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2022 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 **Figure 1**).

This 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 **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[2] 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 April 2022, June 2022, September 2022 and December 2022. Results of the gauging have been provided to Holcim post every gauging event;
- Biannual assessment of 10 springs or seepages in June 2022 and December 2022, including;
  - site walkover to visually assess the condition of each spring;

[1] *Pakenham Quarry Environmental Management Plan, version 3: August 2015.* prepared by Holcim (Australia) Pty Ltd
[2] Beneficial uses are now termed environmental values under the EPA Environmental Reference Standard 2021

  - Collection of supporting photographs at each spring location;
  - 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

4.1.1 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[3] 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 **Figure 2** and **Table 1** (attached) summarises the bore locations, screened interval and aquifer.

4.1.2 Springs

Ten springs[4] 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

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

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 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 of 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 **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								

Observations of salinity at the springs show a range from 149 mg/l (SP09 in February 2002) to 2,808 mg/L (SP02 in January 2003) as TDS (**see Table 4**, attached). 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 mg/l (MB03B in October 2014) and 2,318 mg/L (MB04C in January 2017) (see **Table 5**, attached), 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 4.1.2), 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

6.1.1 Groundwater Monitoring

Quarterly groundwater level gauging from the bore network was undertaken by AECOM during 2022. The historic data set of groundwater elevations for the bore network is presented as **Table 2** (attached).

For simplicity, bores and replacement bores have been plotted as one monitoring location to produce time series hydrographs (**Charts 1a – 1d**). These hydrographs are produced at two different time scales (2002 – 2022 and 2015 – 2022) 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 several bores have been replaced overtime, and in selected events the elevation of the top of casing has been inferred. These limitations are noted on **Table 2** (attached).

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. It is noted that MB06 increased in groundwater elevation by 3.6 m between September and December 2022, increasing the range between the highest and lowest recorded water levels at this bore to approximately 6.6 m. This significant increase in water level coincides with above average monthly rainfall in August, October and November.

6.1.2 Results

The groundwater levels throughout 2022 are consistent with water levels since at least 2015. Groundwater levels in MB06 (Older Volcanics), located upgradient of the quarry 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 and reached the highest elevation since 2015 of 177.53 mAHD in December 2022.

The same pattern has been seen in MB01 (Werribee Formation), located downgradient of the quarry, albeit in a more subdued fashion (see Chart 1c). This suggests that the trends are a regional as they are displayed in both aquifers.

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.

6.1.3 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 **Table 3**, attached) has recorded data from 1961 and 2021, with the following key points:

- Overall average annual rainfall is approximately 798 mm/ year, calculated from data from 2002 to 2022.
- Since 2001, when groundwater monitoring commenced, rainfall has ranged between 587 mm (2008) and 1136 mm (2020).
- 2022 represents an above average, wet year (likely due to the La Niña weather system) with much of this rainfall occurring August through November. December 2002 rainfall was closer to the monthly average The total annual rainfall through to the end of 2022 was 962.3 mm (above average).
- Historically rainfall totals were below the average annual rainfall value of 798 mm/year between 2002 and 2008 and increasing between 2010 and 2012 (a trend which was consistent with regional groundwater level observations). From 2013 to present, the annual rainfall has generally fluctuated both above and below the annual average, however 2020, 2021 and 2022 have all been above the long term annual average rainfall volume (see **Table 3,** attached).

Charts 2a-2b (attached) present the groundwater level data from Charts 1a -1d with the monthly rainfall totals.

Charts 3a-3d (attached) 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.

- The 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.
- 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
- The AMRR plot can be seen to trend upwards throughout 2020 and 2022, particularly with the much higher than average rainfalls in October and November 2022. Chart 3d shows the AMRR plotted with groundwater levels from MB01 and MB06. Groundwater in both wells appear to reflect the increase in rainfall recharge with an increase in levels over this period (169.23 to 171.74 m AHD in MB01 and 172.20 m AHD to 177.53 m AHD in MB06.

6.1.4 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.
- 2022 - Continued mining Western side of Quarry, focusing on the southwestern corner. New land bridge was constructed across the pit (northern side) to reduce hauling distance, constructed from rocky overburden. No reclamation works occurred during the period, however 1.25ha of a previously backfilled area was topsoiled, hydroseeded and planted.

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.

6.1.5 Response to revegetation across plateau surface

Holcim continued rehabilitation works at the quarry in 2022, although these were minor with hydroseeding and planting taking place on a 1.25ha area previously reclaimed. (highlighted 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.

6.1.6 Response to progressive rehabilitation of the quarry

No reclamation works occurred at the quarry in 2022 although a land bridge was constructed across part of the former pit.

Future 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 2022 and 21 December 2022.

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

Results of the spring survey completed in June 2022 and December 2022 are summarised in **Table 4** below. Historical spring parameters are presented in **Table 4** (attached) and a chart of measured EC over time is presented as **Chart 4.**

Rainfall vs the measured EC is also plotted as **Chart 5** and AMRR vs the measured EC is also plotted in **Chart 6**. 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/Use (if any)	Location/history/use/changes	EC (µS/cm) June 2022	EC (µS/cm) December 2022	Observations June 2022	Observations December 2022
SP01	West of quarry Provides irrigation and stock water to a number of properties in the local area	928	753	113mL/s flowing from spring (9.8m^3/day)	Water flowing into bin, losing some water which misses the capture system. Flow rate = 19m^3/day
SP02	West of the quarry historically been observed to be a small dam fed by groundwater and surface water runoff from a relatively steep slope above Previous rounds underestimated flow at the bore due to the addition of a pipe to divert flow from the spring to the tank which was not taken into account. Flow is	1995	2265	Thick vegetation. Flow measured at tank downhill – 0.027L/s (2.3m^3/day)	Flow rate 5L/171 secs from second trough outflow, thick veg around spring (2.5m^3/day)

SPRING ID/Use (if any)	Location/history/use/changes	EC (µS/cm) June 2022	EC (µS/cm) December 2022	Observations June 2022	Observations December 2022
	now measured at the pipe outflow to the tank.				
SP03	West of the quarry Vegetation has historically, and continues to be, healthy bin was installed since November 2020 to manage overflow	662	673	Healthy vegetation. Sunken bin leading to only intermittent flow from spring. Unable to gauge during visit but trough filled from spring lower down slope full.	Flow rate 5L in 142 Secs, healthy veg, flow into bin with some seepage (3.0m^3/day)
SP04	Northwest of the quarry Spring is historically observed to be dry or with damp seep with healthy vegetation.	Dry	1232	Dry	Thick vegetation, clear water, algae, no flow from spring. Audible flow on bank above spring but not visible through vegetation or without soil disturbance.
SP05	South of quarry Spring is historically observed to be dry with healthy vegetation	Dry	Dry	Vegetation healthy. Sign reads Spring 1	Vegetation healthy. Sign corrected.
SP06	Northwest of quarry Generally displays as turbid standing water. Accessible by livestock	444	474	Brown, medium turbidity. Cattle pugging evident. No outflow visible.	Light brown, medium turbidity, healthy veg. Standing water at spring. Audible flow on slope beneath spring, not visible through vegetation or without soil disturbance.
SP07	Furthest north spring with 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 (when accessible) Was reclassified as a seep in 2005	Not taken	Not taken	Not observed	Not observed Reclassified as seep

SPRING ID/Use (if any)	Location/history/use/changes	EC (µS/cm) June 2022	EC (µS/cm) December 2022	Observations June 2022	Observations December 2022
SP08	North of quarry Spring is a wetland with a lot of reeds. Flow has increased in this spring from standing/stagnant water prior to 2020 to clear and flowing water. Vegetation is consistently healthy. Recommendation to install means of measuring flow such as v-notch or elevated pipe.	612	640	Measured in riding club grounds. Water flowing diffusely, unable to gauge accurately. 100-200 mL/s estimated (8.6 – 17.2 m^3/day)	1L/10sec, consistent flow. Healthy vegetation. Recommendation to install means of measuring flow such as v-notch or elevated pipe (8.6 m^3/day)
SP09	East of the quarry Has gone from being dry in 2009 to low flow in 2014. Since approximately 2016 the spring has become a wetland with healthy vegetation. Has historically been mislabelled as Spring 10 but this has been rectified by December 2022.	770	776	Wetland. Reeds and other vegetation healthy. Outflow at pipe measured at 0.311 L/s – impacted by surface water flow. Sign reads Spring 10. (26.9 m^3/day)	2.5L/3 min. Thick veg, clear water. (1.2 m^3/day)
SP10	East of the quarry, close to Spring 9. area has been recorded as dry since 2014, including in the recent December 2022 monitoring event when only a damp seep in the exposed embankment was observed. Was reclassified as a seep in 2005	Not taken	Not taken	Damp seep in embankment	Damp seep in embankment. Reclassified as seep.

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** (attached). Rainfall in 2022 (962.3 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.

The seasonal pattern of EC would be expected to generally reflect rainfall levels in winter and summer as well as longer term changes in rainfall. Higher EC values should reflect reflects lower levels of recharge/rainfall and lower EC values should reflect higher levels of recharge/rainfall. EC (on its own), EC versus rainfall and EC versus AMRR is shown for all springs in Charts 4, 5, 5a (2015 onwards), 6, 6a (2015 onwards) respectively.

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 (see comments in Table 4) 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 more strongly influenced by rainfall.

As discussed in previous reviews, SP05 has typically been dry since 2009, and SP04, SP09 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 does not appear to have resulted in SP05 and SP07 reporting standing water or spring flows. Therefore, as reported previously the spring conditions at these two locations are not considered to be strongly correlated with increased rainfall volumes and/or change in groundwater levels.

SP10 has been heavily altered by the creation of a fire access track in 2014 such that seepage from this point is intercepted by the upslope drain beside the track and commingled with other surface water which then enters the wetland identified as SP09. Visible only as damp soil on the embankment next to the track it is not possible to identify trends at this seep. Any increased or decreased discharges from this seep will be captured in flows from SP09.

Wet conditions in the preceding months up to December 2022 appear to have influenced SP04 and SP06. Standing water was observed in December 2022 at SP04 for the first time since October 2017 and flow observed for the first time since June 2010. SP06 has typically been observed to contain standing water, however, flow has not been observed historically and so assumed to be subsurface. In December 2022 flow was observed on the surface down slope from the bore. At both SP04 and SP06 flow was diffuse beneath vegetation and unable to be recorded without extensive soil disturbance.

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 6.1.2 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) is likely to remain as Segment B of the ERS (1201 – 3100 mg/L), suggesting that groundwater is suitable for the environmental values noted in Section 5.0.

Inspection of the data presented in **Chart 7** and **Chart 7a** (2015 onwards) 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.

At that time, 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.

A review of the WMIS via the Visualising Victoria's Groundwater map portal was undertaken in January 2023 for the purposes of updating this report. Table 5 shows the bores which were identified within a 2 km radius.

Table 5 Registered bore (WMIS search January 2023)

WMIS Number	Parish	Depth (m)	Constructed date	Use
114867	NAR-NAR-GOON	103	10/04/1992	
114934	GEMBROOK	65.5	24/10/1992	Domestic and Stock
115444	GEMBROOK	79	12/03/1993	
121918	GEMBROOK	74	24/11/1992	
124394	WORANGA	38.5	20/03/1995	Stock
132497	GEMBROOK	91	10/11/1997	Domestic
84069	NAR-NAR-GOON	55	14/04/1977	
84072	NAR-NAR-GOON	58	23/08/1977	
84073	NAR-NAR-GOON	30.5	25/08/1977	
84074	NAR-NAR-GOON	88	31/08/1977	

WMIS Number	Parish	Depth (m)	Constructed date	Use
84106	NAR-NAR-GOON	14.9	30/04/1990	
WRK057121	Not provided	5	19/05/2010	Observation
WRK057122	Not provided	5	19/05/2010	Observation
WRK057123	Not provided	5	19/05/2010	Observation
WRK082149	Not provided	12	22/10/2014	Observation- In quarry
WRK082152	Not provided	1.5	22/10/2014	Observation- In quarry
WRK990207	NAR-NAR-GOON	25	Not provided	In quarry

7.0 Summary

The key conclusions of this annual review are as follows:

- The groundwater levels throughout 2022 are consistent with water levels since at least 2015. Groundwater levels in MB06 (Older Volcanics), located upgradient of the quarry 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 and reached the highest elevation since 2015 of 177.53 mAHD in December 2022.
- Salinity (based on EC levels) of the springs monitored were well within historical levels.
- Conditions at most springs and seeps remain consistent with general historical observations. Notable exceptions are SP04 and SP06 which appear to have responded to increased rainfall in the months preceding the December 2022 monitoring round. SP04 had standing water for the first time since October 2017. Both SP04 and SP06 had recorded diffuse surface flow; for the first time since 2010 at SP04 and the first time ever recorded at SP06.
- In summary, the groundwater and spring monitoring collected over the 2022 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 2022 groundwater and spring survey events, the following is recommended:

- 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.
- Remove SP10 from ongoing monitoring where ground disturbance associated with the 2014 construction of the fire access track has stopped this seep from being a discrete groundwater discharge point separate from SP09.

9.0 References

AECOM, 2022. 2021 Groundwater and Spring Review, Pakenham Quarry, Letter prepared for Holcim (Australia) Pty Ltd

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Yours faithfully

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Environment
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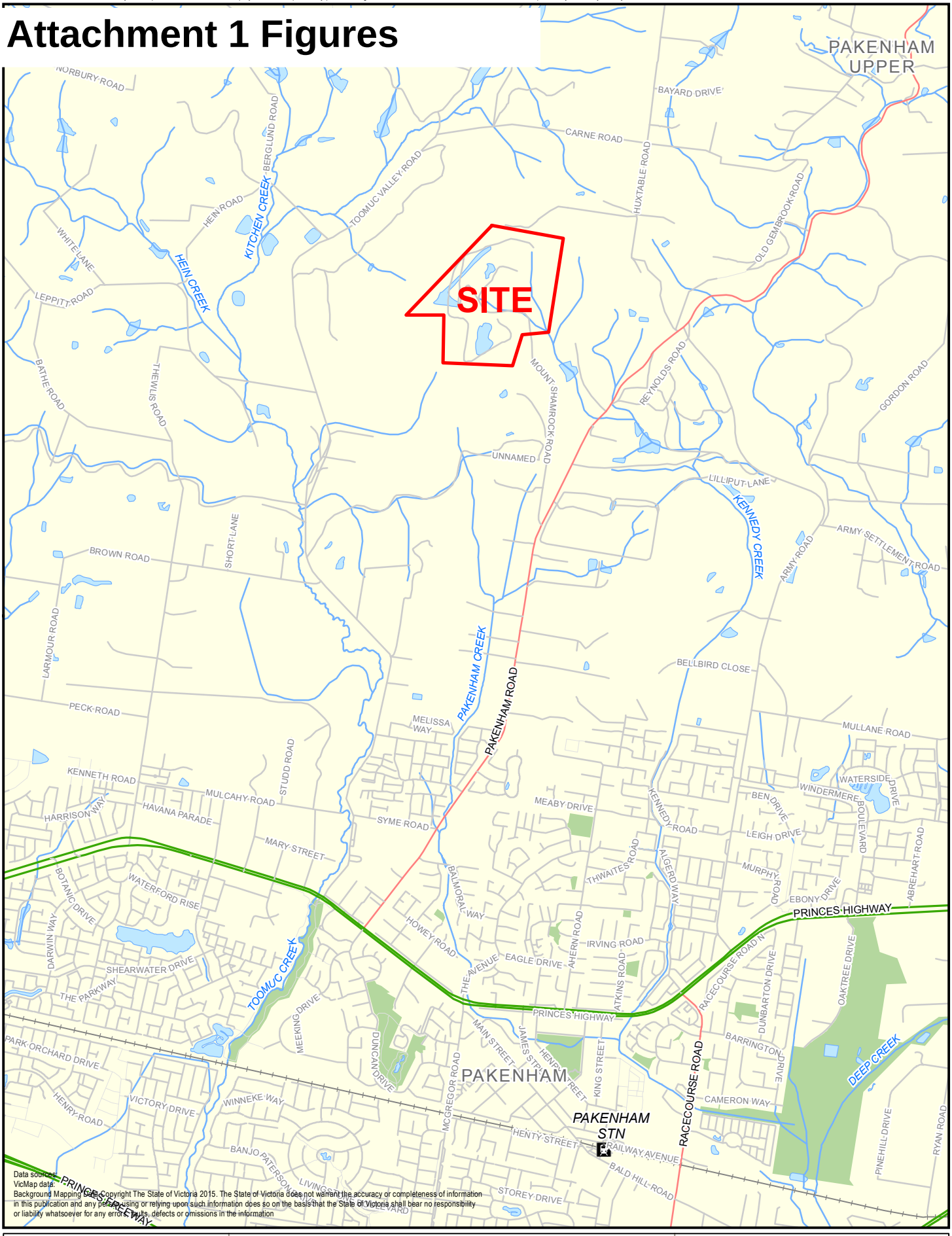
Attachments

Attachment 1	*Figures*
Attachment 2	*Tables*
Attachment 3	*Charts*
Attachment 4	*Site photographs*
Attachment 5	*2022 Areas of overburden placement and revegetation*

Attachment 1 Figures



Data sources:
VicMap data:
Background Mapping Data Copyright The State of Victoria 2015. The State of Victoria does not warrant the accuracy or completeness of information in this publication and any person using or relying upon such information does so on the basis that the State of Victoria shall bear no responsibility or liability whatsoever for any errors, faults, defects or omissions in the information

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0 270 540 810 1,080
metres

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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)

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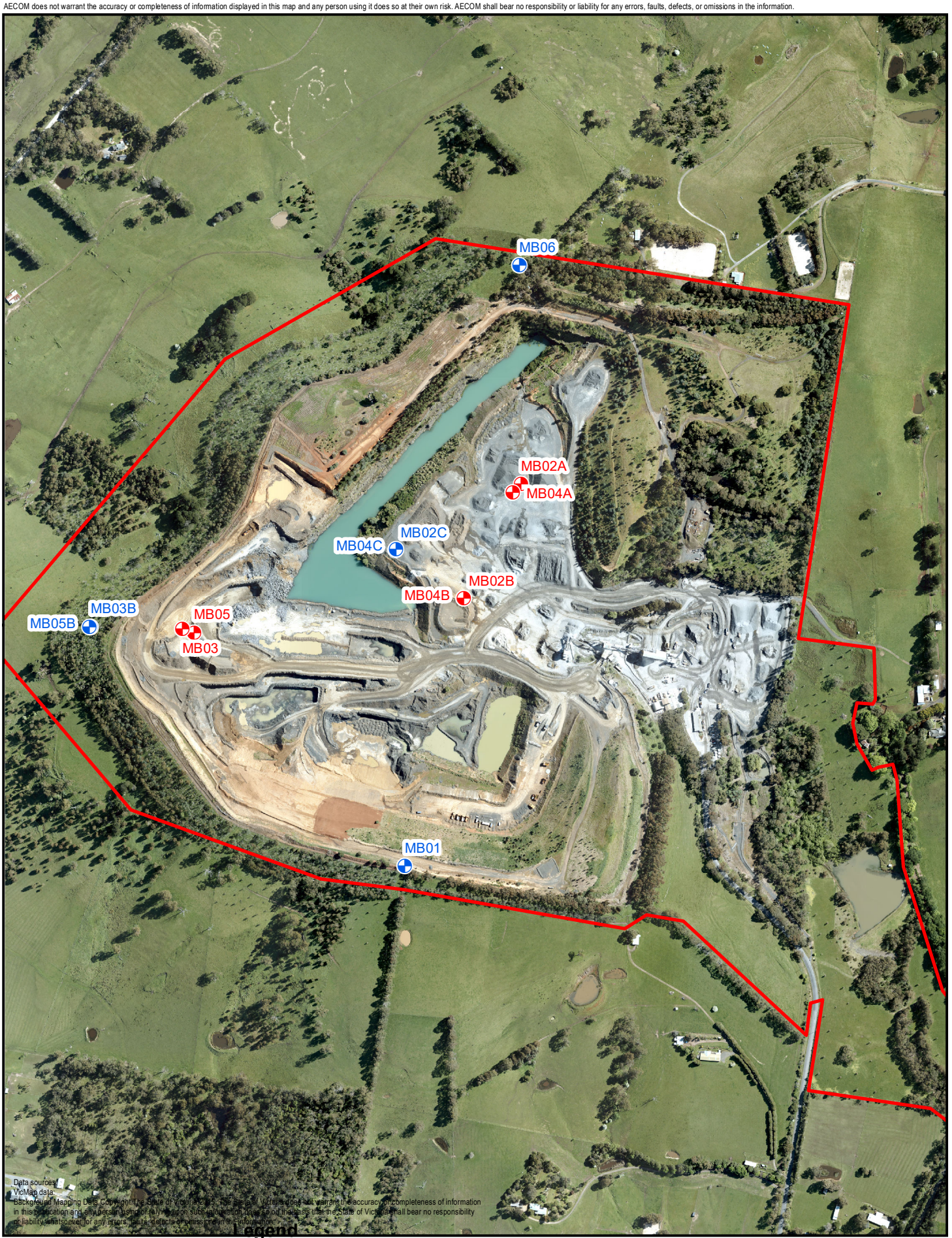

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AECOM

N

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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

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metres

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- Spring Location
- 550 EC (uS/cm) June/Dec 2022
- 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)

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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	216.518	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	219.84	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

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
10/10/2012	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
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	173.23	172.70	169.46	172.85	169.78	173.11
17/06/2016	171.14	173.24	169.22	Dry, bore damaged (potentially error in location)	169.54	172.78
28/09/2016	171.16	173.24	170.36	172.66	170.79	172.83
15/12/2016	171.22		170.78	172.28	171.21	173.41
16/01/2017		Bore decomissioned and replaced with MB02C		Bore decomissioned and replaced with MB04C		
8/05/2017	171.86	172.08	170.10	171.96	170.50	173.29
9/08/2017	171.74	171.62	170.24	171.46	170.69	172.90
9/10/2017	171.49	171.52	170.92	171.26	171.44	171.75
8/12/2017	171.27	171.18	170.69	170.97	171.16	172.61
12/04/2018	170.78	171.32	170.26	170.82	170.70	172.36
3/07/2018	170.04	171.10	170.92	170.89	171.52	172.11
9/10/2018	169.88	171.17	171.71	170.99	172.31	171.95
8/01/2019	169.78	171.24	172.03	171.00	172.57	171.81
5/04/2019	169.35	170.39	170.39	170.30	170.82	171.67
18/07/2019	168.93	170.64	171.58	170.70	172.14	171.38
16/12/2019	169.33	171.69	172.52	171.81	173.04	171.71
31/03/2020	169.39	171.68	172.54	171.94	173.08	171.86
14/08/2020	169.81	172.46	172.01	172.90	172.47	172.67
24/09/2020	169.66	172.30	172.20	172.84	172.59	172.68
30/10/2020	170.89	172.62	172.81	173.24	173.28	174.23
6/11/2020	170.13	172.65	172.99	173.22	173.53	174.35
21/12/2020	170.2	172.36	172.54	172.79	172.99	174.89
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	173.285
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
21/01/2022*	170.68	172.07	171.37	172.65	171.70	174.31
21/02/2022*	170.68	171.77	170.78	172.32	171.10	174.44
22/03/2022*	170.58	171.58	170.54	172.16	170.65	173.76
26/04/2022	170.65	171.53	170.28	172.08	170.65	174.29
24/05/2022*	171.07	171.62	170.41	172.21	170.86	174.39
17/06/2022	170.50	171.87	170.50	172.49	170.98	174.22
20/07/2022*	170.49	171.84	170.47	172.66	170.89	174.03
24/08/2022*	170.56	171.98	170.19	172.85	170.45	173.91
12/09/2022	170.52	172.25	170.75	173.09	171.05	173.93
17/10/2022*	170.87	172.31	170.27	173.17	170.55	174.56
23/11/022*	171.42	172.43	171.55	173.14	171.91	176.33
21/12/2022	171.74	171.74	170.55	172.72	171.02	177.53
Highest Elevation (whole dataset)	178.31	182.38	181.33	183.60	188.74	179.90
Lowest Elevation (whole dataset)	168.93	162.37	169.22	162.14	169.54	170.86
Highest Elevation since 2015	173.23	173.48	172.99	173.37	173.53	177.53
Lowest Elevation since 2015	168.93	162.37	169.22	162.14	169.54	170.86

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
Difference	4.30	11.11	3.77	11.23	3.99	6.67

#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

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

In May 2022 MB01 levels all updated to 216.54 Mahd

In May 2022 MB06 levels all updated to 219.56 Mahd

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	54.0	98.1	60.2	56.1	938.7
1974	54.2	27.0	68.8	119.0	149.6	16.9	97.2	94.8	83.7	74.4	35.0	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	47.0	802.1
1976	26.6	9.3	51.8	37.0	27.4	43.6	22.1	71.4	85.9	66.0	89.2	69.4	599.7
1977	46.0	57.3	22.4	88.2	89.0	135.0	80.0	41.7	49.6	41.0	38.5	24.8	713.5
1978	43.4	86.4	45.4	56.0	86.3	28.1	94.8	101.7	90.0	63.4	113.6	131.3	940.4
1979	53.0	47.6	26.2	52.2	92.6	50.0	30.2	84.6	96.7	105.9	27.8	23.9	690.7
1980	46.0	8.2	14.7	88.1	52.8	71.6	64.8	54.2	36.0	116.8	48.6	47.6	649.4
1981	44.6	17.2	63.8	55.6	93.8	91.0	95.4	101.8	28.4	61.8	84.2	44.0	781.6
1982	59.2	14.0	52.2	74.2	73.8	56.3	28.8	24.9	49.8	42.2	12.0	46.0	533.4
1983	48.8	3.6	39.6	46.4	72.0	75.4	67.0	74.6	93.6	92.8	107.4	24.0	745.2
1984	54.0	38.2	89.4	50.4	28.0	41.2	63.2	80.2	130.0	57.6	63.8	48.2	744.2
1985	17.6	6.6	42.0	83.0	58.4	69.8	75.4	82.1	36.8	105.0	73.4	113.6	763.7
1986	35.9	19.0	13.2	66.0	90.6	53.0	106.8	53.2	52.0	81.4	27.4	74.2	672.7
1987	49.6	45.8	68.0	34.4	76.6	76.2	88.6	34.0	45.8	47.4	52.8	72.0	691.2
1988	61.6	16.8	28.6	28.4	78.2	83.8	77.8	58.6	70.8	39.8	111.0	77.4	732.8
1989	45.7	11.8	78.8	91.6	64.6	87.9	70.4	72.3	66.0	120.4	28.8	37.3	775.6
1990	0.8	65.3	24.3	80.0	23.8	68.2	94.4	79.6	62.8	90.0	61.4	26.1	676.7
1991	131.7	0.6	33.0	43.9	28.3	141.0	97.2	79.6	100.5	21.3	33.0	79.0	789.1
1992	33.0	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	81.0	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	26.0	60.6	70.6	62.6	39.8	46.2	63.8	47.8	28.8	34.2	613.4
2003	33.0	31.2	70.0	110.2	45.8	38.4	117.4	77.0	59.2	104.4	57.0	49.0	792.6
2004	42.2	22.0	22.6	50.4	51.2	129.8	58.4	91.4	96.0	57.2	163.0	45.4	829.6
2005	30.2	171.8	23.6	34.2	26.6	47.0	45.6	93.0	79.8	52.0	92.2	88.0	784.0
2006	59.6	90.2	26.2	108.0	58.6	18.2	43.8	47.4	31.8	17.4	43.0	58.6	602.8
2007	34.0	11.6	50.8	21.6	62.6	62.6	91.8	40.0	50.6	29.6	76.6	161.6	693.4
2008	17.4	31.6	27.4	33.0	60.4	45.0	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	69.0	113.2	59.0	113.4	45.4	669.0
2010	40.4	27.2	90.8	61.4	65.8	107.6	41.8	101.8	63.6	147.0	121.4	98.2	967.0
2011	113.8	205.4	61.0	77.6	99.1	49.6	69.8	32.6	94.9	91.1	134.8	78.3	1108.0
2012	45.2	69.8	76.6	107.0	110.8	135.6	77.0	**64.8**	73.2	62.1	58.4	57.4	937.9
2013	5.6	73.0	71.4	22.2	68.0	116.0	85.2	95.4	**79.1**	78.3	106.6	69.8	870.6
2014	27.2	24.4	26.0	97.3	52.2	101.7	59.2	48.0	60.4	59.2	73.4	49.8	678.8
2015	51.6	43.0	41.4	62.6	75.0	32.6	85.4	81.7	48.0	20.4	50.4	42.0	634.1
2016	71.0	13.4	32.2	69.0	95.4	88.4	95.6	67.2	86.0	107.2	63.2	65.2	853.8
2017	28.0	92.2	60.0	119.8	42.4	35.0	30.2	81.8	48.4	54.8	30.8	131.8	755.2
2018	86.2	7.5	29.0	21.8	97.2	71.6	63.2	54.2	41.0	54.8	135.4	*94.2*	756.1
2019	*13.4*	*22.6*	*45.6*	23.6	88.8	83.4	81.0	*82.0*	75.6	56.6	75.4	17.4	665.4
2020	*113.6*	123.4	78.6	*192.2*	72.8	55.0	62.4	*97.2*	80.4	115.0	76.6	*69.6*	1136.8
2021	86.4	*21.0*	64.0	*92.2*	*67.4*	*69.4*	*44.8*	*60.1*	*73.6*	*133.0*	*105.0*	*104.0*	920.9
2022	*23.2*	*6.4*	*63.6*	*94.2*	*42.6*	*93.5*	*57.0*	*125.1*	*62*	*171.6*	*173.5*	*49.6*	962.3

Italics- data not verified

Data from daily rainfall records

Whole period	51.7	50.9	49.2	68.5	73.1	67.1	67.9	73.6	71.3	74.4	72.7	66.8	789.9
Since 2002	46.6	55.8	49.4	73.3	65.2	70.4	66.4	73.0	67.2	73.6	89.0	71.0	800.9

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. (8640 L/day)
	17-Jun-22	928	7.62	-26.4	5.94	14.4	603	113mL/s flowing from spring (9,792 L/day)
	21-Dec-22	753	7.84	12.8	7.88	13.7	489	Water flowing into bin, losing some water which misses the capture system. Flow rate = 10L/45 secs
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 noted
	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 until was reduced the flow to roughly 250ml / 6 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.
	17-Jun-22	1995	7.6	-55.1	8.93	10.3	1297	Thick vegetation. Flow measured at tank downhill - 27mL/s (2,333L/day)
	21-Dec-22	2265	7.23	-60.5	0.39	17.6	1472	Flow rate 5L/171 secs from second trough outflow, thick veg around spring

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	
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	
	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
	17-Jun-22	662	7.83	-79.4	5.93	12.8	430	Healthy vegetation. Sunken bin leading to only intermittent flow from spring. Unable to gauge during visit but trough filled from spring lower down slope full.
	21-Dec-22	673	7.66	-3.1	4.58	17.6	437	Flow rate 5L in 142 Secs, healthy veg, flow into bin with some seepage
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.						
	17-Jun-22	Spring dry. Vegetation healthy.						
	21-Dec-22	1232	7.33	-101.8	3.73	18.3	801	Thick vegetation, clear water, algae, no flow from spring. Audible flow on bank above spring but not visible through vegetation.
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.
	17-Jun-22	Spring dry. Vegetation healthy.						Vegetation healthy. Sign reads Spring 1.
	21-Dec-22	Spring dry. Vegetation healthy.						Vegetation healthy. Confirmed with Holcim that all signs has been fixed

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	
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						
	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.
	17-Jun-22	444	8.22	-16.6	11.53	12	288	Brown, medium turbidity. Cattle pugging evident. No outflow visible.
	21-Dec-22	474.8	7.52	-67.8	3.7	21.3	NC	Light brown, medium turbidity, healthy veg. Standing water with audible slope flow beneath spring, not visible through vegetation.
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	Dry / Not identified						
	17-Jun-22	Dry / Not identified						
	21-Dec-22	Reclassified as seep						
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
	17-Jun-22	612	8.14	16.4	9.45	12.3	398	Measured in riding club grounds. Water flowing diffusely, unable to gauge accurately. 100-200 mL/s estimated.
	21-Dec-22	640	8.21	41.5	8.22	14.7		1L/10sec, consistent flow. Healthy vegetation. Recommendation to install means of measuring flow such as v-notch or elevated pipe.

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	
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.
	17-Jun-22	770	7.72	-119.3	2.33	11.2	501	Wetland. Reeds and other vegetation healthy. Outflow at pipe measured at 0.311 L/s. Signed has been replaced to read Spring 9
	21-Dec-22	776	8.03	-18	2.67	17.3	504	2.5L/3min. Thick veg, clear water
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						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.
	17-Jun-22	Spring dry						Damp seep in embankment.
	21-Dec-22	Spring dry						Damp seep in embankment. Reclassified as seep.
Max		4320	9	323	14	25	2808	
Min		229	5	-430	0	7	149	

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

Attachment 3 Charts

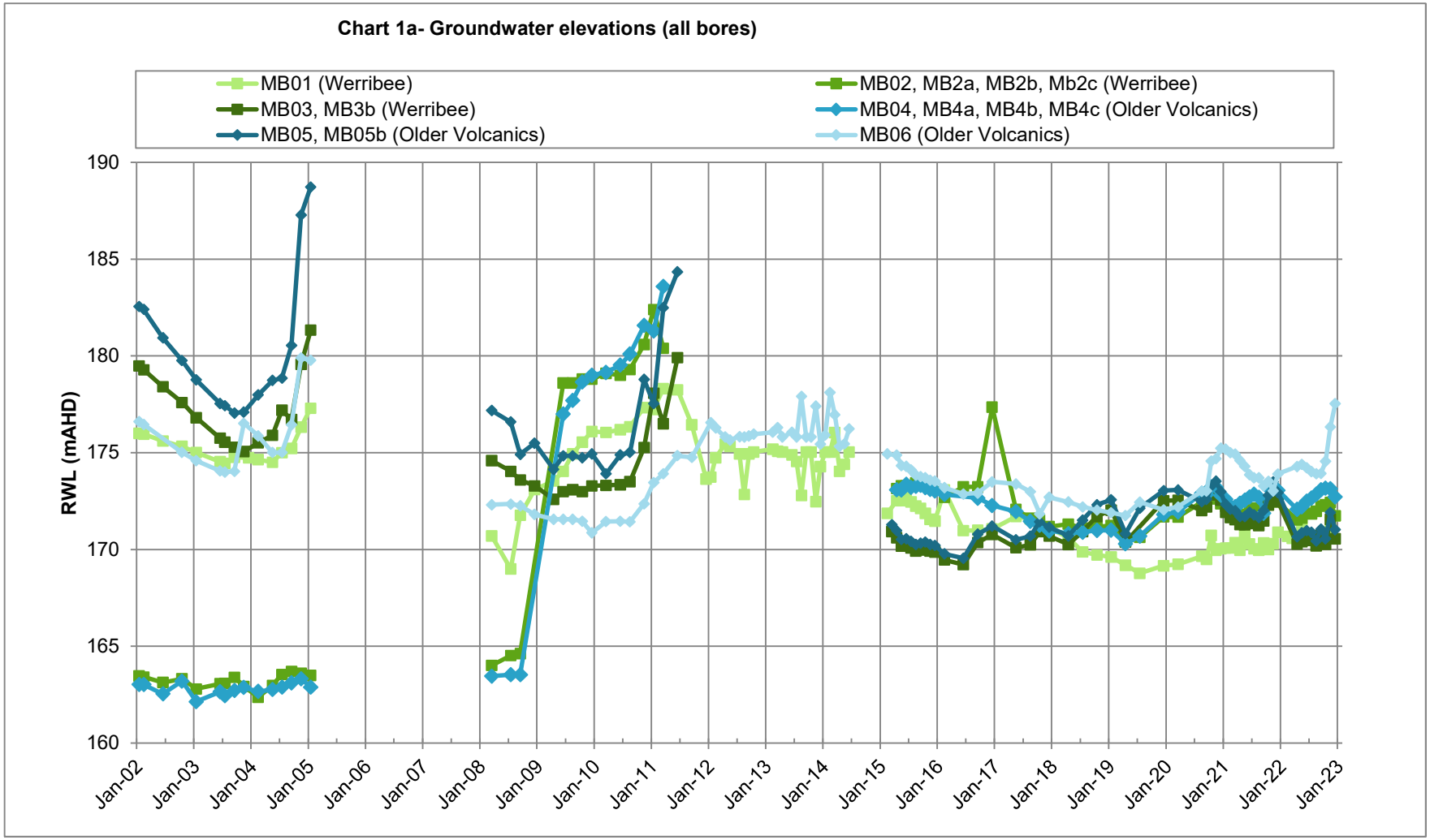


Chart 1b- Groundwater elevations (all bores, 2015 to 2022)

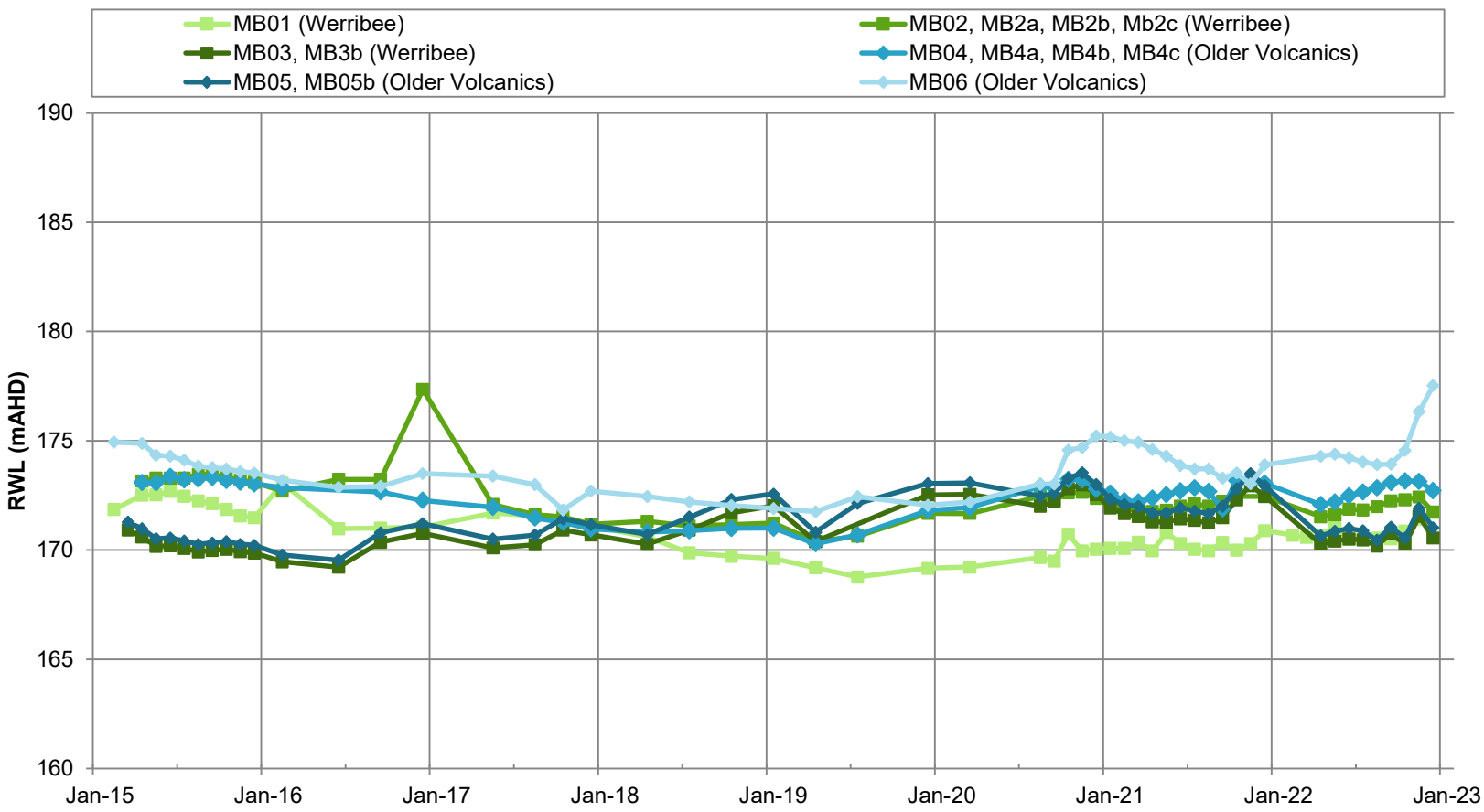


Chart 1c- Groundwater elevations (MB01 and MB06)

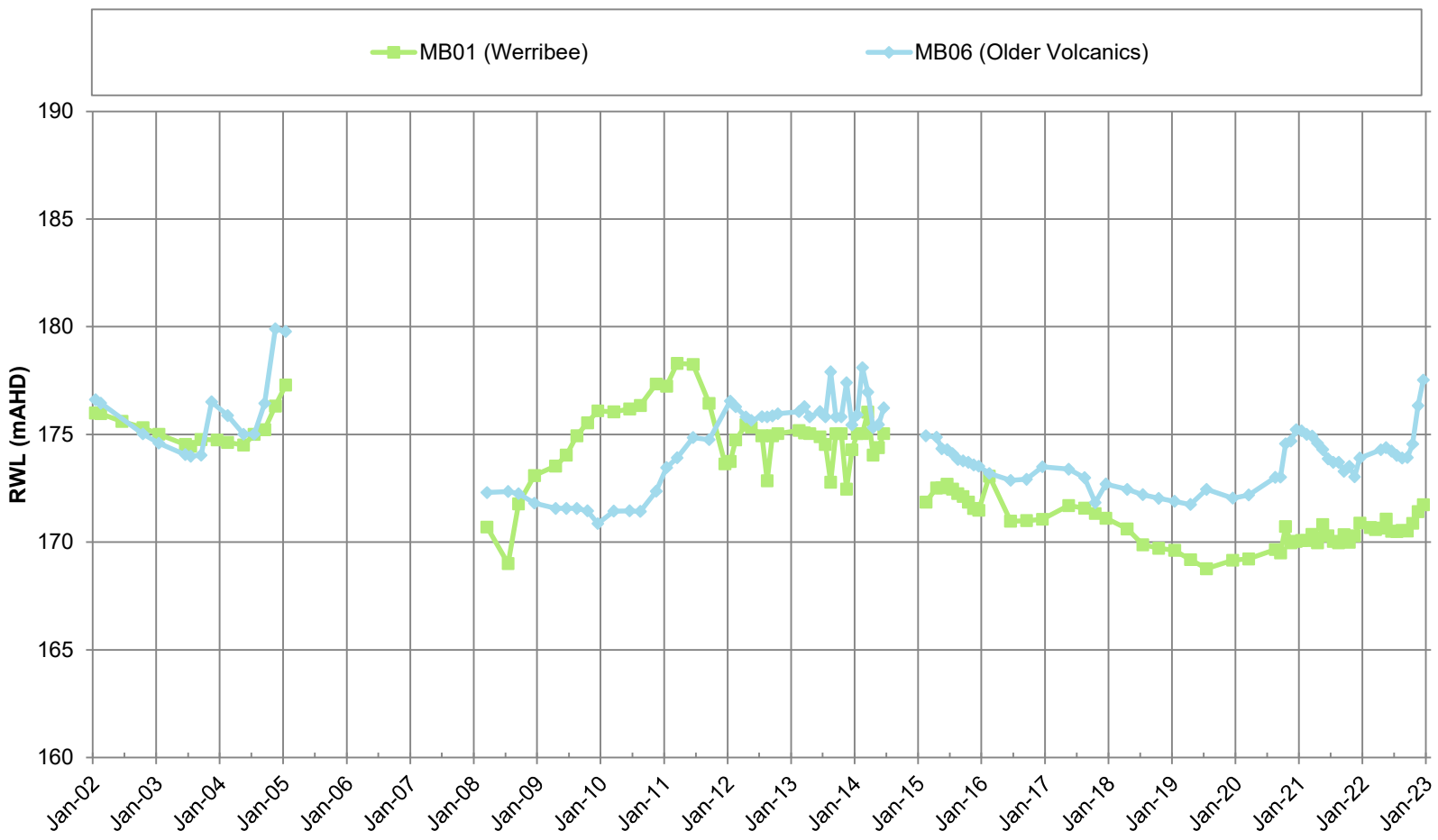


Chart 1d- Groundwater elevations (MB01 and MB06, 2015-2022)

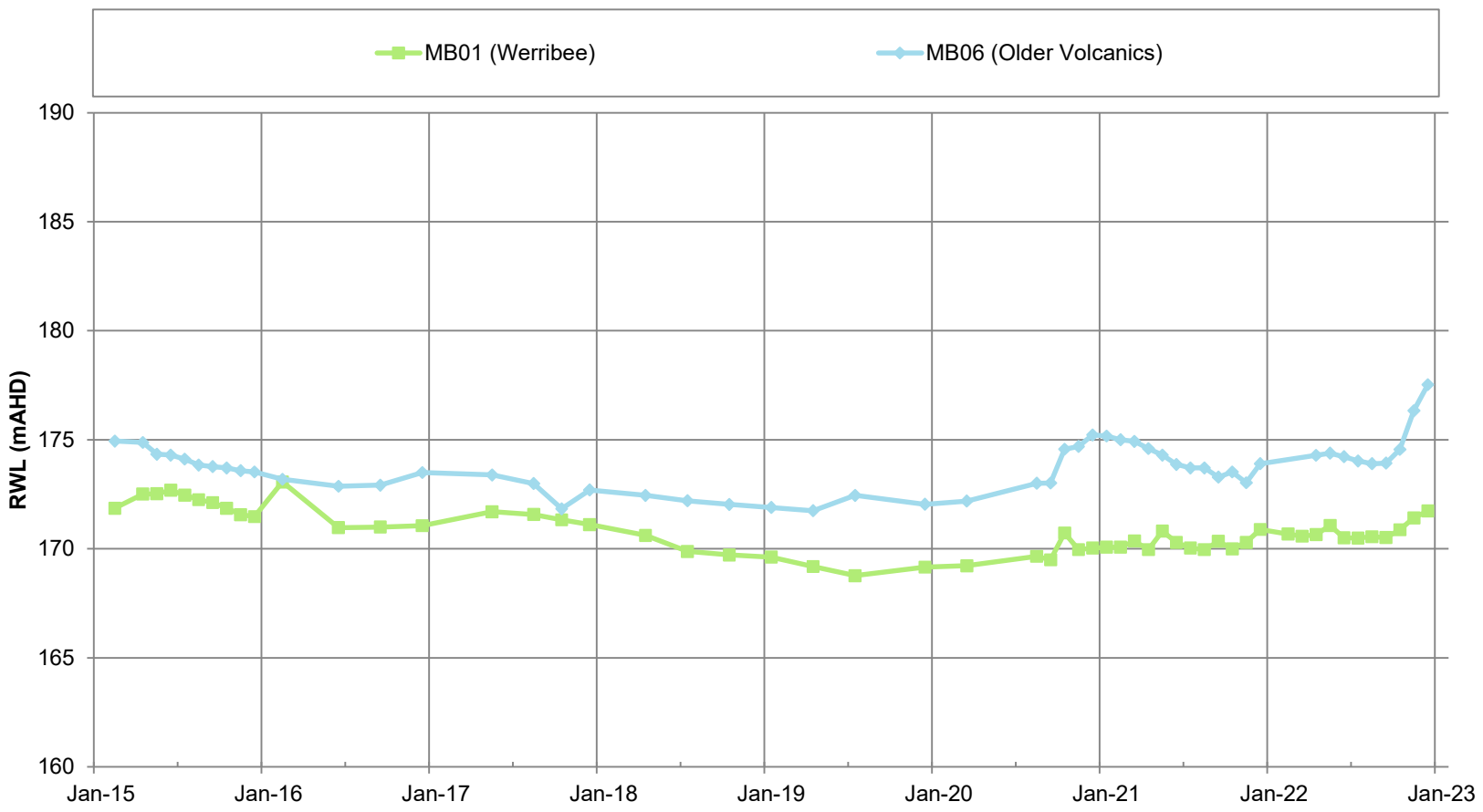


Chart 2a- Groundwater elevations vs. rainfall (all bores)

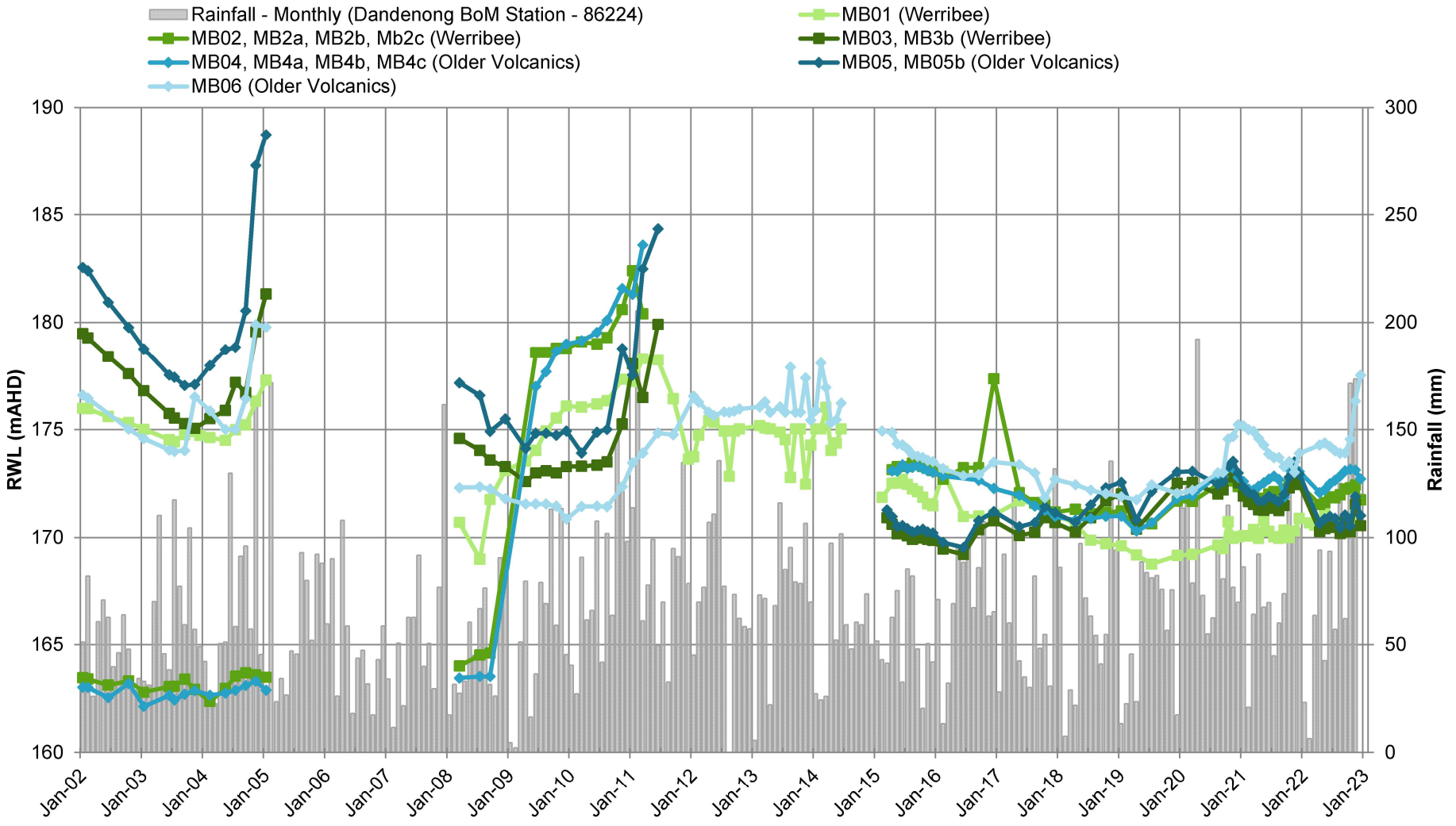


Chart 2b Groundwater elevations vs. rainfall (all bores 2015-2022)

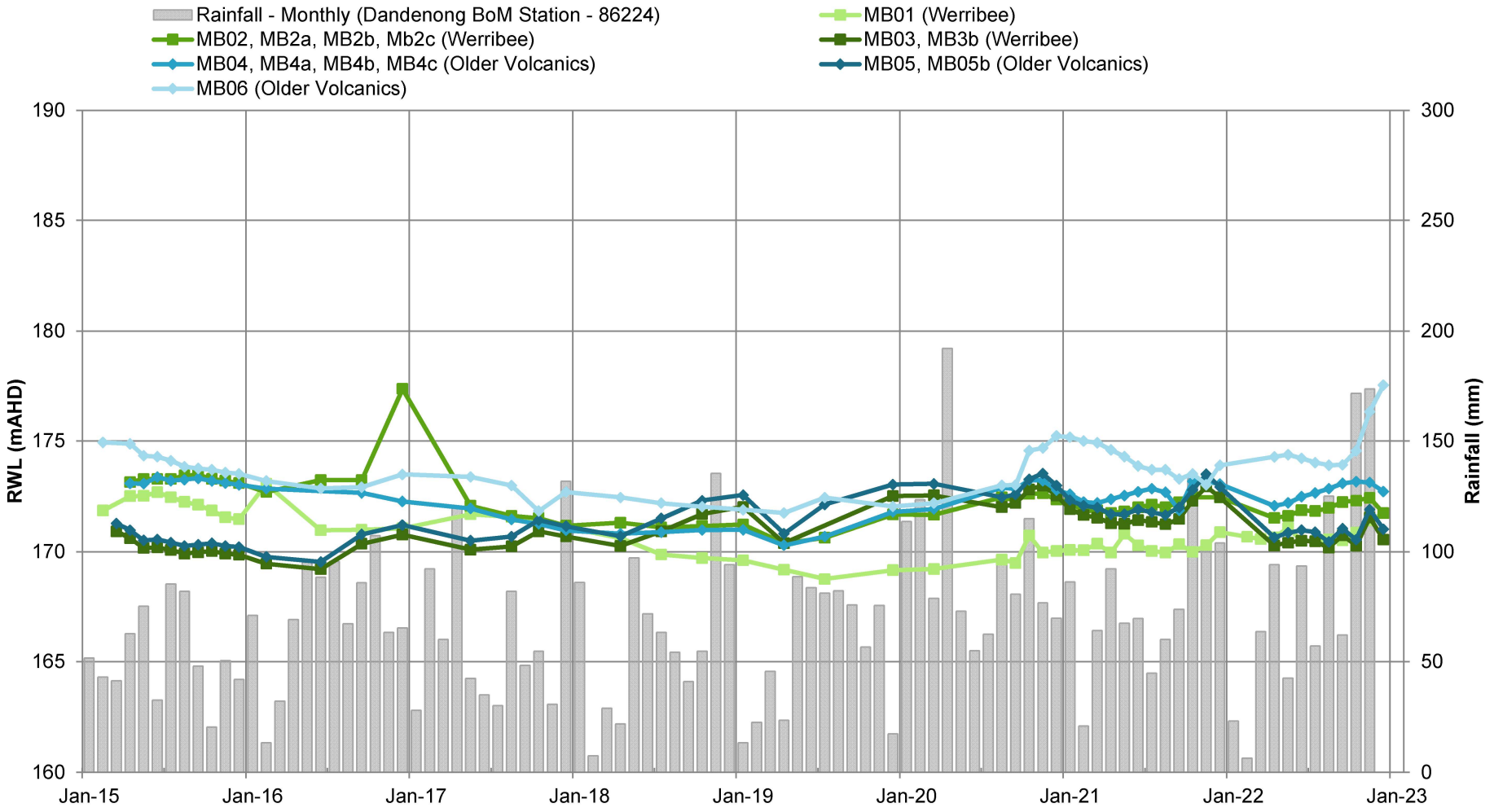


Chart 2c- Groundwater elevation vs. rainfall (MB01 and MB06)

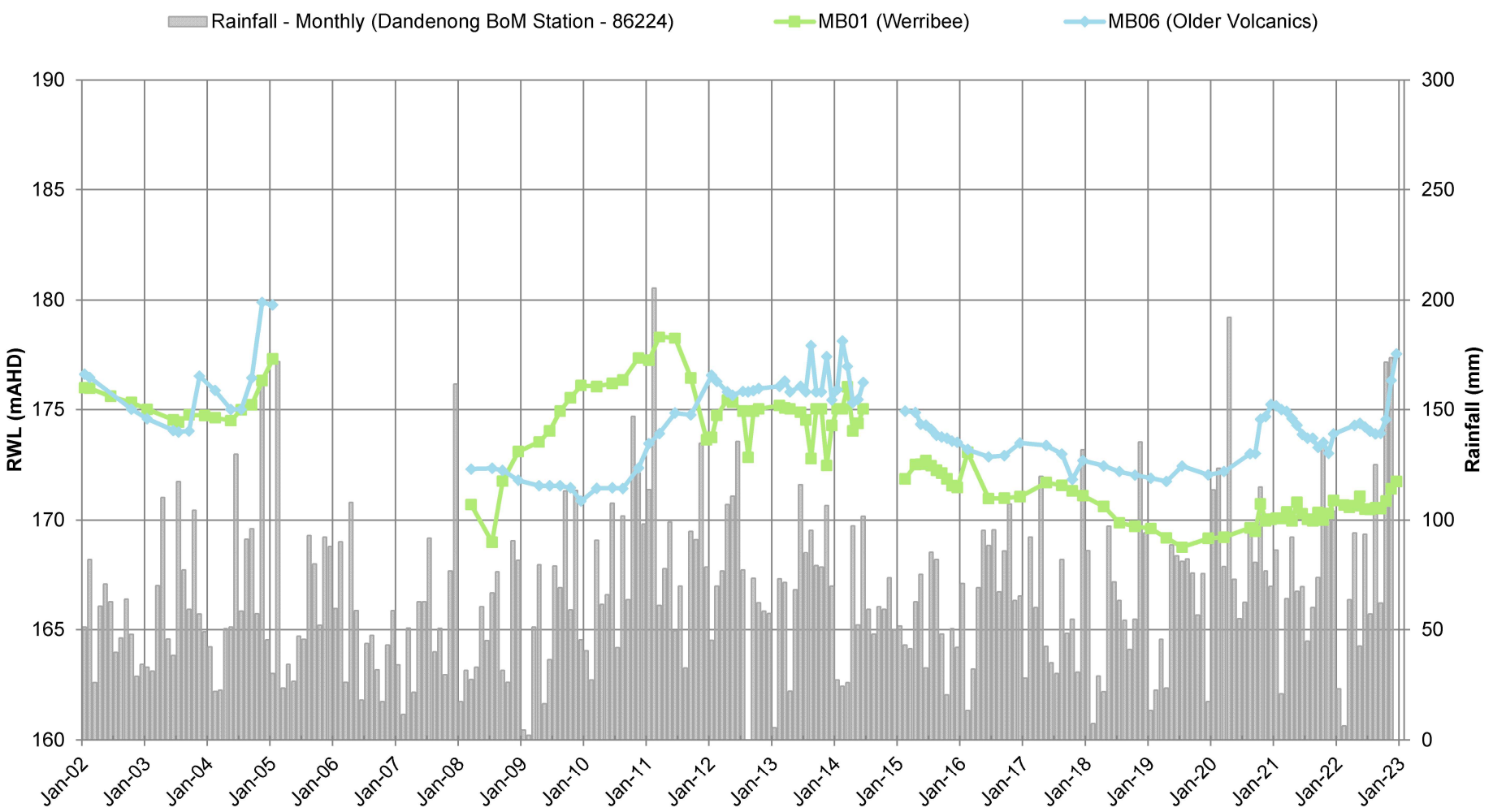


Chart 2d Groundwater elevations vs. rainfall (MB01 and MB06, 2015-2022)

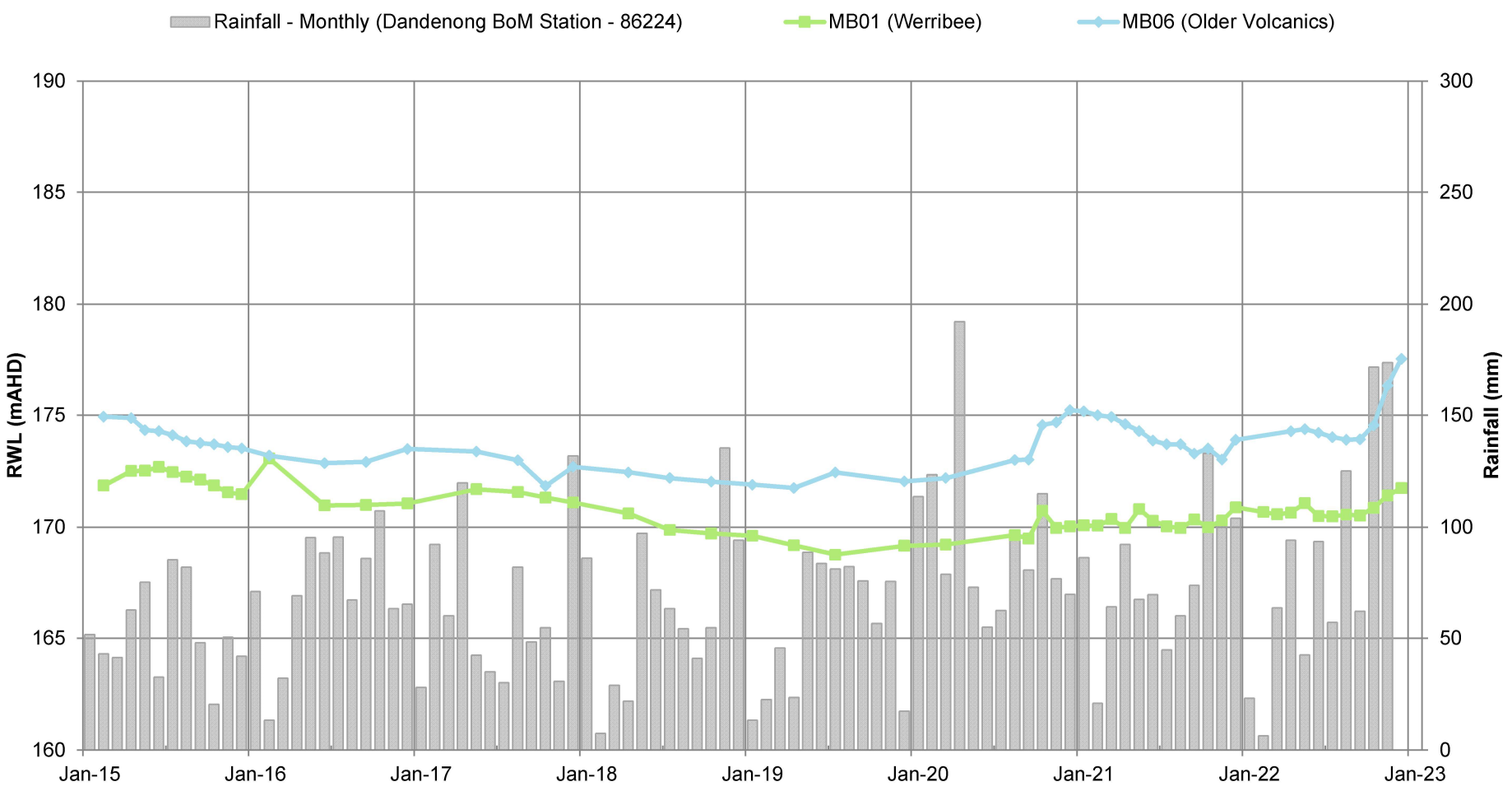


Chart 3a - Groundwater elevations vs. AMRR (all bores)

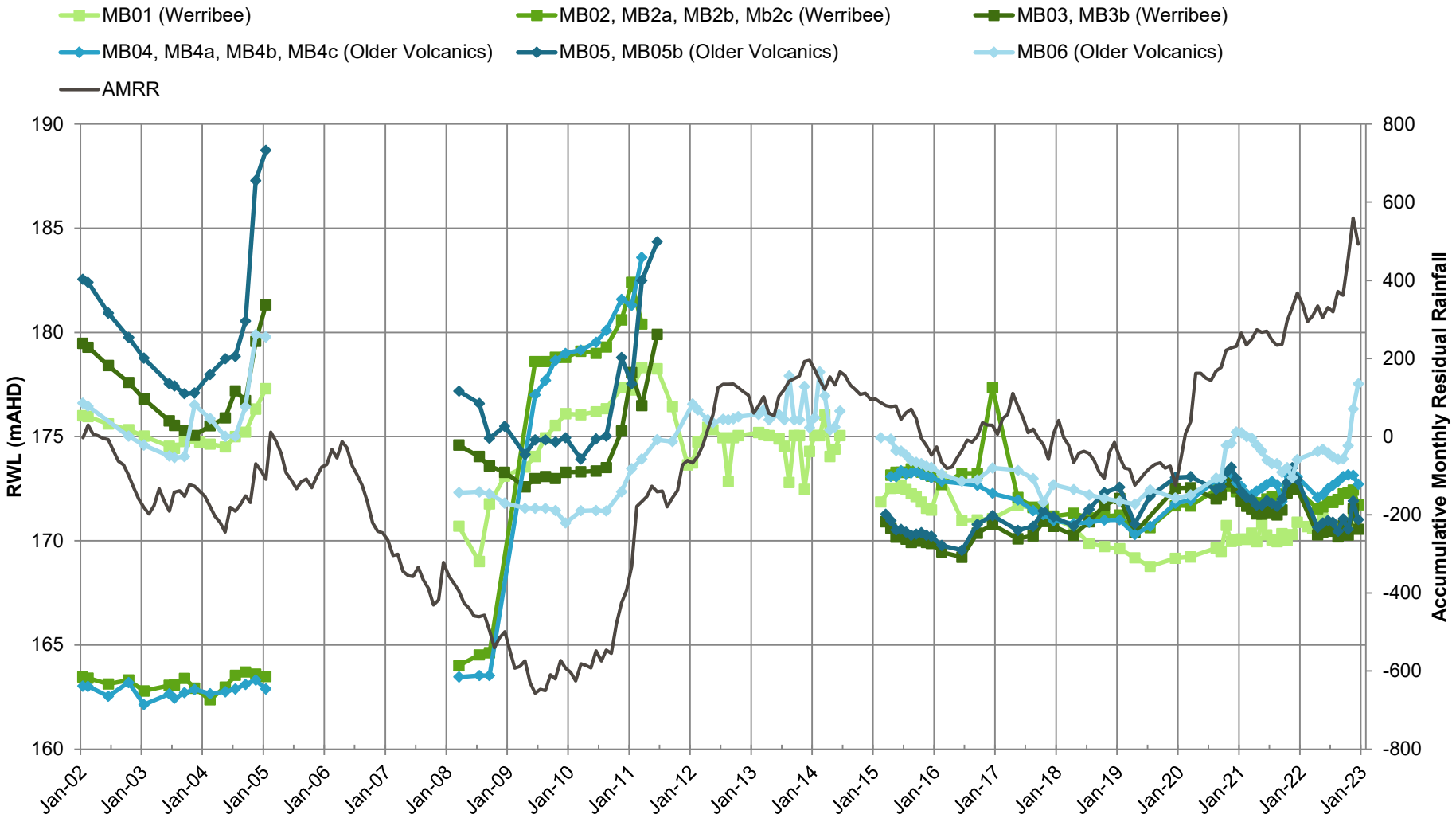


Chart 3b - Groundwater elevations vs. AMRR (MB01 and MB06)

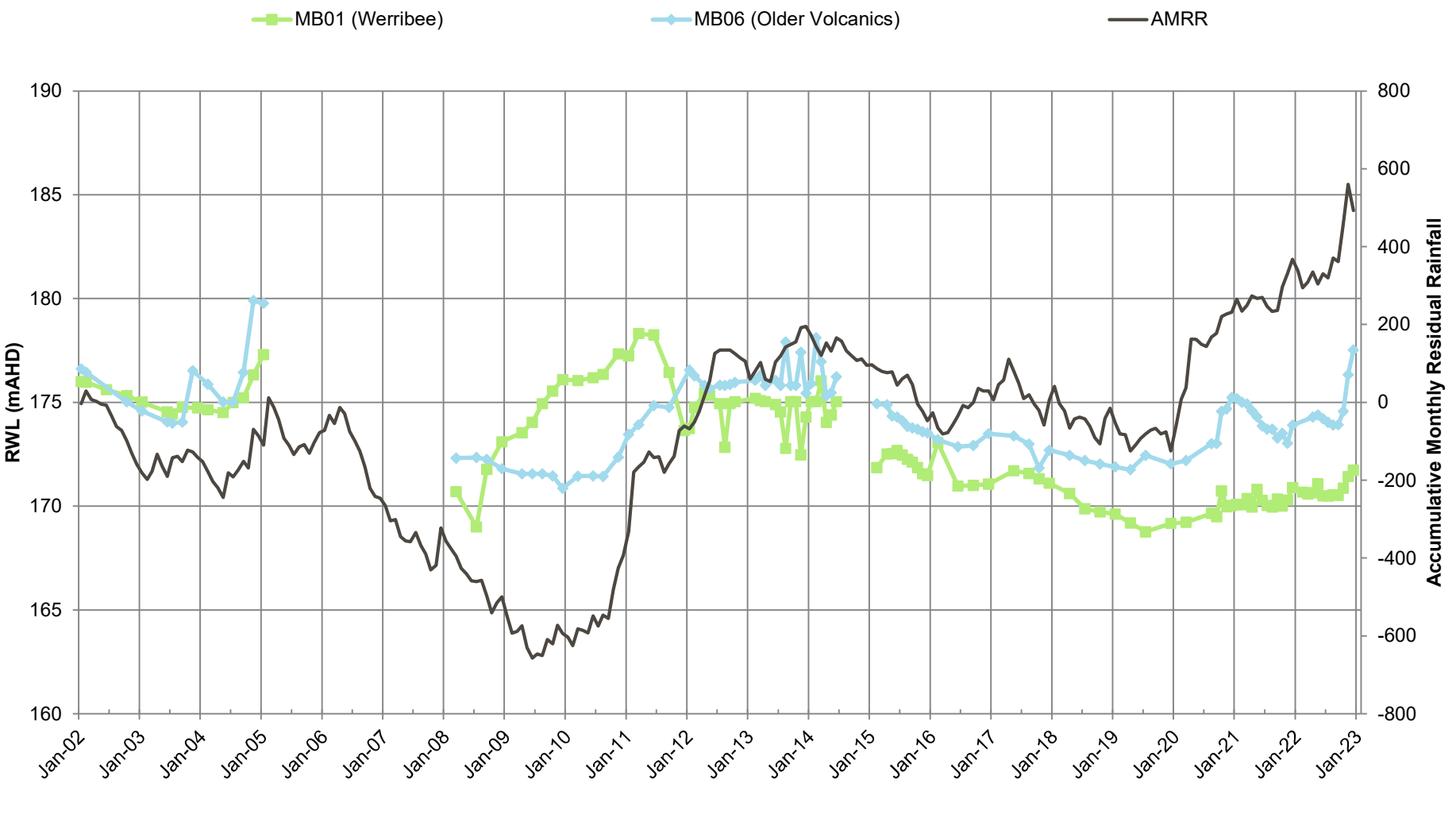


Chart 3c Groundwater elevations vs. AMRR (all bores, 2015 to 2022)

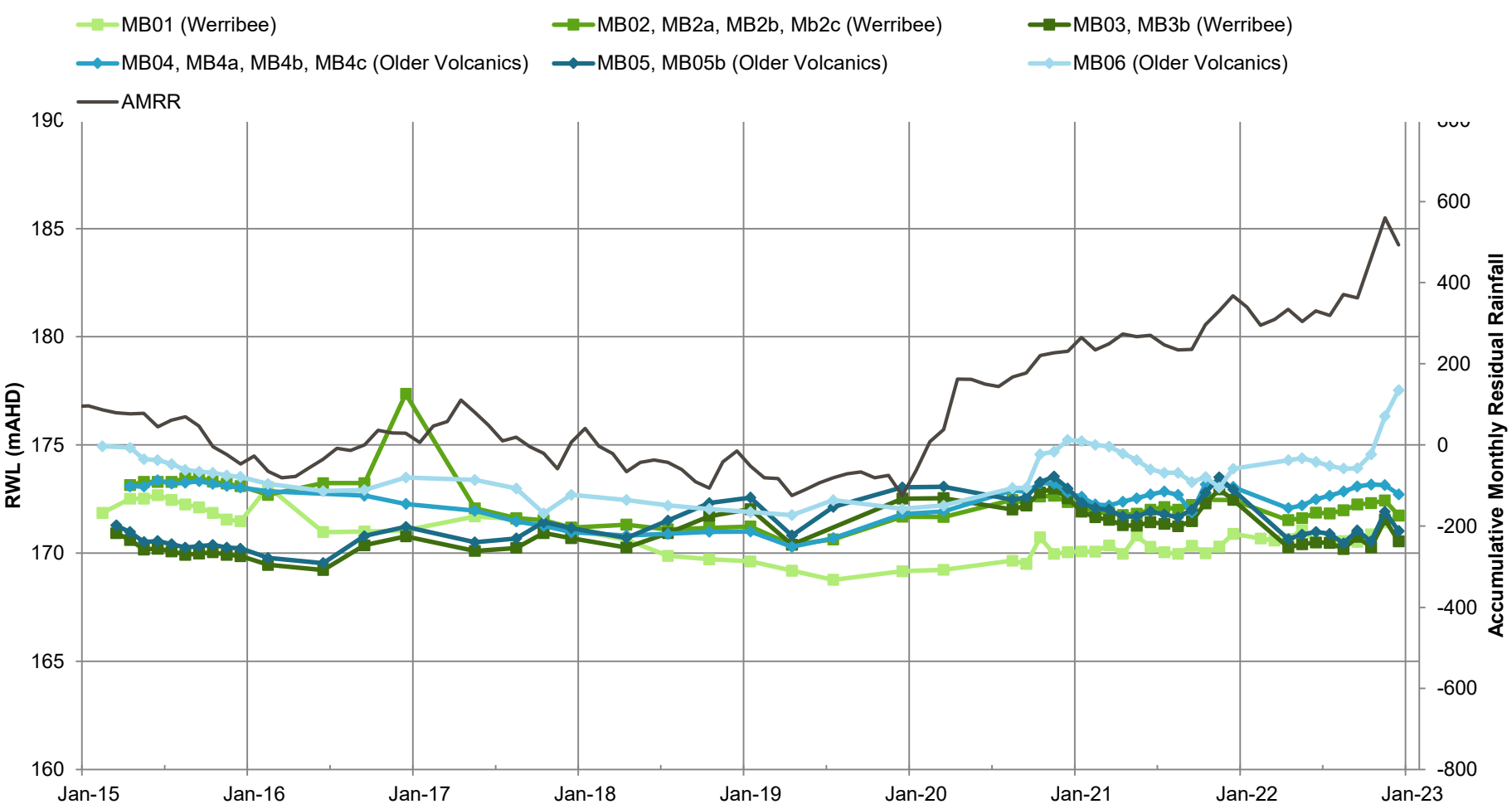


Chart 3d Groundwater elevations vs. AMRR (MB01 and MB06, 2020 to 2022)

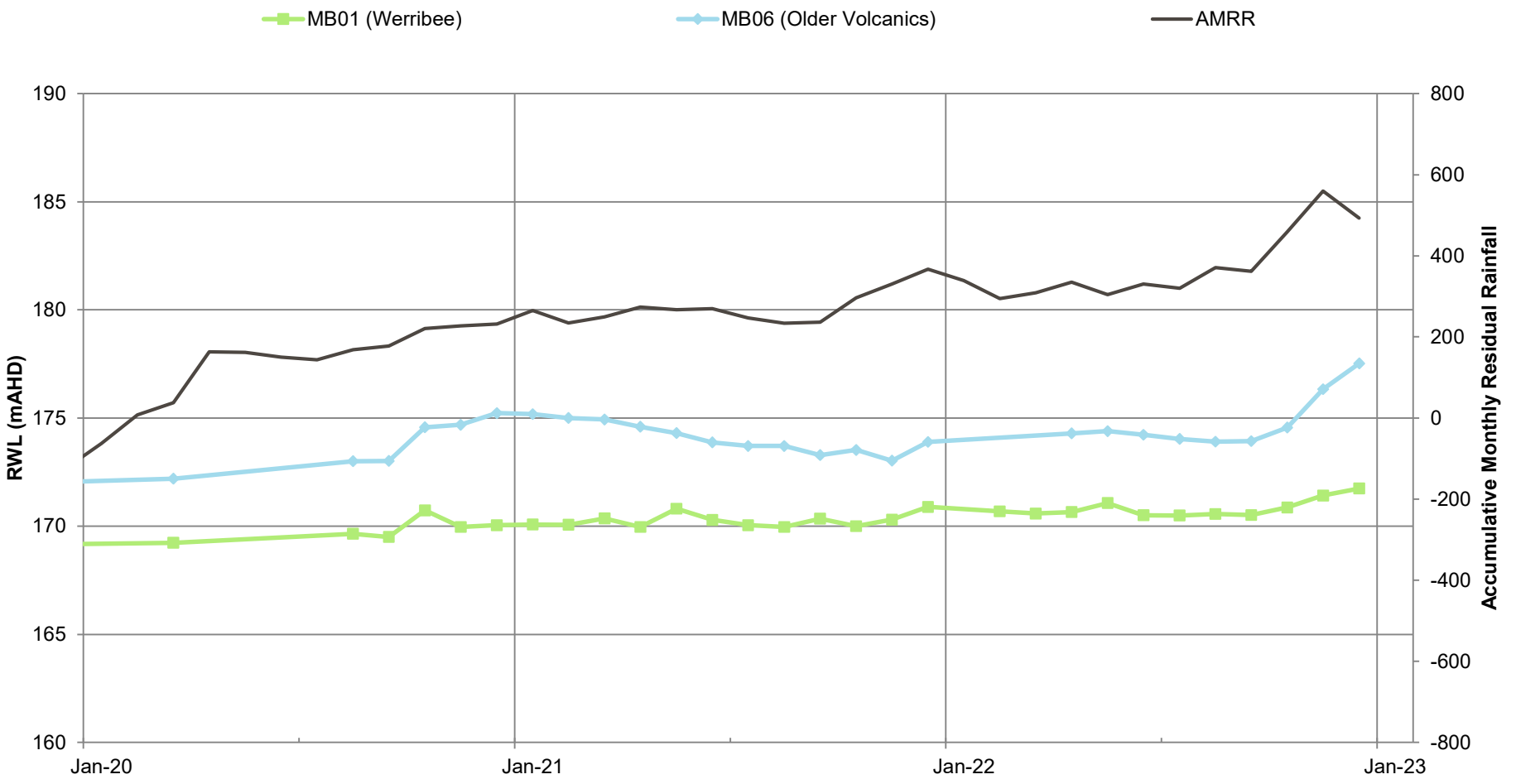
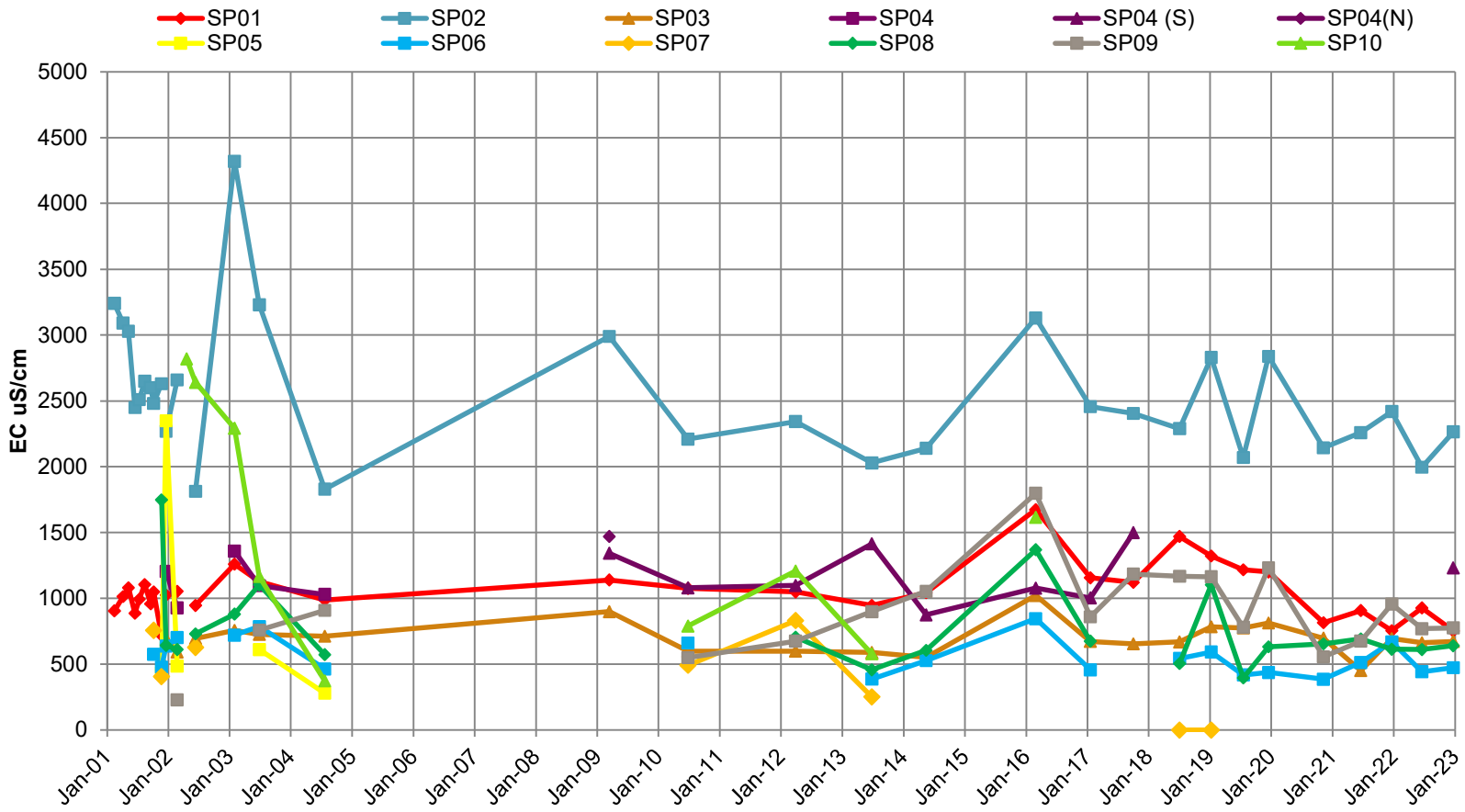


Chart 4- Historic Spring EC Measurements



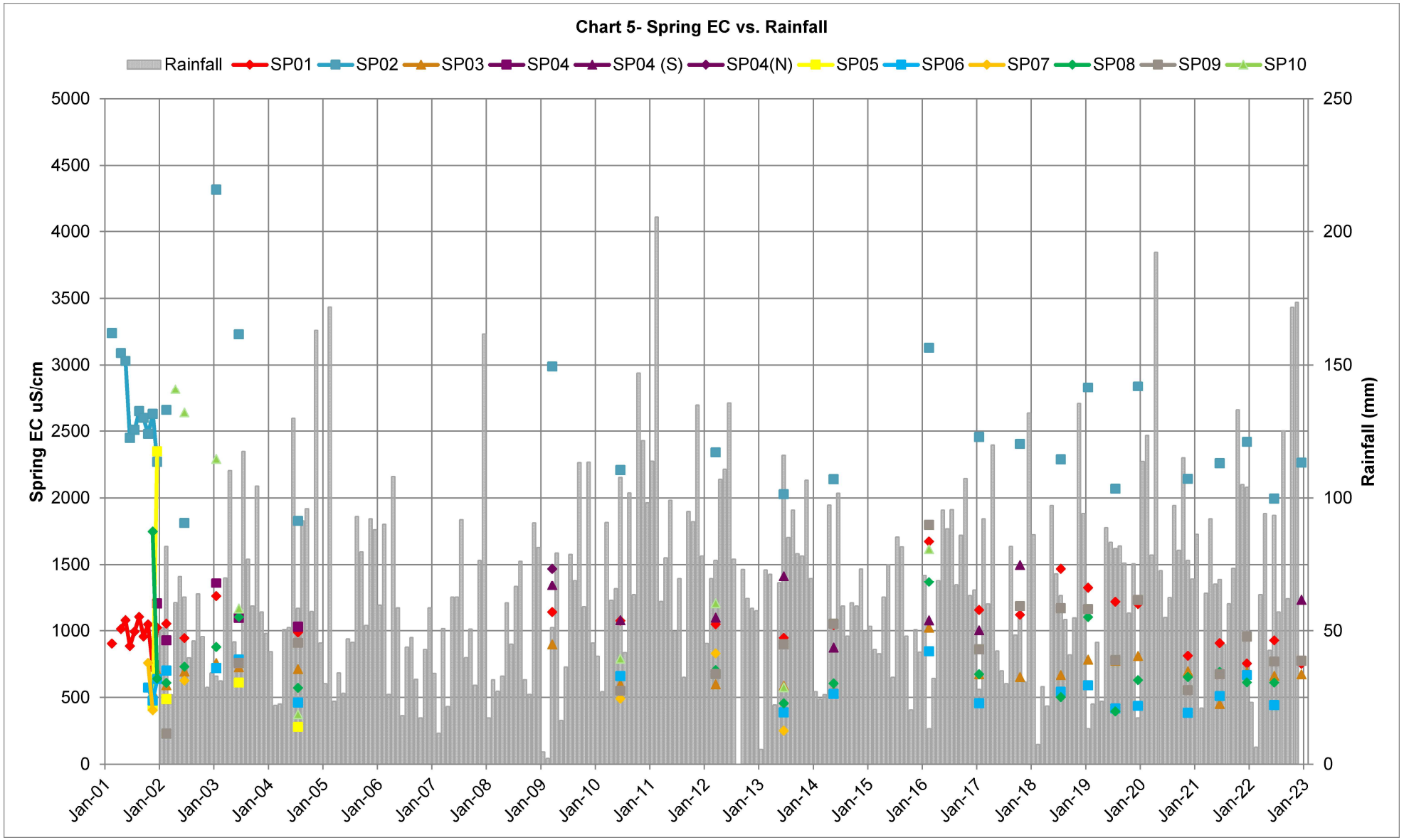


Chart 5- Spring EC vs. Rainfall
Rainfall
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10
Spring EC uS/cm
Rainfall (mm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
250
200
150
100
50
0
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23

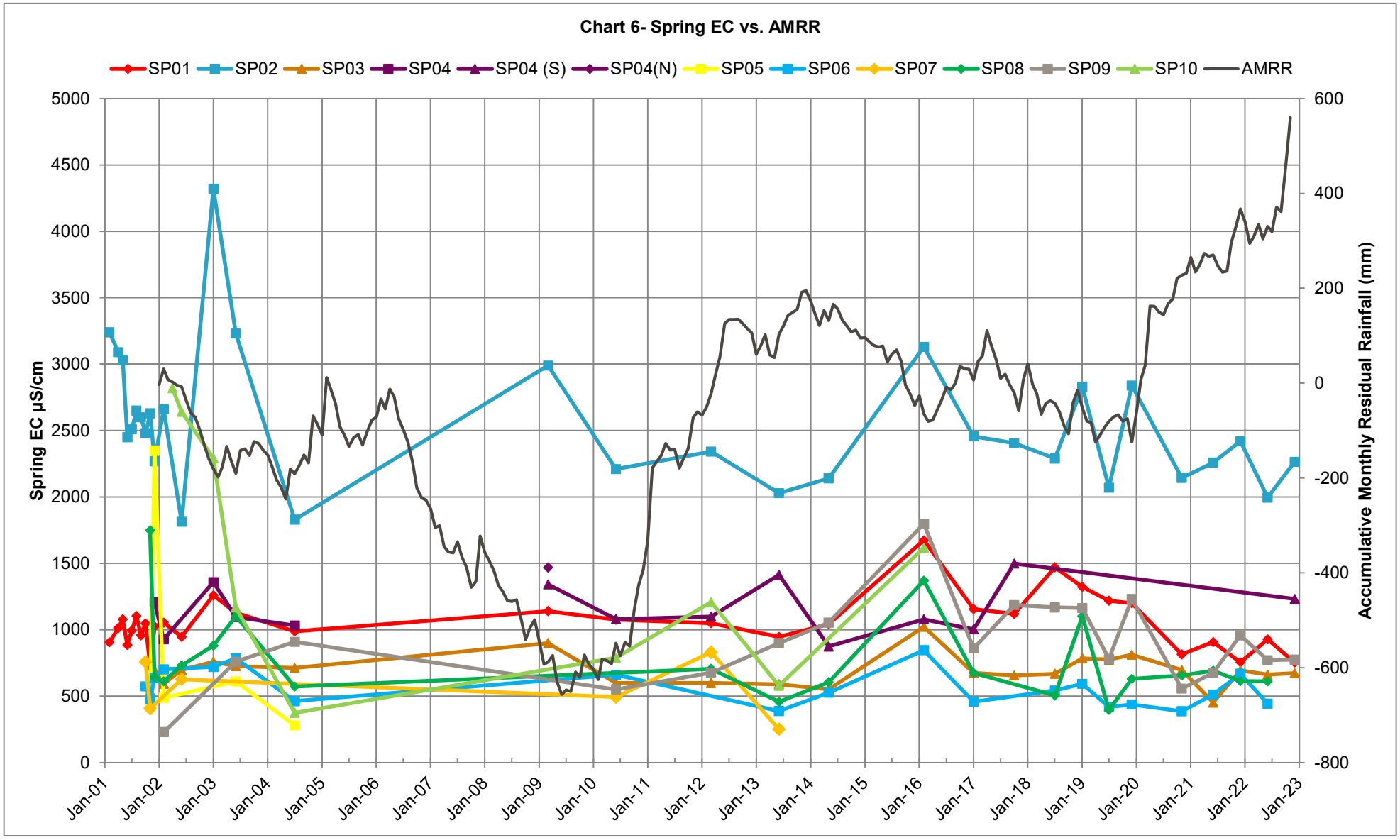


Chart 6- Spring EC vs. AMRR
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10
AMRR
Spring EC µS/cm
Accumulative Monthly Residual Rainfall (mm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
600
400
200
0
-200
-400
-600
-800
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
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
Jan-23

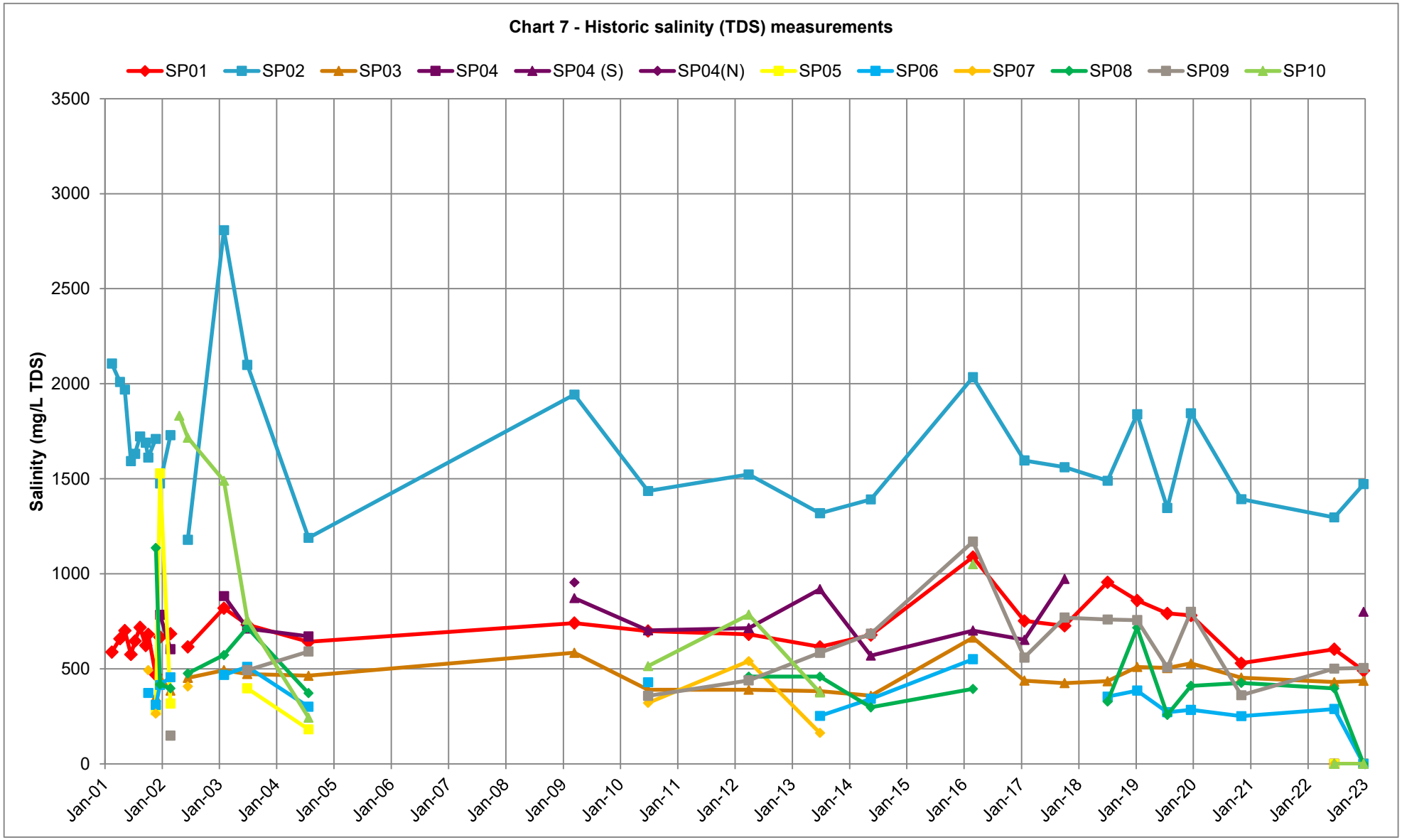


Chart 7 - Historic salinity (TDS) measurements
SP01
SP02
SP03
SP04
SP04 (S)
SP04(N)
SP05
SP06
SP07
SP08
SP09
SP10
Salinity (mg/L TDS)
3500
3000
2500
2000
1500
1000
500
0
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23

AECOM

Attachment 4 Site Photos

Plate 1 Spring 1 June 2022	Plate 1 Spring 1 December 2022
	

Plate 2 Spring 2 June 2022	Plate 2 Spring 2 December 2022
	

AECOM

Plate 3 Spring 3 June 2022	Plate 3 Spring 3 December 2022
	

Plate 4 Spring 4 June 2022	Plate 4 Spring 4 December 2022
	

Plate 5 Spring 5 June 2022 (note that the spring is mislabelled as Spring 1)	Plate 5 Spring 5 December 2022 (is now correctly labelled)
	

Plate 6 Spring 6 June 2022	Plate 6 Spring 6 December 2022
	

Plate 6 Spring 6 Seepage down slope from spring

Plate 7 Seep 7 **June 2022**	**Plate 7 Seep 7** **December 2022**
No longer part of monitoring as has been reclassified as a seep and is generally dry/inaccessible	**No longer part of monitoring as has been reclassified as a seep and is generally dry/inaccessible**
Plate 8 Spring 8 **June 2022**	**Plate 8 Spring 8** **December 2022**
	No photo taken

Plate 9 Spring 9 June 2022 (mislabelled as SP10)	Plate 9 Spring 9 December 2022 (now correctly labelled as SP09)
	

Plate 10 Spring (Seep) 10 June 2022	Plate 10 Spring (Seep) 10 December 2022
	

Attachment 5 2022 Quarry Works