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Dear Matt

2018 Groundwater and Spring Review, Pakenham Quarry

1.0 Introduction

AECOM Services Pty Ltd (AECOM) was engaged by Holcim (Australia) Pty Ltd (Holcim) to conduct ongoing monitoring and review of groundwater levels and spring flow/quality at the Mt Shamrock Quarry (WA174) in Pakenham, Victoria (the site) (see **Attachment 1- Figure 1**).

This (2018) review aims to meet selected requirements of the Mt Shamrock Quarry Environmental Management Plan (Holcim, 2015)[1] (EMP).

It is noted that the groundwater monitoring locations included on Appendix 11- Figure 1 in the EMP were replaced in October 2014, and a revised groundwater monitoring network now exists to replace bores lost (refer to **Attachment 1- Figure 2** for current groundwater monitoring bore locations).

The objective of the groundwater monitoring and assessment detailed in Section 2.4.3 of the EMP is:

- To ensure that water discharged from the Quarry does not affect the beneficial uses of the receiving waters; and
- To assess any long-term trends in groundwater levels.

To meet these objectives, the EMP includes the following requirements;

- Water level gauging will be conducted quarterly, and an annual evaluation undertaken, to determine how the groundwater levels respond to the following:
  - Seasonal rainfall changes;
  - Extension of the quarry;
  - Revegetation to parts of the plateau surface; and
  - Progressive rehabilitation of quarry.
- Properties surrounding the quarry will be regularly assessed to confirm that the assessed beneficial uses of groundwater (in accordance with SEPP Groundwaters of Victoria) on the properties is supported by actual practices; and
- Section 2.5.4- visual inspections of springs.

2.0 Scope

The scope of works undertaken to meet the requirements of the EMP was the following:

- Quarterly gauging of standing water levels (SWLs) of six groundwater bores, between April 2018 and January 2019. Note that gauging for the fourth quarter of 2018 was completed in January 2019 in accordance with recommendations made in 2017;
- Site walkover to visually assess the condition of each spring (10 springs or water seepages);
- Collection of supporting photographs at each spring location;

[1] *Pakenham Quarry Environmental Management Plan, version 3: August 2015.* prepared by Holcim (Australia) Pty Ltd

- Collection of field parameters electrical conductivity (EC - µS/cm), pH, temperature (°C), redox potential (Eh - mV) and dissolved oxygen (DO – mg/L) at each spring location; and
- Provision of this report including an assessment of how groundwater levels respond to the following;
  - Seasonal rainfall changes;
  - Extension of the quarry, revegetation to parts of the plateau surface and progressive rehabilitation of the quarry (through reviewing provided plans indicating any quarterly changes in the extent of the quarry, revegetation and rehabilitation of the quarry completed at the time of groundwater level monitoring);
  - Comparison of current EC data against historical data collected from previous spring monitoring events, which date back to February 2001; and
  - Review of historical data and discussion of results with respect to potential impacts on beneficial uses.

3.0 Background

The site is located on Mt Shamrock Rd, approximately 5km north of the Pakenham township and 65km south-east of the Melbourne CBD. The surrounding land is predominantly used for agricultural purposes.

Topographically, the Site is located at the southern end of an elevated, basalt plateau, which is aligned in an approximate north-south orientation.

Toomuc Valley Road and Toomuc Creek run along the western edge of the plateau, while Pakenham Road is aligned to the south and east of the site.

The site sits at the southern end of a basalt ridgeline (Older Volcanics) which forms one continuous unconfined fracture rock aquifer along the 4 km ridgeline. The basalt overlies Palaeozoic basement, with a thin veneer of unconsolidated Werribee Formation sediments between in some locations. The basalt aquifer is limited in lateral extent by the nature of the valley fill basalt flow.

4.0 Monitoring Networks

4.1 Groundwater Bore Network

Six groundwater monitoring bores (MB01, MB02, MB04, MB03 and MB05 and MB06); formed the original groundwater monitoring bore network for the site. The bores were drilled installed by KH Adams and Sons Drilling Pty Ltd between 6 and 14 March 2001. These bores were drilled at four locations around and within the quarry to provide spatial coverage across the site. At two locations, two bores were constructed into different formations (Older Volcanics & Werribee Formation) to allow for groundwater comparison between the aquifer units.

Two bores (MB02 and MB04) that were located at the base of the pit were damaged in 2008 and subsequently replaced March 2009. The replacement bores (MB02a and MB04a) were installed approximately 50 metres from the original bores however, the quarterly monitoring event in August 2009 revealed the integrity of MB04a had been compromised with a blockage at 6.4 metres below the top of the PVC casing.

The two replacement groundwater bores, MB02a and MB04a, and bores MB03 and MB05 were then removed during the 2012 stripping campaign.

Subsequently, four additional bores were installed (MB02b, MB03b, MB04b and MB05b) in October 2014[2] to replace the bores historically lost during stripping to restore the monitoring network to be in compliance with the EMP.

In June 2016, the casings of bores MB02b and MB04b were extended, and damaged in the process of overburden placement in the area. These bores were subsequently decommissioned and replacement bores were installed in January 2017 as MB02c and MB04c.

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[2] Documented in URS Australia Pty Ltd, December 2014. *Drilling of Groundwater Bores- Mt Shamrock Quarry, Pakenham, October 2014.* Prepared for Holcim (Australia) Pty Ltd

The bore network gauged during 2018 is presented on **Attachment 1- Figure 2**.

Table 1 summarises the bore locations, screened interval and aquifer, as monitored during 2018.

Table 1 Monitoring Bore Network

Well ID	Installation Date	Top of Well Casing mAHD [1]	Eastings (AMG)	Northings (AMG)	Top of Well Screen mbgl	Top of Well Screen mAHD	Bottom of Well Screen mbgl	Bottom of Well Screen mAHD	Aquifer
MB01	7-Mar-01	216.54	366135.13	5789516.00	67.00	149.54	72.50	144.04	WERRIBEE FORMATION
MB02c	17-Jan-17	191.68	366232.07	5790211.78	33.77	157.91	36.77	154.91	WERRIBEE FORMATION
MB03b	24-Oct-14	209.9	365739.25	5790087.04	49	160.9	52	157.9	WERRIBEE FORMATION
MB04c	17-Jan-17	191.84	366233.33	5790213.41	30.40	161.44	30.90	160.94	OLDER VOLCANICS
MB05b	27-Oct-14	209.55	365736.94	5790087.88	40	169.55	46	163.55	OLDER VOLCANICS
MB06	13-Mar-01	219.56	366321.06	5790488.40	44.00	175.56	50.00	169.56	OLDER VOLCANICS

mAHD meters above Australian Height Datum

AMG Australian Map Grid

4.2 Springs

Ten springs[3] surrounding the site have been identified in previous investigations and form part the ongoing monitoring of potential effects from quarry dewatering operations.

The occurrence of the springs is interpreted as being the result of outcropping saturated Werribee Formation sediments (comprising silts, clays and sands) which allow groundwater to discharge to the surface, after rainfall recharge through the overlying basalts.

It is noted that during the 2014 survey two of the mapped springs (SP09 & SP10) were not considered to be discrete groundwater discharge points due to significant surface water and seepage influences and/or changes in topography and infrastructure at the site. The locations of all mapped seepages/springs/water catchments are presented in **Attachment 1- Figure 3**.

5.0 Assessment of beneficial uses

The State Environmental Protection Policy (SEPP) Waters 2018 sets the regulatory framework for the assessment and management of surface water and groundwater. The SEPP Waters (2018) is a revision of the SEPP (Waters of Victoria (2003) which was referenced the site EMP, and for the purposes if this assessment are still considered relevant[4].

The aim of the SEPP Waters of Victoria (2003) (SEPP WoV) was to maintain surface water quality sufficient to protect existing and potential beneficial uses of surface waters throughout Victoria.

The SEPP WoV and its schedules define the site as being in Schedule F8 – Waters of the Western Port and Catchment and located in the Northern Hills segment.

The beneficial use of groundwater, in Victoria, is defined by the salinity of the water. Table 2 summarises the Protected Beneficial Use segments, defined by a waters' salinity, as set out by the State Environmental Protection Policy (SEPP) - Groundwaters of Victoria:

Table 2 SEPP Groundwaters of Victoria - Protected Beneficial Uses of the Segments

BENEFICIAL USE		SEGMENTS (mg/L TDS)				
		A1 (0-500)	A2 (501-1,000)	B (1,001-3,500)	C (3,501-13,000)	D (>13,000)
Potable Water Supply	Desirable					
	Acceptable					
Potable Mineral Water						
Agriculture, Parks and Gardens						
Stock Watering						
Primary Contact Recreation (e.g. Bathing and swimming)						
Industrial Water Use						
Buildings and Structures						
Maintenance of Ecosystems						

[3] A spring is defined as a groundwater discharge or "exit" point

[4] In accordance with the EMP, the previous version of the SEPP (Waters of Victoria (2003) has been used as the guidance framework for this 2018 review. The justification being that this groundwater and spring review are required in order to comply with the 2015 EMP and that the previous SEPP iteration was in place for most of the 2018 review period. Future reviews should consider the updated SEPP (2018) and it is recommended that the EMP be revised to reflect the updated regulatory document.

Historical observations of salinity at the springs show a range from 149 to 2,808 mg/L as TDS (**see Attachment 3 - Table 3**). Spring salinity is considered to be a combination of runoff, interflow and groundwater discharge, thus groundwater salinity is likely diluted in these measurements.

A groundwater resource report, generated from Victorian Department of Environment, Land, Water and Planning notes the quarry lies within the Westernport groundwater catchment. Water table salinity is noted to range from 1001 – 3500 mg/L (TDS). Groundwater bore development records, associated with drilling of groundwater monitoring bores at the quarry report groundwater salinity to range between 1140 and 2318 mg/L (see **Attachment 2 - Table 4**), which is consistent with the groundwater resource report.

This assessment indicates the groundwater quality at the Site can be classified as 'Segment B'. Given the current local activities in the area, consideration of the beneficial use of groundwater and the level of protection has been provided:

- **Maintenance of Ecosystems:** Groundwater is known to feed a number of nearby springs in the area (as discussed in Section 4.2), which feed nearby surface water body Kennedy Creek (freshwater aquatic ecosystem). Protection of the ecosystems of the nearby surface water body and local springs are considered a relevant beneficial use.
- **Buildings and Structures**: Current land use around the site is agricultural and rural residential. Buildings associated are not expected to have deep footings; this beneficial use is not considered relevant at this time.
- **Industrial Water Use:** There are no industrial zones in the immediate vicinity of the Site. As such, this beneficial use is not considered relevant for this assessment.
- **Primary Contact Recreation:** The downstream receiving water body, Kennedy Creek, is not expected to support primary contract recreation activities due to the size of the water body. However, based on a review of registered groundwater users on the Water Management Information System (WMIS) maintained by DELWP indicates stock and domestic bores are registered within 2km of the quarry. Therefore, these bores could be used to fill dams or pools for swimming. Therefore, this beneficial use has been considered.
- **Stock Watering:** Stock and domestic bores are registered in the area and stock grazing is known to occur at a number of properties in the area, water from springs are used as a source of water for stock, and this beneficial use is considered relevant as part of this assessment.
- **Agriculture:** Agricultural farming is known to occur at a number of properties in the area, water from the springs are used as a water supply for irrigation, this beneficial use is considered relevant as part of this assessment.

As per the water management flow chart within the EMP, all water collected in the quarry pits is contained and reused on-site or discharged via a v-notch to surface water under licence from EPA. As stated in Section 3.3.6 of the statement from the Minister of Planning on the 2006 Environmental Effects Statement for the quarry expansion, the quarry operations were not expected to impact on groundwater and surface water systems, however groundwater inflows into the pit and the water system may increase the total dissolved solids (TDS) within the water system.

As part of this review, the water quality collected at the site has been reviewed against the water quality guideline criteria for TDS as summarised in Table 3 below.

Table 3 Adopted groundwater beneficial use guidelines

Beneficial use	Adopted guideline
Maintenance of Ecosystems	Schedule F8- Waters of the Western Port and Catchment and located in the Northern Hills segment- Waters of Victoria SEPP (2003)
Stock Watering	Criteria for Livestock Water Supply: ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality.

Beneficial use	Adopted guideline
Agriculture, Parks and Gardens	Criteria for Irrigation Water Supply: ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality.

5.1 Summary of groundwater beneficial use guideline criteria

The adopted Groundwater Screening Criteria (GSC) are summarised below in Table 4.

Table 4 Groundwater Screening Criteria

Analyte	Maintenance Of Freshwater Ecosystems (90% Protection)	Irrigation	Stock Watering
Salinity (mg/L TDS)	200	Specific to crop species*	4,000#

Livestock watering considers horses, dairy cattle and sheep. Adopted criteria considers loss of production and a decline in animal conditional and health.

*ANZECC (2000) presents a range of acceptable water salinities for variation crops with regard to *Average root zone salinity thresholds*. It is expected that farming crop choice in area would consider the available water salinity (among other climatic factors) and as such the assessment of groundwater as a supply for irrigation should consider more any changing trends in water salinity.

6.0 Results and Discussion

6.1 Groundwater Monitoring

Quarterly groundwater level gauging from the bore network was undertaken by AECOM during 2018. As noted earlier the gauging for the final quarter of 2018 was completed in early January 2019. This was conducted in accordance with a recommendation made in 2017 to sample the springs during a drier period in order to capture data more representative of spring flow rather than surface flow.

The historic data set of groundwater elevations for the bore network is presented as **Attachment 2- Table 1**. For simplicity, bores and replacement bores have been plotted as one monitoring location to produce time series hydrographs (**Attachment 3- Chart 1**). The following limitations have been noted with the relative level data over time:

- Groundwater level gauging was not undertaken between May 2005- January 2008;
- All bores inside the pit were submerged between June 2011 and February 2012;
- Bores MB02a and MB04b were not surveyed to relative levels, and therefore relative elevations from gauging data measured between June 2009- March 2011 is based on the TOC elevation collected by handheld GPS. However, the trends noted within each bore were consistent to trends observed in other bores;
- A blockage in MB04a at 6.2mbgl was identified in August 2009, not long after replacement. This is inferred to have impacted the gauging data collected between August 2009- end of 2011, when the bore was removed in the stripping campaign;
- The PVC of bores MB02b and MB04b were extended during works in mid-2016 by around 12 metres, however were damaged during the extension process and not re-surveyed, hence relative levels are estimates only for this period. Relative levels for the extended PVC (from June 2016) were based on client information and not on bore hole survey data; and
- Despite the replacement and relocation of some of the bores, the relative changes in water levels between monitoring events can still be inferred.

6.1.1 Results

The groundwater levels throughout 2018 have remained within historic water levels, with the following noted:

- MB01, and MB6 continue on declining trends from historical (2013) levels
- MB02c and MB04c have remained relatively stable throughout 2018; and
- MB03 and MB05 have continued to recover since May 2016 levels.

Relative elevations between pairs of bores installed in the Werribee Formation and the Older Volcanics aquifer (i.e. MB03 and MB05; MB02 and MB04) have had similar groundwater elevations and similar patterns of fluctuating water levels over the monitoring period.

6.1.2 Response to rainfall totals

Rainfall data obtained from the nearest meteorological station with a complete rainfall dataset over the total monitoring period (Dandenong - refer to **Attachment 2- Table 2**) has recorded data from 1961 and 2018, with the following key points:

- Overall average annual rainfall is approximately 779 mm/ year.
- Since 2001, when groundwater monitoring commenced, rainfall has ranged between 587 mm (2008) and 1108 mm (2011).
- In 2018, rainfall was just below the current annual average calculated, with 756 mm recorded in 2018.

Historically rainfall totals were below average between 2002 and 2008 and increasing between 2010 and 2012 (consistent with regional observations). From 2013 to present the annual rainfall has generally fluctuated above and below the long-term average.

Attachment 3- Chart 2 presents groundwater level data versus monthly rainfall totals. **Chart 3** presents groundwater level data versus Accumulative Monthly Residual Rainfall (AMRR). The plots indicate the following key points:

- Overall there is a good correlation between rainfall totals and groundwater levels, particularly prior to 2005;
- Between June 2011 and February 2012, when the pit was submerged, monitored bores remained stable throughout a continued upward AMRR trend;
- The strongest correlation is in the basalt bores outside the pit, which is believed to reflect the aquifer's better connection to rainfall infiltration;
- Bores screened in the aquifer directly beneath the basalt (Werribee Formation) respond at comparable times and trends, suggesting hydraulic connection; and
- The recent declining trends in groundwater bores correlate with the declining AMRR (from Jan 2014 to Dec 2018).

6.1.3 Response to quarry extensions

The following summarises the stripping/extraction campaigns that have taken place since the expansion of the quarry in 2005:

- 2009:
  - An excavation of approximately 50m² to the south west corner (towards MB03 and MB05);
  - An excavation of approximately 100m² to the north (towards MB06);
  - Vegetation and surface material removal of approximately 200m² to the south (west of MB01); and
  - Vegetation and surface material removal of approximately 200m² to the south (east of MB01).
- 2012 - Extension of the western area of the quarry. Material from here was being placed in the northern extent of the quarry.
- 2015 - Further excavation of the southwestern quarry area.
- 2016 - Further excavation of the south western quarry area.
- 2017 - Continued excavation of the quarry in the south-west portion of the site.

- 2018 - Continued excavation in the southwestern area of the quarry.

The stripping of the surface materials (overburden) as part of quarrying is potentially increasing rainfall infiltration when more permeable fresh basalt are exposed to surface. This increased infiltration potential and in combination with relatively high rainfall is believed to a key reason for the increase in groundwater levels throughout 2010 and 2011, most notably in MB03 (6.4 m increase) and MB05 (9.3 m increase).

Overall, the monitoring bores appear to respond to rainfall trends, with a marked increase in groundwater levels between 2010 and 2011 at the break of drought.

6.1.4 Response to revegetation across plateau surface

Holcim continued rehabilitation works at the quarry in 2018, with revegetation being progressed in the south eastern area of the site (highlighted in green the aerial photograph in **Attachment 5)**. This has included tree planting on these terminal faces. Revegetation occurred around springs SP02 and SP05 in June 2018. A total of 1.2 hectares of revegetation was planted in fenced areas around the springs.

There continues to be no observable trend in levels that can be attributed to revegetation. Revegetation areas are relatively minor in comparison to the overall quarry footprint and any change in infiltration from an increase in evapotranspiration is likely to be minor at this time.

6.1.5 Response to progressive rehabilitation of the quarry

In previous years overburden from the quarry has been placed in the south east of the site. This area has now been extensively revegetated and is undergoing rehabilitation. Through 2018 overburden was placed in the smaller pit to the north east which formerly contained a pond. As of 2018 this pit and the former pond appear to have been infilled (See aerial photograph in **Attachment 5)**.

The former pit is located approximately equidistant from bores MB02C, MB04C and MB06. Each bore is approximately 200m from the former pit. No trend or influence due to the filling in of the pit is yet apparent in the gauging data.

Overburden placement as part of the rehabilitation works will likely decrease infiltration and recharge and the shaping of the overburden will likely re-direct runoff. Although rehabilitated areas are comparably minor in relation to the overall quarry footprint, as rehabilitation continues the effect may become more apparent.

6.2 Spring Survey

Historically ten seeps were identified as being groundwater fed springs. Based on the observations in the 2014 review, SP09 and SP10 were interpreted to be surface water collection points and not considered groundwater seepage. Springs have generally been surveyed biannually.

Photographs taken for each location during the survey are presented in **Attachment 4**.

Results of the spring survey completed on 8 January 2019 are summarised in **Table 5** below. Historical spring parameters are presented in **Table 3-Attachment 2** and a chart of measured EC over time is presented as **Chart 4- Attachment 3**.

Rainfall vs the measured EC is also plotted as **Chart 5- Attachment 3**. We note that when comparing the historical salinity measurements collected at the springs, rainfall can influence the measured EC as some events have been collected in higher rainfall months and saturated ground conditions may dilute the groundwater and therefore reduce the measured salinity.

Table 5 Spring Survey Results

SPRING ID	EC (µS/cm)	OBSERVATIONS
SP01	1323	Grey, no odour, medium turbidity, very overgrown
SP02	2829	Black, organic odour, medium-high turbidity, overgrown
SP03	784	Black/clear, no odour, low-medium turbidity
SP04	Dry	-

SPRING ID	EC (µS/cm)	OBSERVATIONS
SP05	Dry	-
SP06	592	Brown, no odour, low-medium turbidity
SP07	Not Accessed	-
SP08	1103	Overgrown, brown/clear, no odour, low-medium turbidity
SP09	1163	Black/clear, no odour, low-medium turbidity
SP10	Dry	

Spring observations are discussed below:

SP01

SP01 located to the west of the quarry site, provides irrigation and stock water to a number of properties in the local area. The area was observed to be boggy and vegetation in good health.

In January 2019, the flow at SP01 was observed at approximately 2.25L/min. Previous observations in 2017 note a flow rate of approximately 1.5L/min, about 4L/min in 2015, about 5L/min in 2014 and approximately 6 L/min in June 2013.

The spring water EC (1,323 µS/cm) was within the range of EC values reported in previous surveys.

SP02

SP02 located to the west of the quarry, was observed to be a small dam feed by groundwater and surface water runoff from a relatively steep slope above. The area was fenced, with no flow measured.

The dam exhibits instability on the downslope face. It was previously understood that under heavy rainfall, the pond overtops resulting in erosion and instability on the face of the dam. The spring was noted to have the potential to break free of the wall constructed at the location to reduce flow down the slope. A tank is apparently planned to be constructed downgradient from which water is fed to, to reduce stress on the wall.

In January 2019 the the spring was noted to be a deep pond with a large amount of duckweed and overgrown grass. Although no flow was observed, troughs and tanks in the area were full. No evidence of new seeps was noted.

The water EC (2,829 µS/cm) was within the historical range of EC values reported at SP02, with EC continuously higher at SP02 than other spring locations.

SP03

SP03 contains a concrete lined ponded water outflow and water pooling on the ground from both. Vegetation in January 2019 was very healthy and the surrounding area boggy. Flow was not observed however water troughs full.

Measured EC (784 µS/cm) values were within those historically reported (540-1,022 µS/cm). Following an observed spike in EC in 2016 values have stabilised at a lower level since then.

SP04

SP04 located to the north west of the quarry was noted to be overgrown in places. A small depression was observed down topographic gradient of the spring line and slope. The area has been fenced off, preventing livestock access.

In January 2019 the spring was observed to be dry and water quality measurements could not be collected. Despite the dry spring vegetation was noted to appear healthy and overgrown.

SP05

In January 2019 the spring was observed to be dry, as it has been since 2009, and water quality measurements could not be collected. Despite the dry spring vegetation was noted to appear healthy and overgrown

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SP06

Spring water at SP06 accumulates in a collection pond accessible to livestock, with cattle prints observed. Pool at spring was noted to be stagnant and very boggy. The poll is approximately 15-20m^2 and up to 0.5m deep. EC was measured as 592 µS/cm, within the historical range.

SP07

SP07 located to the north of the quarry has a lower elevation than the other mapped springs. Discharge is towards the bottom of a significant and moderately steep drainage line, indicating that surface water runoff could be a partial contributor to the water logging of the ground surface. This location has been intermittently dry or had very little flow in some of the previous events.

SP07 was unable to be accessed during the January 2019 monitoring round.

SP08

Spring is a wetland with a lot of reeds. EC is 1103 µS/cm. Within historic range but the EC at this spring shows high variability since observations began in 2001.

SP09

An access road was constructed in the vicinity of SP09 in 2014 and the access road includes a culvert installed underneath that diverts water away from the quarry. The topography of the area was noted to be slightly altered during the construction.

A pond of water was observed down gradient of the former SP09 location that is most likely a combination of seepage and surface water run-off, and is unlikely to have a significant groundwater contribution at the location observed.

Since the road construction, monitoring in the vicinity has continued and and field parameters are collected from the pond downgradient. EC was measured as 1,163 µS/cm in January 2019. This is close to the historical high of 1,185 µS/cm measured in 2017.

SP10

Similar to SP09, the monitoring point, SP10, was noted to be changed by the previous construction of an access road and culvert.

Monitoring has continued and the area has been recorded as dry since 2014, including in the recent January 2019 monitoring event. .

6.2.1 Spring changes in comparison to rainfall totals and quarry development

The spring EC measurements have been plotted against the rainfall data (refer to **Table 2-Attachment 2**). Rainfall is slightly less than average in 2018. In 2019, EC measurements have varied at each location. In general, no trend is observed across the springs. Measured EC has been within historical ranges at each spring.

In summary:

- As in previous surveys, spring flows and quality trends do not appear to show any correlation to rainfall totals;
- The observation that SP05 has been dry since 2009 may be an indication of the quarry face developing towards this location, however, it is noted adjacent springs (SP01 and SP02), which are comparable distances from the pit, show no change/reduction in flow.

6.3 Assessment of Impacts to Beneficial Use

Quarrying operations at the site began mid-1970s, monitoring of groundwater levels and of spring water quality (electrical conductivity and other field parameters) has been conducted at the Site since 2001.

As an overview, water is managed at the site via a pump and containment system around the site, with water that is collected in north and south pits, used on site for either dust suppression or in the processing plant.

For management of excess water, Holcim hold an off-site discharge licence from EPA for the discharge of water to Kennedy Creek via the v-notch at Donazzan's Dam.

As part of this licence, Holcim undertake testing during discharge for the parameters defined within the licence, including flow and water quality- primarily TDS. Monitoring of Off-site discharge to Kennedy Creek is undertaken weekly during discharge for water quality and flow as per the EPA licence and Holcim maintain records.

Should quality not comply with the limits set in the EPA licence, then discharge does not occur. Therefore, the impacts on the creek system (beneficial use of maintenance of ecosystems) is considered to be met.

As discussed in Section 6.1.1 observations of groundwater levels continuing to remain within historic measurements and indicates that the access to groundwater for the purpose of beneficial uses outlined in Section 4.0 has not been impinged by decreasing water levels. Further, groundwater seepage and flow has continued to be observed in the springs since the commencement of monitoring. Therefore, where surrounding land users access water, in particular for stock watering, this does not appear to be affected by quarry operations.

Quarry operations are not expected to impact on surrounding groundwater quality, as local groundwater flow is inferred to be towards the pit, and any inflows are captured as part of the on-site water management network. Groundwater quality monitoring is not required by the EMP, as discussed above the key indicators of impact to surrounding beneficial users are flows at the spring monitoring locations.

A brief review of available water quality records for the site including groundwater bore development records (2014 – 2017), and field measurements at the springs indicate that TDS (based on field measured EC readings) remains within the range as defined by Segment B (SEPP WoV) (1001 – 3500 mg/L), suggesting that groundwater is suitable for the beneficial uses noted in Section 4.0.

Inspection of the data presented in **Attachment 3 - Chart 7** shows a relatively stable salinity at most springs since monitoring commenced. Spring number 2 (SP02) has a higher salinity than other springs. Groundwater quality measured in bore development and expressed by the springs is considered suitable for livestock watering and has been since monitoring commenced.

Groundwater quality observed during bore development suggests that salinity varies and exceeds the adopted criteria for maintenance of ecosystems. This is also the case for water quality monitored at adjacent springs. However, this is considered to be the background quality within the aquifers.

Groundwater discharge via springs is considered a natural hydraulic process in the area and as such slightly saline groundwater expression from some springs in the area is considered natural and not an impediment to ecosystem maintenance given the dilution occurring at the spring sites. Further, the key beneficial use of the surface water environment, is managed via the EPA licence as discussed above, whereby, water quality parameters must be met prior to discharge.

Suitability of groundwater for crop irrigation will depend on the crop chosen, based on average root zone salinity thresholds presented in Table 4.2.5 of the ANZECC (2000) guidelines, water quality is likely suitable for most/many field crops fruits, pastures and vegetables, with the exception of some low tolerant species. The stable trend observed in the spring data shows that suitability for crop irrigation has not degraded since monitoring commenced in 2001 and is not likely impeding adjacent land holder beneficial use. TDS is also below the adopted criteria for stock watering.

Based on the available data, the water quality and spring flow observations suggest that recent activities (post 2001) at the quarry have had not impacted on the current surrounding beneficial uses of groundwater.

7.0 Compliance with EMP

A summary of the compliance with the requirements relevant to this assessment in the EMP are included in the table below.

Table 6 Compliance with EMP

EMP Reference	Requirement	Comment
2.4.3-Management Measures	Water level gauging will be conducted quarterly, and an annual evaluation undertaken, to determine how the groundwater levels respond to the following: • Seasonal rainfall changes; • Extension of the quarry; • Revegetation to parts of the plateau surface; and • Progressive rehabilitation of quarry.	Compliant
	Properties surrounding the quarry will be regularly assessed to confirm that the assessed beneficial uses of groundwater (in accordance with SEPP Groundwaters of Victoria) on the properties is supported by actual practices	Compliant
2.5.4 Slope stability Monitoring	Visual Inspection of springs- six months and after heavy rain	Spring surveys were completed in July 2018 and January 2019. Spring 7 was unable to be accessed in January 2019. The EMP states that the spring inspections should be undertaken following heavier rainfall, however previous monitoring events in spring surveys collected following rain affected the ability at some locations to determine whether the spring flow had increased or whether the ground was saturated due to rainfall. Heavy rainfall also generally impedes access to many spring locations and therefore continuing to include a spring monitoring event in the summer months is recommended, and the EMP should be updated to reflect this.

8.0 Conclusions

The key conclusions of this annual review are as follows:

- Groundwater levels appear to be generally falling and consistent with rainfall trends (AMRR) over the monitored time period.
- MB03B and MB05B, show a minor rise in groundwater levels over the year, which are well within any historical levels, and considered to reflect removal of overburden material and likely higher recharge rates.
- Salinity (based on EC levels) of the springs monitored were well within historical levels and within relevant criteria.
- SP05 was dry, as has been noted since at least 2009, with SP10, also noted to be dry since 2014, due to changed site conditions.

In summary, the monitoring collected over the 2018 monitoring period does not show impacts from on the relevant beneficial uses of groundwater based on quarry operations.

9.0 Recommendations

The following recommendations are made;

- Continue groundwater level monitoring at all bores quarterly;
- Record a summary of extensions to the quarry, revegetation to parts of the plateau surface and progressive rehabilitation of quarry on a quarterly basis;
- Remove site SP10 from the annual spring survey for future monitoring events as due to modification, this area is not appropriate to assess seepage;
- Due to the access issues at the site associated with bogging and mud following such rainfall events, survey following high rainfall events are impeded and are not considered necessary to assess impact. Update the EMP to include a spring monitoring event in the drier summer months, when evidence of springs will be more apparent and
- Revise the current EMP to reflect recent changes to the SEPP Waters regulatory framework.

Yours faithfully

pp

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Attachments

Attachment 1 Figures

Attachment 2 Tables

Attachment 3 Charts

Attachment 4 Site photographs

Attachment 5 2018 Areas of Overburden Placement and Revegetation

Limitations

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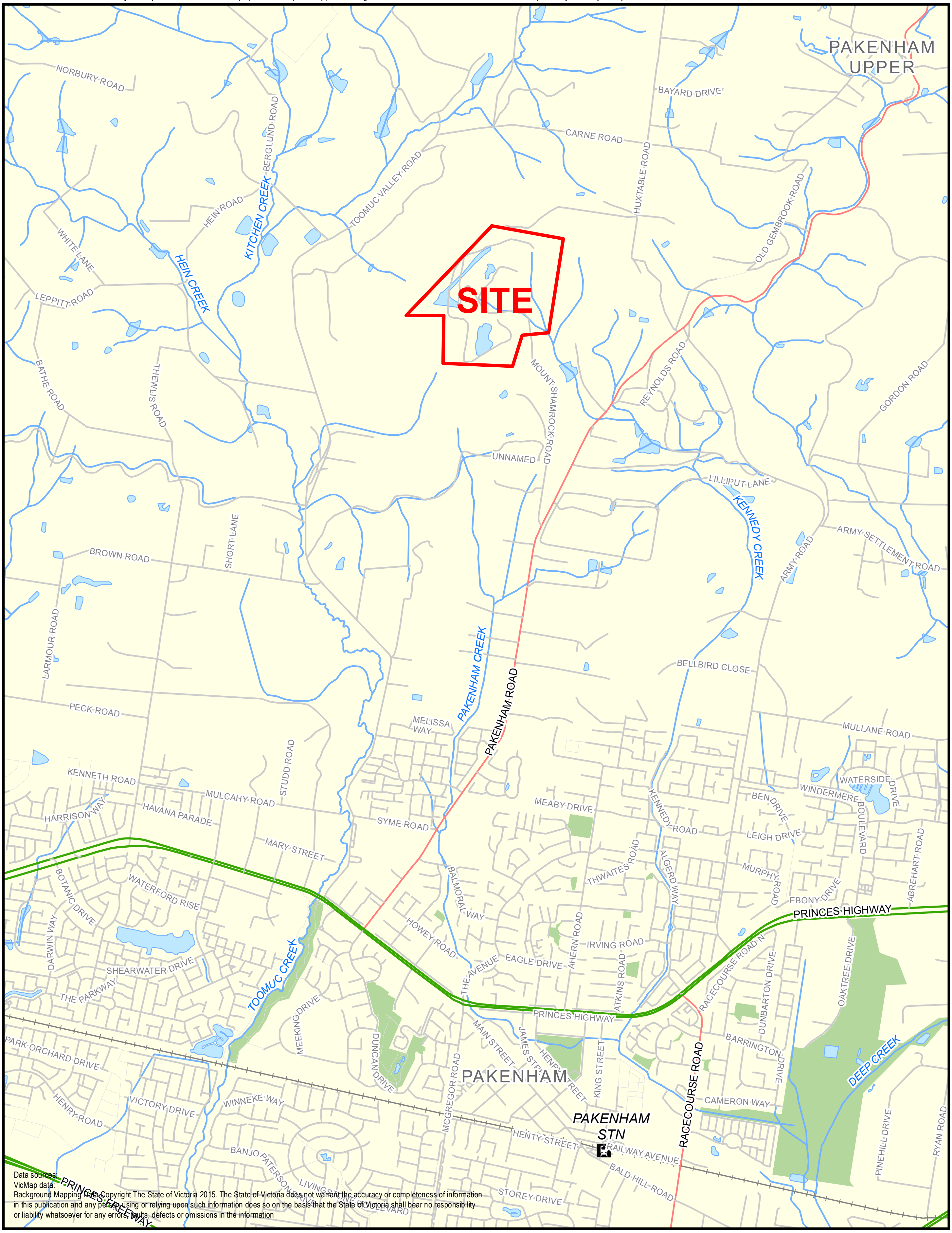
Attachment 1

Figures

AECOM does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. AECOM shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.



PROJECT ID	60451395
CREATED BY	DJB
LAST MODIFIED	T SMITH 05 FEB 2019

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N

DATUM GDA 1994, PROJECTION MGA ZONE 55

0 270 540 810 1,080

metres

1:35,000 when printed at A4

Legend

Site Boundary

SITE LOCATION PLAN

Holcim (Australia) Pty Ltd

Groundwater and Spring Review

Mt Shamrock Road, Pakenham

Figure

1

Map Document: (\\aumel1fp003.au.aecomnet.com\GIS\Jobs\43283833\GIS\MXD\2018 Survey\Figure 1.mxd)

A4 size

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N

DATUM GDA 1994, PROJECTION MGA ZONE 55

0 40 80 120 160
metres

1:7,500 when printed at A4

Legend

- Monitoring Bore Location
- Monitoring Bore (Decommissioned)

NOTE:
* Location not surveyed- approximate only.

GROUNDWATER MONITORING LOCATIONS

Holcim (Australia) Pty Ltd

Groundwater and Spring Review

Mt Shamrock Road, Pakenham

Figure **2**

Map Document: (\\aumel1fp003.au.aecomnet.com\GIS\Jobs\43283833\GIS\MXD\2018 Survey\Figure 2.mxd)

A4 size

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AECOM

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DATUM GDA 1994, PROJECTION MGA ZONE 55

0 50 100 150 200
metres

1:8,000 when printed at A4

Legend

● Spring Location

550 EC (uS/cm) - January 2019

SPRING LOCATIONS AND ELETRICAL CONDUCTIVITY RESULTS

Holcim (Australia) Pty Ltd

Groundwater and Spring Review

Mt Shamrock Road, Pakenham

Figure

3

Attachment 2

Tables

Table 1- Historic Groundwater Elevation Monitoring Data
Mt Shamrock Quarry, Pakenham

Date	MB01 (Werribee)- Relative Water Level mAHD	MB02, MB2a, MB2b (Werribee)- Relative Water Level mAHD	MB03, MB3b (Werribee) - Relative Water Level mAHD	MB04, MB4a, MB4b (Basalt)- Relative Water Level mAHD	MB05, MB05b (Basalt)- Relative Water Level mAHD	MB06 (Basalt)- Relative Water Level mAHD
30/3/01	175.84	163.35	180.16	163.55	183.76	177.84
6/4/01	#N/A	163.35	#N/A	163.39	#N/A	#N/A
7/5/01	175.75	163.63	180.26	163.56	183.55	177.21
24/5/01	175.94	163.67	180.40	163.55	183.46	177.00
31/5/01	175.92	163.62	180.32	163.57	183.36	176.87
7/6/01	175.96	163.63	180.33	163.50	183.34	176.87
14/6/01	176.04	163.70	180.32	163.75	183.30	176.77
21/6/01	176.01	163.87	180.25	163.68	183.23	176.78
28/6/01	175.95	163.75	180.18	163.51	183.04	176.62
5/7/01	176.00	163.73	180.23	163.48	183.13	176.61
12/7/01	175.96	163.73	180.14	163.59	183.02	176.56
19/7/01	175.95	163.75	180.11	163.56	182.95	176.52
26/7/01	175.95	163.74	180.05	163.45	182.87	176.54
2/8/01	175.93	163.76	180.02	163.63	182.85	176.52
9/8/01	175.94	163.75	180.05	163.48	182.84	176.46
16/8/01	175.91	163.57	180.00	163.45	182.75	176.51
23/8/01	175.86	163.85	179.94	163.77	182.68	176.33
30/8/01	175.86	163.78	179.91	163.60	182.60	176.38
6/9/01	175.74	163.82	179.94	163.53	182.53	176.38
13/9/01	175.91	163.89	179.82	163.53	182.55	176.36
20/9/01	175.89	163.87	179.75	163.46	182.50	176.51
27/9/01	175.89	163.75	179.70	163.54	182.55	176.56
4/10/01	175.89	163.64	179.78	163.53	182.65	176.68
11/10/01	175.93	163.63	179.80	163.55	182.69	176.78
18/10/2001	175.94	163.60	179.82	163.60	182.75	176.79
25/10/2001	175.95	163.66	179.82	163.61	182.79	176.80
1/11/2001	175.93	163.99	179.75	163.55	182.77	176.74
8/11/2001	175.93	163.92	179.72	163.53	182.76	176.71
15/11/2001	175.93	163.95	179.70	163.57	182.73	176.69
22/11/2001	175.98	164.00	179.74	163.50	182.78	176.70
30/11/2001	176.03	163.89	179.74	163.44	182.77	176.71
7/12/2001	176.00	163.79	179.94	163.58	182.79	176.65
20/12/2001	176.01	163.66	179.63	163.06	182.70	176.67
11/01/2002	176.00	163.47	179.48	163.03	182.56	176.61
18/01/2002	175.99	163.46	179.47	163.03	182.54	176.62
25/01/2002	175.96	163.42	178.99	163.37	182.44	176.50
1/02/2002	175.97	163.41	179.29	163.02	182.41	176.46
11/02/2002	175.94	163.59	179.20	163.43	182.35	176.32
20/02/2002	175.85	163.52	179.17	163.40	182.27	176.29
28/02/2002	175.81	163.32	179.11	163.08	182.14	176.17
11/06/2002	175.61	163.13	178.41	162.54	180.94	#N/A
16/10/2002	175.33	163.32	177.60	163.20	179.77	175.02
30/01/2003	175.02	162.79	176.81	162.14	178.77	174.59
27/06/2003	174.54	163.06	175.75	162.65	177.55	174.06
9/07/2003	174.44	163.08	175.54	162.44	177.44	174.00
11/09/2003	174.77	163.40	175.28	162.71	177.06	174.04
1/11/2003	#N/A	162.93	175.06	162.87	177.10	176.52
27/02/2004	174.64	162.37	175.51	162.66	177.99	175.87
19/05/2004	174.51	162.98	175.90	162.76	178.74	175.01
21/07/2004	175.00	163.55	177.20	162.89	178.85	175.02
3/09/2004	175.22	163.70	176.72	163.11	180.55	176.44
10/11/2004	176.32	163.60	179.57	163.32	187.29	179.90
13/01/2005	177.30	163.49	181.33	162.89	188.74	179.78
20/03/2008	170.70	164.01	174.59	163.46	177.18	172.31
18/07/2008	169.00	164.52	174.04	163.53	176.59	172.35
29/09/2008	171.77	164.62	173.59	163.53	174.92	172.26
22/12/2008	173.10	Bore Destroyed	173.29	Bore Destroyed	175.50	171.81
2/04/2009	173.54	Installation and monitoring of MB2a commences	172.59	Installation and monitoring of MB4a commences	174.14	171.56
18/06/2009	174.04	*178.60*	172.99	*177.00*	174.84	171.56
18/08/2009	174.94	*178.60*	173.09	*177.70*	174.84	171.56
29/09/2009	175.54	*178.80*	172.99	*178.66*	174.74	171.46
13/12/2009	176.10	*178.84*	173.29	*179.00*	174.94	170.86
11/03/2010	176.05	*179.14*	173.31	*179.15*	173.92	171.44
15/06/2010	176.19	*179.03*	173.35	*179.53*	174.89	171.46
3/08/2010	176.34	*179.31*	173.51	*180.10*	175.02	171.43
25/11/2010	177.34	*180.57*	175.27	*181.58*	178.79	172.36
26/01/2011	177.24	*182.38*	178.07	*181.30*	177.54	173.46
1/03/2011	178.31	*180.40*	176.49	*183.60*	182.49	173.92
14/06/2011	178.25	Bore Destroyed	179.91	Bore Destroyed	184.35	174.85
8/09/2011	176.44	#N/A	Bore Destroyed	#N/A	Bore Destroyed	174.76
14/12/2011	173.64	#N/A	#N/A	#N/A	#N/A	#N/A
14/01/2012	173.74	#N/A	#N/A	#N/A	#N/A	176.56
29/02/2012	174.74	#N/A	#N/A	#N/A	#N/A	176.28
12/04/2012	175.44	#N/A	#N/A	#N/A	#N/A	175.81
10/05/2012	175.34	#N/A	#N/A	#N/A	#N/A	175.66
9/07/2012	174.94	#N/A	#N/A	#N/A	#N/A	175.83
3/08/2012	172.84	#N/A	#N/A	#N/A	#N/A	175.81
12/09/2012	174.94	#N/A	#N/A	#N/A	#N/A	175.86
10/10/2012	175.04	#N/A	#N/A	#N/A	#N/A	175.96
14/02/2013	175.19	#N/A	#N/A	#N/A	#N/A	176.06
12/03/2013	175.08	#N/A	#N/A	#N/A	#N/A	176.30
8/04/2013	175.04	#N/A	#N/A	#N/A	#N/A	175.81
4/06/2013	174.89	#N/A	#N/A	#N/A	#N/A	176.06
2/07/2013	174.54	#N/A	#N/A	#N/A	#N/A	175.81
5/08/2013	172.79	#N/A	#N/A	#N/A	#N/A	177.91
9/09/2013	175.04	#N/A	#N/A	#N/A	#N/A	175.81

Table 1- Historic Groundwater Elevation Monitoring Data
Mt Shamrock Quarry, Pakenham

Date	MB01 (Werribee)- Relative Water Level mAHD	MB02, MB2a, MB2b (Werribee)- Relative Water Level mAHD	MB03, MB3b (Werribee) - Relative Water Level mAHD	MB04, MB4a, MB4b (Basalt)- Relative Water Level mAHD	MB05, MB05b (Basalt)- Relative Water Level mAHD	MB06 (Basalt)- Relative Water Level mAHD
7/10/2013	175.04	#N/A	#N/A	#N/A	#N/A	175.81
12/11/2013	172.47	#N/A	#N/A	#N/A	#N/A	177.41
10/12/2013	174.29	#N/A	#N/A	#N/A	#N/A	175.44
13/01/2014	175.04	#N/A	#N/A	#N/A	#N/A	175.91
11/02/2014	175.04	#N/A	#N/A	#N/A	#N/A	178.11
10/03/2014	176.04	#N/A	#N/A	#N/A	#N/A	176.96
8/04/2014	174.04	#N/A	#N/A	#N/A	#N/A	175.32
15/05/2014	174.39	#N/A	#N/A	#N/A	#N/A	175.46
10/06/2014	175.04	Installation and monitoring of MB2b commences	Installation and monitoring of MB3b commences	Installation and monitoring of MB4b commences	Installation and monitoring of MB5b commences	176.23
19/02/2015	No access	No access	170.92	No access	171.28	No access
28/03/2015	172.51	173.15	170.61	173.09	170.98	174.88
25/05/2015	172.52	173.29	170.17	173.08	170.52	174.34
23/06/2015	172.69	173.29	170.20	173.37	170.56	174.30
23/07/2015	172.46	173.29	170.08	173.21	170.42	174.12
31/08/2015	172.25	173.45	169.92	173.26	170.26	173.84
29/09/2015	172.12	173.48	169.98	173.32	170.32	173.77
30/10/2015	171.86	173.30	170.04	173.20	170.39	173.71
27/11/2015	171.56	173.21	169.92	173.11	170.26	173.59
17/12/2015	171.47	173.10	169.87	173.03	170.22	173.53
26/02/2016	173.07	172.70	169.46	172.85	169.78	173.20
17/06/2016	170.98	173.24	169.22	Dry, bore damaged	169.54	172.87
28/09/2016	171.00	173.24	170.36	172.66	170.79	172.92
15/12/2016	171.06	177.36	170.78	172.28	171.21	173.50
8/05/2017	171.70	172.08	170.10	171.96	170.50	173.38
9/08/2017	171.58	171.62	170.24	171.46	170.69	172.99
9/10/2017	171.33	171.52	170.92	171.26	171.44	171.84
8/12/2017	171.11	171.18	170.69	170.97	171.16	172.70
12/04/2018	170.62	171.32	170.26	170.82	170.70	172.45
3/07/2018	169.875	171.1	170.92	170.89	171.515	172.2
9/10/2018	169.717	171.165	171.71	170.99	172.313	172.035
8/01/2019	169.617	171.235	172.03	171.00	172.565	171.898

#NA No gauging data available

Italics *RL mAHD estimated from client provided GPS data*

Table 2- Annual Rainfall Dandenong (086224)

Monthly totals (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1960	null	null	null	null	null	null	null	null	null	60.2	138.4	13.2	null
1961	32.6	42.3	48.4	91.4	72.3	80.5	74.9	106.8	41.3	55.1	26.6	44.5	716.7
1962	54	41.4	21.4	30.2	143.4	75.4	69	94.4	69	106.1	24.8	52.3	781.4
1963	157.6	38.6	47	13.5	91.9	63.1	87.8	66.3	95.1	79.1	38	23.8	801.8
1964	11	112.5	41.4	83.9	76	55.6	90.2	81.9	108.1	111.7	55.6	125.6	953.5
1965	20.3	3	42.1	128.4	58.4	16.9	98.4	87.2	42.9	28.5	74.5	49.3	649.9
1966	50	null	null	null	null	null	null	null	null	null	null	null	null
1967	null	null	27.7	29	56.9	56.9	38.6	104.2	81.4	22.9	45.2	60.3	null
1968	26.7	4.9	18.7	114.5	131.7	83.5	68.2	64.2	47.9	64.8	71.3	72.6	769
1969	37.5	104.1	65	33.2	120	20	65.7	56.1	93.6	24.9	51.8	67.1	739
1970	101.9	16.5	153.8	107.5	126	58.4	62.2	123.4	56.2	58.4	72.2	109.7	1046.2
1971	56	63.2	26.4	83.8	139.8	84.8	41.7	53.4	64.4	133.7	116.9	79.2	943.3
1972	52.3	172.2	14	92.6	52	17.3	64.8	60.8	49.3	null	null	null	null
1973	57.2	198.7	101.1	44.7	74.1	73.2	44.6	76.7	54	98.1	60.2	56.1	938.7
1974	54.2	27	68.8	119	149.6	16.9	97.2	94.8	83.7	74.4	35	76.7	897.3
1975	41.2	10.6	55.6	31.6	63.6	54.4	67.6	116.9	109.8	143.4	60.4	47	802.1
1976	26.6	9.3	51.8	37	27.4	43.6	22.1	71.4	85.9	66	89.2	69.4	599.7
1977	46	57.3	22.4	88.2	89	135	80	41.7	49.6	41	38.5	24.8	713.5
1978	43.4	86.4	45.4	56	86.3	28.1	94.8	101.7	90	63.4	113.6	131.3	940.4
1979	53	47.6	26.2	52.2	92.6	50	30.2	84.6	96.7	105.9	27.8	23.9	690.7
1980	46	8.2	14.7	88.1	52.8	71.6	64.8	54.2	36	116.8	48.6	47.6	649.4
1981	44.6	17.2	63.8	55.6	93.8	91	95.4	101.8	28.4	61.8	84.2	44	781.6
1982	59.2	14	52.2	74.2	73.8	56.3	28.8	24.9	49.8	42.2	12	46	533.4
1983	48.8	3.6	39.6	46.4	72	75.4	67	74.6	93.6	92.8	107.4	24	745.2
1984	54	38.2	89.4	50.4	28	41.2	63.2	80.2	130	57.6	63.8	48.2	744.2
1985	17.6	6.6	42	83	58.4	69.8	75.4	82.1	36.8	105	73.4	113.6	763.7
1986	35.9	19	13.2	66	90.6	53	106.8	53.2	52	81.4	27.4	74.2	672.7
1987	49.6	45.8	68	34.4	76.6	76.2	88.6	34	45.8	47.4	52.8	72	691.2
1988	61.6	16.8	28.6	28.4	78.2	83.8	77.8	58.6	70.8	39.8	111	77.4	732.8
1989	45.7	11.8	78.8	91.6	64.6	87.9	70.4	72.3	66	120.4	28.8	37.3	775.6
1990	0.8	65.3	24.3	80	23.8	68.2	94.4	79.6	62.8	90	61.4	26.1	676.7
1991	131.7	0.6	33	43.9	28.3	141	97.2	79.6	100.5	21.3	33	79	789.1
1992	33	27.4	55.5	64.5	86.8	53.2	44.1	64.5	140.6	92.1	122.4	92.8	876.9
1993	120.8	99.7	42.8	22.1	39.2	81	54.4	76.5	153.1	107.2	91.1	160.4	1048.3
1994	52.9	108.1	null	46	41.3	48.8	18.6	30.8	73.2	35.2	65.7	10.8	null
1995	94.2	21.6	93.2	118.3	93.2	101	96.8	60.8	49.6	84	null	47.5	null
1996	98.8	89.2	null	null	null	null	null	null	null	null	null	null	null
2002	51.2	81.8	26	60.6	70.6	62.6	39.8	46.2	63.8	47.8	28.8	34.2	613.4
2003	33	31.2	70	110.2	45.8	38.4	117.4	77	59.2	104.4	57	49	792.6
2004	42.2	22	22.6	50.4	51.2	129.8	58.4	91.4	96	57.2	163	45.4	829.6
2005	30.2	171.8	23.6	34.2	26.6	47	45.6	93	79.8	52	92.2	88	784
2006	59.6	90.2	26.2	108	58.6	18.2	43.8	47.4	31.8	17.4	43	58.6	602.8
2007	34	11.6	50.8	21.6	62.6	62.6	91.8	40	50.6	29.6	76.6	161.6	693.4
2008	17.4	31.6	27.4	33	60.4	45	66.6	76.2	31.6	26.2	90.6	81.4	587.4
2009	4.6	2.2	51.2	79.4	16.4	36.4	78.8	69	113.2	59	113.4	45.4	669
2010	40.4	27.2	90.8	61.4	65.8	107.6	41.8	101.8	63.6	147	121.4	98.2	967
2011	113.8	205.4	61	77.6	99.1	49.6	69.8	32.6	94.9	91.1	134.8	78.3	1108
2012	45.2	69.8	76.6	107	110.8	135.6	77	64.8	73.2	62.1	58.4	57.4	937.9
2013	5.6	73	71.4	22.2	68	116	85.2	95.4	79.1	78.3	106.6	69.8	870.6
2014	27.2	24.4	26	97.3	52.2	101.7	59.2	48	60.4	59.2	73.4	49.8	678.8
2015	51.6	43	41.4	62.6	75	32.6	85.4	81.7	48	20.4	50.4	42	634.1
2016	71	13.4	32.2	69	95.4	88.4	95.6	67.2	86	107.2	63.2	65.2	853.8
2017	28	92.2	60	119.8	42.4	35	30.2	81.8	48.4	54.8	30.8	131.8	755.2
2018	*86.2*	7.5	29	21.8	97.2	*71.6*	*63.2*	*54.2*	*41*	*54.8*	*135.4*	94.2	756.1
2019													
	Italics- data not verified												
	50.42549	52.39	48.43878	65.99412	73.53922	66.39	68.562	72.554	71.75	71.1449	68.50417	66.74694	778.6745
	40.9375	61.925	47.325	66.82941	64.59412	69.15625	67.9	69.59375	67.475	63.35625	81.475	72.25625	772.5706

Spring Survey Field Parameters

Table 3- Historic Field Parameters Recorded at Spring Locations
Pakenham Quarry

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*
		µS/cm		mV	mg/L	°C	mg/L
SP01	13-Feb-01	905	7.53	193	-	22.9	588
	6-Apr-01	1013	6.65	240	1.03	18.4	658
	7-May-01	1079	7.21	215	5.67	17.2	701
	15-Jun-01	886	8.21	151	7.11	16.1	576
	11-Jul-01	994	7.31	194	**	15.8	646
	13-Aug-01	1104	7.25	189	8.07	17.0	718
	17-Sep-01	958	7.16	203	5.91	17.0	623
	4-Oct-01	1048	7.17	230	**	16.0	681
	20-Nov-01	721	7.06	320	6.07	16.1	469
	17-Dec-01	1025	7.17	190	9.78	18.8	666
	22-Feb-02	1054	7.36	173	5.28	22.7	685
	12-Jun-02	946	6.88	8	4.68	14.7	615
	30-Jan-03	1260	7.21	43	5.98	19.7	819
	27-Jun-03	1127	7.08	208	6.10	10.6	733
	21-Jul-04	988	7.57	305	**	12.1	642
	12-Mar-09	1140	7.11	-	-	-	741
	25-Jun-10	1076	7.80	-	-	-	699
	28-Mar-12	1049	***	-	-	19.3	682
	25-Jun-13	947	7.58	79.9	10.39	14.4	616
	15-May-14	1043	7.60	18	9.3	15.8	678
	26-Feb-16	1674	6.42	105	0.25	16.6	1088
	18-Jan-17	1156	7.99	73	4.33	20.3	751
	9-Oct-17	1120	6.99	167	6.16	14.9	728
	3-Jul-18	1470	7.01	197	5.70	12.3	956
	8-Jan-19	1323	7.38	73.8	6.15	16.1	860
SP02	13-Feb-01	3240	8.01	166	-	20.8	2106
	6-Apr-01	3090	7.24	219	0.00	19.4	2009
	7-May-01	3030	7.78	187	4.18	13.8	1970
	15-Jun-01	2450	8.66	130	7.39	14.5	1593
	11-Jul-01	2510	7.95	166	**	12.5	1632
	13-Aug-01	2650	8.08	202	7.68	14.2	1723
	17-Sep-01	2600	8.38	135	8.03	16.4	1690
	4-Oct-01	2480	7.83	168	**	14.7	1612
	20-Nov-01	2630	8.32	139	6.14	18.1	1710
	17-Dec-01	2270	7.07	197	6.87	18.0	1476
	22-Feb-02	2660	7.04	191	2.02	21.9	1729
	12-Jun-02	1813	7.41	201	4.59	12.0	1178
	30-Jan-03	4320	7.15	-40	1.28	21.7	2808
	27-Jun-03	3230	7.63	183	7.68	10.3	2100
	21-Jul-04	1829	8.20	311	**	9.9	1189
	12-Mar-09	2990	7.56	-	-	-	1944
	25-Jun-10	2209	8.15	-	-	-	1436
	28-Mar-12	2342	***	-	-	21	1522
	25-Jun-13	2029	8.09	106.3	11.09	12.5	1319
	15-May-14	2140	7.65	39	12.8	12.3	1391
	26-Feb-16	3130	6.41	199	7.34	17.8	2035
	18-Jan-17	2456	7.38	-18	2.26	20.2	1596
	9-Oct-17	2405	7.02	52	2.72	15	1563
	3-Jul-18	2290	6.05	243	5.66	7.8	1489
	8-Jan-19	2829	7.19	-107	6.11	17.5	1839

Spring Survey Field Parameters

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*
SP03	21-Nov-01	540	6.80	242	0.12	18.2	351
	17-Dec-01	696	7.32	177	5.01	17.9	452
	22-Feb-02	592	7.38	187	2.38	22.6	385
	12-Jun-02	696	7.55	192	2.42	12.7	452
	30-Jan-03	758	8.57	153	6.28	20.7	493
	27-Jun-03	727	6.85	203	7.82	12.3	473
	21-Jul-04	713	7.86	295	**	11.9	463
	12-Mar-09	899	7.16	-	-	-	584
	25-Jun-10	599	7.62	-	-	-	389
	28-Mar-12	599	***	-	-	11.3	389
	25-Jun-13	589	7.91	72.1	7.86	12.6	383
	15-May-14	552	8.50	39.5	4.05	13.9	359
	26-Feb-16	1022	6.37	84	7.34	17.6	664
	18-Jan-17	674	7.88	52	2.55	19.7	438
	9-Oct-17	655	6.97	101	7.30	14.5	426
	3-Jul-18	669	7.8	200	8.31	10.4	435
	8-Jan-19	784	7.39	-430	5.10	18.2	510
SP04	17-Dec-01	1206	7.11	196	2.05	17.1	784
	22-Feb-02	928	7.08	185	3.75	21.8	603
	12-Jun-02	Could not find any signs of flow, ground wet in this area.					
	30-Jan-03	1359	7.58	145	6.08	18.1	883
	27-Jun-03	1096	7.89	176	8.07	11.5	712
	21-Jul-04	1031	8.84	296	**	11.6	670
SP04(N)	12-Mar-09	1469	7.43	-	-	-	955
SP04 (S)	12-Mar-09	1342	7.69	-	-	-	872
	25-Jun-10	1080	6.75	-	-	-	702
	28-Mar-12	1099	***	-	-	19.5	714
	25-Jun-13	1414	7.39	15.5	0.00	14.9	919
	15-May-14	875	7.43	-43	4.05	12.7	569
	26-Feb-16	1078	6.80	97	1.24	17.8	701
	18-Jan-17	1004	7.92	65	4.33	20.3	653
	9-Oct-17	1498	6.89	232	3.33	14.5	974
	3-Jul-18	Spring dry. Vegetation healthy.					
	8-Jan-19	Spring dry. Vegetation healthy.					
SP05	21-Nov-01	434	6.93	107	5.04	16.6	282
	17-Dec-01	2350	6.92	206	5.24	17.3	1528
	22-Feb-02	487	6.76	207	1.77	22.0	317
	12-Jun-02	Could not find any signs of flow, ground wet in this area.					
	30-Jan-03	No obvious water even with digging, but area green					
	27-Jun-03	612	7.85	212	6.01	10.2	398
	21-Jul-04	280	7.34	280	**	9.9	182
	12-Mar-09	Could not locate, no obvious flow					
	25-Jun-10	Could not locate, no obvious flow					
	28-Mar-12	Could not find signs of flow					
	25-Jun-13	Could not be located					
	15-May-14	Spring dry					
	26-Feb-16	Spring dry					
	18-Jan-17	Spring dry					
	9-Oct-17	Spring dry					
	3-Jul-18	Spring dry. Vegetation healthy.					
	8-Jan-19	Spring dry. Vegetation healthy.					

Spring Survey Field Parameters

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*
SP06	4-Oct-01	574	7.65	174	**	16.5	373
	21-Nov-01	477	7.19	135	6.39	20.9	310
	17-Dec-01	638	7.04	195	3.22	21.5	415
	22-Feb-02	701	7.41	170	2.17	24.3	456
	30-Jan-03	720	8.01	103	5.75	17.0	468
	27-Jun-03	785	6.54	234	5.86	10.5	510
	21-Jul-04	463	8.01	315	**	11.7	301
	12-Mar-09	No flow					
	25-Jun-10	660	7.07	-	-	-	429
	28-Mar-12	No flow					
	25-Jun-13	388	7.12	51.9	5.30	16.6	252
	15-May-14	527	7.58	-40.5	13.00	13.6	343
	26-Feb-16	846	6.98	143.0	3.86	22.2	550
	18-Jan-17	Spring dry					
	9-Oct-17	Not able to be accessed					
	3-Jul-18	543	7.32	222	8.52	9.8	353
	8-Jan-19	592	8.1	38.7	10.62	22.3	385
SP07	4-Oct-01	758	7.74	166	**	15.4	493
	21-Nov-01	406	7.05	110	7.03	21.1	264
	12-Jun-02	627	7.04	218	3.45	13.2	408
	12-Mar-09	No flow					
	25-Jun-10	493	6.14	-	-	-	320
	28-Mar-12	831	***	-	-	16.4	540
	25-Jun-13	251	7.56	98.9	10.55	14.6	163
	15-May-14	No flow					
	26-Feb-16	Dry					
	18-Jan-17	Dry					
	9-Oct-17	Not able to be accessed					
	3-Jul-18	Not able to be accessed					
	8-Jan-19	Not able to be accessed					
SP08	21-Nov-01	1748	7.12	118	4.60	17.9	1136
	17-Dec-01	642	7.11	194	2.95	19.2	417
	22-Feb-02	611	7.81	131	7.83	25.2	397
	12-Jun-02	731	7.36	201	3.61	12.6	475
	30-Jan-03	880	7.60	122	4.76	18.4	572
	27-Jun-03	1103	6.73	232	6.98	9.6	717
	21-Jul-04	572	8.02	323	**	11.7	372
	12-Mar-09	No flow					
	25-Jun-10	No flow					
	28-Mar-12	706	***	-	-	16.4	459
	25-Jun-13	457	7.57	100.3	10.42	14.6	459
	15-May-14	606	7.88	32	13	13	297
	26-Feb-16	1369	6.29	116	4.7	22.1	394
	18-Jan-17	Spring dry					
	9-Oct-17	Not able to be accessed					
	3-Jul-18	504	6.62	222	5.76	8.6	328
	8-Jan-19	1103	7.79	86.2	6.98	21.7	717

Spring Survey Field Parameters

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*
SP09	22-Feb-02	229	6.90	198	6.90	23.3	149
	12-Jun-02	Could not find any signs of flow, ground wet in this area.					
	30-Jan-03	Could not find any signs of flow, area green.					
	27-Jun-03	759	6.40	142	8.23	10.6	493
	21-Jul-04	909	7.04	254	4.52	8.9	591
	12-Mar-09	No flow					
	25-Jun-10	550	6.66	-	-		358
	28-Mar-12	676	***	-	-	20	439
	25-Jun-13	899	8.56	133.7	10.06	15.9	584
	15-May-14	1053	6.68	-40	1.7	15.4	684
	26-Feb-16	1798	6.40	-22	0.26	22.2	1169
	18-Jan-17	860	8.36	65	12.23	22.2	559
	9-Oct-17	1185	7.33	85	4.44	16.4	770.25
	3-Jul-18	1169	5.16	199	6.47	10.8	760
	8-Jan-19	1163	7.63	86.7	6.58	21.5	756
SP10	19-Apr-02	2819	6.15	260	9.52	17.4	1832
	12-Jun-02	2640	6.80	230	7.20	10.6	1716
	30-Jan-03	2292	7.43	43	6.15	24.6	1490
	27-Jun-03	1167	6.52	137	8.63	10.6	759
	21-Jul-04	374	7.71	282	9.13	9.2	243
	12-Mar-09	No flow					
	25-Jun-10	790	7.03	-	-	-	514
	28-Mar-12	1207	***	-	-	19.8	785
	25-Jun-13	578	7.37	29.8	6.99	11.3	376
	15-May-14	Spring dry					
	26-Feb-16	1616	6.34	73	8.48	19.7	1050
	18-Jan-17	Spring dry					
	9-Oct-17	Water as per SP09					
	3-Jul-18	Spring dry					
	8-Jan-19	Spring dry					

* TDS estimated by electrical conductivity x 0.65
**Dissolved Oxygen not recorded as probe malfunctioning
***pH readings not reported due to probe error

Groundwater salinity data

Table 4 - Historical groundwater bore development data

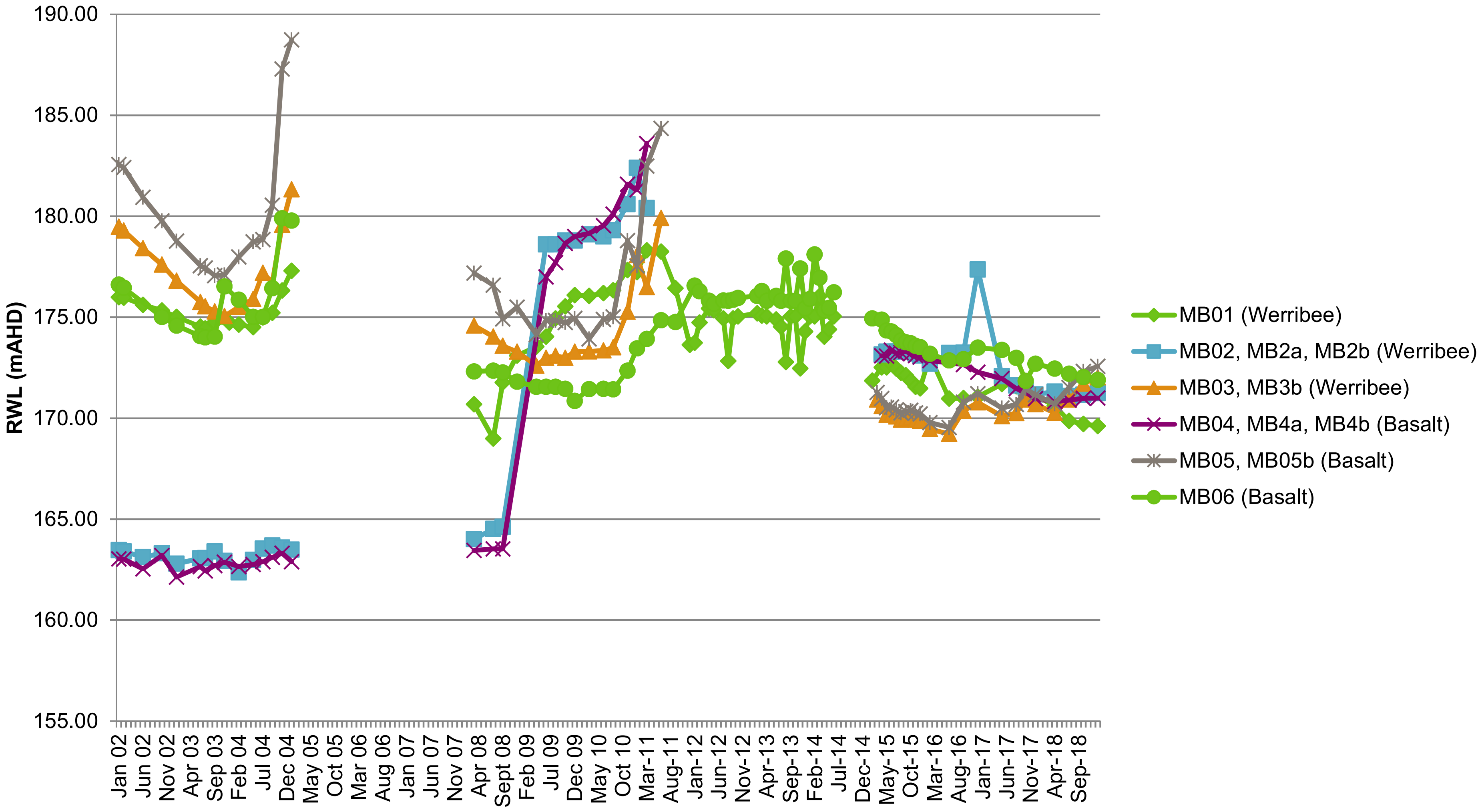
BORE ID	DATE	EC (µS/cm)	TDS* (mg/L)
MB04C	18/01/2017	3461	2318.87
MB02C	18/01/2017	2964	1985.88
MB02B	21/10/2014	2017	1351.39
MB04B	23/10/2014	2161	1447.87
MB03B	28/10/2014	1702	1140.34
MB05B	28/10/2014	1806	1210.02

* TDS calculation = EC (uS/cm) X 0.67

Attachment 3

Charts

Chart 1- Hydrograph



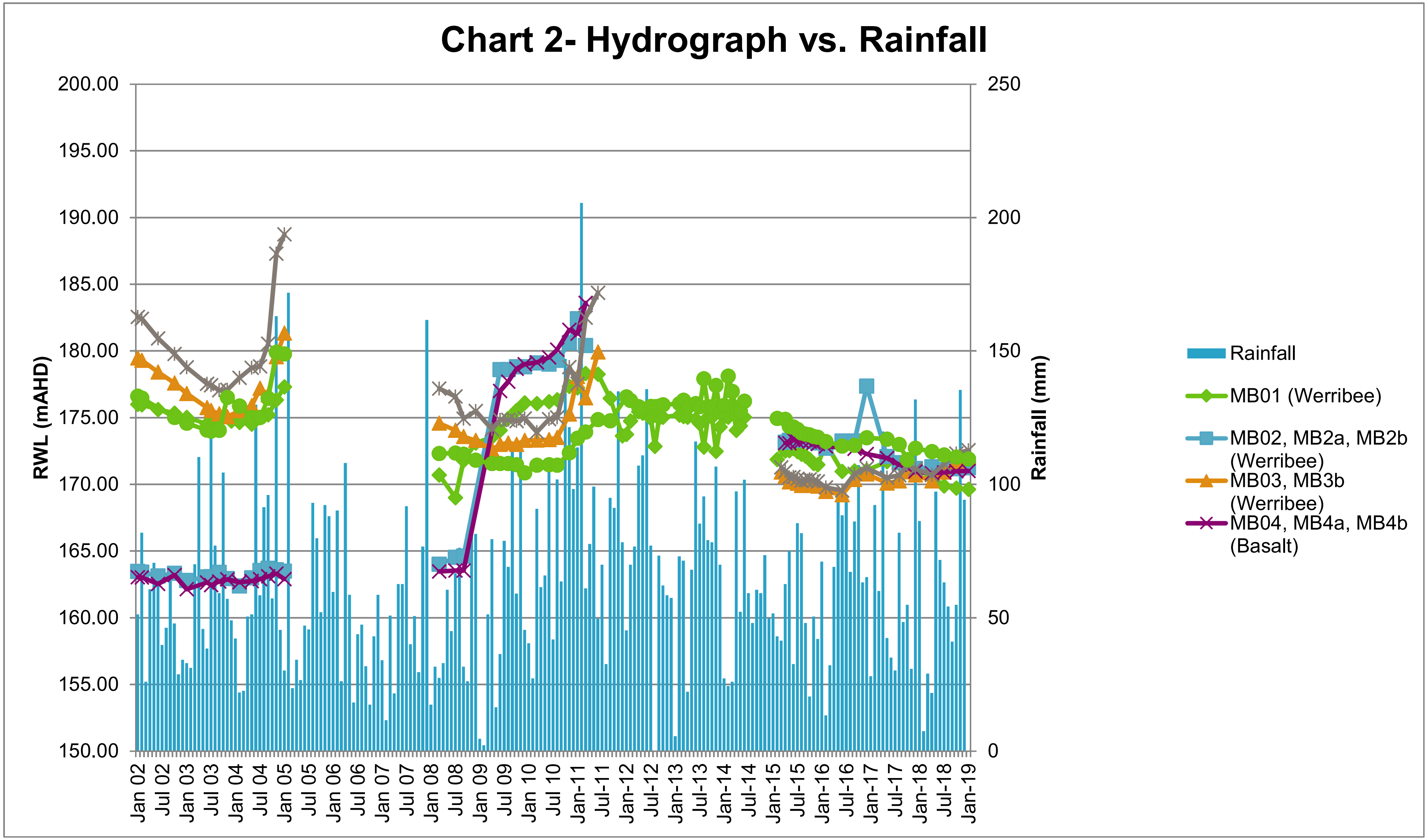


Chart 2- Hydrograph vs. Rainfall
RWL (mAHD)
200.00
195.00
190.00
185.00
180.00
175.00
170.00
165.00
160.00
155.00
150.00
Rainfall (mm)
250
200
150
100
50
0
Jan 02
Jul 02
Jan 03
Jul 03
Jan 04
Jul 04
Jan 05
Jul 05
Jan 06
Jul 06
Jan 07
Jul 07
Jan 08
Jul 08
Jan 09
Jul 09
Jan 10
Jul 10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Rainfall
MB01 (Werribee)
MB02, MB2a, MB2b (Werribee)
MB03, MB3b (Werribee)
MB04, MB4a, MB4b (Basalt)

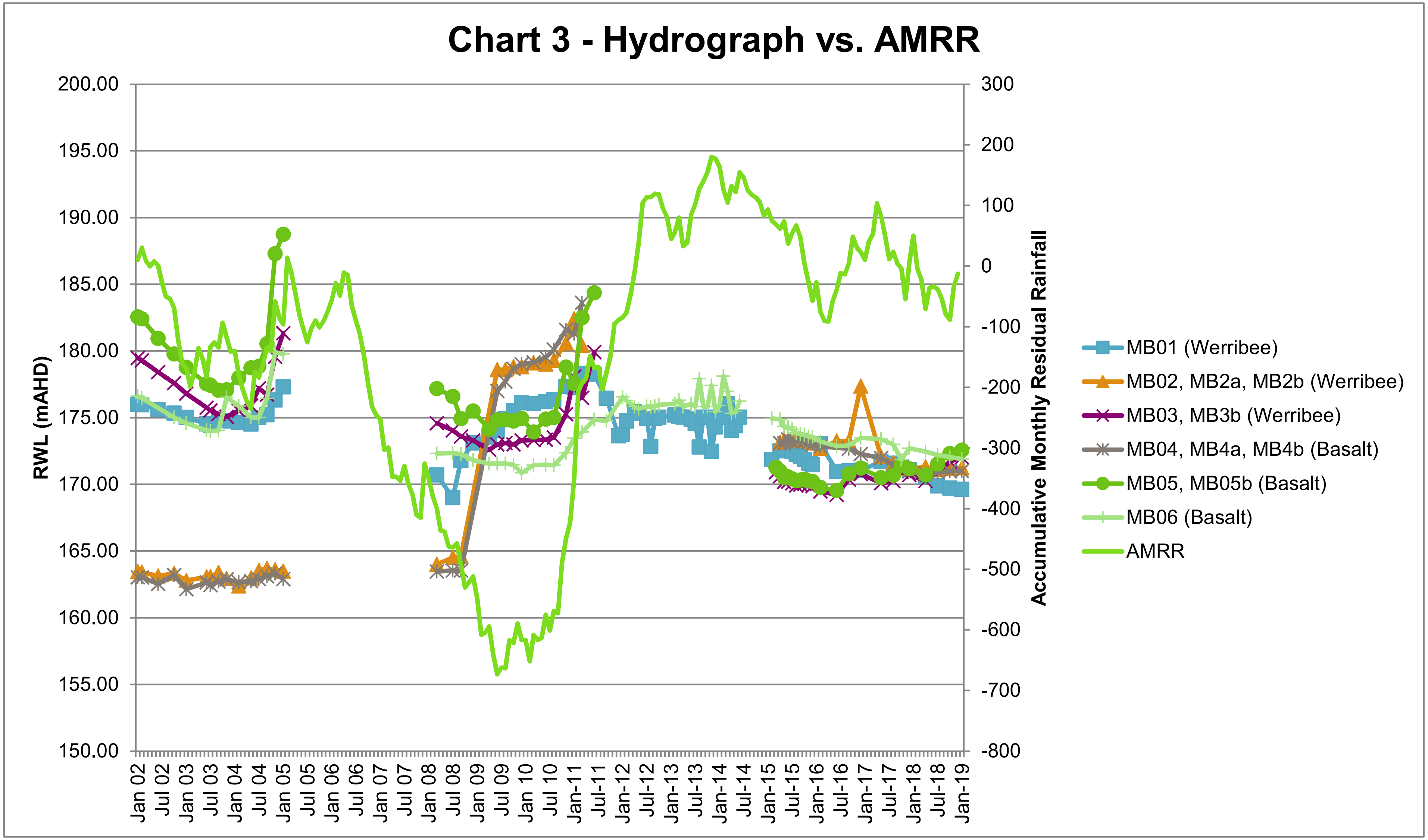


Chart 3 - Hydrograph vs. AMRR
RWL (mAHD)
Accumulative Monthly Residual Rainfall
200.00
195.00
190.00
185.00
180.00
175.00
170.00
165.00
160.00
155.00
150.00
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
Jan 02
Jul 02
Jan 03
Jul 03
Jan 04
Jul 04
Jan 05
Jul 05
Jan 06
Jul 06
Jan 07
Jul 07
Jan 08
Jul 08
Jan 09
Jul 09
Jan 10
Jul 10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
MB01 (Werribee)
MB02, MB2a, MB2b (Werribee)
MB03, MB3b (Werribee)
MB04, MB4a, MB4b (Basalt)
MB05, MB05b (Basalt)
MB06 (Basalt)
AMRR

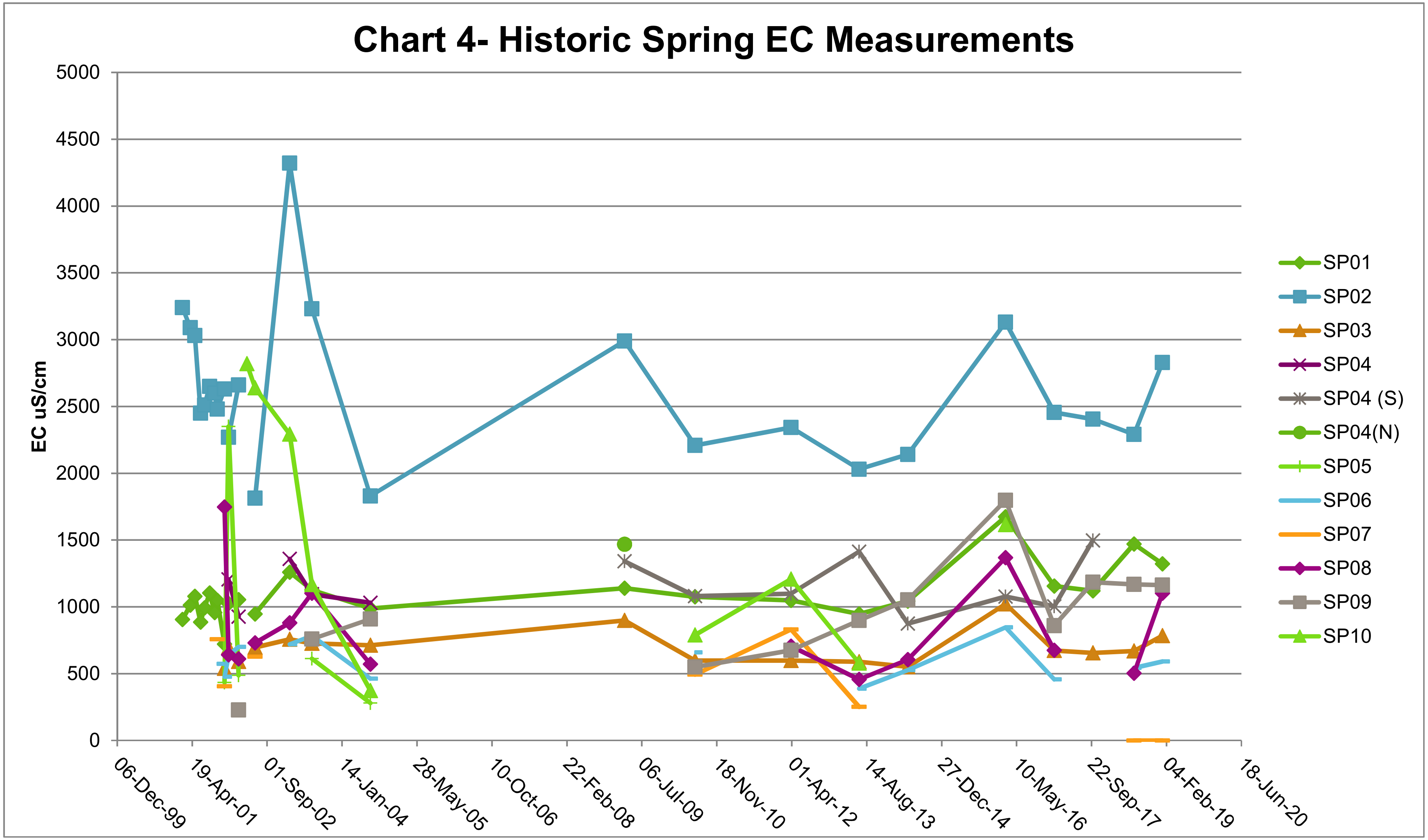


Chart 4- Historic Spring EC Measurements
EC uS/cm
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
06-Dec-99
19-Apr-01
01-Sep-02
14-Jan-04
28-May-05
10-Oct-06
22-Feb-08
06-Jul-09
18-Nov-10
01-Apr-12
14-Aug-13
27-Dec-14
10-May-16
22-Sep-17
04-Feb-19
18-Jun-20
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10

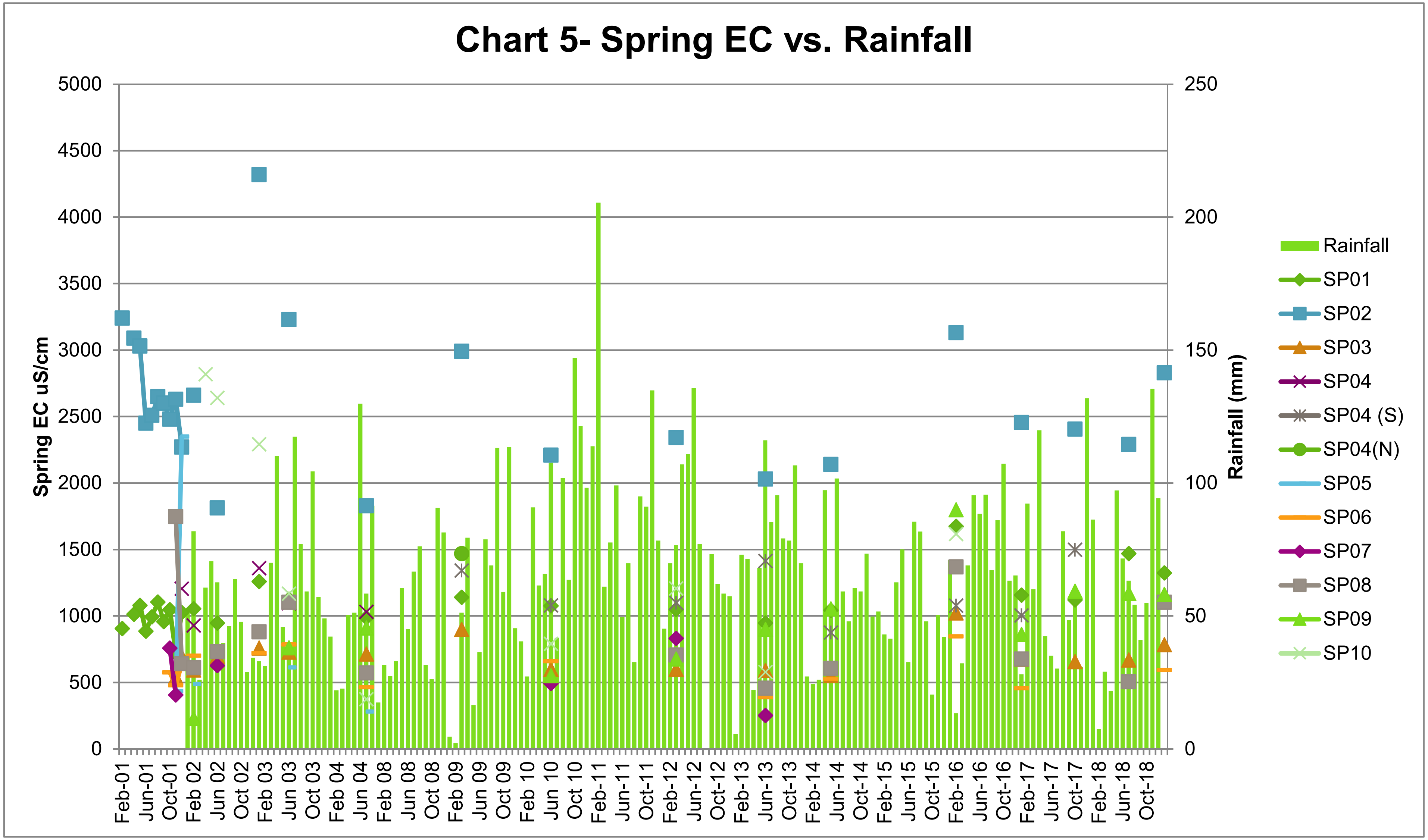


Chart 5- Spring EC vs. Rainfall
Spring EC uS/cm
Rainfall (mm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
250
200
150
100
50
0
Feb-01
Jun-01
Oct-01
Feb 02
Jun 02
Oct 02
Feb 03
Jun 03
Oct 03
Feb 04
Jun 04
Feb 08
Jun 08
Oct 08
Feb 09
Jun 09
Oct 09
Feb 10
Jun 10
Oct 10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Jun-16
Oct-16
Feb-17
Jun-17
Oct-17
Feb-18
Jun-18
Oct-18
Rainfall
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10

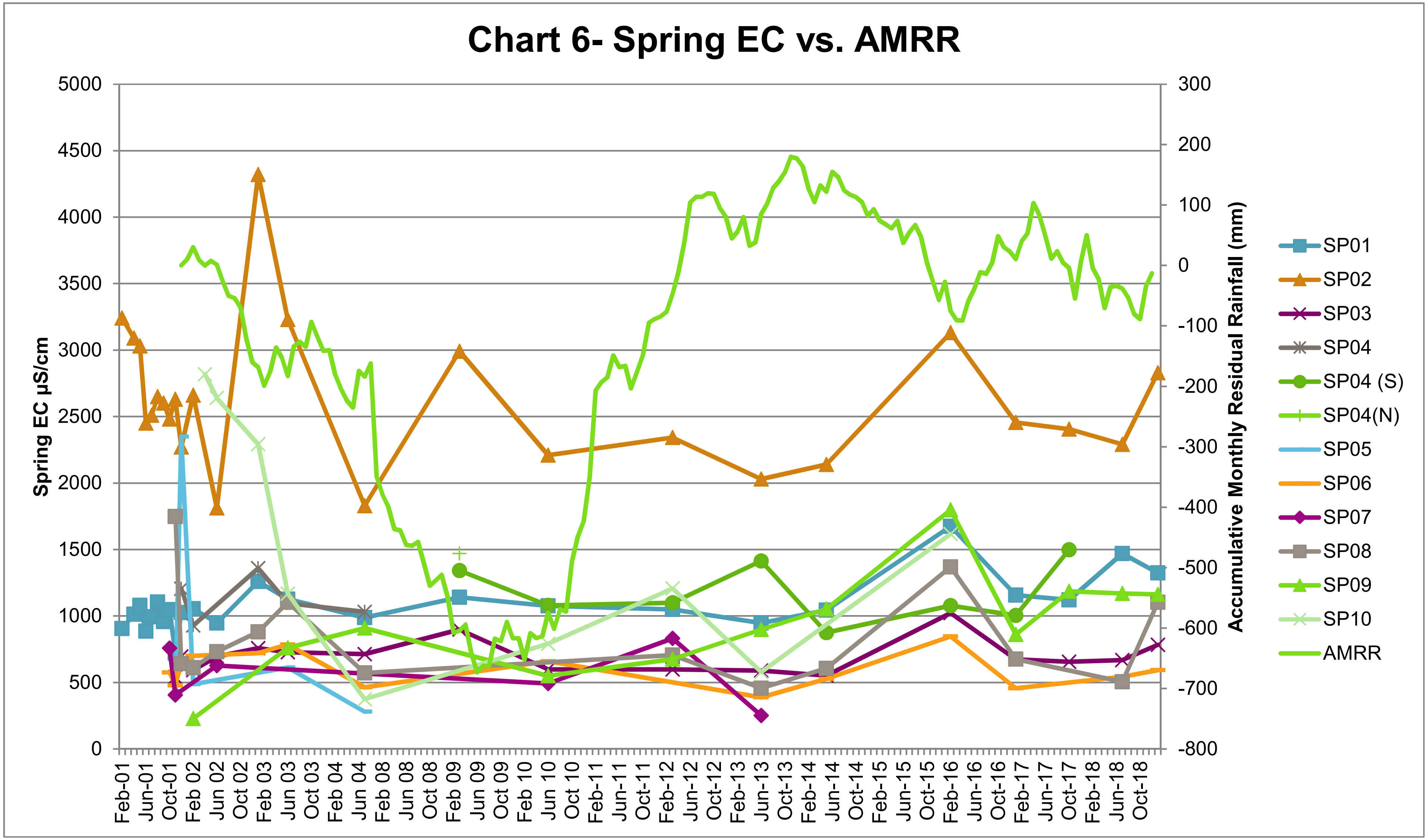
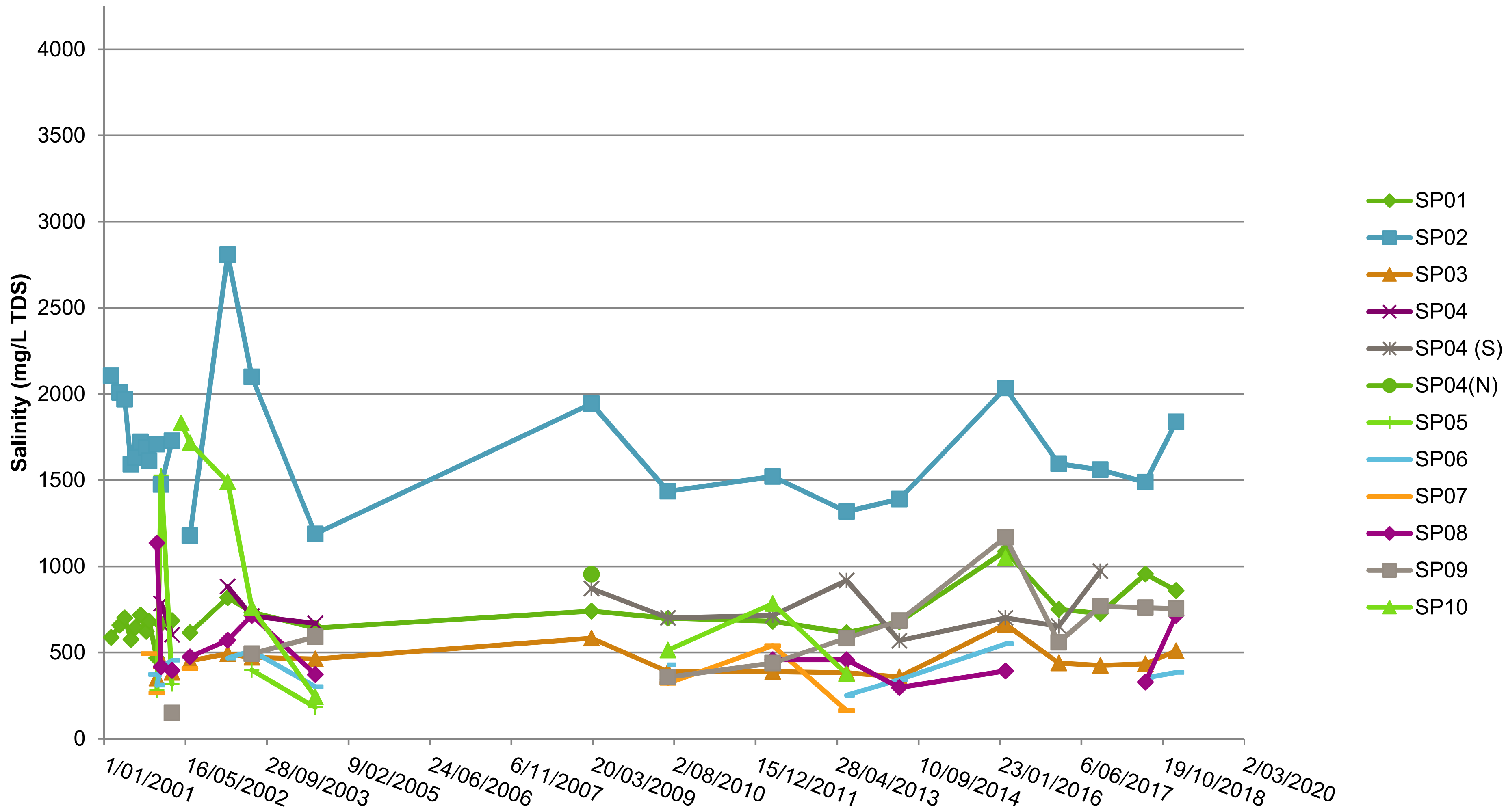


Chart 6- Spring EC vs. AMRR
Spring EC µS/cm
Accumulative Monthly Residual Rainfall (mm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
Feb-01
Jun-01
Oct-01
Feb 02
Jun 02
Oct 02
Feb 03
Jun 03
Oct 03
Feb 04
Jun 04
Feb 08
Jun 08
Oct 08
Feb 09
Jun 09
Oct 09
Feb 10
Jun 10
Oct 10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Feb-15
Jun-15
Oct-15
Feb-16
Jun-16
Oct-16
Feb-17
Jun-17
Oct-17
Feb-18
Jun-18
Oct-18
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10
AMRR

Chart 7 - Historic salinity (TDS) measurements



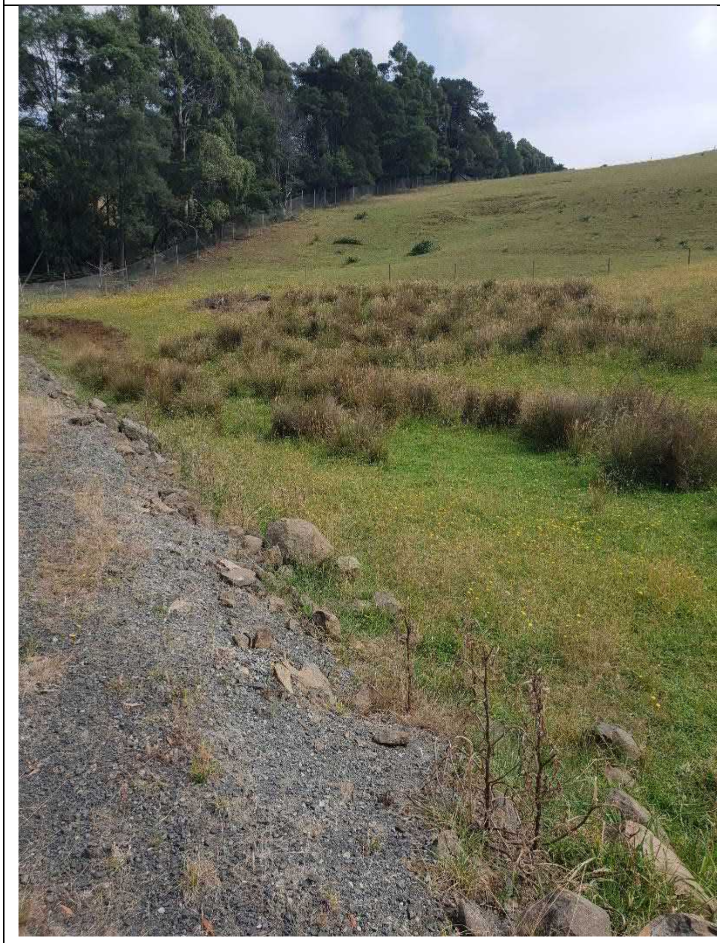
Attachment 4

Site photographs

	Plate 1 Spring 1
	Plate 2 Spring 2

	Plate 3 Spring 3
	Plate 4 Spring 4

	Plate 5 Spring 5
	Plate 6 Spring 6
	Plate 7 Spring 7
	Plate 8 Spring 8

	Plate 9 Spring 9
	Plate 10 Spring 10

Attachment 5

Areas of Progressive Stripping and Revegetation


Overburden Placement
Landslip Movement
Re-vegetation Zone
Re-vegetation Zone
Re-vegetation Zone