Dewatering and Settlement Monitoring Report

2020

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DEWATERING & SETTLEMENT MONITORING REPORT 2020

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EXECUTIVE SUMMARY

This Annual Dewatering and Settlement Monitoring Report is a requirement of the consent conditions for the Martha, Favona, Trio, Correnso and SUPA, MDDP and Project Martha mining projects, Waihi, New Zealand. Compliance monitoring and assessment of groundwater and settlement trends is reported for the period 1 January to 31 December 2020 and is in accordance with the current Dewatering and Settlement Monitoring Plan submitted to the Hauraki District and Waikato Regional Councils in May 2019.

On 16 July 2017, the Correnso groundwater take permit 124860 was replaced by the Project Martha groundwater take permit 139551. This allows dewatering to a lower level (500 mRL cf. 700 mRL).

New settlement triggers were applied during 2020 following the approval of Project Martha consents. Settlement survey results indicated that 97% (359/370) of marks graphed were within the predicted settlement ranges, based on the settlement resulting from mining activities. Eleven marks triggered further investigation. Most settlement marks triggered were above the Favona mining area where four Favona marks exceeded settlement predictions. The other seven triggered marks are located in the wider Waihi area and are not believed to be related to dewatering. No effects were observed at surface near these locations and nearby shallow piezometers have not displayed any associated affect. This is considered an acceptable number of marks triggered.

Martha Open Pit

Dewatering from the Martha Pit was discontinued on 04 May 2015 after a slip in the pit when access and power supply to the dewatering pumps became limited. Dewatering from within the Correnso underground mine was initiated on 18 May 2015. The Martha, Trio, Correnso and SUPA groundwater systems are hydraulically linked, and water levels are controlled by Correnso underground dewatering.

No drawdown effects caused by mine dewatering were indicated in monitoring bores and no tilt trends have developed during 2020 that can be attributed to dewatering operations.

The analysis of data has indicated that most settlement around Martha Pit had developed by the mid to late 1990s, but widespread small magnitude settlement has been ongoing and is likely to be related to dewatering of deeper structures within the andesite rock mass. Groundwater monitoring data does not show any widespread or significant dewatering of alluvium; of the upper portions of the younger volcanic materials; or dewatering of the upper layers of the andesite rock body which could lead to a greater magnitude of settlement.

No property damage complaints attributable to mine dewatering or settlement in response to mine dewatering were reported during 2020. Compliance was achieved with the consent conditions granted for the Martha Extended Project.

Favona

At the Favona mine, piezometer levels indicate continued dewatering of the vein system, with the water level maintained at approximately 800mRL mine datum by the end of 2020. Water levels in the country rock surrounding the vein system stand higher and are either not responding or responding slowly to dewatering.

During 2019, a separate flow meter to measure dewatering flow from Favona was installed.

Four Favona marks exceeded settlement prediction, fewer than 2019 due to updated maximum predicted settlement triggers applied during 2020.

A settlement trend exists over a 150 m wide area above the underground workings with a maximum total settlement of 347 mm (F18), of which up to 298 mm can be attributed to Favona mining activity. This is greater than the 80 mm initially predicted by URS (2002 Technical Report) to be due to dewatering. Settlement is attributed to a combination of depressurisation stress (primary consolidation) associated with drawdown in the andesite rock and relaxation of the country rock as mining proceeded. Primary consolidation (the first time a mine is dewatered) is greater than a second cycle (subsequent dewatering activities). The Favona mine is outside of the Martha groundwater system; the Martha system was historically dewatered for a longer period and to greater depth and is currently undergoing a second period of dewatering.

Five tilt gradients attributable to Favona mining activity remain steeper than 1:1000; these are on farmland owned by the company and south of the residential area along Barry Road and have all been recorded in previous surveying events.

One piezometer in the Favona network breached the trigger level in 2020. This piezometer was affected by an underground drill hole in 2016 (subsequently grouted and sealed), and the 2020 trigger level breach is considered to reflect the piezometer continuing to stabilise from the earlier drop in pressure.

Compliance with the conditions of the Favona consents and Monitoring Plan was achieved.

Trio

Water levels were controlled by Correnso dewatering.

Correnso

The Correnso underground mine was granted consent and operations began on 20 December 2013.

Waikato Regional Council consents were granted in 2019 permitting the development of the Martha underground mine (Project Martha) and allowing groundwater levels to be lowered beyond the lowest level allowed for the mining of Trio. The Correnso water take permit was activated in July 2017, allowing dewatering to lower the groundwater down to 700 mRL (124860, Schedule One – General Conditions, Condition 1). At the end of 2020 the water level was at approximately 705 mRL.

New settlement trigger levels for Correnso were applied in 2017 and Project Martha superseded these in 2020. During 2020, no settlement mark in the Correnso Extensions Project Area (CEPA) displayed excessive settlement and no consent related groundwater trigger was activated. Compliance was achieved with the consent conditions granted for the Correnso Project.

SUPA

The Slevin Underground Project Area is essentially an extension of the Correnso mining area. Mining within the SUPA area began January 16, 2017. No new Waikato Regional Council consents were required for the activity which is covered by the existing WRC consent conditions. The HDC dewatering and settlement related conditions are similar to the WRC conditions for Correnso. No new monitoring or reporting is required as the existing networks adequately encompass SUPA.

MDDP

The Martha Drill Drives Project (MDDP) was granted consent on August 9, 2017. Mining in the MDDP began August 17, 2017 and was completed during 2019. The project involved the construction of two underground drill drives from the SUPA area towards Martha Pit. No specific HDC conditions relate to dewatering and settlement, rather it is covered by the existing WRC Correnso consent conditions. No new monitoring or reporting is required as the existing networks adequately encompass MDDP.

PROJECT MARTHA

Consents for Project Martha were granted on 01 February 2019. Joint HDC and WRC consents were activated on July 27, 2019 when blasting began in the project area. The WRC dewatering consent which allows dewatering below 700 mRL for Project Martha was activated on the 1st of January

2020. New dewatering bores were installed during 2020 to progressively lower the water level to enable Project Martha activities.

1 INTRODUCTION

This report is submitted to meet the requirements of various consents held by OGNZL related to Dewatering and Settlement. New consents have been issued for different projects as mining has progressed at Waihi with many having conditions and reporting requirements in common. A full list of conditions pertaining to Dewatering and Settlement are included in Appendix A. Consents for Martha, Favona, Trio, Correnso, SUPA, MDDP and Project Martha all require a Dewatering and Settlement Monitoring Plan. Below is a summary of the current consent requirements common to those consents:

The report shall, as a minimum, provide the following information:

a) The volume of groundwater abstracted;

b) The data from monitoring undertaken during the previous year, including groundwater contour plans (derived from the data) in respect of the piezometer network;

c) An interpretation and analysis of the monitoring data, in particular any change in the groundwater profile over the previous year, predictions of the future impacts that may arise as a result of any trends that have been identified including review of the predicted post closure effects based on actual monitoring data, and what contingency actions, if any, the consent holder proposes to take in response to those predictions, this analysis shall be undertaken by a party appropriately experienced and qualified to assess the information;

d) Any contingency actions that may have been taken during the year; and

e) Comment on compliance with [any conditions] of this schedule including any reasons for non-compliance or difficulties in achieving conformance with the conditions of consent.

f) The report shall be forwarded in a form acceptable to the Councils.

2 GEOLOGICAL SETTING

The mineralised veins of the Martha, Favona, Trio and Correnso gold deposits in Waihi are developed within Miocene age lava flows, intrusives and volcaniclastics of predominantly andesitic (and minor dacitic) composition (Figure 1). The andesites extend to depths greater than 600m below the surface and are extensively modified in places by weathering and hydrothermal alteration. The andesites are unconformably overlain by younger, unmineralised rhyolitic ignimbrites that cover much of the Waihi township. The ignimbrites drape over an eroded andesitic graben and horst landscape resulting in a volcaniclastic package that is highly variable in thickness (0 to >100m). Additionally, the ignimbrites exhibit variable textures, ranging from light weight, soft and pumice-rich horizons that are highly permeable to hard, resistant, welded ignimbrites that appear less permeable. Paleosols (buried soils) and sedimentary deposits, such as alluvium and boulder alluvium in places mark the tops of successive eruption sequences.

There is a discontinuous layer of recent alluvium beneath the Waihi township located in areas where old streams and river channels cut into the ignimbrites and andesite units (Figure 1). These alluvial deposits are extensive to the east of Waihi where they are associated with the drainage systems of the Ohinemuri River catchment.

The most common effect of hydrothermal alteration on the andesitic host rocks surrounding the veins is the alteration of primary feldspars to illite and smectite clays and the introduction of pervasive potassic feldspar. Illite and smectite clays generally cause the host rocks to lose their internal strength forming weaker and usually more friable rock. The extent of clay alteration is highly variable and dependant on veining and host rock type. In Waihi the strongly clay altered zones are usually concentrated within close proximity to the veins or faults (eg within the hanging wall of Favona) and within the vein zones themselves (eg Martha, Correnso and Trio). Potassic alteration on the other hand generally increases the overall strength of the host rocks which often results in the rocks surrounding the veins being resistant to weathering and forming bluffs such as the Martha Hill (prior to mining of the Martha Open Pit) and Union Hill in Waihi. Paleo-weathering and hydrothermal alteration appear to have created an extensive low-permeability clay-rich horizon within the upper part of the andesite sequence. This horizon generally separates the andesites, hydrogeologically, from the younger overlying sequence of permeable rhyolitic ignimbrites. Exposure of the altered andesite in the southern wall of the Martha Pit indicates that the weathered clay horizon may extend up to 30m in thickness.

In the vicinity of the Martha vein zone the groundwater is largely concentrated within old underground mine workings, faults and veins where the historical mine workings act as effective conduits allowing inflow of groundwater water from the area surrounding the current Martha Open pit.

Principal veins and faults at both Martha and Favona dip to the south-east while the Correnso vein strikes north-north-west with an easterly dip (Figure 1). The Trio-Union-Amaranth veins are located on a paleotopographic high, informally referred to as the Union Horst that separates the Martha vein system from the Favona-Moonlight vein systems.

There is a hydrogeological connectivity between the Martha vein system and the Trio-Union-Amaranth vein system thought to be facilitated by the connecting Correnso structure. This was demonstrated historically by the rise and fall of ground water levels in the Union Hill shaft in unison with the rise and fall of water levels in the Martha open pit. There is only a very weak hydrogeological connectivity between the Martha system with the Favona system, shown by a lack of mutual response in the measured ground water levels. The zone of separation of the two groundwater systems is not well defined but may be due to a fault boundary, either the No 9 fault or the Favona footwall fault (Figure 1), both of which are north to northeast trending and have a perceived strike extent exceeding 1km.

Groundwater inflow is, predominantly, controlled by infiltration from overlying layers and through outcrops of ignimbrite in the beds of streams and at the ground surface. The rhyolitic ignimbrite sequence is considered to be compressible and has accounted for most of the dewatering induced settlement around the mine site. This is indicated by settlement magnitude generally corresponding to the thickness of and the magnitude of dewatering in these materials.

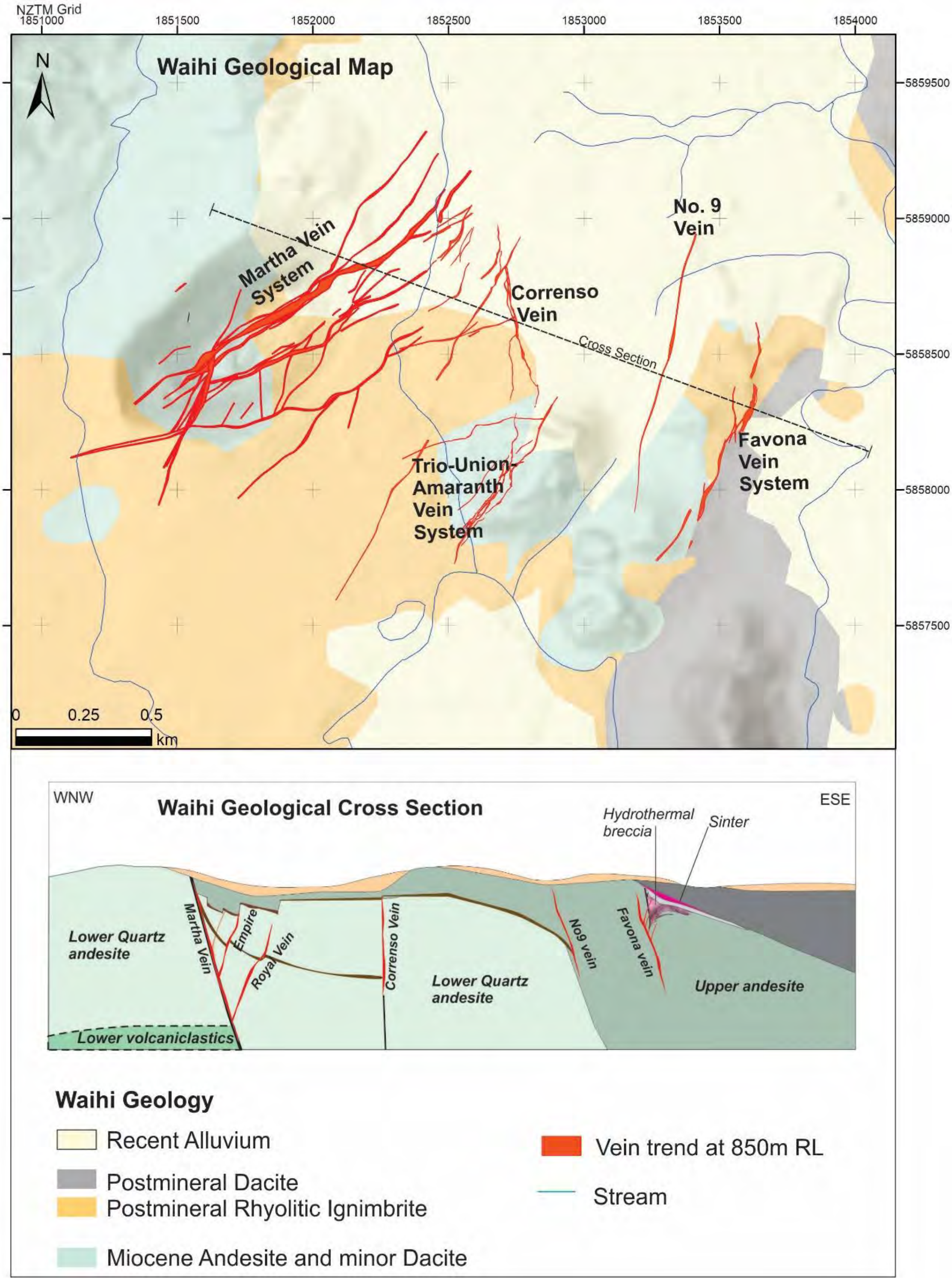


Figure 1: Geological map and cross section of the Waihi area showing the distribution of quartz veining and dominant geological rock units.

3 MINING ACTIVITIES

The main features of the mining activities during 2020 (in relation to dewatering and settlement) are described in the following sections.

3.1 Martha Open Pit

Access to Martha Pit during 2020 has been restricted due to the North Wall slip. No works were undertaken in the pit during 2020. The pit remains in care and maintenance.

3.2 Underground

3.2.1 Development

2020 saw development in the Correnso Upper, Daybreak Upper, Correnso Deeps, and Trio Deeps mine areas (Figure 2 & Figure 3). Exploration drives and access development was also carried out into the Martha Project area. Throughout 2020, 8,382 m of both capital and operating development advance occurred, with the breakdown as follows:

- 7,301 m of capital development in the access drives in Martha Underground
- 1,081 m of operating level development located in Correnso Upper and Louis.

2020 saw approximately 125,000 tonnes of ore being extracted from stopes, primarily from the Upper and Lower Correnso areas.

3.3 Future Mining Activities

Production for 2021 will be focused on the Upper Correnso area (~942 mRL) initially and will then move into the Edward section of Martha Underground in the second half of the year. For a full outline of planned activities for the 2020/2021 period, refer to the Annual Work Programme July 2020 – June 2021.

3.4 Waste rock management

Waste rock is managed in two ways; underground stockpiling and backfilling into stopes and placement on temporary stockpiles on the surface.

On the surface, a short-term stockpile is maintained immediately behind the mill area, enabling easy access for backloading. Larger or longer-term volumes may be stored at the Favona 'Polishing Pond' Stockpile (near the water treatment plant polishing pond). Waste rock placement at this stockpile started in early February 2007 and the site has also been utilised for interim placement of Martha ore. Before undertaking stockpile construction, the Favona Underground Mine Settlement, Dewatering and Water Quality Monitoring Plan was prepared, and approved by Waikato Regional Council (WRC). A separate Favona Water Quality Monitoring Report is prepared mid-year and submitted to WRC.

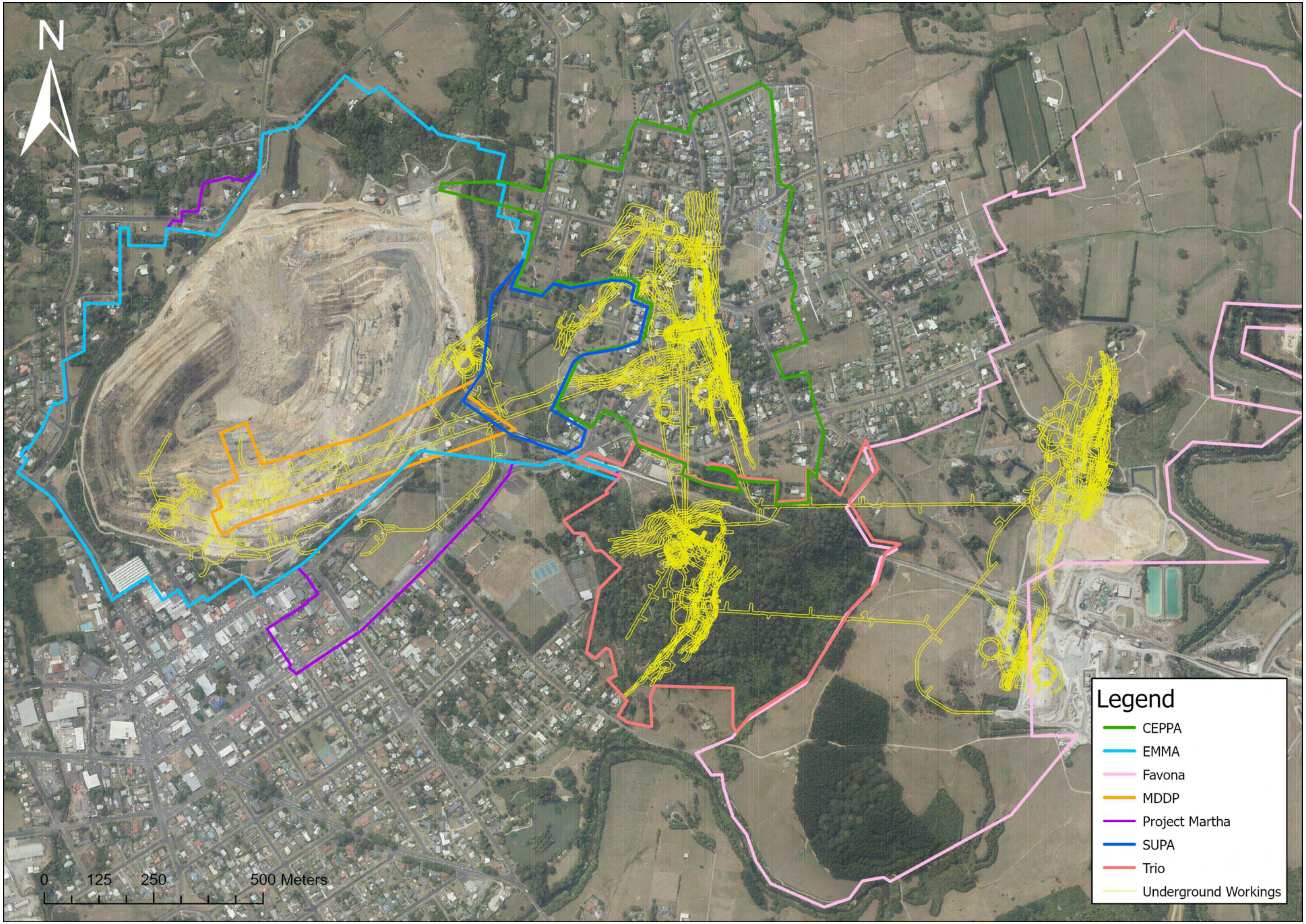


Figure 2: Current workings and boundaries

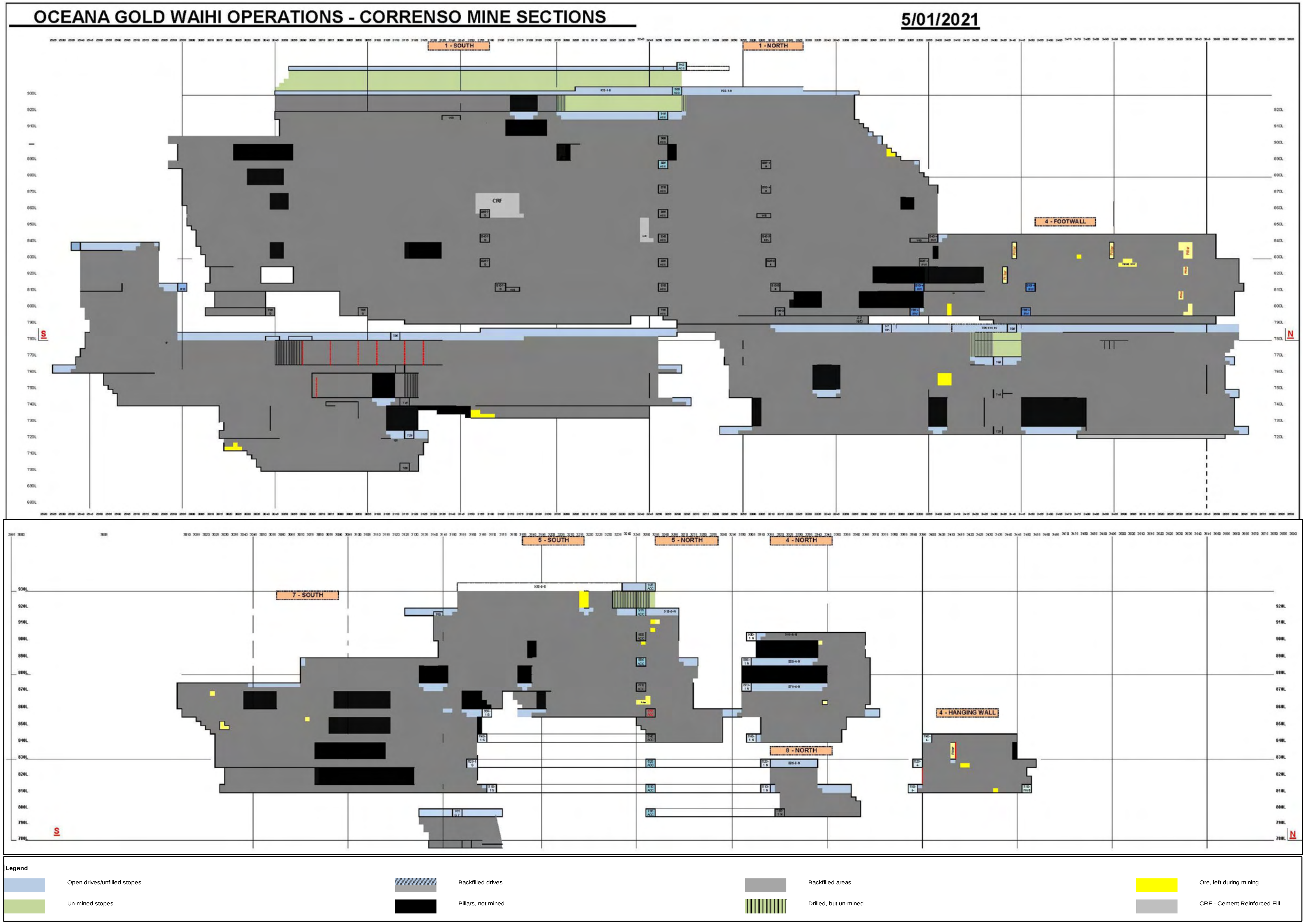


Figure 3: Mine Sections of Correnso Operations (Development and Backfilling)

4 DEWATERING

Table 1 shows the annual combined abstraction rate from Martha, Favona, Correnso and Trio. Figure 4 shows groundwater take rates and water levels and Figure 6 and 7 show the current pump arrangement for underground dewatering.

During 2020, four dewatering pumps in two bores (800 PC1 and 800 PC2) were installed from the 800 mRL level to lower water levels for Project Martha development. Dewatering to 500 mRL is permitted under the Project Martha consent. Dewatering water from these bores is connected to the existing Correnso dewatering line. Water levels began to be drawn down using these pumps during 2020, though were not lowered beyond 700 mRL (Figure 5).

Table 1 - Martha, Favona, Trio & Correnso Mines Annual Dewatering Volumes and Rates

Year	Total mine take (m^3)	Average pump rate (m^3/day)	Service water pumped underground (m^3)	Total Mine take minus Service Water (m^3)
2015 (May 18th onwards)	1,338,760	5,871	60,727 (23 Sep onwards)	1,278,033
2016	2,911,046	7,954	181,466	2,729,580
2017	3,637,734	9,996	219,198	3,418,536
2018	4,285,048	11,511	262,227	4,022,821
2019	3,153,288	8,639	254,859	2,898,429
2020	2,687,124	7,342	173,290	2,513,834

At the request of a peer reviewer, a standalone flow meter for the Favona dewatering line was installed in December 2019, abstraction rates from Favona are shown in Table 2.

Table 2 - Favona Mine Annual Dewatering Volumes and Rates

Year	Favona Mine take (m^3)	Average pump rate (m^3/day)
2019	1,637 (first reading 12 December 2019)	125
2020	14,313	39

Note: for continuity, Favona abstraction volumes are also included in 'Total mine take' numbers reported in Table 1.

4.1 Future Dewatering

The Project Martha dewatering consent, which allows dewatering to no lower than 500 mRL. Underground water levels were not drawn below 700 mRL in 2020 but will be progressively lowered during 2021. The target pumping rate when the system is 37 L/s at each of the four pumps. Water levels are projected to be lowered by an additional 40 m in 2021. Water levels in the dewatering bores are currently being measured weekly using a water level dip meter. Pressure transducers will be installed during 2021 to collect continuous water level readings.

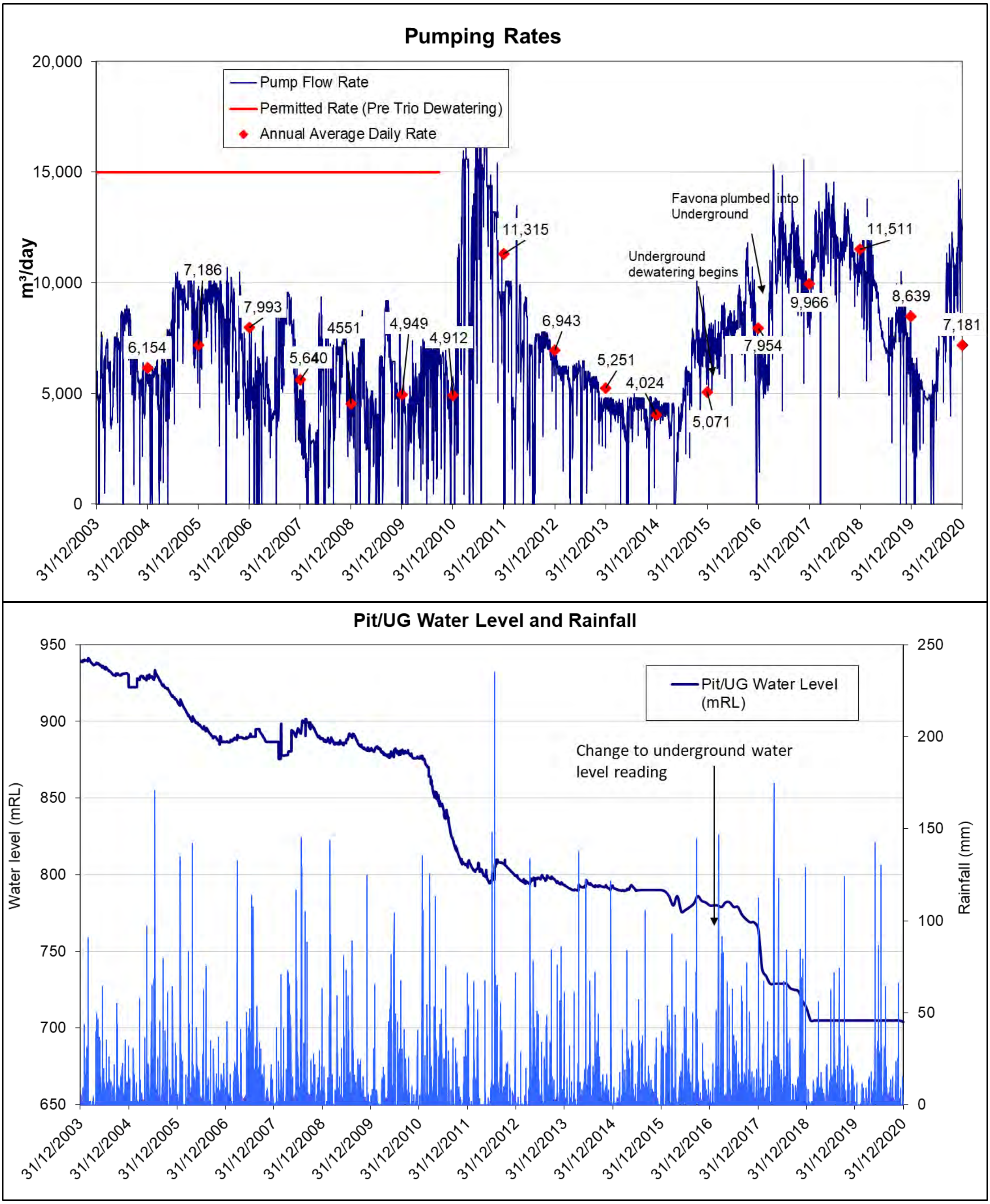
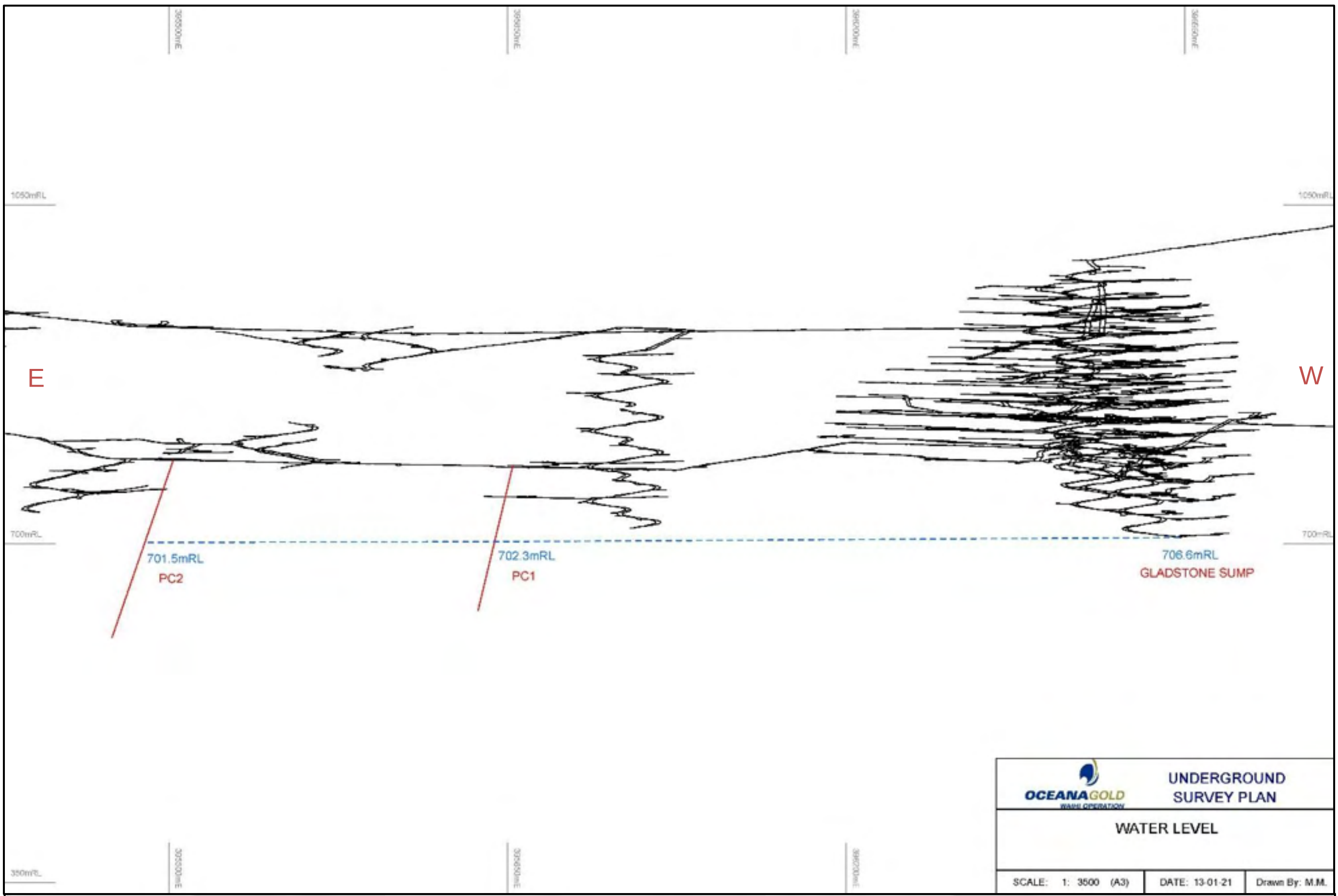


Figure 4: a) Martha Mine/Correnso dewatering rates, and b) Dewatering water level and rainfall



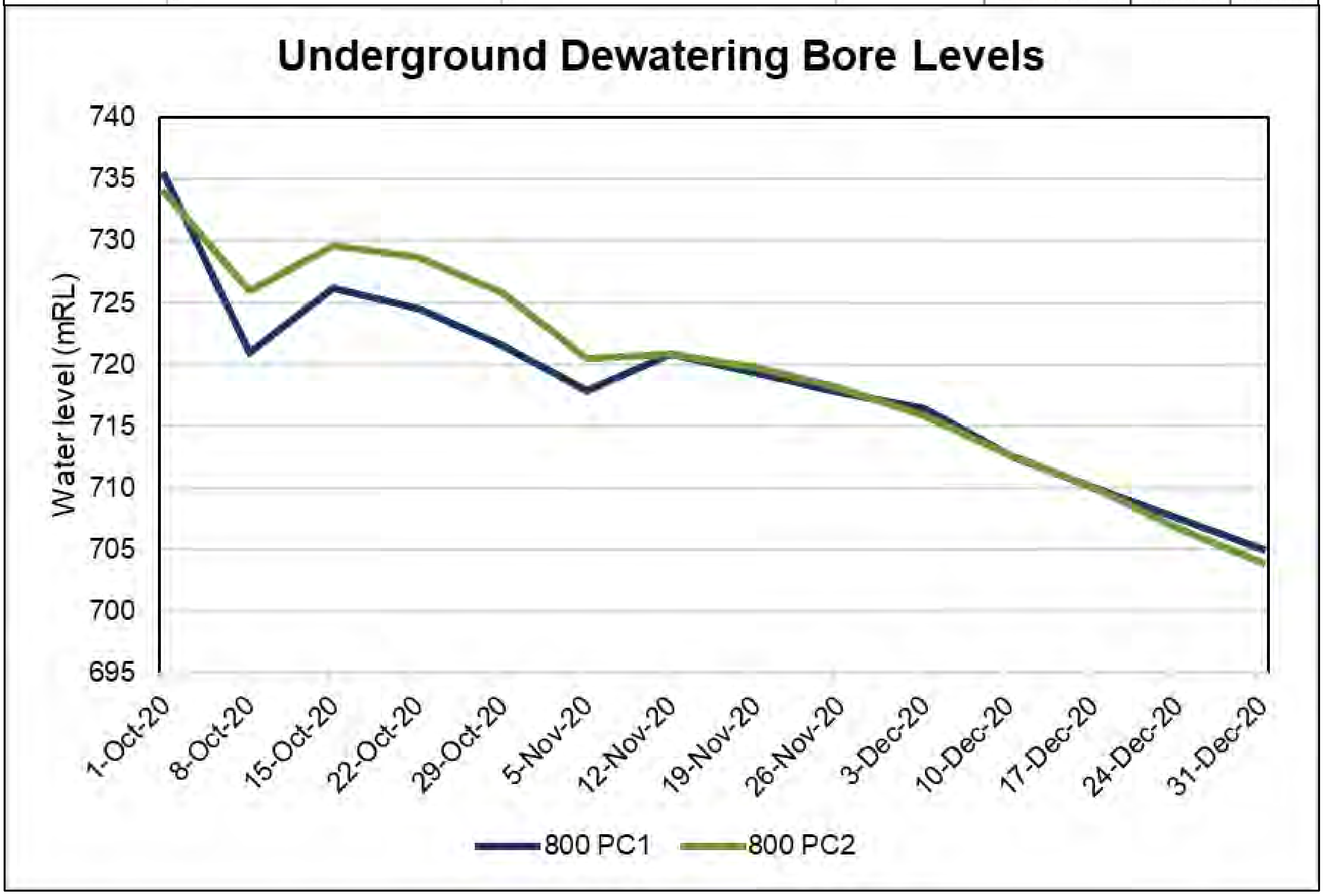


Figure 5: a) Project Martha dewatering bore locations, and b) 2020 dewatering bore water levels

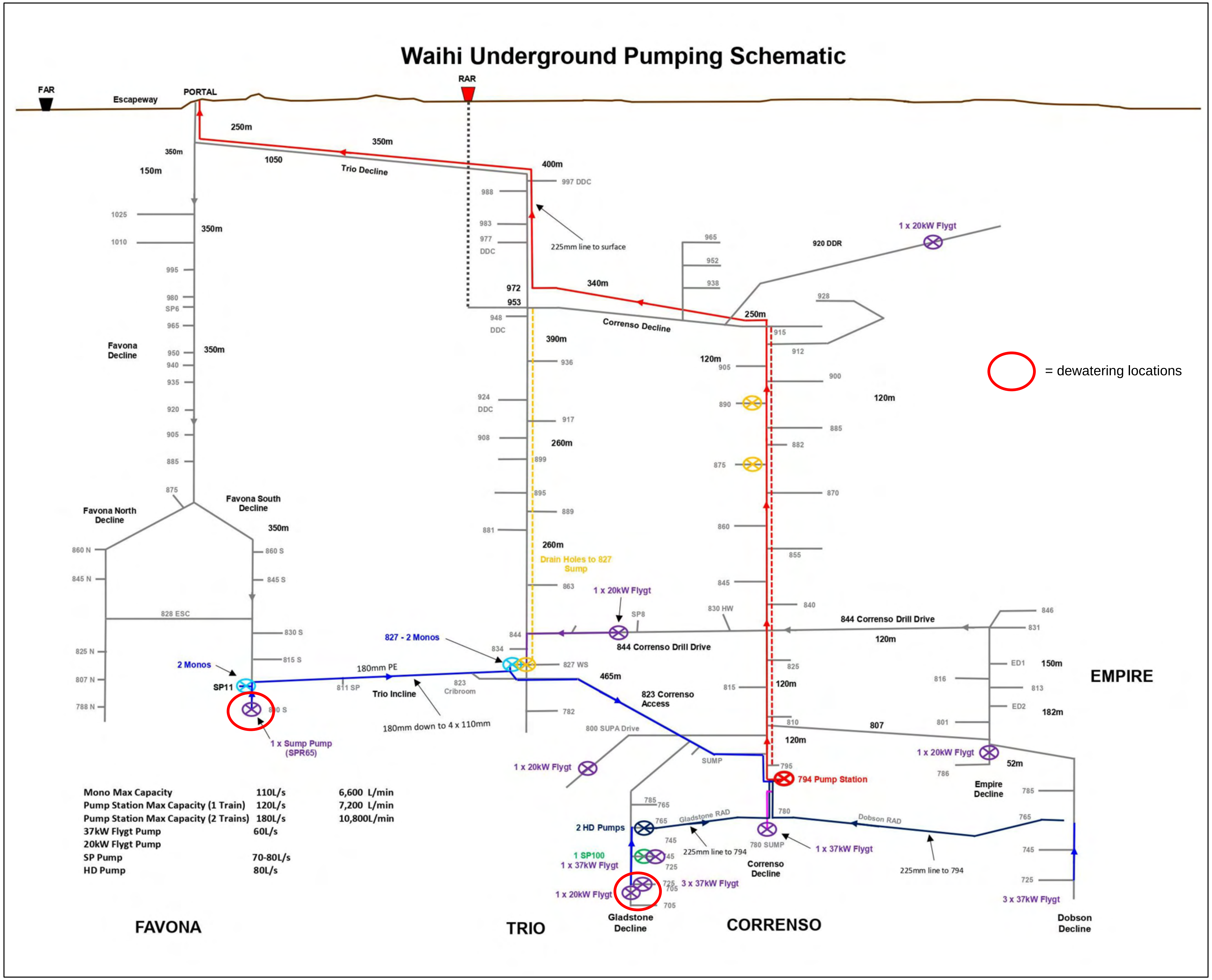


Figure 6: Underground Pumping Schematic December 2020

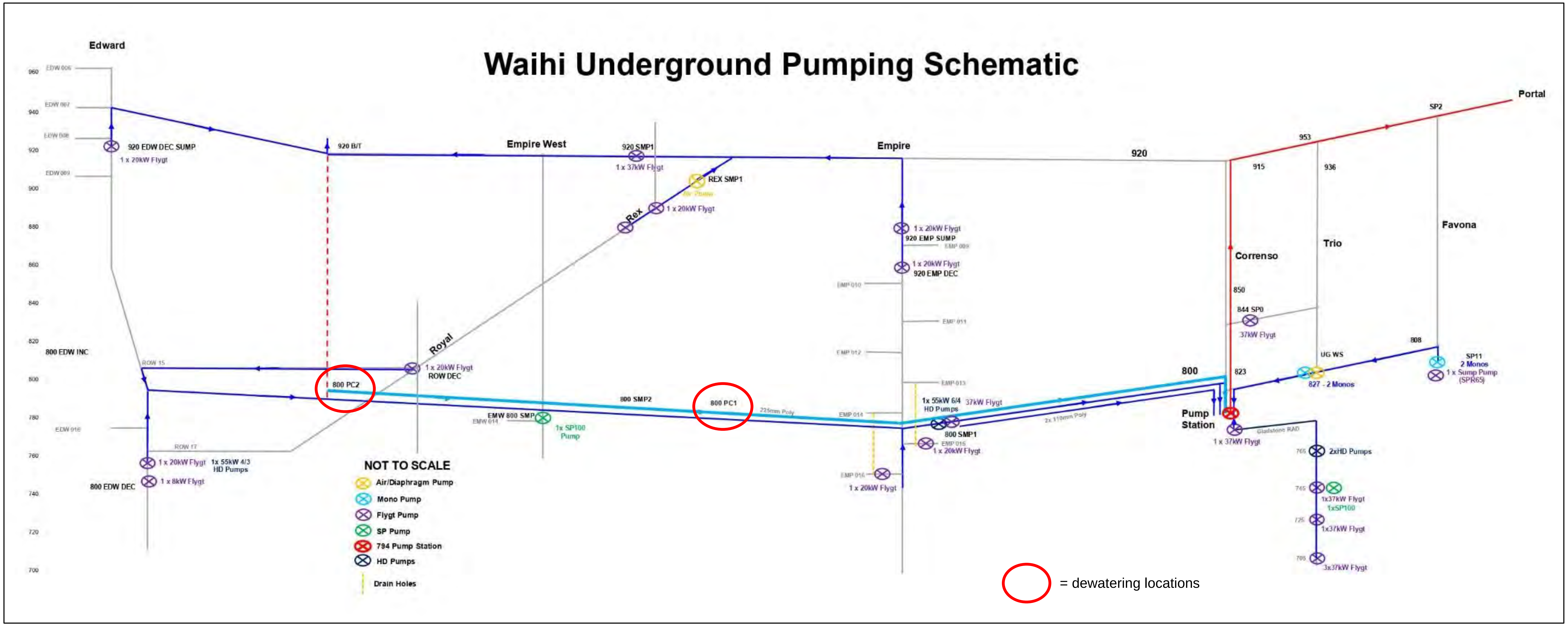


Figure 7: Underground Pumping Schematic - New borehole pumps commissioned 2020

5 GROUNDWATER MONITORING

This section is provided to meet Conditions 13 a, b and c of the Martha consent, Conditions 2a, 4b, and 4c Schedule 2 of the Favona consent, Conditions 6(ii) and (iii) of the Trio Development consent (referred to by the Trio Underground Mine Consent 6.1.1), Condition 35 of the Correnso Underground Mine Consent and Condition 29 of the SUPA Consent. It includes:

- Data from monitoring undertaken during the previous year including groundwater contour plans (derived from the data) in respect of the piezometer network.
- Identification and interpretation of any environmentally important trends in dewatering behaviour or groundwater profile. Existing trends identified prior to end of 2020 will not be discussed in depth unless there has been a significant change or trigger reached.

5.1 Method

OGNZL has maintained a piezometer network within and around Martha Mine since 1987 and Favona Mine since 2004. Additional Correnso/SUPA piezometers were installed in 2011, 2014 and 2016. P106 was drilled and four vibrating wire piezometers installed in that drill hole during 2017. It is located to the north west of Martha Pit (Figure 8). Seven Project Martha piezometers were added to the network during 2019 and a further three were completed during 2020 (Figure 33). Table 3 lists the piezometers currently operational that are assigned to each of the three main geological units.

Table 3 - Current Waihi Piezometer Network

Alluvium	Depth (mRL)	Younger Volcanics	Depth (mRL)	Martha Andesite	Depth (mRL)	Favona Andesite	Depth (mRL)
~~DM21-1 dry~~	~~1103~~	BH6-1	1052	BH11	1074	~~P60 ** dry~~	~~1075~~
~~DM31-1~~	1112	BH7-1	1078	~~P1-1 dry~~	~~1065~~	~~P61~~	1076
~~DM71~~	1114	BH8-1 dry	1048	P2-1 dry	974	P64-D dry	1062
~~DM81-1~~	~~1117~~	BH9-1	1073	P2-2	1034	P75	979
~~DM82-1~~	~~1114~~	BH12	1090	~~P4-1~~	~~994~~	P76-D	1055
~~DM83-1~~	~~1116~~	~~P1-2~~	~~1091~~	P7-1	988	P77-D	1031
~~DM85-1~~	~~1115~~	P2-3	1073	P8-2	1044	P78-D	1052
P2-4	1111	P4-2	1047	P8-1	975	P79-D	1047
~~P4-3*~~	~~1093~~	P7-2	1039	P9-1	1036	P87-D	1024
P8-4	1113	P7-3	1080	~~P62 dry~~	~~1021~~		
~~P9-3~~	~~1108~~	P8-3	1092	P69-S	1114		
P63-S*	1111	~~P9-2~~	~~1084~~	P69-D	1063		
P76-S*	1109	P27-1	1073	WC201-1	1058		
P77-S*	1110	P63-1	1070	WC201-2	1077		
P78-S	1103	P64-I	1086	WC201-3	1096		
P87-S	1110	P76-I	1072	WC202-1	1031		
WC201-4	1103	P77-I and	1045	P90-3	982		
WC201-5	1109	P77-I2	1051	P91-4	970		
~~WC202-4 dry~~	~~1099~~	P78-I	1066	P92-3	965		
~~WC202-5 dry~~	~~1112~~	P79-I	1061	P93-4	974		
P90-1	1096	P79-S	1090	P94-4	976		
P91-1	1105	P87-I	1069	P95-3	1000		
P92-1	1114	~~WC202-2~~	~~1048~~	P100-3	981		
P93-1	1102	P90-2	1019	P100-4	956		
P94-1	1108	P91-2	1096	P101-4	1037		
P101-1	1102	P91-3	1010	P102-4	1026		
P102-1	1108	P92-2	1000	P106-1	1100		
		~~P93-2~~	~~1091~~	P106-2	1060		
		P93-3	1014	P106-3	1010		
		P94-2	1094	P106-4	974		
		P94-3	1016	P111-2	1088		
		P95-1	1090	P111-3	1055		
		P95-2	1030	P112-2	1035		
		P100-1	1066	P112-3	997		
		P100-2	996				
		P101-2	1083				
		P101-3	1068				
		P102-2	1078				
		P102-3	1054				
		P107	1090				
		P108	1115				
		P109	1090				
		P110	1097				
		P111-1	1100				
		P112-1	1057				
		P113	1063				
		P114	1054				
		P115	1103				
		P116	1098				

* - at or just below the contact with weathered young volcanics
** - collapsed piezometer

WC – Pneumatic piezos
~~P93~~ – Strikethrough indicates failed or lost piezometer

All piezometers are monitored on a monthly basis as required by the consent conditions. The water levels are translated to the mine datum reference level to enable comparison between bores or areas. Where installed, vibrating wire piezometers record values at daily intervals with the data downloaded monthly.

5.2 Inspection and Maintenance

The piezometer dip-meter is maintained in good working condition. A calibration of the dip-meter tape against a reference tape is carried out annually by Hydrologic NZ Ltd. The dip-meter tape is replaced if the difference against the reference tape is more than 0.1%. The dip-meter was calibrated in January 2020.

The consent conditions require an inspection of the piezometer installations and appraisal of the piezometer network every two years. In effect, inspections of the piezometer network are undertaken more frequently, with the piezometer monitoring procedure requiring 6-monthly sounding to the bottom of all standpipe piezometers to identify any with excess silt and mud.

The piezometer designs have screens which allow water inflow into the pipe. Piezometers that are most impacted by sediment are on a flushing schedule, with flushing of silted boreholes occurring in November of 2019. Piezometers P8-2 and P7-2 have showed little change after multiple flushing attempts.

5.3 Groundwater Results

The Waihi town piezometer network currently has 52 dipped piezometers and six pneumatic piezometers. An additional 14 data loggers connected to 41 vibrating wire piezometers are also included in monitoring Waihi East and south of Martha Pit (Figure 8). On the north east side of the pit, seven real time data loggers are installed in wells, these were installed to investigate the source of a seepage and data collection is ongoing. Groundwater contour plans have been updated for the three principal geological units: alluvium (plus shallow groundwater in weathered younger volcanic materials); younger volcanics (including ignimbrite); and andesite. The groundwater plans are presented in Figure 9, Figure 11 and Figure 14 respectively. Discussion of results for each unit follows.

Only the andesite contour map includes data from the vibrating wire piezometers. Alluvium and younger volcanics contour maps have not included vibrating wire piezometers as the vertical gradients evident do not provide a unique water level.

5.3.1 Changes to monitoring network 2020

- Three new piezometer locations were added to the network for Project Martha monitoring during 2020 (P112, P115 and P116).

Figure 8: Waihi Piezometer Network 2020

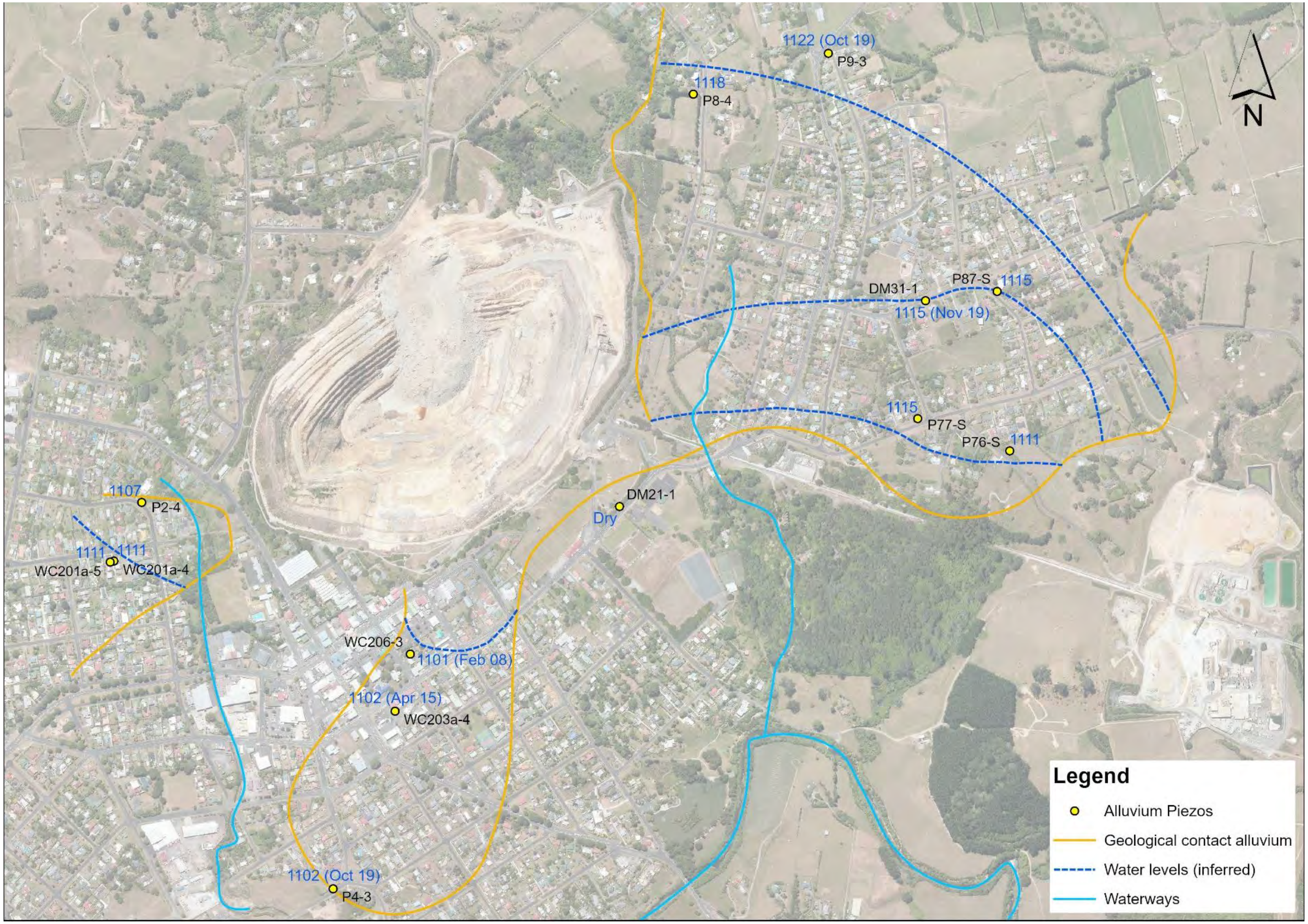


Figure 9: Alluvium water level contours

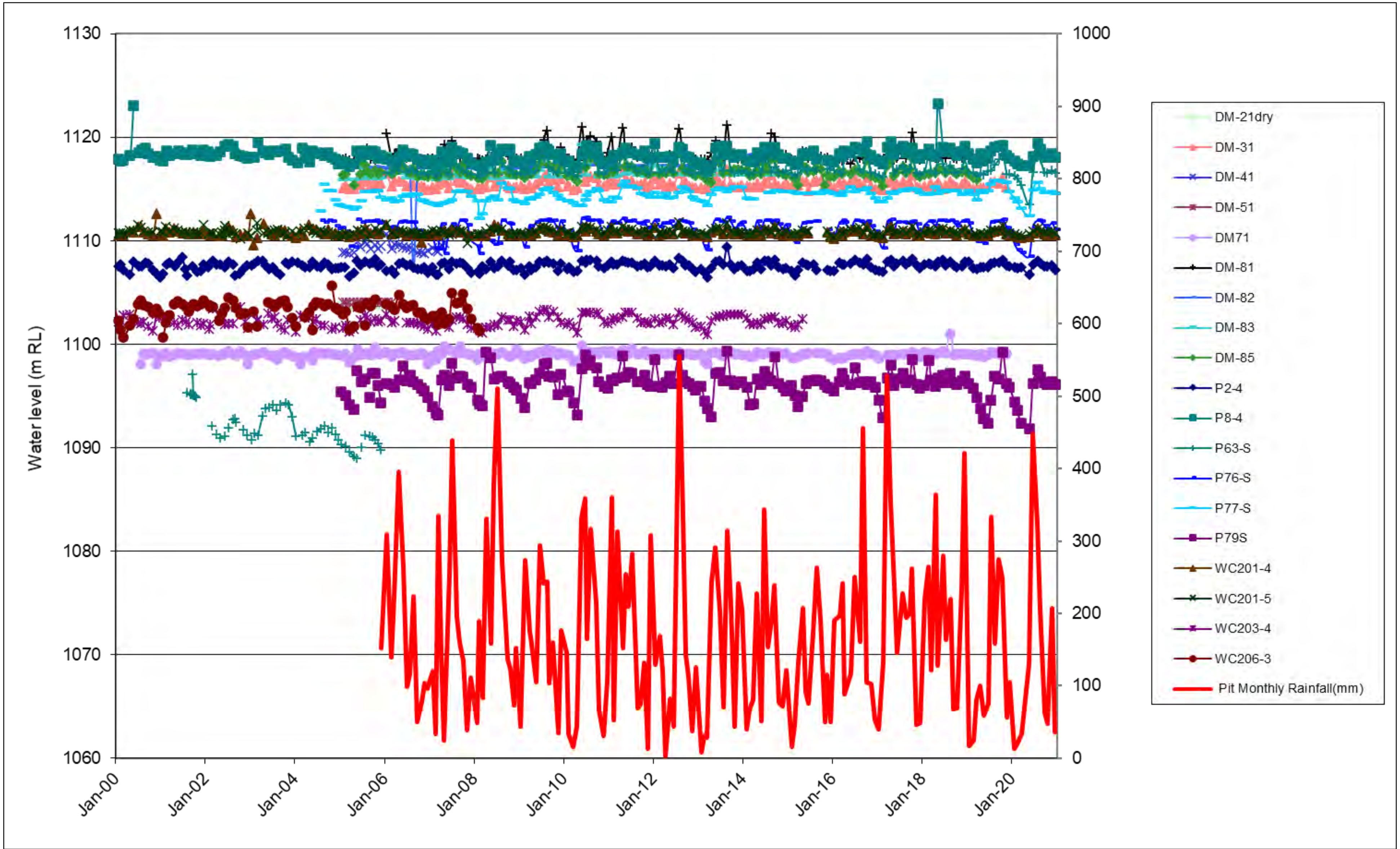


Figure 10: Groundwater Level Trends – Shallow Groundwater (Alluvium & Weathered Contact of Young Volcanics)

5.3.2 Shallow Groundwater

Figure 9 shows the inferred contours for shallow groundwater in alluvium and in weathered younger volcanic materials and shows the water level trends over time. The overall contour pattern and the trend plots demonstrate that the shallow groundwater system remains essentially unaffected by dewatering of the surface and underground mining operations. Shallow groundwater levels are controlled, principally, by rainfall infiltration, low surface soil permeability and natural and assisted drainage to surface water systems.

Contouring of the lobe southwest of Martha Mine (Figure 9) has been restricted by the loss of access to the wells at sites WC203 and WC206. For the purposes of completing the contour plan it was assumed that groundwater levels in the alluvium at these locations remained the same as in previous years.

5.3.3 Younger Volcanics

Groundwater contours in the deeper portions of the younger volcanic materials below the shallow groundwater system are shown on Figure 11 and trends are graphed on Figure 12.

The younger volcanic materials infill topographic depressions in the surface of the andesite rock body in which the open pit and underground mines are constructed.

Groundwater level change and the associated consolidation of the varying thickness of these relatively weak younger volcanic materials is considered to be responsible for much of the settlement and for the settlement patterns around Martha and Favona mines.

The dewatering pattern in the younger volcanics around Martha Mine indicates drainage towards the open pit. The limited groundwater discharge at the contact of the younger volcanic materials with the underlying andesite in the pit (see Figure 11 and 12) suggests drainage is affected by features other than the contact (which defines a paleovalley in the andesite). The most likely additional drain point is a substantial block cave evident in the pit wall. This block cave, referred to as the Milking Cow, was active during historical underground operations and resulted in substantial settlement of the ground surface, down-folding of fill and younger volcanic strata and close fracturing of the welded ignimbrite layers.

Prior to the start of dewatering at Martha Mine, groundwater levels in all rock units were similar. With the onset of mine dewatering, water levels in the veins and historic workings were drawn down. Groundwater levels in the various rock units below the shallow aquifer showed increasing vertical separation until about the mid to late 1990's. Thereafter, the water levels (in other than the veins and workings) stabilised and have remained stable since. This pattern is demonstrated in monitoring wells at site P2. With piezometer P2-1 following the vein water levels until water level dropped below the piezometer tip, P2-2 the upper andesite water levels P2-3, younger volcanic rock water levels and P4-2 alluvium (shallow aquifer) (Figure 14).

Piezometers P1-1 and P1-2 were lost in early 2016 due to public carpark resurfacing.

The development of the settlement pattern has shown a similar behaviour with an initial higher rate of settlement followed by a much-reduced rate of settlement once groundwater levels in the upper rock layers stabilised. These patterns are discussed in the following sections.

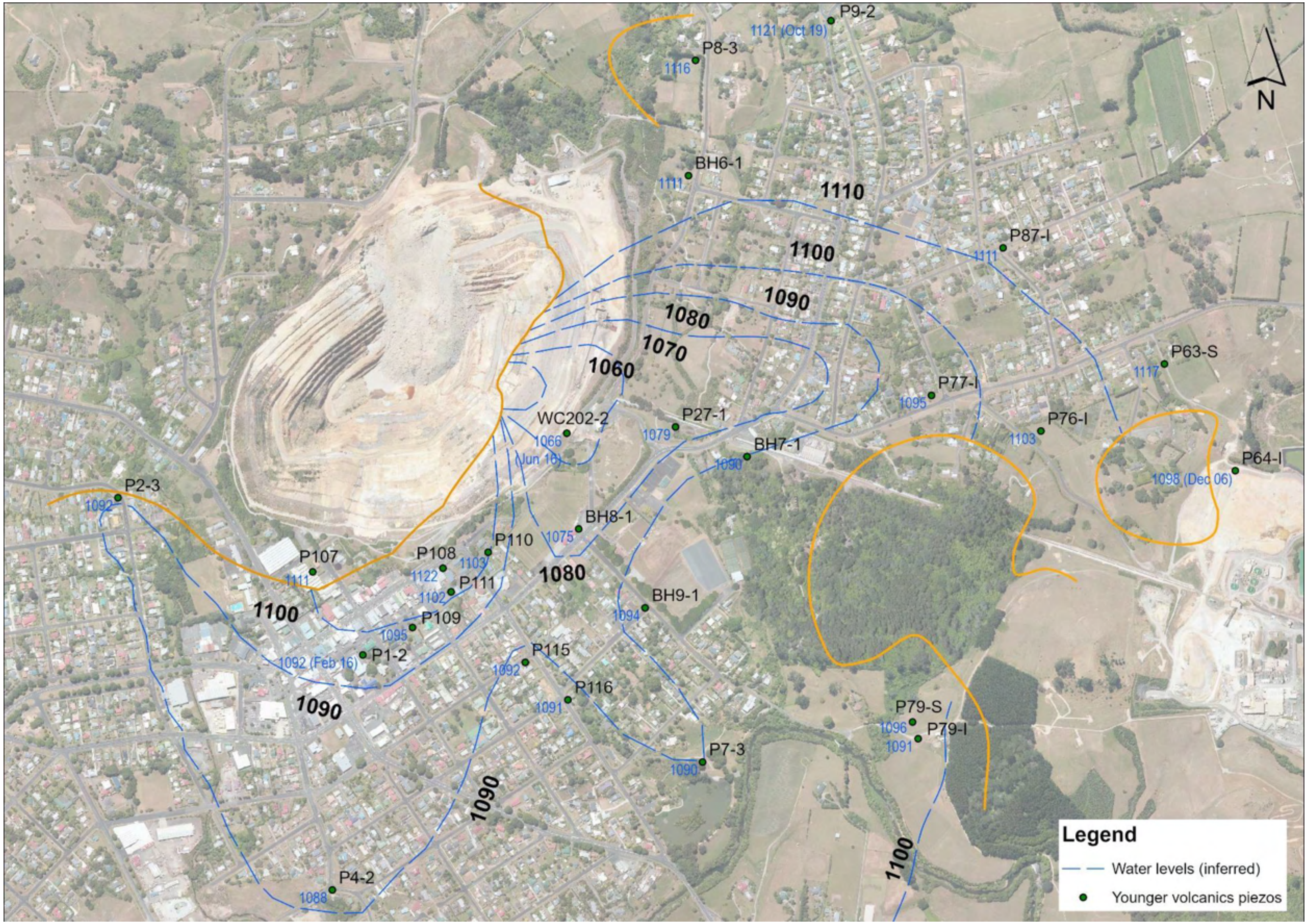


Figure 11: Deeper Younger Volcanic Water Level Contours

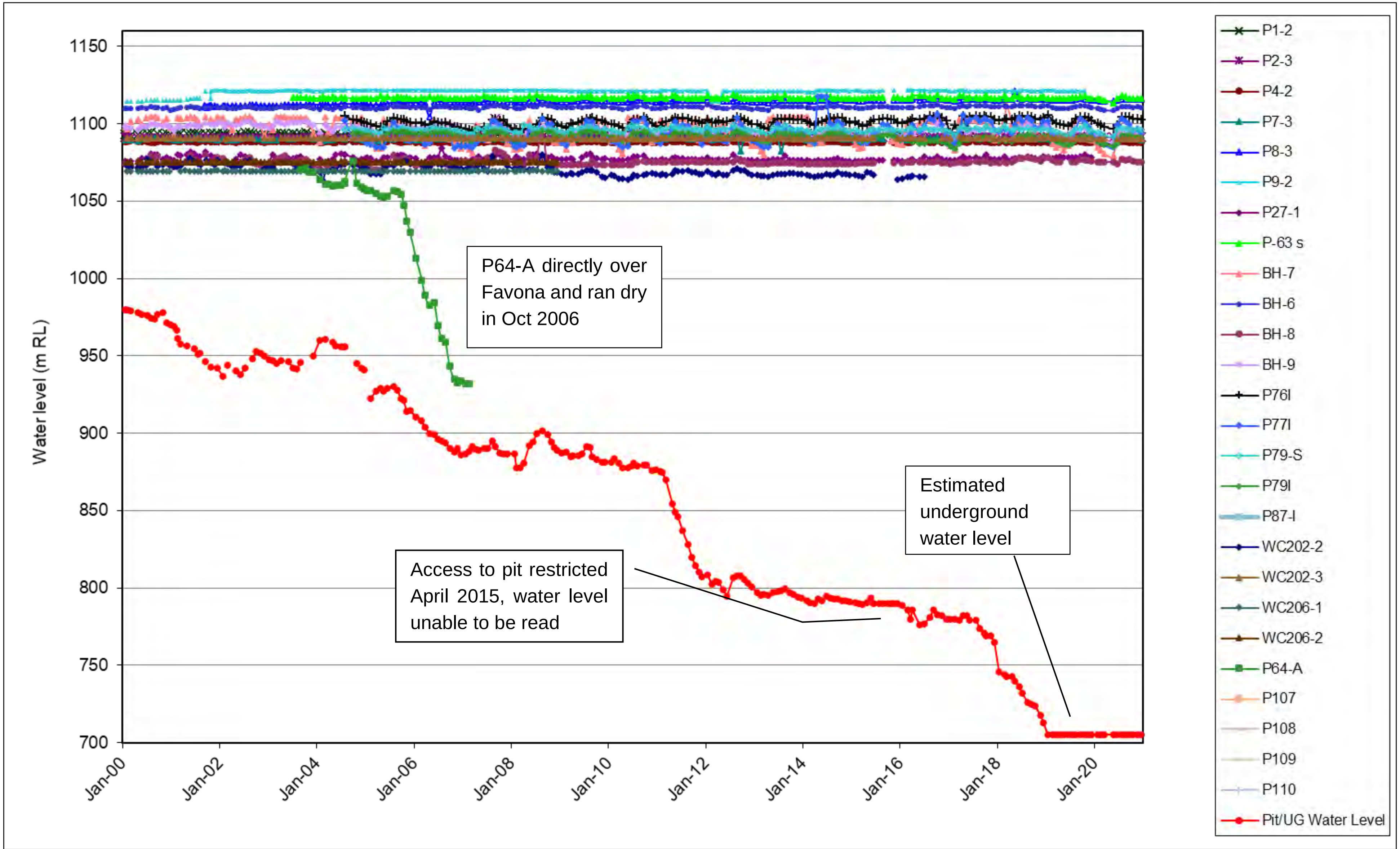


Figure 12: Groundwater Level Trends - Deeper Younger Volcanic Materials

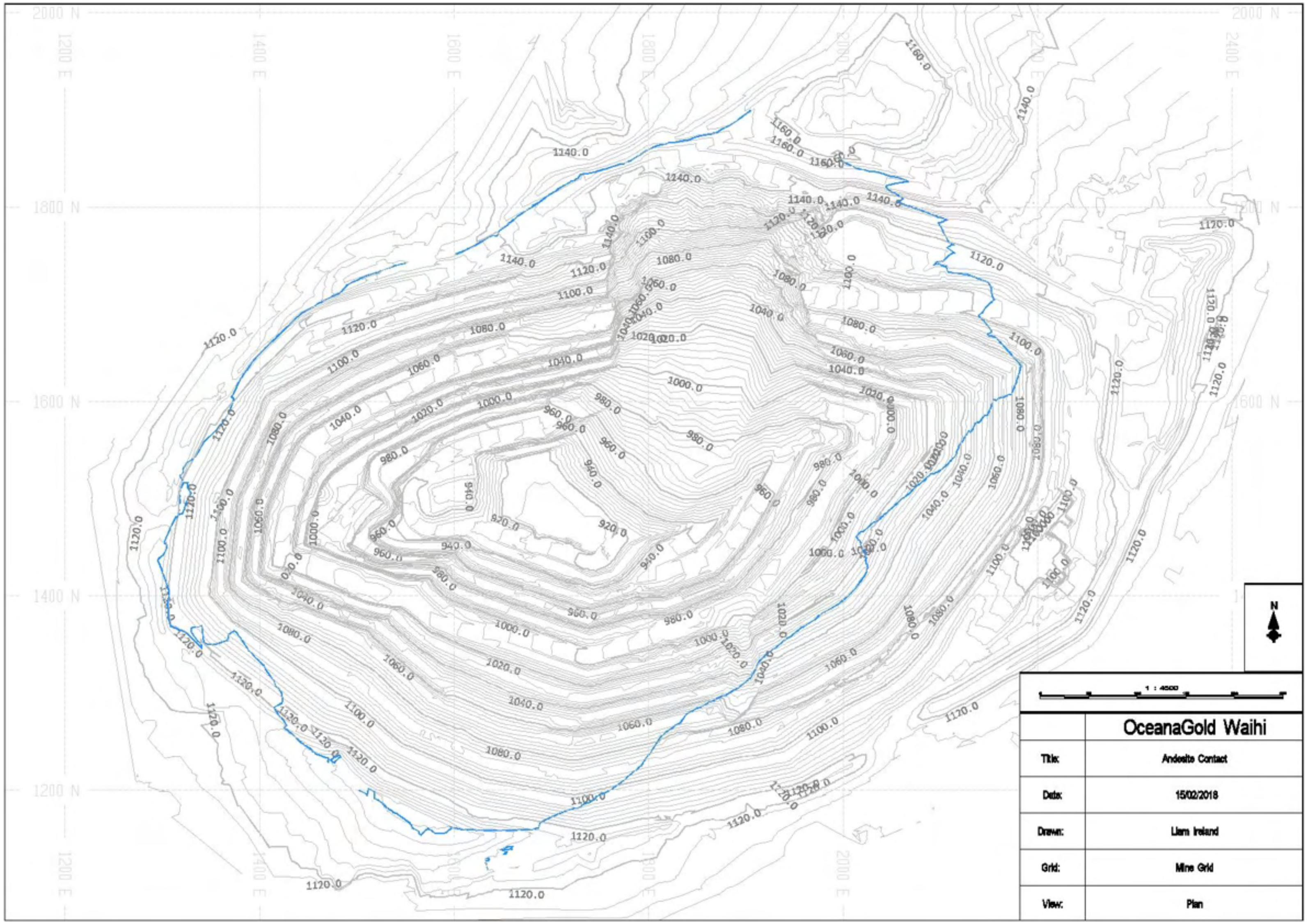


Figure 13: Andesite Younger Volcanic Materials Contact in Martha Pit

5.3.4 Andesite

Andesite rock forms the local basement rock body for the area and hosts the mineralisation which was being mined at Martha Pit and is mined in the Underground.

Figure 14 shows the scope of the dewatering effects in the andesite rock body as a result of dewatering. Data from the Waihi East vibrating wire piezometer units have been included. Figure 15 provides the water level trends in the andesite rock body. While groundwater level data is available for the vein systems and the shallower andesite rock, no monitoring data is available for intermediate depths within the andesite rockmass outside of development areas. Hence, groundwater levels between the vein and the shallow rockmass have been interpolated.

Groundwater levels in the andesite vein systems have responded rapidly and substantially to mine dewatering along the strike of the Martha vein system, along the strike of the Trio vein system beneath Union Hill, and also along the strike of the Favona/Moonlight vein systems (Figure 14). An area of dewatering, indicated between Martha Mine and Trio/Correnso vein systems, suggests a relatively close linkage. Outside of these structures, the dewatering effect in the andesite rock is attenuated or absent. This is illustrated by the different responses shown on Figure 15.

The Martha Mine dewatering effect continues to be abruptly attenuated to the north of the mine and also to the west of the mine. This is considered to be the result of faulting which truncates the veining. A lobe of dewatering extends to the southwest of Martha Mine and this is considered to be due to the drainage effect along the N-S Edward lode structure. Dewatering is shown to reduce eastwards along the Martha system but may extend further at depth as the host rocks are more deeply buried in that direction and no deep monitoring wells are available for confirmation.

Figure 14 also indicates the dewatering centralised on the Favona system with the restriction of connection between Favona and the Union systems. The geological model in Section 3 indicates an up-thrown block (Union Horst, Figure 14) between the Union and Favona systems. This structural hiatus is likely to account for the restricted groundwater interconnection between the Martha-Union and Favona systems.

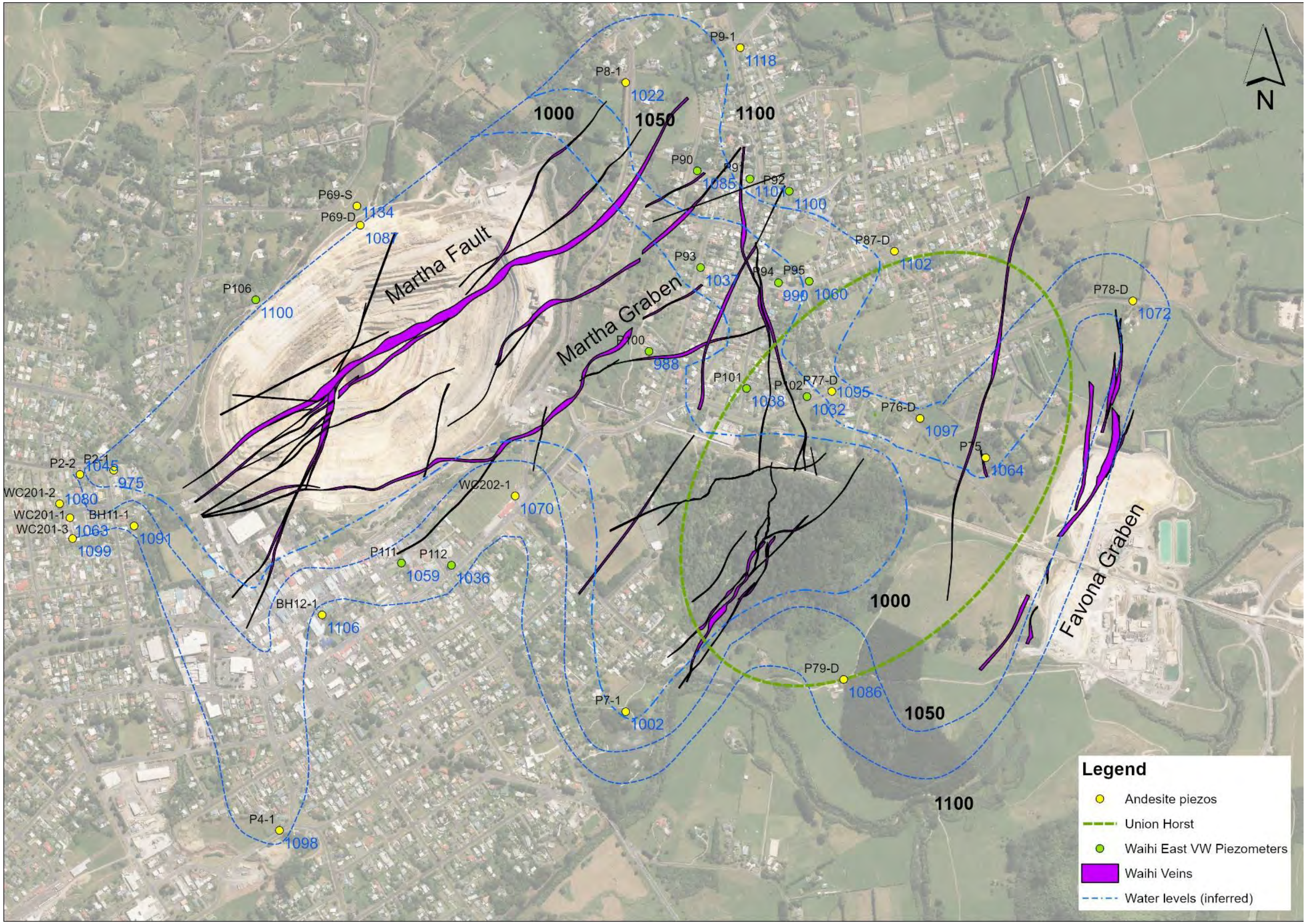


Figure 14: Andesite water level contours

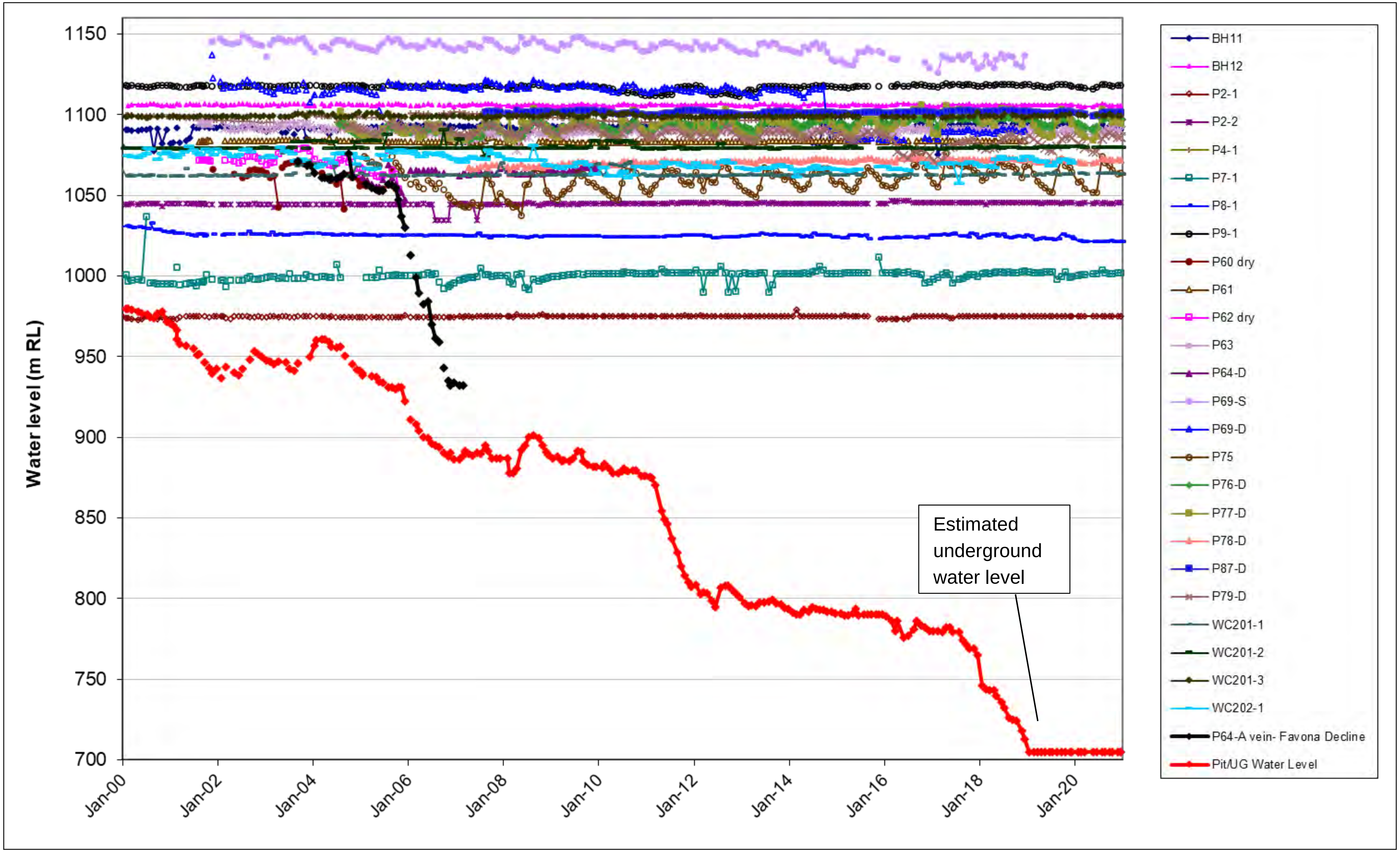


Figure 15: Groundwater Level Trends – Andesite

5.3.5 Martha groundwater assessment

P69D & P69S were installed in 2001 and are located close to the rim of the North Wall of Martha Pit. They were considered control bores and previously uninfluenced by dewatering. Geotechnical stability work in the North Wall was undertaken in October 2014, partly due to excessive water. Drainage holes were drilled into the lower wall. Localised drainage of the wall resulted, and the water levels in P69D and P69S declined. By March 2015 the piezometers had stabilized with P69D and P69S declining by 32m and 12m respectively (Figure 16). With the large North Wall slip in April 2016, access to the piezometers was briefly restricted. Real time loggers were installed in mid-2017 and are currently programmed to record hourly. Water levels have remained stable in both the shallow and the deep hole since that time.

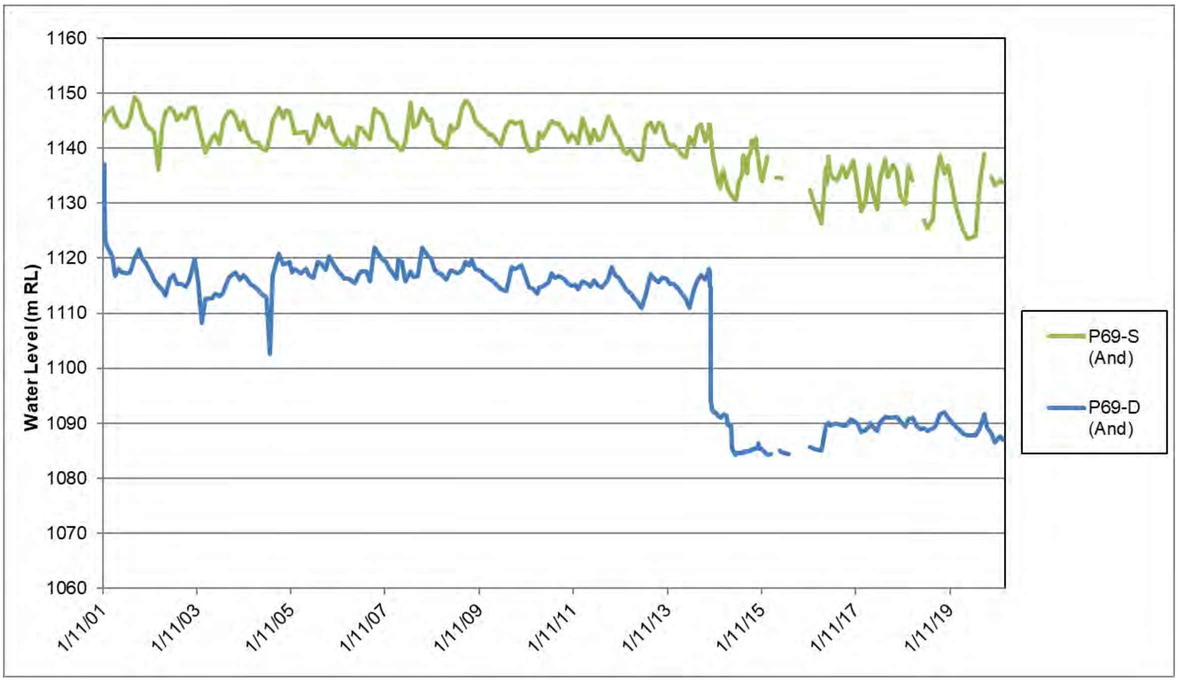


Figure 16: Water Levels P69 Pit North Wall

In September 2017, a piezometer hole (well P106) was drilled on the north-west side of Martha pit (Figure 8). Four piezometers were installed to depths between 37 and 163m. The piezometers tips are in dewatered andesite and results indicate the majority of the rockmass is dry with little or no water pressure.

In mid-2018, five real time loggers recording hourly were installed in new wells (wells P117 – P121) to investigate the source of an area of seepage on the north wall of the pit (Figure 17). Water levels in wells P119, P120 and P121 appear to fluctuate with rainfall while in wells P117 and P118, levels follow long term trends within the andesite. Fluctuations in water level in P117 were observed for the first few months following the installation of loggers before a sudden drop in water level. This effect is likely as a result of the piezometer initially recording the shallower level and responding to rainfall before long term drainage to the pit through the screen occurred, causing the drop to approximately 1118 mRL.

N.B Gaps in data are due to logger malfunction or battery failure.

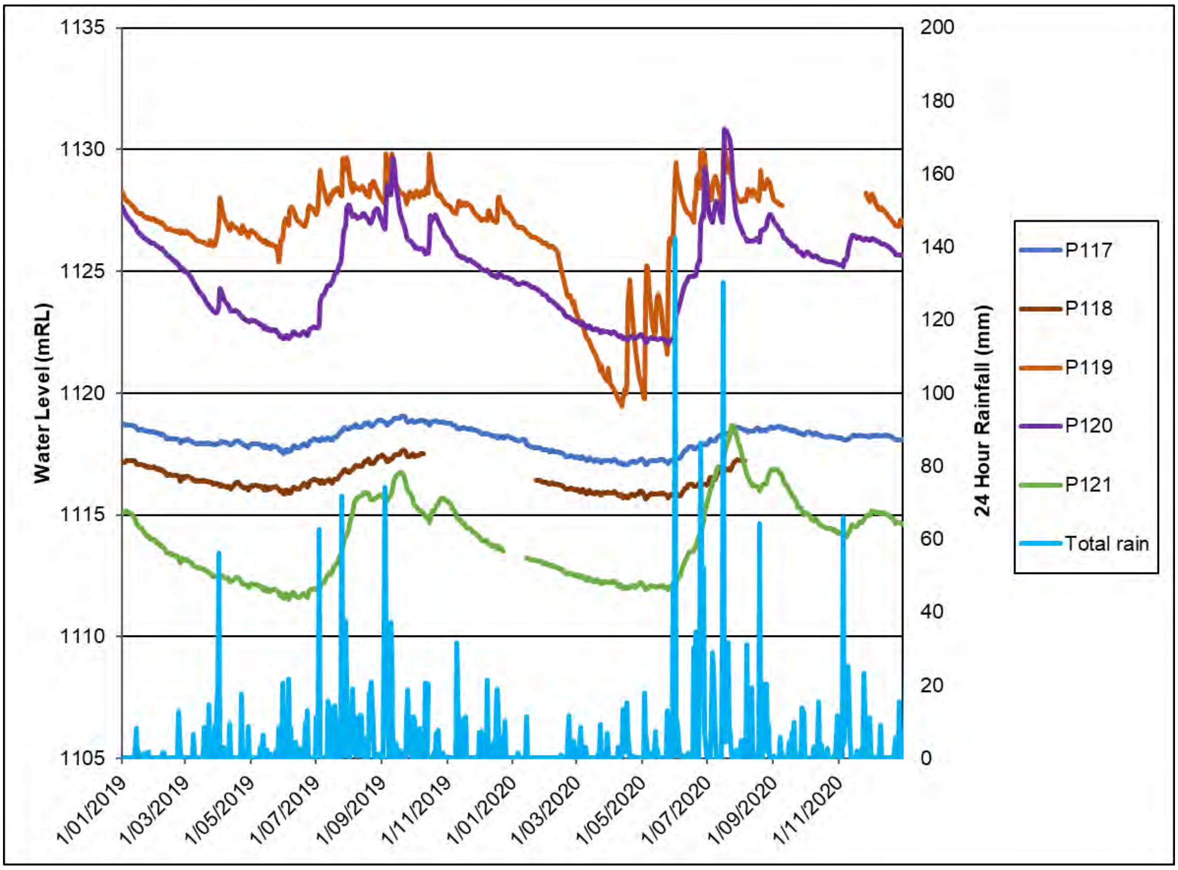


Figure 17: Pit North Wall Piezometer Levels

5.3.6 Private Wells

The private wells show seasonal fluctuations in groundwater levels and these levels can also be influenced by landowners using the bore. The Whangamata Rd and Mataura Rd bores can no longer be accessed due to health and safety concerns. Additional monitoring has been undertaken at an existing well at Black Hill Orchard after a local orchardist requested OGNZL monitor their bore.

Overall, there is no indication of any influence in the bores from mine dewatering (Figure 18Figure).

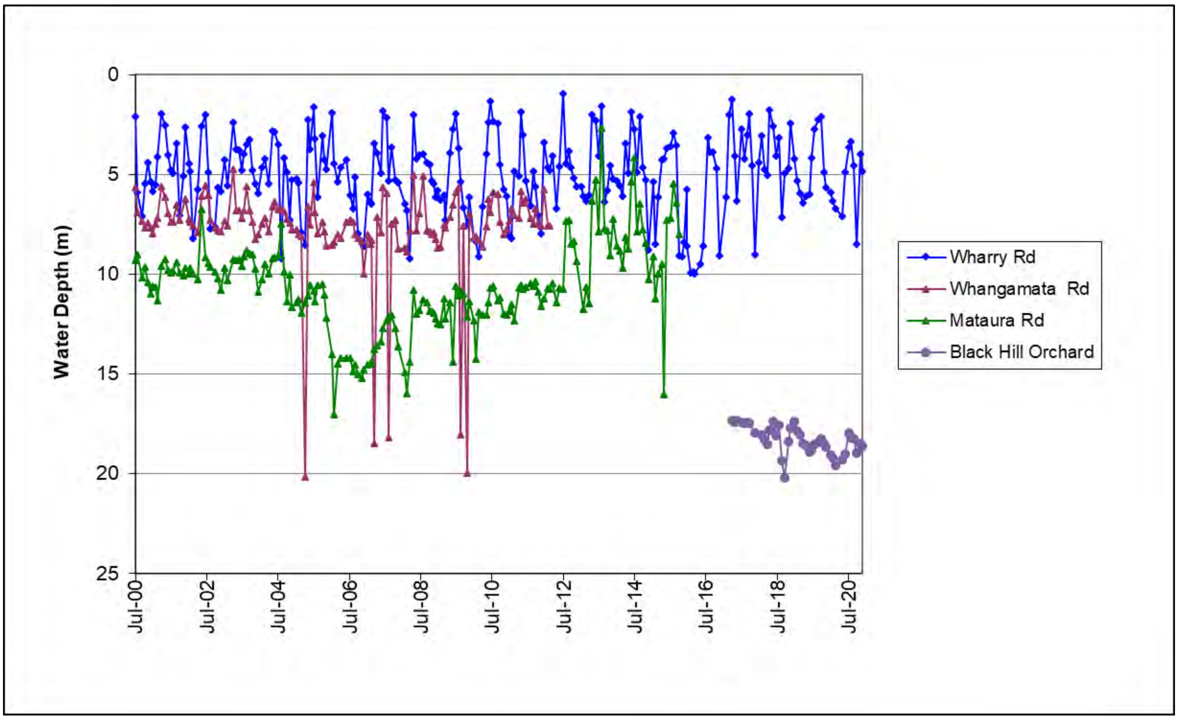


Figure 18: Private Bore Water Levels

5.3.7 Favona Trigger Levels

The Favona dewatering effect is indicated to be limited to the vein system or structures interconnected to the vein system. Apart from P64-A which was directly above Favona workings and ran dry in 2006, the dewatering effect does not extend to wells in andesite rock overlying or adjacent to the vein system (wells P76-D; P77-D and P79-D, Figure 14).

The Dewatering and Settlement Monitoring Plan (2019) sets out trigger levels to alert of rapid depressurisation in the andesite as it could affect the overlying younger volcanic rocks.

The Tier 1 trigger level for groundwater change at Favona is defined as, "a drop in water levels greater than seasonal fluctuation in wells tapping the upper 50m of andesite in response to a water level drop in deeper wells (100m) in andesite rock". Five wells were selected as suitable for assessment (Figure 19 to 23).

The Tier 1 action involves increasing the monitoring in intermediate wells (i.e. wells tapping the younger volcanic materials) with one option being the installation of pressure transducers. The regulator is to be advised when Tier 1 action is initiated. The trigger level has been calculated as the summer water level less the average seasonal water level change over the record.

Wells P76-D, P77-D, P78-D and P87-D all show a rising trend in water levels; as such, Tier 1 action is not forecast.

Piezometer P79-D reached the trigger limit in 2016 when the piezometer recorded a rapid loss in pressure, most likely due to a reaction to water loss from an underground horizontal drill hole. The drill hole was grouted and no further water loss from the hole occurred. Water levels subsequently recovered to above the trigger level with amplified seasonal variation noted since this time. During May and June 2020, water levels in P79D dropped below the trigger level before recovering in July. This is likely due to the amplified seasonal variation caused by a reduction in rock mass storage following the grouting of the drill hole nearby. Continuous water levels are now being recorded in the P79 well set to monitor the trend (Figure 22). Overall, there appears to be a stabilisation in pressure since 2016. Refer to Appendix G for GWS Limited's review of the trigger breach.

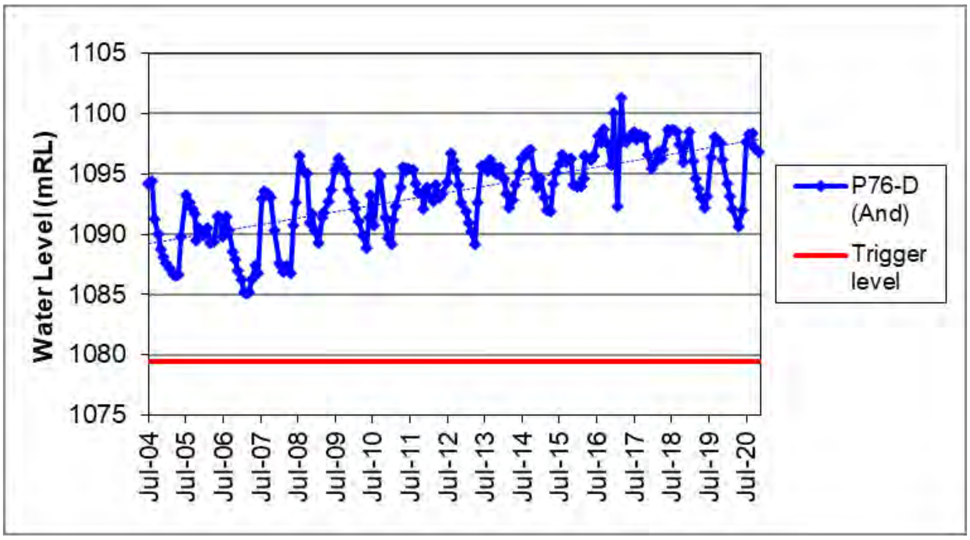


Figure 19: Trigger Level P76-D

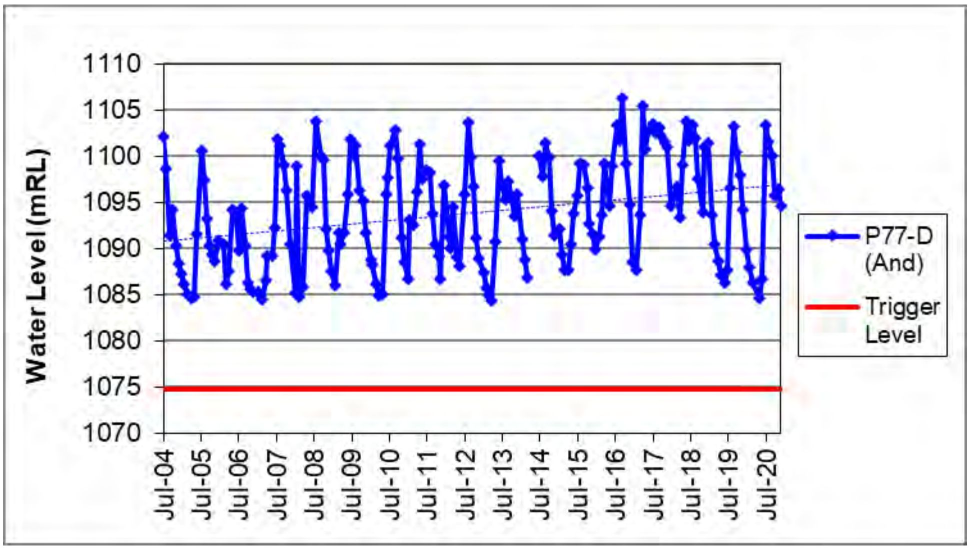


Figure 20: Trigger Level P77-D

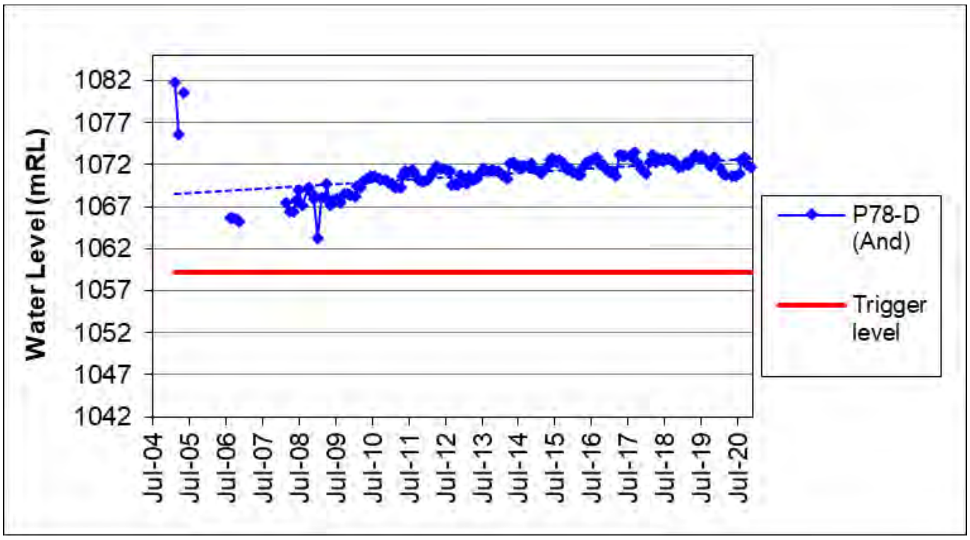


Figure 21: Trigger Level P78-D

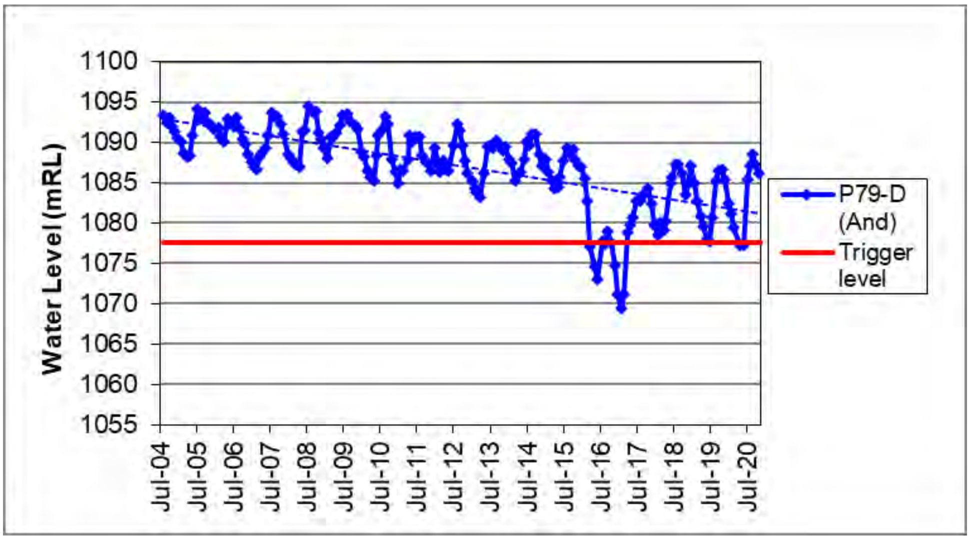


Figure 22: Trigger Level P79-D

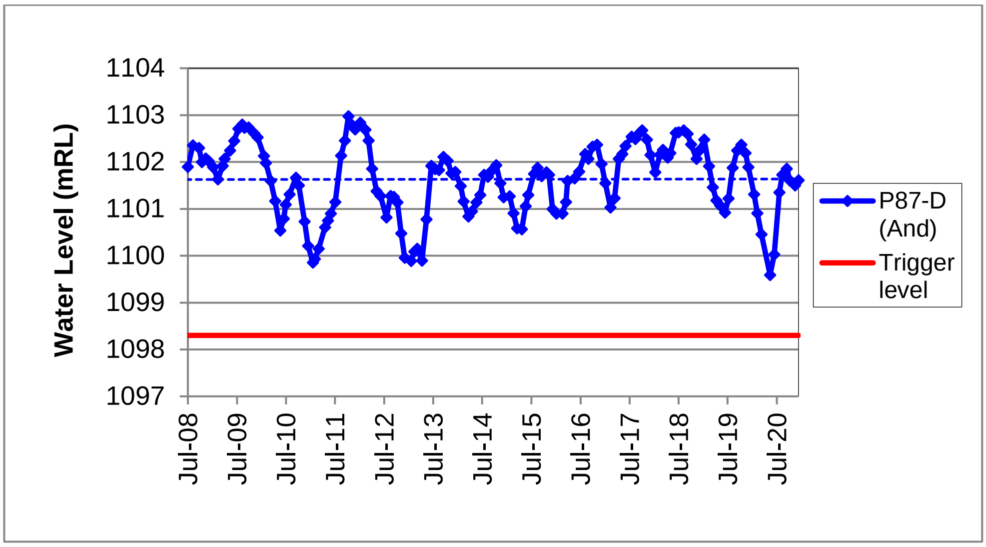


Figure 23: Trigger Level P87-D

<u>Andesite Groundwater Summary</u>

The ongoing evaluation of the groundwater level responses to mining at Martha Mine and at Trio/Favona/Correnso/SUPA Mines has been updated. The data continues to confirm that dewatering effects within the andesite rock are transmitted via interlinked vein systems, faults and historic workings at depth. When the natural conditions are unmodified, these effects are not extending into shallower geological layers or affecting shallower groundwater. Where trigger levels have been set around the Favona Mine, one exceedance of the trigger levels occurred in 2016 and briefly during 2020 (the 2016 trigger was investigated and mitigated; monitoring is ongoing to determine whether further response is warranted for the 2020 trigger). Current trends do not forecast any new exceedances of trigger levels due to mining and dewatering.

5.3.8 Waihi East - CEPA

Six groundwater monitoring boreholes were installed between July – September 2011. They are located east of the Martha pit to provide improved groundwater information in an area with few existing wells and in the vicinity of the Correnso Project. Two additional vibrating wire piezometer boreholes and 39 additional settlement markers were installed in early 2014. One further borehole was installed in 2016 for monitoring related to the Daybreak/SUPA orebody.

The piezometers were located across and perpendicular to the Correnso vein system in three lines (P90, P91 and P92 forming one line, P93, P94 and P95 a second line and P100, P101 and P102 the third). Separation distance between the northern and southern lines is some 500m (Figure 8). The piezometers were constructed to intercept the shallow aquifer, younger volcanics, and andesite rock (Table 4).

Table 4: Geological Units and Depths P90-P95, P100-P102 Piezometers

<table>
<tr><th>Bore</th><th>Shallow</th><th colspan="2">Younger Volcanics</th><th colspan="2">Andesite</th></tr>
<tr><th></th><th></th><th>Upper</th><th>Basal Zone</th><th colspan="2"></th></tr>
<tr><td>P90</td><td>-</td><td>20</td><td>100</td><td colspan="2">137</td></tr>
<tr><td>P91</td><td>9.3</td><td>25.5</td><td>111.3</td><td colspan="2">151.3</td></tr>
<tr><td>P92</td><td>-</td><td>23.3</td><td>121.3</td><td colspan="2">156.3</td></tr>
<tr><td>P93</td><td>12.3</td><td>26</td><td>100</td><td colspan="2">143</td></tr>
<tr><td>P94</td><td>6</td><td>25</td><td>104</td><td colspan="2">144</td></tr>
<tr><td>P95</td><td>-</td><td>35</td><td>90</td><td colspan="2">120</td></tr>
<tr><td>P100</td><td>-</td><td>50</td><td>120</td><td>135</td><td>160</td></tr>
<tr><td>P101</td><td>12.8</td><td>32</td><td>47</td><td colspan="2">78</td></tr>
<tr><td>P102</td><td>8</td><td>38</td><td>62</td><td colspan="2">90</td></tr>
</table>

Figures 22 to 30 provide the records from the piezometers expressed as mRL. The charts also display the depth of the piezometer tips. Separation between the shallow and deeper piezometers is evident in the records. The nine groundwater monitoring boreholes have indicated stable water levels in Waihi East. Exceptions are discussed below.

Note: Gaps in the data are due to either brief logger malfunction issues or flat batteries in the unit

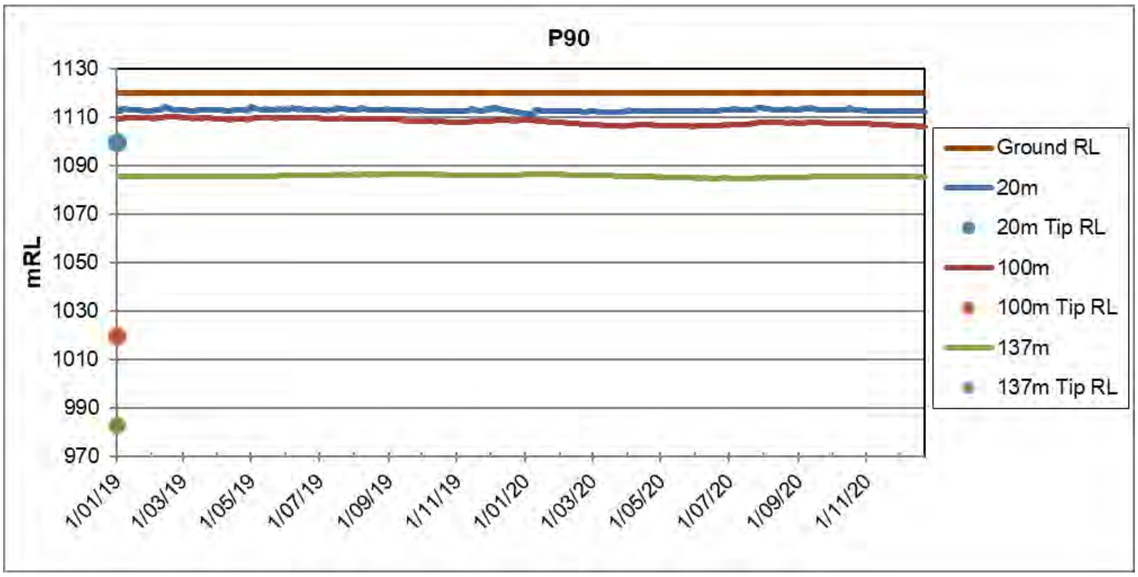


Figure 24: P90 Vibrating Wire Piezometer

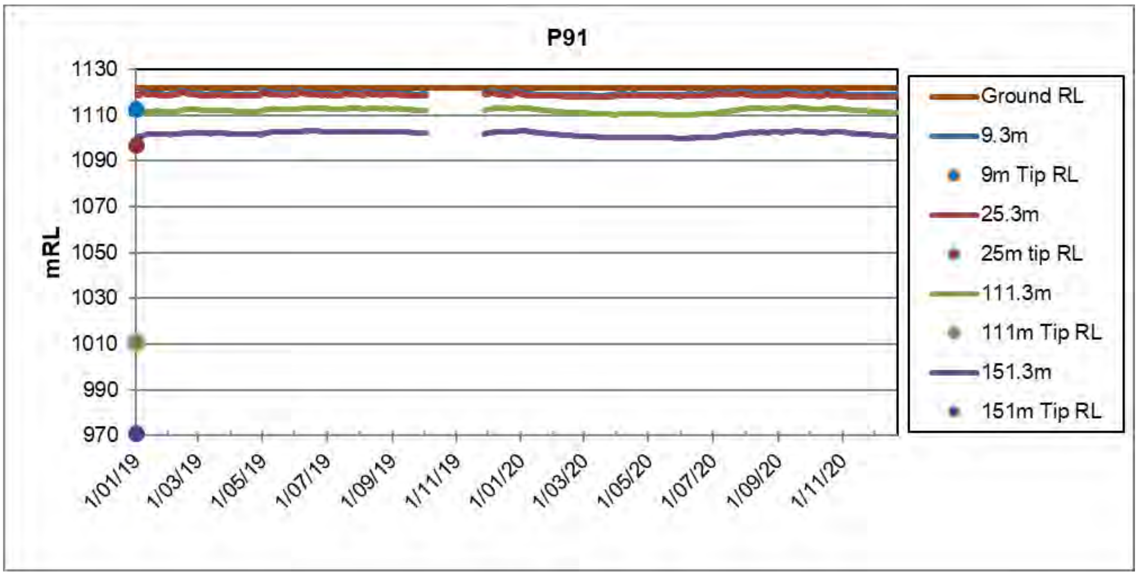


Figure 25: P91 Vibrating Wire Piezometer

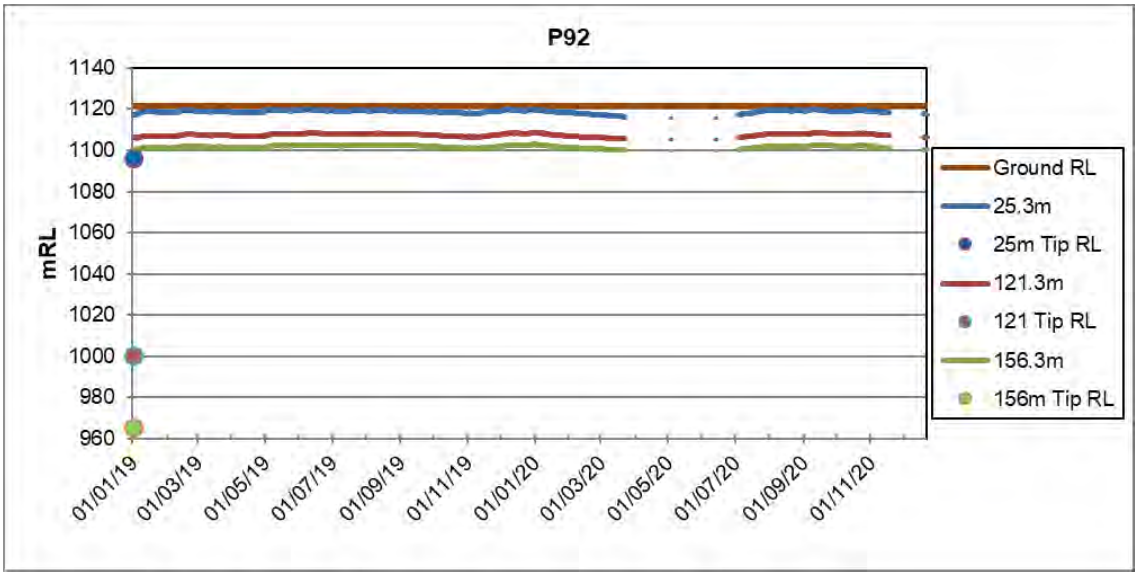


Figure 26: P92 Vibrating Wire Piezometer

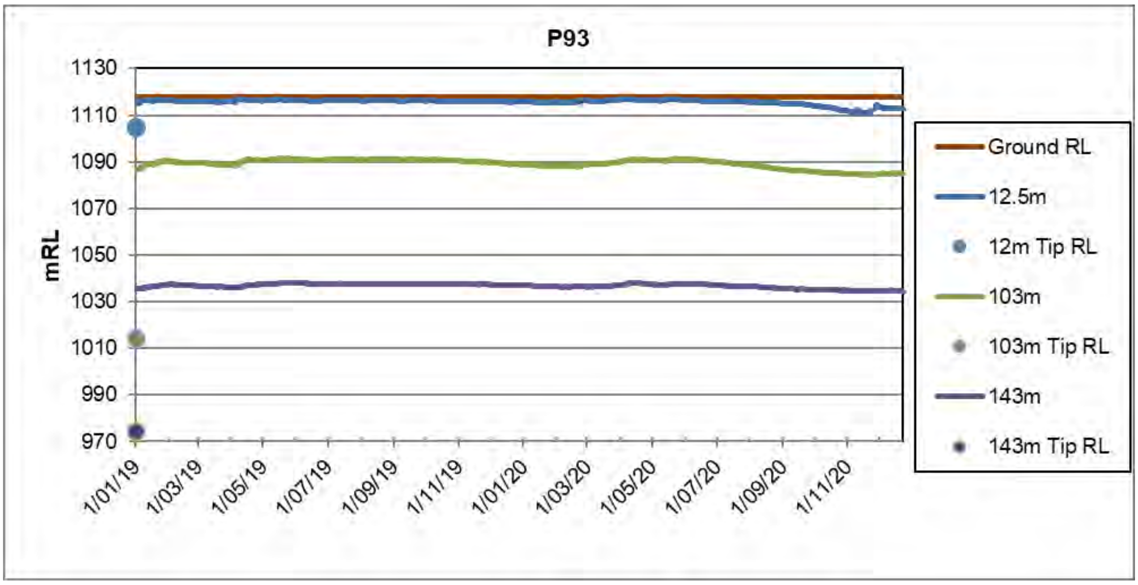


Figure 27: P93 Vibrating Wire Piezometer

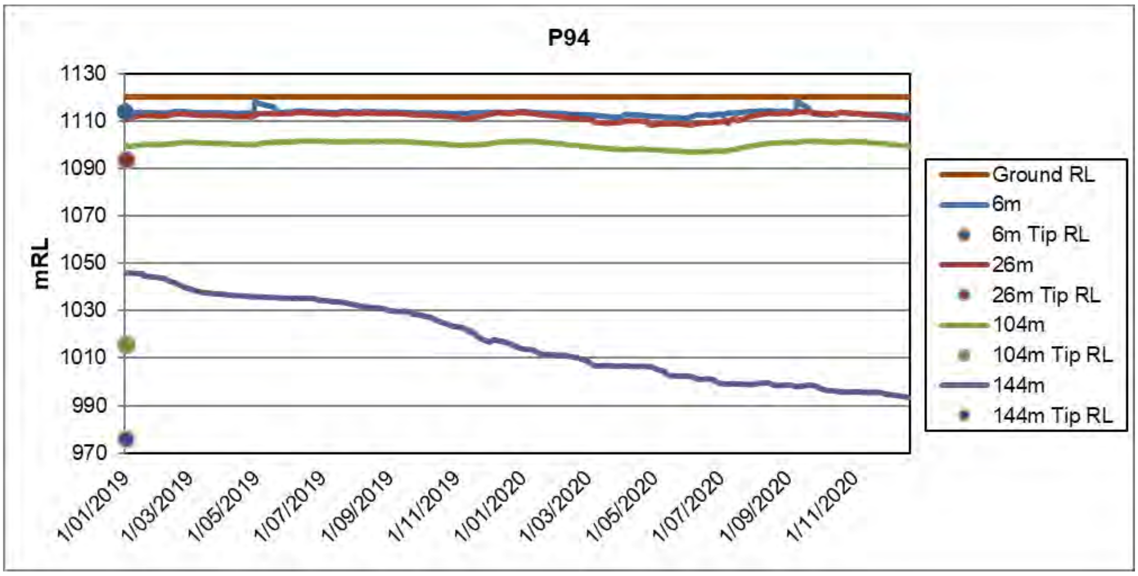


Figure 28: P94 Vibrating Wire Piezometer

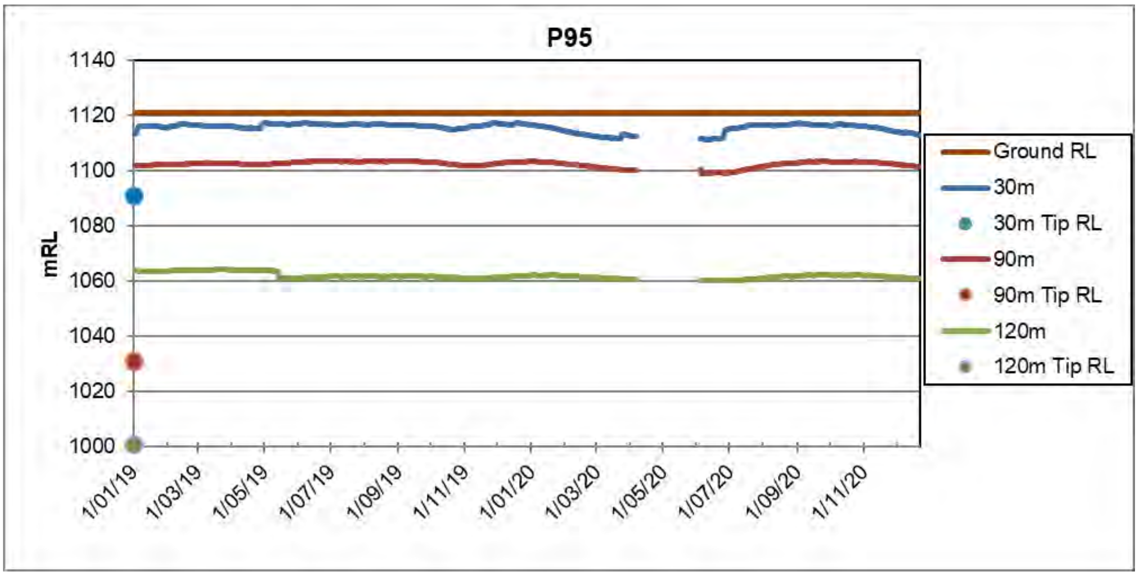


Figure 29: P95 Vibrating Wire Piezometer

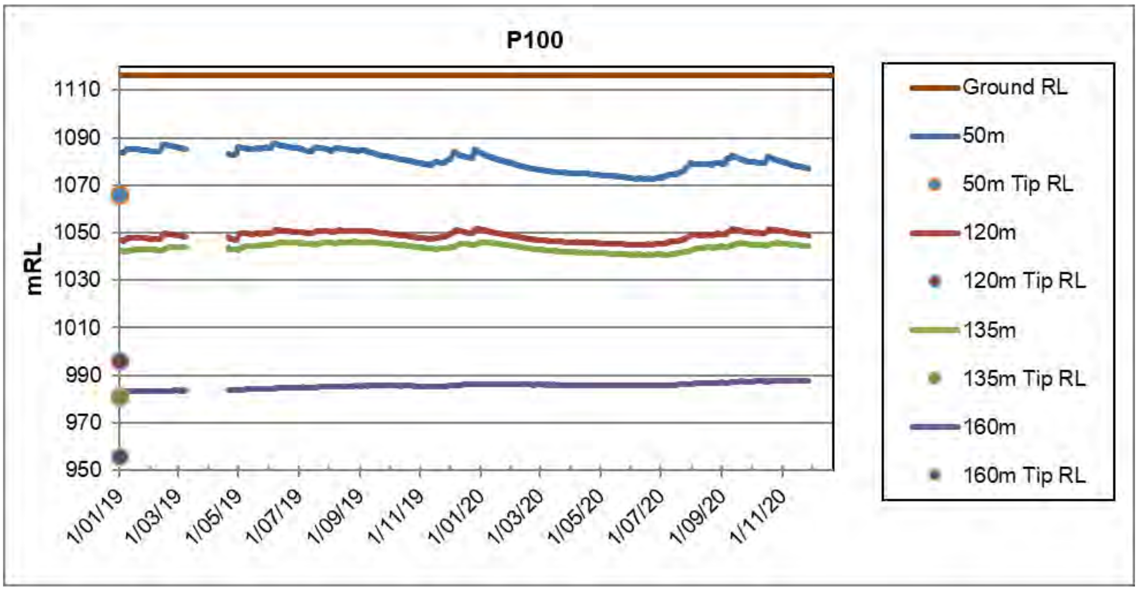


Figure 30: P100 Vibrating Wire Piezometer

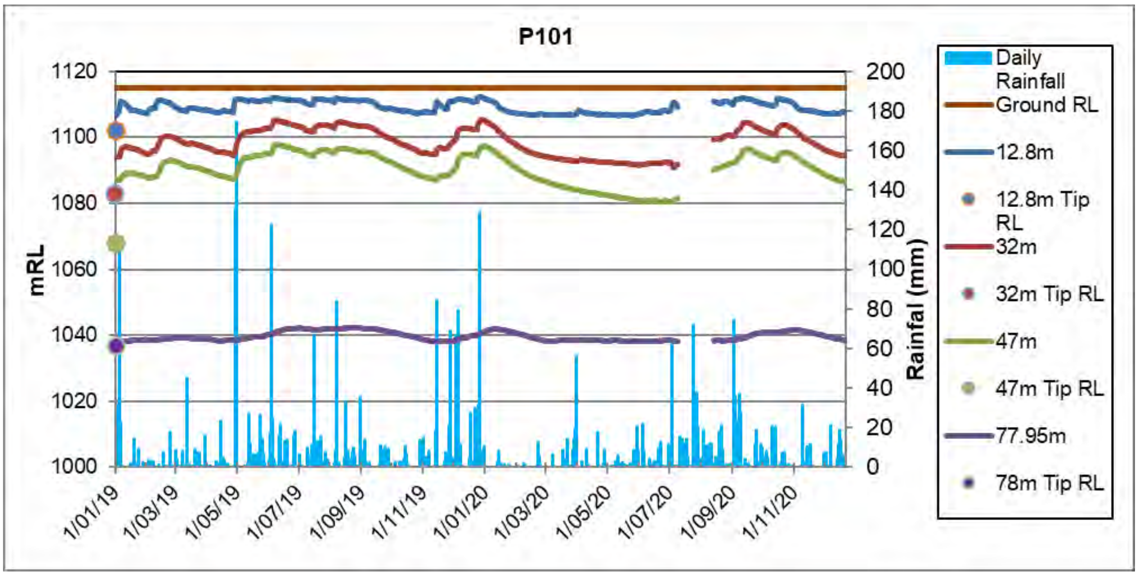


Figure 31: P101 Vibrating Wire Piezometer including daily rainfall

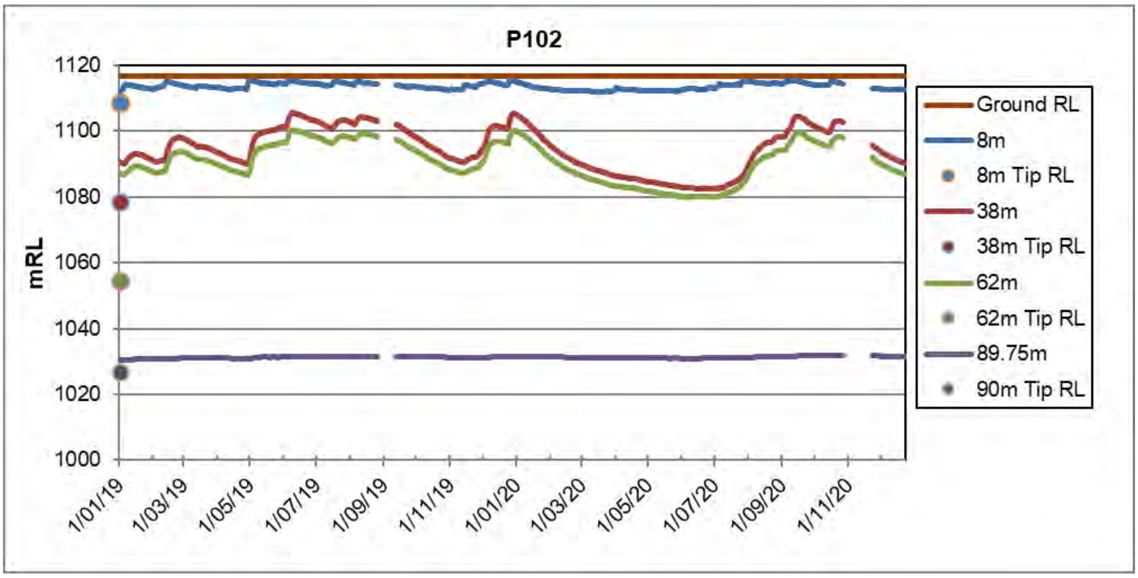


Figure 32: P102 Vibrating Wire Piezometer

Water levels were disrupted during 2012 to 2013 in P90, P91 and P92 by leakage down an incompletely sealed drill hole annulus. Pressures returned to normal after comprehensive effort to seal the leakage pathway.

Piezometric levels in the Younger Volcanics have continued to show some dependence on rainfall. This is particularly evident with P100, P101 and P102. This ongoing fluctuation does not appear to have any significant effect on ground surface settlement.

During 2018 and 2019, the 975 mRL piezometer in well P94 showed a drop in pressure believed to be a result of nearby mining causing relaxation in the country rock host rock surrounding the piezometer tip. The pressure has continued to drop through 2020 but at a slowing rate. The shallower piezometers at this location have not displayed any unusual drop in pressure and there have been no anomalous trends in nearby settlement markers (BM24, MATAURA1, 24F) identified. The effect appears to be stabilising and is expected to reverse once mining has passed the area (Figure 28). Refer to Appendix H for GWS Limited review of the piezometer data.

5.3.9 Waihi South – Project Martha

Following the approval and subsequent development of Project Martha in 2019, 10 new piezometers were installed to monitor the effects of additional dewatering related to the project (Figure 33). Table 5 sets out the piezometer depths of Project Martha piezometers.

Figure 33: Waihi South Piezometers

Table 5: Project Martha piezometer depths

Bore	Young Volcanics		Andesite			
	Depth (m)	Piezo Tip (mRL)	Depth (m)		Piezo Tip (mRL)	
P107	30	1089				
P108	9.8	1116				
P109	22	1091				
P110	16.8	1097				
P111	13	1100	25	58	1088	1055
P112	50	1057	72	110	1035	995
P113	46	1058				
P114	55	1054				
P115	30.8	1103				
P116	53.3	1098				

Project Martha piezometers P107 to P110 and P113 to P116 are standpipes installed at varying ground elevations Figure 34 shows water levels have remained fairly settled. Some initial changes to P109 and P110 are likely due to well flushing after installation. P115 was installed late 2020 and data will be presented in the 2021 report.

Vibrating wire piezometer P111 (Figure 35) was installed with three tips, one in the young volcanics and two in the andesite layer. The younger volcanic piezometer is measuring some water pressure at 1102mRL. The upper andesite piezometer appears to be dry with levels recorded below the tip level (1087mRL cf. 1088mRL), indicating this area may be previously affected by dewatering. The lower andesite piezometer is measuring around 4m of water pressure above the tip, at 1059mRL.

P112 is also a vibrating wire design installed with three tips: one in the young volcanics and two in the andesite layer. Water levels have remained stable in all three piezometers since installation in July 2020 (Figure 36).

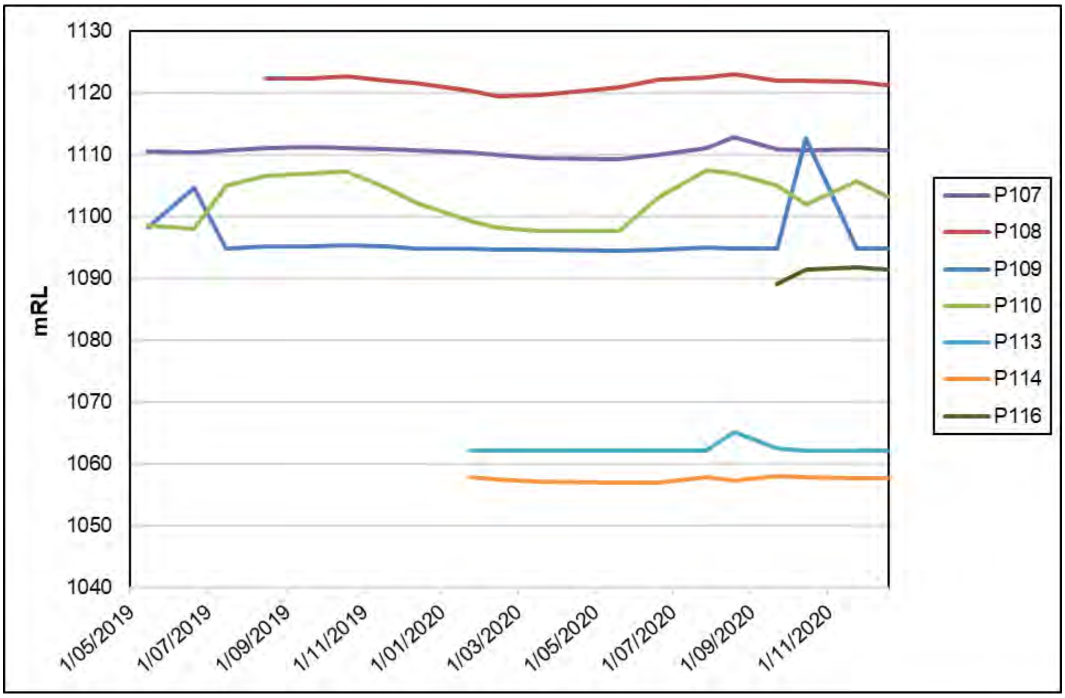


Figure 34: Waihi South Piezometer Levels

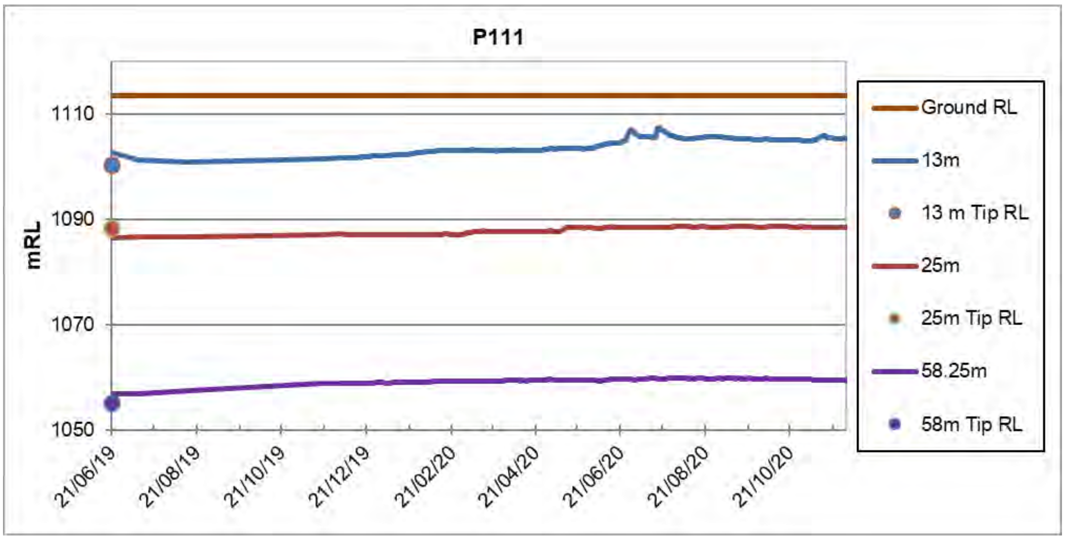


Figure 35: P111 Vibrating Wire Piezometer

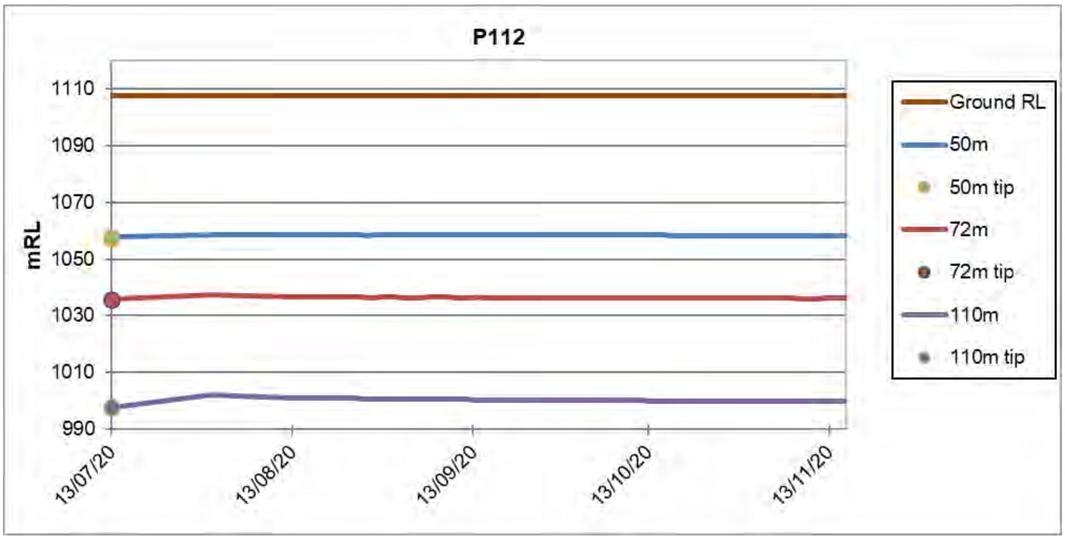


Figure 36: P112 Vibrating Wire Piezometer

6 SETTLEMENT MONITORING

Condition 13b of the Extended Martha Mine consent requires the identification of any environmentally important trends in settlement behaviour. Condition 13d of the same consent requires that a comparison of the settlement survey data with that predicted for the consent.

A reassessment for the settlement prediction was conducted for the Trio Development Project (Engineering Geology, June 2010). This review assessed the effect of pumping from the Martha pit to draw down the groundwater level progressively to 755mRL, which would also dewater the connected Trio system.

Another reassessment was conducted for the Correnso Underground project (Engineering Geology, 2012). The report recommended new trigger levels for settlement based on additional depressurisation of the andesite layer.

Further reassessment was undertaken for Project Martha with dewatering to below 700 mRL authorised. New triggers have been applied during the 2020 reporting period (Table 6).

A review of the settlement marker network was undertaken during 2019 by GWS Ltd (Appendix F). This resulted in the removal of erroneous and high-density settlement markers for 2020 settlement plotting and trigger assessments.

Seven settlements zones were defined around the Martha Mine pit in 1999, extending to the outskirts of Waihi. The zones were established based on the first ten years (pre-extension) of settlement history having regard to the then current knowledge of the thickness and composition of compressible materials (such as ash-soils, alluvium, lake sediments, and unconsolidated younger volcanic deposits) and the expected effect from Martha Mine dewatering. Table 6 provides the most recent update of the Settlement Zone trigger levels, approved in 2019 and applied following the commencement of Project Martha in 2020, to reflect the changed mining and dewatering conditions. Figure 37 shows the predicted settlement zones. These have also been updated with the commencement of Project Martha.

Table 6 - Table of Predicted Settlement with Project Martha Trigger Levels

Zone	New Trigger Levels (mm) Project Martha (2020)
Settlement Zone 1	55
Settlement Zone 2	65
Settlement Zone 3	95
Settlement Zone 4	160
Settlement Zone 5	260
Settlement Zone 6	340
Settlement Zone 7	540

The settlement measured is an accumulation of all causes of settlement. Generally, this is considered to be the result of mine dewatering, but close to the mines and (in the case of Favona) overlying the mine areas, additional settlement may be the result of primary consolidation settlement (as opposed to reconsolidation settlement which is the process in the Martha groundwater system where historic dewatering resulted in groundwater levels dropping to lower elevations for a longer time period than is proposed for current mining activity). Nevertheless, it is the total settlement that is discussed in this report as settlement due to dewatering alone cannot be separated from other causes.

Comment is provided in relation to the predicted settlements given in Table 6 and these comments are expanded on where monitoring data show exceedance of the trigger values.

6.1 Method

The initial settlement survey network was established in 1980 during the exploration phase of the project and has been regularly monitored since December 1987. Over the course of the project, settlement survey marks have been added, removed or replaced, as required, to extend the network or to compensate for damaged sites.

Figure 38 shows the location of settlement marks monitored by OGNZL up to the end of 2020. Also, included on Figure 38 are the defined subsidence hazard zones related to historical underground mine stopes and shafts (IGNS, 2002). Figure 39 provides the settlement monitoring marks across the Favona Mine and shows the locations of the Favona Mine workings in relation to the marks. Figure 40 provides the marks identified as triggered during the November 2020 survey.

Settlement monitoring was undertaken in May/June and November/December 2020 across the settlement network surrounding Waihi Township (refer Appendix C) and also along the Favona network which is an extension of the Martha mine survey network (Figure 39). Appendix B presents the two summary settlement monitoring reports. For simplicity this report refers to surveys as May and November 2020.

The raw data provided by the surveyors has been graphed and where changes in the record are apparent as a result of mark relocation or replacement, corrections have been applied using graphical projection so that total settlement over the life of mining can be determined for each location. The correction process applied was as follows:

- Updating the time-history graph for all data from settlement markers with data up to 1/11/2020.
- Where changes in the time-history graph identified a datum change, a correction was arrived at by projecting the initial data visually on the graph to the time of the new datum and a correction calculated. A smooth settlement curve resulting after the correction was applied and similarity of curve shape to those of adjacent marks was taken as indicating an acceptable correction.
- Where marks were installed in May 1999, the previously determined settlement for that location from 1988 to 1999 was applied as a correction.
- Where marks were installed or changed other than in May 1999, the previously assessed settlement at the location as of May 1999 was used with “Goal Seek” on the (Excel) spreadsheet to correct the values to be consistent with the May 1999 value.
- For Favona marks, settlement values as at 1/12/2005 were assessed for each location and used to correct the new marks to account for settlement from 1988 to 2005.
- The corrected data has then been used to generate:
  - Settlement-time trend graphs for each zone.
  - Plans of total settlement.
  - Contours of total settlement.
  - Calculation of tilt.
  - Settlement-time trend graphs of specific areas.
- Where Favona development has affected settlement, a projection of the pre-Favona mine settlement trend has been made as a means to estimate the current Martha Mine settlement and this settlement value has been subtracted from the total measured settlement to provide an estimate of the settlement due to the Favona Mine development.

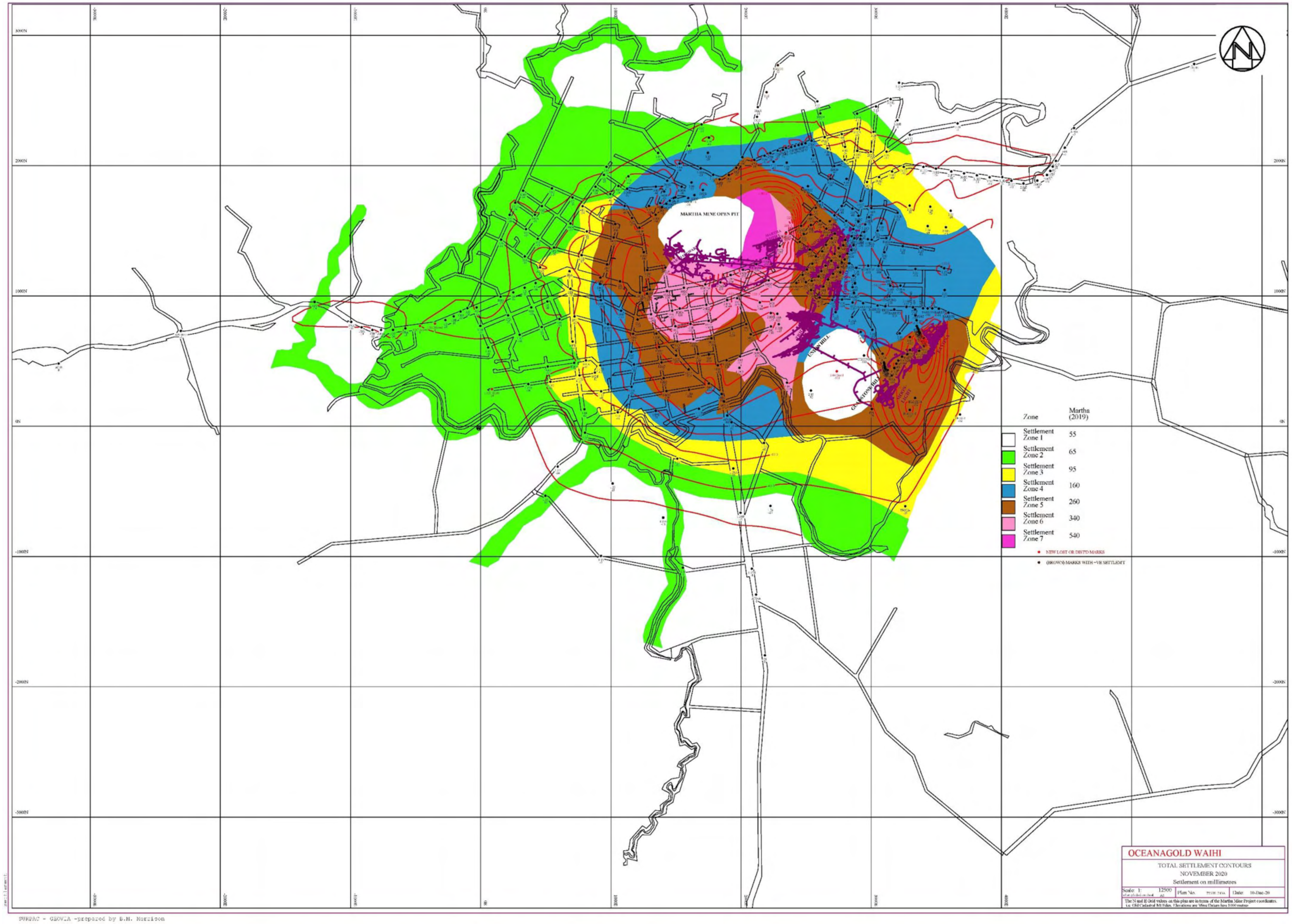


Figure 37: Project Martha Settlement Zones, Trigger Levels and Total Settlement November 2020 Survey

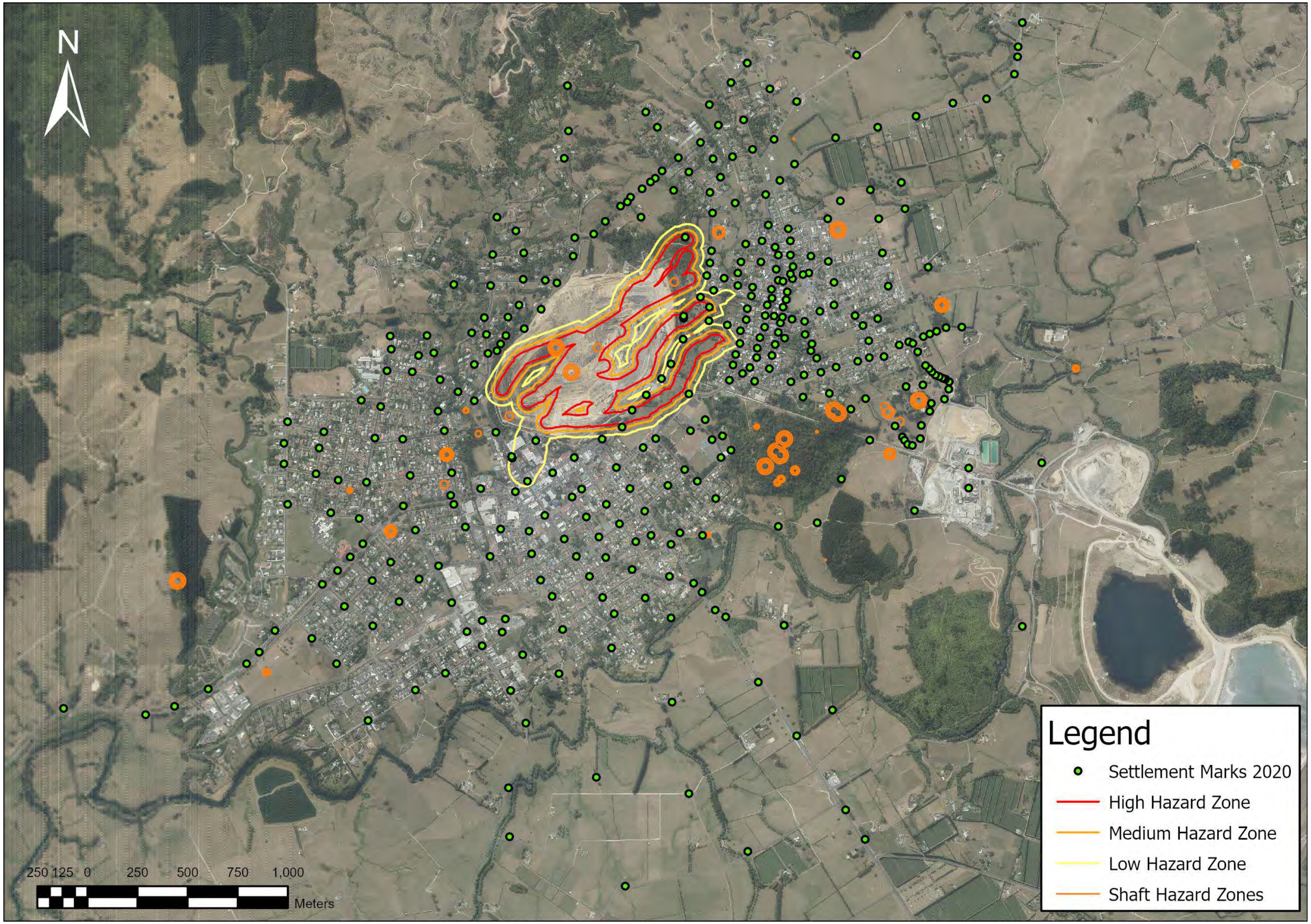
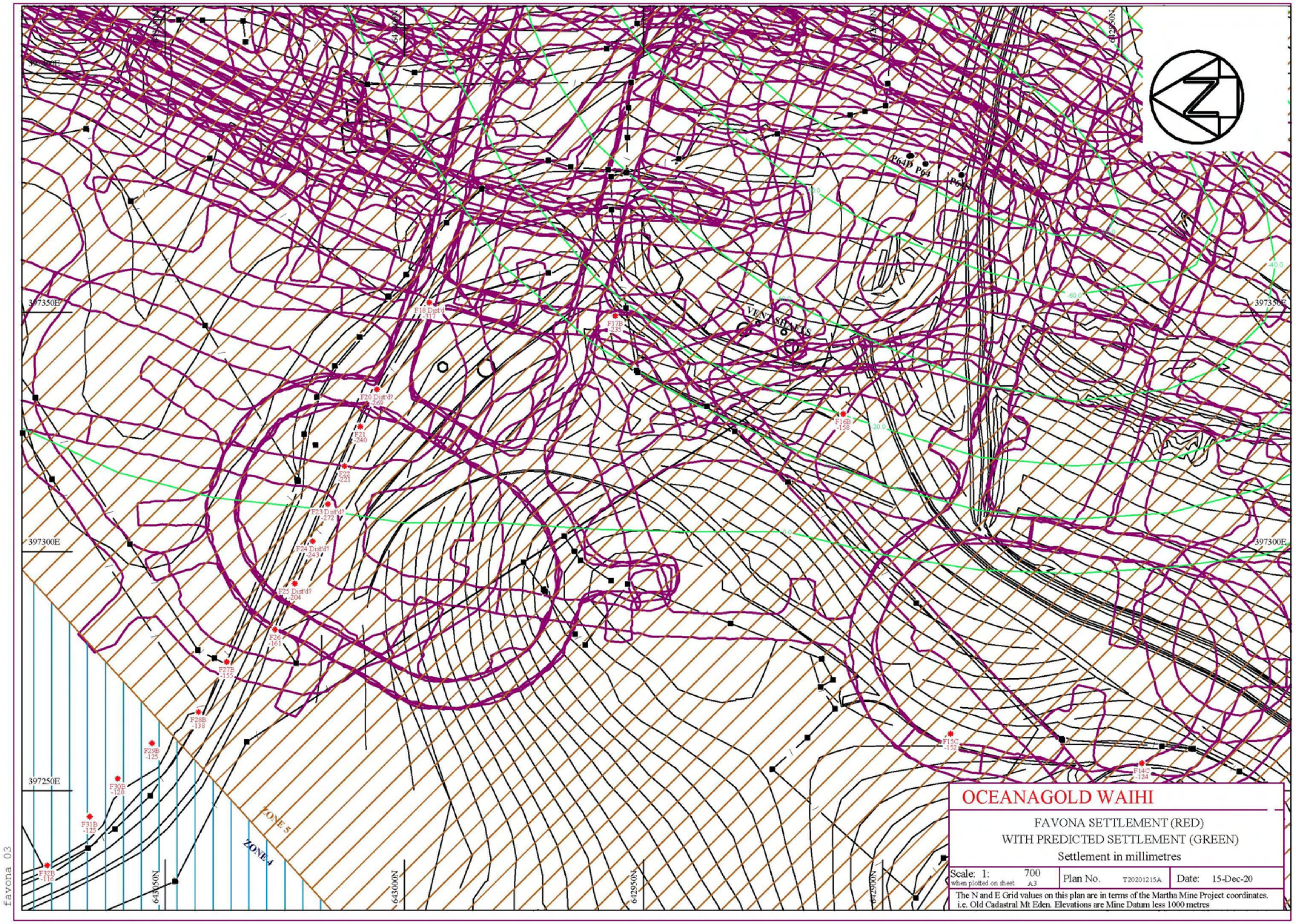


Figure 38: Settlement Marker Location Plan & Hazard Zones



SURPAC - GEOVIA -prepared by B.M. Morrison

Figure 39: Favona Settlement November 2020 Survey

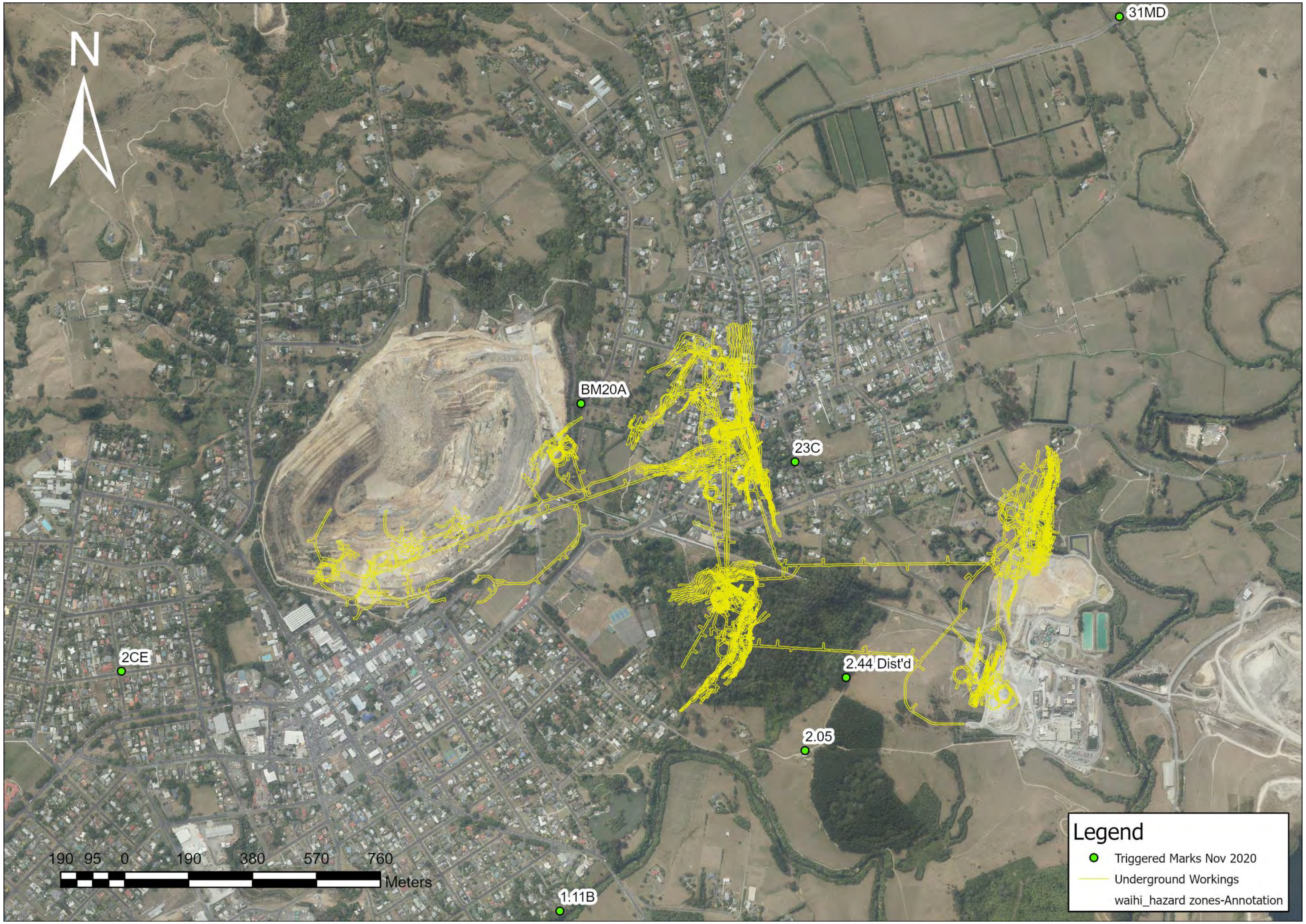


Figure 40: Settlement Marks Triggered During November 2020 Survey

NB: Favona Marks excluded from Figure 40

6.2 Results

Appendix C presents plans showing settlement marks, settlement values and settlement contours.

Time-history plots of settlement survey data for each zone are presented in Appendix D. The plots also depict the zone settlement predictions (for the Martha Extended Project, Trio Development, Correnso Project and Project Martha) shown as horizontal lines on each set of graphs.

The projected trends and the maximum settlements are provided on the graphs in Appendix D. Key trends are described below.

97% (359/370) of the marks did not exceed the settlement trigger levels; 11 marks were triggered. This number is significantly lower than the number triggered in 2019 due to the application of new Project Martha settlement triggers and zones during 2020 (Table 6). Figure 40 displays the seven settlement marks from the November 2020 survey outside the influence of the Favona Underground that exceeded the trigger limits. The other four marks that exceeded the trigger limits are located above the Favona Underground.

The differences between the May and November 2019 surveys showed an increase in settlement at most locations across the settlement network. In May 2020 there was a rebound and then in November 2020 an increase in settlement. The total settlement in November 2020 was similar to that in November 2019.

6.2.1 ZONE 1 – Trigger 55mm

The Zone 1 time-history plot (Appendix D) shows three groupings, one showing a steady increase in settlement after about 1999 of between 10 to 30 mm (Figures 41 and 42), another with little settlement until November 2015 and then increasing (Figure 43) and another group with no trends evident. To further assess these observations the marks for Zone 1 were re-plotted as groups namely:

- Zone 1 along Waihi Whangamata Road (see Figure 41)
- Zone 1 south of Waihi (see Figure 42)
- Zone 1 west of Waihi (see Figure 43)
- Zone 1 north of Waihi (no trends evident)

This grouping shows that the marks with a slow downward trend are located along Waihi Whangamata Road to the east of Waihi and to the south of Waihi. A steady increase in settlement from about 1999 can also be observed in most marks in Zones 2 to 6, suggesting that there is a small and widespread effect occurring. Two settlement marks to the west show little settlement until 2015 and then a steady on-going, but small increase in settlement (Figure 43).

These observations suggest the following:

- The widespread 10 to 40 mm settlement observed from about 1999 at many Zone 1 marks and also the increasing settlement in Zones 2 to 6 marks is a response to the ongoing dewatering of the deeper structures in the andesite rock body (fracture depressurisation) as a result of mine dewatering. This is a broad effect and has negligible influence on differential tilt between marks.

The settlement evident at marks in the vicinity of the Favona Mine is in response to the dewatering of the deeper structures linked to that system and to rockmass relaxation into mining voids.

The stable water levels in the wells monitoring the deeper younger volcanic materials and the upper andesite layers show that the observed settlement behaviour is not related to on-going consolidation of these materials at these locations as no on-going dewatering is evident at these locations.

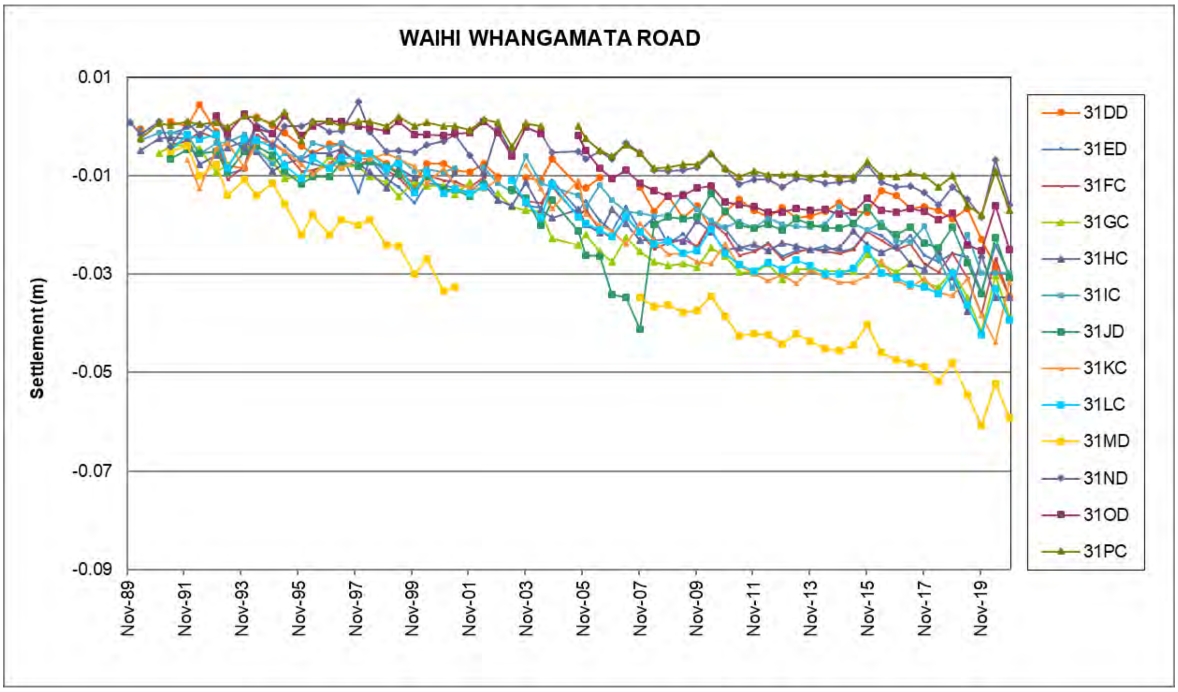


Figure 41: Zone 1 Waihi Whangamata Road

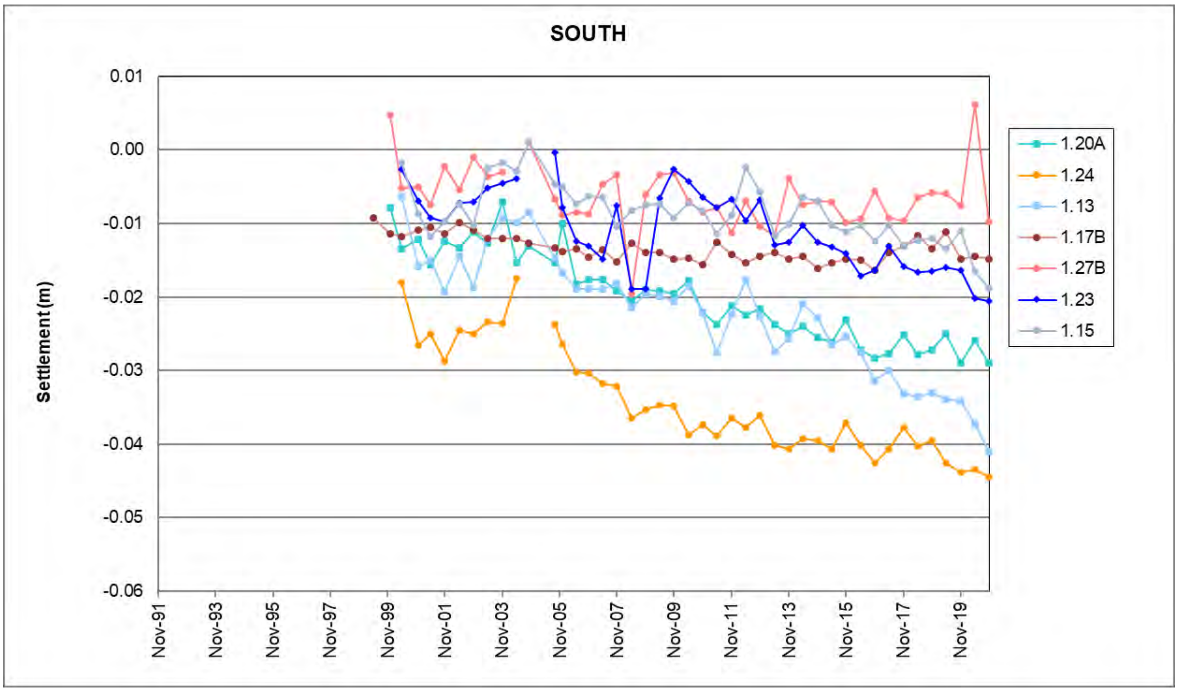


Figure 42: Zone 1 Waihi South

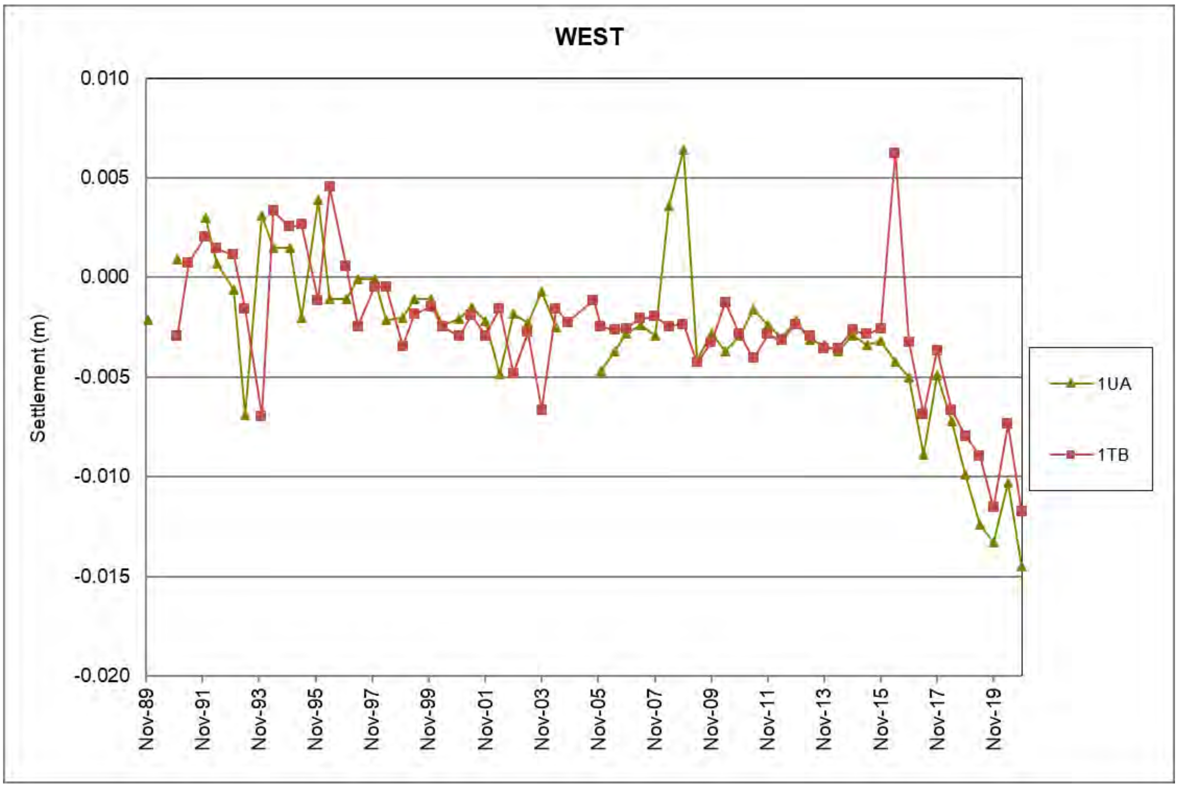


Figure 43: Zone 1 West of Waihi

The absence of widespread effect from Favona dewatering supports the current geological and hydrogeological models.

Anomalous results shown on the Zone 1 time – history plot are discussed below.

Three marks in Zone 1 showed settlement greater than the expected maximum: 31MD, 2.05 and 2.44

Mark 31MD is located along the Waihi Whangamata Road and showed a period of greater settlement than nearby marks during the early 1990s. Recent recorded settlement is similar to nearby marks. This mark may be influenced by its proximity to the banks of the Ohinemuri River (Figure 40, Figure 41).

Mark 2.44 has been investigated in the past and the cause has been attributed to some localised surface movement. This mark is listed as disturbed by the surveyor.

Mark 2.05 is near Winner Hill and like other marks to the south of Waihi indicates an acceleration of settlement after 2003 or possibly 2004. Local slope movement is also indicated to be affecting this site.

6.2.2 ZONE 2 – Trigger 65mm

This zone encompasses the western outskirts of Waihi township and some marks to the north and south of Waihi. The time-history plot for Zone 2 (Appendix D) shows all but one of the Zone 2 marks to be tracking less than the predicted maximum settlement rate. As with Zone 1 most of the marks have small settlements. Total settlements to date are generally between 10 to 60 mm with settlements of between 10 to 40 mm since 1999. Anomalous movements are discussed below.

Mark 1.11B is the single mark in Zone 2 to have exceeded the predicted maximum settlement in the November 2020 survey. The mark is located to the south of Waihi township near the Ohinemuri River (Figure 40). This mark has shown an increased rate of settlement compared to nearby marks since the early 2000s. Its location near the bank of a watercourse and downslope soil creep may have contributed to the recorded settlement.

Groundwater records in these areas show no ongoing dewatering and only minor water level changes in the deeper younger volcanic materials or the upper andesite rock mass. However, there is a possibility of underdrainage of the andesite rock at depths associated with the Correnso project that is occurring below the depths of the installed piezometers. However, this is unlikely to be the main cause of the settlement at mark 1.11B, it is more likely to be associated with soil creep. The measured settlements are still small, and tilts are well within acceptable limits.

6.2.3 ZONE 3 – Trigger 95mm

This zone is includes small areas to the east and west of Waihi town, with a part extending to the east of the Favona Mine.

Inspection of the time-history plot for Zone 3 shows, as with Zones 1 and 2, most marks display ongoing steady settlement. The measured total settlements are small and generally between 20 to 80 mm with settlements since 1999 of between about 10 to 50 mm. Tilts between adjacent marks are well within acceptable limits.

One mark (2CE) has moved more than the predicted maximum settlement for the zone. Mark 2CE is located to the west of Waihi township and has showed an increased rate of settlement compared to nearby marks between 1991 and 1995. Thereafter, it settled at a similar rate to nearby marks.

6.2.4 ZONE 4 – Trigger 160mm

Zone 4 time-history plots (Appendix D) show a small but steady increase in settlement in the zone since 1995. The measured total settlements are small and generally between 20 to 120 mm. Settlements since 1999 are generally between 10 to 80 mm. Tilts between adjacent marks are well within acceptable limits.

One mark, 23C, exceeded the predicted maximum settlement for this zone in 2020. This mark showed a sharp increase in settlement in the May 2020 survey. The settlement in the subsequent November 2020 survey was similar to nearby marks. This mark is located near a drain and may have been affected by the dry summer and autumn during 2019/2020 or been influenced by recent drainage works nearby. No effects on surrounding land are visible, and nearby piezometers have not shown any unusual changes.

6.2.5 ZONE 5 – Trigger 260mm

The data for the Zone 5 marks are provided in the time-history plot in Appendix D. Marks show a steady increase in settlement with time and total settlements are generally between 30 and 150 mm. Settlements since 1999 are generally between 15 to 85 mm. No marks in this zone exceeded the predicted maximum settlement for the zone.

6.2.6 ZONE 6 – Trigger 340mm

The settlement in this zone is shown on the Zone 6 time-history plot in Appendix D. This zone extends through the centre of the Waihi commercial area. Marks show a steady increase in settlement with time and total settlements are generally between 70 to 250 mm. Settlements since 1999 are generally between 50 to 190 mm. One mark in this zone exceeded the maximum predicted settlement for the zone. This mark (mark BM20) has been noted as disturbed by the surveyor (Appendix B).

6.2.7 ZONE 7 – Trigger 540mm

Zone 7 settlements are all within the predicted maximum settlement (Zone 7 time-history plot, Appendix D). Total settlements are about 290 mm. Settlements since 1999 are about 160 mm. No new trends are indicated.

6.3 Favona Settlement

Settlement in the vicinity of the Favona Mine has a component of settlement due to Martha Mine dewatering as well as settlement related to Favona Mine dewatering.

A separation of total settlement into Martha and Favona settlement components has been undertaken by projecting the settlement evident before the commencement of the Favona Mine and accepting these projected settlements as Martha settlements. The difference between the projected (Martha) settlement and total measured settlement has been taken as the Favona component of settlement. Table 7 sets out the total settlement, the settlement attributed to Martha dewatering and the settlement attributed to Favona Mine dewatering as assessed for the Favona Mine settlement markers.

Table 7 - Separation of Settlement – Favona Marks (Nov 2020)

Mark	Total Settlement (mm)	Martha Settlement (mm)	Favona Settlement (mm)
F02	98	50	48
F03	98	46	52
F04	103	44	59
F05	105	46	59
F06	105	40	65
F07*	107	42	65
F08A	116	44	72
F09A	119	38	81
F10B	127	44	83
F11C	130	42	88
F12C	131	39	92
F13C	129	55	74
F14C	129	60	69
F15C	154	55	99
F16B	156	55	101
F17B	273	55	218
F18	347	49	298
F20	296	44	252
F21	269	43	226
F22	250	42	208
F23	229	49	180
F24	215	42	173
F25	210	49	161
F26	189	45	144
F27B	176	50	126
F28B	166	49	117
F29B	154	48	106
F30B	153	52	101
F31B	137	55	82
F32B	123	49	74
F33	109	52	57
F34C	108	58	50
F35B	100	61	39

* Disturbed by 40+mm

The largest settlement at Favona Mine occurs where the markers overlie mine workings (marks F16B to F26). The maximum predicted settlement over the workings from dewatering was assessed as 80 mm for earlier projects, with mine dewatering related settlement not extending into the urbanised area. The actual total settlement and the extent of settlement exceeded the predictions for the dewatering settlement. The difference between the predictions and measured settlement was considered to reflect depressurisation and consolidation of the andesite rock body, which was not considered in the initial predictions. Andesite rock was considered to be a stiff material with negligible consolidation characteristics, but the long-term settlement observed in response to Martha Mine dewatering (in Zones 1 to 6, discussed above) suggests that some minor consolidation of the deeper andesite rock is occurring, possibly as a response to fracture depressurisation. In addition, some further relaxation of the rockmass towards the mine workings may be occurring, and this may be providing further volume reduction of the andesite rockmass in the vicinity of the mine.

Another potential influence is that the Favona andesite has been undergoing primary consolidation, as current water level monitoring data suggests that the Favona system was not dewatered to the same extent as the Martha groundwater system during historical mining in the early 1900's. Consolidation predictions for Favona were made based on Martha's second dewatering consolidation data. The amount of primary consolidation is greater for the first time of dewatering compared to the second or subsequent times of dewatering. This is because the first cycle of dewatering results in preconsolidation and an increase in the stiffness of the ground, and subsequent re-watering does not result in full rebound of levels to their original levels.

Settlement predictions for Project Martha have been updated for the zone encompassing Favona marks to reflect the effects outlined above. Four Favona marks exceeded the maximum predicted settlement in the November 2020 survey: F17B, F18, F20 and F21. All are located above underground workings, on company owned land. Marks F18 and F20 are noted by the surveyor as being disturbed (Figure 40)

6.4 Trio Underground

The only anomalous result in the vicinity of Trio Underground has been apparent settlement at mark 2.44 (located on a farm track between Union and Black Hill) with pronounced acceleration since the May 2010 survey. This was investigated and determined to be related to a shallow pre-existing landslide, not any mine influence. It is now noted by the surveyor as being disturbed. The mark will continue to be monitored on a biennial basis as per other survey marks but will not be included in any settlement profiling.

6.5 Summary

The analysis of the data to the end of 2020 continues to indicate that current slow settlements associated with Martha Mine are likely to be related to dewatering of the deeper structures within the andesite rock mass. Groundwater monitoring data does not show any widespread or significant ongoing dewatering of alluvium, younger volcanic materials or the upper layers of the andesite rock body.

Settlement triggers include modification to Martha Mine Extended pit associated with the cutback projects; the extended duration of dewatering at Martha Mine; assumptions made in the Favona settlement predictions (fracture depressurisation, secondary rather than primary consolidation); and localised natural, induced and historic effects.

The area around Martha Mine of greatest settlement is adjacent to the eastern pit wall where the weaker younger volcanic rocks are thickest and dewatering of this geological unit is greatest. This is also an area that has historic underground workings that have not been backfilled.

The main area of settlement at Favona overlies the workings, is directly under farmland and within the area of Company owned land. Outside the workings area, settlement is lower. The conditions giving rise to settlement at Favona differ from those in the Martha Groundwater System as the latter has been dewatered to a greater extent for a longer time than the current dewatering while the former has not been previously dewatered. While settlement has exceeded initial estimates at Favona, those estimates were based on Martha settlement data which was responding to reconsolidation rather than primary consolidation.

In relation to Trio, Correnso and SUPA mines, these are located in the dewatered Martha Groundwater System and settlement as described in this document has already been developing in those areas in response to Martha Mine dewatering. Also, as these are linked to the Martha system, settlement will be based on additional consolidation.

7 TILT

As noted earlier, a full review of the Waihi settlement marker network and database was undertaken by GWS Limited in 2019. The review resulted in the removal of erroneous and high-density settlement marks and an updated settlement database with revised settlement marker corrections where appropriate. Marks proposed for removal have been included in tilt calculations until their removal is approved by Hauraki District and Waikato Regional Councils. Revised settlement marker corrections have been applied in this reporting period. GWS's technical memorandum outlining the process and results of the review is included as Appendix F.

Assessments have been grouped into five areas: Favona, Martha (incl. North Wall), Correnso, Correnso South and SUPA. There is some crossover of marks between Mining Permit boundaries. The assessment of tilt between adjacent settlement marks is summarised in Table 8.

Table 8: Tilt Calculations November 2020 Survey

Mark	x	y	Distance (m)	November 2020 (m)	Abs	Δh (m)	Tilt (1:X)
Favona							
F01A	3096.19	498.96		Lost			
F02	3097.60	490.00	9.07	-0.0979	0.0979		N/A
F05	3104.66	455.54	35.18	-0.1046	0.1046	0.0067	5250
F08A	3126.97	430.49	33.54	-0.1158	0.1158	0.0112	2995
F09A	3157.20	388.28	51.92	-0.1193	0.1193	0.0035	14826
F10B	3176.88	446.75	61.69	-0.1266	0.1266	0.0073	8454
F11C	3192.52	479.44	36.24	-0.1297	0.1297	0.0031	11767
F12C	3207.32	503.82	28.52	-0.1310	0.1310	0.0013	21580
F13C	3236.43	533.63	41.66	-0.1286	0.1286	0.0024	17358
F14C	3275.29	551.31	42.69	-0.1289	0.1289	0.0003	142125
F15C	3297.17	585.32	40.44	-0.1542	0.1542	0.0253	1598
F16B	3367.38	578.70	70.52	-0.1564	0.1564	0.0022	32081
F17B	3405.48	613.91	51.88	-0.2731	0.2731	0.1167	445
F18	3423.83	648.30	38.98	-0.3467	0.3467	0.0736	530
F21	3405.99	672.00	29.66	-0.2686	0.2686	0.0781	380
F24	3388.13	690.85	25.97	-0.2150	0.2150	0.0536	485
F27B	3372.41	717.52	30.96	-0.1758	0.1758	0.0392	790
F29B	3363.20	738.71	23.11	-0.1539	0.1539	0.0219	1055
F32B	3348.78	769.10	33.64	-0.1231	0.1231	0.0308	1092
F33	3348.56	812.51	43.41	-0.1094	0.1094	0.0137	3164
F34C	3339.49	849.57	38.15	-0.1080	0.1080	0.0014	27649

F35B	3336.68	896.06	46.58	-0.1002	0.1002	0.0078	5993

Martha

20BB	2533.26	1622.29		-0.1168	0.1168		N/A
20AC	2461.04	1536.91	111.83	-0.1205	0.1205	0.0037	30224
BM20A	2345.50	1484.90	126.71	-0.2350	0.2350	0.1145	1107
20D	2482.07	1473.48	137.05	-0.1445	0.1445	0.0905	1514
19CB	2296.71	1381.40	206.97	-0.2767	0.2767	0.1322	1566
19BB	2191.56	1292.02	138.00	-0.2893	0.2893	0.0126	10952
BM19B	2117.17	1244.36	88.35	-0.2888	0.2888	0.0005	192068
17CB	2014.23	1201.01	111.70	-0.2897	0.2897	0.0009	129878
17BB	1919.52	1160.79	102.90	-0.2072	0.2072	0.0825	1247
17AB	1841.32	1104.80	96.18	-0.1785	0.1785	0.0287	3348
BM17A	1724.44	1088.92	117.95	-0.0892	0.0892	0.0893	1321

North Wall

27AB	2009.08	2064.33		-0.0094	0.0094		N/A
26Q	1963.00	1982.71	93.73	-0.0327	0.0327	0.0233	4028
26PB	1834.84	1893.11	156.38	-0.0501	0.0501	0.0174	8987
26OB	1706.93	1812.27	151.31	-0.0051	0.0051	0.0450	3365
26NC	1641.16	1772.40	228.22	-0.0430	0.0430	0.0379	6028
26MB	1593.46	1750.66	122.11	-0.0447	0.0447	0.0147	8307
26JB	1495.71	1756.55	93.74	-0.0392	0.0392	0.0075	12499
BM26	1542.45	1837.81	100.98	-0.0317	0.0317	0.0130	7768
3.09	1618.51	1870.17	217.54	-0.0300	0.0300	0.0249	8750

Correnso

25E	2472.35	1162.01		-0.1513	0.1513		N/A
25B	2497.67	1105.83	61.63	-0.1277	0.1277	0.0236	2611
25I	2537.20	1045.04	72.51	-0.1187	0.1187	0.0090	8057
24CD	2603.21	987.72	87.42	-0.1273	0.1273	0.0086	10165
24H	2630.70	1072.28	88.91	-0.1184	0.1184	0.0089	9990
24B	2667.67	1126.40	65.54	-0.1215	0.1215	0.0031	21143
24G	2705.96	1170.46	58.38	-0.1311	0.1311	0.0096	6081
24L	2761.67	1181.33	56.76	-0.1272	0.1272	0.0039	14553

24AC	2743.58	1218.90	41.70	-0.1325	0.1325	0.0053	7868
24F	2772.80	1257.27	48.23	-0.1259	0.1259	0.0066	7308
BM24	2794.55	1279.36	31.00	-0.1160	0.1160	0.0099	3131
24E	2758.43	1303.23	43.29	-0.1225	0.1225	0.0065	6661
24DC	2718.29	1323.13	44.80	-0.1130	0.1130	0.0095	4716
24I	2692.57	1269.71	59.29	-0.1243	0.1243	0.0113	5247
25H	2648.48	1232.96	57.40	-0.1275	0.1275	0.0032	17937
25CB	2615.91	1190.50	53.51	-0.1274	0.1274	0.0001	535124
25G	2594.60	1149.42	46.28	-0.1288	0.1288	0.0014	33059
25F	2542.53	1116.24	61.74	-0.1311	0.1311	0.0023	26842
25B	2497.67	1105.83	46.06	-0.1277	0.1277	0.0034	13546
BM25	2424.91	1100.25	72.97	-0.1408	0.1408	0.0131	5571
25E	2472.35	1162.01	77.88	-0.1513	0.1513	0.0105	7417
25A	2505.13	1203.77	53.09	-0.1485	0.1485	0.0028	18960
25D	2547.05	1248.02	60.95	-0.1492	0.1492	0.0007	87072
21DC	2573.96	1304.15	62.25	-0.1360	0.1360	0.0132	4716
21N	2623.25	1342.44	62.41	-0.1259	0.1259	0.0101	6179
21C	2651.57	1389.82	55.20	-0.1105	0.1105	0.0154	3585
21M	2694.90	1439.65	66.03	-0.0941	0.0941	0.0164	4026
21BC	2719.27	1477.80	45.27	-0.0854	0.0854	0.0087	5204
21EB	2799.95	1429.09	94.24	-0.0876	0.0876	0.0022	42838
24K	2783.89	1387.72	44.38	-0.1052	0.1052	0.0176	2516
24J	2749.39	1365.76	40.89	-0.1019	0.1019	0.0033	12240
24DC	2718.29	1323.13	52.77	-0.1130	0.1130	0.0111	4754
22F	2815.91	1325.41	97.65	-0.1205	0.1205	0.0075	13072
22C	2846.39	1352.54	40.80	-0.1350	0.1350	0.0145	2808
22GB	2866.82	1385.23	38.55	-0.1098	0.1098	0.0252	1528
22BC	2916.75	1435.77	71.05	-0.0951	0.0951	0.0147	4842
22I	2918.98	1461.37	25.69	-0.0913	0.0913	0.0038	6761
22H	2869.25	1441.80	53.44	-0.0824	0.0824	0.0089	6004
21P	2849.17	1456.90	25.13	-0.0838	0.0838	0.0014	17949
21FB	2861.65	1512.21	56.70	-0.0601	0.0601	0.0237	2392
21Q	2899.60	1571.32	70.24	-0.0613	0.0613	0.0012	58534
21GC	2901.12	1614.05	42.76	-0.0637	0.0637	0.0024	17817
22K	2985.12	1610.91	84.06	-0.0567	0.0567	0.0070	12009