline Injection Region (Zone B);
- Brackish Injection Region (Zone C);
- Phreatophytic Vegetation Region (Zone D); and
- The boundary between Christmas Creek and the approved Roy Hill mine to the east.

The objectives are species and habitat dependent and based upon operational activities which were deemed to have a high risk of impact, as defined in the approved hydrogeological assessment of the Cloudbreak water management scheme (FMG, 2010).

7.2 Regulatory Conditions

In response to environmental investigation, surveys and studies at both Christmas Creek and Cloudbreak, a series of regulatory conditions have been applied to both Part IV (MS871) and Part V (L8454/2010/1) environmental licences in operation at Christmas Creek. The key conditions, summarised in Table 7, relate to:

(a) prevention of injection induced mounding directly impacting upon vegetation within defined injection zones; and

(b) alteration of watertable groundwater levels, outside of natural variation, at the fringe of the marsh.

7.3 Trigger Levels

The environmental management objectives and regulatory conditions have formed the basis for establishing water level and electrical conductivity triggers; values which initiate operational responses to prevent likely impacts.

In response to continued monitoring and improved understanding of the system, the trigger levels have been continually reviewed, as additional information on historical variations, hydrogeological behaviour and ecosystem dependency is established. Table 7 lists the trigger levels for the current approved groundwater operating strategy; Table 8 outlines the eight operating strategy revisions that have taken place in the reporting period.

7.4 Hydrogeological Analysis

Monitoring data, as presented in section 0, has been collected with the primary objective of supporting the management objectives for Christmas Creek. In addition, monitoring is also undertaken to:

- Inform operational performance and planning;
- Support model calibration;
- Update hydrogeological conceptualisation; and
- Revise trigger levels by establishing historical baselines.

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Table 7: Christmas Creek Management Objectives and Trigger Level Framework

Zone	Region	Aquifer	Environmental Management Objective	Regulatory Requirements	Trigger Levels			
					Trigger Objective	Groundwater level trigger		Water quality trigger
						Class 1	Class 2	Class 1
N/A	Mining	Marra Mamba Formation	Minimise potential environmental impacts and conserve the groundwater resource whilst achieving required dewatering targets to facilitate mining activity	N/A	N/A	N/A	N/A	N/A
A	Near Marsh	Upper Tertiary Detrital	No adverse impact to Samphire vegetation community as a result of groundwater mounding caused by injection activities.	*'The proponent shall manage the injection of surplus water to ensure that groundwater levels do not rise more than 1.5 metres at MB1 and 1 metre at MB2, MB3 and MB4 from the baseline groundwater level.'*	• Class 1 groundwater level trigger to provide early warning and to signal potential future Class 2 conditions • Class 2 groundwater level trigger as stipulated in Condition 7 of MS871 (Fortescue Marsh)	Absolute change of ±0.80 m from baseline having regard for season variation	Change of ±1 m (±1.5 m for CCFMM01_S) from baseline having regard for season variation	N/A[2]
		Oakover Formation		N/A	• Class 1 groundwater level trigger to provide early warning of potential impact to shallow groundwater. Trigger should be linked to numerical model predictions of pressurisation in the deep aquifer.		N/A	
B	Saline Injection	Upper Tertiary Detrital	No adverse impact to vegetation community or Mulga and associated Acacia species of trees or Samphire vegetation community due to groundwater mounding.	*'Subject to meeting the requirements of condition 8-1 the proponent shall manage the injection of surplus water to ensure that mounding of the groundwater level does not result in groundwater levels rising within 2 metres of the surface'*	• Class 1 groundwater level trigger to provide early warning and to signal potential future Class 2 conditions • Class 2 groundwater level trigger as stipulated in Condition 6-1 of MS871 (groundwater mounding) • Class 1 EC trigger assigned to ensure baseline aquifer water quality is maintained as required by DEC (L8454/2010/1).	3 m below ground level	2 m below ground level	9,000 µS/cm (unless the baseline[3] is higher than 6,000 µS/cm, then 50% increase from baseline)[4]
		Oakover Formation		N/A	• Class 1 groundwater level trigger to provide early warning of potential impact to shallow groundwater. Trigger has been set as the same as Class 2 trigger in shallow aquifer thus negating impact of over pressurisation of deep aquifer.	2 m below ground level	N/A	N/A
C	Brackish Injection	Upper Tertiary Detrital	No adverse impact to vegetation community or Mulga and associated Acacia species of trees or Samphire vegetation community due to groundwater mounding.	*'Subject to meeting the requirements of condition 8-1 the proponent shall manage the injection of surplus water to ensure that mounding of the groundwater level does not result in groundwater levels rising within 2 metres of the surface*).	• Class 1 groundwater level trigger to provide early warning and to signal potential future Class 2 conditions • Class 2 groundwater level trigger as stipulated in Condition 6 of MS871 (groundwater mounding). *See above.* • Class 1 EC trigger assigned to ensure baseline aquifer water quality is maintained as required by DEC (L8454/2010/1).	3 m below ground level	2 m below ground level	9,000 µS/cm (unless the baseline[19] is higher than 6,000 µS/cm, then 50% increase from baseline)[20]
		Marra Mamba Formation		N/A	• Class 1 groundwater level trigger to provide early warning of potential impact to shallow groundwater. Trigger has been set as the same as Class 2 trigger in shallow aquifer thus negating impact of over pressurisation of deep aquifer. • Class 1 EC trigger assigned to ensure baseline aquifer water quality is maintained as required by DEC (L8454/2010/1).	2 m below ground level	N/A	

[2] Baseline EC at the Near Marsh monitoring locations is above 9,000 µS/cm and hence no trigger to be applied.
[3] Baseline EC based on pre-injection and/or pre-dewatering-impact time series data.
[4] If baseline groundwater quality is greater than 9,000 µS/cm no trigger is applied.

Zone	Region	Aquifer	Environmental Management Objective	Regulatory Requirements	Trigger Levels			
					Trigger Objective	Groundwater level trigger		Water quality trigger
						Class 1	Class 2	Class 1
		Bulk flow			• Class 1 EC trigger assigned to ensure baseline aquifer water quality is maintained as required by DEC (L8454/2010/1).	N/A	N/A	9,000 µS/cm
D	Phreatophytic vegetation[5]	Upper Tertiary Detrital	No adverse impact, beyond natural variability, to phreatophytic trees or recruitment due to dewatering. Management of groundwater decline to ensure actual groundwater levels do not fall to below 20m beneath the ground surface in dewatering areas.	• Management of groundwater decline to ensure actual groundwater levels do not fall to below 20m beneath the ground surface in dewatering areas. • Class 1 E.C. trigger assigned to ensure baseline aquifer water quality is maintained as required by DEC (L8454/2010/1).	• Class 1 groundwater level trigger to provide early warning and to signal potential future Class 2 conditions • Class 2 groundwater level defined to prevent environmental impact at areas where phreatophytic vegetation may be susceptible to drawdown. • Groundwater level where phreatophytic vegetation may be susceptible to drawdown of the groundwater level of more than 20 m from the ground surface. Ecoscape's impact assessment for dewatering (Ecoscape, 2009). A 10% precautionary factor has been applied. • Class 1 E.C. trigger assigned to ensure baseline aquifer water quality is maintained as required by DEC (L8454/2010/1).	16 m below ground level	18 m below ground level	50% increase from baseline[19]
		Marra Mamba Formation				16 m below ground level	18 m below ground level	50% increase from baseline[19]
Misc.	Roy Hill/Fortescue tenement boundary	Upper Tertiary Detrital	No adverse impact upon other approved mining operations	*'The proponent shall manage the reinjection of surplus water to ensure that it does not cause a significant increase in dewatering requirements at other non-proponent approved mining operations.'*	• Class 1 groundwater level trigger to provide early warning and to signal potential future Class 2 conditions • Class 2 groundwater level trigger as stipulated in Condition 10 of MS871 (Reinjection impacts to other mines)	Change of ±1.25 m from seasonally varying water levels	Change of ±1.5 m from seasonally varying water levels	N/A
		Marra Mamba Formation				Change of ±1.25 m from seasonally varying water levels	Change of ±1.5 m from seasonally varying water levels	

[5] Other assessment techniques such as projected canopy cover and remote sensing technology are being developed to help assess the impact to phreatophytic vegetation zones and compliment this groundwater monitoring data.

Table 8: Christmas Creek Groundwater Operating Strategy History

Version	Document Reference	Submission Date	Key Strategy Change	Monitoring/Trigger Network Change
1	CC-PH-HY-0001_rev1	27/08/2010	Operations and abstraction of up to 1.15GL to supply construction activities and camp supply. No active abstraction and injection for mine dewatering purposes.	• Two tier trigger level (Class 1 & Class 2) identified. • 16 hydrogeological zones and sub-zones defined based on geology and operational activity, including dewatering. • Trigger levels based on current operational activity, baseline data and numerical model predicted changes within each zone and sub-zone.
2	CC-PH-HY-0002_rev0	19/04/2011	Abstraction increase to 18GL. Strategy updated to reflect commencement of dewatering activities for mining.	• Expansion of existing network to include areas of active abstraction and injection
3	CC-PH-HY-0002_rev1	15/09/2011	Issue for use following endorsement by DoW	N/A
4	CC-PH-HY-0002_rev2	08/11/2011	Abstraction remains constant Spinifex brackish injection borefield added to the system.	• Expansion of existing network to include Spinifex, Hillside East Extension and Roy Hill boundary monitoring locations.
5	CC-PH-HY-0002_rev3	01/03/2012	Abstraction increase to 23GL. Strategy updated to document the commencement of saline injection. Monitoring network amended accordingly.	• Presentation of 4 zone trigger system based on operational activity. • Focus on ensuring zones clearly defines regulatory objectives. • Class 2 trigger levels based on regulatory impacts. • Class 1 triggers no longer based on modelling but on providing an early warning to ensure Class 2 triggers are not breached. •
6	CC-PH-HY-0002_rev4	11/05/2012	Abstraction increase to 48GL. Document prepared to reflect the changes in the number of saline injection bores. The number of saline injection bores increased from 16 to 29.	• Expansion of Zone B trigger network with increasing number of saline injection locations/
7	CC-PH-HY-0002_rev5	21/05/2012	Issue for use following endorsement by DoW	N/A
8	CC-PH-HY-0003_rev0	30/06/2013	Abstraction increase to 50GL. Document not yet endorsed by DoW. Strategy amended to increase abstraction up to 50GL/a and expansion of infrastructure.	• Hillside East monitoring solely included in CC operating strategy. • Zone A shallow Class 1 triggers based change on consideration of seasonal variation rather than an absolute change. • Zone A deep bores no longer assigned a Class 1 trigger due to predicted pressurisation from injection. • Zone B deep Class 1 triggers amended to 2.2 m bgl to allow greater operational flexibility. • Zone B, shallow monitoring bores assigned Class 1 water quality triggers. • All operational Zone B locations included in revised network.

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8. MONITORING OBSERVATIONS

The monitoring results described in this section, cover the period from 18 December 2009 to 31 July 2013. A map of key areas and monitoring locations discussed in this section has been previously referenced and is included in Appendix 6.

Water level, water quality (represented by electrical conductivity, EC) and hydrochemistry data presentation, description and interpretation are arranged according to the mining region and the defined management zones (Brackish Injection; Saline Injection; Near Marsh; Phreatophytic; and Neighbouring Projects). A summary is included to relate the interpretation of each individual zone on a regional level (section 8.6)

Representative hydrographs have been developed to illustrate groundwater level and electrical conductivity data. The hydrographs include ground level and screened aquifer information for each sampling point presented. Where possible, multi-piezometer bores are presented on the same hydrograph; these can be recognised by the similar prefix to the bore name. The suffix, WT, S, I and D, refer to “water table”, “shallow”, “intermediate” and “deep” monitoring horizons respectively; but do not necessarily represent separate aquifers.

Full assessment of Christmas Creek hydrochemistry has been undertaken by RockWater Pty Ltd as part of a Chichester-wide assessment; the complete report is included as Appendix 8.

It is important to note the water level data presented in this section has not been corrected with respect to density. Density corrections of high salinity water can have significant impacts on the relative water level (fresh water equivalence) of adjacent aquifers or monitoring bores, and hence the vertical and lateral gradients interpreted from the data. General comment on the effect density may have on total pressure conditions within the aquifer system are provided in the interpretation section for each region.

8.1 Mining Region

Mining below water table at Christmas Creek has occurred at Flinders (since 2012) and Windich Pit (since 2013) during the reporting period. Dewatering has been facilitated by 45 and 99 abstraction bores at Flinders and Windich Pit respectively.

Representative hydrographs for monitoring bores in these mining areas are shown in Figure 7, Figure 8 and Figure 9; the following sections describe and present interpretation of these data.

8.1.1 Water Levels

Groundwater levels have been lowered in the mineralised MMF and UTD locally in dewatering zones by over 30 m in the Flinders pit area (Figure 7) and 10 m around the Windich pit area (Figure 8).

Flinders Pit

Dewatering of the Flinders pit area has been a staged approach, with additional abstraction from new borefields becoming operational as required as mining advances south and into new areas. The start of each stage and resulting increase in abstraction is outlined in Table 9. The gradual commissioning of stage 2 and 3 was due to either infrastructure constraints or saline injection capacity constraints.

Table 9: Flinders borefield commissioning

Borefield Stage	Commissioning Date
Stage 1	September 2011
Stage 2a	May 2012
Stage 2b	June 2012
Stage 3a	August 2012
Stage 3b	October 2012

The hydrographs shown on Figure 7 and Figure 8 illustrates data from four of the Flinders pit monitoring bores located at varying distances from the borefield in both MMF and UTD screened zones. Water level trends are very similar in both the MMF and UTD at each location; although water levels in FLM09_S have dropped below the base of the piezometer. Observations with regard to the MMF monitoring bores are as follows:

- FLM06_D shows the greatest drawdown of 33.57 m. It is located within mineralisation and is the closest of these bores to active dewatering.
- Drawdown in FLM07_D is more gradual over time, totalling less than 10 m over the reporting period. A rise in water level is evident in January 2012, coincident with cyclone Heidi. It is located upgradient from the borefield, near outcropping bedrock, and may be influenced by greater infiltration and recharge potential at this location.
- Bores FLM08_D and FLM09_D have experienced drawdown totalling approximately 12 m. These bores are up gradient from the active borefield. A step increase in drawdown is seen in FLM09_D in June 2012 due to abstraction bores becoming operational at the northern end of Flinders pit as part of Stage 2b.

Windich Pit

Dewatering at Windich pit area began with Phase 1 in September 2012, and was ongoing at the end of the reporting period. Figure 9 shows groundwater levels WDM02 and WDM03, located approximately 500 m south and east, respectively, from Windich borefield. Observations relating to these data are as follows:

- Groundwater levels and trends are coincident for WDM02_S, WDM02_D and WDM03_S. Drawdown over the reporting period has totalled 7 m, and is coincident with the commencement of dewatering at Windich Pit.

- Drawdown of 10 m has been observed in WDM03_D, which exceeds that observed in WDM02_D. Greater airlift yields were observed when drilling WDM03_D and it is probable that greater levels of permeability and connection with the dewatering borefield exists at this site.

8.1.2 Water Quality

Flinders Pit

EC Data for the UTD aquifer measured at FLM07, FLM08 and FLM09 has remained steady through the reporting period, at values of between 600 and 2,000 µS/cm (Figure 7 and Figure 8). In contrast, FLM06_S, which has been dewatered, showed a rise in EC over 5 months to almost 5,000 µS/cm, whereupon data shows several spiked values of up to 15,000 µS/cm. If correct, these data may be related to vertical connectivity in the monitoring bore due to construction methods; possibly also a reason for similarity in water level behaviour between the deep and shallow piezometers (section 8.1.1).

The MMF monitoring bores illustrate spatial variation in background EC and changes in EC over time. Initial values are higher to the south, ranging from 20,000 µS/cm in FLM06_D down to 500 µS/cm in FLM07_D and FLM09_D, located further to the north. There is a high degree of temporal variation in FLM06_D, with EC ranging from 10,000 µS/cm to 30,000 µS/cm, albeit with no discernable trend. Data has been more consistent since late 2012, with values in the order of 17,000 µS/cm. This steadying of values coincides with dewatering of the shallow piezometer and it is possible the earlier fluctuations were a function of mixing between the MMF aquifer and overlying UTD aquifer.

EC Has increased in FLM09_D since early 2013, consistent with the breakthrough of seepage from the upstream Vasse tailings storage facility (Figure 5).

Windich Pit

EC Data for the UTD aquifer measured at WDM02 and WDM03 have been steady through the reporting period, at values of approximately 1,500 µS/cm and 2,300 µS/cm respectively (Figure 9). WDM03_S has recorded a decrease in EC to below 2,000 µS/cm since the start of 2013. Three large spikes in values for WDM02_S are considered data errors, where data for WDM02_S and WDM02_D have been mistakenly swapped.

MMF EC as measured in WDM02_D and WDM03_D show disparate change over time. WDM03_D, located further south, has an initially higher EC but this had remained largely steady with a possible slow decline in values mirroring the pattern of WDM03_S. In contrast, EC values in WDM02_D have increased steadily since mid-2012, with no corresponding change in WDM02_S. When drilled, both WDM03 and WDM04 intersected a saline interface at the bottom of the hole, where EC values rose above 20,000 µS/cm. However, measurement depth for EC is closer to this saline interface in WDM02, and the bore itself is screened only in the lower portion of the MMF, where permeability is less. In this context, it is considered that upward

movement of saline groundwater (as overlying pressure is reduced from dewatering) is resulting in a more notable impact in the deeper, narrowly screened bore.

8.1.3 Hydrochemistry

There are no hydrochemical management objectives associated with the mining area and, as such, no specific analysis was completed by Rockwater (2014). The assessment of brackish and saline injection water serves as a proxy for groundwater quality in the mining area, as it is from there the water is abstracted.

As discussed above, there has been a steady rise in salinity from dewatering bores, leading to an increase in the TDS of the saline injection line. There are no discernable trends in pH in either brackish or saline injection lines for data up to 31 June 2013.

Data from sampling point CCSP011 appears to show increasing concentrations (in the order of 1 mg/L) for Boron, Manganese, Strontium and Iron (Rockwater (2014), Appendix VII, graphs A – C). These trends have not been observed in the available data for the other three sampling points; and the absolute values are within the range of natural variation identified by Rockwater.

8.1.4 Interpretation

The drawdown cone associated with dewatering is pronounced elliptically along the strike of the MMF. This is interpreted to be due to the:

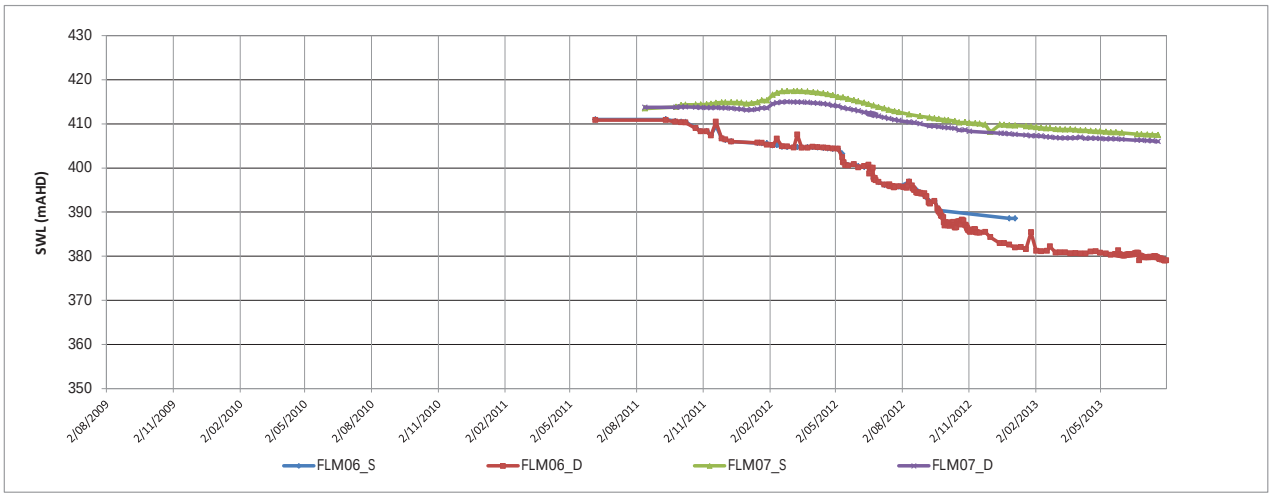
- Presence of a no flow boundary where the aquifer sub-crops/outcrops above the water table in the northern area;
- Presence of a permeability contrast to the south where the mineralisation of the MMF is not developed;
- Lower permeability of the UTD; and
- Injection of saline water into the OF mitigates drawdown to the south.

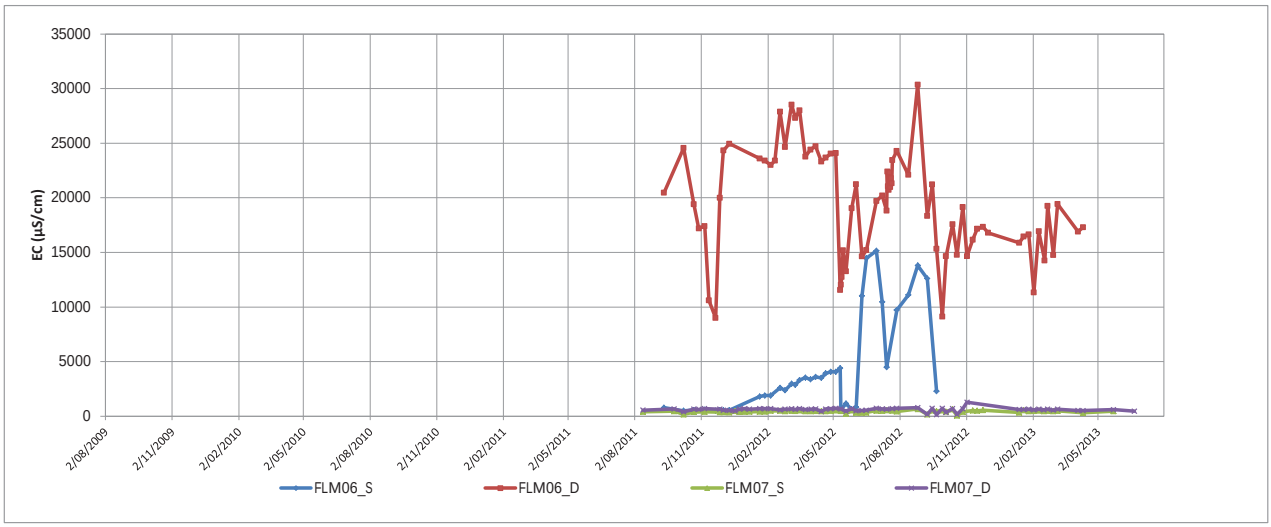
In addition, monitoring data demonstrates some vertical water level difference between UTD and MMF monitoring piezometers in the mining area, suggesting increased potential for leakage of groundwater from the UTD. This pattern of behaviour is also observed to a limited degree in EC data, where a number of MMF bores has shown slight decreases in EC or patterns of change closely resembling the overlying UTD aquifer data.

Drawdown has resulted in some change to the saline interface, with increases in EC observed in MMF monitoring data and increased TDS recorded in bulk flow monitoring.

Mining Area - Representative Hydrograph 1

Area:	*Flinders Pit Area*		***Activity Type:***	*Abstraction*	
Bore Name:	FLM06_S	**Ground RL (mAHD):**	437.24	**Monitored Aquifer:**	Upper TD.
Bore Name:	FLM06_D	**Ground RL (mAHD):**	437.24	**Monitored Aquifer:**	Marra Mamba Fn.
Bore Name:	FLM07_S	**Ground RL (mAHD):**	441.07	**Monitored Aquifer:**	Upper TD.
Bore Name:	FLM07_D	**Ground RL (mAHD):**	441.07	**Monitored Aquifer:**	Marra Mamba Fn.





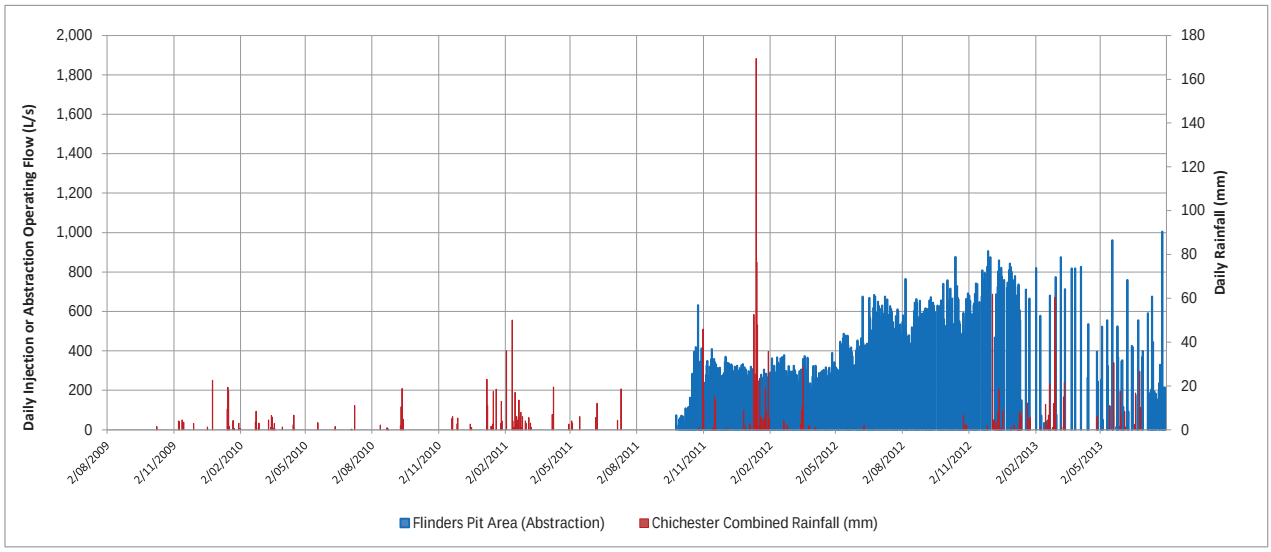
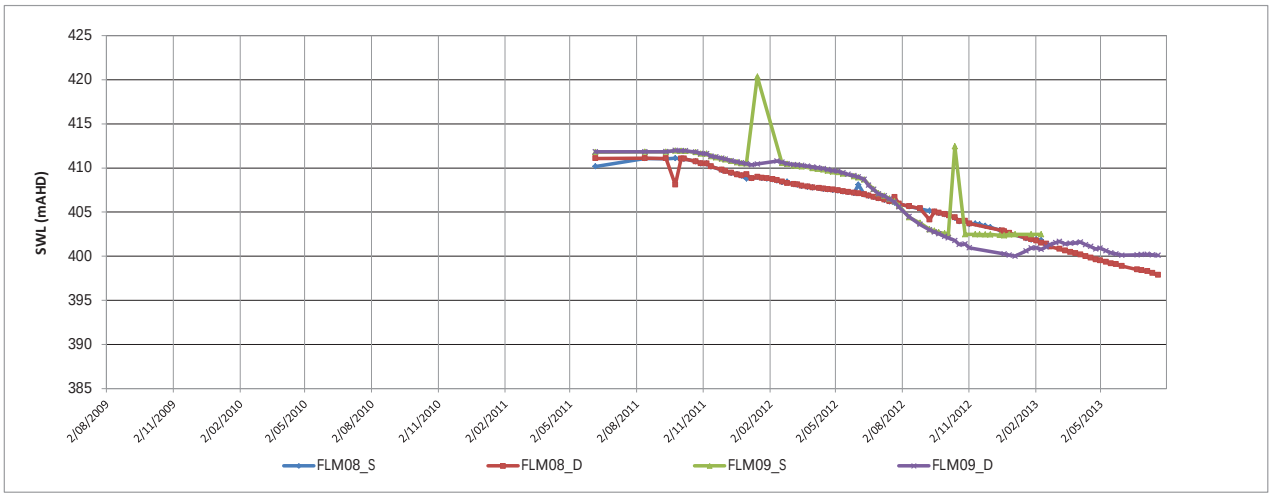
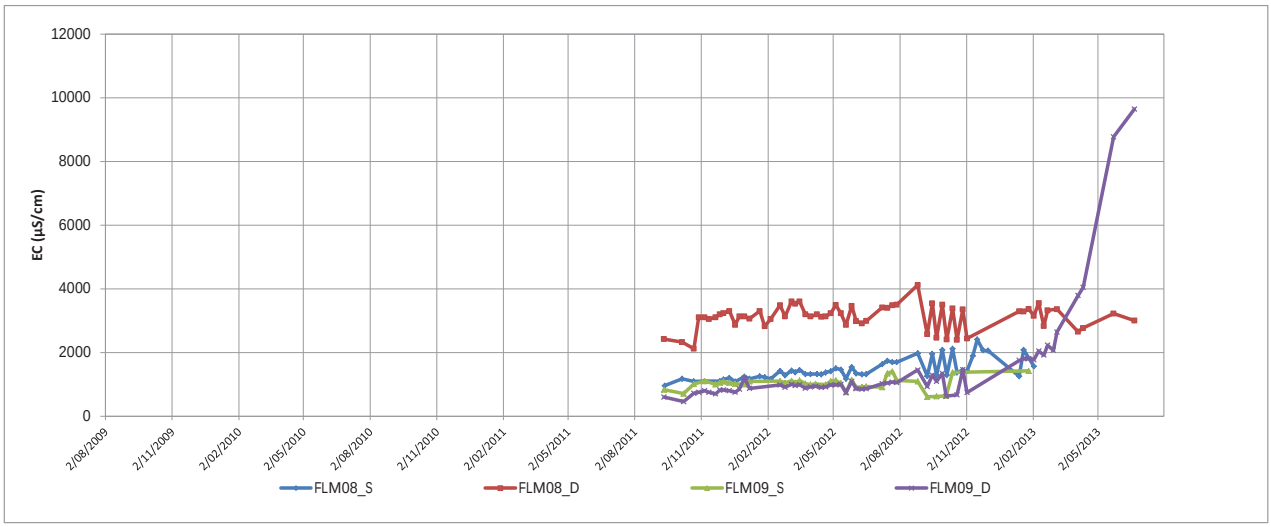


Figure 7: Monitoring data for FLM06 and FLM07, Flinders Pit

Mining Area - Representative Hydrograph 2

Area:	*Flinders Pit Area*		***Activity Type:***	*Abstraction*	
Bore Name:	FLM08_S	**Ground RL (mAHD):**	435.68	**Monitored Aquifer:**	Upper TD.
Bore Name:	FLM08_D	**Ground RL (mAHD):**	435.68	**Monitored Aquifer:**	Marra Mamba Fn.
Bore Name:	FLM09_S	**Ground RL (mAHD):**	442.41	**Monitored Aquifer:**	Upper TD.
Bore Name:	FLM09_D	**Ground RL (mAHD):**	442.41	**Monitored Aquifer:**	Marra Mamba Fn.





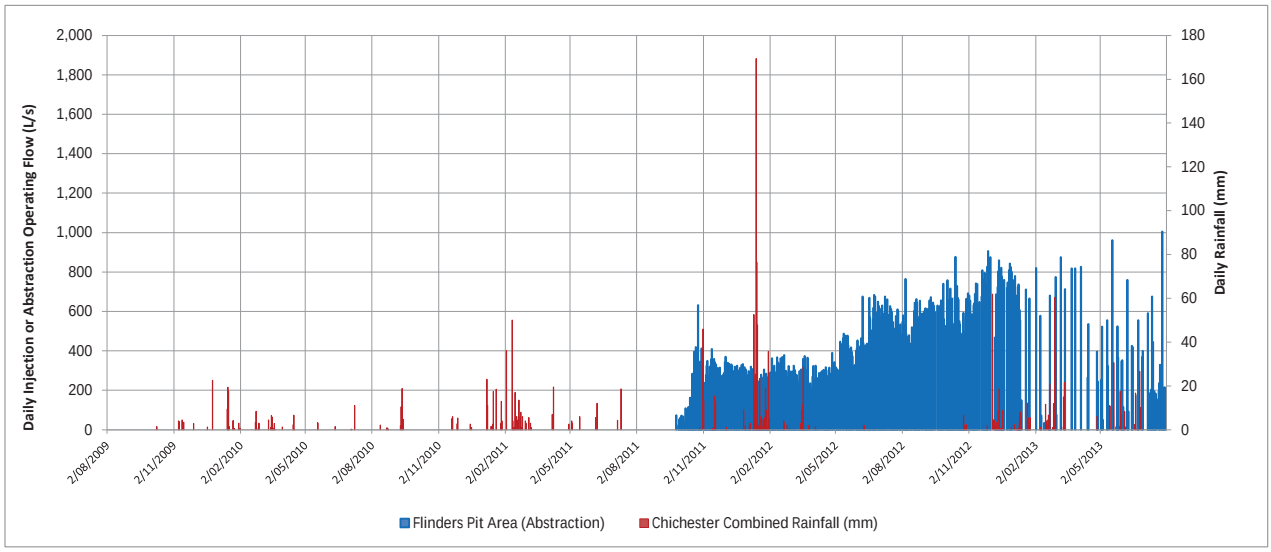
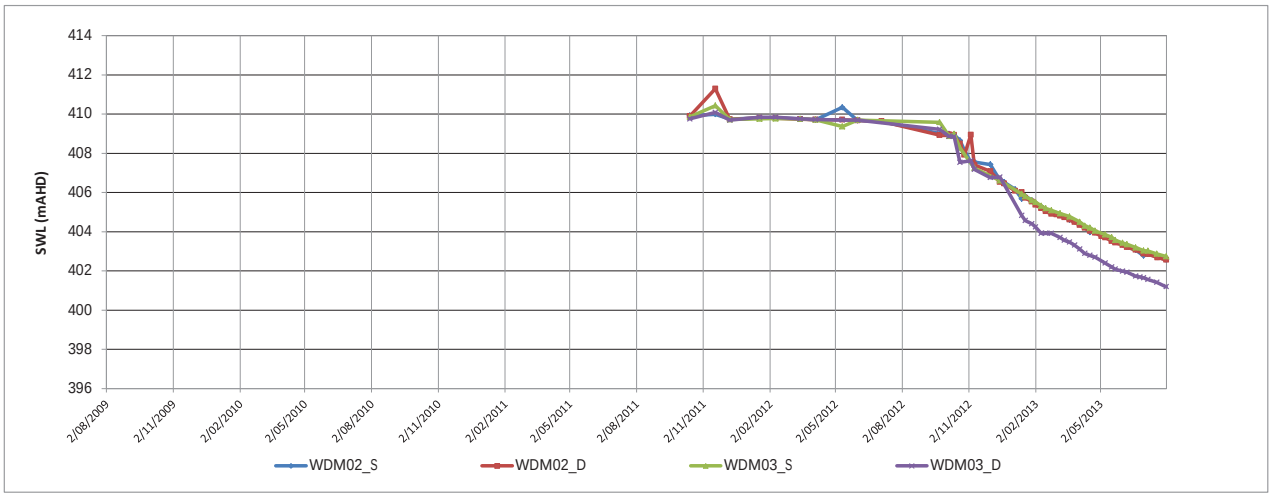
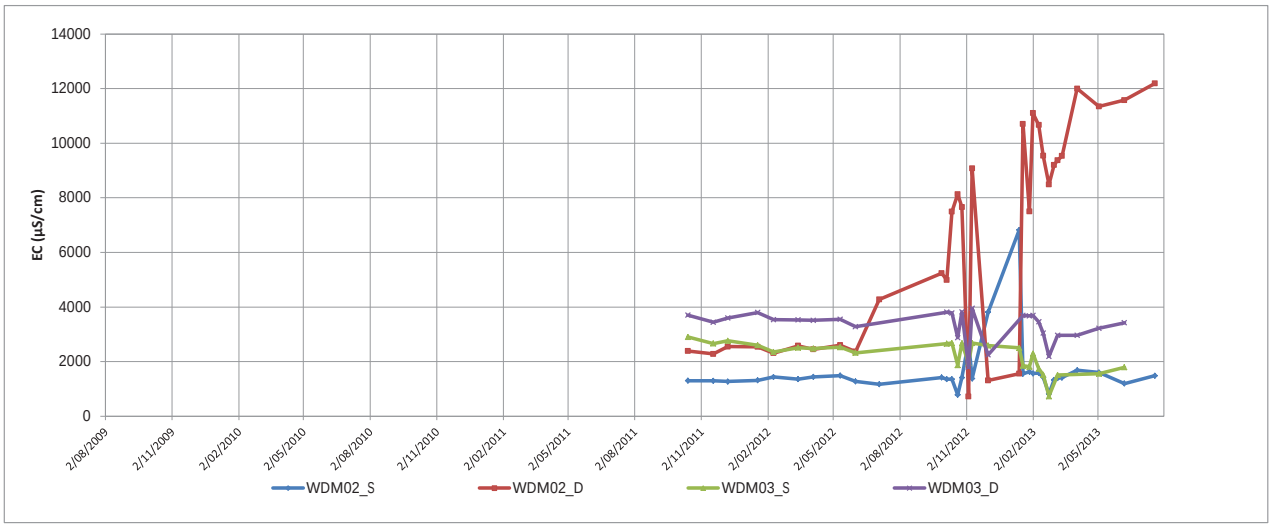


Figure 8: **Monitoring data for FLM08 and FLM09, Flinders Pit**

Mining Area - Representative Hydrograph 3

Area:	*Windich Pit Area*		***Activity Type:***	*Abstraction*	
Bore Name:	WDM02_S	**Ground RL (mAHD):**	432.49	**Monitored Aquifer:**	Upper TD.
Bore Name:	WDM02_D	**Ground RL (mAHD):**	432.49	**Monitored Aquifer:**	Marra Mamba Fn.
Bore Name:	WDM03_S	**Ground RL (mAHD):**	431.78	**Monitored Aquifer:**	Upper TD.
Bore Name:	WDM03_D	**Ground RL (mAHD):**	431.78	**Monitored Aquifer:**	Marra Mamba Fn.





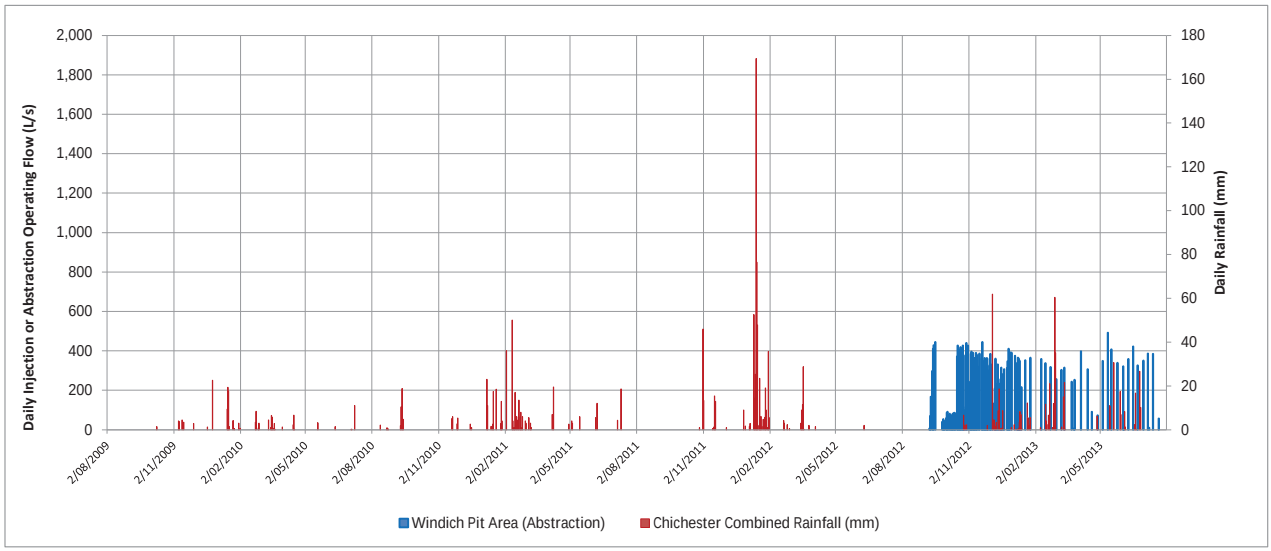


Figure 9: **Monitoring data for WDM02 and WDM03, Windich Pit**

8.2 Zone A – Near Marsh

Five nested monitoring bores were constructed in October 2011 along the northern edge of the Fortescue Marsh, approximately 5km south of the mine site. The five locations extend the entire east-west strike length of the mine site; CCFMM01 and 2 are located in the west (western area), CCFMM03 and 4 directly to the south of the mining region (central area), and CCFMM05 is located in the east (eastern area). Monthly monitoring of the sites has occurred since installation.

Individual monitoring piezometer hydrographs, illustrating trigger levels, are included in Appendix 9. Representative hydrographs for this zone are shown in Figure 10, Figure 11 and Figure 12, and include both deep and shallow piezometers for each bore; identification of the monitored aquifer and ground level elevation is included on the hydrographs.

8.2.1 Water Levels

Western Area

Figure 10 illustrates an overall rise in groundwater levels since the start of monitoring in October 2011. The rise in levels is most noticeable in the OF and WD aquifer, particularly since late 2012 when saline injection commenced at Christmas Creek. Groundwater levels in the OF appear to have stabilised at approximately 409 m AHD (local ground level), despite no notable reduction in injection volumes in the western part of the saline injection borefield.

OF, WD and UTD aquifers demonstrate an earlier rise in levels in January 2012, at the time of cyclone Heidi. Data from CCFMM01_S suggest a period of recession following the cyclone event, which lasted until a period of rainfall in late 2012 and earlier 2013.

Water level measured in CCFMM02_S was lower at the end of the reporting period than when the bore was constructed in January 2013. Slight increases in UTD water level in CCFMM01_S and CCFMM02_S towards the end of the reporting period may be due to unseasonably high rainfall in December 2013.

Since monitoring commenced, the available data shows the difference in groundwater level between the UTD and the OF has increased from about 1 m in late 2011 to over 3 m in June 2013. This observation is consistent with saline injection into the OF to the north, and the presence of a clay aquitard separating the OF and UTD.

Water levels in the OF and WD represented by CCFMM02_D and CCFMM02_VD have followed almost identical trends, with a difference of approximately 1.1 m. Although these two piezometers are separated by a bentonite seal, the OF and WD are in direct contact at this location.

Central Area

Figure 11 displays monitoring data for the UTD and OF in bores CCFMM03 and CCFMM04. Similar groundwater level behaviour in the UTD has been observed in the central area when compared to the western area. At the end of the reporting period, groundwater levels in CCFMM03_S were 0.7 m lower than in CCFMM04_S, despite registering similar levels in the first half of the data record.

OF Groundwater levels in both monitoring bores have displayed similar behaviour, rising about 1 m over the course of the monitoring period. The majority of the increase occurred in conjunction with the initial period of injection, and a limited decrease in levels occurred in conjunction with a reduction in injection volumes. The final two elevated water level readings in CCFMM03_D are considered erroneous, and possibly due to a change in the reference point where measurements have been taken from.

At the start of the reporting period, UTD groundwater levels were higher (only marginally in the case of CCFMM03) then OF levels, particularly immediately after cyclone Heidi. The rise in OF levels in CCFMM03 has caused a difference of about 0.8 m to develop between the OF and UTD (omitting the last two readings); whilst in CCFMM04 the initial water level difference of 1.5 m between the OF and UTD has been reduced to less than 0.5 m.

Eastern Area

Groundwater levels in the eastern Near Marsh area are represented by CCFMM05, which has piezometers in the UTD and LTD (Figure 12); interestingly calcrete of the OF is absent in this borehole and shallow water levels are consistently higher than the deeper levels.

Data from the UTD aquifer illustrates response from cyclone Heidi in January 2012, in the order of 0.5 m. As per the western area, the rise in levels is followed by a period of recession until periods of rainfall in late 2012/early 2013 and again in June 2013. These events have resulted in water levels remaining steady at 405.2 m AHD.

In contrast, the LTD data suggests a steady rise in groundwater levels over the period of monitoring data, also in the order of 0.5 m. There is a period of slightly accelerated water level rise between September and October 2012, which does correspond to the period of ‘ramp-up’ in injection volumes. The data then shows a subsequent recovery to the initial long term trend, which loosely corresponds to a reduction in injection volumes. It is worth noting that the slight overall change in water level over time means centimetre inaccuracies in data collection may exaggerate supposed short term trends.

8.2.2 Water Quality

Western Area

In terms of absolute values, all monitoring bores in this area have hypersaline conditions, with EC above 100,000 µS/cm. The monitoring data suggests EC increases with depth; with a larger difference between the WD and OF compared to the OF and UTD.

Apart from erroneous data collected in May 2013, EC data from all four monitoring piezometers has been largely steady throughout the reporting period, and have displayed similar patterns (Figure 10). CCFMM02_D is an exception with what appears to be a sustained increase in EC from 125,000 µS/cm in early 2013 to 140,000 µS/cm by the end of the reporting period, whilst EC in the other monitoring bores recovered to long term average values in that time.

Central Area

Overall, the central area data has lower EC values than the western area, and there is a greater difference between the OF and UTD in both monitoring bores (Figure 11).

Values of EC in the OF have increased slightly over the reporting period, rising between 5,000 and 10,000 µS/cm. An accelerated rise in EC from late 2012 was followed by a subsequent decline in early 2013; a pattern which is mimics that of the western area.

Values of EC for the UTD have remained steady at approximately 75,000 µS/cm in both CCFMM03_S and CCFMM04_S, with the exception of an erroneous reading in the latter for February 2013. As with the OF, there is also a rise and fall in EC between late 2012 and early 2013.

Eastern Area

The EC values in CCFMM05_S (UTD) and CCFMM05_D (LTD) both experienced a reduction in February 2012, coinciding with cyclone Heidi (Figure 12). After this, the EC stabilised and rose approximately 10,000 µS/cm higher than initial values by the end of the reporting period. Data in December 2012 is considered erroneous.

8.2.3 Hydrochemistry

Hydrochemical data for Zone A was assessed by Rockwater (2014). No changes in concentrations of the measured metals were observed and baseline values were set for the UTD and OF/WD from these data. Naturally elevated levels of strontium and manganese were identified from the data; however these were considered within the expected range for hypersaline groundwater conditions.

8.2.4 Interpretation

Water levels in Zone A within the UTD demonstrate the influence of a large recharge event, caused by cyclone Heidi, and there is some evidence this cyclone temporarily lowered EC in this aquifer.

Data from CCFMM02 indicates a relationship between the OF and underlying WF. Water level monitoring data from both aquifers indicates a mirrored response over time, and suggests a direct connection (pressure or otherwise) of these units.

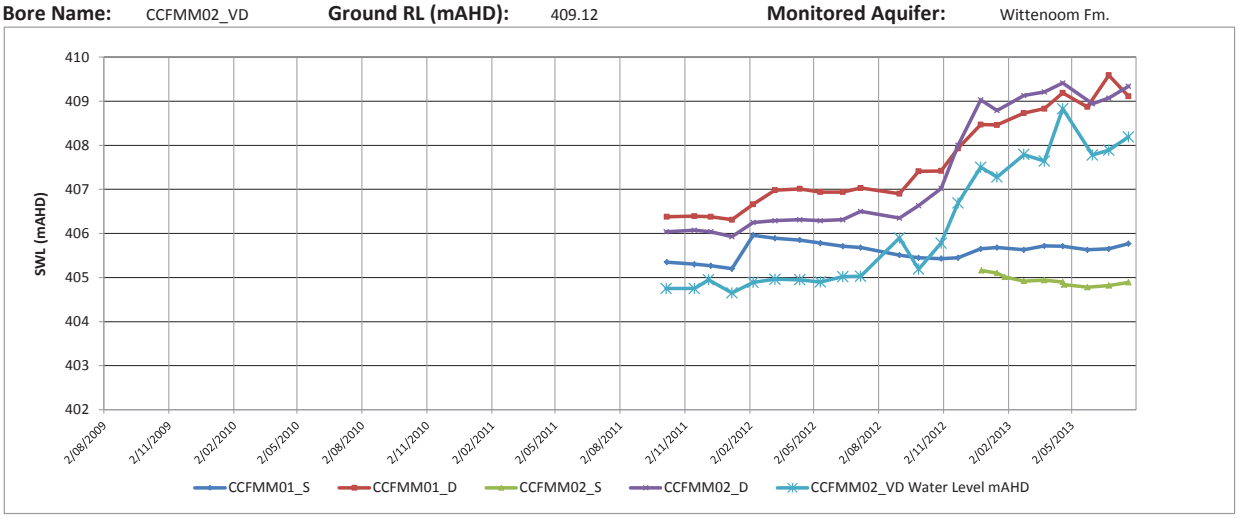
There is no evidence of upward vertical groundwater movement, despite what appears to be an increase in gradients between the OF and UTD, caused by injection activity. Artesian pressures in the OF should continue to be managed through the adaptive approach already undertaken.

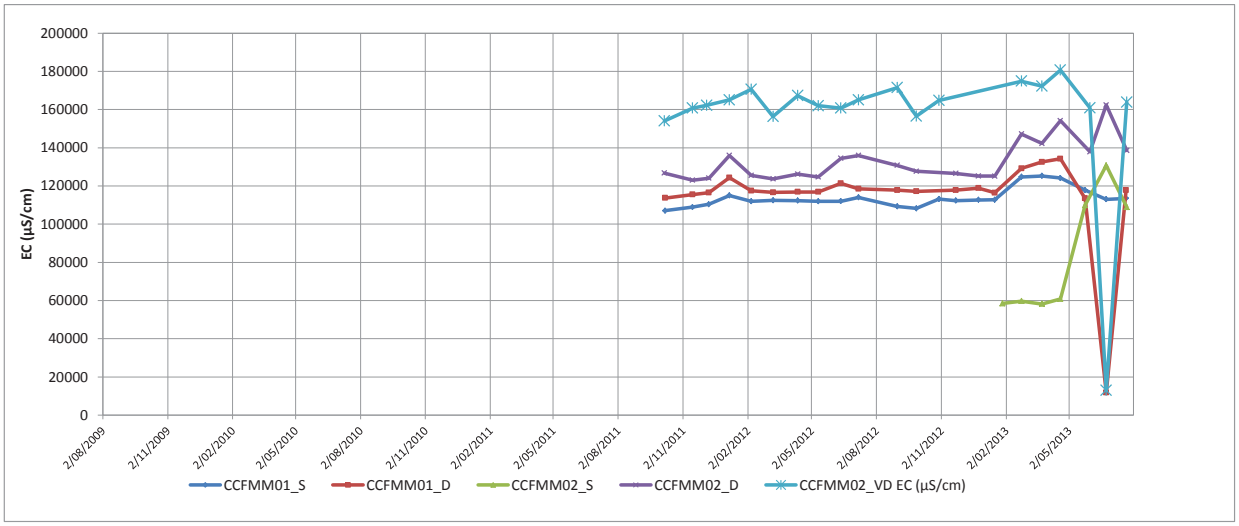
The level of background EC in this area far exceeds the bulk EC injected in the saline borefield. No ‘breakthrough’ has been observed where mixing reduces the aquifer EC; this suggests that saline injection is causing a pressure response in the OF only, and as yet no injected water has reported to the Near Marsh monitoring bores.

Near Marsh - Representative Hydrograph 1

Nearest Activity Area: *CC Saline Injection* ***Activity Type:*** *Injection*

Bore Name:	CCFMM01_S	**Ground RL (mAHD):**	408.92	**Monitored Aquifer:**	Upper TD.
Bore Name:	CCFMM01_D	**Ground RL (mAHD):**	408.92	**Monitored Aquifer:**	Oakover Fmn.
Bore Name:	CCFMM02_S	**Ground RL (mAHD):**	409.12	**Monitored Aquifer:**	Upper TD.
Bore Name:	CCFMM02_D	**Ground RL (mAHD):**	409.12	**Monitored Aquifer:**	Oakover Fmn.
Bore Name:	CCFMM02_VD	**Ground RL (mAHD):**	409.12	**Monitored Aquifer:**	Wittenoom Fm.





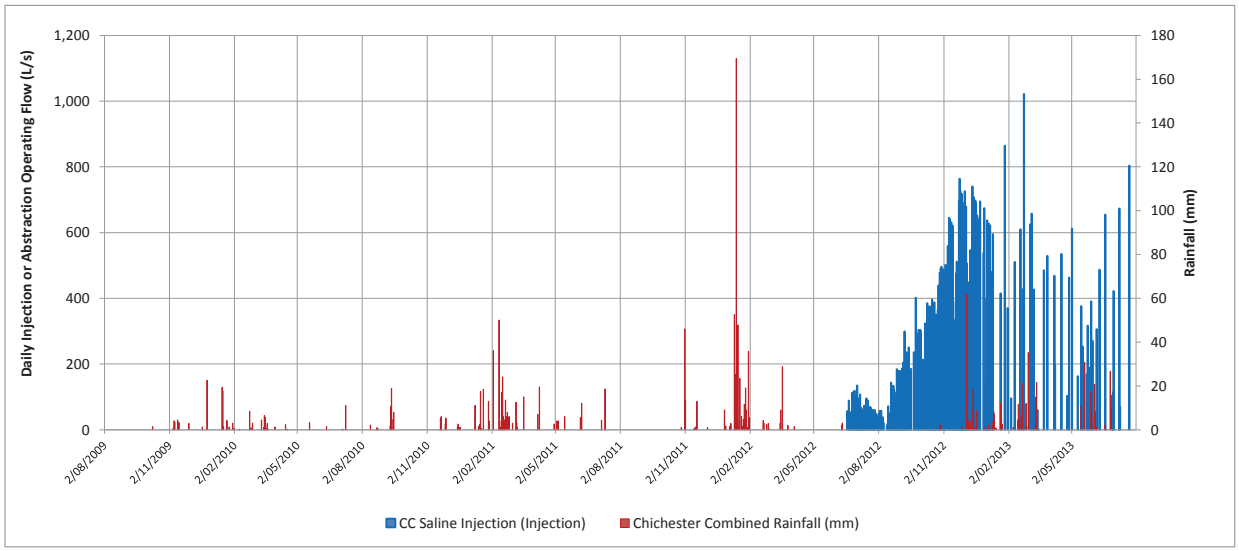


Figure 10: Monitoring data for CCFMM01 and CCFMM02, western Near Marsh area

Near Marsh - Representative Hydrograph 2

Nearest Activity Area: *CC Saline Injection* ***Activity Type:*** *Injection*

Bore Name:	CCFMM03_S	**Ground RL (mAHD):**	408.70	**Monitored Aquifer:**	Upper TD.
Bore Name:	CCFMM03_D	**Ground RL (mAHD):**	408.70	**Monitored Aquifer:**	Oakover Fmn.
Bore Name:	CCFMM04_S	**Ground RL (mAHD):**	409.50	**Monitored Aquifer:**	Upper TD.
Bore Name:	CCFMM04_D	**Ground RL (mAHD):**	409.50	**Monitored Aquifer:**	Oakover Fmn.

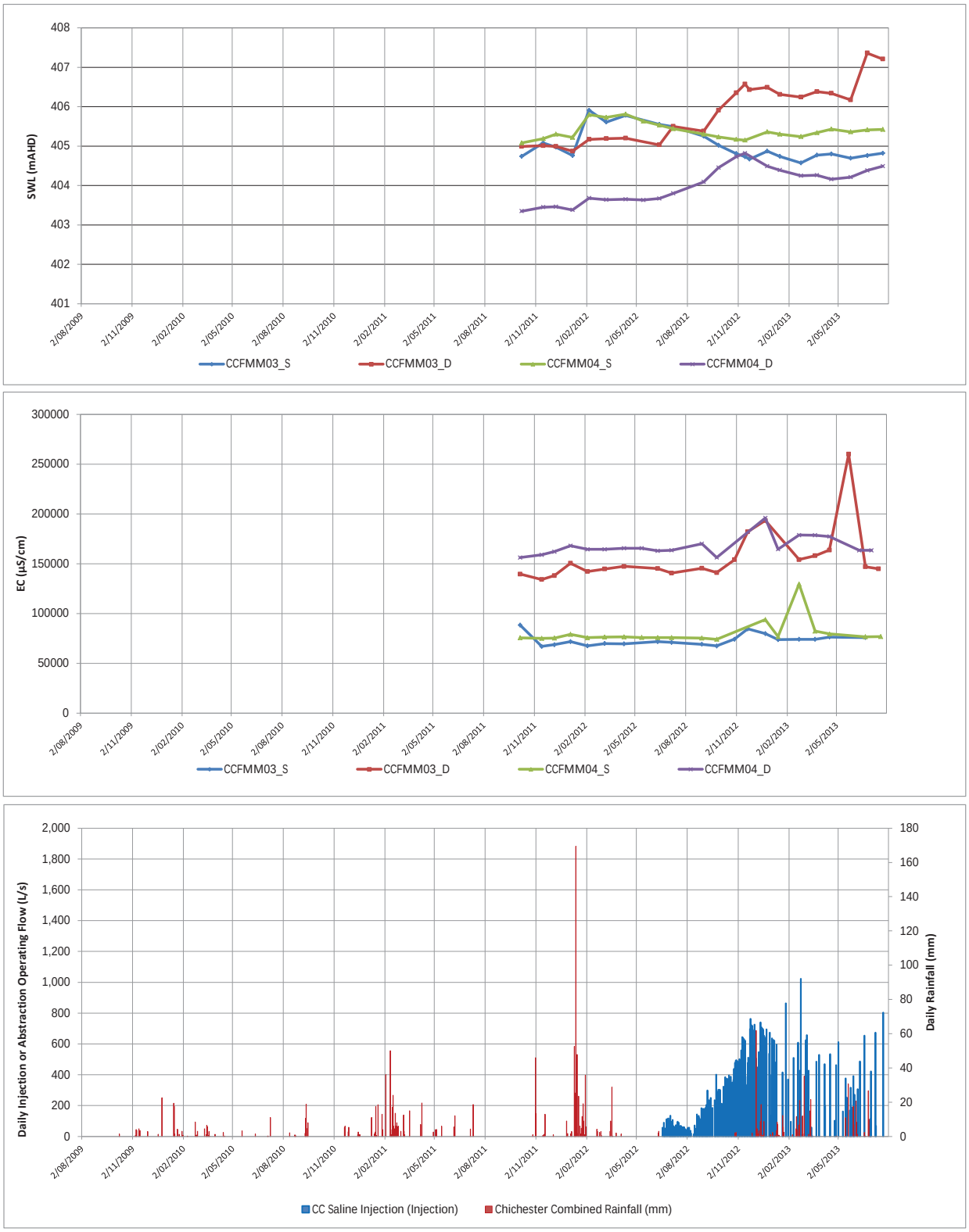


Figure 11: **Monitoring data for CCFMM03 and CCFMM04, central Near Marsh area**

Near Marsh - Representative Hydrograph 3

Nearest Activity Area: *CC Saline Injection* ***Activity Type:*** *Injection*

Bore Name:	CCFMM05_S	**Ground RL (mAHD):**	408.92	**Monitored Aquifer:**	Upper TD.
Bore Name:	CCFMM05_D	**Ground RL (mAHD):**	408.92	**Monitored Aquifer:**	Upper TD.
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Bore Name:		**Ground RL (mAHD):**		**Monitored Aquifer:**	

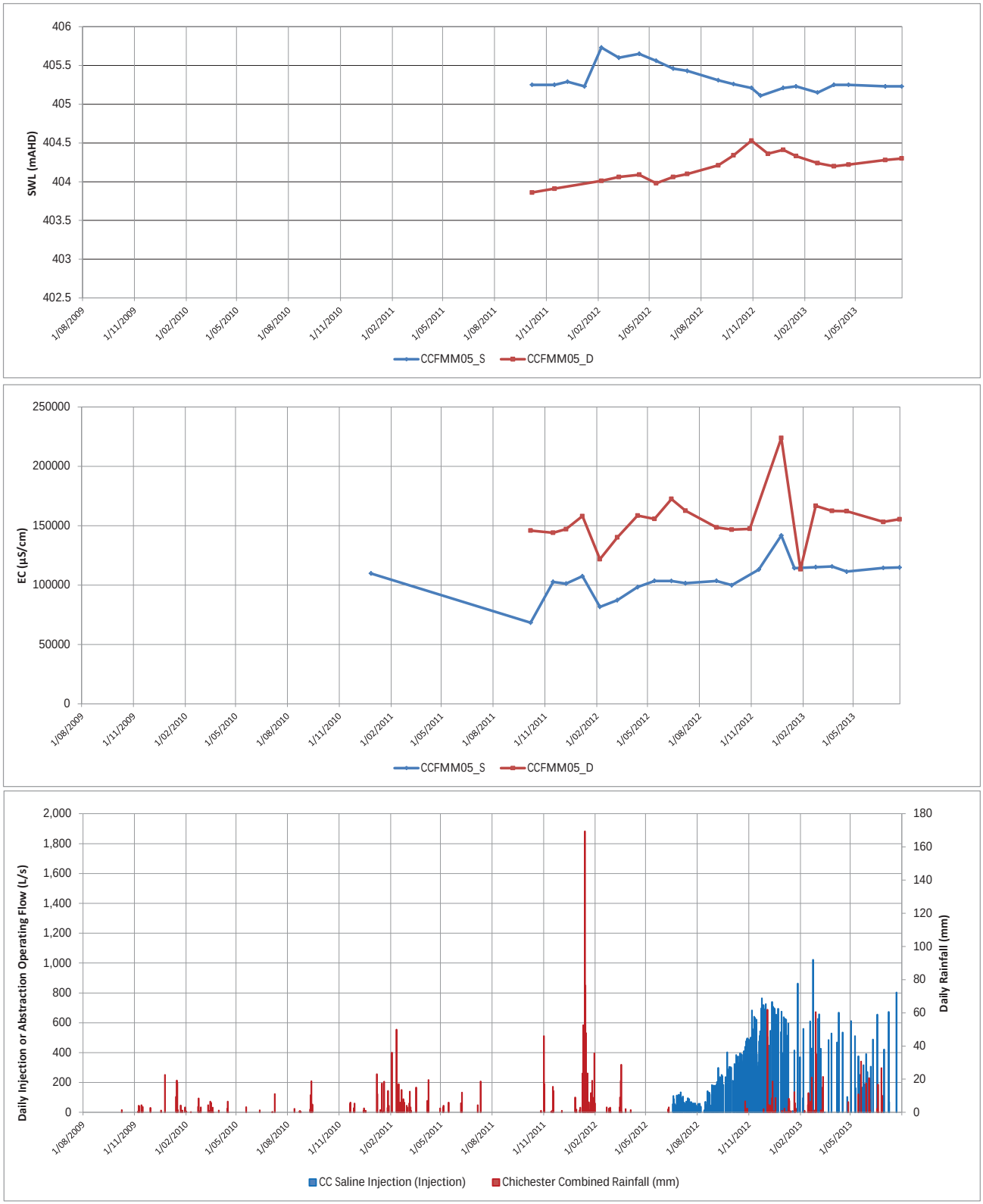


Figure 12: **Monitoring data for CCFMM05, eastern Near Marsh area**

8.3 Zone B – Saline Injection

There are over 60 monitoring bores (with nested piezometers) in the saline injection area. Most of these are constructed in proximity to injection bores and water level data from both UTD and OF aquifers are used to control injection rates (section 0).

A total of 37 of these monitoring bores (with nested piezometers) form part of the trigger network. Individual monitoring piezometer hydrographs, illustrating trigger water levels and EC, are included in Appendix 9. Representative hydrographs for this zone are shown in Figure 13 and Figure 14, and include both deep and shallow piezometers for each bore; identification of the monitored aquifer and ground level elevation is included on the hydrographs.

8.3.1 Water Levels

UTD water levels illustrated in the representative hydrographs have not varied notably during the monitoring period, and water levels are approximately 0.1 m higher at the end of the reporting period than when monitoring commenced in late 2011. SAM18_S is an exception, with a 0.6 m rise in water level between March and April 2013. At that time, there had actually been a reduction in local injection flow volumes, and there is no evidence to support a correlation between injection and UTD groundwater level rise.

In contrast, UTD data have shown a subdued response to climatic events, with small (~0.2 m), sustained rises in water level for up to three months after cyclone Heidi and periods of rainfall in 2013.

Referring to the trigger bore hydrographs in Appendix 9, there are some bores showing a rise in water level, although not all can be considered representative of UTD. Water levels in SAM16_S have risen by approximately 2 m since injection commenced but, on closer inspection, the bore is actually screened within the lowermost part of the TC unit, arguably in some connection with the OF. Other bores, such as SAM21_S, SAM23_S and SAM25_S, do show a steady increase in water levels since measurements started in December 2012. However, it is unclear whether this response is solely due to injection activity or the result of a wetter than average start to 2013.

Deeper groundwater levels in the OF and MMF demonstrate direct response to injection. The nature of the response is very dependent on the proximity of the monitoring points to active injection bores and the level of use of these bores. For example, the response to injection at SAI01 was measured in the OF less than 10 m away at SAM17_D, and in the MMF at SAM18_D, a distance of over 1,000 m. Upon commencement of saline injection in August 2011, the water levels in the Oakover Formation increased, with the more distant MMF monitoring data showing a rise in groundwater levels 2 months afterwards. Injection volume subsequently declined due to clogging of the open hole injection zone and, as a result, groundwater levels in both MMF and OF plateaued between December 2012 and May 2013. Once again, the MMF showed a delayed response to this change in injection regime. In May 2013, the injection bore

SAI01 was cleaned out as part of the regular maintenance of the injection borefield and, since injection rates are lower than before, groundwater level rise has not been as rapid as previously.

8.3.2 Water Quality

EC Values in the UTD monitoring piezometers have been stable, with some fluctuations most likely reflecting variation in the depth at which the EC was measured by field operators. SAM09_S does show a gradual reduction in EC after cyclone Heidi and through the 2013 wet season. This bore is located closest to active creek lines when compared to the other representative bores.

The OF and MMF EC in the saline injection area has also been largely stable, with no reduction in EC as a response to injection of lower EC water into the OF aquifer. There is a pattern of a peak in EC in early 2013; observed in SAM13_D, SAM12_D, SAM05_D and SAM16_D (the latter three are displayed in Appendix 9). Although the pattern is consistent, there has been no physical stressor identified which would directly result in increased salinity of the aquifer; the EC of injected water is lower than native groundwater EC. It is believed this pattern is due to a variation in the calibration of measuring equipment used to monitor these bores at that time, or alternatively variations in measurement depth.

8.3.3 Hydrochemistry

Groundwater chemistry data for the saline injection area are representative of a mixing zone between the sodium-chloride dominated Marsh environment and the sodium-chloride-calcium-bicarbonate recharge zone in the mining area and further north (Rockwater, 2014).

Rockwater (2014) assigned baseline values for some metals and based on time series data for the OF and UTD within the saline injection zone (Table 6, Appendix 8). This has been based on no observed changes to time series data since operation began; limited pre-operation data was available.

8.3.4 Interpretation

The Saline Injection region at Christmas Creek represents a transition zone between the fresher, MMF dominated Hillslope region and the saline to hypersaline Marsh region with greater thicknesses of Tertiary deposits (UTD, TC and OF).

Monitoring data to date suggests that, despite increases in water levels in the OF, there has been no widespread change in shallow groundwater levels or EC in the UTD. This is a likely indication of the function of the TC unit as a regional aquitard where, despite increases in vertical gradients, limited movement of groundwater has taken place. Localised increases in UTD water levels may be occurring due to leakage through the TC unit, although additional time series data is required to further assess this behaviour.

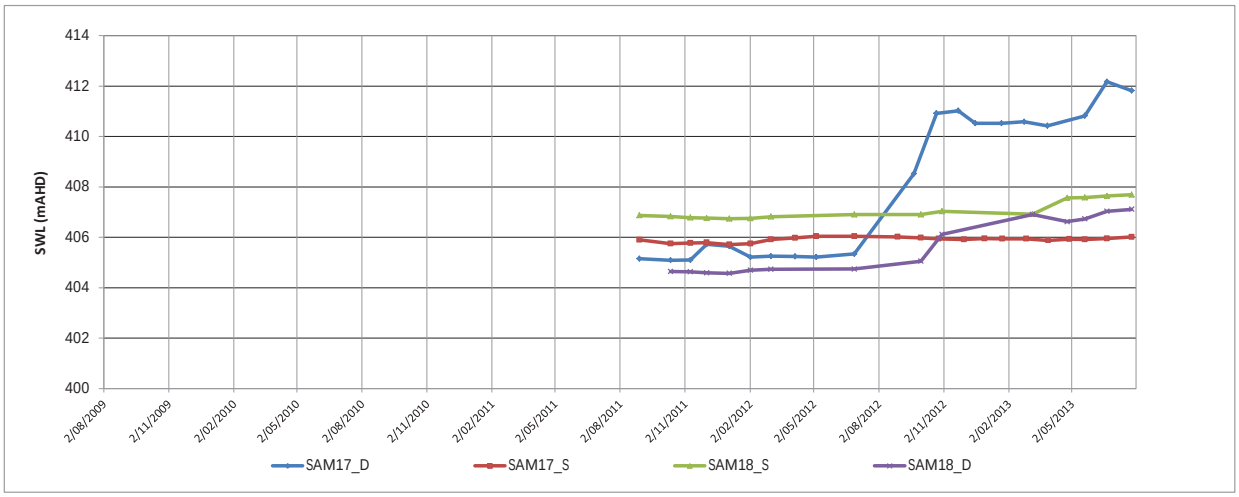
Electrical conductivity and hydrochemistry data support the interpretation of minimal vertical flux through the TC; as there is no evidence for mixing of groundwater across the aquitard, or suggestions that injected water is reporting to the UTD aquifer.

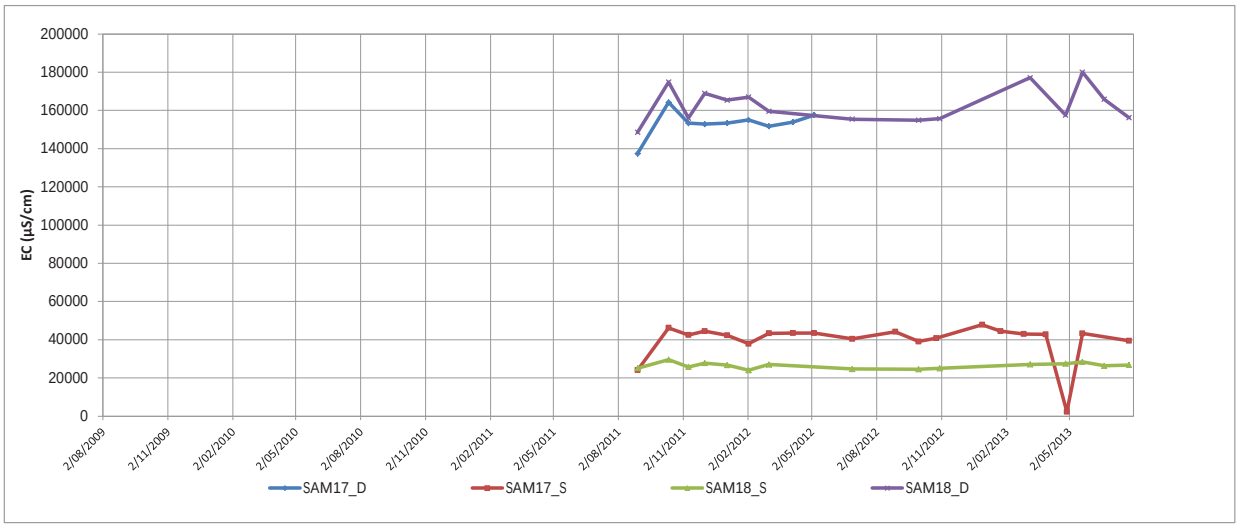
There is very little monitoring data which clearly demonstrates a lowering of aquifer EC, something with could be expected when mixing injected water (EC less than 80,000 µS/cm) with native groundwater (EC greater than 120,000 µS/cm). Some of the fluctuations in monitoring data may represent a shift in the saline water interface due to changing pressurisation of the aquifer. However, by the next sampling event, the pressure has largely equilibrated and the saline interface has returned to its long term average position. This capacity for responding to the volumes of water injected in the reporting period reflects the highly transmissivity and large storage potential of the OF aquifer.

Saline Injection - Representative Hydrograph 1

Nearest Activity Area: *CC Saline Injection* ***Activity Type:*** *Injection*

Bore Name:	SAM17_D	**Ground RL (mAHD):**	415.59	**Monitored Aquifer:**	Oakover Fmn.
Bore Name:	SAM17_S	**Ground RL (mAHD):**	415.59	**Monitored Aquifer:**	Upper TD.
Bore Name:	SAM18_S	**Ground RL (mAHD):**	416.85	**Monitored Aquifer:**	Upper TD.
Bore Name:	SAM18_D	**Ground RL (mAHD):**	416.85	**Monitored Aquifer:**	Marra Mamba Fn.





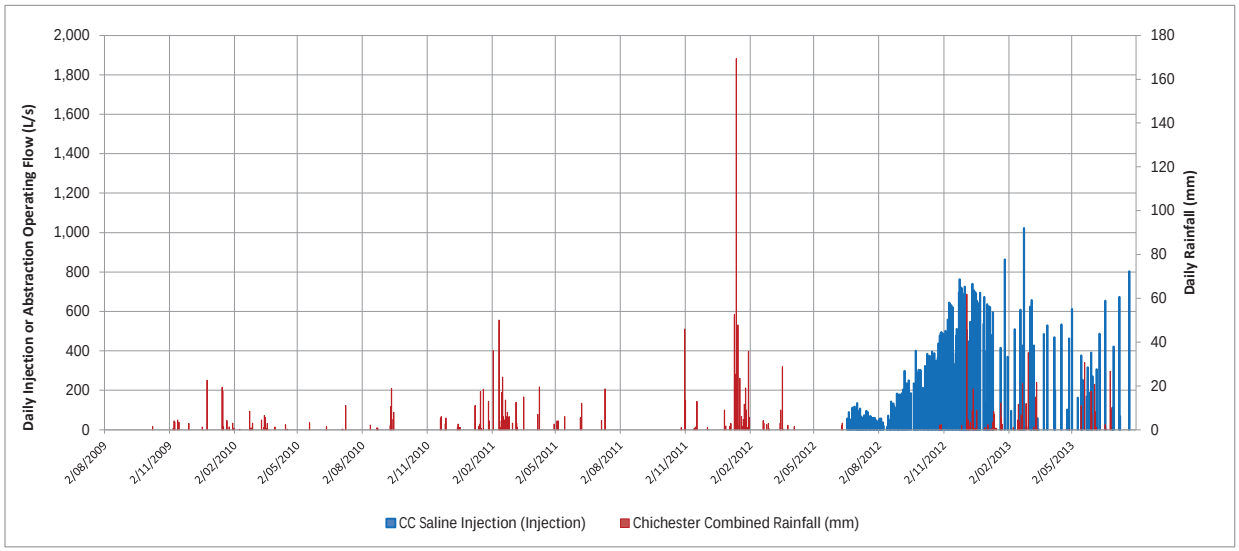


Figure 13: Monitoring data for SAM17 and SAM18, Saline Injection area

Saline Injection - Representative Hydrograph 2

Nearest Activity Area: *CC Saline Injection* ***Activity Type:*** *Injection*

Bore Name:	SAM09_S	**Ground RL (mAHD):**	417.09	**Monitored Aquifer:**	Upper TD.
Bore Name:	SAM09_D	**Ground RL (mAHD):**	417.09	**Monitored Aquifer:**	Oakover Fm.
Bore Name:	SAM13_S	**Ground RL (mAHD):**	419.10	**Monitored Aquifer:**	Upper TD.
Bore Name:	SAM13_D	**Ground RL (mAHD):**	419.10	**Monitored Aquifer:**	Oakover Fm.

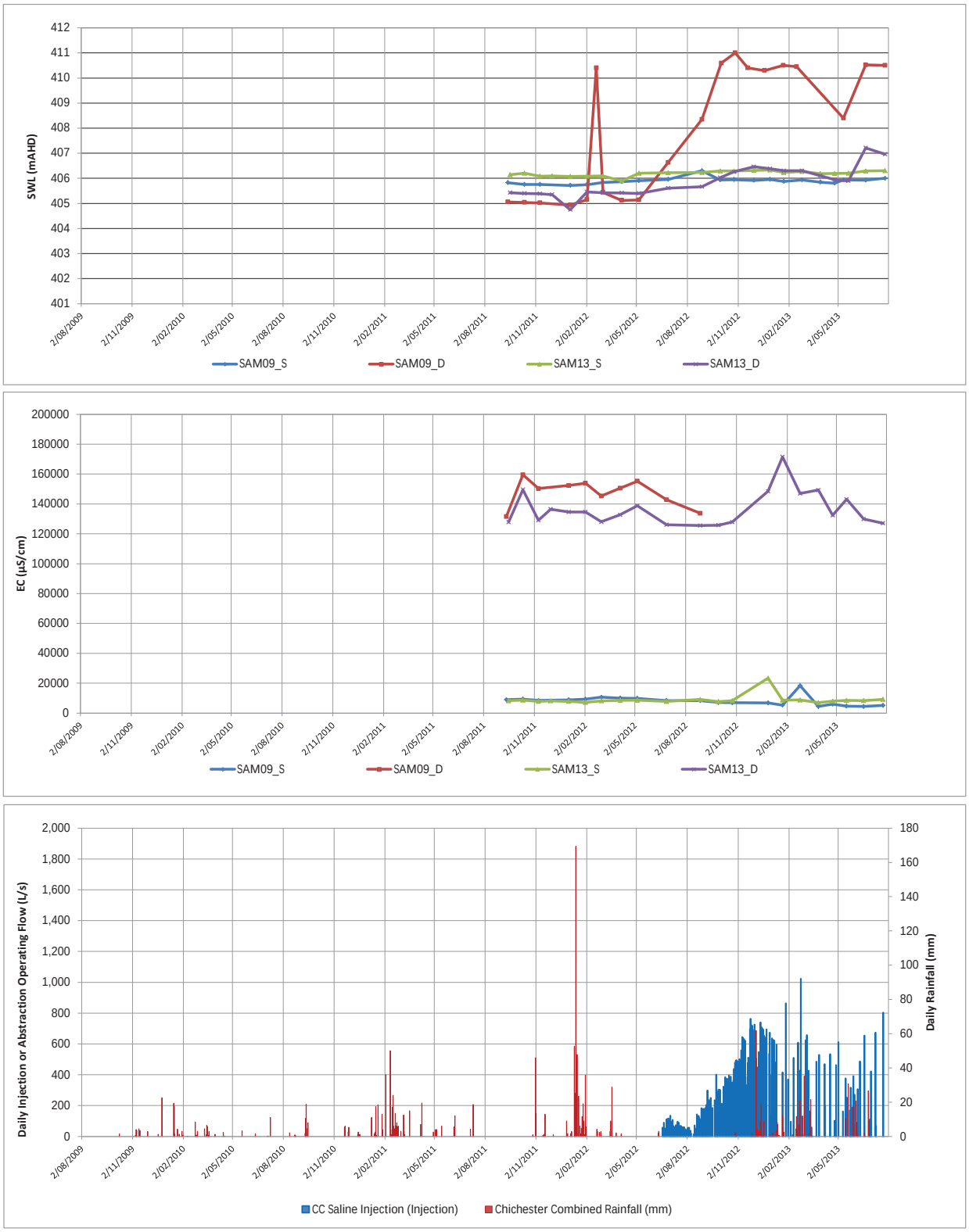


Figure 14: Monitoring data for SAM09 and SAM13, Saline Injection area

8.4 Zone C – Brackish Injection

Brackish injection occurs at the Spinifex and Hillside East borefields (Figure 5), to the east and west respectively of Christmas Creek's current mining area.

Individual monitoring piezometer hydrographs for Zone C's trigger network are included in Appendix 9. Representative hydrographs for this zone are shown in Figure 15 (Spinifex) and Figure 16 (Hillside East), and include both deep and shallow piezometers for each of the two bores; identification of the monitored aquifer and ground level elevation is included on the hydrographs.

8.4.1 Water Levels

Spinifex Injection area

Brackish water injection occurred intermittently at Spinifex from February 2012 to October 2012. The peak daily injection volume was 939 kL/d on the 12 November 2012. The injection borefield was converted to an abstraction borefield to supply the mine site with water for dust suppression and ore processing in January 2013. Abstraction was intermittent and generally was only used as a backup supply during peak demand periods.

SPM01 is a monitoring bore with shallow and deep piezometers, located within the Spinifex borefield. Monitoring data shows groundwater levels in SPM01_D (MMF) and SPM01_S (UTD) are very similar, with an average water level difference of 0.02 m, within the range of measurement error. Groundwater levels in both piezometers were approximately 409.9 m AHD prior to the start of brackish injection. Groundwater levels increased during periods of injection and decreased once again during periods of abstraction. Maximum rise in water level during the injection period was 1.95 m and 1.63 m in SPM01_D and SPM01_S respectively, with a net rise in groundwater level of 0.4 m.

SPM08 is a monitoring bore also with shallow and deep piezometers, although it is located approximately 3,600 m from the borefield. Data for both piezometers, SPM08_D (MMF) and SPM08_S (UTD), show similar trends, with an overall rise in water level of approximately 0.3 m. It is possible to infer a plateau in water levels measured in SPM08_D during the period of abstraction in 2013. Response to climatic events is not discernable and may be masked by the influence of nearby injection.

Hillside East Brackish Injection Area

Brackish water injection occurred intermittently in the Hillside East area from October 2011 to October 2012, although injection as part of the Cloudbreak operation had been occurring since early 2010 and became centred in the west of the borefield in 2011. The peak daily injection volume was 2,113 kL/d on the 21 November 2011. The injection bores were also converted to abstraction bores as per the Spinifex borefield.

HEMB02 is a monitoring bore with shallow and deep piezometers, located in the eastern extent of the Hillside East borefield. Monitoring data shows groundwater levels in HEMB02_D (MMF) and HEMB02_S (UTD) to be very similar prior to injection commencing in the eastern part of the borefield. Although both piezometers respond similarly to injection and later abstraction, a difference in groundwater level has quickly developed, with MMF water levels consistently 0.9 m lower than UTD levels. By the end of the monitoring period, groundwater levels had risen 0.5 m and 1.8 m in the MMF and UTD respectively. It is suspected the offset in groundwater levels is due to a calculation error for HEMB02_S; the reduced level for the measurement point was raised approximately 1 m at the end of August 2011.

The monitoring bore HEM01 is completed similarly to HEM02, with both shallow (UTD) and deep (MMF) piezometers. The data for this bore demonstrates very similar (arguably identical) water level readings throughout the monitoring period. Groundwater levels show similarly timed responses to HEM02's piezometers, yet the magnitude of the responses is subdued. The nearest injection bore, HEI01, is reported to have been operated at approximately half the rate of the nearest injection bore to HEM02.

8.4.2 Water Quality

Spinifex Injection area

Both the MMF and UTD aquifer in the vicinity of the borefield appear to respond directly to changes in EC of injected water, and recover once abstraction commences. EC values are slightly less in the UTD aquifer, although this is only noticeable in mid-2012 when injection activities were at their peak.

Neither of the monitoring piezometers at a distance from the active borefield area demonstrates a notable change in EC during the reporting period.

Hillside East Brackish Injection Area

EC values for the MMF aquifer in Hillside East also show a direct response to injection and abstraction activity (Figure 16). Both HEMB02_D and HEMB01_D experience a rise in EC in conjunction with rising EC in the injection bulk transfer line. When abstraction commences in 2013, the EC values start to fall, although only HEMB01_D returns to its original value.

Aside from what appear to be some erroneous readings in HEMB01_S, there is minimal change in EC for the UTD monitoring piezometers; with only HEMB02_S starting to reflect some rise in EC during the 2013 period of abstraction.

8.4.3 Hydrochemistry

As with the saline injection region, Rockwater (2014) have assigned baseline values for some metals and based on time series data for the UTD and MMF within the Brackish Injection region (Table 6, Appendix 8). There was no observed change in injection hydrochemistry for the

metals assessed; also no trends were identified to suggest response to operational activities in the zone.

8.4.4 Interpretation

Data from the Spinifex and Hillside East borefields clearly demonstrate the response to brackish injection and abstraction activities during the reporting period. This is reflected in changes to groundwater level and electrical conductivity in the vicinity of the borefields. Groundwater chemistry does not appear to have changed in this time.

Despite the shallow bore construction in injection bores adjacent to representative monitoring bores, there has been more of a response in the MMF aquifer to changes in injection EC. However, groundwater levels in both MMF and UTD seem to be closely aligned, if not identical. This is interpreted to reflect the higher injection capacity in the MMF, borne of higher permeability, and the likely direct connection between the MMF and the UTD in these locations. In this case, although the MMF receives more of the injection water (thereby impacting salinity mass balance), there is a direct transfer of any additional pressure head imparted by the injection; or vice versa in the case of abstraction.

The lack of response measured in SPM08 gives some qualitative indication of the range of influence of injection and abstraction activities undertaken at the Spinifex borefield.

Brackish Injection - Representative Hydrograph 1

Nearest Activity Area: *Spinifex Pigeon* ***Activity Type:*** *Injection*

Bore Name:	SPM01_S	**Ground RL (mAHD):**	433.71	**Monitored Aquifer:**	Upper TD.
Bore Name:	SPM01_D	**Ground RL (mAHD):**	433.71	**Monitored Aquifer:**	Marra Mamba Fn.
Bore Name:	SPM08_S	**Ground RL (mAHD):**	442.60	**Monitored Aquifer:**	Upper TD.
Bore Name:	SPM08_D	**Ground RL (mAHD):**	442.60	**Monitored Aquifer:**	Marra Mamba Fn.

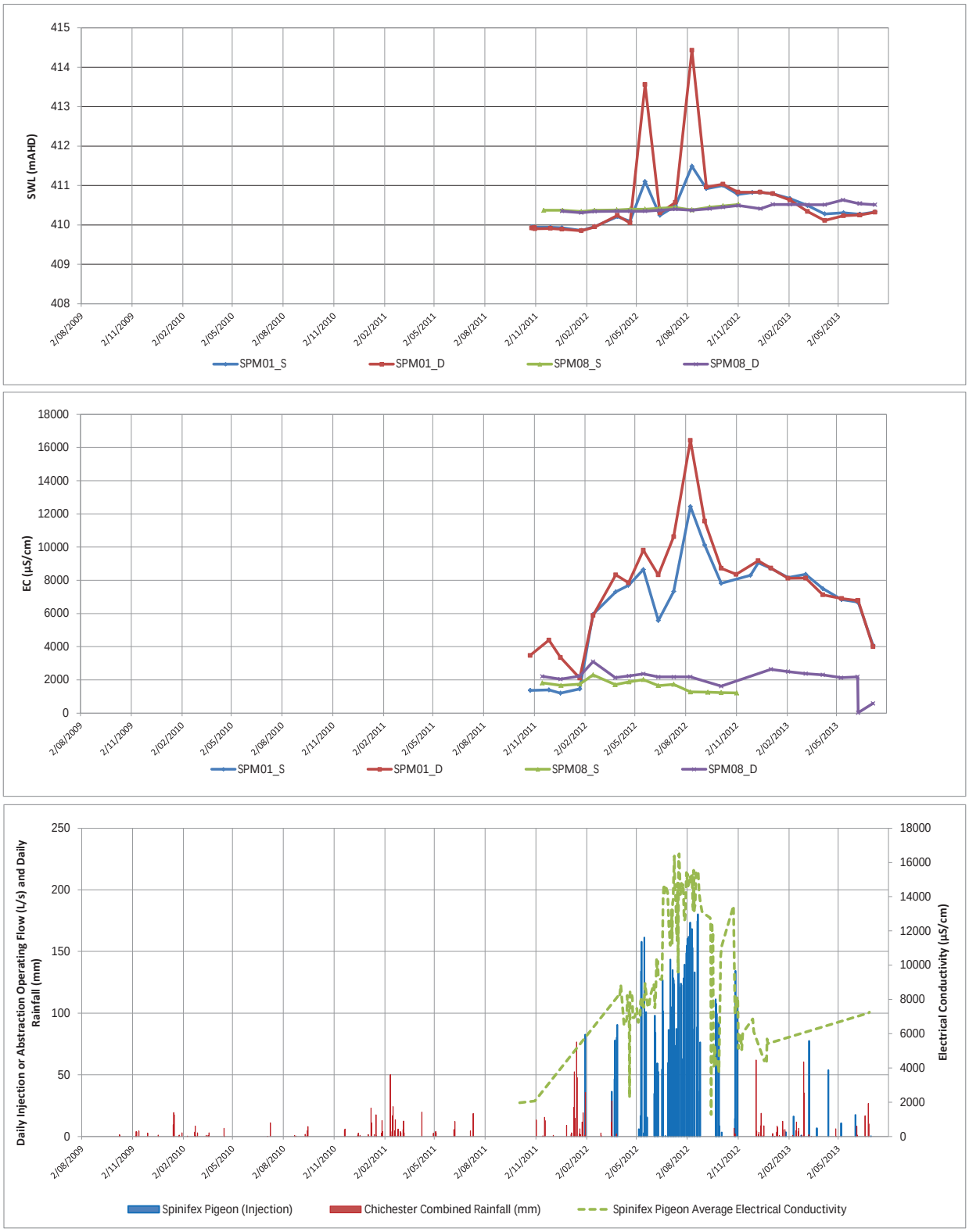


Figure 15: Monitoring data for SPM01 and SPM08, Brackish Injection area

Brackish Injection - Representative Hydrograph 2

Nearest Activity Area: *Combined Hillside Eas* ***Activity Type:*** *Injection*

Bore Name:	HEMB01_S	**Ground RL (mAHD):**	427.20	**Monitored Aquifer:**	Upper TD.
Bore Name:	HEMB01_D	**Ground RL (mAHD):**	427.20	**Monitored Aquifer:**	Marra Mamba Fn.
Bore Name:	HEMB02_S	**Ground RL (mAHD):**	427.18	**Monitored Aquifer:**	Upper TD.
Bore Name:	HEMB02_D	**Ground RL (mAHD):**	427.18	**Monitored Aquifer:**	Marra Mamba Fn.

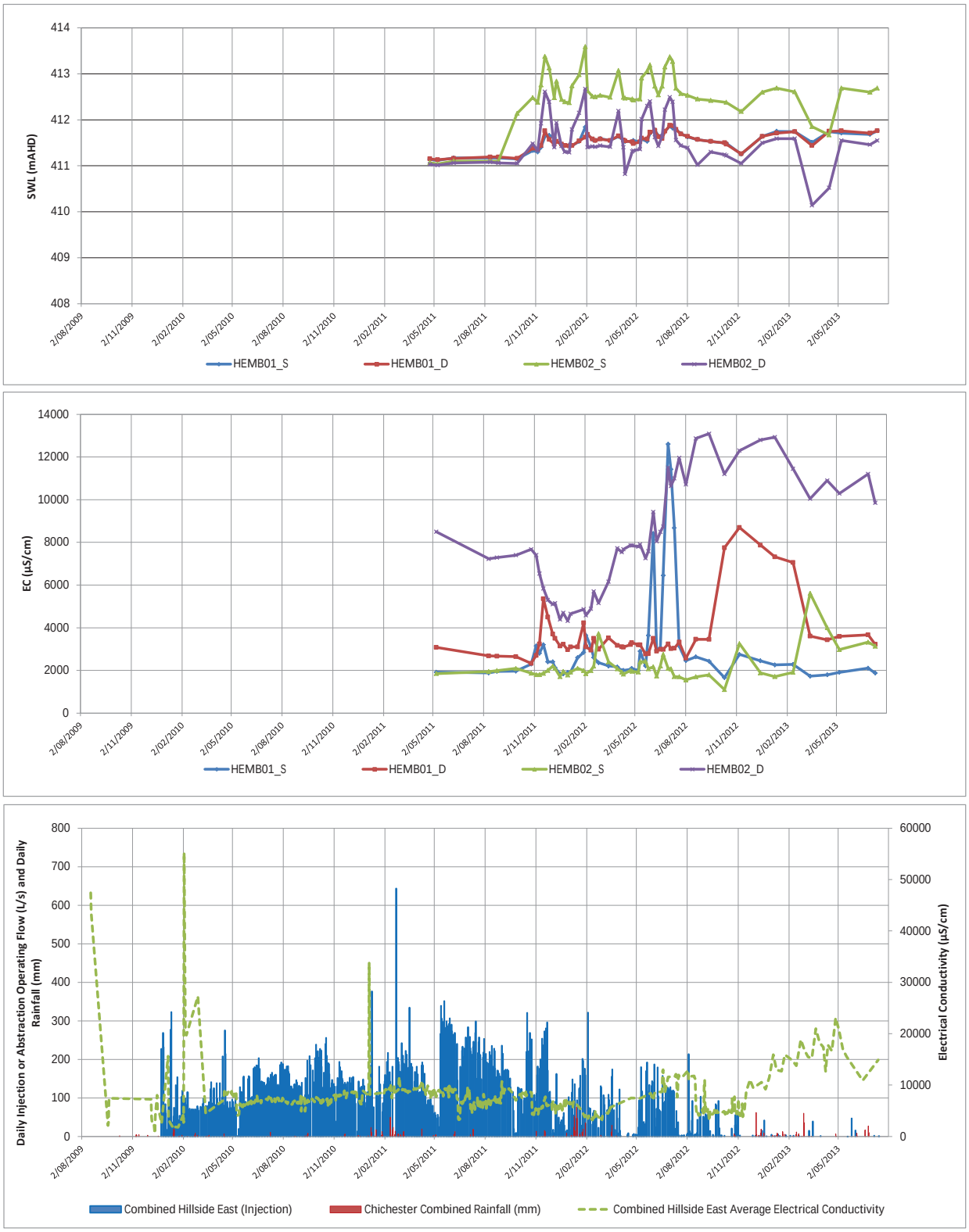


Figure 16: **Monitoring data for HEMB01 and HEMB02, Brackish Injection area**

8.5 Zone D – Phreatophytic

Monitoring bores for the Phreatophytic region are located along major drainage features, including Christmas Creek (Appendix 6).

Individual monitoring piezometer hydrographs for Zone D's trigger network are included in Appendix 9. A combined hydrographs for bores in this zone is shown in Figure 15; identification of the monitored aquifer and ground level elevation is included on the hydrograph. Please note the customised scale for EC time series data; values for SCX05_D were an order of magnitude higher than other bores in this hydrograph.

8.5.1 Water Levels

Western Creek (unnamed)

Groundwater levels, as measured in SCX05_D (OF) and SCX05_S (UTD) reflect the proximity of the bore to the Christmas Creek Saline Injection region. Prior to injection commencing in August 2012, there was an approximately 1.5 m difference in levels between the UTD and OF, with the latter having deeper readings. Both piezometers responded similarly to rainfall in the 2010/2011 wet season and 2011/2012 wet season, rising almost 0.5 m over a period of 3 months on both occasions. In November 2012, saline injection had ramped up to almost 300 L/s, and water levels in both piezometers rose by over 2 m. The difference in water level also reduced between the two piezometers to 1.5 m and has remained so until the end of the monitoring period. Groundwater levels have continued to rise and are now 4 m higher than baseline in both UTD and OF.

The similarity of response in SCX05, particularly given the presence of clay rich material between the UTD and OF, is suggestive of a failed nested construction. SCX05 was constructed in 2005, with a thin bentonite seal and what is recorded as backfill between the shallow and deep piezometers. The interpretation of data from this bore considers the possibility of artificial connection at this location.

Central Creek (unnamed)

CCF07B_S represents water levels in the UTD aquifer, originally screened to 27 m but reconstructed in May 2013 and only screened to 18 m. Water level data shows a series of recharge and recession cycles; most notably in the 2010/2011 wet season and 2011/2012 wet season. A rise in water levels in the latter half of 2012, where no rain occurred, may have been a reflection of the start of saline injection to the south of CCF07B. Since injection volumes were reduced at the start of 2013, water levels have recovered to approximately 408 m AHD. There is no indication whether the new construction of the bore will impact its response to future changes in injection or dewatering.

Eastern Creek (Christmas Creek)

CCF03A_S also represents water levels in the UTD aquifer, and is screened to 30 m. Water levels during the reporting period have behaved almost identically to those measured in CCF07B_S, although there has been no noticeable fluctuation in water levels since the commencement of saline injection. The bore is approximately 4 km from the eastern end of the saline injection line.

8.5.2 Water Quality

Western Creek (unnamed)

EC values in the UTD have fluctuated within a range of 3,100 – 10,000 µS/cm. It is not clear whether there are any trends due to the narrow range of values and uncertainty over measurement accuracy. Although EC values at the end of the reporting period are above average, pre-operation values have been higher in the past. This appears to have occurred in the 2 – 3 months after summer rainfall events.

Values of EC in the OF increased gradually from 60,000 µS/cm in September 2009 to over 140,000 µS/cm in November 2011 before declining to 70,000 µS/cm by the end of the reporting period. The decline in values coincided with the start of saline injection.

Central Creek (unnamed)

EC values in the UTD prior to September 2012, represented by CCF07B_S, show a steady decline from 3,200 µS/cm in September 2009 to 1,600 µS/cm three years later, interjected by elevated levels (up to 8,500 µS/cm) during the 2010/2011 wet season. Data between September 2012 and February 2013 suggests a rise and fall in EC coincident with the ramp up and subsequent reduction in saline injection. The latter part of the reporting period's data is more stable, with EC gradually rising to approximately 5,000 µS/cm.

Eastern Creek (Christmas Creek)

Data from CCF03A_S illustrates fluctuating EC values within a narrow range of 2,100 µS/cm and 5,000 µS/cm. As with SCX05_S, it is possible to relate the timing of increases in EC with large or prolonged rainfall events.

8.5.3 Hydrochemistry

Rockwater (2014) categorised data from Zone D as part of the 'rainfall recharge zone. The study of hydrochemical data for the zone resulted in the establishment of baseline values for a number of elements and there were no notable changes in available data for the reporting period.

8.5.4 Interpretation

From the monitoring data, it seems likely that SCX05_S is in direct connection with SCX05_D and its suitability as a valid phreatophytic monitoring bore should be investigated. Levels in SAM18_S, which is closer to the saline injection borefield than SCX05_S, have only risen 0.6 m (section 8.3.1) as opposed to over 2 m of change observed in SCX05_S.

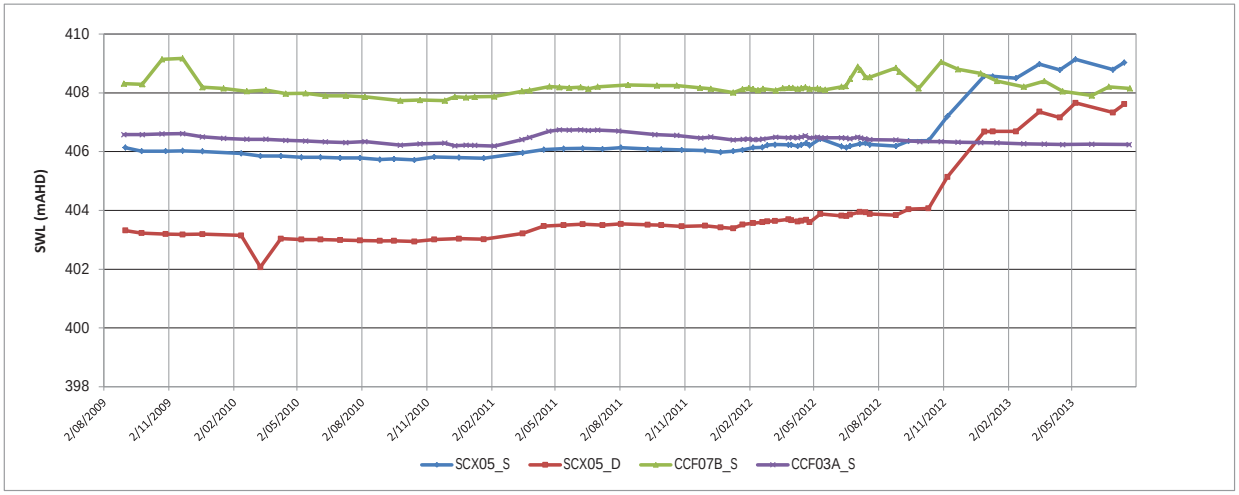
Data from the other monitoring piezometers in Zone D are interpreted to represent an area of rainfall and runoff recharge, where water levels are seen to respond slowly to large rainfall events. Rises in EC after rainfall events are thought to represent leaching of previously evaporated salts in the soil profile, and the slow response of both EC and water level reflects both the deep slotted profile of the monitoring bores and perhaps the limited permeability in the UTD (when compared to expected responses from coarse grained alluvial gravel systems).

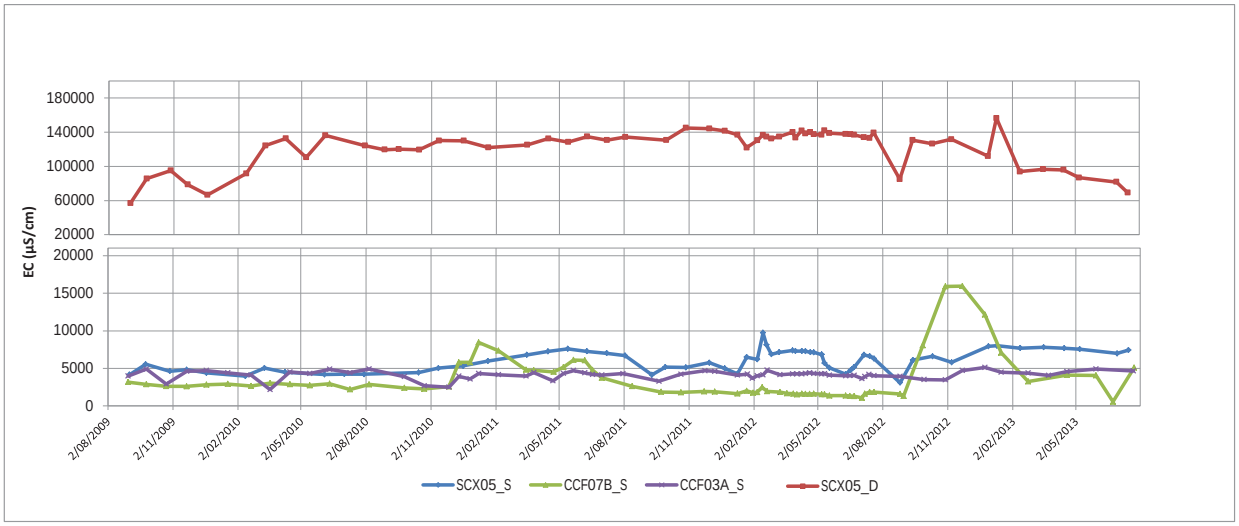
The data for this zone does not suggest either injection or dewatering operations have influenced groundwater availability or quality. With the exception of SCX05_D, which is arguably not suitable for phreatophytic monitoring, all monitoring piezometers in this zone are cased within the UTD only. It does appear unlikely that saline intrusion would report to this horizon, particularly without any notable increases in EC.

Phreatophytic - Representative Hydrograph 1

Nearest Activity Area: *CC Saline Injection* ***Activity Type:*** *Injection*

Bore Name:	SCX05_S	**Ground RL (mAHD):**	415.00	**Monitored Aquifer:**	Upper TD.
Bore Name:	SCX05_D	**Ground RL (mAHD):**	416.00	**Monitored Aquifer:**	Oakover Fm.
Bore Name:	CCF07B_S	**Ground RL (mAHD):**	423.00	**Monitored Aquifer:**	Upper TD.
Bore Name:	CCF03A_S	**Ground RL (mAHD):**	421.26	**Monitored Aquifer:**	Upper TD.





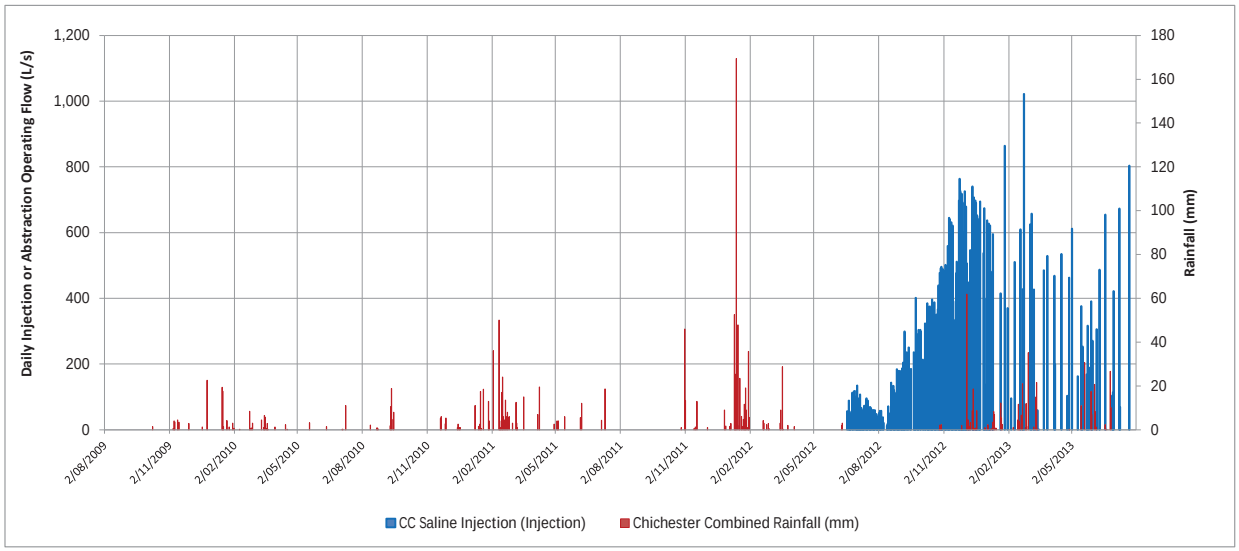


Figure 17: Monitoring data for SCX05, CCF03A_S and CCF07B_S, Phreatophytic Monitoring area

8.6 Neighbouring Project

Four monitoring bores, SPM07, SPM08, SPM09 and SPM10, have been identified as trigger bores for managing impacts from injection on Roy Hill's mining project to the east of Christmas Creek.

Representative hydrographs from SPM09 and SPM10 are shown in Figure 18; identification of the monitored aquifer and ground level elevation is included on the hydrograph.

8.6.1 Water Level

Water level in the MMF, as measured inSPM09_D, have fluctuated over a narrow range in the reporting period, and have risen a total of 0.08 m in this time.

Water level measured in SPM10_D, currently interpreted as LTD, has risen a total of 0.14 m over the reporting period, with a peak of 409.27 m AHD in November 2012. This is 0.7 m above the baseline water level measured in December 2011. Water levels in SPM10_D have been falling since the start of 2013. SPM10_D is located 6 km and 7 km from Spinifex borefield and the saline injection borefield respectively.

There is only a short data set for UTD water levels, measured in SPM10_S. The available data indicates a similar, albeit subdued, rise in water level as measured in SPM10_D.

8.6.2 Water Quality

EC values in the LTD have fluctuated between 40,000 µS/cm and 50,000 µS/cm, but with no consistent trends. There have been no clear responses to rainfall, injection or abstraction at nearby Spinifex borefield.

Similarly, EC values in the MMF and UTD have not displayed any clear trends, fluctuating in a 2,000 µS/cm range over the reporting period (data for the UTD ceases in November 2011).

8.6.3 Hydrochemistry

Hydrochemical analysis of these bores was not required for meeting the management objective of this zone.

8.6.4 Interpretation

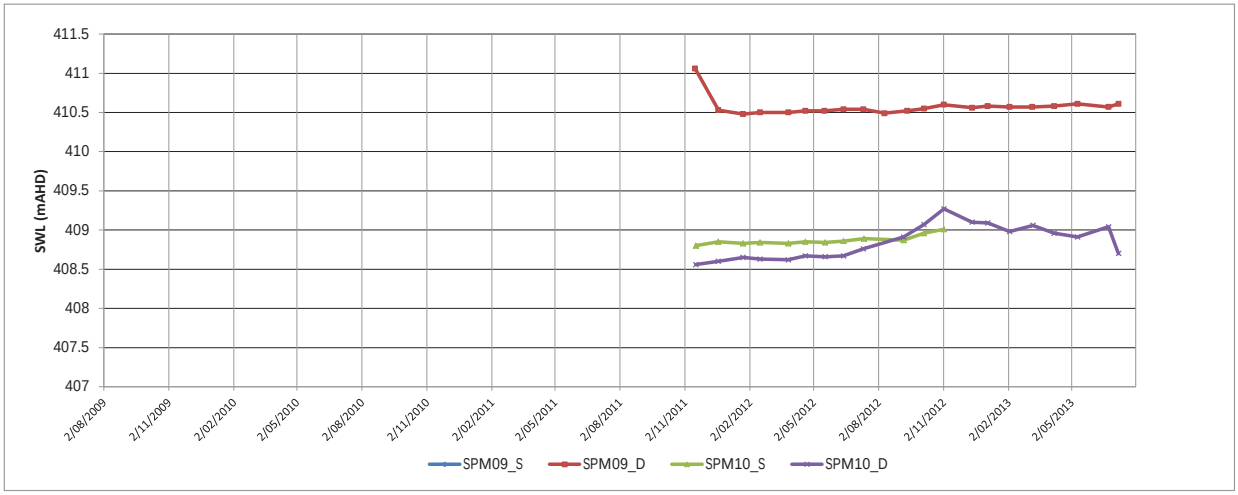
Monitoring data at the boundary of Christmas Creek and Roy Hill can be interpreted as demonstrating a subdued response to water management activities at Spinifex borefield. The rises and subsequent recovery of levels in SPM10_D is timed concurrently with the peak of injection at Spinifex followed by the commencement of abstraction in 2013. The limited

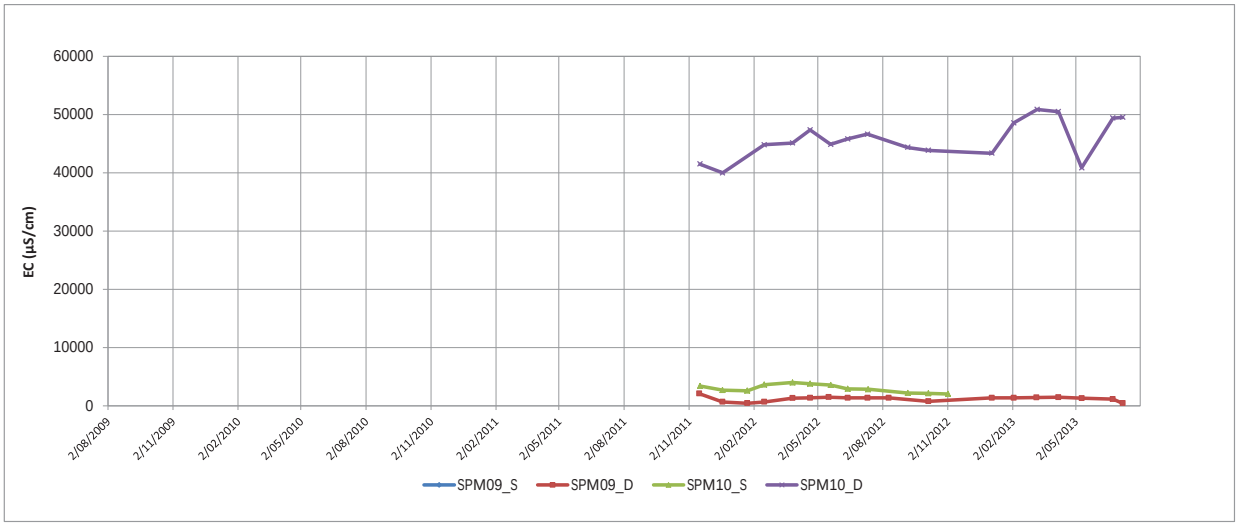
response of the MMF, measured at SPM09, can be due to variable connectivity between the bore and Spinifex borefield along strike in this location. The LTD observed in SPM10 may be part of a palaeochannel deposit cutting through the MMF; in a sub-parallel direction to modern drainage (NNE-SSW).

Neighbouring Tenement - Representative Hydrograph 1

Nearest Activity Area: *Spinifex Pigeon* ***Activity Type:*** *Injection*

Bore Name:	SPM09_S	**Ground RL (mAHD):**	442.60	**Monitored Aquifer:**	Upper TD.
Bore Name:	SPM09_D	**Ground RL (mAHD):**	442.60	**Monitored Aquifer:**	Marra Mamba Fn.
Bore Name:	SPM10_S	**Ground RL (mAHD):**	424.71	**Monitored Aquifer:**	Upper TD.
Bore Name:	SPM10_D	**Ground RL (mAHD):**	424.71	**Monitored Aquifer:**	Lower TD.





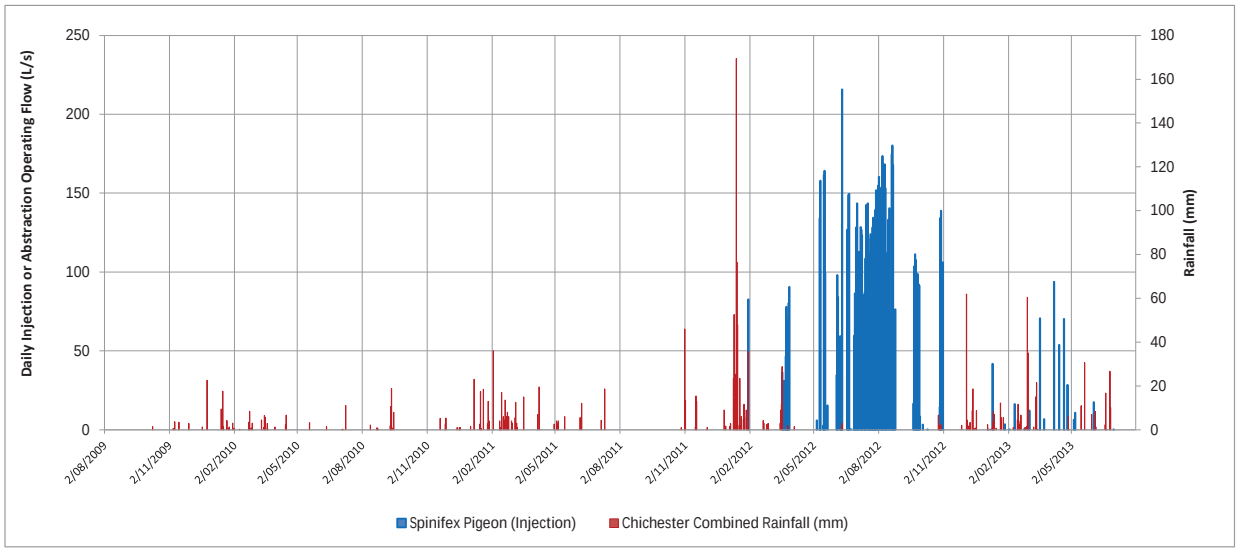


Figure 18: Monitoring data for SPM09 and SPM10, Monitoring Neighbouring Tenements

8.7 Regional Summary

Monitoring data, and an interpretation thereof, has been presented for the four management zones of Christmas Creek and the active mining area separately. The following is an amalgamation of these interpretations; with the purpose of establishing a regional perspective on groundwater level, EC and hydrochemical changes within the reporting period.

The regional interpretation recognises there is complexity and uncertainty associated with:

- Local hydrostratigraphic variation;
- Spatially variable injection or abstraction operations;
- Variable bore construction and degradation of seals over time; and
- Inaccuracy and uncertainty associated with some measurements, particularly EC.

To this effect, assessing data at a broad spatial level through contour plots enables local averaging of individual bore results and smoothing of variability which does not represent the regional trend. Appendix 10 contains illustrations of groundwater level[6] and EC contours for the UTD, OF and MMF aquifers, at the following times:

- Towards the commencement of Christmas Creek operations in October 2011, although there was limited spatial coverage of monitoring bores;
- At the peak of saline injection operations in January 2013; and
- In July 2013, at the end of the reporting period.

8.7.1 Water Level

The water level contour maps for the MMF and OF aquifers over time show drawdown of water levels around Flinders and, to a lesser degree, Windich Pit. Mounded water levels are evident around the Vasse TSF, although the hydraulic gradient to the south has reduced between January 2013 and July 2013. There has been little change in groundwater levels at Spinifex borefield over time, whilst Hillside east has experienced an up to 2 m increase in water levels between October 2011 and January 2013, followed by a 2 m decrease to July 2013.

Additional data has become available for OF water levels in the saline and Near Marsh region over time. Where comparable, contour interpretations suggest an increase in OF water levels in the west of the injection borefield.

There has been little regional change in the UTD water levels as represented by a comparison of the three contour maps. The exception is a cone of depression around Flinders pit which

[6] Not corrected to a freshwater equivalent level

developed between October 2011 and January 2013, and has extended slightly westwards by July 2013.

8.7.2 Electrical Conductivity

Comparison of the EC contour maps for the MMF and OF aquifers for the three time periods indicates the saline interface has regionally migrated northwards, with the effect most notable in the pit areas. Between January and July 2013, the data does indicate two instances of slight reduction of EC:

a) Around Spinifex borefield, with the 40,000 µS/cm contour shifting to the south; and

b) In the central and western part of the injection borefield, where the maximum recorded EC levels reduced from 200,000 µS/cm to approximately 160,000 µS/cm

The UTD EC contour maps indicate there has been very little change in EC over the three representative periods. Additional resolution for contouring has occurred through the addition of monitoring bores over time, and some ‘bullseye’ features occur from erroneous input data.

8.7.3 Hydrochemistry

Assessment of hydrochemistry data included in Appendix 8 by Rockwater suggests there has been minimal change during the review period.

8.7.4 Interpretation

Active dewatering has caused significant dewatering of the MMF and overlying Tertiary sediments and fringing depressurisation. The zone of impact is elliptical and aligned with the strike of the MMF due to the orientation of mine pits, permeability restrictions and injection occurring in the OF to the south. Groundwater levels around the Flinders pit area are approximately 30-50 m below pre-mining groundwater levels. Groundwater levels around the Windich pit area are approximately 10-15 m below pre-mining levels.

Groundwater levels just south of the Vasse TSF are elevated which may be due to leakage from the TSF. Elevated groundwater levels also occur south of the Windich TSF. High groundwater gradients exist between Vasse TSF and Flinders dewatering area. This may be due to mounding south of the TSF or higher groundwater levels associated with outcropping MMF and drawdown from the dewatering occurring around the Flinders pit area.

The salinity of groundwater within the mining domain has increased in proximity to active dewatering areas. This is interpreted to be due to a combination of lateral flux of saline groundwater (from the OF) and vertical migration of saline water due to depressurisation of overlying brackish aquifers.

Groundwater EC is fresh in the northern area of the mine site along the base of the outcropping MMF. This is due to the groundwater recharge that occurs via rainfall and infiltration through the outcropping MMF. EC increases to the south by two orders of magnitude in the OF aquifer and the WF that has been intercepted on the northern edge of the Fortescue Marsh. The 1,000 µS/cm water quality contour (Appendix 10) to the northeast of Flinders pit area represents a small hill of outcropping bedrock. This is a pathway for recharge during rainfall and thus has a lower EC than the surrounding deeper monitoring bores.

Limited to no mounding in the UTD has occurred in the Saline Injection region. No decline in groundwater levels on the northern edge of the Fortescue Marsh has occurred due to abstraction activities.

Groundwater electrical conductivity gradients in the UTD increase steeply to the south towards the Fortescue Marsh. EC around the mining region is fresh-brackish due to better connectivity with the brackish MMF aquifer. The presence of a shallow freshwater lens in the Saline Injection region and along the flanks of the Fortescue Marsh is not evident from the data that has been collected over the monitoring period.

Injection of saline groundwater into the OF has caused pressurisation of the aquifer in the vicinity of the borefield. Groundwater mounding in the OF is occurring around the saline injection borefield as injection volumes have increased over time. The area of mounding has developed along the injection borefield operating area. Groundwater levels are approximately 405-410 m AHD (2 m bgl) which is the limit of mounding that can occur, due to the system controls currently in place. Mounding is extending to the south, which is due to the presence of a confined high permeability calcrete aquifer. The pressure gradient has not resulted in any changes to UTD conditions.

Some decrease in salinity of the OF groundwater around the saline injection borefield has occurred due to the injection of lower EC water than the native hypersaline groundwater.

9. COMPLIANCE

This section describes compliance with the following:

- 5C licence abstraction limits;
- Class 1 and 2 trigger levels for water level and EC; and
- Required monitoring frequency

As Christmas Creek is a relatively new site, an evolving operating strategy has been required as the site develops. This short duration of operations and the nature of the mining at Christmas Creek have resulted in changes in the bi-annual monitoring positions over the duration of the review period. These changes have been logged in each review of the Operating Strategy (Table 8), but do complicate review of compliance over long periods.

9.1 5C Licence Abstraction Limits

A summary of compliance with 5C licence abstraction limits is presented in Table 10. The data illustrates that Fortescue have not exceeded the annual water entitlement during the reporting period.

Table 10: Summary of compliance with 5C licence abstraction limits

Water Year	Operating licence at end of Water Year	Annual Water Entitlement (kL)	Volume abstracted (kL) (with % of entitlement)
Aug 2009 – July 2010	167593 (1)	1,150,000	930,100 (81%)
Aug 2010 – July 2011	167593 (1)	1,150,000	924,868 (80%)
Aug 2011 – July 2012	167593 (5)	48,000,000	9,170,000 (22%)
Aug 2012 – July 2013	167593 (5)	48,000,000	36,285,000 (76%)

9.2 Triggers

As discussed in section 7.3 there has been ongoing development of trigger levels for monitoring bores as part of reviews to the groundwater operating strategy. This section will present trigger compliance data for the 2012/2013 water year, summarise annual compliance (as reported in previous Annual Aquifer Reviews) for the entire reporting period and discuss any patterns in exceedances.

9.2.1 2012/13 Water Year Trigger Exceedances

There have been 71 level 1 trigger exceedances during the 2012/13 water year. All level 1 trigger exceedances have been reported internally to key stakeholders as a report containing the trigger value and a hydrogeological review and explanation. Level 1 trigger reports have

been included in each subsequent Quarterly Aquifer Review submitted to the Department of Water. The most recent (June – August 2013) level 1 trigger exceedances have been included in Appendix 11. Table 11 below summarises the exceedances that have occurred during the monitoring period.

Table 11: Level 1 trigger exceedances during monitoring period

Monitoring zone	Date	Bore	Category	Explanation
A	22/11/2012	CCFMM01_D	WL	Mounding from saline injection
A	24/12/2012	CCFMM01_D	WL	Mounding from saline injection
A	16/01/2013	CCFMM01_D	WL	Mounding from saline injection
A	24/03/2013	CCFMM01_D	WL	Mounding from saline injection
A	19/04/2013	CCFMM01_D	WL	Mounding from saline injection
A	25/05/2013	CCFMM01_D	WL	Mounding from saline injection
A	23/06/2013	CCFMM01_D	WL	Mounding from saline injection
A	26/06/2013	CCFMM01_D	WL	Mounding from saline injection
A	21/07/2013	CCFMM01_D	WL	Mounding from saline injection
A	16/08/2013	CCFMM01_D	WL	Mounding from saline injection
A	24/12/2012	CCFMM02_D	WL	Mounding from saline injection
A	16/01/2013	CCFMM02_D	WL	Mounding from saline injection
A	24/03/2013	CCFMM02_D	WL	Mounding from saline injection
A	19/04/2013	CCFMM02_D	WL	Mounding from saline injection
A	2/05/2013	CCFMM02_D	WL	Mounding from saline injection
A	23/06/2013	CCFMM02_D	WL	Mounding from saline injection
A	26/06/2013	CCFMM02_D	WL	Mounding from saline injection
A	19/08/2013	CCFMM02_D	WL	Mounding from saline injection
A	22/11/2013	CCFMM02_D	WL	Mounding from saline injection
A	14/11/2012	CCFMM03_D	WL	Mounding from saline injection
A	24/12/2012	CCFMM03_D	WL	Mounding from saline injection
A	16/01/2013	CCFMM03_D	WL	Mounding from saline injection
A	23/02/2013	CCFMM03_D	WL	Mounding from saline injection
A	23/02/2013	CCFMM03_D	WL	Mounding from saline injection
A	24/03/2013	CCFMM03_D	WL	Mounding from saline injection
A	19/04/2013	CCFMM03_D	WL	Mounding from saline injection
A	25/05/2013	CCFMM03_D	WL	Mounding from saline injection
A	23/06/2013	CCFMM03_D	WL	Mounding from saline injection
A	19/08/2013	CCFMM03_D	WL	Mounding from saline injection
A	19/08/2013	CCFMM04_D	WL	Mounding from saline injection
C	1/07/2012	HEMB01_S	EC	Injecting saline water
C	1/07/2012	HEMB01_S	EC	Injecting saline water. EC declined immediately after injection stopped
C	2/08/2012	HEMB02_D	EC	Injecting saline water
C	12/09/2012	HEMB02_D	EC	From historical injected saline water
C	11/10/2012	HEMB02_D	EC	From historical injected saline water
C	8/11/2012	HEMB02_D	EC	From historical injected saline water

Monitoring zone	Date	Bore	Category	Explanation
C	15/12/2012	HEMB02_D	EC	From historical injected saline water
C	10/01/2013	HEMB02_D	EC	From historical injected saline water
C	12/02/2013	HEMB02_D	WL	From historical injected saline water
C	12/02/2013	HEMB02_D	EC	From historical injected saline water
C	12/02/2013	HEMB02_D	EC	From historical injected saline water. Decreasing trend
C	15/03/2013	HEMB02_D	EC	Saline up-coning from abstraction
C	15/04/2013	HEMB02_D	EC	Saline up-coning from abstraction
C	28/06/2013	HEMB02_D	EC	From historical injected saline water. Decreasing trend
C	11/07/2013	HEMB02_D	EC	From historical injected saline water. Decreasing trend
C	10/08/2013	HEMB04_D	EC	Saline up-coning from abstraction HEI04
C	12/02/2012	HEMB26_D	EC	From historical injected saline water
C	2/08/2013	HEMB26_D	EC	From historical injected saline water. Decreasing trend
C	15/07/2013	HEMB29_D	EC	From historical injected saline water. Decreasing trend
C	11/08/2013	HEMB29_D	EC	From historical injected saline water. Decreasing trend
C	12/02/2013	HSMB26_D	EC	Vertical saline stratification and measurement taken from incorrect depth
C	17/05/2012	SPM01_D	EC	Injecting saline water
C	11/07/2012	SPM01_D	EC	Injecting saline water
C	10/08/2012	SPM01_D	EC	Injecting saline water
C	5/09/2012	SPM01_D	EC	From historical injected saline water
C	11/12/2012	SPM01_D	EC	Injecting saline water
C	10/08/2012	SPM01_S	EC	Injecting saline water
C	5/09/2012	SPM01_S	EC	Injecting saline water
C	11/12/2012	SPM01_S	EC	Injecting saline water
C	17/05/2012	SPM05	EC	Injecting saline water
C	11/07/2012	SPM05	EC	Injecting saline water
C	17/05/2012	SPM06_D	EC	Injecting saline water
C	11/07/2012	SPM06_D	EC	Injecting saline water
C	10/08/2012	SPM06_D	EC	From historical injected saline water. Decreasing trend
C	5/09/2012	SPM06_D	EC	From historical injected saline water. Decreasing trend
C	11/12/2012	SPM06_D	EC	Injecting saline water
C	7/03/2013	SPM06_D	EC	From historical injected saline water. Decreasing trend
C	7/04/2013	SPM06_D	EC	From historical injected saline water. Decreasing trend
D	29/10/2012	CCF07B_S	EC	Poor bore construction of nearby monitoring bore (CCF07A_D). Both have been reconstructed to Australian standards.
D	22/11/2012	CCF07B_S	EC	Poor bore construction of nearby monitoring bore (CCF07A_D). Both have been reconstructed to Australian standards.

Monitoring zone	Date	Bore	Category	Explanation
D	24/12/2012	CCF07B_S	EC	Poor bore construction of nearby monitoring bore (CCF07A_D). Both have been reconstructed to Australian standards.

9.2.2 Summary of Trigger Exceedances in Reporting Period

On an annual water year basis, the number of trigger exceedances can be listed as:

- 2009/2010: No exceedances reported;
- 2010/2011: One Level 1 EC exceedance was noted but later retracted due to concerns over measurement accuracy;
- 2011/2012: Eight Level 1 exceedances were reported from 4 locations, with multiple exceedances in a short time frame considered as one event; and
- 2012/2013: Seventy-one Level 1 exceedances (as per Table 11).

No level 2 exceedances have been reported in Christmas Creek during the reporting period. The following observations have been made in relation to patterns of level 1 exceedance:

- All cases of mounding water level trigger exceedance have occurred in the Near Marsh OF monitoring bores, and have been attributed to saline injection;
- EC trigger exceedances have occurred in the Hillside East and Spinifex borefields, during both periods of injection and abstraction; and
- Concerns over bore construction have been identified and managed.

9.3 Monitoring Compliance

A summary of monitoring compliance, developed from previous Annual Aquifer Reviews, is presented in Table 12. There have been some changes in the monitoring requirements, as specified by the different versions of the groundwater operating strategy active during the reporting period (Table 8).

Table 12: Summary of Monitoring Compliance in the Reporting Period

Item		Monitoring Frequency	2009/10	2010/11	2011/12	2012/13
Producing Bores	Abstraction	Monthly	Compliant	Compliant	Compliant	Compliant
	Field electrical conductivity	Monthly	Partly[7]	Compliant	Compliant	Compliant
	Hydrochemistry	Six monthly	Compliant	Compliant	Compliant	Compliant
Monitoring Bores	Groundwater level	Monthly	n/a	Compliant	Compliant	Partly[8]
	Field electrical conductivity	Monthly	n/a	Compliant	Compliant	Compliant
	Hydrochemistry	Six monthly (February and August	Compliant	Compliant	Compliant	Compliant
Site Use	Meter readings	Monthly	Compliant	Compliant	Compliant	Compliant
	Comparison of meter readings with associated groundwater demands	Monthly	Compliant	Compliant	Compliant	Compliant

[7] EC data for later part of the reporting period was not available for producing bores.
[8] WL data not monitored due to wet weather

10. ASSESSMENT OF IMPACTS

As discussed in section 7, monitoring has been undertaken in accordance with operating strategy conditions and to meet the defined management objectives. This section evaluates the monitoring data presented in section 0 with regard to:

- The effect of activities on the management objectives;
- Aquifer capacity to sustain ongoing dewatering and injection activities; and
- Significant changes to the aquifer system highlighted by monitoring results.

Reference is made to vegetation monitoring conducted as part of separate operational approval requirements.

Observed impacts or changes to the groundwater system are compared with those predicted by the approved groundwater model and future predictions are discussed.

10.1 Impacts on Management Objectives

Zoned management objectives, supported by trigger levels of water level and EC, have been established and are discussed in section 7. Impacts in each of the sub domains are described below.

10.1.1 Mining Region

Groundwater abstraction activities in the Mining region during the reporting have met the required management objective. Dewatering operations have achieved lowering of groundwater levels to facilitate mining. Drawdown has propagated along strike of the MMF, and has not impacted outside the footprint of the Mining region. Conservation of the groundwater resource has been facilitated through managed aquifer recharge in the Brackish Injection region (see below).

The Mining region has been declared for disturbance through mining (and related) activities and there are no relevant vegetation impacts associated with dewatering in this area.

10.1.2 Near Marsh Region

Saline injection and dewatering activities during the reporting period have not impacted on the management objective for the Near Marsh region.

UTD water table levels have remained within the upper and lower bounds defined by the trigger levels, despite pressurisation of the deeper OF aquifer. No impacts to Samphire vegetation communities have been observed from vegetation monitoring stations in this domain (FMG, 2014). This is consistent with the trigger level compliance reported; class 1 exceedances are

designed as an early warning system to prevent impacts to management objectives. Class 1 exceedances within the OF have proven to be conservative and should be revised in line with numerical modelling predictions.

10.1.3 Saline Injection Region

The management objective for the Saline Injection region has been met during the reporting period. Water table levels and EC values have remained below the assigned triggers. No impacts to Mulga (and associated Acacia species of trees) or Samphire vegetation have been observed from vegetation monitoring stations in this domain (FMG, 2014). This is consistent with the trigger level compliance reported; class 1 exceedances are designed as an early warning system to prevent impacts to management objectives.

10.1.4 Brackish Injection Region

Brackish injection and abstraction activities during the reporting period have not impacted on the management objective in the Brackish Injection region, and trigger levels have assisted in adapting operations to reduce impact potential.

Groundwater levels measured in the UTD have remained greater than 2.2m bgl, and there have been no level 1 water level trigger exceedances in either the UTD or MMF. EC Data have exceeded level 1 trigger values on a number of occasions in both the Spinifex and Hillside East borefields. Injection and abstraction activity has been managed to mitigate these exceedances and no long term changes in EC have been observed. No impacts to Mulga (and associated Acacia species of trees) or Samphire vegetation have been observed from vegetation monitoring stations in this domain (FMG, 2014). This is consistent with the trigger level compliance reported; class 1 exceedances are designed as an early warning system to prevent impacts to management objectives.

10.1.5 Phreatophytic Region

Dewatering activities have not impacted on the management objective for this region. Water levels have remained about the adopted trigger levels for maintaining vegetation health and recruitment potential. Environmental monitoring trigger levels were exceeded although further investigation of the exceedance is likely to indicate that groundwater drawdown was not the cause of the trends observed and that the trees are maintaining good health (FMG, 2014). This is consistent with the trigger level compliance reported; class 1 exceedances are designed as an early warning system to prevent impacts to management objectives.

10.1.6 Neighbouring Operations (Regional)

The management objective for neighbouring operations has been met during the reporting period as injection operations have not resulted in significant increases in water level at non-Fortescue approved projects.

10.2 Impacts to Aquifer Capacity

Injection of groundwater into aquifer systems has the potential to exceed the natural capacity of the aquifer. This can manifest as uncontrolled over-pressurisation in confined aquifer systems, where water level rise cannot be mitigated through reduction in injection volumes.

Monitoring data in the review period does not indicate this impact has taken place. Pressurisation of the OF aquifer is occurring due to saline injection activities; however the data does not indicate accelerating and uncontrolled increases in water level data. In fact, data supports a pattern of reducing or recovering water levels in response to a reduction in injection volumes.

Increased water levels in the OF will result in increased pressure head and may drive vertical leakage through the aquitard. This is not an indication of exceeding aquifer capacity; however trigger levels are in place in the UTD aquifer system to ensure vertical leakage does not impact management objectives.

10.3 Impacts to Groundwater System

There have been no significant changes to the groundwater system indicated by the water level, EC and hydrochemical data, beyond those expected from the approved dewatering, injection and abstraction activities.

10.4 Comparison of Monitoring Data with Modelled Predictions

Modelled and observed results for a large operation are best compared through contour plots, as individual bore hydrographs can be impacted by the differences in the local modelled vs. actual abstraction or injection. Contour plots of modelled heads[9] within the UTD and combined MMF and OF aquifers are included in Appendix 12 for the end of July 2013, which is year 4 of the approved PER model. Appendix 10 contains the equivalent contour maps created from monitoring data; these have been discussed in detail in section 8.6.

Comparison of modelled head (corrected to freshwater equivalent heads) and measured water level (uncorrected) in the UTD is favourable, with similar values in the Mining region and along

[9] Accurate modelling of solute transport in a regional groundwater model is computationally challenging. Approximations are utilised to facilitate modelling of head gradients; however the exact modelled concentrations are not considered suitable for comparison with measured data.

strike to the east and west. Suggested flow directions are similar, and honour the influence of the dewatering cone of depression and managed aquifer recharge activities at Spinifex and Hillside East. The model predicts heads up to 2 m higher in the Saline Injection region, although this could be due to the difference between corrected and uncorrected values.

There is a similar pattern when comparing modelled and measured values in the OF and MMF, although the difference between uncorrected and corrected values results in differences of up to 4 m in the Saline Injection region.

Overall, the Christmas Creek groundwater model prediction has adequately represented measured groundwater flow directions in both the UTD and OF/MMF horizons. Actual values differ in saline parts of the aquifer system; this is most likely due to model's use of density correct head.

11. RECOMMENDATIONS & FUTURE WORK

Recommendations for improvement are discussed in this section, along with a summary of future studies and other work that may improve groundwater management at Christmas Creek. Recommendations are based upon data presented in this aquifer review, improved conceptual understanding of the Chichester Range hydrogeology and operational observations.

11.1 Trigger Network Development

The trigger network at Christmas Creek has been reviewed and updated throughout the reporting period with development and expansion of the project and associated infrastructure. The key developments in the trigger network, reflected in revised groundwater operating strategies, are summarised in Table 8. It is recommended the most recent revision is adopted to incorporate ongoing understanding of the system, particularly incorporating modelling predictions within the OF to assign trigger values.

11.2 Managing Aquifer Capacity

One of the major benefits offered by the extensive injection network is flexibility to transfer water to specific areas to manage mounding or drawdown responses in the OF (and overlying UTD). Fortescue recommends integrating the saline injection system for Cloudbreak and Christmas Creek to enhance this flexibility. This change is currently subject to assessment by the Environmental Protection Authority (EPA).

11.3 Future Work

The University of Western Australia (UWA) are currently working on a series of projects to better understand the Fortescue marsh and its interaction with the surrounding environment. One key aspect of this ongoing work is the definition of historical extent of flooding across the Marsh. Fortescue are currently working closely with UWA to allow estimation of shallow groundwater level fluctuations, at the fringe of the Marsh, associated with periods of significant flooding and prolonged drought. It is hoped that the findings of this work will allow a more accurate assessment of climatic induced shallow groundwater level fluctuations at the fringe of the Marsh which can be utilised in refining the baseline data set for “Zone A” trigger monitoring locations, as discussed above.

Fortescue is actively reviewing methods and tools in areas of groundwater investigation, monitoring, data management, and modelling with a view to continue to develop Fortescues hydrogeological knowledge, data integrity and prediction capability. Initiatives currently under review include; ground based electromagnetic and seismic programs, multilevel monitoring and sampling systems, automated data monitoring and online database systems.

12. CONCLUSIONS

Fortescue had been operating dewatering, injection and managed aquifer recharge at the Christmas Creek mine site, licenced under GWL 167593. During this Triennial Aquifer review's reporting period (18 December 2009 to 31 July 2013), these activities have been completed in accordance with the licence conditions and the management objectives set out a number of revisions to the groundwater operating strategy.

Monitoring data, including water level, electrical conductivity and hydrochemical data, has been collected during the reporting period from a network of monitoring bores. The latter type of data has been obtained via groundwater sampling and subsequent laboratory analysis. These monitoring activities have been compliant with licence requirements and have enabled comparison of measured data with trigger levels set to manage potential impacts to the overall management objectives.

The first two years of the review period review period marked the end of 4 years of below average rainfall. However, the final three years experienced rainfall well above the long term average. The impact of large rainfall events has been noticed in monitoring data, particularly in water level fluctuations in the shallow, UTD aquifer.

The water level has been lowered in the MMF and overlying UTD aquifer in the Mining region; has risen and subsequently started to recede in the MMF and overlying UTD aquifer in the Brackish Injection region; and has risen in the OF in the Saline Injection region and to a lesser extent in the Near Marsh region. There have been responses to climatic events in the UTD measured in the Near Marsh and Saline Injection regions, with no measured response to changes in abstraction or injection activities.

The salinity of groundwater abstracted from dewatering operations has increased in response to depletion of the brackish water resource in the dewatering area; salinity has remained relatively constant in the MMF in the Brackish Injection region; and salinity has remained relatively stable in the OF and overlying UTD in the Saline Injection and Near Marsh regions.

Class 1 triggers were exceeded on 71 occasions in the 2012/13 water year, and are primarily attributable to bore construction issues, monitoring errors and changes to dewatering and injection plans. No breaches of Class 2 triggers have occurred in the reporting period.

The current groundwater model predictions are considered representative of changes to the groundwater flow patterns are overall water levels in the Christmas Creek project area.

The triennial review of monitoring data concludes that licensed dewatering, injection and managed aquifer recharge operations at Christmas Creek have not impacted on environmental and water resource management objectives.

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Appendix 1: Christmas Creek location map

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700,000

800,000

7,700,000

7,600,000

7,500,000

7,400,000

LEGEND

^ Towns

FMG Rail Alignment

FMG Mines & Prospects

^ Christmas Creek

\# Cloudbreak

\# North Star

Port Hedland

Mount Goldsworthy

Marble Bar

Nullagine

Auski Roadhouse

Cloudbreak

Christmas Creek

North Star

0 10 20 30 40 50

Kilometers

Fortescue Metals Group Ltd

The New Force in Iron Ore

Figure 1: Location of Christmas Creek

Requested By: T. Wilkinson	Date: 13/06/2013
Drawn By: B. Ralebala	Size: A4P
Scale: 1:1,000,000	Revision: 0
Projection: GDA 1994 MGA Zone 50	Confidentiality: 1
Doc Name: CC_MP_HY_0165	

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Appendix 2: 5C Licences

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Department of Water
Government of Western Australia

RECEIVED
20 JAN 2009
BY: DE

Our ref: RF167-05
WRD79855
Enquiries: Kevin Hopkinson
Telephone: (08) 9144 0214

Project: CC
Sub-Project/Facility:
Doc Type: POW (s5c) s17 s26d s45c s38
DeC (Wks App) DeC (Lic) DeC (Rego)
Application:
Approval: GWL 167593 - TAKE WATER YES
Other: (NEW) YES
YES
LR-100-E-1052 - BMS

Sean McGunnigle
Fortescue Metals Group Limited
Hyatt Centre, Level 2
87 Adelaide Terrace
EAST PERTH WA 6004

Dear Mr. McGunnigle,

Re: Issue of a Licence to Take Water
Licence: GWL167593
Expiry: 31st July, 2010
Property: E46/334, M46/420, E46/611, E46/612, M46/320, M46/321, M46/322, M46/328, M46/329, M46/333, M46/336, M46/340, M46/341, M46/349, M46/350, M46/414, M46/415- Christmas Creek

I refer to your application for a 5C Licence to take Water which was received by the Department of Water on the 25th September, 2008 for dust suppression, earthwork and construction purposes, general camp purposes and railway construction, within mining tenements E46/334, M46/420, E46/611, E46/612, M46/320, M46/321, M46/322, M46/328, M46/329, M46/333, M46/336, M46/340, M46/341, M46/349, M46/350, M46/414, M46/415- Christmas Creek.

It was noted during assessment that there are registered sites of Aboriginal Heritage Significance in close proximity to the designated exploration areas. Please be advised that it is Fortescue Metals Group Limited's responsibility to ensure appropriate consultation with any affected Traditional Owners and adequate referral to the Department of Indigenous Affairs (DIA) is made, to ensure full compliance with the *Aboriginal Heritage Act 1972*.

Preliminary assessment indicates that there are several populations of Priority 3 flora located within the project area. If you have any queries, please contact the Department of Environment and Conservation on (08) 9182 2000 for further information

Please find enclosed your *Licence to Take Water*, issued under section 5C of the *Rights in Water and Irrigation Act 1914*. This licence entitles you to take water, subject to certain terms, conditions or restrictions. It does not absolve the licensee from responsibility for compliance with the requirements of all Commonwealth and State legislation.

It is important that you read the conditions of your licence carefully. If you do not understand your licence, please contact the Department as soon as possible, as there are penalties for failing to comply with all of your licence conditions. Under Section 26GG(2) of the *Rights in Water and Irrigation Act 1914*, you have a right to apply to the State Administrative Tribunal for a review of the decision to issue a *Licence to Take Water*. You have 28 days from the date you received this letter to request that the decision be reviewed.

Pilbara Region
Lot 4608 Cherratta Road KIE
Karratha Western Australia 6714
PO Box 836 Karratha Western Australia 6714
Telephone (08) 9144 2000 Facsimile (08) 9144 2610
www.water.wa.gov.au

For further information please contact the State Administrative Tribunal:

State Administrative Tribunal
12 St Georges Terrace
PERTH WA 6000

GPO Box U1991
PERTH WA 6845

Telephone: (08) 9219 3111
Toll-free: 1300 306 017
Facsimile: (08) 9202 1180
www.sat.justice.wa.gov.au

Under section 21 of the *State Administrative Tribunal Act 2004*, you have a right to request a written statement of reasons for the decision to issue a *Licence to Take Water*. This request must be made, in writing, to the Department of Water within 28 days after the day on which you received this letter.

If you wish to continue taking water after this *Licence to Take Water* expires, it is your responsibility to apply to the Department of Water for its renewal. If this licence expires and you have not applied to renew it, then the taking of water must cease, or you will be in breach of *the Rights in Water and Irrigation Act 1914*. It is suggested that an application for renewal be made at least one month in advance of the *Licence to Take Water* expiry date.

You may apply to amend or transfer the *Licence to Take Water* at any time. The Department may also amend, suspend or cancel this licence in certain circumstances.

An extract of this licence has been placed in the public register and is available for viewing by appointment at Department of Water offices.

If you have any queries relating to the above matter, please contact Kevin Hopkinson on telephone number (08) 9144 0214.

Yours faithfully

H. Mohsenzadeh

Dr. Hamid Mohsenzadeh
Regional Manager
Department of Water
Pilbara Region

12 January 2010

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Fortescue Metals Group Ltd		
Description of Water Resource	Pilbara Hamersley - Fractured Rock	**Annual Water Entitlement**	1150000 kL
Location of Water Source	E46/334, M46/420, E46/611, E46/612, M46/320, M46/321, M46/322, M46/328, M46/329, M46/333, M46/336, M46/340, M46/341, M46/349, M46/350, M46/414, M46/415		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dust suppression Earthwork and construction purposes General camp purposes Railway construction	M46/320, M46/424, M46/322, M46/323, M46/324, M46/325, M46/326, M46/327, M46/328, M46/329, M46/330, M46/331, M46/332, M46/333, M46/334, M46/335, M46/336, M46/337, M46/338, M46/340, M46/341, M46/342, M46/343, M46/344, M46/402, M46/403, M46/405, M46/406, M46/407, M46/408, M46/409, M46/412, M46/413, M46/414, M46/415, M46/416, M46/417, M46/418, M46/419, M46/420, M46/421, M46/423, M46/321
Duration of Licence	From 18 December 2009 to 31 July 2010	

This Licence is subject to the following terms, conditions and restrictions:

1 Should the monitoring at any time indicate a need for prompt action to prevent or reduce the effect of the licensee's draw on the underground resource, the licensee shall immediately report this to the Department of Water and advise the corrective measures proposed.

2 The licensee must not, in any water year, take more water than the annual water entitlement specified in this licence.

3 Approval by the Department of Water is to be obtained prior to the construction of additional and replacement wells and the modification or refurbishment of existing wells.

4 That should the licensee's draw adversely affect the aquifer or other users in the area, the Department of Water may reduce the amount that may be drawn.

5 That should the drawing of water from the bore adversely affect the aquifer, and/or other users, the Department of Water shall direct the licensee to effect necessary action to make good the supply to affected users.

6 That should the licensee's draw adversely affect other authorised users or environmental values, the licensee shall be required to make good the supply or value to the satisfaction of the Department of Water.

7 This licence has been issued in conjunction with an operational strategy yet to be approved by the Department of Water. The operational strategy is to be provided and committed to by the licensee and submitted to the Department of Water by 31st January 2010

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

This Licence is subject to the following terms, conditions and restrictions:

8 The licensee shall submit to the Department of Water an annual report by 28th February (starting 2011) each year and a triennial report by 28th February 2013 containing the information as required by Operational policy 5.12 'Hydrogeological Reporting associated with a groundwater well licence'.

9 Quarterly Reports reports are to be submitted to the Department of Water for assessment by 31st April, 30th July, 30th October, 31st January each year.

10 The licensee must install a cumulative water meter of a type approved under the Rights in Water and Irrigation (Approved Meters) Order 2009 to each water draw point under this licence.

11 The meter(s) must be installed in accordance with the provisions of the document entitled "Guidelines for Water Meter Installation 2009" before any water is taken under this licence.

End of terms, conditions and restrictions

File No: RF167-06

Government of Western Australia
Department of Water

Instrument No. GWL167593(3)

COPY

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Fortescue Metals Group Ltd		
Description of Water Resource	Pilbara Hamersley - Fractured Rock	**Annual Water Entitlement**	18000000 kL
Location of Water Source	E46/334, M46/420, E46/611, E46/612, M46/320, M46/321, M46/322, M46/328, M46/329, M46/333, M46/336, M46/340, M46/341, M46/349, M46/350, M46/414, M46/415		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dewatering for mining purposes Dust suppression for earthworks and construction purposes Earthwork and construction purposes General campsite purposes Mineral ore processing and other mining purposes Railway construction	M46/320, M46/424, M46/322, M46/323, M46/324, M46/325, M46/326, M46/327, M46/328, M46/329, M46/330, M46/331, M46/332, M46/333, M46/334, M46/335, M46/336, M46/337, M46/338, M46/340, M46/341, M46/342, M46/343, M46/344, M46/402, M46/403, M46/405, M46/406, M46/407, M46/408, M46/409, M46/412, M46/413, M46/414, M46/415, M46/416, M46/417, M46/418, M46/419, M46/420, M46/421, M46/423, M46/321
Duration of Licence	From 21 September 2011 to 20 September 2012	

This Licence is subject to the following terms, conditions and restrictions:

1 Approval by the Department of Water is to be obtained prior to the construction of additional and replacement wells and the modification or refurbishment of existing wells.

2 That should the licensee's draw adversely affect the aquifer or other users in the area, the Department of Water may reduce the amount that may be drawn.

3 That should the drawing of water from the bore adversely affect the aquifer, and/or other users, the Department of Water shall direct the licensee to effect necessary action to make good the supply to affected users.

4 That should the licensee's draw adversely affect other authorised users or environmental values, the licensee shall be required to make good the supply or value to the satisfaction of the Department of Water.

5 The licensee shall submit to the Department of Water an annual report by 30th September each year and a triennial report by 30th September 2012 containing the information as required by Operational policy 5.12 'Hydrogeological Reporting associated with a groundwater well licence'.

6 Quarterly technical reports are to be submitted to the Department of Water for assessment by 31st March, 30th June, 30th September (combined into AAR/TAR) and 31st December each year.

7 The licensee must install a cumulative water meter of a type approved under the Rights in Water and Irrigation (Approved Meters) Order 2009 to each water draw point under this licence.

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000

COPY

COPY

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

This Licence is subject to the following terms, conditions and restrictions:

8 The meter(s) must be installed in accordance with the provisions of the document entitled "Guidelines for Water Meter Installation 2009" before any water is taken under this licence.

9 The annual water year for water taken under this licence is defined as 12:00 pm at 31 July to 12:00 pm at 31 July twelve months later.

10 The licensee shall comply with the 'Christmas Creek Groundwater Operating Strategy (Rev 1 - dated 15th September 2011)' as prepared by Fortescue Metals Group Limited and approved by the Department of Water on 20th September 2011, including any modifications to the 'Christmas Creek Groundwater Operating Strategy (Rev 1 - dated 15th September 2011)' as approved during the term of the licence.

11 Should the monitoring at any time indicate a need for prompt action to prevent or reduce the effect of the licensee's draw on the underground resource, the licensee shall immediately report this to the Department of Water and advise the corrective measures proposed.

End of terms, conditions and restrictions

COPY

Government of **Western Australia**
Department of **Water**

looking after all our water needs

Our ref: RF167-05
WRD145839
Enquiries: Kevin Hopkinson
Telephone: (08) 9144 0214

RECEIVED
1 FEB 2012
BY:

Project: CC
Sub-Project/Facility:
Doc Type: POW s5c s17 s26d s45c s38
DeC (Wks App) DeC (Lic) DeC (Rego)
Application: YES
Approval: CC-EN-0004-ELP 207-BMS YES
Other: Licence to take water GWL167593 YES

Les Egerton
Fortescue Metals Group Limited
Hyatt Centre, Level 2
87 Adelaide Terrace
EAST PERTH WA 6004

Dear Mr. Egerton,

Re: Issue of a Licence to Take Water
Licence: GWL167593(4)
Expiry: 8th February, 2013
Property: E46/611, E46/612, M46/320, M46/321, M46/349, M46/350, E46/610, M46/424, M46/322, M46/323, M46/324, M46/325, M46/326, M46/327, M46/328, M46/329, M46/330, M46/331, M46/332, M46/333, M46/334, M46/335, M46/336, M46/337, M46/338, M46/340, M46/341, M46/342, M46/343, M46/344, M46/402, M46/403, M46/405, M46/406, M46/407, M46/408, M46/409, M46/412, M46/413, M46/414, M46/415, M46/416, M46/417, M46/418, M46/419, M46/420, M46/421, M46/423 - Christmas Creek

I refer to your application for a 5C Licence to take Water which was received by the Department of Water on the 6th December, 2011 for dust suppression, earthwork and construction purposes, general camp purposes, railway construction and maintenance, dewatering for mining purposes, mineral ore processing and other mining purposes within the above mentioned tenements.

It was noted during assessment that there are registered sites of Aboriginal Heritage Significance in close proximity to the designated exploration areas. Please be advised that it is Fortescue Metals Group Limited's responsibility to ensure appropriate consultation with any affected Traditional Owners and adequate referral to the Department of Indigenous Affairs (DIA) is made, to ensure full compliance with the *Aboriginal Heritage Act 1972*.

Preliminary assessment indicates that there are several populations of Priority flora and endangered Fauna located within the project area. If you have any queries, please contact the Department of Environment and Conservation on (08) 9182 2000 for further information.

It was noted that your project area is within an Environmentally Sensitive Area. Please be advised that if you wish to undertake any clearing of vegetation within this area you will need to do so in consultation with the Department of Environment and Conservation. Please contact them on (08) 9182 2000 for further information.

Please find enclosed your *Licence to Take Water*, issued under section 5C of the *Rights in Water and Irrigation Act 1914*. This licence entitles you to take water, subject to certain terms, conditions or restrictions. It does not absolve the licensee from responsibility for compliance with the requirements of all Commonwealth and State legislation.

Pilbara Region
160 Terrace Road KIE
Karratha Western Australia 6714
PO Box 836 Karratha Western Australia 6714
Telephone (08) 9144 2000 Facsimile (08) 9144 2610
www.water.wa.gov.au
wa.gov.au

XDWAL020

It is important that you read the conditions of your licence carefully. If you do not understand your licence, please contact the Department as soon as possible, as there are penalties for failing to comply with all of your licence conditions. Under Section 26GG(2) of the *Rights in Water and Irrigation Act 1914*, you have a right to apply to the State Administrative Tribunal for a review of the decision to issue a *Licence to Take Water*. You have 28 days from the date you received this letter to request that the decision be reviewed.

For further information please contact the State Administrative Tribunal:

State Administrative Tribunal
12 St Georges Terrace
PERTH WA 6000

GPO Box U1991
PERTH WA 6845

Telephone: (08) 9219 3111
Toll-free: 1300 306 017
Facsimile: (08) 9202 1180
www.sat.justice.wa.gov.au

Under section 21 of the *State Administrative Tribunal Act 2004*, you have a right to request a written statement of reasons for the decision to issue a *Licence to Take Water*. This request must be made, in writing, to the Department of Water within 28 days after the day on which you received this letter.

If you wish to continue taking water after this *Licence to Take Water* expires, it is your responsibility to apply to the Department of Water for its renewal. If this licence expires and you have not applied to renew it, then the taking of water must cease, or you will be in breach of *the Rights in Water and Irrigation Act 1914*. It is suggested that an application for renewal be made at least one month in advance of the *Licence to Take Water* expiry date.

You may apply to amend or transfer the *Licence to Take Water* at any time. The Department may also amend, suspend or cancel this licence in certain circumstances.

An extract of this licence has been placed in the public register and is available for viewing by appointment at Department of Water offices.

If you have any queries relating to the above matter, please contact Kevin Hopkinson on telephone number (08) 9144 0214.

Yours faithfully

Dr. Hamid Mohsenzadeh
Regional Manager
Department of Water
Pilbara Region

9 February 2012

Government of Western Australia
Department of Water

Instrument No. GWL167593(4)

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Fortescue Metals Group Ltd		
Description of Water Resource	Pilbara Hamersley - Fractured Rock	**Annual Water Entitlement**	23000000 kL
Location of Water Source	M46/334, E46/610, M46/320, M46/321, M46/322, M46/328, M46/329, M46/333, M46/336, M46/340, M46/341, M46/349, M46/350, M46/414, M46/415 & M46/420		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dewatering for mining purposes Dust suppression for earthworks and construction purposes Earthwork and construction purposes General campsite purposes Mineral ore processing and other mining purposes Railway construction and maintenance	M46/320, M46/321, M46/323, M46/324, M46/325, M46/326, M46/327, M46/328, M46/329, M46/330, M46/331, M46/332, M46/333, M46/334, M46/335, M46/336, M46/337, M46/338, M46/340, M46/341, M46/342, M46/343, M46/344, M46/402, M46/403, M46/405, M46/406, M46/407, M46/408, M46/409, M46/412, M46/413, M46/414, M46/415, M46/416, M46/417, M46/418, M46/419, M46/420, M46/421, M46/423 & M46/424

Duration of Licence	From 9 February 2012 to 8 February 2013

This Licence is subject to the following terms, conditions and restrictions:

1 Approval by the Department of Water is to be obtained prior to the construction of additional and replacement wells and the modification or refurbishment of existing wells.

2 That should the licensee's draw adversely affect the aquifer or other users in the area, the Department of Water may reduce the amount that may be drawn.

3 That should the drawing of water from the bore adversely affect the aquifer, and/or other users, the Department of Water shall direct the licensee to effect necessary action to make good the supply to affected users.

4 That should the licensee's draw adversely affect other authorised users or environmental values, the licensee shall be required to make good the supply or value to the satisfaction of the Department of Water.

5 The licensee shall submit to the Department of Water an annual report by 30th September each year and a triennial report by 30th September 2012 containing the information as required by Operational policy 5.12 'Hydrogeological Reporting associated with a groundwater well licence'.

6 Quarterly technical reports are to be submitted to the Department of Water for assessment by 31st March, 30th June, 30th September (combined into AAR/TAR) and 31st December each year.

7 The licensee must install a cumulative water meter of a type approved under the Rights in Water and Irrigation (Approved Meters) Order 2009 to each water draw point under this licence.

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

This Licence is subject to the following terms, conditions and restrictions:

8 The meter(s) must be installed in accordance with the provisions of the document entitled "Guidelines for Water Meter Installation 2009" before any water is taken under this licence.

9 The annual water year for water taken under this licence is defined as 12:00 pm at 31 July to 12:00 pm at 31 July twelve months later.

10 The licensee shall comply with the 'Christmas Creek Groundwater Operating Strategy (Rev 2 - dated 9th November 2011)' as prepared by Fortescue Metals Group Limited and approved by the Department of Water on 23rd December 2011, including any modifications to the 'Christmas Creek Groundwater Operating Strategy (Rev 2 - dated 9th November 2011)' as approved during the term of the licence.

11 Should the monitoring at any time indicate a need for prompt action to prevent or reduce the effect of the licensee's draw on the underground resource, the licensee shall immediately report this to the Department of Water and advise the corrective measures proposed.

End of terms, conditions and restrictions

Government of **Western Australia**
Department of **Water**

looking after all our water needs

Our ref: RF167-07
WRD158510
Enquiries: Kevin Hopkinson
Telephone: (08) 9144 0214

RECEIVED
17 JUL 2012
BY: SB

Project: CC
Sub-Project/Facility:
Doc Type: POW (s5c) s17 s26d s45c s38
DeC (Wks App) DeC (Lic) DeC (Rego)
Application:
Approval: CC-EN-0057 YES
Other: Amended GWL 167593(5) ELP 207 YES

Sean McGunnigle
Fortescue Metals Group Limited
Level 2
87 Adelaide Terrace
EAST PERTH WA 6004

Dear Mr. McGunnigle,

Re: Fortescue Metals Group Limited (FMG)
Licence: GWL167593(5)
Expiry: 11th July, 2013
Property: Christmas Creek

I refer to your application for a 5C Licence to amend (GWL167593-04) the taking of Water which was received by the Department of Water on the 29th March, 2012 requesting to increase the licensed allocation to 48GL from the East Pilbara Hamersley Fractured Rock Aquifer for dewatering, dust suppression, processing, and camp purpose as part of the Christmas Creek Operations.

It was noted during assessment that there are registered sites of Aboriginal Heritage Significance in close proximity to the designated exploration areas. Please be advised that it is Fortescue Metals Group Limited's responsibility to ensure appropriate consultation with any affected Traditional Owners and adequate referral to the Department of Indigenous Affairs (DIA) is made, to ensure full compliance with the *Aboriginal Heritage Act 1972*.

There is Priority 1 flora and endangered Fauna located within the project area. Additionally, the project area is within an Environmentally Sensitive Area. If you have any queries, please contact the Department of Environment and Conservation on (08) 9182 2000 for further information

Please find enclosed your *Licence to Take Water*, issued under section 5C of the *Rights in Water and Irrigation Act 1914*. This licence entitles you to take water, subject to certain terms, conditions or restrictions. It does not absolve the licensee from responsibility for compliance with the requirements of all Commonwealth and State legislation.

It is important that you read the conditions of your licence carefully. If you do not understand your licence, please contact the Department as soon as possible, as there are penalties for failing to comply with all of your licence conditions. Under Section 26GG(2) of the *Rights in Water and Irrigation Act 1914*, you have a right to apply to the State Administrative Tribunal for a review of the decision to issue a *Licence to Take Water*. You have 28 days from the date you received this letter to request that the decision be reviewed.

For further information please contact the State Administrative Tribunal:

State Administrative Tribunal
12 St Georges Terrace
PERTH WA 6000

Pilbara Region
Lot 4608 Cherratta Road KIE
Karratha Western Australia 6714
PO Box 836 Karratha Western Australia 6714
Telephone (08) 9144 0200 Facsimile (08) 9144 2610
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XDWAL020

GPO Box U1991
PERTH WA 6845

Telephone: (08) 9219 3111
Toll-free: 1300 306 017
Facsimile: (08) 9202 1180
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Under section 21 of the *State Administrative Tribunal Act 2004*, you have a right to request a written statement of reasons for the decision to issue a *Licence to Take Water.* This request must be made, in writing, to the Department of Water within 28 days after the day on which you received this letter.

If you wish to continue taking water after this *Licence to Take Water* expires, it is your responsibility to apply to the Department of Water for its renewal. If this licence expires and you have not applied to renew it, then the taking of water must cease, or you will be in breach of *the Rights in Water and Irrigation Act 1914.* It is suggested that an application for renewal be made at least one month in advance of the *Licence to Take Water* expiry date.

You may apply to amend or transfer the *Licence to Take Water* at any time. The Department may also amend, suspend or cancel this licence in certain circumstances.

An extract of this licence has been placed in the public register and is available for viewing by appointment at Department of Water offices.

If you have any queries relating to the above matter, please contact Kevin Hopkinson on telephone number (08) 9144 0214.

Yours faithfully

Dr. Hamid Mohsenzadeh
Regional Manager
Department of Water
Pilbara Region

13 July 2012

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Fortescue Metals Group Ltd		
Description of Water Resource	Pilbara Hamersley - Fractured Rock	**Annual Water Entitlement**	48000000 kL
Location of Water Source	E46/611, E46/612, M46/320, M46/321, M46/322, M46/328, M46/329, M46/333, M46/334, M46/336, M46/340, M46/341, M46/349, M46/350, M46/414, M46/415, M46/420		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dewatering for mining purposes Dust suppression for earthworks and construction purposes Earthwork and construction purposes General campsite purposes Mineral ore processing and other mining purposes Railway construction and maintenance	M46/320, M46/321, M46/322, M46/323, M46/324, M46/325, M46/326, M46/327, M46/328, M46/329, M46/330, M46/331, M46/332, M46/333, M46/334, M46/335, M46/336, M46/337, M46/338, M46/340, M46/341, M46/342, M46/343, M46/344, M46/402, M46/403, M46/405, M46/406, M46/407, M46/408, M46/409, M46/412, M46/413, M46/414, M46/415, M46/416, M46/417, M46/418, M46/419, M46/420, M46/421, M46/423, M46/424

Duration of Licence	From 12 July 2012 to 11 July 2013

This Licence is subject to the following terms, conditions and restrictions:

1 Approval by the Department of Water is to be obtained prior to the construction of additional and replacement wells and the modification or refurbishment of existing wells.

2 That should the licensee's draw adversely affect the aquifer or other users in the area, the Department of Water may reduce the amount that may be drawn.

3 That should the drawing of water from the bore adversely affect the aquifer, and/or other users, the Department of Water shall direct the licensee to effect necessary action to make good the supply to affected users.

4 That should the licensee's draw adversely affect other authorised users or environmental values, the licensee shall be required to make good the supply or value to the satisfaction of the Department of Water.

5 The licensee shall submit to the Department of Water an annual report by 30th September each year and a triennial report by 30th September 2012 containing the information as required by Operational policy 5.12 'Hydrogeological Reporting associated with a groundwater well licence'.

6 Quarterly technical reports are to be submitted to the Department of Water for assessment by 31st March, 30th June, 30th September (combined into AAR/TAR) and 31st December each year.

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

This Licence is subject to the following terms, conditions and restrictions:

7 The licensee must install a cumulative water meter of a type approved under the Rights in Water and Irrigation (Approved Meters) Order 2009 to each water draw point under this licence.

8 The meter(s) must be installed in accordance with the provisions of the document entitled "Guidelines for Water Meter Installation 2009" before any water is taken under this licence.

9 The annual water year for water taken under this licence is defined as 12:00 pm at 31 July to 12:00 pm at 31 July twelve months later.

10 The licensee shall comply with the 'Christmas Creek Groundwater Operating Strategy (Rev 5 - dated 14th May 2012)' as prepared by Fortescue Metals Group Limited and approved by the Department of Water on 30 May 2012, including any modifications to the 'Christmas Creek Groundwater Operating Strategy (Rev 5 - dated 14th May 2012)' as approved during the term of the licence.

11 Should the monitoring at any time indicate a need for prompt action to prevent or reduce the effect of the licensee's draw on the underground resource, the licensee shall immediately report this to the Department of Water and advise the corrective measures proposed.

End of terms, conditions and restrictions

Appendix 3: Christmas Creek water management scheme

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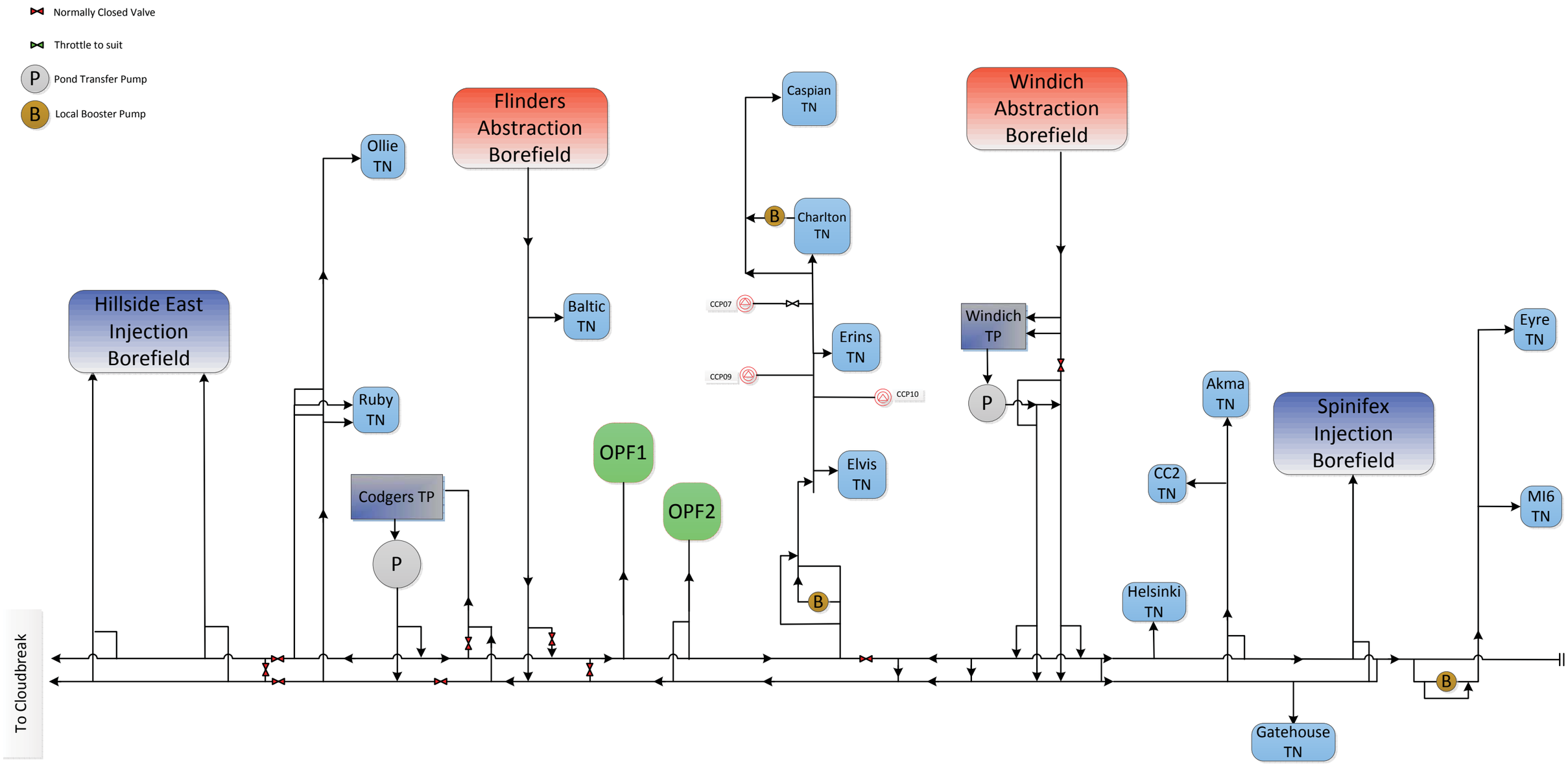
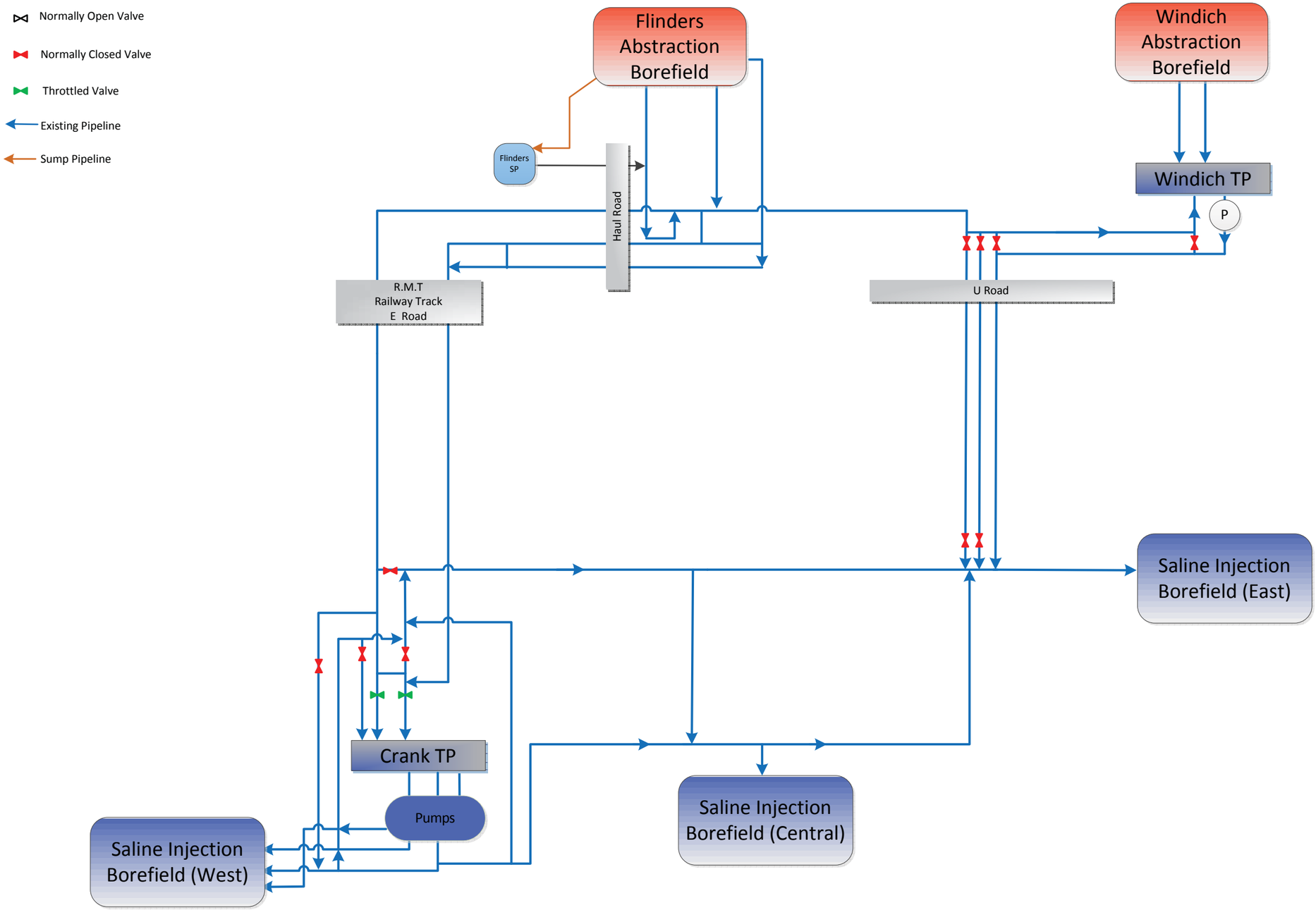
Christmas Creek Brackish System Operating Philosophy



Christmas Creek Saline System Operating Philosophy



Appendix 4: Active abstraction bores during reporting period

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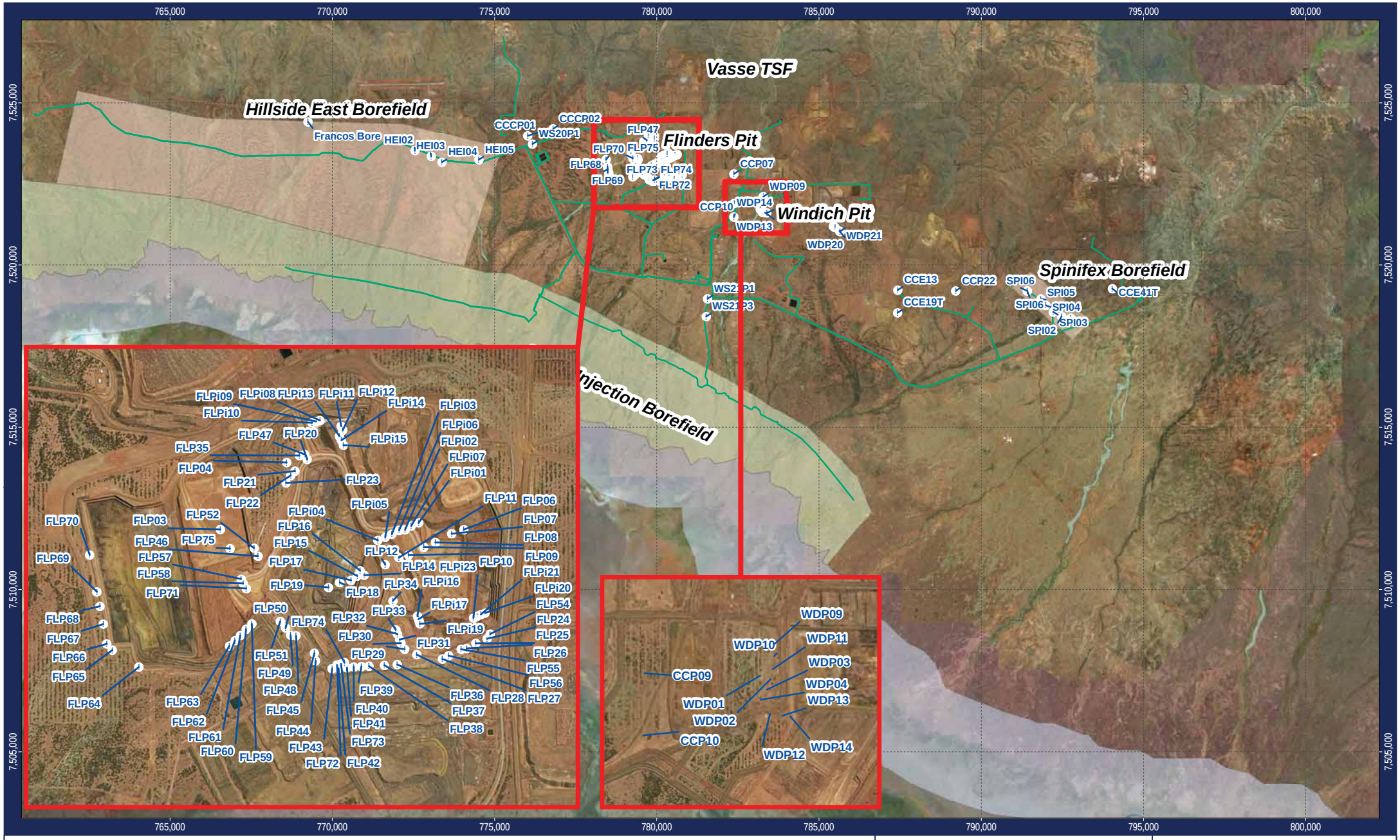

LEGEND

- Active Production Bores
- Existing Pipeline
- Zone_A
- Zone_B
- Zone_C
- Zone_D

0 2 4 6

Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:150,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: Active Abstraction Bores

Date: 30/07/2014
Size: A4L
Revision: 0
Confidentiality: 1

FMG accepts no liability and gives no representation or warranty, express or implied, as to the information provided including its accuracy, completeness, merchantability or fitness for purpose.

Christmas Creek Triennial
Active Abstraction Bores

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Appendix 5: Active injection (saline and brackish) bores during reporting period

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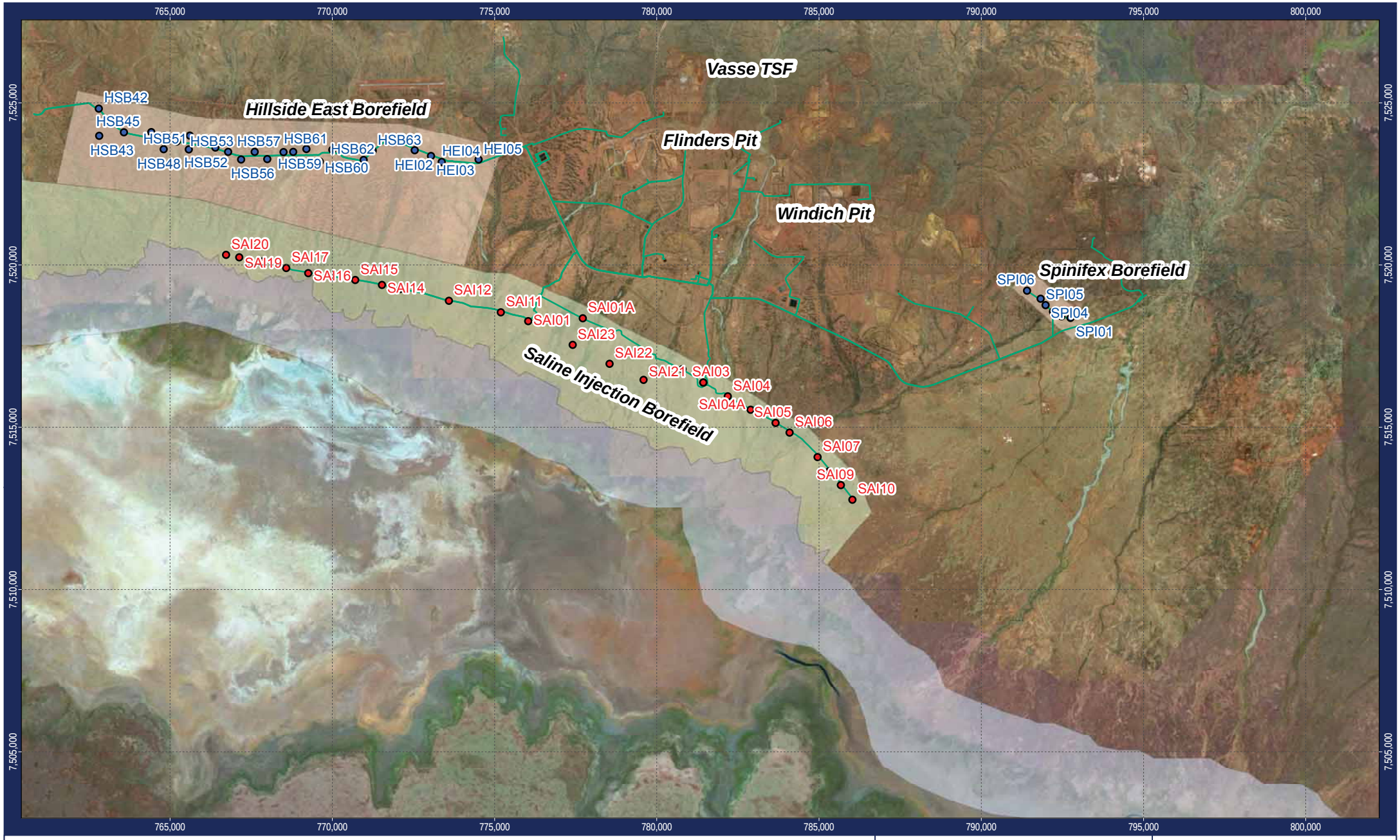

LEGEND

- Brackish Injection
- Saline Injection
- Existing Pipeline
- Zone_A
- Zone_B
- Zone_C
- Zone_D

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:150,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: Active Injection Bores

Date: 30/07/2014
Size: A4L
Revision: 0
Confidentiality: 1

FMG accepts no liability and gives no representation or warranty, express or implied, as to the information provided including its accuracy, completeness, merchantability or fitness for purpose.

Christmas Creek Triennial
Active Injection Bores

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Appendix 6: Active monitoring and trigger bores during reporting period

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LEGEND

- Saline monitoring trigger
- Brackish monitroing trigger
- Phreatophytic monitroing trigger
- Marsh monitoring trigger
- Roy Hill monitoring trigger
- Active_Monitoring_Bores
- Existing Pipeline
- Zone_A
- Zone_B
- Zone_C
- Zone_D

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
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Scale: 1:150,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: Active Monitoring Bores

Date: 30/07/2014
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Christmas Creek Triennial
Active Monitoring and Trigger Bores

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Appendix 7: Saline monitoring bore name change memo (November 2012)

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Memo

HYD_CC_MEM07: CHANGE OF SALINE MONITORING BORE NAMES

TO	FMG CC Hydrogeology; FMG CC Compliance; FMG Water Management Engineers	**DATE**	07/06/2012
FROM	Laura Phillips	**CC**	Kate Shenstone; Andrew Hughes

Introduction:

The saline borefield was originally designed with monitoring bores planned on every *planned* saline injection site; with this in mind monitoring bore names were pre-assigned. As the bore field has developed, monitoring bores have been drilled labeled with their original "planned" name. As all monitoring bores haven't been drilled we have ended up with an erratic numbering system such as SAM23, SAM01, SAM25 in no particular order. This is illustrated in Attachment 1: *Saline Injection Area Phase 1 Current Monitoring Bore Names*

The objective of this memo is to notify all concerned about the proposed name changes to the current monitoring bores. The proposed changes see the monitoring bores being labeled in a sequential order east to west, and takes into account the planned eastern monitoring bores in Phase 2, and will accommodate more monitoring bores further to the east. The map with the proposed name change bores is shown in Attachment 2: *Saline Injection Area Phase 1 Renamed Monitoring Bores.* Table 2 below correlates the old names with the new names.

Table 1: Actions to implement this proposal

Parties involved	
Envirosys	Send through the change request form detailing proposed changes to the monitoring borefield nomenclature
Hydrogeology	Amend all existing logs, spreadsheets, and documents with the old nomenclature translate to the new nomenclature detailed in Table 2
Water Engineering	Alert water engineers to the name change
Compliance	Update Maps and Monitoring Schedules with new names

Table 1: Proposed new monitoring bore names and corresponding previous name

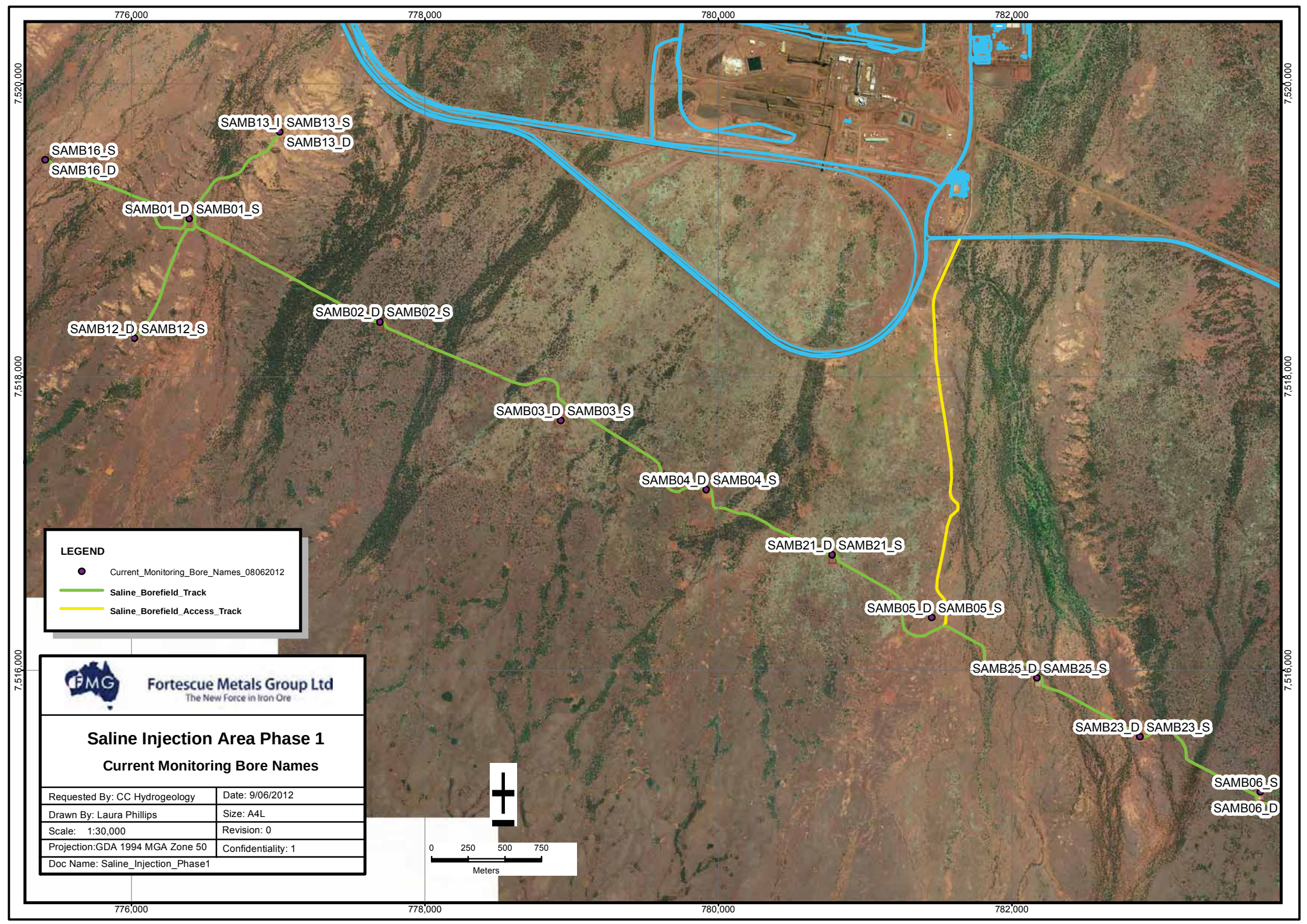
Old Bore Name	New Bore_Name	Easting	Northing	Ground_RL
SAMB06_S	SAMB07_S	783696.745	7515171.152	415.251
SAMB06_D	SAMB07_D	783696.712	7515171.082	415.251
SAMB23_D	SAMB08_D	782873.15	7515546.71	415.666
SAMB23_S	SAMB08_S	782873.12	7515546.62	415.666
SAMB25_S	SAMB09_S	782172.308	7515946.808	417.087
SAMB25_D	SAMB09_D	782172.28	7515946.706	417.087
SAMB05_D	SAMB10_D	781455.007	7516358.884	418.038
SAMB05_S	SAMB10_S	781454.928	7516358.806	418.038
SAMB21_D	SAMB11_D	780776.231	7516787.984	418.876
SAMB21_S	SAMB11_S	780776.143	7516787.98	418.876
SAMB04_D	SAMB12_D	779920.135	7517232.462	419.695
SAMB04_S	SAMB12_S	779920.098	7517232.525	419.695
SAMB03_D	SAMB13_D	778926.646	7517701.325	419.103
SAMB03_S	SAMB13_S	778926.611	7517701.225	419.103
SAMB02_S	SAMB14_S	777695.46	7518375.419	418.067
SAMB02_D	SAMB14_D	777695.388	7518375.423	418.067
SAMB13_S	SAMB15_S	777012.818	7519668.818	421.086
SAMB13_D	SAMB15_D	777012.76	7519668.767	421.086
SAMB13_I	SAMB15_I	777012.751	7519668.746	421.086
SAMB01_D	SAMB16_D	776396.244	7519077.641	418.503
SAMB01_S	SAMB16_S	776396.131	7519077.663	418.503
SAMB12_D	SAMB17_D	776022.633	7518262.394	415.585
SAMB12_S	SAMB17_S	776022.592	7518262.183	415.585
SAMB16_D	SAMB18_D	775413.49	7519477.823	416.852
SAMB16_S	SAMB18_S	775413.421	7519477.752	416.852

Attachment 1 *Saline Injection Area Phase 1 Current Monitoring Bore Names*
Attachment 2 *Saline Injection Area Phase 1 Renamed Monitoring Bores*

LAURA PHILLIPS
Senior Hydrogeologist, Utilities

Attachment 1

Saline Injection Area Phase 1 Current Monitoring Bore Names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Fortescue Metals Group Ltd
The New Force in Iron Ore
Saline Injection Area Phase 1
Current Monitoring Bore Names
Requested By: CC Hydrogeology
Date: 9/06/2012
Drawn By: Laura Phillips
Size: A4L
Scale: 1:30,000
Revision: 0
Projection:GDA 1994 MGA Zone 50
Confidentiality: 1
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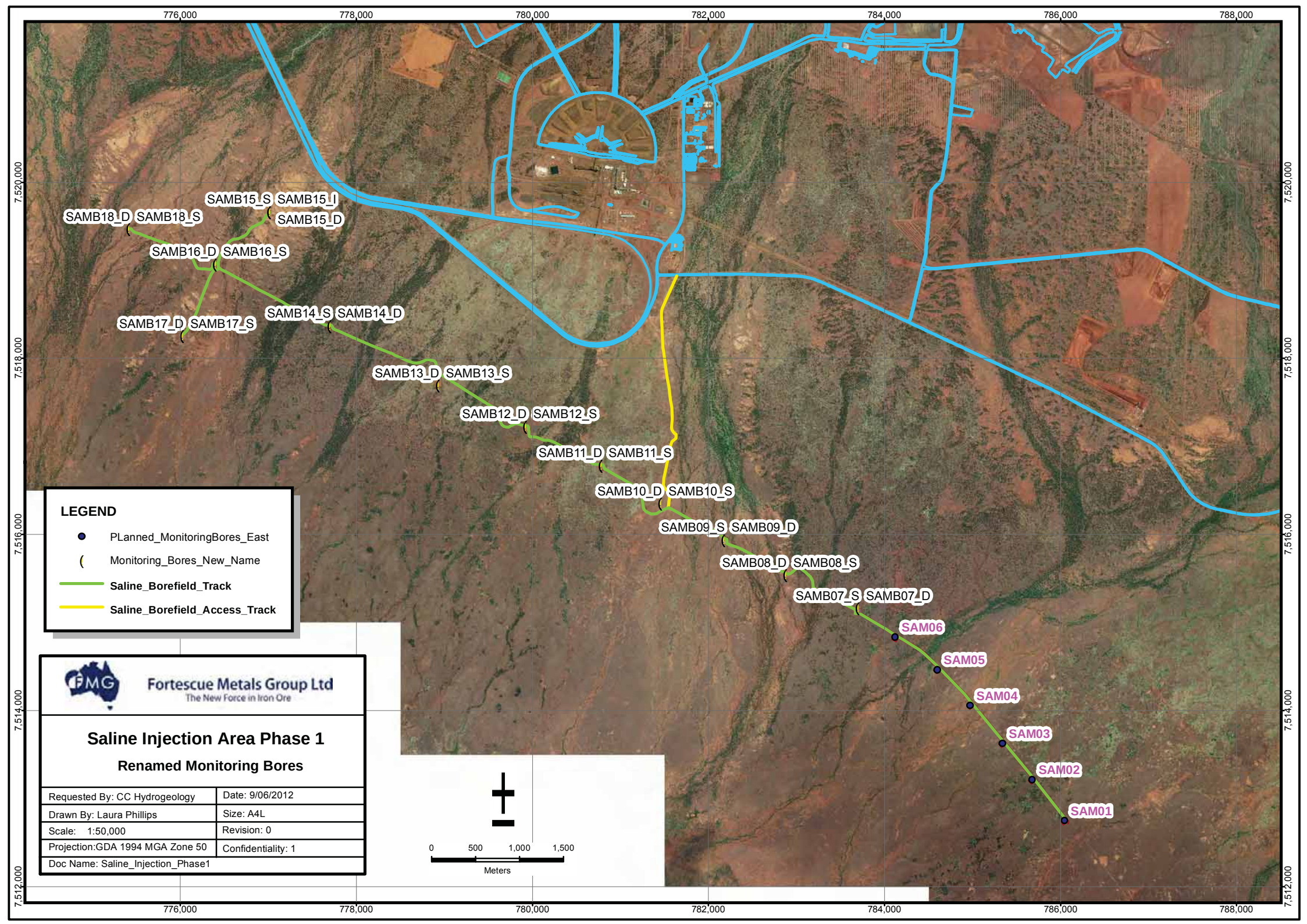
Meters

Attachment 2
Saline Injection Area Phase 1 Renamed Monitoring Bores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SAMB10_S
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SAMB08_D
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SAMB07_S
SAMB07_D
SAM06
SAM05
SAM04
SAM03
SAM02
SAM01
LEGEND
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Monitoring_Bores_New_Name
Saline_Borefield_Track
Saline_Borefield_Access_Track
Fortescue Metals Group Ltd
The New Force in Iron Ore
Saline Injection Area Phase 1
Renamed Monitoring Bores
Requested By: CC Hydrogeology
Date: 9/06/2012
Drawn By: Laura Phillips
Size: A4L
Scale: 1:50,000
Revision: 0
Projection:GDA 1994 MGA Zone 50
Confidentiality: 1
Doc Name: Saline_Injection_Phase1
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Meters

Appendix 8: Groundwater chemistry report (prepared by Rockwater)

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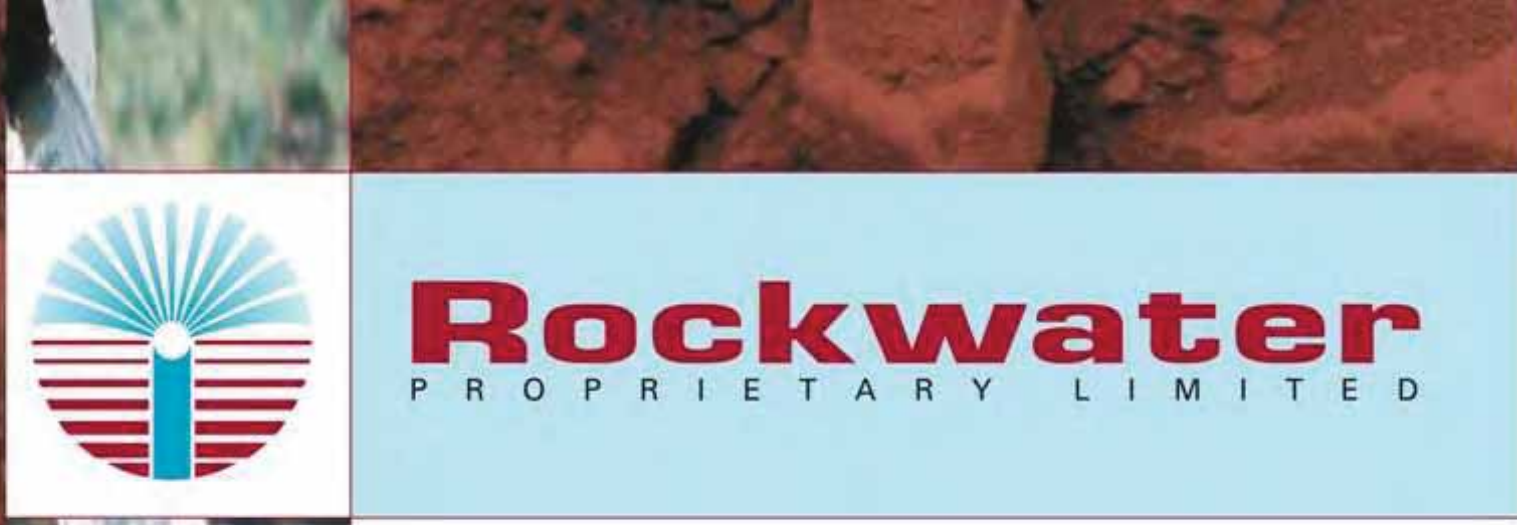

Rockwater
PROPRIETARY LIMITED

CHRISTMAS CREEK MINE

GEOCHEMICAL CHARACTERISATION OF GROUNDWATER RELATING TO DEWATERING AND REINJECTION OPERATIONS

JUNE 2014

REPORT FOR
FORTESCUE METALS GROUP LTD

(Report No. 436-0/14/02)

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1 INTRODUCTION

Christmas Creek Mine (Christmas Creek) is located on the southern slopes of the Chichester Range just north of Fortescue Marsh, approximately 270 km south-east of Port Hedland in the Pilbara region of Western Australia. It is 30 km east of the Cloudbreak Mine site: collectively the two mines are known as the Chichester Operations and they both are operated by Fortescue Metals Group (Fortescue). Each mine site is regulated separately; the information presented herein relates to the Christmas Creek operations specifically. The mine location is presented in Figure 1.

1.1 BACKGROUND

Mining at Christmas Creek occurs on the southern flanks of the Chichester Range and extends below the water-table. Groundwater pumped from active pits ranges from brackish to hypersaline, depending on the location and the aquifer intercepted, any water in excess of operational requirements has been reinjected to the groundwater system at locations commensurate with the quality of the water extracted. More recently most of the excess water pumped during pit dewatering operations has been hypersaline, as the shallow brackish lens has been mostly dewatered at the pit locations. Currently, injection occurs only in the saline injection bores; any brackish water extracted during dewatering is generally used in the processing operations. Some extraction has commenced from the brackish injection zones.

The dewatering and reinjection operations are regulated by the Department of Water (DoW) under groundwater licence GWL167593 and conditions detailed in the Christmas Creek Groundwater Operating Strategy (GWOS) (Fortescue, 2013a). Under the GWOS, groundwater quality is monitored six monthly at specified reinjection pipelines and selected monitoring bores. The results are to be reported along with other monitoring data in a series of annual and triennial reports.

Following submission of the latest Christmas Creek Triennial Review (Fortescue, 2013b) the DoW requested a more rigorous review and discussion of the groundwater chemistry data. Fortescue has subsequently contracted Rockwater to provide a geochemical review of the groundwater quality data set for Christmas Creek with particular regard to the issues raised by the DoW (Appendix I). This report details the results of the review.

1.2 REVIEW OBJECTIVES

The objectives of this review are to:

- Characterise baseline geochemical conditions at the site with particular reference to aquifer and monitoring zones;
- Describe current geochemical conditions and comment on any changes from baseline conditions;
- Provide an interpretation of any observed changes to geochemical conditions;
- Verify quality assurance and quality control (QA/QC) procedures for sample collection and laboratory data, including a review of laboratory QA/QC documents and comments relating to the appropriateness of analytical limits of reporting;
- Review draft groundwater sampling procedures that have been prepared by Fortescue, including comments regarding adherence to relevant regulatory standards; and,
- Make recommendations for changes to the current GWOS including, where applicable, recommendations for changes to collection of geochemical data such as the number and location of monitoring bores and the parameters analysed.

This assessment addresses the above in relation to comments made by the DoW and aims to provide a template for future geochemical reporting associated with the Christmas Creek GWOS.

1.3 FORTESCUE WATER MANAGEMENT OBJECTIVES

The DoW has requested Fortescue provide background context to the collection and reporting of geochemical data, specifically how it relates to management objectives and mine site operations.

The Christmas Creek water management scheme, according to the GWOS, has been developed with the following objectives:

- Manage excess groundwater;
- Minimise potential environmental impacts; and
- Conserve the groundwater resource.

The key component of the scheme is the disposal of abstracted groundwater into nearby suitable aquifers (Fortescue, 2013a). The geochemical characterisation presented herein aims to present data collected to date within the management framework provided.

2 HYDROGEOLOGY

The hydrogeological background has been described in Fortescue's Christmas Creek Triennial Aquifer Review (2013b): the key points are summarised below with additional data as required.

2.1 LOCATION AND LANDUSE

Christmas Creek is an iron ore mine site operated by Fortescue since April 2009. It is located in the Pilbara region of Western Australia approximately 270 km south-east of Port Hedland; the location is presented in Figure 1. Mining is the primary land use in the area along with pastoral activities.

2.2 CLIMATE

The climate of the Pilbara is arid tropical, characterised by low variable rainfall, high daily temperatures and high evaporation rates (approximately 3,000 mm/yr). The hot summer months extend from October to April and the winter months extend from May to September.

The average annual rainfall is approximately 300 mm at nearby Newman, and is characterised by frequent low-intensity events related to localised thunderstorms. High intensity rainfall events related to tropical cyclone activity may occur during summer months.

2.3 DRAINAGE

Rainfall runoff from the Chichester Range flows south towards the Fortescue Marsh and tends to occur as overland sheet flow without well-defined water courses. Any stream flow tends to be of short duration. The drainage system is internal, and water reaching the marsh is subject to high evapotranspiration rates, creating a hypersaline water body in the marsh.

2.4 PHYSIOGRAPHY

The eastern Pilbara regional topography is dominated by the Hamersley Plateau in the south and the Chichester Range in the north with the two features separated by the Fortescue Valley. The Fortescue Marsh forms an extensive intermittent wetland on the valley floor. The eastern section of the Chichester Range immediately adjacent to the Christmas Creek operations occupies an area about 100 km long by 10 km wide, at an elevation of around 400 to 480 m AHD. Between the raised relief of the Chichester Range and the Fortescue Marsh a transitional zone exists, characterised by fluvial deposition and the formation of a series of alluvial fans, which for the most part overlie the Christmas Creek mine mineralisation.

Christmas Creek has an elevation ranging from about 415 to 480 m AHD, which is well above any potential flood storage level in the Fortescue Marsh. Topographic mapping indicates that there are no springs or pools located in the project area.

2.5 GEOLOGY

The Christmas Creek deposits lie within the Hamersley Basin where sedimentary groups overlie granitoid rocks of the Archaean Pilbara Craton. The granitoid rocks are unconformably overlain by the Archaean Fortescue Group, which is conformably overlain by the Archaean-Proterozoic Hamersley Group. Mineralisation at Christmas Creek is confined to the Marra Mamba Formation (MMF), the lowermost Formation of the Hamersley Group. Underlying the MMF is the Jeerinah Formation, represented at this site by the Roy Hill Shale Member.

The MMF outcrops on the flanks of the Chichester Range to the north and is overlain to the south successively by a sequence (in increasing age) of Quaternary and Tertiary deposits, generally referred to as Tertiary Detritals (TD), the Cainozoic Oakover Formation (OF) and the Archaean Wittenoom Formation (WF).

The Hamersley Group consists of various metasedimentary rocks including banded iron formations (BIF) interbedded with minor felsic volcanic rock and intruded by doleritic dykes (Johnson and Wright, 2001). At Christmas Creek the Hamersley Group includes the Wittenoom Formation (dolomite with goethite and hematite alteration and chert inclusions) and the Marra Mamba Formation, represented by the Nammuldi Member (BIF and chert). A hard-cap, which is commonly vuggy, has been formed on the upper contact surface of the MMF.

The “Tertiary Detritals” include the Oakover Formation (calcrete); Clay; Detritals (piesolitic iron gravel in clay matrix) and Alluvium (poorly sorted, angular to sub-angular, polymictic gravel in a silt or clay matrix).

2.6 REGIONAL HYDROGEOLOGY

A schematic cross section of the regional hydrogeology is provided in Figure 2.

In the undisturbed environment, groundwater flow and water quality is dominated by the competing factors of direct rainfall recharge on the elevated flanks of the Fortescue Valley and surrounding plateau, and mounding of hypersaline groundwater beneath the Fortescue Marsh.

Rainfall recharge on the flanks of the Chichester Range has resulted in an extensive fresh to

brackish groundwater lens that extends from the range to edge of the marsh, reaching a maximum depth of about 80 m. The brackish lens occurs in the MMF in elevated areas and within the MMF, WF and Tertiary Detritals in the valley. Groundwater flow generally follows the topography and moves from the elevated land in the north towards the valley in the south.

The Upper Fortescue Valley is an internal drainage system, terminating at the Fortescue Marsh. Water draining to the marsh is subject to very high evaporation rates, creating hypersaline water which infiltrates to the groundwater system, effectively creating a hypersaline mound beneath the marsh and blocking the flow of brackish groundwater from the range. The infiltrating hypersaline water flows down and beneath the fresh/brackish water lens, driven by the higher density, creating a saline interface between the two groundwater bodies.

Salinity categories, based on electrical conductivity (EC) values, for descriptive terms used in the hydrostratigraphic summary table in the triennial review are shown in Table 1.

Table 1: Salinity Categories

Salinity	**Electrical Conductivity (µS/cm)**
Fresh	<800
Brackish	800 – 50,000
Saline	50,000 – 80,000
Hypersaline	>80,000

Fresh to brackish groundwater is present in the unconsolidated surface sediments, forming an unconfined/semi-confined aquifer underlain by an impervious clay layer in the valley and in hydraulic connection with the MMF to the north. Bores completed in this shallow aquifer can yield up to 900 kL/d locally, although generally permeabilities are too low to provide a reliable groundwater supply. Groundwater salinity increases significantly towards Fortescue Marsh, becoming hypersaline near the marsh itself.

The Oakover Formation contains saline to hypersaline groundwater in a very high permeability calcrete aquifer, confined in the valley by overlying clays. Bore yields in this formation are up to 5,000 kL/d, with groundwater flow predominantly though cavities and interconnected voids formed through the partial dissolution of the calcrete. Injection tests completed in five bores indicate maximum injection rates of between 1,300 and 8,200 kL/d showing a high degree of heterogeneity in the secondary-porosity aquifer system. Results from one pumping test indicate a transmissivity of 1,925 m^3/d/m. The formation has variable hydraulic connection with the Wittenoom and Marra Mamba Formations to the north.

The Wittenoom and Marra Mamba Formations form an unconfined (in the north) to confined (in the south) fractured rock aquifer with bore yields of up to 2,500 kL/d. The groundwater is

fresh to hypersaline with salinity increasing with depth and towards the Fortescue Marsh. Assessment of the water-level drawdown response to long-term production at the active pits indicates a typically confined response in the MMF aquifer with transmissivity in the order of 600 to 620 m^3/d/m. The permeability is mostly associated with the mineralised zones, and decreases with depth and to the south. The aquifer is in hydraulic connection with the shallow aquifer on the lower reaches of the flank of the range and has variable hydraulic connection with the Oakover Formation in the valley. Groundwater flow in the MMF is strongly influenced by mineralisation in the region and by structural features such as faulting.

Groundwater through-flow from the Roy Hill Shale to the MMF is generally thought to be low due to low hydraulic conductivities in the shale; however the flux may be locally enhanced along south-west/north-east cross cutting fault zones.

2.7 OPERATIONAL IMPACTS ON THE GROUNDWATER SYSTEM

Mining at Christmas Creek occurs via two open pits on the lower southern flanks of the Chichester Range, which extend below the water table into the MMF. To maintain a dry working environment the pits need to be dewatered and groundwater is extracted from a network of production bores from the active pits as required. The production bores at each pit are generally constructed to intercept either groundwater in the low-salinity lens or the deeper more saline groundwater. There are 167 operational production bores; details of annual production are provided in the triennial review (Fortescue, 2013b) and locations for active production bores are presented in Figure 3.

When dewatering commences in a new pit, the first groundwater intercepted is generally that in the low salinity lens. In order to preserve this higher quality water for future use, the water in excess of immediate mining needs has been pumped to a series of “brackish” injection bores extending along the flanks of the range to the east and west of the mining operations, where it is recharged to the fresh/brackish water lens. As mining extends deeper, the brackish water tends to be mined out of the active pit area and the groundwater pumped from the pits becomes more saline, due largely to the lateral flux of saline groundwater from the Oakover Formation, induced by the steep hydraulic gradient and vertical migration of saline water due to depressurisation of overlying brackish aquifers. This saline groundwater is pumped to a series of “saline” injection bores, located to the south of the mining operations and running parallel to the edge of the Fortescue Marsh, for disposal to the sub-surface, thereby minimising the mining impact on marsh, which is considered to have significant environmental value (EPA, 2013). Details of the water balance and injection regime are provided in the triennial review (Fortescue, 2013b): there are 48 brackish and saline injection bores; locations for active injection bores are presented in Figure 4.

Recently groundwater has been re-extracted from the brackish injection borefields to supplement the mine water supplies, both at Christmas Creek and Cloudbreak Mines.

Groundwater levels have been drawn down in the shallow, Tertiary Detrital aquifer in the pit areas, however there has been no significant rise in groundwater levels at the water table attributable to injection activities.

The overall geochemical impact of dewatering and re-injection operations will be considered further in Section 4 below, however in general mining has dewatered the fresh/brackish groundwater lens in the vicinity of the open pits, and may possibly have increased the thickness and lateral extent of the lens on the flanks of the range to the east and west, where reinjection has taken place. The zone of dewatering impact is elliptical and aligned with the strike of the MMF due to the orientation of mine pits, permeability distribution, and injection in the Oakover Formation to the south. Re-injection of saline water to the south has increased potentiometric heads in the deep aquifer in this region (Fortescue 2013b).

3 GROUNDWATER MONITORING PROGRAMME

A monitoring program for the dewatering/injection system has been proposed in the 2013 Groundwater Operating Strategy (Fortescue, 2013a). The aim of the programme is to monitor the effects of the dewatering and injection operations on the surrounding groundwater systems and potential interactions with the Fortescue Marsh.

For the purposes of groundwater management two classes of groundwater quality are defined:

- Brackish: ≤6,000 mg/L TDS (total dissolved solids), as occurs in the fresh/brackish groundwater lens defined by the shallow aquifer zone of the MMF on the flank of the Chichester Range and shallow detrital and alluvial sediments; and,
- Saline – hypersaline: ≥6,000 – 150,000 mg/L TDS, as occurs beneath the fresh/brackish groundwater lens in the north and to the south, towards the Fortescue Marsh.

The groundwater monitoring results associated with production and injection rates, groundwater level response and environmental trigger levels have been fully reported in the 2013 Triennial Aquifer Review (Fortescue, 2013b). The results discussed in this report are limited to the geochemical sampling undertaken at the injection bore discharge lines and nominated monitoring bores (2013 GWOS), as per the scope of work and data provided.

The sampling points and background data relating to this geochemical review and assessment of water quality changes are shown in Tables 2 and 3. A summary of the monitoring data collected, as detailed in the 2013 GWOS, is provided in Table 4.

Table 2: Geochemical Monitoring at Injection Discharge Pipelines

Sample point	Easting (mE)	Northing (mN)	Sampling point type
CCSP0001 (Hillside East)	775,392	7,523,460	Brackish Injection
CCSP0008 (Spinifex Pigeon)	792,132	7,517,759	
CCSP0011 (Saline Injection - direct)	779,560	7,519,662	Saline Injection
CCSP0015 (Saline Injection - Crank TP outflow)	776,123	7,518,386	

Table 3: Geochemical Monitoring Bores

Sample Point	Easting	Northing	Location	Monitoring Zone[1]	Aquifer	Baseline SWL	Baseline EC
CCF01B_S	786,016.0	7,515,638.3	Christmas Creek		Tertiary Detritals		
CCF03B_S	792,255.0	7,510,749.2	Christmas Creek		Tertiary Detritals		
CCFMM01_D	764,359.7	7,519,790.7	Fortescue Marsh	A	Oakover Fmn.		90,000
CCFMM01_S	764,359.6	7,519,790.6	Fortescue Marsh	A	Tertiary Detritals		110,320
CCFMM02_D	770,340.2	7,518,161.1	Fortescue Marsh	A	Oakover Fmn.		
CCFMM02_S	770,340.0	7,518,157.3	Fortescue Marsh	A	Tertiary Detritals		69,440
CCFMM03_D	777,000.2	7,514,851.3	Fortescue Marsh	A	Oakover Fmn.		
CCFMM03_S	777,000.2	7,514,851.3	Fortescue Marsh	A	Tertiary Detritals		74,265
CCFMM04_D	785,609.9	7,510,126.8	Fortescue Marsh	A	Oakover Fmn.		
CCFMM04_S	785,609.9	7,510,126.8	Fortescue Marsh	A	Tertiary Detritals		87,630
CCFMM05_D	794,938.9	7,504,202.3	Fortescue Marsh	A	Oakover Fmn.		
CCFMM05_S	794,939.0	7,504,202.1	Fortescue Marsh	A	Tertiary Detritals		109,250
HSMB29_D	771,256.8	7,523,532.1	Hillside East	C	Marra Mamba Fmn.	17.98	16,150
HSMB29_S	771,256.8	7,523,532.1	Hillside East	C	Tertiary Detritals	18.09	6,120
SAM02_D	785,673.4	7,513,186.0	CC Saline Injection	B	Oakover Fmn.	13.94	91,300
SAM02_S	785,673.4	7,513,186.0	CC Saline Injection	B	Tertiary Detritals	11.51	
SAM07_D	783,696.7	7,515,171.1	CC Saline Injection	B	Oakover Fmn.		
SAM07_S	783,696.7	7,515,171.2	CC Saline Injection	B	Tertiary Detritals		
SAM13_D	778,926.6	7,517,701.3	CC Saline Injection	B	Oakover Fmn.	16.29	17,300
SAM13_S	778,926.6	7,517,701.2	CC Saline Injection	B	Tertiary Detritals	14.29	14030
SCX01_S*	769,599.1	7,520,600.7	Hillside East	C	Oakover Fmn.		
SCX03_S	769,595.7	7,523,206.1	Hillside East	C	Tertiary Detritals	16.27	770
SCX04_S	771,220.8	7,522,594.5	Hillside East	C	Tertiary Detritals		
SCX05_D	774,400.0	7,520,100.0	Hillside East	C	Marra Mamba Fmn.		
SCX05_S	774,400.0	7,520,100.0	Hillside East	C	Tertiary Detritals		
SCX06(All)	765,200.0	7,521,790.0	Hillside East	C			
SCX06_D*	765,200.0	7,521,790.0	Hillside East	C	Marra Mamba Fmn.		
SCX06_S*	765,200.0	7,521,790.0	Hillside East	C	Oakover Fmn.		
SPM01_D*	792,769.8	7,518,353.8	Spinifex Pigeon	C	Marra Mamba Fmn.	23.77	2,700
SPM01_S	792,769.8	7,518,353.9	Spinifex Pigeon	C	Tertiary Detritals	23.81	1,370

* Nominated as Zone C in 2103 GWOS, but plots in Zone B on map.

1) Monitoring zone nominated in 2013 GWOS for trigger level assessment.

Table 4: Geochemical Monitoring Summary

Sampling Point	Frequency	Monitoring Parameter	Comments
Injection discharge pipelines[1]	Monthly	Field EC	Data not provided
		Volume	Data not provided
	Six monthly	Chemical analysis	Includes: Major ions (Na, K, Ca, Mg, Cl, alk, SO_4 and NO_3); Metals (Al, B, Fe, Cu, Zn, Ag, As, Cr, Pb, Cd, Hg, Ni, Sn, Se and Mn); field and lab pH; TDS and TSS.
Monitoring bores[2]	Monthly	Groundwater Level	Data not provided
		Field EC	Data not provided
	Six monthly	Chemical analysis	Includes: Major ions (Na, K, Mg, Ca, Cl, alk and SO_4); Metals (Al, B, Fe Cu, Zn, Ag, As, Cr, Pb, Cd, Hg, Ni, Sn and Mn); pH; EC; TDS and TSS.

1) Sampling points in Table 2
2) Sampling points in Table 3

Groundwater sampling undertaken at Christmas Creek generally complies with the requirements of the following standards and procedures:

- Australian/New Zealand Standard/NZ 5667.11:1998 Water Quality Sampling Part II: Guidance on sampling of groundwater; and
- Groundwater Sampling Procedure: Dewatering Compliance (Draft). Procedure document CH-PR-WM-0001, December 2013.

Fortescue staff undertake all groundwater sampling associated with compliance with Christmas Creek groundwater quality monitoring requirements as detailed in the GWOS. Sampling locations are shown in Figure 5.

4 GROUNDWATER QUALITY MONITORING RESULTS

Rockwater has been provided with all the laboratory data collected by Fortescue since investigations and operations at Chichester Operations commenced. The volume of data is so large that it is beyond the scope of the current investigation to incorporate it all into this geochemical assessment: the assessment therefore focuses on those sampling points nominated in the 2013 GWOS, which are relevant to the annual and triennial groundwater monitoring reviews with the use of additional data where appropriate.

The results have been grouped according to the monitoring zone (Fortescue, 2013a) in which the monitoring bore is located:

- Zone A – Near-marsh region;
- Zone B – Saline injection region;
- Zone C – Brackish injection region; and
- Zone D – Phreatophytic vegetation region.

The results are also discussed according to the aquifer in which the monitoring bore is completed.

4.1 GROUNDWATER QUALITY

The groundwater sampling results for physical parameters and major ions are tabulated in Appendix II and sampling results for metals and trace elements are tabulated in Appendix III. There are currently no relevant water quality guidelines against which to assess the data, and so the major ions and physical parameters are compared with background groundwater conditions where available and/or trigger values derived previously by Fortescue (2013a). Metals and trace elements are compared against baseline data, where available, and/or marine

water quality guidelines (ANZECC, 2000). The later guidelines have been selected as a guide to water quality based on the hypersaline nature of the groundwater and the environmental conditions of Fortescue Marsh.

4.1.1 Baseline Groundwater Conditions

Groundwater sampling has been conducted at Christmas Creek since January 2007, over two years prior to the start of mining operations in April 2009. Where available, data collected between January 2007 and March 2009 have been highlighted in blue text in the water quality tables (Appendix II-E to -G), and have been used to assess groundwater conditions at the mine site prior to operations (baseline) and any changes that have occurred since mining commenced. It should be noted that a number of the results from the first one or two sampling events appear to be affected by drilling fluids, with sampling results stabilising from around August 2008. Therefore, where baseline values have been specified, the results generally refer to the August 2008 sampling event.

Baseline conditions for groundwater salinity (by Total Dissolved Solids – TDS) and pH in both the shallow (Tertiary Alluvium/Detritals) and the deep (Marra Mamba/Oakover Formation) aquifers are presented in Figures 6 to 9.

Figure 6 shows that groundwater salinity in the shallow aquifer was brackish (between approximately 810 and 1,900 mg/L TDS) in the rainfall recharge area (Zones C and D), generally increasing towards the south. No baseline data are available for the saline injection area (Zone B) or near Fortescue Marsh (Zone A). It should be noted that although the monitoring bores located at SCX06 and SCX01 are nominally in Zone C for trigger value assessment (2013 GWOS) they plot in Zone B on the location plans, and are probably more representative of the saline injection region.

Figure 7 shows that groundwater salinity in the deep aquifer was brackish to saline (between approximately 1,640 and 7,770 mg/L TDS) in the rainfall recharge area (Zones C and D), increasing to hypersaline with depth (up to 65,300 mg/L TDS) and towards the south (Zone B/C). No baseline data are available for the saline injection area (Zone B) or near Fortescue Marsh (Zone A). It should be noted that although the monitoring bores located at SCX06 and SCX01 are nominally in Zone C for trigger value assessment (2013 GWOS) they plot in Zone B on the location plans, and are probably more representative of the saline injection region.

The available baseline salinity results are consistent with the hydrogeological characterisation of the site (Section 2.6).

Figures 8 and 9 show the groundwater pH was neutral to slightly/moderately alkaline in the shallow aquifer, ranging from 7.0 to 8.2 with an average value about 7.5, with similar values in the deep aquifer; ranging from 7.3 to 8.1.

Piper diagrams for each aquifer are provided in Figures 10 and 11; however baseline groundwater composition has not been plotted for Christmas Creek because SO_4 concentrations are not available for the relevant samples.

4.1.2 Baseline Metals and Trace Elements

Monitoring results for metals and trace elements for the current Christmas Creek monitoring bores (2013 GWOS) are tabulated in Appendix III.

Baseline data (taken to be samples collected up to and including March 2009) are available for a limited number of analytes, namely boron (B), iron (Fe), manganese (Mn) and strontium (Sr) for Zones C and D only. A summary of the baseline values for these zones is presented in Table 5. In Appendix III, values measured above the maximum level analysed prior to operations have been highlighted in blue.

Table 5: Summary of Available Baseline Values for Metals and Trace Elements

	Monitoring Zone	Aquifer	B (mg/L)	Fe (mg/L)	Mn (mg/L)	Sr (mg/L)
Minimum	Zone C	Shallow	0.14	0	0	0.13
Maximum			1.12	1.36	3.6	2.61
Average			0.55	0.09	0.62	0.84
Minimum	Zone C	Deep	0.36	0	0	0.39
Maximum			0.85	1.3	17	6.22
Average			0.51	0.22	2.45	2.47
Minimum	Zone D	Shallow	0.38	0	0	1.00
Maximum			0.60	0.16	0.96	1.24
Average			0.49	0.03	0.19	1.12

The elements for which baseline data are available do not have marine water guideline values associated with them; however, with the exception of manganese and strontium they are present at levels commonly found in groundwater (Chapman, 1996).

Background manganese concentrations range from <0.001 to 17 mg/L, with values over 0.1 mg/L considered to be elevated in groundwater (Chapman, 1996). The World Health Organisation (2011) reports Mn concentrations of up to 1.3 mg/L in neutral groundwater and 9.6 mg/L in acidic groundwater, under anaerobic conditions. Apart from sporadic measurements in some other bores, highly elevated Mn concentrations occur mainly in bores

CCFMM04_S & _D and CCFMM05_S & _D in Zone A, and SCX05_S & _D and SCX06_S & _D in Zone C. Concentrations generally increase with depth in each case. The manganese appears to occur naturally, and is probably related to the mineralogy.

Strontium levels are naturally elevated (>0.1 mg/L) at this location, with a maximum value of 6.22 mg/L being measured at depth in the rainfall recharge region prior to operations. Strontium commonly occurs in nature and is found mainly as the sulphate mineral celestite ($SrSO_4$) and the carbonate mineral strontianite ($SrCO_3$). While the levels found in the groundwater at Christmas Creek may be elevated, they are consistent with the hypersaline nature of the groundwater and are generally below the mean strontium concentration for sea water (8 mg/L). Figures 12 and 13 show the baseline groundwater concentrations for strontium in the shallow and deep aquifers, respectively. In general, baseline Sr levels were between 0.2 and 1.0 mg/L in the shallow and between 0.4 and 6.0 mg/L in the deep aquifer prior to operations.

While no data are available for metals in these bores prior to mining operations, time series plots (Appendix IV) have been prepared for metals and trace elements that have concentrations commonly over the limit of reporting (Appendix III). These plots have been used to assign baseline values for the selected metals in the different management zones and assess the level of natural variation. The results are summarised in Table 6.

4.1.3 Changes to General Groundwater Quality

Recent salinity data and changes from baseline values are shown for the shallow aquifer (Tertiary Detritals) in Figures 14 and 15, respectively. Recent salinity results (Fig. 14) show that groundwater is generally hypersaline (52,000 to 121,000 mg/L TDS) in the near-marsh region (Zone A); brackish to saline (5,980 to 26,500 mg/L TDS) to the north of the saline injection region (Zone B); and brackish (500 to 4,980 mg/L TDS) in the rainfall recharge region (Zones C and D). There are few bores for which current and baseline data are available (Fig. 15), however for those bores where a direct comparison can be made, it appears that there has been some increase in salinity, specifically in the brackish injection area (Zone C) and to the north of the saline injection region.

Recent salinity data and changes from baseline values are shown for the deep aquifer (Marra Mamba and Oakover Formations) in Figures 16 and 17, respectively. There are few bores for which current and baseline data are available (Fig. 17), however for those where a direct comparison can be made, it appears that there has been a significant increase in salinity to the north of the saline injection region.

Table 6: Summary of Assigned Baseline Values for Metals and Trace Elements for Each Monitoring Zone and Observed Natural Variations

Monitoring Zone	Aquifer	Boron		Strontium		Zinc		Copper		Nickel		Cadmium		Iron		Manganese		Comments
		Baseline[1]	Natural Variation[2]	Baseline[1]	Natural Variation[2]	Baseline[1]	Natural Variation[2]	Baseline[1]	Natural Variation[2]	Baseline[1]	Natural Variation[2]	Baseline[1]	Natural Variation[2]	Baseline[1]	Natural Variation[2]	Baseline[1]	Natural Variation[2]	
		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		
A	Tertiary Detritals	3	1.0 - 4.0	6	4.0 - 10	0.05	0.01 - 0.1	0.05	0.01 - 0.1	<0.01	<0.01 - 0.015	<0.001	<0.001 - 0.003	<0.5	<0.5 - 1	2.5	0.01 - 20	
A	Oakover/Wittenoom Fmn	3	1.0 - 7.0	8	4.0 - 14	0.05	0.05 - 0.15	0.05	0.02 - 0.1	<0.02	<0.02 - 0.025	<0.002	<0.001 - 0.005	<0.5	<0.5 - 1	5	0.01 - 15	
B	Tertiary Detritals	0.5	0.2 - 1.0	2	1.0 - 3.0	<0.05	<0.05 - 0.1	0.01	0.001 - 0.03	0.002	<0.001 - 0.005	<0.0001	<0.0001 - 0.0002	<0.05	<0.05 - 0.5	0.06	0.003 - 0.3	Few data points. To be reviewed when additonal data available.
B	Oakover Formation	3	1.5 - 5.0	8	6.0 - 12	<0.05	<0.05 - 0.1	0.1	0.03 - 0.15	<0.02	<0.01 - 0.02	<0.0001	<0.0001 - 0.0002	<1.0	<0.5 - 1.5	0.3	0.03 - 1	Few data points. To be reviewed when additonal data available.
C	Tertiary Detritals	0.5	0.1 - 1.5	1	0.1 - 3.0	0.05	0.01 - 0.15	0.02	0.001 - 0.025	0.005	0.001 - 0.025	<0.0001	<0.0001 - 0.0005	0.1	<0.05 - 3	1	<0.001 - 10	
C	Oakover/Marra Mamba Fmn	0.5	0.2 - 2.0	3	0.5 - 12	0.05	0.01 - 0.15	0.05	0.002 - 0.15	0.015	0.002 - 0.05	<0.0001	<0.0001 - 0.001	0.1	<0.05 - 7	1	0.001 - 20	Transitional peaks in B reaching 3.7 mg/L
D	Tertiary Detritals	0.5	0.1 - 1.0	1	0.2 - 1.5	0.05	0.01 - 0.1	0.01	0.001 - 0.05	0.005	<0.001 - 0.02	<0.0001	<0.0001 - 0.0002	<0.05	<0.05 - 0.5	0.2	<0.001 - 1	Few data points. To be reviewed when additonal data available.

1) Taken to be average of early data, excluding samples where bores may not have been fully developed following construction and prior to any observable change.
2) Outliers and transitional peaks have been excluded from assessment of Natural Variation

Changes to salinity with time for the 2013 GWOS monitoring bores (Table 3) are plotted in Figures 18 to 21.

Figure 18 shows salinity in the shallow aquifer in Zone A (near-marsh area) generally ranges between 50,000 and 120,000 mg/L TDS; in the deep aquifer it ranges between about 100,000 and 190,000 mg/L TDS. There is a degree of variability that may be associated with aquifer changes resulting from factors such as rainfall recharge and injection, but may also reflect sampling artefacts associated with rate and duration of pumping during the sampling events. Sampling commenced in these bores in 2012, and no trends are apparent to date, with the possible exception of bores CBFMM02_D and CBFMM05_D, where an increase in salinity may have occurred.

Figure 19 shows the salinity in the shallow aquifer in the saline injection area (Zone B) is generally brackish to saline (about 6,000 to 30,000 mg/L TDS), and is hypersaline (about 95,000 to 160,000 mg/L TDS) in the deep aquifer. There are insufficient data to determine any definite trends, although there may have been a slight increase in salinity in the shallow monitoring bore SAM07_S.

Figure 20 shows the salinity in the shallow aquifer in the rainfall recharge area (Zones C and D) is generally fresh to brackish (about 400 to 7,000 mg/L TDS). Two anomalous readings in SCX04_S during 2010 and 2011, may be in error, or may represent over pumping of the monitoring bore prior to sampling. The groundwater salinity has generally remained stable in the shallow aquifer with a slight increase in SCX05_S, and a possible decrease in HSMB29_S.

Figure 21 shows the salinity in the deep aquifer in the brackish injection area (Zone C). The results show that with the exception of monitoring bores SCX01_S and SCX05_D, the baseline groundwater salinity was fresh to brackish. In SCX01_S and SCX05_D, the groundwater was hypersaline. With time the salinity has increased significantly in SXC06_D and SCX06_S and to a lesser extent in SCX06_All. The reason for the marked increase is unclear, as the bore is not located near dewatering activities and the salinity increase is much higher than the salinity of water being reinjected at either the brackish or the saline injection borefields (Section 4.2), but it may represent a shift in the saline water interface at this location due to pressurisation of the aquifer. It is not possible to fully assess conditions at this location without the groundwater level data associated with the bores. Salinity has remained fairly constant at HSMB29_D, SPM01_D and SCX01_S. Salinity measurements from the deep aquifer can be highly variable, and are probably affected by pumping rate and volume.

Recent groundwater pH values (from August 2013) and changes to pH for the shallow and deep aquifers are shown in Figures 22 and 23, respectively. Changes to pH are shown in Figures 24 and 25. Values for pH with time for each of the monitoring zones are shown in Figures 26 to 29. The results show that pH monitoring results tend to be quite variable,

particularly in the rainfall recharge area (Zones C and D), but generally range between about 7 and 8 in the near-marsh and saline injection areas (Zones A and B). There are no clear trends in the data and average values have remained approximately the same (Appendix II).

The piper diagrams (Figs 10 and 11) show the recent geochemical composition of groundwater from bores nominated in the 2013 GWOS. The shallow groundwater (Fig. 10) in the near-marsh region (Zone A) is predominantly a sodium-chloride type, with a shift towards a more fresh water signature (sodium-chloride-calcium-bicarbonate) towards the north of the rainfall recharge area (monitoring bores SCX03_S and SCX04_S in Zone C). Groundwater in the saline injection area (Zone B) tends to be a mix between the two, as expected. One bore in Zone D has a geochemical signature consistent with saline intrusion (Appello and Postma 1994), which might reflect mixing with the deeper saline water in this bore. It may also be indicative of groundwater interactions within the mineralised zone: it is the same composition as measured in a number of the Cloudbreak monitoring bores. Groundwater in the deep aquifer (Fig. 11) is primarily of a sodium-chloride type, with some recent recharge evident in monitoring bore SPM01_D: it is not possible to determine whether the recharge is naturally occurring or due to injection with the available data.

4.1.4 Changes to Metals and Trace Elements

Metals and trace elements measured above baseline values, where available, have been highlighted in blue in the Tables in Appendix III. Values for metals and trace elements above marine water guidelines have been similarly highlighted in light red: the marine water guidelines have been selected as the most relevant guidelines available in the absence of baseline data; they can be considered a conservative reference for groundwater conditions at Fortescue Marsh.

The tables show sporadic elevated measurements, relative to available background data, of Fe in each of the monitoring zones, possibly related to sampling and elevated turbidity levels.

Boron and strontium are frequently measured above background levels. Concentrations of B and Sr in the 2013 GWOS monitoring bores have been plotted with time, and the results are shown in Appendix IV (App IV-A to -H).

The plots for B show the results can be quite variable in some bores, and it is difficult to definitively confirm an increasing trend, although it is possible concentrations have increased in bores CBFMM04_D and CBFMM05_D in Zone A and SCX06_D in Zone C. Some anomalous results have been obtained but it is not clear that these are in error and they may represent a natural variability in the groundwater conditions, possibly exacerbated by sampling artefacts due to pumping rate and volume.

While Sr levels are generally elevated and show a degree of variability and occasional spurious results, the time series plots for Christmas Creek do not indicate any clear increasing trends, as observed at Cloudbreak, with the possible exception of bores located at SCX06. Strontium values at this location are significantly elevated and highly variable; the results are more consistent with bores constructed in the saline injection area (Zone B) than the brackish injection area (Zone C) (Rockwater, 2014).

Copper and zinc are consistently measured above marine water quality guidelines, however this is likely to be a natural occurrence in this area. Baseline and natural variations for these and other metals have been assessed in Section 4.1.2. There are too few data to identify any definite trends, although values for Cu, Ni, Cd and Zn appear to remain fairly consistent in most bores.

Iron and manganese (App. IV-Y – AF) can be highly variable in some bores, particularly in Zone C, and in some instances are significantly elevated (especially Mn), however there are no clear trends and it is likely related to the mineralisation of the area.

It is noted that there are occasional sampling events where metals and trace elements are anomalously high, with concentrations in a number of monitoring bores being an order of magnitude or more above the usual levels measured. It is likely that these results are in error or result from some sampling or analytical artefact such as bailing, filtration failure, or sample contamination. Close adherence to the latest sampling and QA/QC procedures (Fortescue 2013c) should minimise these events in the future.

4.2 INJECTION WATER QUALITY

The sampling results for physical parameters and major ions measured at the brackish and saline injection line locations nominated in the 2013 GWOS are tabulated in Appendix V and sampling results for metals and trace elements are tabulated in Appendix VI.

4.2.1 Brackish Injection Lines

Salinity and pH data for the brackish injection line monitoring points are plotted with time in Figure 30. The results show that the nominated Class 1 salinity trigger of 9,000 µS/cm (or approximately 5,500 mg/L TDS) was breached in three of the four samples collected between August 2012 and March 2014. The salinity ranged between about 5,000 and 10,000 mg/L TDS. The pH was between 7.5 and 7.7.

Appendix VI tabulates the results for metal analyses undertaken in accordance with the 2013 GWOS. The results show that Cu, Ni and Zn are commonly measured above marine guideline limits (ANZECC 2000) and range from 0.004 to 0.014 mg/L; 0.001 to 0.009 mg/L;

and, 0.035 to 0.106 mg/L respectively. Time series plots for these metals and other metals are provided in Appendix VII. The values are consistent with the levels measured in the groundwater in the area (Table 6). Aluminium and nitrate data were not available in the raw data provided.

4.2.2 Saline Injection Lines

Salinity and pH data for the saline injection line monitoring points are plotted with time in Figure 31. The results show that after an initial decline in salinity, from about 50,000 to 25,000 mg/L from August to December 2012, the salinity in the saline injection lines has increased, and is currently greater than 70,000 mg/L, as mining extends further below the fresh/brackish groundwater lens. Daily salinity measurements taken in April 2013 from CCSP0011 show a significant variability in salinity over a four day period. The pH is variable, generally ranging between 7.0 and 8.0; no definite trend is discernable.

Appendix VI tabulates the results for metal analyses undertaken in accordance with the 2013 GWOS. The results show that Cd, Mn and Ni are commonly measured above limits of reporting and range from 0.0009 to 0.0013 mg/L; 0.7 to 2.48 mg/L; and, 0.034 to 0.047 mg/L respectively. The values for Ni are above the marine water quality guidelines at both locations, as is Cd, Cu and Zn. Time series plots for these metals are provided in Appendix VII. With the exception of Zn, concentrations for these elements are within the levels measured in the groundwater in the area (Table 6). Aluminium and nitrate data were not available in the raw data provided.

4.3 ASSESSMENT OF GROUNDWATER QUALITY CHANGES

Groundwater quality is monitored in both the shallow aquifer and deep aquifers at Christmas Creek, although regular monitoring in Zones A (near-marsh area) and B (saline injection area) has only commenced in the last two years; long term data are available for Zones C and D (rainfall recharge area) only.

A review of the results relating primarily to the monitoring bores specified in the 2013 GWOS supports the conceptual hydrogeochemical model for the site, namely the presence of a fresh/brackish groundwater lens recharged on the flanks of the Chichester Range flowing south towards the Fortescue Marsh, where it is trapped by hypersaline water infiltrating from Fortescue Marsh and creating a saline wedge beneath the southern edge of the lens.

An assessment of changes to groundwater quality with time generally indicates no significant impact from either dewatering or injection on the groundwater quality in the shallow or deep aquifers in any of the monitoring zones, although there has been a significant unexplained rise in salinity and associated parameters in monitoring bores SCX06_S and _D. There are

insufficient data to determine definite salinity trends in the near-marsh (Zone A) or saline injection area (Zone B), but there may be an increasing trend in the deep bores CBFMM02_D and CBFMM05_D in Zone A and the shallow bore SAM07_S in Zone B. As no groundwater level data have been provided for these bores and specific sampling events it is difficult to comment further. In the brackish injection region (Zone C) there has been a slight increasing trend in the shallow bore SCX05_S and a possible decline in HSMB29_S; in the deep aquifer there has been a rapid increase in salinity in monitoring bores SCX06_S and _D, from fresh to hypersaline suggesting a shift in the saline water interface at this site. No groundwater data have been provided for these bores and so full assessment of the cause is not possible, but it may be related to hydraulic pressure increases related to injection. A bore location map showing the position of the monitoring bores relative to the production and injection bores would be useful, but is beyond the scope of this investigation as the bore type and location data for the relevant bores is not readily available in the data set provided.

It is noted that the groundwater quality, as indicated by salinity and pH, can be highly variable particularly in some of the near-marsh (Zone A) and rainfall recharge area (Zone C) monitoring bores. While variability in total dissolved solids may be due to natural fluctuations, it is more likely to be due sampling artefacts resulting from the salinity stratification in the aquifer. The salinity time series plots for these parameters have been reviewed to identify likely baseline conditions and expected natural variability under current conditions; the results are presented in Table 7. Electrical conductivity values have been calculated from measured TDS based on the empirical relationship established for Cloudbreak (Rockwater, 2014).

5 QUALITY ASSURANCE AND QUALITY CONTROL

Sampling and data quality assurance and quality control (QA/QC) procedures for the groundwater monitoring programme currently undertaken at Fortescue's Chichester Operations (Christmas Creek and Christmas Creek mine sites) have been developed as detailed in their Groundwater Sampling Procedure document, CH-PR-WM-0001 (Fortescue, 2013c). This section briefly reviews these procedures and their implementation, and assesses their adherence to the AS/NZS 5667.1:1998 water quality sampling guidelines and ANZECC 2000 water quality monitoring and reporting guidelines.

Some of the key QA/QC components currently conducted and recommended for Fortescue's groundwater data quality control procedures at the Christmas Creek mine site are summarised in Table 8.

Table 7: Assessment of Baseline and Natural Variability for Salinity

Monitoring Bore	Monitoring Zone[1]	Aquifer	Baseline EC[2]	Baseline TDS	Natural Variation TDS[3]	Baseline EC[4]	Natural Variation EC[3, 4]	Comments
			(µS/cm)	(mg/L)	(mg/L)	(µS/cm)	(µS/cm)	
CCF01B_S	D	Tertiary Detritals		3,000	800 - 5,000	4,326	1,050 - 7,300	
CCF03B_S	D	Tertiary Detritals		2,600	2,500 - 3,100	3,730	3,500 - 4,500	
CCFMM01_D	A	Oakover Fmn.	90,000	100,000	100,000 - 110,000	125,373	125,400 - 138,000	
CCFMM01_S	A	Tertiary Detritals	110,320	100,000	100,000 - 130,000	125,373	125,400 - 163,000	
CCFMM02_D	A	Oakover Fmn.		115,000	105,000 - 140,000	143,973	130,000 - 175,000	
CCFMM02_S	A	Tertiary Detritals	69,440	80,000	80,000 - 85,000	100,573	100,000 - 107,000	
CCFMM03_D	A	Oakover Fmn.		128,000	120,000 - 135,000	160,093	150,000 - 170,000	
CCFMM03_S	A	Tertiary Detritals	74,265	70,000	50,000 - 115,000	88,173	64,000 - 144,000	Slots appear to be across saline interface
CCFMM04_D	A	Oakover Fmn.		175,000	155,000 - 180,000	218,373	194,000 - 225,000	
CCFMM04_S	A	Tertiary Detritals	87,630	65,000	55,000 - 70,000	81,973	70,000 - 88,000	May be suseptable to over-pumping
CCFMM05_D	A	Oakover Fmn.		160,000	145,000 - 175,000	199,773	180,000 - 220,000	
CCFMM05_S	A	Tertiary Detritals	109,250	75,000	70,000 - 100,000	94,373	88,000 - 125,000	May be suseptable to over-pumping
HSMB29_D	C	Marra Mamba Fmn.	16,150	10,000	9,000 - 11,000	14,756	13,000 - 16,500	
HSMB29_S	C	Tertiary Detritals	6,120	6,500	2,500 - 7,000	9,541	3,500 - 10,500	
SAM02_D	B	Oakover Fmn.	91,300	140,000		174,973		Too few points to properly assess
SAM02_S	B	Tertiary Detritals		30,000		38,573		Too few points to properly assess
SAM07_D	B	Oakover Fmn.		140,000	125,000 - 160,000	174,973	156,000 - 200,000	
SAM07_S	B	Tertiary Detritals		9,000	8,000 - 11,000	13,266	12,000 - 16,250	
SAM13_D	B	Oakover Fmn.	17,300	110,000		137,773		Too few points to properly assess
SAM13_S	B	Tertiary Detritals	14030	8,000		11,776		Too few points to properly assess
SCX01_S*	C	Oakover Fmn.		37,000	30,000 - 70,000	47,253	39,000 - 88,000	
SCX03_S	C	Tertiary Detritals	770	400	350 - 900	452	375 - 1,200	May be suseptable to over-pumping
SCX04_S	C	Tertiary Detritals		1,000	800 - 3,000	1,346	1,050 - 4,500	May be suseptable to over-pumping
SCX05_D	C	Marra Mamba Fmn.		65,000	55,000 - 140,000	81,973	70,000 - 175,000	May be suseptable to over-pumping
SCX05_S	C	Tertiary Detritals		2,500	2,000 - 7,500	3,581	3,000 - 11,000	
SCX06(All)	C			1,000	750 - 50,000	1,346	1,000 - 64,000	Stepwise increase in early 2012.
SCX06_D	C	Marra Mamba Fmn.		350	200 - 165,000	378	150 - 205,000	Sudden unexplained increase in salinity in early 20
SCX06_S	C	Oakover Fmn.		1,100	1,100 - 100,000	1,495	1,500 - 125,400	Sudden unexplained increase in salinity in early 20
SPM01_D	C	Marra Mamba Fmn.	2,700	4,000	3,000 - 6,000	5,816	4,300 - 8,800	
SPM01_S	C	Tertiary Detritals	1,370	5,000	3,000 - 6,000	7,306	4,300 - 8,800	

1) Zone description: A - near-marsh; B - saline injection; C - brackish injection; D - phreatophytic vegetation
2) From 2013 GWOS
3) Outliers have been excluded from assessment of Natural Variation
4) Taken to be average of early data, excluding samples where bores may not have been fully developed following construction and prior to any observable change.

Table 8: Quality Assurance and Control Measures

QA/QC Element	Acceptable	Criteria for Acceptable QA/QC
Bore Purging	Yes	Most monitoring bores are sampled using an Airwell purge pumping system. Field parameters (pH, EC, temperature) are measured to detect when field parameters have stabilised. If field parameters are not stable, samples are collected after three bore volumes. *(It should be noted that the AS/NZS 5667,11:1998 groundwater sampling guidelines specify four to six bore volumes, however three bore volumes is commonly accepted as adequate.)*
Field Measurements	Not currently implemented	Field data may be compared to historical data whilst in the field to ensure consistency between the data sets. New data are expected to fall within 3 standard deviations compared to historical data from 2 years (or five sampling rounds). If the parameter is outside this limit then the bore is re-sampled immediately. This reduces the chance for anomalous data. The data provided in Table 7 above could be used as a guide to expected values for each monitoring bore.
Field Equipment Calibration	Yes	Calibration of the field pH and EC probes is reportedly undertaken prior to each sampling event and checked daily. Cleaning and calibration is to be undertaken following the manufacturers recommended procedures.
Sample Preservation	Yes	Samples are collected in appropriate bottles (preserved where required) as supplied by the analysing laboratory. The samples are stored on ice (~4°C) and protected from sunlight following sampling and during transit to the laboratory.
Holding Times	Yes	Samples are generally delivered to the laboratory and prepared for analysis within the required holding times. Where this is not possible it should be recorded in the data set for reference during reporting and assessment.
Chain of Custody	Yes	Water quality samples are submitted to the laboratory accompanied by a signed and dated Chain of Custody Form.
Use of a NATA Accredited Laboratory	Yes	All laboratory analyses are undertaken at the NATA-accredited ALS laboratories.
Field Duplicates and Blanks	Not currently assessed	Field duplicates are indicated as part of the QA/QC process in the 2013 groundwater sampling procedures. Review of the groundwater sampling procedures indicates that field blanks are not currently collected during sampling events; however a recommendation has been made for them to be collected in the future. Results for the field duplicate sampling during the period of review have not been assessed; recommendations have been made regarding collection, recording and assessment of QA/QC data.
Internal Laboratory Duplicates, Method Blanks, Control Samples and Matrix Spikes	Assessed by laboratory	For every laboratory analysis carried out, one in every ten samples is duplicated and one in twenty has a method blank, laboratory control and matrix spike (for metals). The laboratory QA/QC procedures are assessed and reported in the QCI documents provided with the sampling results.
Consistency with Historic Data	Not currently implemented	Laboratory analytical results are assessed in comparison to historical analytical data to ensure consistency of the data sets. New data are expected to fall within three standard deviations compared to data from the last two years (or five sampling rounds). If the analytical results fall outside this range a repeat sample from the bore is requested. It is recommended that this be implemented along with the other recommended QA/QC procedures to address the number of spurious results present in the data set.

5.1 FIELD DUPLICATES AND BLANKS

A total of 34 samples are to be collected every six months for chemical analysis at Christmas Creek Mine (GWOS, 2013a). Assuming the quality control procedures specified in the sampling and analysis programme were followed, four field duplicates would have been collected as part of the QA/QC process during each sampling event or a total of 24 samples would have been collected over the period of the triennial review.

To date, it does not appear that the results from the QA/QC sampling have been incorporated into the Fortescue data base. Rockwater was provided with over 630 emails, each with one to ten files, which have been received by Fortescue from ALS over the period of review; many of these contain QC and QCI documents from the laboratory. An attempt was made to sort these documents and to extract the QA/QC data relevant to the groundwater sampling programme for Christmas Creek over the period of review (July 2010 to August 2013), however it was found that very few of the sample identification numbers on the documents correspond to the sampling points indicated in the 2013 GWOS, and those that did had results for only one or two analytes. With each document being from one to thirty pages long and containing results for between one and 57 or more samples, it is not considered feasible to formally document and assess the results here.

Review of a random selection of the QC documents provided indicate QC samples are collected and analysed, and appear to generally meet requirements with regard to holding times. A number of anonymous samples are indicated, which are presumably field duplicates; however no cross reference has been made available to identify the sampling locations and therefore comparison and assessment the results is not possible.

Field blanks, which provide an indication of possible sample contamination in the field or during transport, do not appear to have been collected to date. Recommendations have been made for them to be collected and analysed in the future. In future, the QA/QC results from each sampling event should be input to the data base and reported with the sampling results from Christmas Creek and referred to in any assessment of the water quality results.

5.2 LABORATORY DUPLICATES, BLANKS, CONTROLS AND SPIKES

The analysing laboratory, ALS, is NATA registered and provides Interpretive Quality Control (QCI) documents for each sampling event. As part of their procedures ALS undertakes the required laboratory duplicates with relative percent difference analysis, method blanks, laboratory control spikes and matrix spikes according to the 1999 NEPM guidelines.

The QA/QC procedures are summarised below:

- Samples to be appropriately preserved and handled;
- Sample to be submitted to the laboratory within appropriate sample holding time;

- Laboratory LOR to be less than the adopted assessment criteria;
- Laboratory method blank analyses to be less than the laboratory LOR;
- Laboratory duplicate samples to be analysed;
- Matrix spike recoveries to be conducted by the laboratory;
- Laboratory control sample (LCS) analysis to be conducted; and
- Matrix, LCS and surrogate recoveries to be within the range of 70–130 %.

Review of a random selection of laboratory QCI documents indicates:

- Laboratory LOR for the Christmas Creek data are not always below the adopted groundwater assessment criteria used herein and are therefore not a good reference for use in the annual and triennial reviews: the LOR currently used for Cloudbreak should be adopted for Christmas Creek also;
- Samples were received by the laboratory in appropriate condition (chilled and intact);
- Groundwater samples were generally extracted and analysed within acceptable holding times, with some exceptions;
- Method blank sample results were less than laboratory LOR in the random selection reviewed;
- Laboratory duplicate samples were analysed.
- Laboratory control sample, surrogate and matrix spike recoveries met the DQI in the random selection reviewed.

5.3 QA/QC DATA EVALUATION

To date no data validation procedure has been clearly employed by Fortescue in the assessment of the field and laboratory QA/QC data. In future, the results for QA/QC data should be input into the water quality data base with the other sampling results and reported and assessed to show that the analytical results are representative of groundwater conditions at the sample locations and that the overall quality of the analytical data produced is acceptably reliable for the purpose of the investigation. This can be achieved for field duplicates by using a statistical assessment method such as the Relative Percentage Difference (RPD).

The RPD is a measure of the numerical difference between two values expressed in comparison to one or both values and is calculated using the procedure described in AS 4482.1:2005 (Standard Australia 2005):

$$RPD\ (\%) = \left| \frac{\left(X_{primary} - X_{duplicate}\right)}{\left(X_{primary} + X_{duplicate}\right)/2} \right| \times 100$$

Where: $X_{primary}$ is the result for the primary sample; and
$X_{duplicate}$ is the result for the duplicate sample.

Where an analytical result for one of the samples is below the laboratory limit of reporting (LOR), a value of half of the LOR is used for calculating the RPD. Where both analysis results are below the LOR no RPD is calculated. The commonly adopted RPD criteria is 50% (i.e. the percentage difference between the sample and its duplicate should be less than 50% to be considered acceptable).

The laboratory QCI reports for each sampling event should be included as appendices for reference where the water quality results are reported.

5.4 FURTHER RECOMMENDATIONS

It has been noted that there is a very large amount of data provided to Rockwater that is not related specifically to the water quality monitoring requirements as indicated in the 2013 GWOS. This additional data has made it difficult to assess the results and the QA/QC compliance. It is recommended that all sampling relating to the Christmas Creek GWOS (i.e. the six monthly sampling from the nominated monitoring bores and injection pipelines) and the results obtained therefrom, be kept separate from the Cloudbreak sampling and any other sampling that may be undertaken for other operations at the mine. Care should also be taken to collect only samples as required under the proposed monitoring programme (Tables 2 to 4).

6 CONCLUSIONS AND RECOMMENDATIONS

The geochemical data collected for regulatory review relating to the Christmas Creek Groundwater Operating Strategy has been clearly tabulated and assessed against background and marine water quality guideline data with the aid of spatial distribution plots, time series graphs and Piper diagrams, as per the scope of work provided.

Assessment of baseline data supports the conceptual hydrogeochemical model proposed by Fortescue and found the trace elements boron and strontium, and metals copper, manganese and zinc to be present at elevated concentrations at this location under natural conditions. A review of current geochemical data and historical trends suggests that mining activities to date have had minimal impact on the groundwater quality in the shallow aquifer system outside of the pit areas, near the water table. There is indication of a shift in the saline water interface at SXC06, possibly relating to hydraulic pressure increases induced by injection.

Baseline values have been assigned for metals and trace elements with measurements regularly above limits of reporting, and the natural variation assessed: outliers were excluded from the determination.

It was noted that groundwater parameters such as total dissolved solids and pH can be variable, particularly in the near-marsh and brackish injection zones, and that the data set contains a number of spurious data points, likely to be in error. A review of Fortescue's proposed sampling procedures and QA/QC protocols has identified several areas whereby data collection and compilation can be improved. The following recommendations are made:

- Sampling relating to Christmas Creek's GWOS should be undertaken in isolation from other sampling requirements, with samples collected only from the bores nominated in the proposed monitoring programme and analysed only for the parameters indicated therein.
- Field parameters should be assessed against historical data at the time of sampling to ensure consistency in the data set. Where the field values differ significantly from historical values the cause should be assessed, and re-sampling undertaken as necessary.
- Consistency between sampling events may be assisted by ensuring each bore is purged using the same method, flow-rate and pumping duration prior to collection of the samples. These should be recorded in the sampling procedures for ease of reference.
- Samples should be submitted to the laboratory as a single batch, or a sub-set thereof, with a chain of custody (CoC) form associated with those samples only.
- Quality control samples, field duplicates and field blanks, should be collected as required and submitted at the same time and be included on the same CoC form as the samples to which they apply.
- Water quality results relating to the GWOS and associated QA/QA samples should be maintained in an independent data base (or as a sub-set of the main data base) for ease of collation and reference.
- The laboratory is NATA registered, and can confidently be assumed to be using appropriate analytical techniques. Where sampling results come back outside of the historical range, validation of the result should be sought. Limits of reporting (LOR's) should be specified as per those currently used for Cloudbreak.
- Groundwater level data collected at the time of sampling should be kept with the associated water quality data to facilitate assessment of the results in any geochemical review.

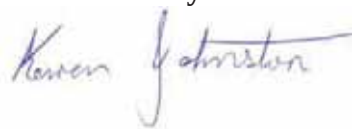
The data have been assessed in relation to the monitoring zones proposed in the GWOS: Zone A (near-marsh area); Zone B (saline injection area); Zone C (brackish injection area); and Zone D (phreatophytic vegetation area), and the aquifer (shallow or deep) in which the bores are completed.

The monitoring programme for Christmas Creek incorporates a greater number of bores in the deep aquifer than that for Cloudbreak, and with time the impact of injection on the receiving aquifer should be adequately addressed. A bore location map showing the position of the

monitoring bores relative to the production and injection bores would assist in the assessment of any impacts observed and should be incorporated into future monitoring reviews.

Dated: 11 June 2014

Rockwater Pty Ltd



Karen Johnston
Principal Hydrogeochemist

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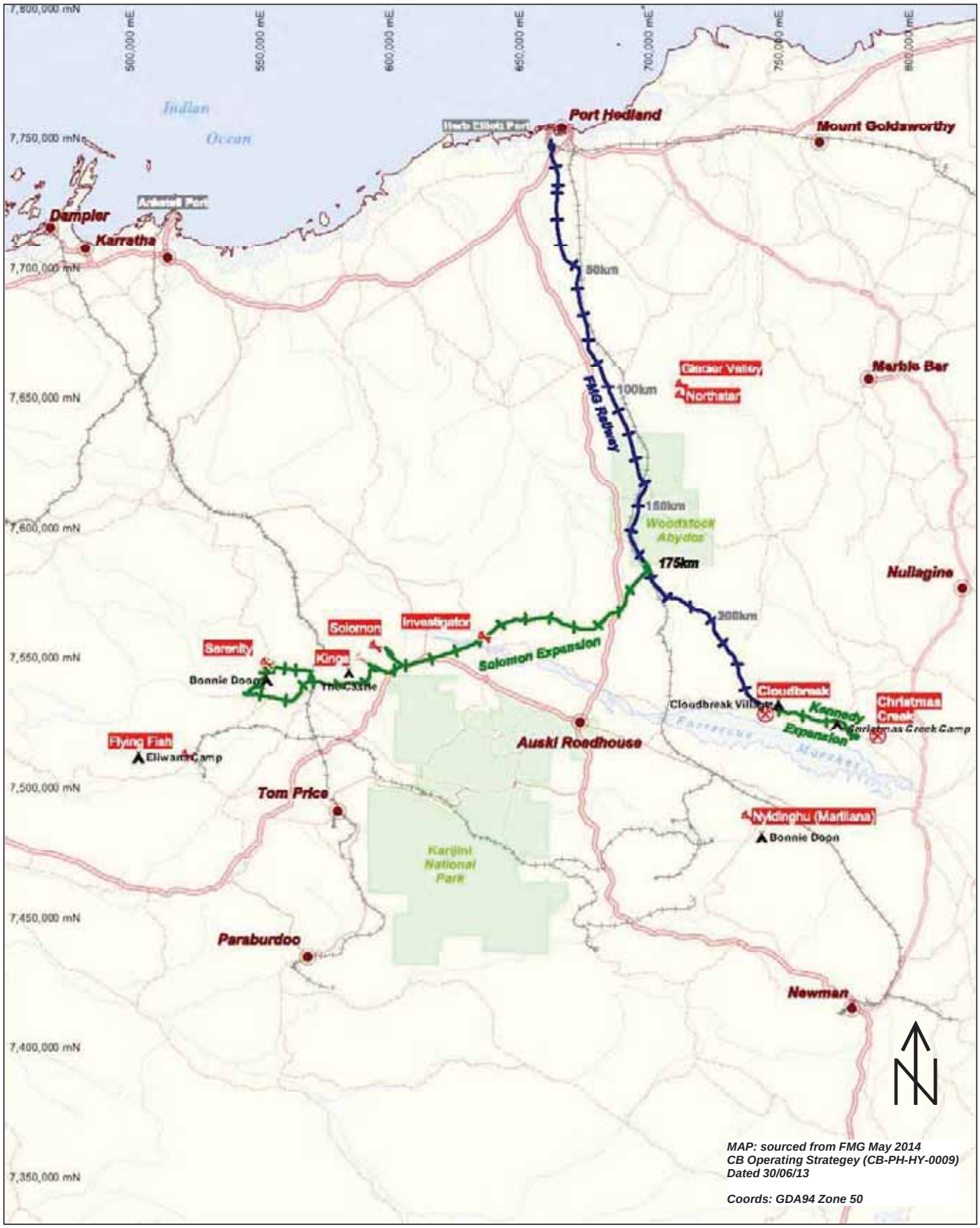
FIGURES

Figure 1



I/436-0/Surfer/CC 14-02/Figure 01 locality.srf

CLIENT:	Fortescue Metals Group
PROJECT:	Christmas Creek Mine Geochemical Assesment
DATE:	June 2014
Dwg. No:	Client No.436-0/14/02-1

REGIONAL MAP

Rockwater

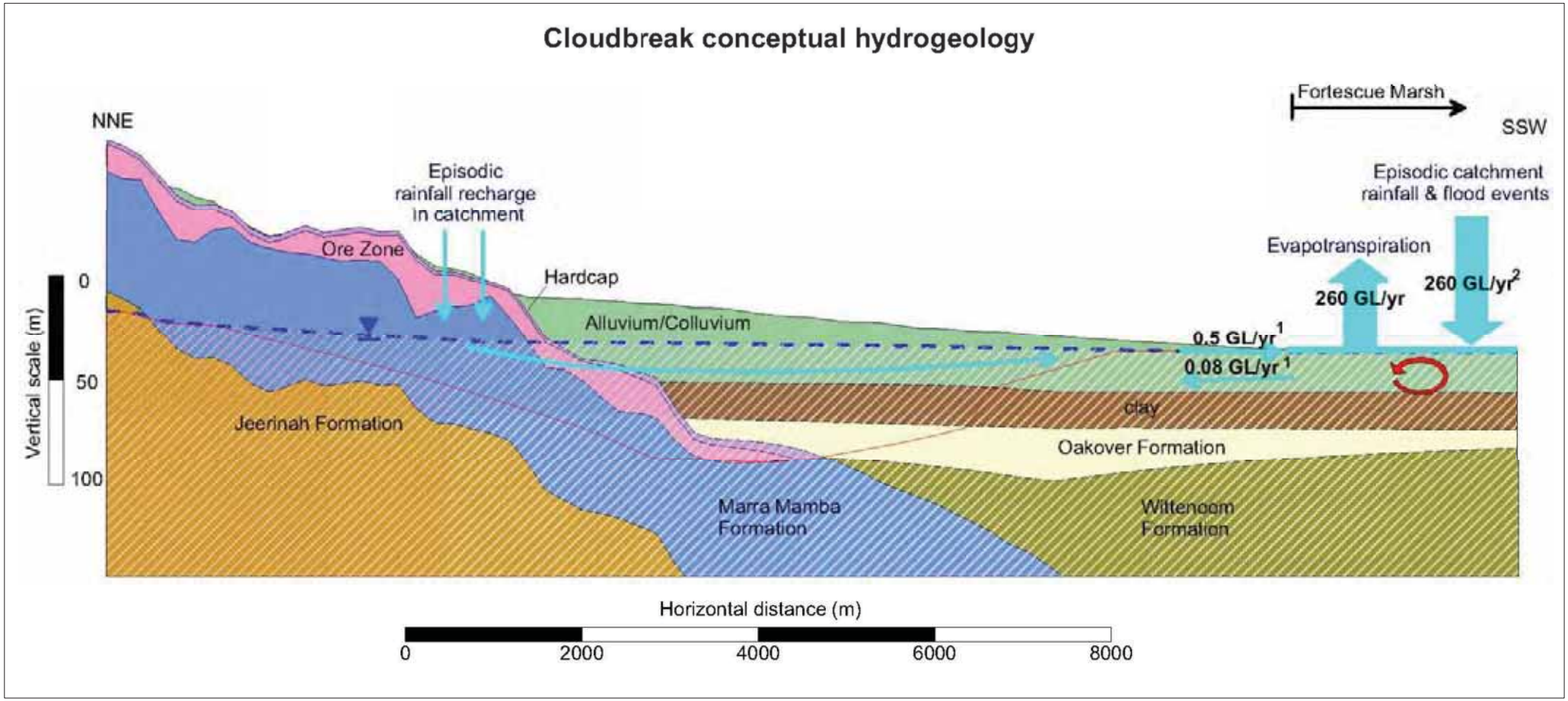
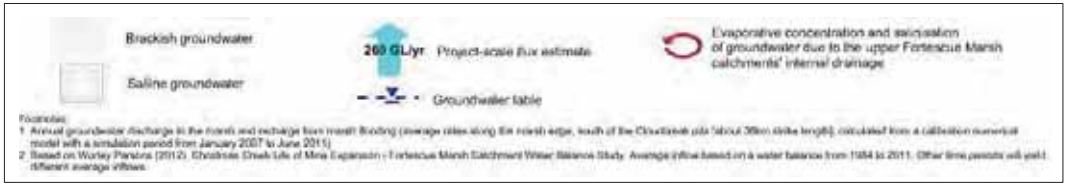


DIAGRAM: sourced from FMG May 2014
CB Operating Strategey (CB-PH-HY-0009)
Dated 30/06/13



I/436-0/Surfer/CC 14-02/Figure 02 hydro section.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

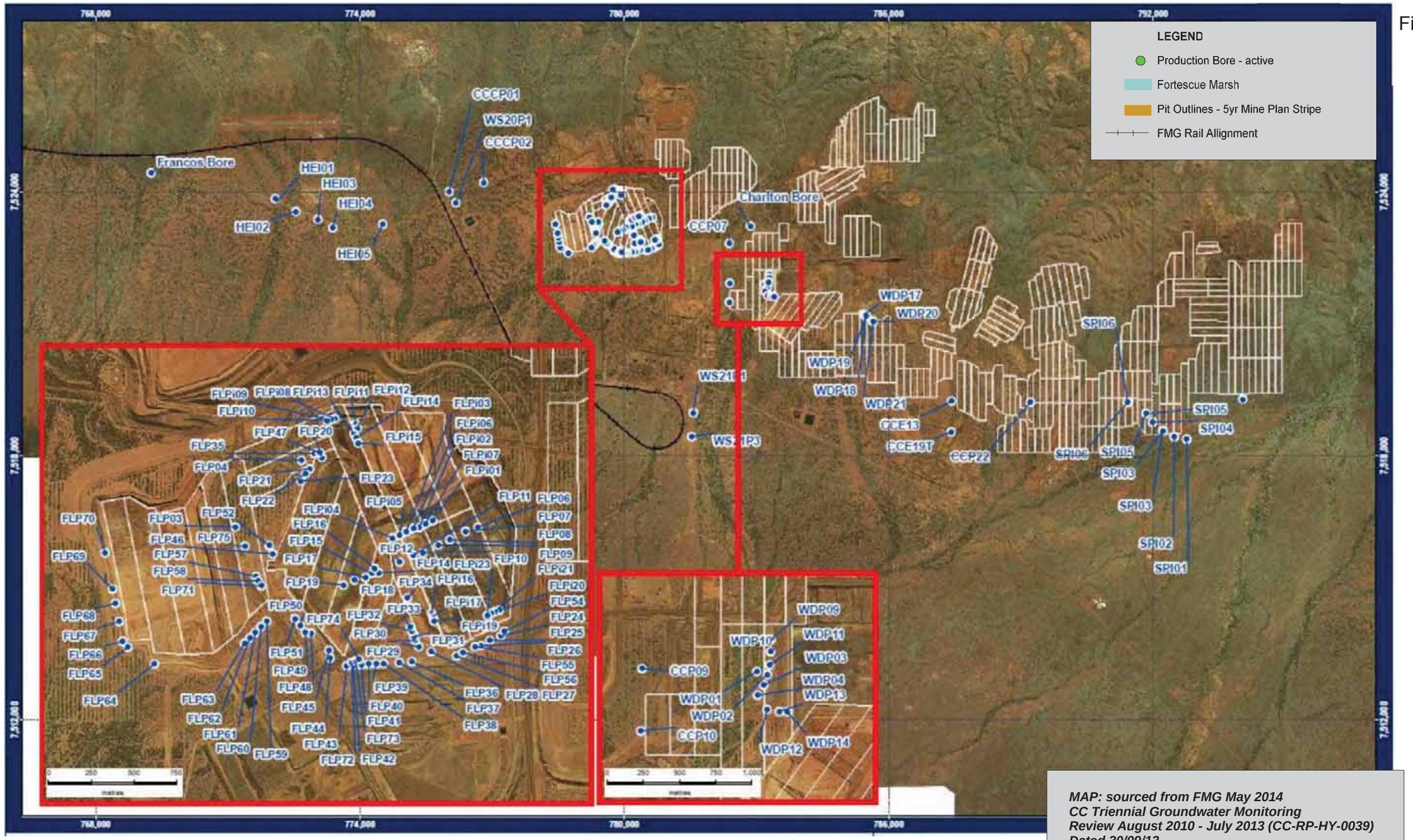
DATE: June 2014

Dwg. No: Client No.436-0/14/02-2

HYDOGEOLOGICAL CROSS SECTION

Rockwater

Figure 3



MAP: sourced from FMG May 2014
CC Triennial Groundwater Monitoring
Review August 2010 - July 2013 (CC-RP-HY-0039)
Dated 30/09/13

GDA94 Zone 50

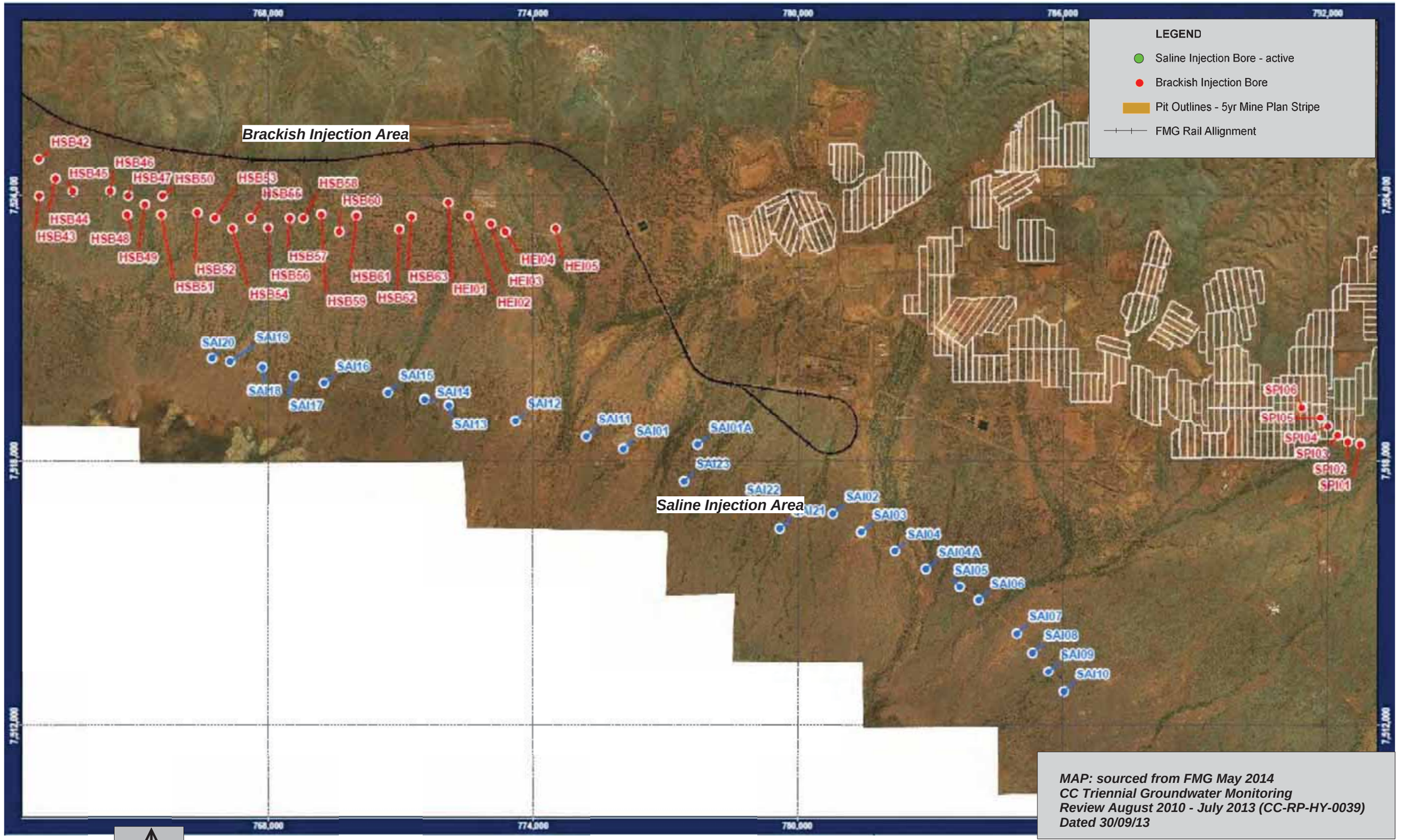
I/436-0/Surfer/CB 14-0/Figure 03 production bore locations.srf

CLIENT:	Fortescue Metals Group
PROJECT:	Christmas Creek Mine Geochemical Assesment
DATE:	June 2014
Dwg. No:	Client No.436-0/14/02-3

Rockwater PROPRIETARY LIMITED

PRODUCTION BORE LOCATIONS

Figure 4



MAP: sourced from FMG May 2014
CC Triennial Groundwater Monitoring
Review August 2010 - July 2013 (CC-RP-HY-0039)
Dated 30/09/13

GDA94 Zone 50

I/436-0/Surfer/CC 14-02/Figure 04 injection bore locations.srf

CLIENT:	Fortescue Metals Group
PROJECT:	Christmas Creek Mine Geochemical Assesment
DATE:	June 2014
Dwg. No:	Client No.436-0/14/02-4

Rockwater PROPRIETARY LIMITED

INJECTION BORE LOCATIONS

Figure 5

Cloudbreak ⟷ Christmas Creek

HSMB07
HSMB06
CBX05
HSMB05
SRM41
SRM40
SRM21
SRM45
SRM43
SRM07
SRM22
SRM06
SRM19
SRM08R
CBX07
SRM20
SRM26
SRM56
SRM59
CBFMM06
CBX10a
SRM25
CBX11
SRM63
SRM27
SRM60
SRM48
SRM64
SRM28
SCX08
CBX13
HSMB24
HSMB27
HEMB01
HEMB02
HEMB04
HEMB05
HSMB25
SCX03_S
SCX04_S
HSMB29_S
HSMB29_D
HSMB26
HSMB28
SCX05_D
SCX01_S
SCX05_S
SRM29
SRM14
SCX06_D
CCFMM01_S
SCX06_S
CCFMM01_D
CCE02MB
CCFMM02_S
CCFMM02_D
SAM13_S
SAM13_D
CCF07B
SAM12
SAM07_S
SAM07_D
CCF01B_S
CCFMM03_S
CCFMM03_D
CCE10MB
SAM02_S
SAM02_D
CCFMM04_S
CCFMM04_D
CCF03B_S
SPM06
SPM05
SPM03
SPM01_S
SPM01_D
SPM08
SPM09
SPM07
SPM10
CCFMM05_S

LEGEND

- Trigger Zone A
- Trigger Zone B
- Trigger Zone C
- Trigger Zone D
- Fortescue Marsh
- Pit Outlines
- Monitoring Bore
- Monitoring Bore - included in GLOS
- CCF_ 'Shallow' aquifer represents monitoring intervals intersecting Tertiary Detritals & Tertiary Alluvials.
- CCF_ 'Deep' aquifer represents monitoring intervals intersection the Marra Mamba & Oakover Fmn.s

7540000
7535000
7530000
7525000
7520000
7515000
7510000
7505000
7500000

740000 745000 750000 755000 760000 765000 770000 775000 780000 785000 790000 795000 800000 805000 810000

I/436-0/Surfer/CB 14-0/Figure 05 monitoring bore locations.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

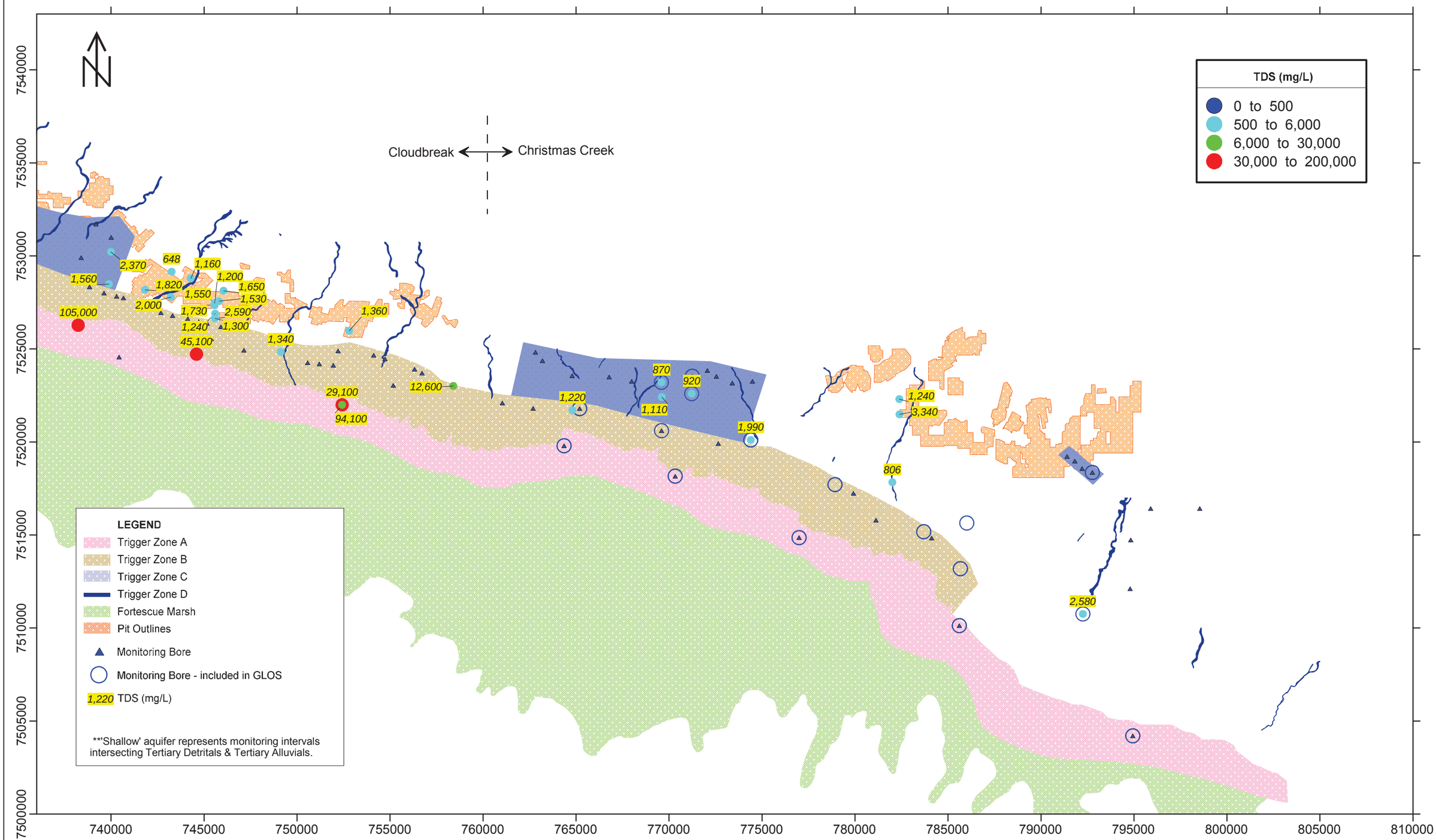
Dwg. No: Client No.436-0/14/02-5

Rockwater PROPRIETARY LIMITED

Scale (m)
0 5000 10000 15000 20000
GDA94 Zone 50

MONITORING BORE LOCATIONS

Figure 6



I/436-0/Surfer/CC 14-02/Figure 06 shallow baseline.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

Dwg. No: Client No.436-0/14/02-6

Rockwater PROPRIETARY LIMITED

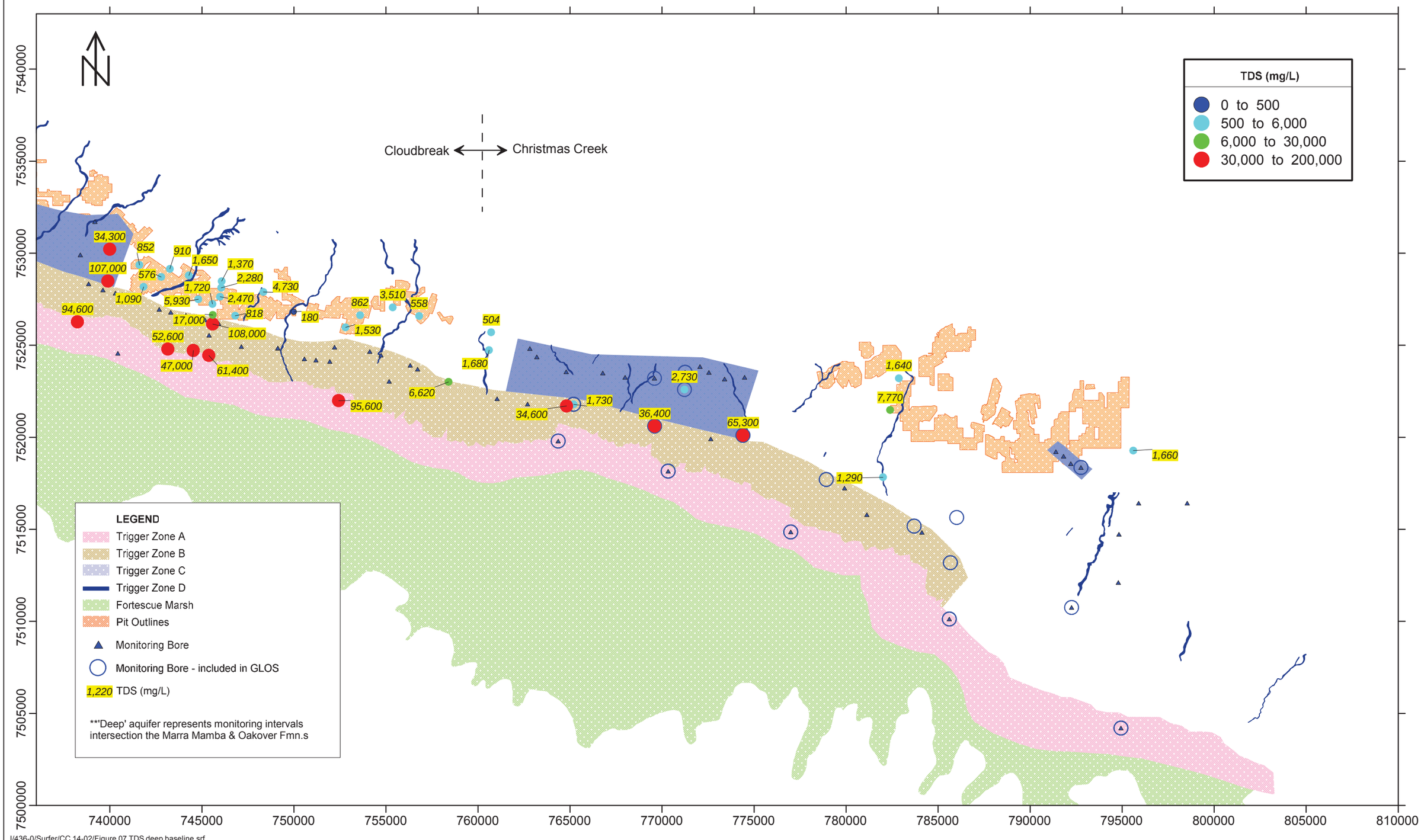
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

TOTAL DISSOLVED SOLIDS BASELINE DATA (2008) SHALLOW AQUIFER**

Figure 7



I/436-0/Surfer/CC 14-02/Figure 07 TDS deep baseline.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

Dwg. No: Client No.436-0/14/02-7

Rockwater PROPRIETARY LIMITED

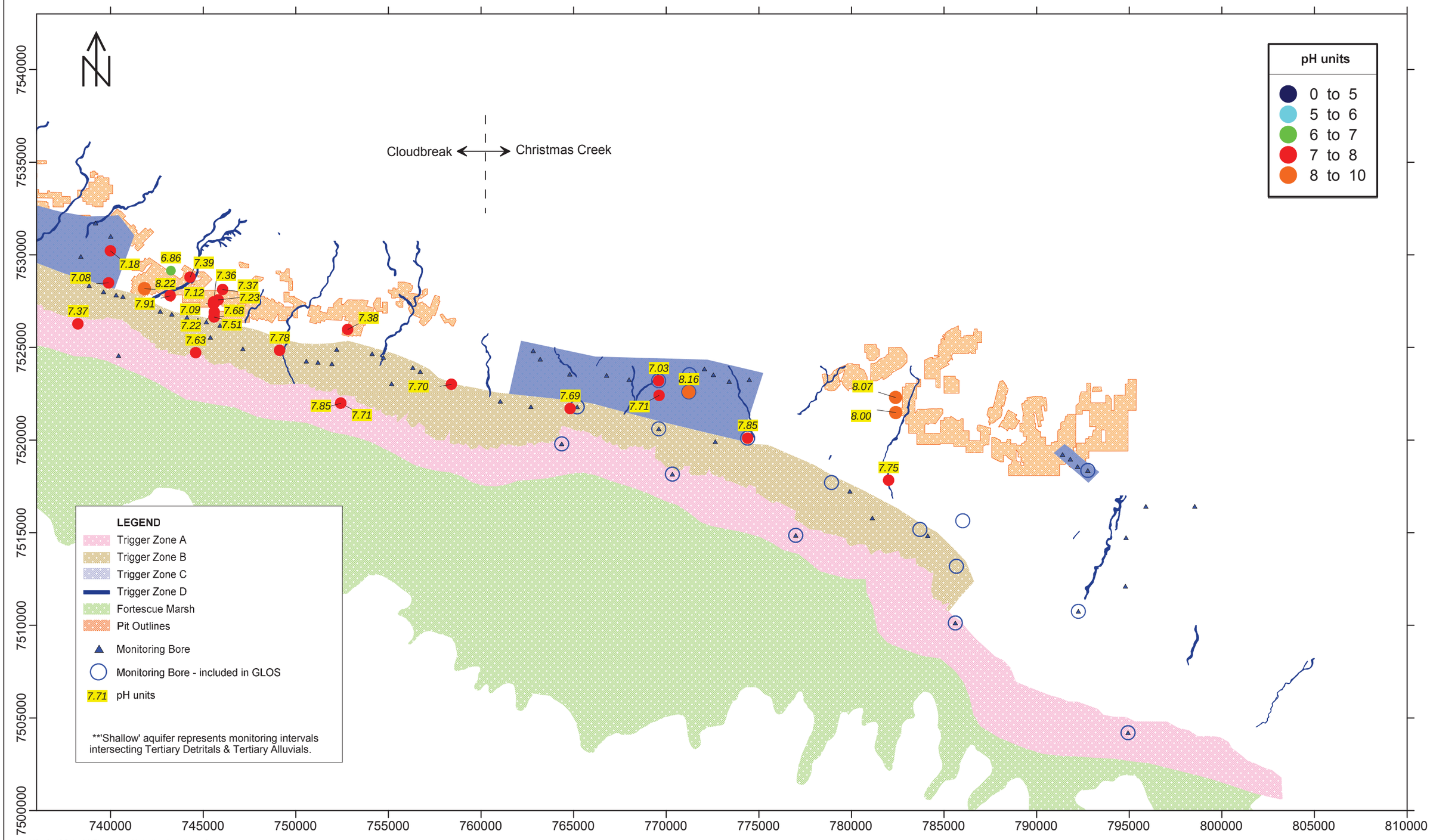
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

TOTAL DISSOLVED SOLIDS BASELINE DATA (2008) DEEP AQUIFER**

Figure 8



I/436-0/Surfer/CC 14-02/Figure 08 pH shallow baseline.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

Dwg. No: Client No.436-0/14/02-8

Rockwater PROPRIETARY LIMITED

Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

pH
BASELINE DATA (2008/2009)
SHALLOW AQUIFER**

Figure 9

Cloudbreak ↔ Christmas Creek

pH units

- 0 to 5
- 5 to 6
- 6 to 7
- 7 to 8
- 8 to 10

LEGEND

- Trigger Zone A
- Trigger Zone B
- Trigger Zone C
- Trigger Zone D
- Fortescue Marsh
- Pit Outlines
- Monitoring Bore
- Monitoring Bore - included in GLOS
- 7.71 pH units

**'Deep' aquifer represents monitoring intervals intersection the Marra Mamba & Oakover Fmn.s

7.05, 7.33, 7.75, 7.48, 6.78, 7.69, 7.34, 7.28, 7.81, 7.33, 6.92, 7.16, 7.38, 7.42, 7.26, 7.76, 7.23, 7.42, 7.22, 7.67, 7.80, 7.55, 7.88, 7.91, 7.62, 7.65, 7.47, 7.34, 8.05, 7.90, 8.06

7540000, 7535000, 7530000, 7525000, 7520000, 7515000, 7510000, 7505000, 7500000

740000, 745000, 750000, 755000, 760000, 765000, 770000, 775000, 780000, 785000, 790000, 795000, 800000, 805000, 810000

I/436-0/Surfer/CC 14-02/Figure 09 pH deep baseline.srf

CLIENT:	Fortescue Metals Group
PROJECT:	Christmas Creek Mine Geochemical Assesment
DATE:	June 2014
Dwg. No:	Client No.436-0/14/02-9

Rockwater PROPRIETARY LIMITED

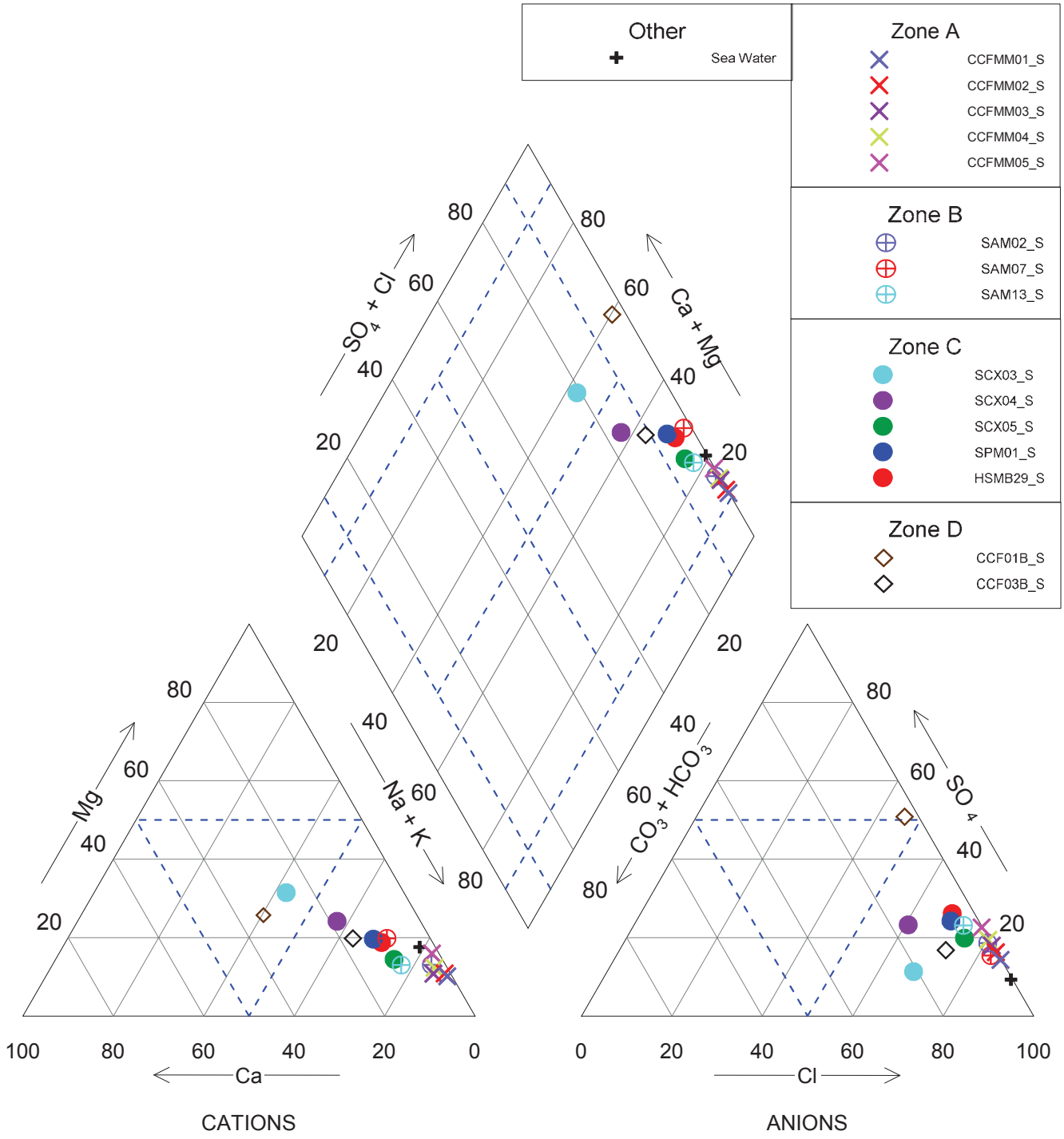
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

pH
BASELINE DATA (2008/2009)
DEEP AQUIFER**

Figure 10



I/436-0/Grapher/CC 14-02/Figure 10 - Shallow aquifer - PIPER.grf

Client: Fortescue Metals Group

Project : Christmas Creek Geochemical Assessment

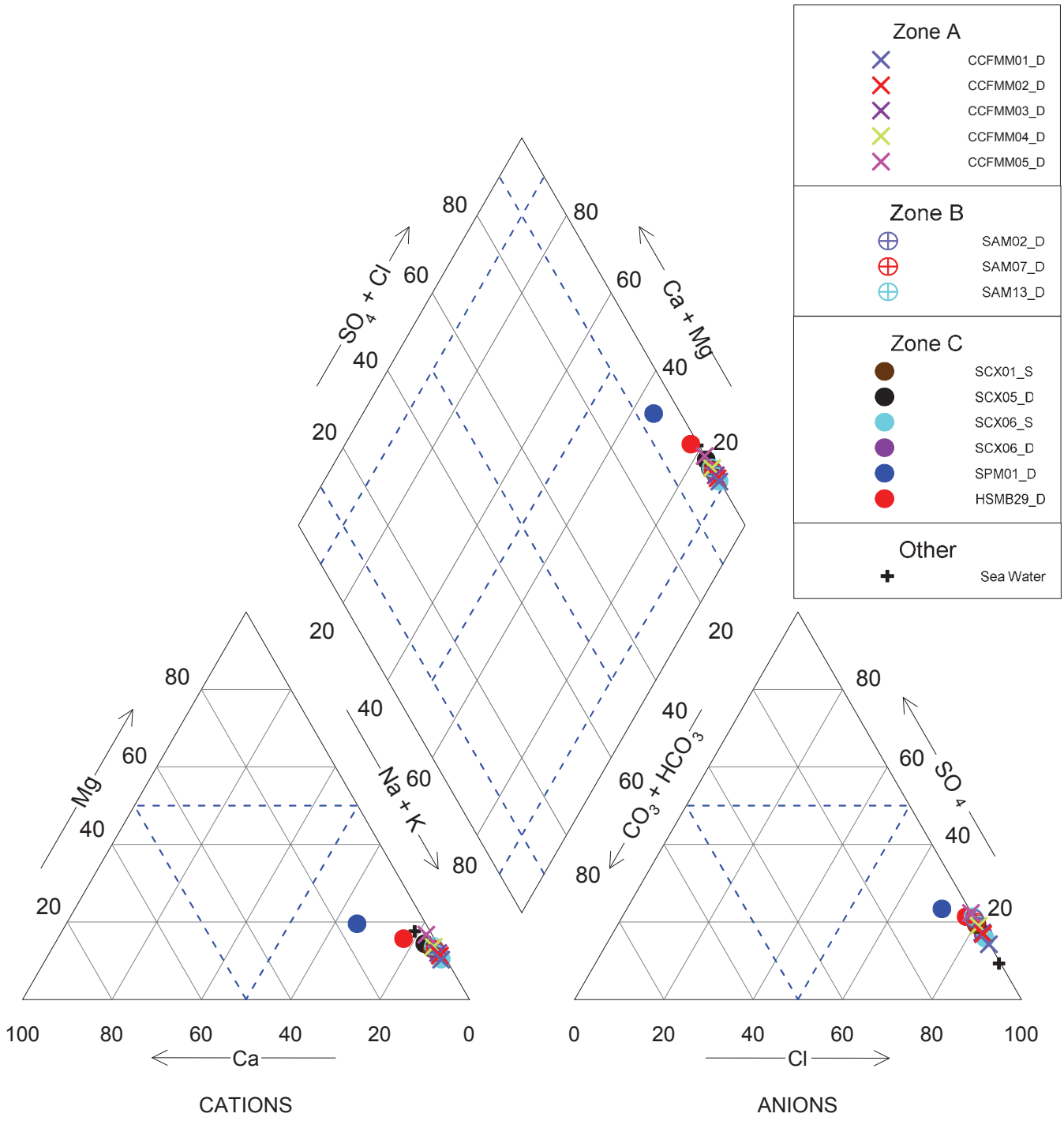
Date : June 2014

Dwg. No: 436-0/14/2-10

PIPER DIAGRAM
SHALLOW AQUIFER

Rockwater PROPRIETARY LIMITED

Figure 11



I/436-0/Grapher/CC 14-02/Figure 11 - Deep aquifer - PIPER.grf

Client: Fortescue Metals Group

Project : Christmas Creek Geochemical Assessment

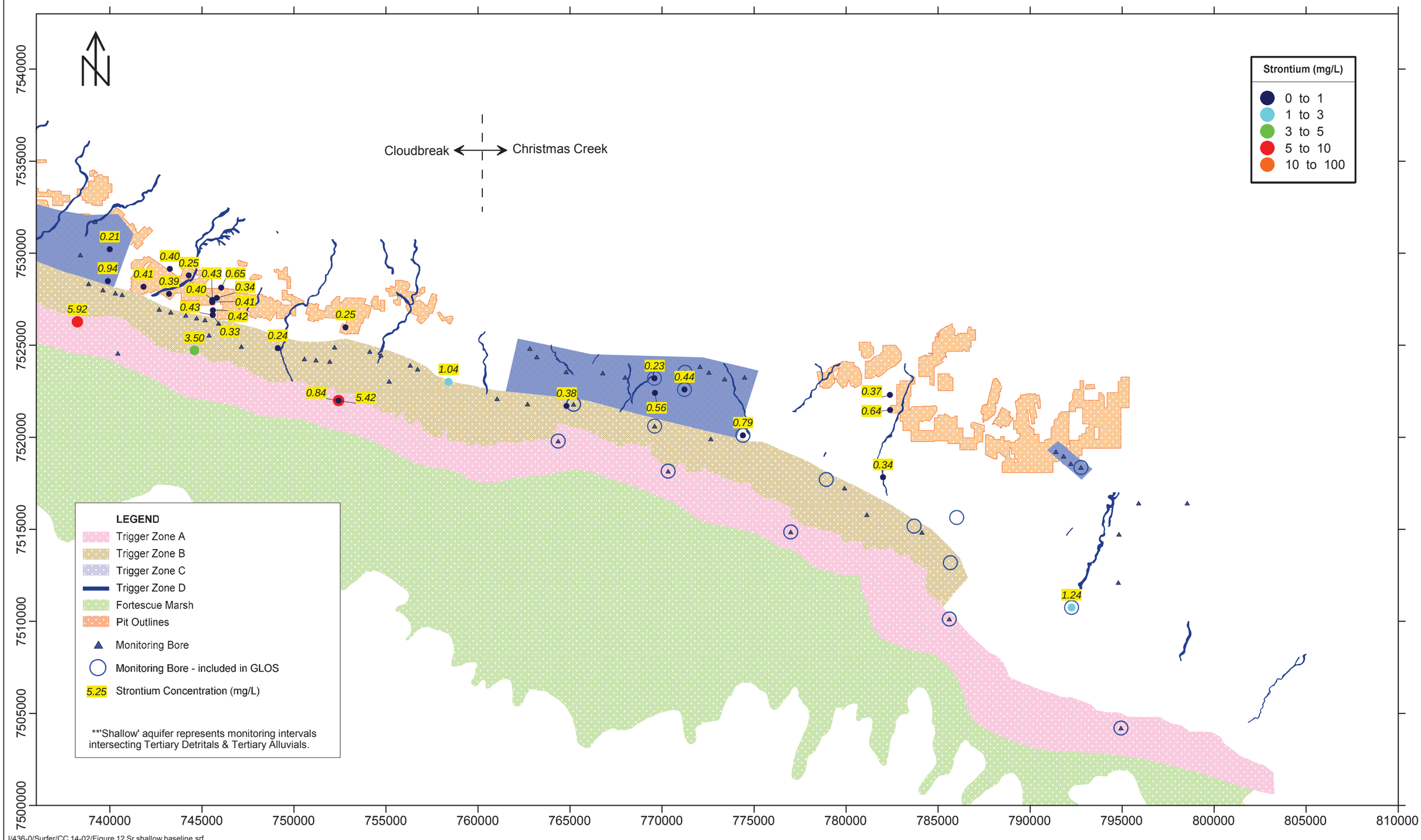
Date : June 2014

Dwg. No: 436-0/14/2-11

PIPER DIAGRAM
DEEP AQUIFER

Rockwater
PROPRIETARY LIMITED

Figure 12



I/436-0/Surfer/CC 14-02/Figure 12 Sr shallow baseline.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

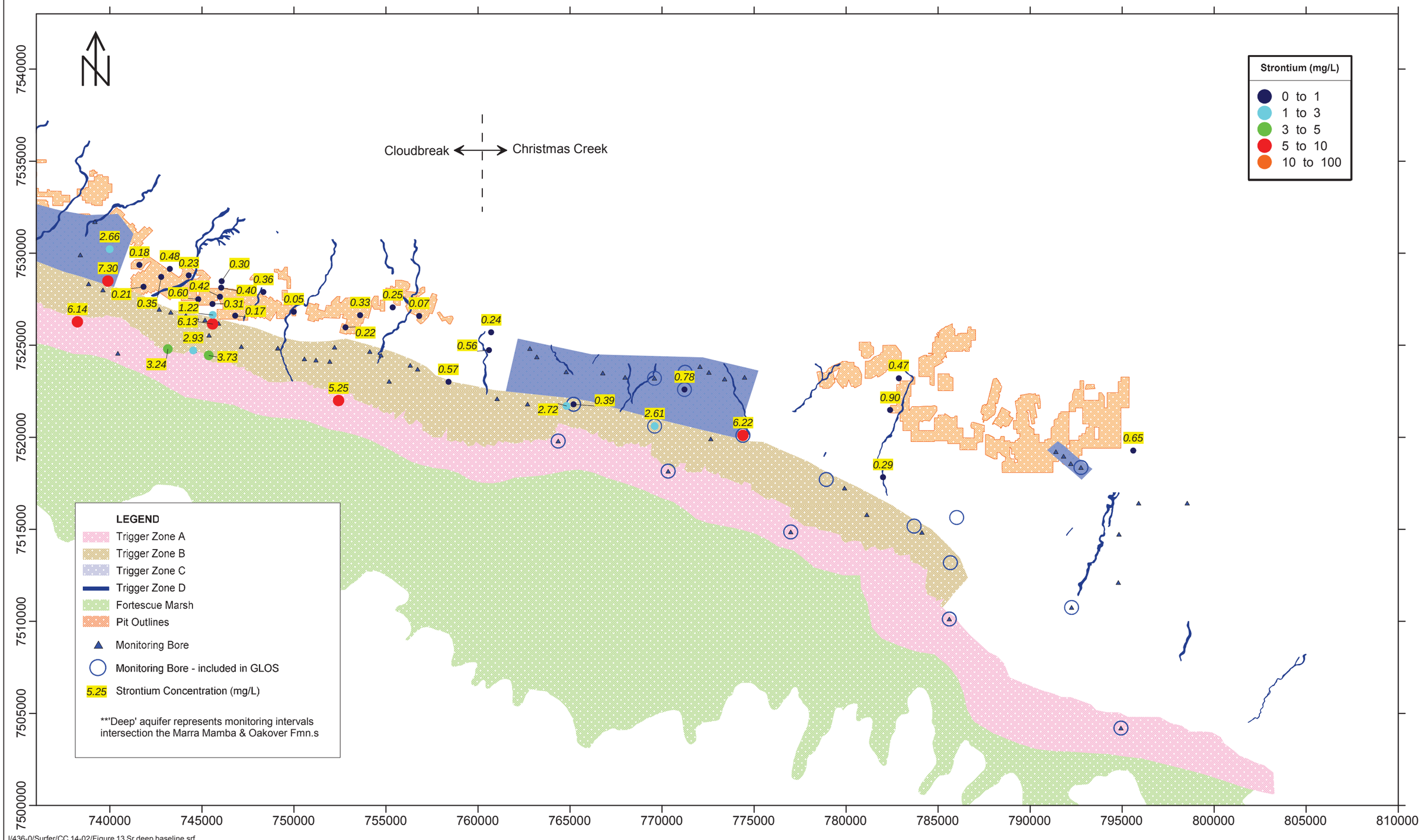
Dwg. No: Client No.436-0/14/02-12

Rockwater PROPRIETARY LIMITED

Scale (m)
0 5000 10000 15000 20000
GDA94 Zone 50

STRONTIUM
BASELINE DATA (2008/2009)
SHALLOW AQUIFER**

Figure 13



I/436-0/Surfer/CC 14-02/Figure 13 Sr deep baseline.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

Dwg. No: Client No.436-0/14/02-13

Rockwater PROPRIETARY LIMITED

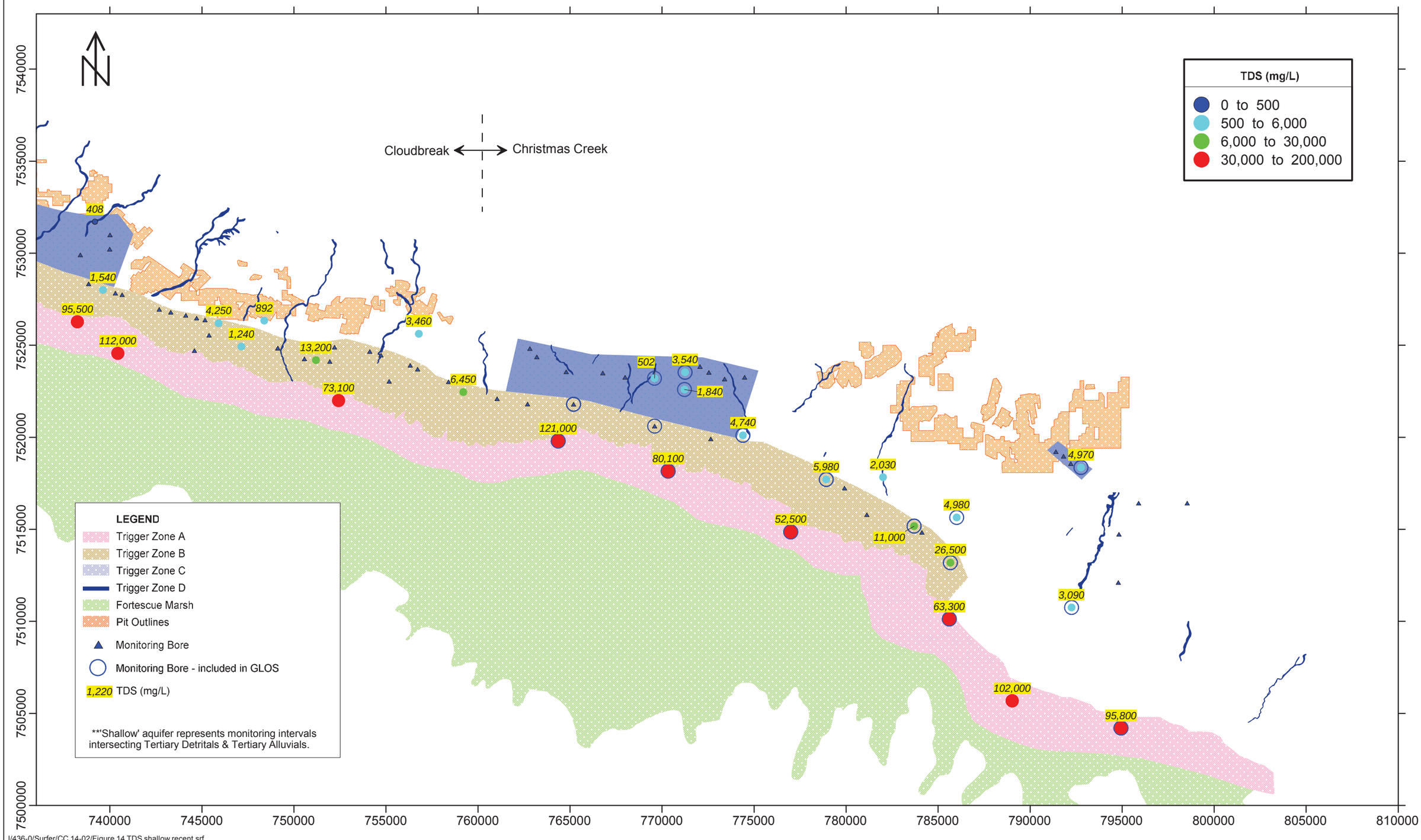
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

STRONTIUM
BASELINE DATA (2008/2009)
DEEP AQUIFER**

Figure 14



I/436-0/Surfer/CC 14-02/Figure 14 TDS shallow recent.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

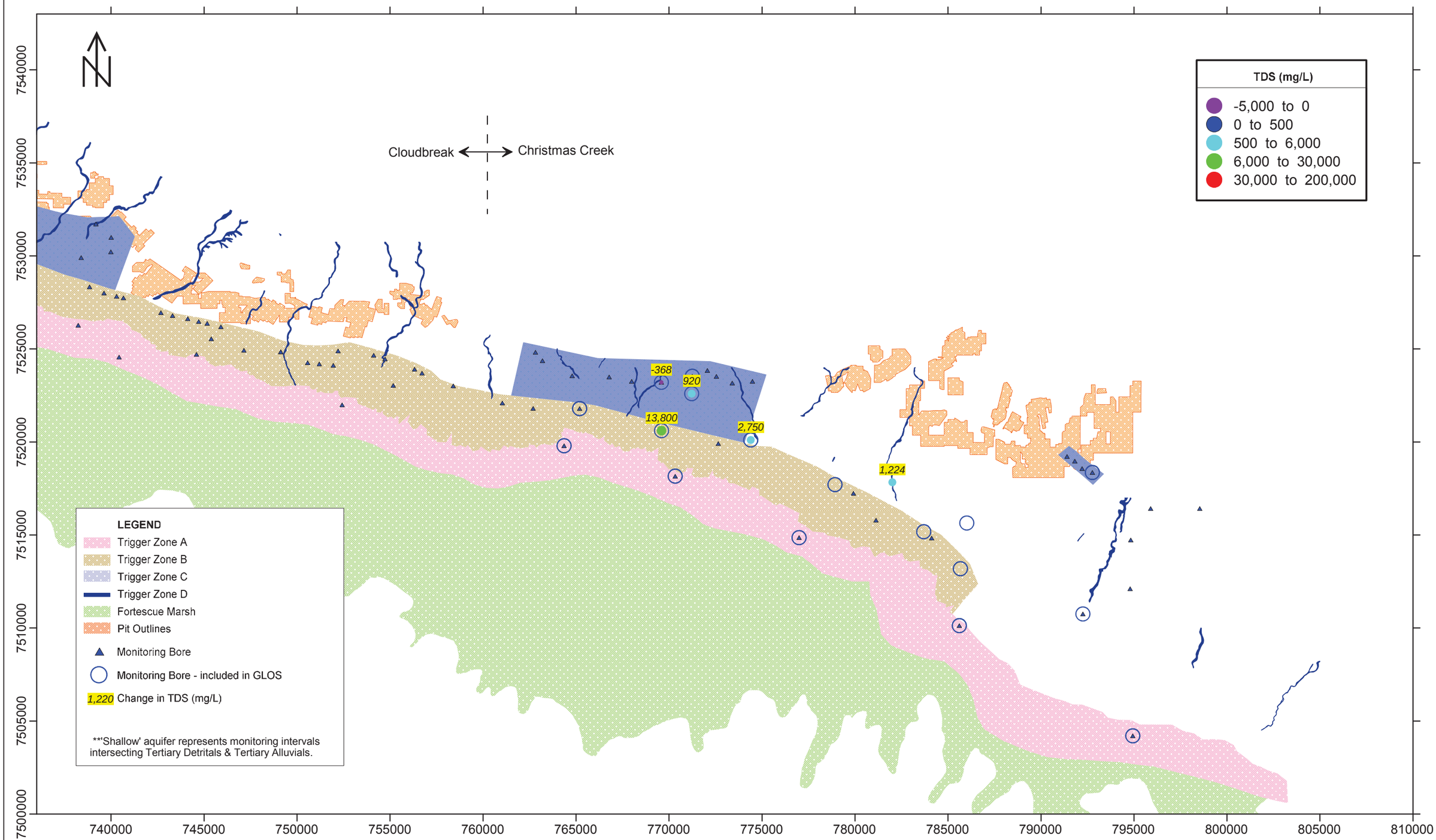
Dwg. No: Client No.436-0/14/02-14

Rockwater PROPRIETARY LIMITED

Scale (m)
0 5000 10000 15000 20000
GDA94 Zone 50

TOTAL DISSOLVED SOLIDS RECENT DATA (2013/2014) SHALLOW AQUIFER**

Figure 15



I/436-0/Surfer/CC 14-02/Figure 15 TDS shallow change.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2015

Dwg. No: Client No.436-0/14/02-14

Rockwater PROPRIETARY LIMITED

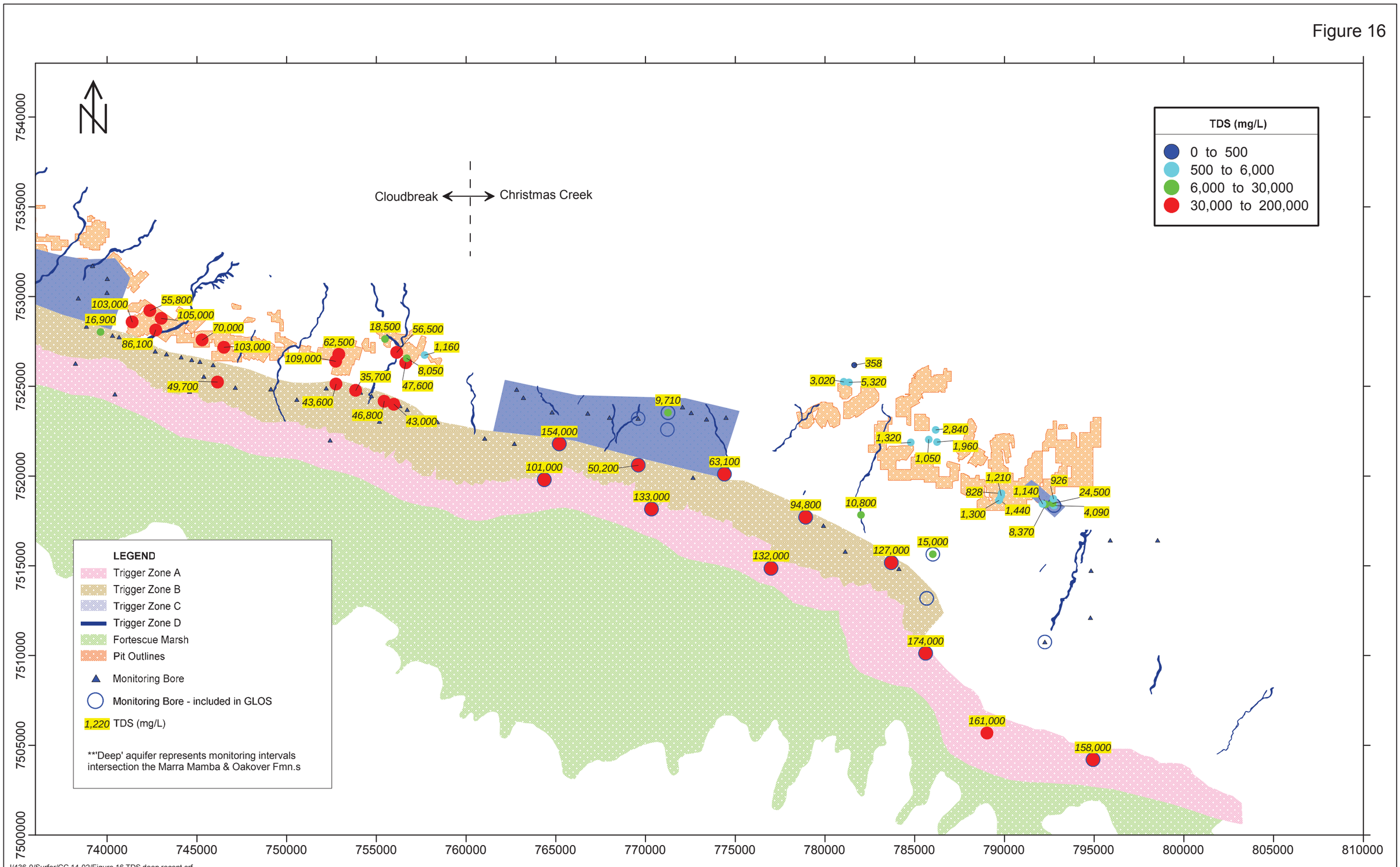
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

TOTAL DISSOLVED SOLIDS CHANGE FROM BASELINE DATA SHALLOW AQUIFER**

Figure 16



I/436-0/Surfer/CC 14-02/Figure 16 TDS deep recent.srf

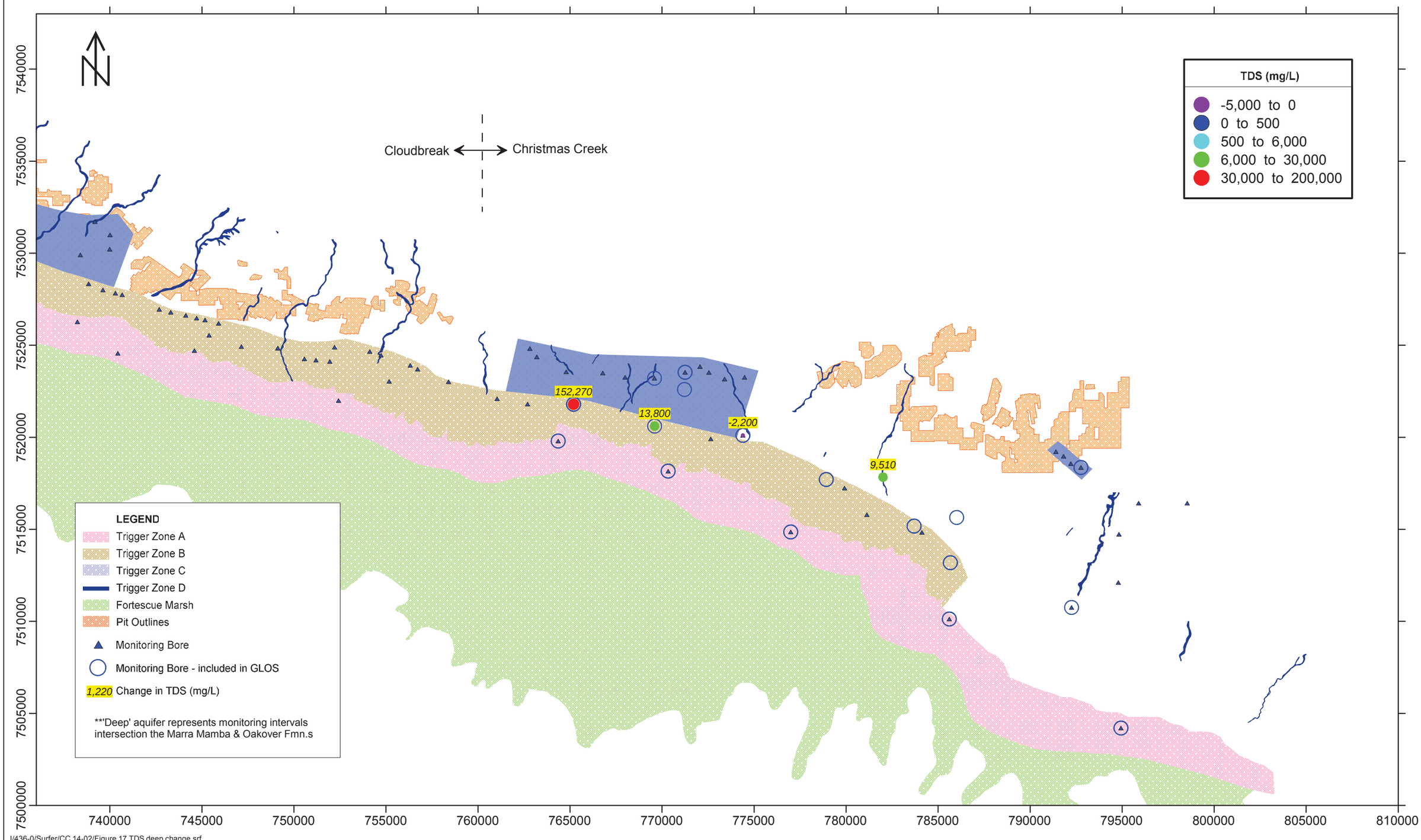
CLIENT:	Fortescue Metals Group
PROJECT:	Christmas Creek Mine Geochemical Assesment
DATE:	June 2014
Dwg. No:	Client No.436-0/14/02-16

Rockwater PROPRIETARY LIMITED

Scale (m)
0 5000 10000 15000 20000
GDA94 Zone 50

TOTAL DISSOLVED SOLIDS RECENT DATA (2013/2014) DEEP AQUIFER**

Figure 17



I/436-0/Surfer/CC 14-02/Figure 17 TDS deep change.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2015

Dwg. No: Client No.436-0/14/02-17

Rockwater PROPRIETARY LIMITED

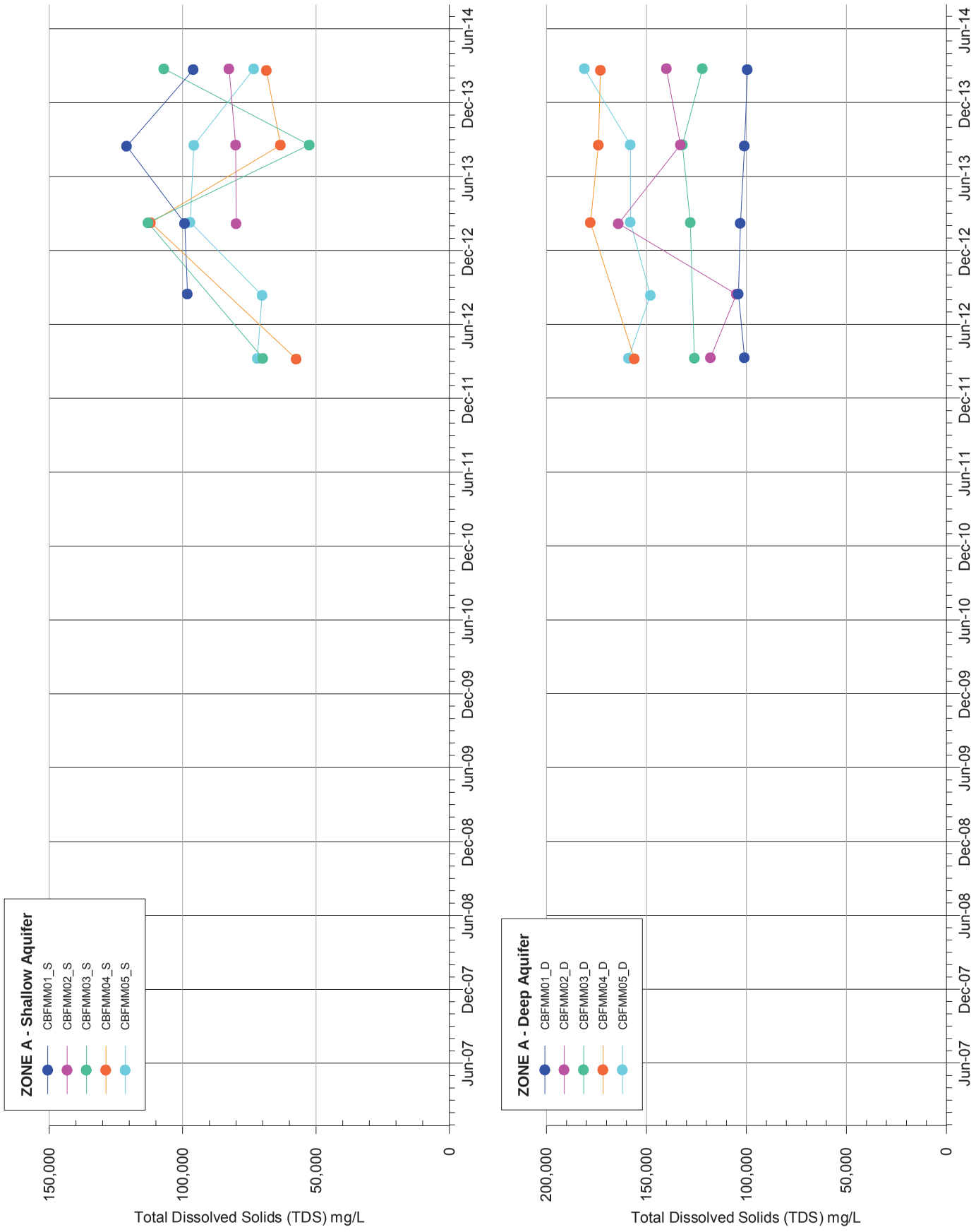
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

TOTAL DISSOLVED SOLIDS CHANGE FROM BASELINE DATA DEEP AQUIFER**

Figure 18



I:\\436-0\Grapher\CC 14-02\Figure 18 Salinity 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

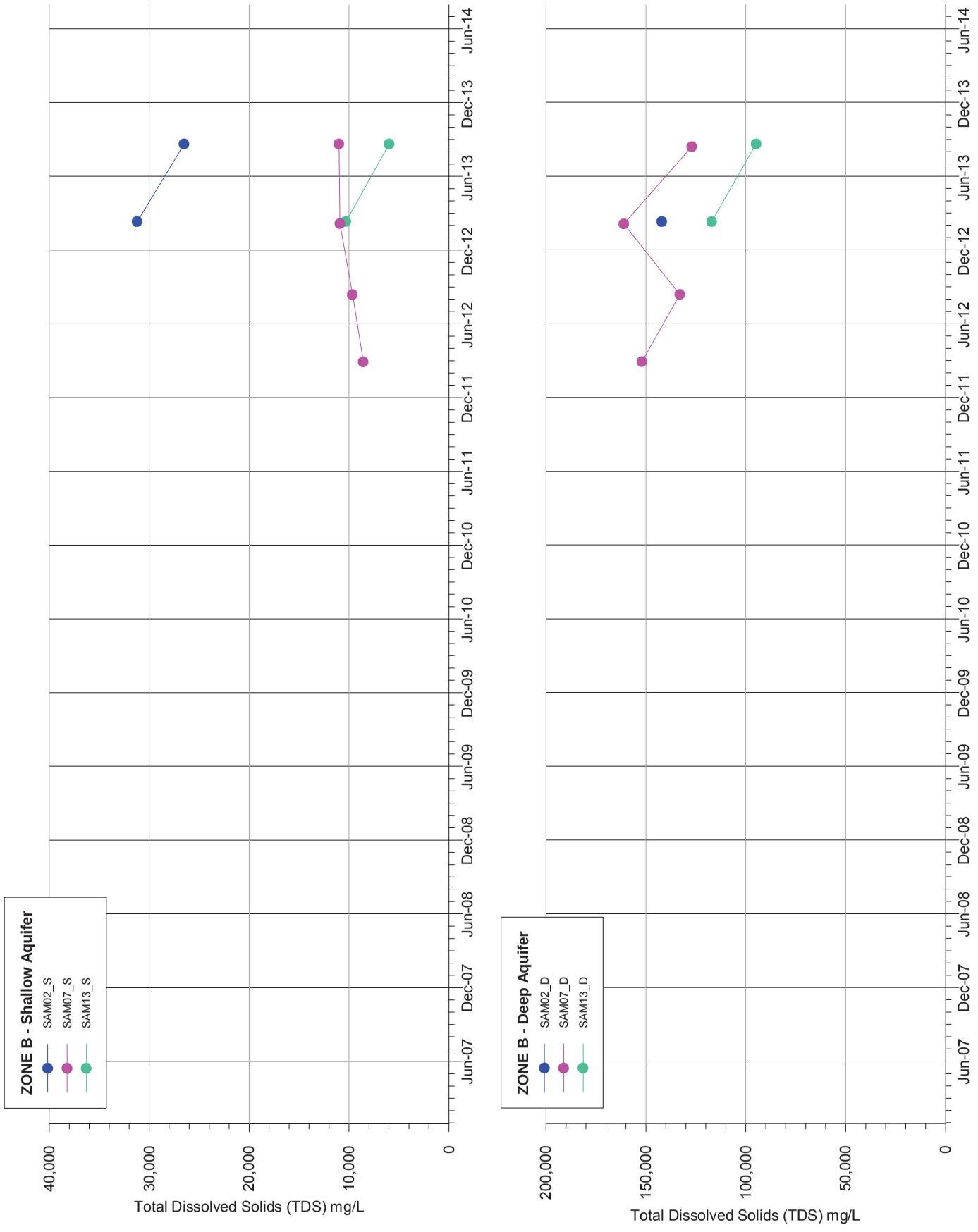
Dwg. No: 436-0/14/2-18

2013 GWOS MONITORING BORES

SALINITY IN SHALLOW & DEEP AQUIFER

Zones A : Near Marsh Region

Figure 19



I:\\436-0\Grapher\CC 14-02\Figure 19 Salinity 2007-13 Zn B.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

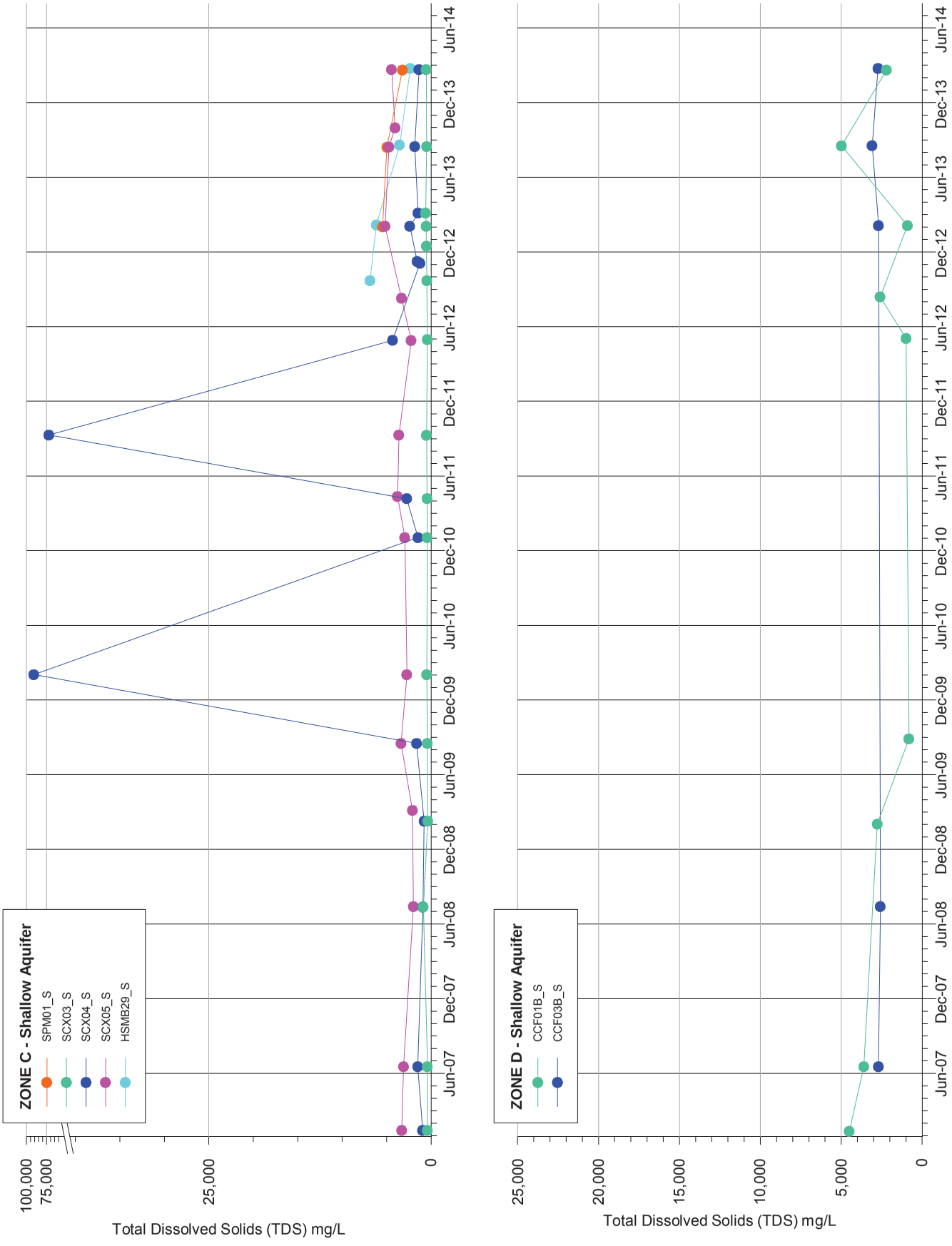
Dwg. No: 436-0/14/2-19

2013 GWOS MONITORING BORES

SALINITY IN SHALLOW & DEEP AQUIFER

Zone B : Saline Injection Region

Figure 20



I:\\436-0\Grapher\CB 14-01\Figure 20 Salinity 2007-13 Zn C,D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

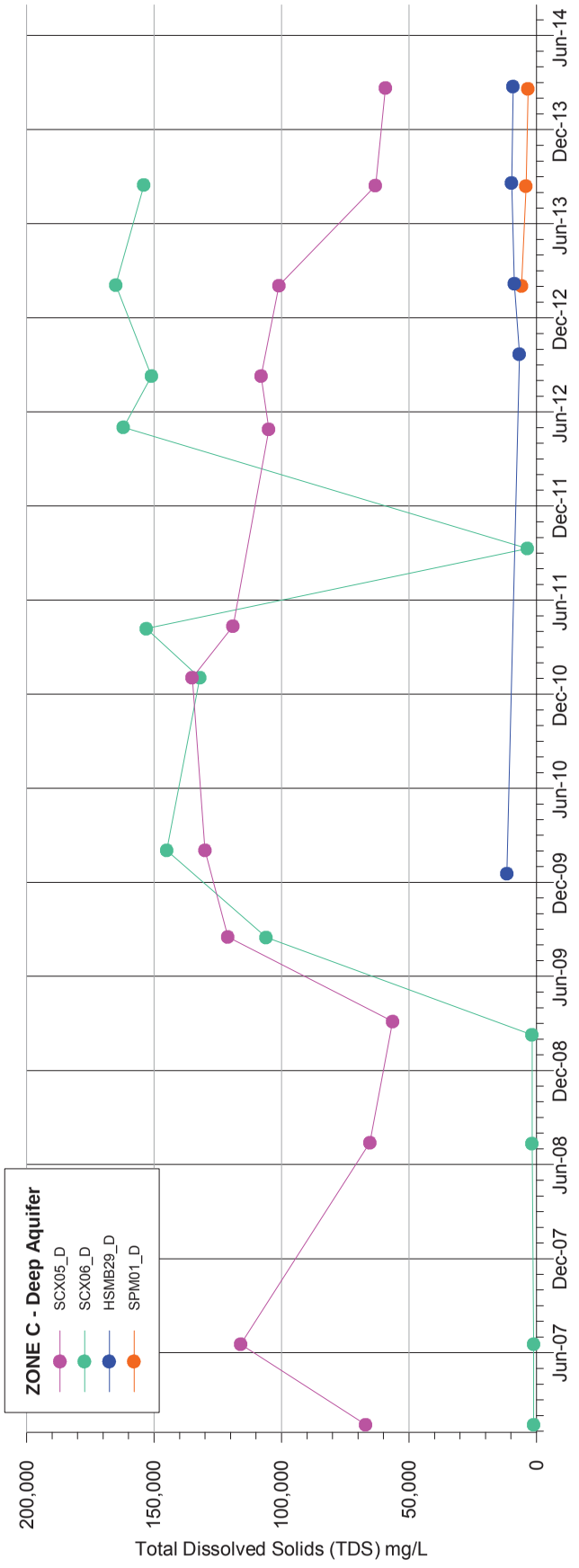
Dwg. No: 436-0/14/2-20

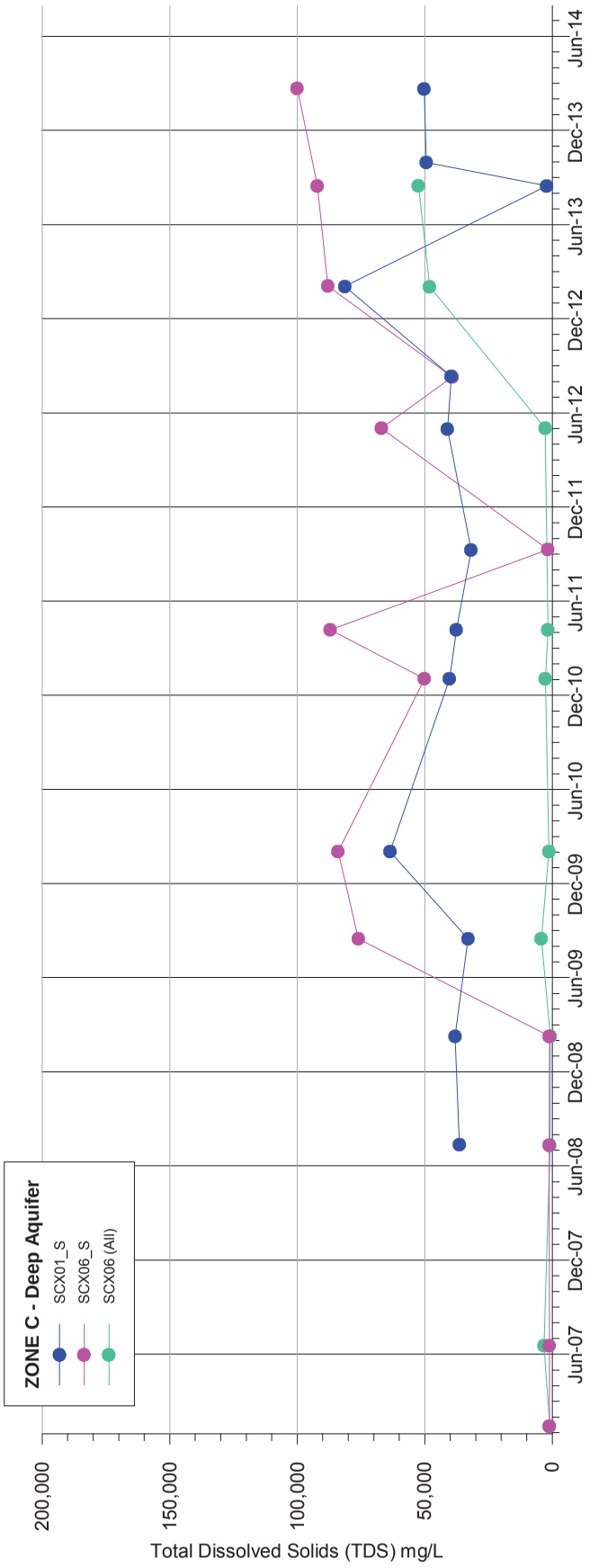
2013 GWOS MONITORING BORES

SALINITY IN SHALLOW AQUIFER

Zone C & D : Brackish Injection Region

Figure 21





I:\\436-0\Grapher\CC 14-02\Figure 21 Salinity 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

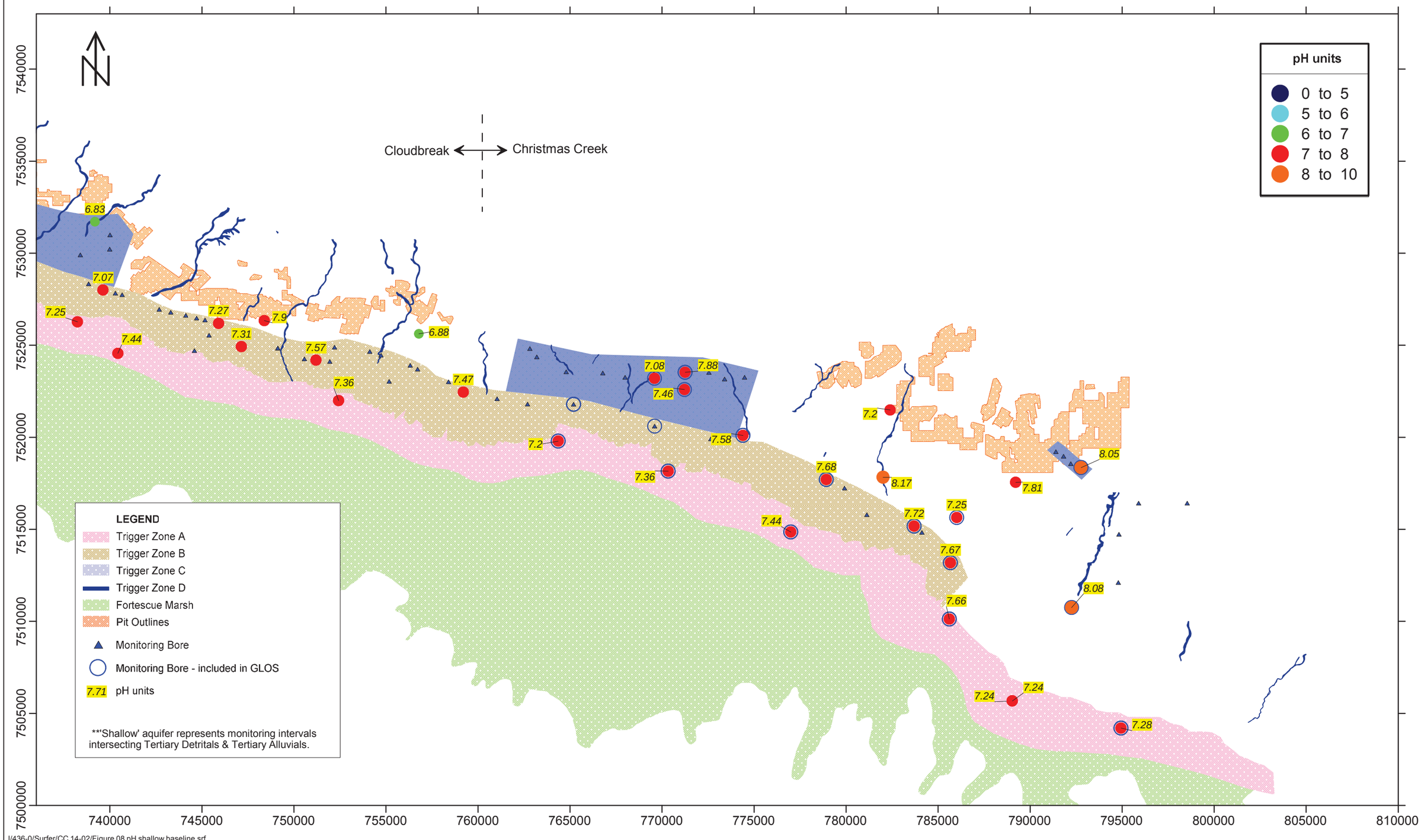
Dwg. No: 436-0/14/2-21

2013 GWOS MONITORING BORES

SALINITY IN DEEP AQUIFER

Zone C : Brackish Injection Region

Figure 22



I/436-0/Surfer/CC 14-02/Figure 08 pH shallow baseline.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

Dwg. No: Client No.436-0/14/02-22

Rockwater PROPRIETARY LIMITED

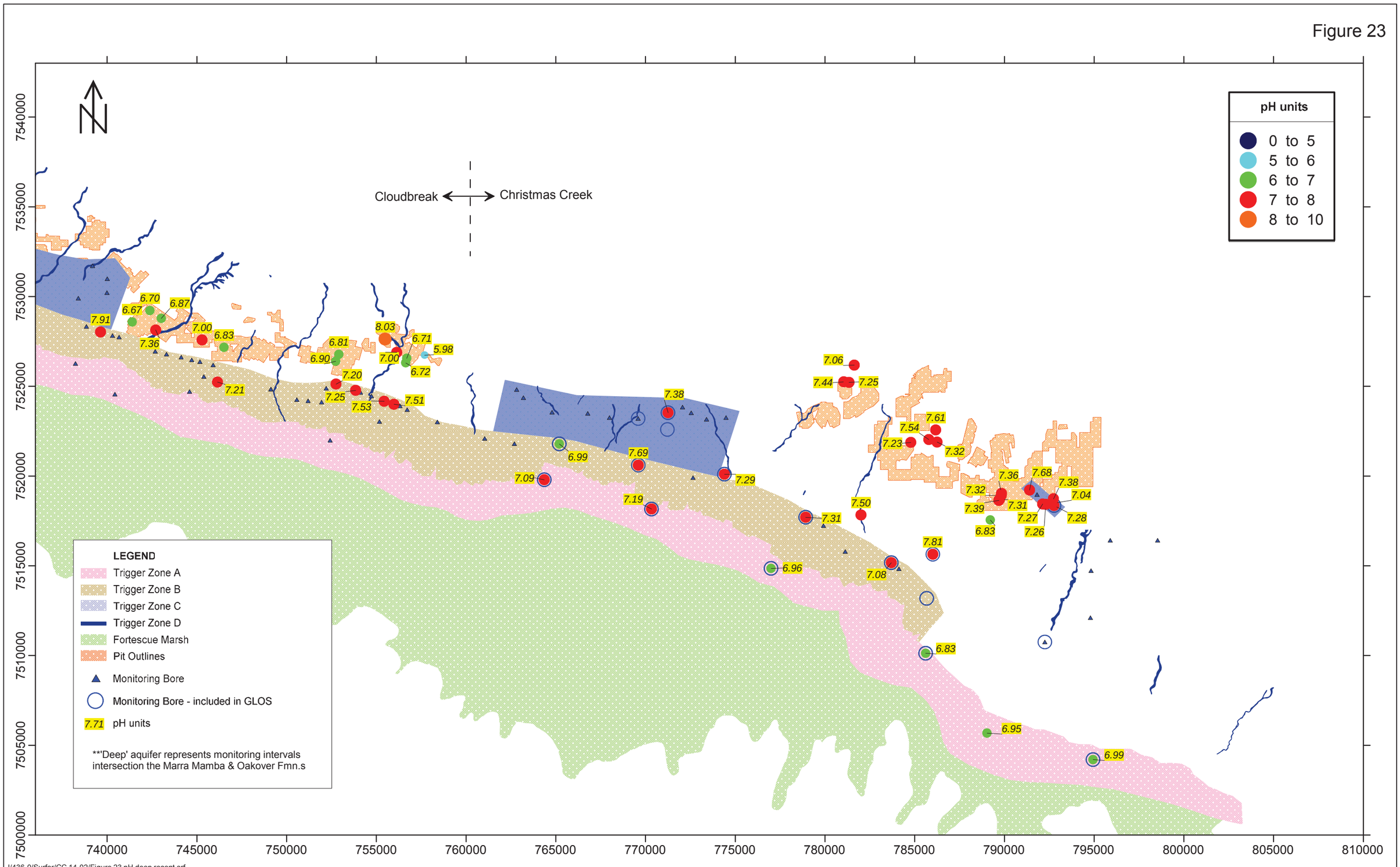
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

pH
RECENT DATA (2013/2014)
SHALLOW AQUIFER**

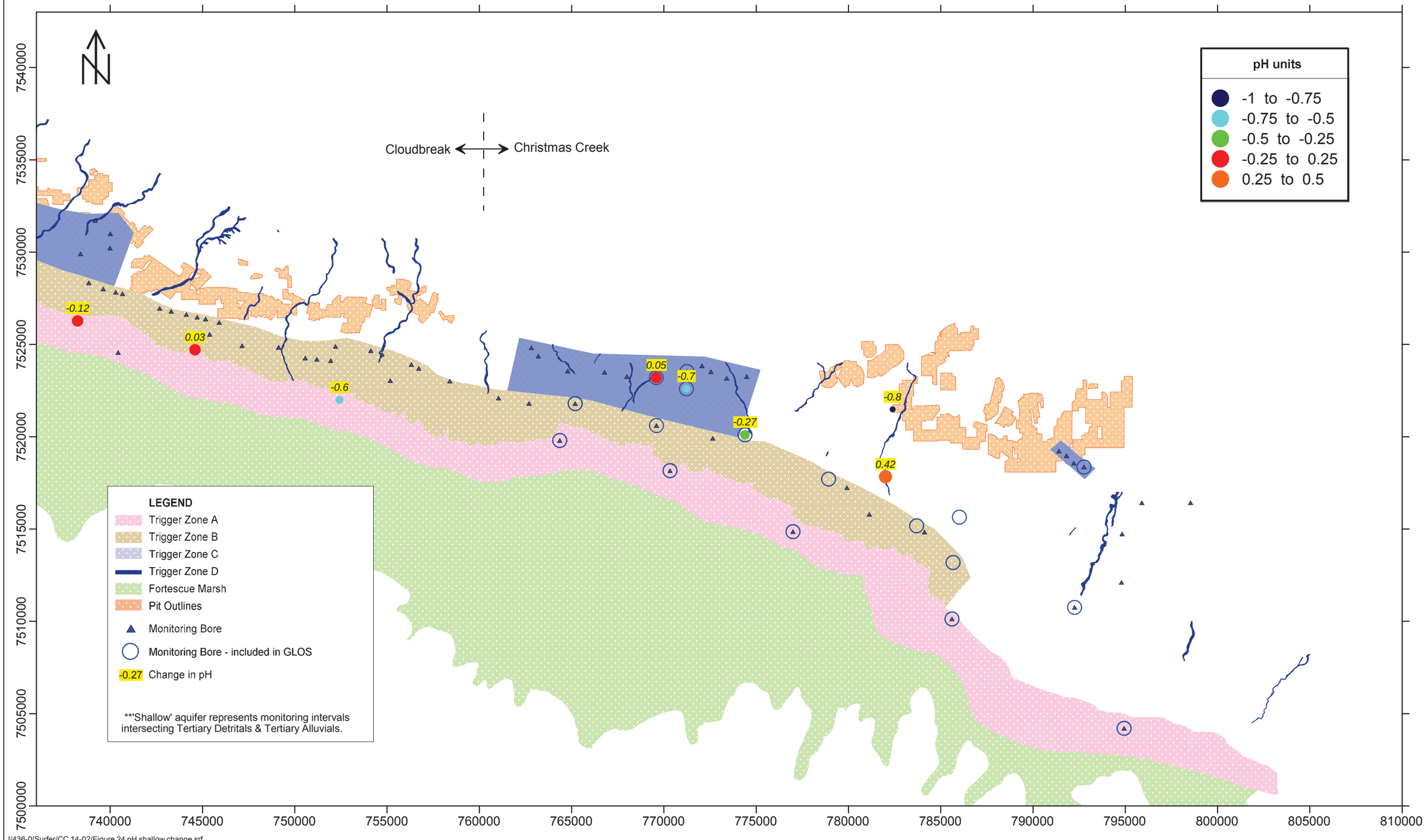
Figure 23



I/436-0/Surfer/CC 14-02/Figure 23 pH deep recent.srf

CLIENT: Fortescue Metals Group PROJECT: Christmas Creek Mine Geochemical Assesment DATE: June 2014 Dwg. No: Client No.436-0/14/02-23	Rockwater PROPRIETARY LIMITED	Scale (m) 0 5000 10000 15000 20000 GDA94 Zone 50	**pH** **RECENT DATA (2013/2014)** **DEEP AQUIFER****

Figure 24



I/436-0/Surfer/CC 14-02/Figure 24 pH shallow change.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

Dwg. No: Client No.436-0/14/02-24

Rockwater PROPRIETARY LIMITED

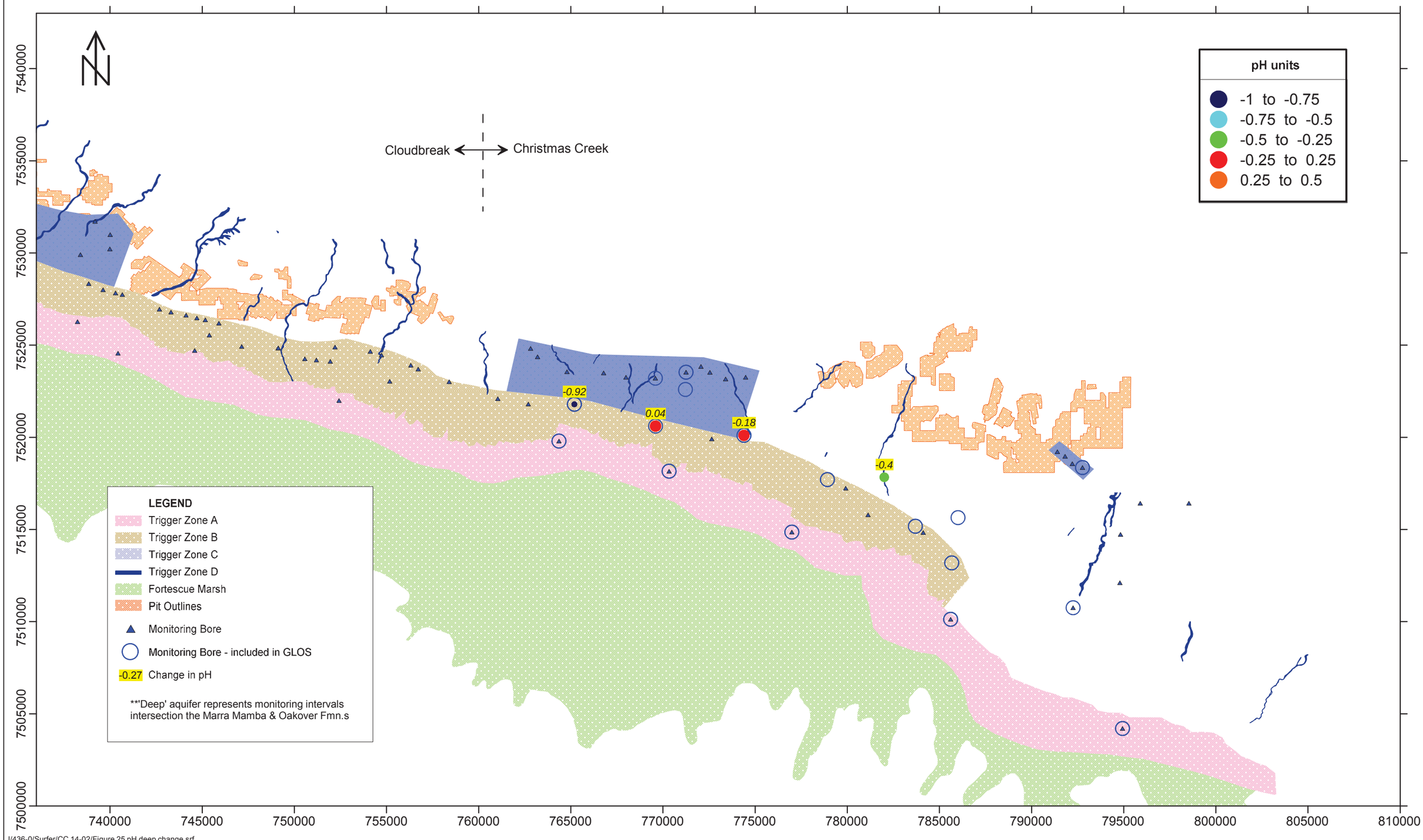
Scale (m)

0 5000 10000 15000 20000

GDA94 Zone 50

pH
CHANGE FROM BASELINE DATA
SHALLOW AQUIFER**

Figure 25



I/436-0/Surfer/CC 14-02/Figure 25 pH deep change.srf

CLIENT: Fortescue Metals Group

PROJECT: Christmas Creek Mine Geochemical Assesment

DATE: June 2014

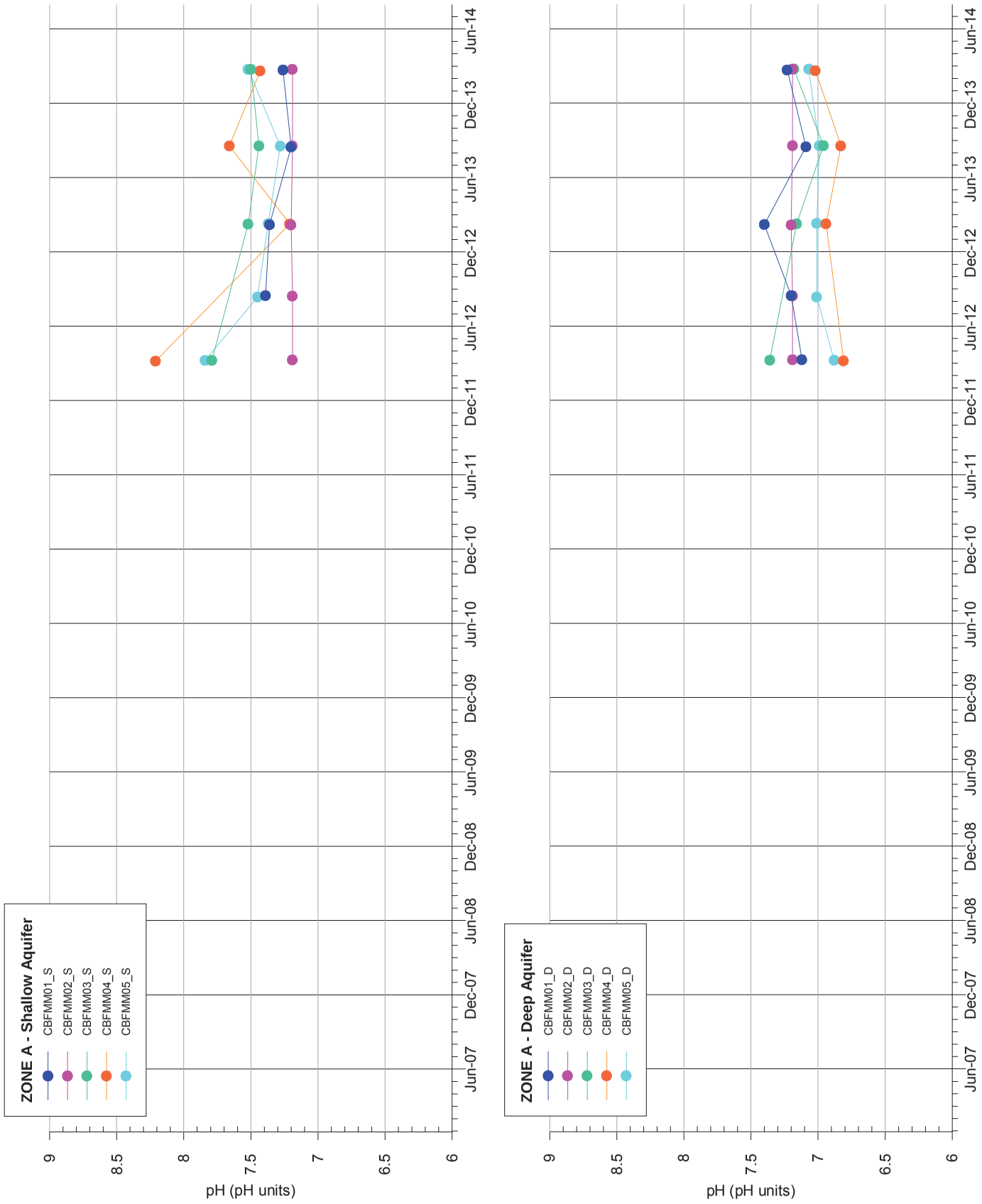
Dwg. No: Client No.436-0/14/02-25

Rockwater PROPRIETARY LIMITED

Scale (m)
0 5000 10000 15000 20000
GDA94 Zone 50

pH
CHANGE FROM BASELINE DATA
DEEP AQUIFER**

Figure 26



I:\\436-0\Grapher\CC 14-02\Figure 26 pH 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

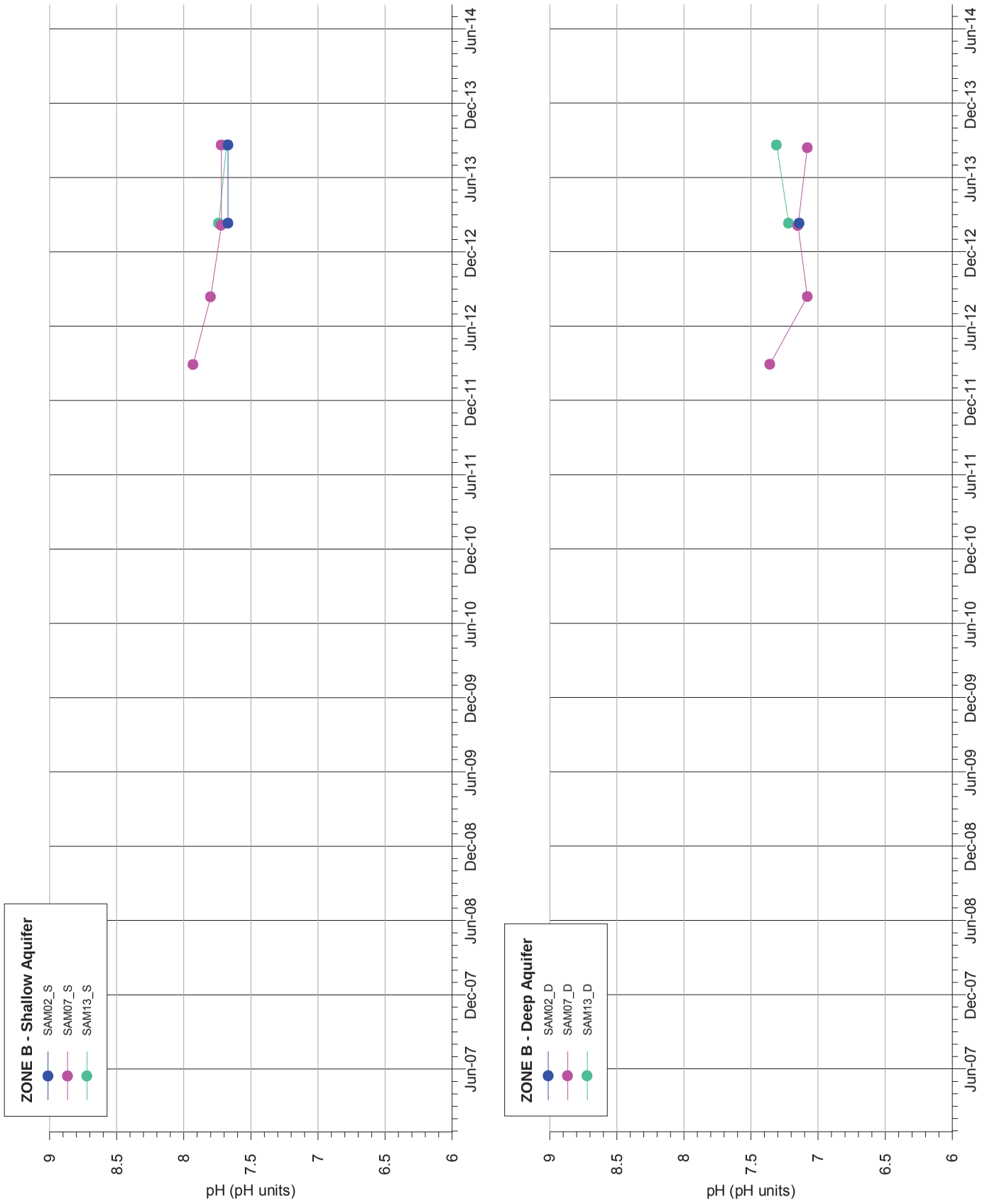
Dwg. No: 436-0/14/2-26

2013 GWOS MONITORING BORES

pH IN SHALLOW & DEEP AQUIFER

Zones A : Near Marsh Region

Figure 27



I:\\436-0\Grapher\CC 14-02\Figure 27 pH 2007-13 Zn B.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

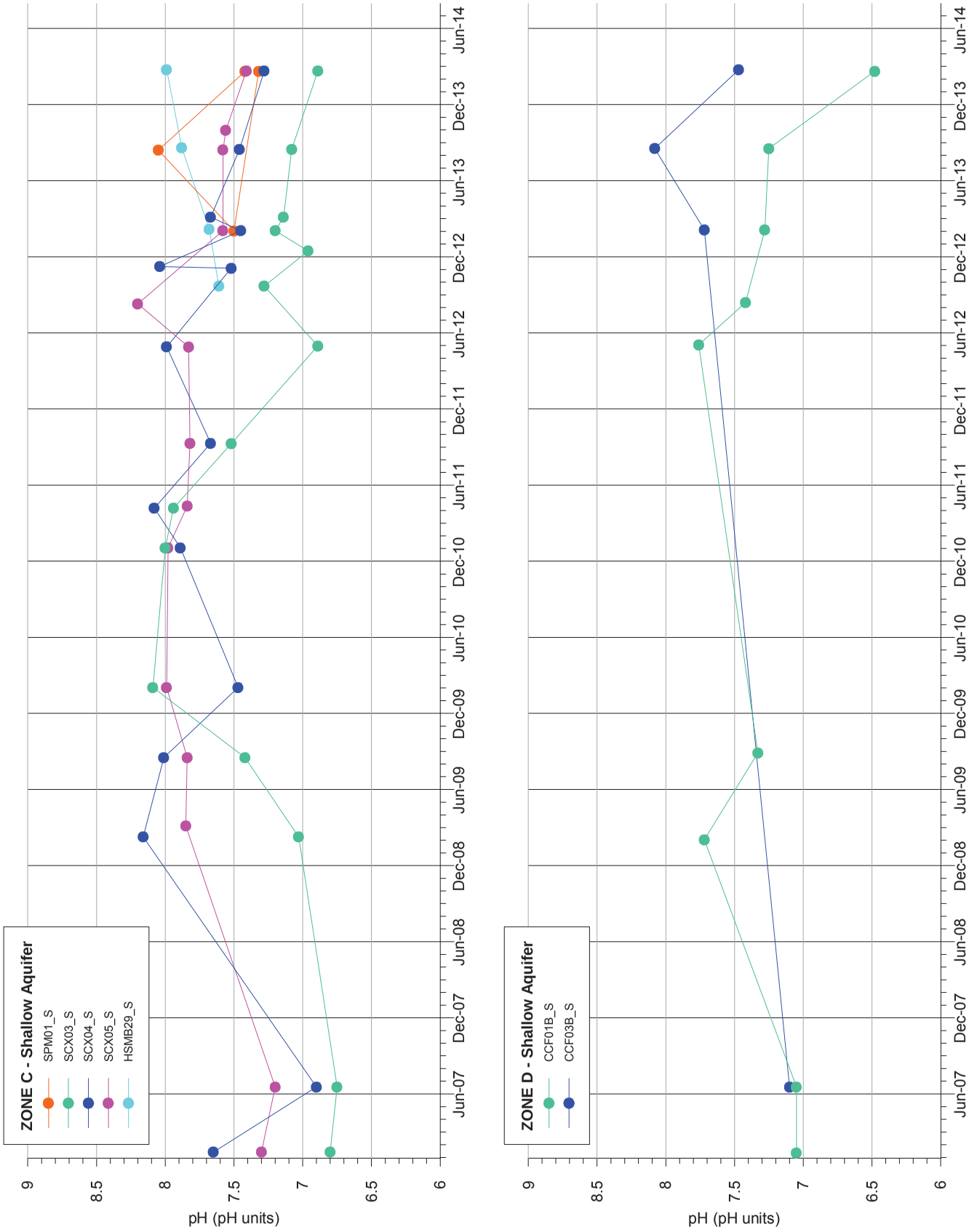
Dwg. No: 436-0/14/2-27

2013 GWOS MONITORING BORES

pH IN SHALLOW & DEEP AQUIFER

Zone B : Saline Injection Region

Figure 28



I:\\436-0\Grapher\CC 14-02\Figure 28 pH 2007-13 Zn C,D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

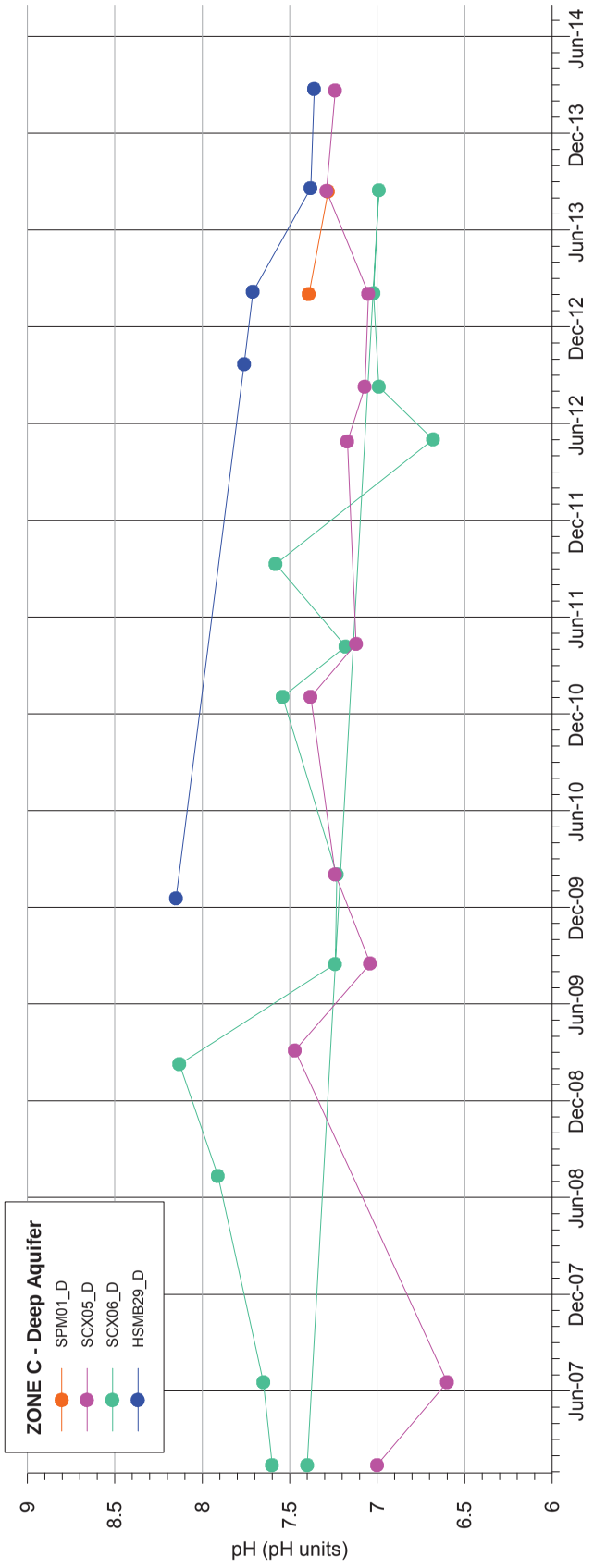
Dwg. No: 436-0/14/2-28

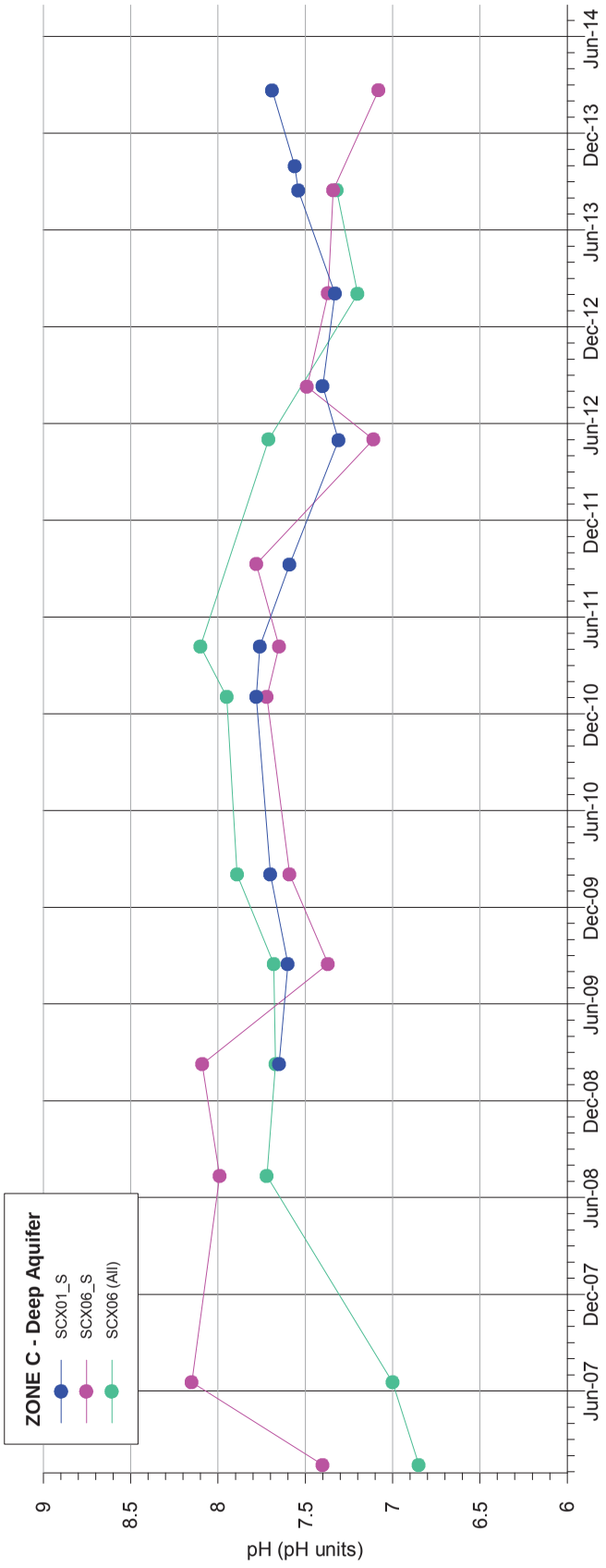
2013 GWOS MONITORING BORES

pH IN SHALLOW AQUIFER

Zone C & D : Brackish Injection Region

Figure 29





I:\\436-0\Grapher\CC 14-02\Figure 29 pH 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

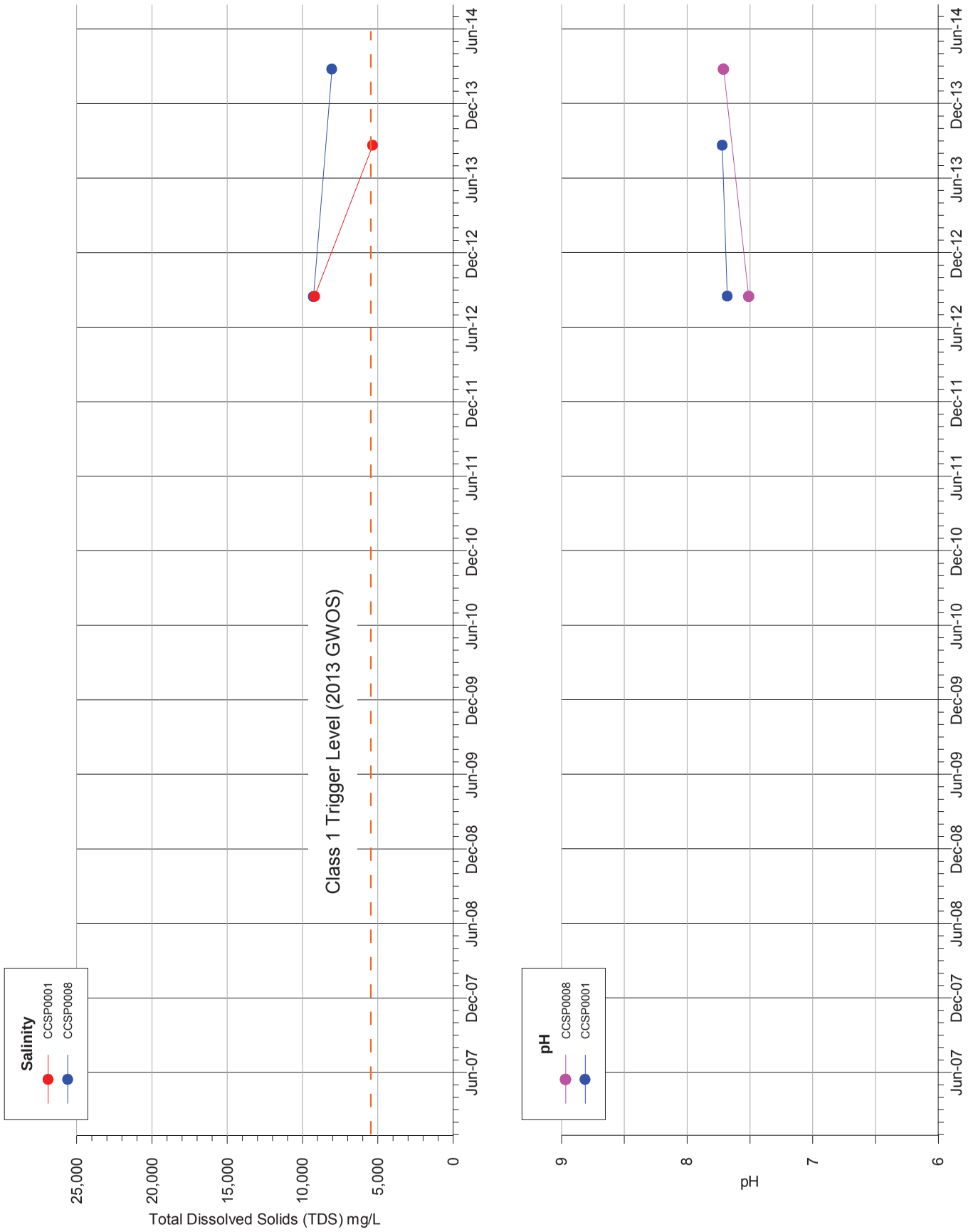
Dwg. No: 436-0/14/2-29

2013 GWOS MONITORING BORES

pH IN DEEP AQUIFER

Zone C : Brackish Injection Region

Figure 30



I:\\436-0\Grapher\CC 14-02\Figure 30 Salinity & pH 2007-13 Brackish.grf

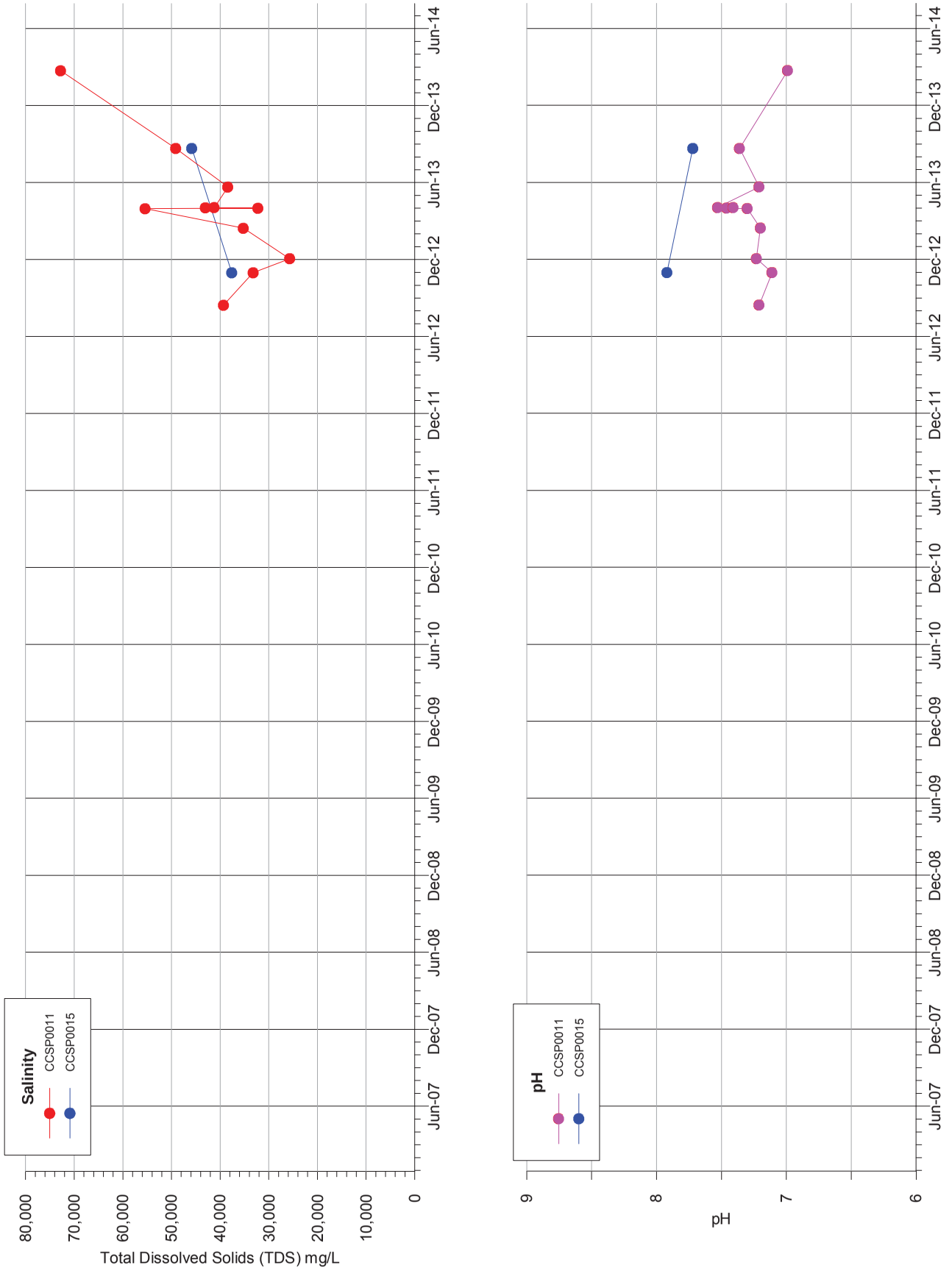
Client: Fortescue Metals Group Ltd

Project : Cloudbreak Geochemical Assessment

Date : May 2014

Dwg. No: 436-0/14/2-30

2013 GWOS
BRACKISH INJECTION LINES
SALINITY AND PH



I:\\436-0\Grapher\CC14-02\Figure 31 Salinity & pH 2007-13 Saline Inj Lines.grf

Client: Fortescue Metals Group Ltd

Project : Cloudbreak Geochemical Assessment

Date : May 2014

Dwg. No: 436-0/14/2-31

2013 GWOS
SALINE INJECTION LINES
SALINITY AND PH

APPENDIX I

Memo

DOW COMMENTS REGARDING GEOCHEMISTRY

OUR REF		**DATE**	31/03/2014
TO	Ian Brandes de Roos	**CC**	
FROM	Jordin Barclay		

This memo provides a summary of the comments provided by the Department of Water (DoW) in regards to the geochemistry section of Fortescue Metals Group's Christmas Creek and Cloudbreak Triennial Groundwater Monitoring Review.

General comments include:

- The review needs to clearly outline the management objectives for the water quality monitoring.
- Provide discussion of water quality trends and management implications relevant to specific management zones and relate back to management objectives.

The key outcomes that should be met through the completion of the triennial aquifer review are:

- Demonstration that life of mine monitoring data is supporting FMG to meet defined management objectives, or if necessary to re-define management objectives.

Other Specific comments include:

PR21	6.2	Title	No problems with two sections, but need to make the link with data and observations. Different bores are discussed from a quality point of view compared to WL so no real direct comparison can be made. No comment made that hydrogrpahs presented represent the area they are being discussed in.
PR22	6.2.2	2	Drinking water guidelines used as a reference point, not applicable in this environment. If no relevant guidelines are available, monitor to baseline data. E.C is limit as per triggers, metals and other parameters based on observations and deviation from baseline.

Comment ID	Chapter.Section	Paragraph	Comment
PR23	6.2.2	Subtitle	Quality procedure clearly not in place. Needs work to document methodology to be adopted, either in Operating strategy or as appendix to this document. No discussion of QA/QC in this section. Ionic balance, pH and field readings matching. Description of when things are not right. Field E.C, compensated to 25 degrees or for various temperatures?
PR24	6.2.3	Subtitle	Report does not present a reasoning for why geochemistry is being looked at and monitored. Managing to mine closure, need to reinforce what is being monitored and why, what are objectives and what is being observed. How does this relate to operations and what impact if any is being identified. A link or reference to key components managed under additional licences (bulk fuels tailing etc.) would be good to paint the bigger picture.
PR25	6.2.4	Title	Reliance on piper diagrams, tend to bulk parameters. relationships between determinants will give a better idea of processes, chloride sulphate relationships

- Analysis of long-term trends from commencement of Cloudbreak dewatering/reinjection operations (circa 2007) for:
    - Groundwater levels in Marra Mamba/Oakover, detritals/alluvium aquifers
    - Salinity and pH in Marra Mamba/Oakover, detritals/alluvium aquifers
    - Water quality in Marra Mamba/Oakover, detritals/alluvium aquifers – specifically discussion of all analytes (major ions and metals) outlined in the Cloudbreak Stage 6 Operating Strategy CB-PH-HY-0008. Refer to Table 7 (includes pH, EC, TDS, Major ions: Na, K, Ca, Mg, Cl, HCO3/CO3, NO3, SO4, Metals: Al, B, Fe, Cu, Zn, Ag, As, Cr, Pb, Cd, Hg, Ni, Sn, Mn, Se). These need to be represented in a meaningful way – graphical time series is appropriate.

JORDIN BARCLAY
Specialist Hydrogeologist, Hydrogeology

APPENDIX II

Appendix II-A: Results for Physical Parameters and Major Ions in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone A (Near-marsh)

Sample Point	Sample Date	Monitoring Zone		pH (pH units)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
CCFMM01_S	16/08/2012	Zone A	Tertiary Detritals	7.39	119000	98200	38800	160	11100	326	1860	2540	26000		
CCFMM01_S	7/02/2013			7.36	120000	99200	38400	145	10300	341	1930	2790	30600		7
CCFMM01_S	16/08/2013			7.2	119000	121000	47300	145	10700	397	2170	3160	34300	6.3	45
CCFMM01_S	21/02/2014			7.26	127000	96000	42200	144	10500	351	1960	2730	30200		
CCFMM02_S	6/02/2013			7.43	99500	79900	31600	161	9260	373	1610	2040	23600		242
CCFMM02_S	19/08/2013			7.36	104000	80100	37500	161	9870	346	1740	2200	25500	9.98	55
CCFMM02_S	23/02/2014			7.41	109000	82600	34700	163	9280	356	1770	2280	26100		
CCFMM03_S	10/03/2012			7.79	87800	69900	30000	136	8770	767	1680	1790	20300		
CCFMM03_S	8/02/2013			7.52	126000	113000	43200	153	13600	430	2520	2690	36000		58
CCFMM03_S	19/08/2013			7.44	70500	52500	24400	120	7250	739	1260	1640	18000	4.47	154
CCFMM03_S	23/02/2014			7.5	133000	107000	47400	148	12300	418	2280	2780	31400		
CCFMM04_S	9/03/2012			8.21	81000	57400	27100	142	9070	958	1420	1510	18000		
CCFMM04_S	8/02/2013			7.21	125000	112000	42400	149	15600	534	2810	2470	34400		26
CCFMM04_S	19/08/2013			7.66	76200	63300	26300	166	8610	588	1520	1590	19000	0.92	46
CCFMM04_S	19/02/2014			7.43	78500	68600	24700	166	8280	521	1340	1580	17400		
CCFMM05_S	10/03/2012			7.84	91100	72000	30800	230	13800	731	2840	1510	21400		
CCFMM05_S	13/08/2012			7.45	87200	70200	22700	223	14900	683	2500	1470	17900		
CCFMM05_S	9/02/2013			7.37	111000	97200	37000	198	14200	463	2940	1840	27700		150
CCFMM05_S	18/08/2013			7.28	112000	95800	39400	186	15600	534	3280	2230	30800	2.42	1880
CCFMM05_S	23/02/2014			7.52	89700	73300	27700	224	12900	650	2500	1640	20600		
Period of Triennial review															
	Minimum	Zone A	Tertiary Detritals	7.2	70,500	52,500	22,700	120	7,250	326	1,260	1,470	17,400	1	7
	Maximum			8.2	133,000	121,000	47,400	230	15,600	958	3,280	3,160	36,000	10	1,880
	Average			7.5	103,325	85,460	34,680	166	11,295	525	2,097	2,124	25,460	5	266

Appendix II-B: Results for Physical Parameters and Major Ions in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone A (Near-marsh)

Sample Point	Sample Date	Monitoring Zone		pH (pH units)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
CCFMM01_D	11/03/2012	Zone A	Oakover Fmn	7.12	123000	101000	46400	143	10700	370	2230	2950	31300		
CCFMM01_D	16/08/2012			7.2	125000	104000	36500	148	12800	334	1950	2690	27200		
CCFMM01_D	7/02/2013			7.4	124000	103000	41000	142	11500	333	1960	2850	31000		9
CCFMM01_D	16/08/2013			7.09	125000	101000	52500	132	11800	387	2030	2920	31600	5.99	28
CCFMM01_D	21/02/2014			7.23	131000	99500	46400	140	10600	382	2160	2990	32700		
CCFMM02_D	11/03/2012			7.19	134000	118000	52500	139	13200	383	2490	3110	32700		
CCFMM02_D	15/08/2012			7.19	139000	105000	50700	148	13700	375	2490	3250	35100		
CCFMM02_D	6/02/2013			7.2	174000	164000	66700	136	19800	539	3880	4580	51800		34
CCFMM02_D	19/08/2013			7.19	152000	133000	59300	139	16300	455	3230	3990	45300	2.7	16
CCFMM02_D	23/02/2014			7.19	144000	140000	49100	136	12600	354	2210	3200	34500		
CCFMM03_D	10/03/2012			7.36	150000	126000	60000	124	16000	433	3360	3510	38300		
CCFMM03_D	8/02/2013			7.16	143000	128000	58800	127	15800	415	3250	3420	43000		16
CCFMM03_D	19/08/2013			6.96	150000	132000	64900	126	18300	455	3240	3690	42400	4.64	12
CCFMM03_D	23/02/2014			7.18	160000	122000	54700	138	16200	387	2870	3500	39000		
CCFMM04_D	9/03/2012			6.81	181000	156000	76300	129	25500	759	5400	4550	55200		
CCFMM04_D	8/02/2013			6.94	172000	178000	73600	139	25000	627	4700	3970	52900		27
CCFMM04_D	19/08/2013			6.83	180000	174000	82300	129	26200	758	5300	5000	59900	0.12	144
CCFMM04_D	19/02/2014			7.02	190000	173000	69000	139	25800	637	4430	4450	52200		
CCFMM05_D	10/03/2012			6.88	161000	159000	64600	131	23700	716	6050	3580	48200		
CCFMM05_D	13/08/2012			7.01	167000	148000	60200	143	27300	604	5630	3530	46200		
CCFMM05_D	9/02/2013			7.01	156000	158000	63800	135	23600	624	5290	3180	47900		25
CCFMM05_D	19/08/2013			6.99	163000	158000	68300	133	26600	676	5300	3450	47300	4.47	<5
CCFMM05_D	23/02/2014			7.07	169000	181000	59600	134	23800	615	4850	3470	46000		
Period of Triennial review		Zone A	Oakover Fmn												
	Minimum			6.8	123,000	99,500	36,500	124	10,600	333	1,950	2,690	27,200	0	9
	Maximum			7.4	190,000	181,000	82,300	148	27,300	759	6,050	5,000	59,900	6	144
	Average			7.1	152,739	137,457	59,009	136	18,557	505	3,665	3,558	42,248	4	35

Appendix II-C: Results for Physical Parameters and Major Ions in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone B (Saline Injection)

Sample Point	Sample Date	Monitoring Zone		pH (pH units)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
SAM02_S	10/02/2013			7.67	35600	31200	11600	239	3450	277	670	559	7090		13
SAM02_S	21/08/2013			7.67	40200	26500	12900	234	4040	306	778	697	9050	5.03	26
SAM07_S	29/02/2012			7.93	13600	8560	4350	149	1100	220	303	185	2090		
SAM07_S	14/08/2012			7.8	14000	9650	4550	165	1100	275	353	185	2080		
SAM07_S	5/02/2013			7.72	13600	10900	4060	158	1020	310	362	188	2310	11.5	<5
SAM07_S	21/08/2013			7.72	16400	11000	4570	166	1150	352	439	194	2860	10.1	706
SAM13_S	10/02/2013			7.74	12400	10300	3520	212	1180	219	217	231	2510		12
SAM13_S	21/08/2013			7.68	9520	5980	2210	208	947	180	144	161	1530	2.83	<5
Period of Triennial review		Zone B	Tertiary Detritals												
	Minimum			7.7	9,520	5,980	2,210	149	947	180	144	161	1,530	3	12
	Maximum			7.9	40,200	31,200	12,900	239	4,040	352	778	697	9,050	12	706
	Average			7.7	19,415	14,261	5,970	191	1,748	267	408	300	3,690	7	189

Appendix II-D: Results for Physical Parameters and Major Ions in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone B (Saline Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	pH (pH units)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
SAM02_D	10/02/2013	Zone B		7.14	147000	142000	58100	156	20600	544	3280	3070	42400		38
SAM07_D	29/02/2012			7.36	164000	152000	73300	120	20600	522	3940	4070	44800		
SAM07_D	14/08/2012			7.08	164000	133000	49900	131	22100	376	2730	3230	31100		
SAM07_D	4/02/2013			7.15	171000	161000	57200	128	20000	443	3390	3320	47700	5.91	<5
SAM07_D	14/08/2013			7.08	149000	127000	59300	146	20100	484	3060	3060	36900	4.39	63
SAM13_D	10/02/2013			7.22	128000	117000	43000	156	16500	396	2920	2500	34800		104
SAM13_D	21/08/2013			7.31	128000	94800	44300	165	16300	441	3000	2310	33800	1.05	28
Period of Triennial review		Zone B	Oakover/ Wittenoom Fmn												
	Minimum			7.1	128,000	94,800	43,000	120	16,300	376	2,730	2,310	31,100	1	28
	Maximum			7.4	171,000	161,000	73,300	165	22,100	544	3,940	4,070	47,700	6	104
	Average			7.2	150,143	132,400	55,014	143	19,457	458	3,189	3,080	38,786	4	58

Appendix II-E: Results for Physical Parameters and Major Ions in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	pH (pH units)	EC (uS\cm)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
HSMB29_S	22/09/2012			7.61		11200	6870	3300	118	1180	209	261	143	1840		7120
HSMB29_S	6/02/2013			7.68		9220	6150	2370	116	940	185	209	113	1600		12
HSMB29_S	20/08/2013			7.88		5230	3540	1140	141	585	113	113	63	763	12.1	606
HSMB29_S	23/02/2014			7.99		3720	2340	776	160	491	84	77	52	518		
SCX03_S	16/01/2007			6.8	640		410	61	160		25	19	10	55	2.8	
SCX03_S	21/06/2007			6.75	640		410	86	150		28	20	11	56	5.5	
SCX03_S	15/07/2008						870	101	109		26	19	11	69	1.78	
SCX03_S	10/02/2009			7.03	426		372	75	83		19	13	10	59	2.98	
SCX03_S	19/08/2009			7.42	624		416	88	131		29	22	13	49		
SCX03_S	3/02/2010			8.09	718		490	93	129		35	25	13	56		
SCX03_S	4/01/2011			8	624		434	121	95		25	18	12	71		
SCX03_S	9/04/2011			7.94		572	451	94	88	36	24	18	12	63		
SCX03_S	10/09/2011			7.52		713	514	83	143	65	36	26	12	62		
SCX03_S	2/05/2012			6.89		595	419	102	100	46	28	21	11	59		
SCX03_S	22/09/2012			7.28		627	476	120	89	35	32	21	12	61		8
SCX03_S	16/12/2012			6.96		710	529	141	76	40	32	23	12	74		1150
SCX03_S	2/02/2013			7.2		743	552	169	77	33	35	27	12	72	2.84	<5
SCX03_S	7/03/2013			7.14		817	612	184	73	34	40	30	13	77	2.94	857
SCX03_S	16/08/2013			7.08		715	502	151	80	34	30	22	9	51	2.95	22
SCX03_S	20/02/2014			6.89		667	542	152	80	37	32	23	12	62		
SCX04_S	16/01/2007			7.65	1500		950	180	280		65	44	22	140	8.1	
SCX04_S	21/06/2007			6.9	4400		1500	1100	270		150	110	58	580	33	
SCX04_S	15/07/2008						920	187	271		71	45	24	185	6.26	
SCX04_S	10/02/2009			8.16	1220		787	147	268		63	40	24	153	10	
SCX04_S	19/08/2009			8.01	2140		1630	383	303		102	69	27	208		
SCX04_S	3/02/2010			7.47	96700		90800	35800	113		371	1840	1790	23700		
SCX04_S	4/01/2011			7.89	2310		1480	493	292		93	73	25	262		
SCX04_S	9/04/2011			8.08		4060	2740	1150	219	434	162	121	52	578		
SCX04_S	11/09/2011			7.67		99400	72000	48400	181	11400	376	1990	2550	29800		
SCX04_S	29/04/2012			7.99		5120	4320	1120	259	652	156	90	62	799		
SCX04_S	4/11/2012			7.52		2360	1250	456	278	258	101	73	26	262		15
SCX04_S	8/11/2012			8.04		2540	1560	465	278	262	107	73	26	260		17
SCX04_S	2/02/2013			7.45		3610	2390	836	252	362	140	108	42	478	8.76	<5
SCX04_S	7/03/2013			7.67		2250	1460	402	276	260	108	77	26	272	9.12	30
SCX04_S	16/08/2013			7.46		2840	1840	577	264	299	102	81	27	348	9.22	<5
SCX04_S	20/02/2014			7.28		2020	1360	396	271	268	93	63	24	243		
SCX05_S	16/01/2007			7.3	4900		3300	760	370		180	88	32	740	15	
SCX05_S	21/06/2007			7.2	4700		3100	970	410		170	83	52	750	4.6	
SCX05_S	16/07/2008						1990	629	324		145	63	25	608	0.064	
SCX05_S	8/03/2009			7.85	3120		2090	608	297		137	58	26	373	0.15	
SCX05_S	19/08/2009			7.84	4940		3370	1040	390		149	81	59	631		
SCX05_S	3/02/2010			7.99	4370		2720	872	340		127	66	44	656		
SCX05_S	4/01/2011			7.98	4800		2950	1040	378		98	78	54	757		
SCX05_S	14/04/2011			7.84		6750	3780	1290	282	750	160	96	69	877		
SCX05_S	11/09/2011			7.82		4290	3620	929	292	558	151	75	40	780		
SCX05_S	29/04/2012			7.83		3460	2230	775	249	348	138	103	42	432		
SCX05_S	11/08/2012			8.2		4200	3330	922	247	632	136	73	50	620		
SCX05_S	2/02/2013			7.58		6980	5180	1680	242	708	152	124	126	1140	7.12	<5
SCX05_S	15/08/2013			7.58		7350	4740	1970	244	708	152	124	117	1150	6.45	<5

Appendix II-E: Results for Physical Parameters and Major Ions in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	pH (pH units)	EC (uS\cm)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
SCX05_S	1/10/2013			7.56		6370	4040	1630	238	697	159	126	121	1140	6.91	
SCX05_S	20/02/2014			7.41		6590	4440	1780	238	719	132	108	116	1070		
SCX06(All)	16/01/2007			6.85	1600		1000	390	130		100	45	14	100	19	
SCX06(All)	21/06/2007			7	3600		3200	980	180		330	140	34	140	12	
SCX06(All)	14/07/2008			7.72	1240		903	201	174		74	37	22	138	12.4	
SCX06(All)	10/02/2009			7.67	1110		749	134	180		66	33	21	126	11.3	
SCX06(All)	18/08/2009			7.68	2120		4290	464	164		58	24	31	269		
SCX06(All)	3/02/2010			7.89	1990		1300	414	178		57	27	26	312		
SCX06(All)	4/01/2011			7.95	1970		2710	436	205		52	29	34	332		
SCX06(All)	9/04/2011			8.1		1550	1680	443	124	98	80	40	35	189		
SCX06(All)	3/05/2012			7.71		3860	2770	1010	159	235	123	82	71	524		
SCX06(All)	2/02/2013			7.2		54900	48100	19500	170	4560	561	954	957	13700	4.86	12
SCX06(All)	16/08/2013			7.32		60300	52500	21400	187	5020	549	1060	1120	15000	5.04	38
SPM01_S	1/02/2013			7.5		7650	5460	1930	194	761	185	172	83	1190	3.26	2050
SPM01_S	14/08/2013			8.05		6000	4970	1380	210	649	154	144	56	911	2.94	2740
SPM01_S	19/02/2014			7.42		5040	3220	1180	214	492	165	123	52	649		
Background	Minimum	Zone C	Shallow	6.8	426		372	61	83		19	13	10	55	0	
	Maximum			8.2	4900		3300	1100	410		330	140	58	750	33	
	Average			7.3	2238		1409	413	229		103	54	25	267	9	
Period of Operations		Zone C	Tertiary Detritals													
	Minimum			6.9	624	572	416	83	73	33	24	18	9	49	3	8
	Maximum			8.2	96700	99400	90800	48400	390	11400	376	1990	2550	29800	12	7120
	Average			7.6	13025	6800	6231	2809	201	751	118	169	148	1778	6	1219

Appendix II-F: Results for Physical Parameters and Major Ions in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	pH (pH units)	EC (uS\cm)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
HSMB29_D	20/12/2009			8.15	17300		11600	4620	247		251	324	234	2430		
HSMB29_D	22/09/2012			7.76		10500	6690	3170	122	1140	186	243	140	1730		6
HSMB29_D	6/02/2013			7.71		11700	8640	3650	172	1240	200	277	166	2430		<5
HSMB29_D	20/08/2013			7.38		14500	9710	3890	146	1460	217	298	178	2680	0.65	5
HSMB29_D	23/02/2014			7.36		14400	9180	4470	142	1340	216	291	215	2420		
SCX01_S	15/07/2008						36400	18000	226		214	806	1060	12200	10.1	
SCX01_S	10/02/2009			7.65	49700		38100	16400	240		231	866	1010	11500	10.2	
SCX01_S	18/08/2009			7.6	49700		33000	15300	230		224	830	1190	9720		
SCX01_S	3/02/2010			7.7	73600		63600	28400	175		270	1000	1520	17000		
SCX01_S	4/01/2011			7.78	48800		40300	18800	243		203	772	937	10200		
SCX01_S	9/04/2011			7.76		45800	37600	17000	225	5480	234	880	1090	12000		
SCX01_S	10/09/2011			7.59		47500	31800	19200	236	4810	233	866	996	13200		
SCX01_S	2/05/2012			7.31		54200	41100	17800	229	5030	223	916	1180	11200		
SCX01_S	12/08/2012			7.4		54800	39600	17900	230	6000	206	836	1130	10500		
SCX01_S	2/02/2013			7.33		98100	81300	33200	172	9760	358	1960	2420	28100	7.32	11
SCX01_S	16/08/2013			7.54		3120	2160	683	154	359	95	81	43	418	16	45
SCX01_S	1/10/2013			7.56		70700	49400	23000	209	7500	398	1390	1480	16400	3.56	
SCX01_S	20/02/2014			7.69		67100	50200	24400	194	6580	422	1280	1310	15300		
SCX05_D	16/01/2007			7	83000		67000	31000	340		300	1700	1400	25000	0.8	
SCX05_D	21/06/2007			6.6	128000		116000	51000	260		590	3400	2500	37000	0	
SCX05_D	16/07/2008						65300	33200	246		541	1730	1340	21000	0	
SCX05_D	8/03/2009			7.47	6940		56400	29700	202		510	1680	1300	17500	0	
SCX05_D	19/08/2009			7.04	131000		121000	51400	232		592	3160	3340	32600		
SCX05_D	3/02/2010			7.24	131000		130000	58900	223		569	3240	2700	34700		
SCX05_D	4/01/2011			7.38	123000		135000	49000	241		556	3020	2450	31000		
SCX05_D	14/04/2011			7.12		133000	119000	58300	142	18000	474	3030	2970	35100		
SCX05_D	29/04/2012			7.17		140000	105000	49200	127	15400	495	2900	2930	34700		
SCX05_D	11/08/2012			7.07		130000	108000	44800	165	17500	518	2720	2500	29700		
SCX05_D	2/02/2013			7.05		114000	101000	39700	151	13200	548	2530	2420	33000	0.63	26
SCX05_D	15/08/2013			7.29		82800	63100	28500	156	9280	626	1920	1350	20200	0.45	20
SCX05_D	20/02/2014			7.24		71100	59200	26700	145	8050	559	1650	1220	16800		
SCX06(All)	16/01/2007			6.85	1600		1000	390	130		100	45	14	100	19	
SCX06(All)	21/06/2007			7	3600		3200	980	180		330	140	34	140	12	
SCX06(All)	14/07/2008			7.72	1240		903	201	174		74	37	22	138	12.4	
SCX06(All)	10/02/2009			7.67	1110		749	134	180		66	33	21	126	11.3	
SCX06(All)	18/08/2009	Zone C		7.68	2120		4290	464	164		58	24	31	269		
SCX06(All)	3/02/2010			7.89	1990		1300	414	178		57	27	26	312		
SCX06(All)	4/01/2011			7.95	1970		2710	436	205		52	29	34	332		
SCX06(All)	9/04/2011			8.1		1550	1680	443	124	98	80	40	35	189		
SCX06(All)	3/05/2012			7.71		3860	2770	1010	159	235	123	82	71	524		
SCX06(All)	2/02/2013			7.2		54900	48100	19500	170	4560	561	954	957	13700	4.86	12
SCX06(All)	16/08/2013			7.32		60300	52500	21400	187	5020	549	1060	1120	15000	5.04	38
SCX06_D	16/01/2007			7.6	1600		1100	190	260		81	57	24	130	6.6	
SCX06_D	21/06/2007			7.65	1700		1100	190	250		110	64	28	150	10	
SCX06_D	14/07/2008			7.91	2420		1730	496	204		110	86	49	348	1.85	
SCX06_D	10/02/2009			8.13	2530		1720	456	224		106	76	43	304	1.67	
SCX06_D	18/08/2009			7.24	117000		106000	44400	195		409	2360	3650	28900		
SCX06_D	3/02/2010			7.23	147000		145000	67200	179		448	3090	3900	40200		
SCX06_D	4/01/2011			7.54	144000		132000	69200	184		363	2540	2970	39000		

Appendix II-F: Results for Physical Parameters and Major Ions in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	pH (pH units)	EC (uS\cm)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
SCX06_D	9/04/2011			7.18		148000	153000	74200	156	26900	500	3510	4330	46900		
SCX06_D	11/09/2011			7.58		4830	3530	1200	224	358	167	129	55	716		
SCX06_D	3/05/2012			6.68		178000	162000	71100	167	19300	520	3770	5020	47100		
SCX06_D	11/08/2012			6.99		181000	151000	78900	162	22500	504	3600	4430	47300		
SCX06_D	3/02/2013			7.02		207000	165000	72200	154	19000	483	3420	4110	56800	<0.01	38
SCX06_D	16/08/2013			6.99		172000	154000	70600	153	19500	485	3170	3900	43300	<0.01	24
SCX06_S	16/01/2007			7.4	1600		1100	180	260		78	54	23	130	12	
SCX06_S	21/06/2007			8.15	1700		1100	190	260		110	63	28	150	10	
SCX06_S	14/07/2008			7.99	1630		1180	212	211		110	73	33	167	0.248	
SCX06_S	10/02/2009			8.09	1620		1110	207	226		104	69	31	158	0.58	
SCX06_S	18/08/2009			7.37	98200		76000	36600	194		357	1720	2660	22000		
SCX06_S	3/02/2010			7.59	91400		84000	35100	192		334	1570	1970	22100		
SCX06_S	4/01/2011			7.72	60200		50100	24400	238		255	1020	1300	14100		
SCX06_S	9/04/2011			7.65		98800	87000	37700	171	9620	361	1830	2290	25700		
SCX06_S	11/09/2011			7.78		2730	1660	586	271	149	117	83	29	289		
SCX06_S	3/05/2012			7.11		87000	67000	30200	200	7630	319	1500	1810	19100		
SCX06_S	11/08/2012			7.49		53400	39200	17900	233	4740	276	787	1200	10600		
SCX06_S	3/02/2013			7.37		100000	88000	35000	177	9800	404	2020	2490	29800	3.29	8
SCX06_S	16/08/2013			7.34		116000	92100	44800	169	11400	336	1870	2170	28900	2.91	42
SCX06_S	21/02/2014			7.08		121000	100000	43900	160	12300	359	2010	2830	30900		
SPM01_D	1/02/2013			7.39		8150	5830	2100	183	842	207	190	91	1330	3.42	15
SPM01_D	14/08/2013			7.28		5940	4090	1360	202	609	183	141	50	860	2.85	<5
SPM01_D	19/02/2014			7.32		5000	3300	1180	200	457	186	124	43	614		
Background	Minimum	Zone C	Deep	6.6	1600		1100	180	202		78	54	23	130	0	
	Maximum			8.2	128000		116000	51000	340		590	3400	2500	37000	12	
	Average			7.6	23537		27810	12959	244		228	766	634	8981	5	
Period of Operations																
	Minimum	Zone C	Deep	6.7	1,970	1,550	1,300	414	122	98	52	24	26	189	0	5
	Maximum			8.2	147,000	207,000	165,000	78,900	271	26,900	626	3,770	5,020	56,800	16	45
	Average			7.4	77,393	72,968	63,710	28,620	186	8,083	332	1,465	1,661	18,710	4	22

Appendix II-G: Results for Physical Parameters and Major Ions in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone D (Phreatophytic Vegetation)

Sample Point	Sample Date	Monitoring Zone		pH (pH units)	EC (uS\cm)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
CCF01B_S	14/01/2007	Zone D		7.05	5800		4500	1100	220		210	170	52	780	1.6	
CCF01B_S	21/06/2007			7.05	5100		3600	1000	210		240	160	59	660	180	
CCF01B_S	3/02/2009			7.72	3200		2770	625	215		202	139	39	347	0.17	
CCF01B_S	30/08/2009			7.33	1200		818	238	94		57	37	27	119		
CCF01B_S	4/05/2012			7.76		1310	993	128	100	400	83	47	26	134		
CCF01B_S	14/08/2012			7.42		3190	2590	516	154	1020	231	135	45	324		
CCF01B_S	4/02/2013			7.28		1320	910	88	86	384	68	38	28	155	0.05	10
CCF01B_S	18/08/2013			7.25		6620	4980	1180	136	1760	508	233	54	661	2.83	263
CCF01B_S	19/02/2014			6.48		3120	2200	791	29	254	207	92	36	223		
CCF03B_S	21/06/2007			7.1	4500		2700	1100	270		220	70	29	600	24	
CCF03B_S	16/07/2008						2580	923	254		239	84	31	549	5.92	
CCF03B_S	4/02/2013			7.72		4090	2690	968	261	297	169	98	51	549	6.01	<5
CCF03B_S	18/08/2013			8.08		4300	3090	974	256	306	139	97	44	561	5.92	32
CCF03B_S	23/02/2014			7.47		4240	2730	1070	252	325	175	89	49	548		
Background	Minimum	Zone D	Shallow	7.1	3200		2580	625	210		202	70	29	347	0	
	Maximum			7.7	5800		4500	1100	270		240	170	59	780	180	
	Average			7.2	4650		3230	950	234		222	125	42	587	42	
Period of Triennial review		Zone D	Tertiary Detritals													
	Minimum			6.5	1,200	1,310	818	88	29	254	57	37	26	119	0	10
	Maximum			8.1	5,800	6,620	4,980	1,180	270	1,760	508	233	59	780	180	263
	Average			7.4	3,960	3,524	2,654	764	181	593	196	106	41	444	25	102

APPENDIX III

Appendix III-A: Results for Metals and Trace Elements in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone A (Near-marsh)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
ater Quality Guidelines (ANZECC 2000)				**ID**	**ID**	**0.0007**	**0.0044**	**0.0013**	**ID**	**0.0044**	**ID**	**ID**	**0.007**		**0.0014**	**ID**	**ID**	**0.015**
						0.0274												
CCFMM01_S	16/08/2012	Zone A	Tertiary Detritals	<0.01	1.3	<0.001	<0.01	0.052	<0.5	<0.01	0.01	<0.0001	0.013			4.64		<0.05
CCFMM01_S	7/02/2013			<0.01	1.82	0.0012	<0.01	0.06	<0.5	<0.01	0.488	<0.0001	0.014	<0.1	<0.01	6.71	<0.01	0.056
CCFMM01_S	16/08/2013			<0.02	1.48	<0.002	<0.02	0.043	<1	<0.02	<0.02	<0.0001	<0.02	<0.2	<0.02	5.45	<0.02	<0.1
CCFMM01_S	21/02/2014			<0.02	1.29	<0.002	<0.02	<0.02	<1	<0.02	<0.02	<0.0001	<0.02	<0.2	<0.02	4.44		<0.1
CCFMM02_S	6/02/2013		Tertiary Detritals	<0.01	1.05	<0.001	<0.01	0.026	<0.5	<0.01	0.065	<0.0001	<0.01	<0.1	<0.01	4.62	<0.01	0.061
CCFMM02_S	19/08/2013			<0.01	1.12	<0.001	<0.01	0.041	<0.5	<0.01	0.035	<0.0001	<0.01	<0.1	<0.01	4.77	<0.01	<0.05
CCFMM02_S	23/02/2014			<0.02	1.19	<0.002	<0.02	0.025	<1	<0.02	0.525	<0.0001	<0.02	<0.2	<0.02	4		<0.1
CCFMM03_S	10/03/2012		Tertiary Detritals	<0.01	1.13	<0.001	<0.01	0.028	<0.5	<0.01	1.17	<0.0001	0.02			6.55		<0.05
CCFMM03_S	8/02/2013			<0.01	1.27	<0.001	<0.01	0.02	<0.5	<0.01	0.132	<0.0001	<0.01	<0.1	<0.01	5.93	<0.01	<0.05
CCFMM03_S	19/08/2013			<0.01	1.24	<0.001	<0.01	0.019	<0.5	<0.01	0.018	<0.0001	<0.01	<0.1	<0.01	5.14	<0.01	<0.05
CCFMM03_S	23/02/2014			<0.02	1.45	<0.002	<0.02	0.023	<1	<0.02	<0.02	<0.0001	<0.02	<0.2	<0.02	5.16		<0.1
CCFMM04_S	9/03/2012		Tertiary Detritals	<0.01	1.42	<0.001	<0.01	0.023	<0.5	<0.01	1.73	<0.0001	<0.01			6.3		<0.05
CCFMM04_S	8/02/2013			<0.01	3.88	<0.001	<0.01	0.01	<0.5	<0.01	5.54	<0.0001	<0.01	<0.1	<0.01	9.72	<0.01	0.06
CCFMM04_S	19/08/2013			<0.01	2.1	<0.001	<0.01	0.019	<0.5	<0.01	1.04	<0.0001	<0.01	<0.1	<0.01	6.58	<0.01	<0.05
CCFMM04_S	19/02/2014			<0.01	1.94	<0.001	<0.01	0.023	<0.5	<0.01	0.24	<0.0001	<0.01	<0.1	<0.01	5.92		0.071
CCFMM05_S	10/03/2012		Tertiary Detritals	<0.01	3.18	<0.001	<0.01	0.11	<0.5	<0.01	4.28	<0.0001	0.022			7.44		0.073
CCFMM05_S	13/08/2012			<0.01	27.8	0.0033	<0.01	0.487	2.08	<0.01	17.3	<0.0001	0.101			75.3		0.296
CCFMM05_S	9/02/2013			<0.01	2.73	<0.001	<0.01	<0.01	<0.5	<0.01	3.25	<0.0001	<0.01	0.13	<0.01	8.01	<0.01	<0.05
CCFMM05_S	18/08/2013			<0.01	2.32	<0.001	<0.01	0.028	<0.5	<0.01	3.21	<0.0001	<0.01	<0.1	<0.01	7.21	<0.01	<0.05
CCFMM05_S	23/02/2014			<0.01	3.44	<0.001	<0.01	0.025	<0.5	<0.01	2.09	<0.0001	<0.01	<0.1	<0.01	6.44		<0.05
Period of Triennial review																		
	Minimum	Zone A	Tertiary Detritals		1.05	0.001		0.01			0.01		0.013			4.0		0.06
	Maximum				27.80	0.003		0.49			17.30		0.101			75.3		0.30
	Average				3.16	0.002		0.06			2.42		0.034			6.1		0.10

Red highligt indicates values above Marine Water Quality Guidelines (ANZECC 2000)

Appendix III-B: Results for Metals and Trace Elements in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone A (Near-marsh)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
ater Quality Guidelines (ANZECC 2000)				ID	ID	0.0007	0.0044	0.0013	ID	0.0044	ID	ID	0.007		0.0014	ID	ID	0.015
						0.0274												
CCFMM01_D	11/03/2012	Zone A	Oakover Fmn	<0.01	1.02	<0.001	<0.01	0.058	<0.5	<0.01	<0.01	<0.0001	0.021			5.2		0.051
CCFMM01_D	16/08/2012			<0.01	1.34	<0.001	<0.01	0.038	<0.5	<0.01	0.013	<0.0001	0.012			4.64		<0.05
CCFMM01_D	7/02/2013			<0.01	1.17	<0.001	<0.01	0.026	<0.5	<0.01	<0.01	<0.0001	<0.01	<0.1	0.018	4.84	<0.01	<0.05
CCFMM01_D	16/08/2013			<0.02	1.43	<0.002	<0.02	0.039	<1	<0.02	<0.02	<0.0001	<0.02	<0.2	0.033	5.38	<0.02	<0.1
CCFMM01_D	21/02/2014			<0.02	1.38	<0.002	<0.02	0.027	<1	<0.02	<0.02	<0.0001	<0.02	<0.2	<0.02	4.66		<0.1
CCFMM02_D	11/03/2012		Oakover/ Wittenoom Fmn	<0.01	1.12	<0.001	<0.01	0.054	<0.5	<0.01	<0.01	<0.0001	<0.01			5.68		<0.05
CCFMM02_D	15/08/2012			<0.01	1.63	<0.001	<0.01	0.071	<0.5	<0.01	0.012	<0.0001	0.015			5.52		0.073
CCFMM02_D	6/02/2013			<0.02	2.58	<0.002	<0.02	0.06	<1	<0.02	0.758	<0.0001	<0.02	<0.2	<0.02	7.75	<0.02	<0.1
CCFMM02_D	19/08/2013			<0.02	2.1	<0.002	<0.02	0.036	<1	<0.02	0.307	<0.0001	<0.02	<0.2	<0.02	6.88	<0.02	<0.1
CCFMM02_D	23/02/2014			<0.02	1.76	<0.002	<0.02	0.024	<1	<0.02	<0.02	<0.0001	<0.02	<0.2	<0.02	5.7		<0.1
CCFMM03_D	10/03/2012			<0.01	1.57	<0.001	<0.01	0.054	<0.5	<0.01	0.027	0.0001	<0.01			6.91		<0.05
CCFMM03_D	8/02/2013			<0.01	2.36	<0.001	<0.01	0.032	<0.5	<0.01	0.016	<0.0001	<0.01	<0.1	<0.01	7.27	<0.01	<0.05
CCFMM03_D	19/08/2013			<0.02	2.49	<0.002	<0.02	0.065	<1	<0.02	<0.02	<0.0001	<0.02	<0.2	<0.02	7.02	<0.02	<0.1
CCFMM03_D	23/02/2014			<0.02	2.2	<0.002	<0.02	0.029	<1	<0.02	0.029	<0.0001	<0.02	<0.2	<0.02	5.64		<0.1
CCFMM04_D	9/03/2012			<0.01	3.91	0.0015	<0.01	0.412	<0.5	0.014	9.09	<0.0001	0.138			11.8		0.148
CCFMM04_D	8/02/2013			0.014	5.88	0.0011	<0.01	0.021	<0.5	<0.01	10.9	<0.0001	<0.01	<0.1	<0.01	13.4	<0.01	0.053
CCFMM04_D	19/08/2013			<0.05	7.04	<0.005	<0.05	0.067	<2.5	<0.05	13.9	<0.0001	<0.05	<0.5	<0.05	13.6	<0.05	<0.25
CCFMM04_D	19/02/2014			<0.02	5.3	<0.002	<0.02	0.058	<1	<0.02	9.94	<0.0001	<0.02	<0.2	<0.02	10.7		0.131
CCFMM05_D	10/03/2012			<0.01	3.37	0.0028	<0.01	0.075	<0.5	<0.01	5.23	<0.0001	0.017			11.1		0.051
CCFMM05_D	13/08/2012			<0.01	4.7	0.0032	<0.01	0.086	0.55	<0.01	8	<0.0001	0.018			10.3		<0.05
CCFMM05_D	9/02/2013			<0.01	5.23	0.0028	<0.01	0.019	<0.5	<0.01	8.35	<0.0001	<0.01	<0.1	<0.01	13.5	<0.01	<0.05
CCFMM05_D	19/08/2013			<0.02	5.43	0.0038	<0.02	0.043	<1	<0.02	8.98	<0.0001	<0.02	<0.2	0.033	11.3	<0.02	<0.1
CCFMM05_D	23/02/2014			<0.02	4.47	0.0031	<0.02	0.056	<1	<0.02	7.81	<0.0001	<0.02	<0.2	<0.02	10.1		<0.1
Period of Triennial review		Zone A	Oakover Fmn															
	Minimum				1.02	0.001		0.02			0.01		0.012		0.018	4.6		0.05
	Maximum				7.04	0.004		0.41			13.90		0.138		0.033	13.6		0.15
	Average				3.02	0.003		0.06			5.21		0.037		0.028	8.2		0.08

Red highligt indicates values above Marine Water Quality Guidelines (ANZECC 2000)

Appendix III-C: Results for Metals and Trace Elements in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone B (Saline Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
ater Quality Guidelines (ANZECC 2000)				ID	ID	0.0007	0.0044	0.0013	ID	0.0044	ID	ID	0.007		0.0014	ID	ID	0.015
						0.0274												
SAM02_S	10/02/2013	Zone B	Tertiary Detritals	<0.01	0.52	<0.001	<0.01	<0.01	<0.5	<0.01	<0.01	<0.0001	<0.01	<0.1	<0.01	2.19	<0.01	<0.05
SAM02_S	21/08/2013			<0.005	0.6	<0.0005	0.008	0.009	<0.25	<0.005	<0.005	<0.0001	<0.005	<0.05	0.008	2.28	<0.005	<0.025
SAM07_S	29/02/2012			<0.001	0.29	<0.0001	0.006	0.023	<0.05	<0.001	0.004	<0.0001	<0.001			1.92		0.037
SAM07_S	14/08/2012			<0.001	0.29	<0.0001	0.006	0.008	<0.05	<0.001	0.011	<0.0001	0.003			2.25		0.017
SAM07_S	5/02/2013			<0.001	0.26	<0.0001	0.007	0.017	<0.05	0.001	0.003	<0.0001	0.003	<0.01	<0.001	2.82	<0.001	0.041
SAM07_S	21/08/2013			<0.001	0.3	<0.0001	<0.001	0.003	<0.05	<0.001	0.281	<0.0001	0.002	<0.01	<0.001	2.73	<0.001	<0.005
SAM13_S	10/02/2013		Tertiary Detritals	0.002	0.48	0.0001	<0.001	0.001	<0.05	<0.001	0.044	<0.0001	0.002	<0.01	<0.001	1.4	<0.001	0.006
SAM13_S	21/08/2013			0.002	0.26	<0.0001	0.003	0.002	<0.05	<0.001	0.006	<0.0001	<0.001	<0.01	<0.001	1.13	<0.001	<0.005

Period of Triennial review		Zone B	Tertiary Detritals															
	Minimum				0.26		0.003	0.001			0.003		0.002			1.13		0.006
	Maximum				0.60		0.008	0.023			0.281		0.003			2.82		0.041
	Average				0.38		0.006	0.009			0.058		0.003			2.09		0.025

Red highligt indicates values above Marine Water Quality Guidelines (ANZECC 2000)

Appendix III-D: Results for Metals and Trace Elements in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone B (Saline Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
ater Quality Guidelines (ANZECC 2000)				**ID**	**ID**	**0.0007**	**0.0044**	**0.0013**	**ID**	**0.0044**	**ID**	**ID**	**0.007**		**0.0014**	**ID**	**ID**	**0.015**
						0.0274												
SAM02_D	10/02/2013	Zone B		<0.01	4.25	<0.001	<0.01	<0.01	1.22	<0.01	0.155	<0.0001	<0.01	<0.1	<0.01	11.4	<0.01	<0.05
SAM07_D	29/02/2012		Oakover/ Wittenoom Fmn	<0.01	2.9	<0.001	<0.01	0.053	<0.5	<0.01	0.036	<0.0001	<0.01			9.17		<0.05
SAM07_D	14/08/2012			<0.01	2.92	<0.001	<0.01	0.116	0.75	<0.01	0.025	0.0001	0.016			7.14		<0.05
SAM07_D	4/02/2013			<0.02	3.32	<0.002	<0.02	0.085	<1	<0.02	0.255	<0.0001	<0.02	<0.2	<0.02	8.01	<0.02	<0.1
SAM07_D	14/08/2013			<0.02	3.16	<0.002	<0.02	0.064	<1	<0.02	0.177	<0.0001	<0.02	<0.2	<0.02	7.12	<0.02	<0.1
SAM13_D	10/02/2013		Oakover/ Wittenoom	<0.01	1.95	<0.001	<0.01	<0.01	<0.5	<0.01	1	<0.0001	<0.01	<0.1	<0.01	6.79	<0.01	<0.05
SAM13_D	21/08/2013			<0.02	2.03	<0.002	<0.02	0.03	<1	<0.02	0.469	<0.0001	<0.02	<0.2	<0.02	6.48	<0.02	<0.1

Period of Triennial review		Zone A	Oakover Fmn															
	Minimum				1.95			0.030			0.025					6.48		
	Maximum				4.25			0.116			1.000					11.40		
	Average				2.93			0.070			0.302					8.02		

Red highligt indicates values above Marine Water Quality Guidelines (ANZECC 2000)

Appendix III-E: Results for Metals and Trace Elements in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
Marine Water Quality Guidelines (ANZECC 2000)				**ID**	**ID**	**0.0007**	**0.0044**	**0.0013**	**ID**	**0.0044**	**ID**	**ID**	**0.007**		**0.0014**	**ID**	**ID**	**0.015**
						0.0274												
HSMB29_S	22/09/2012			<0.001	0.25	<0.0001	<0.001	0.006	<0.05	<0.001	0.002	0.0001	0.003			0.981		0.041
HSMB29_S	6/02/2013			<0.001	0.34	<0.0001	<0.001	<0.001	<0.05	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.001	1.18	<0.001	0.037
HSMB29_S	20/08/2013			<0.001	0.39	<0.0001	0.002	0.002	<0.05	<0.001	0.032	<0.0001	0.003	<0.01	<0.001	0.779	<0.001	<0.005
HSMB29_S	23/02/2014			<0.001	0.41	<0.0001	0.003	0.022	<0.05	<0.001	0.005	<0.0001	0.002	<0.01	<0.001	0.668		0.105
SCX03_S	16/01/2007								0		0.018							
SCX03_S	21/06/2007								0		0.37							
SCX03_S	15/07/2008				0.19				0		0.005					0.225		
SCX03_S	10/02/2009				0.14				0		0.281					0.134		
SCX03_S	19/08/2009				0.23				0		0.015					0.253		
SCX03_S	3/02/2010				0.24				0		0.005					0.255		
SCX03_S	4/01/2011				0.15				0		0					0.21		
SCX03_S	9/04/2011			<0.001	0.12	<0.0001	<0.001	0.006	<0.05	<0.001	0.015	<0.0001	0.006			0.23		0.066
SCX03_S	10/09/2011				0.26				<0.05		<0.001					0.278		
SCX03_S	2/05/2012			<0.001	0.16	<0.0001	<0.001	0.003	<0.05	<0.001	0.008	<0.0001	0.003			0.248		0.013
SCX03_S	22/09/2012			<0.001	0.17	<0.0001	<0.001	0.01	<0.05	<0.001	0.002	<0.0001	0.003			0.246		0.064
SCX03_S	16/12/2012			<0.001	0.14	<0.0001	<0.001	<0.001	<0.05	<0.001	0.002	<0.0001	0.002			0.282		0.026
SCX03_S	2/02/2013			<0.001	0.16	<0.0001	<0.001	0.002	<0.05	<0.001	0.01	<0.0001	0.004	<0.01	<0.001	0.346	<0.001	0.046
SCX03_S	7/03/2013			<0.001	0.17	<0.0001	<0.001	<0.001	<0.05	<0.001	0.001	<0.0001	0.004		<0.001	0.283	<0.001	0.027
SCX03_S	16/08/2013			<0.001	0.16	<0.0001	<0.001	0.002	<0.05	<0.001	0.018	<0.0001	0.004	<0.01	<0.001	0.29	<0.001	0.024
SCX03_S	20/02/2014			<0.001	0.14	<0.0001	<0.001	0.008	<0.05	<0.001	0.006	<0.0001	0.003	<0.01	<0.001	0.272		0.09
SCX04_S	16/01/2007								0		0							
SCX04_S	21/06/2007								0		0.017							
SCX04_S	15/07/2008				0.83				0		0.009					0.435		
SCX04_S	10/02/2009				1.12				0		0.001					0.372		
SCX04_S	19/08/2009				0.28				0		0.008					0.562		
SCX04_S	3/02/2010				1.08				0		0					0.464		
SCX04_S	4/01/2011				0.33				0		0					0.596		
SCX04_S	9/04/2011			<0.001	0.26	<0.0001	<0.001	0.017	<0.05	<0.001	0.004	<0.0001	0.004			0.968		0.083
SCX04_S	11/09/2011				0.97				0.68		1.21					5.58		
SCX04_S	29/04/2012			0.003	0.36	<0.0001	<0.001	0.01	0.9	<0.001	2.51	<0.0001	0.007			1.22		0.016
SCX04_S	4/11/2012			<0.001	0.28	<0.0001	0.001	0.003	<0.05	<0.001	0.005	<0.0001	0.002			0.571		0.028
SCX04_S	8/11/2012	Zone C	Tertiary	<0.001	0.57	<0.0001	<0.001	0.001	<0.05	<0.001	0.002	<0.0001	0.001			0.622		0.012
SCX04_S	2/02/2013	(Brackish Injection)	Detritals	<0.001	0.29	<0.0001	<0.001	0.004	<0.05	<0.001	0.009	<0.0001	0.002	<0.01	<0.001	0.911	<0.001	0.041
SCX04_S	7/03/2013			<0.001	0.33	<0.0001	<0.001	<0.001	<0.05	<0.001	0.001	<0.0001	0.001		<0.001	0.542	<0.001	0.012
SCX04_S	16/08/2013			<0.001	0.32	<0.0001	<0.001	0.002	<0.05	<0.001	0.007	<0.0001	<0.001	<0.01	<0.001	0.64	<0.001	0.01
SCX04_S	20/02/2014			<0.001	0.3	<0.0001	<0.001	0.01	<0.05	<0.001	0.021	<0.0001	0.001	<0.01	<0.001	0.516		0.056
SCX05_S	16/01/2007								0.03		3							
SCX05_S	21/06/2007								0.07		3.6							
SCX05_S	16/07/2008				0.55				1.36		2.52					0.787		
SCX05_S	8/03/2009				0.27				0		1.23					0.634		
SCX05_S	19/08/2009				0.34				2.72		4.43					0.916		
SCX05_S	3/02/2010				0.54				0		0.005					2.34		
SCX05_S	4/01/2011				0.38				0		2.63					0.742		
SCX05_S	14/04/2011			<0.001	0.31	<0.0001	<0.001	0.004	2.12	<0.001	3.1	<0.0001	0.006			0.999		0.023
SCX05_S	11/09/2011				0.32				0.5		2.38					0.859		
SCX05_S	29/04/2012			0.001	0.29	<0.0001	<0.001	0.007	<0.05	<0.001	0.01	<0.0001	0.001			0.762		0.02
SCX05_S	11/08/2012			<0.001	0.72	0.0004	<0.001	0.126	2.95	0.004	10.2	<0.0001	0.031			7.18		0.061
SCX05_S	2/02/2013			0.001	0.29	<0.0001	<0.001	0.004	<0.05	<0.001	1.27	<0.0001	0.009	0.02	<0.001	1.02	<0.001	0.018
SCX05_S	15/08/2013			0.002	0.31	<0.0001	<0.001	0.003	<0.05	<0.001	0.86	<0.0001	0.008	0.02	<0.001	0.881	<0.001	0.012
SCX05_S	1/10/2013			0.001	0.31	<0.0001	<0.001	0.006	<0.05	<0.001	1.02	<0.0001	0.011	0.02	<0.001	0.911		0.034

Appendix III-E: Results for Metals and Trace Elements in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
Marine Water Quality Guidelines (ANZECC 2000)				**ID**	**ID**	**0.0007**	**0.0044**	**0.0013**	**ID**	**0.0044**	**ID**	**ID**	**0.007**		**0.0014**	**ID**	**ID**	**0.015**
						0.0274												
SCX05_S	20/02/2014			0.001	0.3	<0.0001	<0.001	0.011	<0.05	<0.001	0.765	<0.0001	0.008	0.02	<0.001	0.74		0.049
SCX06(All)	16/01/2007								0		0							
SCX06(All)	21/06/2007								0		0.062							
SCX06(All)	14/07/2008				0.35				0		0					0.394		
SCX06(All)	10/02/2009				0.5				0		0.002					0.339		
SCX06(All)	18/08/2009				0.27				0.13		0.02					0.322		
SCX06(All)	3/02/2010				0.33				0		0.02					0.311		
SCX06(All)	4/01/2011				0.42				1.08		0.052					0.446		
SCX06(All)	9/04/2011			<0.001	0.18	<0.0001	0.001	0.005	<0.05	<0.001	0.004	<0.0001	0.002			0.467		0.038
SCX06(All)	3/05/2012			<0.001	0.4	<0.0001	<0.001	0.008	<0.05	<0.001	0.36	<0.0001	0.003			1.16		0.013
SCX06(All)	2/02/2013			<0.001	0.21	0.0007	<0.001	0.04	<0.05	<0.001	0.029	<0.0001	0.017	<0.01	0.003	5.02	0.001	0.067
SCX06(All)	16/08/2013			<0.01	0.83	<0.001	<0.01	0.024	<0.5	<0.01	0.033	<0.0001	<0.01	<0.1	<0.01	4.05	<0.01	<0.05
SPM01_S	1/02/2013			<0.001	0.21	<0.0001	<0.001	0.002	<0.05	<0.001	0.011	<0.0001	0.001	<0.01	<0.001	1.04	<0.001	0.008
SPM01_S	14/08/2013			<0.001	0.22	<0.0001	0.002	0.002	<0.05	<0.001	<0.001	<0.0001	0.001	<0.01	<0.001	0.791	<0.001	<0.005
SPM01_S	19/02/2014			<0.001	0.21	<0.0001	0.002	0.009	<0.05	<0.001	0.005	<0.0001	0.002	<0.01	<0.001	0.724		0.08
Background	Minimum	Zone C	Shallow		0.14				0.00		0.00					0.13		
	Maximum				1.12				1.36		3.60					0.79		
	Average				0.49				0.09		0.69					0.42		
Period of Operations		Zone C	Shallow															
	Minimum			0.001	0.120	0.000	0.001	0.001	0.000	0.004	0.000		0.001	0.020		0.210		0.008
	Maximum			0.003	1.080	0.001	0.003	0.126	2.950	0.004	10.200		0.031	0.020		7.180		0.105
	Average			0.002	0.332	0.001	0.002	0.012	0.652	0.004	0.676		0.005	0.020		1.055		0.039

Red highligt indicates values above Marine Water Quality Guidelines (ANZECC 2000)
Blue highlight indicates values above maximum concentration measured prior to operations.

Appendix III-F: Results for Metals and Trace Elements in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
ater Quality Guidelines (ANZECC 2000)				ID	ID	0.0007	0.0044	0.0013	ID	0.0044	ID	ID	0.007		0.0014	ID	ID	0.015
						0.0274												
HSMB29_D	20/12/2009				0.44				0		0.014					1.72		
HSMB29_D	22/09/2012			<0.001	0.24	<0.0001	<0.001	0.011	<0.05	<0.001	<0.001	<0.0001	0.004			0.827		0.057
HSMB29_D	6/02/2013			<0.001	0.36	<0.0001	<0.001	<0.001	<0.05	<0.001	0.438	<0.0001	0.004	<0.01	<0.001	1.01	<0.001	0.051
HSMB29_D	20/08/2013			<0.001	0.32	<0.0001	<0.001	0.005	<0.05	<0.001	0.51	<0.0001	0.007	<0.01	<0.001	1.09	<0.001	0.024
HSMB29_D	23/02/2014			<0.001	0.33	<0.0001	<0.001	0.014	<0.05	<0.001	0.003	<0.0001	0.003	<0.01	<0.001	1.04		0.124
SCX01_S	15/07/2008				0.81				0		0.002					2.61		
SCX01_S	10/02/2009				0.79				0		0.002					2.57		
SCX01_S	18/08/2009				0.46				0		0.006					2.72		
SCX01_S	3/02/2010				0.47				0		0					2.4		
SCX01_S	4/01/2011				0.3				0		0.009					1.05		
SCX01_S	9/04/2011			<0.001	0.56	0.0003	0.003	0.043	0.07	<0.001	0.005	<0.0001	0.008			2.81		0.097
SCX01_S	10/09/2011				0.37				<0.05		<0.001					2.62		
SCX01_S	2/05/2012			<0.001	0.52	<0.0001	0.001	0.019	<0.05	<0.001	0.001	<0.0001	0.004			2.78		0.017
SCX01_S	12/08/2012			<0.001	0.56	0.0003	<0.001	0.04	<0.05	0.001	0.012	<0.0001	0.005			2.7		0.045
SCX01_S	2/02/2013			<0.01	1.26	<0.001	<0.01	0.03	<0.5	<0.01	0.07	<0.0001	<0.01	<0.1	<0.01	4.79	0.01	<0.05
SCX01_S	16/08/2013			0.001	0.39	<0.0001	<0.001	0.001	<0.05	<0.001	0.003	<0.0001	0.002	<0.01	<0.001	0.726	<0.001	0.011
SCX01_S	1/10/2013			<0.01	1.14	<0.001	<0.01	0.012	<0.5	<0.01	<0.01	<0.0001	<0.01	<0.1	0.03	3.97		<0.05
SCX01_S	20/02/2014			<0.01	0.78	<0.001	<0.01	0.011	<0.5	<0.01	<0.01	<0.0001	<0.01	<0.1	<0.01	3.46		<0.05
SCX05_D	16/01/2007								0.14		1.2							
SCX05_D	21/06/2007								1.3		17							
SCX05_D	16/07/2008				0.85				0.1		1.43					6.22		
SCX05_D	8/03/2009				0.36				0		0.003					2.87		
SCX05_D	19/08/2009				0.93				6.36		16.8					11.4		
SCX05_D	3/02/2010				0.72				0		0					3.76		
SCX05_D	4/01/2011				1.32				0		12.8					7.77		
SCX05_D	14/04/2011			<0.01	1.53	<0.001	<0.01	0.045	3.47	<0.01	9.49	<0.0001	0.048			8.59		<0.05
SCX05_D	29/04/2012			<0.01	0.69	<0.001	<0.01	0.038	2.69	<0.01	5.06	<0.0001	0.032			6.81		<0.05
SCX05_D	11/08/2012			<0.01	0.34	<0.001	<0.01	<0.01	<0.5	<0.01	2.23	<0.0001	<0.01			0.775		<0.05
SCX05_D	2/02/2013			<0.01	0.9	<0.001	<0.01	0.023	<0.5	<0.01	9.56	<0.0001	0.025	<0.1	<0.01	6.81	0.024	<0.05
SCX05_D	15/08/2013			<0.01	0.6	<0.001	<0.01	0.018	<0.5	<0.01	8.66	<0.0001	0.02	<0.1	<0.01	6.26	<0.01	<0.05
SCX05_D	20/02/2014			<0.01	0.48	<0.001	<0.01	0.026	<0.5	<0.01	4.81	<0.0001	0.024	<0.1	<0.01	4.96		0.066
SCX06(All)	16/01/2007								0		0							
SCX06(All)	21/06/2007								0		0.062							
SCX06(All)	14/07/2008				0.35				0		0					0.394		
SCX06(All)	10/02/2009				0.5				0		0.002					0.339		
SCX06(All)	18/08/2009	Zone C	Deep		0.27				0.13		0.02					0.322		
SCX06(All)	3/02/2010	(Brackish Injection)			0.33				0		0.02					0.311		
SCX06(All)	4/01/2011				0.42				1.08		0.052					0.446		
SCX06(All)	9/04/2011			<0.001	0.18	<0.0001	0.001	0.005	<0.05	<0.001	0.004	<0.0001	0.002			0.467		0.038
SCX06(All)	3/05/2012			<0.001	0.4	<0.0001	<0.001	0.008	<0.05	<0.001	0.36	<0.0001	0.003			1.16		0.013
SCX06(All)	2/02/2013			<0.001	0.21	0.0007	<0.001	0.04	<0.05	<0.001	0.029	<0.0001	0.017	<0.01	0.003	5.02	0.001	0.067
SCX06(All)	16/08/2013			<0.01	0.83	<0.001	<0.01	0.024	<0.5	<0.01	0.033	<0.0001	<0.01	<0.1	<0.01	4.05	<0.01	<0.05
SCX06_D	16/01/2007								0.01		0							
SCX06_D	21/06/2007								0		0							
SCX06_D	14/07/2008				0.38				0.18		0					0.389		
SCX06_D	10/02/2009				0.45				0		0					0.414		
SCX06_D	18/08/2009				1.51				0.76		5.85					4.72		
SCX06_D	3/02/2010				0.8				2.5		9.43					6.91		
SCX06_D	4/01/2011				3.7				0		7.47					7.01		
SCX06_D	9/04/2011			<0.001	1.83	0.0002	<0.001	0.099	1.54	0.005	7.04	<0.0001	0.025			11.6		0.045
SCX06_D	11/09/2011				0.27				<0.05		0.067					0.838		
SCX06_D	3/05/2012			<0.01	2.29	<0.001	<0.01	0.073	1.35	<0.01	6.55	<0.0001	0.011			7.05		<0.05
SCX06_D	11/08/2012			<0.01	2.79	<0.001	<0.01	0.088	2.08	<0.01	8.67	<0.0001	0.017			7.73		0.052
SCX06_D	3/02/2013			<0.02	3.37	<0.002	<0.02	0.053	<1	<0.02	9.13	<0.0001	<0.02	<0.2	<0.02	9.49	<0.02	<0.1

Appendix III-F: Results for Metals and Trace Elements in the Deep Aquifer 2013 GWOS Monitoring Bores - Zone C (Brackish Injection)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
ater Quality Guidelines (ANZECC 2000)				ID	ID	0.0007	0.0044	0.0013	ID	0.0044	ID	ID	0.007		0.0014	ID	ID	0.015
						0.0274												
SCX06_D	16/08/2013			<0.02	3.07	<0.002	<0.02	0.05	1.51	<0.02	8.57	<0.0001	<0.02	<0.2	<0.02	8.55	<0.02	<0.1
SCX06_S	16/01/2007								0		0							
SCX06_S	21/06/2007								0		0							
SCX06_S	14/07/2008				0.37				0.09		0.05					0.317		
SCX06_S	10/02/2009				0.44				0		0.001					0.356		
SCX06_S	18/08/2009				0.38				0.2		0.501					2.04		
SCX06_S	3/02/2010				0.69				0		1.86					4.1		
SCX06_S	4/01/2011				1.13				0		2.46					2.73		
SCX06_S	9/04/2011			<0.01	1.4	<0.001	0.015	0.051	<0.5	<0.01	1.14	<0.0001	0.019			4.88		0.058
SCX06_S	11/09/2011				0.28				<0.05		0.007					0.699		
SCX06_S	3/05/2012			<0.01	0.98	<0.001	<0.01	0.048	<0.5	<0.01	0.795	<0.0001	<0.01			3.5		<0.05
SCX06_S	11/08/2012			<0.001	0.53	0.0002	<0.001	0.029	0.5	<0.001	2.14	<0.0001	0.008			2.43		0.04
SCX06_S	3/02/2013			<0.01	1.29	<0.001	<0.01	0.025	<0.5	<0.01	1.01	<0.0001	<0.01	<0.1	<0.01	4.64	<0.01	<0.05
SCX06_S	16/08/2013			<0.02	5.67	0.0037	<0.02	0.085	<1	<0.02	9.36	<0.0001	<0.02	<0.2	<0.02	16.2	<0.02	<0.1
SCX06_S	21/02/2014			<0.02	1.49	<0.002	<0.02	0.032	<1	<0.02	1.51	<0.0001	<0.02	<0.2	<0.02	4.63		<0.1
SPM01_D	1/02/2013			<0.001	0.21	<0.0001	<0.001	0.002	<0.05	<0.001	0.005	<0.0001	0.002	<0.01	<0.001	1.1	<0.001	0.018
SPM01_D	14/08/2013			<0.001	0.21	<0.0001	<0.001	0.002	<0.05	<0.001	0.002	<0.0001	0.002	<0.01	<0.001	0.824	<0.001	0.017
SPM01_D	19/02/2014			<0.001	0.21	<0.0001	<0.001	0.013	<0.05	0.001	0.002	<0.0001	0.002	<0.01	<0.001	0.797		0.133
Background	Minimum	Zone C	Deep		0.35				0.00		0.0					0.3		
	Maximum				0.85				1.30		17.0					6.2		
	Average				0.53				0.10		1.1					1.6		
Period of Operations																		
	Minimum	Zone C	Deep		0.18	0.000		0.001	0.00		0.0		0.002			0.3		0.011
	Maximum				5.67	0.004		0.099	6.36		16.8		0.048			16.2		0.133
	Average				0.98	0.001		0.032	1.01		3.1		0.012			4.0		0.051

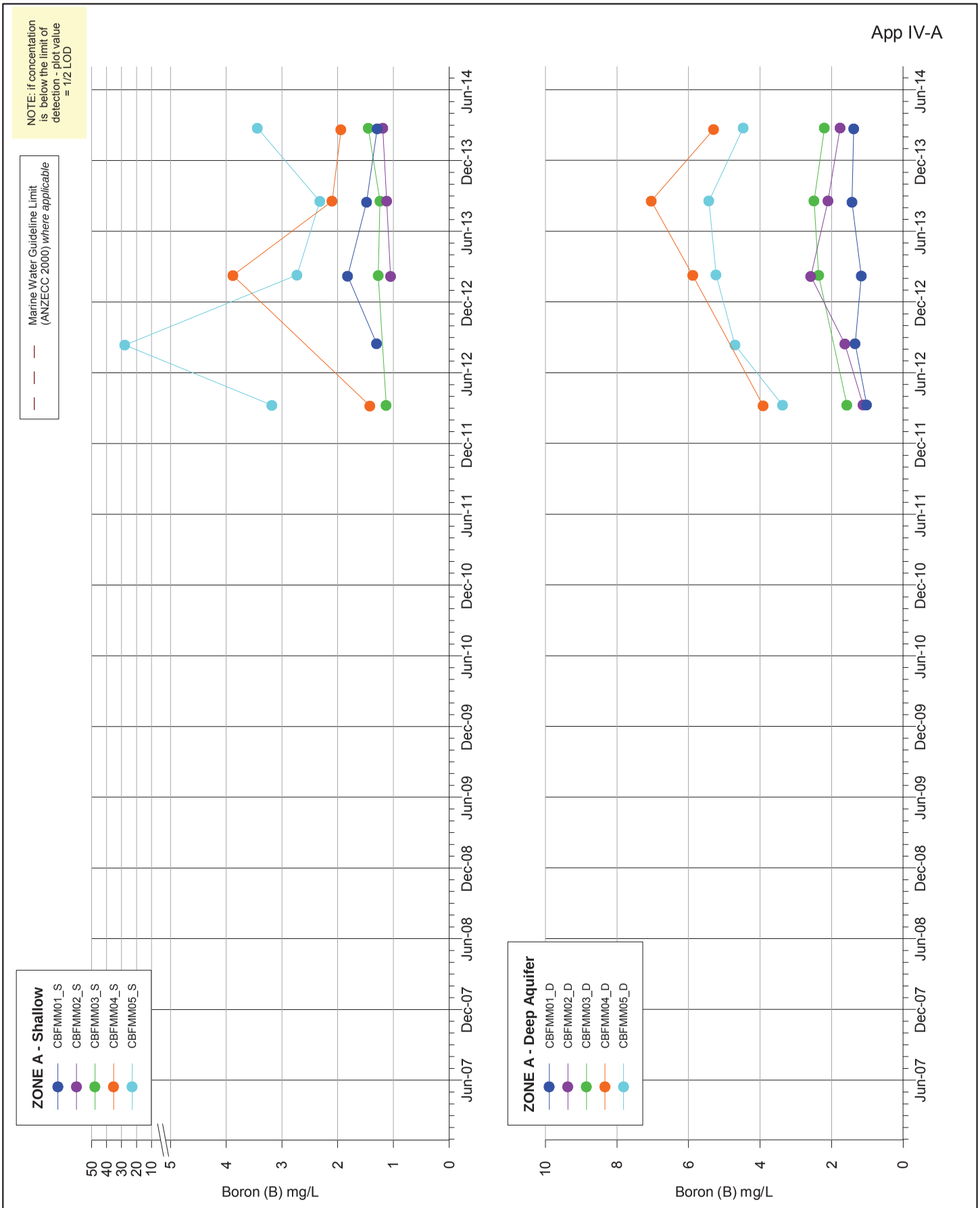
Red highligt indicates values above Marine Water Quality Guidelines (ANZECC 2000)
Blue highlight indicates values above maximum concentration measured prior to operations.

Appendix III-G: Results for Metals and Trace Elements in the Shallow Aquifer 2013 GWOS Monitoring Bores - Zone D (Phreatophytic Vegetation)

Sample Point	Sample Date	Monitoring Zone	Aquifer	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
ater Quality Guidelines (ANZECC 2000)				ID	ID	0.0007	0.0044	0.0013	ID	0.0044	ID	ID	0.007		0.0014	ID	ID	0.015
						0.0274												
CCF01B_S	14/01/2007 00:00:00	Zone D							0		0							
CCF01B_S	21/06/2007 00:00:00		Tertiary Detritals						0		0.003							
CCF01B_S	03/02/2009 00:00:00				0.38				0.16		0.959					0.996		
CCF01B_S	30/08/2009 00:00:00				0.08				0		0.152					0.277		
CCF01B_S	04/05/2012 15:00:00			<0.001	0.16	<0.0001	<0.001	0.008	<0.05	<0.001	0.187	<0.0001	0.004			0.403		0.024
CCF01B_S	14/08/2012 00:00:00			<0.001	0.24	<0.0001	<0.001	0.005	<0.05	<0.001	0.397	<0.0001	0.01			1.07		0.064
CCF01B_S	04/02/2013 11:10:00			0.002	0.15	<0.0001	<0.001	0.003	<0.05	<0.001	0.136	<0.0001	0.008	<0.01	<0.001	0.356	<0.001	0.071
CCF01B_S	18/08/2013 08:15:00			<0.001	0.46	0.0001	<0.001	0.005	<0.05	<0.001	0.219	<0.0001	0.006	<0.01	<0.001	2.11	<0.001	0.016
CCF01B_S	19/02/2014 15:00:00			<0.001	0.09	<0.0001	<0.001	0.001	<0.05	<0.001	0.006	<0.0001	0.009	<0.01	<0.001	1.07		0.011
CCF03B_S	21/06/2007 00:00:00		Tertiary Detritals						0		0.002							
CCF03B_S	16/07/2008 00:00:00				0.6				0		0					1.24		
CCF03B_S	04/02/2013 13:25:00			0.001	0.36	<0.0001	0.014	0.006	<0.05	<0.001	0.001	<0.0001	<0.001	0.01	<0.001	0.988	<0.001	0.026
CCF03B_S	18/08/2013 11:15:00			0.002	0.35	<0.0001	0.013	0.002	<0.05	<0.001	<0.001	<0.0001	<0.001	0.01	<0.001	0.863	<0.001	0.008
CCF03B_S	23/02/2014 15:00:00			<0.001	0.34	<0.0001	0.015	0.05	<0.05	<0.001	0.004	<0.0001	0.004	<0.01	<0.001	0.862		0.01
Background	Minimum	Zone D	Shallow		0.38				0.00		0.00					1.00		
	Maximum				0.60				0.16		0.96					1.24		
	Average				0.49				0.03		0.19					1.12		
Period of Triennial review		Zone D	Tertiary Detritals															
	Minimum			0.001	0.080		0.013	0.001	0.00		0.000		0.004			0.28		0.01
	Maximum			0.002	0.600		0.015	0.050	0.16		0.959		0.010			2.11		0.07
	Average			0.002	0.292		0.014	0.010	0.03		0.159		0.007			0.93		0.03

Blue highlight indicates values above maximum concentration measured prior to operations.

APPENDIX IV



I:\\436-0\Grapher\CB 14-01\Appendix IV\App IV-A Boron 2007-13 Zn A.grf

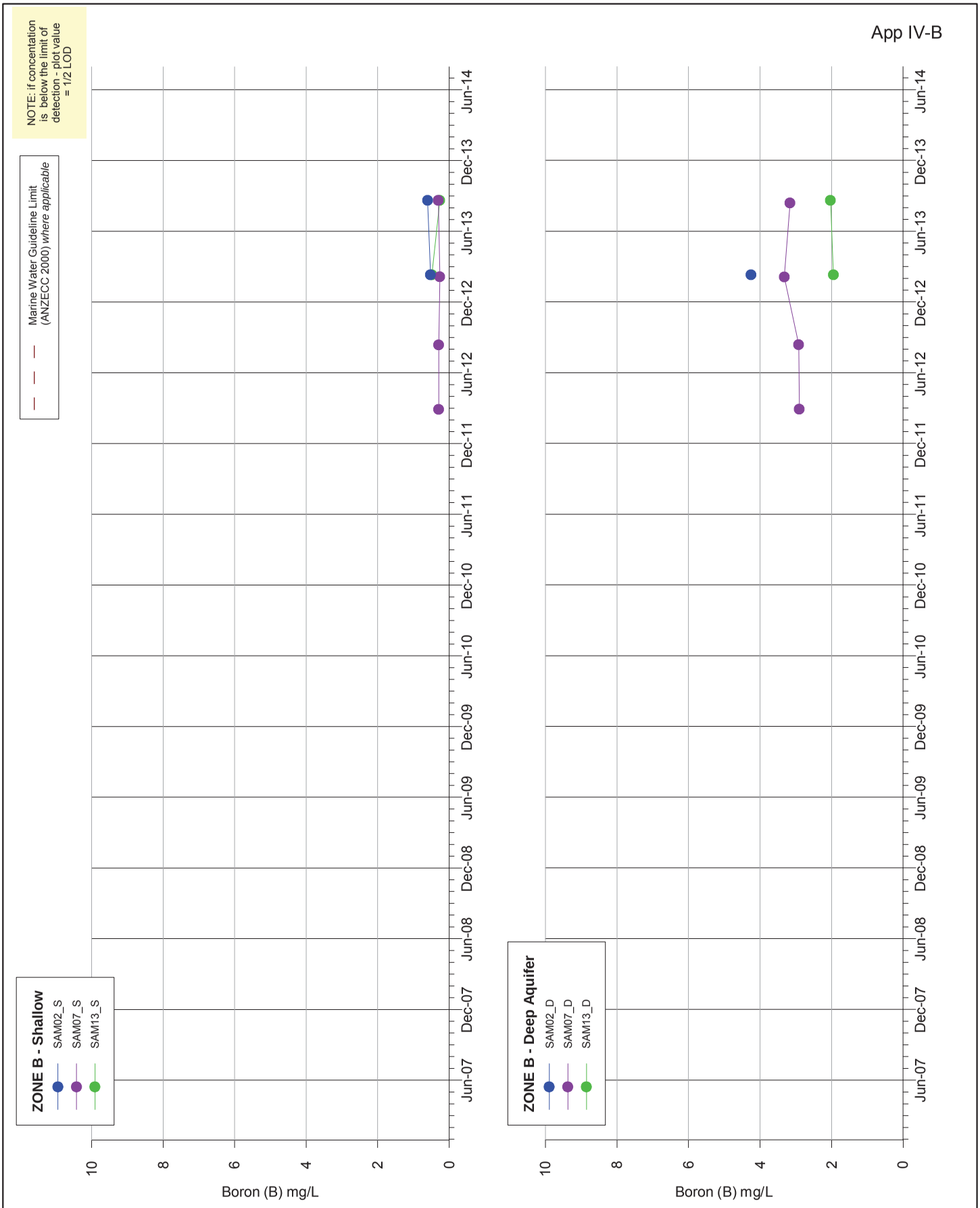
Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/2-App IV-A

2013 GWOS MONITORING BORES
BORON IN SHALLOW & DEEP AQUIFER
Zone A : Near Marsh Region



I:\\436-0\Grapher\CB 14-01\Appendix IV\App IV-B Boron 2007-13 Zn A.grf

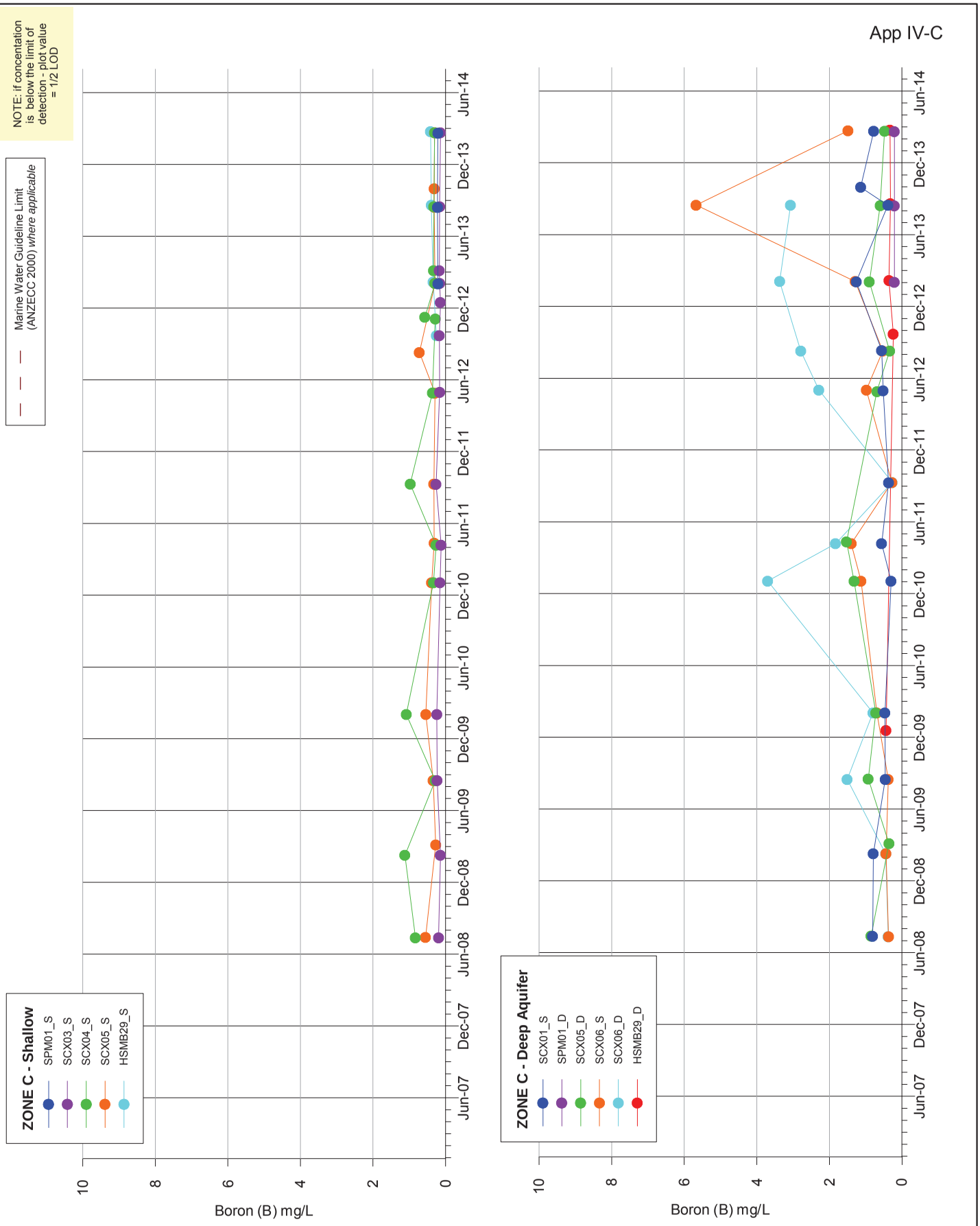
Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/2-App IV-B

2013 GWOS MONITORING BORES
BORON IN SHALLOW & DEEP AQUIFER
Zone B : Saline Injection Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-C Boron 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

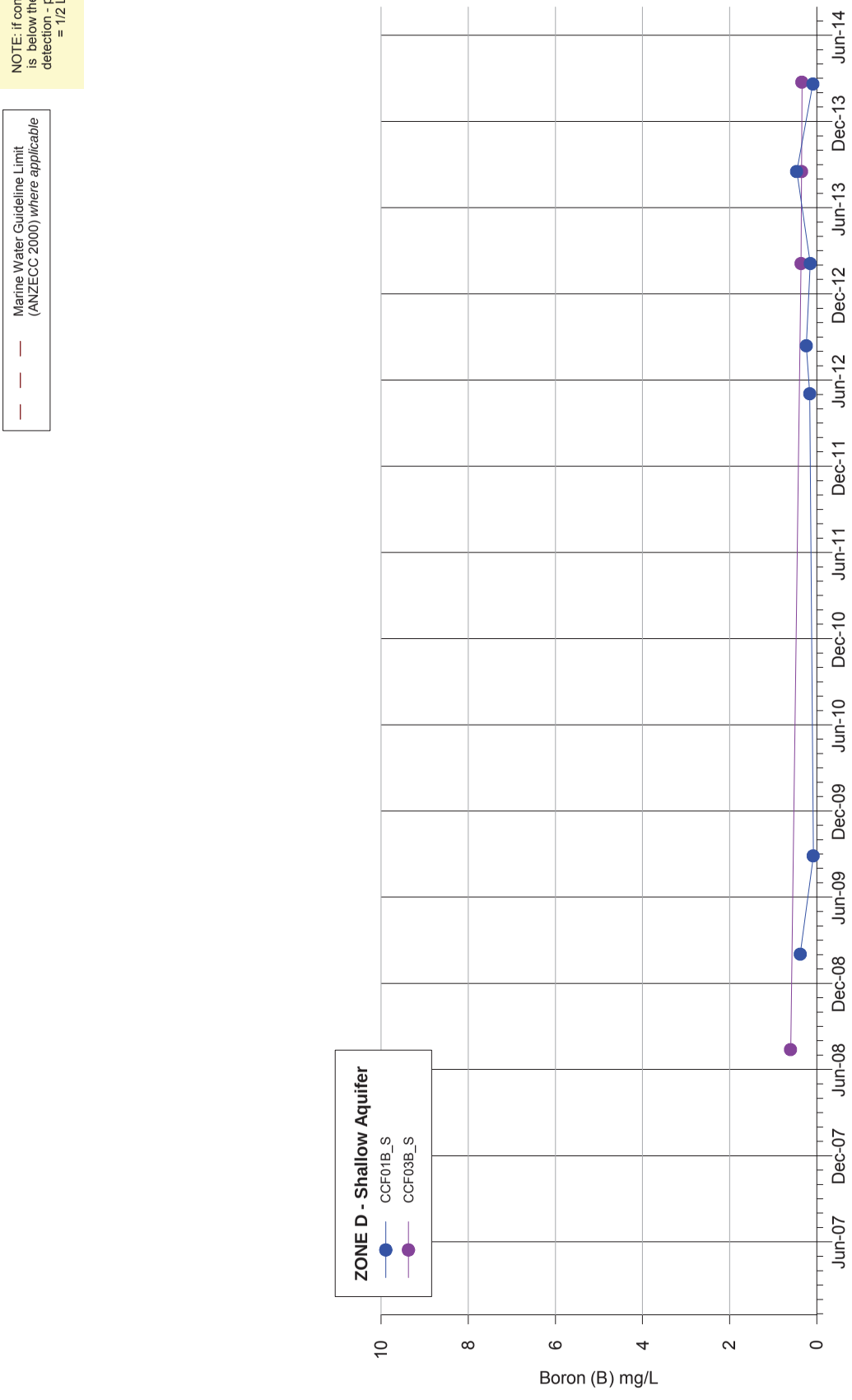
Dwg. No: 436-0/14/2-App IV-C

2013 GWOS MONITORING BORES

BORON IN SHALLOW & DEEP AQUIFER

Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-D Boron 2007-13 Zn C,D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

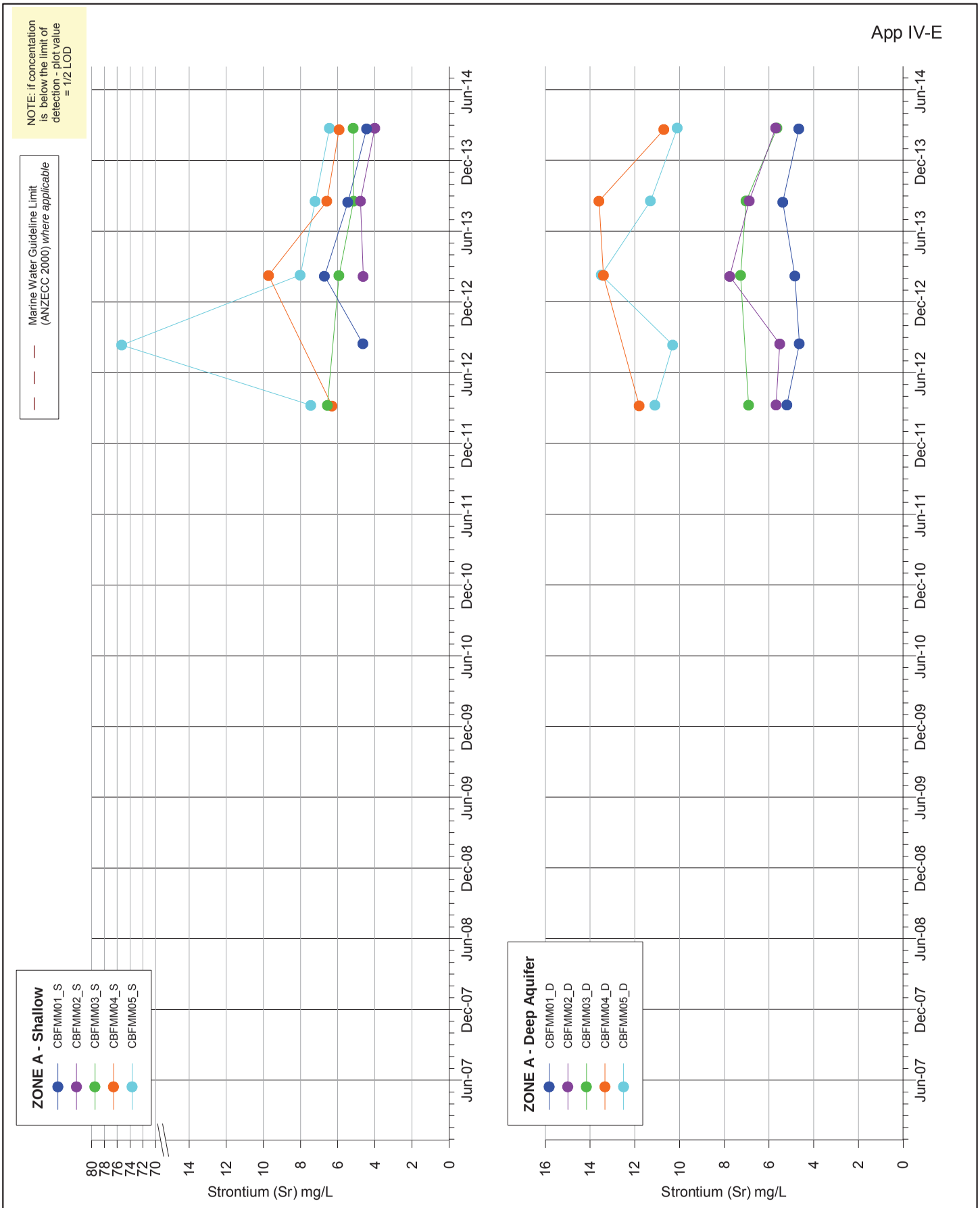
Date : June 2014

Dwg. No: 436-0/14/2-App IV-D

2013 GWOS MONITORING BORES

BORON IN SHALLOW AQUIFER

Zone D : Phreatophytic Vegetation Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-E Strontium 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

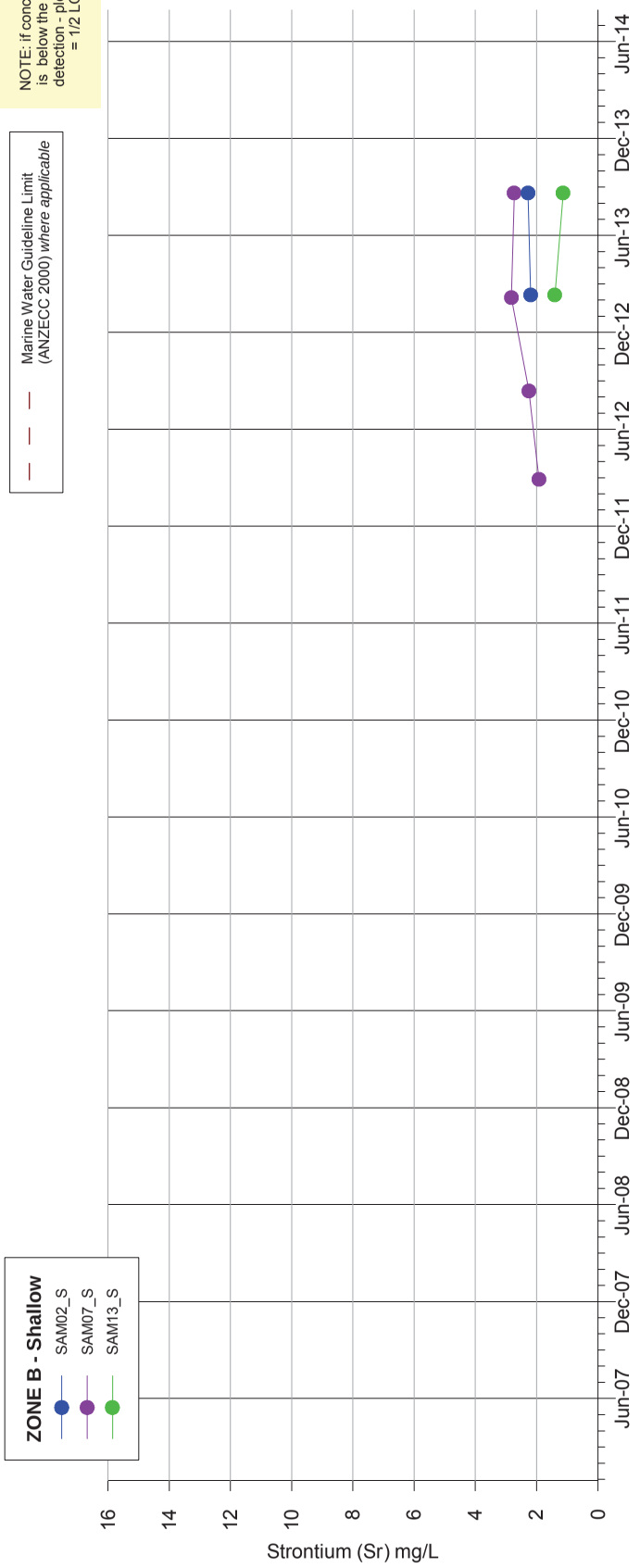
Dwg. No: 436-0/14/2-App IV-E

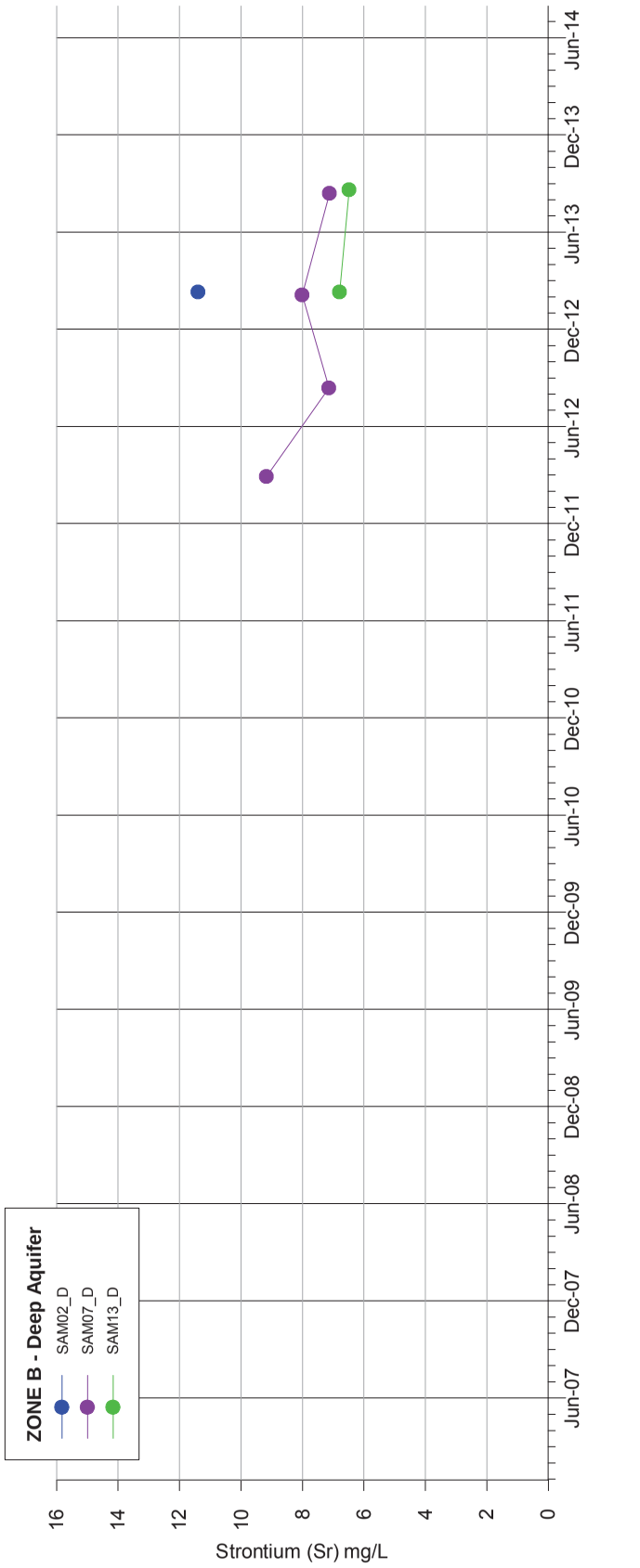
2013 GWOS MONITORING BORES

STRONTIUM IN SHALLOW & DEEP AQUIFER

Zone A : Near Marsh Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD





I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-F Strontium 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

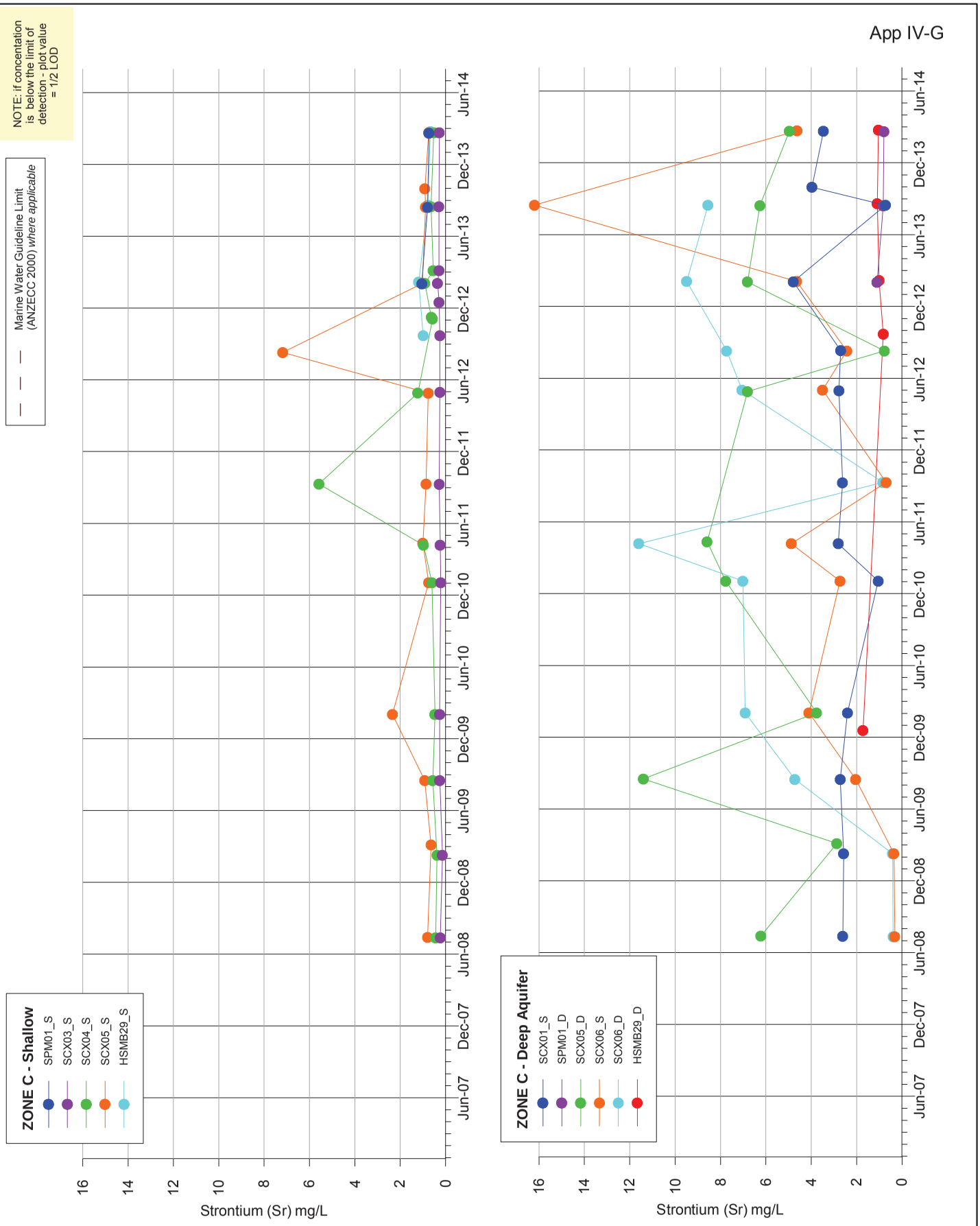
Date : June 2014

Dwg. No: 436-0/14/2-App IV-F

2013 GWOS MONITORING BORES

STRONTIUM IN SHALLOW & DEEP AQUIFER

Zone B: Saline Injectio Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-G Strontium 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

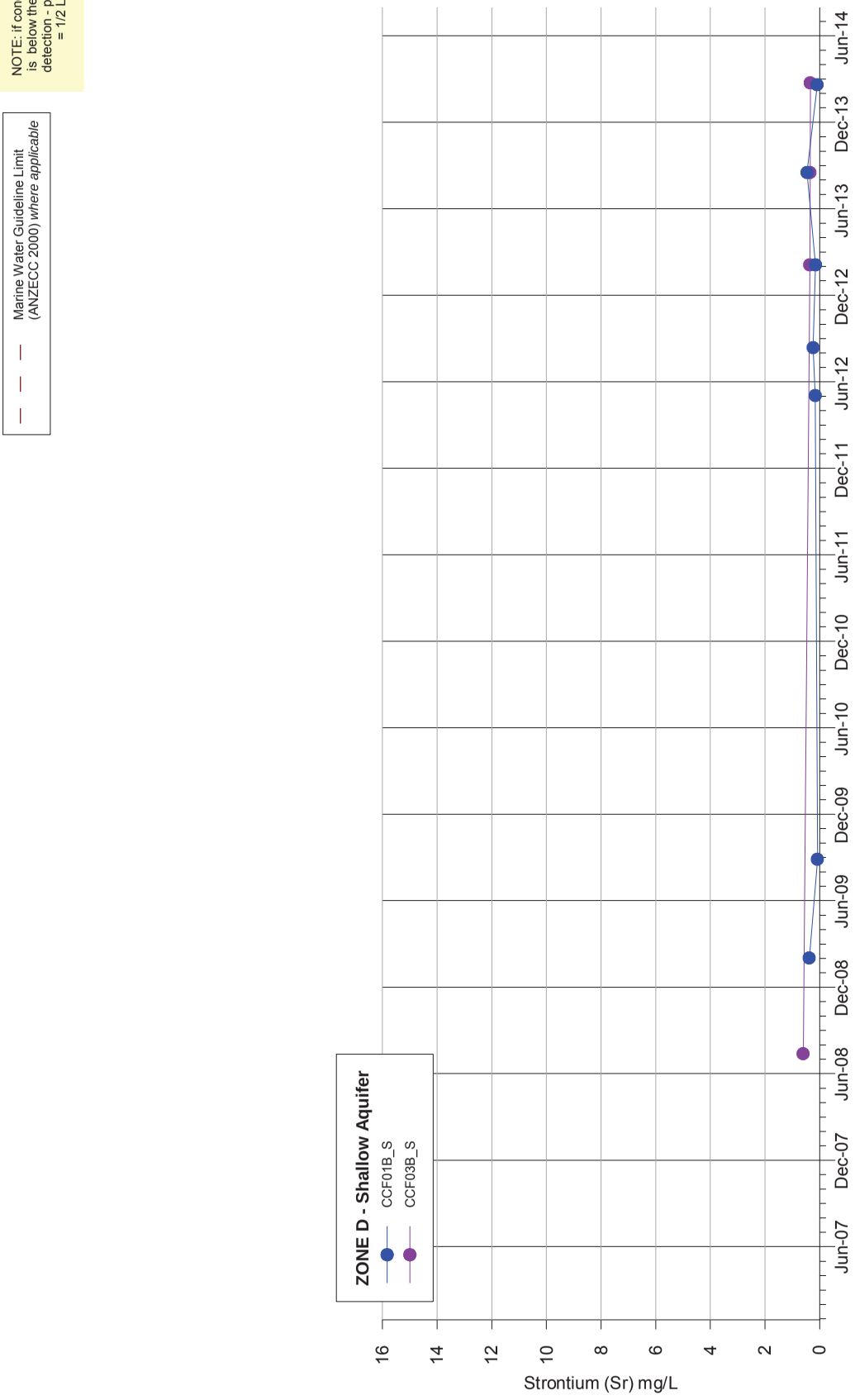
Dwg. No: 436-0/14/2-App IV-G

2013 GWOS MONITORING BORES

STRONTIUM IN SHALLOW & DEEP AQUIFER

Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-H Strontium 2007-13 Zn C,D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

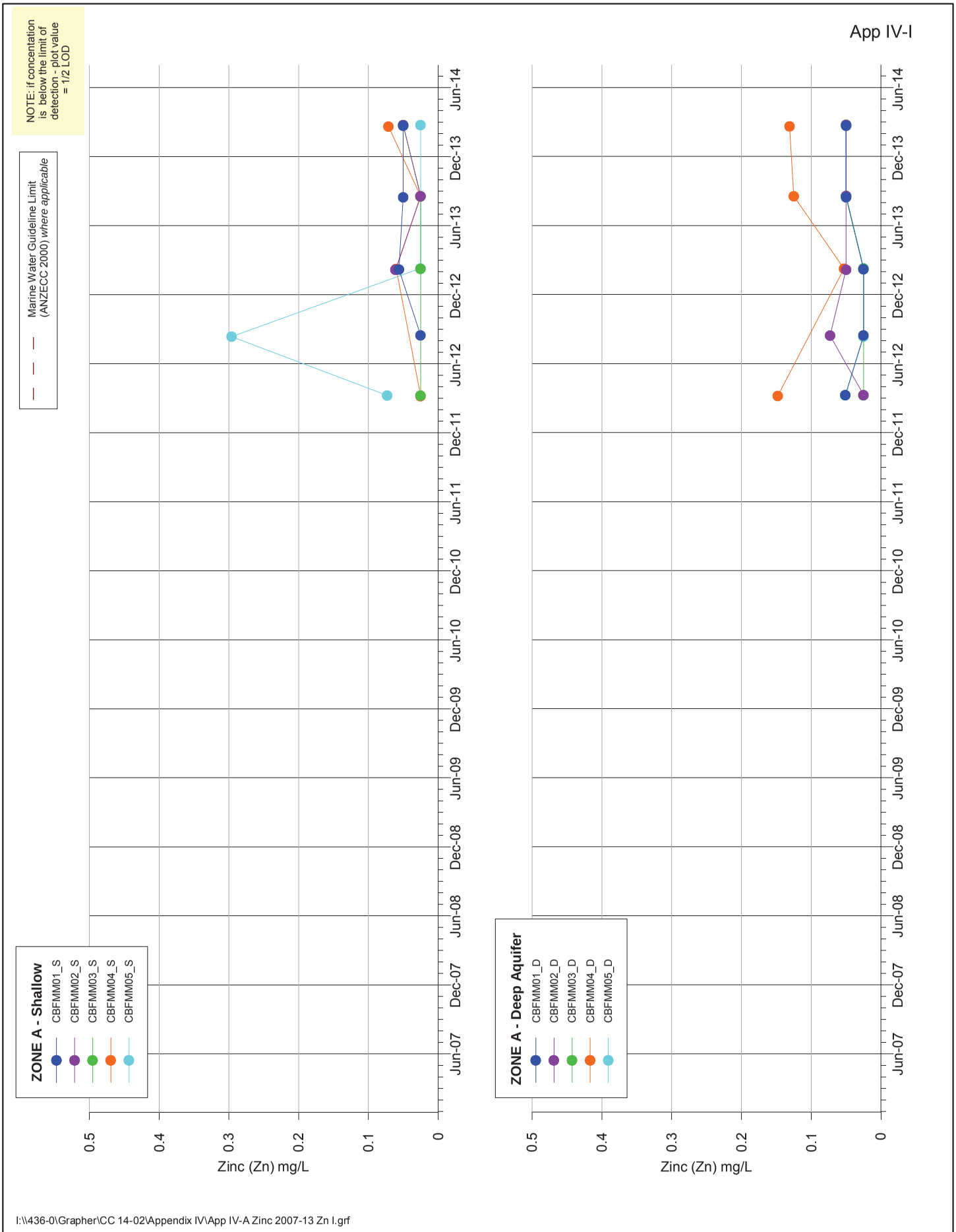
Date : June 2014

Dwg. No: 436-0/14/2-App IV-H

2013 GWOS MONITORING BORES

STRONTIUM IN SHALLOW AQUIFER

ZoneD : Phreatophytic Vegetation Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-A Zinc 2007-13 Zn I.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

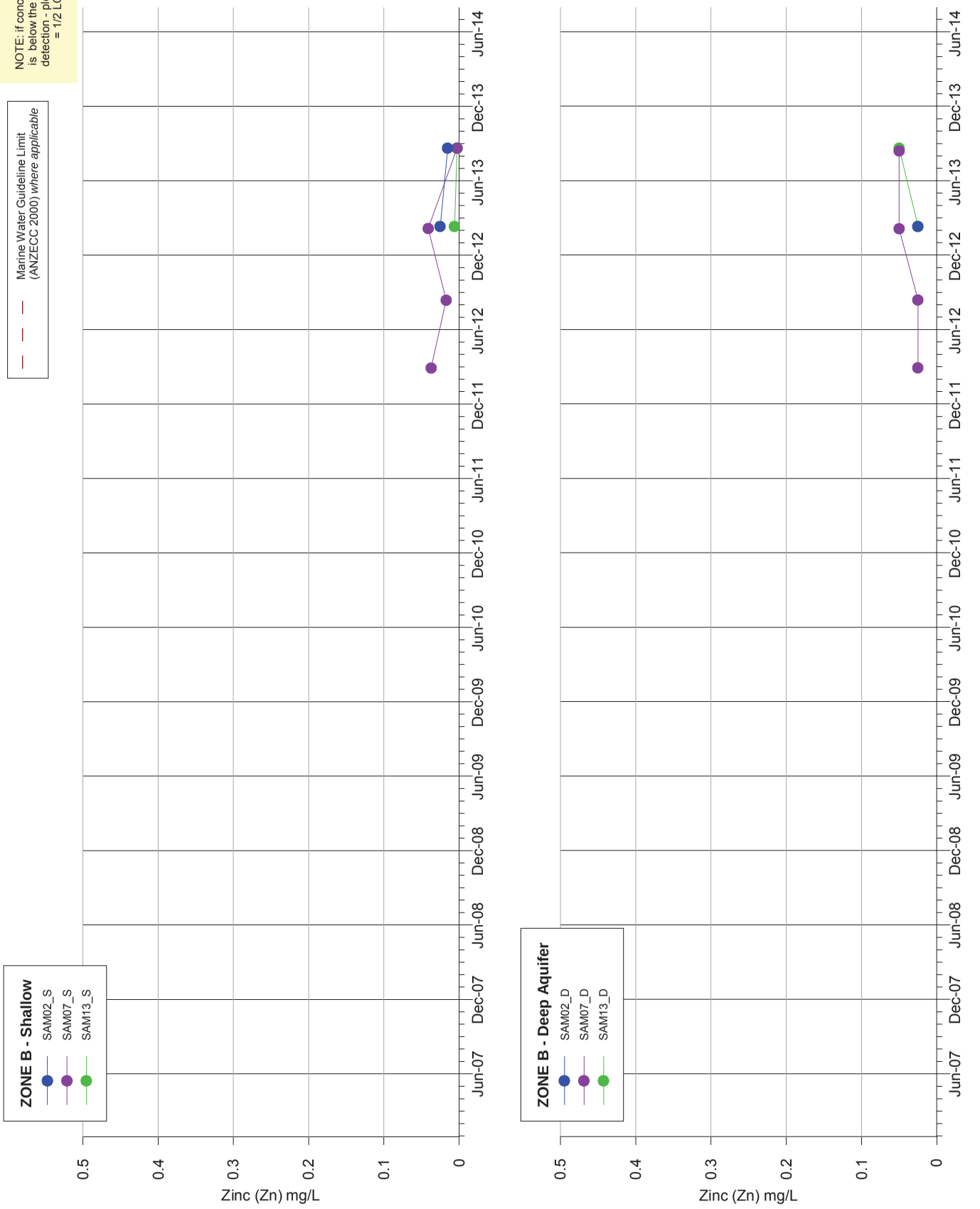
Dwg. No: 436-0/14/2-App IV-I

2013 GWOS MONITORING BORES

ZINC IN SHALLOW & DEEP AQUIFER

Zone A : Near Marsh Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-J Zinc 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

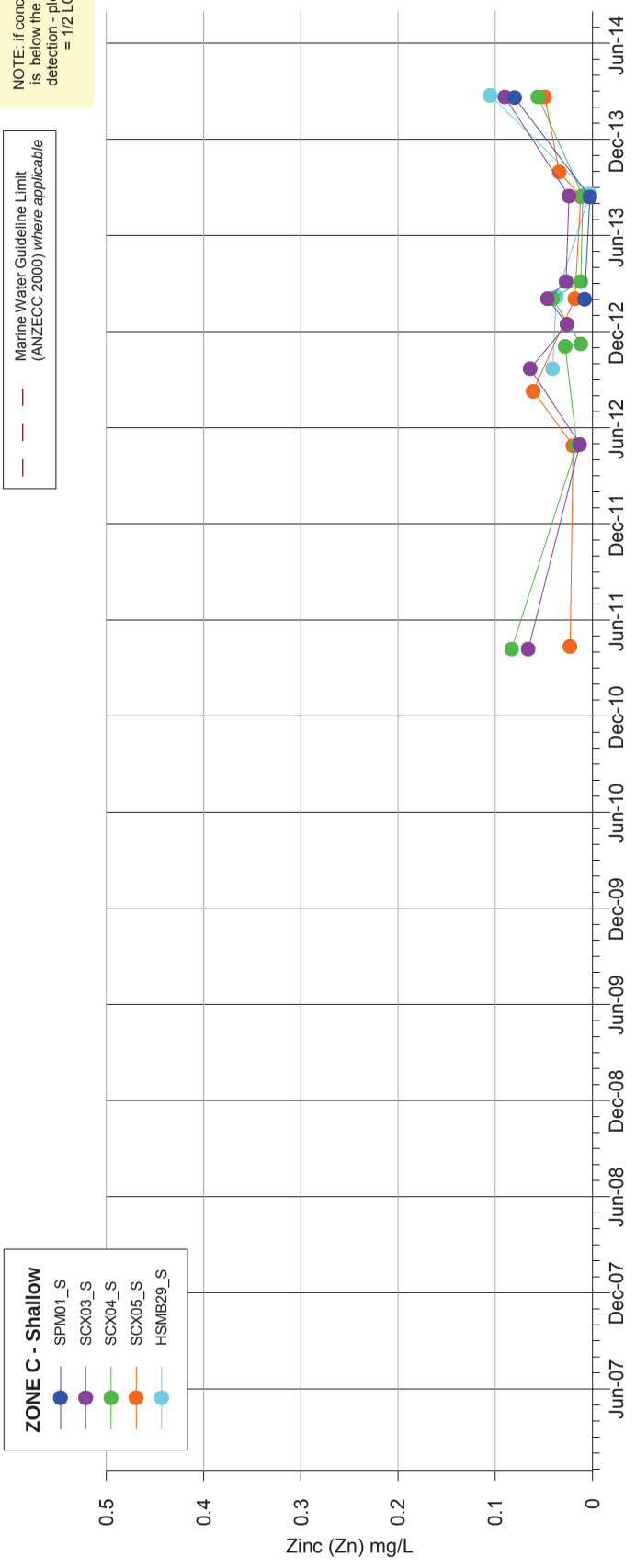
Dwg. No: 436-0/14/2-App IV-J

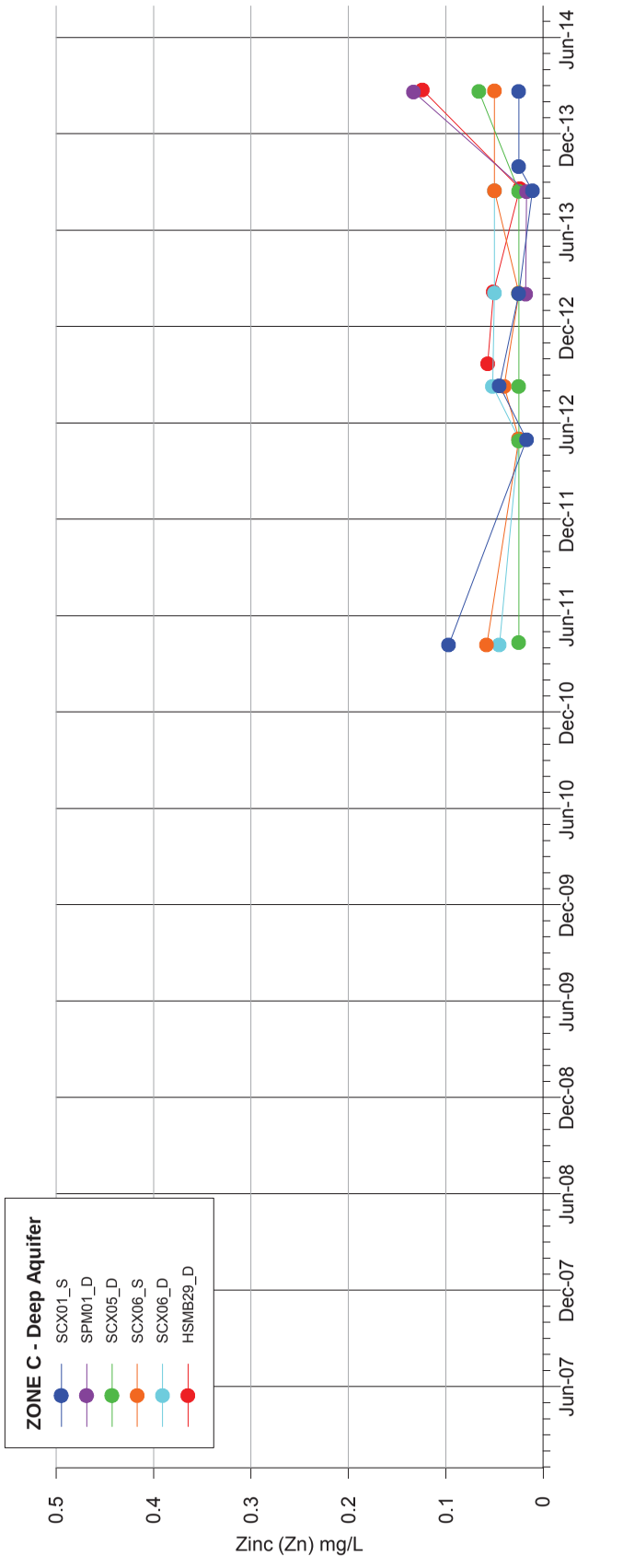
2013 GWOS MONITORING BORES

ZINC IN SHALLOW & DEEP AQUIFER

Zone B : Saline Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD





I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-K Zinc 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

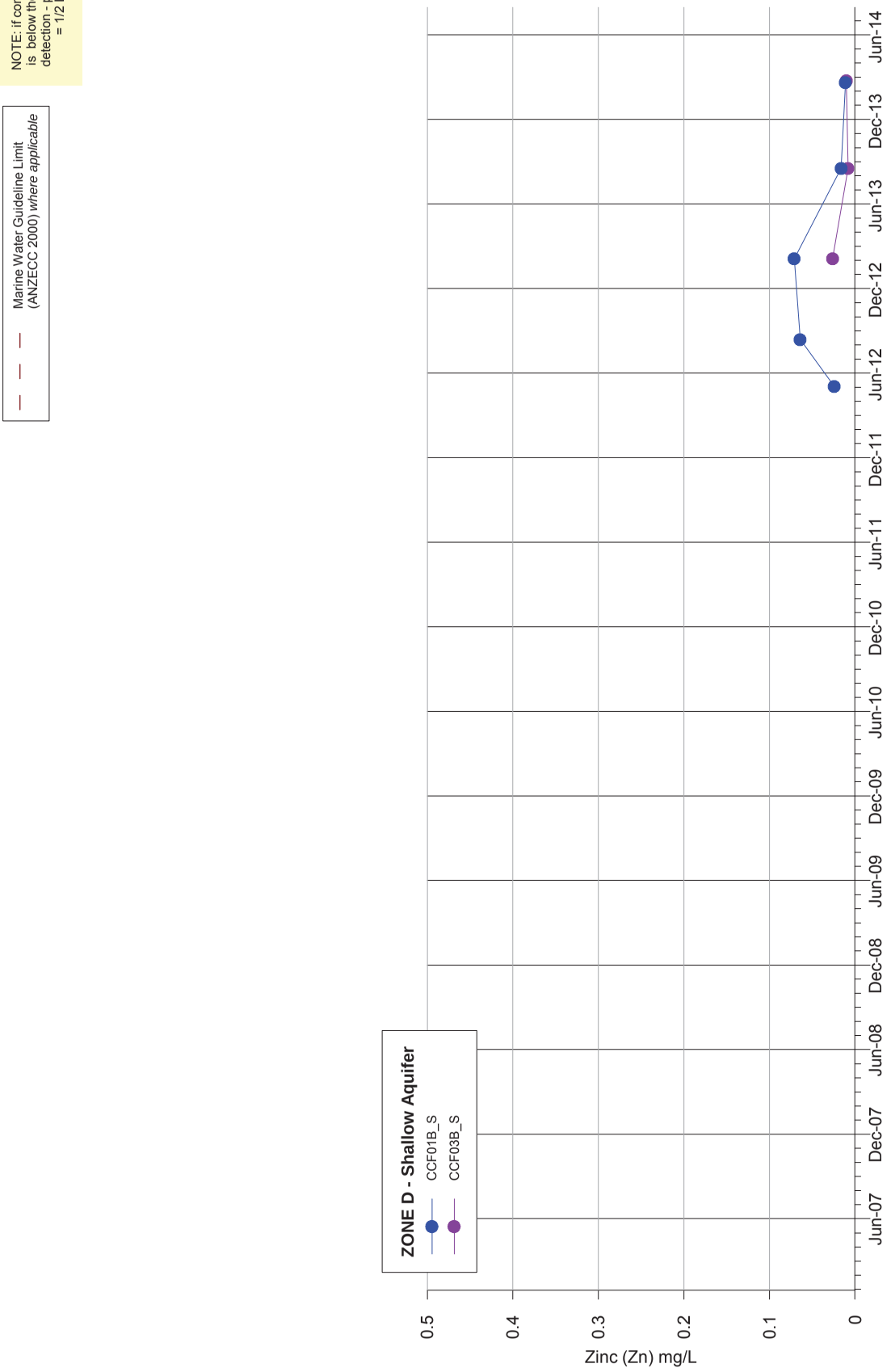
Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/2-App IV-K

2013 GWOS MONITORING BORES
ZINC IN SHALLOW & DEEP AQUIFER
Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-L Zinc 2007-13 Zn D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

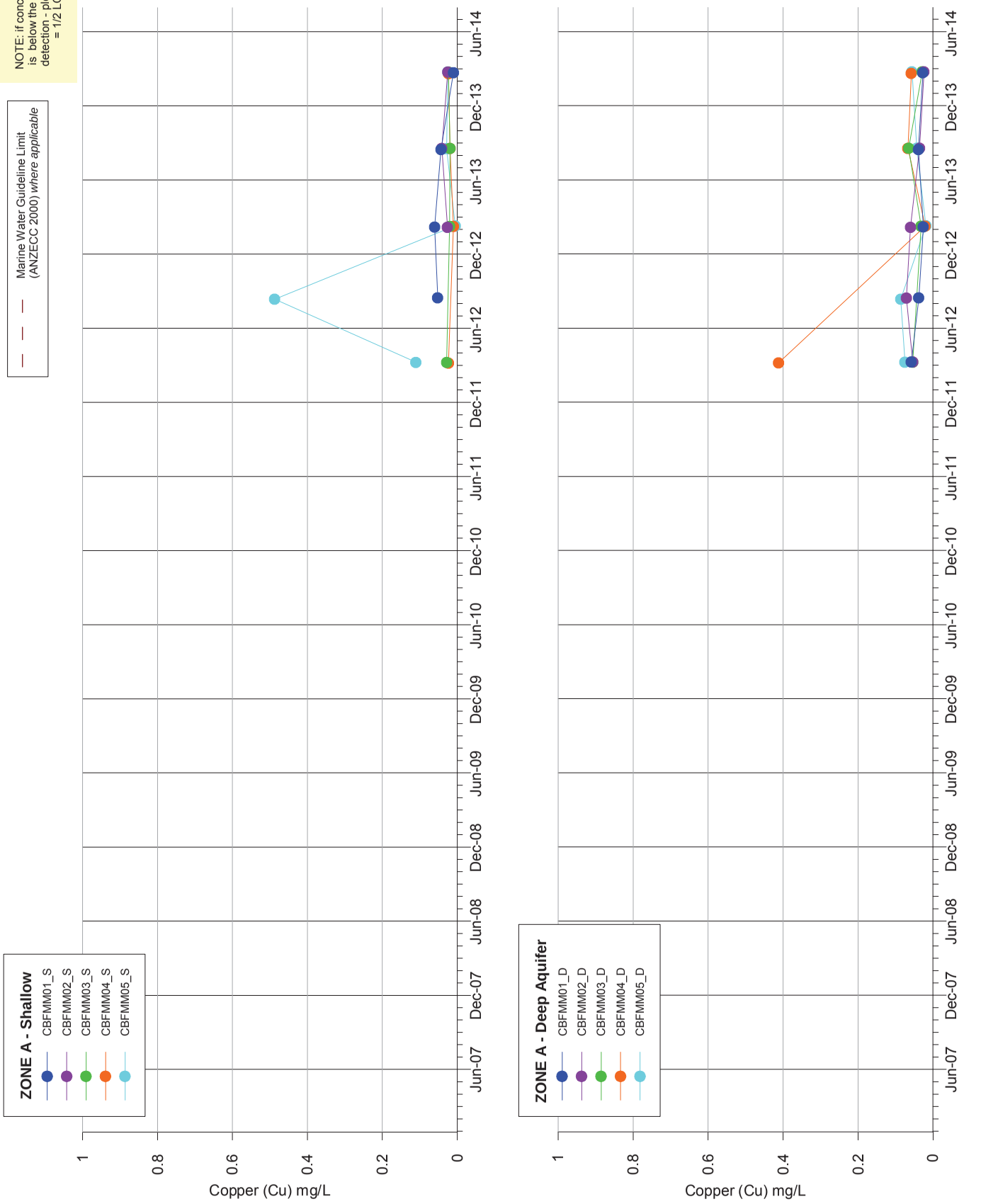
Dwg. No: 436-0/14/2-App IV-L

2013 GWOS MONITORING BORES

ZINC IN SHALLOW AQUIFER

Zone D : Phreatophytic Vegetation Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-M Copper 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/1-App IV-M

2013 GWOS MONITORING BORES
COPPER IN SHALLOW & DEEP AQUIFER
Zone A : Near Marsh Region

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

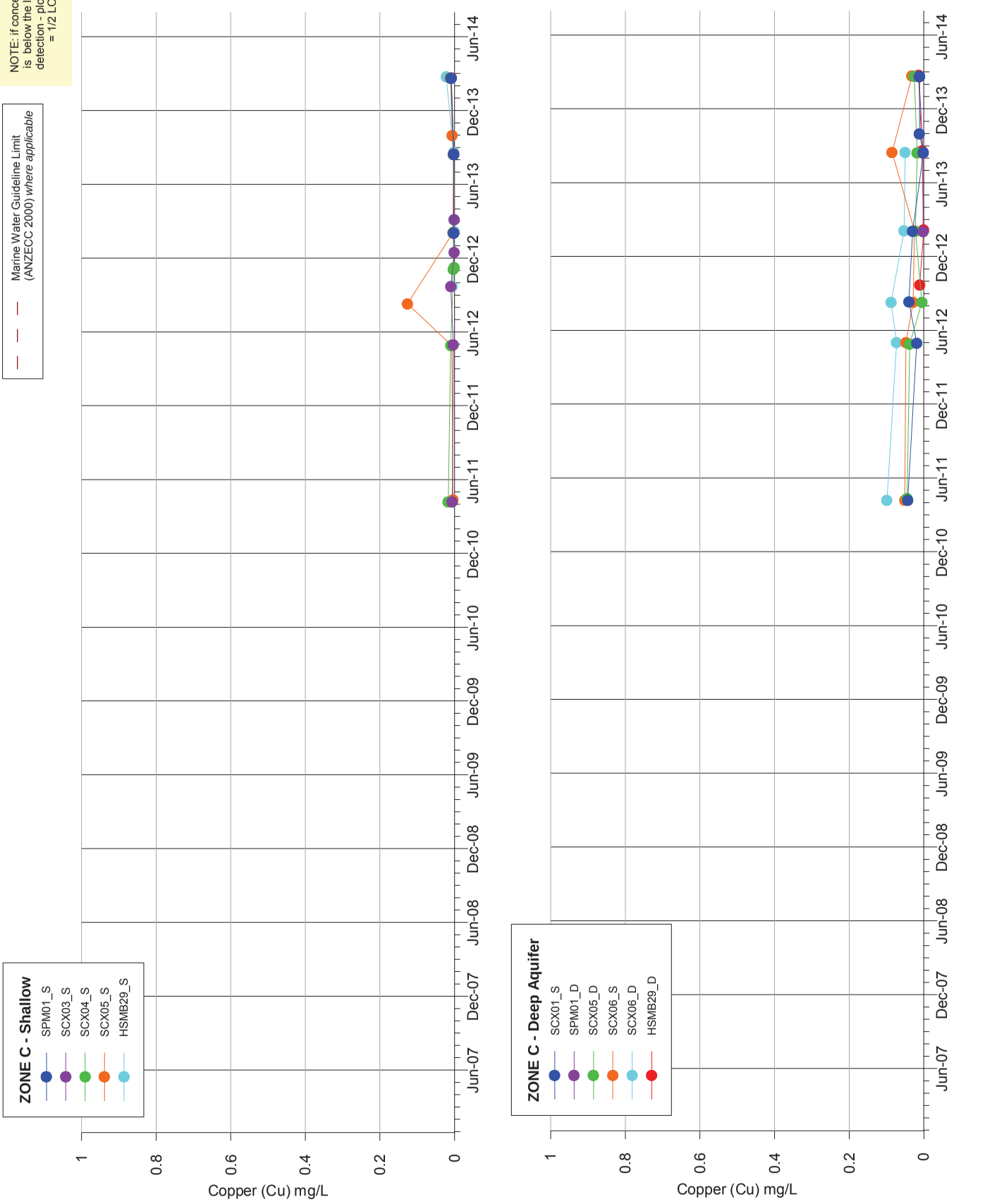
Date : June 2014

Dwg. No: 436-0/14/1-App IV-N

I:\436-0\Grapher\CC 14-02\Appendix IV\App IV-N Copper 2007-13 Zn A.grf

2013 GWOS MONITORING BORES
COPPER IN SHALLOW & DEEP AQUIFER
Zone B : Saline Injection Region

App IV-N



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-O Copper 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

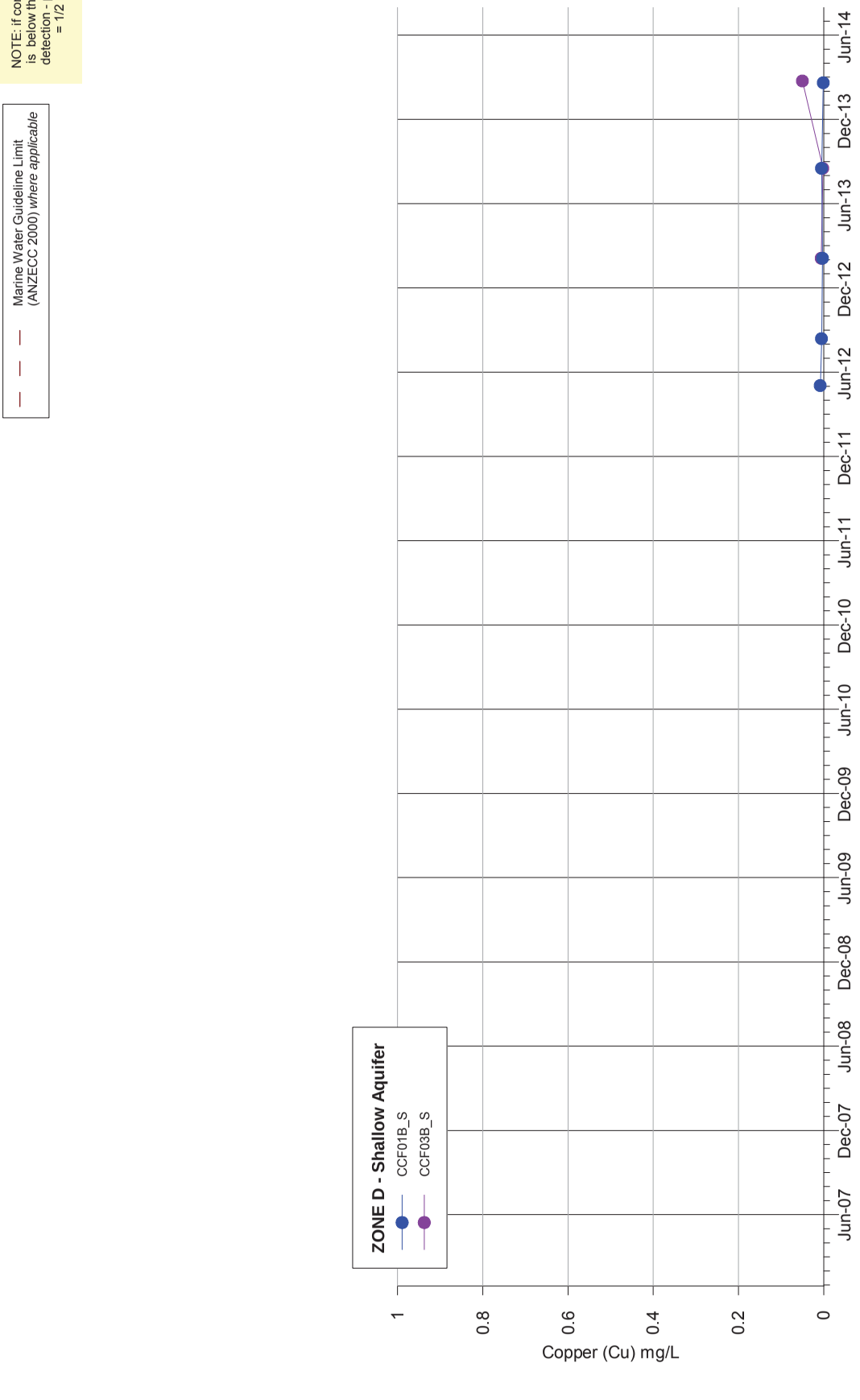
Dwg. No: 436-0/14/1-App IV-O

2013 GWOS MONITORING BORES

COPPER IN SHALLOW & DEEP AQUIFER

Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-P Copper 2007-13 Zn D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

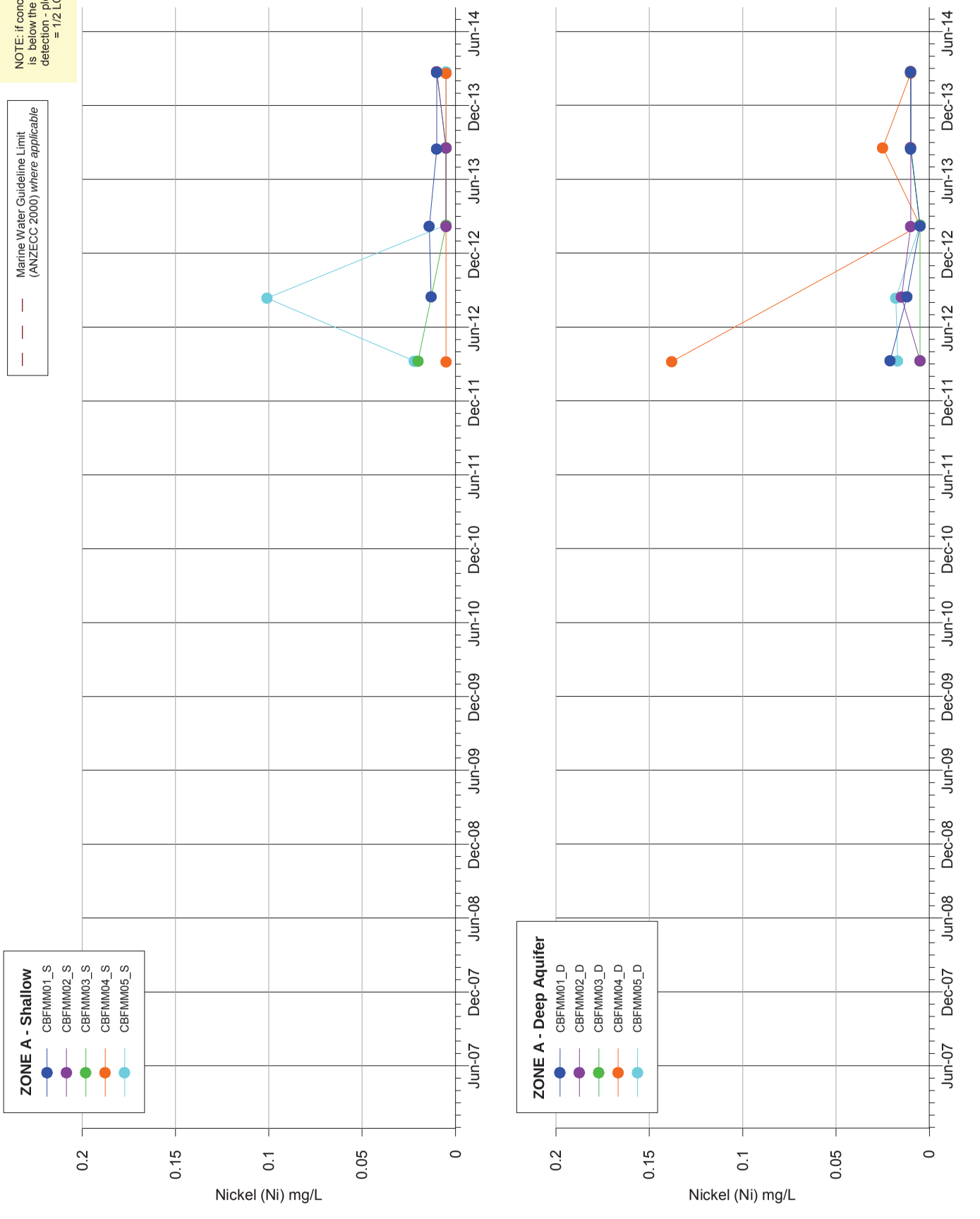
Dwg. No: 436-0/14/1-App IV-P

2013 GWOS MONITORING BORES

COPPER IN SHALLOW AQUIFER

Zone D : Phreatophytic Vegetation Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-Q Nickel 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

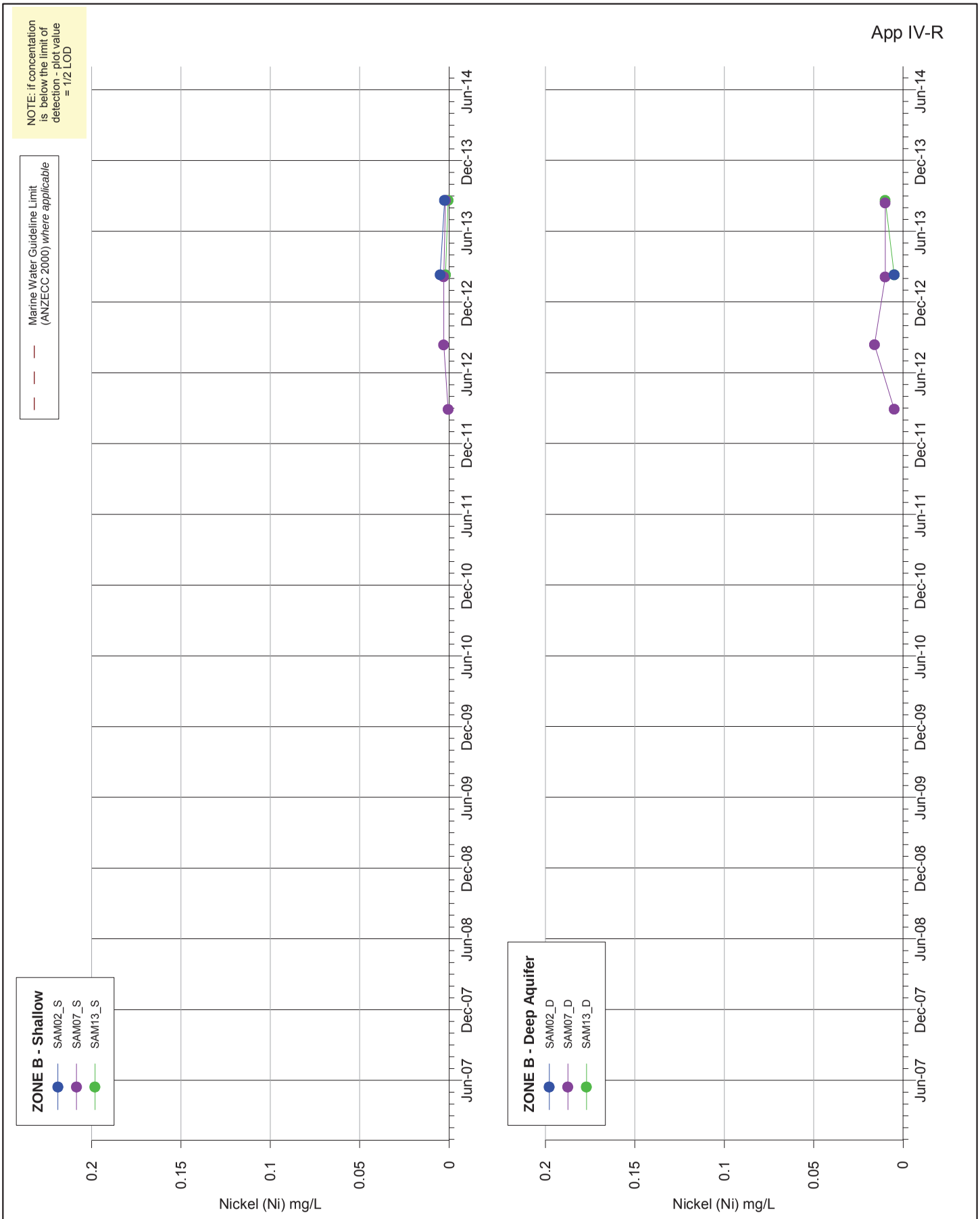
Date : June 2014

Dwg. No: 436-0/14/1-App IV-Q

2013 GWOS MONITORING BORES

NICKEL IN SHALLOW & DEEP AQUIFER

Zone A : Near Marsh Region



I:\436-0\Grapher\CC 14-02\Appendix IV\App IV-R Nickel 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

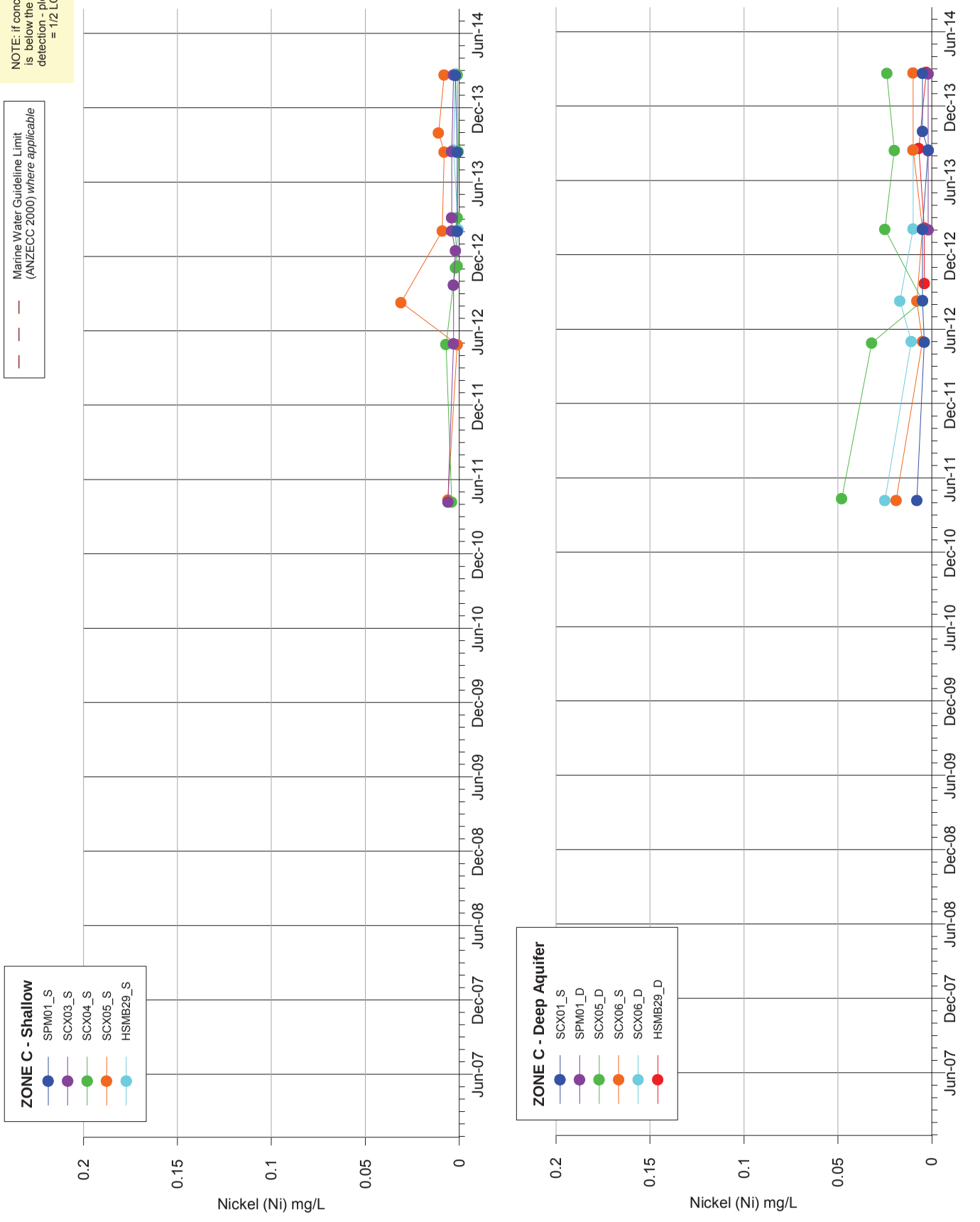
Date : June 2014

Dwg. No: 436-0/14/1-App IV-R

2013 GWOS MONITORING BORES

NICKEL IN SHALLOW & DEEP AQUIFER

Zone B : Saline Injection Region



I:\\436-0\Grapher\CC 14-021\Appendix IV\App IV-S Nickel 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/1-App IV-S

2013 GWOS MONITORING BORES

NICKEL IN SHALLOW & DEEP AQUIFER

Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD

I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-T Nickel 2007-13 Zn D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

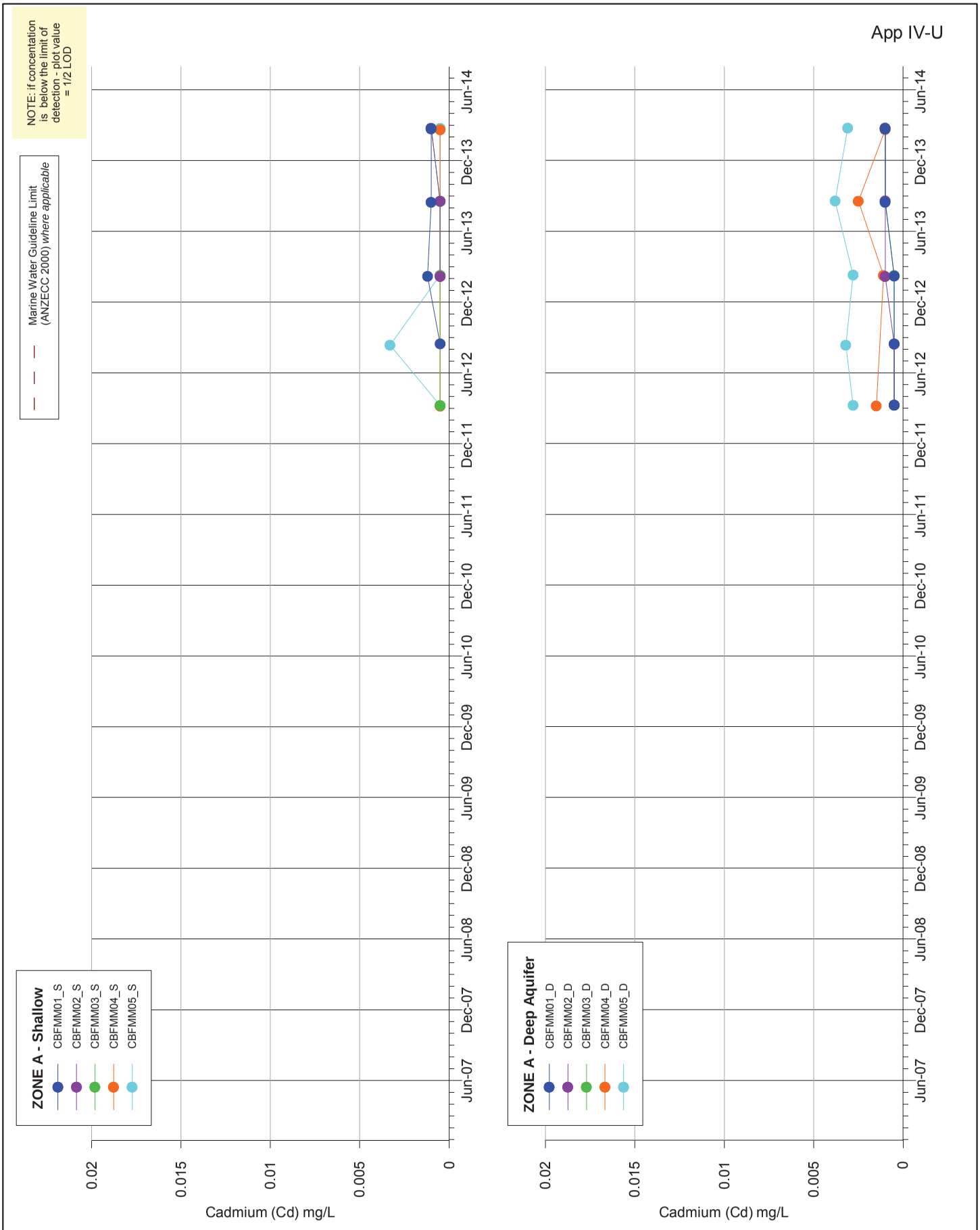
Date : June 2014

Dwg. No: 436-0/14/1-App IV-T

2013 GWOS MONITORING BORES

NICKEL IN SHALLOW AQUIFER

Zone C & D : Phreatophytic Vegetation Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-U Cadmium 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/1-App IV-U

2013 GWOS MONITORING BORES
CADMIUM IN SHALLOW & DEEP AQUIFER
Zone A : Near Marsh Region

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

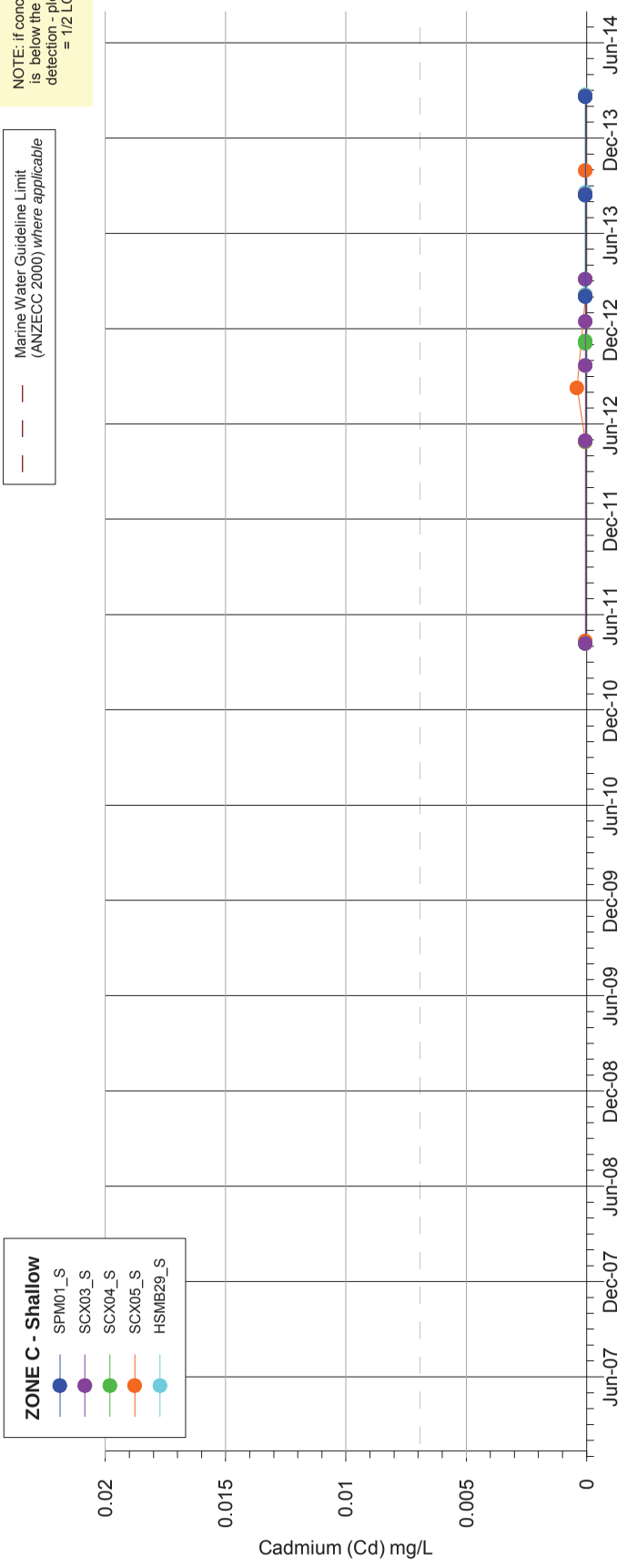
Dwg. No: 436-0/14/1-App IV-V

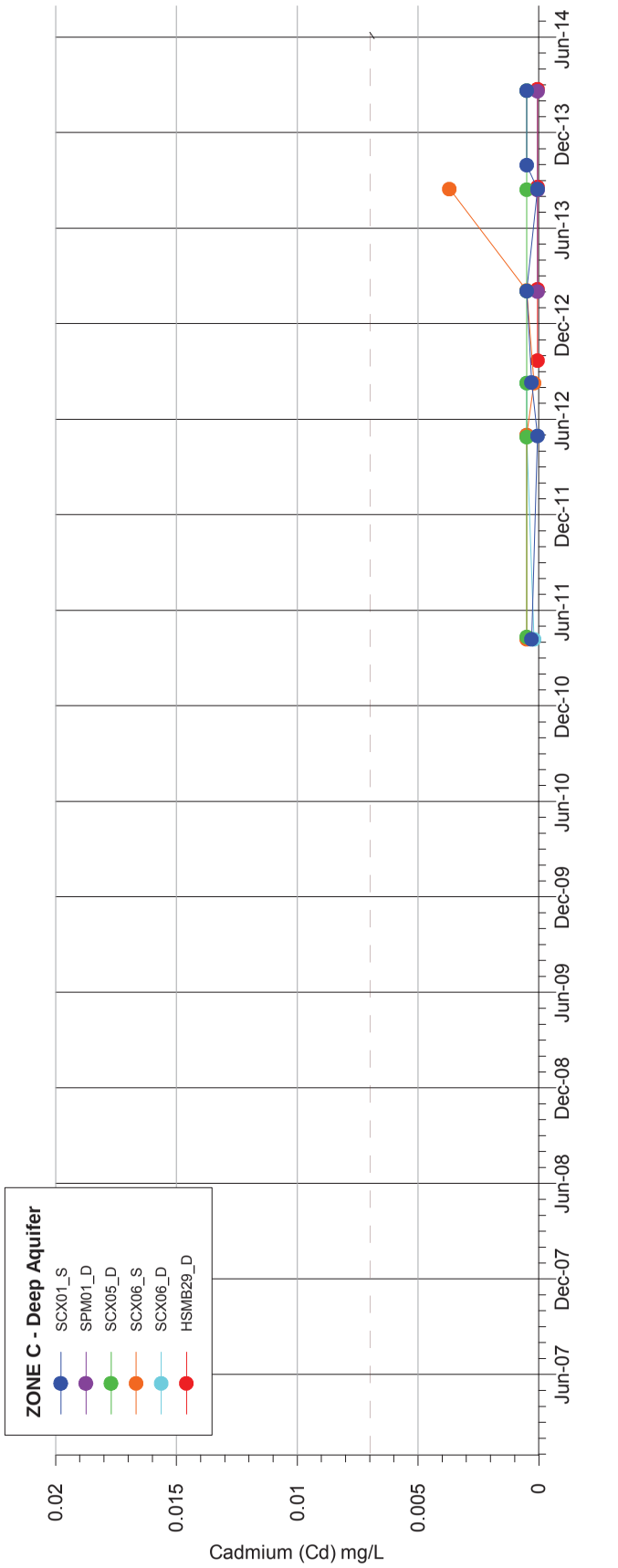
I:\436-0\Grapher\CC 14-02\Appendix IV\App IV-V Cadmium 2007-13 Zn A.grf

2013 GWOS MONITORING BORES
CADMIUM IN SHALLOW & DEEP AQUIFER
Zone B : Saline Injection Region

App IV-V

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD





I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-W Cadmium 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

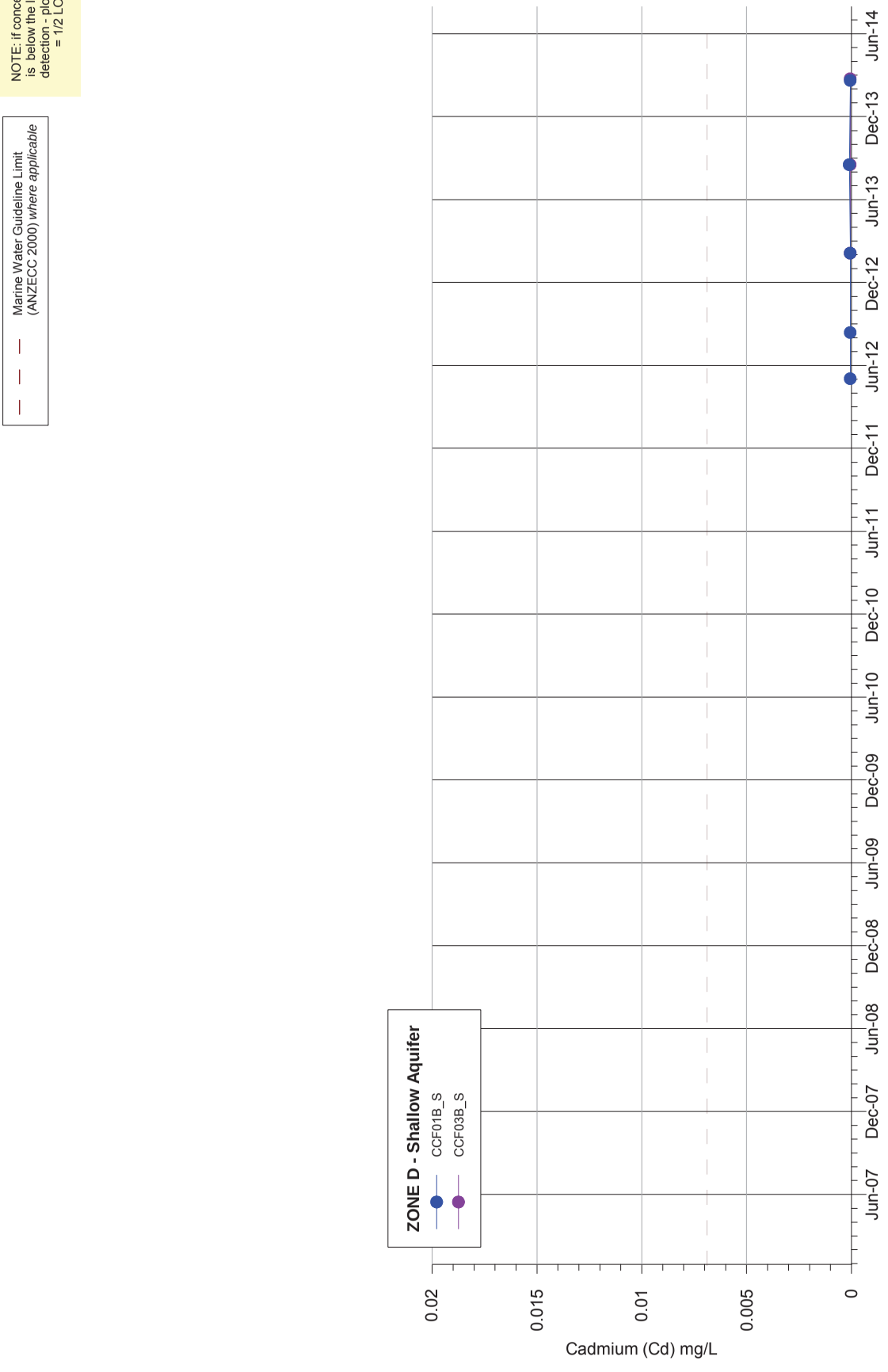
Dwg. No: 436-0/14/1-App IV-W

2013 GWOS MONITORING BORES

CADMIUM IN SHALLOW & DEEP AQUIFER

Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CB 14-01\Appendix IV\App IV-X CADMIUM 2007-13 Zn D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

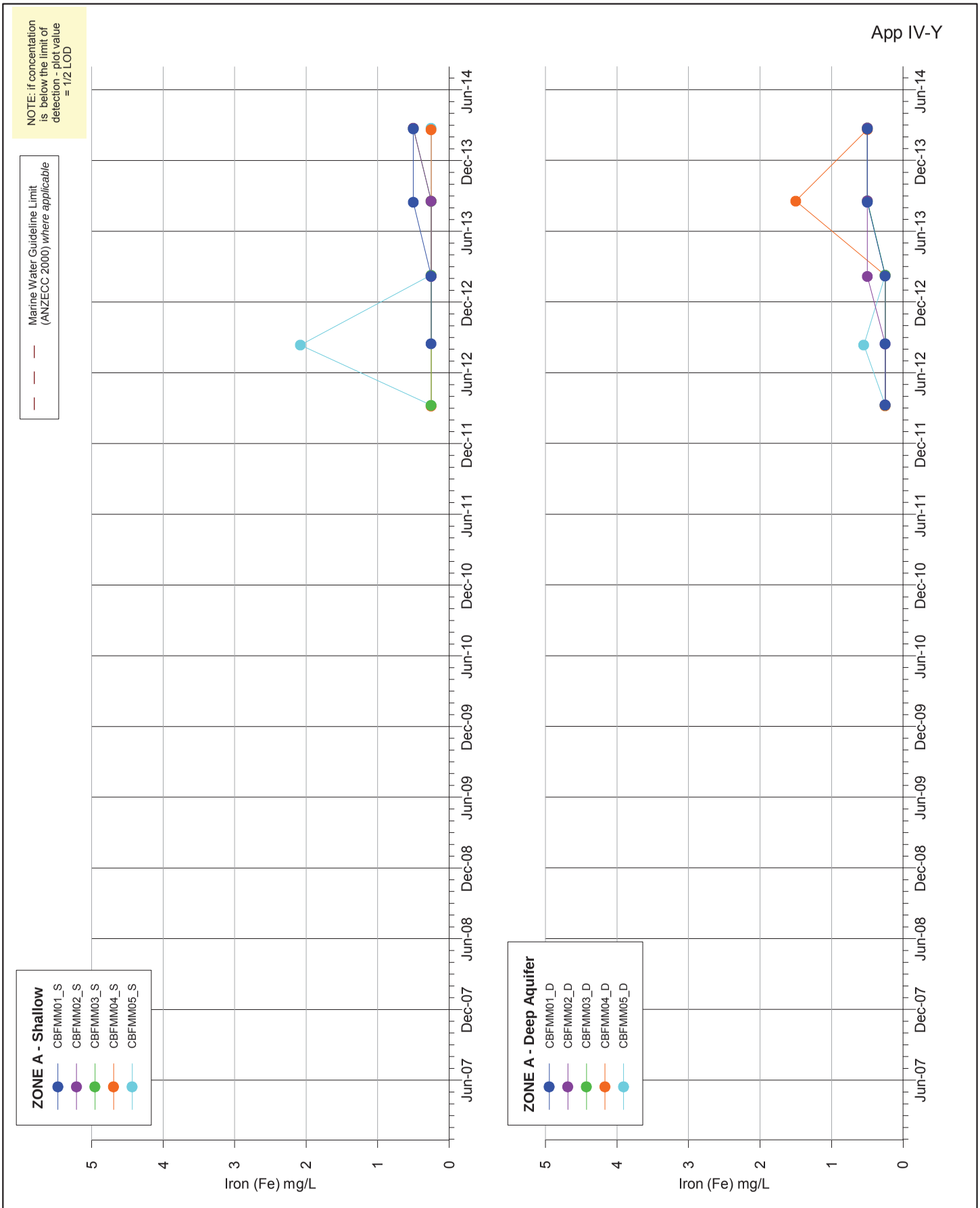
Date : June 2014

Dwg. No: 436-0/14/1-App IV-X

2013 GWOS MONITORING BORES

CADMIUM IN SHALLOW AQUIFER

Zone D : Phreatophytic Vegetation Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-Y Iron 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

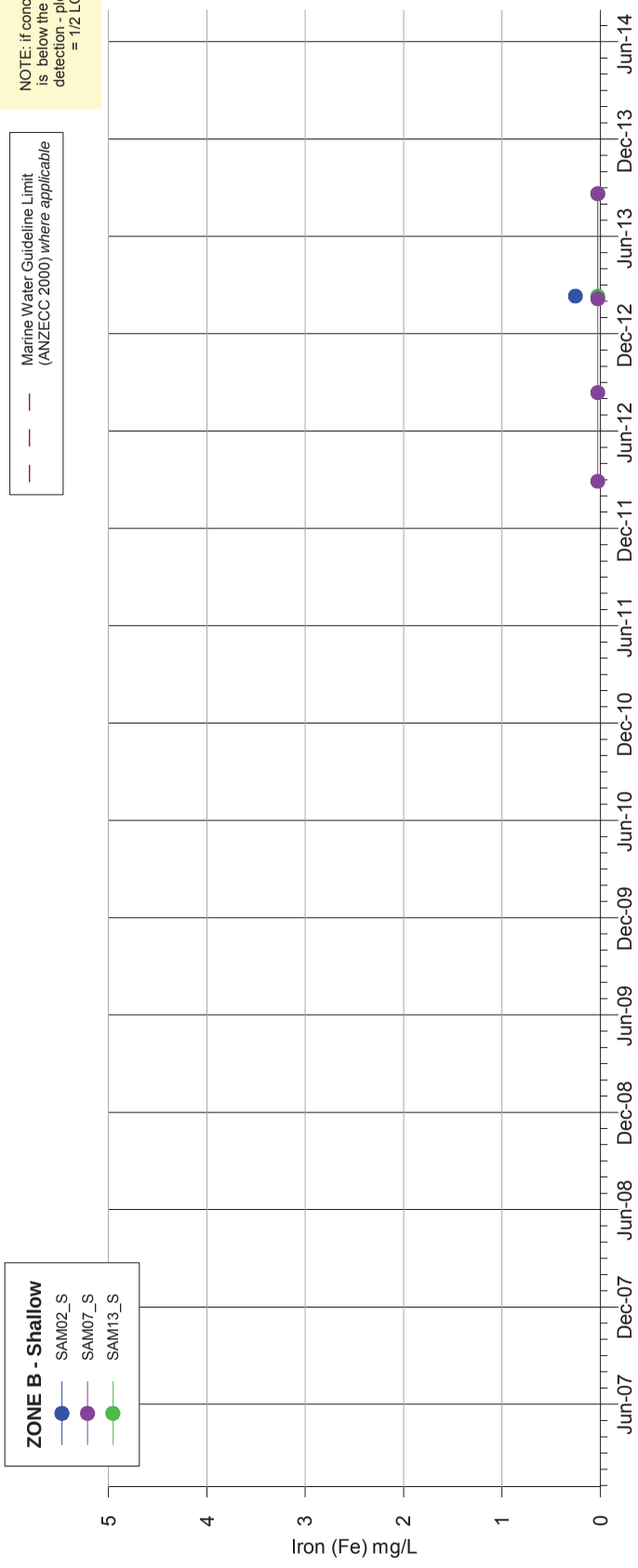
Dwg. No: 436-0/14/1-App IV-Y

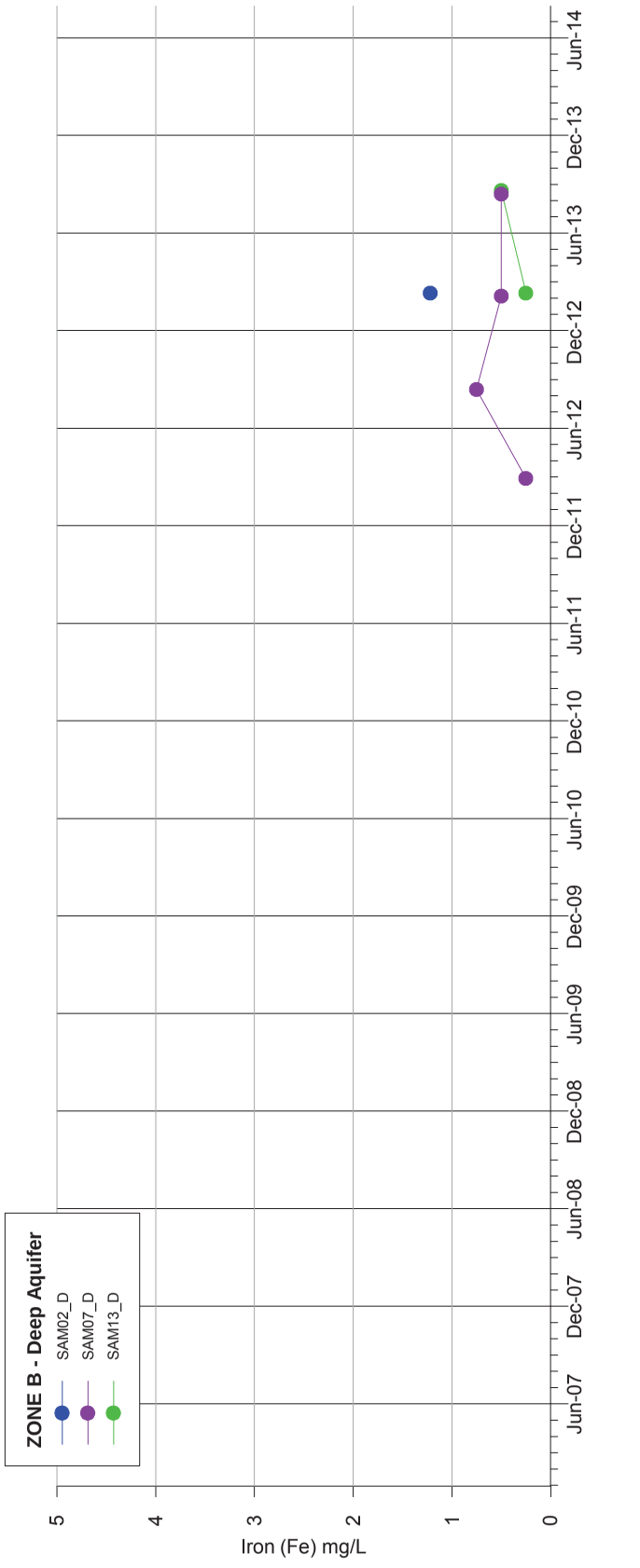
2013 GWOS MONITORING BORES

IRON IN SHALLOW & DEEP AQUIFER

Zone A : Near Marsh Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD





I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-Z Iron 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

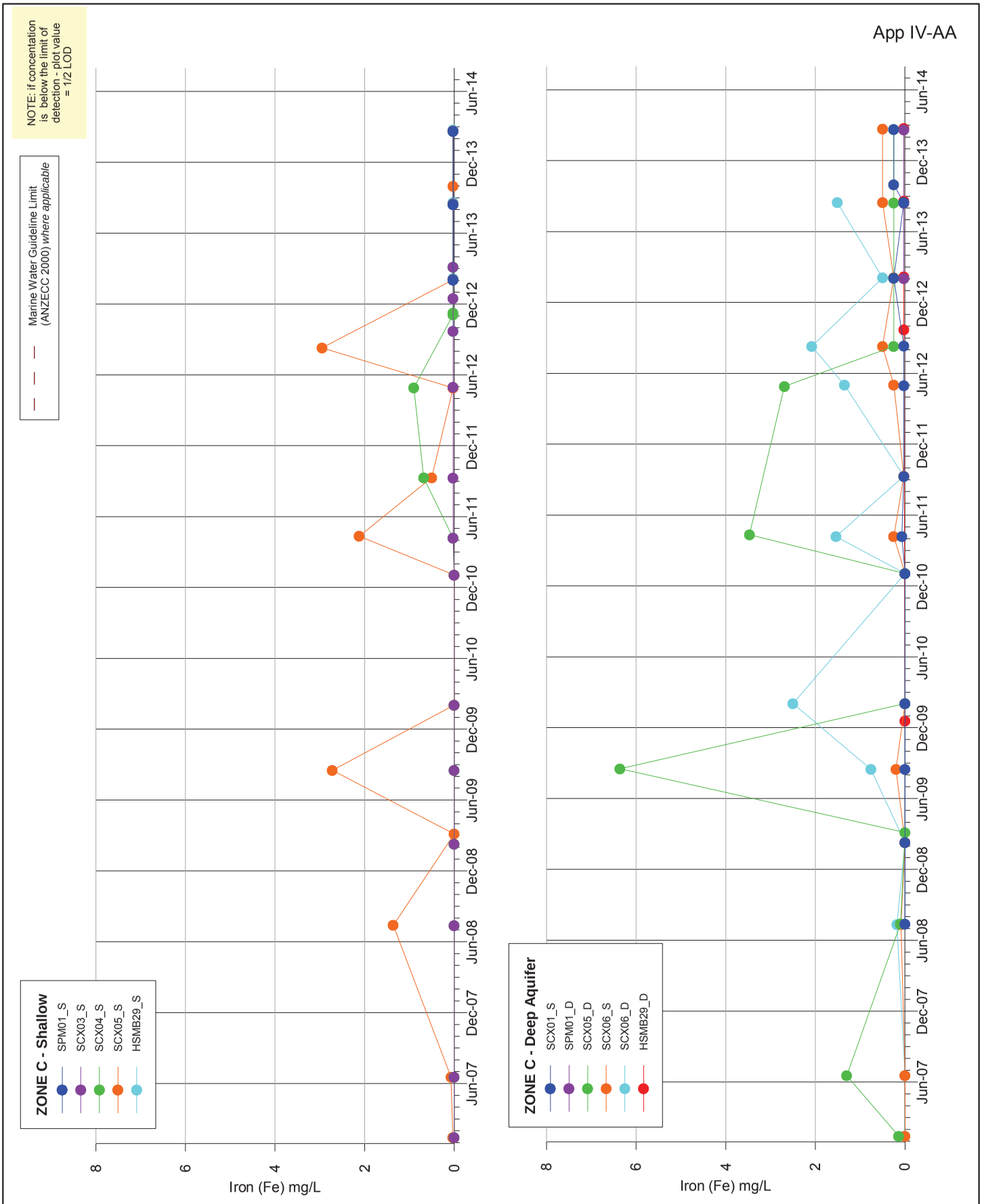
Date : June 2014

Dwg. No: 436-0/14/1-App IV-Z

2013 GWOS MONITORING BORES

IRON IN SHALLOW & DEEP AQUIFER

Zone B : Saline Injection Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-AA Iron 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

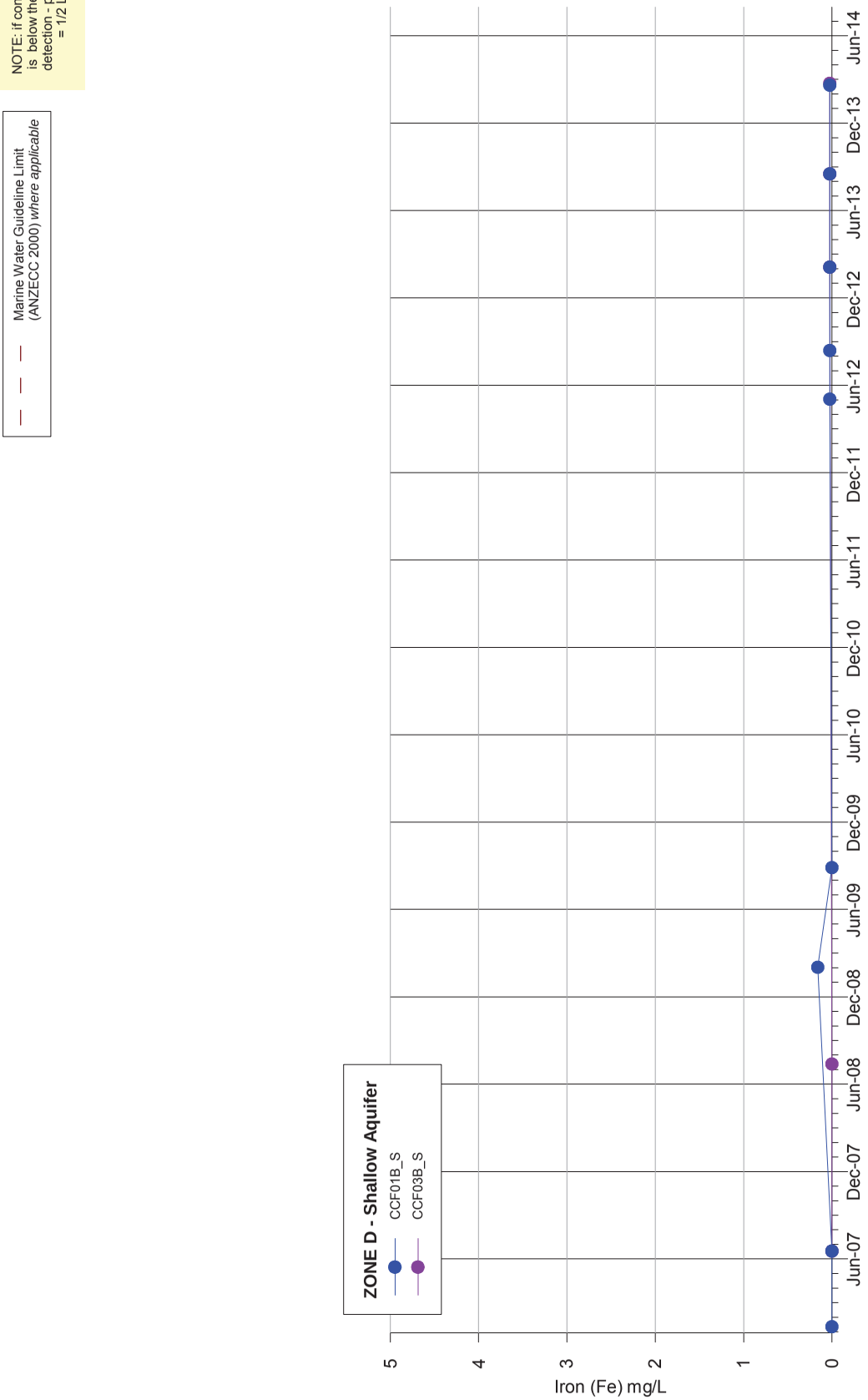
Dwg. No: 436-0/14/2-App IV-AA

2013 GWOS MONITORING BORES

IRON IN SHALLOW & DEEP AQUIFER

Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-01\Appendix IV\App IV-AB Iron 2007-13 Zn D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

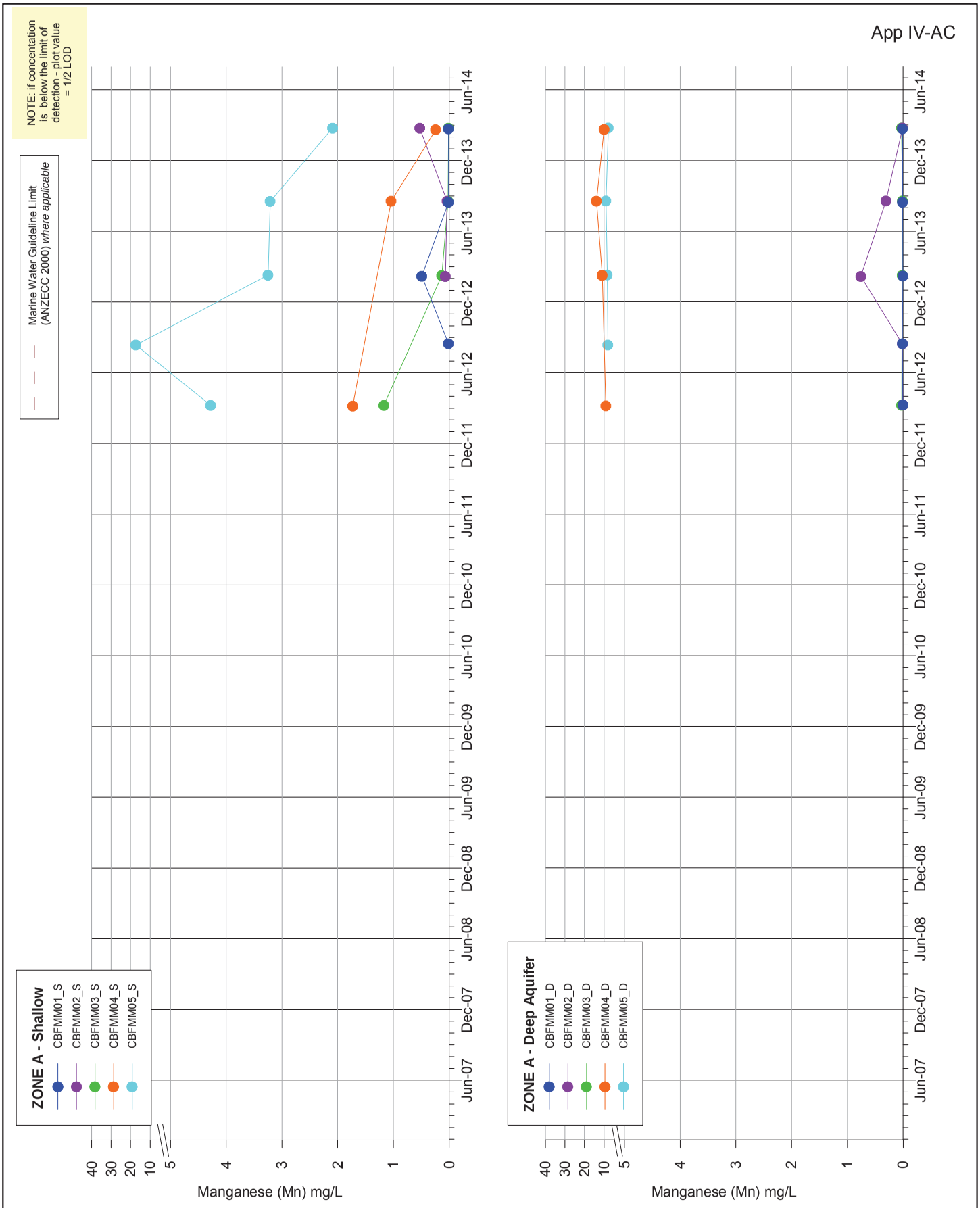
Date : June 2014

Dwg. No: 436-0/14/2-App IV-AB

2013 GWOS MONITORING BORES

IRON IN SHALLOW AQUIFER

Zone D : Phreatophytic Vegetation Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-AC Manganese 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

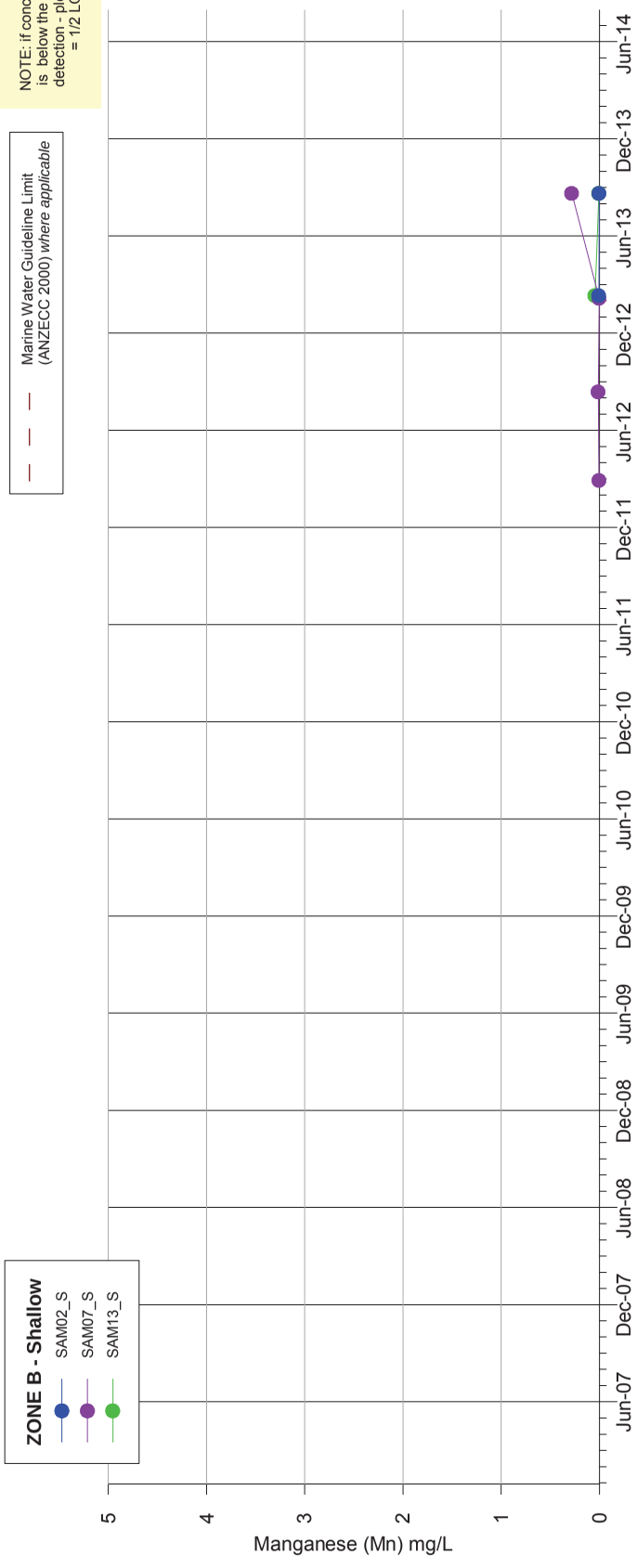
Dwg. No: 436-0/14/2-App IV-AC

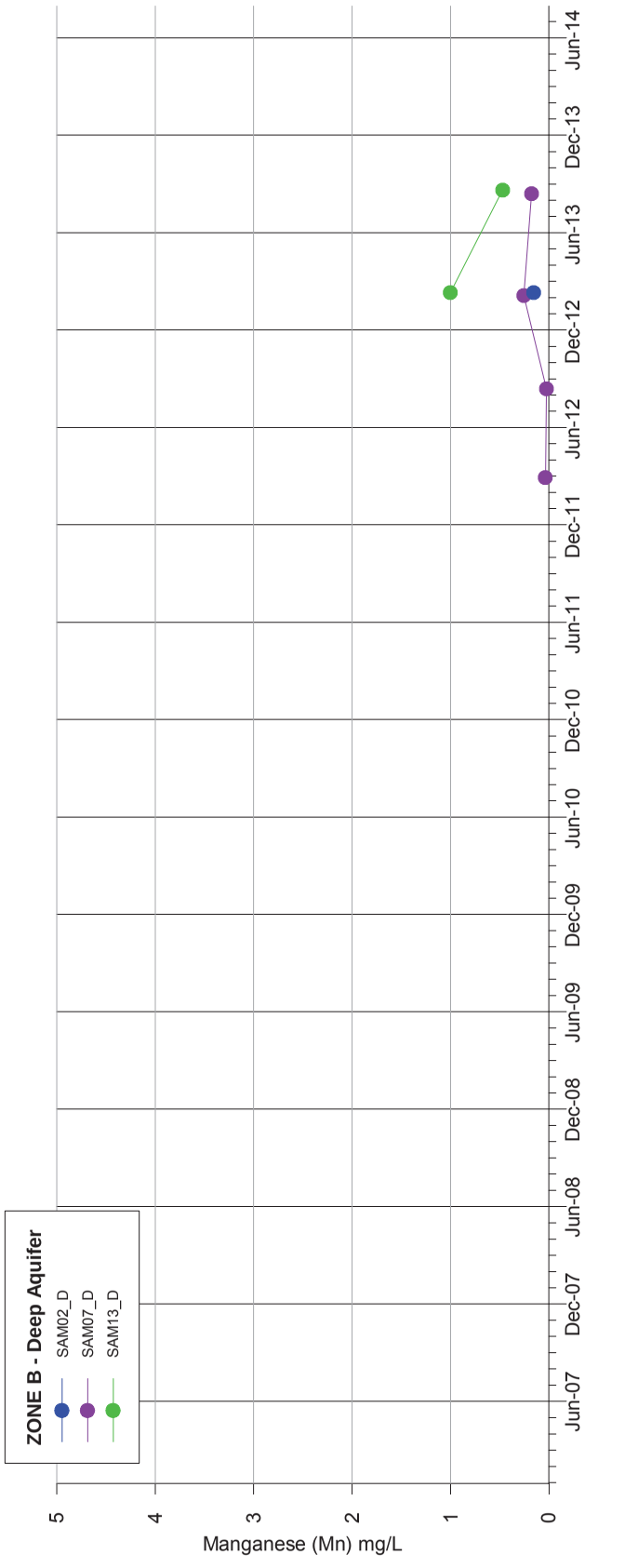
2013 GWOS MONITORING BORES

MANGANESE IN SHALLOW & DEEP AQUIFER

Zone A : Near Marsh Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD





I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-AD Manganese 2007-13 Zn A.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

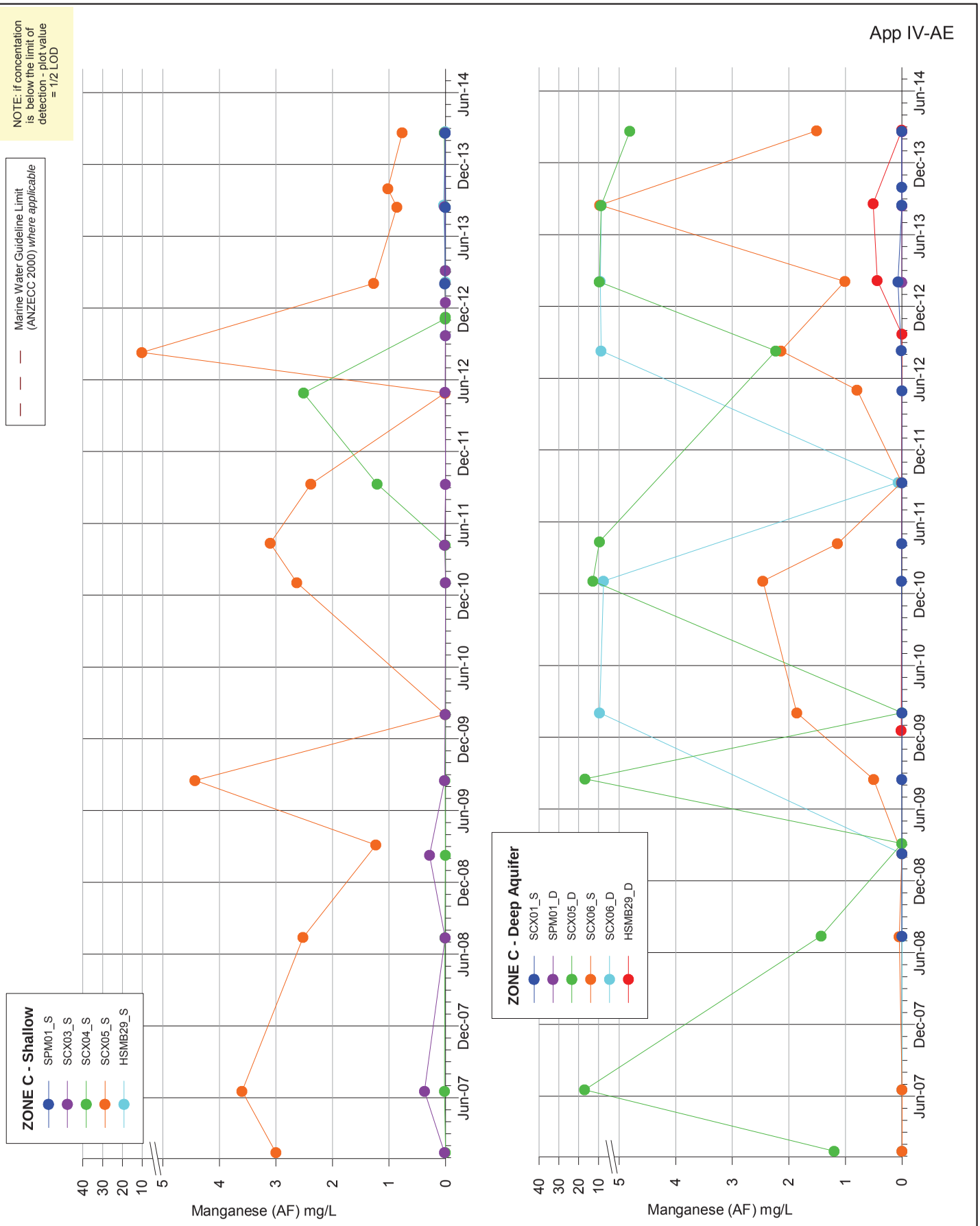
Date : June 2014

Dwg. No: 436-0/14/2-App IV-AD

2013 GWOS MONITORING BORES

MANGANESE IN SHALLOW & DEEP AQUIFER

Zone B : Saline Injection Region



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-AE Manganese 2007-13 Zn C.grf

Client: Fortescue Metals Group Ltd

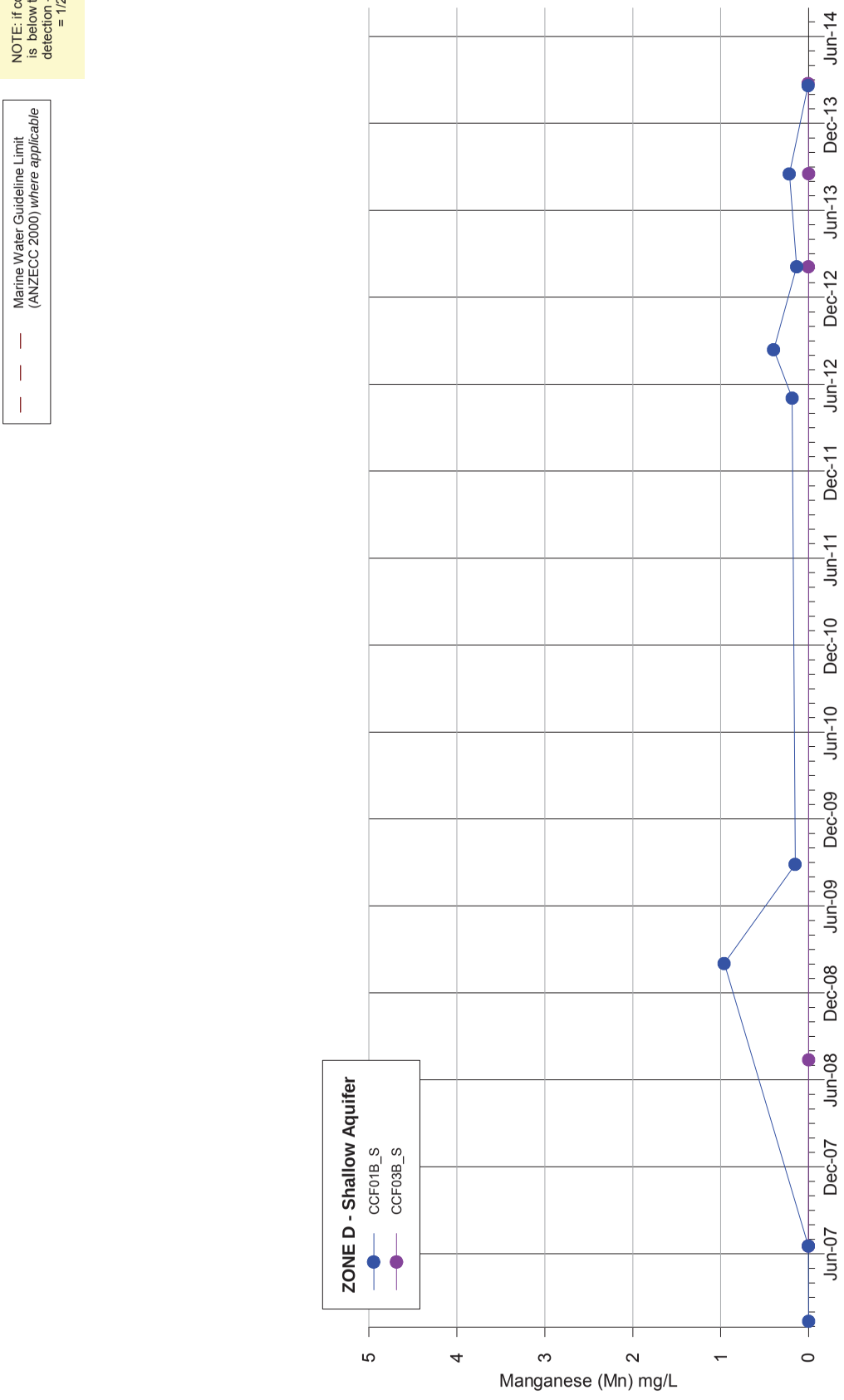
Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/2-App IV-AE

2013 GWOS MONITORING BORES
MANGANESE IN SHALLOW & DEEP AQUIFER
Zone C : Brackish Injection Region

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD



I:\\436-0\Grapher\CC 14-02\Appendix IV\App IV-AF Manganese 2007-13 Zn D.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/2-App IV-AF

2013 GWOS MONITORING BORES

MANGANESE IN SHALLOW AQUIFER

Zone D : Phreatophytic Vegetation Region

APPENDIX V

Appendix V: Results for Physical Parameters and Major Ions at the 2013 GWOS Injection Line Sampling Points

Sample Point	Sample Date	Injection Zone	pH (pH units)	EC @ 25 Deg C (uS\cm)	TDS (mg/L)	Cl (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NO3 (mg/L)	TSS (mg/L)
CCSP0001	17/08/2012	Brackish Injection	7.68	12500	9190	3830	125	1430	192	287	164	2080		
CCSP0001	22/08/2013		7.72	8620	5340	2020	183	850	162	178	105	1330	4.56	<5
CCSP0008	16/08/2012		7.51	13200	9280	3730	133	1490	206	304	172	2200		
CCSP0008	24/02/2014		7.71	10500	8050	3150	196	1090	173	218	150	1880		
CCSP0011	15/08/2012	Saline Injection	7.21	53800	39300	17800	186	5880	380	1140	1050	10700		
CCSP0011	31/10/2012		7.11	59600	33200	19900	171	5840	399	1200	1120	11400		37
CCSP0011	4/12/2012		7.23	37200	25700	12300	151	3380	314	768	635	7340	3.18	65
CCSP0011	14/02/2013		7.2	47900	35200	15000	162	4570	392	957	759	10700	1.14	<5
CCSP0011	1/04/2013		7.3	75700	55400	22600	168	8700	430	1650	1450	18900	1.27	14
CCSP0011	2/04/2013		7.46	43200	32200	14200	164	4790	411	949	817	10300	1.39	<5
CCSP0011	3/04/2013		7.41	56300	43000	17700	169	5970	503	1310	1080	14000	1.13	<5
CCSP0011	4/04/2013		7.53	54900	41200	17400	178	5160	476	1150	993	12500	0.97	<5
CCSP0011	23/05/2013		7.21	52100	38400	19600	185	5320	455	1120	977	12900	0.79	20
CCSP0011	22/08/2013		7.36	68300	49100	22000	186	7180	454	1420	1240	16100	0.91	11
CCSP0011	22/02/2014		6.99	83600	72800	28000	171	8820	532	1700	1950	20400		
CCSP0015	31/10/2012		7.92	56500	37600	18200	174	5620	413	1280	1230	12200		21
CCSP0015	22/08/2013		7.72	63800	45800	20400	184	6900	454	1340	1150	15300	0.96	16

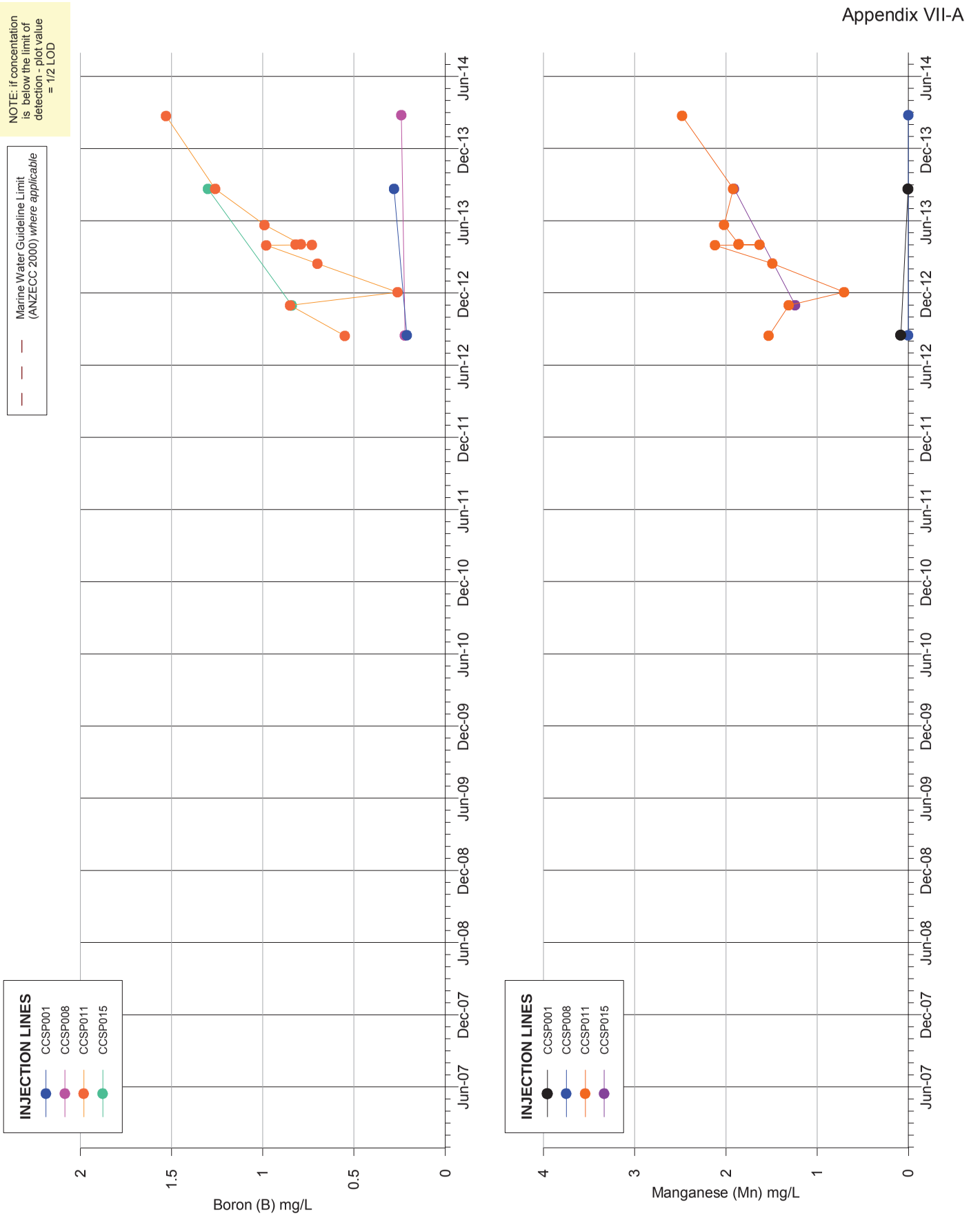
APPENDIX VI

Appendix VI: Results for Metals and Trace Elements at the 2013 GWOS Injection Line Sampling Points

Sample Point	Sample Date	Injection Zone	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)	Sr (mg/L)	Sn (mg/L)	Zn (mg/L)
Marine Water Quality Guidelines (ANZECC 2000)			**ID**	**ID**	**0.0007**	**0.0044**	**0.0013**	**ID**	**0.0044**	**ID**	**ID**	**0.007**		**0.0014**	**ID**	**ID**	**0.015**
						0.0274											
CCSP0001	17/08/2012	Brackish	<0.001	0.21	0.0002	<0.001	0.008	<0.05	<0.001	0.084	<0.0001	0.009			0.97		0.096
CCSP0001	22/08/2013		<0.001	0.28	<0.0001	<0.001	0.004	<0.05	<0.001	0.004	<0.0001	0.002	<0.01	<0.001	0.855	<0.001	0.038
CCSP0008	16/08/2012		<0.001	0.22	0.0002	<0.001	0.013	<0.05	<0.001	0.002	0.0002	0.009			1.04		0.106
CCSP0008	24/02/2014		<0.001	0.24	<0.0001	<0.001	0.014	<0.05	<0.001	<0.001	<0.0001	0.001	<0.01	<0.001	0.723		0.035
CCSP0011	15/08/2012	Saline	<0.001	0.55	0.0009	<0.001	0.035	2.63	0.003	1.53	0.0002	0.035			2.93		0.322
CCSP0011	31/10/2012			0.85				0.12		1.31			<0.01		3.11		
CCSP0011	4/12/2012			0.26				0.3		0.703			<0.01		2.16		
CCSP0011	14/02/2013			0.7				<0.25		1.49			<0.05	0.006	2.79	<0.005	
CCSP0011	1/04/2013			0.98				<0.25		2.12			<0.05	<0.005	4.2	<0.005	
CCSP0011	2/04/2013			0.73				<0.25		1.63					3.08		
CCSP0011	3/04/2013			0.82				<0.25		1.86			<0.05	<0.005	3.92	<0.005	
CCSP0011	4/04/2013			0.79				0.68		1.86			<0.05	<0.005	3.86	<0.005	
CCSP0011	23/05/2013			0.99				0.97		2.02					3.96		
CCSP0011	22/08/2013		<0.01	1.26	<0.001	<0.01	0.018	1.49	<0.01	1.92	<0.0001	0.034	<0.1	<0.01	3.76	<0.01	0.244
CCSP0011	22/02/2014		<0.01	1.53	<0.001	<0.01	0.017	1.18	<0.01	2.48	<0.0001	0.037	<0.1	<0.01	4.64		0.16
CCSP0015	31/10/2012			0.84				<0.05		1.24			<0.01		3.07		
CCSP0015	6/02/2013																
CCSP0015	22/08/2013		<0.01	1.3	0.0013	<0.01	0.02	<0.5	<0.01	1.91	<0.0001	0.047	<0.1	<0.01	3.81	<0.01	0.44

Red highlight indicates values above Marine Water Quality Guidelines (ANZECC 2000).

APPENDIX VII



I:\\436-0\Grapher\CB 14-01\Appendix VII\App VII-A Boron & Manganese Injection Lines.grf

Client: Fortescue Metals Group Ltd

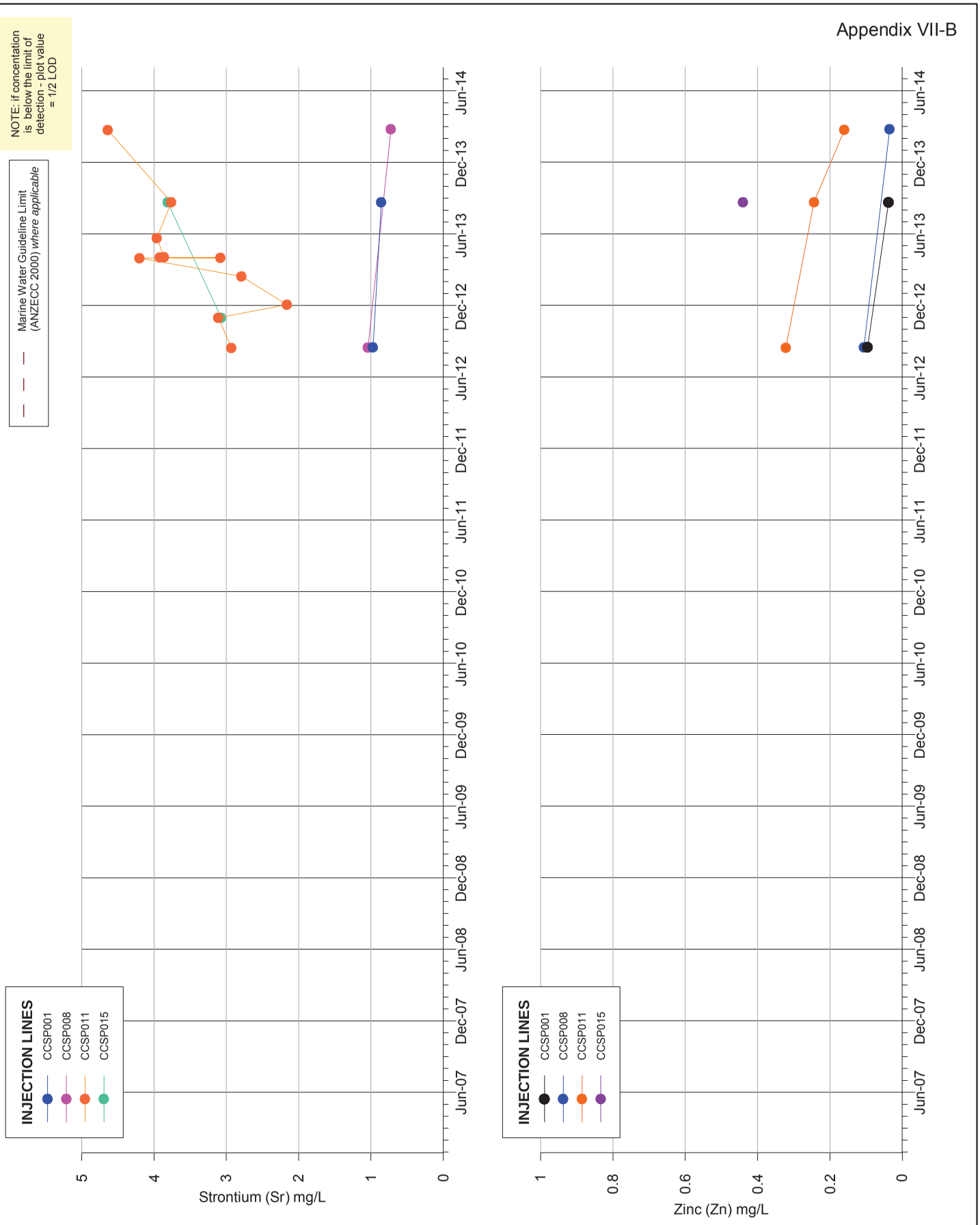
Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/2-App VII-A

2013 GWOS INJECTION LINE SAMPLING POINT

BORON & MANGANESE IN INJECTION LINES



I:\\436-0\Grapher\CB 14-01\Appendix VII\App VII-B Strontium & Zinc Injection Lines.grf

Client: Fortescue Metals Group Ltd

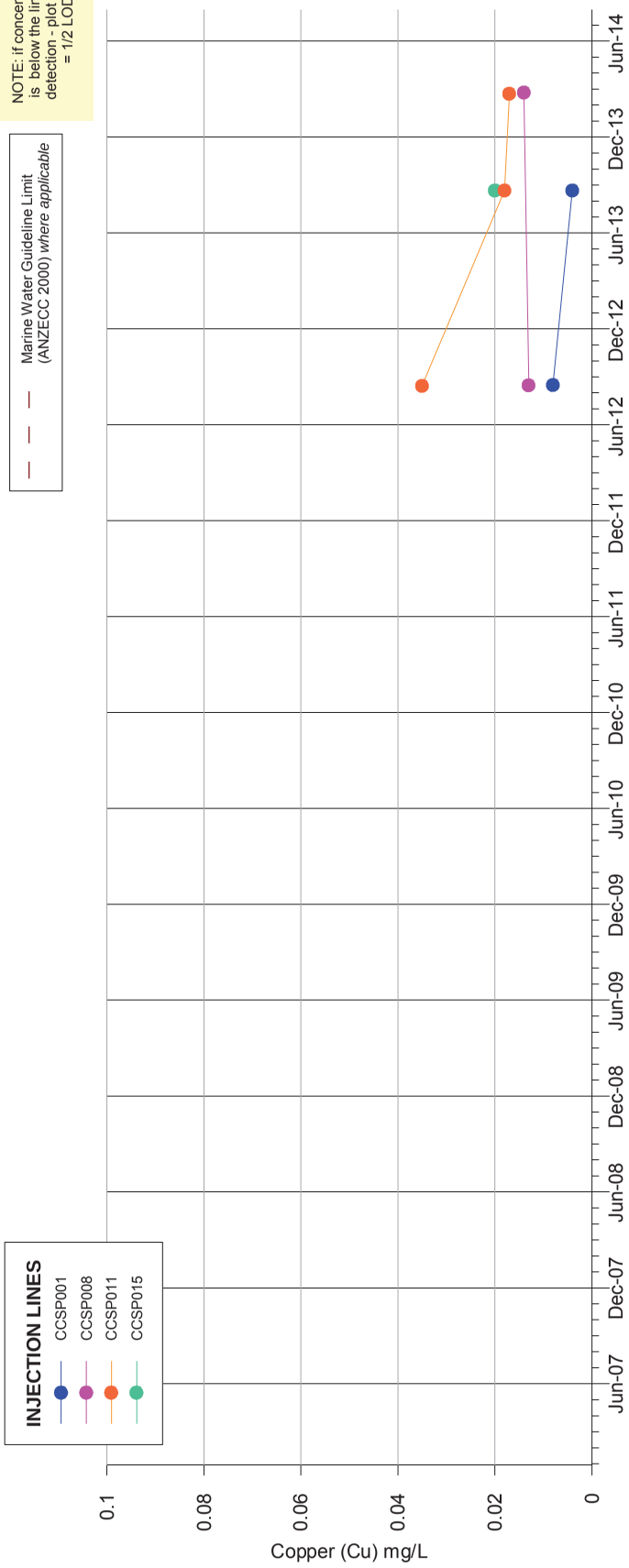
Project : Christmas Creek Geochemical Assessment

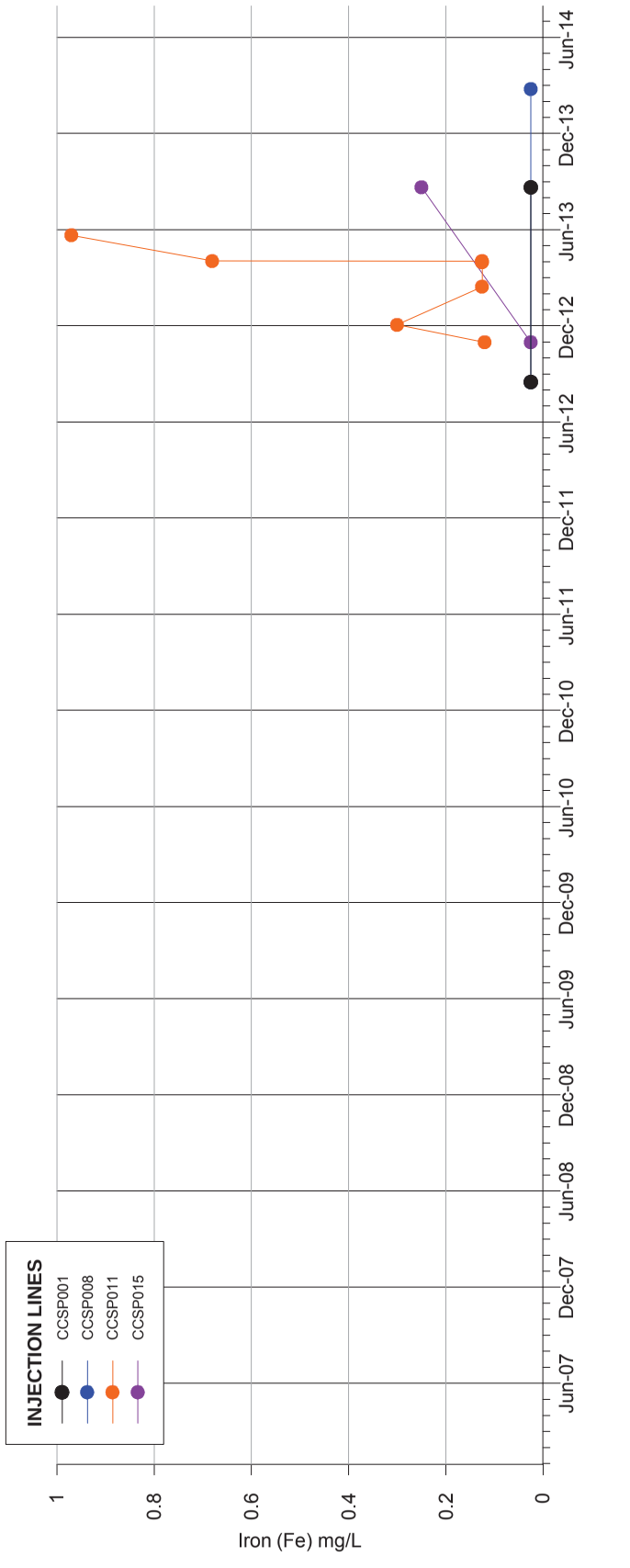
Date : June 2014

Dwg. No: 436-0/14/2-App VII-B

2013 GWOS INJECTION LINE SAMPLING POINT STRONTIUM & ZINC IN INJECTION LINES

NOTE: if concentation is below the limit of detection - plot value = 1/2 LOD





I:\\436-0\Grapher\CB 14-01\Appendix VII\App VII-C Copper & Iron Injection Lines.grf

Client: Fortescue Metals Group Ltd

Project : Christmas Creek Geochemical Assessment

Date : June 2014

Dwg. No: 436-0/14/2-App VII-C

2013 GWOS INJECTION LINE SAMPLING POINT COPPER & IRON IN INJECTION LINES

Appendix 9: Trigger bore hydrographs

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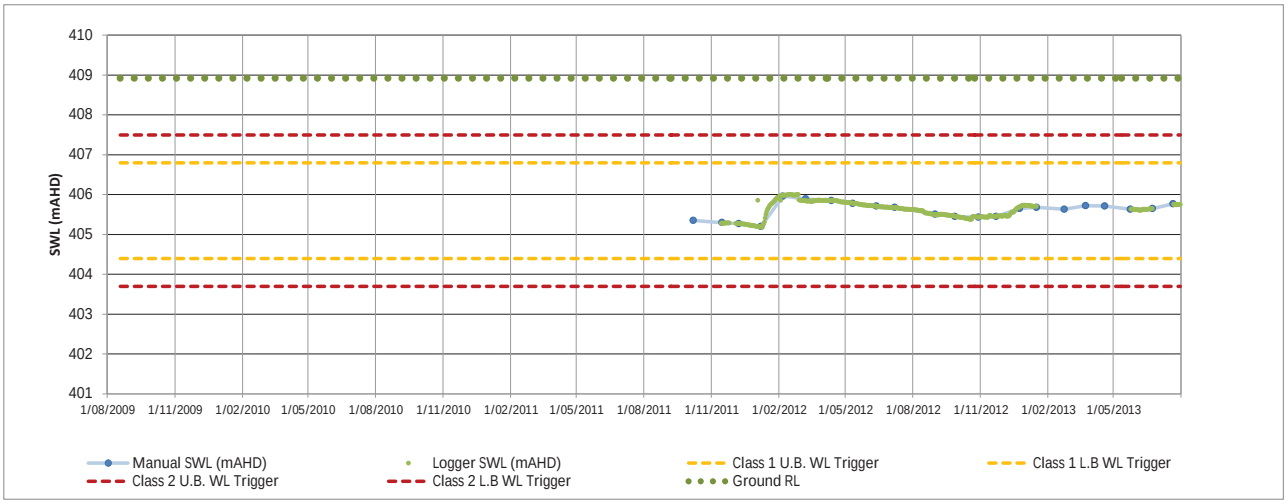
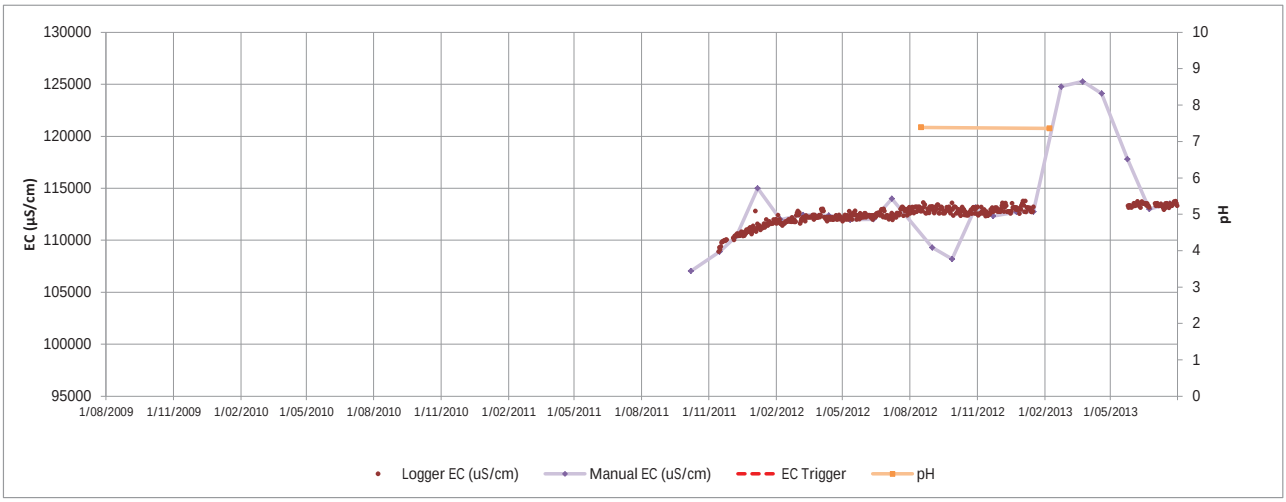
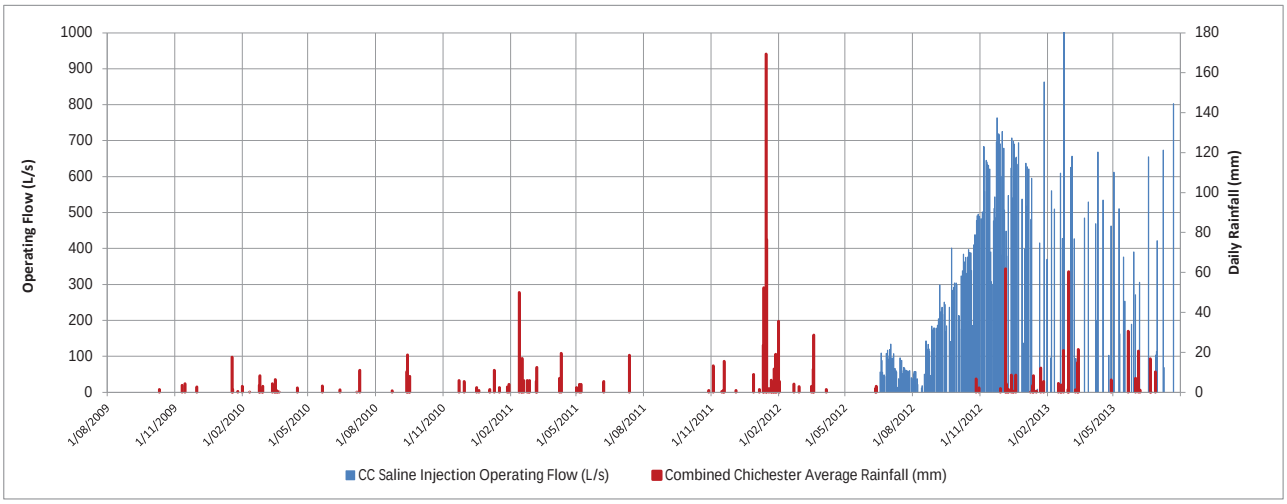
CCFMM01_S Hydrograph

Bore Name: CCFMM01_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone A

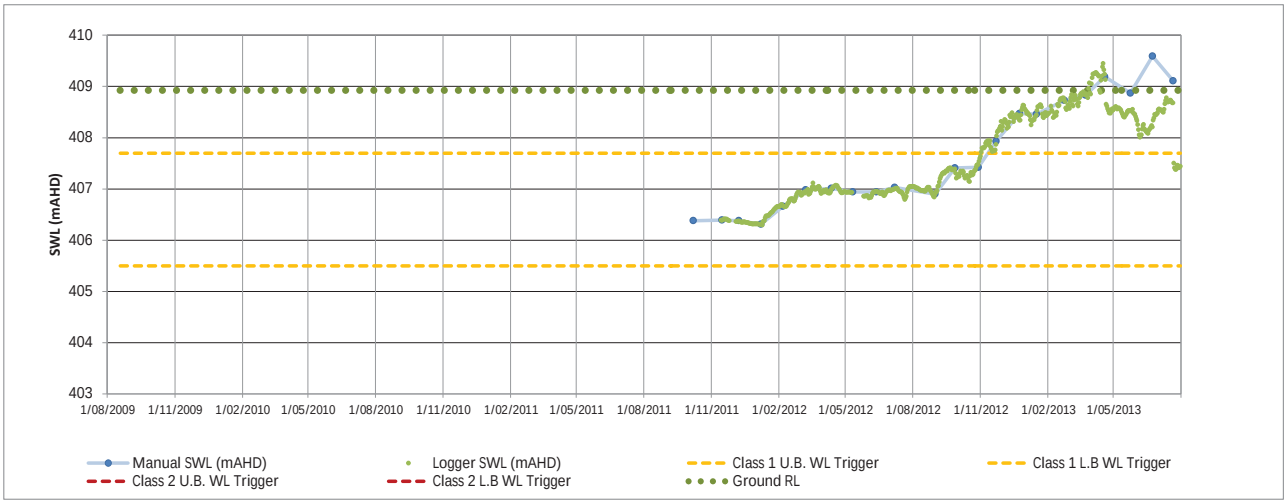


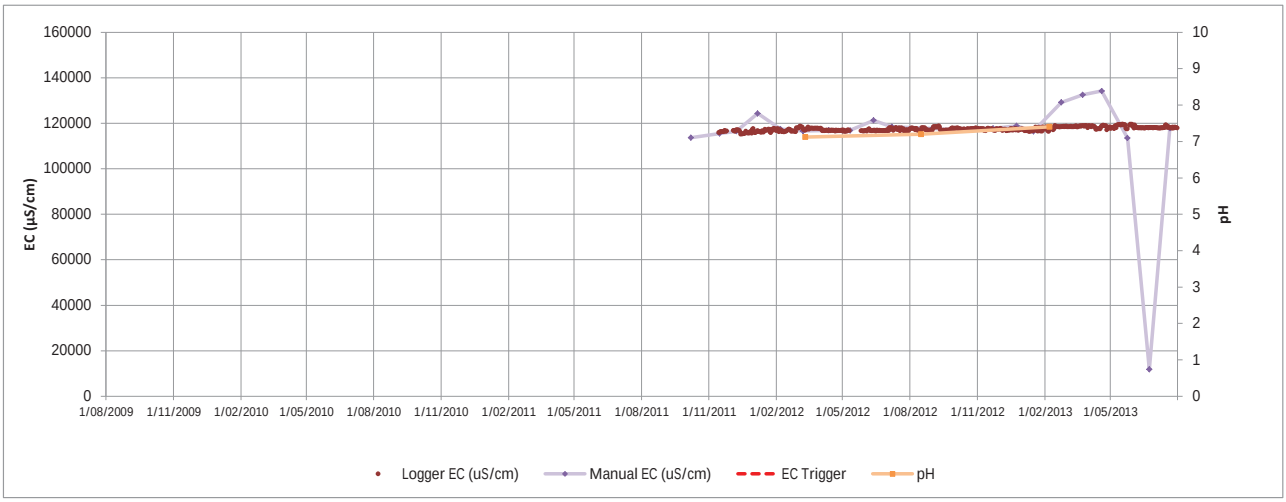


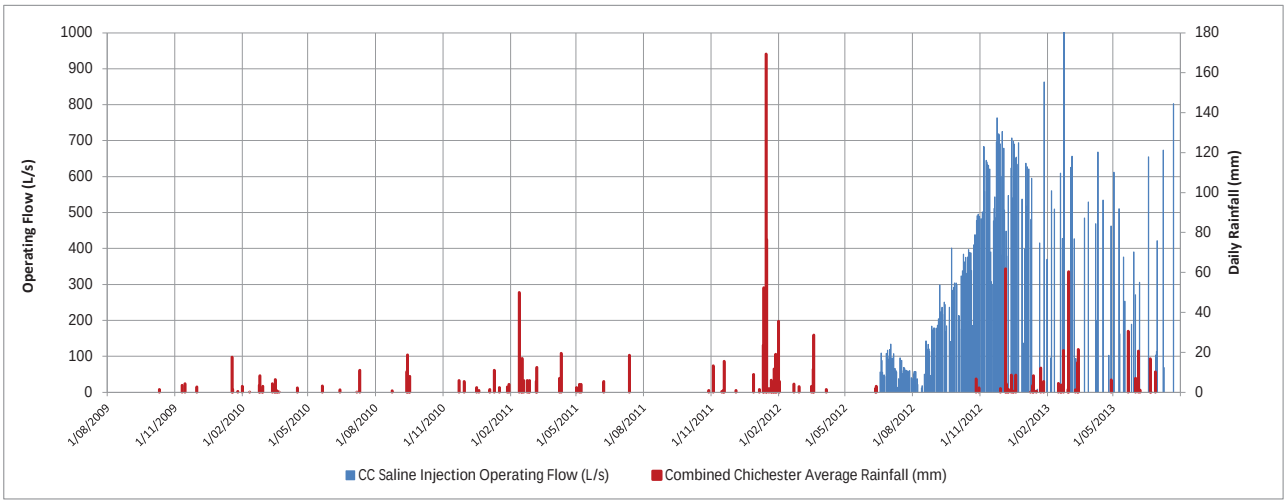


CCFMM01_D Hydrograph

Bore Name: CCFMM01_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone A

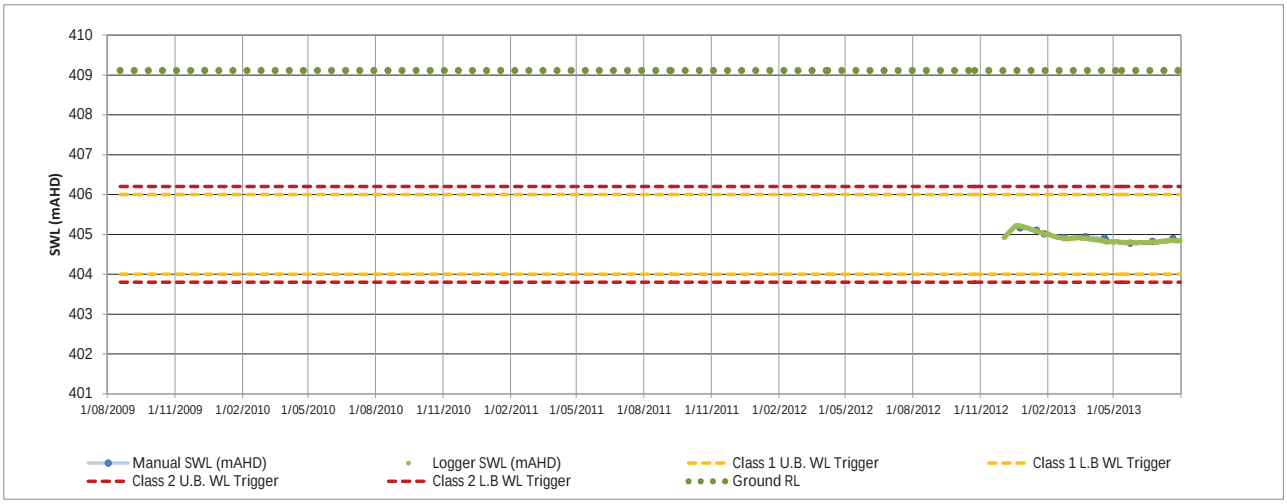


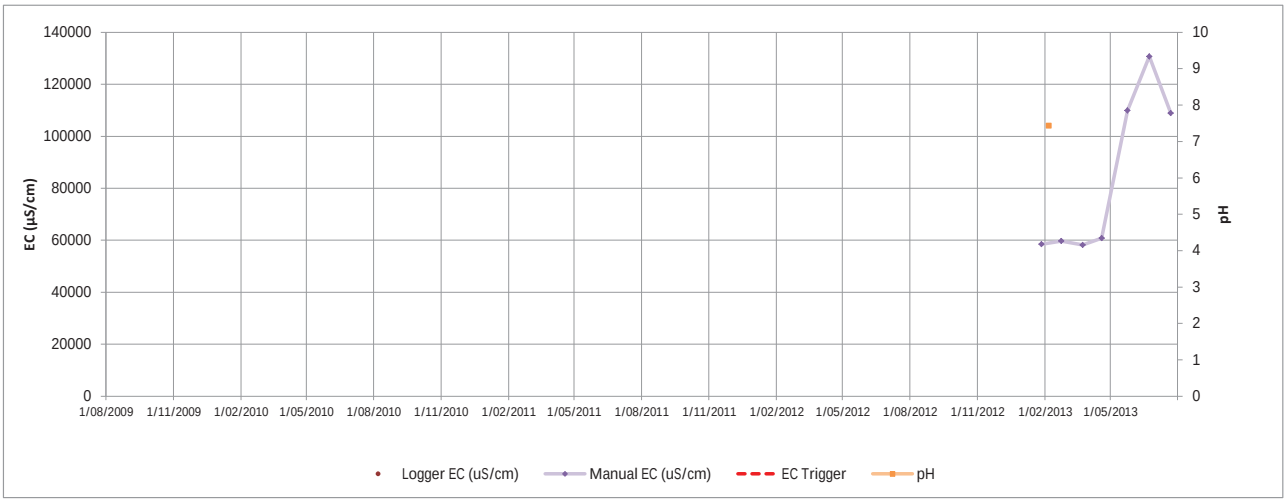


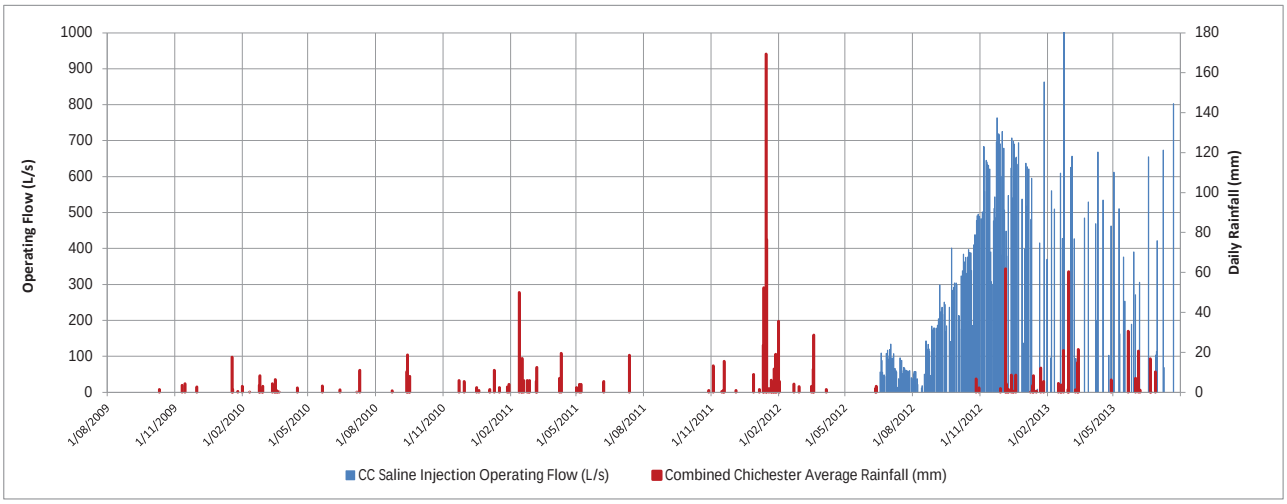


CCFMM02_S Hydrograph

Bore Name: CCFMM02_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone A

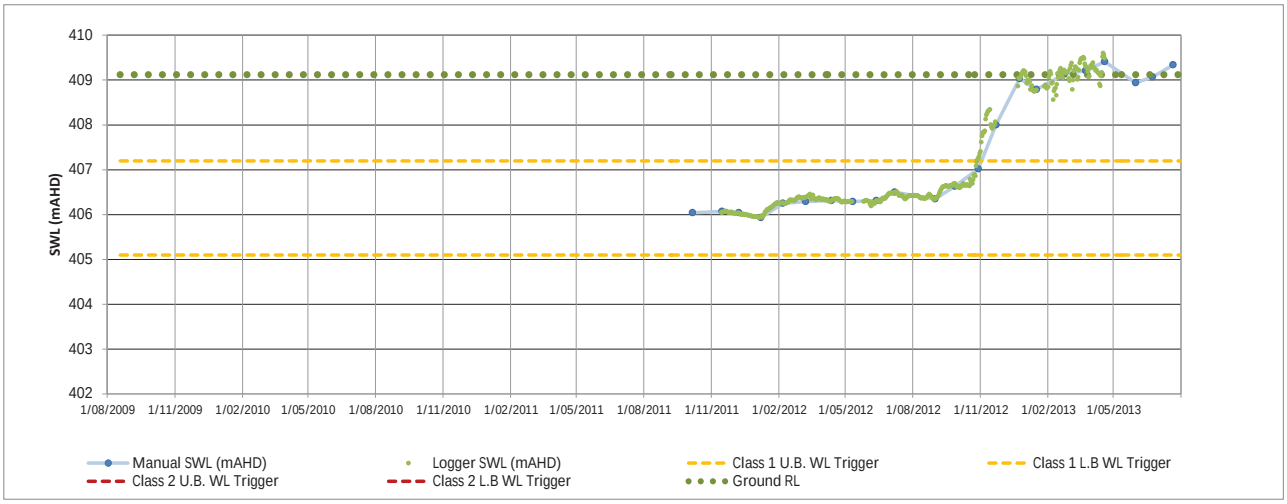


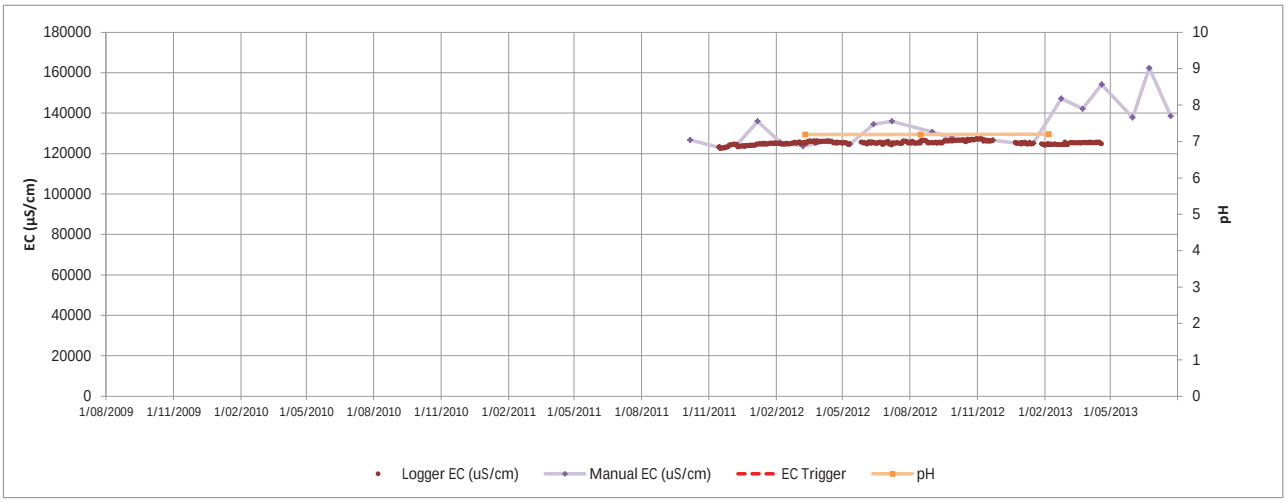


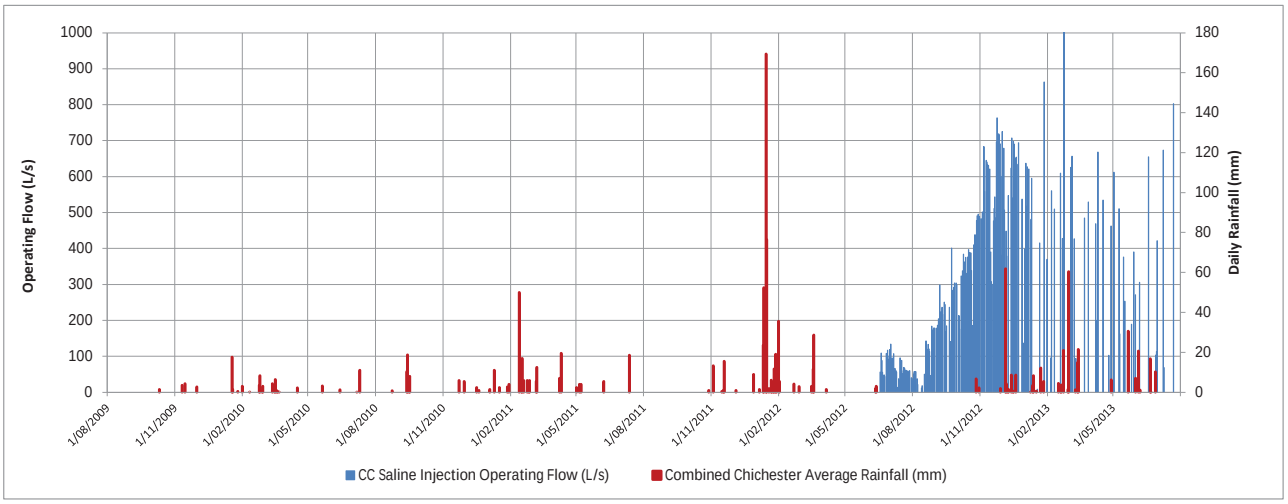


CCFMM02_D Hydrograph

Bore Name: CCFMM02_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone A

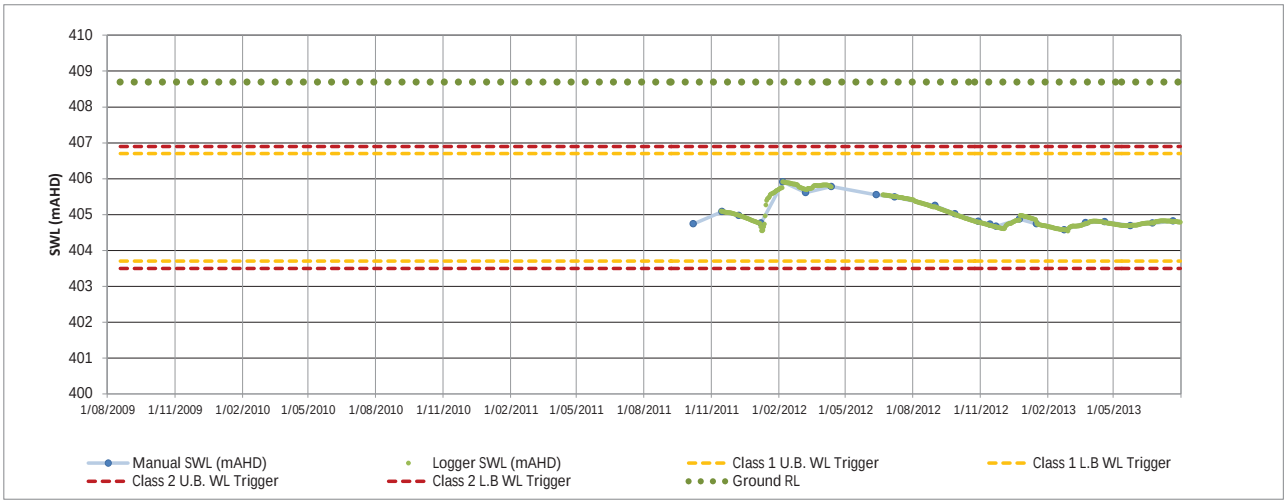


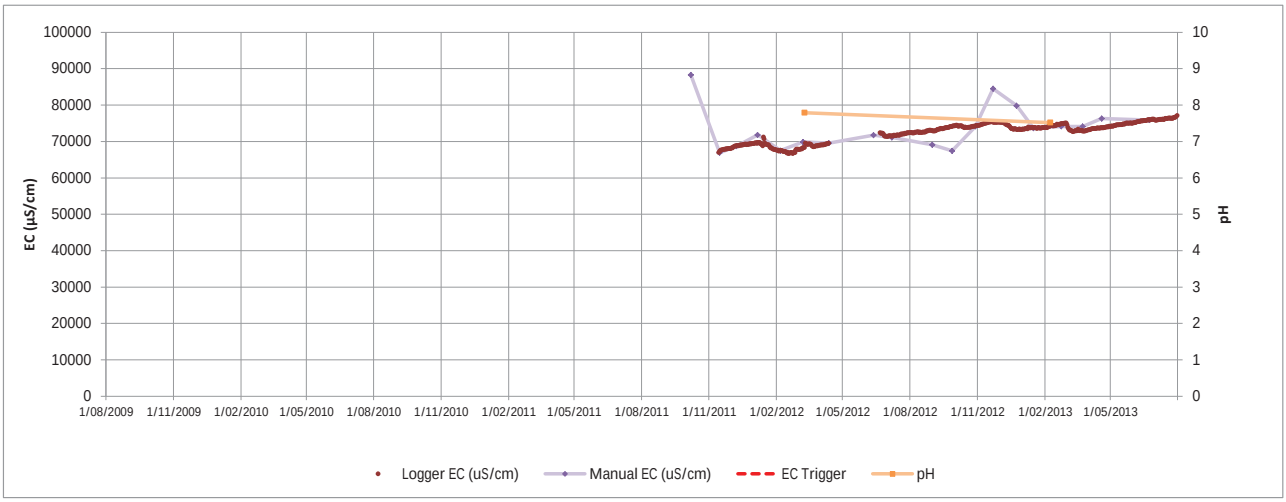


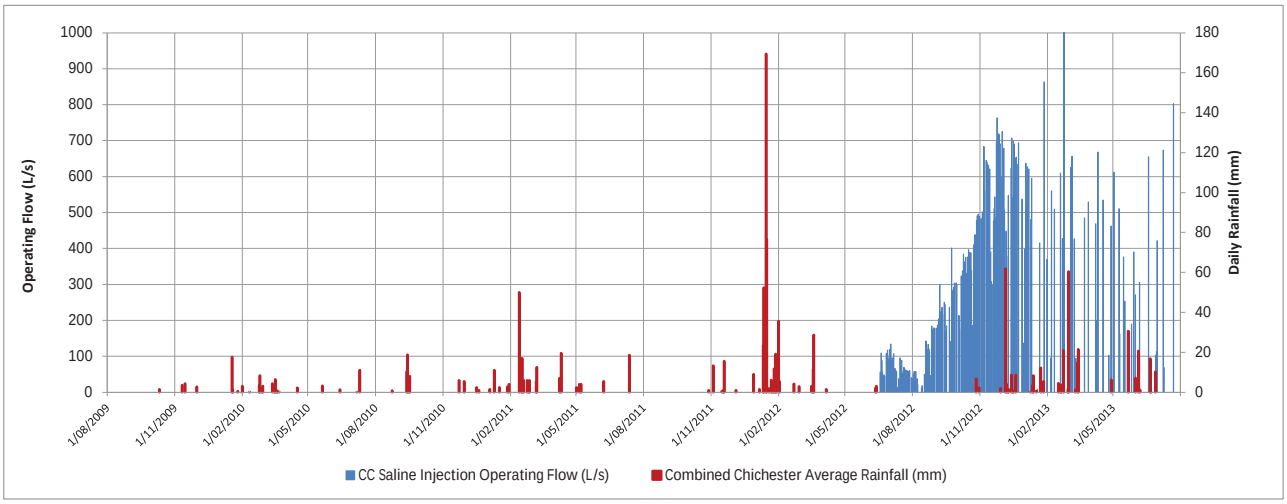


CCFMM03_S Hydrograph

Bore Name: CCFMM03_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone A

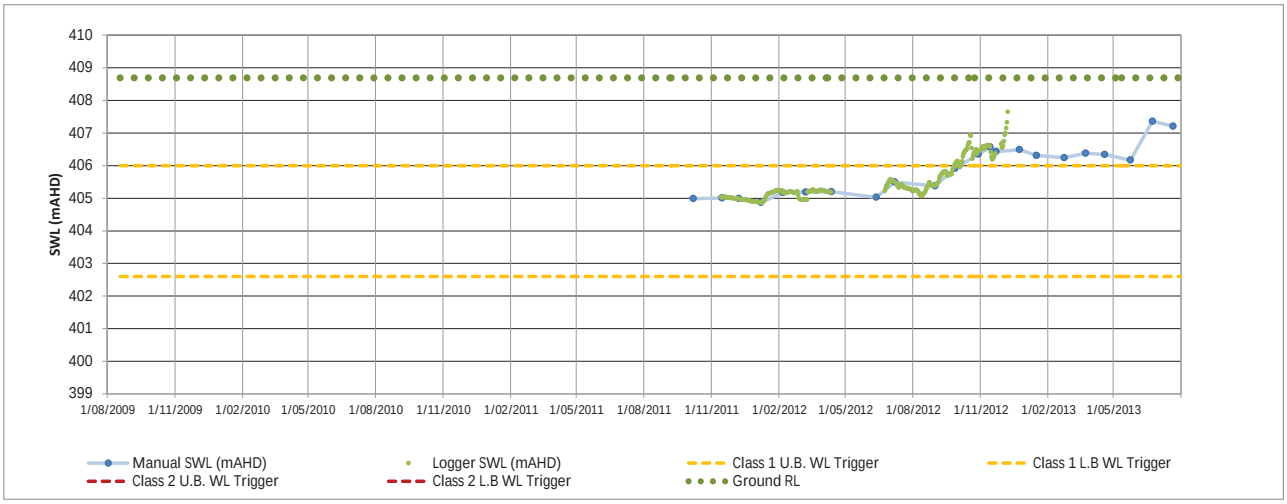


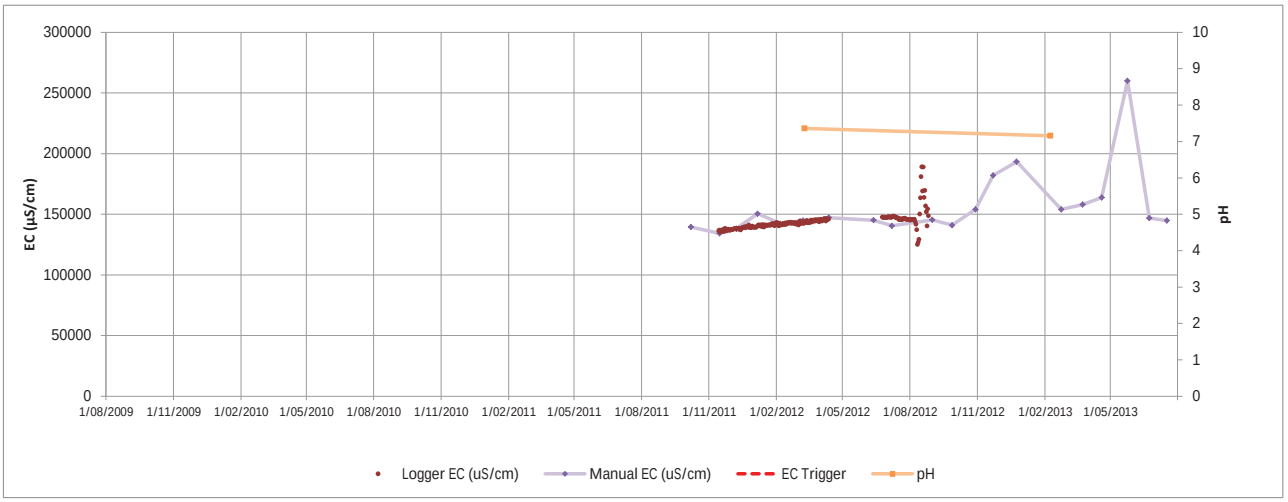


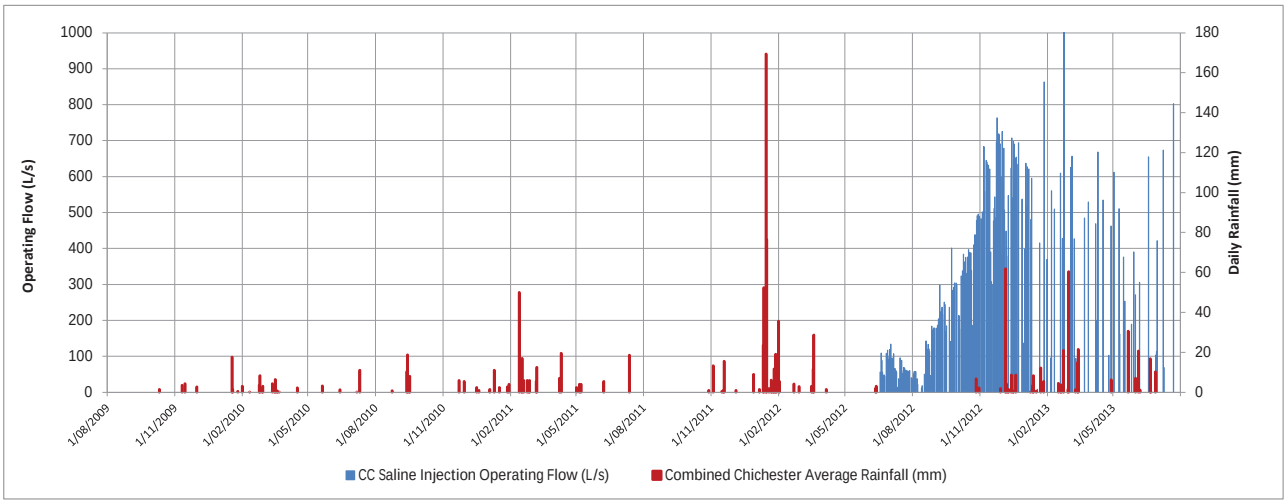


CCFMM03_D Hydrograph

Bore Name: CCFMM03_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone A

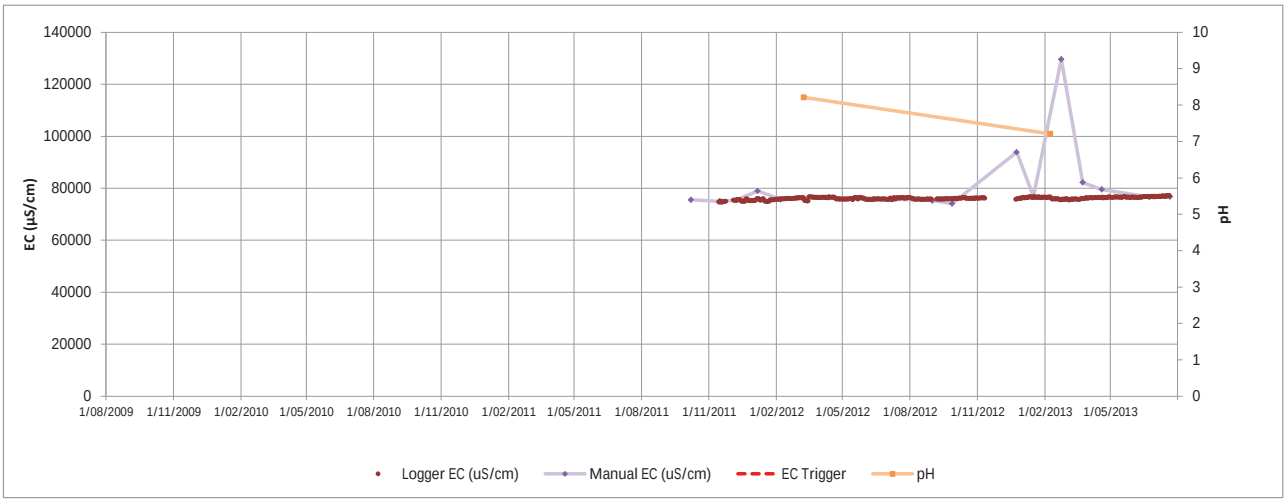


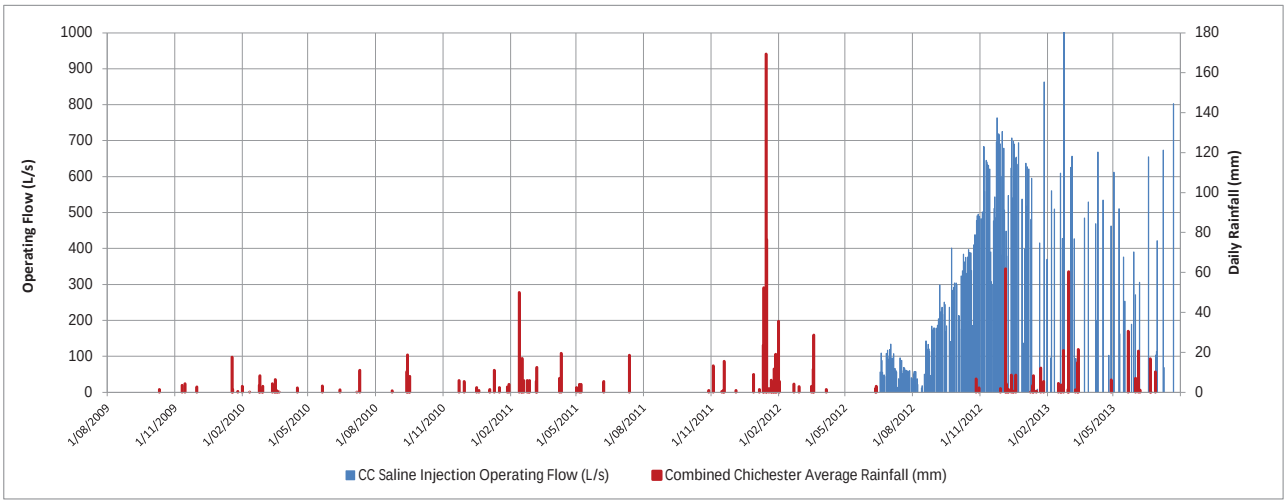




CCFMM04_S Hydrograph

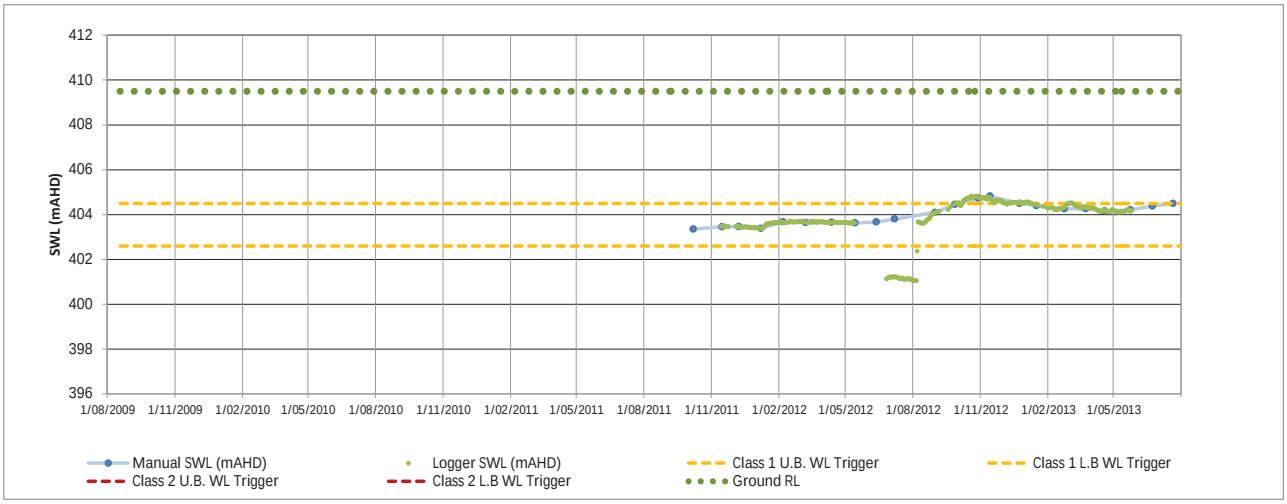
Bore Name: CCFMM04_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone A

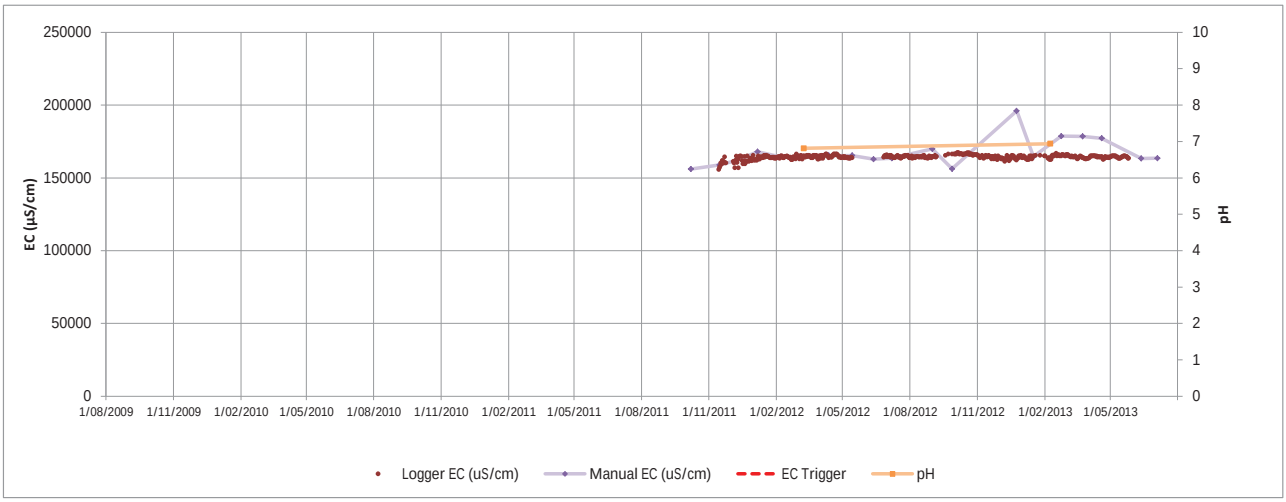


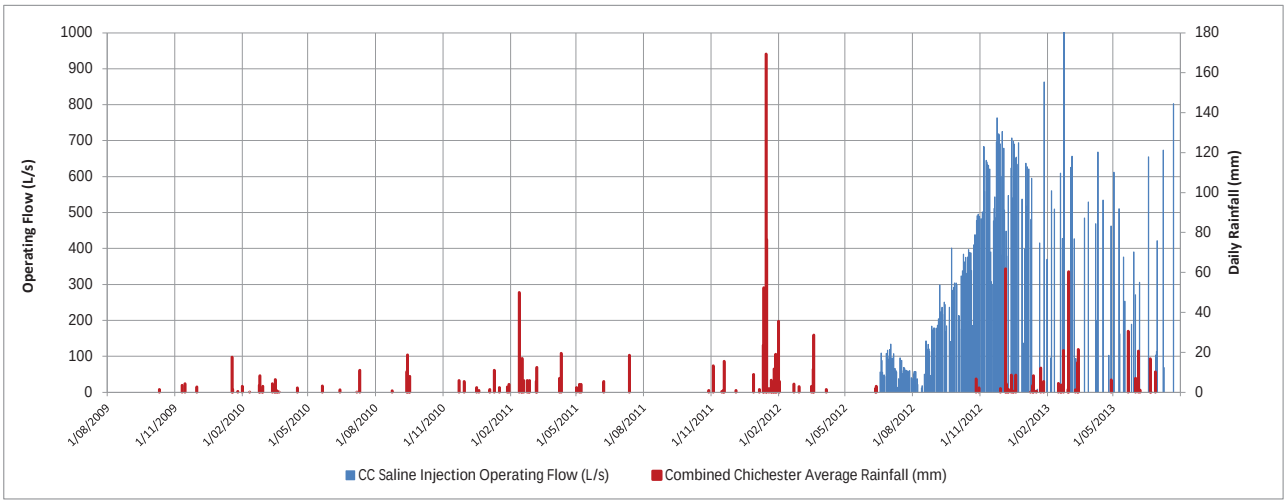


CCFMM04_D Hydrograph

Bore Name: CCFMM04_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone A

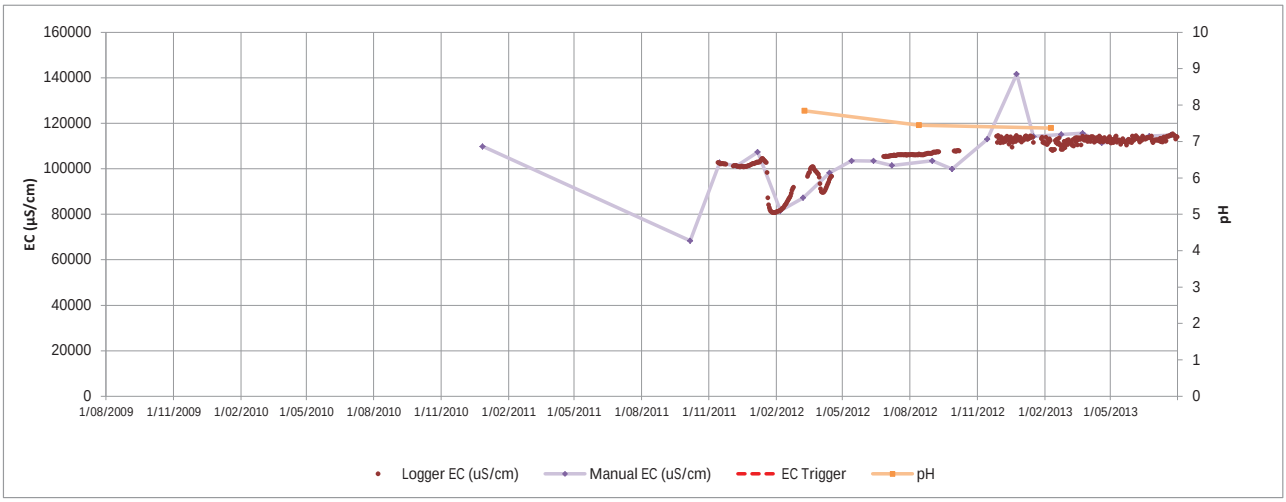


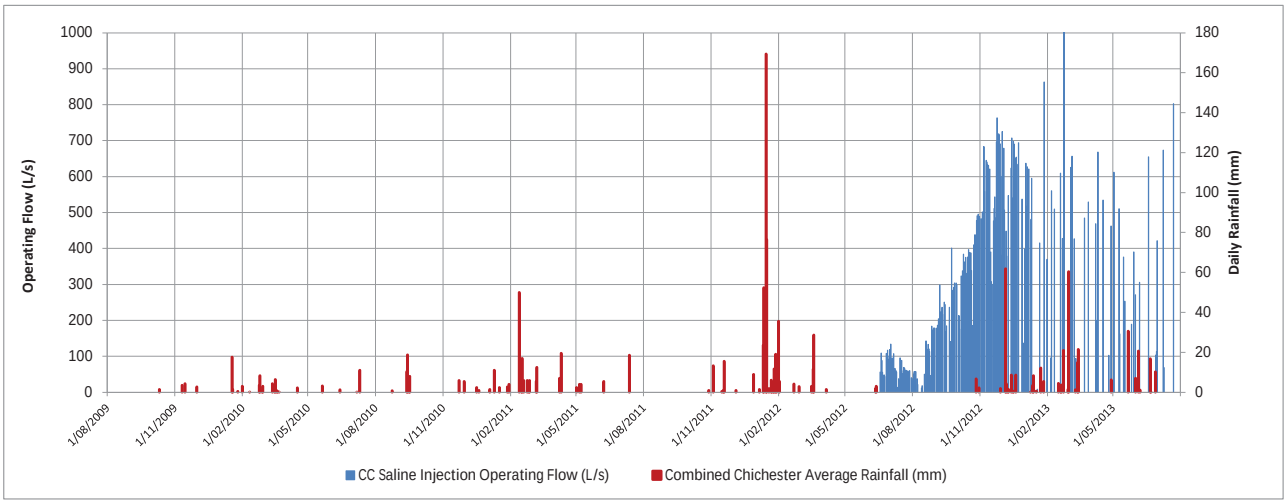




CCFMM05_S Hydrograph

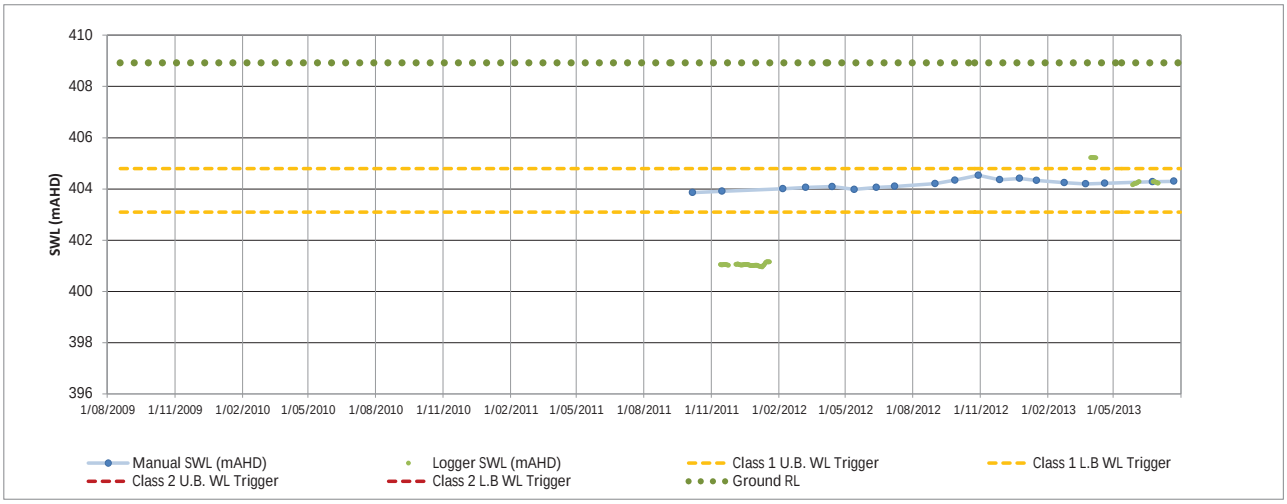
Bore Name: CCFMM05_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone A

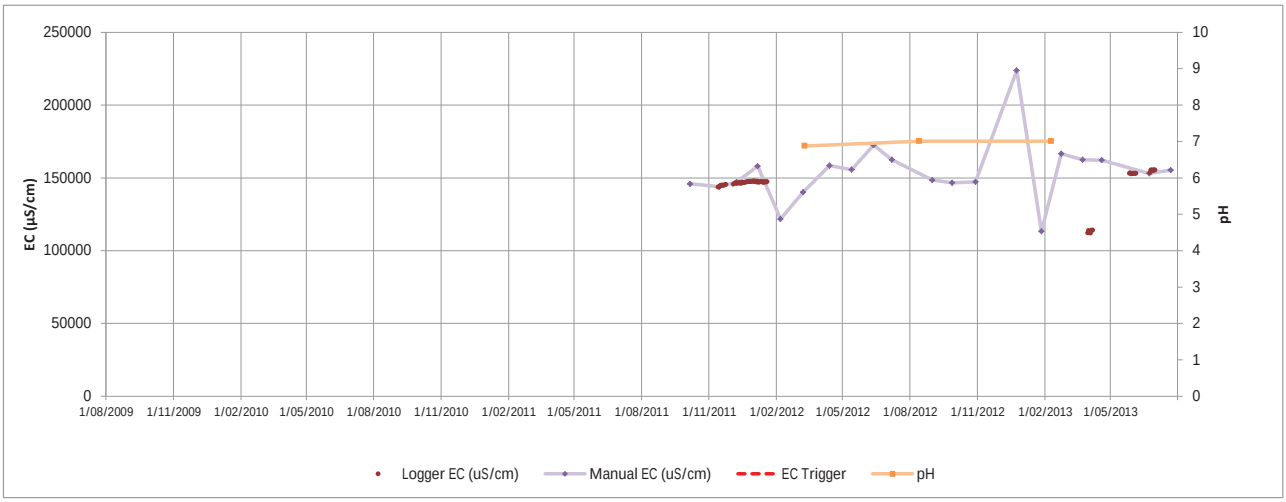


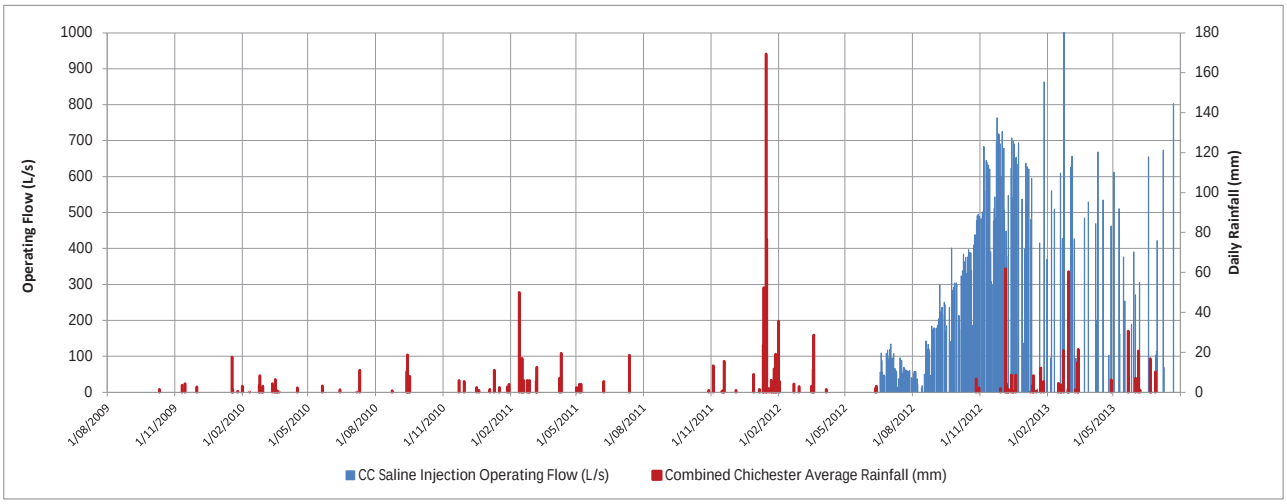


CCFMM05_D Hydrograph

Bore Name: CCFMM05_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone A

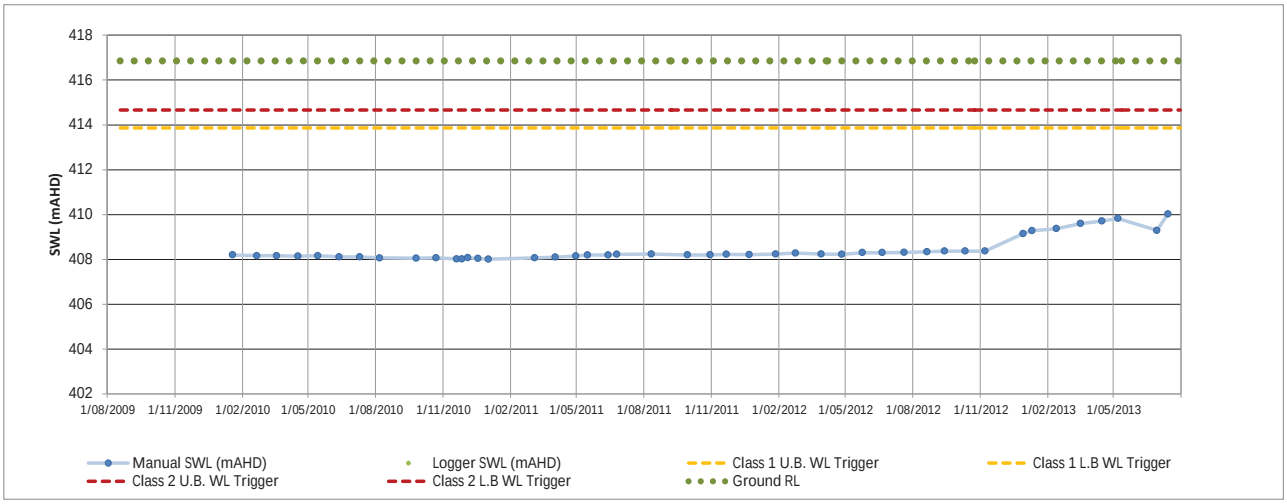


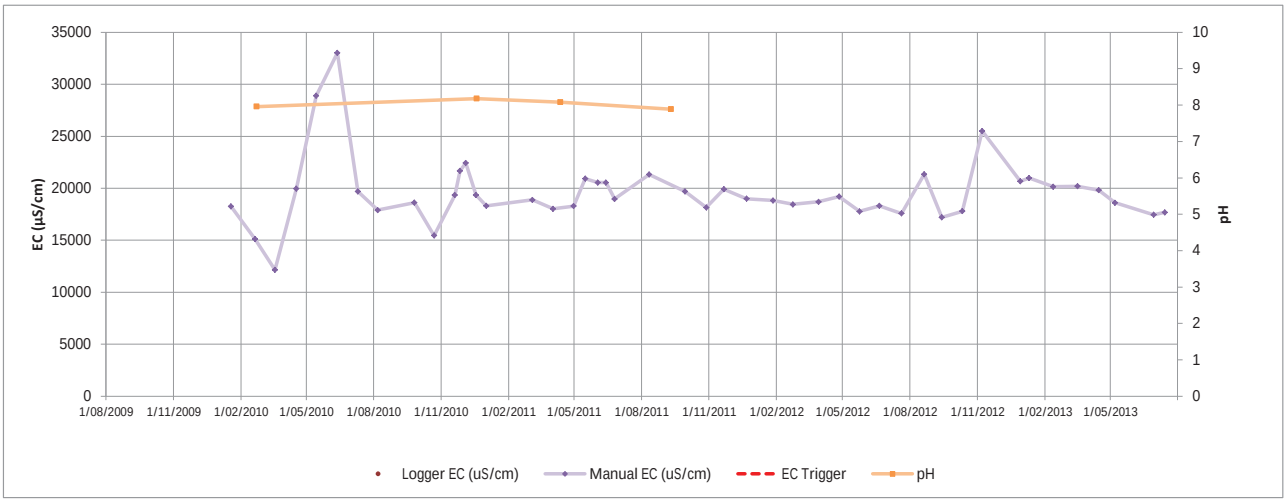


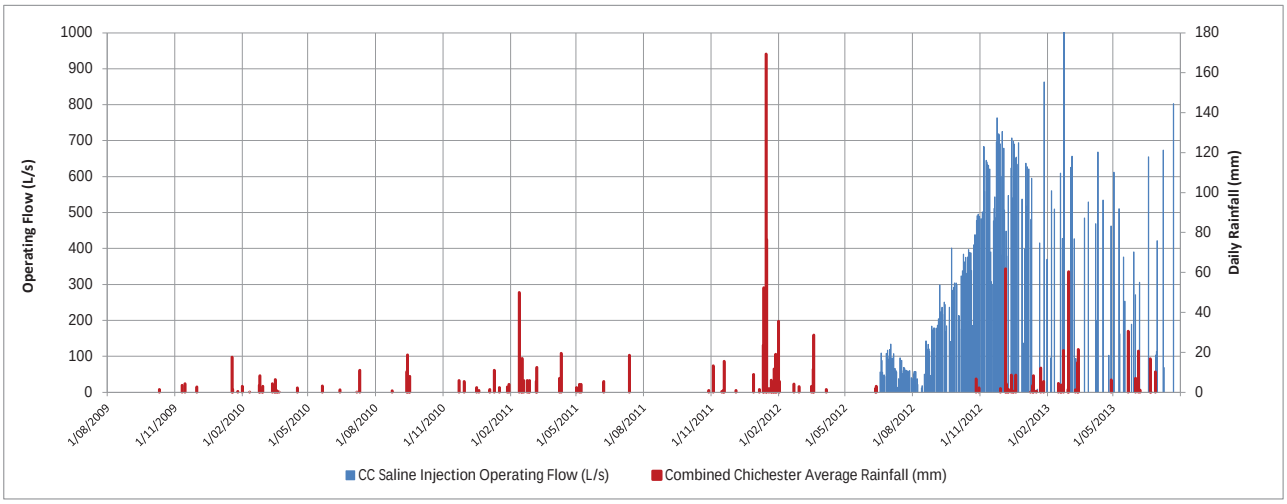


CCE02MB_S Hydrograph

Bore Name: CCE02MB_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

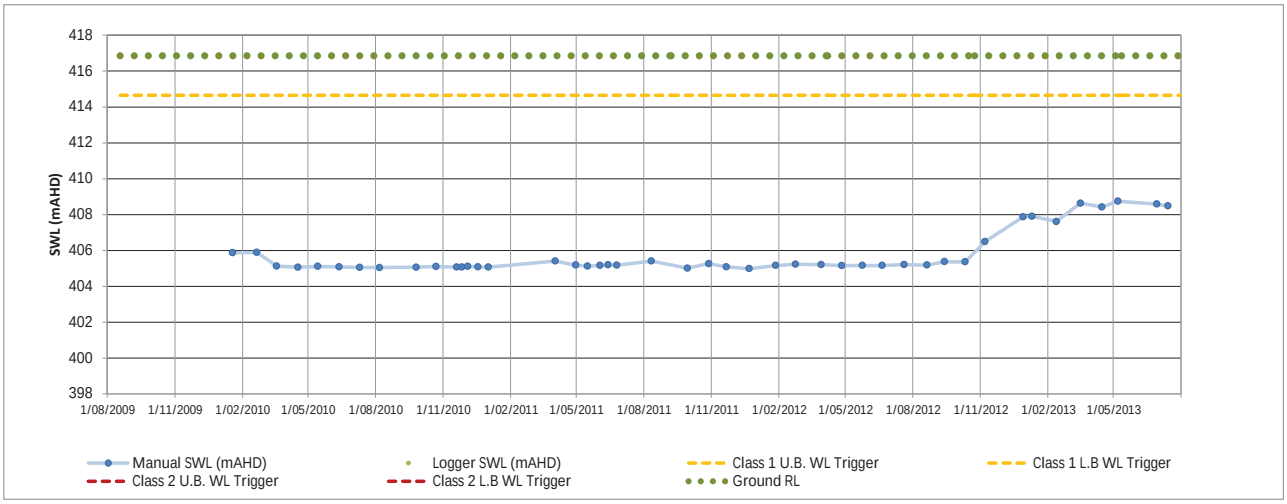


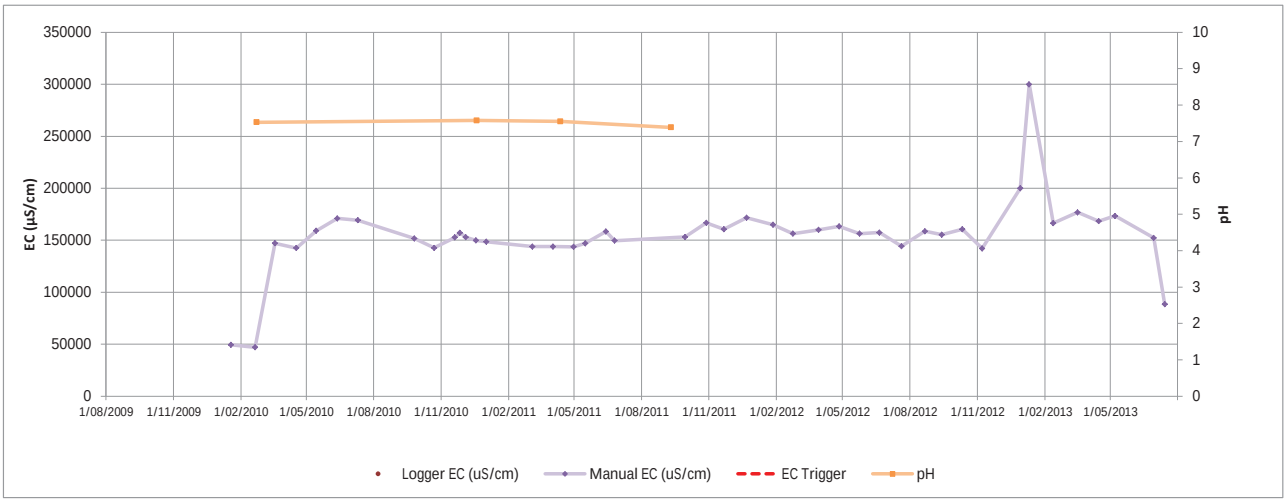


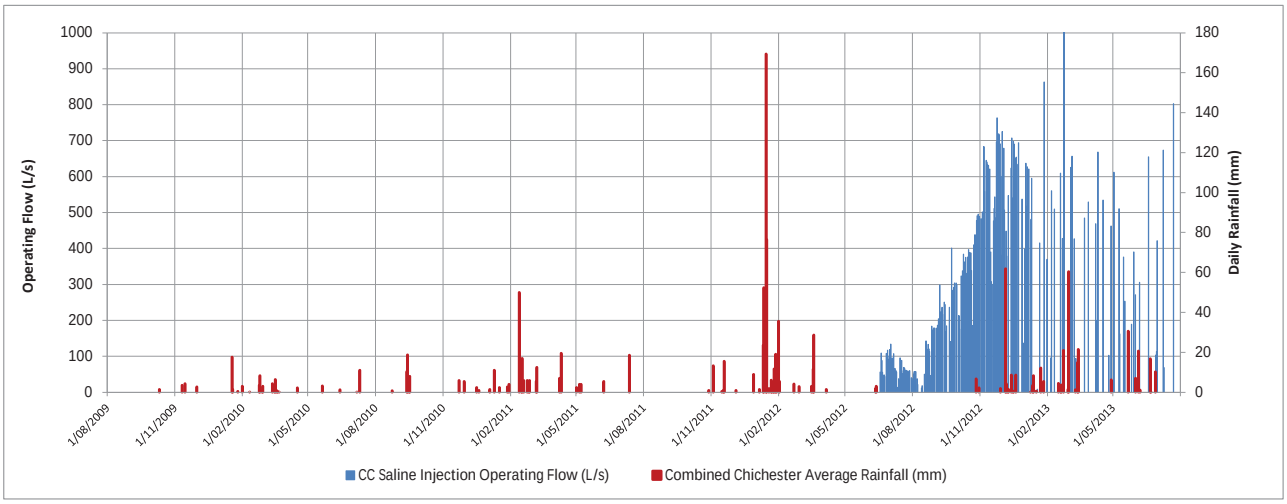


CCE02MB_D Hydrograph

Bore Name: CCE02MB_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

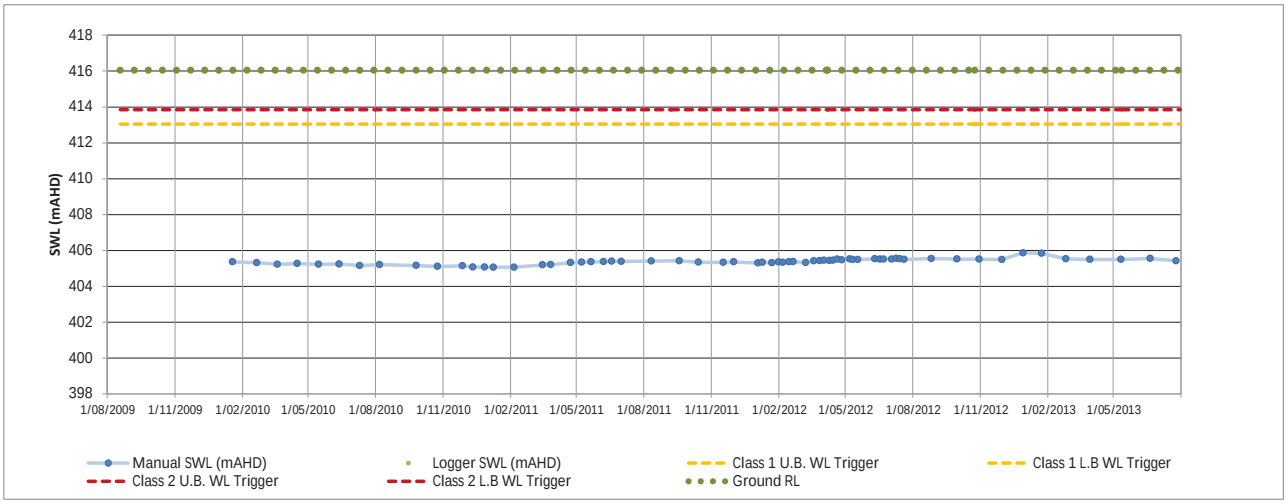


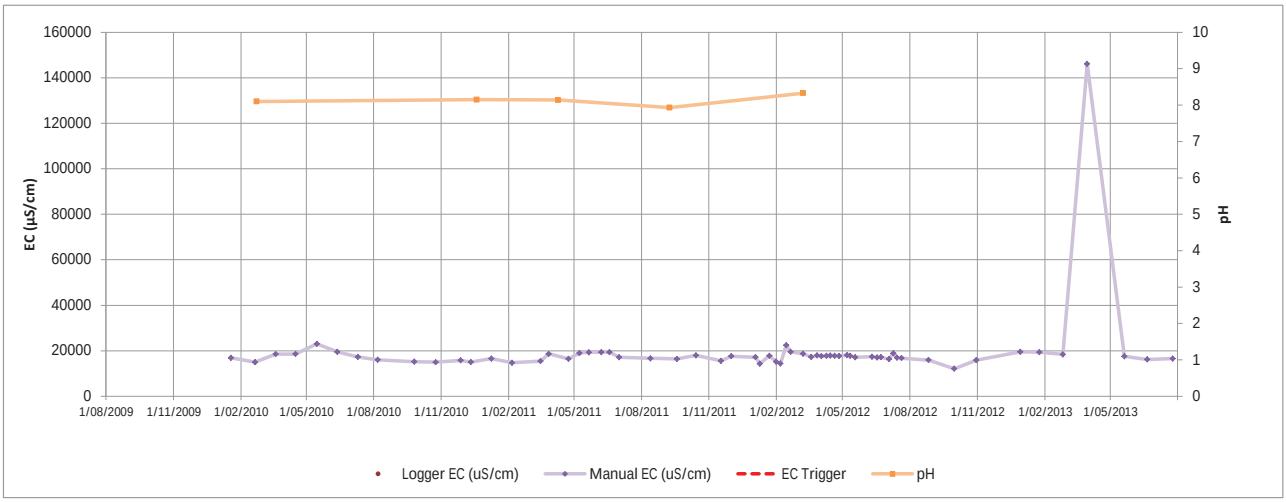


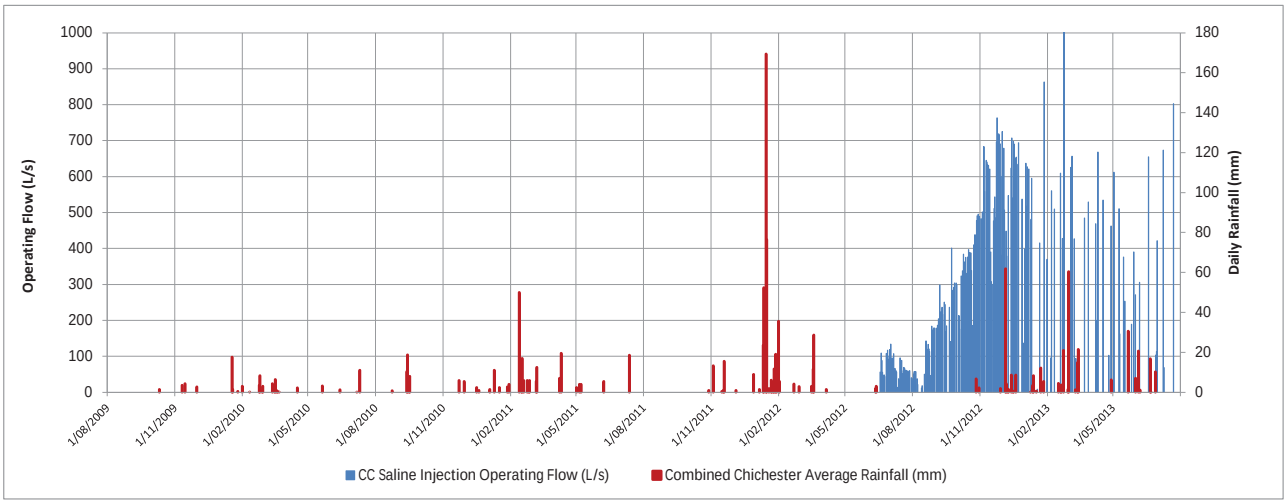


CCE10MB_S Hydrograph

Bore Name: CCE10MB_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

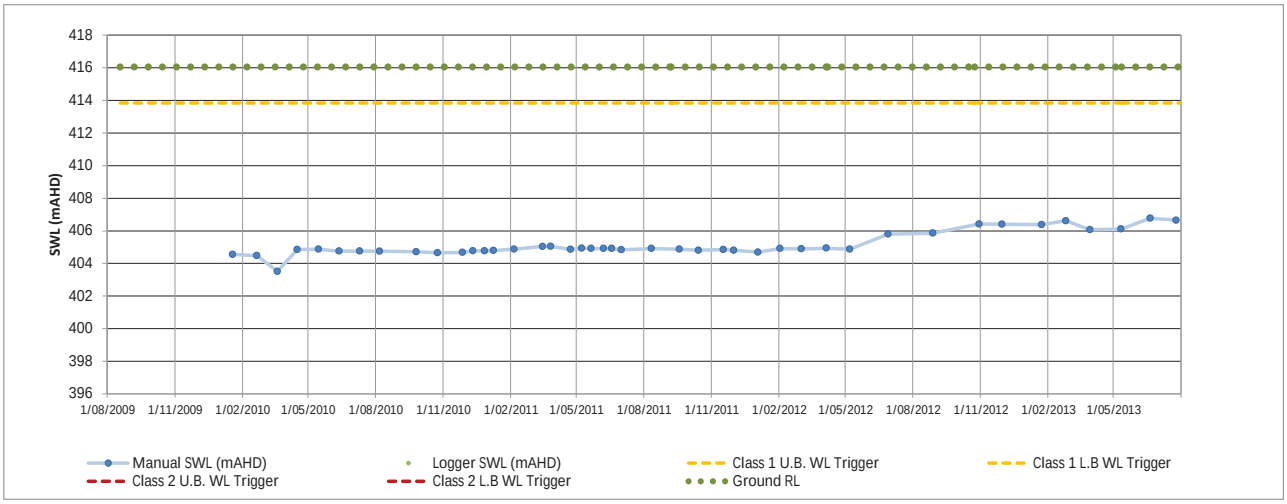


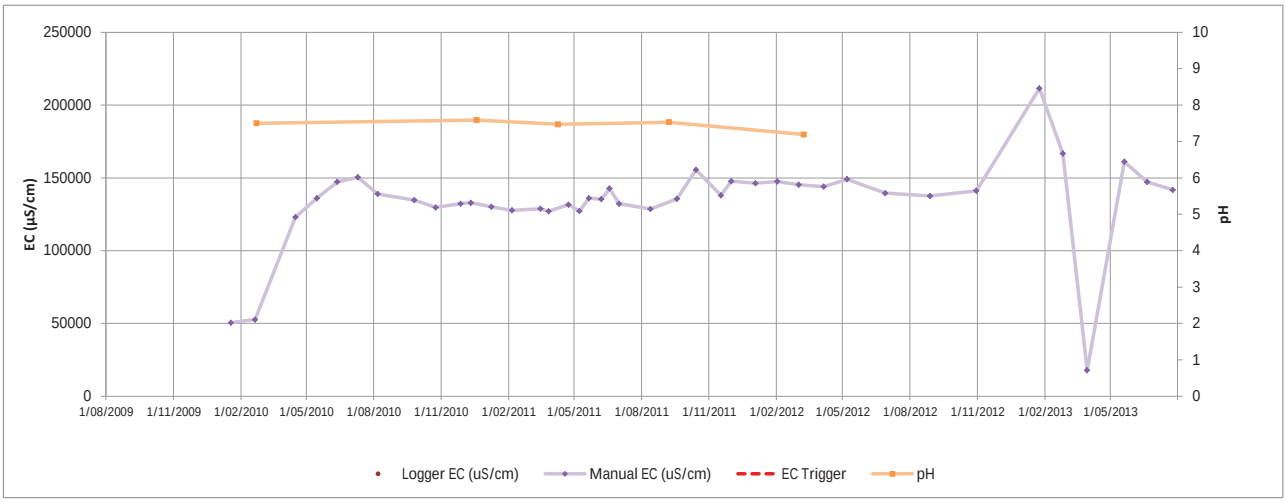


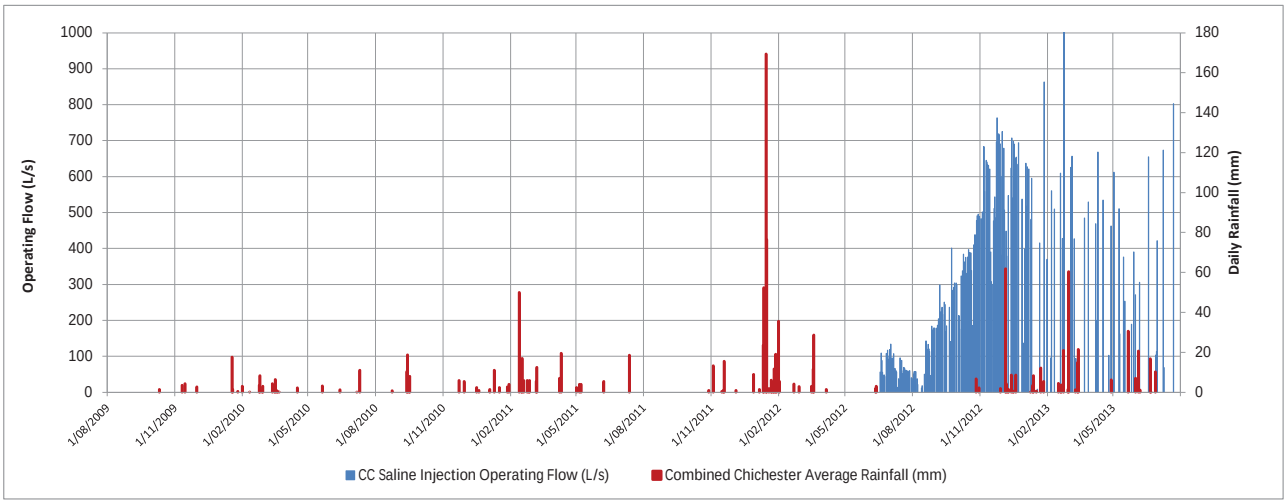


CCE10MB_D Hydrograph

Bore Name: CCE10MB_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

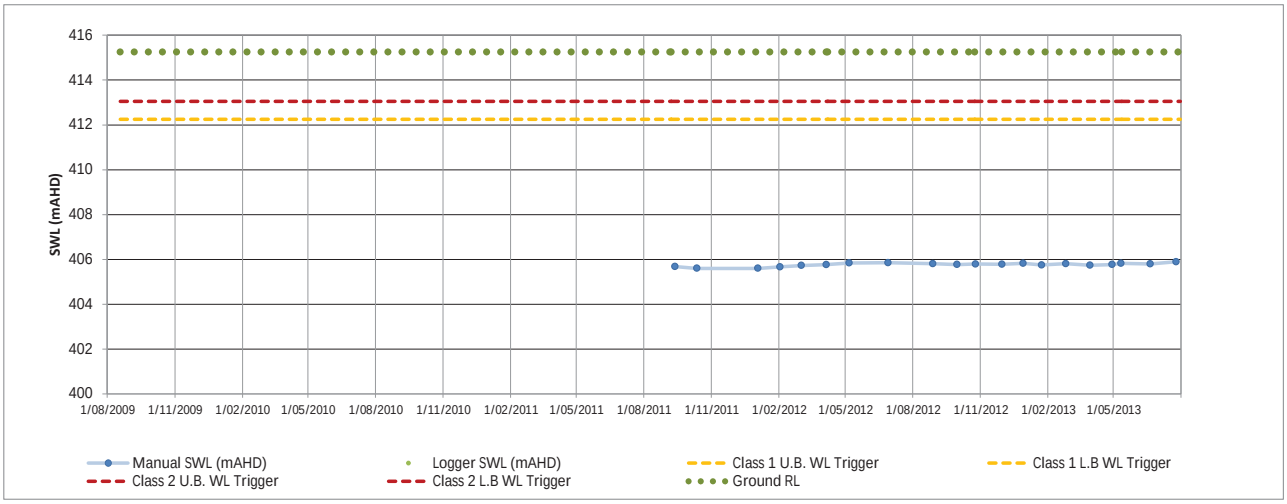


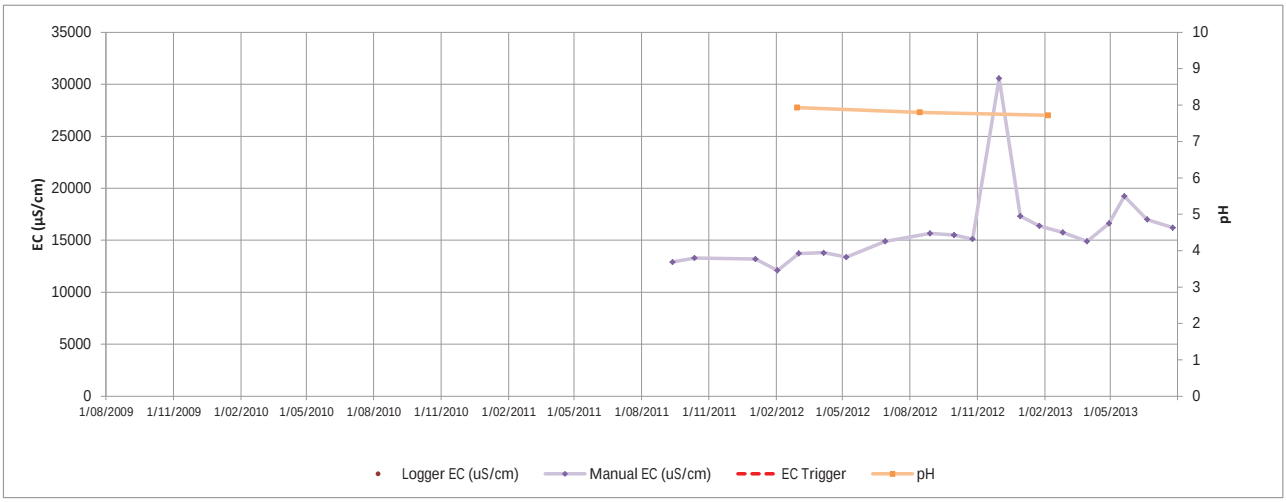


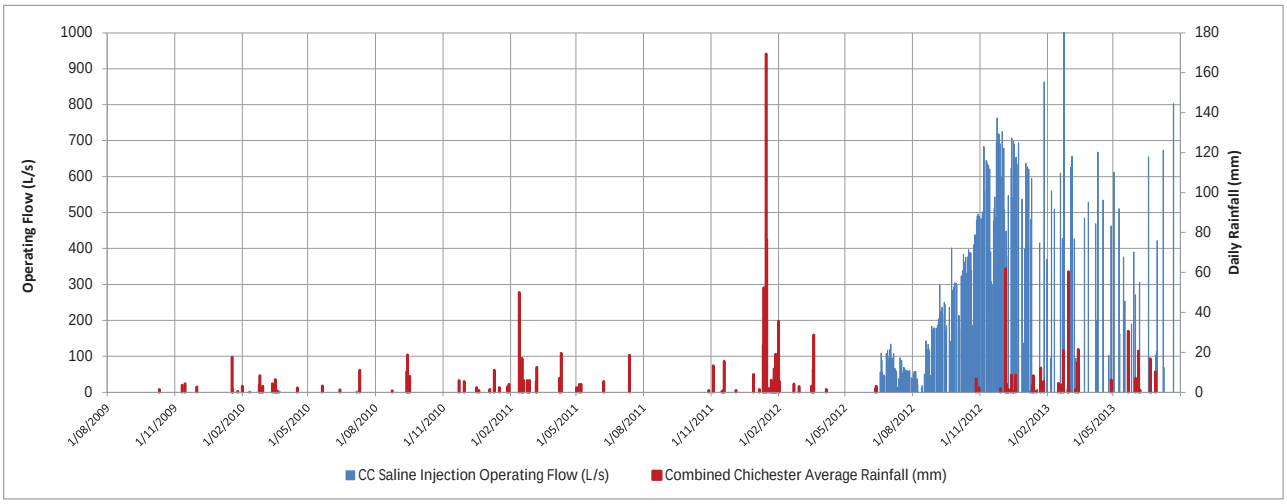


SAM07_S Hydrograph

Bore Name: SAM07_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

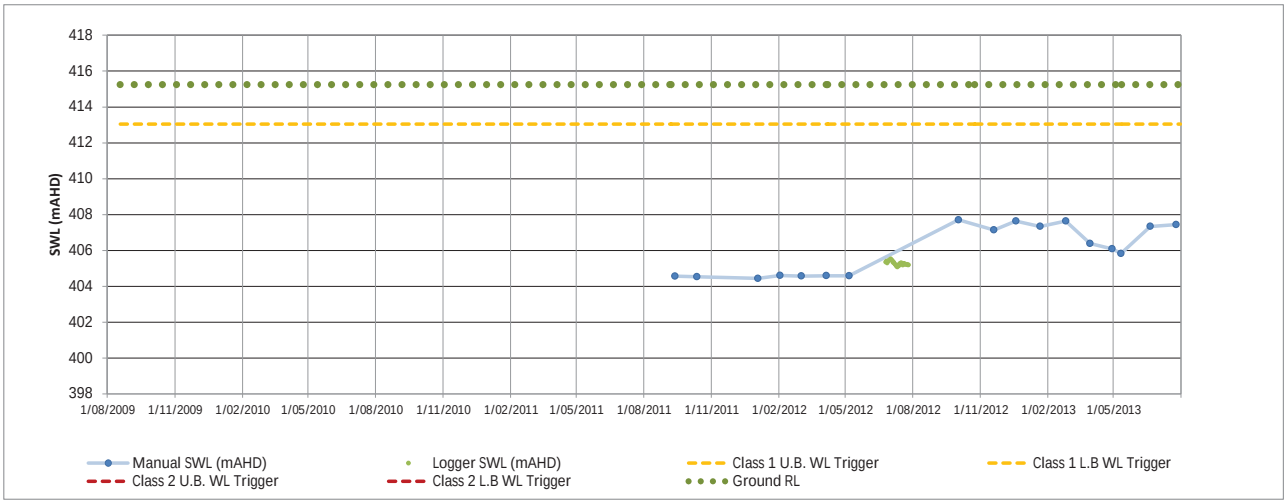


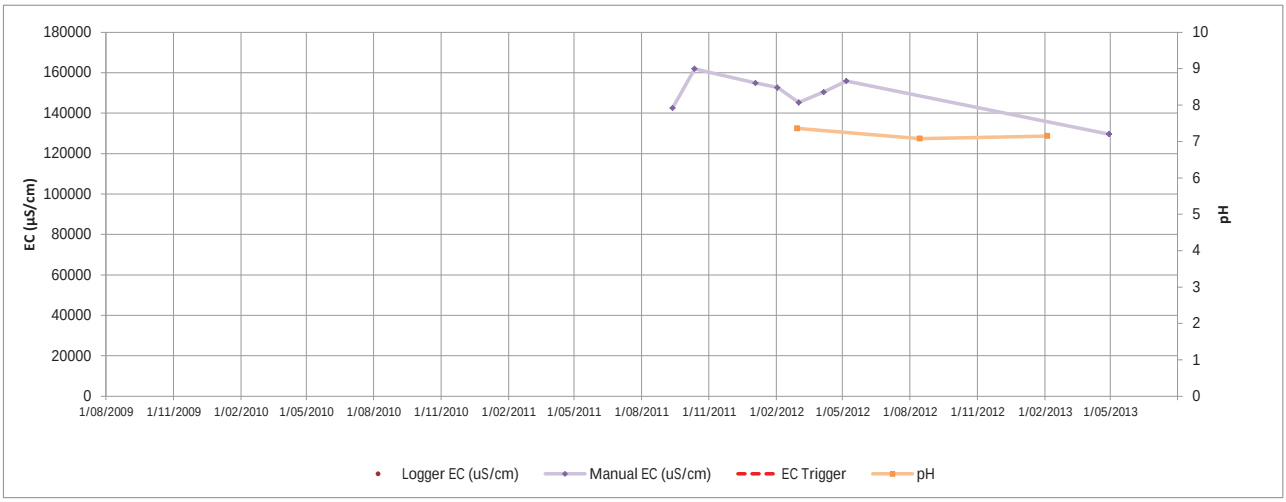


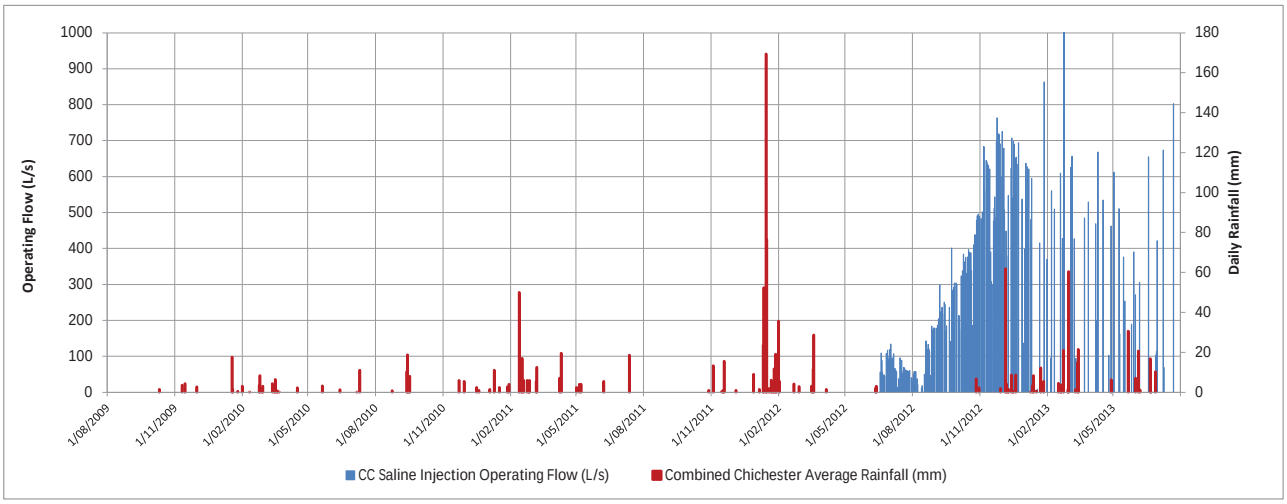


SAM07_D Hydrograph

Bore Name: SAM07_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

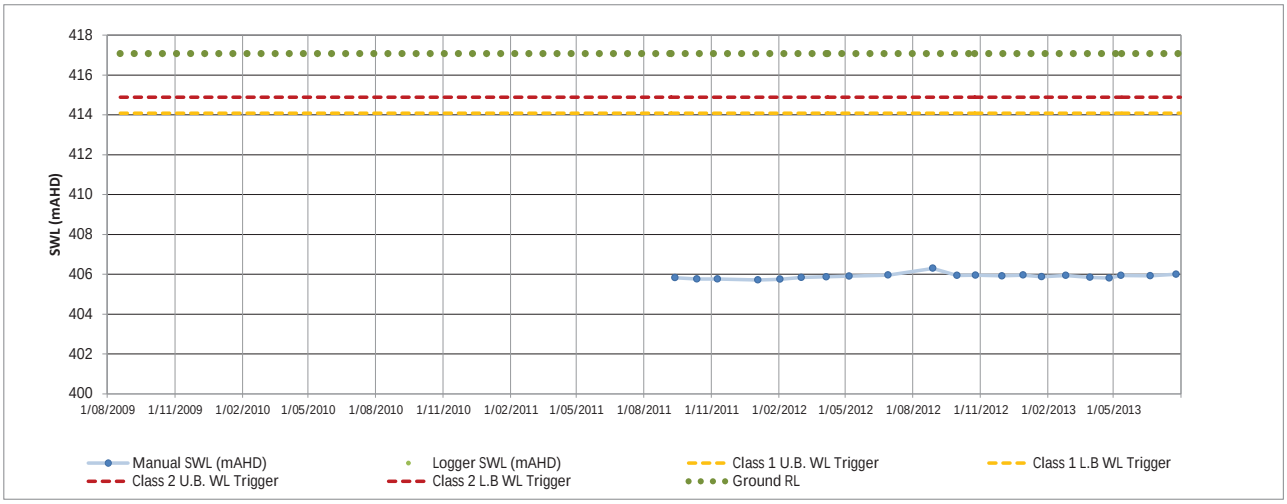


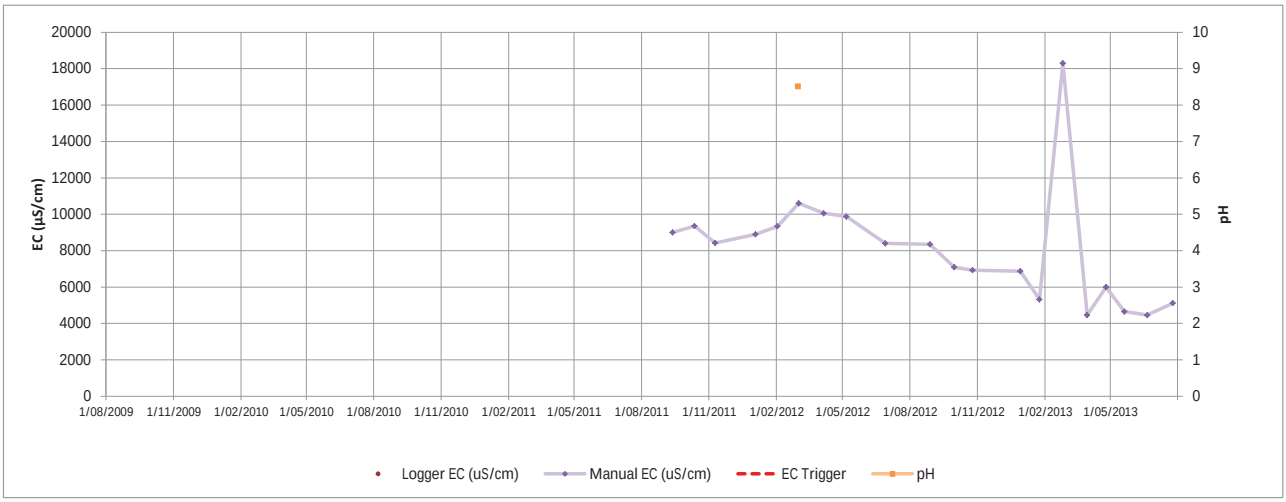


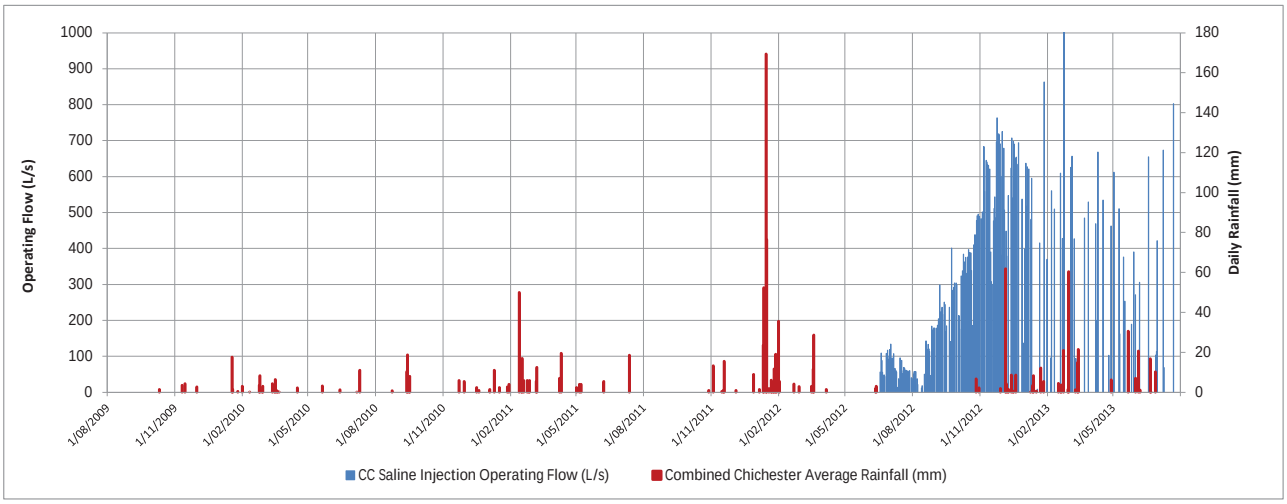


SAM09_S Hydrograph

Bore Name: SAM09_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

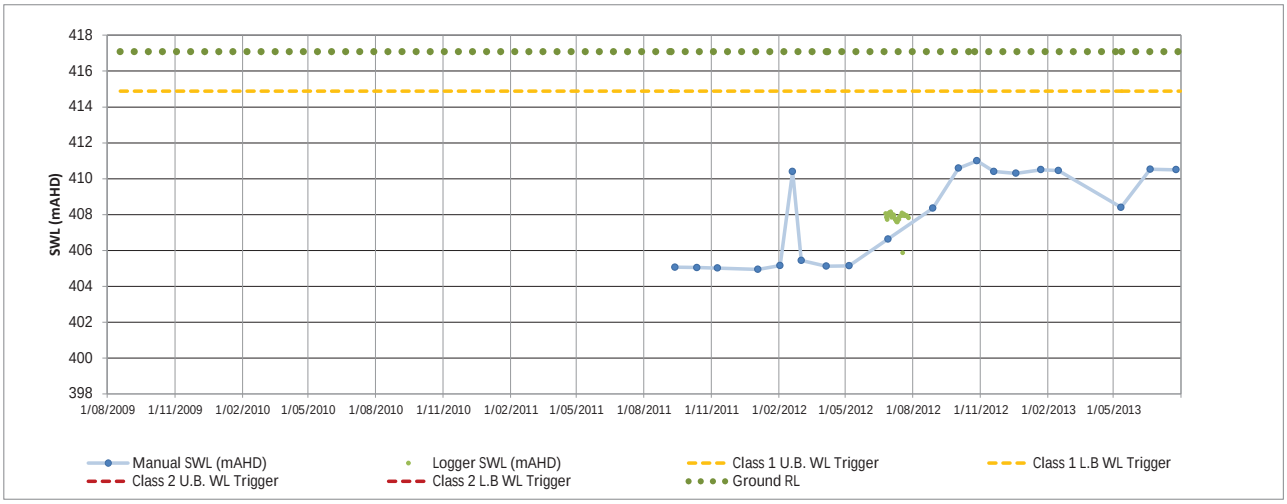


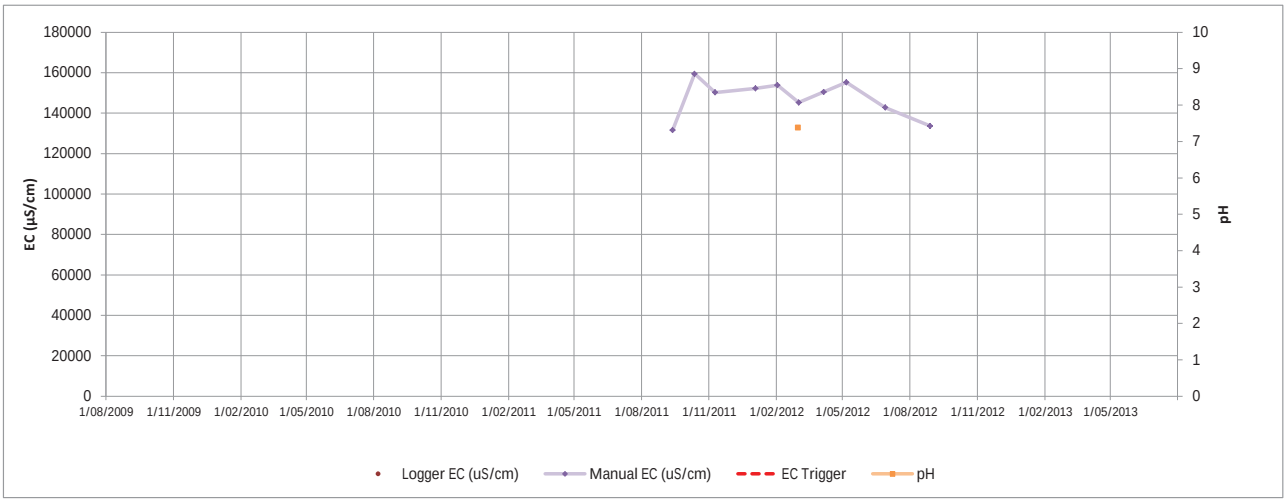


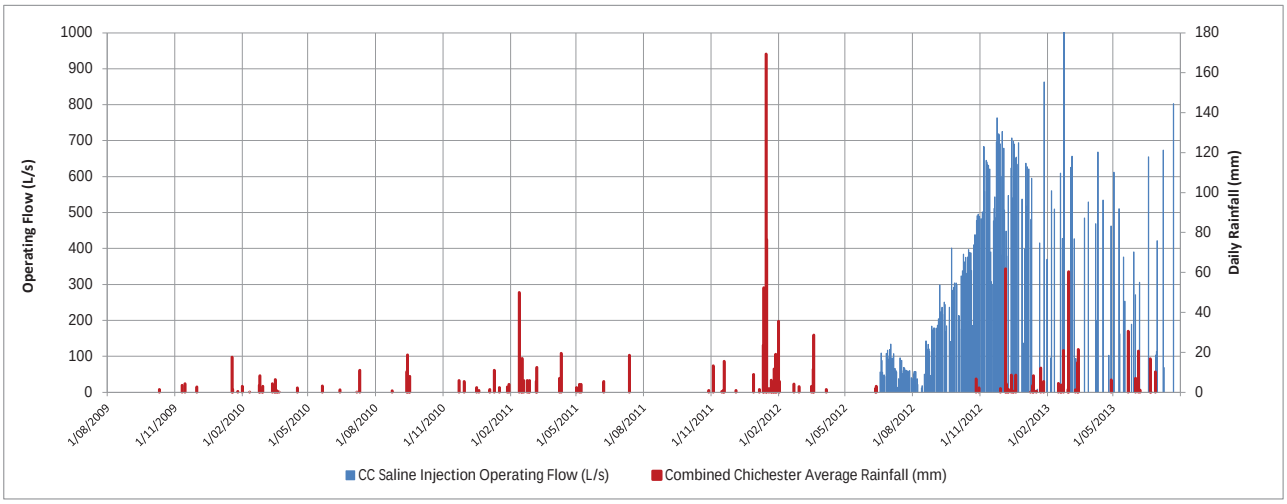


SAM09_D Hydrograph

Bore Name: SAM09_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

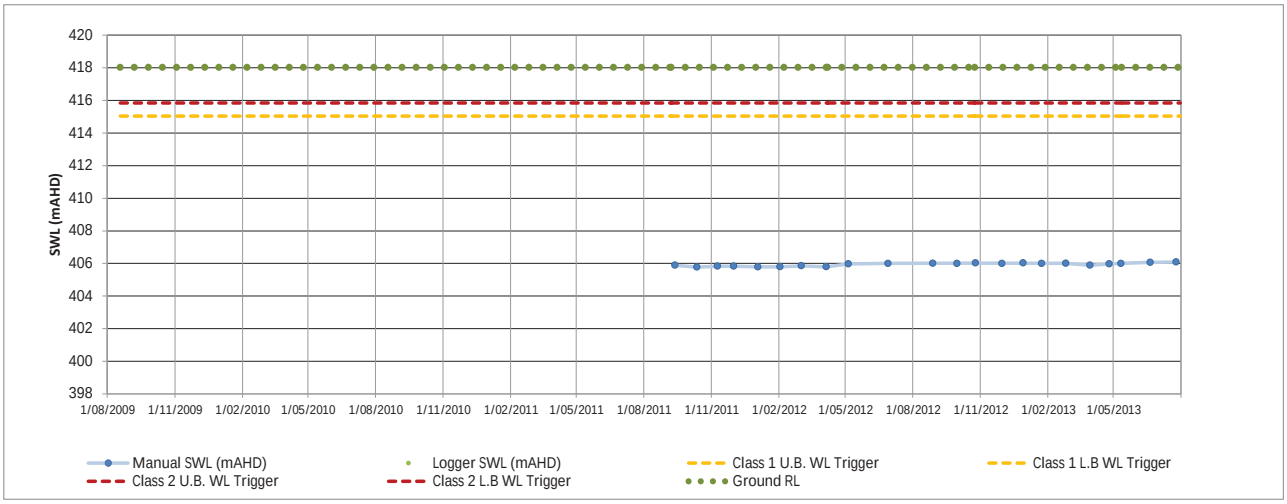


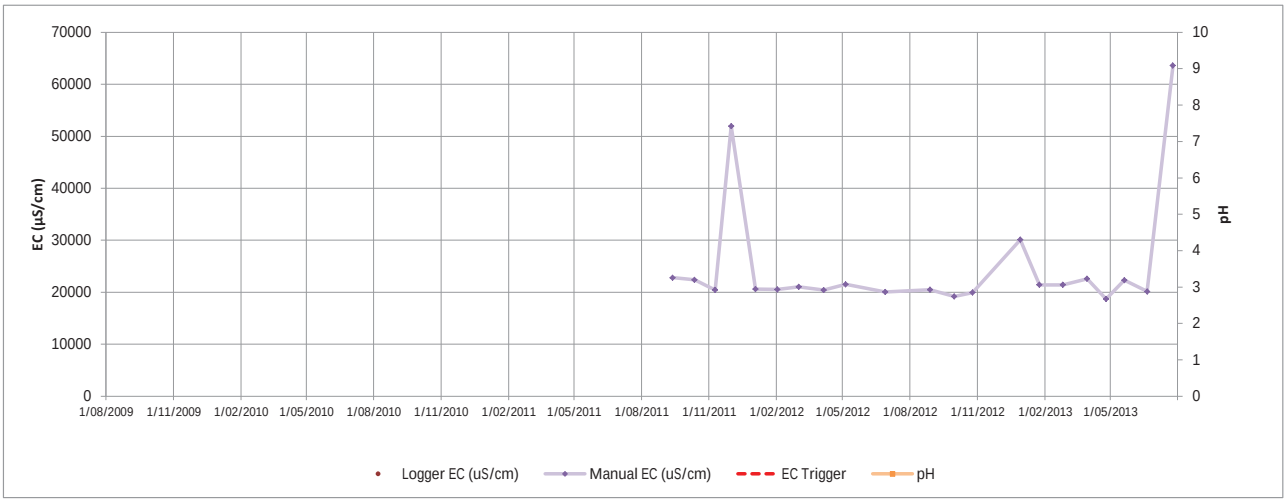


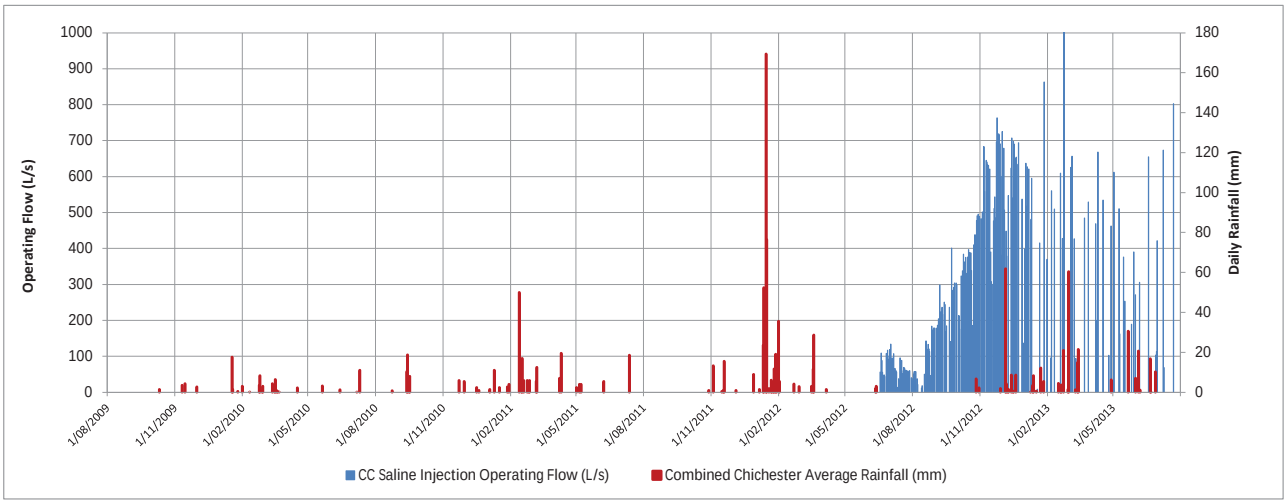


SAM10_S Hydrograph

Bore Name: SAM10_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

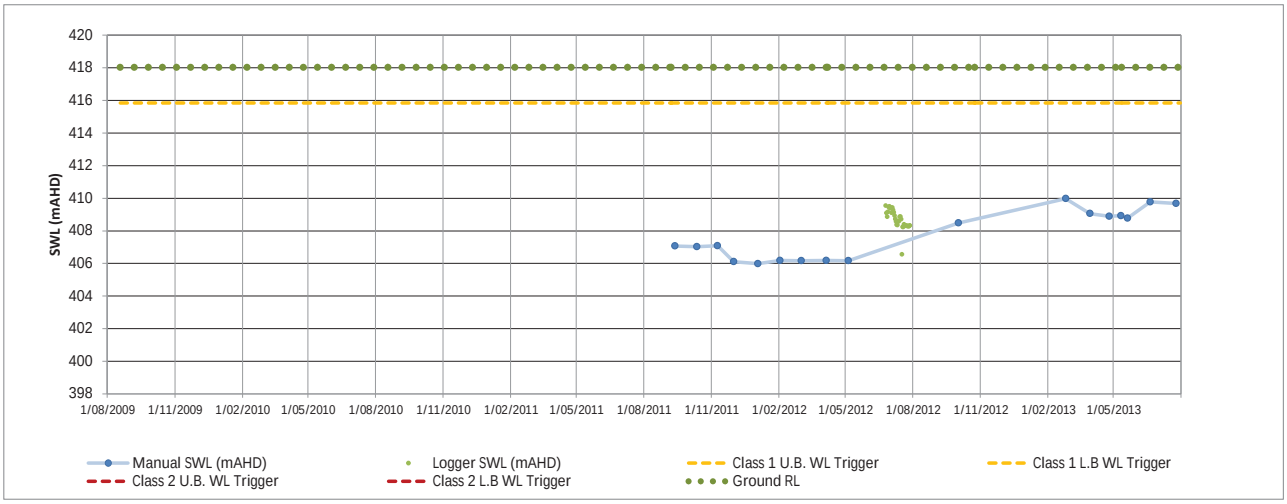


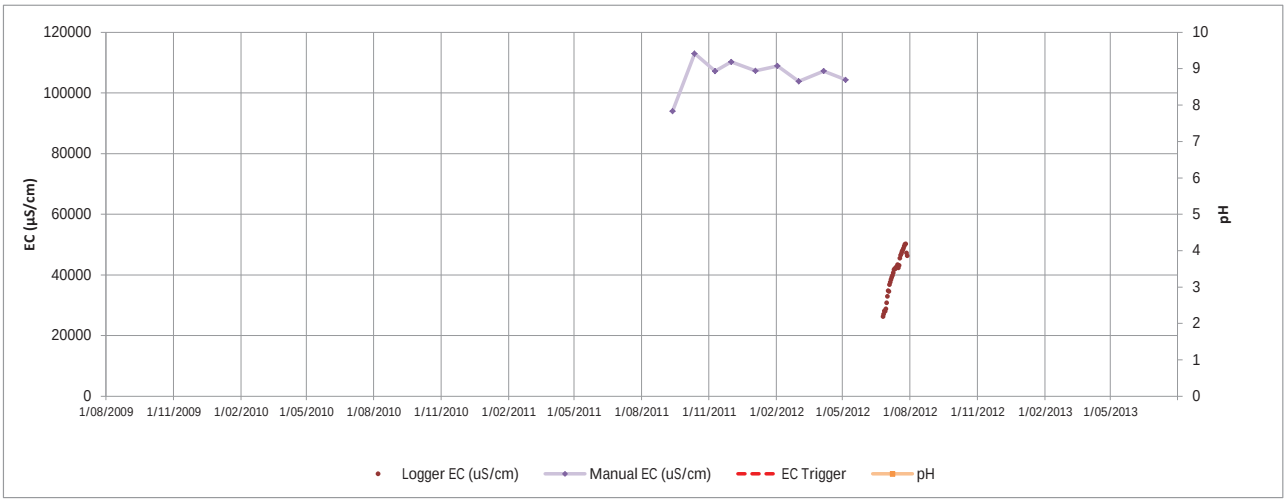


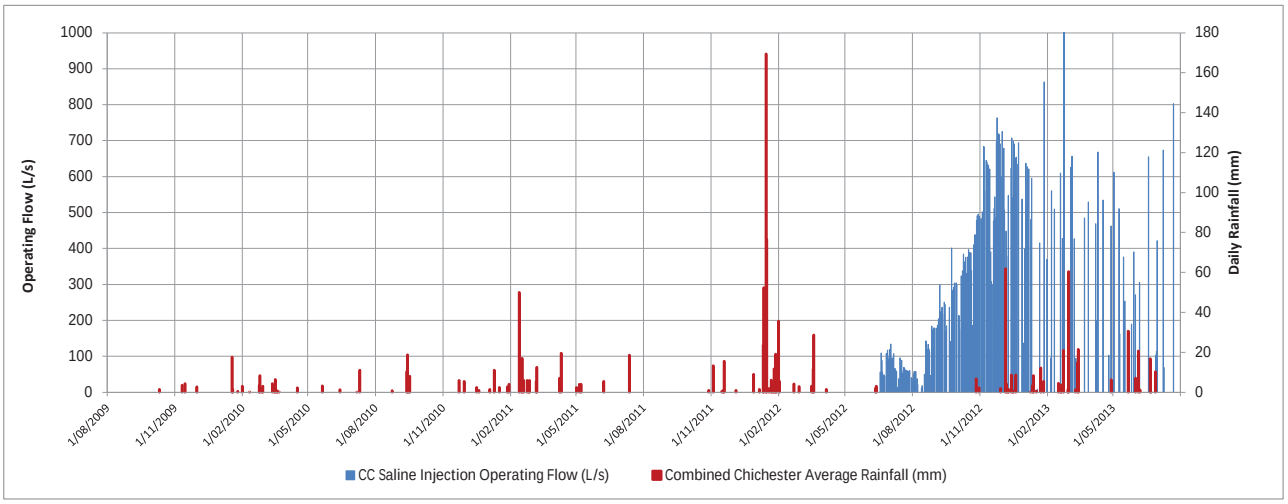


SAM10_D Hydrograph

Bore Name: SAM10_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

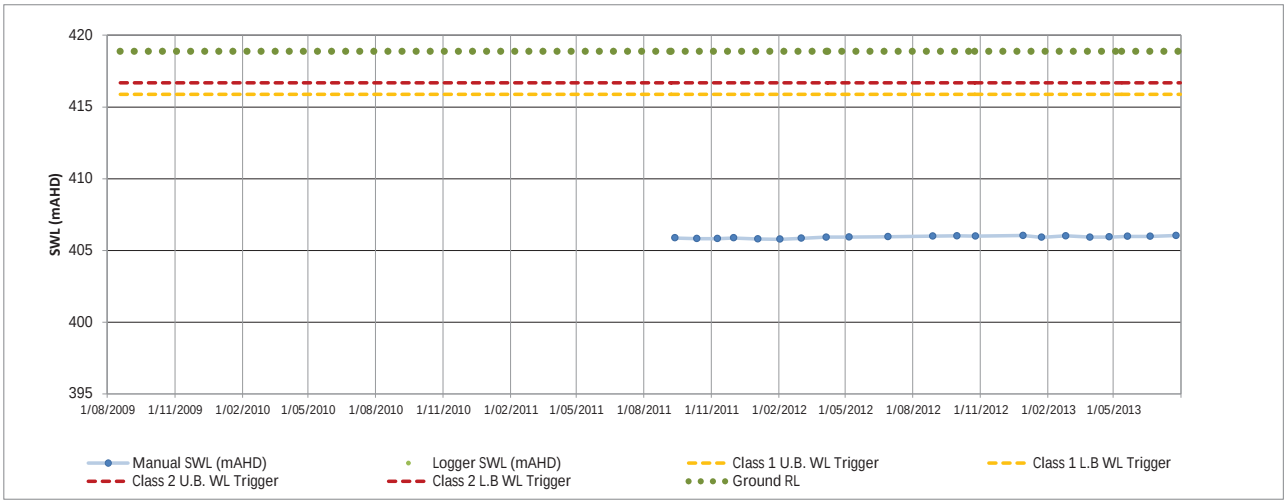


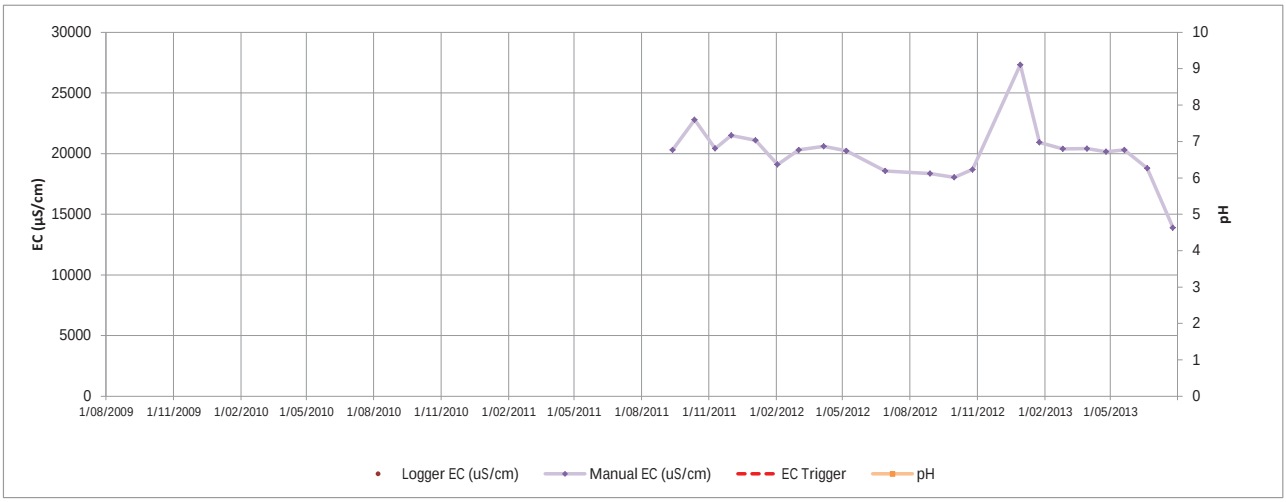


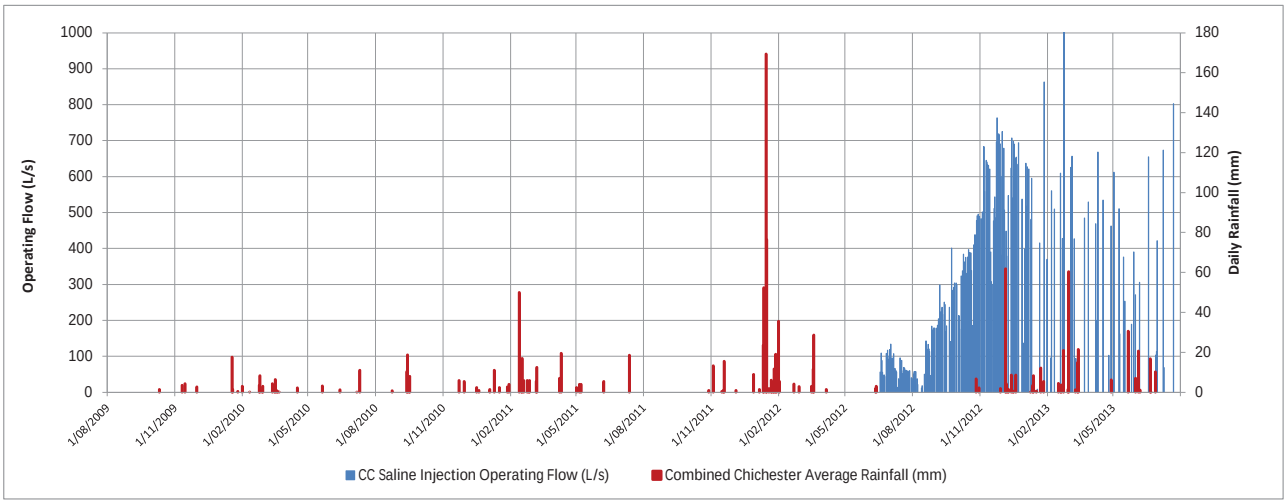


SAM11_S Hydrograph

Bore Name: SAM11_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

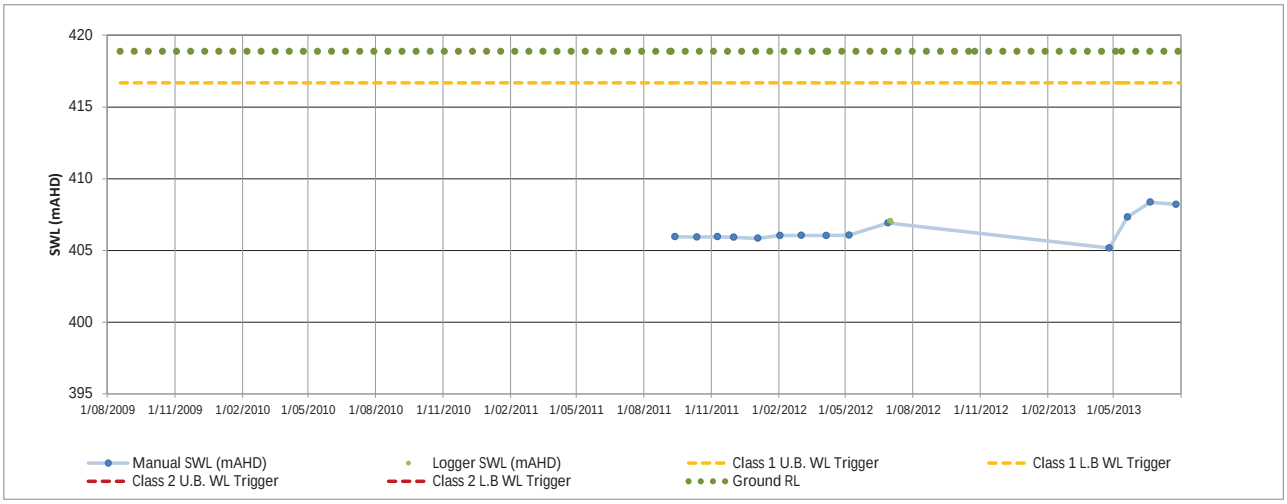


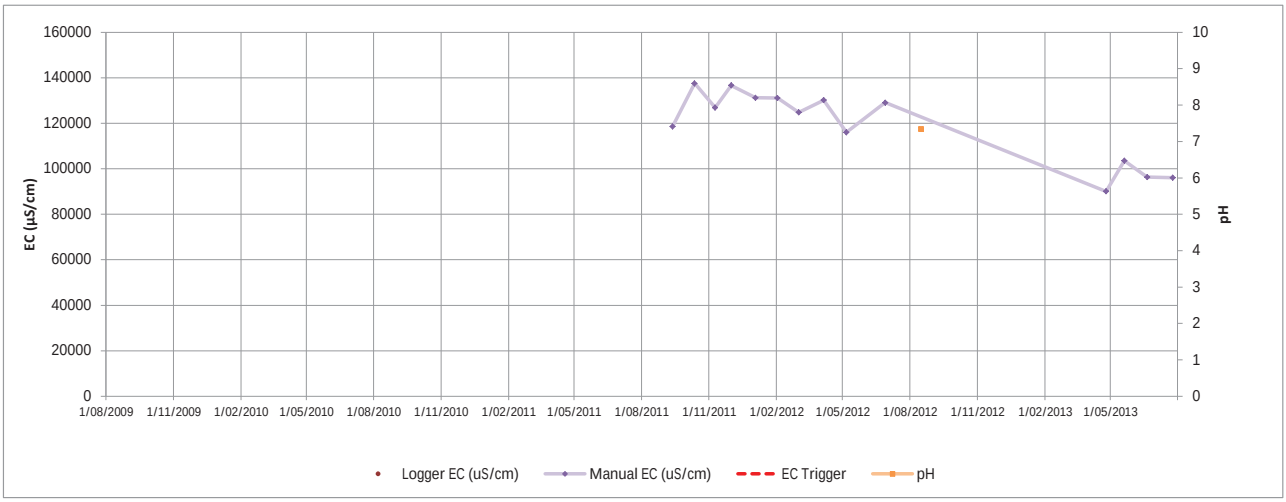


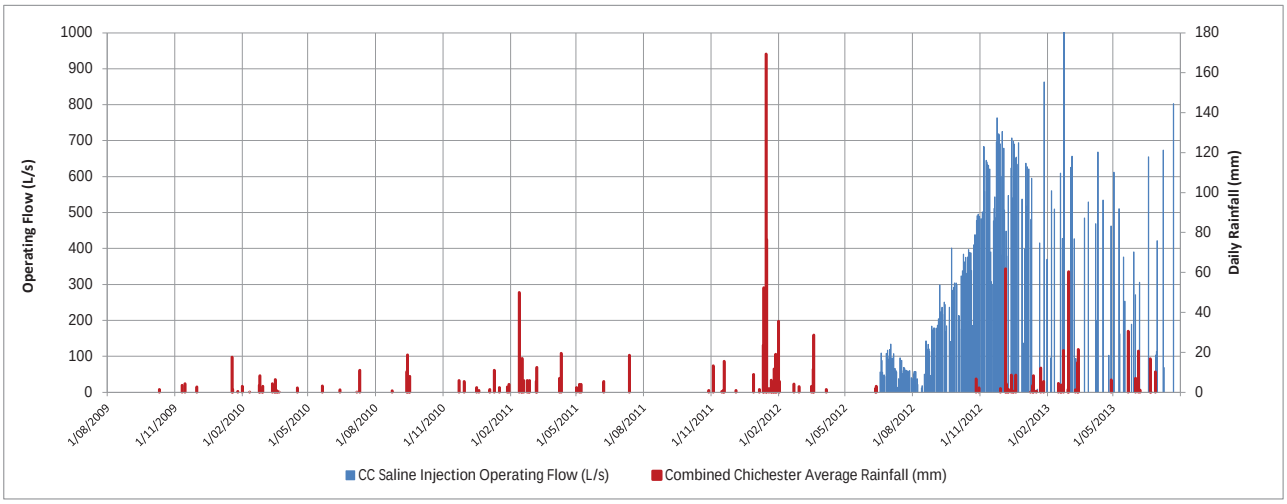


SAM11_D Hydrograph

Bore Name: SAM11_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

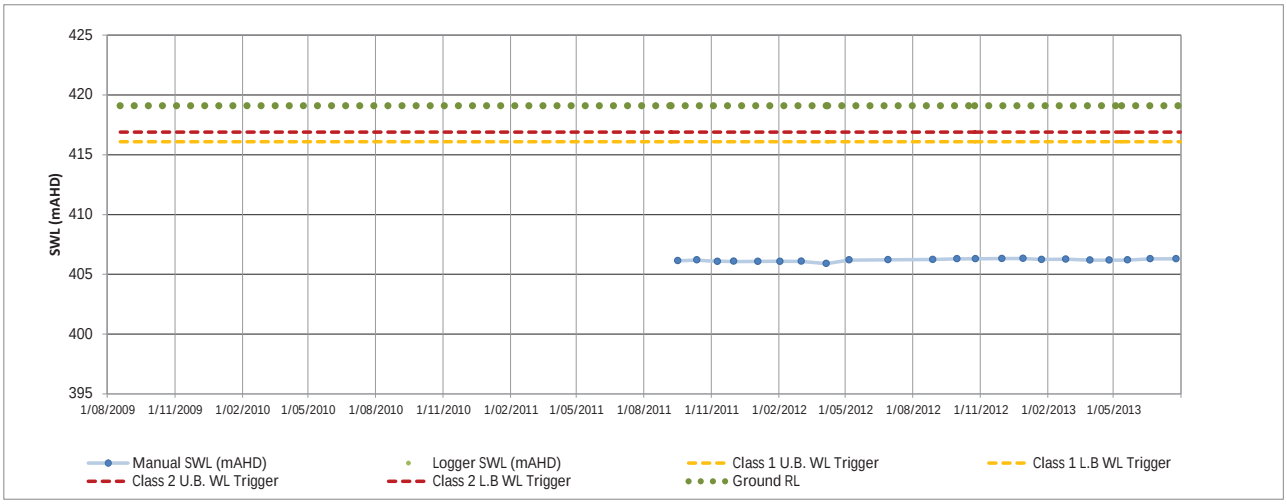


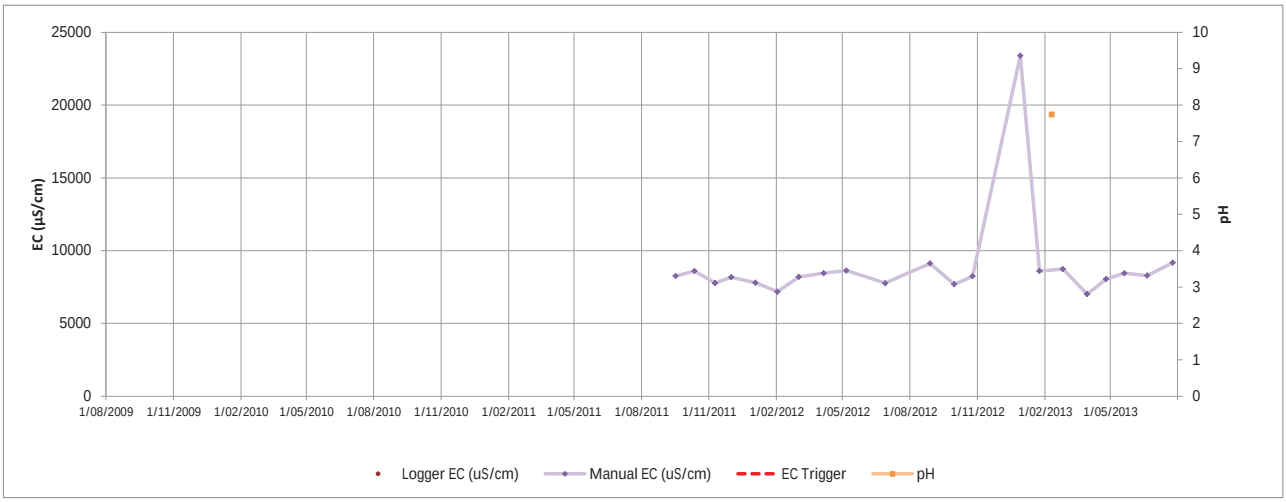


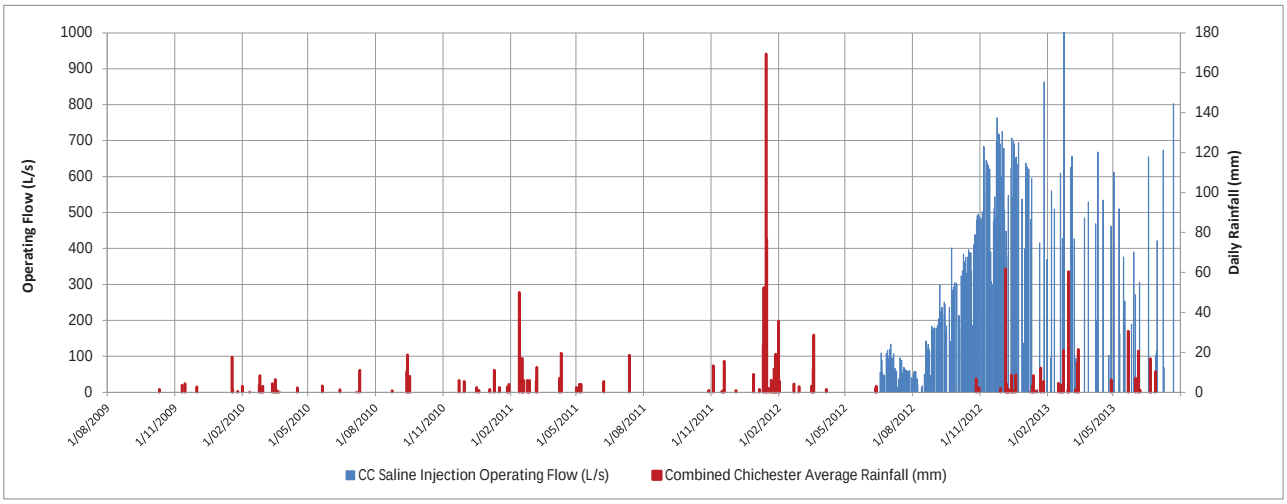


SAM13_S Hydrograph

Bore Name: SAM13_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

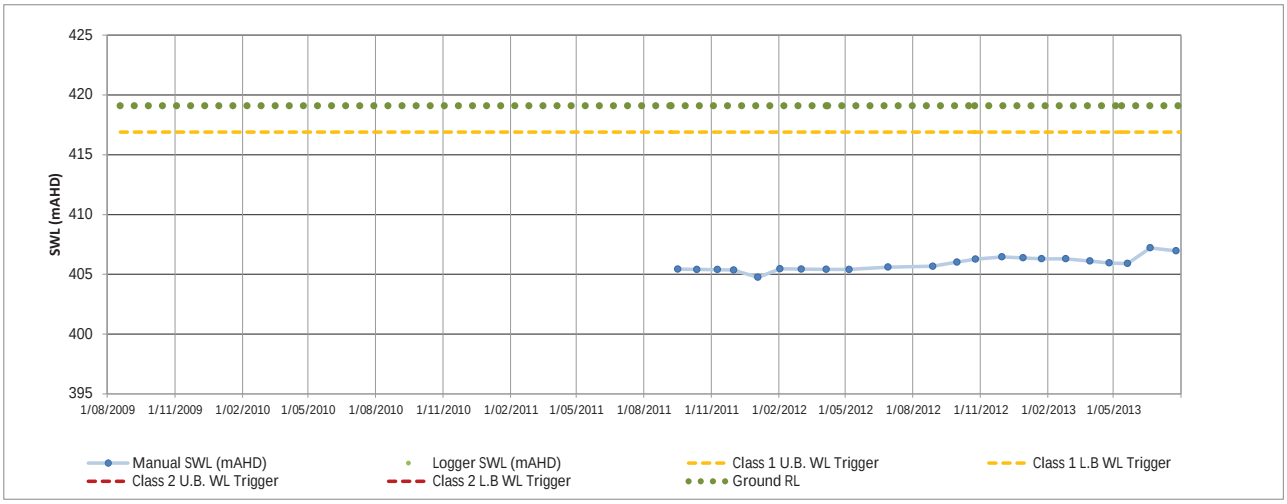


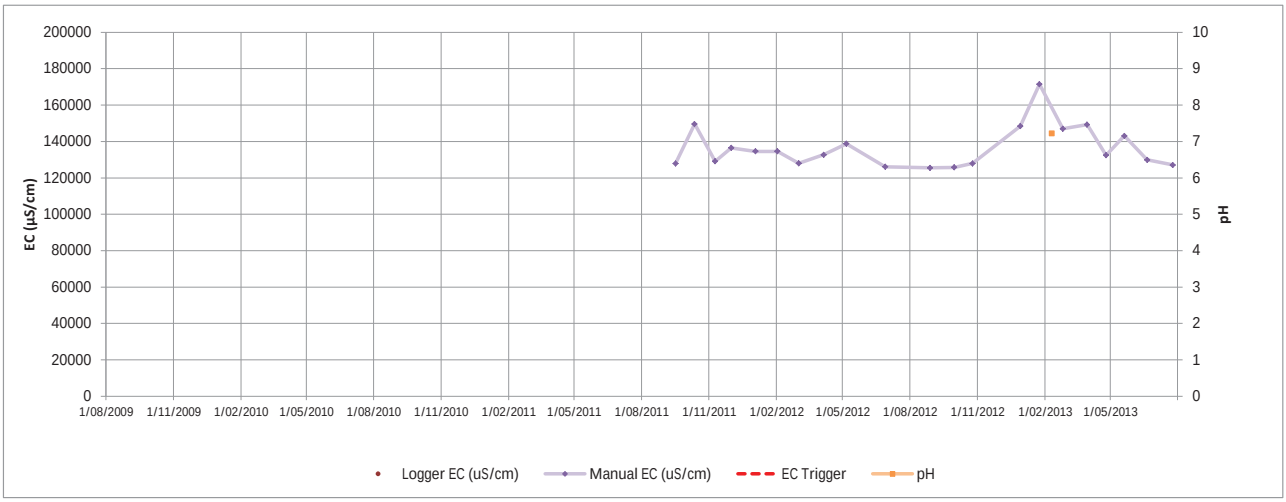


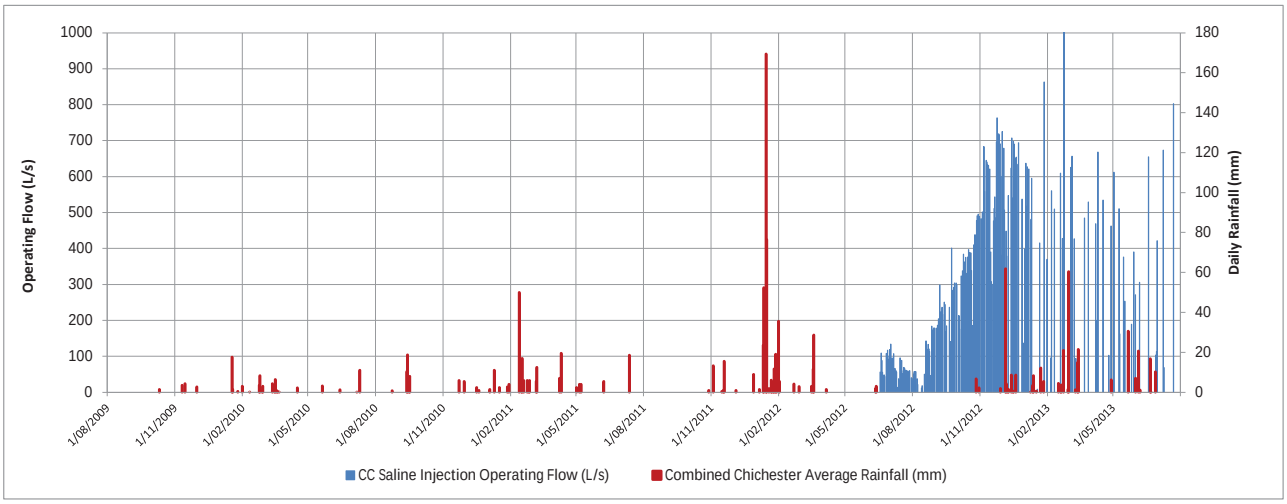


SAM13_D Hydrograph

Bore Name: SAM13_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

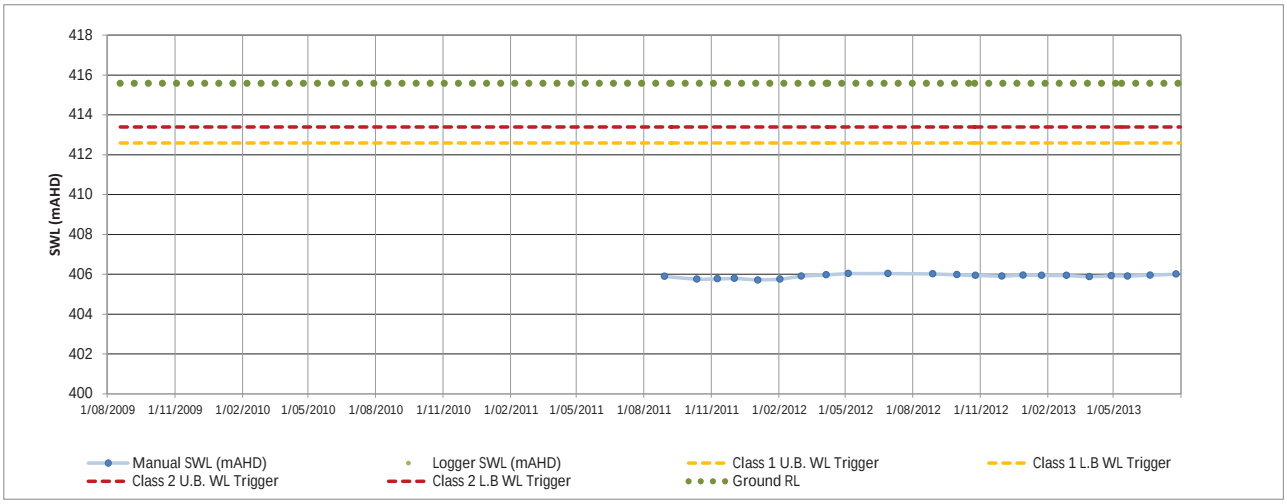


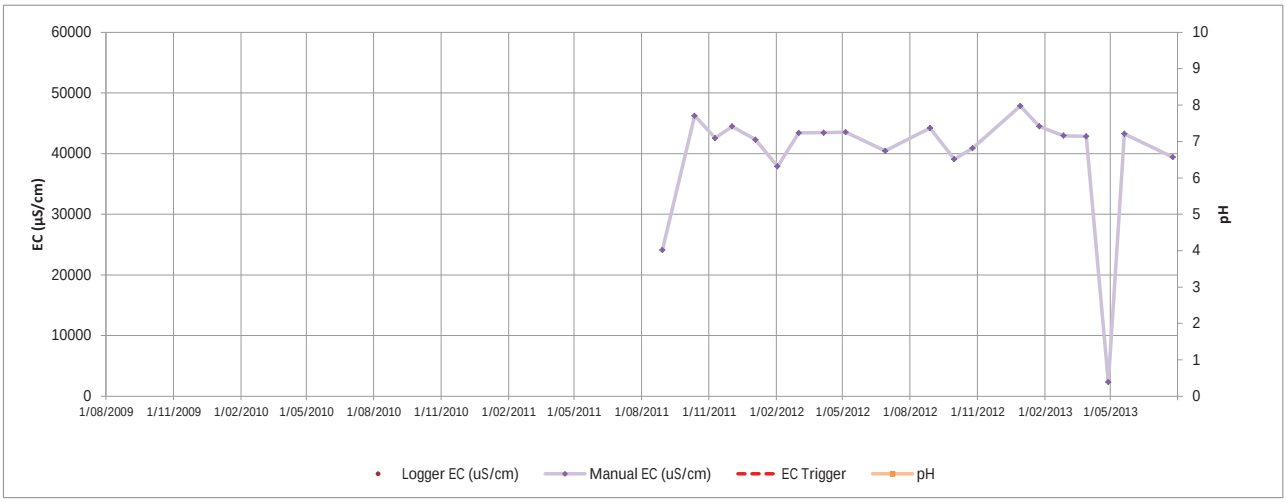


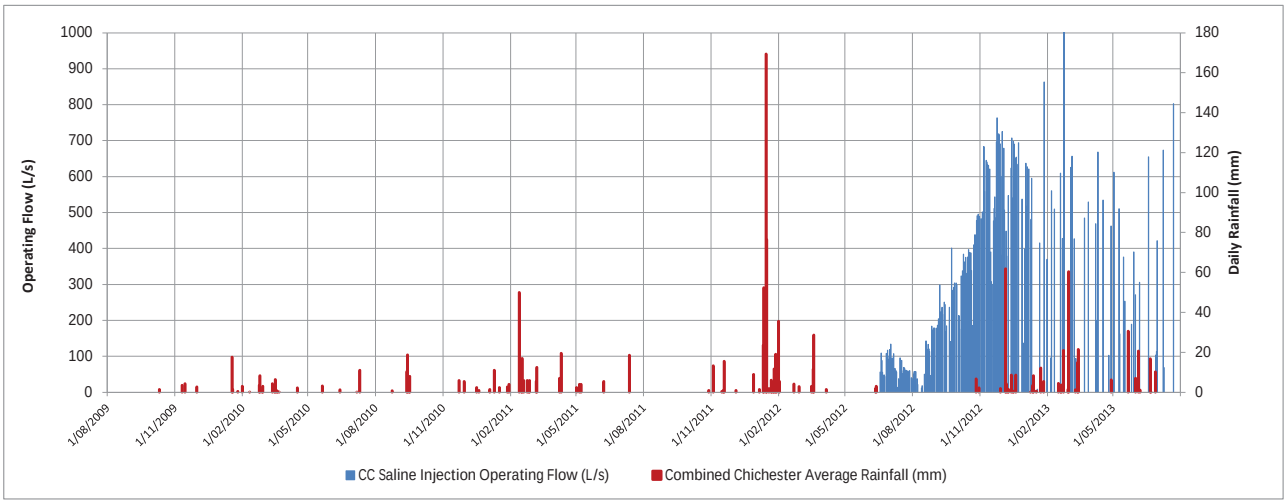


SAM17_S Hydrograph

Bore Name: SAM17_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

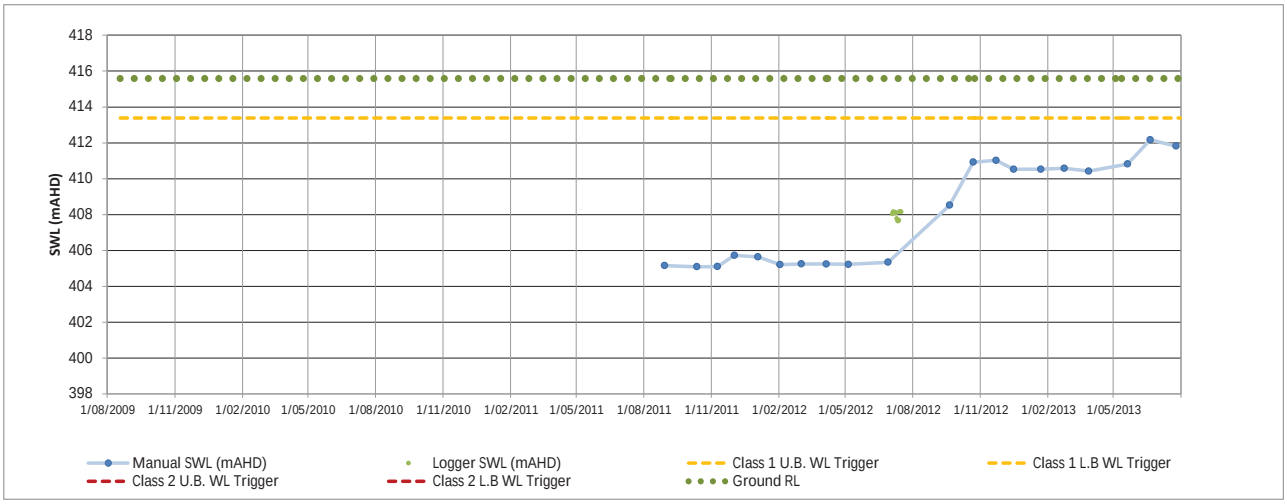


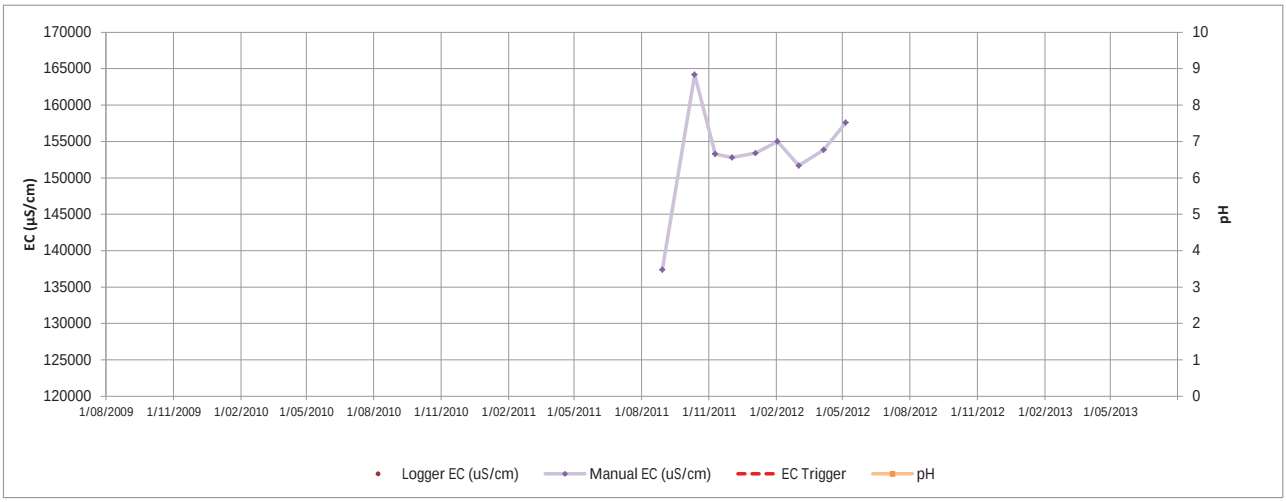


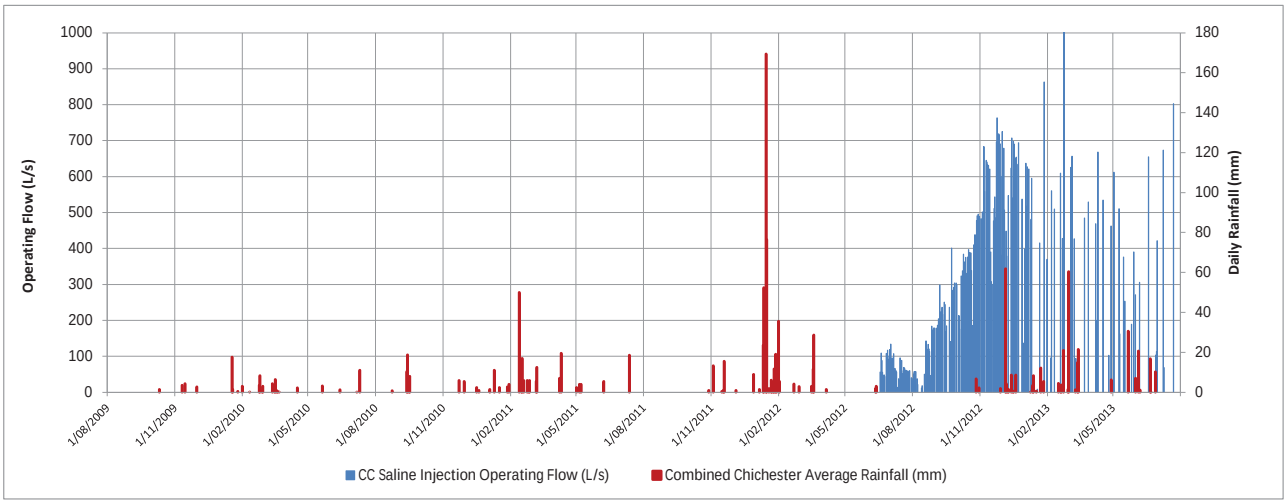


SAM17_D Hydrograph

Bore Name: SAM17_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

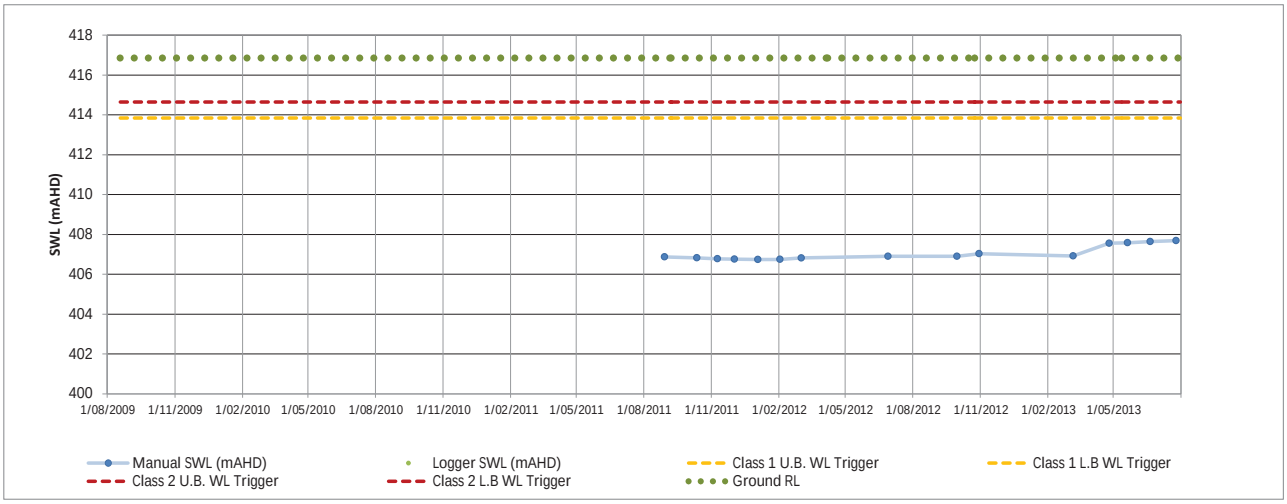


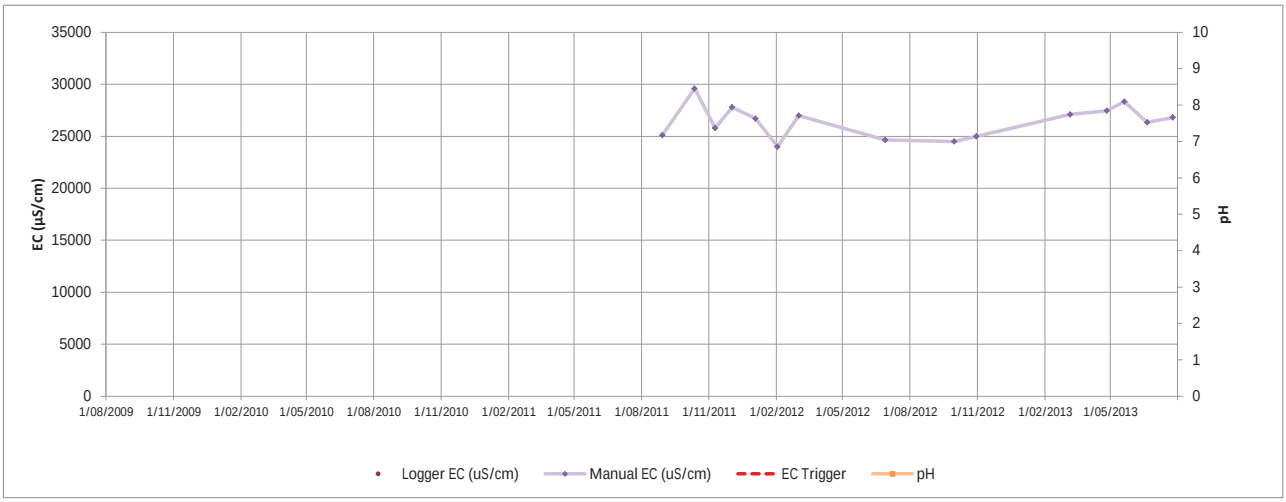


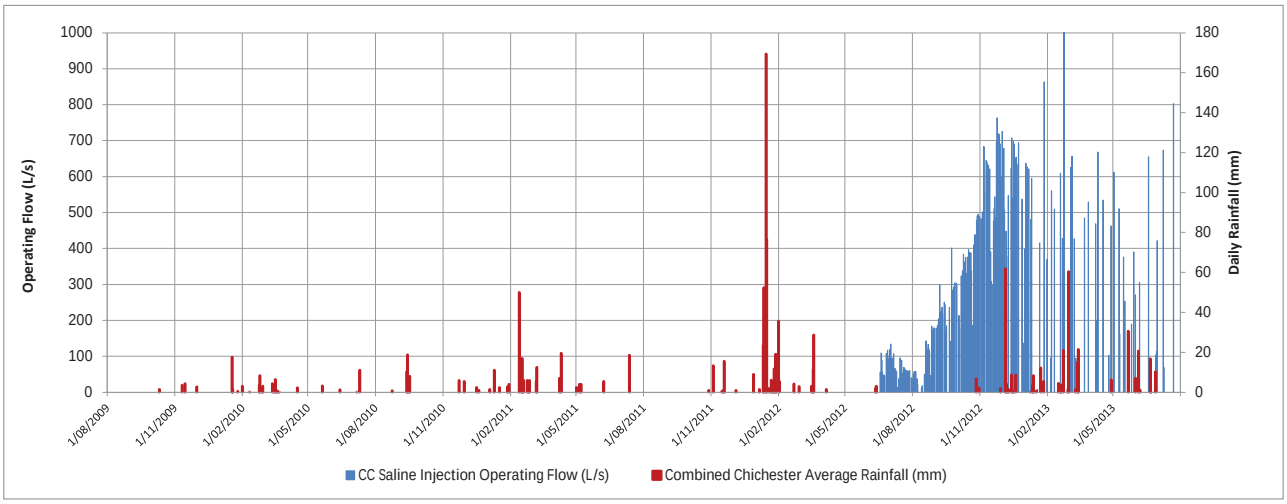


SAM18_S Hydrograph

Bore Name: SAM18_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

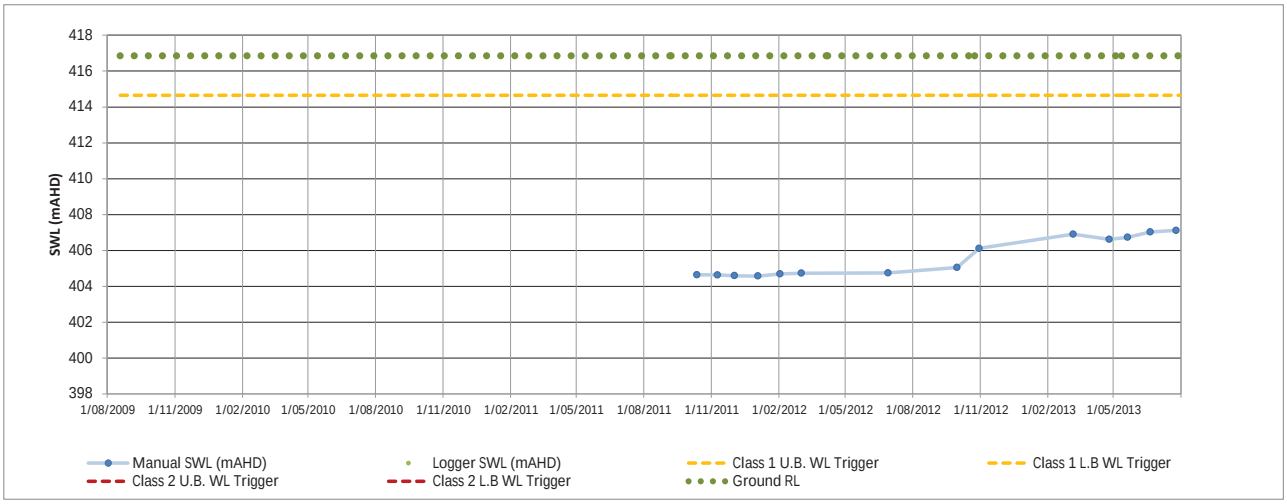


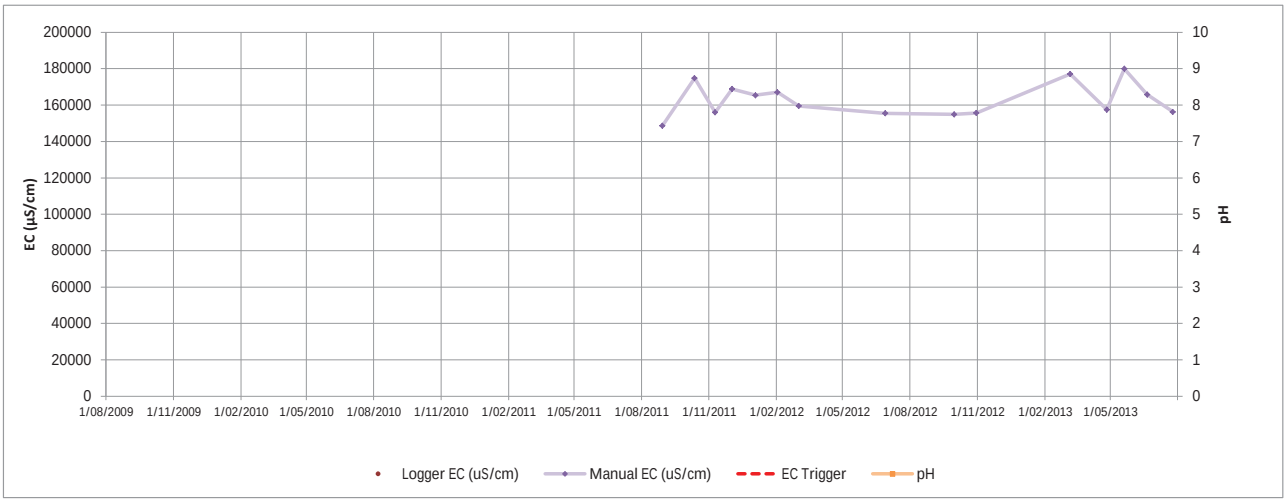


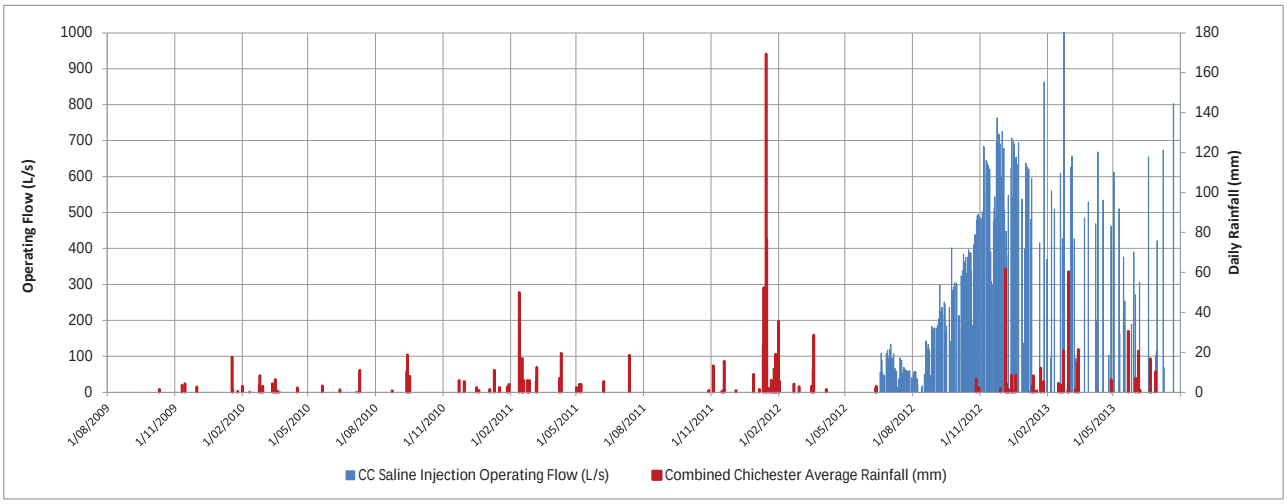


SAM18_D Hydrograph

Bore Name: SAM18_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

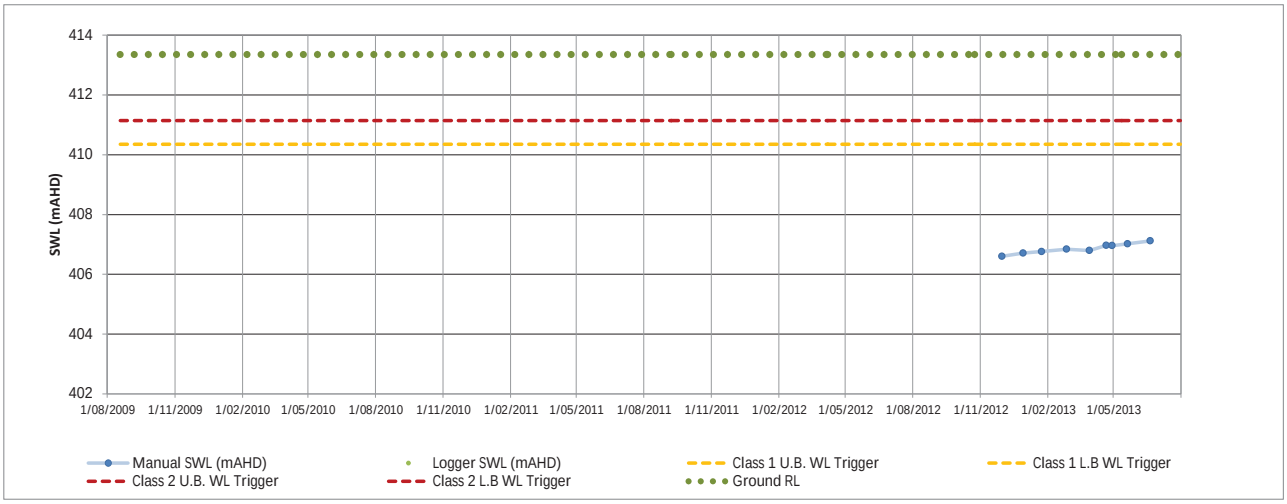


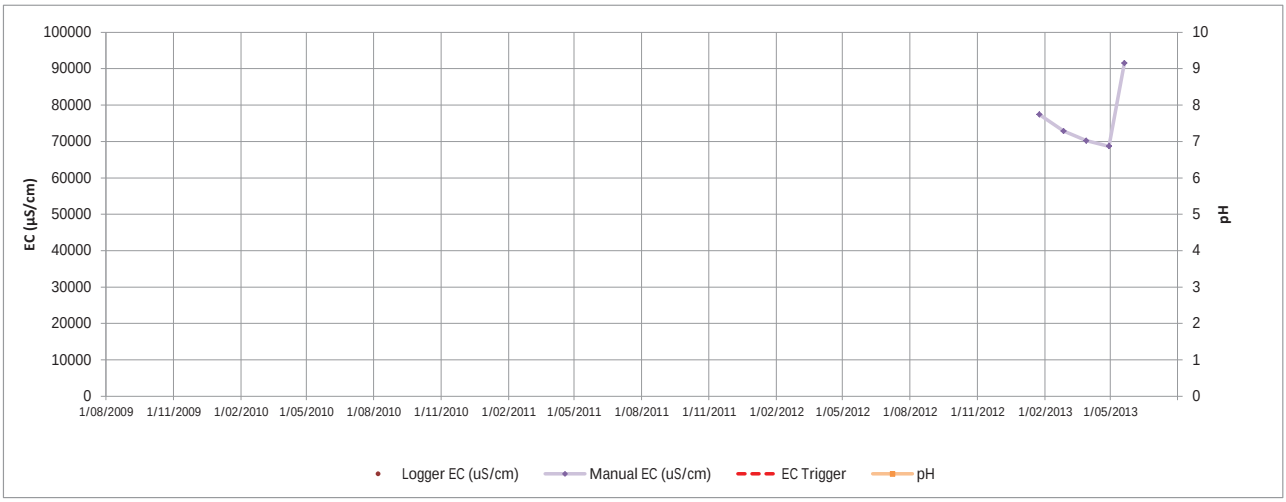


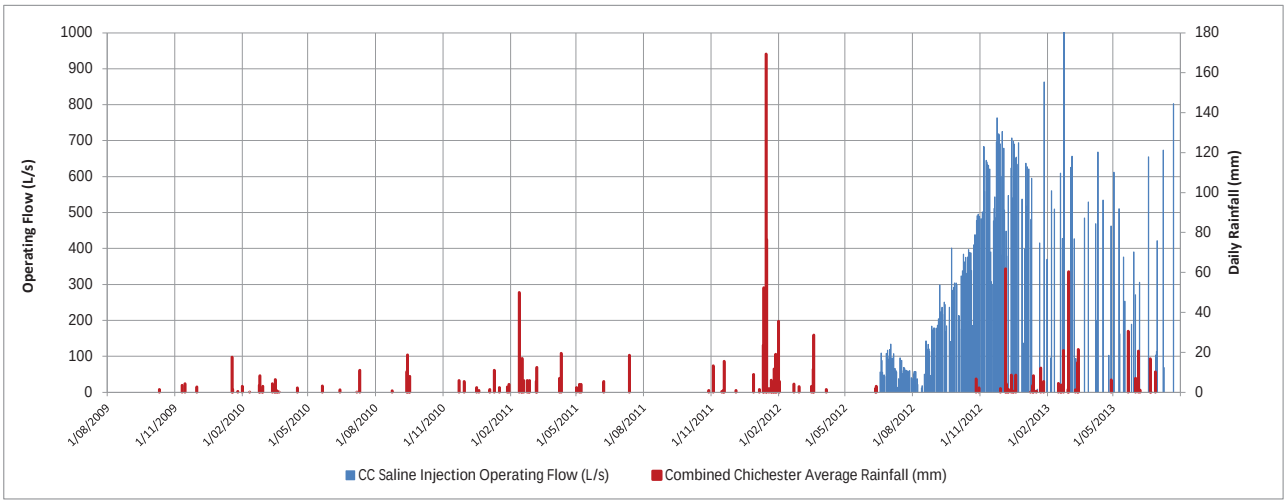


SAM25_S Hydrograph

Bore Name: SAM25_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone B

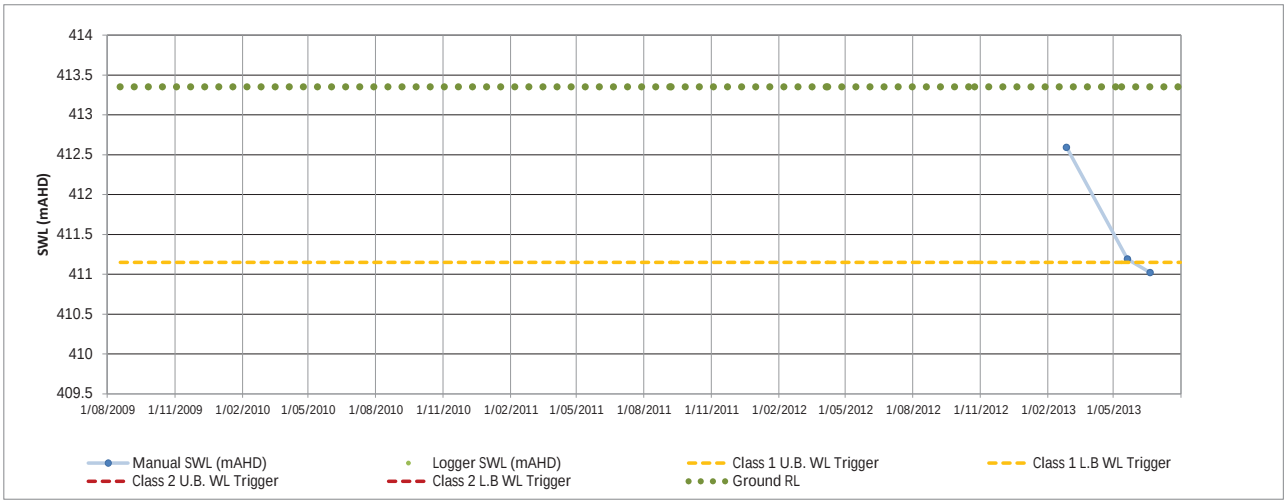


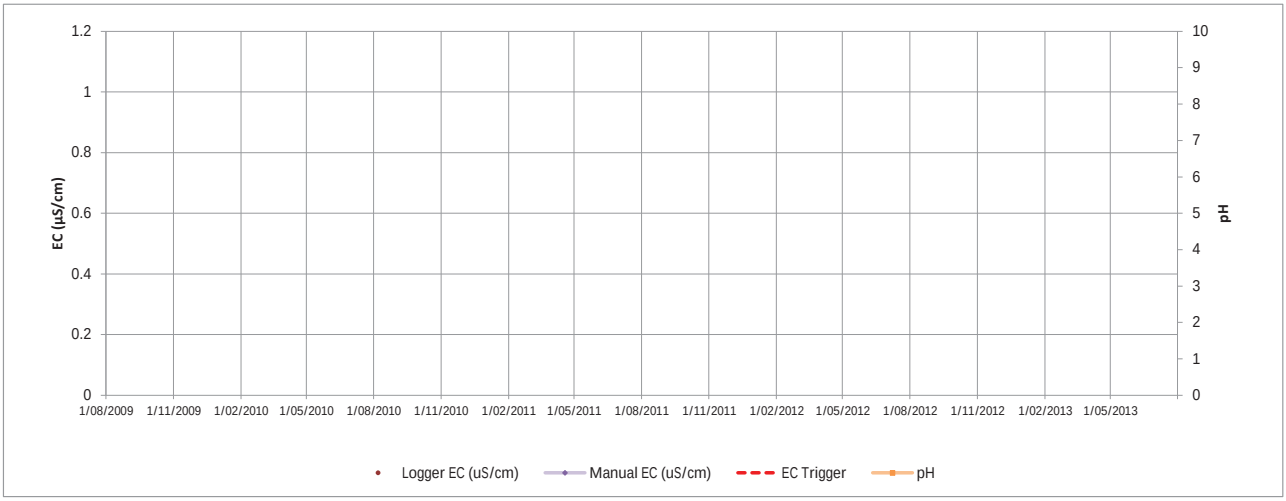


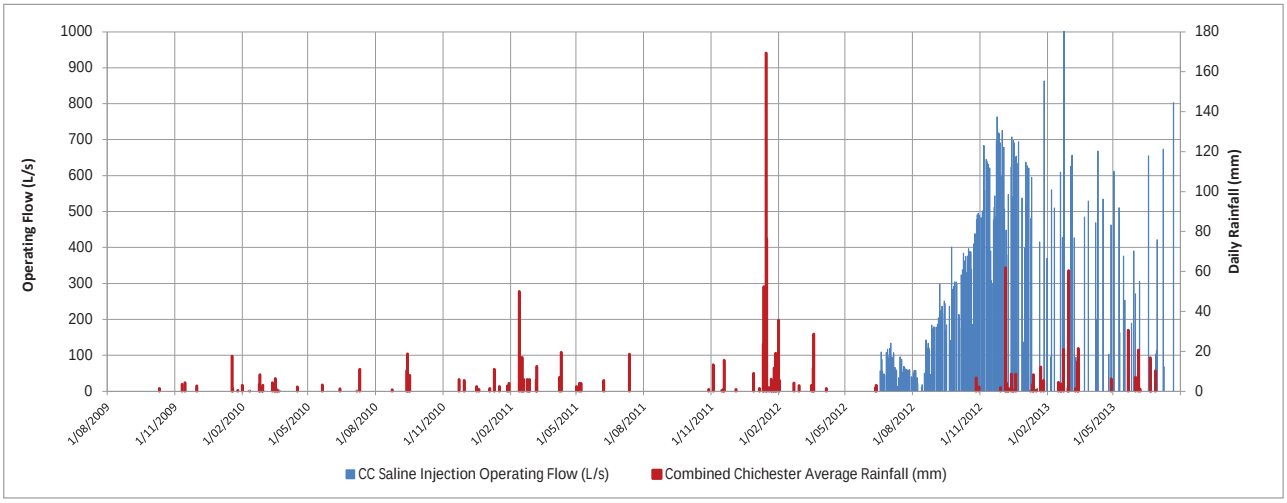


SAM25_D Hydrograph

Bore Name: SAM25_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

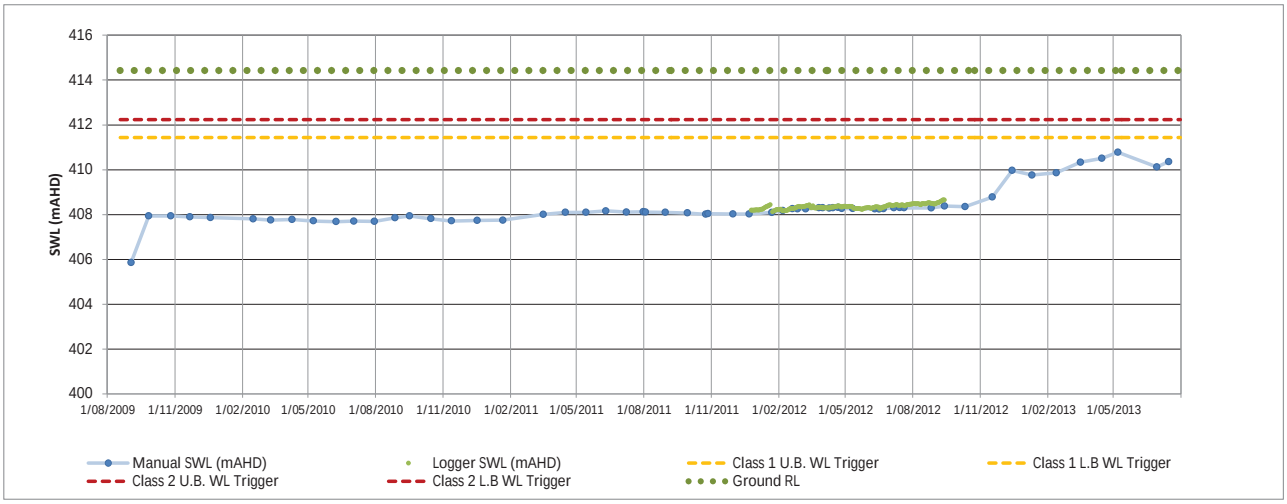


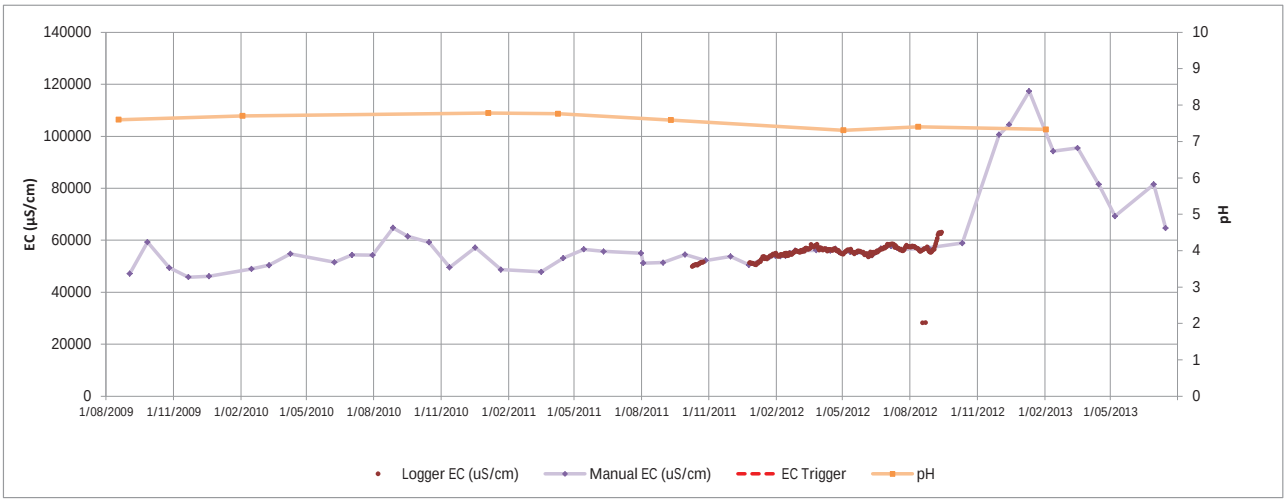


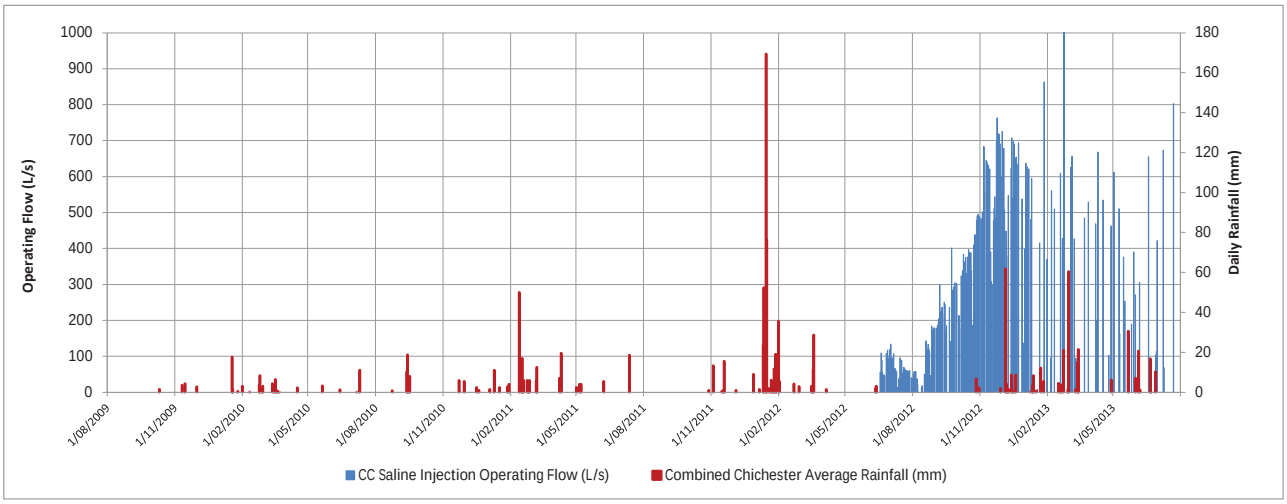


SCX01_S Hydrograph

Bore Name: SCX01_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

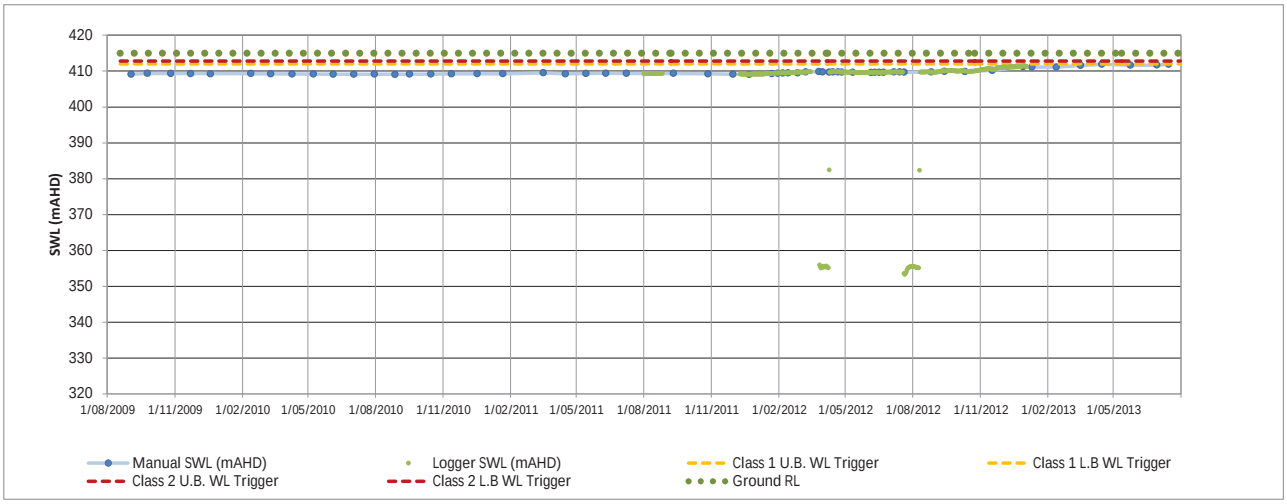


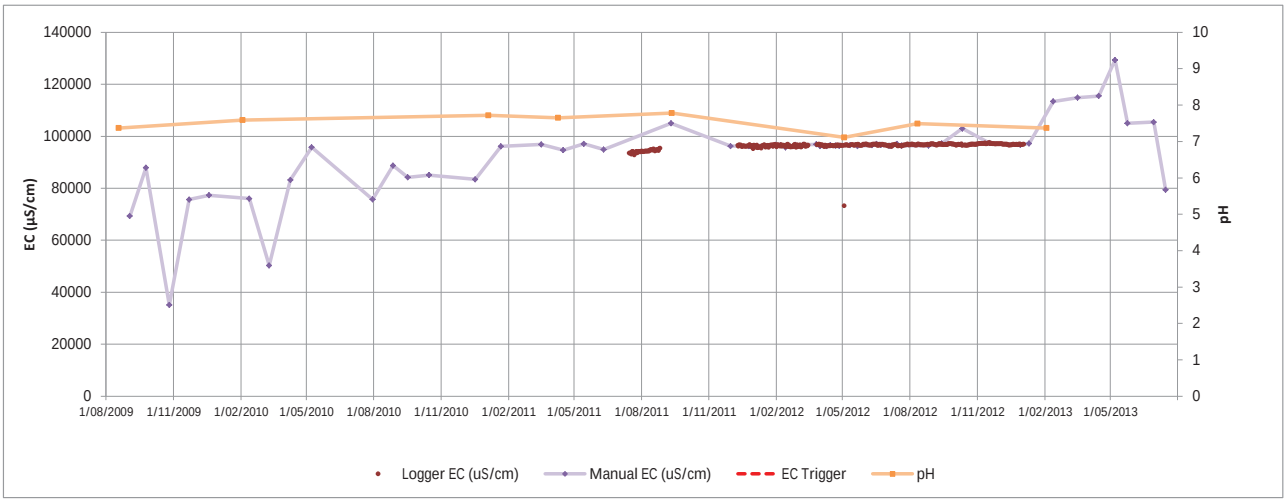


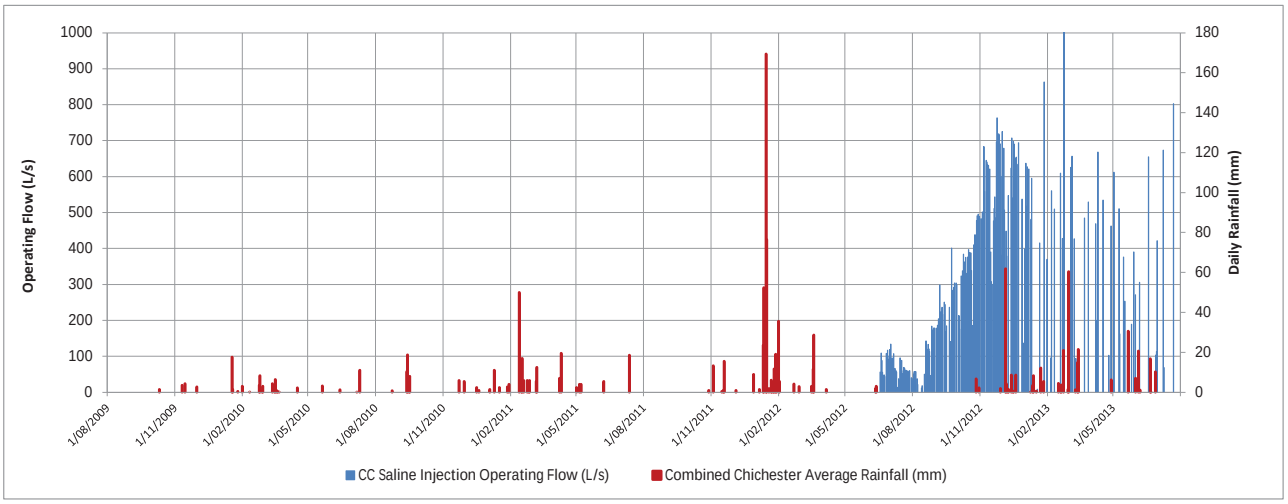


SCX06_S Hydrograph

Bore Name: SCX06_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Oakover Fmn.
Management Zone: Zone B

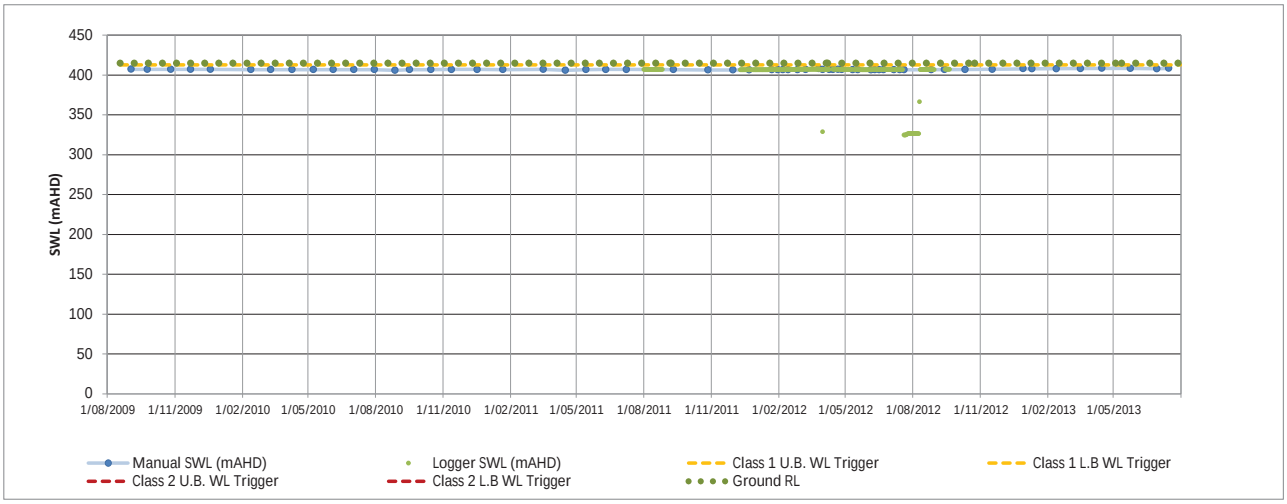


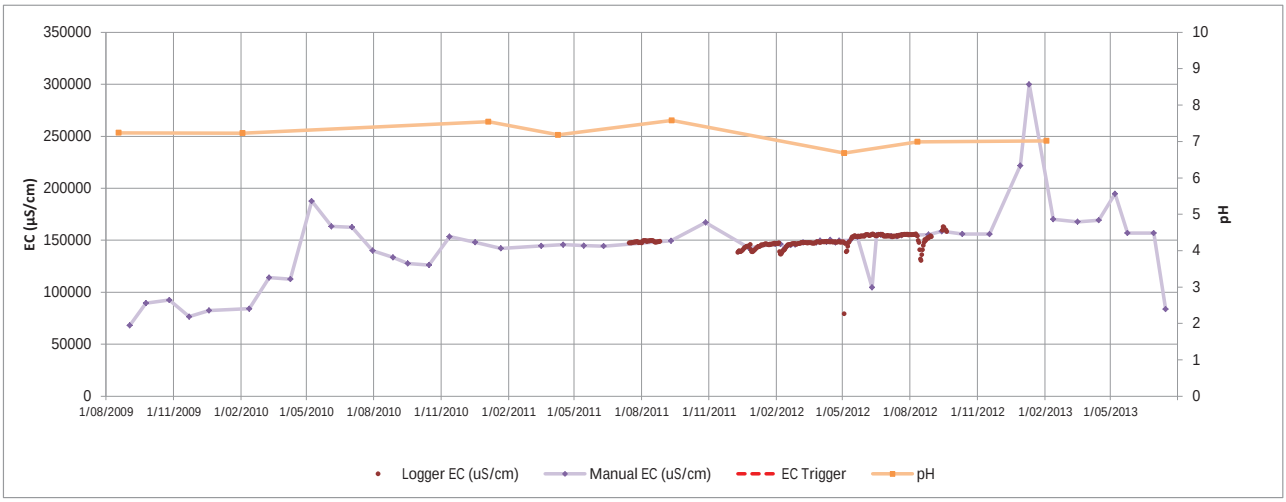


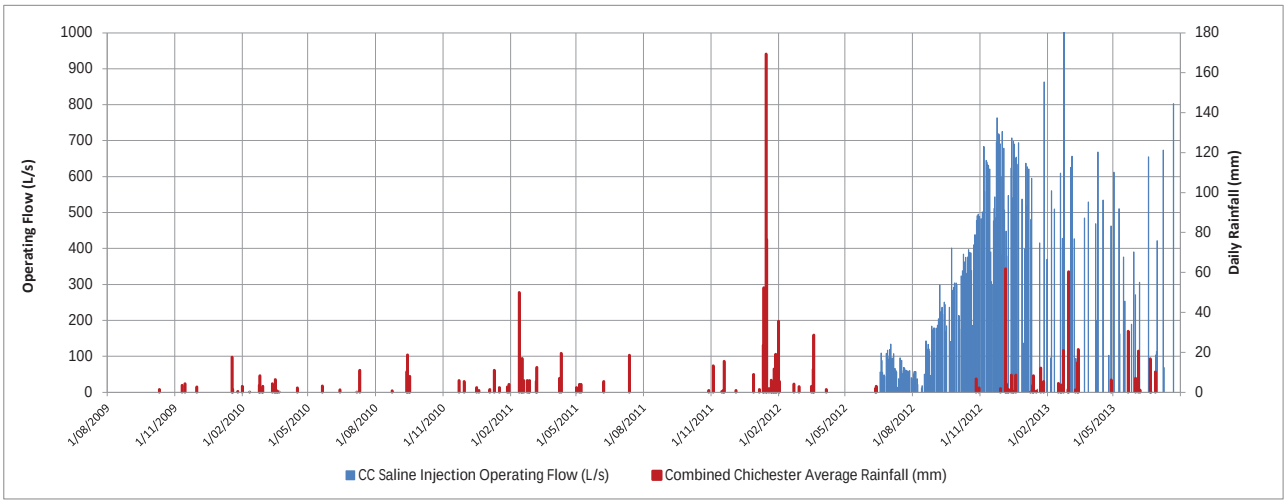


SCX06_D Hydrograph

Bore Name: SCX06_D
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone B

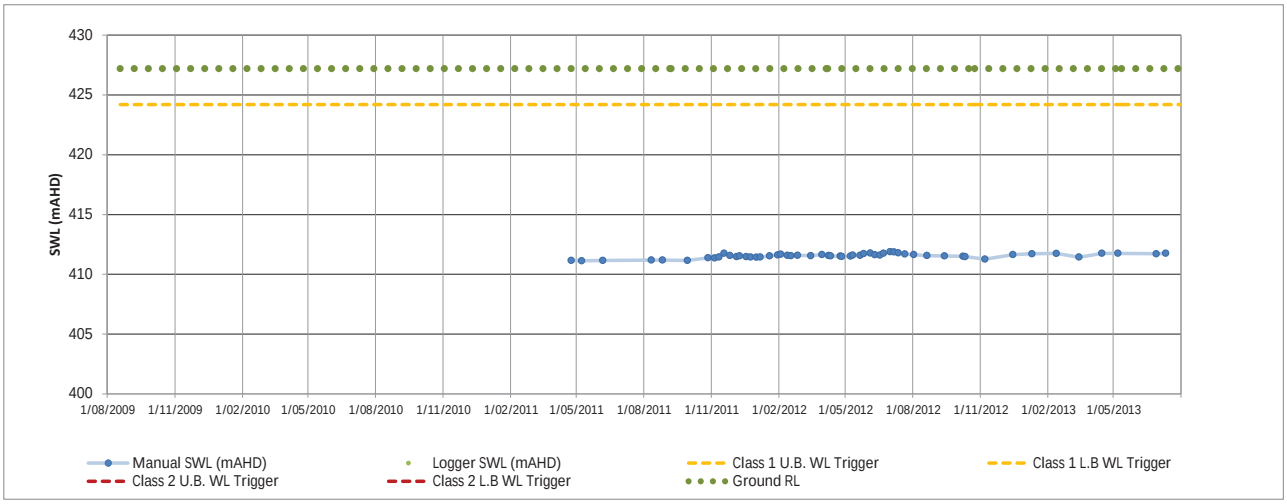


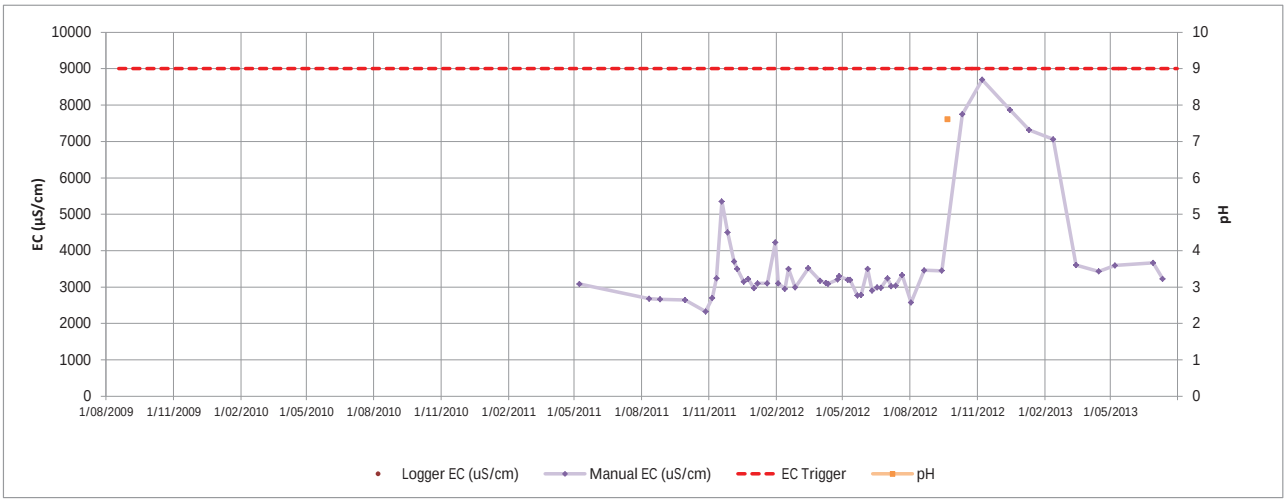


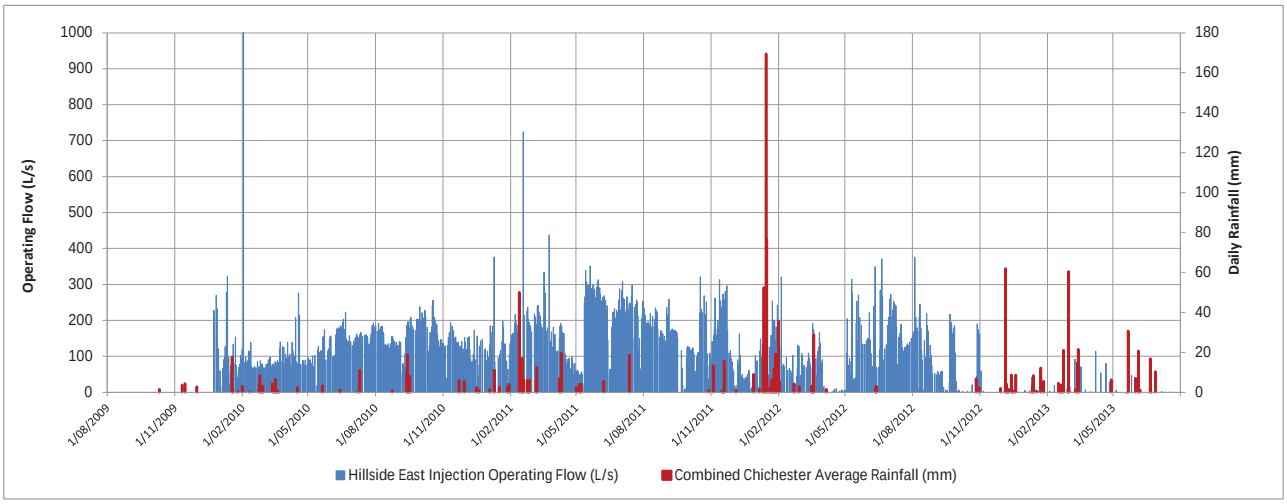


HEMB01_D Hydrograph

Bore Name: HEMB01_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

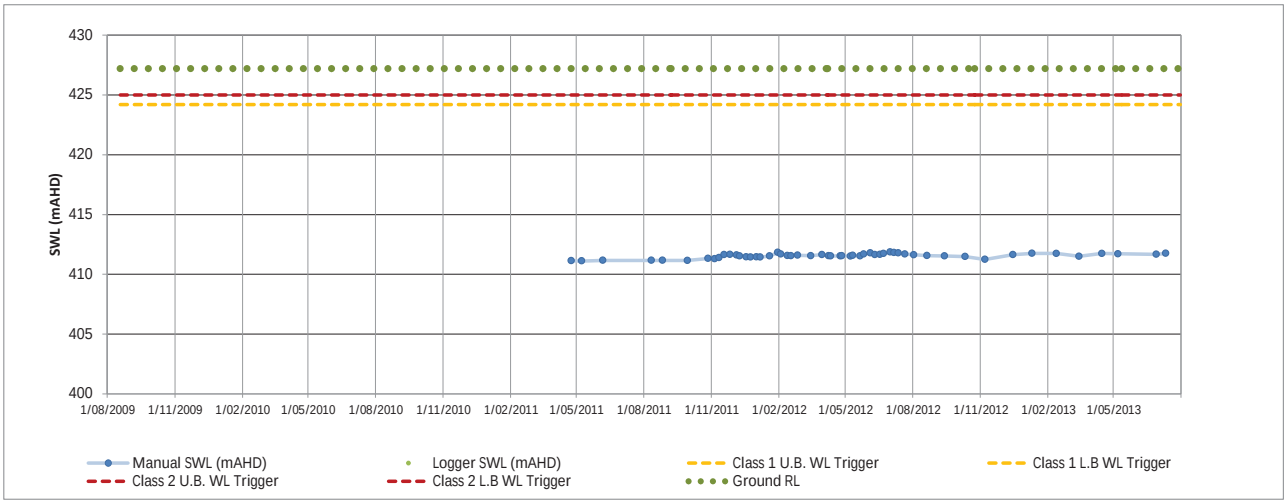


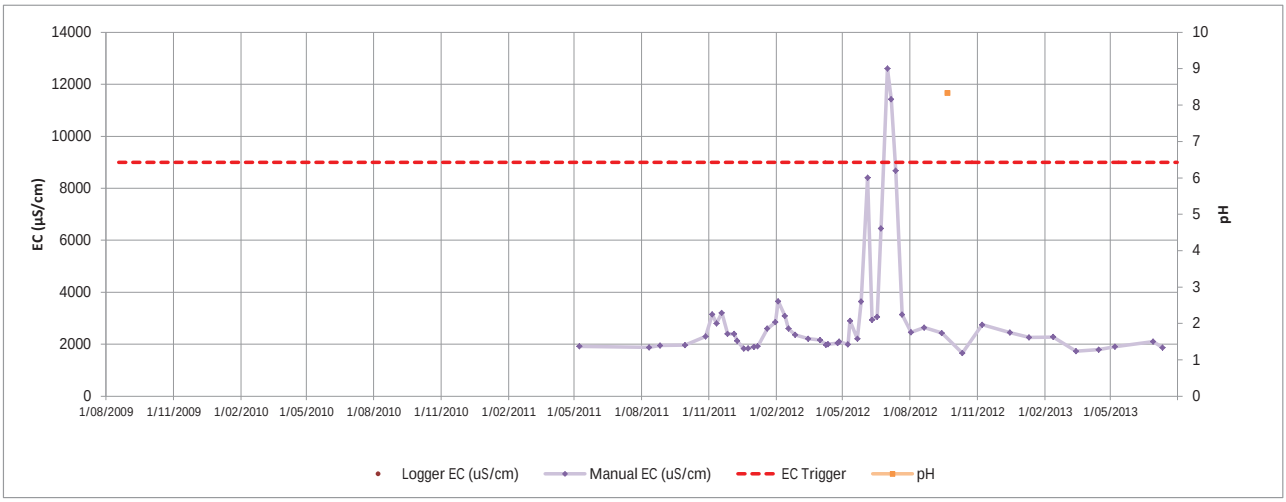


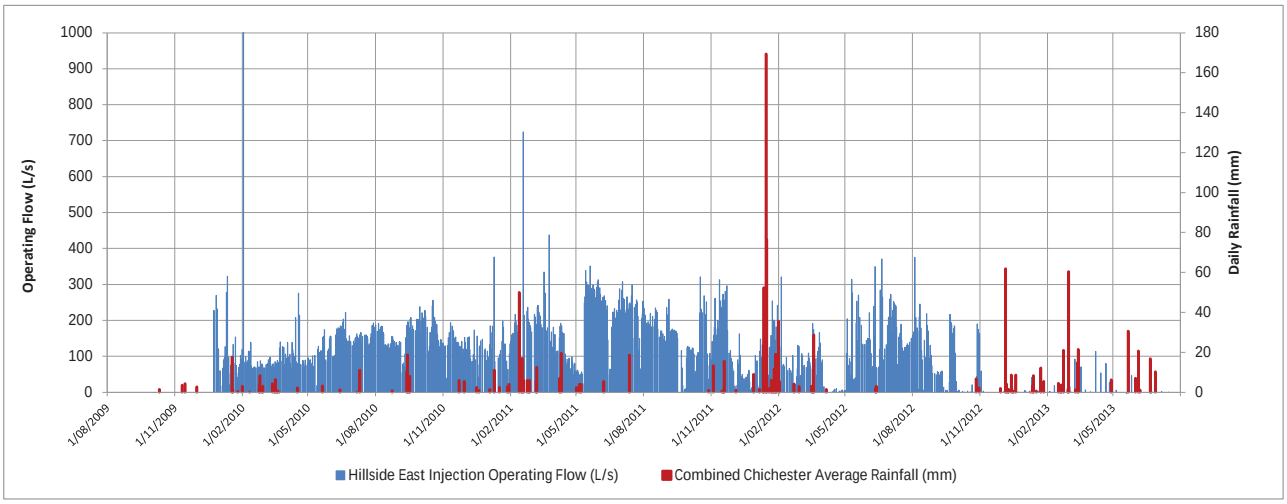


HEMB01_S Hydrograph

Bore Name: HEMB01_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

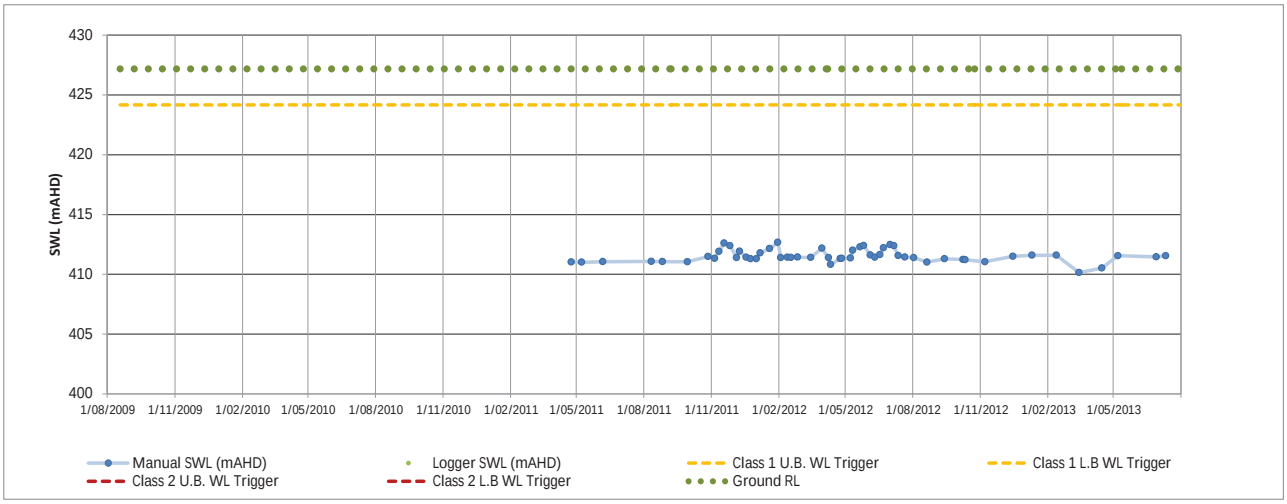


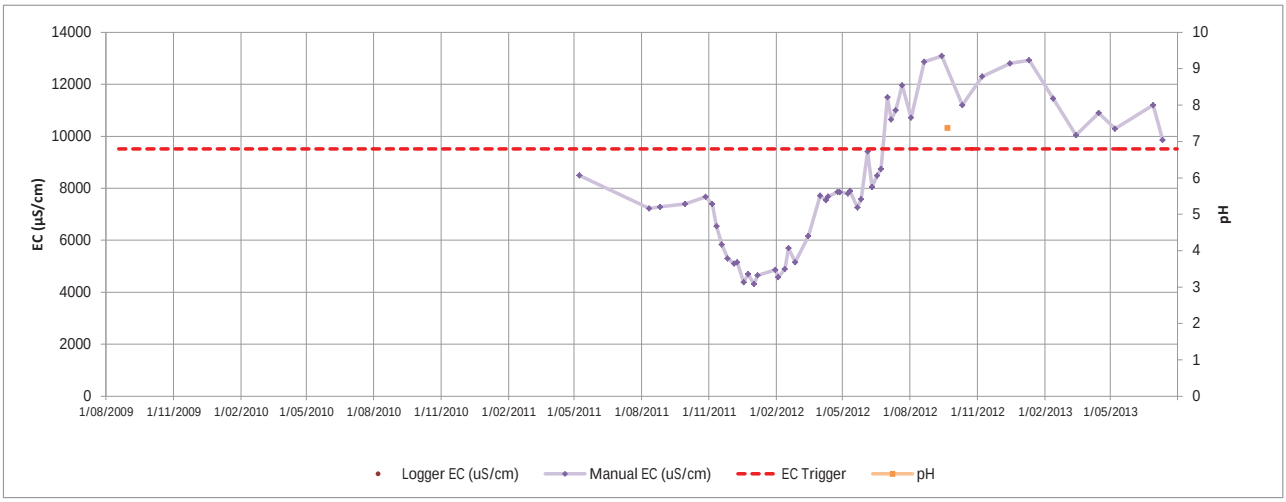


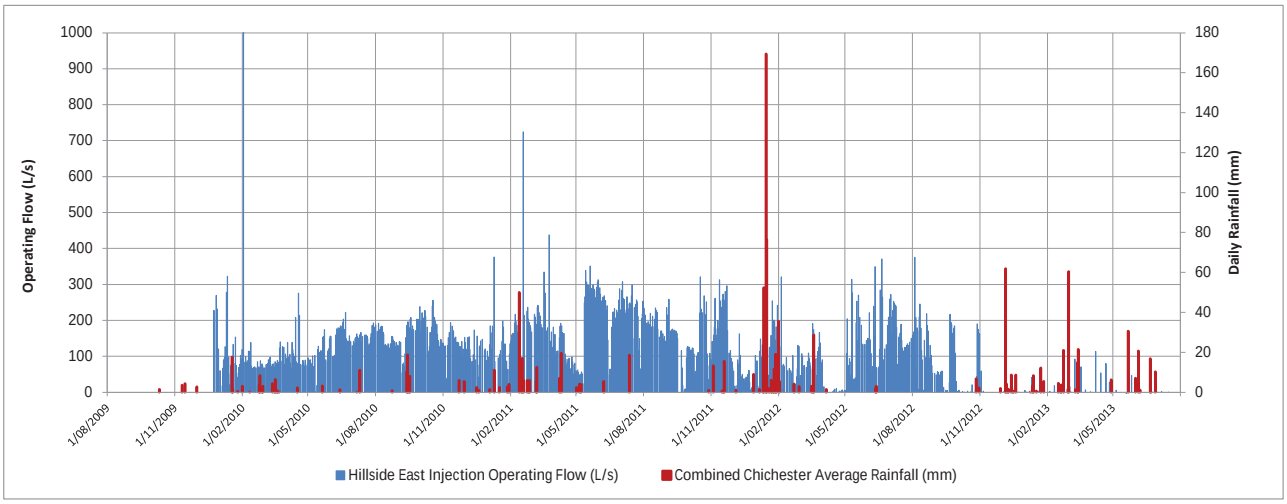


HEMB02_D Hydrograph

Bore Name: HEMB02_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

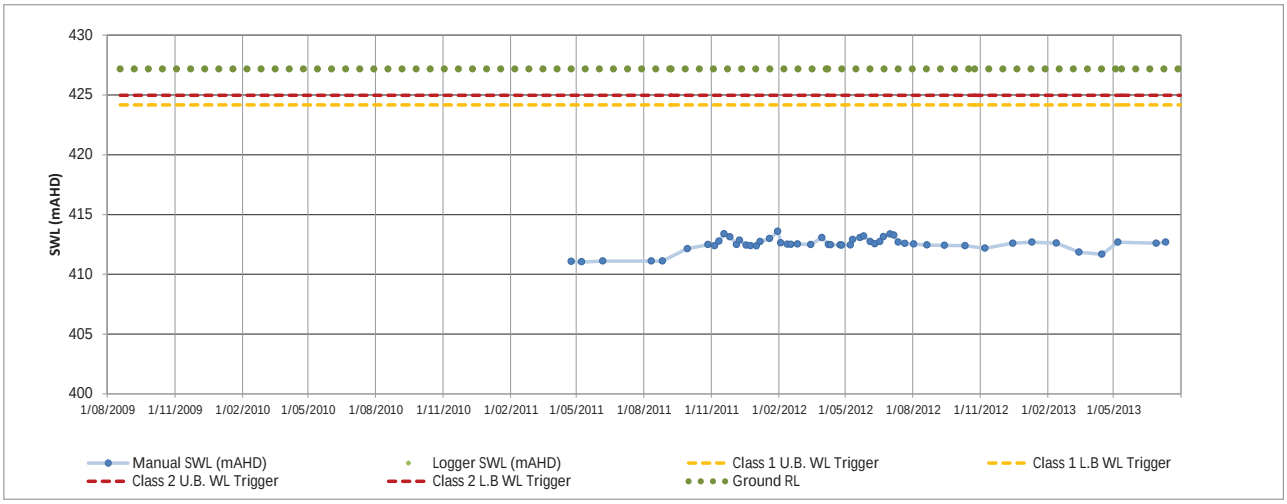


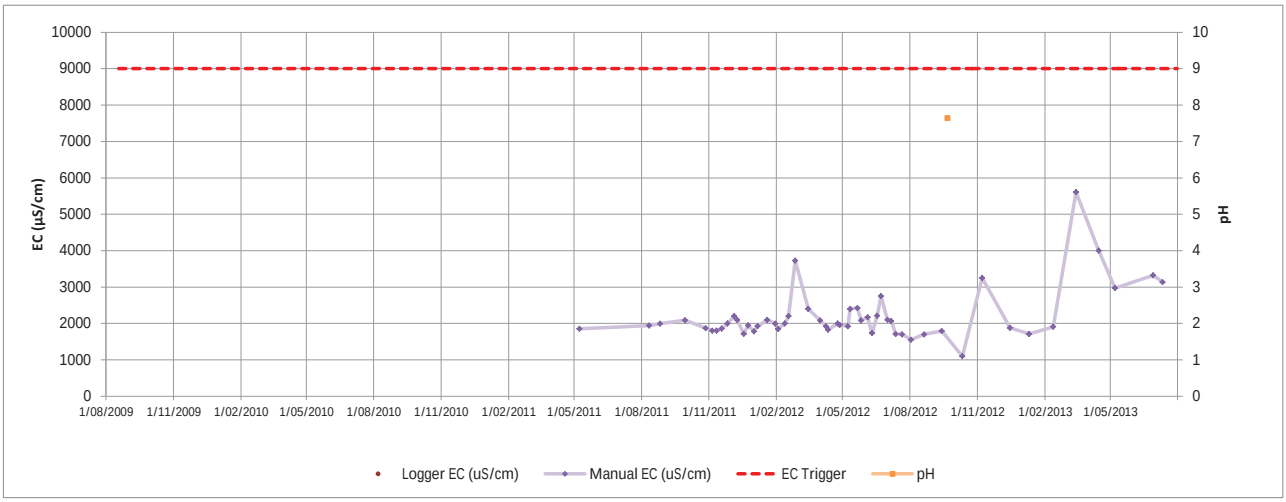


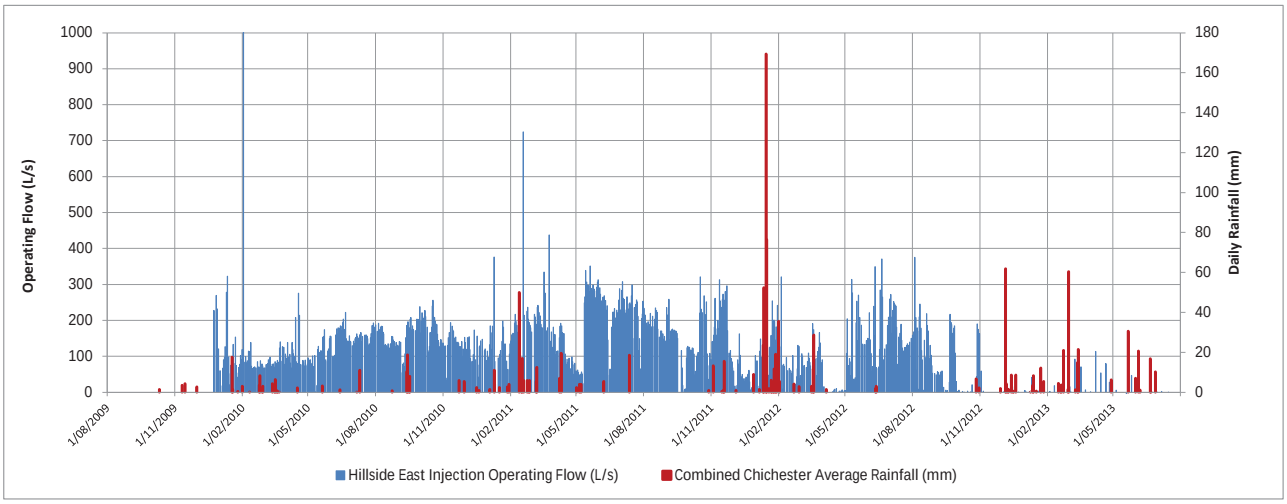


HEMB02_S Hydrograph

Bore Name: HEMB02_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

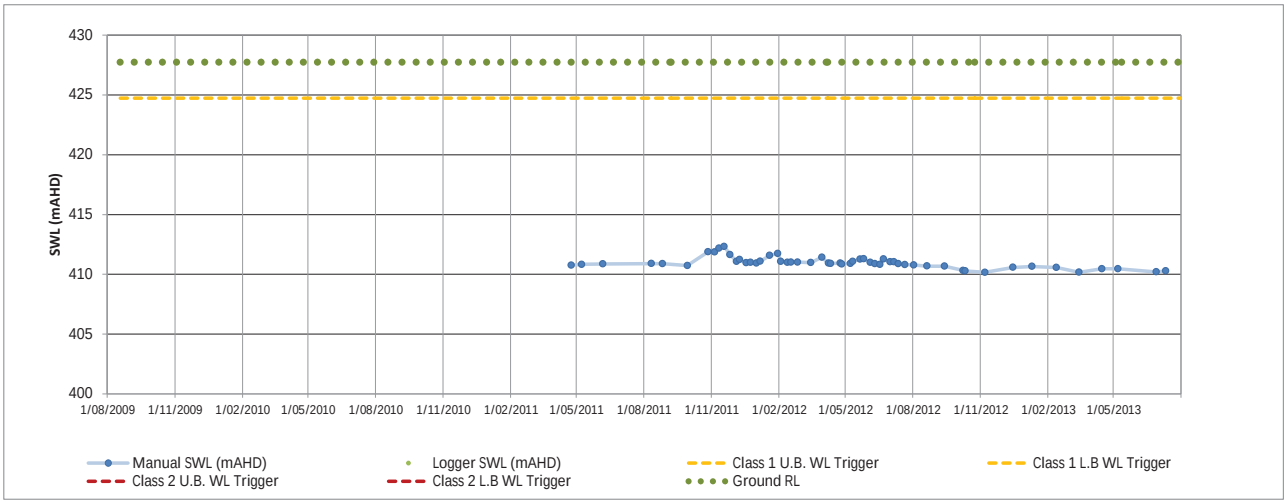


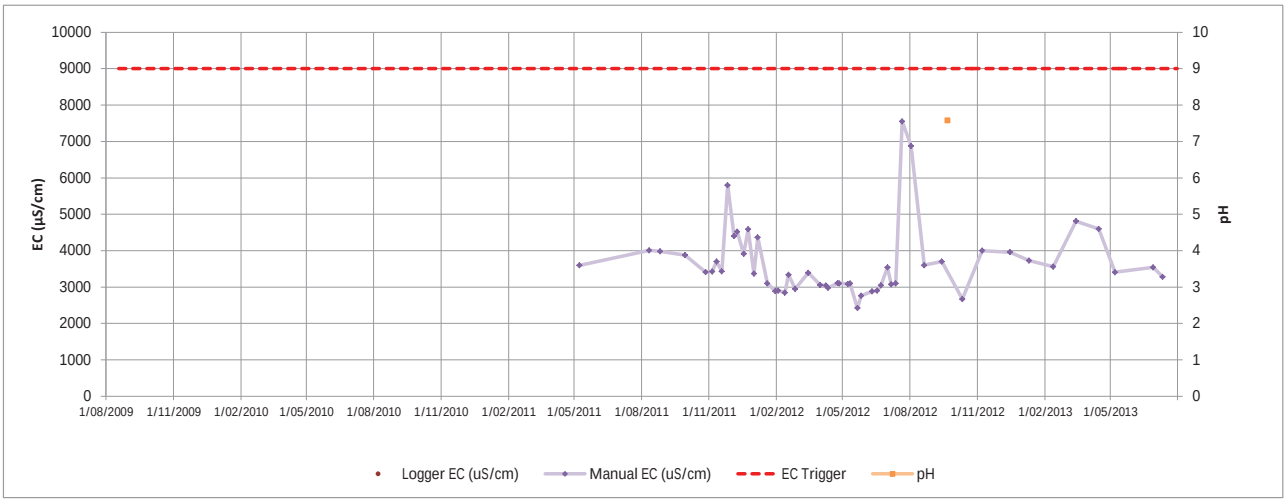


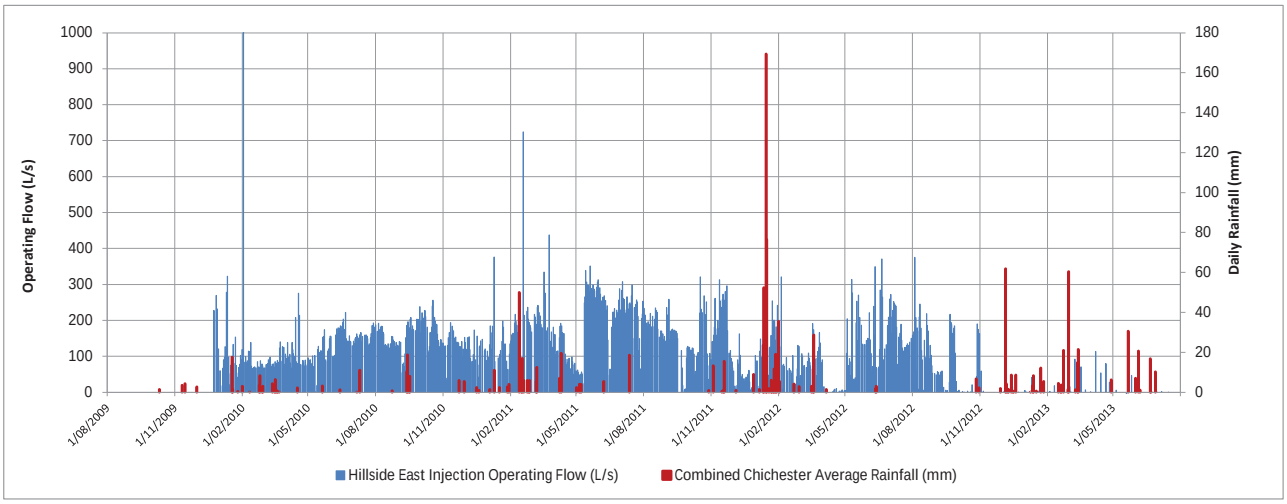


HEMB04_D Hydrograph

Bore Name: HEMB04_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

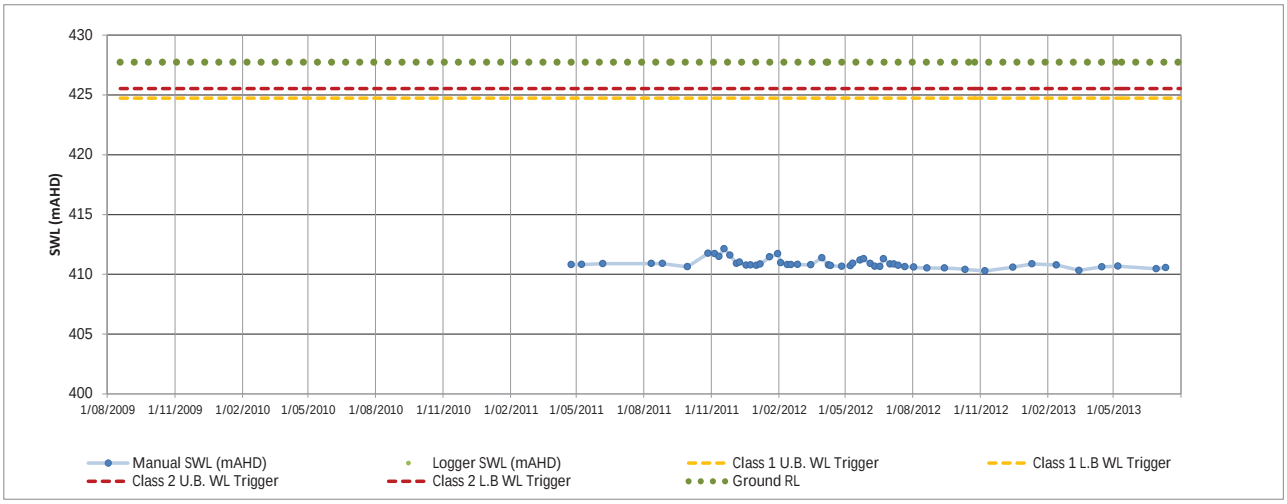


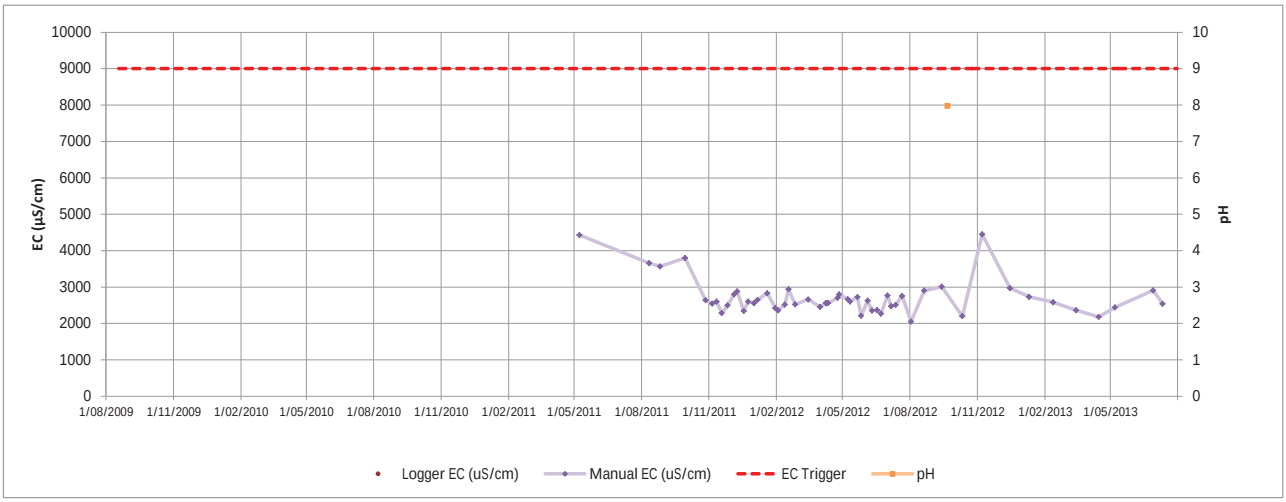


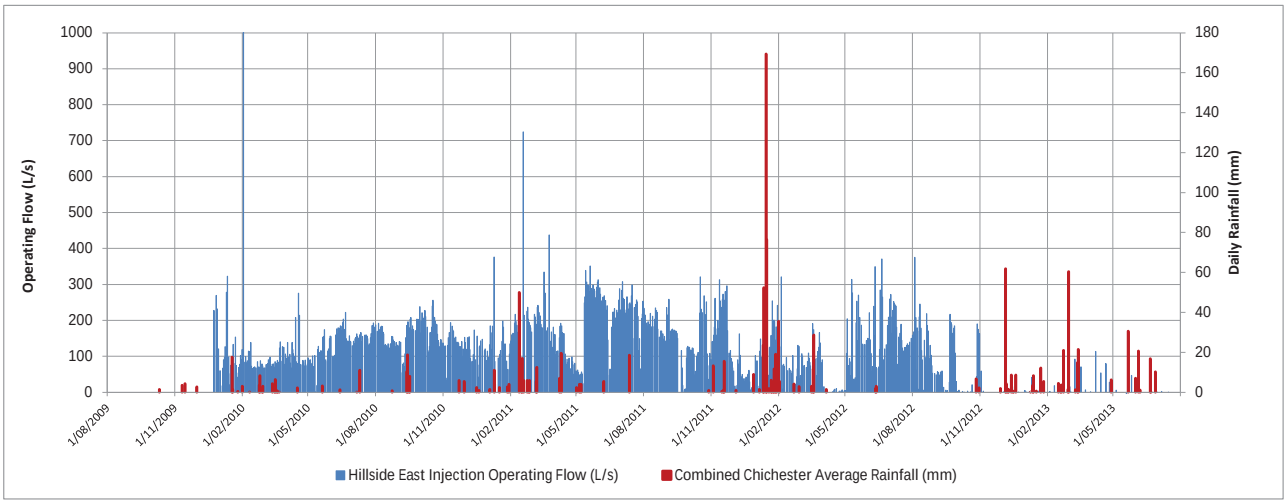


HEMB04_S Hydrograph

Bore Name: HEMB04_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

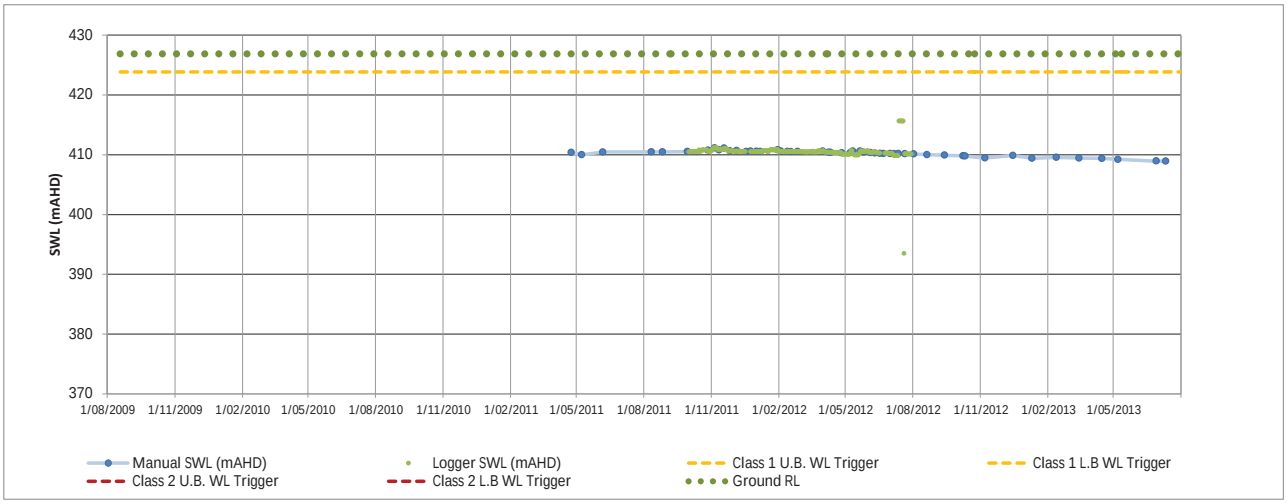


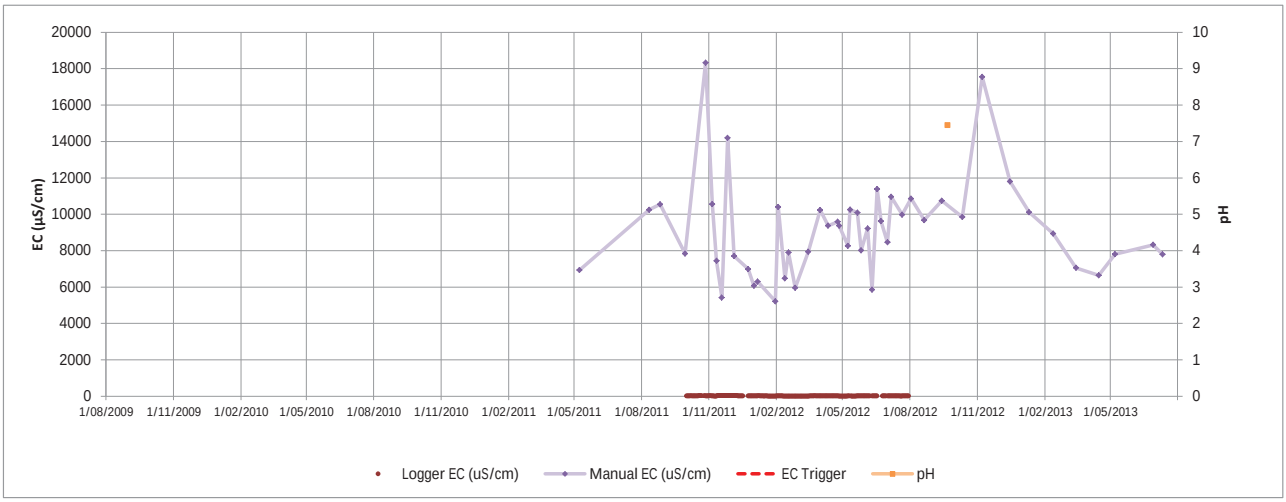


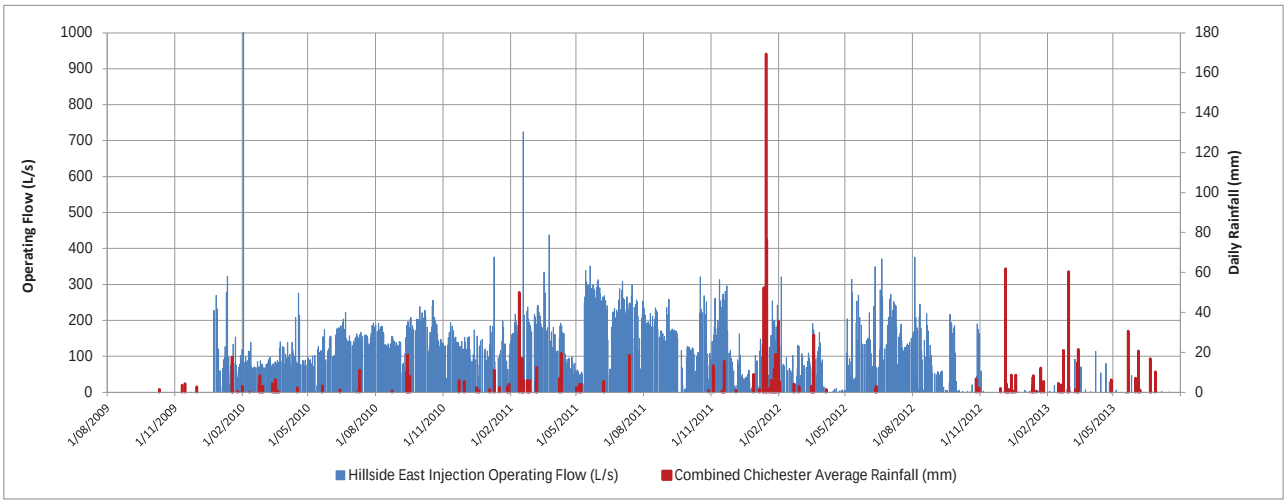


HEMB05_D Hydrograph

Bore Name: HEMB05_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

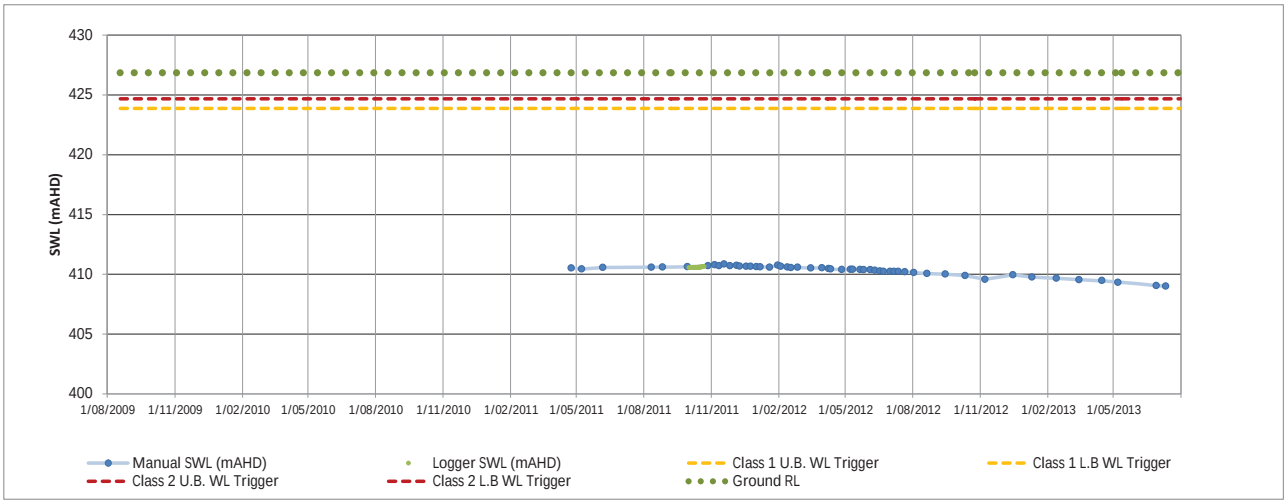


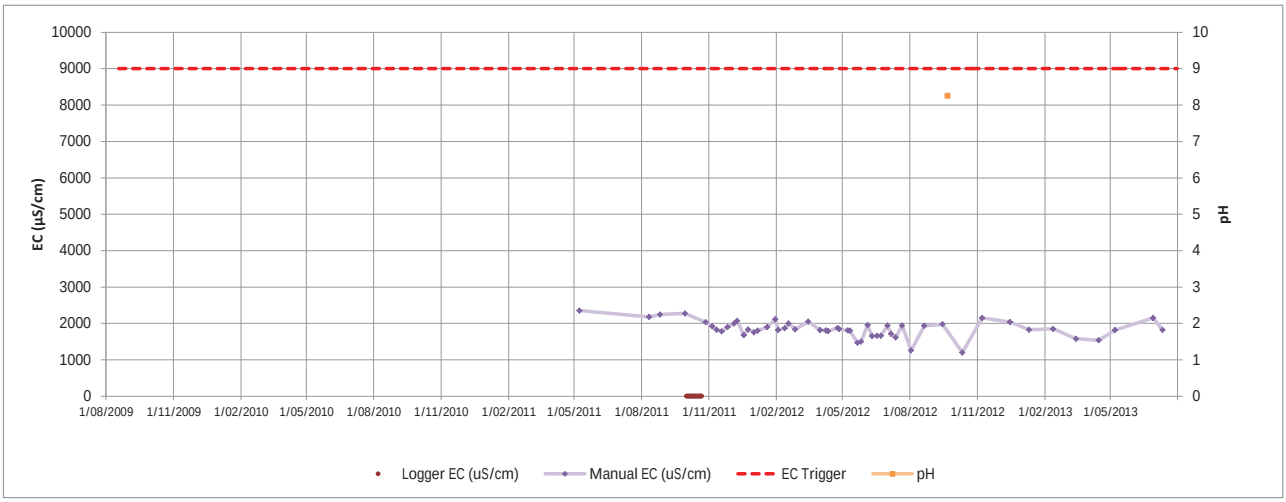


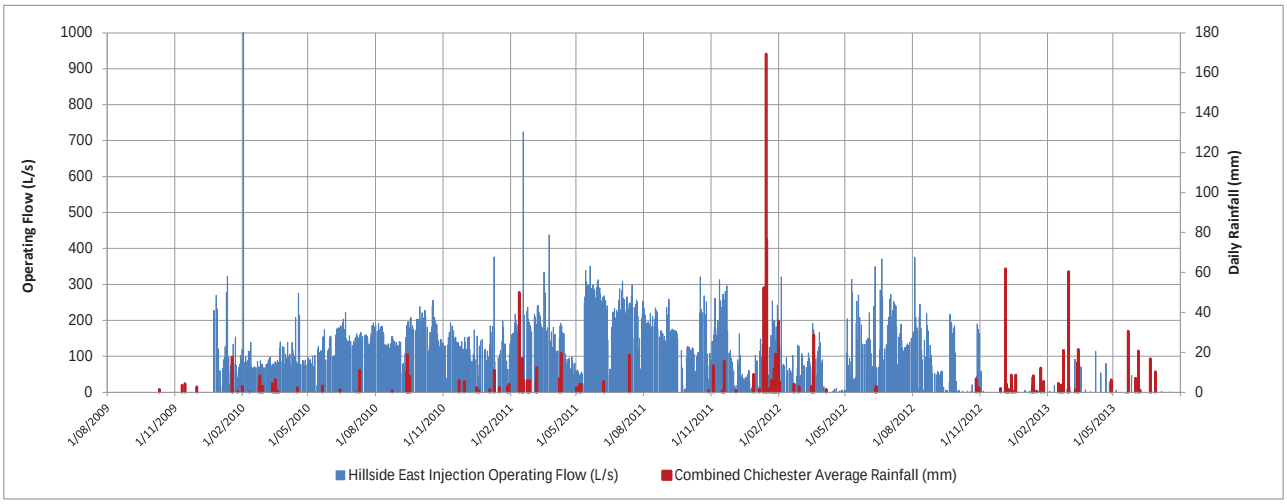


HEMB05_S Hydrograph

Bore Name: HEMB05_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

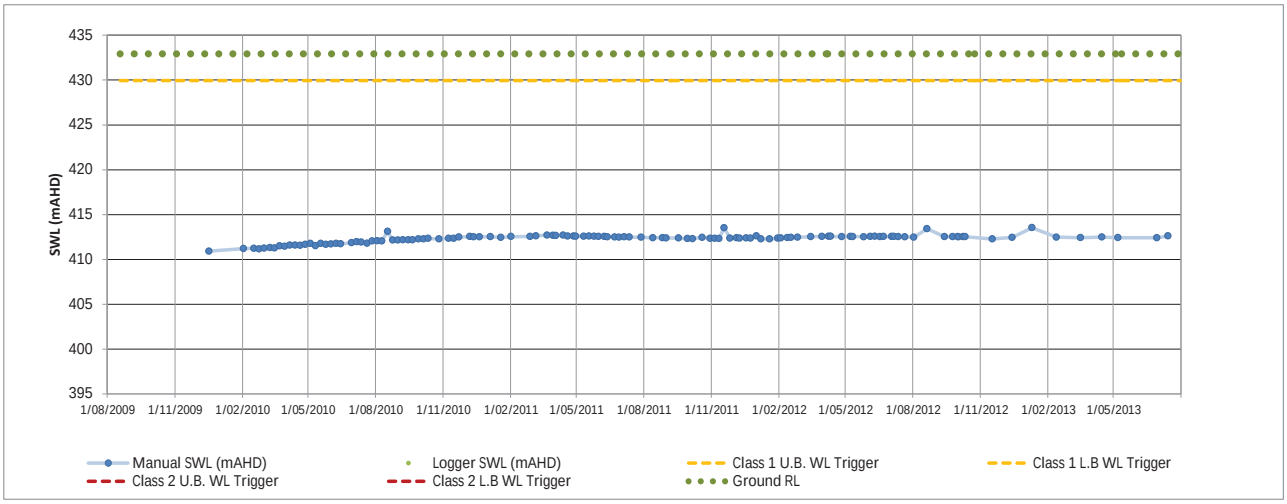


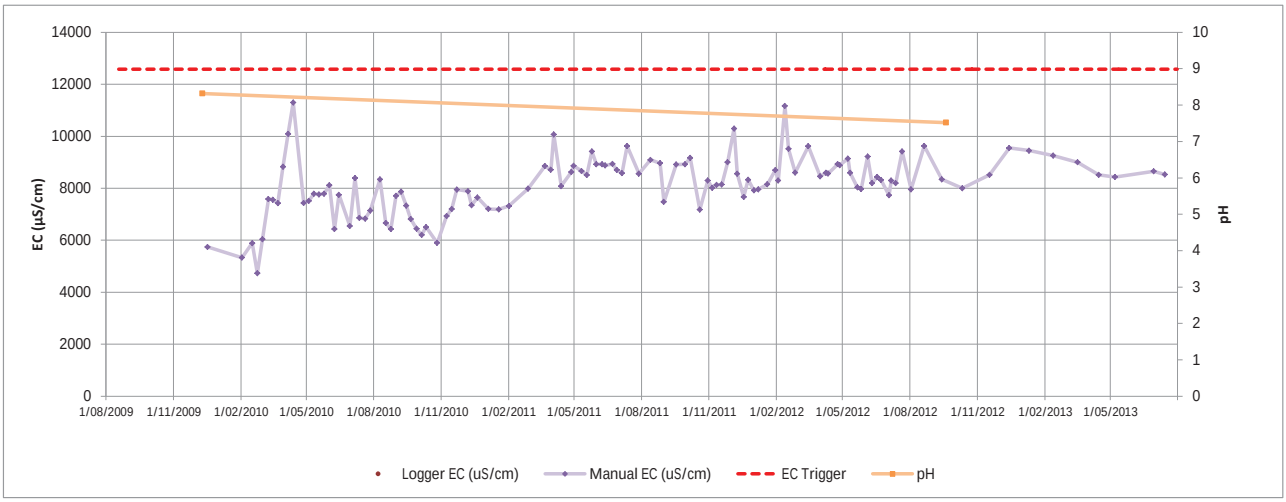


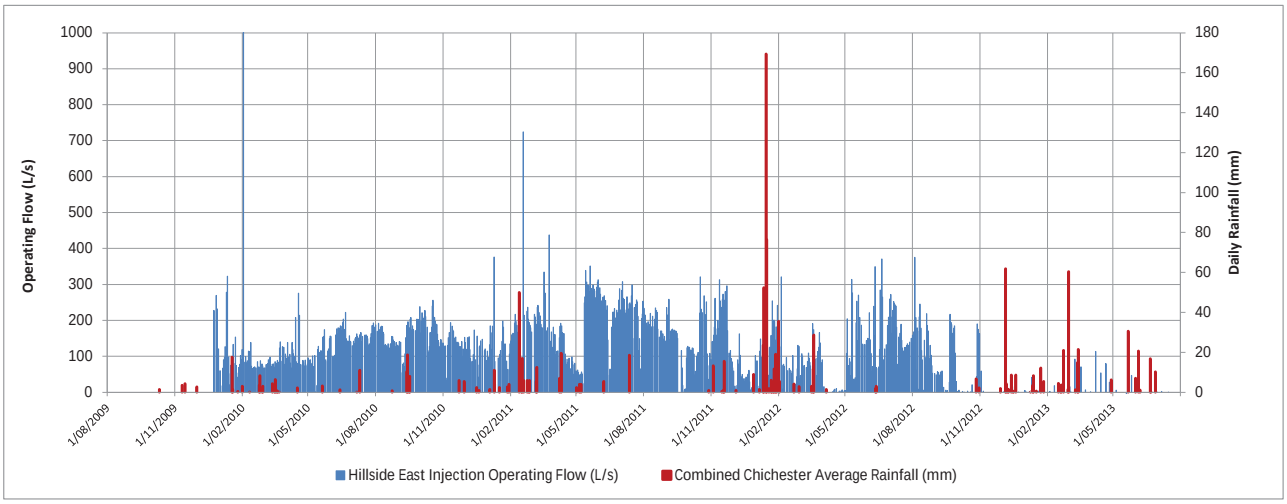


HSMB24_D Hydrograph

Bore Name: HSMB24_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

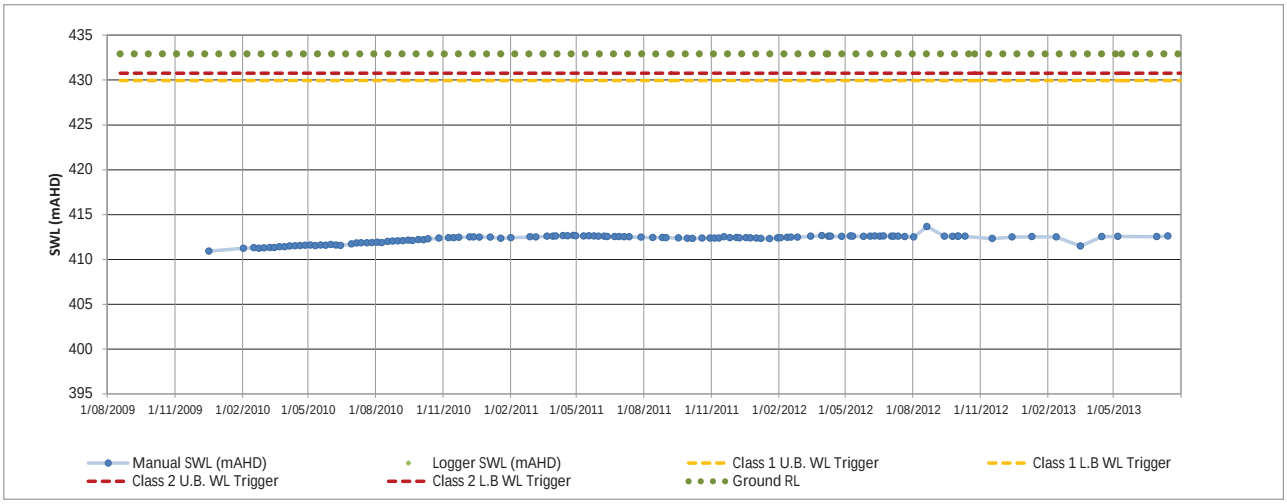


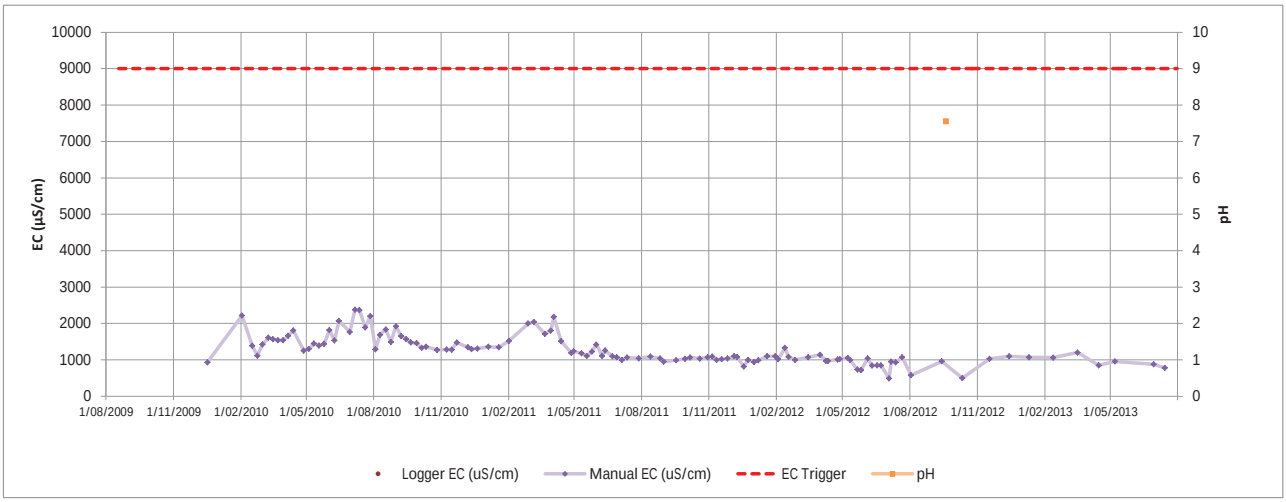


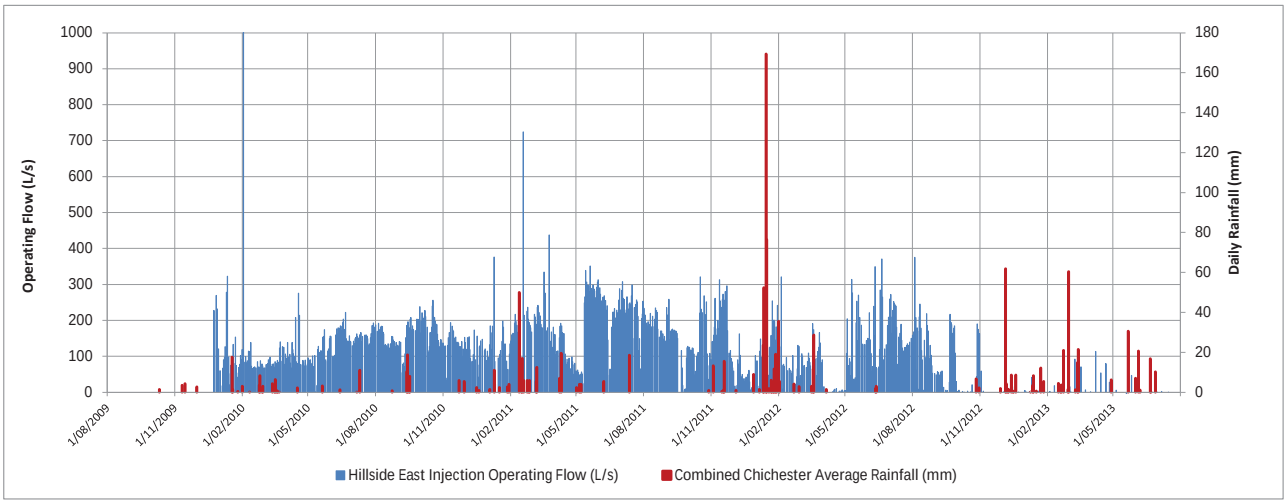


HSMB24_S Hydrograph

Bore Name: HSMB24_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

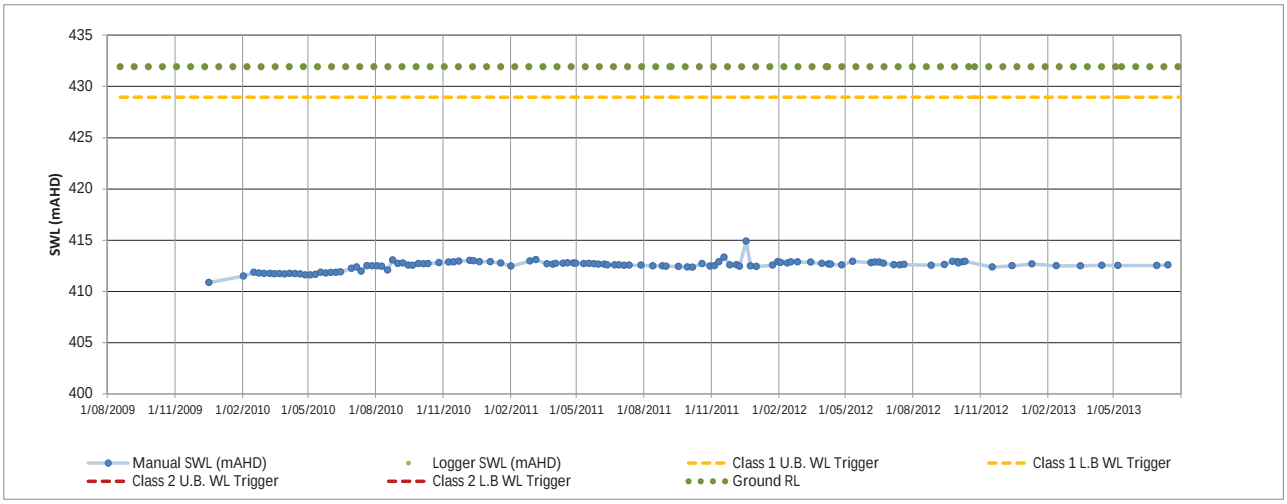


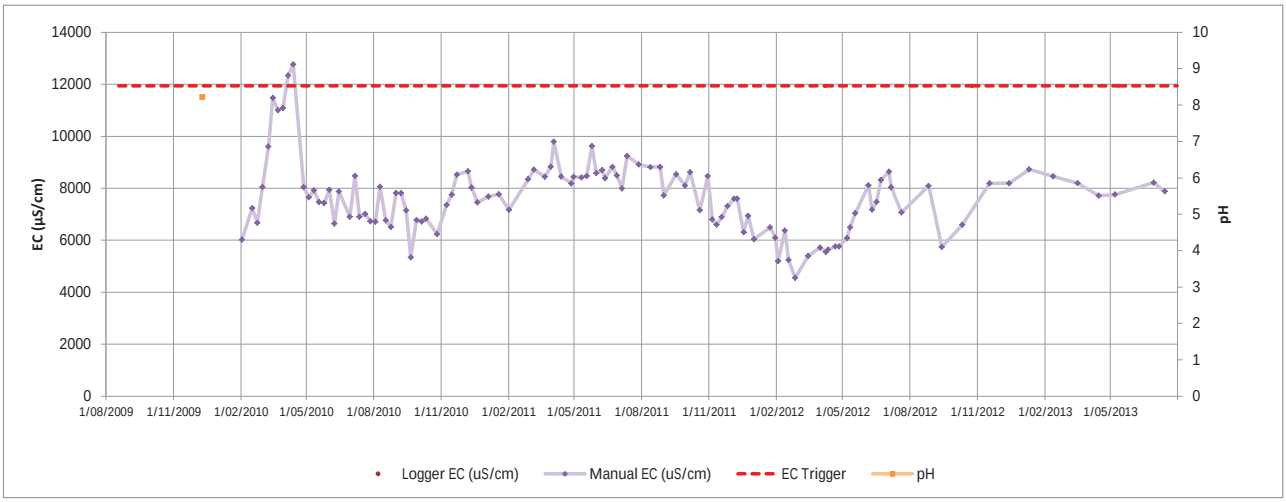


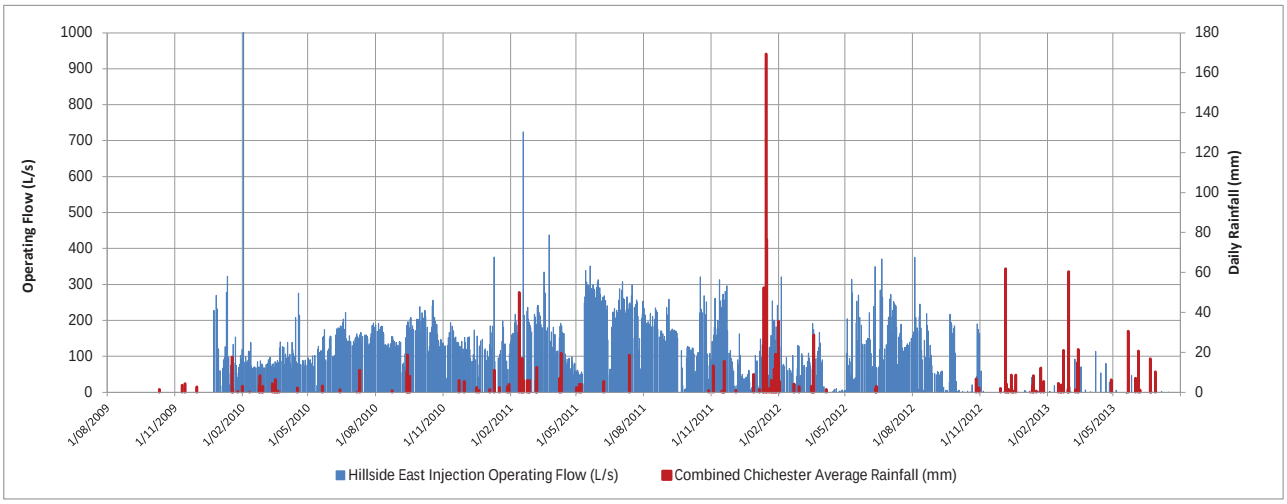


HSMB25_D Hydrograph

Bore Name: HSMB25_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

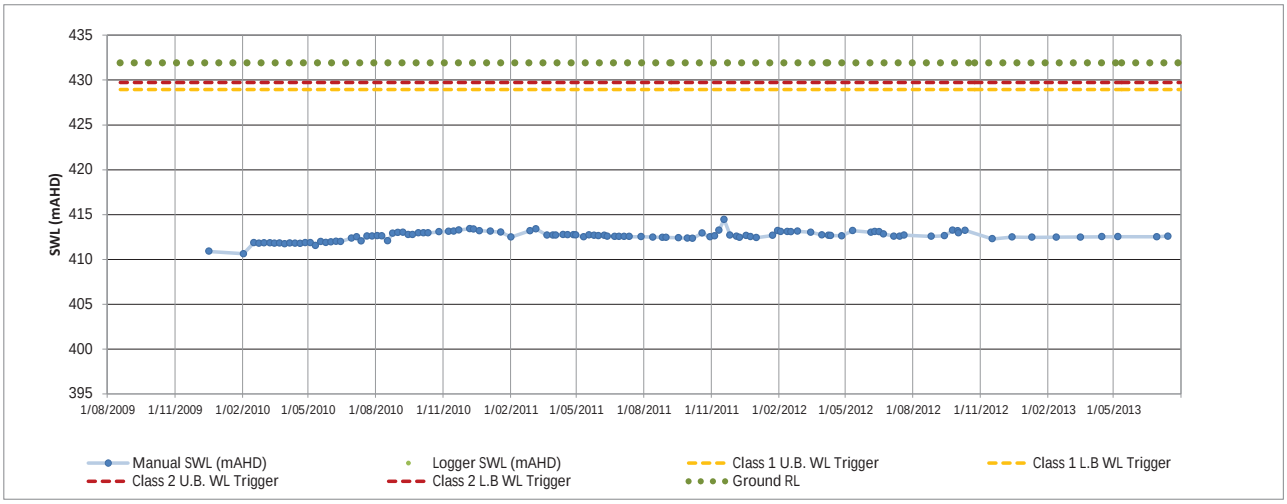


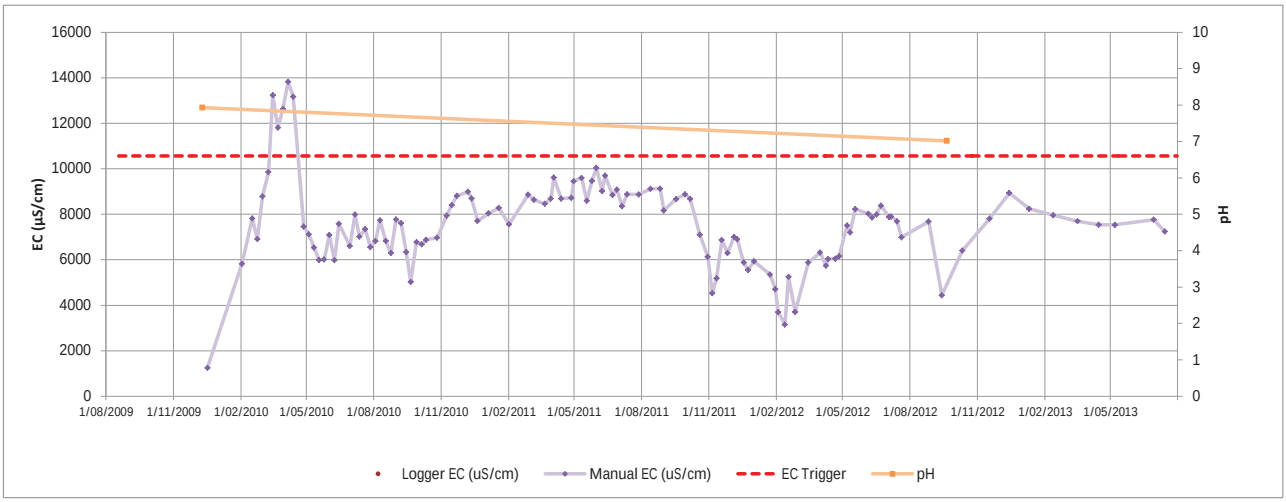


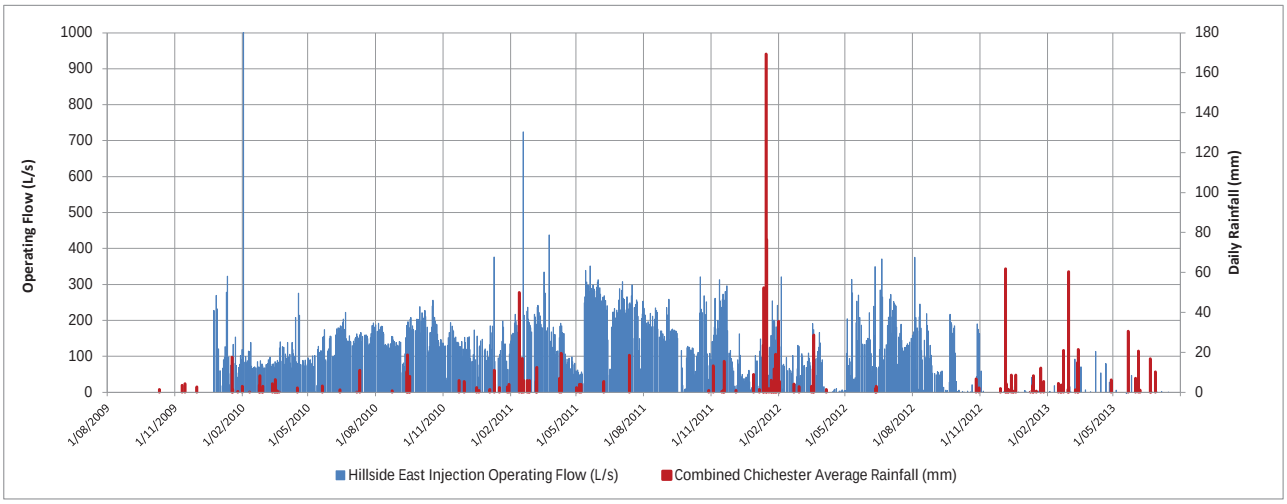


HSMB25_S Hydrograph

Bore Name: HSMB25_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

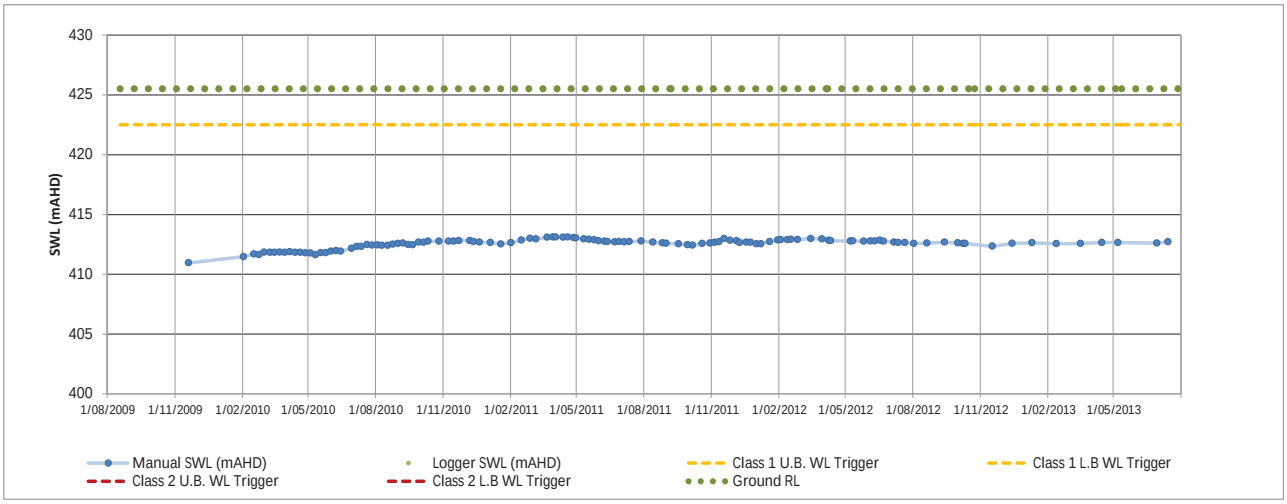


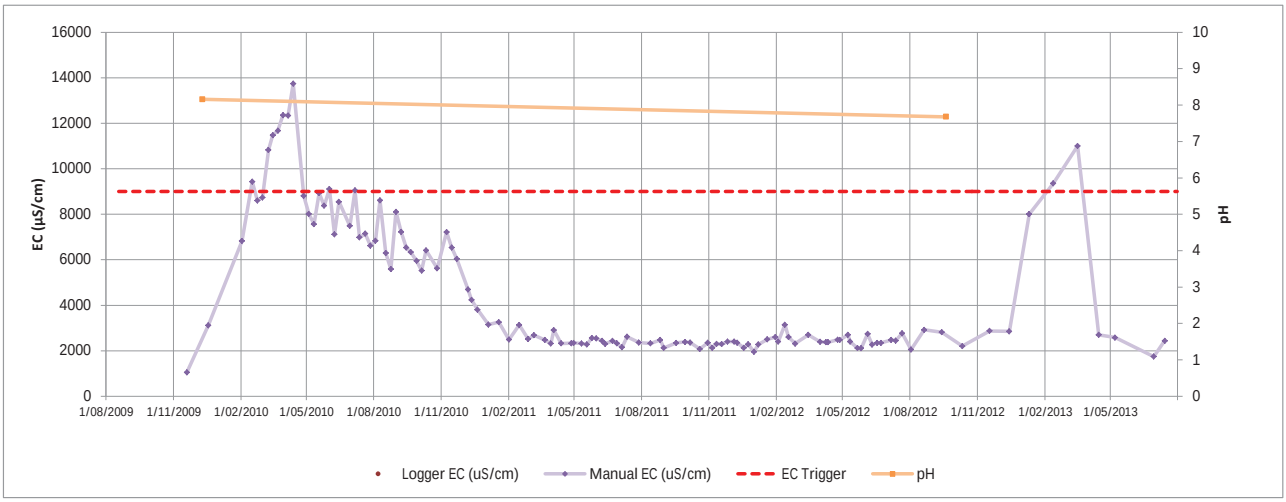


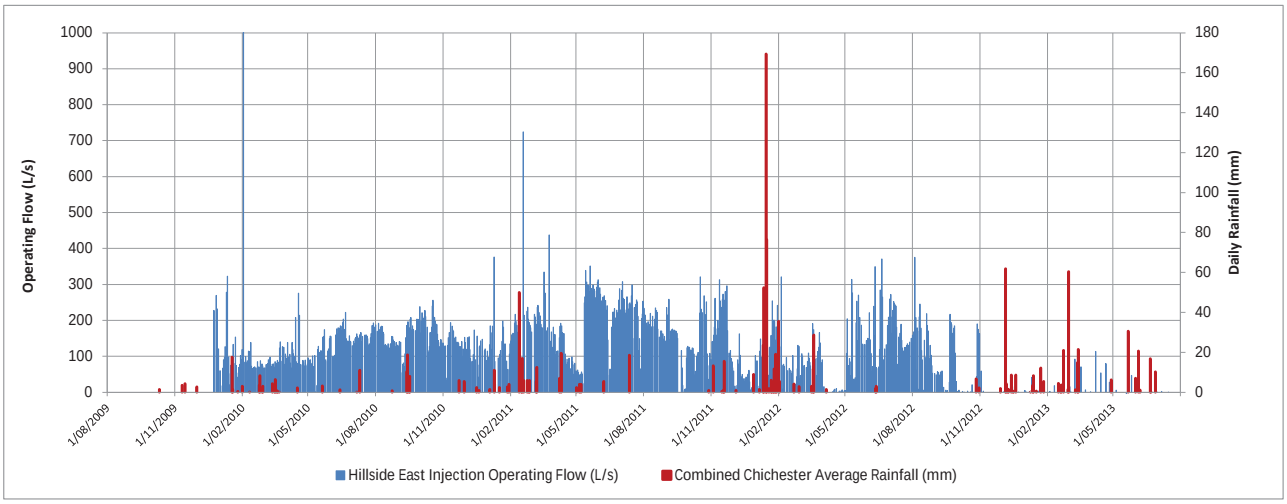


HSMB26_D Hydrograph

Bore Name: HSMB26_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

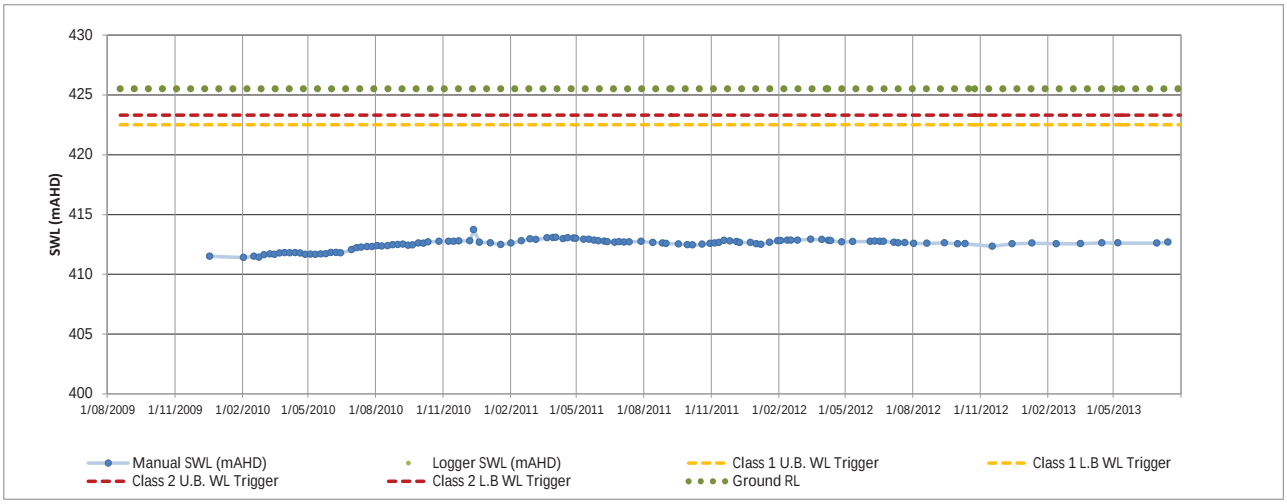


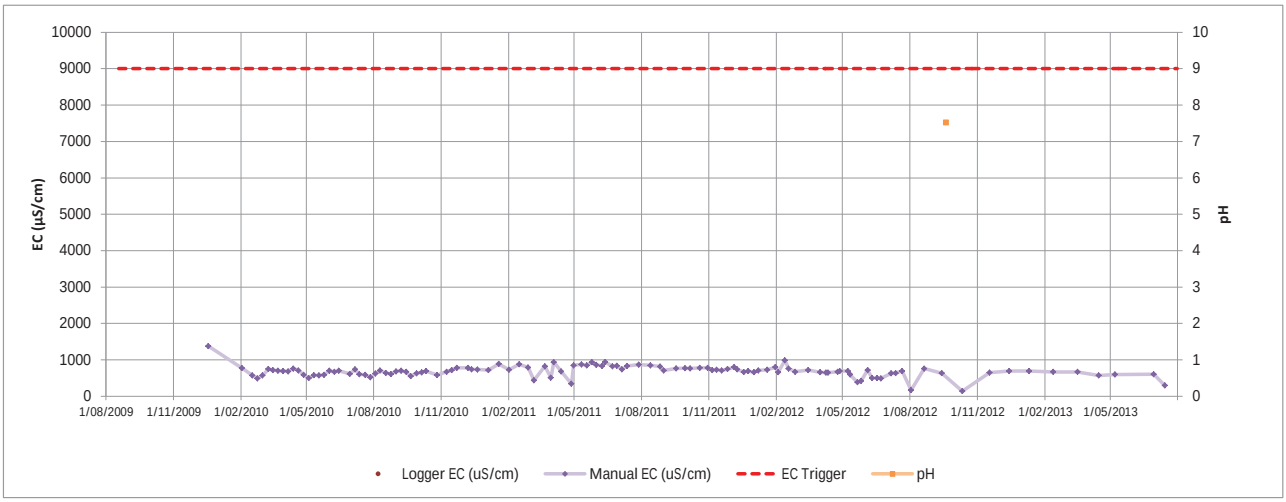


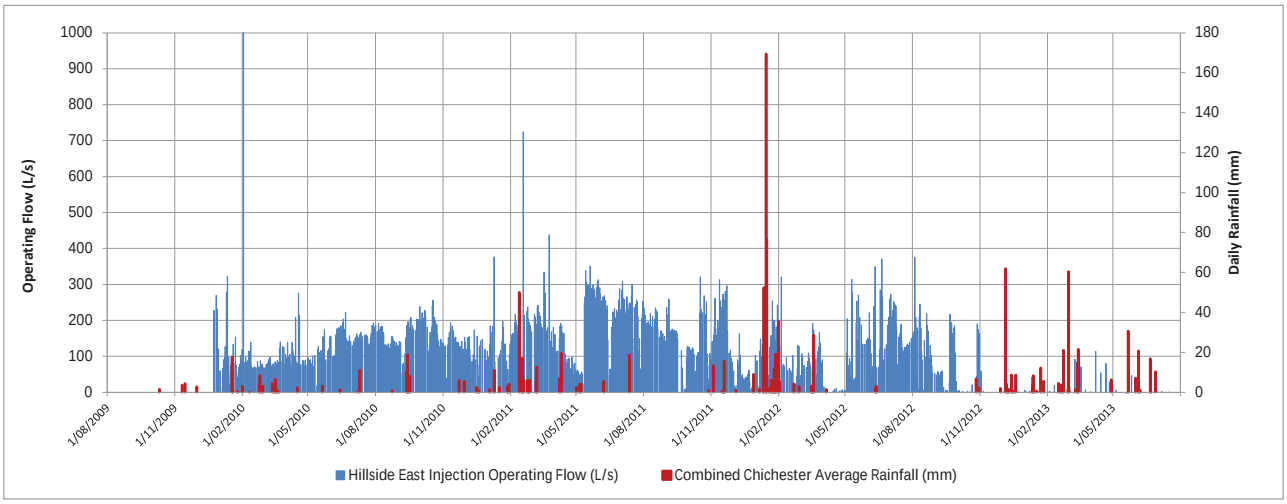


HSMB26_S Hydrograph

Bore Name: HSMB26_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

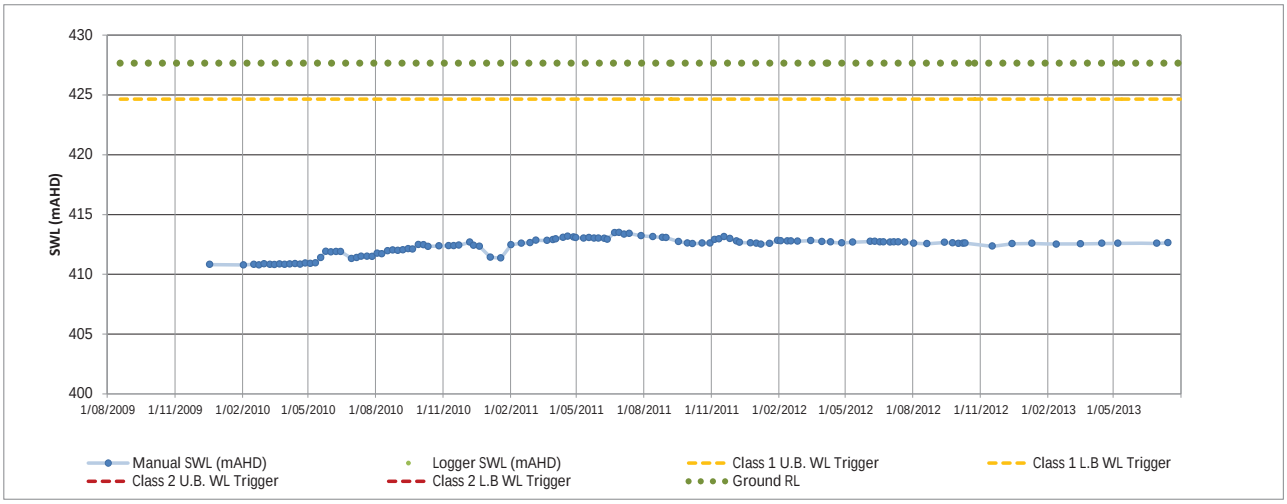


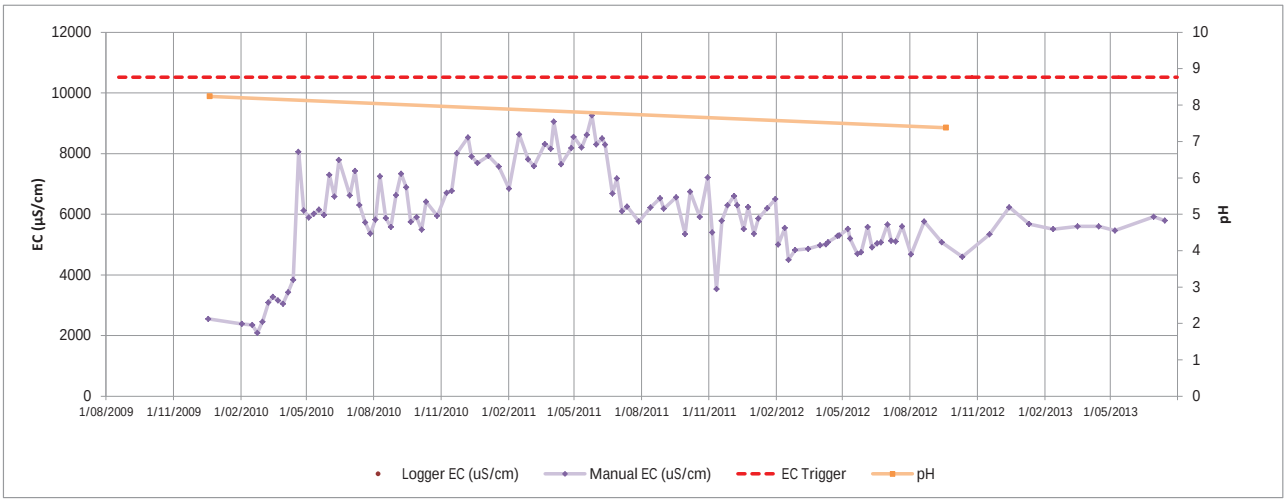


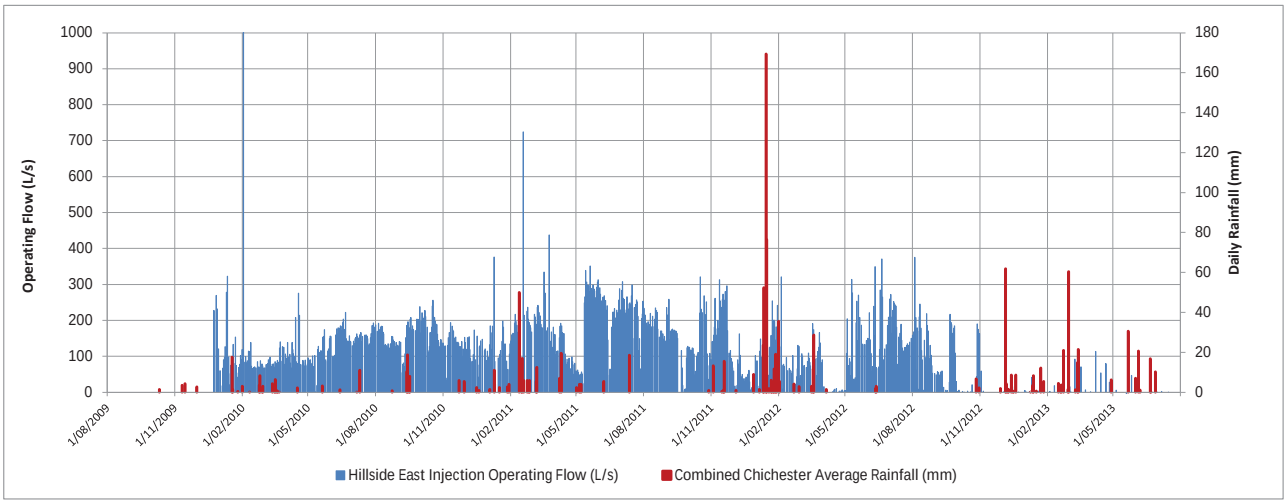


HSMB27_D Hydrograph

Bore Name: HSMB27_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

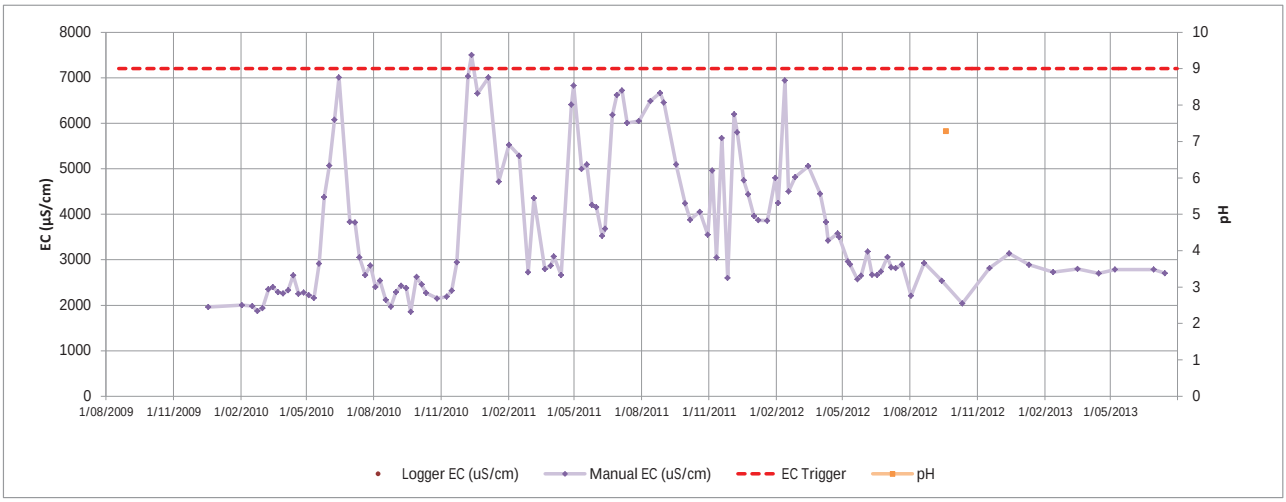


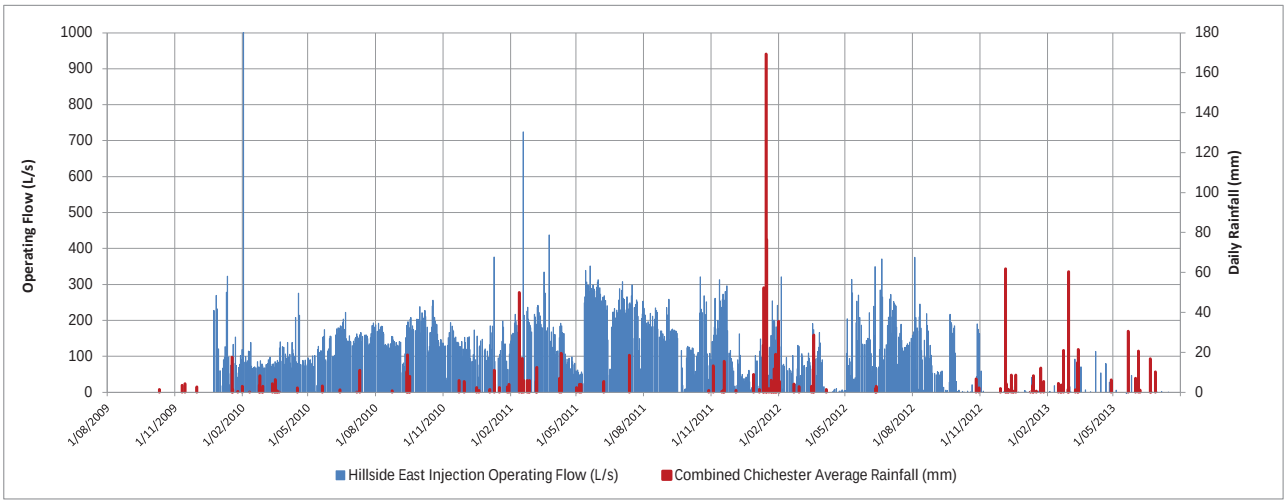




HSMB27_S Hydrograph

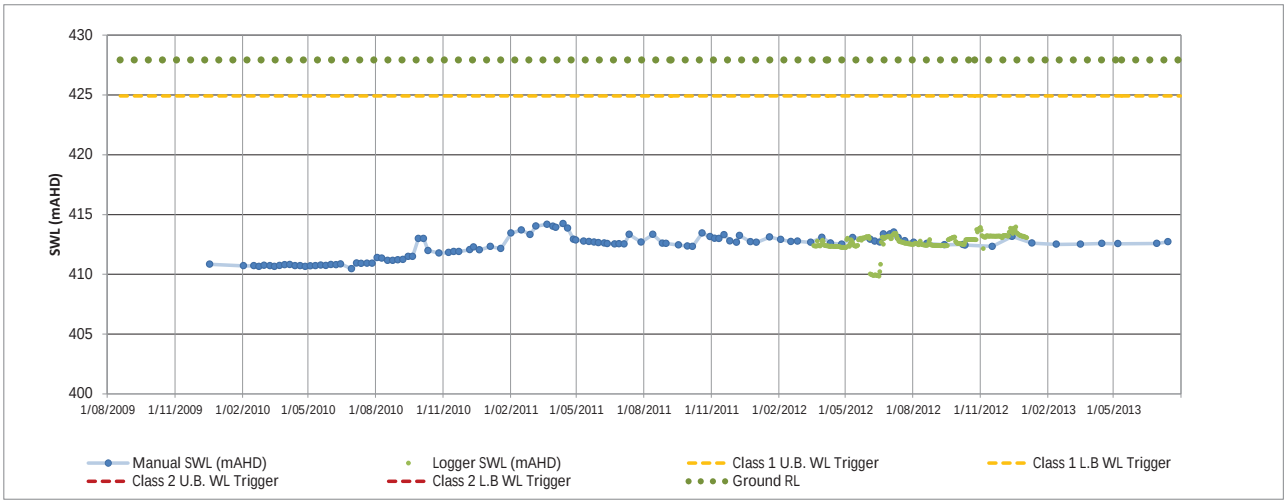
Bore Name: HSMB27_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

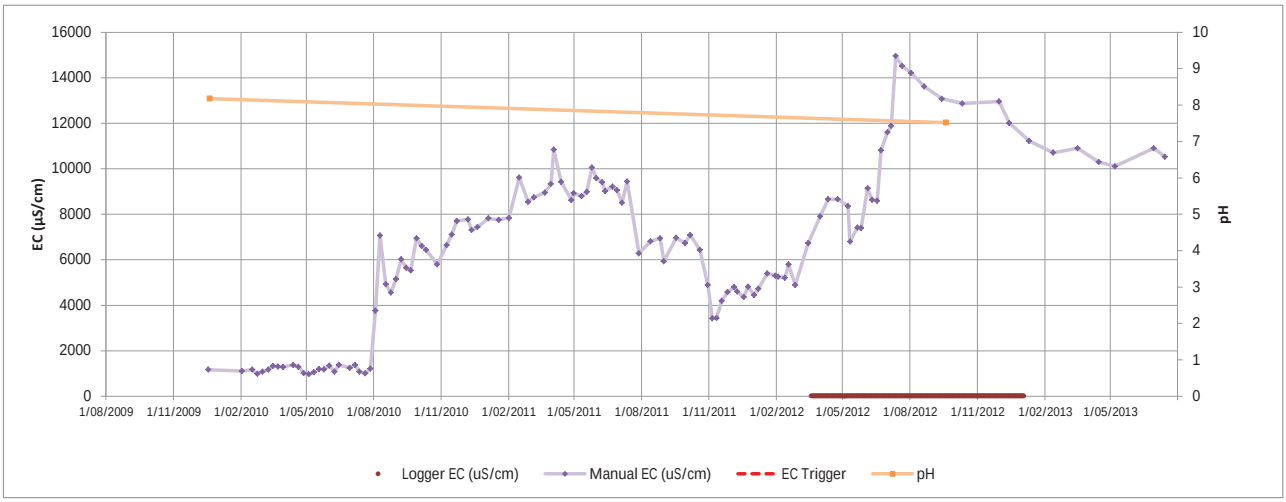


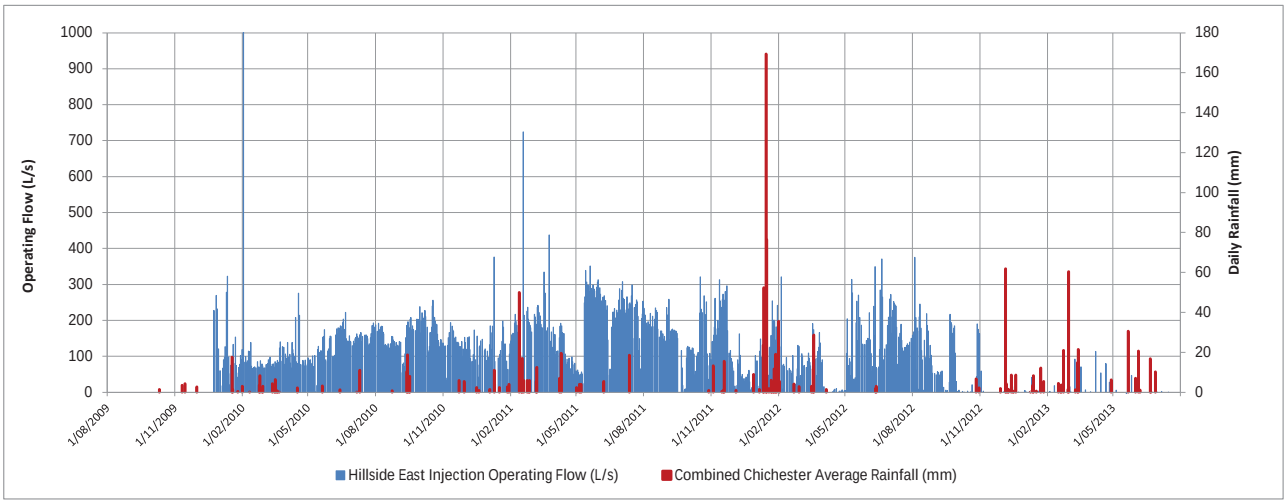


HSMB28_D Hydrograph

Bore Name: HSMB28_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

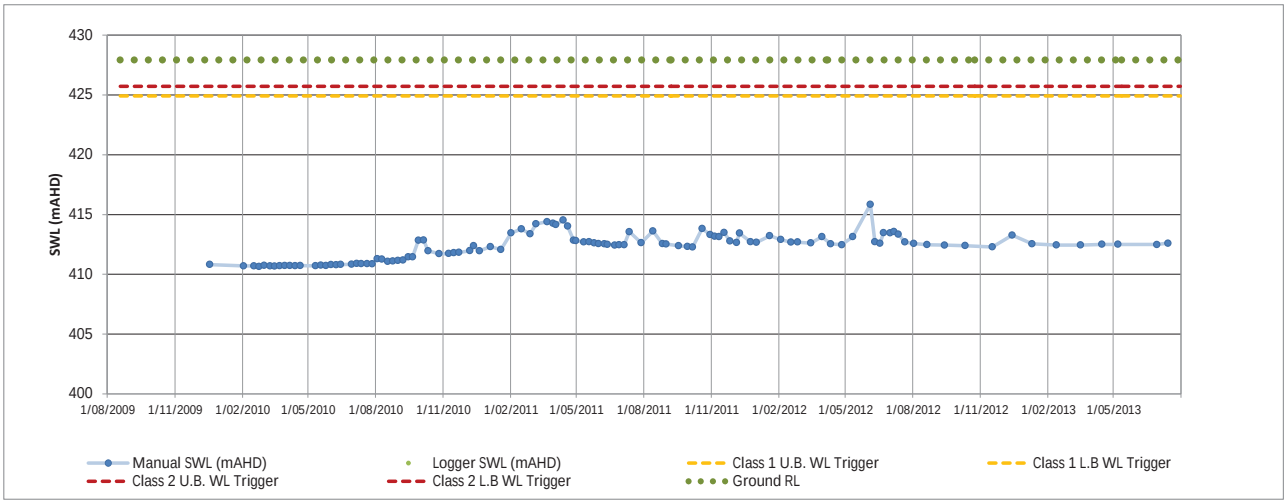


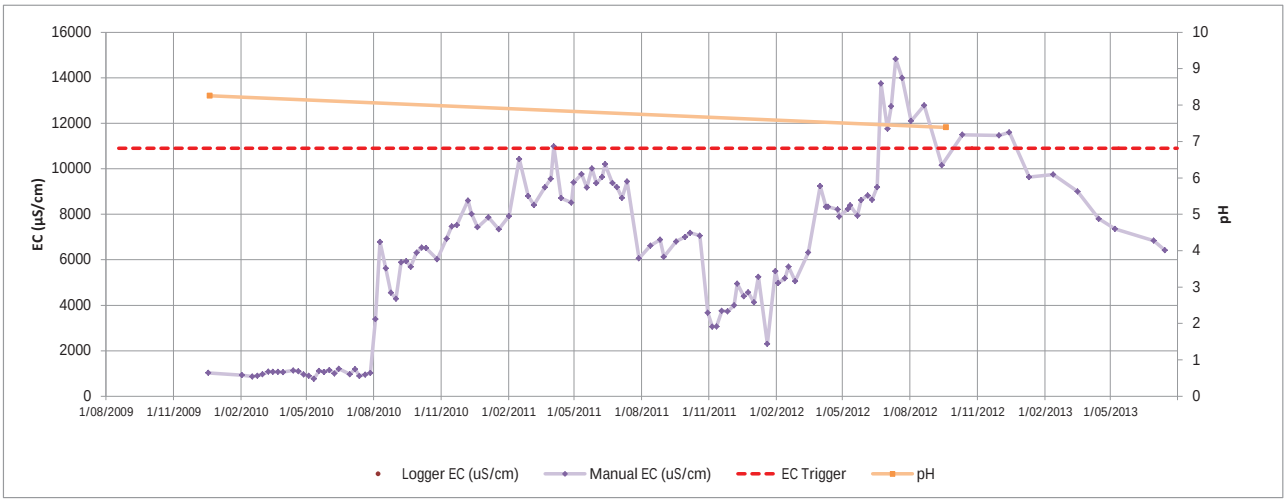


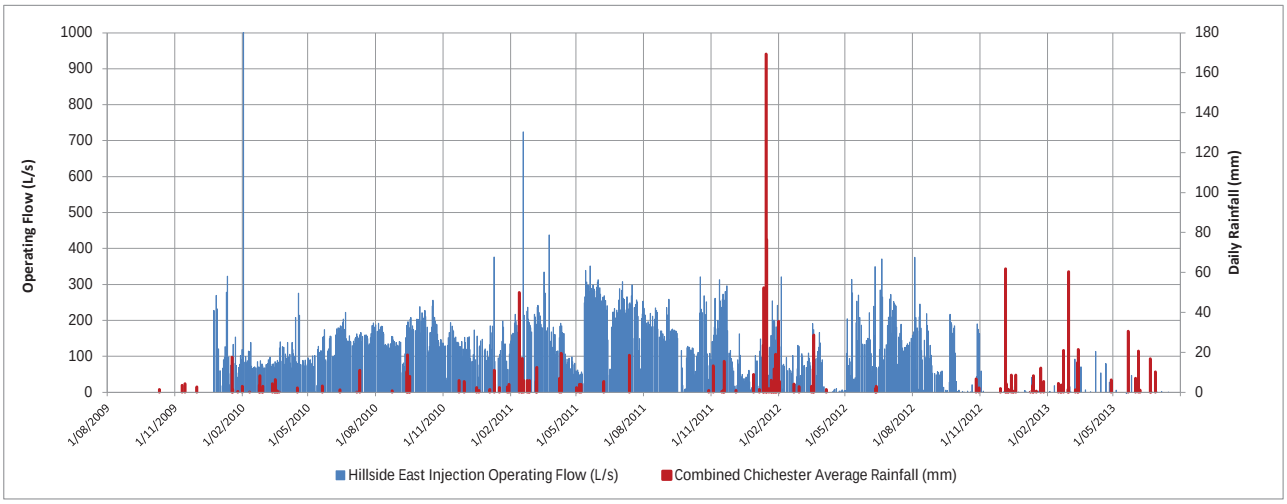


HSMB28_S Hydrograph

Bore Name: HSMB28_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

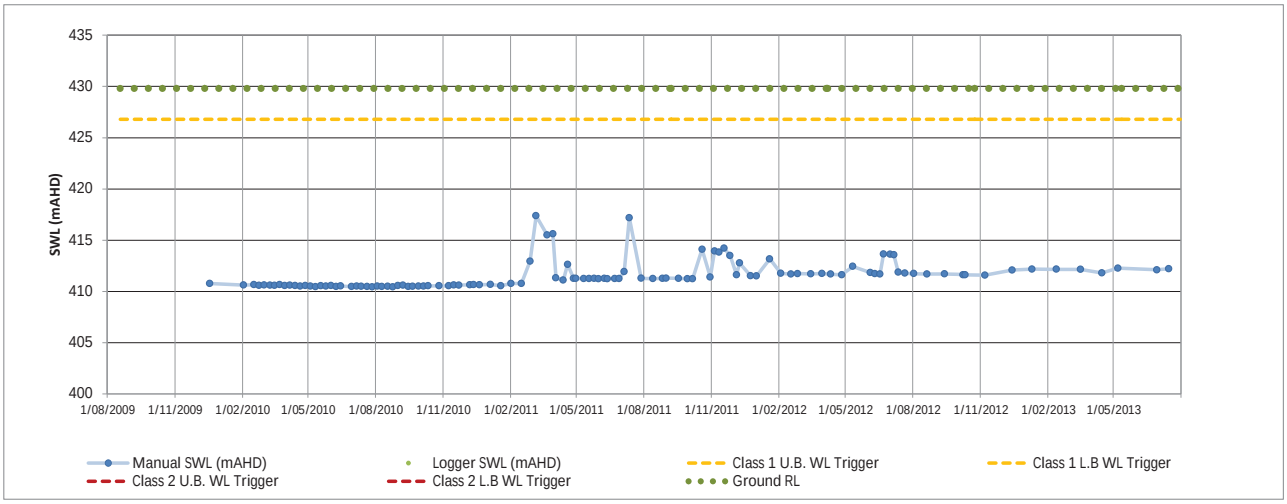


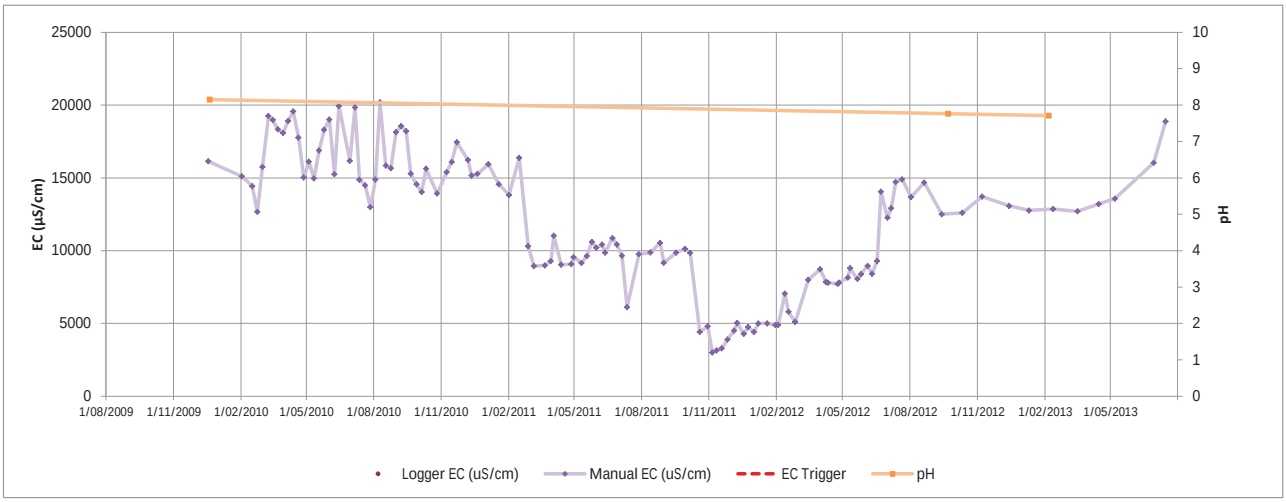


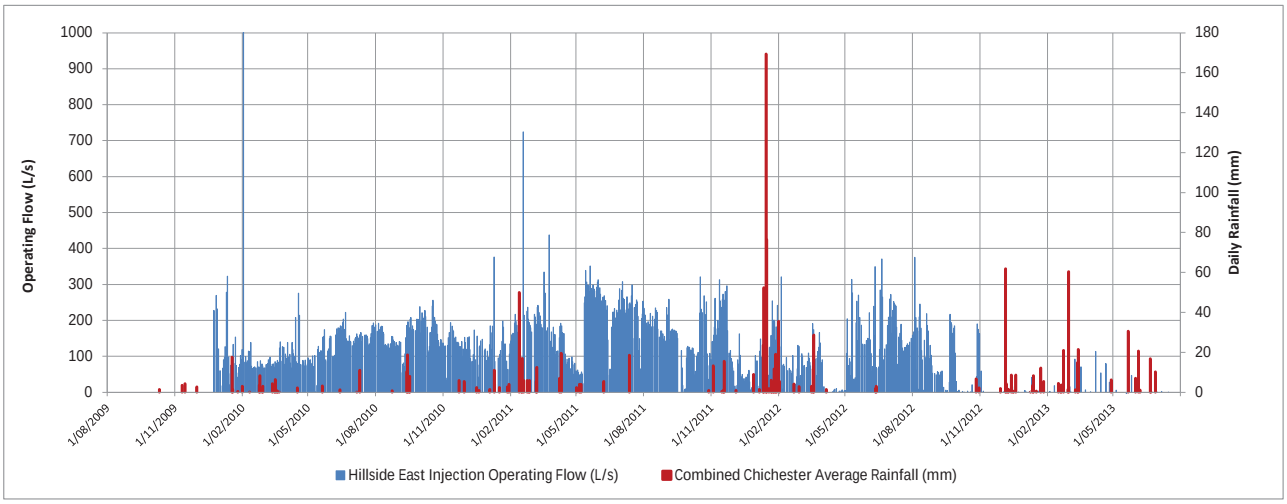


HSMB29_D Hydrograph

Bore Name: HSMB29_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

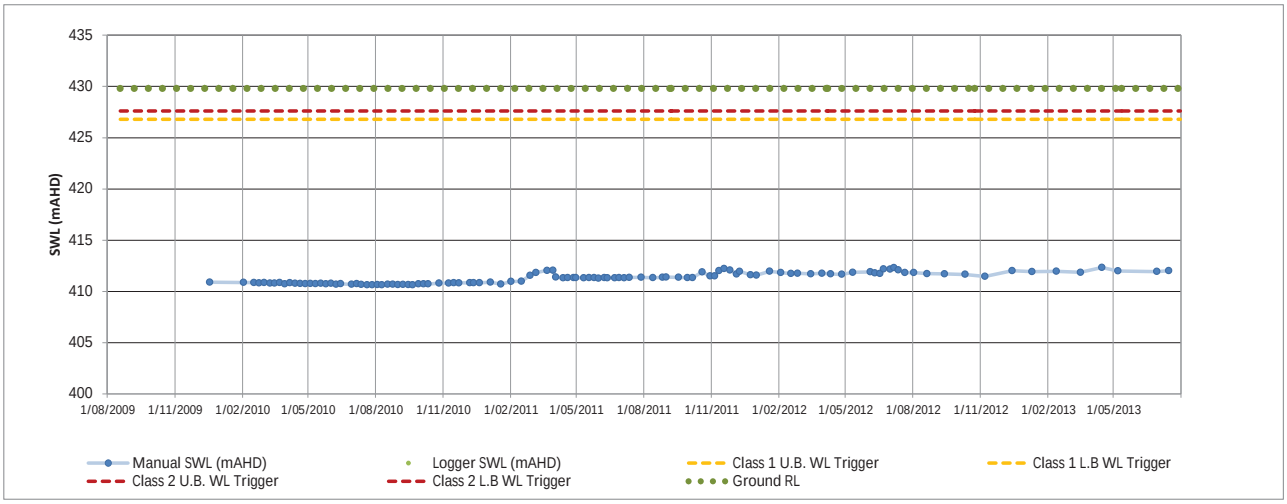


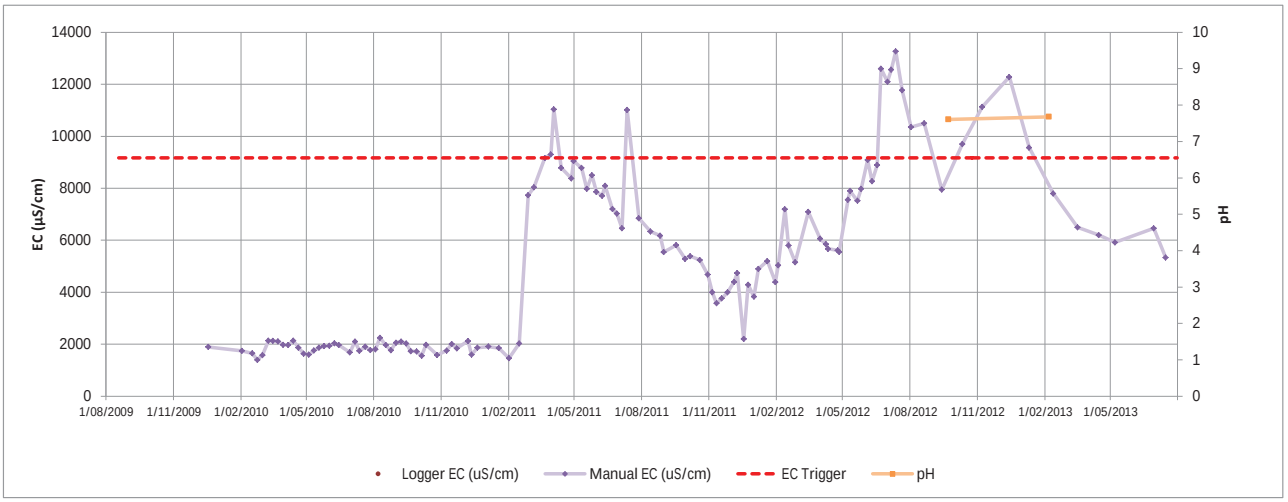


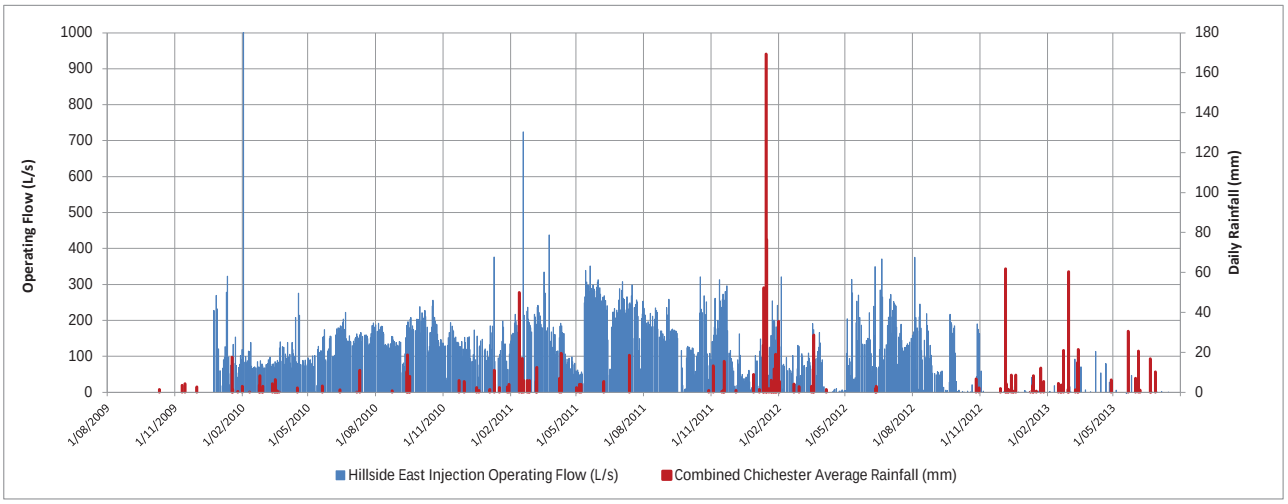


HSMB29_S Hydrograph

Bore Name: HSMB29_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

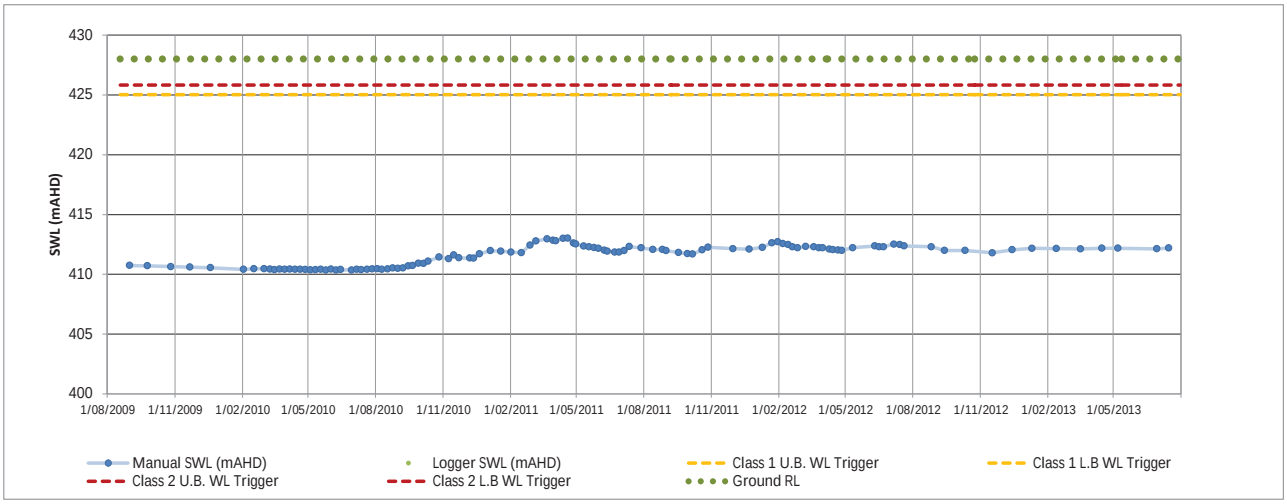


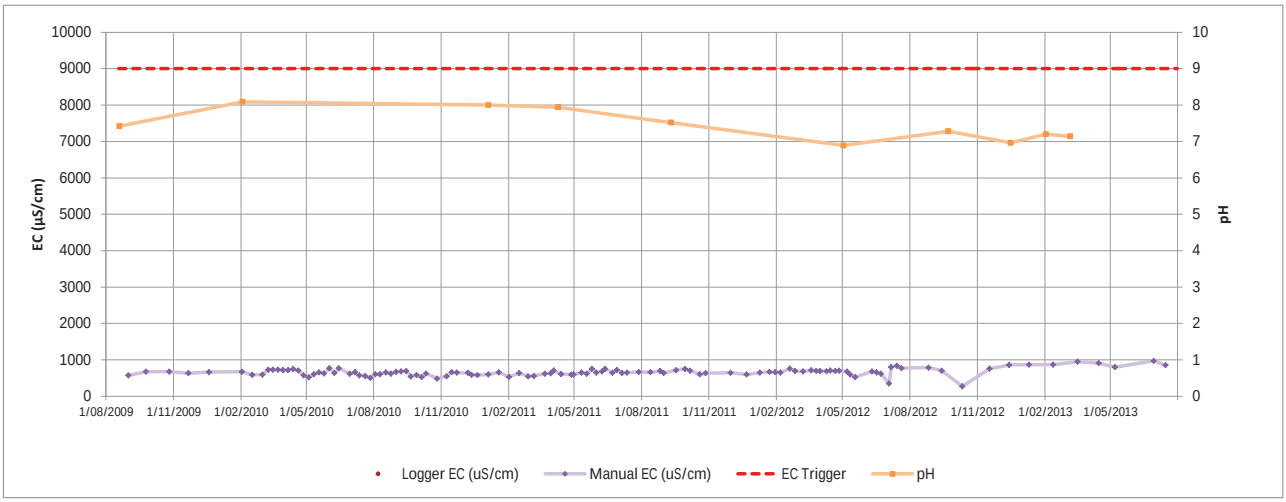


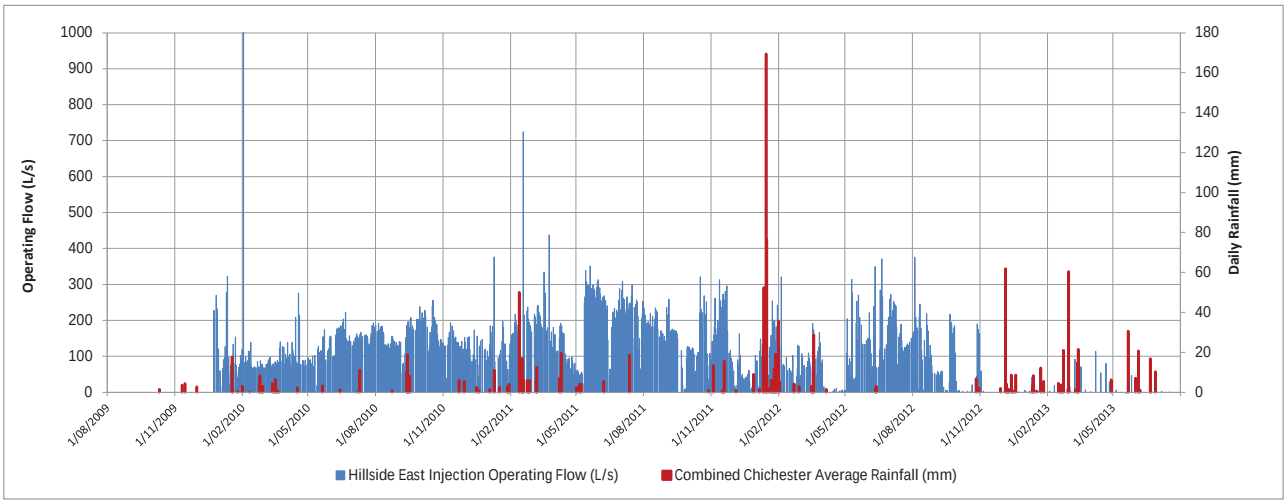


SCX03_S Hydrograph

Bore Name: SCX03_S
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone C

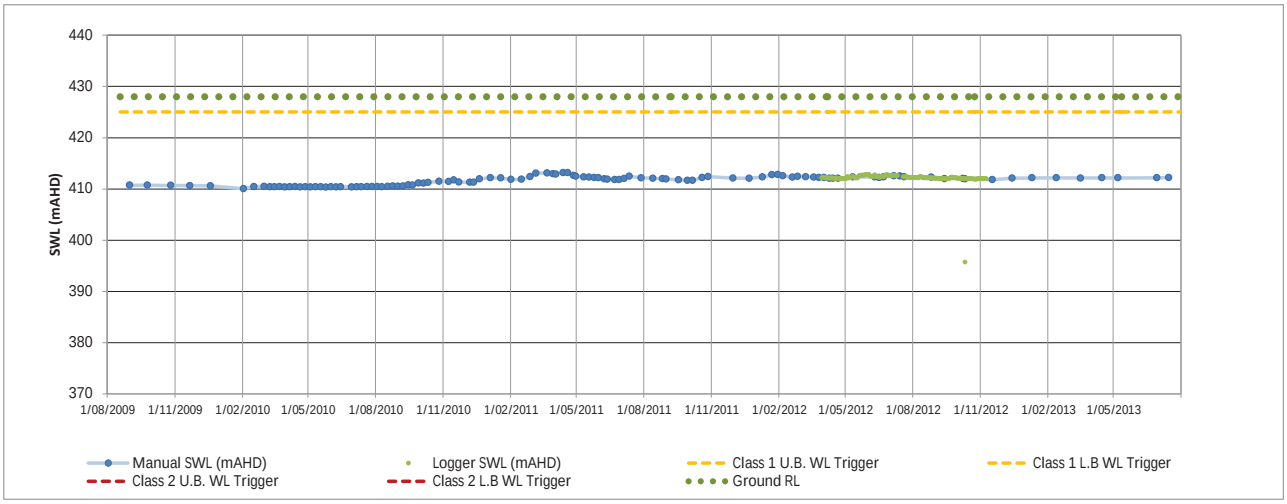


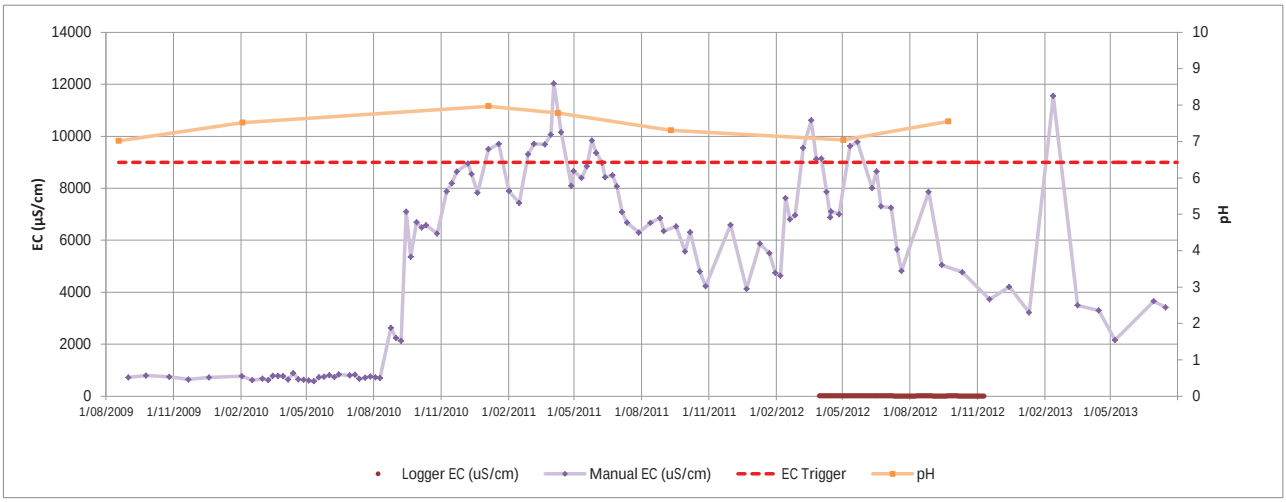


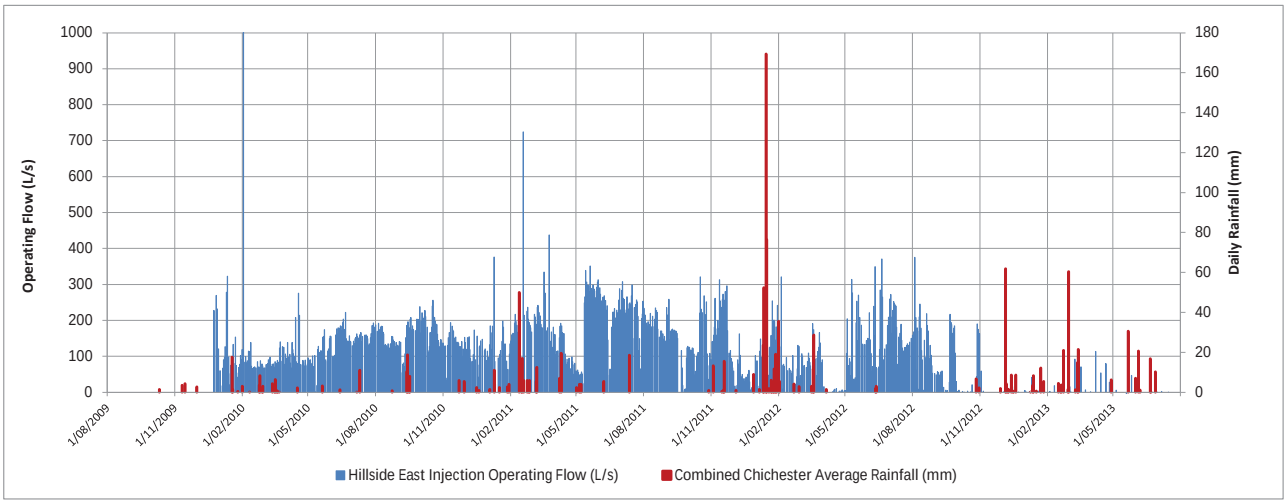


SCX03_D Hydrograph

Bore Name: SCX03_D
Abs/Inj Totals: Hillside East Injection
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

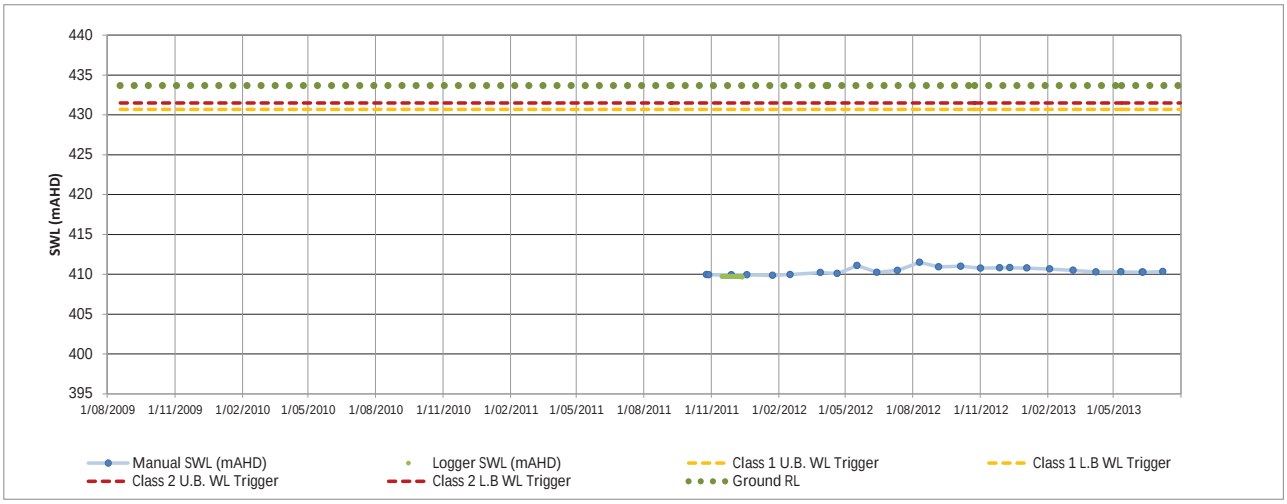


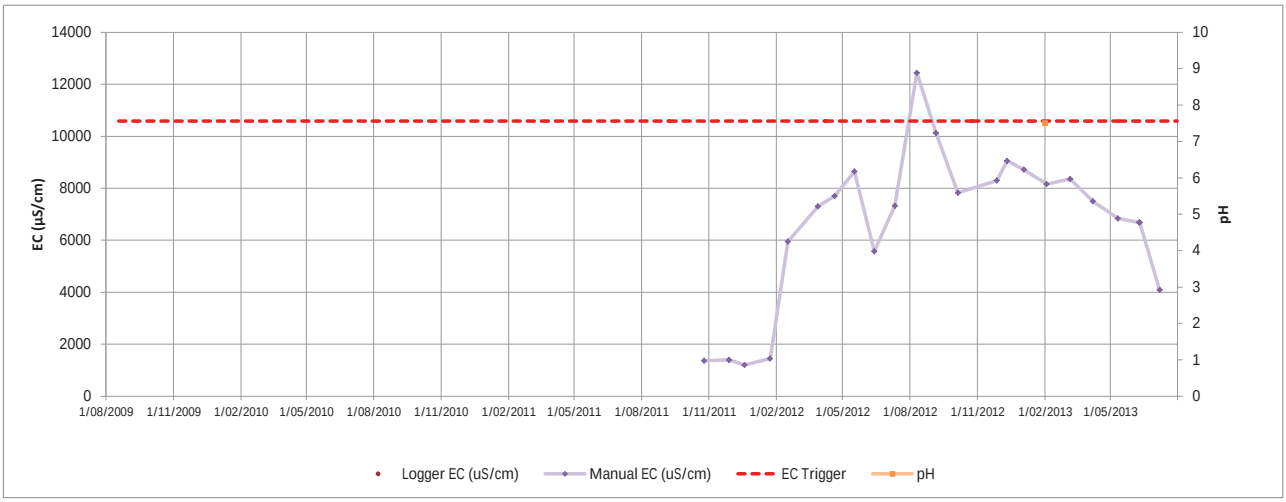


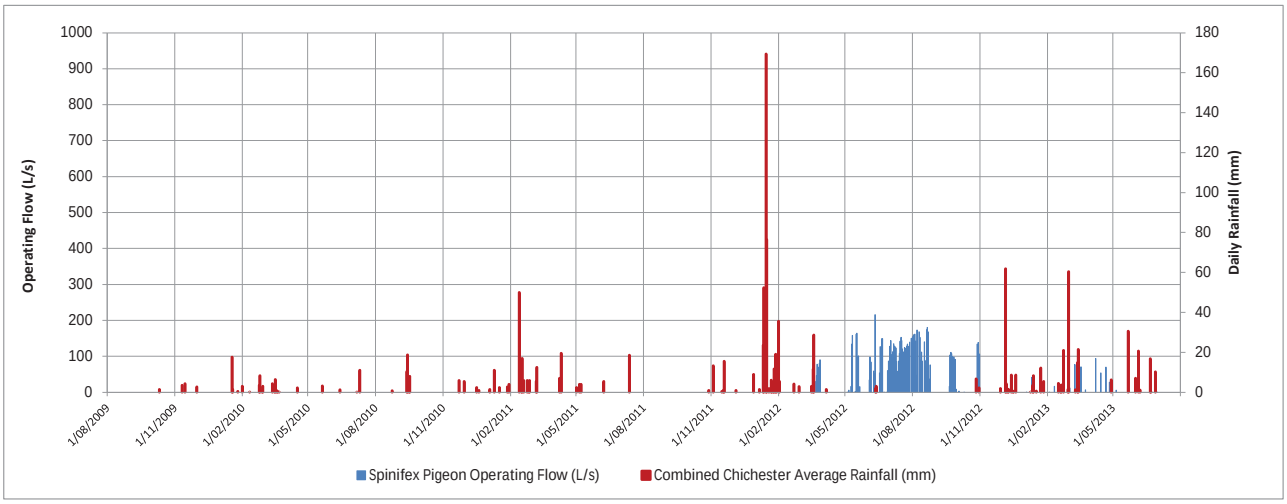


SPM01_S Hydrograph

Bore Name: SPM01_S
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Upper TD.
Management Zone: Zone C

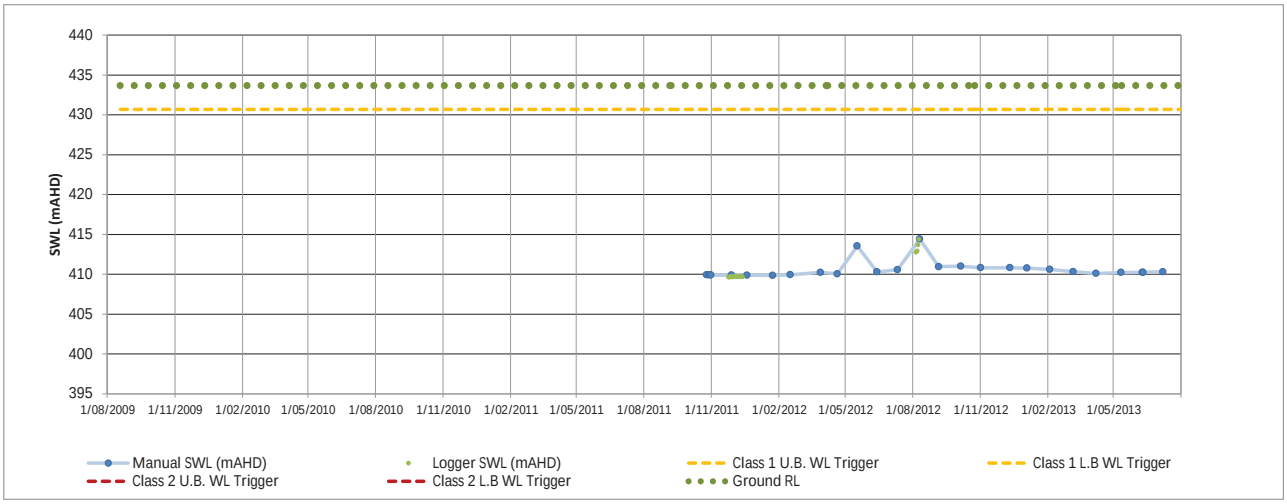


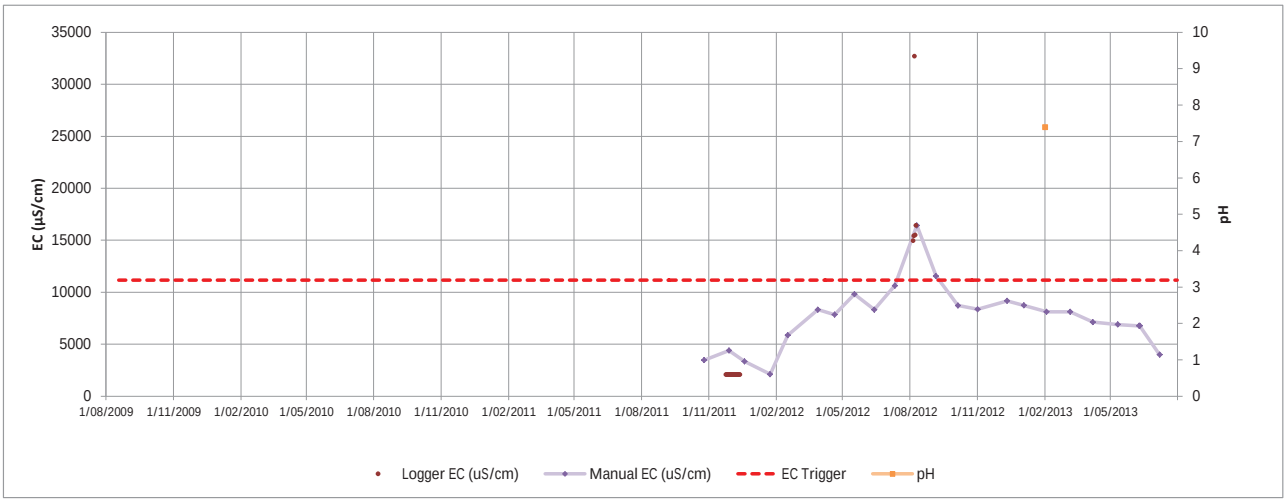


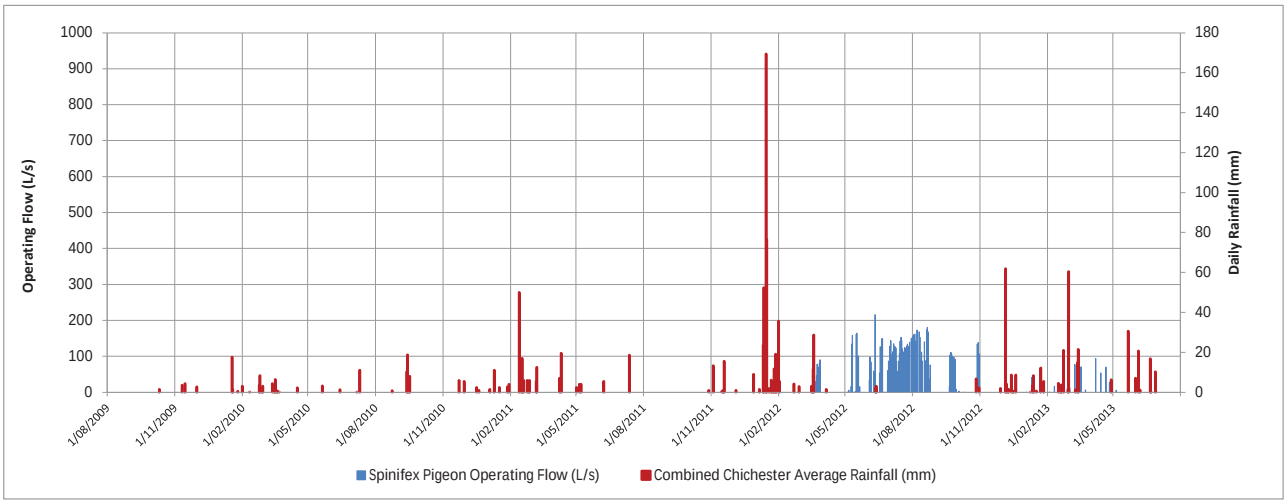


SPM01_D Hydrograph

Bore Name: SPM01_D
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

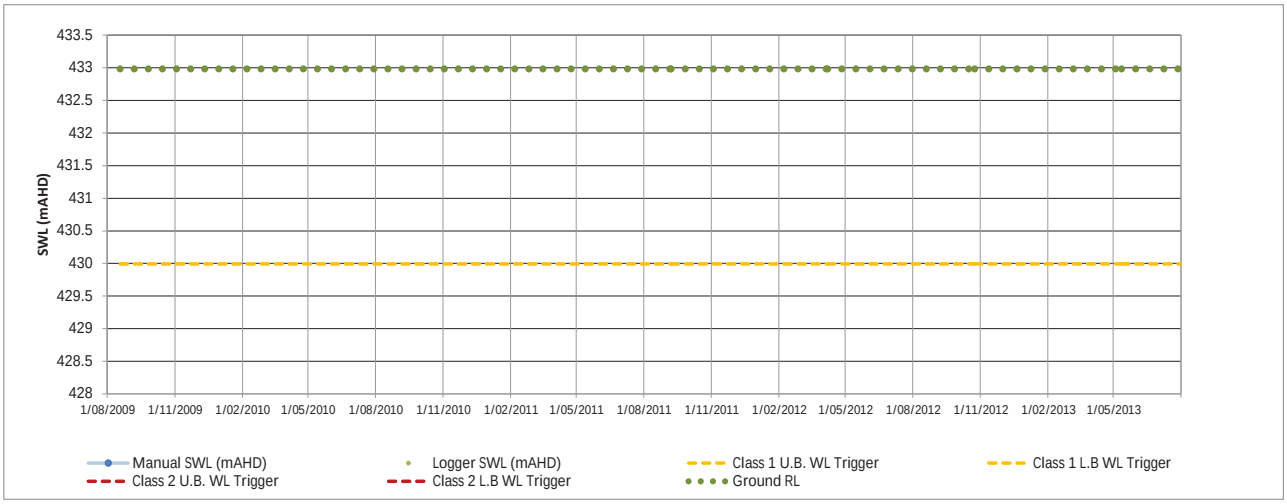


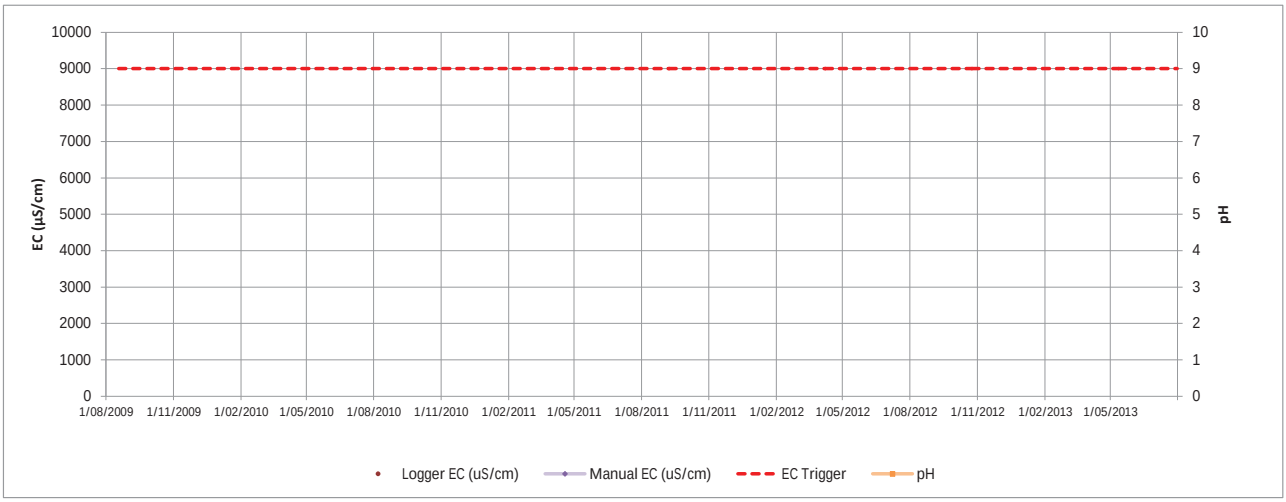


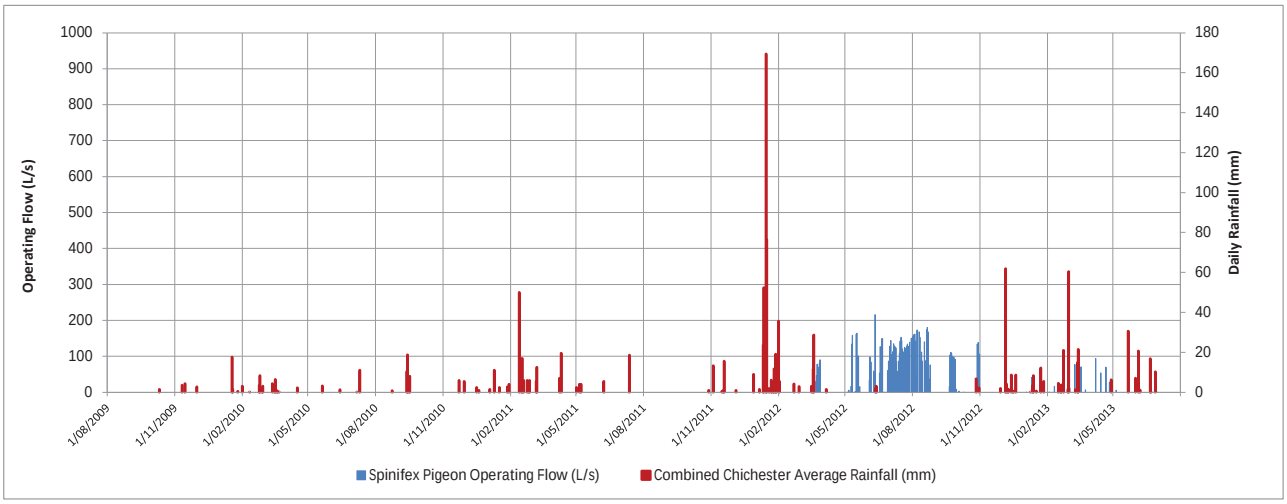


SPM03 Hydrograph

Bore Name: SPM03
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

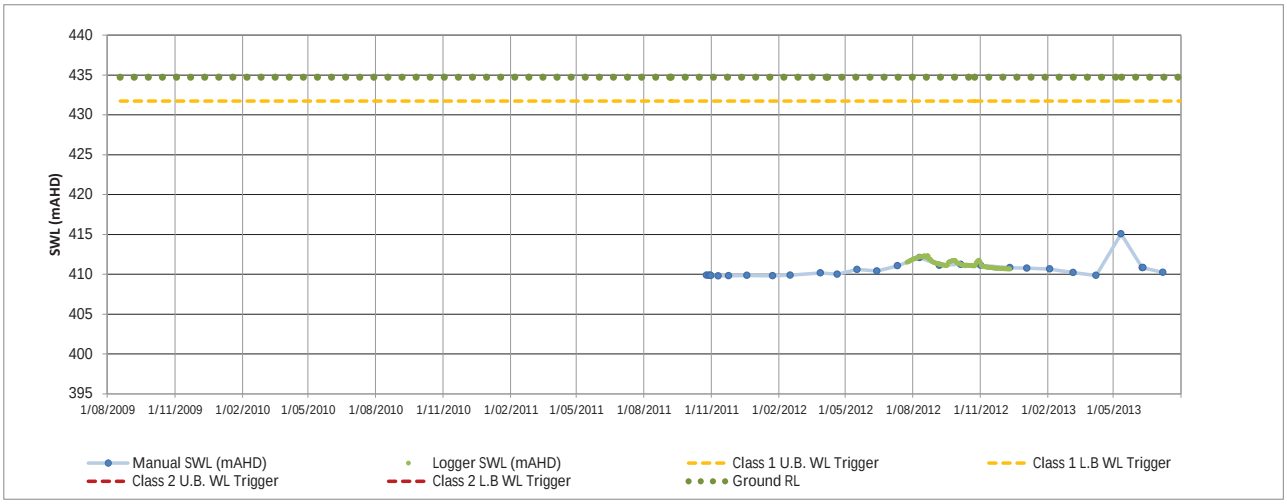


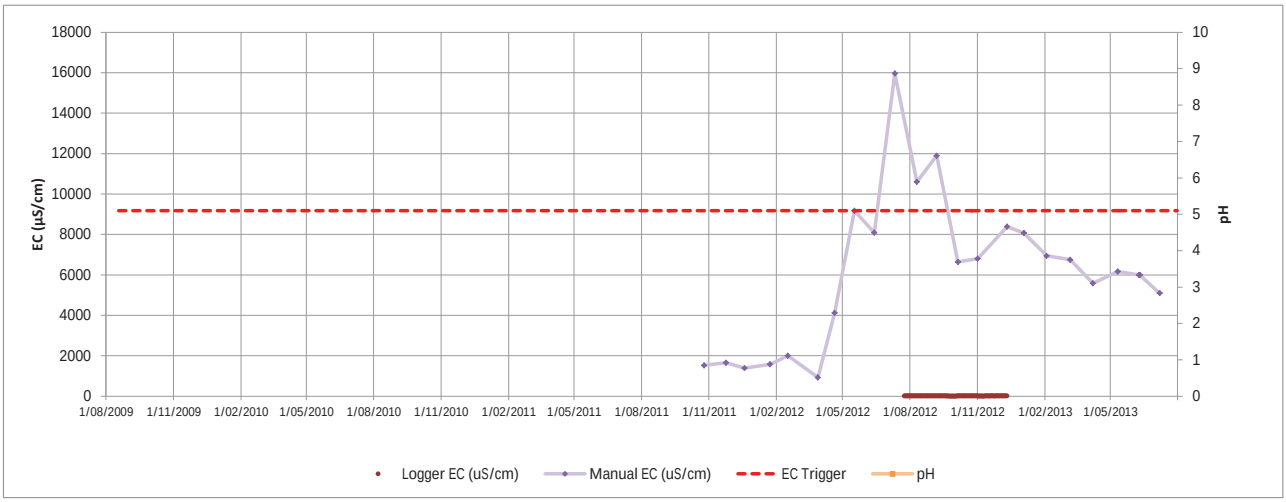


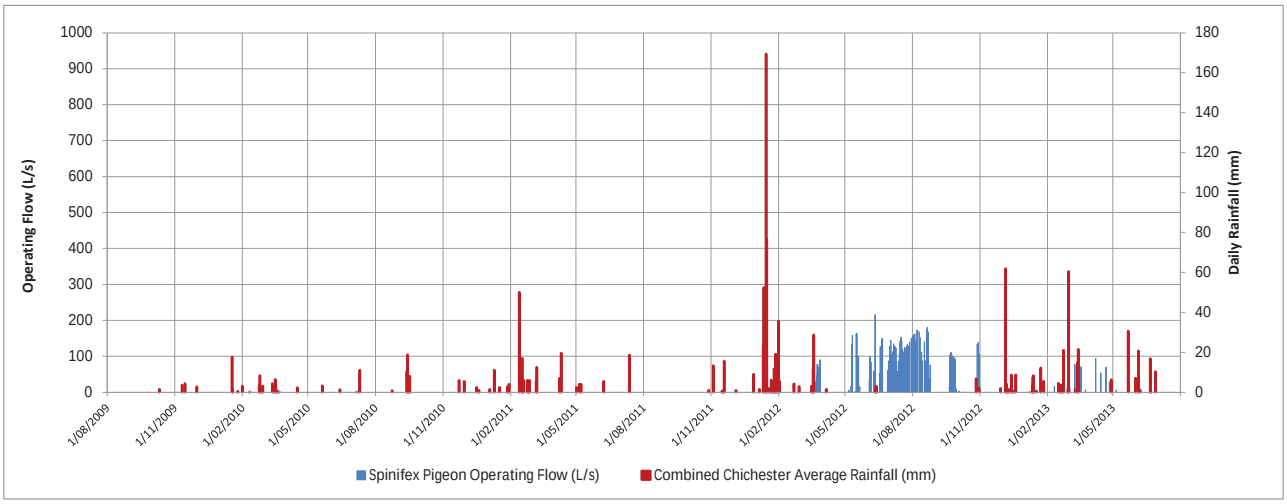


SPM05 Hydrograph

Bore Name: SPM05
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

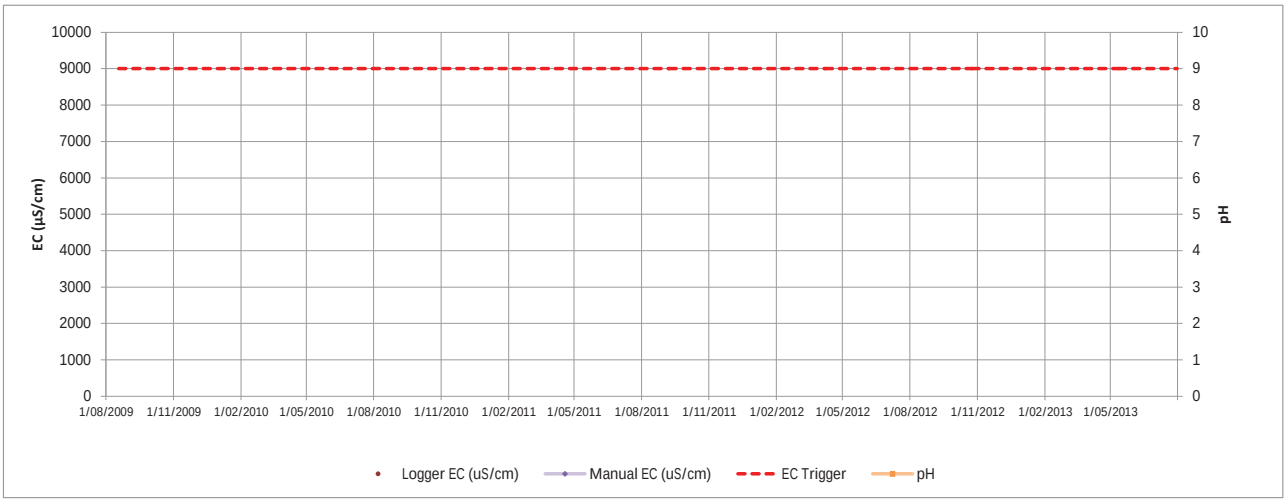


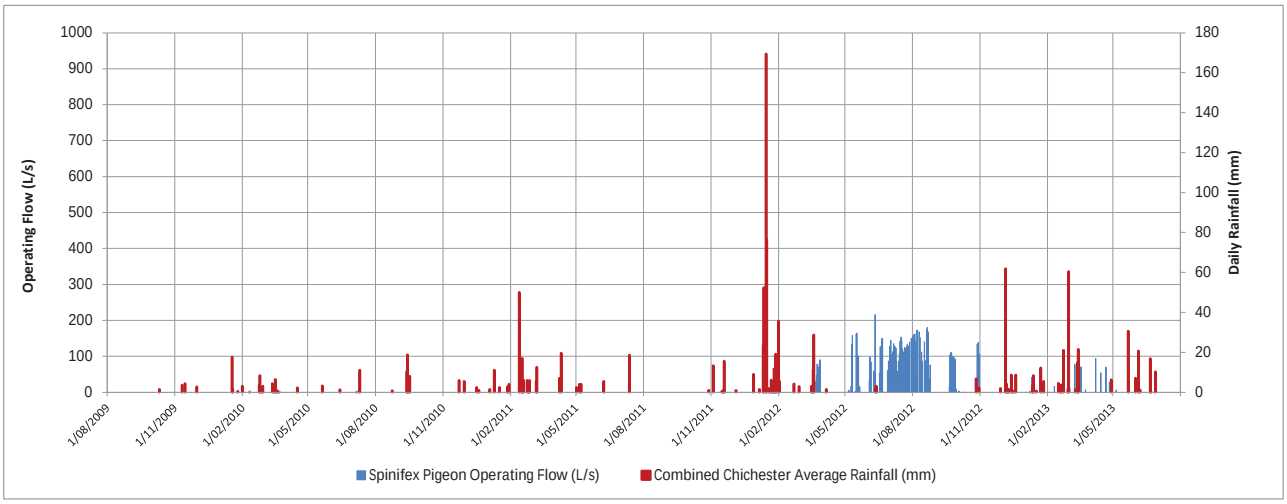




SPM06_S Hydrograph

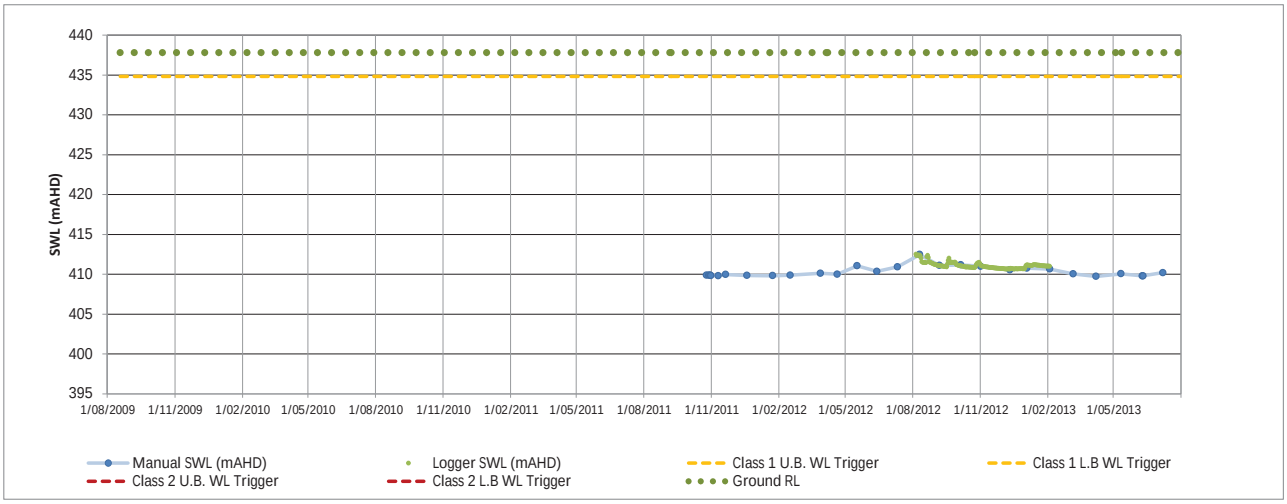
Bore Name: SPM06_S
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Upper TD.
Management Zone: Zone C

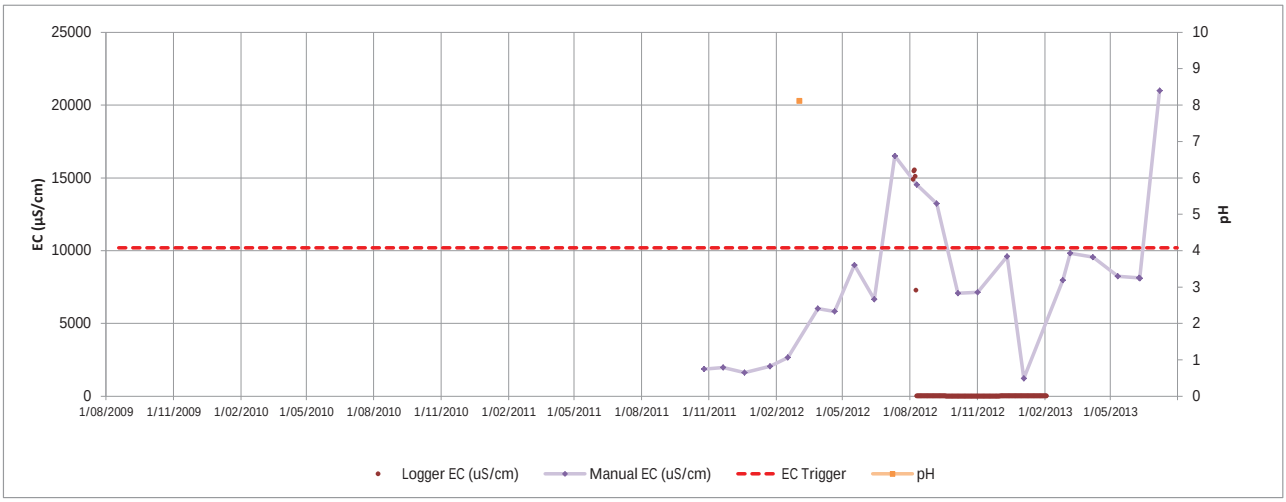


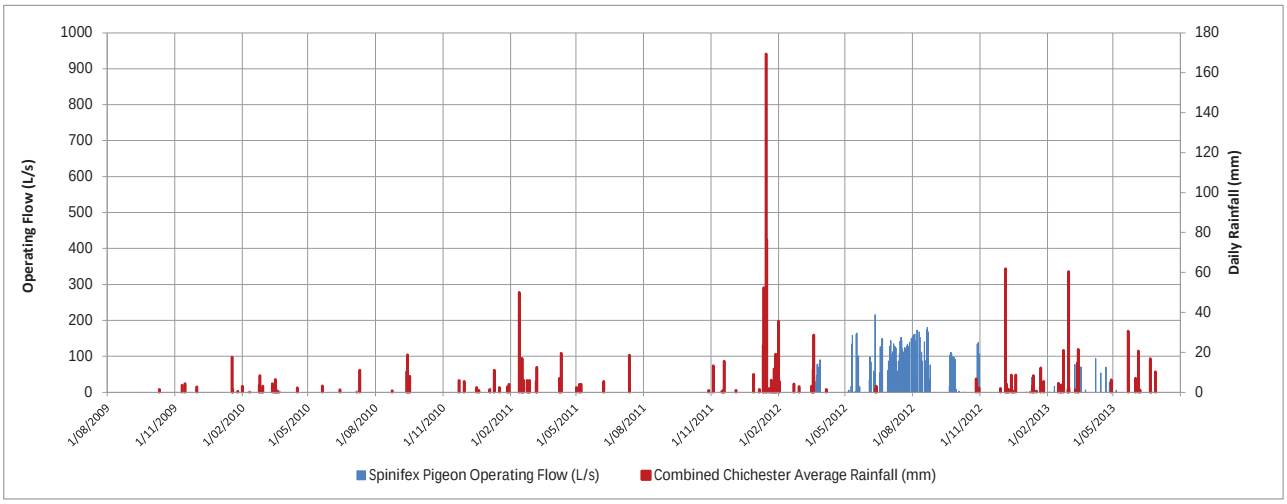


SPM06_D Hydrograph

Bore Name: SPM06_D
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

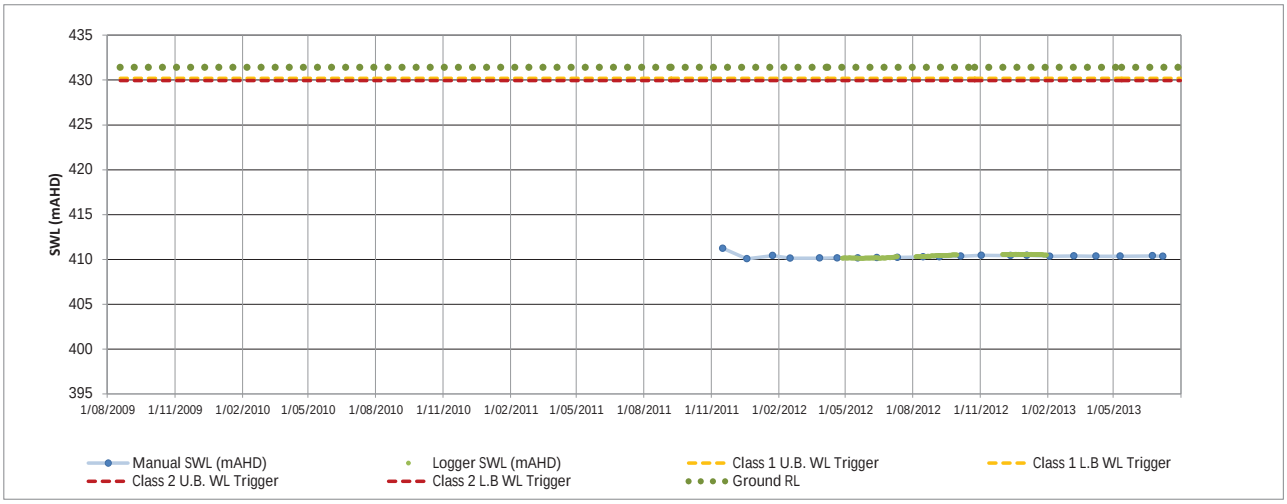


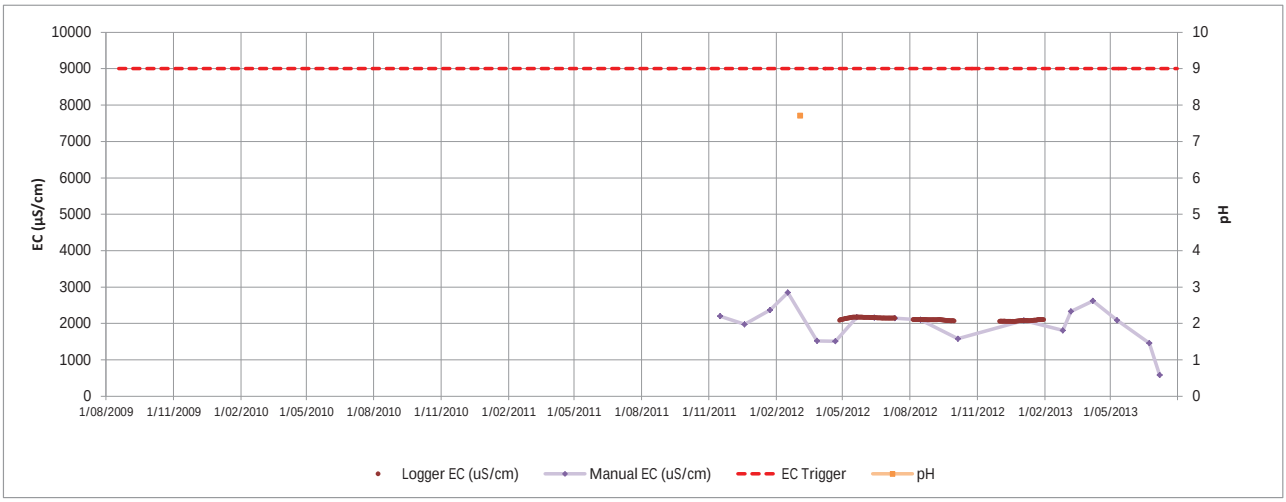


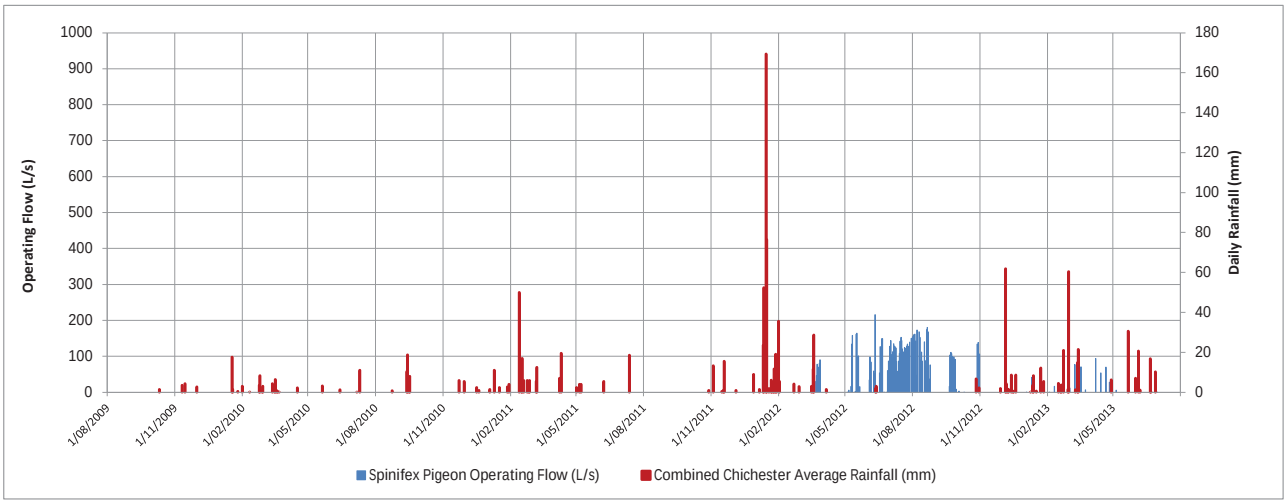


SPM07_D Hydrograph

Bore Name: SPM07_D
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

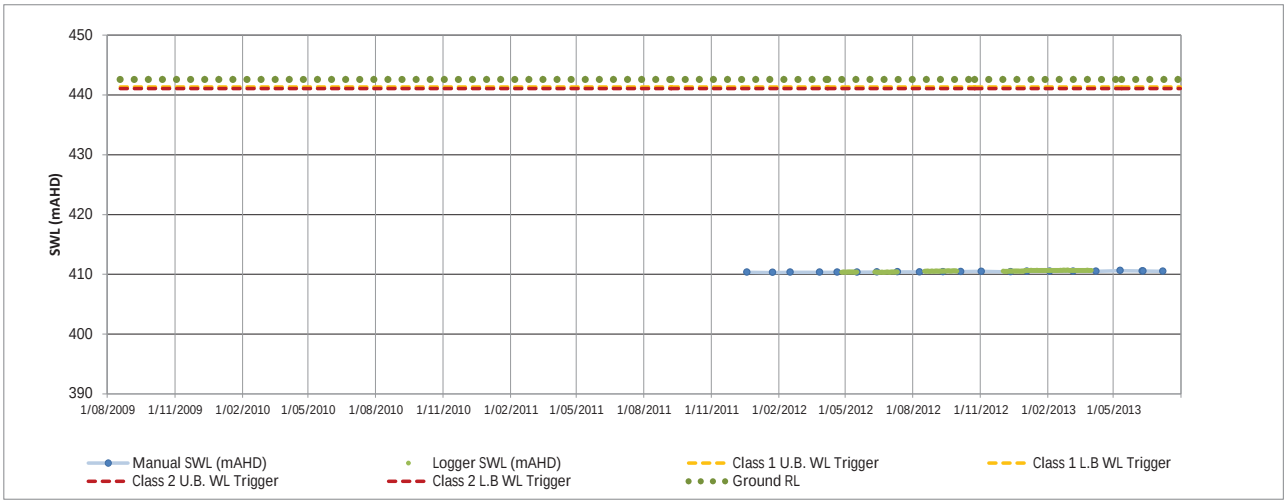


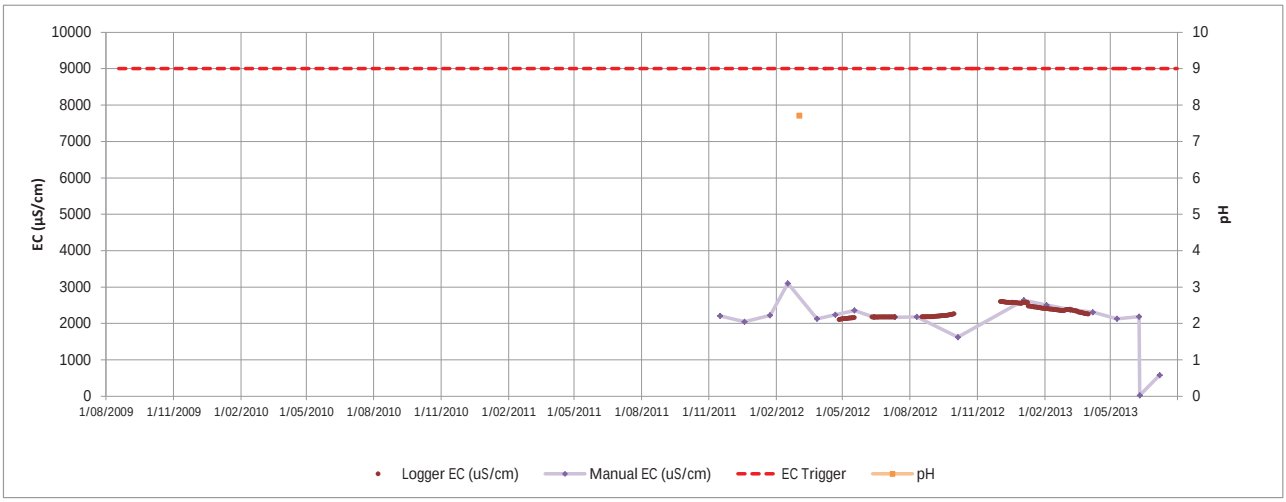


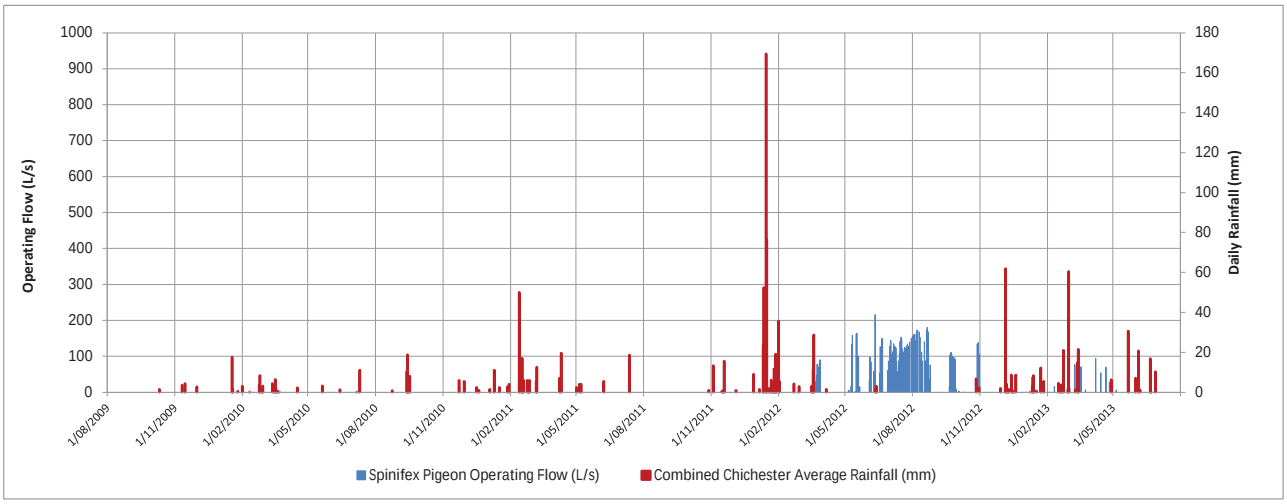


SPM08_D Hydrograph

Bore Name: SPM08_D
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

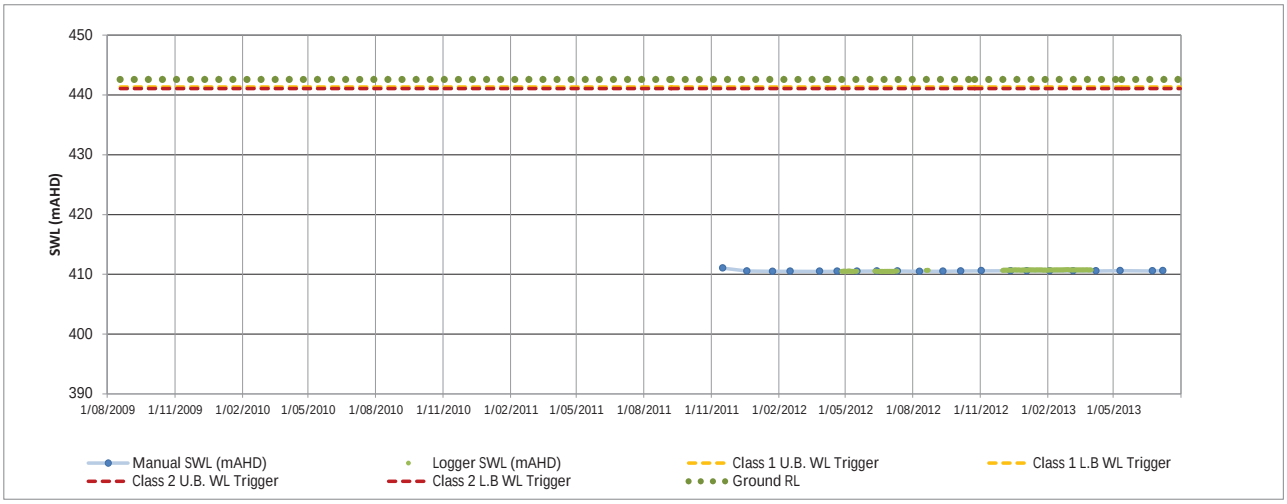


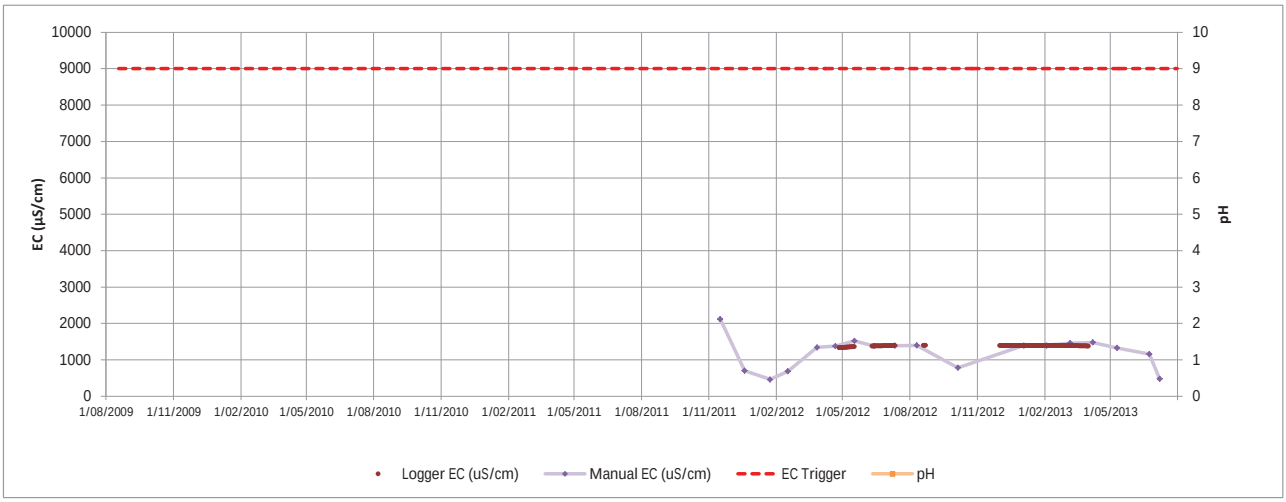


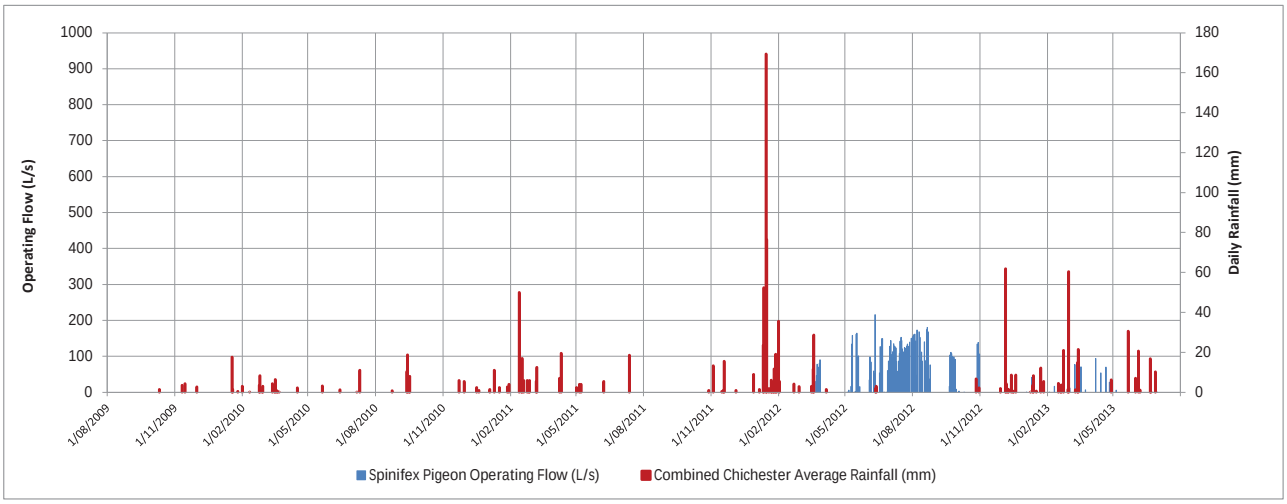


SPM09_D Hydrograph

Bore Name: SPM09_D
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Marra Mamba Fmn.
Management Zone: Zone C

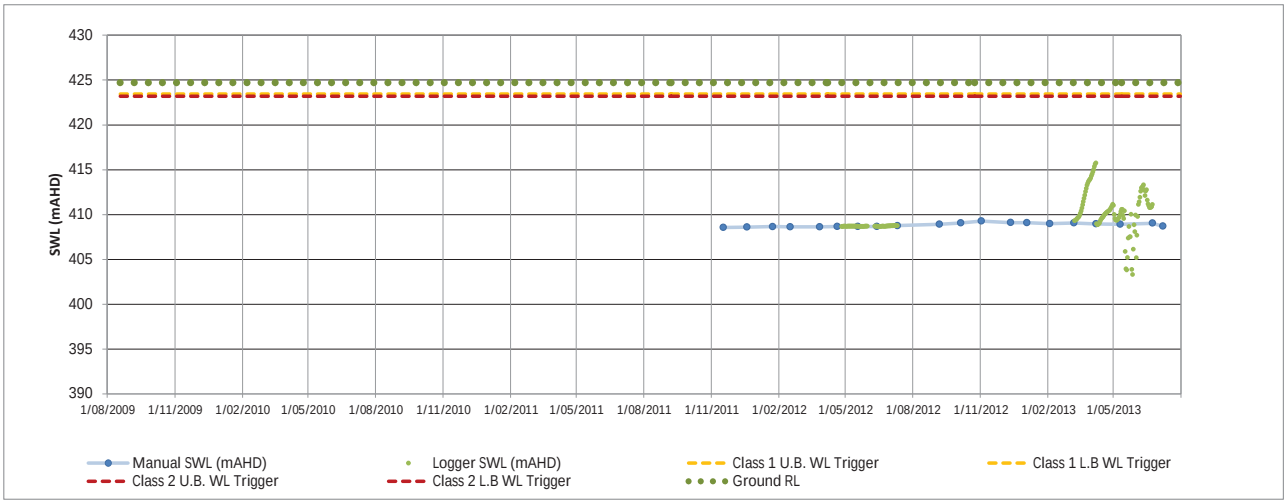


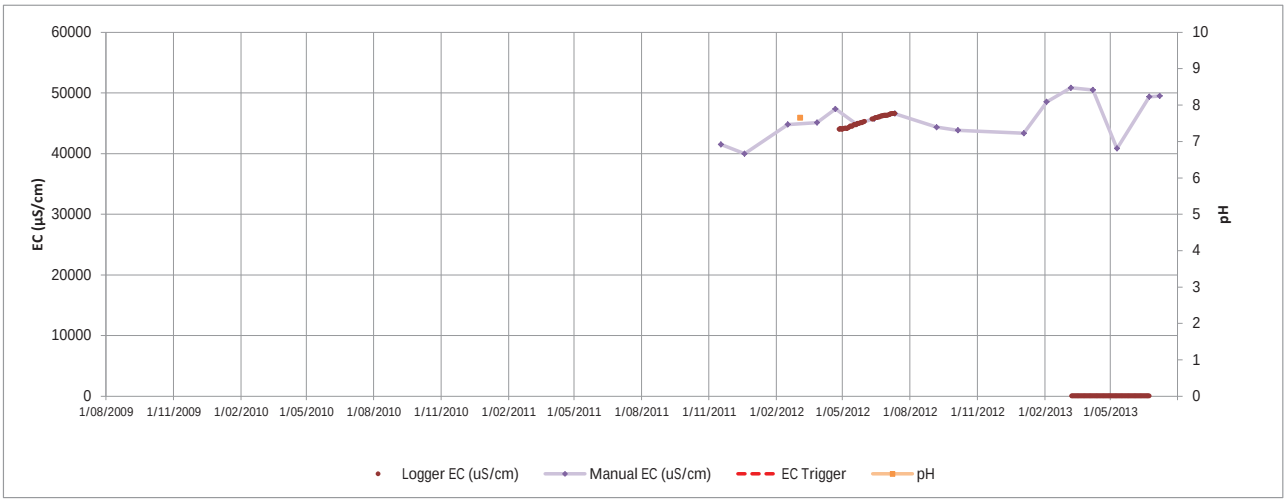


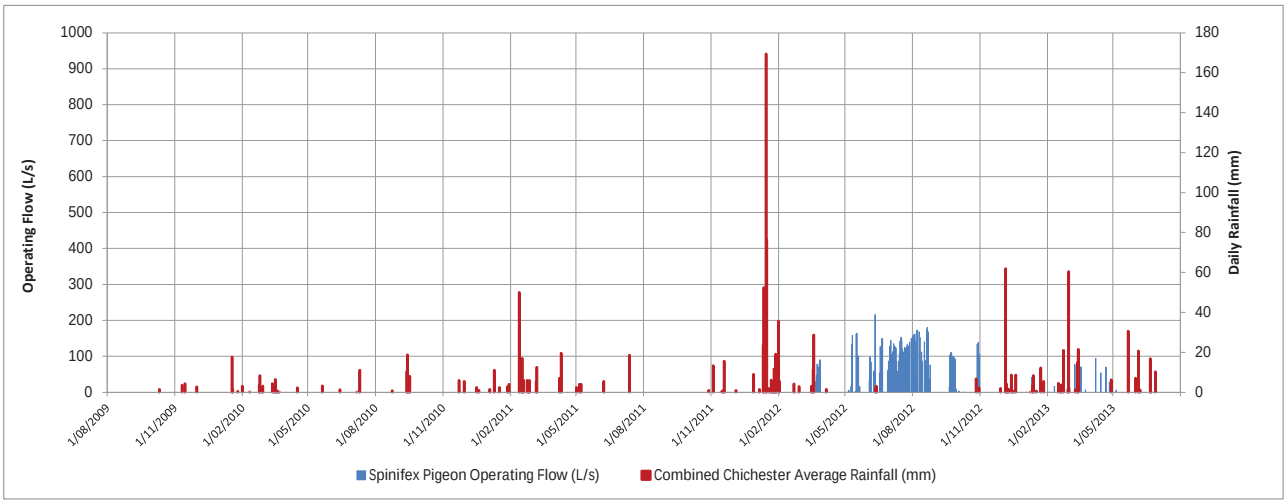


SPM10_D Hydrograph

Bore Name: SPM10_D
Abs/Inj Totals: Spinifex Pigeon
Monitored Aquifer: Upper TD.
Management Zone: Zone C

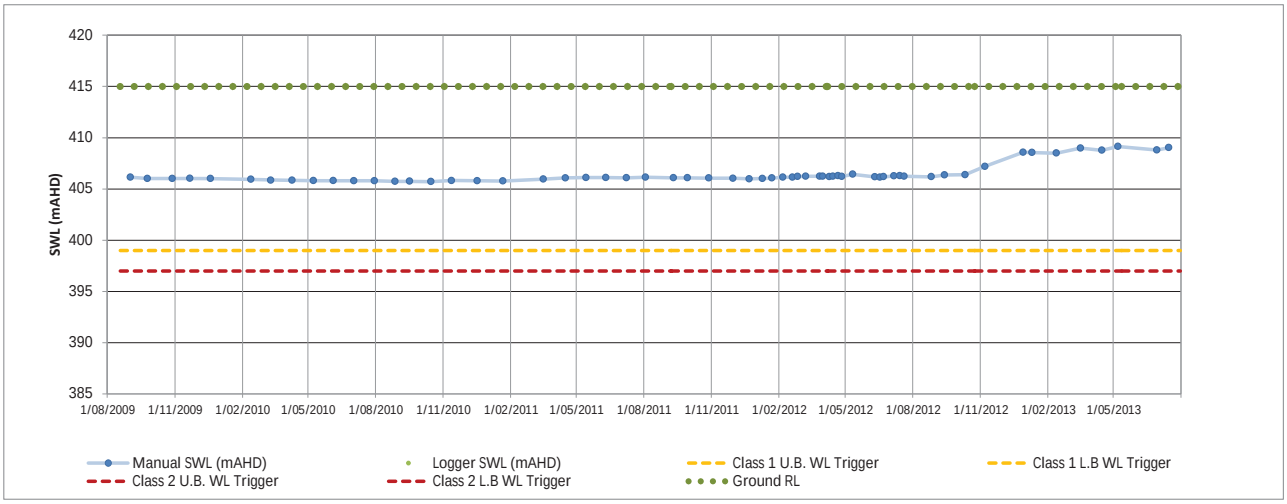


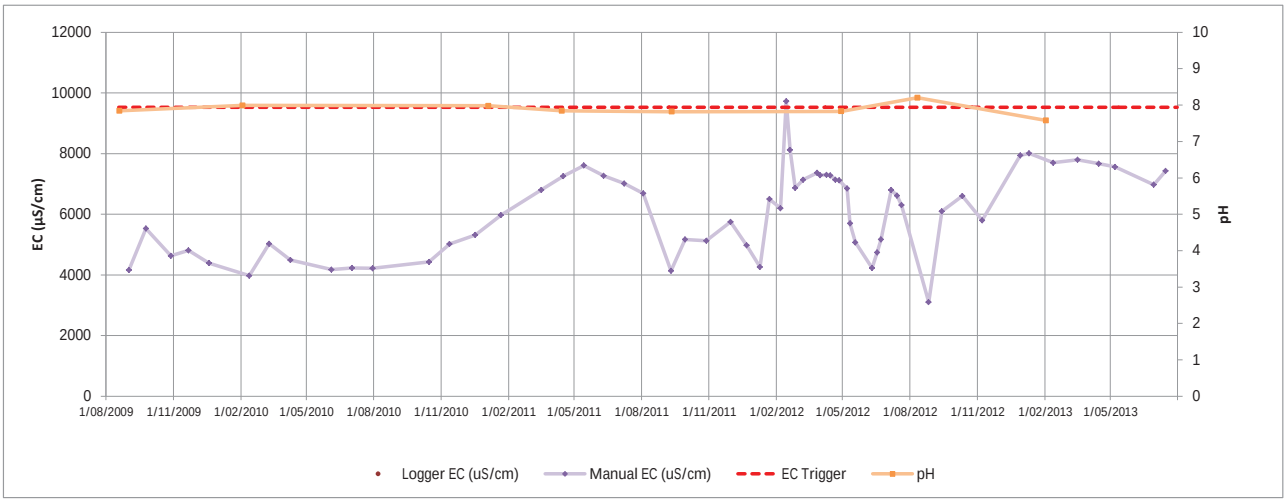


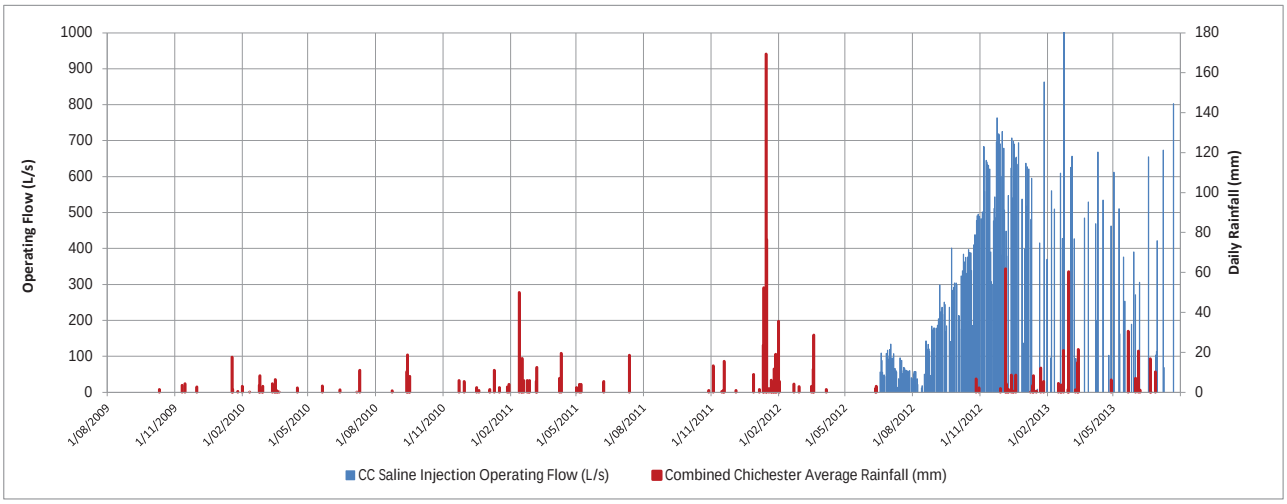


SCX05_S Hydrograph

Bore Name: SCX05_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone D

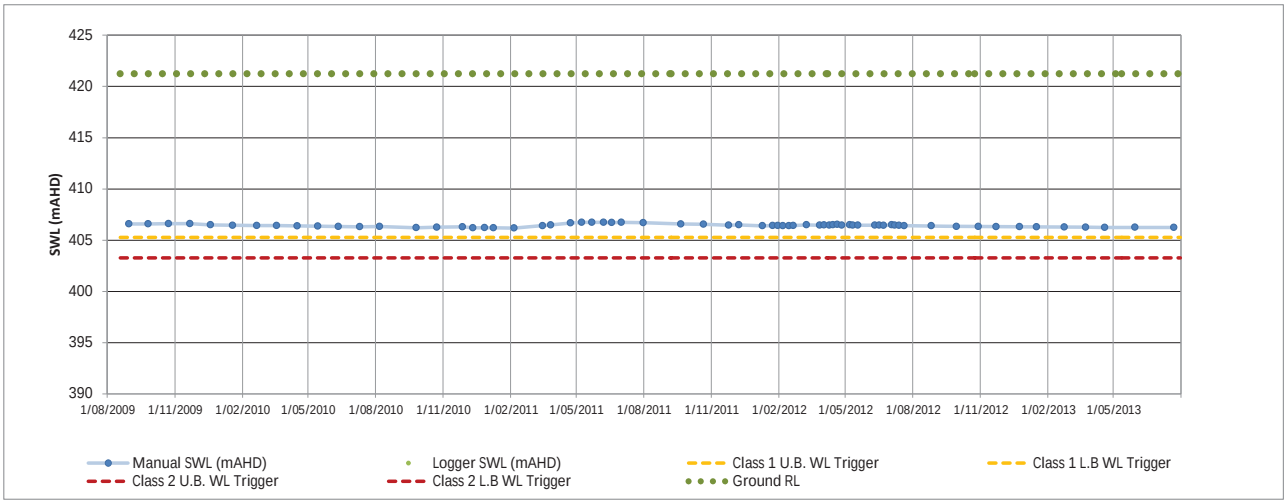


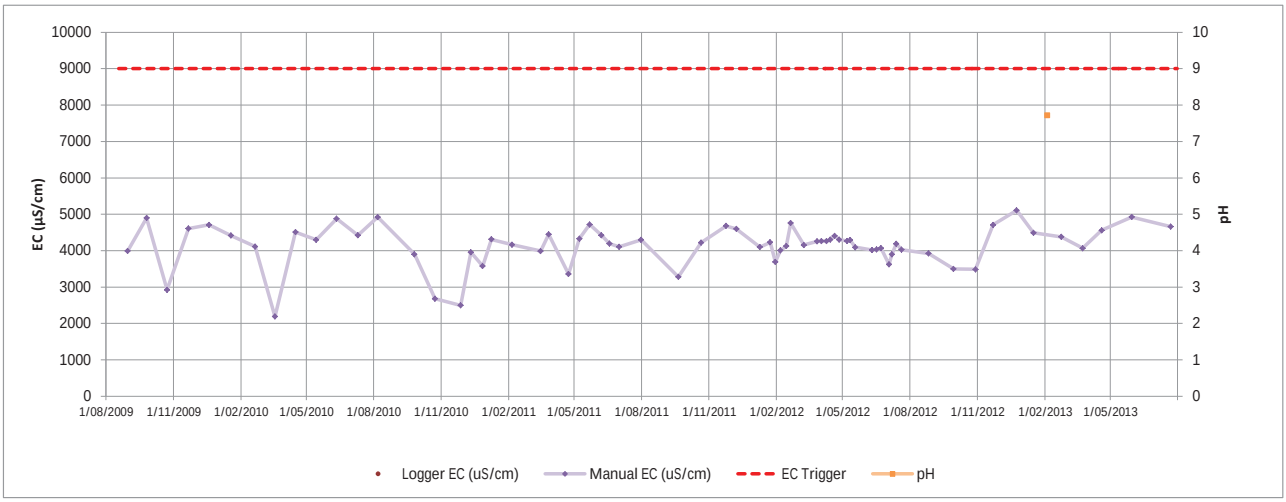


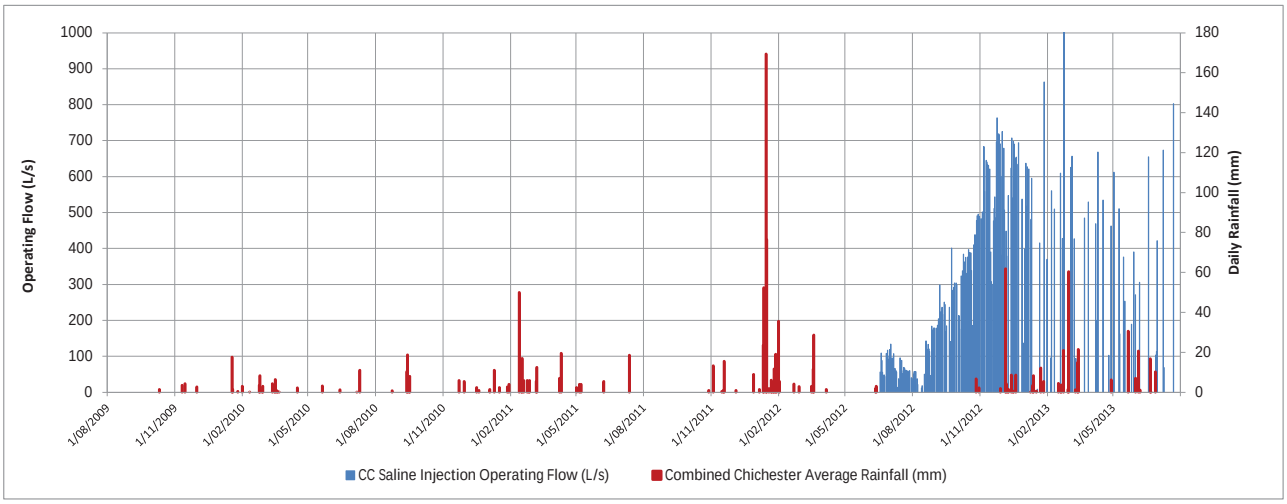


CCF03A_S Hydrograph

Bore Name: CCF03A_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone D

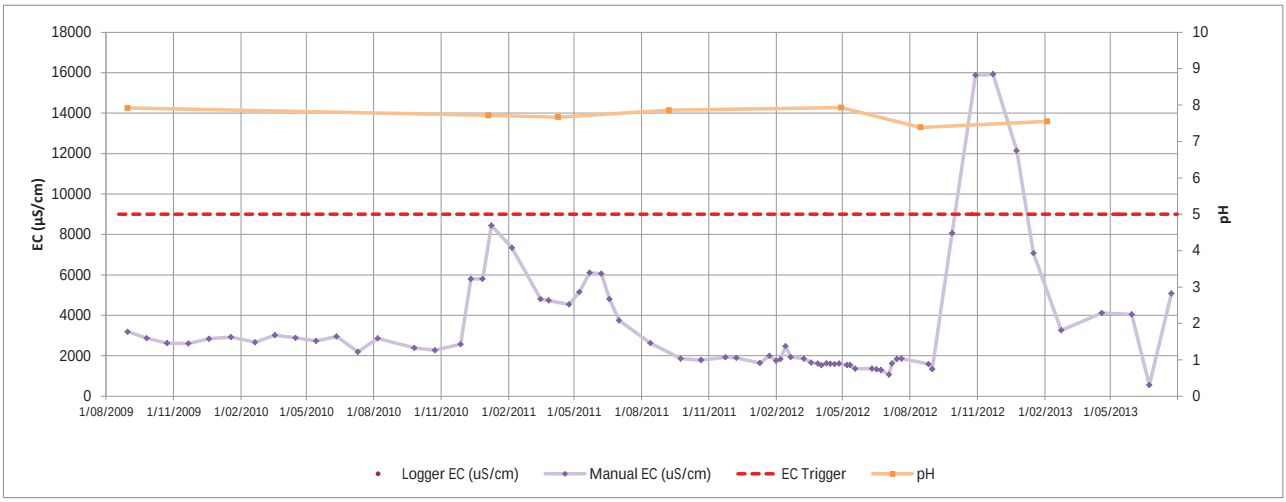


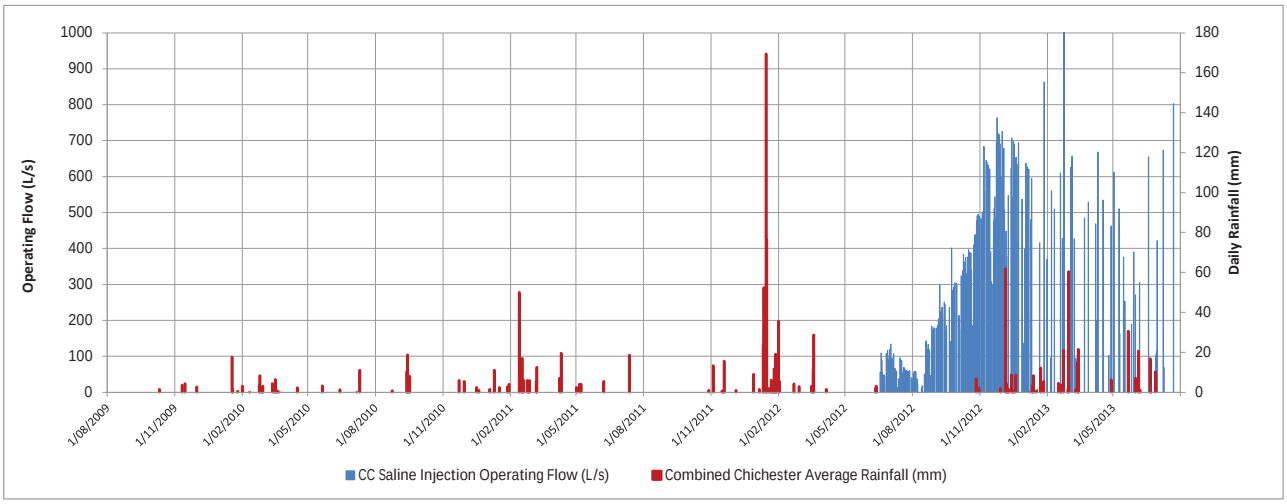




CCF07B_S Hydrograph

Bore Name: CCF07B_S
Abs/Inj Totals: CC Saline Injection
Monitored Aquifer: Upper TD.
Management Zone: Zone D





Appendix 10: Measured groundwater contours (water level and electrical conductivity)

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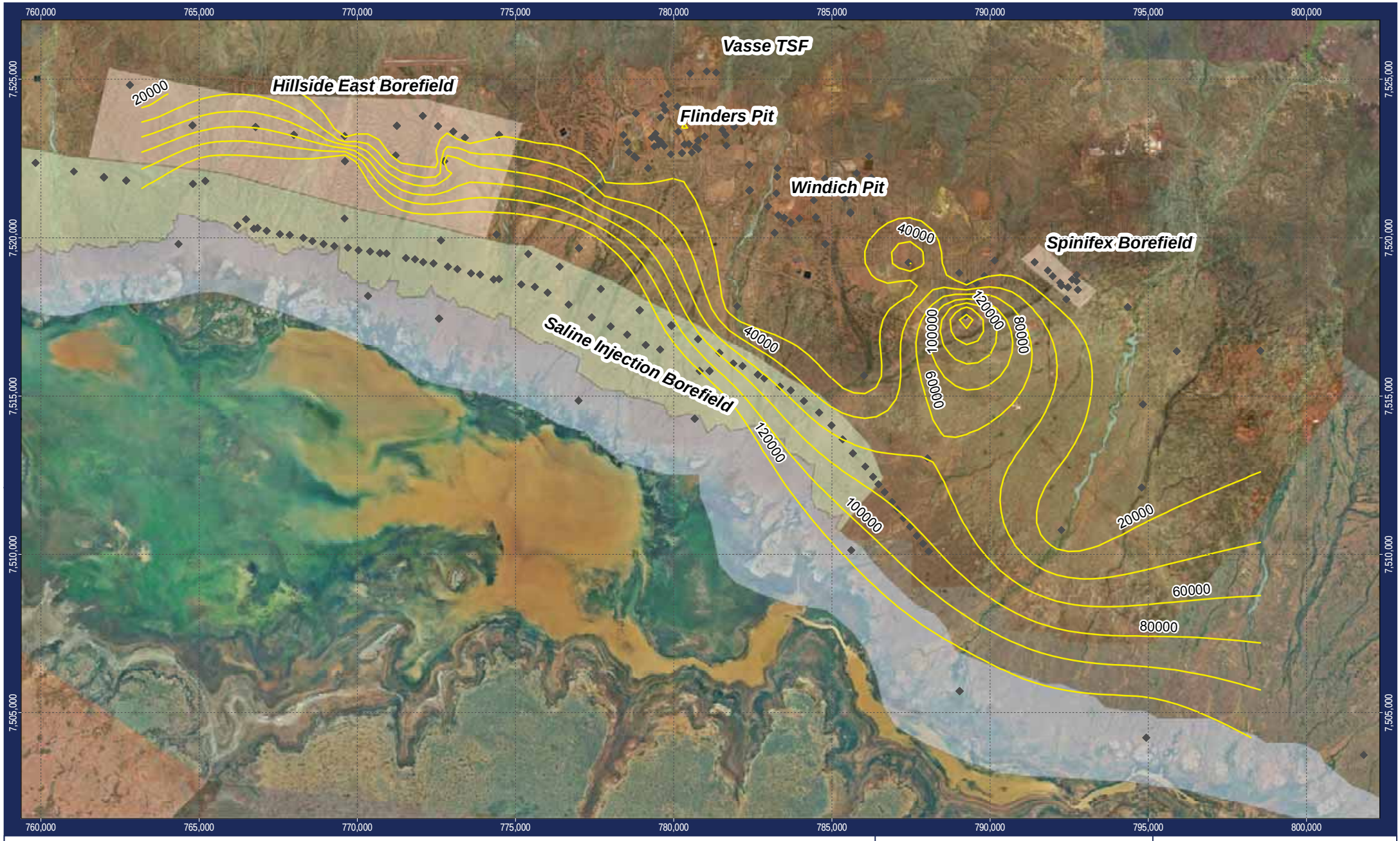

LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- MMF and OF EC Contours (uS/cm)

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template

Date: 17/07/2014
Size: A4L
Revision: 0
Confidentiality: 1

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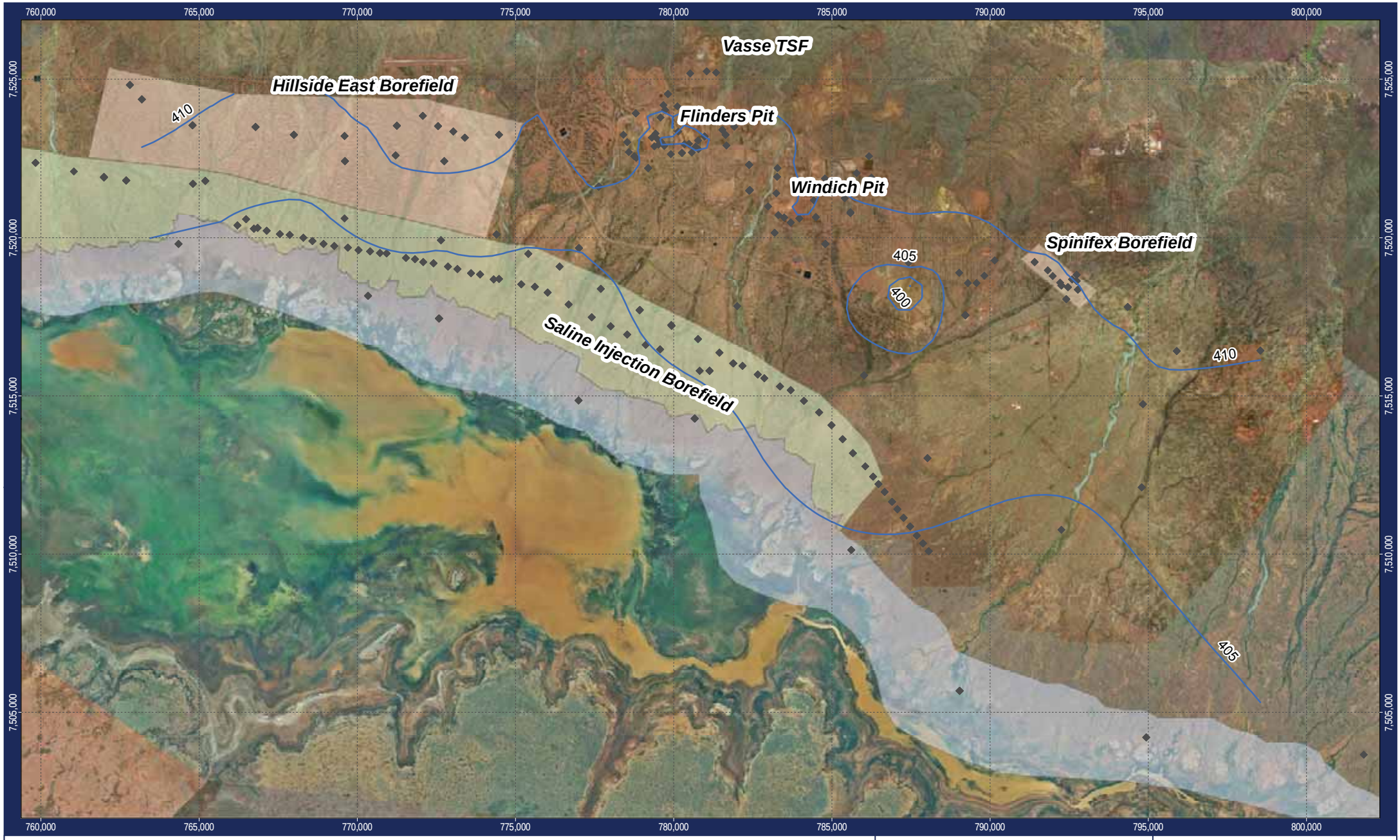
Christmas Creek Triennial
MMF and OF EC Contour Map
October 2011

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- MMF and OF WL (m AHD)

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template

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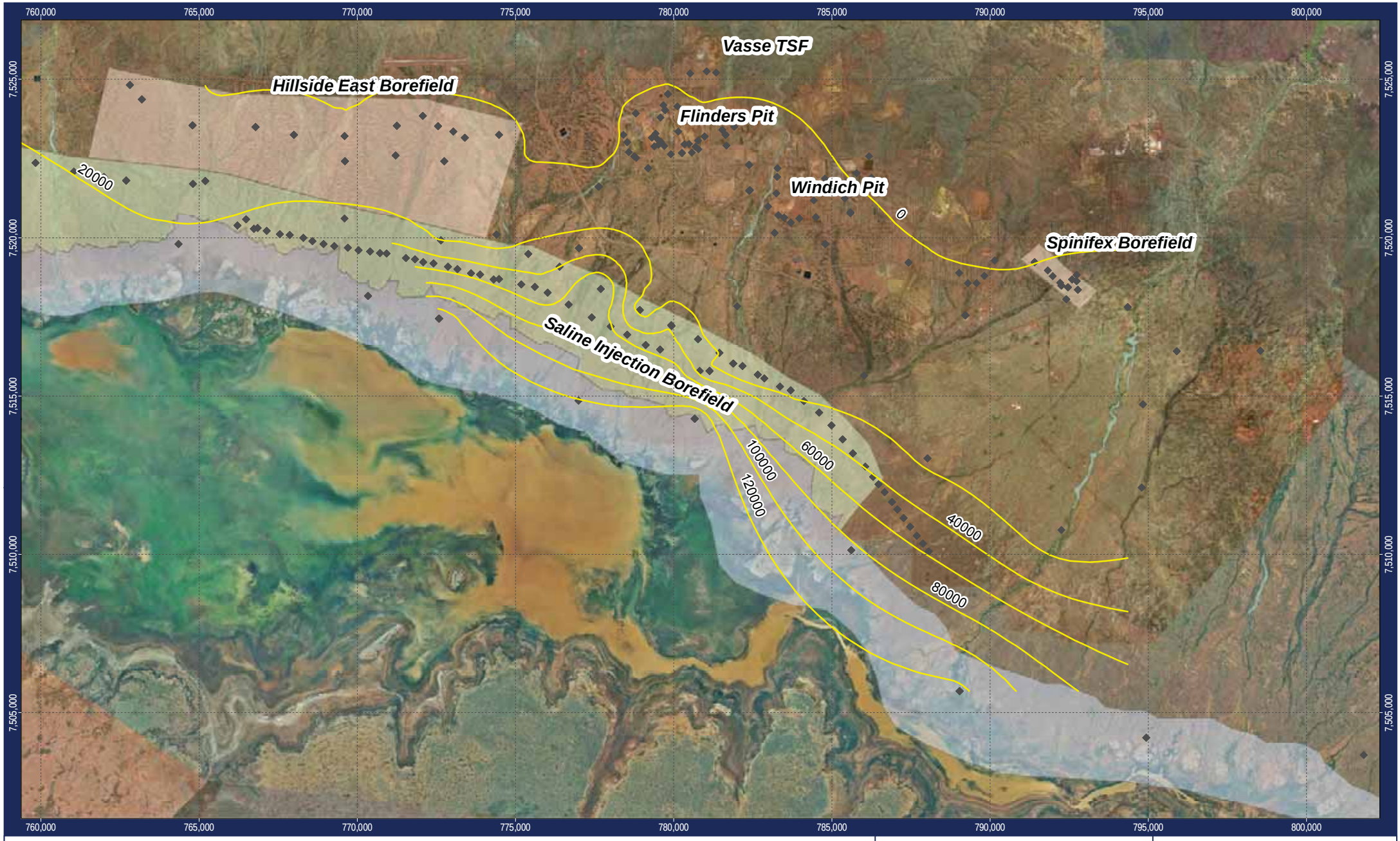
Christmas Creek Triennial
MMF and OF WL Contour Map
October 2011

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- UTD EC Contours (uS/cm)

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template

Date: 17/07/2014
Size: A4L
Revision: 0
Confidentiality: 1

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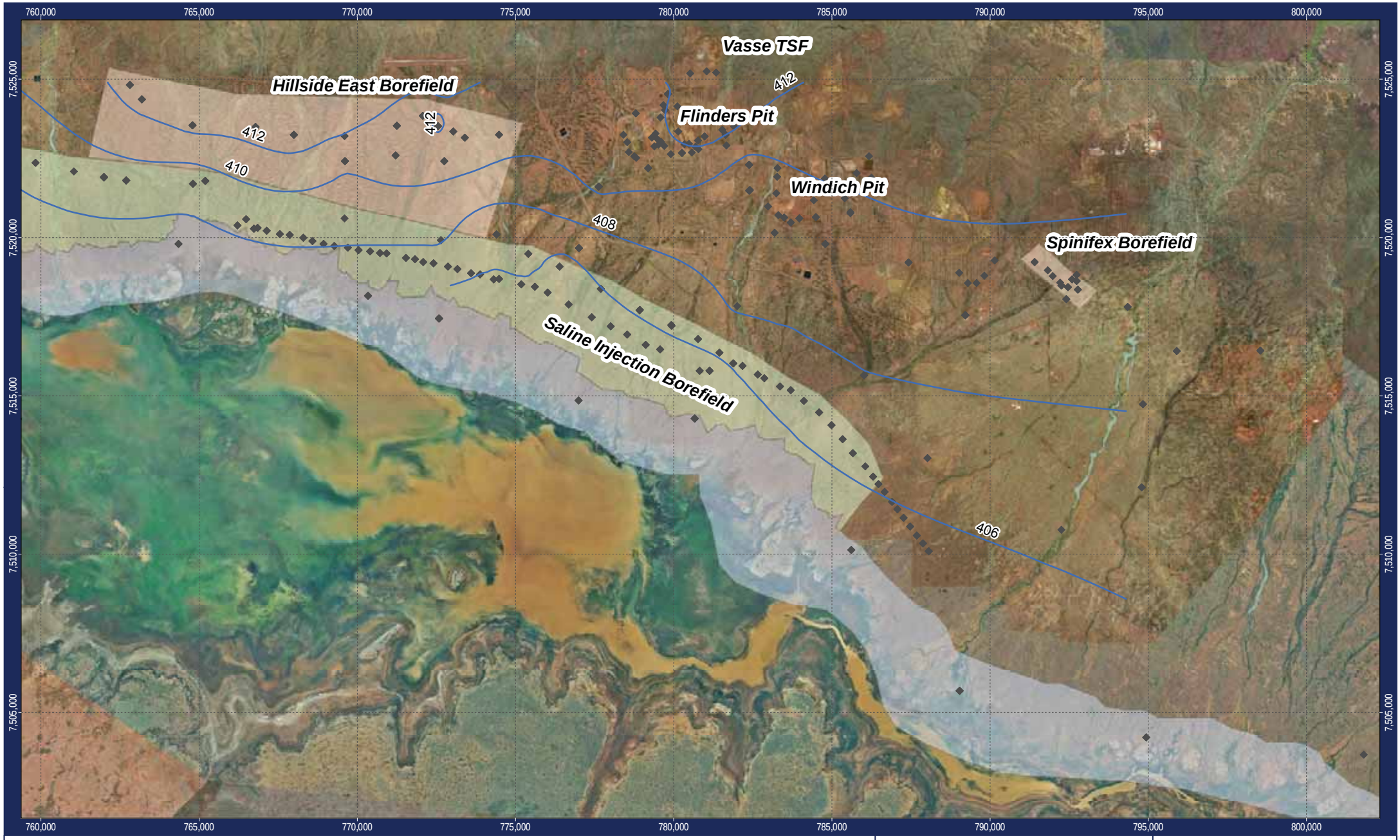
Christmas Creek Triennial
UTD EC Contour Map
October 2011

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- UTD WL (m AHD)

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template

Date: 17/07/2014
Size: A4L
Revision: 0
Confidentiality: 1

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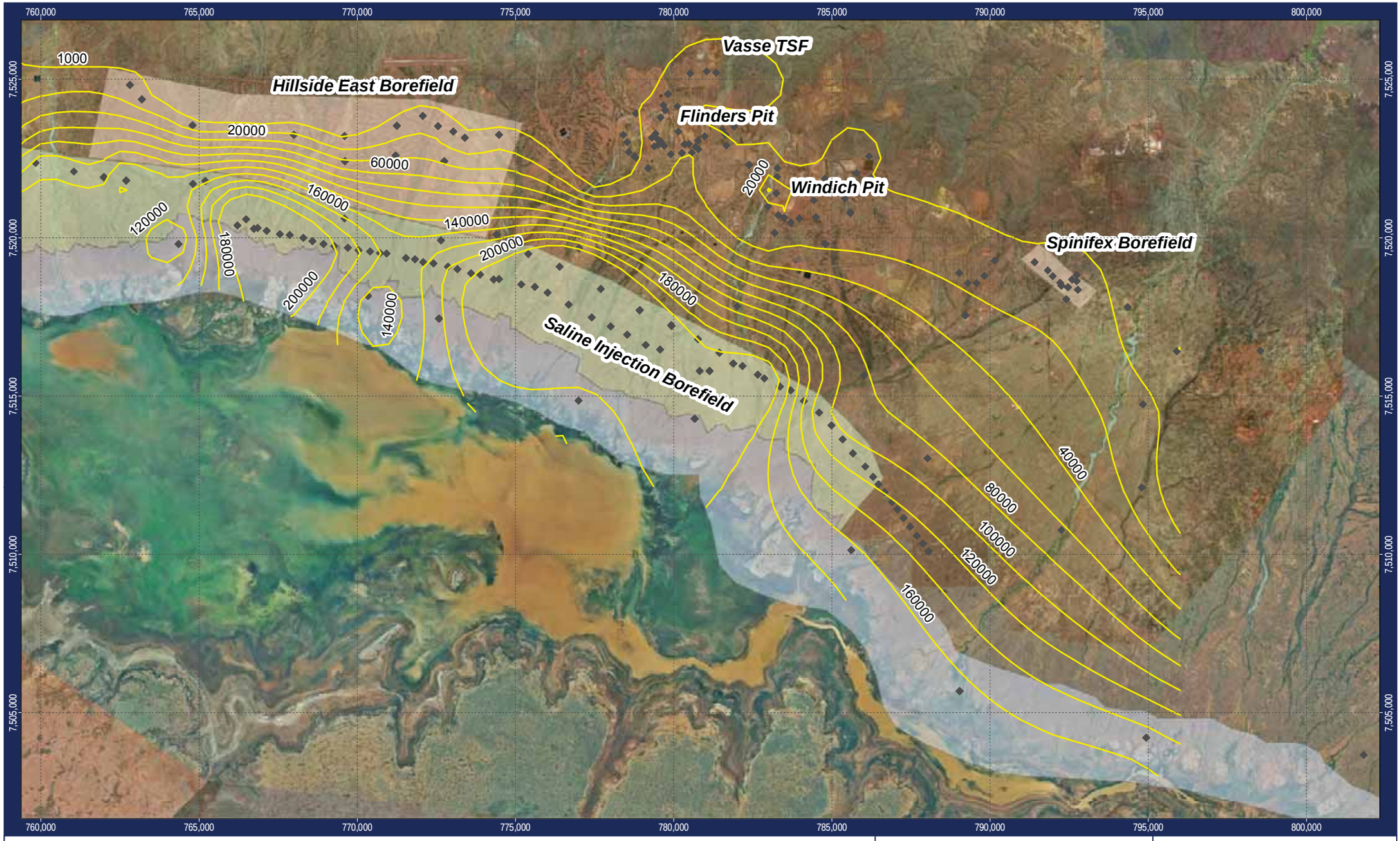
Christmas Creek Triennial
UTD WL Contour Map
October 2011

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- MMF and OF EC Contours (uS/cm)

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template_

Date: 17/07/2014
Size: A4L
Revision: 0
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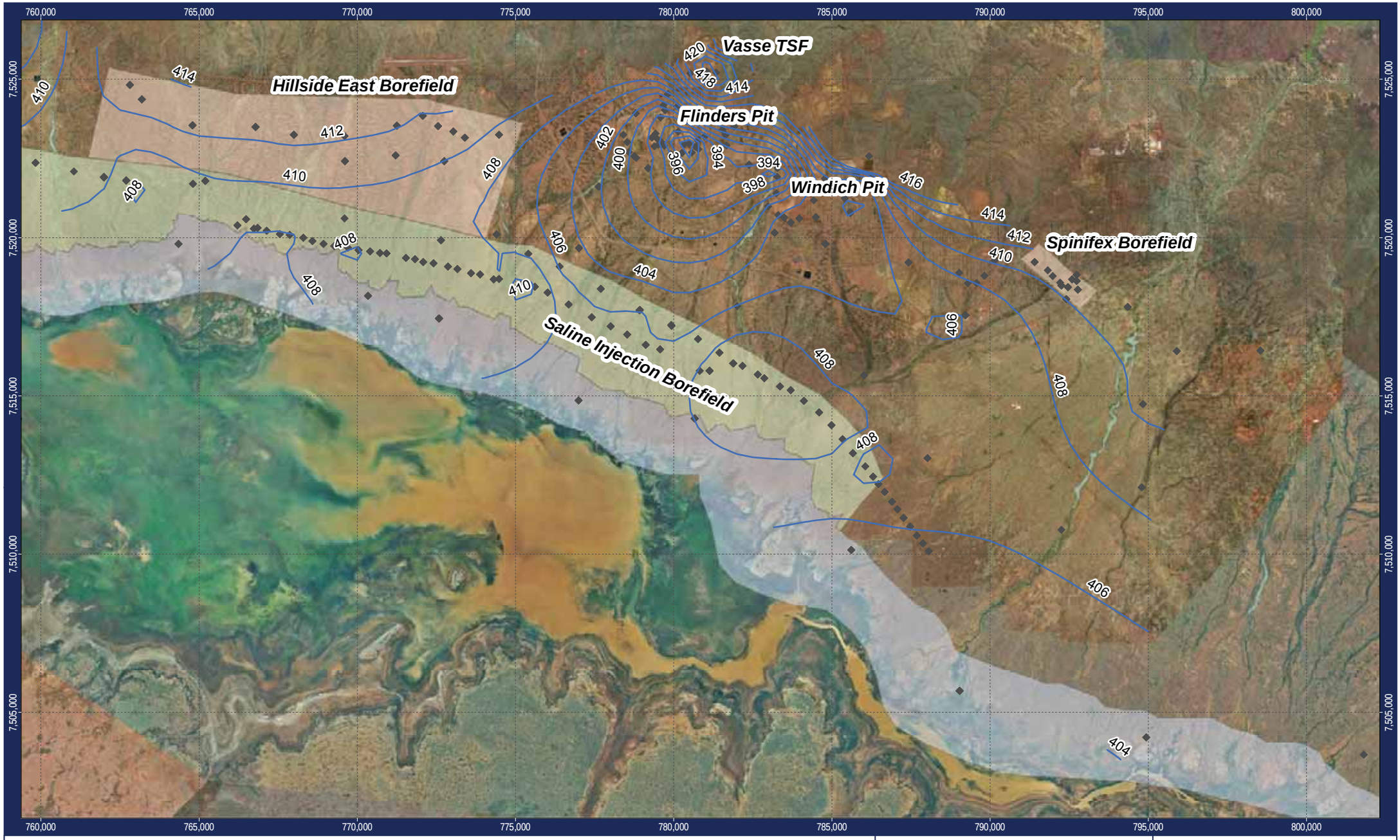
Christmas Creek Triennial
MMF and OF EC Contour Map
January 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- MMF and OF WL Contours (m AHD)

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template_

Date: 17/07/2014
Size: A4L
Revision: 0
Confidentiality: 1

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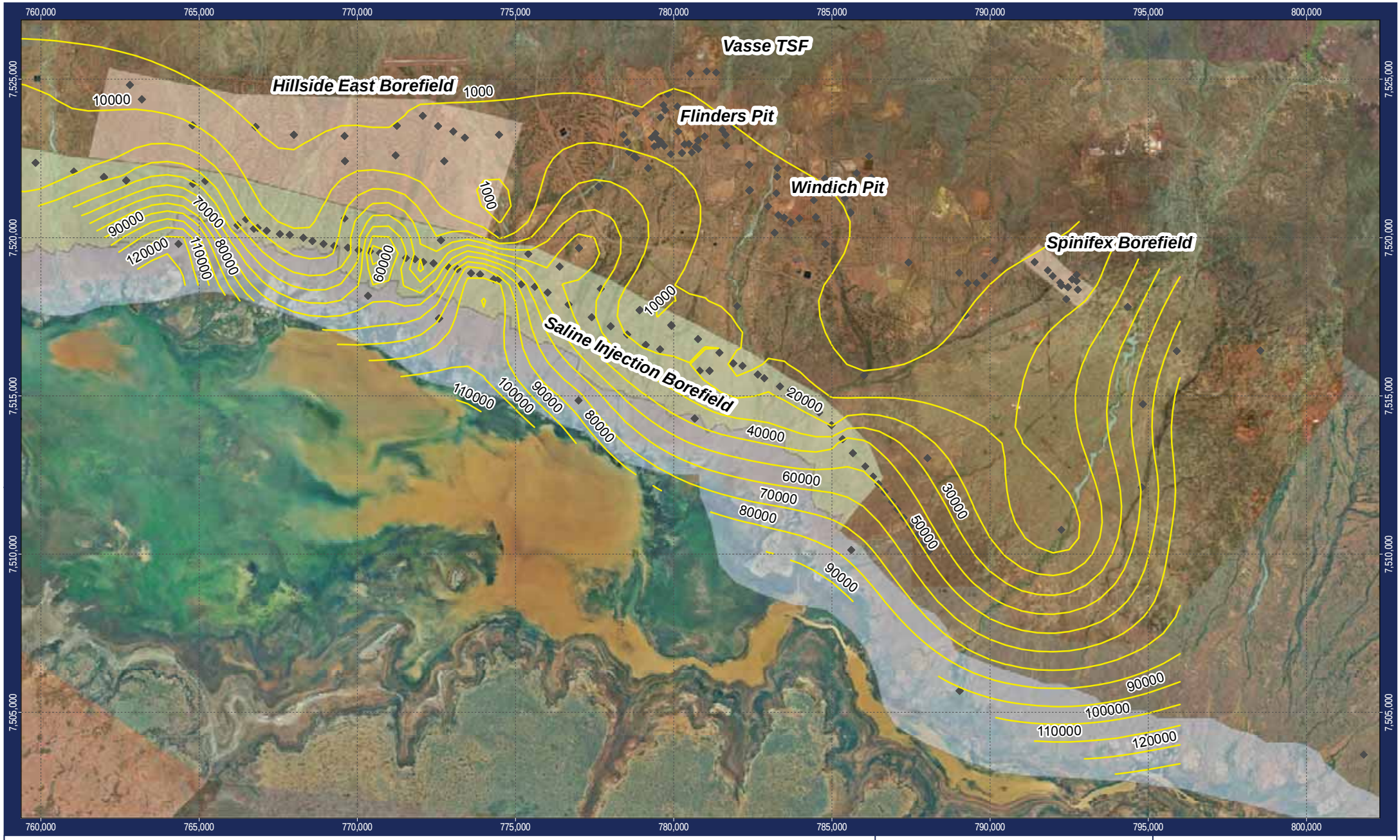
Christmas Creek Triennial
MMF and OF WL Contour Map
January 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- UTD EC Contours (uS/cm)

0 2 4 6
Kilometres

Requested By: M Carroll
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Revised By: Mcarroll
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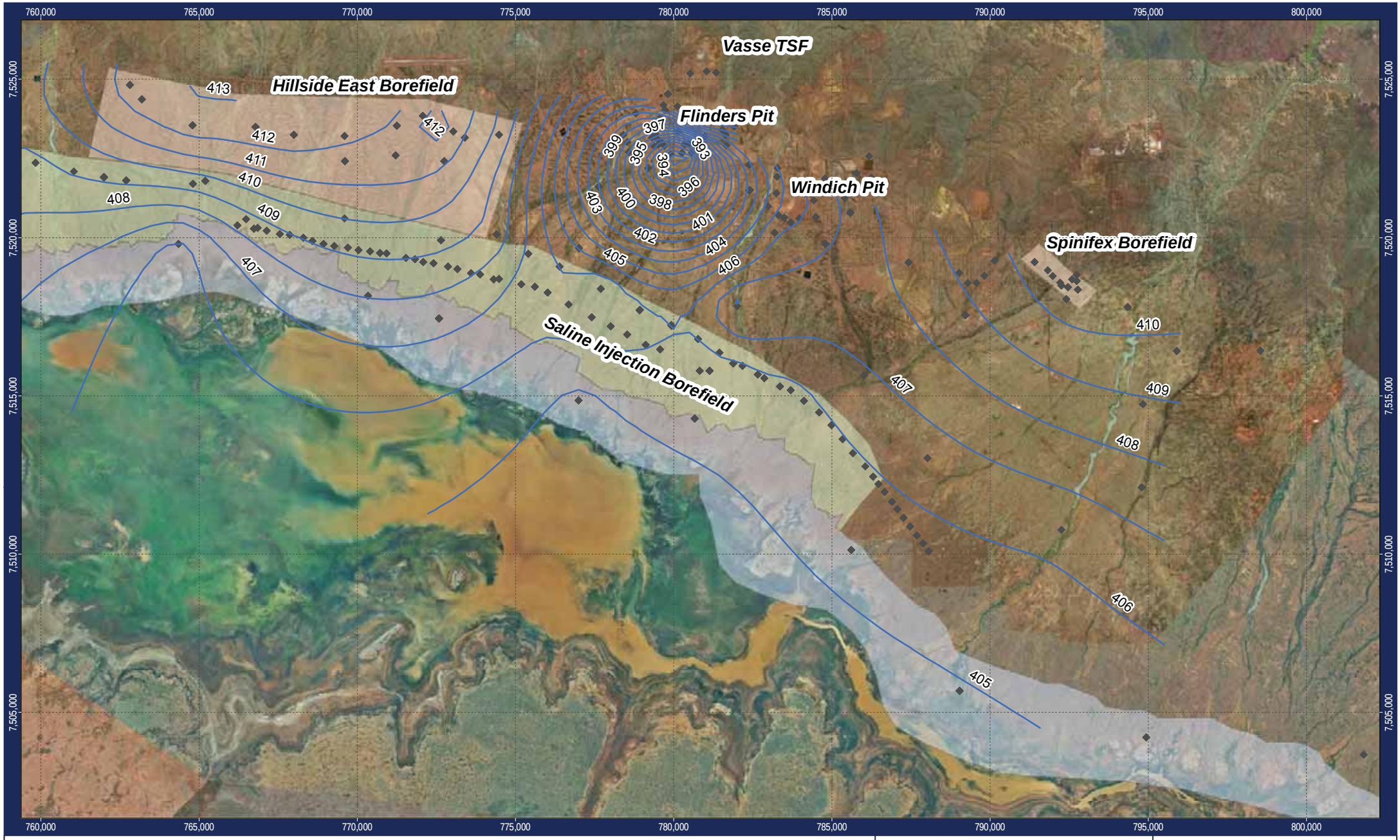
Christmas Creek Triennial
UTD EC Contour Map
January 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- UTD WL Contours (m AHD)

0 2 4 6
Kilometres

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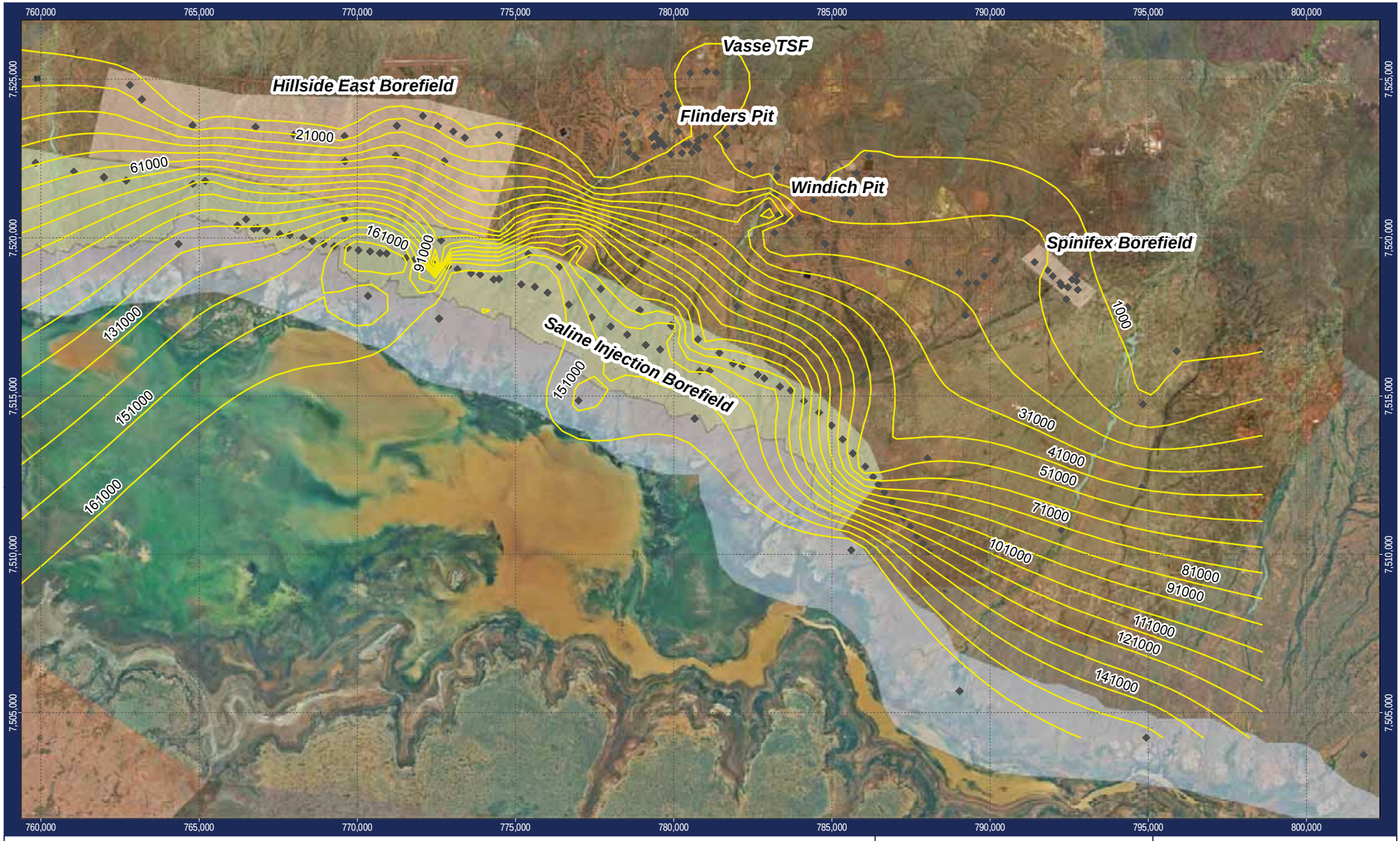
Christmas Creek Triennial
UTD WL Contour Map
January 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- MMF and OF EC Contours (uS/cm)

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template

Date: 17/07/2014
Size: A4L
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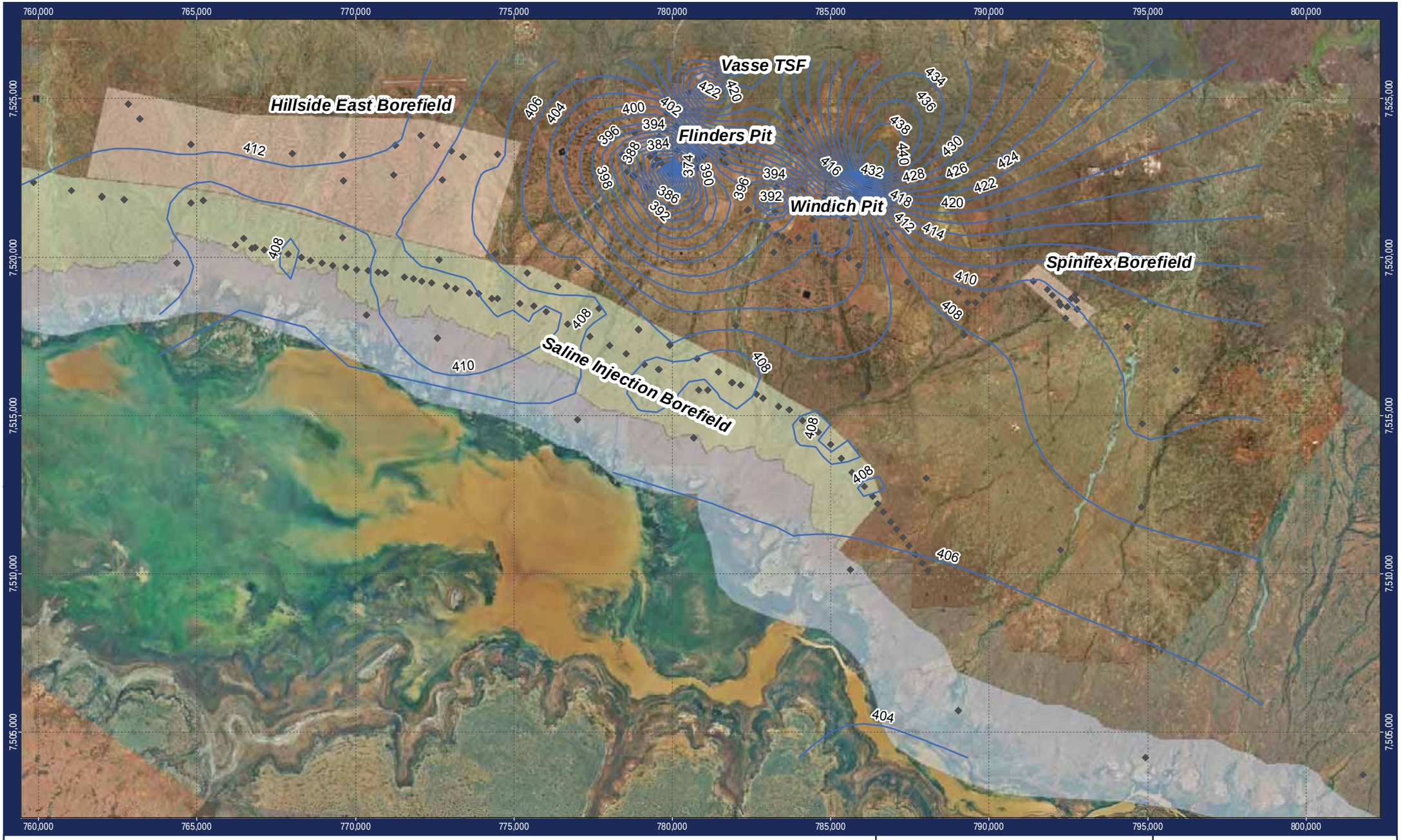
Christmas Creek Triennial
MMF and OF EC Contour Map
July 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- July 2013 MMF and OF WL (m AHD)
- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
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Date: 4/08/2014
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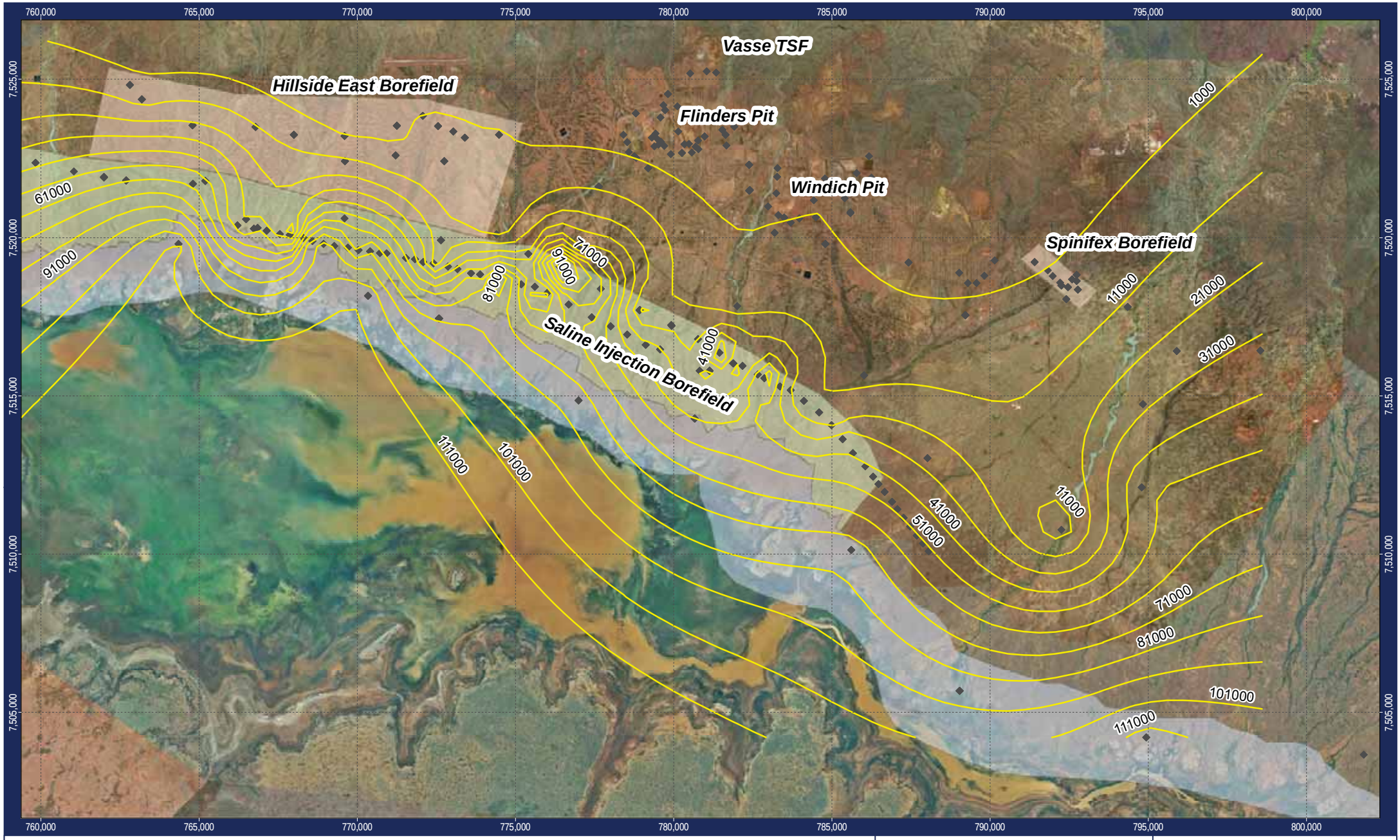
Christmas Creek Triennial
OF and MMF Modelled WL Contour
July 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- UTD EC Contours (uS/cm)

0 2 4 6
Kilometres

Requested By: M Carroll	Date: 17/07/2014
Drawn By: M Carroll	Size: A4L
Revised By: Mcarroll	Revision: 0
Approved By:	Confidentiality: 1
Scale: 1:153,700	
Coordinate System: GDA 1994 MGA Zone 50	
Document Name: CC_Contour Map Template	

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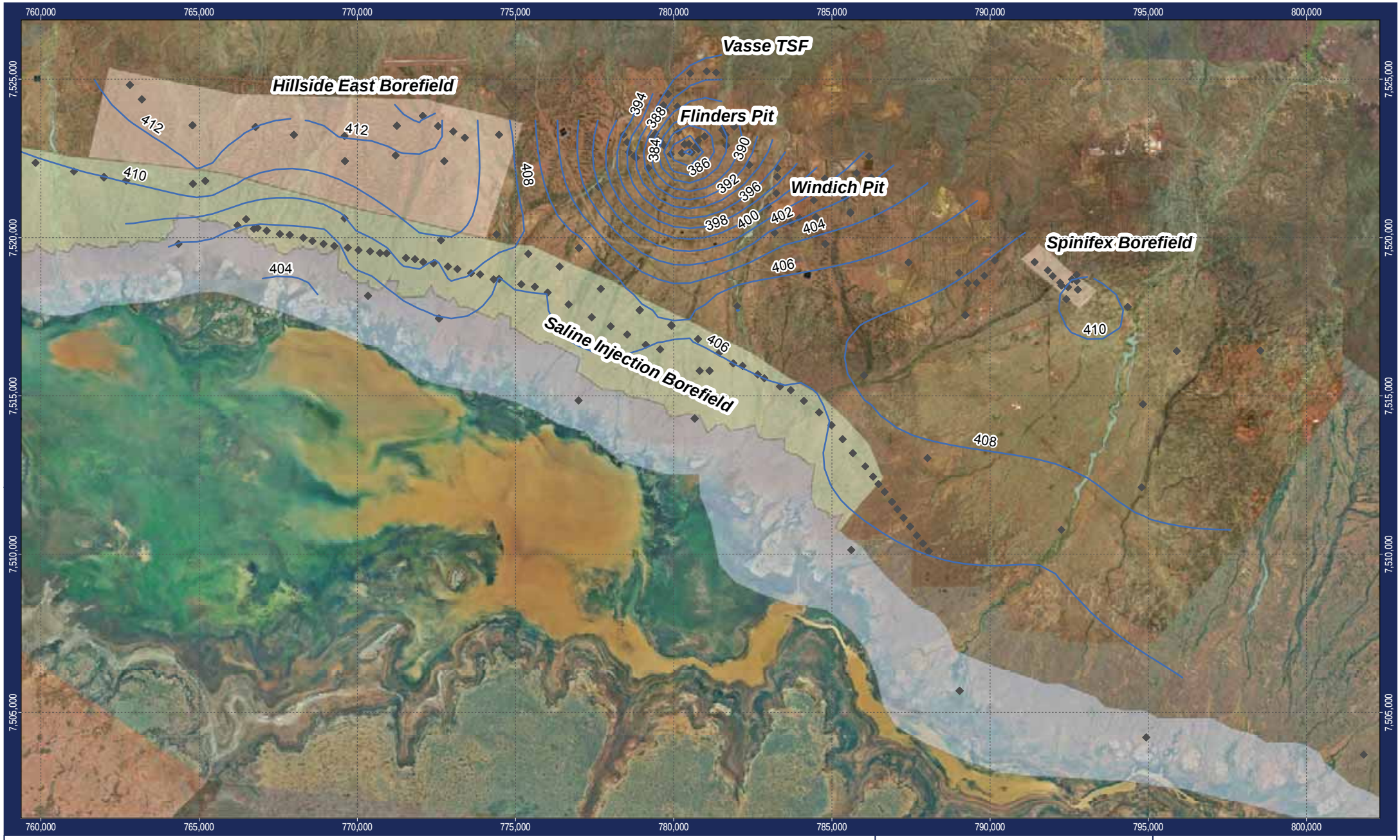
Christmas Creek Triennial
UTD EC Contour Map
July 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore



LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- UTD WL (m AHD)

0 2 4 6
Kilometres

Requested By: M Carroll
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Christmas Creek Triennial
UTD WL Contour Map
July 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore

Appendix 11: Level 1 trigger exceedance reports

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DATE	26 May 2013
BORE NAME	CCFMM01_D
LOCATION	Fortescue Marsh
TRIGGER	< 406.3 mAHD or > 407.9 mAHD
EXCEEDANCE VALUE	408.87

REASON/EXPLANATION FOR EXCEEDANCE:

Class 1 trigger levels have been developed at CCFMM01 – CCFMM05 (shallow and deep) to serve as an internal early warning for potential significant water level changes adjacent to the Fortescue Marsh. Class 1 triggers are calculated as an absolute water level change over a 12 month period. The Class 1 base line water level is defined at the start of each water year (1st August).

The baseline water level used for the Class 1 trigger level at CCFMM01_D is not less than 406.03 mAHD or 2.89 mbgl to not greater than 407.9 mAHD or 1.02 mbgl.

The Oakover Formation is a highly transmissive part of the gravel aquifer. The increase in aquifer pressure caused by the saline injection is resulting in an increase in observed groundwater levels (piezometric head) along the northern edge of the marsh. The mounding responses observed at the monitoring sites are expected due to the volume and rate of saline injection. The injection borefield is approx. 1.5 km away.

Figure 1 shows the groundwater piezometric head response since saline injection has started. Figure 2 shows the groundwater level in the shallow monitoring bore at the same location. No impact from the saline injection is seen in the shallow water table.

Figure 1: shows the response in the deep aquifer since the commencement of saline injection

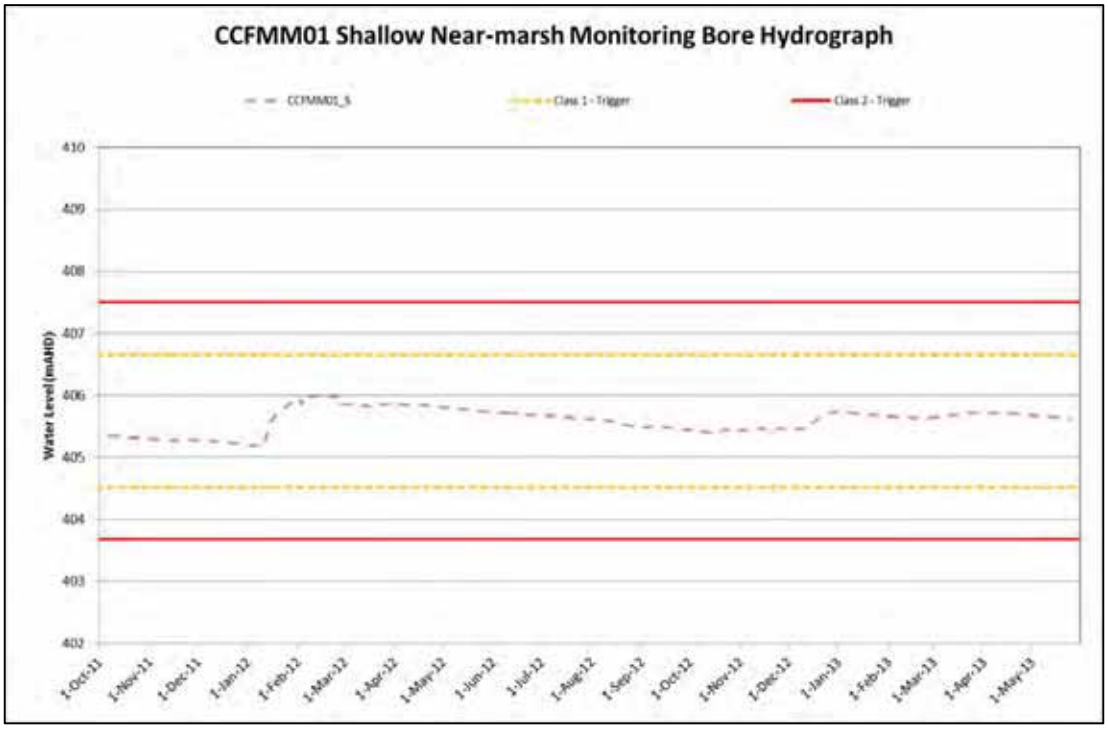
ACTIONS TAKEN

In response to the rise in deep groundwater levels and the Class 1 exceedence saline injection was immediately reduced from the western section (closest to the Fortescue Marsh) and diverted to the eastern and central sections where possible. Additional injection capacity is now available in the central section due to recent completion of 3 new injection bores.

An assessment of the shallow near marsh monitoring bores (Class 2 trigger bores) has also been completed. Figure 2 shows that there are no obvious trends associated with the saline injection and resulted mounding and groundwater levels are within the 0.8m of seasonal variation. The groundwater level trace shows a gradual decline in groundwater level, which is attributed to evapotranspiration and the drying out of the surface water. The sharp rise in December 2012 and 2013 is due to heavy rainfall throughout the Christmas Creek area at that time.

Since the immediate actions have been taken, the groundwater levels have decreased as the aquifer pressure has been reduced.

Figure 2: Groundwater Levels at CCFMM01_S (Shallow Aquifer)



CONCLUSION

The Class 1 trigger exceedance at CCFMM01_D is as a direct result of ongoing saline injection into the Oakover formation. Water level rise within the deep Oakover formation, as a result of injection, is as expected. The assessment has shown there is no impact to the shallow aquifer (CCFMM01_S) as a result of saline injection.

Monitoring in both the shallow and deep monitoring bores will continue to be reviewed to confirm adverse impacts are not observed in the shallow aquifer.

DATE	31/05/2013
BORE NAME	CCFMM02_D
LOCATION	Fortescue Marsh
TRIGGER	<405.7 mAHD or > 407 mAHD
EXCEEDANCE VALUE	408.94 mAHD

REASON/EXPLANATION FOR EXCEEDANCE:

Class 1 trigger levels have been developed at CCFMM01 – CCFMM05 (shallow and deep) to serve as an internal early warning for potential significant water level changes adjacent to the Fortescue Marsh. Class 1 triggers are calculated as an absolute water level change over a 12 month period.

The baseline water level used for the Class 1 trigger level at CCFMM02_D is the taken from the average over August 2012 and is 406.39 mAHD. Level 1 trigger values are +- 0.65 m from this and are not less than 405.7 mAHD and not greater than 407 mAHD.

The Oakover Formation is a highly transmissive part of the gravel aquifer. The increase in aquifer pressure caused by the saline injection is resulting in an increase in observed groundwater levels (piezometric head) along the northern edge of the marsh. The mounding responses observed at the monitoring sites are expected due to the volume and rate of saline injection. The injection borefield is approx. 1.5 km away.

Figure 1: Response in the deep aquifer since the commencement of saline injection

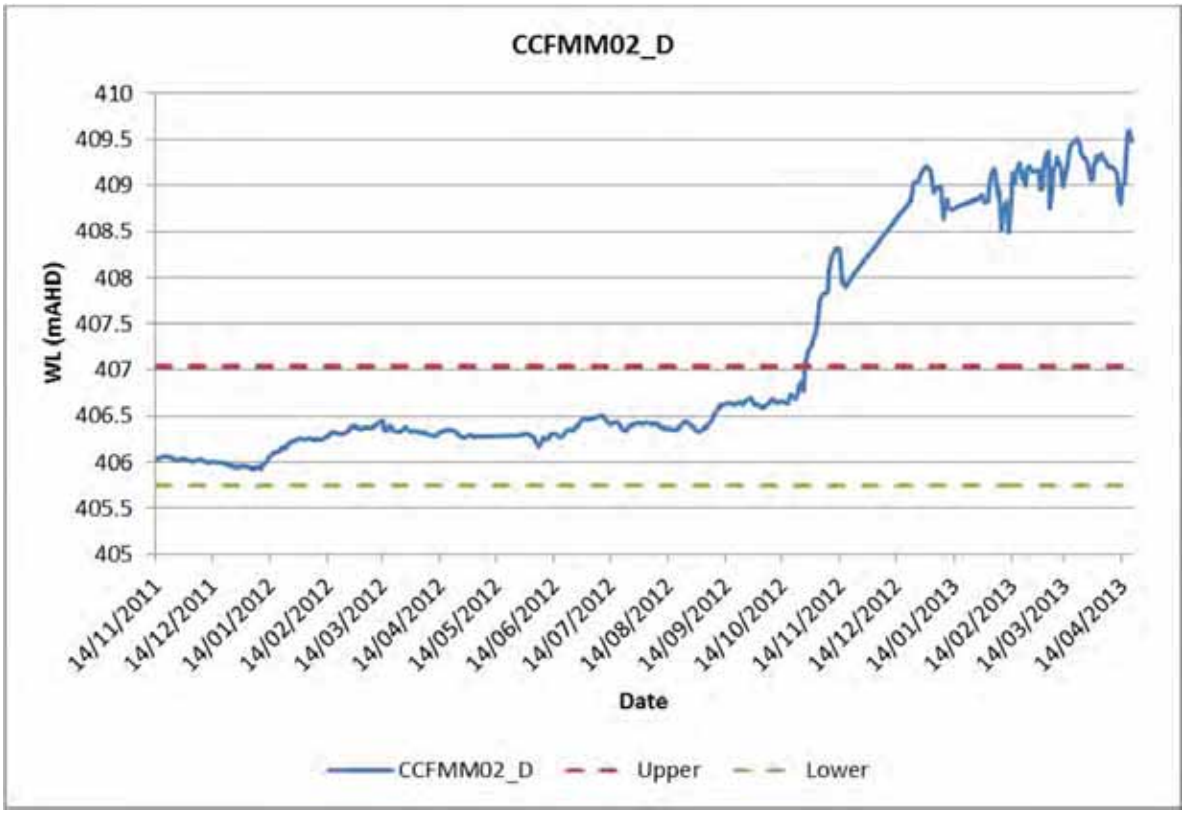
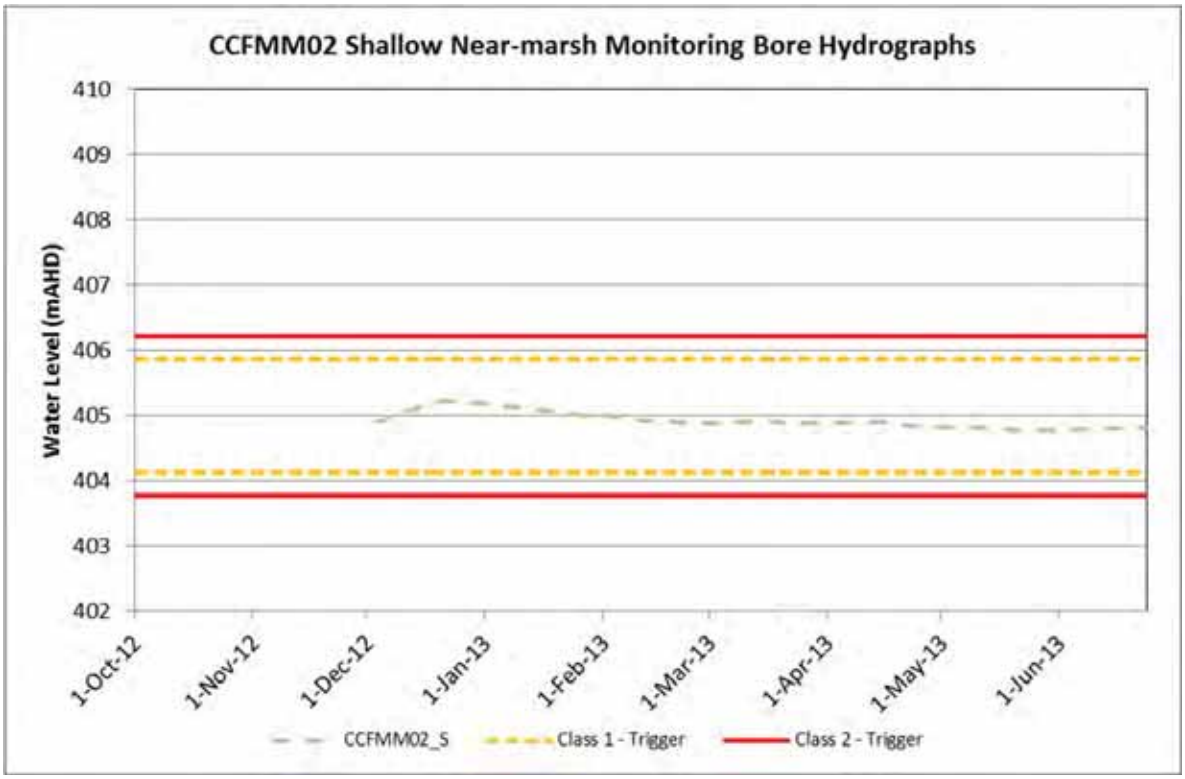


Figure2: Groundwater Levels at CCFMM02_S (Shallow Aquifer)



ACTIONS TAKEN

In response to the rise in deep groundwater levels and the Class 1 exceedence saline injection was immediately reduced from the western section (closest to the Fortescue Marsh) and diverted to the eastern and central sections where possible.

An assessment of the shallow near marsh monitoring bores (Class 2 trigger bores) has also been completed. Figure 2 shows that there are no obvious trends associated with the saline injection and resulted mounding and groundwater levels are within the 0.8m of seasonal variation. The groundwater level trace shows a rise in December 2012, which is attributed to cyclonic event. This is followed by a gradual decline in groundwater level throughout early 2013 which is attributed to evapotranspiration and the drying out of the surface water.

Since the immediate actions have been taken, the groundwater levels have decreased as the aquifer pressure has been reduced.

Monitoring at all locations will continue with no further action required.

CONCLUSION

The Class 1 trigger exceedance at CCFMM02_D is as a direct result of ongoing saline injection into the Oakover formation. Groundwater level rise within the deep Oakover formation, as a result of injection, is as expected. The assessment has shown there is no impact to the shallow aquifer (CCFMM02_S) as a result of saline injection.

Monitoring in both the shallow and deep monitoring bores will continue to be reviewed to confirm adverse impacts are not observed in the shallow aquifer.

CLASS 1 TRIGGER EXCEEDANCE

DATE	16 April 2013
BORE NAME	CCFMM03_D
LOCATION	Fortescue Marsh
TRIGGER	<404.61 mAHD or > 405.91 mAHD
EXCEEDANCE VALUE	406.17 mAHD

REASON/EXPLANATION FOR EXCEEDANCE:

Class 1 trigger levels have been developed at CCFMM01 – CCFMM05 (shallow and deep) to serve as an internal early warning for potential significant water level changes adjacent to the Fortescue Marsh. Class 1 triggers are calculated as an absolute water level change over a 12 month period.

The baseline water level used for the Class 1 trigger level is based on the average groundwater level of August 2012 at CCFMM03_D is 405.26 mAHD.

The Oakover Formation is a highly transmissive part of the gravel aquifer. The increase in aquifer pressure caused by the saline injection is resulting in an increase in observed groundwater levels (piezometric head) along the northern edge of the marsh. The mounding responses observed at the monitoring sites are expected due to the volume and rate of saline injection. The injection borefield is approx. 2.5 km away.

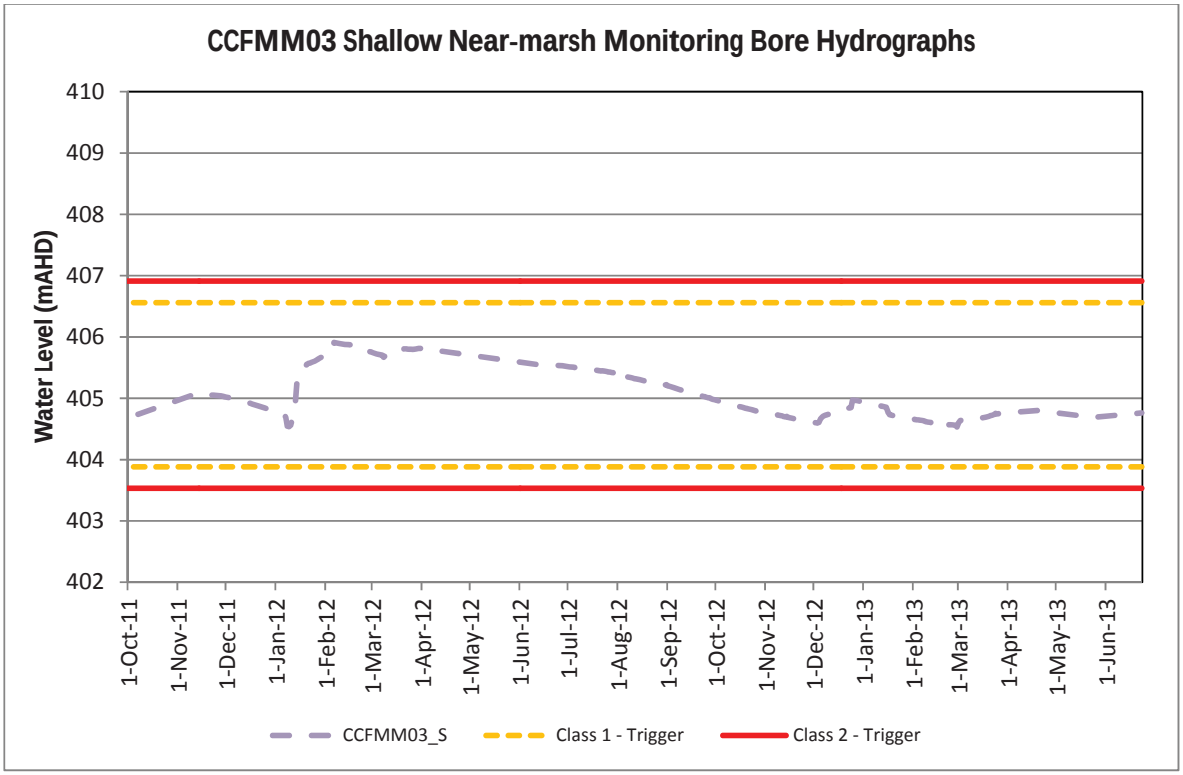
ACTIONS TAKEN

In response to the rise in deep groundwater levels and the Class 1 exceedence saline injection was immediately reduced from the western section (closest to the Fortescue Marsh) and diverted to the eastern and central sections where possible.

An assessment of the shallow near marsh monitoring bores (Class 2 trigger bores) has also been completed. Figure 1 shows that there are no obvious trends associated with the saline injection and resulted mounding and groundwater levels are within the 0.8m of seasonal variation. The groundwater level trace shows a sharp rise in January and November 2012 are attributed to cyclonic events. This is followed by a gradual decline in groundwater level throughout early 2013 which is attributed to evapotranspiration and the drying out of the surface water.

Monitoring at all locations should continue with no further action required.

Figure 1: Groundwater Levels at CCFMM03_S (Shallow Aquifer)



CONCLUSION

The Class 1 trigger exceedance at CCFMM03_D is as a direct result of ongoing saline injection into the Oakover formation. Groundwater level rise within the deep Oakover formation, as a result of injection, is as expected. The assessment has shown there is no impact to the shallow aquifer (CCFMM03_S) as a result of saline injection.

Monitoring in both the shallow and deep monitoring bores will continue to be reviewed to confirm adverse impacts are not observed in the shallow aquifer.

DATE	26 June 2013
BORE NAME	CCFMM02_D
LOCATION	Fortescue Marsh
TRIGGER	<405.74 or > 407.04
EXCEEDANCE VALUE	409.07

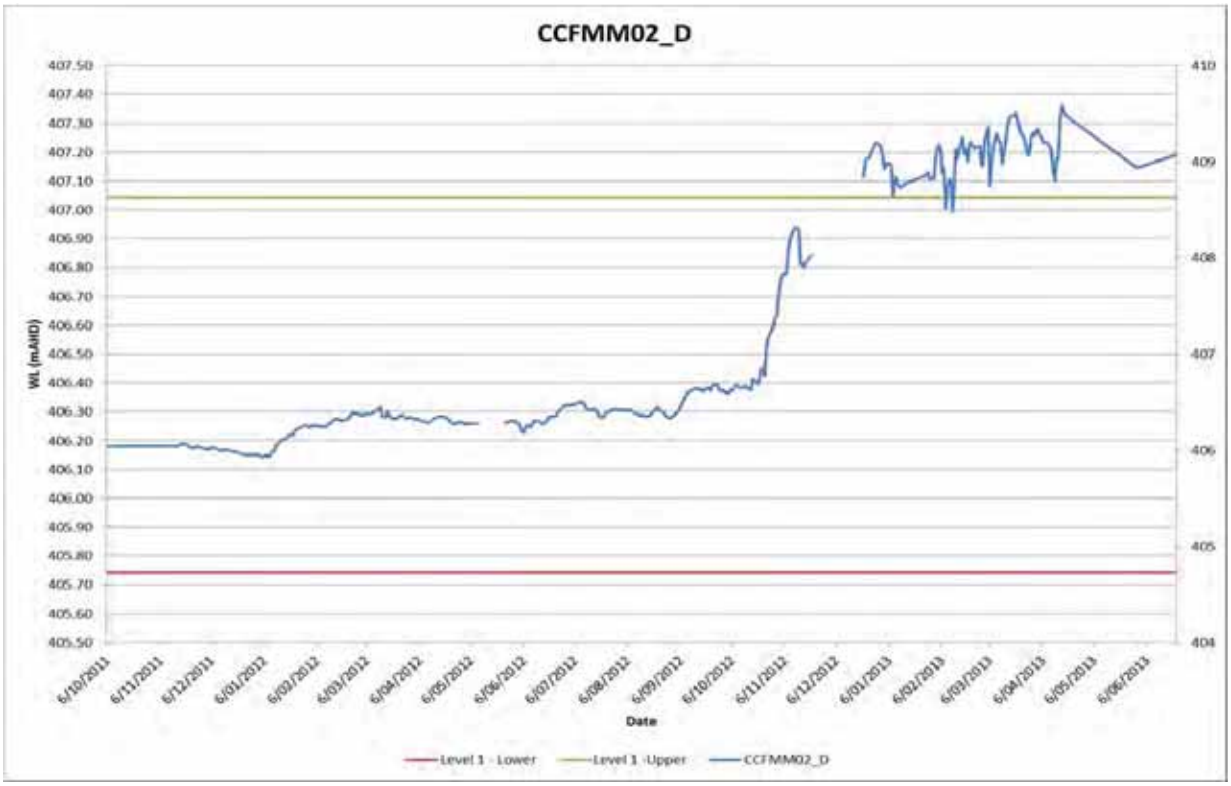
REASON/EXPLANATION FOR EXCEEDANCE:

Class 1 trigger levels have been developed at CCFMM01 – CCFMM05 (shallow and deep) to serve as an internal early warning for potential significant water level changes adjacent to the Fortescue Marsh. Class 1 triggers are calculated as an absolute water level change over a 12 month period.

The baseline water level used for the Class 1 trigger level at CCFMM02_D is 406.39 mAHD.

The Oakover Formation is a highly transmissive part of the gravel aquifer. The increase in aquifer pressure caused by the saline injection is resulting in an increase in observed groundwater levels (piezometric head) along the northern edge of the marsh. The mounding responses observed at the monitoring sites are expected due to the volume and rate of saline injection. The injection borefield is approx. 1.5 km away.

Figure 1: Response in the deep aquifer since the commencement of saline injection



ACTIONS TAKEN

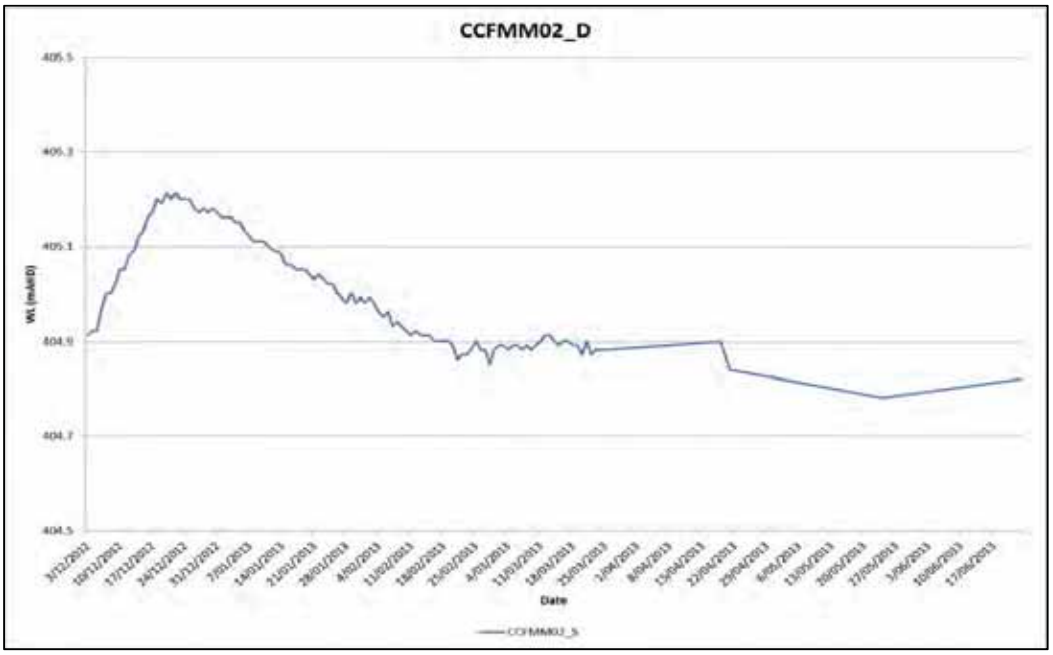
In response to the rise in deep groundwater levels and the Class 1 exceedence saline injection has been reduced from the western section (closest to the Fortescue Marsh) and diverted to the eastern and central section's where possible. Saline abstraction from the Flinders pit area was also limited to reduce the total required injection volumes.

An assessment of the shallow near marsh monitoring bores (Class 2 trigger bores) has also been completed. Figure 2 shows that there are no obvious trends associated with the saline injection and resulted mounding and groundwater levels are within the 0.8m of seasonal variation. The groundwater level trace shows a sharp rise in December 2012, which is attributed to cyclonic event. This is followed by a gradual decline in groundwater level throughout the dry season of 2012 which is attributed to evapotranspiration and the drying out of the surface water. Limited impact was noticed during the 2013 wet season.

Since injection has been limited in the western injection area, groundwater levels have decreased as the aquifer pressure has been reduced.

Monitoring at all locations should continue with no further action required.

Figure 2: Groundwater Levels at CCFMM02_S (Shallow Aquifer)



CONCLUSION

The Class 1 trigger exceedance at CCFMM02_D is as a direct result of ongoing saline injection into the Oakover formation. Groundwater level rise within the deep Oakover formation, as a result of injection, is as expected. The assessment has shown there is no impact to the shallow aquifer (CCFMM02_S) as a result of saline injection.

Monitoring in both the shallow and deep monitoring bores will continue to be reviewed to confirm adverse impacts are not observed in the shallow aquifer.

DATE	26 June 2013
BORE NAME	CCFMM01_D
LOCATION	Fortescue Marsh
TRIGGER	< 406.3 mAHD or > 407.9 mAHD
EXCEEDANCE VALUE	409.59 mAHD

REASON/EXPLANATION FOR EXCEEDANCE:

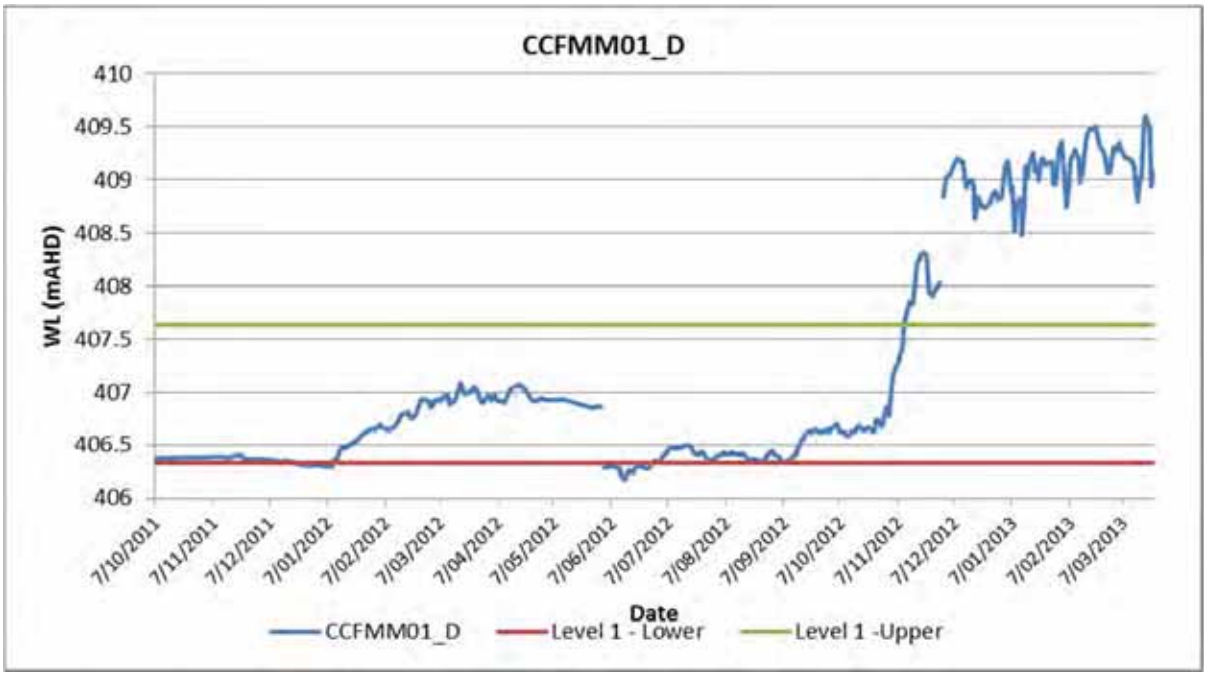
Class 1 trigger levels have been developed at CCFMM01 – CCFMM05 (shallow and deep) to serve as an internal early warning for potential significant water level changes adjacent to the Fortescue Marsh. Class 1 triggers are calculated as an absolute water level change over a 12 month period. The Class 1 base line water level is defined at the start of each water year (1st August).

The baseline water level used for the Class 1 trigger level at CCFMM01_D is 406.98 mAHD. Level 1 trigger levels are plus or minus 0.65 m of this baseline value.

The Oakover Formation is a highly transmissive part of the gravel aquifer. The increase in aquifer pressure caused by the saline injection is resulting in an increase in observed groundwater levels (piezometric head) along the northern edge of the marsh. The mounding responses observed at the monitoring sites are expected due to the volume and rate of saline injection. The injection borefield is approx. 1.5 km away.

Figure 1 shows the groundwater piezometric head response since saline injection has started. Figure 2 shows the groundwater level in the shallow monitoring bore at the same location. No impact from the saline injection is seen in the shallow water table.

Figure 1: shows the response in the deep aquifer since the commencement of saline injection



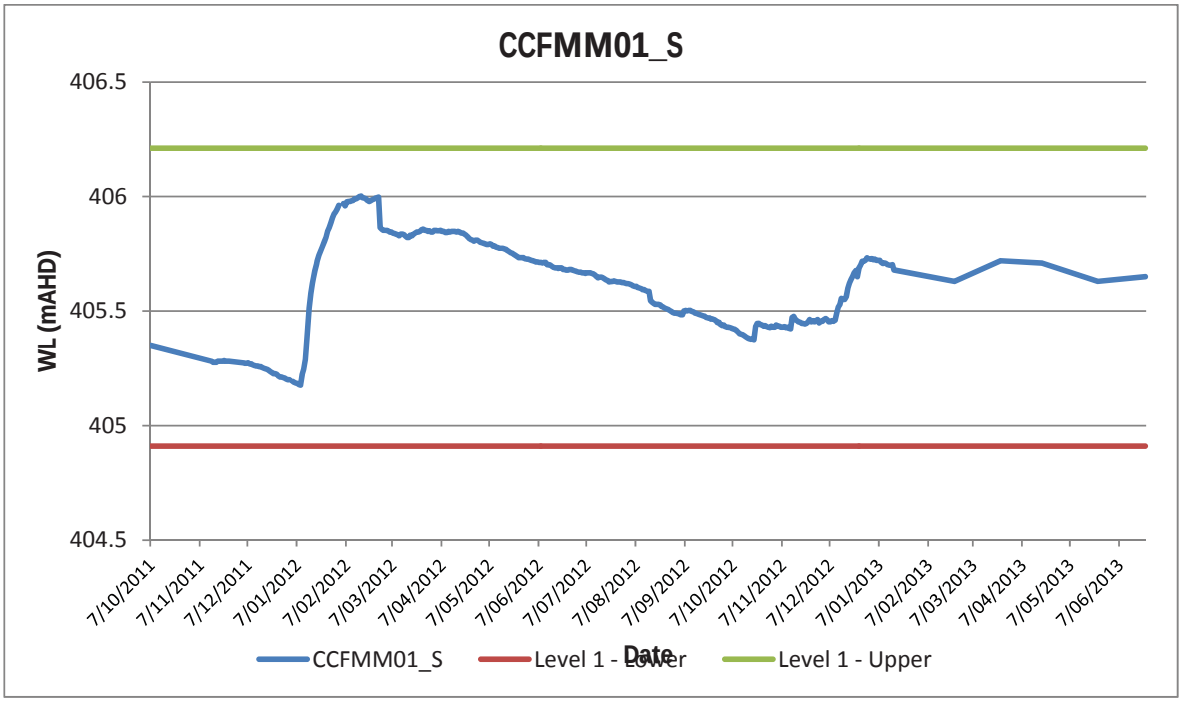
ACTIONS TAKEN

In response to the rise in deep groundwater levels and the Class 1 exceedence saline injection was immediately reduced from the western section (closest to the Fortescue Marsh) and diverted to the eastern and central sections where possible. Additional injection capacity is now available in the central section due to recent completion of 3 new injection bores.

An assessment of the shallow near marsh monitoring bores (Class 2 trigger bores) has also been completed. Figure 2 shows that there are no obvious trends associated with the saline injection and resulted mounding and groundwater levels are within the 0.8m of seasonal variation. The groundwater level trace shows a gradual decline in groundwater level, which is attributed to evapotranspiration and the drying out of the surface water. The sharp rise in December 2012 and 2013 is due to heavy rainfall throughout the Christmas Creek area at that time.

Since the immediate actions have been taken, the groundwater levels in the deep monitoring bore have decreased as the aquifer pressure has been reduced.

Figure 2: Groundwater Levels at CCFMM01_S (Shallow Aquifer)



CONCLUSION

The Class 1 trigger exceedance at CCFMM01_D is as a direct result of ongoing saline injection into the Oakover formation. Water level rise within the deep Oakover formation, as a result of injection, is as expected. The assessment has shown there is no impact to the shallow aquifer (CCFMM01_S) as a result of saline injection.

Monitoring in both the shallow and deep monitoring bores will continue to be reviewed to confirm adverse impacts are not observed in the shallow aquifer.

DATE	28 June 2013
BORE NAME	HEMB02_D
LOCATION	Hillside East Extension
TRIGGER	9,000 µS/cm
EXCEEDANCE VALUE	11200 uS/cm

REASON/EXPLANATION FOR EXCEEDANCE:

HEM02_D is a monitoring bore on the Hillside East injection line and sits adjacent to abstraction bore HEI02 (previously a brackish injection bore). HEI02 has been converted to an abstraction bore in early 2013. Abstraction is used as a backup and only as required.

As per the Level 1 trigger level exceedence procedure the monitoring bore was re-sampled and a saline profile was completed. This is to ensure that the original measurement is not an error and provides QAQC to the groundwater data that is being collected. The procedure is outlined in the Christmas Creek Operating Strategy.

The two saline profiles shown in Figure 1 show that there has been a decrease in EC across the screened interval from April 2013 to July 2013. The EC profile relating to this trigger exceedence was completed on the 7 July. The decrease is due to no abstraction occurring from HEI02 and the rebound of natural brackish groundwater to the area.

Figure 2 shows the EC trace of time. The period started in 2013 when injection seased and limited abstraction began has resulted in a decrease in the measured EC. This decline in EC is expected to continue.

ACTIONS TAKEN:

The trigger exceedence was flagged on 28 June 2013 via EnviroSys result validation system, and report issued on 29 July 2013.

CONCLUSION:

Limited abstraction from HEI02 for brackish water supply has resulted in the rebound of natural brackish groundwater to the vicinity. It is expected if no abstraction or injection occurs in this area that over time, natural groundwater quality will completely return

Figure 1: EC levels at HEMB02_D

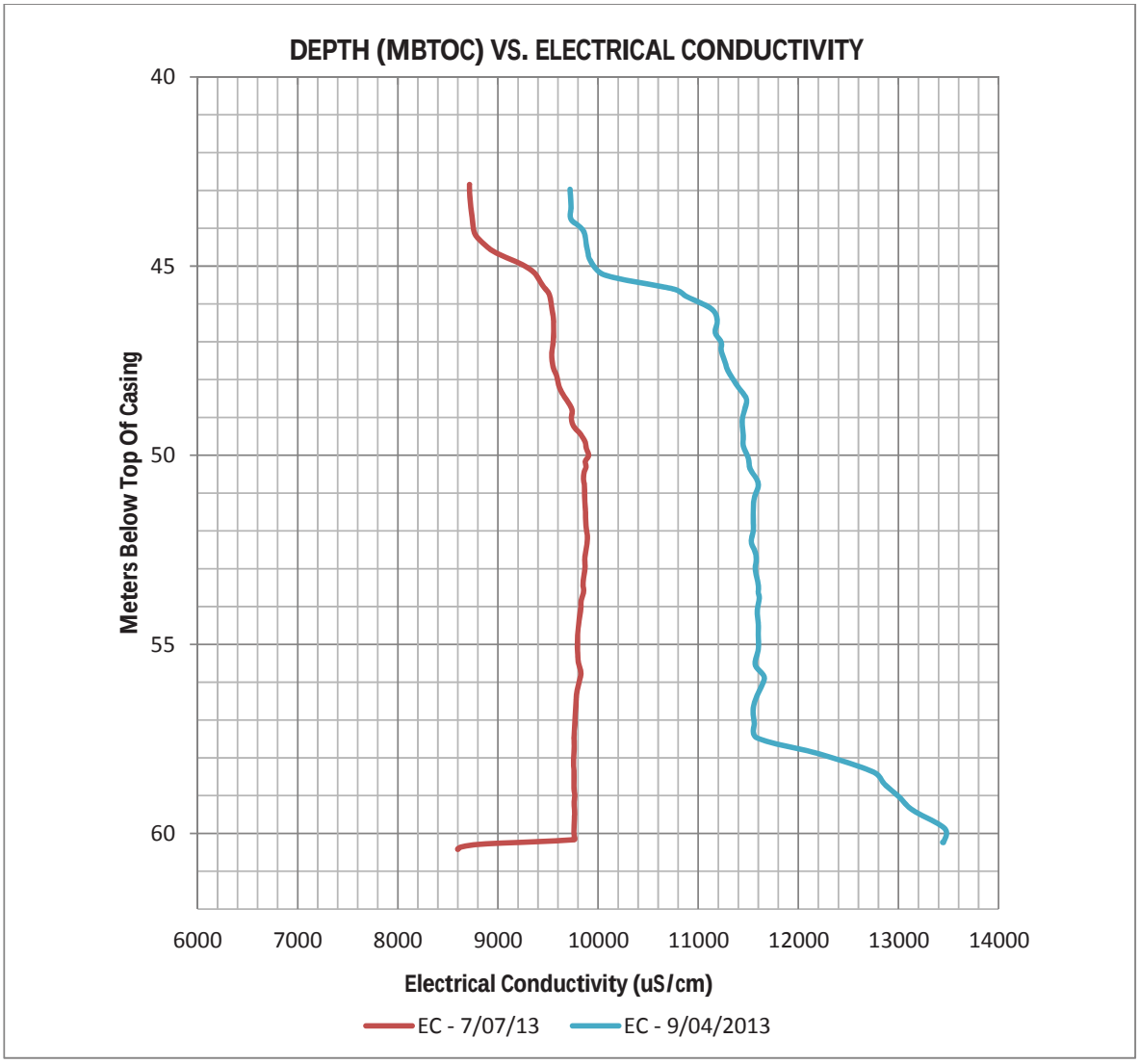
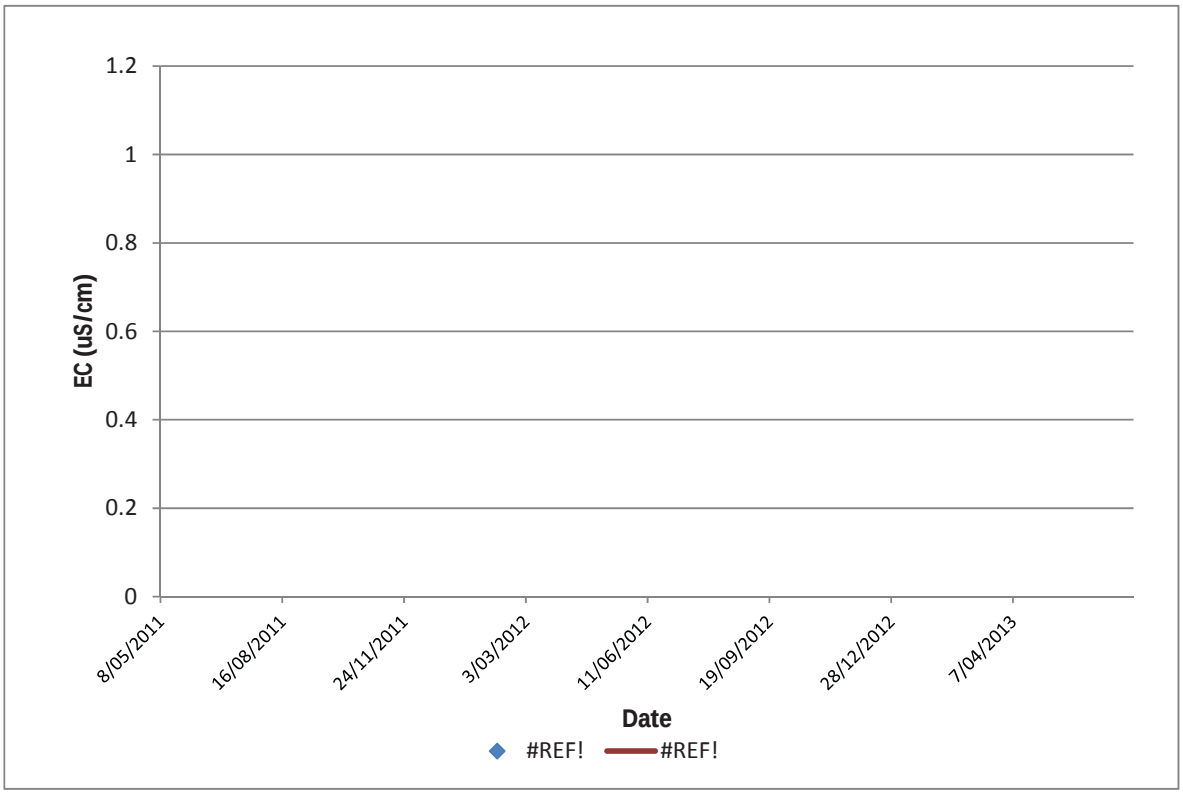


Figure 2: EC trace over time



CLASS 1 TRIGGER EXCEEDANCE

DATE	15/07/2013
BORE ID	HEMB29_D
LOCATION	Hillside east
TRIGGER LEVEL	16 538 µS/cm
EXCEEDANCE VALUE	18 885 µS/cm

INTRODUCTION

As part of the Christmas Creek Operating Strategy Revision 5, water levels and electrical conductivity of HEMB29_D were checked on the 11/07/2013. An electrical conductivity value of 18 885 µS/cm was recorded. This is above the trigger level of 16 538 µS/cm.

EXPLANATION

HEMB29_D is located in the Hillside east area of Christmas Creek mine site and is located in monitoring zone C. It has been installed to monitor the Marra Mamba formation trigger target aquifer. Figure 1 shows the EC trend over time in HSMB29_D.

The measured change is a result of remnant saline water being injected along the Hillside east injection borefield. Figure 2 below shows the saline profile through the screened interval that was completed after the trigger level value was recorded. The profile shows some stratification of EC, with more saline water occurring at greater depth. This is likely to be a result of the heavier, more saline water sinking to the bottom of the very low conductive aquifer. The monthly EC reading is recorded at 60 m depth, which is within the saline part of the water column. Low groundwater velocities, due to little hydraulic gradient and high effective porosity have resulted in the saline water sinking to the bottom of the aquifer. The water quality change is local with surrounding monitoring bores having brackish groundwater at similar depth.

OPERATION RESPONSE

No injection has occurred at the Hillside east injection borefield since late 2012. The eastern end of the borefield (HEI01-05) has been converted to an abstraction borefield to supply brackish water the mine site use. No brackish injection will be required in the short to medium term as all abstracted water is used by mine site demand.

Figure 1: EC trend in HSMB29_D

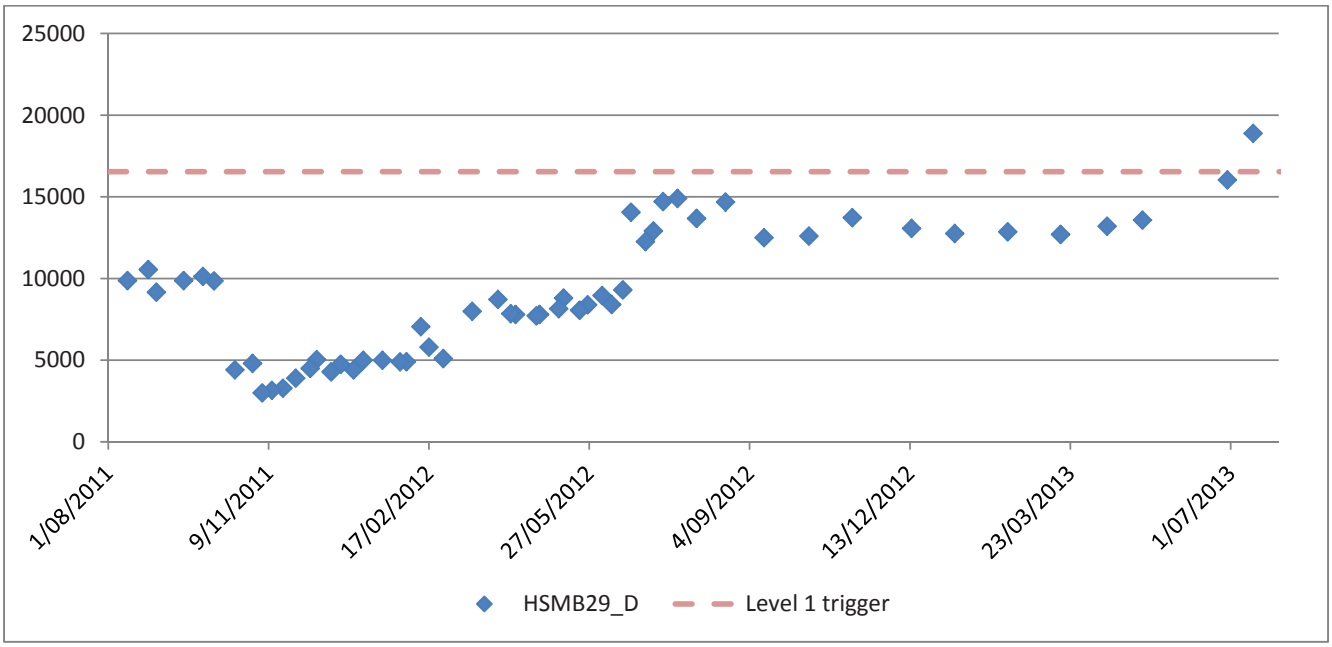
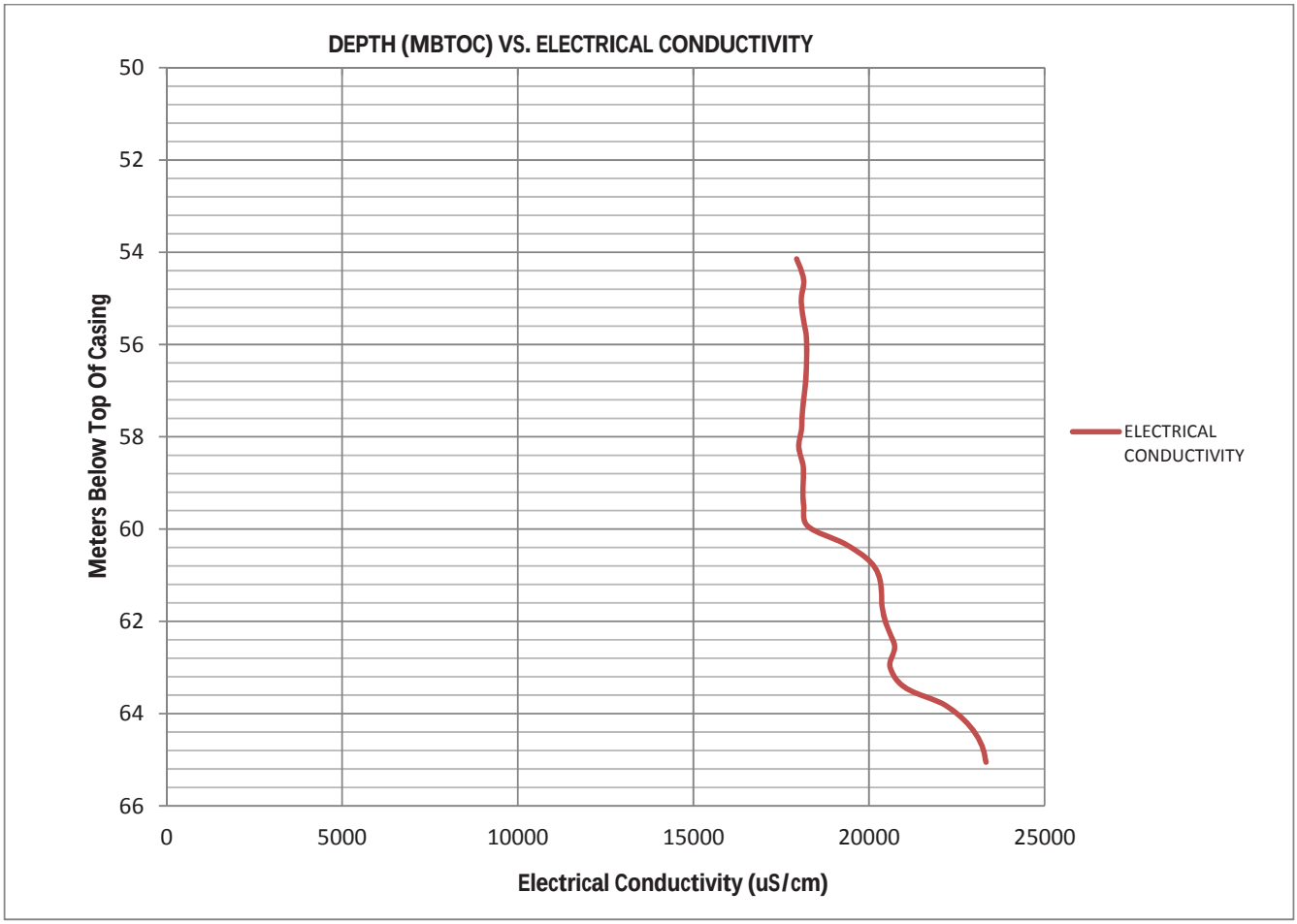


Figure 2: Saline profile



DATE	11/07/2013
BORE ID	HEMB02_D
LOCATION	Hillside east
TRIGGER VALUE	9850 µS/cm
EXCEEDANCE VALUE	9000 µS/cm

INTRODUCTION

As part of the Christmas Creek Operating Strategy Revision 5 the water levels and electrical conductivity of HEMB02_D were checked on the 11/07/2013. A value of 9850 µS/cm was recorded. This is above the level 1 trigger of 9000 set in the operating strategy.

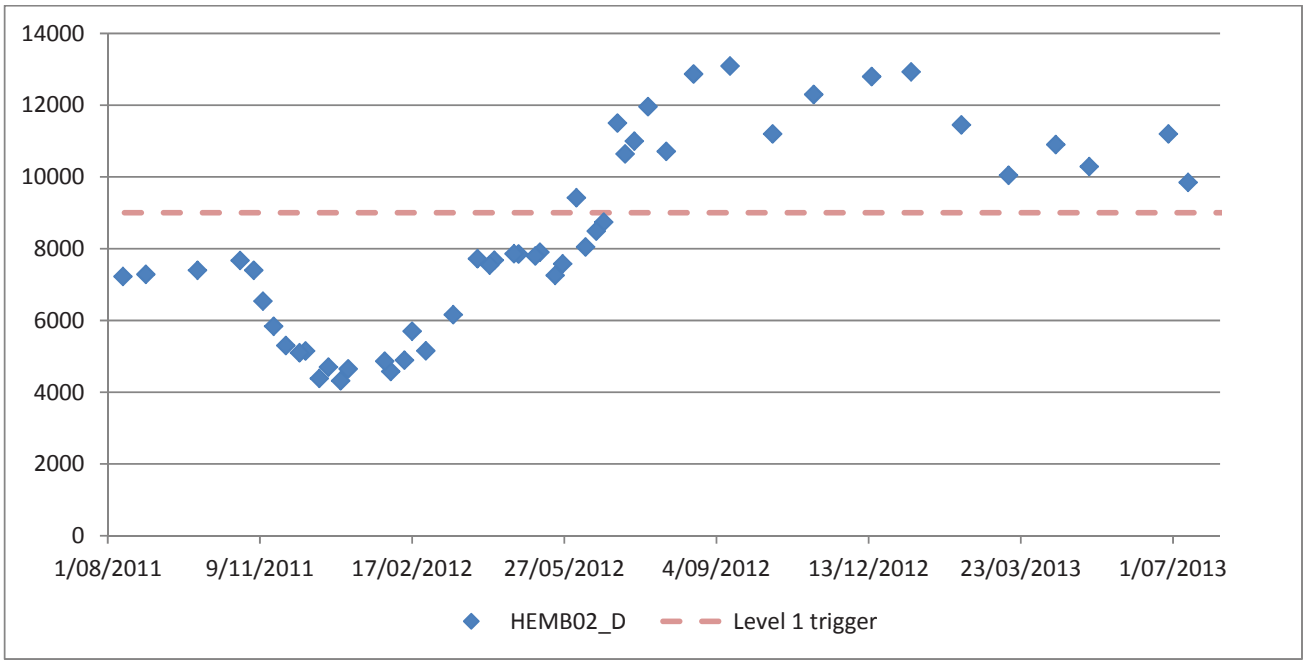
EXPLANATION

HEMB02_D is located in the Hillside East area of Christmas Creek mine site and is located in monitoring zone C. It has been installed to monitor the Marra Mamba formation trigger target aquifer. The measured change is a result of localised saline upconing due to abstraction from HEI02. Historical high EC values are a result of water with a higher than background EC being injected into the Hillside east injection borefield. The EC trend is showing a general decline back to background conditions.

OPERATION RESPONSE

Abstraction from HEI02 is required to meet the mine site water demand. The abstraction is intermittent and occurs during peak demand times. Abstraction will be minimised from HEI02 to limit the extent of the saline upconing.

Figure 1: EC v time in HEMB02_D



CLASS 1 TRIGGER EXCEEDANCE

DATE	21/07/2013
BORE ID	CCFMM01_D
LOCATION	Fortescue Marsh
TRIGGER VALUE	< 406.3 mAHD or > 407.9 mAHD
EXCEEDANCE VALUE	409.11 mAHD

INTRODUCTION

As part of the Christmas Creek Operating Strategy Revision 5 the water levels and electrical conductivity of CCFMM01_D were checked on the 21/07/2013. A value of 409.11 mAHD/was recorded. This is above the level 1 trigger of not less than 406.3 mAHD or not greater than 407.9 mAHD set out in the operating strategy.

EXPLANATION

CCFMM01_D is located along the northern edge of the Fortescue Marsh area of Christmas Creek mine site and is located in monitoring zone A. It has been installed to monitor the Oakover formation trigger target aquifer. Figure 1 shows the measured change is a result of saline injection with mounding occurring in the highly transmissive confined Oakover formation, which is part of the gravel aquifer. The increase in aquifer pressure caused by the saline injection is resulting in an increase in observed groundwater levels (piezometric head) along the northern edge of the marsh. The mounding responses observed at the monitoring sites are expected due to the volume and rate of saline injection. The injection borefield is approx. 1.5 km away.

Figure 2 shows no response has occurred in the shallow tertiary detrital (CCFMM01_S).

OPERATION RESPONSE

Where possible the volume of injection has been reduced in the western part of the saline injection borefield and shifted to the central and eastern sections of the injection borefield. This has been limited due to pipework infrastructure having the ability to move the required large volumes of water.

Figure 1: Water level (piezometric head) change over time in CCFMM01_D

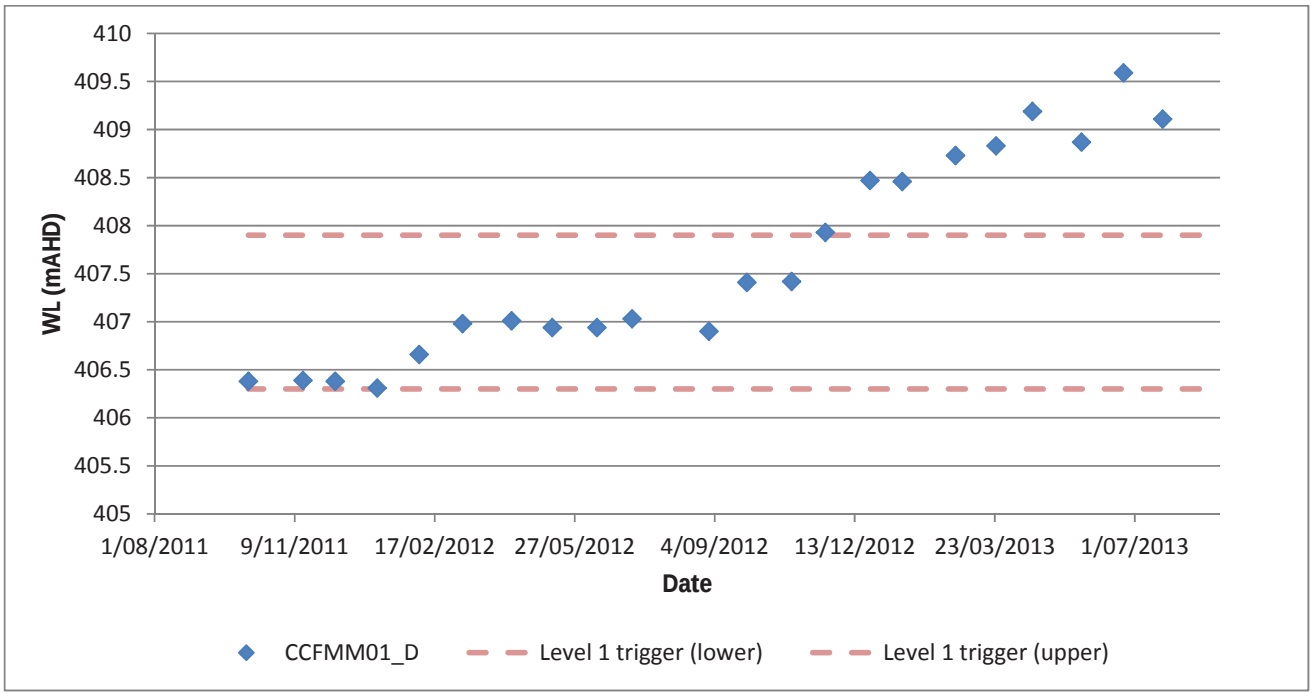
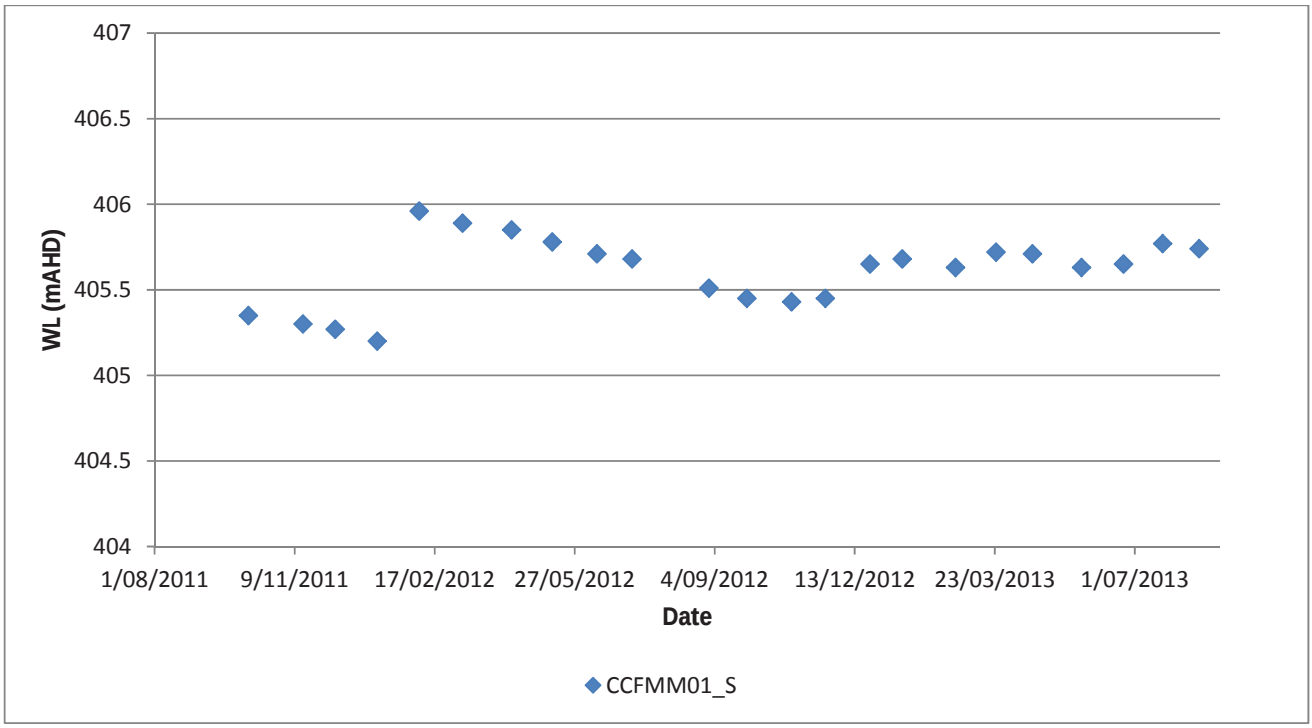


Figure 2: Water levels in CCFMM01_S



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Appendix 12: Modelled groundwater head contours for July 2013

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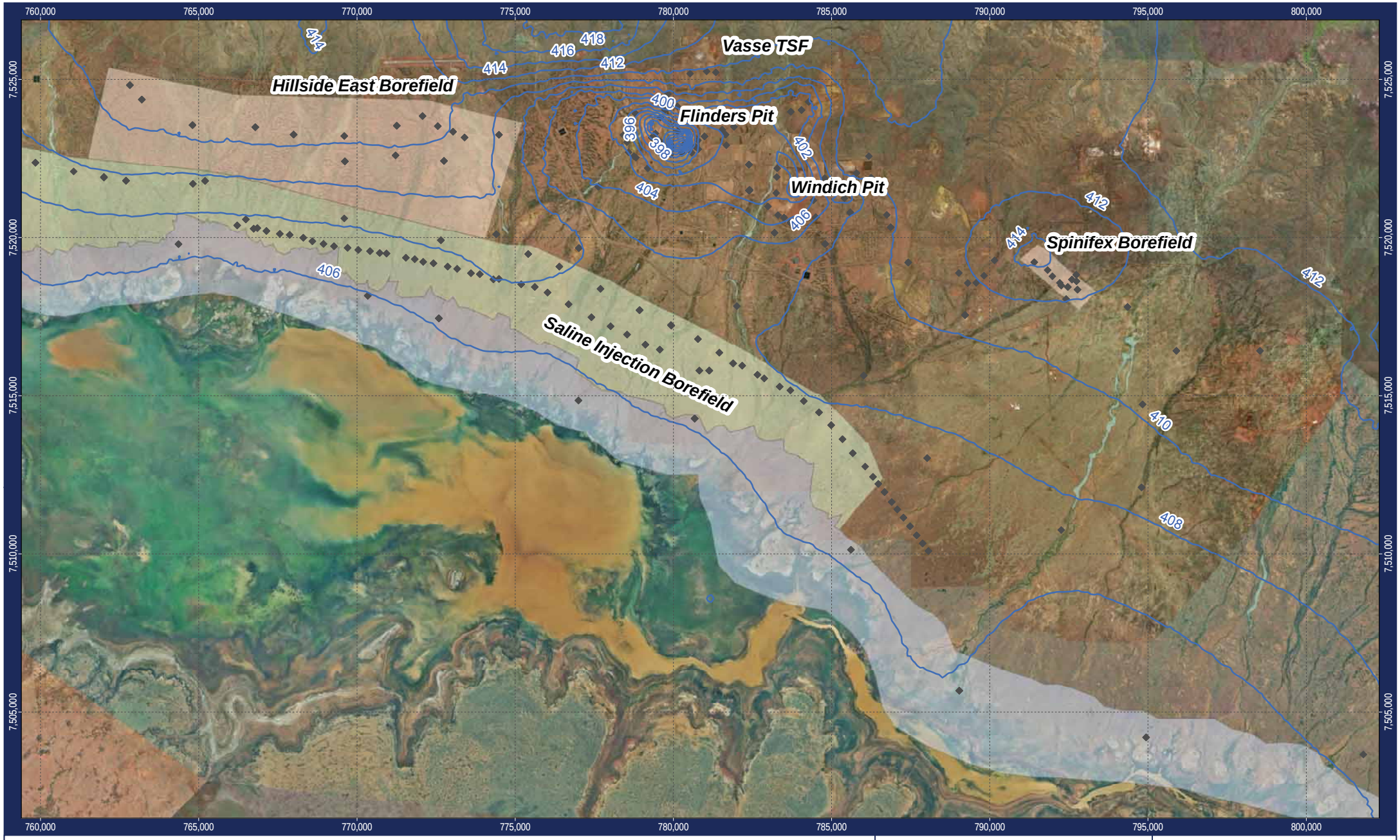

LEGEND

- Monitoring Bore
- Zone_A
- Zone_B
- Zone_C
- Zone_D
- July 2013 WT Modelled

0 2 4 6
Kilometres

Requested By: M Carroll
Drawn By: M Carroll
Revised By: Mcarroll
Approved By:
Scale: 1:153,700
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_Contour Map Template_

Date: 30/07/2014
Size: A4L
Revision: 0
Confidentiality: 1

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Christmas Creek Triennial
UTD Modelled WL Contour Map
July 2013

Fortescue Metals Group Ltd
The New Force in Iron Ore