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2021 Groundwater and Spring Review, Pakenham Quarry

1.0 Introduction

AECOM Services Pty Ltd (AECOM) was engaged by Holcim (Australia) Pty Ltd (Holcim) to conduct annual 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 (2021) review aims to meet selected requirements of the Mt Shamrock Quarry Environmental Management Plan (Holcim, 2015)[1] (EMP).

Groundwater monitoring locations included on Appendix 11- Figure 1 in the EMP were replaced in October 2014 to cater for changing pit extent and areas inundated with water, 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 (Waters)) on the properties is supported by actual practices; and
- Visual inspections of springs as per Section 2.5.4 of the EMP.

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 in March 2021, June 2021, September 2021 and December 2021. Results of the gauging have been provided to Holcim post every gauging event;
- Biannual assessment of 10 springs or seepages in June 2021 and December 2021, including;
  - site walkover to visually assess the condition of each spring;
  - 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 5 km north of the Pakenham township and 65 km 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, installed in 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.

As documented in previous annual reviews (refer to AECOM, 2020[2] for full details of bore replacements overtime) a number of bores have been damaged or lost over time with pit development or inundation. All the bores have been replaced, with bores replaced as close as practicable to former bores in consideration of the constraints of the ongoing stripping campaigns and extraction.

Of the current bore monitoring network, bores MB01 and MB06, installed respectively to the south within the Werribee Formation and to the north within the Older Volcanics, have been operational since the commencement of the monitoring program and therefore there is a consistent set of groundwater levels immediately adjacent to the pit which have been monitored prior to the last approved pit expansion in 2005.

The bore network (including both the existing operational network, and the former bores) is presented on **Attachment 1- Figure 2** and **Table 1 (Attachment 2)** summarises the bore locations, screened interval and aquifer.

4.2 Springs

Ten springs[3] surrounding the site have been identified in the groundwater investigations (URS, 2005) to support the Environmental Effects Statement for the pit expansion. In the 2005 assessment (URS, 2005), the conceptual site model shows that the quarry is targeting the Older Volcanics, whilst the springs are interpreted as being the result of outcropping saturated Werribee Formation sediments (comprising silts,

[2] AECOM, 2020. *2019 Groundwater and Spring Review, Pakenham Quarry,* Letter prepared for Holcim (Australia) Pty Ltd
[3] A spring is defined as a groundwater discharge or "exit" point

clays and sands) which allow groundwater to discharge to the surface, after rainfall recharge through the overlying basalts. It was concluded by URS (2005) that springs SP01 to SP05 may be impacted by future dewatering activities, however all the springs were located on quarry property and none of them contribute to the flow or health of the surface water systems in which they are located. In the 2006 Minister's Assessment for the EES, it was stated that the impacts to springs and surface water quality were not significant subject to the implementation of management measures in the form of an environmental management plan (EMP).

All ten springs form part the site monitoring as required by the EMP to assess changes to the springs over quarry development.

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 (including fire track access construction), however monitoring at these locations has continued based on nomination within EMP and potential seeps have been identified in SP09 area post 2014. The locations of all mapped seepages/ springs are presented in **Attachment 1- Figure 3**.

5.0 Assessment of environmental values

The Environmental Reference Standard (2021) sets the regulatory framework for the assessment and management of surface water and groundwater. The ERS is a revision of the SEPP (Waters) which in turn was a revision of the SEPP (Waters of Victoria) (2003) which was referenced in the site EMP.

The aim of the ERS (Part 5) is to maintain surface and groundwater water quality sufficient to protect existing and potential environmental values of surface and groundwaters throughout Victoria.

The ERS define the surface waters at the site as belonging to the *Rivers and Streams: Central foothills and coastal plains* segment. It is noted that this is no change from SEPP (Waters).

The environmental values of groundwater in Victoria are defined by the salinity of the water. Table 1 summarises the environmental values based on groundwater salinity segments, as set out by the ERS:

Table 1 ERS – Environmental values that apply to the groundwater segments

Environmental value		Segments (mg/L TDS)						
		A1 (0-600)	A2 (601-1,200)	B (1,201-3,100)	C (3,101-5,400)	D (5,400 - 7,100)	E (7,101-10,000)	F (> 10,001)
Water dependent ecosystems and species								
Potable water supply	Desirable							
	Acceptable							
Potable mineral water supply								
Agriculture and irrigation (irrigation)								
Agriculture and irrigation (stock watering)								
Industrial and commercial								
Water-based recreation (primary contact recreation)								
Traditional Owner cultural values								
Cultural and spiritual values								
Buildings and structures								
Geothermal properties								

Historical observations of salinity at the springs show a range from 149 to 2,808 mg/L as TDS (**see Attachment 2 - Table 3**). Spring salinity is considered to be a combination of runoff, interflow and groundwater discharge, thus groundwater salinity is likely to be diluted in these measurements and not representative of true groundwater salinity.

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 1,001 – 3,500 mg/L (TDS). Groundwater bore development records, associated with drilling of groundwater monitoring bores at the quarry report groundwater salinity to range between 1,140 and 2,318 mg/L (see **Attachment 2 - Table 5**), 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 environmental values of groundwater and the level of protection has been provided:

- **Water dependent ecosystems and species:** 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 environmental value.
- **Potable mineral water supply:** No known mineral water supply use occurs in the vicinity of the quarry and this use is not considered relevant as part of this assessment.
- **Agriculture and irrigation (irrigation):** 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 environmental value is considered relevant as part of this assessment.
- **Agriculture and irrigation (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 environmental value is considered relevant as part of this assessment.
- **Industrial and commercial:** There are no industrial zones in the immediate vicinity of the Site. As such, this environmental value is not considered relevant for this assessment.
- **Water-based recreation (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 environmental value has been considered.
- **Traditional Owner cultural values:** This environmental value relates to cultural and spiritual values held by communities such as baptisms, water-based festivals and cultural celebrations. There are no objectives specified in the ERS. In the absence of site-specific criteria, the objectives for water dependent ecosystems and species to be protective of the environmental value of surface water have been considered.
- **Cultural and spiritual values:** This environmental value relates to the cultural values of Traditional Owners, which may include traditional aquaculture, fishing, harvesting, cultivation of freshwater and marine foods, fish, grasses, medicines and filtration of water holes. There are no objectives specified in the ERS. In the absence of site-specific criteria, the objectives for other environmental values of surface water to be protective of this environmental value for surface water in the vicinity of the site, and the objectives for water dependent ecosystems and species to be protective of the environmental value at the point of groundwater discharge to surface water have been considered.
- **Buildings and structures**: Current land use around the site is agricultural and rural residential. Buildings associated are not expected to have deep footings; this environmental value is not considered relevant at this time.

- **Geothermal properties:** No known geothermal uses exist in the vicinity of the quarry and this environmental value is not 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 available water quality (based on field EC collected from the springs) has been reviewed against the water quality guideline criteria for TDS as summarised in Table 2 below.

Table 2 Adopted groundwater environmental value guidelines

Beneficial use	Adopted guideline
Water dependent ecosystems and species	Rivers and streams: Central foothills and coastal plains (slightly to moderately modified)
Agriculture	Criteria for Livestock Water Supply: ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality.
Irrigation	Criteria for Irrigation Water Supply: ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality.

5.1 Summary of groundwater environmental value criteria

The adopted Groundwater Screening Criteria (GSC) are summarised below in Table 3.

Table 3 Groundwater Screening Criteria

Analyte	Water dependent ecosystems (95% Protection)	Irrigation	Stock Watering
Salinity (mg/L TDS)	250	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 2021.

The historic data set of groundwater elevations for the bore network is presented as **Attachment 2- Table 2**.

For simplicity, bores and replacement bores have been plotted as one monitoring location to produce time series hydrographs (**Attachment 3- Charts 1a – 1d**). These hydrographs are produced at two different time scales (2002 – 2021 and 2015 – 2021) and show all of the well data as well as focussing on the upgradient well (MB06) and downgradient well (MB01).

Limitations have been noted with the relative level data over time as a number of bores have been replaced overtime, and in selected events the elevation of the top of casing has been inferred. These limitations are noted on **Attachment 2- Table 2.**

Overall, despite the replacement and relocation of some of the bores, the relative changes in water levels between monitoring events can still be inferred.

The data from 2015 onwards is the most reliable and this indicates that elevations in the Older Volcanics and Werribee Formations are very similar and that the elevation difference between the highest and lowest water levels in this period has been 3 – 4 m.

6.1.1 Results

The groundwater levels throughout 2021 are consistent with water levels since at least 2015. Groundwater levels in MB06, screened within the Older Volcanics formation, which had increased in elevation towards the end of 2020, peaked in January 2021, showed a slight downward trend throughout 2021 but started to increase again in October 2021, which is inferred to reflect the wetter conditions (higher regional rainfall recharge) in the spring months.

Relative elevations between pairs of bores installed in the Werribee Formation and the Older Volcanics aquifer (i.e. MB03 and MB05; MB02 and MB04) continue to have 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 Station number 86224 - refer to **Attachment 2- Table 3**) has recorded data from 1961 and 2021, with the following key points:

- Overall average annual rainfall is approximately 786.4 mm/ year
- Since 2001, when groundwater monitoring commenced, rainfall has ranged between 587 mm (2008) and 1136 mm (2020).
- 2021 represents an above average year, with a total rainfall of 920.9 mm[4].
- 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 both above and below the long-term average. 2021 has been drier than 2020 with rainfall levels in summer and autumn 2021 being lower than the same period in 2020. Winter 2021 rainfall levels have been similar or slightly lower than winter 2020. Spring and summer 2021 (October, November and December) rainfall levels have been well above average.

Attachment 3- Charts 2a-2b present the groundwater level data from Charts 1a -1d with the monthly rainfall totals.

Attachment 3 - Charts 3a-3e present groundwater level data and the Accumulative Monthly Residual Rainfall (AMRR). The plots indicate the following key points:

- There was a good correlation between rainfall totals and groundwater levels prior to 2005;
- Groundwater levels dropped significantly (6 to 7 m in MB01 and MB06) in the time of reduced rainfall between 2005 and 2009. The data from the wells which have been replaced in 2009 (MB02 and MB04) is not considered as reliable as MB01 and MB06 as the elevations in the replaced wells before and after replacement (between December 2008 and June 2009) are significantly different (14 m). Data from 2015 appears more reliable in all wells.
- These groundwater levels in most wells began to increase between 2010 and 2011 due to the increase in rainfall associated with the breaking of the drought apart from MB01 and MB06, located outside of the pit which remained stable throughout a continued upward AMRR trend. Since 2015 elevations in all of the wells are much more consistent temporally and also between wells, potentially indicating that the groundwater levels have re-equilibrated since the drought broke.

[4] The December 2021 data had not been reported by BOM at the time of report preparation, however the data from the two nearest stations Springvale Sandown and Berwick was used instead (104 mm at both stations).
There was no rainfall data collected at Dandenong for the month of August 2021 therefore the average of Springvale Necropolis, Berwick and Bonbeach Stations was used.

- That the bores screened in the aquifer directly beneath the basalt (Werribee Formation) respond at comparable times and trends to the basalt wells suggesting hydraulic connection between the two systems; and
- Over the most recent monitoring period the AMRR plot can be seen to trend upwards throughout 2020 and 2021. Chart 3e shows the AMRR plotted with groundwater levels from MB01 and MB06. Groundwater in both wells appear to reflect the potential increase in rainfall recharge with an increase in levels over this period (169.23 to 170.89 m AHD in MB01 and 172.20 m AHD to 173.90 m AHD in MB06.

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 southwestern 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.
- 2019 – Removal of overburden in the western portion of quarry
- 2020 – Continued stripping and excavation in the western portion of the site area
- 2021 – Continued stripping in the western portion of the site area, backfill and progressive rehabilitation in the southwestern corner of the site, topsoil placement in the south of the site with 0.8 ha of hydroseeding and planting of 1250 plants (highlighted in **Attachment 5**)

The stripping of the surface materials (overburden) as part of quarrying has potentially increased rainfall infiltration when more permeable fresh basalt is exposed to surface. This increased infiltration potential 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). These water levels started to decrease in 2014 and have become more consistent since then possibly as the aquifer re-equilibrated and as topsoil placement and revegetation has progressively occurred on excavated areas and reduced infiltration.

6.1.4 Response to revegetation across plateau surface

Holcim continued rehabilitation works at the quarry in 2020. Previous revegetation efforts in the south east of the quarry were supported with dead vegetation replaced. Progressive infill planting rehabilitation works were completed to the west of the quarry in 2020 (highlighted in green in the aerial photograph in **Attachment 5**).

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 2020, backfilling and topsoil placement was completed in the southern portion of the site along the southern boundary of the quarry pit, with revegetation works scheduled to be completed in 2021.

Ongoing 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 this decrease in infiltration may become more apparent. It appears that the progressive rehabilitation may already be having an influence as water levels in all wells started to decrease in 2014 and have become more consistent since then despite an increasing trend in rainfall.

6.2 Spring Survey

Historically ten seeps were identified as being groundwater fed springs. Two spring surveys were conducted on 17 June 2021 and 20 December 2021.

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

Results of the spring survey completed in on 6 November 2020 are summarised in **Table 4** below. Historical spring parameters are presented in **Table 4-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** and AMRR vs the measured EC is also plotted in **Chart 6- 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 4 2021 Spring Survey Results

SPRING ID	EC (µS/cm) June 2021	EC (µS/cm) December 2021	Observations June 2021	Observations December 2021
SP01	908	755	Overgrown. Water flowing into bin. Fence maintained. Sign reads Spring 3	~100 mL/s flowing into bin
SP02	2259	2420	Fenced off, no cattle access evident. Vegetation healthy. Flow on slope above, no overflow observed	Thick vegetation. Standing water. No flow observed.
SP03	452	694	Bin installed to manage overflow. Some flow into bin	~100 mL/s flowing out of bin
SP04	Not taken	Not taken	Dry	None
SP05	Not taken	Not taken	Vegetation healthy. Sign reads Spring 1	Dry
SP06	512	668	Water light brown. Cows entering water	Brown water. Medium turbidity. No outflow.
SP07	Not taken	Not taken	Inaccessible	Inaccessible
SP08	692	613	Water clear and flowing. Cattle entry to stream evident	Extensive cattle pugging in former channel. Parameters measured in riding club. 200-300 mL/s
SP09	675	957	Wetland	Wetland
SP10	Not taken	Not taken	Damp seep in embankment	Damp seep in embankment

Further spring observations from June and September 2021 survey are discussed below:

SP01 (June 2021)

SP01 located to the west of the quarry site, provides irrigation and stock water to a number of properties in the local area. It was mislabelled as SP03 in June. The vegetation is over-grown, and water is flowing into the bin which has been placed on the spring to manage overflow.

The spring water EC (908 µS/cm) was within the range of EC values reported in previous surveys

SP01 (December 2021)

The spring water EC (755 µS/cm) was within the range of EC values reported in previous surveys but was at the lower end of the range indicating freshwater inflow. This appears to be consistent with flow into the bin (~100 mL/s).

SP02 (June 2021)

SP02 located to the west of the quarry, has historically been observed to be a small dam fed by groundwater and surface water runoff from a relatively steep slope above. In June 2021, the area was fenced off, with no flow observed from the groundwater but flow was observed on the slope above.

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. This has not yet been constructed.

In June 2021 the spring was noted to be a have thick vegetation. The water EC (2,259 µS/cm) was within the historical range of EC values reported at SP02, with EC continuously higher at SP02 than other spring locations.

SP02 (December 2021)

In December 2021 the spring was noted to be a have healthy vegetation. The water EC (2,420 µS/cm) was within the historical range of EC values reported at SP02, with EC continuously higher at SP02 than other spring locations.

SP03 (June 2021)

Vegetation has historically, and continues to be, healthy in this spring. A bin was installed since November 2020 to manage overflow and there was some overflow in June 2021.

Measured EC (452 µS/cm) in June 2021 was the lowest historically reported (previous EC ranged from 540 -1,022 µS/cm). Following an observed spike in EC in 2016 values have stabilised at a lower level since then.

SP03 (December 2021)

Measured EC (694 µS/cm) in December 2021 has increased to between historical levels since the low in June.

SP04 (June 2021)

SP04 was not accessible in June 2021.

SP04 (December 2021)

Spring was observed to be dry with healthy vegetation.

SP05 (June 2021)

In June 2021 the spring was observed to be dry, as it has been since 2009, and water quality measurements could not be collected. Vegetation was observed to be healthy. The sign was reported to incorrectly refer to Spring 1.

SP05 (December 2021)

In December 2021 the spring was still observed to be dry, as it has been since 2009, and water quality measurements could not be collected. Vegetation was observed to be healthy. The sign was still reported to incorrectly refer to Spring 1.

SP06 (June 2021)

Spring water at SP06 accumulates in a collection pond accessible to livestock. Cows were observed to be entering the water in June 2021. The water was observed to be light brown. EC was measured as 512 µS/cm, which was within the historical range.

SP06 (December 2021)

Water was observed to be turbid with no flow. EC was measured as 668 µS/cm, which was within the historical range.

SP07 (June 2021)

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 since May 2014. In June this spring was unable to be accessed.

SP07 (December 2021)

In December this spring was unable to be accessed.

SP08 (June 2021)

Spring is a wetland with a lot of reeds. EC was measured at 692 µS/cm, which is within the historic range. The EC at this spring has shown high variability since observations began in 2001. In June 2021, the spring was observed to have clear water and was flowing. Cattle were observed to be entering the stream.

SP08 (December 2021)

EC was measured at 613 µS/cm, which is within the historic range. Evidence of cattle.

SP09 (June 2021)

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.

In June 2021 the wetland was observed to have water. EC was measured as 675 µS/cm which is within the historic range.

SP09 (December 2021)

In December 2021 the wetland was observed to have water. EC was measured as 957 µS/cm which is within the historic range.

SP10 (June 2021)

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 June 2021 monitoring event when only a damp seep in the exposed embankment was observed.

SP10 (December 2021)

As for June, a damp seep in the exposed embankment was observed.

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 3-Attachment 2**). Rainfall in 2021 (920.9 mm) is slightly above the BOM rainfall annual average (786.4 mm) but is less than the maximum reported rainfall since monitoring commenced in 2001 (1136 mm in 2020), however the annual accumulative monthly residual rainfall (AMRR) has been trending upwards since January 2020. As rainfall, in part is expected to influence the observations at the spring sites, in 2020 EC measurements had generally decreased when compared with December 2019 EC measurements at each location. There is not a strong seasonal pattern in EC in the springs although generally the EC is higher during the summer monitoring events, expected to be commensurate with lower rainfall and may be more reflective of seepage. This is most observable in SP02, particularly since mid-2018. SP02 also consistently has the highest EC concentrations, which appears to reflect a strong groundwater influence.

A qualitative assessment of the flow observed in the springs against the significant upwards trend in the AMRR since January 2020 indicates that SP01 continues to flow strongly, flow has increased (from standing water) in SP02, SP03, SP08, indicating that these springs maybe influenced by rainfall.

As discussed in previous reviews, SP05 has typically been dry since 2009, and SP04, SP9 and SP10 have been influenced by creation of dams/ wetlands in the vicinity of the springs. Increased rainfall as reflected in the AMRR plot since January 2020 do not appear to have resulted in SP04, SP05, SP07 and SP10 reporting standing water or spring flows. Therefore, as reported previously the spring conditions at these four locations are not considered to be strongly correlated with increased rainfall volumes and/or change in groundwater levels.

6.3 Assessment of impacts to environmental values

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 (environmental values of water dependent 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 environmental values 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 environmental values 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 less than Segment B of the ERS (1201 – 3100 mg/L), suggesting that groundwater is suitable for the environmental values 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. 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 water dependent 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 environmental value 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 tolerance 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 environmental values. TDS is also below the adopted criteria for stock watering (4,000 mg/L).

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 environmental values of groundwater.

6.4 Registered Groundwater Bores

A search of registered groundwater bore users on the Water Management Information System (WMIS) maintained by DELWP for registered bores within 2 km of the WA174 boundary was undertaken by AECOM in 2020, provided in a summary letter dated 26 May 2020 (AECOM, 2020a). This was completed to understand potential changes in the local groundwater use since the last approved development of the quarry in 2005.

A total of 16 registered groundwater bore users were located within 2 km of the site, with 12 bores registered for stock or domestic consumptive use. A further 4 bores were registered for observation or unknown purposes. No consumptive use bores have been registered within 2 km of the site since 1990 and therefore, no change to the local groundwater use has been identified for the site since the last assessment. This was confirmed by a review of the WMIS website in November 2021.

7.0 Summary

The key conclusions of this annual review are as follows:

- The groundwater levels throughout 2021 are consistent with water levels since at least 2015. Groundwater levels in MB06, screened within the Older Volcanics formation, which had increased in elevation towards the end of 2020, peaked in January 2021, showed a slight downward trend throughout 2021 but started to increase again in October 2021 due to wetter conditions in the spring months.
- Salinity (based on EC levels) of the springs monitored were well within historical levels.
- 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. SP04 continued to be dry as it has been since 2018. Increased rainfall and AMRR since January 2020 does not appear to have resulted in SP04, SP05, SP07 and SP10 reporting standing water or spring flows. Therefore, spring conditions at these four locations are not considered to be strongly correlated with increased rainfall volumes.
- In summary, the groundwater and spring monitoring collected over the 2021 monitoring period does not show any observable influence based on quarry operations.
- 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 environmental values of groundwater. No additional groundwater bore users registered for consumptive uses were identified within 2 km of the quarry since the last approved development of the quarry in 2005 and associated environmental values assessment.

8.0 Recommendations

Based on the 2021 groundwater and spring survey events, the following is recommended:

- During the June and December 2021 spring survey, it was noted that signage for the labels at spring locations SP01 and SP05, located on the southern and western sides of the quarry, were incorrectly labelled. This should be investigated to confirm the correct signage is in place.
- Decrease the number of spring surveys to one event per annual review period. The spring survey should be completed during the same season to capture late spring and summer conditions, when springs are likely not affected by significant periods of rainfall (such as during winter conditions).
- Remove spring locations from the monitoring program where the ground considerations have changed, such as at SP09 and SP10 due to the fire track construction.

9.0 References

AECOM, 2021. *2020 Groundwater and Spring Review, Pakenham Quarry,* Letter prepared for Holcim (Australia) Pty Ltd

AECOM, 2020. *2019 Groundwater and Spring Review, Pakenham Quarry,* Letter prepared for Holcim (Australia) Pty Ltd

AECOM, 2020a. *Review of Surrounding Groundwater Users.* Letter prepared for Holcim (Australia) Pty Ltd

Holcim (Australia) Pty Ltd, 2015. *Pakenham Quarry Environmental Management Plan, version 3: August 2015.*

URS, 2005. *Final Report Mount Shamrock Quarry (Pakenham) Proposed Extension Environment Effects Statement Groundwater*. Prepared for Readymix Holdings Ltd.

Yours faithfully

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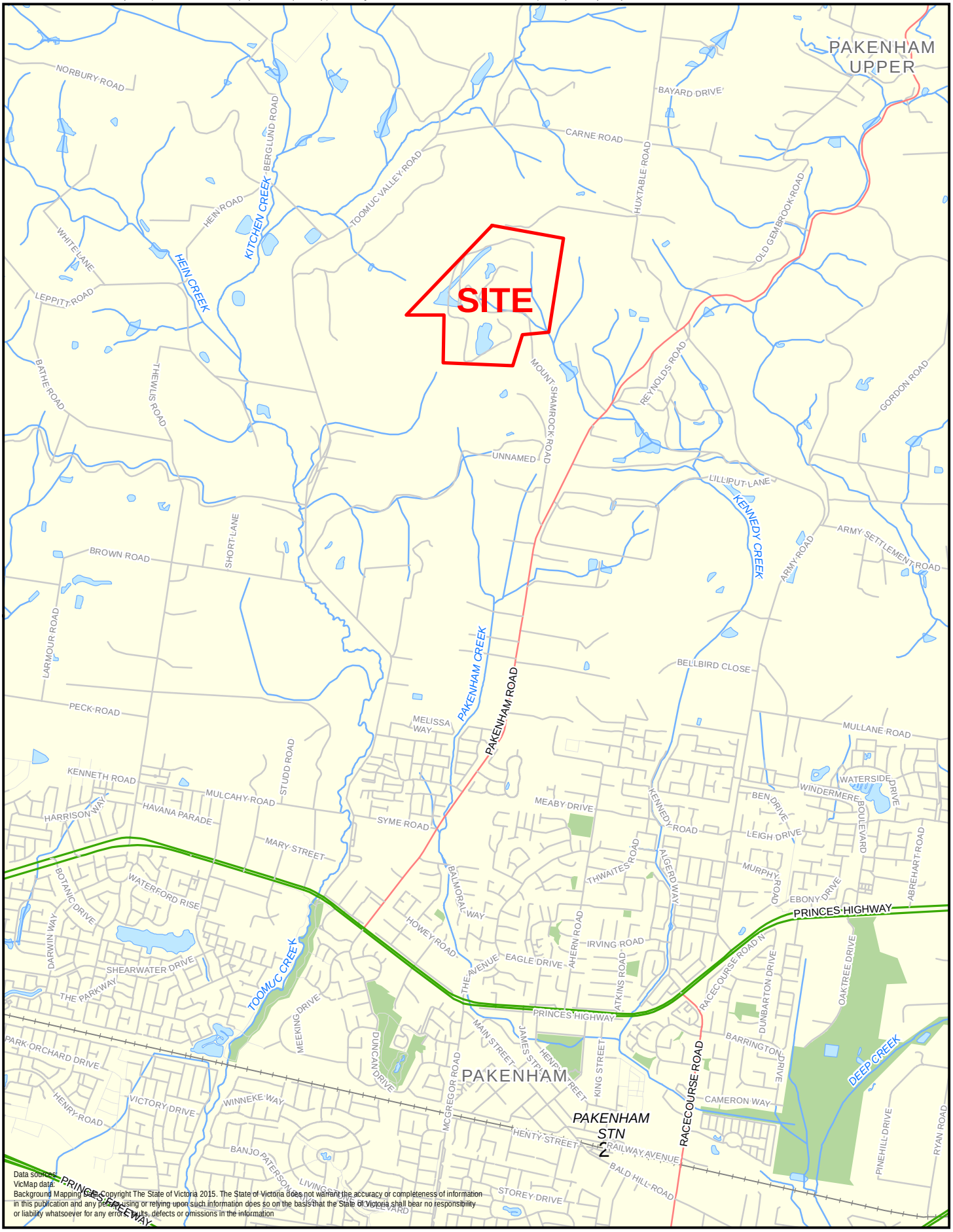
Attachments

Attachment 1	*Figures*
Attachment 2	*Tables*
Attachment 3	*Charts*
Attachment 4	*Site photographs*
Attachment 5	*2021 Areas of overburden placement and revegetation*

Attachment 1

Figures



Data sources:
VicMap data:

PROJECT ID 60451395
CREATED BY DJB
LAST MODIFIED T SMITH 05 FEB 2019 www.aecom.com

AECOM

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

Legend

PROJECT ID 60451395
CREATED BY DJB
LAST MODIFIED T SMITH 19 JAN 2021 www.aecom.com

DATUM GDA 1994, PROJECTION MGA ZONE 55

0 40 80 120 160
metres

1:8,000 when printed at A4

< Monitoring Bore Location

< Monitoring Bore (Decommissioned)

Tenement WA174

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\GIS\Jobs\43283833\GIS\MXD\2021\Figure 2.mxd)

A4 size

PROJECT ID 60451395
CREATED BY DJB
LAST MODIFIED T SMITH 19 JAN 2021 www.aecom.com

AECOM

DATUM GDA 1994, PROJECTION MGA ZONE 55

0 60 120 180 240
metres

1:9,200 when printed at A4

Legend

- Spring Location
- 550 EC (uS/cm) June/Dec 2021
- Mining Tenement WA174

SPRING LOCATIONS AND ELECTRICAL CONDUCTIVITY RESULTS

Holcim (Australia) Pty Ltd

Groundwater and Spring Review

Mt Shamrock Road, Pakenham

Figure

3

Map Document: (\\aumel1fp003\GIS\Jobs\43283833\GIS\MXD\2021\Figure 3.mxd)

A4 size

Attachment 2

Tables

Table 1- Current Monitoring Bore Network
Mt Shamrock Quarry, Pakenham

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	Status
MB01	7-Mar-01	216.54	366135.13	5789516	67	149.54	72.5	144.04	WERRIBEE FORMATION	Operational
MB2a	13-Mar-09				14		17		WERRIBEE FORMATION	Destroyed
MB02b	22-Oct-14	174.64	366344.3	5790135.03	8.8	165.84	11.8	162.84	WERRIBEE FORMATION	Decomissioned
MB02c	17-Jan-17	191.68	366232.07	5790211.78	33.77	157.91	36.77	154.91	WERRIBEE FORMATION	Operational
MB03	6-Mar-01	229.69	365817.18	5789879.64	71	158.69	77	152.69	WERRIBEE FORMATION	Destroyed
MB03b	24-Oct-14	209.9	365739.25	5790087.04	49	160.9	52	157.9	WERRIBEE FORMATION	Operational
MB04a	13-Mar-09				8.7		11.7		OLDER VOLCANICS	Destroyed
MB04b	22-Oct-14	174.7	366342.72	5790133.59	1	173.7	1.5	173.2	OLDER VOLCANICS	Decomissioned
MB04c	17-Jan-17	191.84	366233.33	5790213.41	30.4	161.44	30.9	160.94	OLDER VOLCANICS	Operational
MB05	6-Mar-01	229.84	365820.83	5789879.07	51	178.84	57	172.84	OLDER VOLCANICS	Decomissioned
MB05b	27-Oct-14	209.55	365736.94	5790087.88	40	169.55	46	163.55	OLDER VOLCANICS	Operational
MB06	13-Mar-01	219.56	366321.06	5790488.4	44	175.56	50	169.56	OLDER VOLCANICS	Operational

mAHD meters above Australian Height Datum
AMG Australian Map Grid

Table 2- Historic Groundwater Elevation Monitoring Data
Mt Shamrock Quarry, Pakenham

Date	MB01 (Werribee)- Relative Water Level mAHD	MB02, MB2a, MB2b, Mb2c (Werribee)- Relative Water Level mAHD	MB03, MB3b (Werribee) - Relative Water Level mAHD	MB04, MB4a, MB4b, MB4c (Older Volcanics)- Relative Water Level mAHD	MB05, MB05b (Older Volcanics)- Relative Water Level mAHD	MB06 (Older Volcanics)- Relative Water Level mAHD
30/3/01	175.84	163.35	180.16	163.55	183.76	177.84
6/4/01		163.35		163.39		
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	
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		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		Bore Destroyed		Bore Destroyed	174.76
14/12/2011	173.64					
14/01/2012	173.74					176.56
29/02/2012	174.74					176.28
12/04/2012	175.44					175.81
10/05/2012	175.34					175.66
9/07/2012	174.94					175.83
3/08/2012	172.84					175.81
12/09/2012	174.94					175.86
10/10/2012	175.04					175.96
14/02/2013	175.19					176.06
12/03/2013	175.08					176.30
8/04/2013	175.04					175.81
4/06/2013	174.89					176.06
2/07/2013	174.54					175.81
5/08/2013	172.79					177.91
9/09/2013	175.04					175.81
7/10/2013	175.04					175.81
12/11/2013	172.47					177.41
10/12/2013	174.29					175.44
13/01/2014	175.04					175.91
11/02/2014	175.04					178.11
10/03/2014	176.04					176.96
8/04/2014	174.04					175.32
15/05/2014	174.39					175.46

Table 2- Historic Groundwater Elevation Monitoring Data
Mt Shamrock Quarry, Pakenham

Date	MB01 (Werribee)- Relative Water Level mAHD	MB02, MB2a, MB2b, Mb2c (Werribee)- Relative Water Level mAHD	MB03, MB3b (Werribee) - Relative Water Level mAHD	MB04, MB4a, MB4b, MB4c (Older Volcanics)- Relative Water Level mAHD	MB05, MB05b (Older Volcanics)- Relative Water Level mAHD	MB06 (Older Volcanics)- Relative Water Level mAHD
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	
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 (potentially error in location)	169.54	172.87
28/09/2016	171.00	173.24	170.36	172.66	170.79	172.92
15/12/2016	171.06		170.78	172.28	171.21	173.50
16/01/2017		Bore decomissioned and replaced with MB02C		Bore decomissioned and replaced with MB04C		
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	169.88	171.10	170.92	170.89	171.52	172.20
9/10/2018	169.72	171.17	171.71	170.99	172.31	172.04
8/01/2019	169.62	171.24	172.03	171.00	172.57	171.90
5/04/2019	169.19	170.39	170.39	170.30	170.82	171.76
18/07/2019	168.77	170.64	171.58	170.70	172.14	171.71
16/12/2019	169.17	171.69	172.52	171.81	173.04	172.05
31/03/2020	169.23	171.68	172.54	171.94	173.08	172.20
14/08/2020	169.65	172.46	172.01	172.90	172.47	173.01
24/09/2020	169.50	172.30	172.20	172.84	172.59	173.02
30/10/2020	170.73	172.62	172.81	173.24	173.28	174.57
6/11/2020	169.97	172.65	172.99	173.22	173.53	174.69
21/12/2020	170.04	172.36	172.54	172.79	172.99	175.23
10/03/2021	170.36	171.86	171.54	172.21	172.00	174.59
19/04/2021*	169.96	171.76	171.29	172.38	171.7	174.6
25/05/2021*	170.81	171.82	171.27	172.54	171.7	174.3
17/06/2021	170.29	172.01	171.44	172.71	171.92	173.87
28/07/2021*	170.04	172.13	171.35	172.85	171.79	173.71
27/08/2021*	169.96	172.01	171.24	172.69	171.66	173.71
14/09/2021	170.34	172.23	171.48	171.88	172.01	173.29
27/10/2021*	170	172.46	172.3	173.18	172.8	173.52
23/11/2021*	170.30		172.95	173.17	173.50	173.03
20/12/2021	170.89	172.46	172.47	173.06	172.94	173.90
Highest Elevation since 2015	173.07	173.48	172.99	173.37	173.53	175.23
Lowest Elevation since 2015	168.77	170.39	169.22	170.30	169.54	171.71
Difference	4.30	3.09	3.77	3.07	3.99	3.52

#NA No gauging data available

Italics *RL mAHD estimated from client provided GPS data - may not be reliable*

* Additional gauging data provided by Holcim site

Notes on gauging:

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.

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 placement of overburden 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.

Table 3- Annual Rainfall Dandenong (Station 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	*13.4*	*22.6*	*45.6*	23.6	88.8	83.4	81	*82*	75.6	56.6	75.4	17.4	665.4
2020	*113.6*	123.4	78.6	*192.2*	72.8	55	62.4	*97.2*	80.4	115	76.6	*69.6*	1136.8
2021	86.4	*21*	64	*92.2*	*67.4*	*69.4*	*44.8*	*60.1*	*73.6*	*133*	*105*	*104*	920.9

Italics- data not verified

Data from daily rainfall records

Whole period	52.2	51.7	48.9	68.0	73.7	66.6	68.1	72.6	71.4	72.6	70.8	67.1	786.4
Since 2002	47.7	58.3	48.7	72.2	66.4	69.3	66.9	70.4	67.5	68.7	84.8	72.1	792.8

Table 4- Historic Field Parameters Recorded at Spring Locations
Pakenham Quarry

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*	Observations
		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	Main irrigation spring, flow ~1.2L/min, sampled from tank inlet
	25-Jun-10	1076	7.80	-	-	-	699	Parameters gauged at source, flow ~3 L/min
	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	Clear, moderate flow
	26-Feb-16	1674	6.42	105	0.25	16.6	1088	Clear, water flow into tank ~4L/s. Wheelie bin where water collects was half full of water
	18-Jan-17	1156	7.99	73	4.33	20.3	751	Clear, no odour. Water is collected in wheelie bin prior to discharge.
	9-Oct-17	1120	6.99	167	6.16	14.9	728	Vegetation in area in very healthy condition, weeds growing over bin lid. Very boggy in area. Water had been extracted from the tank during the morning and therefore it was recharging. Flowing quickly into tank at approximately 250 mL / 10 seconds. Water clear with suspended solids.
	3-Jul-18	1470	7.01	197	5.70	12.3	956	Vegetation in area in very healthy condition. Very boggy in area. Flowing from Spring via pipe into tank quickly at approximately 250 mL / 4 seconds.
	8-Jan-19	1323	7.38	73.8	6.15	16.1	860	Grey, no odour, medium turbidity, very overgrown
	18-Jul-19	1218	7.44	71	7.15	12.9	792	Clear, low turbidity, no odour, moderate flow into tank.
	16-Dec-19	1200	7.54	37.2	7.37	15.3	780	Thick vegetation. Flowing water in bin.
	6-Nov-20	814	7.26	20.1	5.92	14.6	529	Overgrown. Flowing into bin. Sign at spring reads Spring 3.
	17-Jun-21	908	7.46	28.2	7.4	13.6	590	Overgrown. Water flowing into bin. Fence maintained. Sign reads Spring 3.
	20-Dec-21	755	7.63	23	5.7	14.8	491	~100mL/s flowing into bin.
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	Low flow, sample taken from grassy pool / dam
	25-Jun-10	2209	8.15	-	-	-	1436	Low flow, parameters taken from dam
	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	No flow
	26-Feb-16	3130	6.41	199	7.34	17.8	2035	Clear-brown, strong flow with potential to break through wall. Water fed through pipes to trough down slope.
	18-Jan-17	2456	7.38	-18	2.26	20.2	1596	Organic odour. Large pond; water levels managed to prevent bund from collapsing.
	9-Oct-17	2405	7.02	52	2.72	15	1563	Difficult to locate due to healthy vegetation and thick cover of duckweed on pond surface. Troughs that are fed by the spring are full. Pond is deep, no flow
	3-Jul-18	2290	6.05	243	5.66	7.8	1489	Deep pond with large amount of duckweed. This Spring directly feeds into trough and a tank. The flow downhill into the tank was approx. 250ml / 3 sec
	8-Jan-19	2829	7.19	-107	6.11	17.5	1839	Black, organic odour, medium-high turbidity, overgrown
	18-Jul-19	2070	7.46	86.8	6.26	8.4	1346	No flow, brown, low turbidity, no odour
	16-Dec-19	2838	7.24	41.6	4.87	15.5	1845	Thick grass. Standing water within grass. No visible flow.
	6-Nov-20	2143	7.19	52	-	13.1	1393	Overgrown. Standing water.
	17-Jun-21	2259	7.48	-6.8	12.73	8.3	1468	Fenced off, no cattle access evident. Vegetation healthy. Flow on slope above, no overflow observed.
	20-Dec-21	2420	7.33	-3	0.36	14	1573	Thick vegetation. Standing water. No flow observed.
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	Low flow, degraded/eroded by cattle, organic material
	25-Jun-10	599	7.62	-	-	-	389	Parameters taken from dam below the discharge point
	28-Mar-12	599	***	-	-	11.3	389	

Table 4- Historic Field Parameters Recorded at Spring Locations
Pakenham Quarry

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*	Observations
		µS/cm		mV	mg/L	°C	mg/L	
	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	Low flow, cattle prints evident
	26-Feb-16	1022	6.37	84	7.34	17.6	664	Large pool spilling down slope, duckweed, cow hoof imprints, water brown-clear
	18-Jan-17	674	7.88	52	2.55	19.7	438	Large pool, no flow observed. Water pooled in cow hoof prints to half way down slope.
	9-Oct-17	655	6.97	101	7.30	14.5	426	Vegetation and spring both appear very healthy as per last time. Large pool and boggy in area. Cattle trough full so no flow observed.
	3-Jul-18	669	7.8	200	8.31	10.4	435	Large pool and boggy in area. Cattle trough full so no flow observed.
	8-Jan-19	784	7.39	-430	5.10	18.2	510	Black/clear, no odour, low-medium turbidity
	18-Jul-19	775	7.14	-40.1	1.33	9.8	504	Cow in Springs. No odour, grey, low turbidity
	16-Dec-19	812	7.87	-17.1	2.36	14.5	528	Tall grass and floating vegetation. No flow.
	6-Nov-20	697	7.79	-24.1	-	13.4	453	Standing water. Seeping down slope. Sign reads Spring 4
	17-Jun-21	452	7.46	-25.3	6.20	9.5	294	Bin installed to manage overflow. Some flow into bin.
	20-Dec-21	694	7.98	32.2	8.05	13.5	451	~100mL/s flowing out of bin
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	Northern discharge point, low to no flow
SP04 (S)	12-Mar-09	1342	7.69	-	-	-	872	Southern discharge point, low flow
	25-Jun-10	1080	6.75	-	-	-	702	Low flow, parameters taken from groundwater discharge pooling in hoof impressions
	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	No measurable flow, stagnant
	26-Feb-16	1078	6.80	97	1.24	17.8	701	Small puddle of water (<30cm^2, and <5cm deep), wet, marshy grass, water clear
	18-Jan-17	1004	7.92	65	4.33	20.3	653	Small puddle; clear, marshy, overgrown and boggy; around 30 cm2 x 5 cm deep.
	9-Oct-17	1498	6.89	232	3.33	14.5	974	Shallow pool (~5cm) and very boggy in area. Vegetation healthy.
	3-Jul-18	Spring dry. Vegetation healthy.						Dry Spring, vegetation healthy
	8-Jan-19	Spring dry. Vegetation healthy.						Dry
	18-Jul-19	Spring dry. Vegetation healthy.						Dry Spring, vegetation healthy though overgrown
	16-Dec-19	Spring dry. Vegetation healthy.						Slightly damp seep observed.
	6-Nov-20	Spring dry. Vegetation healthy.						Thicker vegetation. Sign reads Spring 3
	17-Jun-21	Unable to be accessed.						
	20-Dec-21	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						No 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	No parameters could be taken.						Muddy and minor water pooling in cow hoof prints.
	9-Oct-17	Spring dry						Very boggy in area, no large pool observed. Large boggy area with the only pooling in cattle hoof depressions. Unable to get a large enough pool to take reliable parameters.
	3-Jul-18	Spring dry. Vegetation healthy.						Dry Spring, vegetation healthy
	8-Jan-19	Spring dry. Vegetation healthy.						Dry
	18-Jul-19	Spring dry. Vegetation healthy.						Dry Spring, vegetation healthy though overgrown
	16-Dec-19	Spring dry. Vegetation healthy.						Tall vegetation. No damp ground observed.
	6-Nov-20	Spring dry. Vegetation healthy.						Thicker vegetation. Sign reads Spring 1.
	17-Jun-21	Spring dry. Vegetation healthy.						Vegetation healthy. Sign reads Spring 1.
	20-Dec-21	Spring dry. Vegetation healthy.						Vegetation healthy. Sign reads Spring 1.
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						Dry, some subsurface flow assumed
	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	No measurable flow, stagnant
	26-Feb-16	846	6.98	143.0	3.86	22.2	550	Pool of water, 10x5m, duckweed, water clear to moderate turbidity
	18-Jan-17	457	8.29	58	8.70	25.4	297	Pool of water, 10 x 5 m, with duckweed.
	9-Oct-17	Not able to be accessed						

Table 4- Historic Field Parameters Recorded at Spring Locations
Pakenham Quarry

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*	Observations
		µS/cm		mV	mg/L	°C	mg/L	
	3-Jul-18	543	7.32	222	8.52	9.8	353	Stagnate water, very boggy and pool approx. 15-20m2 and 0.5 deepest point.
	8-Jan-19	592	8.1	38.7	10.62	22.3	385	Brown, no odour, low-medium turbidity
	18-Jul-19	417.9	7.68	36.1	9.01	9.4	272	Brown, no odour, low turbidity, boggy
	16-Dec-19	437.5	7.88	49.3	7.64	17.5	284	Standing water. Livestock pugging evident.
	6-Nov-20	386	7.67	18.3	-	15	251	Standing water. Livestock pugging evident.
	17-Jun-21	512	7.42	-34.4	4.88	9.5	333	Water light brown. Cows entering water.
	20-Dec-21	668	7.85	-25.3	1.51	16.3	434	Brown water, medium turbidity. No outflow.
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						Dry, some subsurface flow assumed
	25-Jun-10	493	6.14	-	-	-	320	Significant pooling in valley floor
	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						No flow, very shallow/small ponds, parameters not possible
	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						-
	18-Jul-19	Dry						Dry and no sign of water in valley going towards dam. Large amounts of blackberry plants and some dumped rubbish in valley.
	16-Dec-19	Dry / Not identified						No damp ground observed.
	6-Nov-20	Dry / Not identified						Damp patches. No spring positively identified.
	17-Jun-21	Unable to be accessed.						
	20-Dec-21	Unable 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						Dry, no indication of recent flow
	25-Jun-10	No flow						No flow
	28-Mar-12	706	***	-	-	16.4	459	
	25-Jun-13	457	7.57	100.3	10.42	14.6	297	
	15-May-14	606	7.88	32	13	13	394	No measurable flow, stagnant. Cattle prints evident
	26-Feb-16	1369	6.29	116	4.7	22.1	890	Hoof indentations, area marshy.
	18-Jan-17	675	7.82	64	6.16	25.4		Water pooling in dozens of small locations, with minor flow in parts.
	9-Oct-17	Not able to be accessed						
	3-Jul-18	504	6.62	222	5.76	8.6	328	Large wetland with alot of reeds, clear/orange tinge, water, no odour and suspended solids.
	8-Jan-19	1103	7.79	86.2	6.98	21.7	717	Overgrown, brown/clear, no odour, low-medium turbidity
	18-Jul-19	396.4	7.36	42.1	8.31	10.3	258	Reeds, no odour, low turbidity, clear
	16-Dec-19	631	7.94	46.9	9.61	16.9	410	Standing water in pond. Low flow down slope. Oxidised iron apparent in stream.
	6-Nov-20	655	7.51	-54.7	-	14	426	Flowing approx 0.1-0.2L/s. Standing water.
	17-Jun-21	692	7.64	-106.3	3.8	6.9	450	Water clear and flowing. Cattle entry to stream evident.
	20-Dec-21	612.5	8.02	60.8	7.75	14.2	398	Extensive cattle pugging in former channel. Parameters measured over fence in riding club grounds where flowing water (200-300 mL/s) was present
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						Dry, subsurface flow assumed
	25-Jun-10	550	6.66	-	-		358	Low to moderate flow with ponding below at the break of slope, parameters from discharge zone
	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	Very low flow, doesn't now appear to be a spring
	26-Feb-16	1798	6.40	-22	0.26	22.2	1169	Measurement collected at large pond with reeds, clear. Unlikely that the pond is reflective of seepage only. Will be collecting rainfall and run off also.
	18-Jan-17	860	8.36	65	12.23	22.2	559	Large pond. Spring area cannot be observed.
	9-Oct-17	1185	7.33	85	4.44	16.4	770	Former spring 9 is now a small wetland. Wetland full with water. Highest water level observed in the area. Vegetation very healthy and wildlife.
	3-Jul-18	1169	5.16	199	6.47	10.8	760	Small wetland full of water. Vegetation very healthy due to large amount of water
	8-Jan-19	1163	7.63	86.7	6.58	21.5	756	Black/clear, no odour, low-medium turbidity
	18-Jul-19	780	7.53	-8.8	10.24	9.4	507	Large pond, cloudy/grey no-odour, low turbidity
	16-Dec-19	1231	7.59	-2	6.81	18.4	800	Wetland. Reeds and other vegetation healthy.
	6-Nov-20	556	6.96	-2	8.26	14.2	361	Vegetated wetland. Standing water. Sign reads Spring 10
	17-Jun-21	675	7.53	59.7	13.74	8.1	439	Wetland.
	20-Dec-21	957	7.8	55.9	6.32	18.2	622	Wetland.
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	

Table 4- Historic Field Parameters Recorded at Spring Locations
Pakenham Quarry

Spring Number	Date	Electrical Conductivity	pH	Redox Potential	Dissolved Oxygen	Temperature	TDS*	Observations
		µS/cm		mV	mg/L	°C	mg/L	
	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						Spring dry, sample taken from dam fed by spring
	25-Jun-10	790	7.03	-	-	-	514	Low flow, parameters from discharge pooling in cattle hoof impression
	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	Hoof indentations with water pooling in them- about 5cm deep, water clear.
	18-Jan-17	Spring dry						Dry- spring area cannot be observed.
	9-Oct-17	Water as per SP09						Boggy area that feeds the wetland at the location of former Spring 9. Vegetation healthy and very wet and boggy. No parameters taken and water only pooled in small amounts and the same water feeds spring 9 wetland.
	3-Jul-18	No parameters could be taken.						Boggy area that feeds the wetland at the location of former Spring 9. Vegetation healthy and very wet and boggy. No parameters taken and water only pooled in small amounts and the same water feeds spring 9 wetland
	8-Jan-19	Spring dry						Dry
	18-Jul-19	Spring dry						Dry. Vegetation healthy
	16-Dec-19	Spring dry						Damp seep in embankment.
	6-Nov-20	Spring dry						Damp seep in embankment.
	17-Jun-21	Spring dry						Damp seep in embankment.
	20-Dec-21	Spring dry						Damp seep in embankment.

* 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 5 - Historical groundwater bore development data

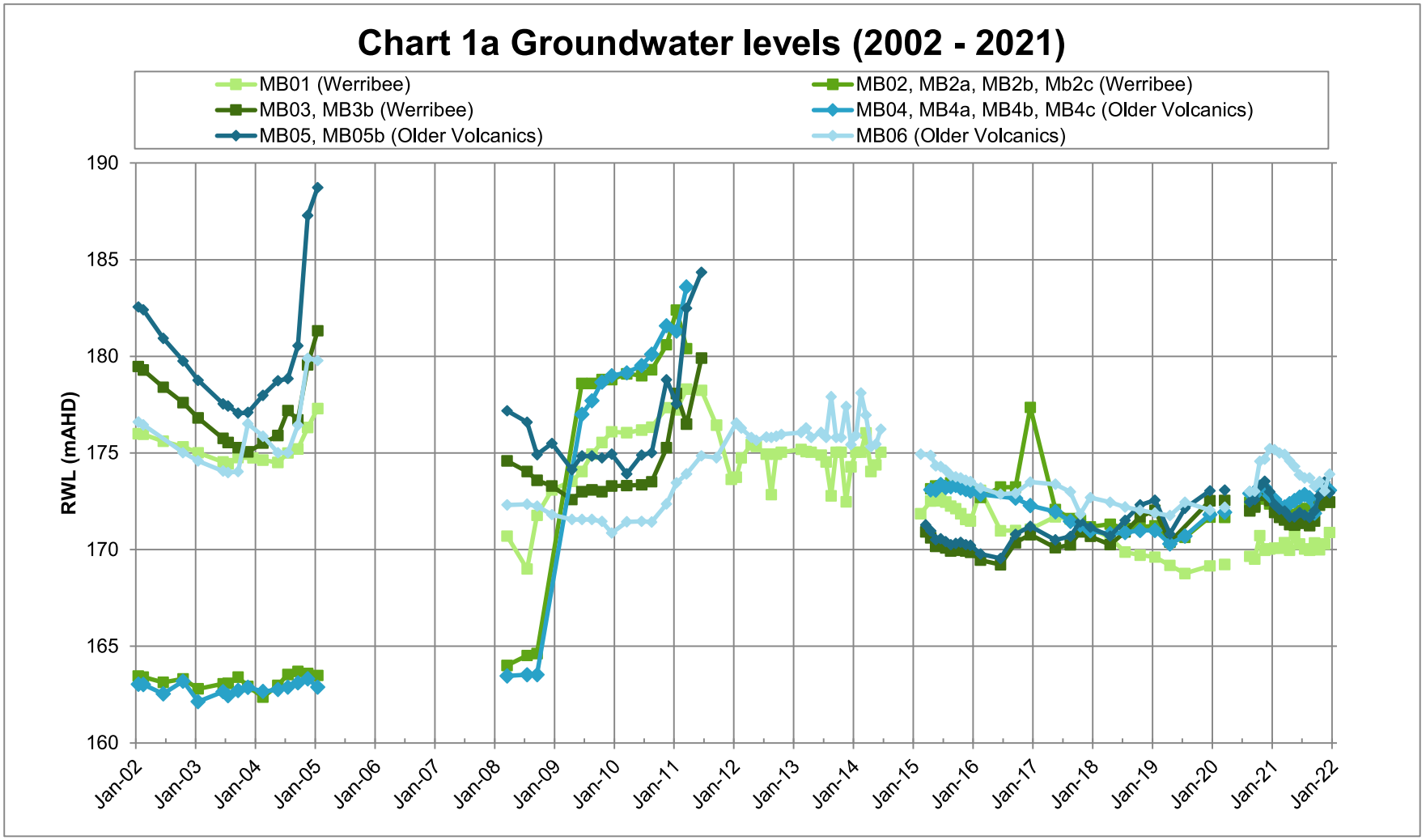
BORE ID	DATE	EC (µS/cm)	TDS* (mg/L)
MB04C	18/01/2017	3461	2318.87
MB02C	18/01/2017	2964	1985.88
MB02B	21/10/2014	2017	1351.39
MB04B	23/10/2014	2161	1447.87
MB03B	28/10/2014	1702	1140.34
MB05B	28/10/2014	1806	1210.02

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

Attachment 3

Charts

Chart 1a Groundwater levels (2002 - 2021)



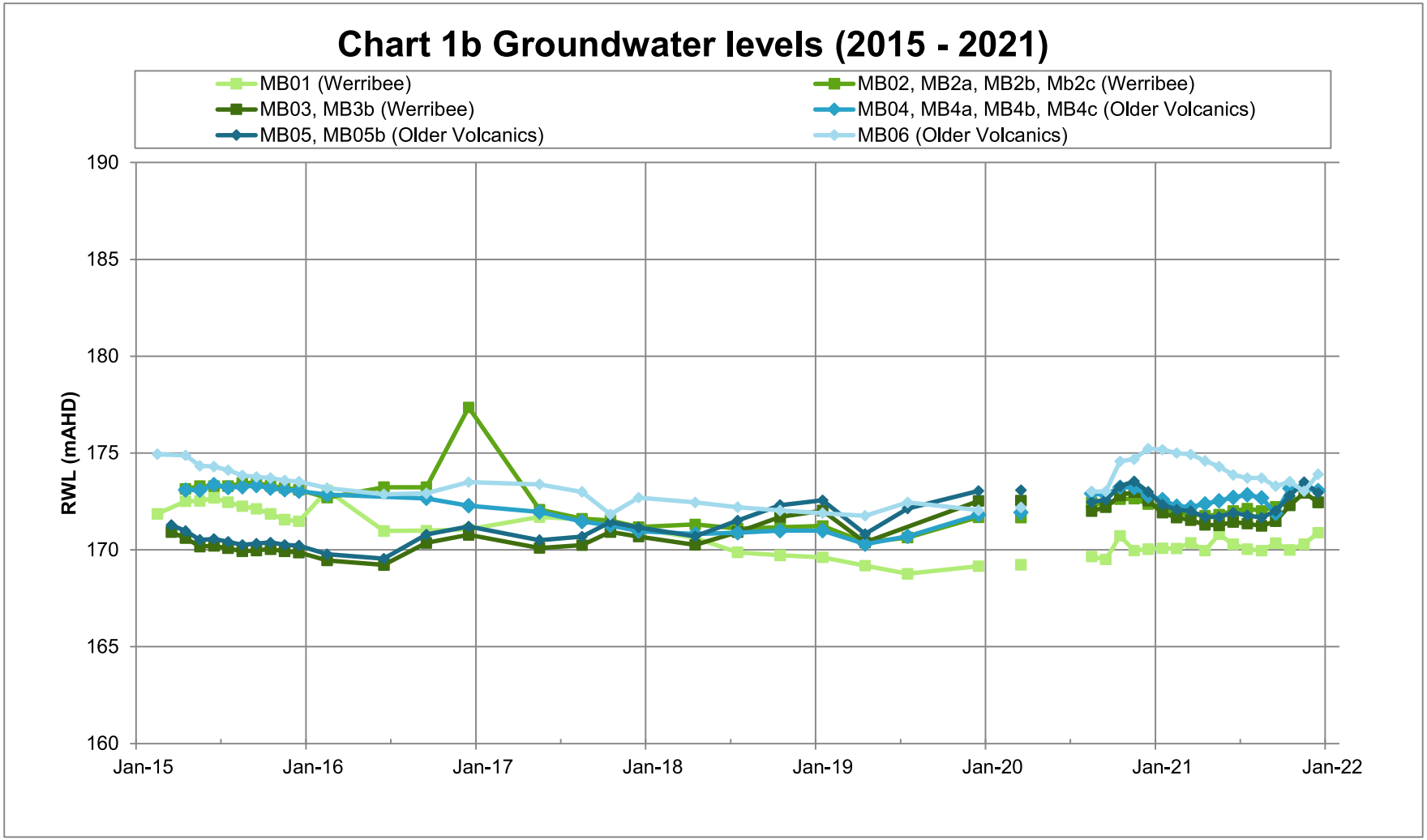
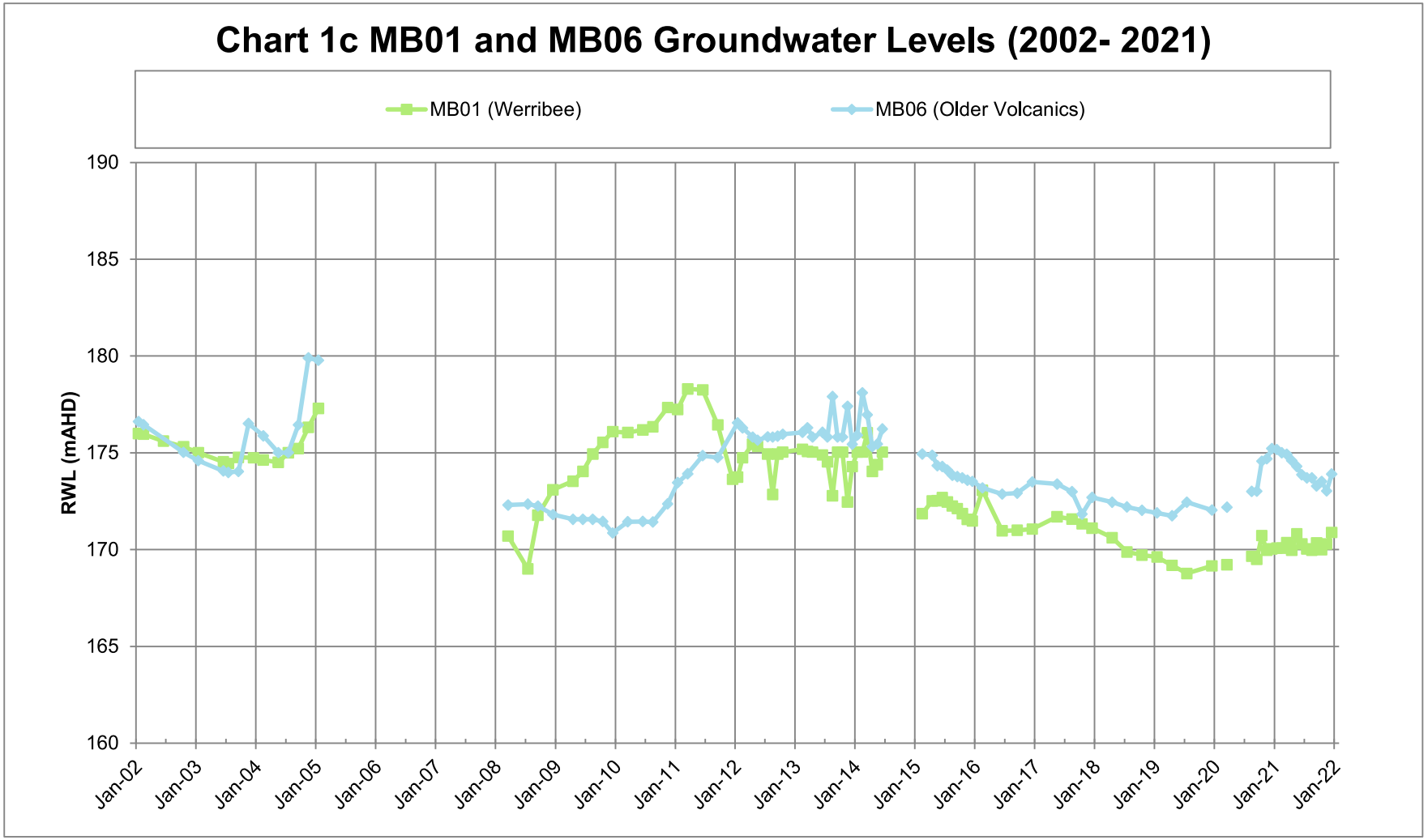


Chart 1b Groundwater levels (2015 - 2021)
MB01 (Werribee)
MB02, MB2a, MB2b, Mb2c (Werribee)
MB03, MB3b (Werribee)
MB04, MB4a, MB4b, MB4c (Older Volcanics)
MB05, MB05b (Older Volcanics)
MB06 (Older Volcanics)
RWL (mAHD)
190
185
180
175
170
165
160
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

Chart 1c MB01 and MB06 Groundwater Levels (2002- 2021)



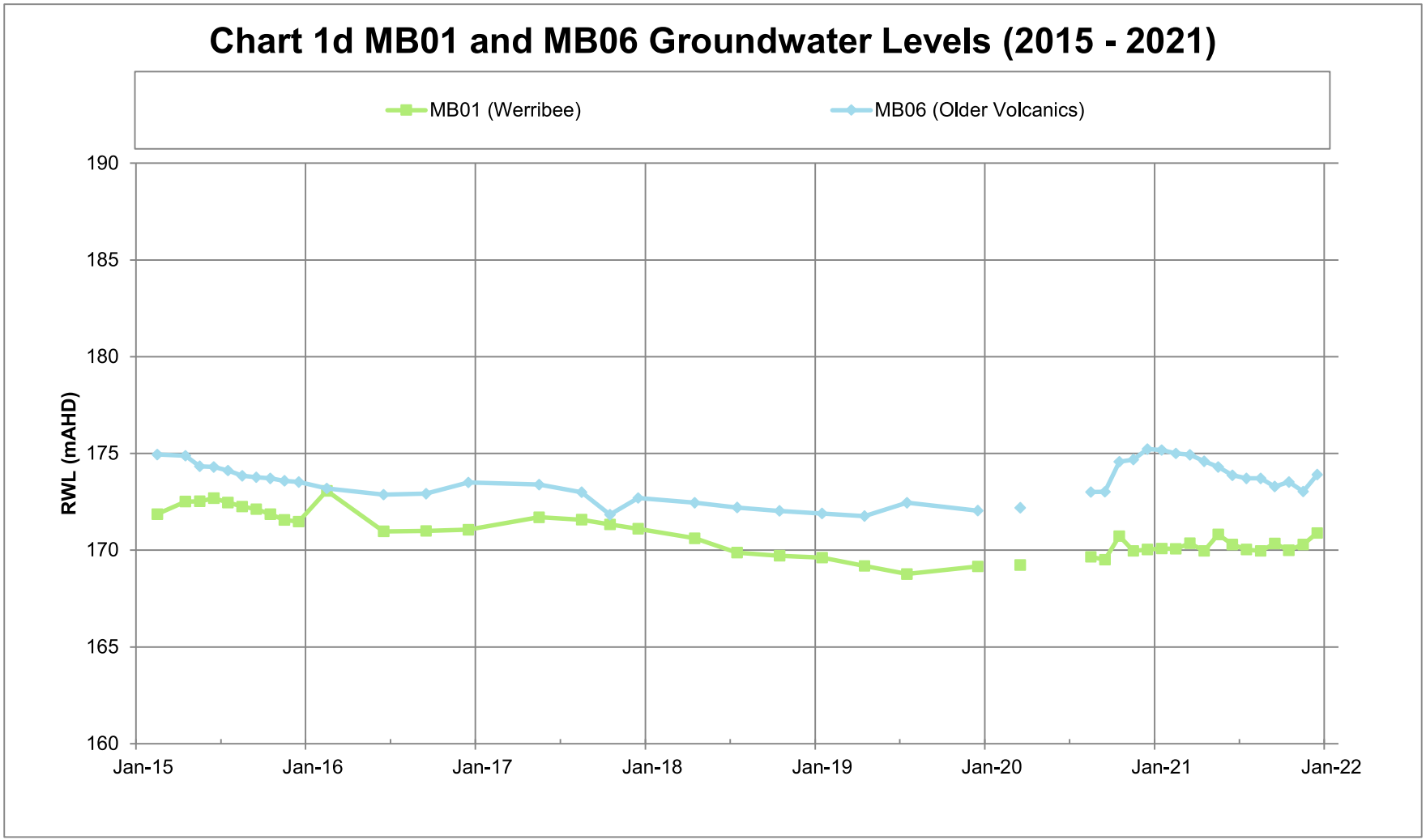


Chart 1d MB01 and MB06 Groundwater Levels (2015 - 2021)
MB01 (Werribee)
MB06 (Older Volcanics)
RWL (mAHD)
190
185
180
175
170
165
160
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

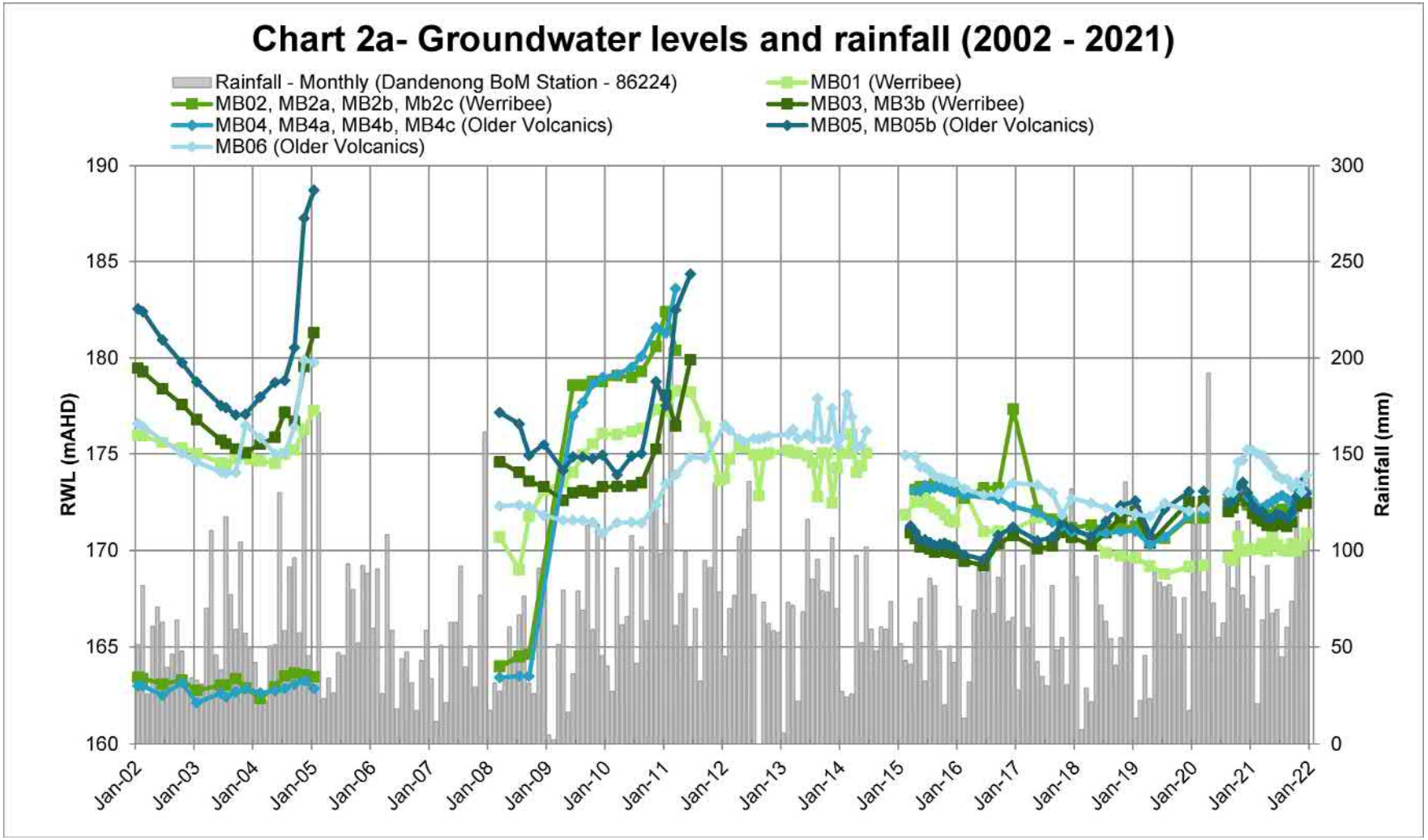


Chart 2a- Groundwater levels and rainfall (2002 - 2021)
Rainfall - Monthly (Dandenong BoM Station - 86224)
MB01 (Werribee)
MB02, MB2a, MB2b, Mb2c (Werribee)
MB03, MB3b (Werribee)
MB04, MB4a, MB4b, MB4c (Older Volcanics)
MB05, MB05b (Older Volcanics)
MB06 (Older Volcanics)
RWL (mAHD)
Rainfall (mm)
190
185
180
175
170
165
160
300
250
200
150
100
50
0
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

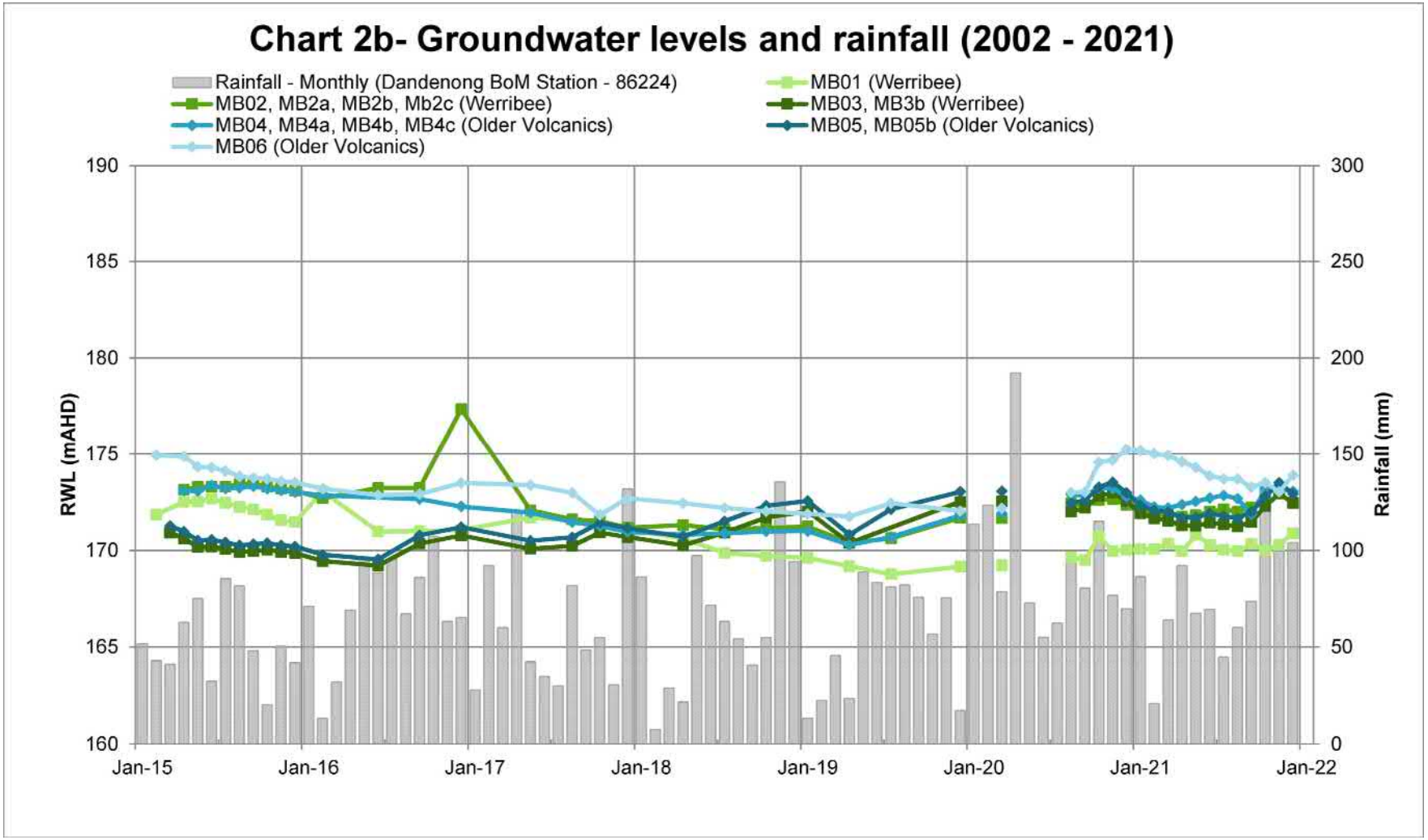
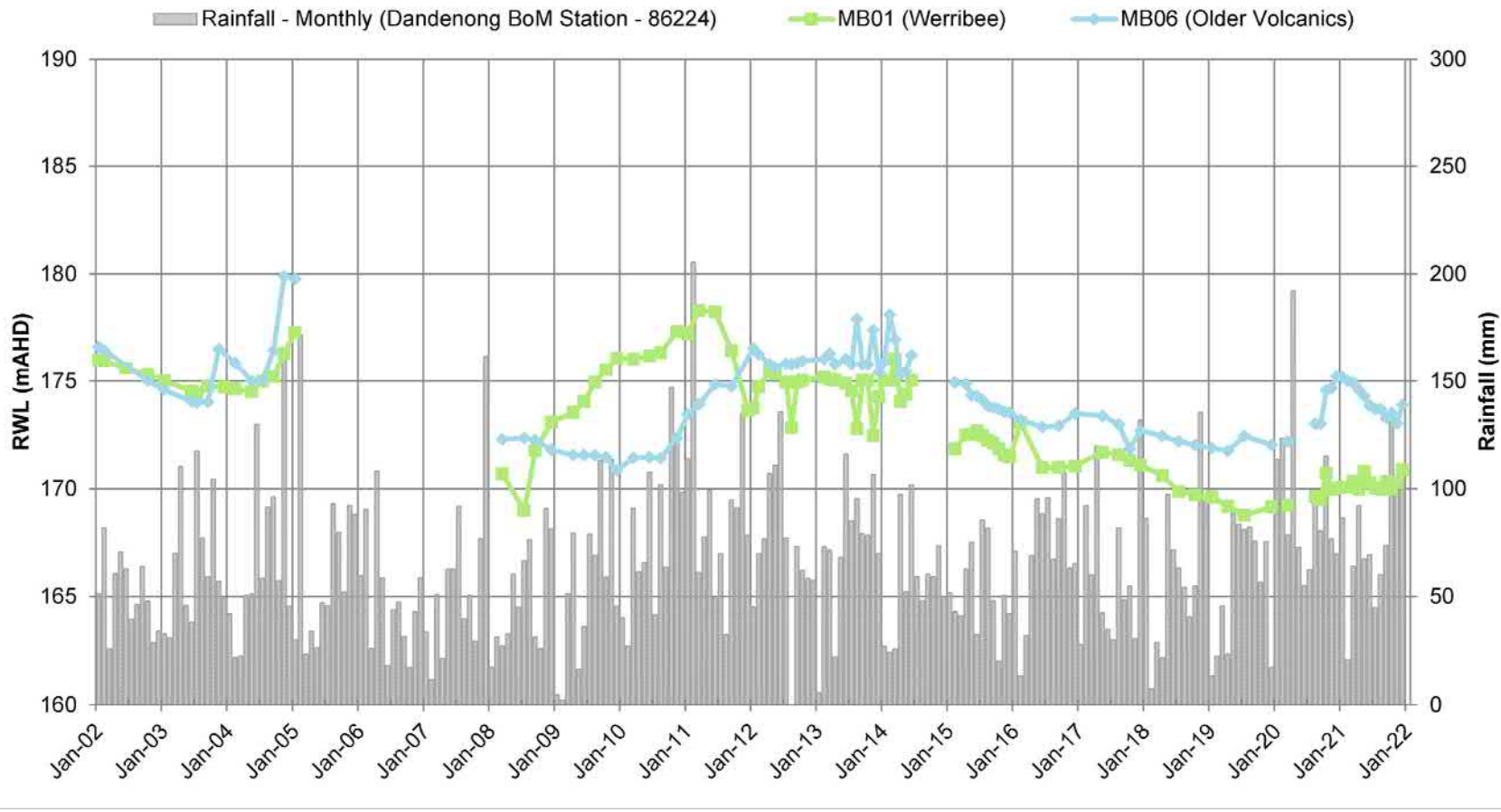


Chart 2b- Groundwater levels and rainfall (2002 - 2021)
Rainfall - Monthly (Dandenong BoM Station - 86224)
MB01 (Werribee)
MB02, MB2a, MB2b, Mb2c (Werribee)
MB03, MB3b (Werribee)
MB04, MB4a, MB4b, MB4c (Older Volcanics)
MB05, MB05b (Older Volcanics)
MB06 (Older Volcanics)
RWL (mAHD)
Rainfall (mm)
190
185
180
175
170
165
160
300
250
200
150
100
50
0
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

Chart 2c- Groundwater levels (MB01 and MB06) and rainfall (2002 - 2021)



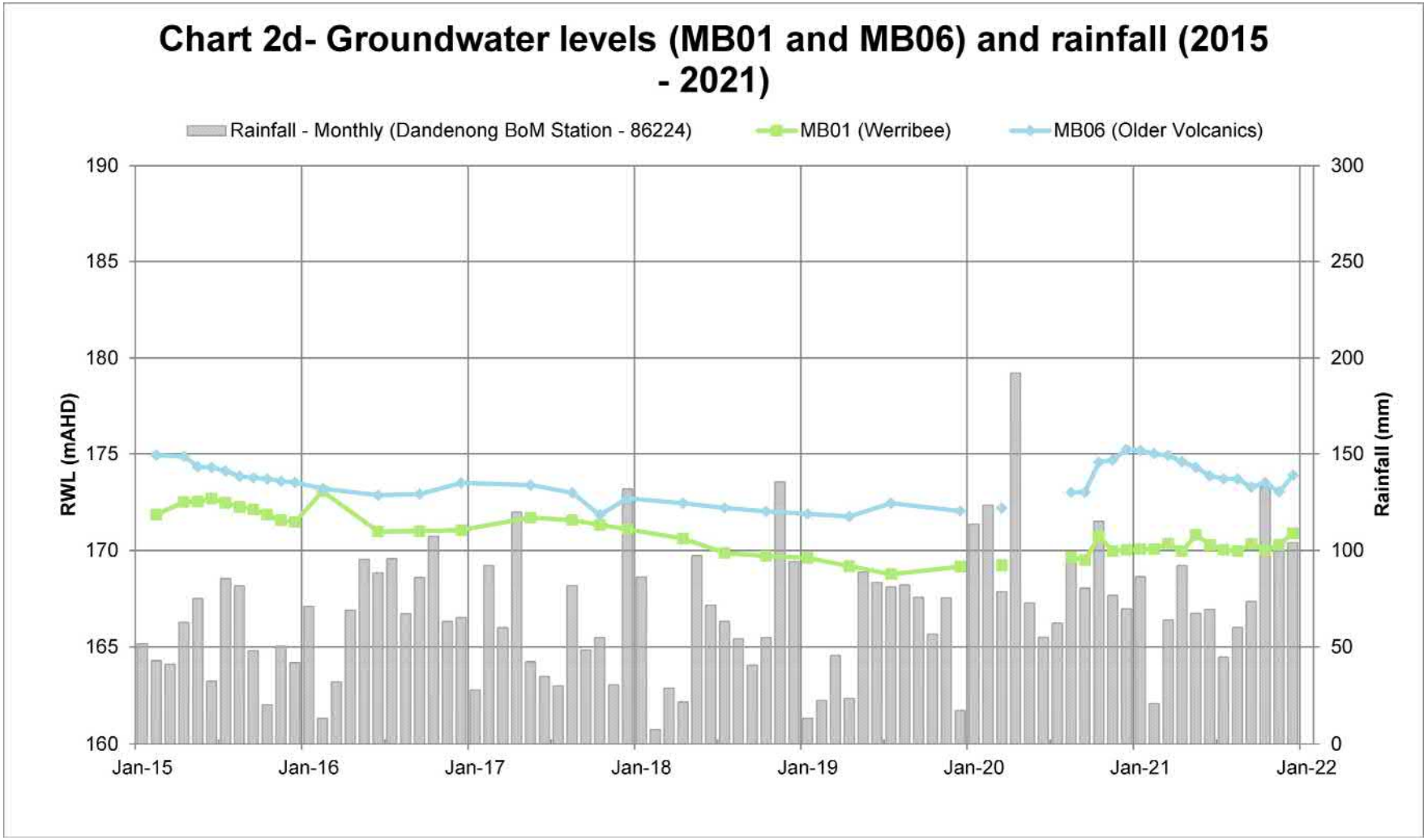


Chart 2d- Groundwater levels (MB01 and MB06) and rainfall (2015 - 2021)
Rainfall - Monthly (Dandenong BoM Station - 86224)
MB01 (Werribee)
MB06 (Older Volcanics)
RWL (mAHD)
Rainfall (mm)
190
185
180
175
170
165
160
300
250
200
150
100
50
0
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

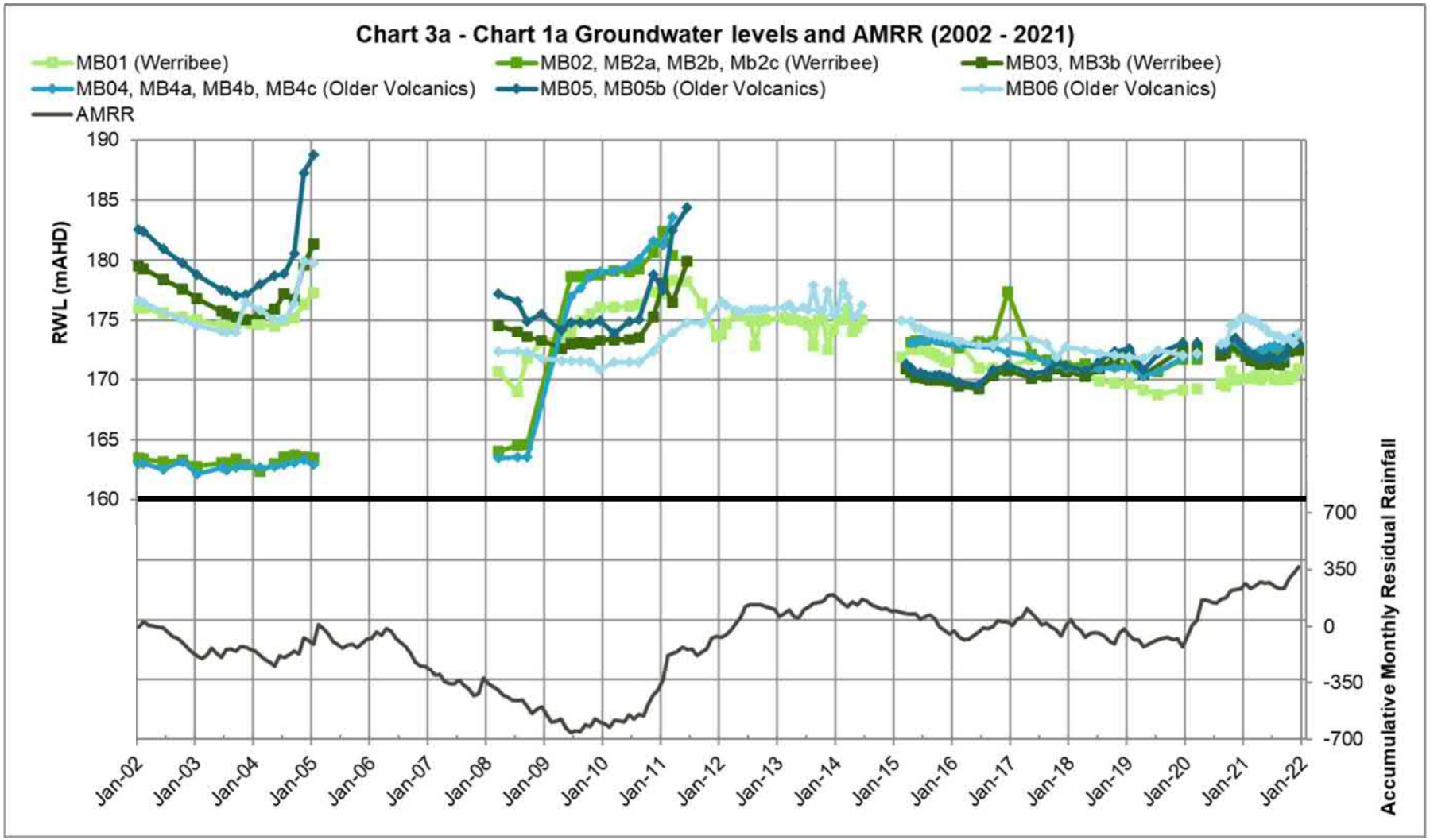


Chart 3a - Chart 1a Groundwater levels and AMRR (2002 - 2021)
MB01 (Werribee)
MB02, MB2a, MB2b, Mb2c (Werribee)
MB03, MB3b (Werribee)
MB04, MB4a, MB4b, MB4c (Older Volcanics)
MB05, MB05b (Older Volcanics)
MB06 (Older Volcanics)
AMRR
RWL (mAHD)
190
185
180
175
170
165
160
700
350
0
-350
-700
Accumulative Monthly Residual Rainfall
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

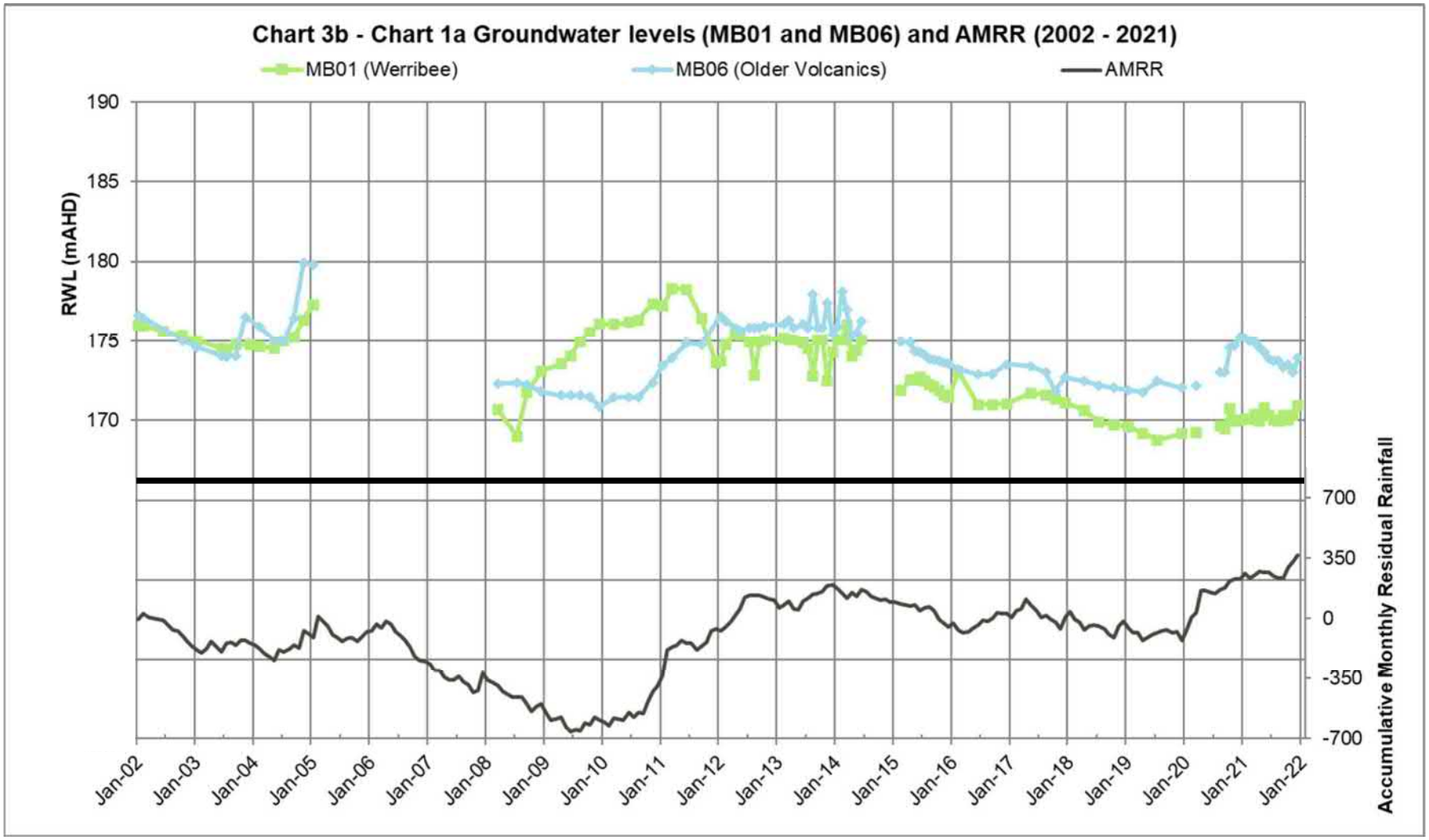


Chart 3b - Chart 1a Groundwater levels (MB01 and MB06) and AMRR (2002 - 2021)
MB01 (Werribee)
MB06 (Older Volcanics)
AMRR
RWL (mAHD)
190
185
180
175
170
700
350
0
-350
-700
Accumulative Monthly Residual Rainfall
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

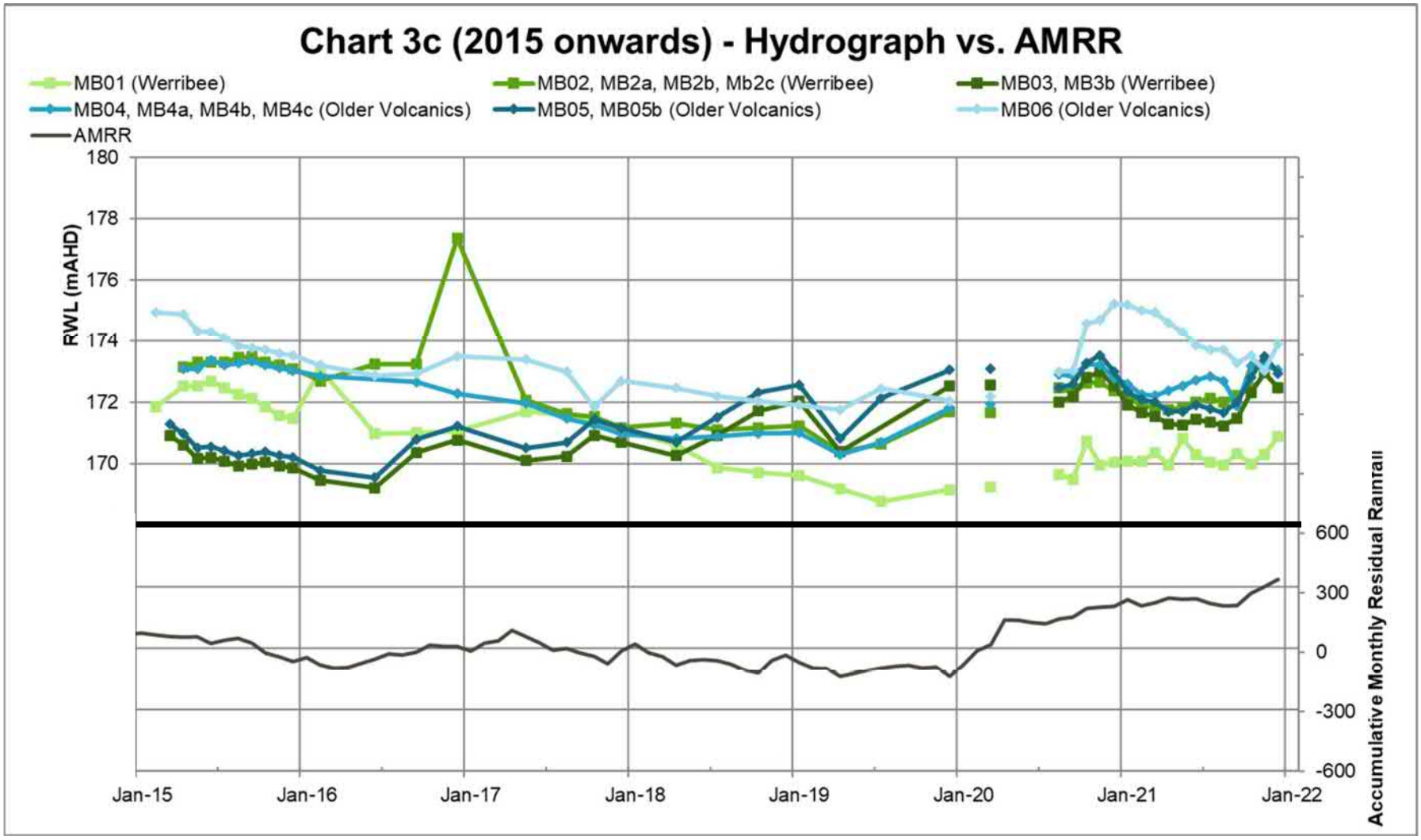


Chart 3c (2015 onwards) - Hydrograph vs. AMRR
MB01 (Werribee)
MB02, MB2a, MB2b, Mb2c (Werribee)
MB03, MB3b (Werribee)
MB04, MB4a, MB4b, MB4c (Older Volcanics)
MB05, MB05b (Older Volcanics)
MB06 (Older Volcanics)
AMRR
RWL (mAHD)
180
178
176
174
172
170
600
300
0
-300
-600
Accumulative Monthly Residual Rainfall
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

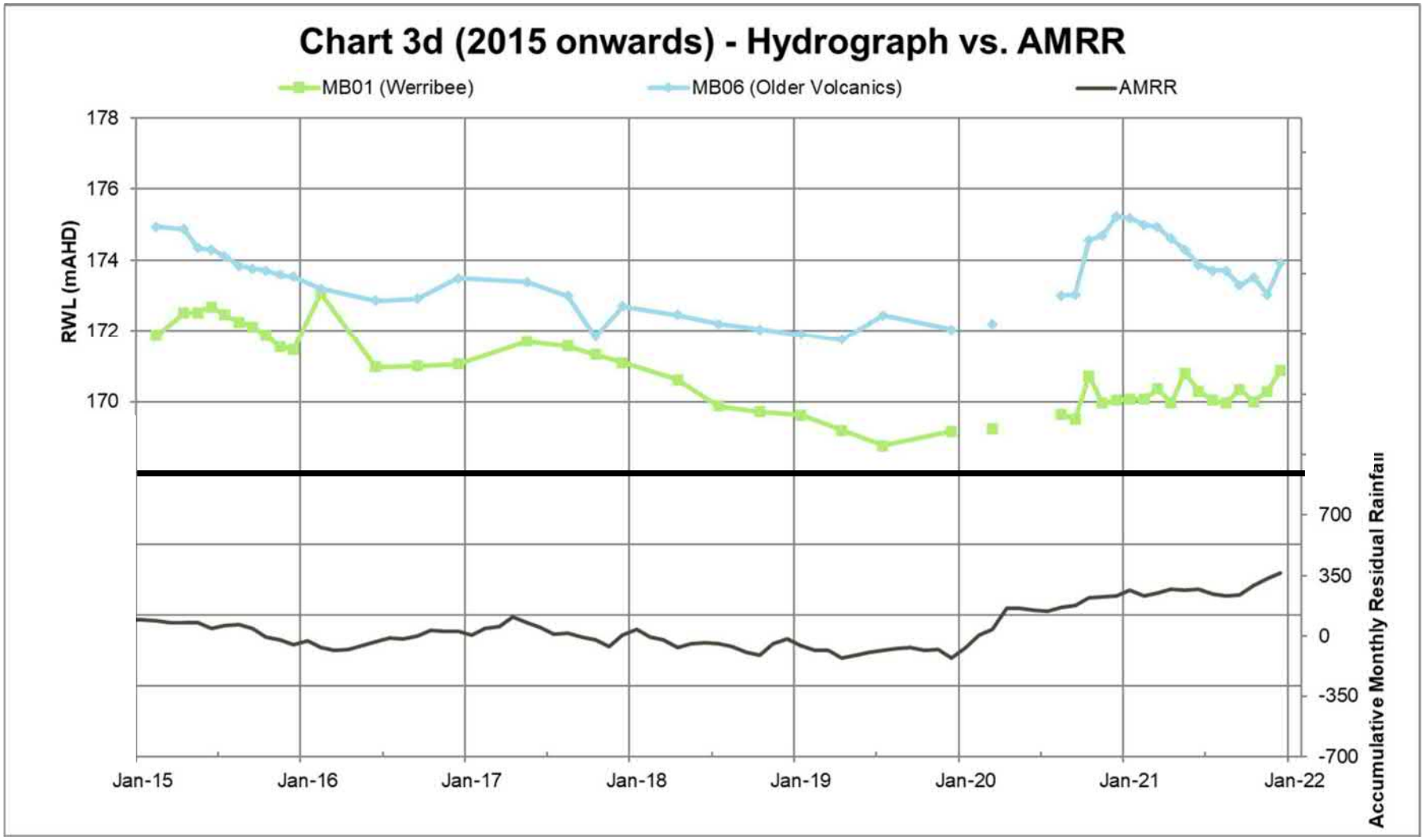


Chart 3d (2015 onwards) - Hydrograph vs. AMRR
MB01 (Werribee)
MB06 (Older Volcanics)
AMRR
RWL (mAHD)
178
176
174
172
170
700
350
0
-350
-700
Accumulative Monthly Residual Rainfall
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

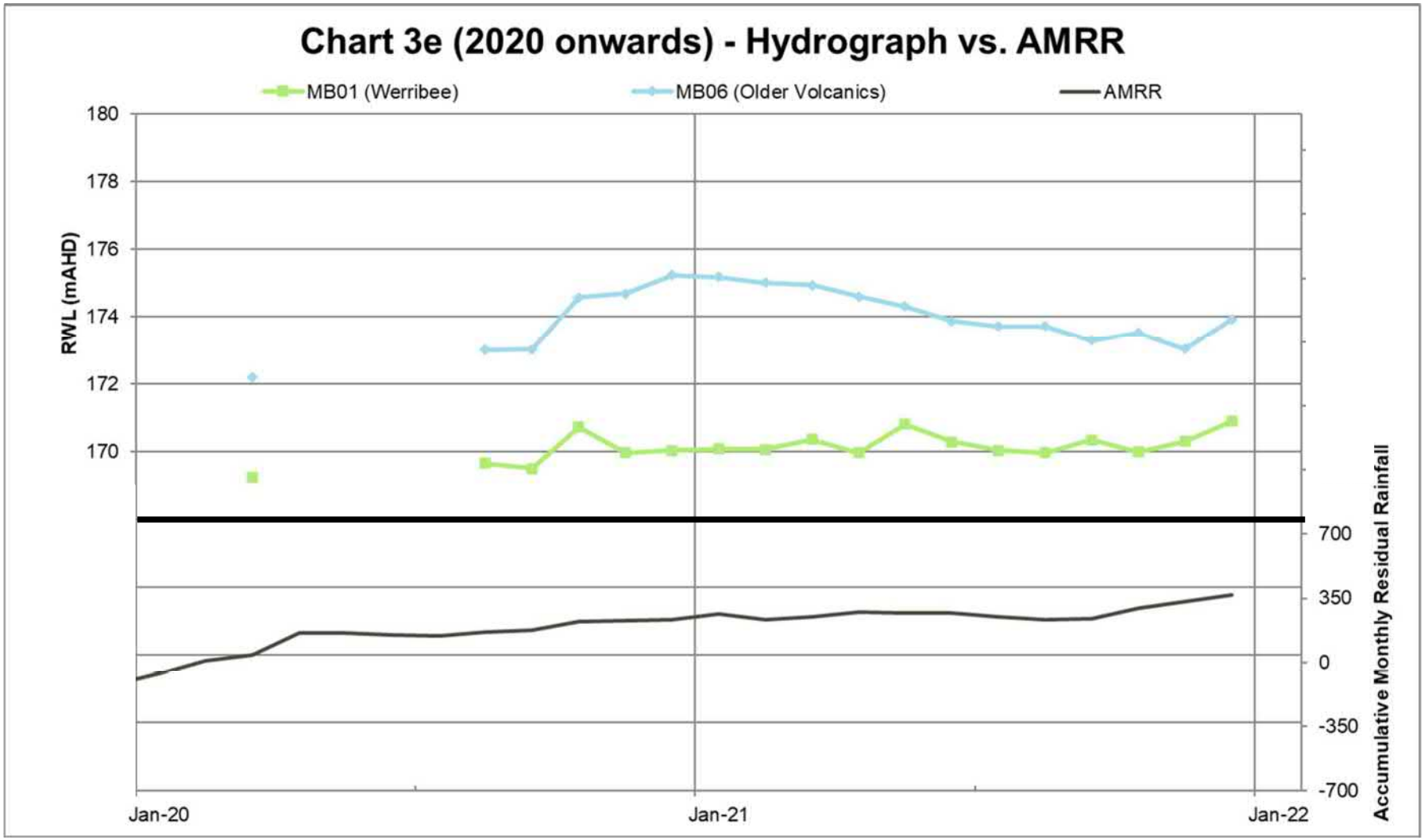


Chart 3e (2020 onwards) - Hydrograph vs. AMRR
MB01 (Werribee)
MB06 (Older Volcanics)
AMRR
RWL (mAHD)
180
178
176
174
172
170
700
350
0
-350
-700
Accumulative Monthly Residual Rainfall
Jan-20
Jan-21
Jan-22

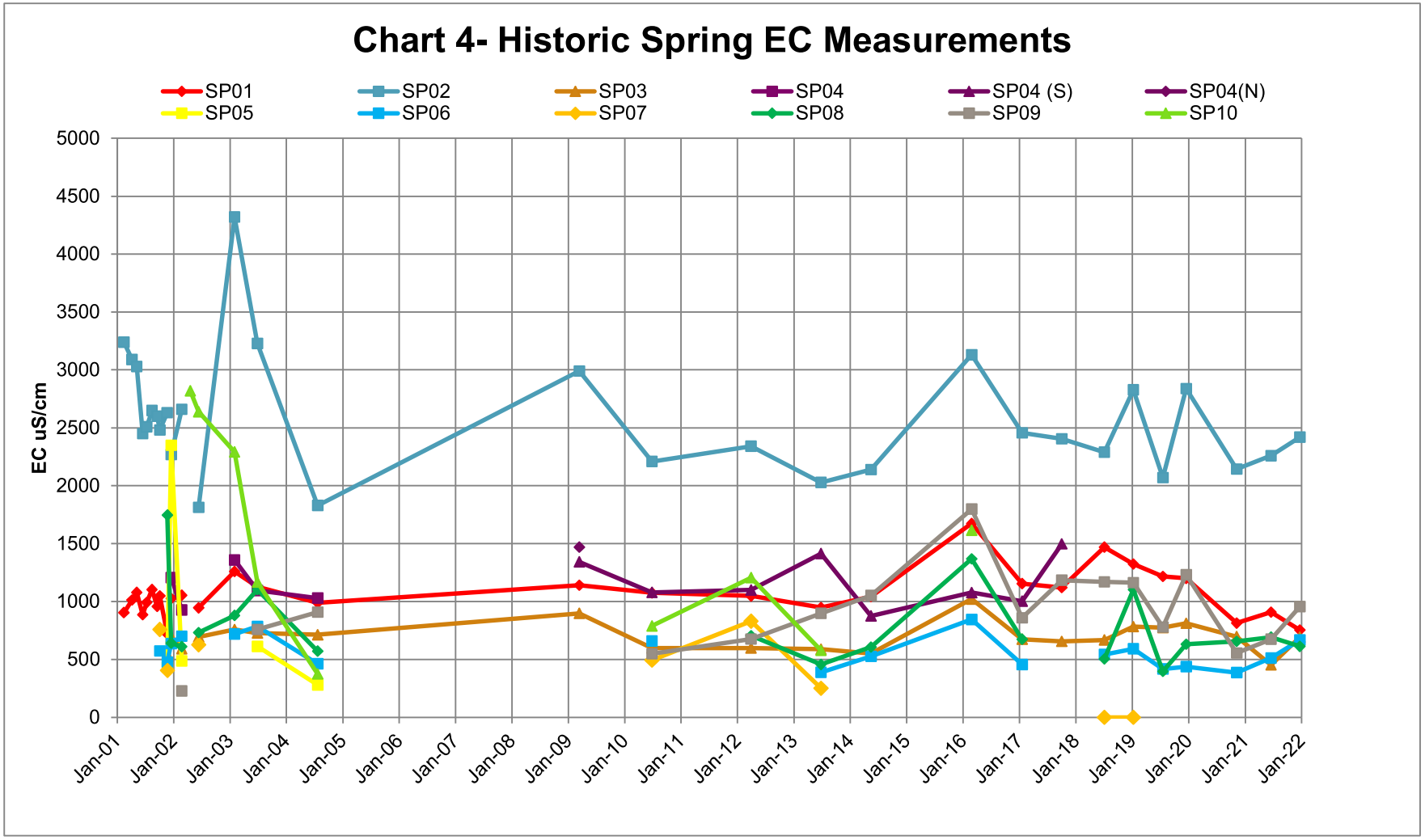


Chart 4- Historic Spring EC Measurements
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10
EC uS/cm
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

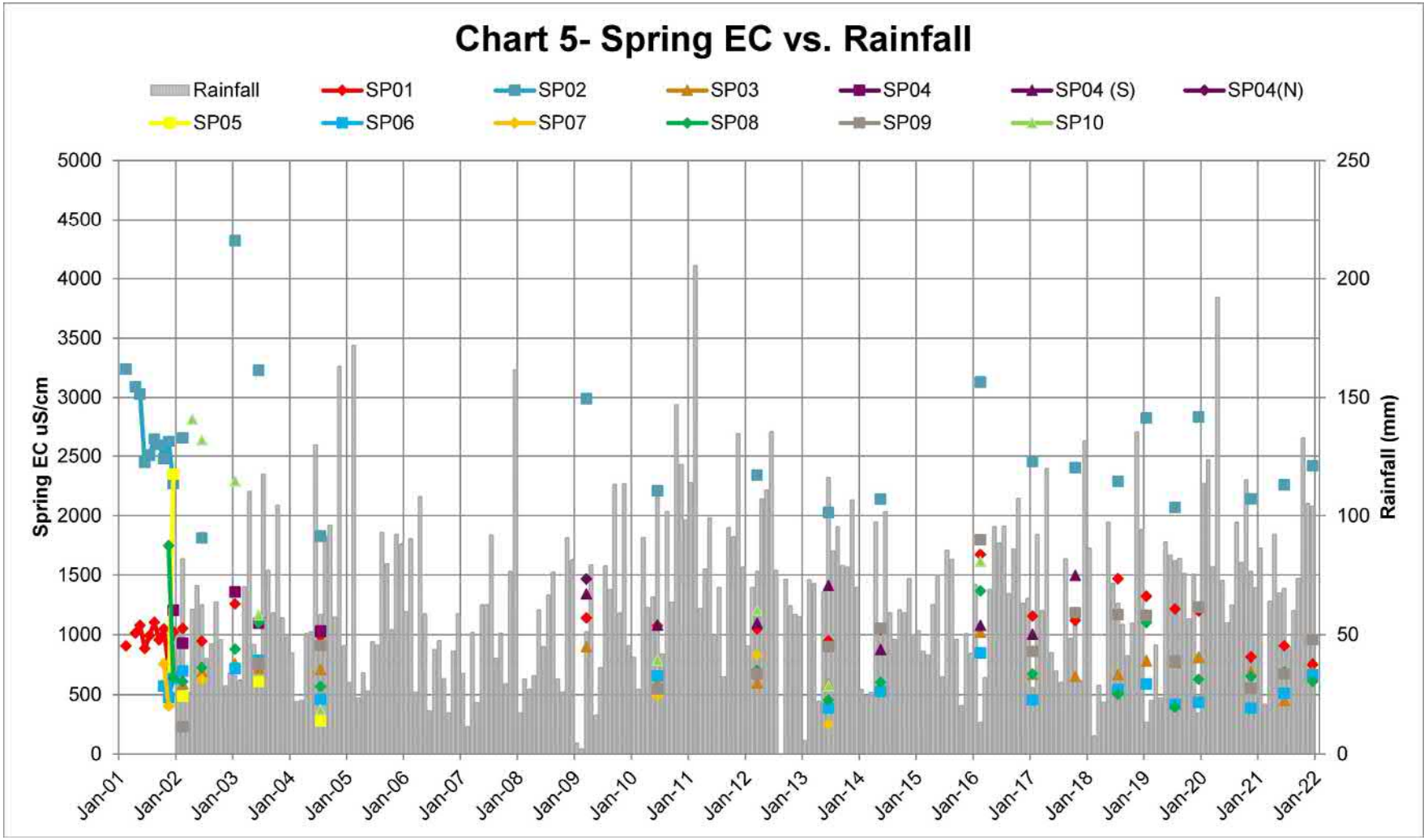


Chart 5- Spring EC vs. Rainfall
Rainfall
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10
Spring EC uS/cm
Rainfall (mm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
250
200
150
100
50
0
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

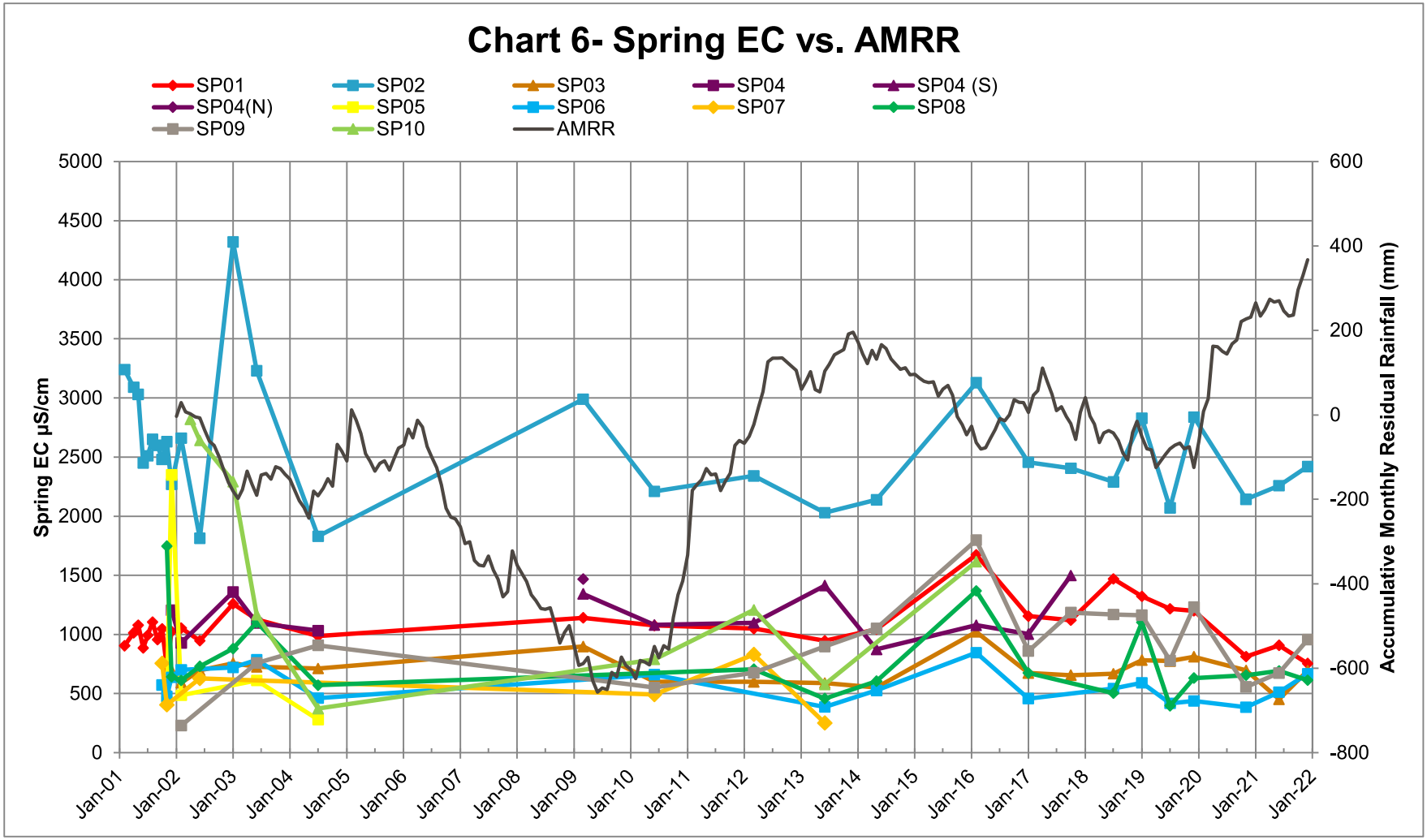
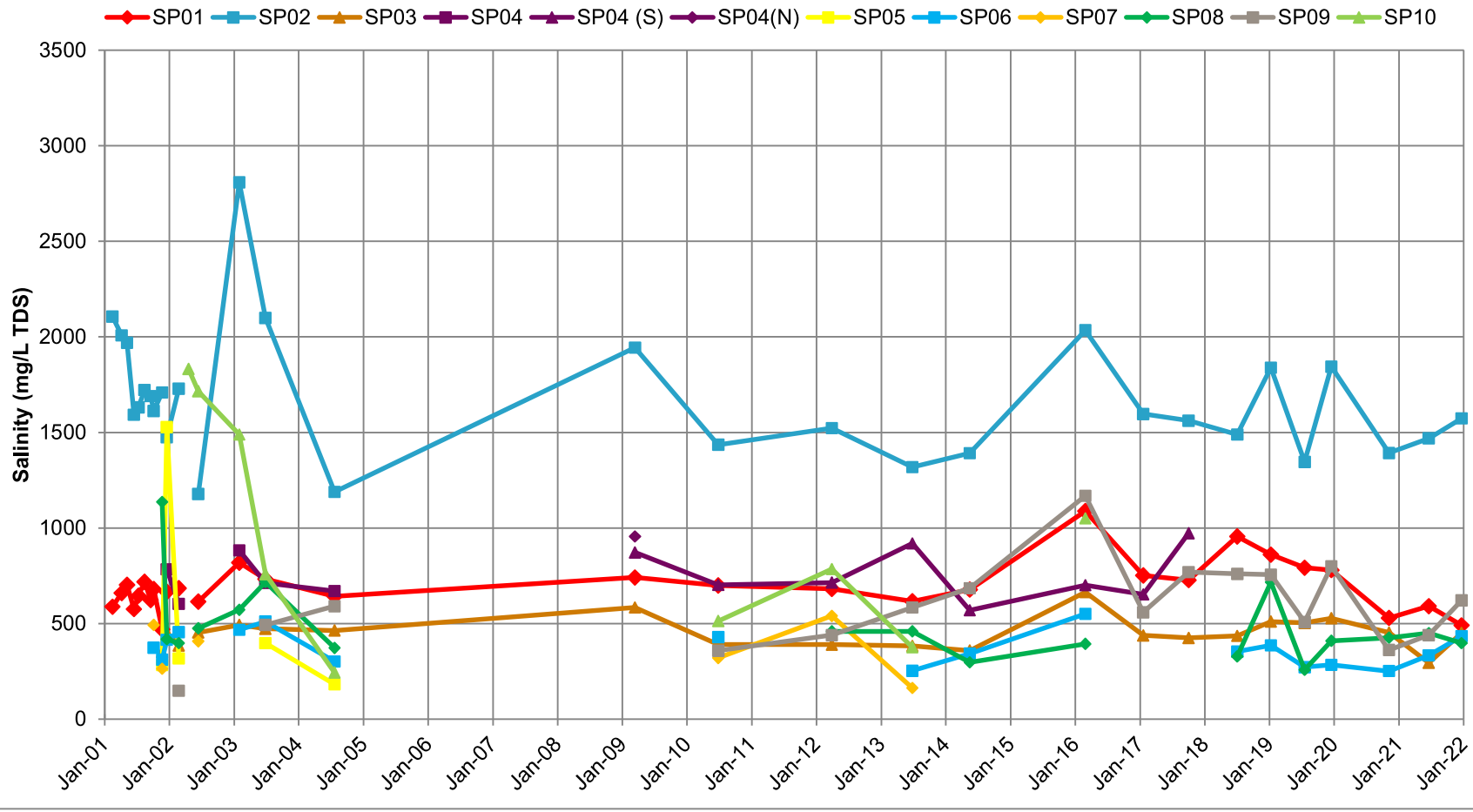


Chart 6- Spring EC vs. AMRR
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10
AMRR
Spring EC µS/cm
Accumulative Monthly Residual Rainfall (mm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
600
400
200
0
-200
-400
-600
-800
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22

Chart 7 - Historic salinity (TDS) measurements



Attachment 4

Site Photographs

Attachment 4 Site Photographs

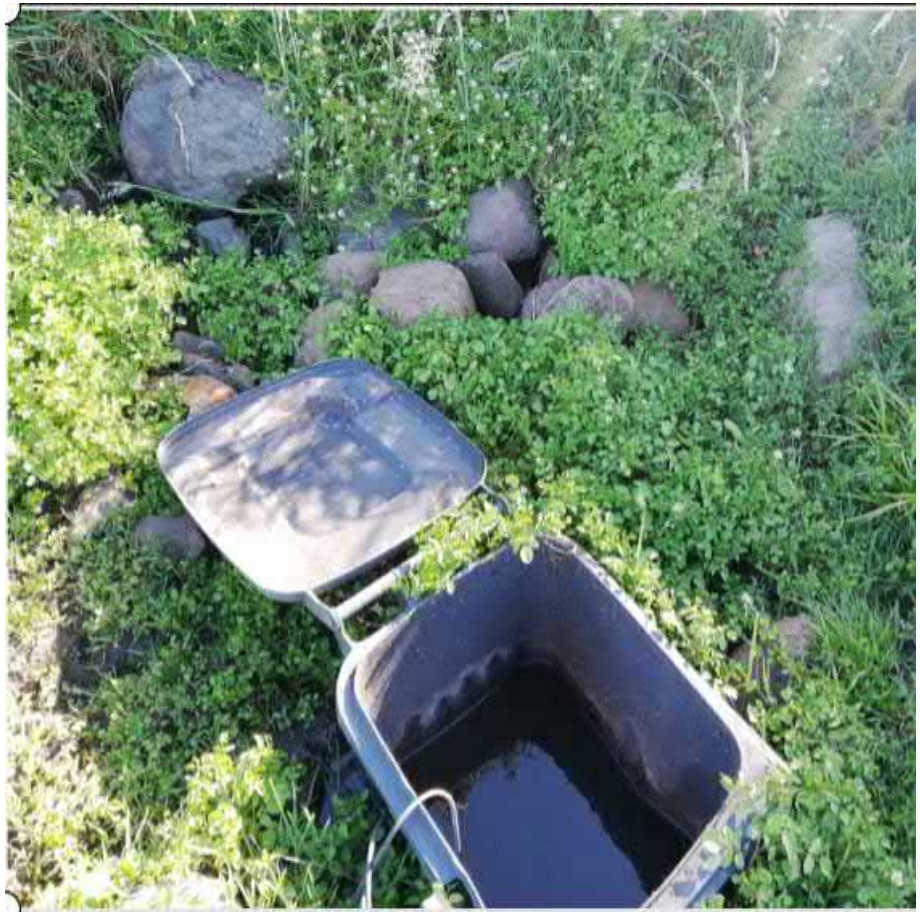
Plate 1 Spring 1 **June 2021**	**Plate 1 Spring 1** **December 2021**
	

Plate 2 Spring 2 June 2021	Plate 2 Spring 2 December 2021
	

Plate 3 Spring 3 June 2021	Plate 3 Spring 3 December 2021
	

Plate 4 Spring 4 June 2021	Plate 4 Spring 4 December 2021
Inaccessible	

Plate 5 Spring 5 June 2021	Plate 5 Spring 5 December 2021
	

Plate 6 Spring 6 **June 2021**	**Plate 6 Spring 6** **December 2021**
	
Plate 7 Spring 7 **June 2021**	**Plate 7 Spring 7** **December 2021**
Inaccessible	**Inaccessible**

Plate 8 Spring 8 June 2021	Plate 8 Spring 8 December 2021
	

Plate 9 Spring 9 June 2021	Plate 9 Spring 9 December 2021
	

Plate 10 Spring 10 June 2021	Plate 10 Spring 10 December 2021
	

Attachment 5

2021 Areas of overburden placement and revegetation

Attachment 5 Pakenham Quarry 2021 overburden placement and revegetation