

Tahimana Subdivision: Fast Track Hydrogeology Assessment

✦ Prepared for

Tahimana Limited

✦ July 2026



solutions for your environment

Quality Control Sheet

TITLE	Tahimana Subdivision: Fast Track Hydrogeology Assessment
CLIENT	Tahimana Limited
ISSUE DATE	21 July 2026
JOB REFERENCE	C04732500

Revision History					
REV	Date	Status/Purpose	Prepared By	Reviewed by	Approved
1	12 May 2026	Draft 2			
2	10 June 2026	Final Draft			
3	21 July 2026	Final			

DOCUMENT CONTRIBUTORS

Prepared by

Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Tahimana Limited and others (not directly contracted by PDP for the work), including Tasman District Council, Staig and Smith, Sally Gepp Law and Envirolink. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Tahimana Limited for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

© 2026 Pattle Delamore Partners Limited

Table of Contents

SECTION	PAGE
1.0 Introduction	1
1.1 Project background	1
1.2 Assessment aim	2
2.0 Site description	2
2.1 Topography and hydrology	3
2.2 Soils	4
2.3 Geology and hydrogeology	5
2.4 Climate	6
3.0 Site visit and field assessment	6
3.1 Wetland delineation	6
3.2 Site walkover	6
4.0 Proposed development	8
4.1 Eastern catchment stormwater management	9
4.2 Western catchment development	9
5.0 Water mass balance calculation	10
5.1 Conceptual hydrogeological description	10
6.0 Assessment of site development	17
6.1 Mass water balance results	17
6.2 Potential for interception of groundwater	21
7.0 Policy consistency and regulatory compliance	22
7.1 TRMP – Rural 3	22
7.2 National Environmental Standard (NES) for Freshwater (2020)	23
8.0 Conclusions	26
9.0 References	28

Table of Tables

Table 1: Summary of calculated hydraulic conductivities	1
Table 2: Details of bores within 1 km	3
Table 3: Summary of groundwater levels measured at Tahimana for the period October 2023 to May 2026	4
Table 4: Results of mass balance modelling – Western catchment	18
Table 5: Results of mass balance modelling – Eastern catchment	19
Table 6: Summary of potentially relevant NES-F (2020) regulations and discussion	24

Appendices

Appendix A: Figures

Appendix B: Tables

Appendix C: Borelogs

Appendix D: Slug test analysis outputs

Appendix E: Excavation depth maps (provided by Staig and Smith)

1.0 Introduction

1.1 Project background

Tahimana Limited are developing an area of land near Mapua, in the Tasman District as a residential and lifestyle subdivision. The project is to subdivide and develop land for the purpose of establishing a residential and rural lifestyle development on approximately 70 hectares of land off Stagecoach Road, Tasman. The project will include works within the Stagecoach Road, Dicker Road and Williams Road reserves.

The project will include:

- ✧ Subdivision to create approximately 145 allotments, including 4 allotments for reserve, roading and services, and enable construction of approximately 141 residential units across a range of densities.
- ✧ Development of an open space network including a public reserve and walkways, and upgrades to shared pathways.
- ✧ Landscape planting and restoration and enhancement of waterways and wetlands.
- ✧ Associated infrastructure, including for three waters services and transport (including external road upgrade works).

The development is located within Rural 3 zoned land under the Tasman Resource Management Plan (TRMP) (Design Guide Part 2, Appendix 3). The National Policy Statement for Freshwater Management 2020 (NPS-FM) and the National Environment Standard for Freshwater 2020 (NES-F) have implications for activities that occur within 100 m of natural inland wetlands.

The development of the proposed subdivision is not expected to have any significant effects on groundwater. However, it is likely that the development may have an indirect impact on groundwater recharge at the Site that may be contributing to the health of wetlands. RMA Ecology has identified a number of wetlands within the subdivision development area. Based on the presence of these wetlands, the requirements of land zoned Rural 3 and requirements of the NPS-FM and NES-F, the proposed subdivision design needs to consider impacts of the development on wetland health. In particular, this will need to consider any changes in surface flow to the wetlands (i.e. stormwater/overland flow) and also groundwater recharge that may contribute to recharge to the wetlands.

As the development will involve activities that includes damming, diversion or discharge of water within a 100 m setback from a natural wetland under the National Environmental Standards for Freshwater 2020 (NES-F), this technical assessment has been prepared to assess the effects of the development on groundwater and any subsequent changes that may change recharge to the wetlands.

This assessment has been prepared based on a mixture of available Site-specific information (hydrogeological and geotechnical investigations) as well as regional geological and hydrogeological information.

Figure 1, Appendix A also shows the location of the proposed Tahimana Subdivision, along with the proposed development area and wetland areas (as identified by RMA Ecology).

The report authors record that they have read and agree to and comply with the Environment Court's Code of Conduct for Expert Witnesses as specified in the Environment Court's Practice Note 2023. This report is within the authors' areas of expertise, except where the report states that the authors relied upon the reports of other experts. The authors have not omitted to consider any material facts known to them that might alter or detract from the conclusions reached.

1.2 Assessment aim

This technical report will support Tahimana Limited's application under the Fast-track Approvals Act 2024 for resource consents to develop the Tahimana subdivision (referred to as the "Site") which includes damming, diverting or discharging water within 100 m of a natural inland wetland under the NES-F. More specifically, this report will cover the following:

- ✧ Desktop review of all available geological, hydrogeological and relevant geotechnical information.
- ✧ Develop a conceptual hydrogeological description to understand groundwater flow directions, groundwater recharge areas/mechanisms and groundwater / surface water interactions.
- ✧ Identify the recharge mechanisms for sustaining the wetlands (i.e. groundwater discharge, overland flow, stream flow etc).
- ✧ Estimate the potential effect of the diversion of surface water / stormwater from the proposed subdivision development on groundwater recharge and runoff and subsequent recharge to the wetlands, including the major established wetland located outside of the development boundary to the southeast of the subdivision Site.
- ✧ Assess the proposal in relation to groundwater related aspects of the TRMP – Rural 3 development guidelines (Design Part 2, Appendix 3) and the relevant regulations of the NES-F.

2.0 Site description

Aerial imagery available from Google Earth indicates that the Site was previously a forestry plantation prior to 2003 before it was cleared for agricultural purposes through to the present day. The sections below provide more information regarding the Site.

2.1 Topography and hydrology

Land information New Zealand (LINZ) has LiDAR available for the Tasman region (1m DEM, flown between 2020 and 2022) and indicates hilly, irregular terrain with incised gullies at the subdivision Site. The LiDAR data also indicates that the elevation of the Site generally ranges between 44 – 108 masl (NZVD 2016).

A prominent ridge crest that trends southwest to northeast through the centre of the Site is a surface water catchment divide between two main surface waterways of the valleys, separating the Site into east and west catchments.

The onsite wetlands identified by RMA Ecology are located predominantly within the western catchment which is the headwaters of a small unnamed stream that drains to the northeast alongside Horton Road. Several smaller wetlands are located on the southeastern side of the ridge crest, within a smaller gully system, although there is a significant established wetland that borders the southeastern boundary of the Site and is located outside of the Site boundary. This large wetland drains to the northeast via an unnamed stream alongside Mamuku Road.

Both of these two unnamed streams eventually combine at a confluence approximately 2 km northeast of the Site and discharge to the Moutere Inlet around 3.6 km downstream of the Site. No flow data is available for streams at the Site.

The two overall catchments at the Site in the current pre-development state described above have been designated West and East by Envirolink and are shown in Figure 2, Appendix A along with the onsite wetlands and the significant established wetland to the southeast of (outside) the Site. The existing surface water catchment (pre-development) has been delineated by Staig and Smith. As part of the development, the existing broader east and west catchments will be modified to manage stormwater associated with the development. The two modified east and west catchments post-development of the Site are shown in Figure 3, Appendix A.

The proposed development at the Site will alter the shape and area of the overall stormwater catchments so that stormwater can be managed by a number of stormwater retention ponds. Each of the stormwater ponds are located within a smaller sub-catchment delineated by Staig and Smith and are within areas of the broader catchments which will be modified/impacted by the proposed development at the Site. These smaller, post-development sub-catchments are displayed in Figure 3. It is worth noting that the broader east and west catchments also include areas located outside of the sub-catchments which will not be modified/impacted by the development of the Site but have been included as they contribute surface flow to the environment downstream of the development areas. To provide a comparison, equivalent sub-catchment areas for the pre-development state of the Site have also been delineated by Staig and Smith and are shown in Figure 2, Appendix A.

Appendix B provides summary tables of the broader catchment areas, wetland areas as well as stormwater ponds and catchment areas for both the pre-development and post-development states of the Site that are shown in Figures 2 and 3, Appendix A respectively.

The information provided in Appendix B has been used to assist with the assessments provided in subsequent sections of this report.

2.2 Soils

The Manaaki Whenua/Landcare Research online SMap tool does not provide any soil information for the Site. However, available literature indicates there are three general soil types at the Site which are as follows (Campbell, 2018):

- ✧ Mapua soils – located on hill slopes and ridge crests, sandy silty texture, derived from weathering of underlying Moutere Gravels, moderately drained.
- ✧ Neudorf soils – located at the toe / base of slopes in valleys and gullies, derived from slope wash / colluvium / alluvium, imperfectly to poorly drained. No profile available water (PAW) information available.
- ✧ Kina soils – located in valleys, derived from alluvium / colluvium in areas of poor drainage (i.e. wetlands), poorly drained. No PAW information available.

Profile available water or PAW is the amount of water a soil can hold that is available for plant growth and is between the field capacity and permanent wilting point for defined depth of a soil (i.e. in this case at 60 cm depth).

Manaaki Whenua/Landcare Research does not have any specific PAW information specific to the Site, but a sibling soil report for the Mapua soils (Mapuaf) was available from Manaaki Whenua/ Landcare Research's online S-Map database, which indicates a PAW (60) of 81 mm. The PAW (60) value of 81 mm has been used in the assessments detailed in subsequent sections of this report.

No PAW values for the Neudorf or Kina soils were available but a PAW of 81 mm is considered reasonable for all soils because the Mapua soils cover the vast majority of the Site with the Neudorf and Kina soils restricted to small areas within the base of the gullies/valleys and are more prominent downstream of the Site. Due to minor coverage of the Neudorf and Kina soils at the Site and no available PAW information for these two soil types, the Mapua soils have been assumed to be the dominant soil type at the Site and incorporated into the assessment discussed later in this report.

2.3 Geology and hydrogeology

2.3.1 Geology

The 1:250,000 geological map of the area (Rattenbury, et al., 1998) indicates that the Site is underlain by the Moutere Gravel Formation. The Moutere Gravel Formation is of Pliocene-early Pleistocene age and has infilled the Moutere depression up to depths of 2,500 m (near the eastern side of the depression) and covers an area over 10,000 ha of lower-lying land between the Richmond Range to the east and the Arthur Range to the west (Basher & Jackson, 2002) (Stewart & Thomas, 2002) (Thomas, 2001). Following deposition, the Moutere Gravel Formation has been incised by the Motueka, Moutere and Waimea Rivers (Stewart & Thomas, 2002).

The Moutere Gravels are described as uniform, yellow-brown claybound gravels, containing deeply weathered clasts which are made up of Torlesse-derived sandstone and semi-schist (Stewart, et al., 2004). The bulk of the gravel is comprised of well-rounded, quartzofeldspathic sandstone clasts in a brown and weathered muddy sand matrix, containing up to boulder sized clasts (Stewart, et al., 2004). Within the valley floors, Moutere Gravels have been reworked by fluvial processes to form a veneer on top of the Moutere Gravel Formation in these areas. At depth, the Moutere Gravel Formation is underlain by Tertiary sediments and the basement rocks of the Separation Point Granite suite.

A major inactive fault splits the Moutere Valley into the western and eastern groundwater zones, with the Tahimana Site residing in the eastern Moutere coastal groundwater zone.

Figure 4, Appendix A provides a geological map of the Tahimana Site and surrounding area.

Fourteen test pits were excavated at the Tahimana Site as part of geotechnical investigations by Swanney Limited in July 2023. The information from the geotechnical investigations indicates the following generalised geology and the range of depths to the top of each unit that were encountered during test pitting at the Site:

- ✧ Topsoil – ground level to 0.2 m bgl.
- ✧ Silt/Clay (Moutere Clay (Mapua Soils)) – 0.2 to 1.6 m bgl.
- ✧ Moutere Gravel Formation – 1.6 m bgl+

The test pit data indicated that the near surface soils were wet but no groundwater was encountered within the Moutere Gravels. The test pits also identified some areas of fill material consisting of silt, clay and organics material overlying the Moutere Gravel, interpreted by Swanney Limited to be associated with previous forestry land use and logging activities.

A groundwater monitoring bore (WWD24683) was drilled by CW Drilling under PDP's supervision on 11 September 2023. The bore was drilled to a depth of 20 metres below ground level (m bgl) and screened between 5 and 19.8 m bgl. The borelog for this bore indicates predominantly yellowish-brown silty gravel strata with varying amounts of sand and cobbles of the Moutere Gravels. Within the top 4 m, the strata is weathered and consists mostly of clayey sand but at deeper depths, the gravels are less weathered and gravel clasts become more defined. The location of the deep monitoring bore (WWD24683) at the Site is shown in Figure 4, Appendix A.

Two riparian margin monitoring Site standpipes were also installed in nearby wetlands via hand auger by PDP on 8 September 2023 and the strata encountered in both standpipes consisted predominantly of very wet, dark grey sandy silt to depths of up to 2.1 m bgl before the underlying Moutere Gravels were encountered. The locations of these are also shown in Figure 4, Appendix A.

The borelogs for the monitoring bore (WWD24683) and the two standpipes are provided in Appendix C.

2.3.1 Hydrogeology

The hydrogeology in the wider Moutere Valley area including the Tahimana Site consists of three aquifers (Thomas, 1989):

- ✧ Shallow Moutere Aquifer (SMA).
- ✧ Middle Moutere Aquifer (MMA).
- ✧ Deep Moutere Aquifer (DMA).

Thomas (1989) indicates that these aquifers are separated by aquitards consisting of leaky clay layers that contain carbonaceous materials. The Tahimana Site resides within the Moutere Gravels upper Unit 2 (tm₂) which has been interpreted to be the SMA (Stewart & Thomas, 2002). The available literature also indicates that the Moutere Gravels lower Unit 1 (tm₁) correlates with the MMA and DMA (Stewart & Thomas, 2002).

The Moutere aquifers are recharged by direct rainfall into an unconfined aquifer section in the southwest area of the Moutere Valley and around 10 km southwest of the Site (Thomas, 1992). Rainfall recharge to the SMA has also been interpreted to occur in the hills east of the Moutere Valley where the Tahimana Site is located (Stewart & Thomas, 2002).

A schematic cross-section in Figure 5, Appendix A shows the interpreted regional geology and regional groundwater recharge mechanisms for the area, including the Site.

Bore information available from TDC indicates that there are five bores within 600 m of the Tahimana Site boundary that have borelog information (excluding the onsite bores installed as part of this investigation). These bores range in depth from 21 m bgl to 176 m bgl. The shallow bore (21 m deep) indicates that the strata is mostly yellow clay with brown medium gravels from surface level to 18 m bgl, with a water bearing gravel layer at 20.4 – 20.7 m bgl. The deeper bores (150 – 176 m deep) are all screened over three water bearing layers that are each around 0.2 – 0.3 m thick. In between the water bearing layers are interbedded layers of gravels/cobbles and sands, which are usually claybound, and layers of yellow or grey clay. The borelog geology is generally consistent with the Moutere Gravels lithology. The available borelogs for these bores are provided in Appendix C.

2.3.1.1 Aquifer parameters and slug testing

The available information indicates that SMA generally has transmissivities less than 15 m²/day, transmissivity in the MMA typically ranges between 25 and 40 m²/day and the DMA generally has transmissivities greater than 50 m²/day (Thomas, 2001).

No infiltration testing has been undertaken at the Site, although information provided by Envirolink indicates that the hydraulic conductivity of the near surface soils in the vicinity of the Site (Mapua Soils) is in the order of 20 to 50 mm/hr (0.48 to 1.2 m/day) (pers. comm. David McColl (Envirolink), August 2023). These infiltration rates were measured at a Site located approximately 1 km south of the Tahimana Site.

Slug testing was undertaken in the monitoring bore (WWD24683) as well as the two standpipes at the Site on 5 October 2023. Water levels in the bore and the two standpipes were measured manually using a water level dipper as well as continuously using automated non-vented water level loggers at 1 second intervals. A dedicated barometric pressure transducer was used to record changes in atmospheric pressure during the slug testing and was used to remove the atmospheric pressure component from the transducer datasets for all bores. The compensated water pressure data was used for the analysis of the slug test data.

Two falling head tests and two rising head tests were undertaken in the bore and the two standpipes. The slugs were placed in the bore/standpipe as quickly as possible (falling head test) and after water levels recovered close to pre-test levels, the slugs were removed as quickly as possible (rising head test).

Figures 6 and 7 (Appendix A) show the change in water levels measured during the slug testing as a result of the slugs being introduced and removed for the bore and the two standpipes respectively.

The slug test data for the monitoring bore (WWD24683) show that water levels took around 1.5 to 2 hours to recover back to pretest levels during the falling head test. Conversely water levels during the rising head tests took around 17 minutes to recover. The cause of the asymmetric water level response during the testing is not clear although it may be from possible smearing of the formation during drilling and/or drilling mud infilling pore spaces immediately surrounding the borehole. Regardless of the asymmetric response, the data from falling head and rising head tests provide similar order of magnitude results, which is noted below.

The slug test data for Standpipes 1 and 2 (also labelled as riparian monitoring sites 1A and 1B respectively in Figure 4) show a very slow recovery following the falling head test and subsequently did not recover back to the pretest water level and recovered less than 0.01 m after approximately 15 minutes. Due to the very slow recovery, any subsequent tests were not analysed.

The water level data from the monitoring bore and the two standpipes were analysed to estimate the hydraulic conductivity of the strata using the Bouwer and Rice (1976) method. Example copies of the slug test analysis outputs for the tests described above are provided in Appendix D and show the analysis of the data. The analysis indicates a relatively good fit with the respective datasets for each test.

A summary table of the calculated hydraulic conductivity values is provided below:

Table 1: Summary of calculated hydraulic conductivities		
WWD24683 – Monitoring bore		
Test	Falling head (m/day)	Rising head (m/day)
Test 1	0.0012	0.0088
Test 2	0.00095	0.0097
Geometric mean	0.001	0.009
Standpipes		
Bore	Falling head (m/day)	
Standpipe 1	0.008	
Standpipe 2	0.003	
Geometric mean	0.004	

The results of the slug tests indicate a geometric mean of the hydraulic conductivity in the range of 0.001 to 0.009 m/day for the Moutere Gravels and a hydraulic conductivity of 0.004 for the silty material that comprises the wetlands at the Site.

A comparison of the hydraulic conductivity data calculated from the slug testing in the monitoring bore (WWD24683 – screened within the Moutere Gravels) is generally consistent with the available literature which indicates hydraulic conductivities in the range of 0.001 to 0.1 m/day for gravel and clay mixes (Kruseman and de Ridder, 1990) although as noted above, the calculated hydraulic conductivities for the bore may potentially be impacted by the drilling process. In addition, the results of slug testing in the wetland standpipes is generally consistent with the available literature for silt dominated strata which is in the range of 8.6×10^{-5} and 86 m/day (Freeze and Cherry, 1979). Due to the issues encountered the hydraulic conductivities estimated from the onsite slug testing are considered to be indicative, although due to limited availability of hydraulic conductivity data for the wetlands, the estimated values from the testing have been included in the water balance modelling discussed in Section 5.0.

2.3.1.2 Groundwater levels

Information available from TDC's database indicates that there is limited groundwater level information for the area, although the available information for bores within 1 km of the Site indicates static water levels ranging from 4.4 m bgl in a shallow bore (23700, 21 m deep), and 20.7 – 37.5 m bgl in the deep bores (102 – 176 m deep). The static water levels recorded in these bores were measured in the years ranging 1974 – 2019. Most of the bores within 1 km of the Site are expected to be screened within the MMA or DMA aquifers, with only one shallow bore (23700) expected to be screened within the SMA. It is worth noting that bore 23700 is located approximately 100 m from an unnamed stream so it may be possible that the groundwater level in the bore is similar to the water level in the stream. Figure 4, Appendix A shows the locations and screened intervals/depths of the bores within 1 km of the Site and Table 2 below provides a summary of the available bore information.

Table 2: Details of bores within 1 km						
Bore Number	Depth (m)	Screened Interval (m)	Static Water Level (m)	Status	Use	Distance from Site boundary (m)
23065	120		37.5	Unknown	Domestic	335
23142	100			Used	Irrigation	900
23147	102			Used	Irrigation	925
23153	102	0 – 58	33.6	Used	Irrigation	770
23374	150	70 – 150	30	Used	Domestic	250
23417	150			Not used	Domestic	715
23466	257			Not used	Domestic	540
23471	150			Not used	Domestic	545
23700	21	12 – 21	4.4	Used	Domestic	335
23979	158	60 – 158	30	Used	Domestic & Stockwater	530
24043	150			Used	Domestic	575
24066	150			Unknown	Domestic	350
24140	150	60 – 150	33.9	Unknown	Domestic & Stockwater	80
24156	150	80 – 150	20.7	Unknown	Domestic & Stockwater	570
24435	176	106 – 176	27.6	Unknown	Domestic & Stockwater	460

As noted previously, test pitting as part of onsite geotechnical investigations was undertaken predominantly along ridgelines and spurs at the Site, close to the vicinity of where most of the development will occur. It did not encounter any groundwater at depths of up to 3 m, consistent with the available groundwater level data. The test pitting information indicated that the near surface soils were wet but became dry with depth, possibly consistent with interflow.

The regional hydrogeological cross-section of the area shown in Figure 5, Appendix A indicates that groundwater beneath the hills where the Site is located is generally deep, although shallow groundwater has been encountered at the Site and this will be recharged from rainfall recharge across the hilly area where the Site is located. The connection between this and deeper groundwater is unknown.

Water levels have been measured in the monitoring bore (WWD24683) and the two standpipes (1 and 2) using a combination of water level loggers and manual measurements for the period between 5 October 2023 and 1 May 2026. The water level logger data was recorded using non-vented water pressure transducers which were compensated for atmospheric pressure effects using an onsite, dedicated barometric pressure logger.

A timeseries plot of groundwater levels measured in the monitoring bore (WWD24683) and the two standpipes (1 and 2) are shown in Figure 8, Appendix A. Table 3 below provides a summary of the statistics of the water level data.

Table 3: Summary of groundwater levels measured at Tahimana for the period October 2023 to May 2026

Bore Number	Lowest (m bgl)	Average (m bgl)	Median (m bgl)	Highest (m bgl)	Range (m)
WWD24683	2.76	2.28	2.26	1.54	1.21
Standpipe 1	0.44	0.09	0.09	-0.28	0.72
Standpipe 2	1.05	0.57	0.54	-0.12	1.17

Due a temporary water level logger malfunction in the logger in Standpipe 1, there is a gap in the data between 16 May 2024 and 12 September 2024. The data for Standpipe 2 shows that the water level dropped below the logger for the period between February and June 2024 before the logger was lowered to a deeper depth.

The data indicate that water levels for monitoring bore (WWD24683) and the two standpipes (1 and 2) generally display a similar overall pattern of water level fluctuations, although the range of fluctuations in Standpipe 1 are smaller and the peaks are less pronounced compared to the data for Standpipe 2 and the monitoring bore (WWD24683). Figure 8 also provides a comparison of the groundwater level data collected to date with rainfall (measured at the NIWA climate station “Nelson Aero”, agent number 4241). The data indicate that water levels in monitoring bore (WWD24683) and the two standpipes (1 and 2) all respond to rainfall, although response to rainfall is smaller and less pronounced in Standpipe 1. The data indicate that higher water levels in the two standpipes and the monitoring bore generally occur between May to August while lower water levels generally occur between December to April.

Water levels measured at the Site on 13 November 2023 have been used to provide an indicative shallow groundwater flow direction for the western catchment for the monitoring bore (WWD24683), the two standpipes (1 and 2) and an additional surface water level monitoring Site (labelled “Downstream Wetland Staff Gauge”) located downstream of the monitoring bore. The water level measured at the Downstream Wetland Staff Gauge is expected to be reflective of shallow groundwater in this part of the catchment. The measuring points at the four water level monitoring sites were surveyed by Staig and Smith and manual water levels measured by PDP on 13 November 2023 were converted to a water level elevation (i.e., meters above sea level (masl) – NZVD2016).

The measured water level elevation data and indicative flow direction are shown in Figure 9, Appendix A. The available information indicates a shallow groundwater flow direction from roughly south to north, broadly similar to the surface water flow direction. A hydraulic gradient in the order of 0.05 m/m was estimated between the standpipes and the downstream wetland staff gauge, roughly similar to the topography of this part of the catchment.

Overall, the available groundwater level data measured at the Site indicates that there may be a hydraulic connection between the broader groundwater system and the water levels for the wetland in the vicinity of the monitoring bore (WWD24683) and the two standpipes. This connection is also expected to occur within the lower reaches of the catchments at the Site with groundwater levels expected to be close to ground level/similar level to open surface water in the more downstream wetlands. The depth to groundwater for the broader system is expected to increase within the upgradient/upstream extents of the wetlands/catchment and as such, the wetlands in the more upstream parts of the catchments may be perched above the broader groundwater system at the Site. Continued groundwater level monitoring will assist with refining understanding of the groundwater and surface interactions at the Site.

2.4 Climate

The closest climate station with concurrent rainfall, open-water evaporation and Penman evapotranspiration data is the Nelson Aero climate station (Agent number 4241) available from the National Institute of Water and Atmospheric Research's (NIWA) online CliFlow database. This climate station is located around 17 km southwest of the Site at Nelson Airport. The data from this climate station is available on a daily timestep over 38-year period between 1963 and 2017. For the years with complete rainfall and evapotranspiration records, total annual averages were calculated and are summarised below:

- ✧ Average total annual rainfall – 967 mm/year.
- ✧ Average total annual Penman evapotranspiration – 930 mm/year.
- ✧ Average total annual open water evaporation – 948 mm/year.

It is worth noting that for years that had incomplete records, (i.e. missing data for 16 years between 1963 and 2017) the data was excluded from the calculated averages listed above.

3.0 Site visit and field assessment

3.1 Wetland delineation

There are several “natural inland wetlands” identified on the Site which have been identified and mapped by RMA Ecology as meeting the definition in the National Policy Statement for Freshwater Management (NPS-FM). The extents of the natural inland wetlands at the Site as provided by RMA Ecology are provided in Figures 2 and 3, Appendix A.

As previously mentioned, an existing, established wetland is located to the southeast and outside the Site. The extent of this wetland has not been delineated, but for the purposes of the assessments in this report, an approximate extent expected to be connected to the Site via groundwater and surface water inflows from the eastern catchment of the Site has been delineated as shown in Figures 2 and 3.

Furthermore, a wider wetland extent has been estimated for the downstream-most portion of the wetlands in the western catchment for the purposes of the assessments in this report. This extent is also shown in Figures 2 and 3.

3.2 Site walkover

A site visit was conducted by PDP staff in November 2022. A brief description of the wetlands within the western and eastern catchments are described in the following paragraphs based on PDP's site visit.

3.2.1 Western Wetlands

The western catchment wetlands are located within the base of gullies that have been incised into the underlying Moutere Gravels. At the heads of the gullies, there are generally wet areas with wetland vegetation (i.e. rushes) indicating where the wetland begins with the vegetation primarily restricted to within the gullies.

There were some small areas of surface water ponding, although these were generally located within the lower reaches of the wetlands. The individual open water areas along this reach were generally around 1 to 2 m in length and a visual inspection of the flow in these open water areas was generally low (less than 1 L/s) at the time of the site visit.

Small areas of open water occur in some of the upstream reaches of the tributaries such as where a gully/stream has been modified into a small pond, likely to be for stock water supply purposes, and these generally have a diameter of less than 10 m.

Outside of the gully areas, the wetlands transition abruptly to pasture. A larger wetland occurs at the downstream extent of the western catchment which extends beyond the northern boundary of the Site. The area of this downstream wetland within the Site boundary is around 0.47 ha.

Figure 10A, Appendix A shows an example photo of one of the wetlands within the western catchment.

3.2.2 Eastern Wetlands

The eastern wetlands are also located within a slightly steeper catchment than the western wetlands. Although the wetlands are generally restricted to gullies and at the toe of slopes, there are smaller, scattered mid-slope seeps identified by wetland vegetation (i.e. rushes) and these generally occur where there is a change in slope angle. These mid-slope wetlands are expected to occur where interflow emerges at the surface as a result of a change in slope angle. Figure 10B, Appendix A shows a photo of these wetlands.

Only one stream was identified within the eastern catchment during the site visit and was located roughly in the middle of the eastern catchment. At the time of the site visit, there was minimal stream flow (generally <1 L/s) within this stream and flow emerging from a number of smaller seeps. Geotechnical investigations undertaken by Swanney Limited identified an area of fill material associated with forestry activities near the head of this stream (TP2) and it may be possible that interflow discharges at the downgradient extent of the fill material contribute to flow within this stream.

Small areas of open water occur in some of the upstream reaches of the tributaries where a gully has been modified into small ponds, likely to be for

stock water supply purposes, and these generally have a diameter of less than 10 m.

A significant and established wetland occurs immediately beyond the northeast boundary of the Site and has an area of around 7.2 ha.

4.0 Proposed development

The proposed development for the Site will consist predominantly of residential sections and some lifestyle sections in the western catchment, while the eastern catchment will consist entirely of lifestyle sections. The development will generally be restricted to areas just below hilltops, ridges and spurs to minimise disturbance of the wetland areas within the gully areas at the Site. Figure 1, Appendix A provides an overview of the proposed layout of the subdivision development at the Site.

In terms of the overall development resulting in effects on groundwater recharge or runoff and subsequent effects on wetland health, the main aspects that will have the largest impact are the creation of impervious surfaces causing changes in wetland recharge mechanisms, and also the excavation of trenches to install infrastructure (such as water, stormwater and wastewater pipes etc) intercepting groundwater/interflow creating a preferential flow path/diverting or reducing groundwater recharge to wetlands. This latter issue is more likely to have an effect where trenches extend laterally across ridges and spurs.

Trenching to install below ground infrastructure, and cuts to create roading corridors and building platforms, are typically expected to occur at depths of around 2 m bgl, although some cuts up to 4 m bgl are expected as part of the development. It should be noted that nearly all of the cuts and certainly the deeper cuts will be generally restricted near to but below ridgelines and spurs within the road reserves and housing lots.

Impervious areas such as roads, building roofs and hardstand areas will create stormwater during rainfall events. Stormwater generated at the Site will be managed with diversions to a number of small stormwater retention ponds. The ponds will allow some water to infiltrate to groundwater although the majority of the stormwater will be discharged as surface flow downstream. As there are a number of wetlands that extend into the gully areas throughout the wider Site, it is understood that some stormwater from impervious surfaces (i.e. roofs on some individual lots) will not be incorporated into stormwater pond catchments and instead will discharge stormwater towards the closest wetland area in order to sustain the existing wetland recharge mechanisms currently occurring in the undeveloped parts of the Site. Further discussion on the management of stormwater at the Site as part of the development for the eastern catchment and western catchments are described in the subsequent sections.

4.1 Eastern catchment stormwater management

Development of the eastern catchment will involve earthworks over approximately 20% of the post-development catchment as development in this area of the Site is proposed to consist exclusively of larger, lifestyle development lots. The lots in the eastern catchment will harvest rainwater for domestic use (i.e. drinking water, irrigation of gardens/lawns etc) and wastewater generated at these lots will be discharged to ground onsite via dripline disposal systems (Envirolink, 2026). Stormwater generated on roads and other impervious surfaces will be discharged into stormwater ponds where there will be some infiltration into ground through the base of the stormwater ponds. Overflow from the rainwater harvesting at individual lots will be discharged as overland flow upstream/upgradient of wetlands located in gully heads (Envirolink, 2026). The harvesting of rainwater into tanks will provide some attenuation during stormwater events and ultimately, the majority of the rainwater collected in the tanks will be discharged upgradient of wetlands (as the building footprints (BLA) are located upgradient of wetlands) within the eastern catchment property lots in the form of irrigation of collected rainwater on lawns and gardens as well as disposal of treated wastewater via dripline irrigation. It is worth noting that the treated wastewater disposal will occur year-round and assist with providing a consistent groundwater recharge and interflow that would be contributing to recharge in downgradient wetlands.

4.2 Western catchment development

Development of the western catchment will involve earthworks over approximately 46% of the post-development catchment, as a result of more intensive, residential development for this part of the Site. It is worth noting that the western catchment, 15 lots will be lifestyle lots (lots 20, 32, 60, 75-80, 87, 111, 112, 137, 138 and 145) and the remaining lots will be residential development. The residential development lots will have water supplied via a reticulated supply and treated wastewater will be disposed of outside of the western catchment.

As the more intensive development of the western catchment will result in a larger proportion of earthworks, it is possible that the changes to interflow and groundwater recharge that contribute to the wetlands within this part of the Site could be more impacted by the establishment of upgradient impervious surfaces. Therefore, to encourage as much discharge of stormwater generated on impervious surfaces within the residential parts of the western catchment development as possible, the project team has considered options for reducing impacts on groundwater recharge/interflow in the form of soak pits and have identified a preferred soak pit design option. The proposed design will utilise a total of 10 soak pits distributed throughout the western catchment at locations upgradient of the wetlands. The locations of these chambers and the catchments

from which stormwater water will be diverted to the chambers is shown in Figure 3, Appendix A. The soak pits have been sited so that infiltrated water will occur as groundwater recharge/interflow at locations as far upgradient as possible of all of the major wetland extents within the gullies in the western catchment.

Information provided by Staig and Smith and Envirolink Limited indicates that the soak pits are proposed to consist of groups of 2 to 4 manholes (diameter of 1.8 m and depth of 2.4 m) installed within a single excavation within the ground at each proposed location. Each manhole will have a storage volume of around 6 m³ and will not be backfilled with any material (i.e. will be an open void). The base of the manhole will be left open to the underlying natural ground and the sides of the manholes will be perforated to allow water to flow horizontally. The volume between the concrete manholes and the sides of the excavation will be backfilled with a permeable gravel with an expected porosity in the order of 0.3 (Pers. Comm. David Carlson-McColl of Envirolink Limited, 6 September 2024). Therefore, the total storage of the soak pits will be the combined volume of the manholes and the pore spaces within the backfill material used to backfill between the manholes and the sides of the excavations. The soak pits will essentially form an underground tank with a pervious base and sides to allow stormwater that enters the chamber to infiltrate to ground downwards and horizontally in all directions, encouraging groundwater recharge/interflow to downgradient wetlands.

The following section includes a description of the modelled effect of the proposed stormwater soak pits.

5.0 Water mass balance calculation

5.1 Conceptual hydrogeological description

The hydrology of the wetlands in both the western and eastern catchments at the Site is expected to be driven by direct rainfall, evaporation, evapotranspiration, shallow groundwater/interflow seeps and overland flow (during rainfall events).

To describe how the wetlands function and the interactions between surface water and groundwater within the wetlands and their associated catchments, conceptual hydrological descriptions have been developed. Based on Site inspections, two possible conceptual descriptions have been developed, which are described below:

- ✧ Groundwater connected wetland – Wetlands at lower elevations in each of the eastern and western catchments (i.e. within the valley floor of both catchments) are expected to be directly hydraulically connected to groundwater within the area. Figure 11, Appendix A shows a schematic diagram of this groundwater connected wetland hydrology.
- ✧ Perched wetland hydrology – The wetlands within the upper catchment areas of both the western and eastern catchments are expected to be perched above the wider groundwater system in the area.

The two conceptual wetland hydrological descriptions are based on Site observations and available geological information for the area.

The groundwater connected wetland hydrology is expected to be representative of the broader western and eastern catchments as the wetlands located in the valley floors near the boundaries of the Site (i.e. the significant wetland to the southeast of the eastern catchment and the wetland at the northeastern end of the western catchment) are expected to have a direct hydraulic connection with the wider groundwater system in the area. This situation is expected to be the case for the groundwater connected wetland located southeast of the Site and also the groundwater connected wetland extent at the downstream extent of the western wetland (near the northwest extent of the Site). Both of the approximate groundwater connected wetlands are shown in Figures 2 and 3, Appendix A with shallow groundwater within the two catchments ultimately expected to discharge through the downstream Site extent of these wetlands.

The perched wetland hydrology is considered to be representative of the smaller wetlands located higher up in both the western and eastern catchments that are expected to receive recharge from overland flow and interflow seeps at the heads of the gullies. Groundwater seeps around wetlands located near the heads of gullies at the Site are expected to be from interflow seeps discharging into the wetlands at these locations.

To assess the net changes in recharge to the wetlands at the Site, a water balance for the pre-developed Site has been compared to a water balance for the post-developed Site assuming the groundwater connected wetland conceptual hydrology described above.

Due to the small footprint and disseminated distribution of the various mapped wetlands, assessments have been undertaken at the broader, eastern and western catchment scale which provides a more averaged assessment. A more granular assessment (i.e. individual wetland catchment scale) was considered. However, to undertake more detailed and granular scale water balance assessments, detailed information for each individual wetland and its catchment would be required, including the wetted area of each wetland (including seasonal changes to the wetted area), the connection with underlying groundwater/interflow of each wetland, and specific aquifer parameters of each

wetland and associated catchment. Acquiring information at this scale would be very involved and would not reduce the level of assumptions but would instead likely further increase the level of uncertainty of an assessment at such a scale. An alternative would be to use the same inputs used for the broader catchment scale modelling. However, as the inputs would all be the same (soil types, rainfall, groundwater recharge etc) it is expected that the changes at a smaller wetland catchment scale using the same inputs would show even smaller changes than at the broader catchment scale. This is because the sum of the changes for individual wetlands equals the overall modelled changes at the broader catchment scale assessment. As a result, the broader, catchment scale assessments are considered appropriate and suitable for the scale of the proposed development at the Site.

The eastern and western catchment scale water balance assessments have been based on the following mass balance equation, and the assumption that the water volume within the downgradient wetlands in each catchment do not change significantly over an annual basis in its current stage.

Equation 1 (adapted from Campbell & Jackson, 2004).

$$(P + Q_{in} + I_{in} + G_{in}) = (ET + Q_{out} + I_{out} + G_{out})$$

Where:

Inputs

- ✧ P = precipitation (mm/year – converted to m³/year for calculation).
- ✧ Q_{in} = overland surface water inflows/runoff (m³/year).
- ✧ I_{in} = interflow inflows (m³/year).
- ✧ G_{in} = groundwater inflows (m³/year).

Outputs

- ✧ ET = evapotranspiration (mm/year – converted to m³/year for calculation).
- ✧ Q_{out} = surface water outflows (m³/year).
- ✧ I_{out} = interflow outflows (m³/year).
- ✧ G_{out} = groundwater outflow (m³/year).

Interflow is the flow of water within the unsaturated zone above the groundwater table and is most likely to occur both during and for a period of time after a rainfall event.

A conservative assumption was made in that there was no groundwater inflow as part of the water balance as it is very difficult to determine what this component is. This means that G_{in} is conservatively considered to be zero for this assessment.

To determine groundwater recharge and overland flow (Q_{in}), a soil moisture balance calculator was used and applied P and ET data from the Nelson Aero Climate station (as described in Section 2.4) on a daily time step for the total pre-development surface water catchment area of the Site (total area of 606,254 m²). For the purposes of this assessment, we have applied all groundwater recharge as interflow ($I_{in} = P - ET$) but this is referred to as groundwater recharge for the purpose of the discussion below. In reality, recharge to the wetlands will consist of a combination of saturated and unsaturated groundwater inflow.

The soil moisture balance calculator removes the initial 2 mm of a rainfall event as this portion of rainfall was assumed to be intercepted by plant leaves. Due to the sloping nature of the Site, rainfall event thresholds of 25 mm and 50 mm were applied to estimate the groundwater recharge and associated overland flow (Q_{in}) portions of the water balance. In other words, when rainfall totals between 25 and 50 mm occurred, 25 mm was assumed to occur as groundwater recharge with the remainder occurring as runoff. When rainfall totals greater than 50 mm occurred, 50 mm was assumed to occur as groundwater recharge with the remainder occurring as runoff. This is a simplistic assumption that does result in some discrepancy above and below rainfall events of 50 mm. However, for the purposes of this assessment and the available information, it was considered reasonable.

While groundwater recharge and surface water runoff were calculated at a daily timestep over a 38-year period between 1963 and 2017 (excluding 16 years of missing or incomplete data for this period), annual average groundwater recharge and runoff volumes were calculated for the total pre-development surface water catchment area of the Site (606,254 m²).

Runoff (Q_{in}) inflow rates were calculated from the difference between rainfall and the calculated groundwater recharge.

The soil moisture calculator allowed annual, average groundwater recharge (equivalent to $I_{in} = P - ET$) and runoff (Q_{in}) rates to be calculated, which are summarised below:

- ∴ Annual average groundwater recharge ($I_{in} = P - ET$) rate = 0.20 m/year.
- ∴ Annual average surface water runoff (Q_{in}) = 0.09 m/year.

As these rates were calculated for the entire pre-development catchment, they can be applied to the water balances for both the western and eastern catchment for both the pre and post development states of the Site.

For the post-development water balance, the groundwater recharge area was reduced to account for the increase in impervious areas from roading, hardstand and roof areas located within stormwater retention pond catchments. Of the total impervious areas for the developed Site provided by the project three waters engineer (David Carlson-McColl of Envirolink), 71% and 90% of the total impervious area for the western and eastern catchments respectively were assumed to discharge surface runoff to the stormwater ponds. Although a significant portion of the surface runoff generated on the impervious areas is discharged to stormwater ponds in the eastern catchment, it is noted that the total impervious area for each catchment is around 23% and 10% of the western and eastern total post-development catchment areas, respectively.

Based on information from Envirolink and Staig and Smith provided to PDP, impervious surfaces located outside of stormwater catchments were assumed to discharge as a diffused discharge, allowing water to discharge to ground and as overland flow.

It is difficult to distinguish between interflow outflows (I_{out}) and groundwater outflows (G_{out}) so they were assessed as a single value for the water balance assessments. The combined interflow and groundwater outflows were calculated using Darcys Equation at the downstream most section for each of the western and eastern catchments. Darcys Equation is as follows:

$$Q = -KiA$$

Where:

- ✧ Q = groundwater outflow (m^3/day).
- ✧ K = hydraulic conductivity (m/day).
- ✧ i = hydraulic gradient (unitless).
- ✧ A = cross sectional area of the downstream extent of the wetland through which groundwater through-flow occurs (m^2).

The hydraulic gradient was estimated based on the topographical slope for the wetland at the downstream extent of the eastern and western catchments. The cross-sectional area was estimated by an estimated saturated thickness of the wetland and the width of the wetland at the downstream extent.

A summary of the parameters used for calculating the groundwater outflows for both the western and eastern catchments are provided in Table B3, Appendix B.

The remaining surface water outflow (Q_{out}) was calculated from balancing the total inflow to the catchment minus the groundwater outflow.

5.1.1 Western catchment soak pits

As detailed in Section 4.2, soak pits in the western catchment will be used to allow the direct discharge of stormwater into the ground to encourage a level of groundwater recharge/interflow to wetlands located downgradient. To determine the volume of stormwater that can be discharged to ground via each of the soak pits, a water balance was created for each soak pit. As noted above, water that enters a chamber is infiltrated through both the base and side walls of the chamber with volumes of stormwater that exceed the infiltration rate of the chamber either stored within the chamber or, if the volume exceeds both the infiltration rate and the storage of the chamber, occurring as overland flow toward downstream wetlands.

To determine the infiltration rate through the base of the soak pit, the following inputs were used in Darcy's equation to determine an infiltration rate:

- ✧ Hydraulic conductivity (K) = 0.005 m/day.
- ✧ Hydraulic gradient (i) = 1 m/m.
- ✧ Area of soak pit floor (A) = between 14 to 25 m² (depending on size of excavation to fit manholes in).

The hydraulic conductivity value is for the underlying Moutere Gravels and is an average value derived from slug testing undertaken in bore WWD24683 located at the Tahimana Site, as documented in the Hydrogeology report. Based on this, the recharge rate through the base of the proposed soak pits was estimated to range between 0.07 and 0.125 m³/day, depending on the size of the chamber.

The infiltration rate through the sides of the soak pits was also estimated using Darcy's equation using the following range of inputs:

- ✧ Hydraulic conductivity (K) = 0.5 m/day.
- ✧ Hydraulic gradient (i) = 0.3 m/m.
- ✧ Area of soak pit side walls (A) = between 13 to 21 m². (dependent on size of excavation to fit manholes in).

As described in Section 2.3.1.1, the overlying Mapua soils at the Site are expected to have an infiltration rate in the order of 0.48 m/day. A conservative approach was taken and a hydraulic gradient of 0.3 was assumed for recharge through the side walls. Furthermore, recharge was only assumed to occur through a third of the infiltration side wall area as the Mapua soils are not expected to extend the full depth of the soak pit. Based on this, sidewall recharge rates were estimated to range between 1.9 and 2.9 m³/day and are assumed to occur as interflow within the soils overlying the Moutere Gravels.

The water balance for each soak pit was undertaken on a daily time step and stormwater generated within the catchments of the soak pits was estimated using total daily rainfall from NIWA's climate station at Nelson Aero (agent number 4241). Only years between 1963 and 2017 that had complete daily rainfall records for each day of the year were used. This information was then used to determine the annual average volume of water infiltrated to ground and the volume of water that could not be infiltrated to ground (i.e. overflow) for each soak pit. Undertaking the water balance for each soak pit on a daily time step allowed for the water stored within each soak pit to be accounted for.

The modelled average annual volume of stormwater infiltrated to ground within the soak pits was then used to update the overall western catchment water balance model by reducing the surface water input and increasing the groundwater recharge component for the post-development western catchment.

5.1.2 Water balance assumptions

A number of assumptions were made for calculating the water balances which are listed below:

- ∴ No groundwater inflow but groundwater outflows at downstream extent of water balance catchment.
- ∴ Impervious surfaces located outside of stormwater pond catchments assumed to discharge water to ground/surface waterways and nearby wetlands/streams.
- ∴ For post-development water balance assessments, no open water evaporation of rainfall directly onto impervious surfaces within stormwater catchments was assumed. Open water evaporation was applied to water captured within the stormwater retention ponds.
- ∴ Discharges from stormwater ponds will be a combination of seepage to ground beneath the ponds and a surface water discharge. However, for the assessment, all the stormwater basin outflow was assumed to be surface water discharge into the catchment downstream of the ponds. Estimating potential losses to groundwater from the stormwater ponds is difficult as the hydraulic gradient would likely change with groundwater level fluctuations throughout the year. Furthermore, the hydraulic conductivity of the underlying geology immediately beneath the pond would also likely reduce with time from siltation of the pond base, infilling pore spaces. Although the ponds will contribute to groundwater recharge, a conservative approach has been taken and their contribution not included in the water balance modelling.

- ✧ Rainfall events in excess of 25 mm were assumed to occur as overland flow, although it is likely that there will be runoff at events less than 25 mm due to the sloping nature of the Site, rainfall events exceeding soil infiltration rates and the potential for runoff if soil is already saturated. This is therefore likely to underestimate predevelopment runoff.
- ✧ As there is limited soil drainage characteristics for the Site, Mapua soils have been assumed as the dominant soil type across the entire Site and PAW (60) information has been taken from a sibling soil report for the Mapua soils (Mapua^f), available from Manaaki Whenua/ Landcare Research's online S-Map database as discussed in Section 2.2 of this report.
- ✧ For lifestyle sections in both of the western and eastern catchments, rainwater harvested at each dwelling will ultimately be discharged back to ground as either treated wastewater or as irrigation of gardens/lawns and will contribute to groundwater recharge of downgradient wetlands. A conservative approach has been taken and the water balance model has excluded this recharge input.
- ✧ The entire stormwater catchment for the soak pit calculations as part of the western catchment water balance assessment has been assumed to be impervious. This is a very conservative assumption as not all of the area within the soak pit catchments is expected to be impervious. Therefore, the amount of water infiltrated to ground is expected to be higher than what has been modelled and the amount of overflow from the soak pits would be expected to be less than what has been modelled.
- ✧ Stormwater generated on roof areas within the soak pit catchments in the western catchment will be discharged to the soak pits.

6.0 Assessment of site development

6.1 Mass water balance results

6.1.1 Western catchment

The results of the water balance modelling for the western catchment are presented in Table 4 below.

Table 4: Results of mass balance modelling – Western catchment								
Flows		Pre-development		Post-development		Change		
		(m ³ /yr)	(%)	(m ³ /yr)	(%)	(m ³ /yr)	L/s ³	(%)
Inflow	Groundwater recharge (I_{in})	60,690	69	55,723	46	-4,967	-0.2	-8
	Q_{in}	27,311	31	64,666	54	37,355	1.2	137
	Total	88,001	100	120,388	100	32,388	1	37
Outflow	$I_{out} + G_{out}^2$	9	<1	9	<1	0	0	0
	Q_{out}	87,992	>99	120,380	>99	32,388	1	37
	Total	88,001	100	120,388	100	32,388	1	37
Note: 1. Groundwater inflow (G_{in}) assumed to be zero. 2. $I_{out} + G_{out}$ is the combined interflow and groundwater outflows. 3. Change in L/s is the annual average change as an instantaneous rate.								

The water balance model results shown in Table 4 indicates that for the pre-development scenario, groundwater recharge is the dominant inflow, with surface water the dominant outflow. The modelling shows that for the post-development scenario there will be a redistribution of groundwater and surface water inflow contributions with an increased surface water contribution and subsequent reduction of the groundwater recharge component. It is noted that difference between the pre-development and the post development modelled groundwater recharge will be relatively small (-8%). This small reduction in groundwater recharge is equivalent to an average annual change in groundwater recharge of -0.2 L/s and a change in groundwater recharge of this magnitude across the western catchment is unlikely to be measurable as a change in groundwater levels.

The contribution of the proposed soak pit discharges to ground have been incorporated into the results presented in Table 4. The modelled effect of the soak pits contributes an annual average of 6,610 m³ as groundwater recharge which otherwise would have occurred as part of the modelled surface water inflow (Q_{in}). The modelled recharge contributions for each of the ten soak pits are shown in Table B2, Appendix B.

While there is expected to be an overall increase in surface water outflows in the western catchment as result of the development, it should be noted that the actual magnitude of the increase in surface water outflows is relatively small with an annual average increase in the order of 1 L/s at the downstream extent of the western catchment. While the modelling indicates that there will be a small increase in the overall annual average discharge at the downstream extent

of the western catchment, the peak discharges from the developed site during storm events will be detained by the stormwater retention ponds.

Further to the assessment described above, it is worth noting that the larger lifestyle lots will have a similar level of development to the lifestyle lots within the eastern catchment (i.e. less impervious surfaces) and will harvest rainwater in tanks that will be used for drinking water, irrigation or gardens and lawns. Treated wastewater in these larger lots will also be disposed of to ground via dripline irrigation. Similar to the lots in the eastern catchment, the disposal of treated wastewater to ground and irrigation of gardens/lawns within the larger lifestyle lots in the western catchment provide a source for groundwater recharge and interflow to the wetlands in the western catchment. This contribution has conservatively been left out of the modelled water balance which would further increase the groundwater recharge contribution.

6.1.2 Eastern catchment

The results of the water balance modelling for the eastern catchment are presented in Table 5 below.

Table 5: Results of mass balance modelling – Eastern catchment								
Flows		Pre-development		Post-development		Change		
		(m ³ /yr)	(%)	(m ³ /yr)	(%)	(m ³ /yr)	(L/s) ³	(%)
Inflow	Groundwater recharge (I_{in}) ¹	63,966	69	56,474	52	-7,492	-0.2	-12
	Surface water input (Q_{in})	28,785	31	51,756	48	22,972	0.7	80
	Total Inflow	92,751	100	108,230	100	15,479	0.5	17
Outflow	$I_{out} + G_{out}$ ²	119	<1	119	<1	0	0	0
	Surface Water Outflow (Q_{out})	92,632	>99	108,111	>99	15,479	0.5	17
	Total Outflow	92,751	100	108,230	100	15,479	0.5	17
Note: 1. Groundwater inflow (G_{in}) assumed to be zero. 2. $I_{out} + G_{out}$ is the combined interflow and groundwater outflows. 3. Change in L/s is the annual average change as an instantaneous rate.								

The pre-development water balance model for the eastern catchment indicates groundwater recharge is the dominant inflow for wetlands in the eastern catchment of the Site. Post-development, the model indicates that there will a small reduction in the groundwater recharge contribution and an increase in surface water inflows, although groundwater recharge will remain the dominant

inflow. Groundwater recharge is still expected to be the major inflow even post-development as the eastern catchment is proposed to be comprised only of lifestyle blocks and therefore there will still be a significant component of rainfall infiltration entering the shallow groundwater system as recharge. Surface water outflows are the dominant outflow for both the pre and post development states of the Site.

The modelling for the eastern catchment indicates that there will be an overall increase in surface water outflows from the catchment as result of the development. However, the actual magnitude of the increase in surface water outflows is relatively small as the model indicates an annual average increase in the order of 0.7 L/s. It should be noted that although the modelling indicates a small overall annual average increase in the discharge from the eastern catchment into the established wetland east of the Site, the peak discharges from the developed Site during storm events will be detained by the stormwater retention ponds. The modelling also indicates that there will be a small decrease in the annual average groundwater recharge by around 0.2 L/s (on an annual basis). These small changes in the annual average groundwater recharge and surface water flow are not likely to be measurable as the effect they will have will be within the natural fluctuations.

As previously noted, the proposed development of the eastern catchment will only consist of lifestyle sections which have relatively small impervious areas associated with them (compared with residential development) and therefore will generally require less modification of catchments upgradient/upstream of the smaller, disseminated wetlands located in the upper reaches of the eastern catchment. The relatively small extent of these wetlands (wetland areas generally less than 130 m²) indicates that their catchments are also relatively small and therefore less likely to be impacted by development in this catchment.

As previously noted, there are additional groundwater inputs which would increase groundwater recharge but have been conservatively excluded from the assessment component. These are:

- ✧ Seepage losses to ground through the base of the stormwater ponds.
- ✧ Discharge of stormwater from building roofs located near the heads of gullies and/or upstream of wetlands located higher in the catchment (and upstream of stormwater detention ponds).
- ✧ Groundwater recharge of onsite disposal of treated wastewater and irrigation of lawns/gardens.

These groundwater recharge aspects are difficult to estimate and therefore have been excluded, adding to the conservatism of the assessment as including the effect of these discharges would make the already small change in groundwater recharge between pre- and post-development states even smaller.

Overall, the modelling indicates that there will be an annual average increase of 0.5 L/s or 17% increase in the total throughflow of water through the eastern catchment wetland on an annual basis which is expected to result in a positive increase in water flow through the broader eastern catchment. The overall increase in throughflow and increased frequency of inflow to the wetlands is considered to be a beneficial and net positive outcome for wetland areas within the Site boundary as well as the large, developed wetland located southeast of the Site boundary. It is worth noting that an annual average increase in throughflow of 0.5 L/s is of a magnitude that will likely be difficult to discern from the natural fluctuations in groundwater levels or surface flows at the Site.

Further to the assessments described above for both the western and eastern catchments, international research into the broader, longer-term effect of urbanisation on groundwater recharge indicates that it is possible for urbanisation to increase groundwater recharge as it causes a reduction in evapotranspiration compared to the pre-development state and also an additional source of groundwater recharge in the form of leakage from water pipes and sewer connections over time (Mining et al., 2018). This supports the conservative nature of the water balance modelling.

6.2 Potential for interception of groundwater

As noted previously, a potential issue from the proposed development is the interception of groundwater during excavations for cuts or trenching for service installations. Staig and Smith have provided an isoline map of expected excavation depths and a copy of this map is shown in Appendix E, and the percentage of earthworks extent across each of the western and eastern catchments have been discussed in Section 4.0. The excavation depth isoline maps indicate that the maximum expected excavation depths at the Site during development will be in the order of 4 m below existing ground level. The maps also indicate the majority of the earthworks and excavations will occur below ridgelines and spurs but more than 10 m from any wetland areas.

The available groundwater level measurements in the monitoring bore (WWD24683) indicate that groundwater levels are on average around 2 m bgl (up to 1.5 m) at a distance of approximately 10 m from the closest wetland and the depth to groundwater is expected to increase with distance upgradient of the wetlands. The isoline maps in Appendix E indicate that there will be no earthworks/excavations within 10 m of any wetland at the Site with the closest excavation proposed to a depth of 1 m bgl at a distance of approximately 13 m from the nearest wetland. While groundwater levels are likely to vary across the Site as well as seasonally, excavations at the Site as part of the development are unlikely to result in diversion or interception of groundwater with the development aspect likely to cause the biggest changes being from the establishment of impervious surfaces. However, even changes in recharge from

the establishment of impervious surfaces is expected to be relatively small and immeasurable, as described in Section 6.1.

7.0 Policy consistency and regulatory compliance

This section of the report describes the relevant groundwater-related aspects of the TRMP – Rural 3 (Part 2, Appendix 3) design guidelines that need to be considered as part of Rural 3 land development and the NES-F.

7.1 TRMP – Rural 3

As previously mentioned, the Tahimana Subdivision is zoned Rural 3 in the TRMP. Part 2, Appendix 3 of the TRMP provides guidelines for subdivisions and developments within the Coastal Tasman region to help developers minimise adverse environmental effects on rural land and to retain rural and coastal values.

In terms of impacts on groundwater that need to be considered as part of developments and subdivisions within land zoned Rural 3, the guidelines indicate that stormwater management should be considered as an option for enhancing groundwater recharge (Section 3.4 (f) of the guidelines) and that groundwater should be considered as part of the design of wastewater disposal fields (Section 3.6 (b) of the guidelines).

The available groundwater level data indicate that groundwater is generally on average around 2 m bgl approximately 10 m from wetlands at the Site and is inferred to be at greater depths with increasing distance upgradient of the wetlands due to the sloping nature of the Site. Envirolink (2026) indicate that onsite wastewater disposal will occur at a minimum of 20 m from any mapped wetlands. The depth of wastewater driplines at the Site are expected to be 100 – 150 mm (Envirolink. Pers. Comm. 23 August 2023). Based on the available data, groundwater is unlikely to inundate the proposed dripline disposal system.

In their assessment, Envirolink initially indicated that soakage rates for soils at the Site would be too low for disposal of stormwater to ground and therefore was not considered a viable option (Envirolink, 2026). However, it should be noted that soak pits have now been included for the western catchment and stormwater management for the Site involves the use of stormwater detention ponds which will be unlined and will likely allow a small quantity of water to recharge back to groundwater.

In terms of hydrogeology, the proposed development of the Tahimana subdivision is consistent with the relevant guidelines for Rural 3 land as outlined in the TRMP (Part 2, Appendix 3).

7.2 National Environmental Standard (NES) for Freshwater (2020)

This section provides a discussion of the relevant regulations in the National Environmental Standard for Freshwater (NES-F) (2020). Activities that require hydrogeological consideration are:

- ✧ Regulation 38 – Restoration, wetland maintenance, and biosecurity of natural wetlands.
- ✧ Regulation 52 – Drainage of natural wetlands.
- ✧ Regulation 54 – Other activities.

Table 6 provides a summary of the relevant regulations along with a discussion of the relevant regulations and activity associated with the development.

Table 6: Summary of potentially relevant NES-F (2020) regulations and discussion

Activity / Regulation	Discussion
Wetland restoration activities: <u>Regulation 38:</u> ❖ If any restoration activities involve taking, use, damming, diversion or discharge of water within a 100m setback from a natural inland wetland, is there a hydrological connection between the taking, use, damming, diversion, or discharge and the wetland; and will the taking, use, damming, diversion, or discharge change, or be likely to change, the water level range or hydrological function of the wetland?	No restoration activities as part of the development will involve the taking, use, damming, diversion or discharge of water within a 100m setback from a natural inland wetland.
Stormwater detention basins: <u>Regulation 52:</u> ❖ Do the basins require earthworks or the taking, use, damming, or diversion of water within 100m of a natural inland wetland where the earthworks will or are likely to result in complete or partial drainage of all or part of a natural inland wetland? <u>Regulation 54:</u> ❖ Do the basins involve taking, use, damming, or diversion of water within a 100 m setback from a natural inland wetland where there is a hydrological connection between the taking, use, damming, or diversion and the wetland; and the taking, use, damming, or diversion will change, or is likely to change, the water level range or hydrological function of the wetland?	The groundwater assessments presented in this report show that the activities within 100 m of the wetlands at the Site will have a hydrological connection and will result in a small, positive change to surface water flows through the wetlands. Stormwater detention basins at the Site will not result in complete or partial drainage of inland natural wetlands at the Site.

Table 6: Summary of potentially relevant NES-F (2020) regulations and discussion

Activity / Regulation	Discussion
Earthworks for roads and building platforms: <u>Regulation 54:</u> ❖ Will cuts result in diversion of water within 100m of a natural inland wetland where the earthworks will or are likely to result in complete or partial drainage of all or part of a natural inland wetland?	Earthworks associated with the development will occur within 100 m of the wetlands at Site. However, the earthworks will not result in the complete or partial drainage of any wetlands at the Site. Available groundwater level information measured at the Site indicates that earthworks and cuts are unlikely to intercept groundwater and therefore will not result in complete or partial drainage of the wetlands at the Site.

The proposed subdivision development at the Site will involve earthworks within 100 m of natural inland wetlands. The catchment scale assessments discussed in the previous sections of this report indicate that there will be a hydrological connection and that the development will also result in a change in the hydrological function of the wetlands primarily from the creation of impervious surfaces (i.e. roads, driveways, roof areas etc.). However, it should be emphasized that the change in hydrological function will be a small reduction in groundwater at a scale that will be indiscernible from natural fluctuations in groundwater level. The development of the Site will result in an increase in the overall annual average surface water flow through the wetlands at Site. This overall increase in surface flow through the wetlands is considered by the project ecologist to have a “*...potential benefit to the health of the wetlands*” (RMA Ecology, 2026) due to an increased availability of water moving through the system. Furthermore, the proposed development within 100 m of the wetlands at the Site will not result in partial or complete drainage of the wetlands.

8.0 Conclusions

A number of wetlands have been identified at the Tahimana Subdivision. The main concerns from the proposed subdivision development on the wetlands across the Site are:

- ✧ Interception of groundwater via excavations such as cuts and trenches, diverting groundwater recharge from wetlands.
- ✧ Reduction of groundwater recharge that sustains wetlands at the Site from establishing impervious surfaces and stormwater management systems.

Site inspections of the wetlands indicate that the wetlands located near the heads of gullies are likely sustained by groundwater/interflow seeps as well as overland flow while the wetlands located lower in the catchment at the bottom of the valley areas are expected to be connected to a broader groundwater system in the area, although this interaction with deeper groundwater is unknown.

To assess these potential issues, groundwater level monitoring between October 2023 and May 2026 indicates that groundwater levels are on average 2 m bgl (highest recorded water level of around 1.5 m bgl) at approximately 10 m upgradient of the wetlands and the depth to groundwater is expected to increase with distance upgradient of the wetlands. Isoline contours of areas of cut and fill for the proposed subdivision indicate that the deepest excavations (up to 4 m bgl) will occur outside of wetland areas, below ridgelines, where the depth to groundwater is expected to be greater. The available information does not indicate that there will be any interception of groundwater from excavations as part of development at the Site.

To assess the impact of the establishment of impervious surfaces, mass water balance models were developed for the broader eastern and western catchments at the Site. To determine the inputs to the water balance, a soil moisture balance calculator was used to calculate annual average groundwater recharge and surface water runoff volumes in the existing pre-development state of the Site. Post-development mass water balance models were also created which allowed the effect of the establishment of impervious surfaces and stormwater management systems for each of the broader western and eastern catchments to be assessed. The model for the western catchment included the contributions of soak pits as a means of reducing stormwater runoff and increasing groundwater recharge for the post-development scenario.

The modelling indicates that there will be a small decrease in the groundwater recharge component for both the eastern and western catchments due to the creation of impervious surfaces and a subsequent overall increase in the surface flow contribution from stormwater. The modelling for the western catchment indicated a small increase in groundwater recharge resulting from the proposed soak pit contributions, and a subsequent net increase in the surface flow contribution from stormwater, resulting from a higher proportion of impervious areas on residential properties. It is emphasized that the modelling indicates that the reduction in groundwater recharge in the eastern and western catchments will be a small reduction in groundwater levels at a scale that will likely be indiscernible from natural fluctuations in groundwater level/surface water flows.

The mass water balance modelling also indicated that there will be a net overall increase in the total volume of water through each of the eastern and western catchment systems post-development which the project ecologist has indicated will have an overall positive outcome for the wetlands at the Site. Furthermore, the increase in throughflow predicted for the eastern catchment is also expected to result in a positive outcome for the large, developed wetland located southeast of the Site boundary.

The proposed development at Site is consistent with the TRMP (Part 2, Appendix 3) guidelines for developments within land zoned Rural 3. A comparison of the groundwater related aspects of the proposed development with the relevant regulations of the NES-F (2020) has been provided to assist an assessment of compliance with the NES-F.

9.0 References

- Basher, L. R. & Jackson, R., 2002. *Soil properties and hydrological processes on Moutere gravels*, Nelson, s.l.: Landcare Research.
- Bouwer, H., Rice, R.C. 1976. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. *Water Resources Research*. 12(3). 423.
- Campbell, D.I. & Jackson, R.J. 2004. Hydrology of wetlands. *Freshwaters of New Zealand* (ed. by J. Harding, P. Mosley, C. Pearson and B. Sorrell). New Zealand Hydrological Society Inc., New Zealand Limnological Society Inc., Christchurch, New Zealand.
- Envirolink. 2026. Stormwater, Wastewater and Water Servicing Assessment: Tahimana Limited. 30 June 2026. Prepared by David Carlson-McColl.
- Freeze, R.A. and Cherry, J.A. (1979) *Groundwater*. 2nd Edition, Prentice Hall, Eaglewood, Cliff, NJ, 604 pp
- Kruseman, G. P., de Ridder, N. A. 1990. *Analysis and evaluation of pumping test data. 2nd edition*. International Institute for Land Reclamation and Improvement. Wageningen, The Netherlands.
- Minning, M, Moeck, C., Radny, D., Schirmer, M. (2018). *Impact of urbanisation on groundwater recharge rates in Dubendorf, Switzerland*. *Journal of Hydrology* 563 (2018), pg 1135 - 1146).
- RMA Ecology Ltd. 2026. Tahimana, Subdivision, Tasman: Fast Track Ecological Effects Assessment. Prepared by Emily Roper. July 2026.
- Rattenbury, M., Cooper, R. & Johnson, M., 1998. *Geology of the Nelson Area*, Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences.
- Stewart, M. K., Thomas, J. T., Norris, M. & Trompetter, V., 2004. Paleogroundwater in the Moutere Gravel Aquifers Near Nelson, New Zealand. *Radiocarbon*, 46(2), pp. 517 - 529.
- Thomas, J., 1992. *Hydrogeology of the Moutere Valley with emphasis on groundwater recharge*, s.l.: Unpublished Tasman District Council Report, 8 pp.
- Thomas, J. T., 1989. *Hydrogeology of the Moutere Valley, Nelson, New Zealand.*, University of Canterbury: Unpublished MSc Eng. Geol. Thesis, Department of Geology.

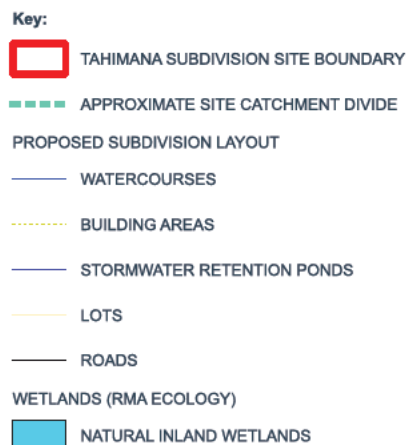
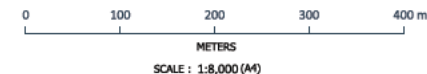


FIGURE 1: TAHIMANA SUBDIVISION LOCATION AND SITE EXTENT

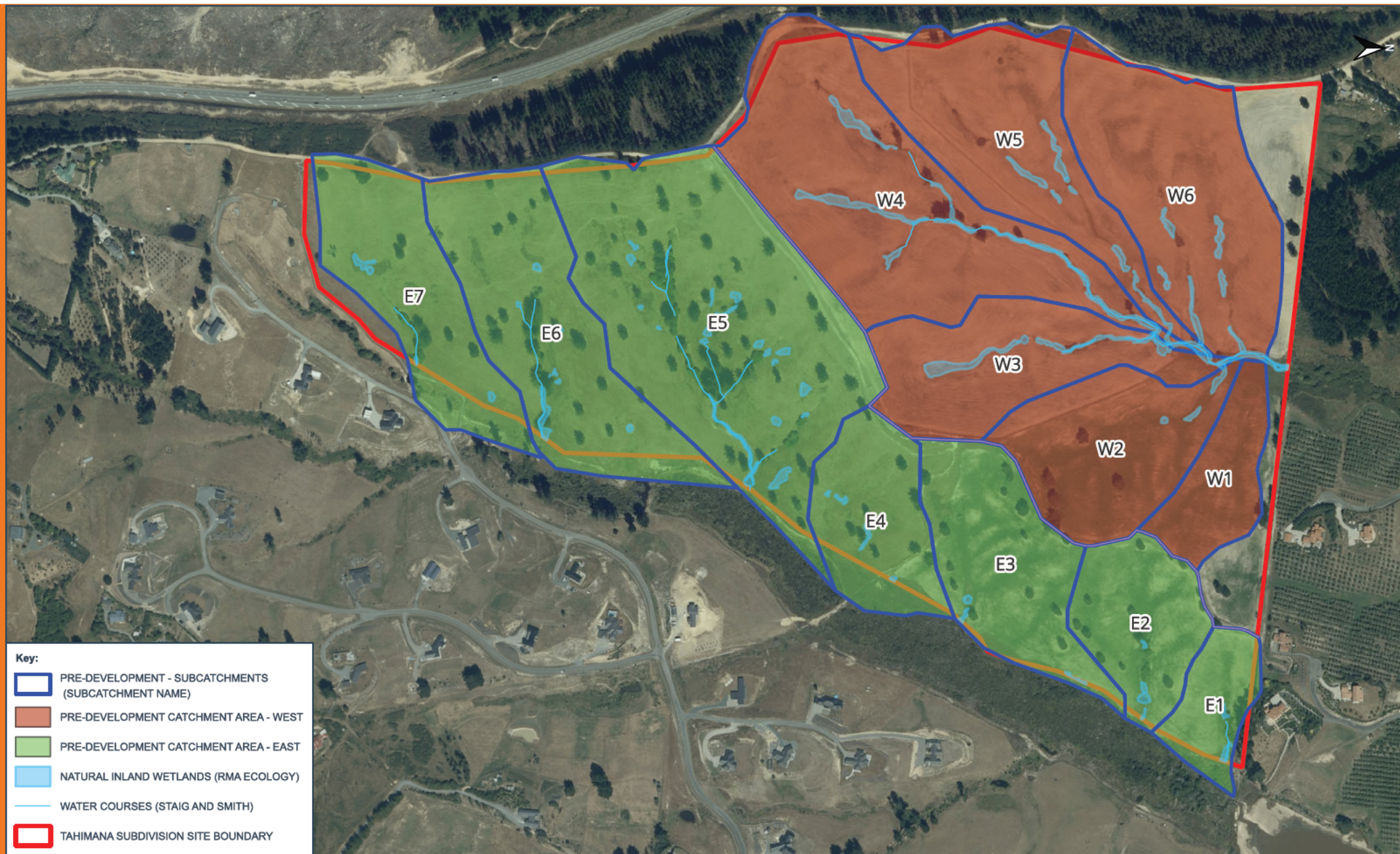


NOTES:
1. AERIAL IMAGERY SOURCED FROM THE LINZ DATA SERVICE (<https://data.linz.govt.nz/>) AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.

THIS DRAWING REMAINS THE PROPERTY OF PATTLE DELAMORE PARTNERS LTD AND MAY NOT BE REPRODUCED OR ALTERED WITHOUT WRITTEN PERMISSION. NO LIABILITY SHALL BE ACCEPTED FOR UNAUTHORISED USE OF THE DRAWING



REVISION: 03 | DATE: MAY 26 | BY: RN
CLIENT: TAHIMANA LIMITED



Key:

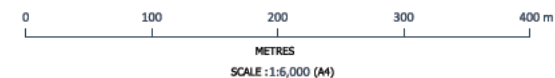
- PRE-DEVELOPMENT - SUBCATCHMENTS (SUBCATCHMENT NAME)
- PRE-DEVELOPMENT CATCHMENT AREA - WEST
- PRE-DEVELOPMENT CATCHMENT AREA - EAST
- NATURAL INLAND WETLANDS (RMA ECOLOGY)
- WATER COURSES (STAIG AND SMITH)
- TAHIMANA SUBDIVISION SITE BOUNDARY



FIGURE 2: TAHIMANA SUBDIVISION PRE DEVELOPMENT CATCHMENTS AND WETLANDS

NOTES:
1. AERIAL IMAGERY SOURCED FROM THE LINZ DATA SERVICE (<https://data.linz.govt.nz/>) AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.

THIS DRAWING REMAINS THE PROPERTY OF PATTLE DELAMORE PARTNERS LTD AND MAY NOT BE REPRODUCED OR ALTERED WITHOUT WRITTEN PERMISSION. NO LIABILITY SHALL BE ACCEPTED FOR UNAUTHORISED USE OF THE DRAWING



REVISION: 05 | DATE: JUL 26 | BY: RN
CLIENT: TAHIMANA LIMITED

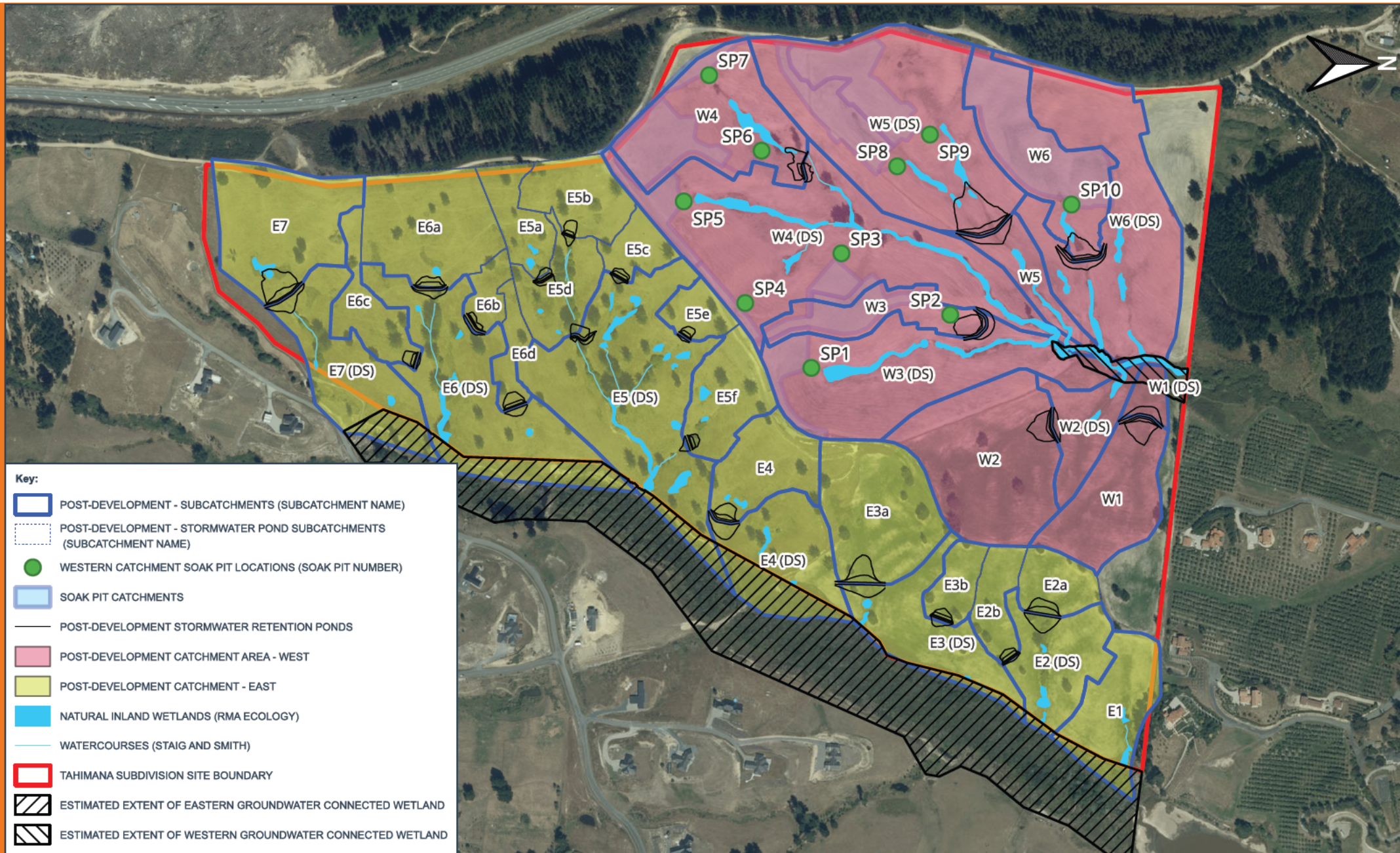


FIGURE 3: TAHIMANA SUBDIVISION POST-DEVELOPMENT CATCHMENTS AND WETLANDS

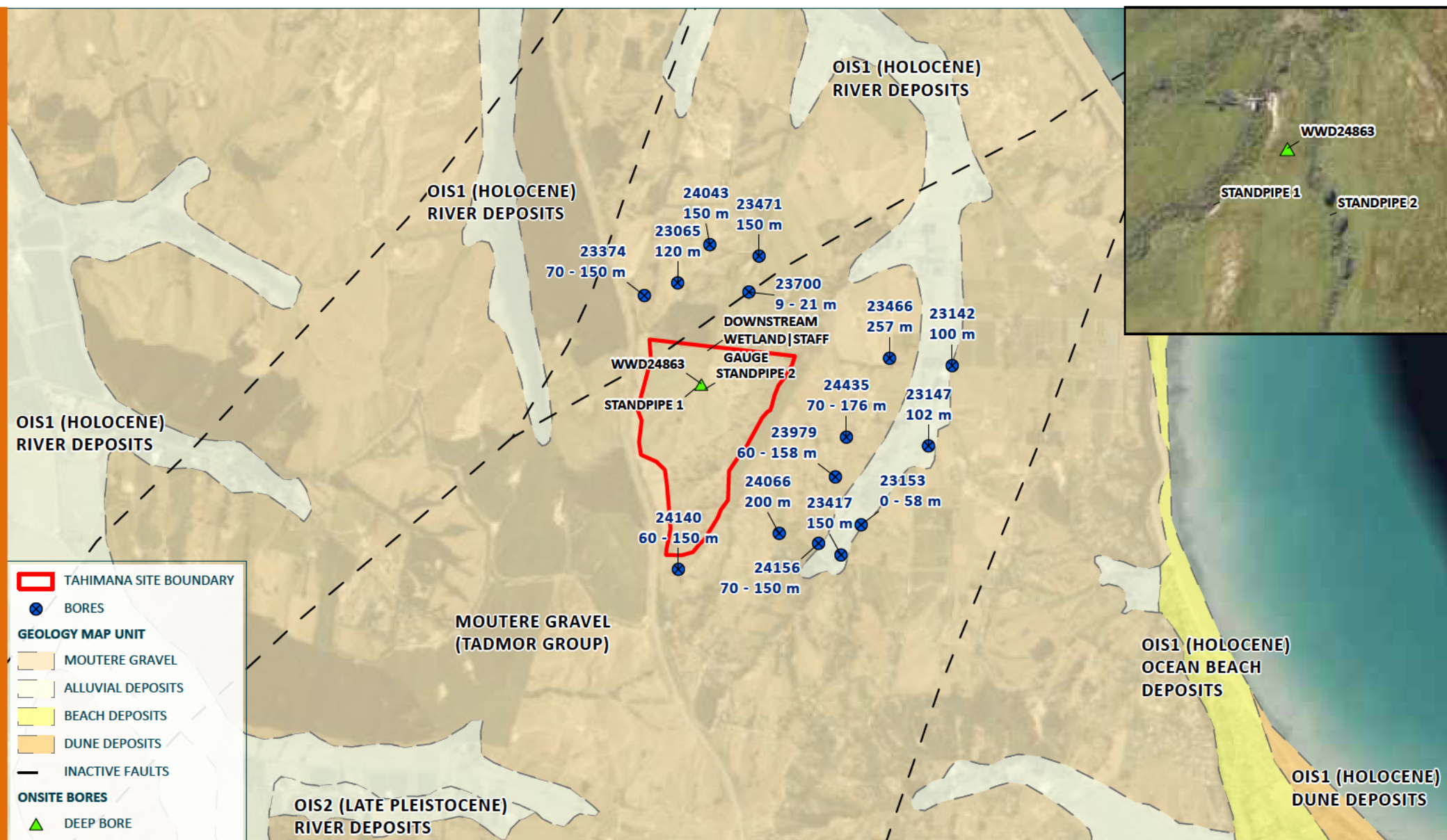


FIGURE 4: BORES WITHIN 1 KM AND GEOLOGY SURROUNDING THE TAHIMANA SUBDIVISION SITE

TAHIMANA SUBDIVISION HYDROGEOLOGY INVESTIGATION

SOURCE:
 1. AERIAL IMAGERY: EAGLE TECHNOLOGY, LINZ, STATS NZ, NIWA, NATURAL EARTH, © OPENSTREETMAP CONTRIBUTORS, DEPRECATED BASEMAP - EAGLE TECHNOLOGY, LAND INFORMATION NEW ZEALAND, EAGLE TECHNOLOGY, LAND INFORMATION NEW ZEALAND, GBCO, COMMUNITY MAPS CONTRIBUTORS.
 2. QMAP GEOLOGY MAP DERIVED FROM GNS SCIENCE WEB MAPS AND WEB SERVICES (19/07/2023)

0 400 800
 METRES

SCALE : 1:30,000 (A4)

REVISION: 01 | DATE: JUL 23 | BY: CF
 CLIENT: TAHIMANA LIMITED

THIS DRAWING REMAINS THE PROPERTY OF PATTLE DELAMORE PARTNERS LTD AND MAY NOT BE REPRODUCED OR ALTERED WITHOUT WRITTEN PERMISSION. NO LIABILITY SHALL BE ACCEPTED FOR UNAUTHORISED USE OF THE DRAWING.
 CD4732500R001_FIGURE2

© 2024 Pattle Delamore Partners Limited

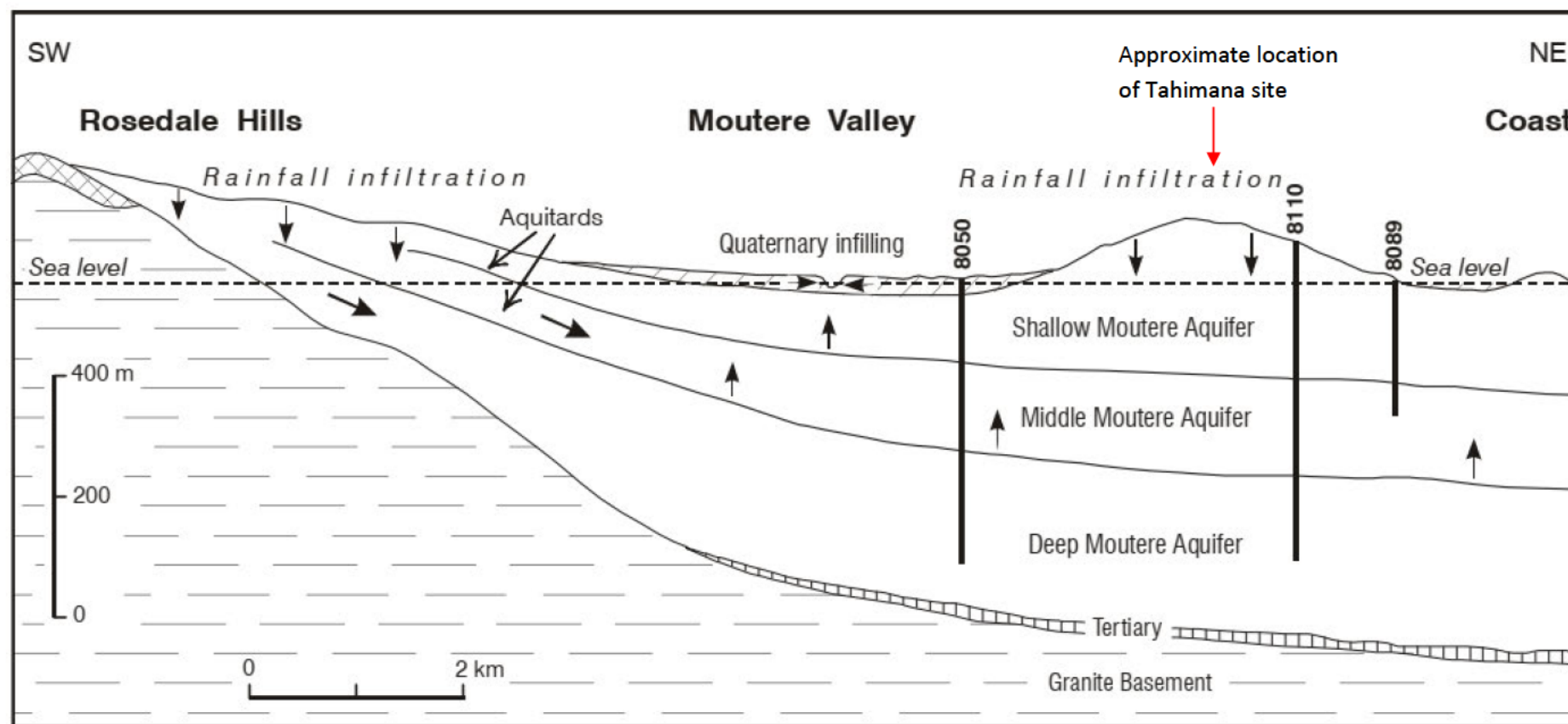
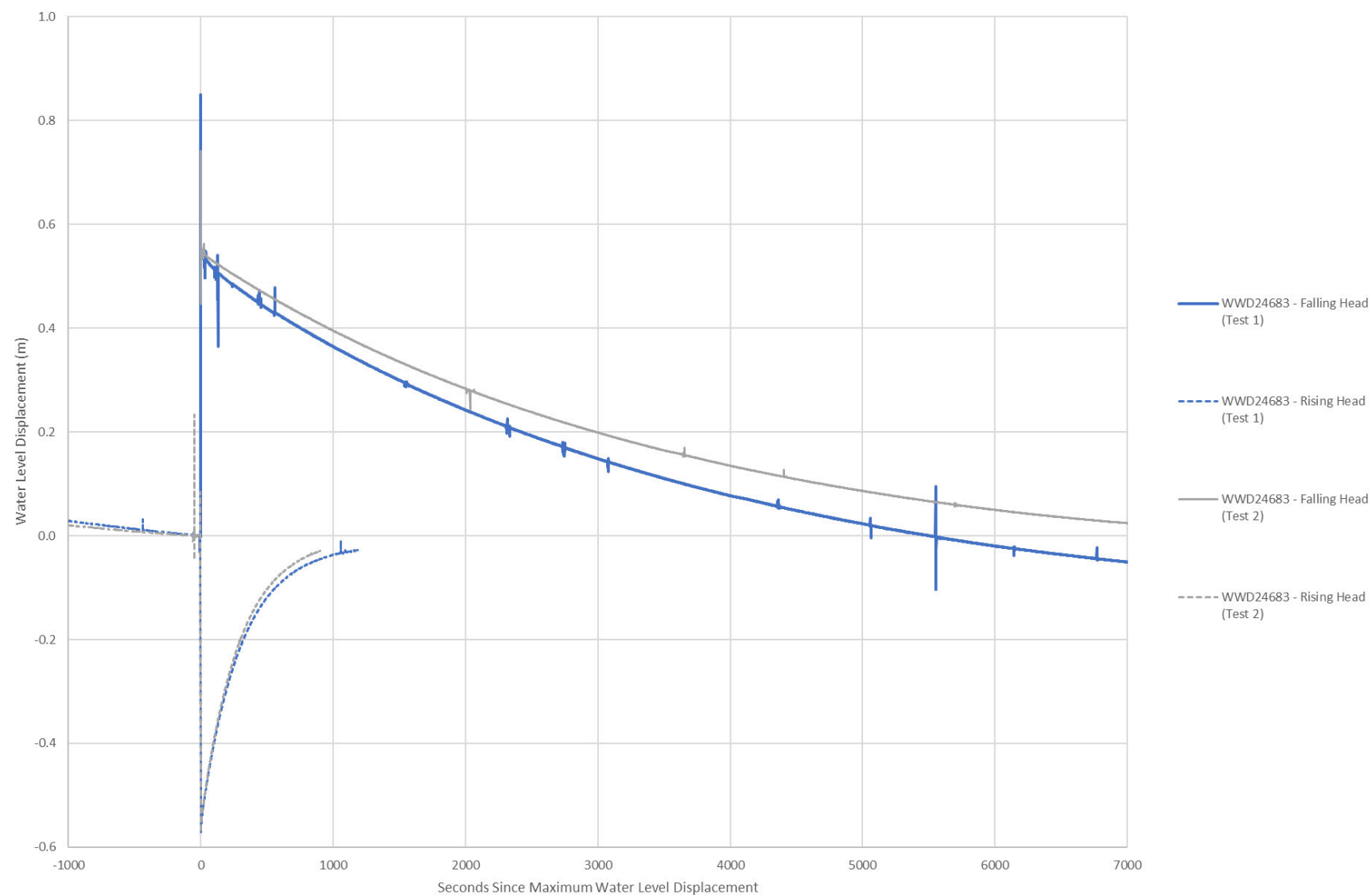


FIGURE 5: SCHEMATIC GEOLOGICAL CROSS SECTION FOR THE MOUTERE VALLEY AREA. APPROXIMATE TAHIMANA SITE LOCATION INDICATED BY THE RED ARROW. ADAPTED FROM STEWART & THOMAS (2002).

**FIGURE 6: OBSERVED WATER DISPLACEMENT DURING SLUG TESTING IN MONITORING BORE WWD24683**

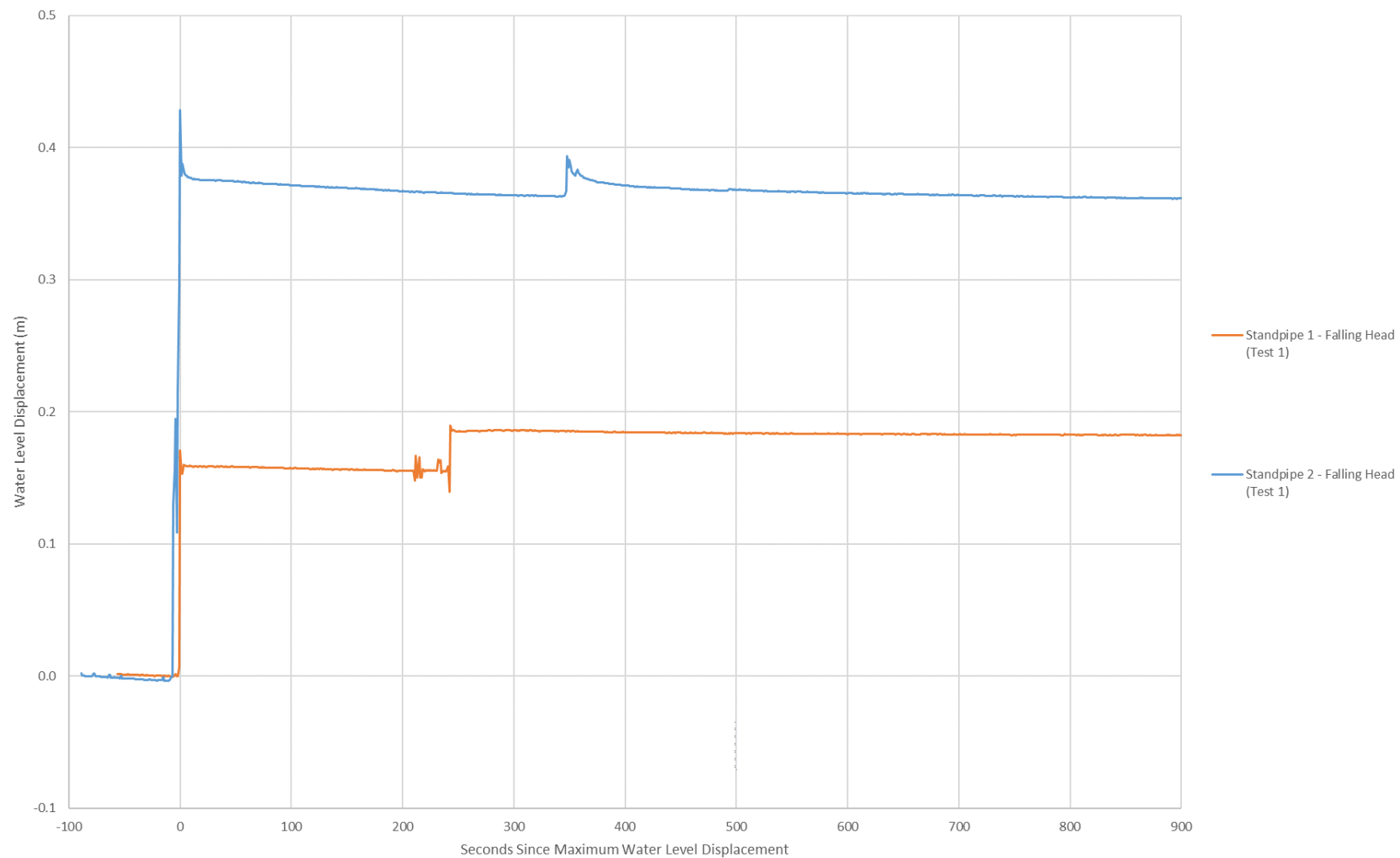


FIGURE 7: OBSERVED WATER DISPLACEMENT DURING SLUG TESTING IN THE WETLAND STANDPIPES 1 AND 2.



FIGURE 8: GROUNDWATER LEVELS MEASURED AT THE TAHIMANA SITE

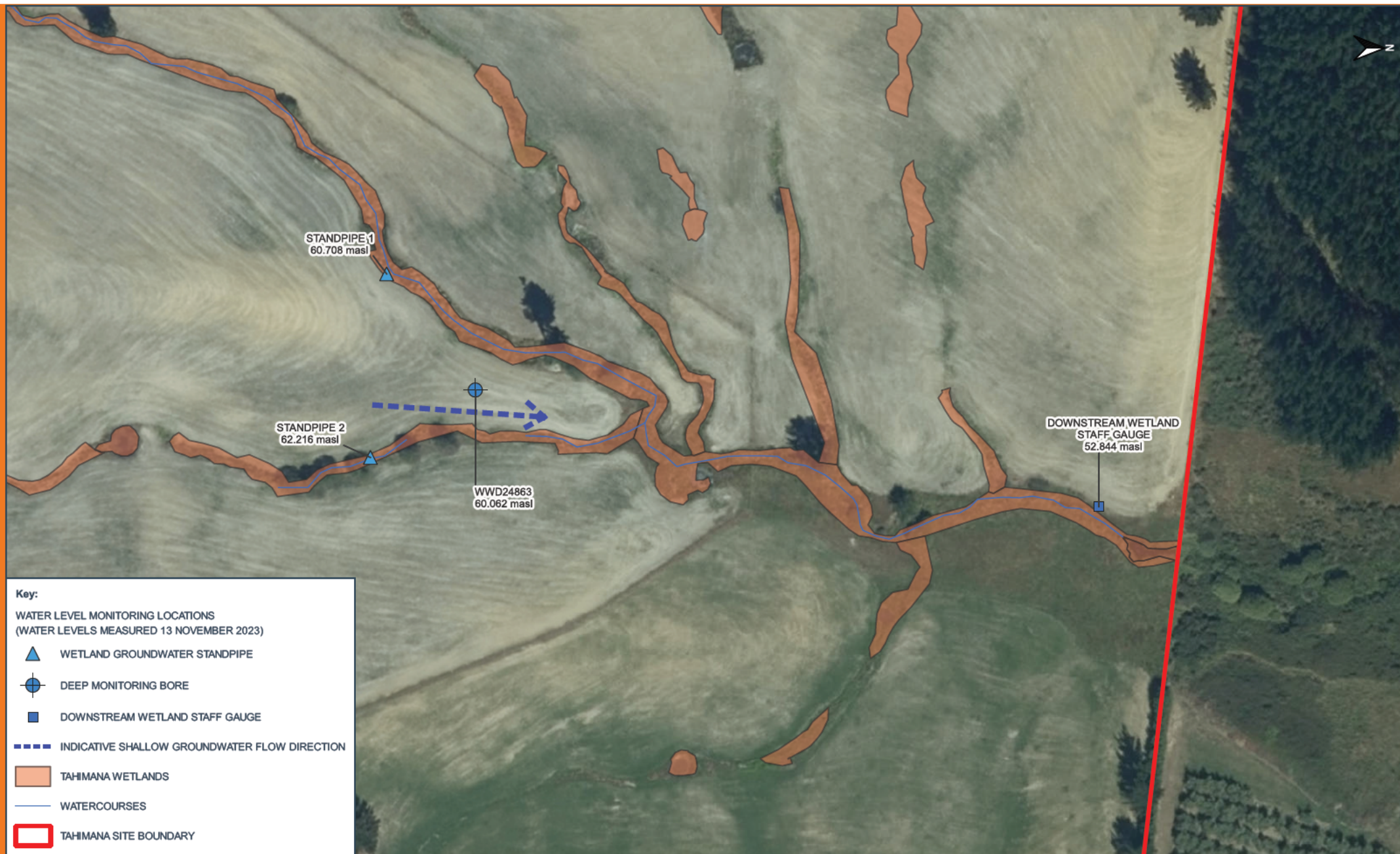


FIGURE 9: WATER LEVEL MONITORING LOCATIONS AND INDICATIVE GROUNDWATER FLOW DIRECTION

NOTES:
1. AERIAL IMAGERY SOURCED FROM THE LINZ DATA SERVICE (<https://data.linz.govt.nz/>) AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.

THIS DRAWING REMAINS THE PROPERTY OF PATTLE DELAMORE PARTNERS LTD AND MAY NOT BE REPRODUCED OR ALTERED WITHOUT WRITTEN PERMISSION. NO LIABILITY SHALL BE ACCEPTED FOR UNAUTHORISED USE OF THE DRAWING

REVISION: 02 | DATE: FEB 24 | BY: RN
CLIENT: TAHIMANA LIMITED



FIGURE 10A: TYPICAL WESTERN CATCHMENT WETLAND.



FIGURE 10B: TYPICAL EASTERN CATCHMENT WETLANDS. NOTE MID-SLOPE WETLAND RIGHT OF CENTRE, WETLANDS WITHIN GULLIES AND AT TOE OF SLOPE TO LEFT. THE LARGE, ESTABLISHED WETLAND TO THE LEFT IS LOCATED OUTSIDE OF TAHIMANA SITE BOUNDARY.

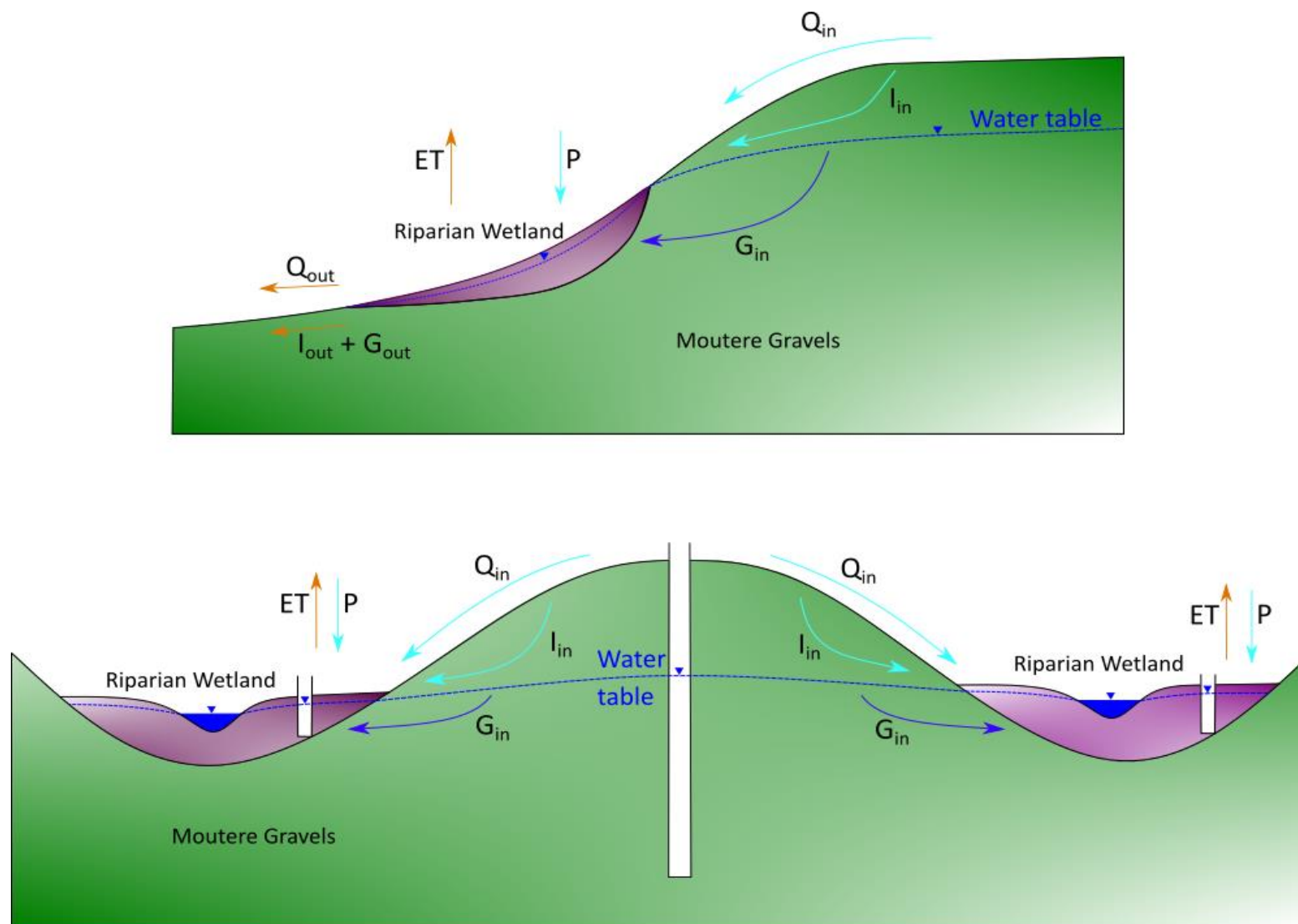


FIGURE 11: SCHEMATIC OF GROUNDWATER CONNECTED WETLAND CONCEPTUAL HYDROLOGY

Table B1: Summary of Tahimana catchment areas**Pre-development**

Catchment	Western (m²)	Eastern (m²)	Total (m²)
Catchment Areas	303,450	319,830	623,280
Wetland area ²	9,498	3,734	13,232

Post-development

Catchment	Western (m²)	Eastern (m²)	Total (m²)
Overall catchment areas	304,420	315,000	619,420
Estimated area of earthworks (excluding stormwater dams) ¹	140,496 (46%)	62,930 (20%)	203,426 (33%)
Wetland area within catchment boundaries ²	9,498	3,734	13,232
Area of eastern boundary wetland (eastern catchment only)	-	71,817	-
Area of catchment upstream of Stormwater Pond	152,300	157,300	306,350
Stormwater Pond Area ³	8,166	5,496	15,324
Total impervious area ³	71,160	30,271	101,431
Impervious area within stormwater pond catchment ³	50,690	27,133	77,823
Impervious area outside of stormwater pond catchment ³	20,470	3,138	23,608

Notes:

1. Earthworks associated with contouring of site (roading, building platforms etc.).
2. Wetland areas delineated by RMA Ecology.
3. Areas provided by Envirolink

Table B2: Summary of western catchment soak pit catchment areas and stormwater infiltration/recharge to ground

Soak pit Catchment	Soak pit catchment area (m ²)	Number of manholes	Total water storage Volume (m ³)	Average annual volume infiltrated to ground (m ³)	Average annual overflow volume (m ³)
1	3,800	2	18.5	623	3,051
2	6,000	2	18.5	603	5,198
3	1,700	2	18.5	574	1,070
4	1,300	2	18.5	547	710
5	4,200	3	27.2	832	3,228
6	6,900	2	18.5	641	6,030
7	1,600	4	35.1	853	694
8	6,200	2	18.5	638	5,356
9	8,400	2	18.5	645	7,476
10	15,300	2	18.5	655	14,137
Total			209.9	6,610	46,950

Table B3: Summary of groundwater outflow calculation parameters

Groundwater connected wetland	Western	Eastern
Wetland width (m)	42	1,115
Saturated thickness (m)	2.8	2.8
Calculated cross-sectional area (m ²)	117	3,122
Hydraulic conductivity (m/day) ¹	0.004	0.004
Hydraulic gradient (m/m)	0.05 ²	0.026 ³

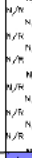
Notes:

1. *hydraulic conductivity estimate of Moutere Gravel Formation soils provided by information from Envirolink for the area.*
2. *estimated from inferred groundwater level contours measured on 13 November 2023.*
3. *estimated from topography of the Eastern catchment.*

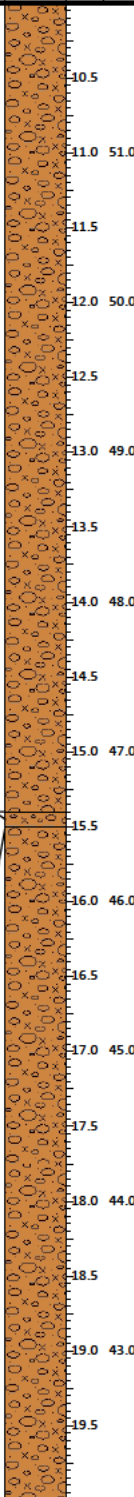
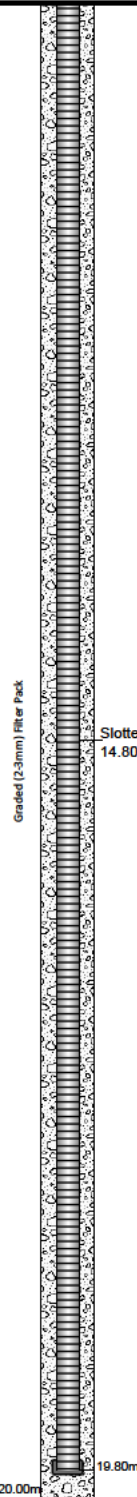
BOREHOLE LOG

Job No.: C04732500
Borehole.: WWD 24683
Sheet: 1 of 3
Date: 08/09/23
Ground Level mRL: 62m (NZVD2016)

Client: Tahimana Limited
Project: Tahimana Subdivision Development
Site Address: Stagecoach Road, Upper Moutere, Tasman
Coordinates: 1604393mE, 5436838mN

Interpretation	Geological Description	Graphic Log	Depth (m)	RL (m)	Method	TCR (%)	PID (ppm)	Samples	SPT N - VALUE	SPT Data (Uncorrected)	Laboratory Results	Installation	Water
Top soil	Sandy SILT; dark brown; moist, non-palstic. Sand: fine.		0.0									0.30m	
No Returns	No Core Recovery - soft and fines washed away.		0.3										
Residual Soil	Clayey sandy SILT; brwon mixed orange, white and grey; 'soft', moist, low plasticity. Sand: fine.		1.5										
Moutere Gravel	Clayey silty, fine to coarse SAND, some gravel, trace cobble; light yellowish brown; moist, well graded. Gravel/Cobble: fine to coarse, slightly weathered to moderately weathered, rounded to subrounded, sandstone, siltstone and granite, max dia. 100 mm.		1.7										
	Silty sandy, fine to coarse GRAVEL, some cobble; light yellowish brown; 'very dense', dry, well graded. Gravel/Cobble: fine to coarse, slightly weathered to moderately weathered, rounded to subrounded, sandstone, siltstone and granite, max dia. 150 mm.		4.0										
	Sandy SILT, some gravel; light yellowish brown; 'medium dense' moist, low plasticity. Sand: fine to coarse. Gravel: fine, slightly weathered to moderately weathered, rounded to subrounded, sandstone, siltstone and granite.		7.5										
	Silty, sandy, cobbly, fine to coarse GRAVEL; light yellowish brown; 'very dense', dry, well graded. Gravel/Cobble: fine to coarse, slightly weathered to moderately weathered, rounded to subrounded, sandstone, siltstone and granite, max dia. 150 mm.		7.7										
			8.0										
			8.5										
			9.0										
			9.5										
			10.0										
			10.5										
Remarks			Grading Legend			Water			Piezometer Data				
No groundwater encountered, center of the core was recovered dry. Stand up toby installed into 0.3 m cement base. Top of PVC casing is 0.2 m above ground level.			% Clay % Silt % Sand % Gravel % Cobble % Boulder			▼ Standing Water Level ↶ In flow ↷ Out flow			REF	DATE / TIME	LEVEL	REMARK	
									24683	11/09/2023	0.55	BH Finished (Not GW)	
									24683	13/09/2023	1.55	Pre-developmnet (Not GW)	
Contractor:		Rig/Plant Used:		Logged By:		Checked By:		Hole Depth:					
CWDRILL		Rotary Drill		EW		KJ		20.00 m					

Site Address:
Stagecoach Road, Upper Moutere, Tasman
Coordinates:
1604393mE, 5436838mN

Interpretation	Geological Description Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).	Graphic Log	Depth (m)	RL (m)	Method	TCR (%) 25 50 75	PID (ppm)	Samples	SPT N - VALUE 10 20 30 40	SPT Data (Uncorrected)	Laboratory Results	Installation	Water
Moultre Gravel	[CONT] Silty, sandy, cobbly, fine to coarse GRAVEL; light yellowish brown; 'very dense', dry, well graded. Gravel/Cobble: fine to coarse, slightly weathered to moderately weathered, rounded to subrounded, sandstone, siltstone and granite, max dia. 150 mm.		10.5	51.0	Rotary cored	100%						 Slotted pipe: 14.80m	Groundwater Not Encountered
	11.0		50.0	100%									
	11.5			100%									
	12.0			100%									
	12.5			100%									
	13.0		49.0	100%									
	13.5			100%									
	14.0		48.0	100%									
	14.5			100%									
	15.0		47.0	100%									
15.5	15.5m: Possible drill binding causing break. Silty, clayey, fine to medium GRAVEL, some sand; light yellowish brown; 'loose', wet, well graded. Gravel: slightly weathered to moderately weathered, rounded to subrounded, sandstone, siltstone and granite. Sand: fine to coarse.	15.5		100%									
16.0	46.0	100%											
16.5	Silty, sandy, cobbly, fine to coarse GRAVEL; light yellowish brown; 'very dense', dry, well graded. Gravel/Cobble: fine to coarse, slightly weathered to moderately weathered, rounded to subrounded, sandstone, siltstone and granite, max dia. 150 mm.	16.5		100%									
17.0	45.0	100%											
17.5		100%											
18.0	44.0	100%											
18.5		100%											
19.0	43.0	100%											
19.5		100%											
EOH: 20.00m Target Depth			20.00m									19.80m	
Remarks			Grading Legend			Water			Piezometer Data				
No groundwater encountered, center of the core was recovered dry. Stand up toby installed into 0.3 m cement base. Top of PVC casing is 0.2 m above ground level.			% Clay % Silt % Sand % Gravel % Cobble % Boulder			▼ Standing Water Level ◁ In flow ▷ Out flow			REF	DATE / TIME	LEVEL	REMARK	
									24683	11/09/2023	0.55	BH Finished (Not GW)	
									24683	13/09/2023	1.55	Pre-developmnet (Not GW)	
Contractor:		Rig/Plant Used:	Logged By:		Checked By:		Hole Depth:						
CWDRILL		Rotary Drill	EW		KJ		20.00 m						

INVESTIGATION LOG

Job No.: C04732500

Test No.: HA01

Sheet: 1 of 1

Date: 08/09/23

Ground Level mRL:

60m (NZVD2016)

Client:
Tahimana Limited

Project:
Tahimana Subdivision Development

Site Address:
Stagecoach Road, Upper Moutere, Tasman
Coordinates:
1604376mE, 5436827mN

Interpretation	Geological Description Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).	Graphic Log	Depth (m)	RL (m)	Squeeze Zone	Samples	Vane Shear Strength (kPa)				Installation	Water
							50	100	150	200		
							Vane: Values					
Topsoil	Sandy SILT, some clay, some organics; dark brown; wet, non-plastic. Sand: fine. Organics: rootlets, vegetated surface.											
Swamp Deposits	Sandy SILT; dark grey; 'very soft', saturated, non-plastic. Sand: fine.		0.5	59.5								
			1.0	59.0								
Moutere Gravel	Sandy, silty, fine to medium GRAVEL; light orange-brown mixed white and grey; 'medium dense', moist, well graded. Gravel: moderately weathered to highly weathered, angular to subrounded, granite and sandstone. Sand: fine to coarse.		1.5	58.5								
			2.0	58.0								
			2.5	57.5								
Remarks Water encountered throughout hole due to surface water from wetlands. Partial sidewall collapse.							Investigation Type ☒ Hand Auger ☐ Test Pit				Water ▼ Standing Water Level ↖ In flow ↗ Out flow	
Contractor: PDP			Rig/Plant Used: 50 mm Hand Auger				Logged By: EW		Checked By: KJ		Hole Depth: 2.50 m	

INVESTIGATION LOG

Job No.: C04732500

Test No.: HA02

Sheet: 1 of 1

Date: 08/09/23

Ground Level mRL:

62.5m (NZVD2016)

Client:
Tahimana Limited

Project:
Tahimana Subdivision Development

Site Address:
Stagecoach Road, Upper Moutere, Tasman
Coordinates:
1604413mE, 5436803mN

Interpretation	Geological Description Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).	Graphic Log	Depth (m)	RL (m)	Squeeze Zone	Samples	Vane Shear Strength (kPa)				Installation	Water
							50	100	150	200		
							Vane: Values					
Topsoil	Sandy SILT, some clay, some organics; dark brownish grey; wet. Sand: fine. Organics: rootlets, grassed surface.											13/09/2023 13:00
Swamp Deposits	Sandy SILT, trace clay; dark grey; 'very soft', saturated, non-plastic. Sand: fine. 0.2m - 1.2m: Poor recovery - saturated and not recovered from auger.		0.5	62.0	Minor							
Moutere Gravel	Silty, fine to coarse SAND; orange-brown mixed white and grey; 'medium dense', wet, poorly graded. EOH: 1.50m Target Material		1.0	61.5								
			1.5	61.0								
			2.0	60.5								
			2.5	60.0								
Remarks							Investigation Type				Water	
Water encountered throughout hole due to surface water from wetlands. Partial sidewall collapse.							☒ Hand Auger ☐ Test Pit				▼ Standing Water Level ◁ In flow ▷ Out flow	
Contractor:			Rig/Plant Used:				Logged By:		Checked By:		Hole Depth:	
PDP			50 mm Hand Auger				EW		KJ		1.50 m	

Waimea Drilling Co Ltd

Drillers Water Well Log Form

RMO30331
WWD 23374
8202

MEMBER OF
N.Z.D.F.

WDC Log No 6620

Well Owner

Contact Name

Map Sheet No N27

Altitude (m): 83.00

Grid Ref East 0

North 0

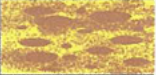
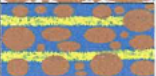
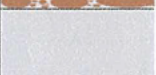
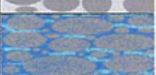
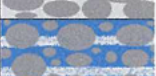
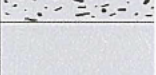
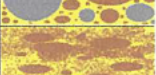
GPS Easting 251-40-550

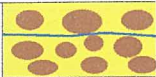
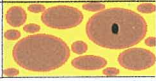
GPS Northing: 59-99-040

Driller

Drilling Date 09/07/2007

Locality Southern end of Williams Rd.

Depth To Strata		Strata Thickness (m)	Static Level (m)	Strata Description	Strata Picture
Top (m)	Bottom (m)				
0.00	1.00	1.00		Yellow clay and brown medium gravels	
1.00	88.00	87.00		Brown coarse gravels to medium sand yellow clay bound	
88.00	90.00	2.00		Brown coarse gravel to medium sand, grey clay bound	
90.00	90.20	0.20	30.00	Brown coarse gravels, some yellow clay, water bearing	
90.20	97.50	7.30		Brown coarse gravels to medium sand yellow clay bound	
97.50	98.50	1.00		Brown coarse gravel to medium sand, grey clay bound	
98.50	101.00	2.50		Grey clay	
101.00	121.00	20.00		Brown and grey coarse gravels, yellow clay bound	
121.00	125.50	4.50		Grey coarse gravels, grey clay bound	
125.50	125.70	0.20	30.00	Grey/blue coarse gravels to coarse sand, some blue clay, water bearing	
125.70	129.00	3.30		Grey/blue cobble to medium sand, blue clay	
129.00	130.20	1.20		Grey coarse gravels, grey clay bound	
130.20	130.50	0.30	30.00	Grey coarse gravel, some grey clay, water bearing	
130.50	132.00	1.50		Grey clay, some lignite	
132.00	135.00	3.00		Grey clay	
135.00	139.00	4.00		Brown and grey cobble to medium sand, yellow clay bound	
139.00	141.00	2.00		Brown coarse gravels to medium sand yellow clay bound	

141.00	141.20	0.20	30.00	Brown coarse gravels, yellow clay bound, very poor water bearing	
141.20	150.00	8.80		Brown cobble, coarse gravels, yellow clay bound	

Finished Static
Water Level: 30.00

Test Pumping: 5.00 Hours

Draw Down (m): 14.00 Below Static Water Level

Flow Rate: 3.00 cubic mph

Step Test By:

No: 0 Screen Type open hole

Casing above ground (mm): 300

Casing NB Dia
(mm): 150

Ground Level

Screen NB Dia
(mm): 150

Steel Casing
Length (m): 70.00

PVC Casing
Length (m):

Top of Screen Leader (m): 0.00

Top Of Screen (m): 70.00

From:	To:	Slot Size	Length
70.00	150.00	0.00	80.00

Bottom Of Screen (m): 150.00

Length of Sump (m): 0.00

Total Screen
Length (m): 80.00

Finished Depth of Well (m): 150.00

Remarks:

This well has not been fitted with any pvc screen so it can be deepened at a later date if ever nessacery.

PLEASE NOTE:

This well log report is subject to being edited (eg. A down hole flow test may be carried out at any time).

Test pumping flow rates, static levels, and water level draw down are as recorded at the time of test pumping. These figures could change at a later time due to influences beyond our control (e.g. seasonal variations).

Waimea Drilling Co Ltd

Drillers Water Well Log Form

MEMBER OF
N.Z.D.F.

WDC Log No 213

Well Owner

Contact Name

Map Sheet No

Altitude (m): 0.00

Driller

Grid Ref East 0

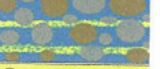
North 0

Drilling Date 09/11/1974

GPS Easting:

GPS Northing:

Locality

Depth To Strata Top (m)	Strata Bottom (m)	Strata Thickness (m)	Static Level (m)	Strata Description	Strata Picture
0.00	9.75	9.75		Concrete lined, existing well	
9.75	11.58	1.83		Yellow clay and brown medium gravels	
11.58	12.19	0.61		Yellow clay	
12.19	14.63	2.44		Yellow clay and brown medium gravels	
14.63	15.54	0.91		Yellow clay	
15.54	18.28	2.74		Yellow clay and brown medium gravels	
18.28	20.42	2.14		Green and grey boulder to fine sand some brown clay	
20.42	20.72	0.30		Brown and grey coarse gravel, some yellow clay, water bearing	
20.72	21.33	0.61		Yellow clay and brown medium gravels	

Casing above ground (mm): 500

Casing NB Dia
(mm): 125

Finished Static
Water Level: 4.38

Test Pumping: 1.00 Hours

Draw Down (m): 0.70 Below Static Water Level

Flow Rate: 2.25 cubic mph

Step Test By:

No: 1 Screen Type Slotted 125mm casing

Leader Length
(m): 0.50

Top of Screen Leader (m): 8.50

Top Of Screen (m): 9.00

From:	To:	Slot Size	Length
9.00	21.00	6.00	12.00

Bottom Of Screen (m): 21.00

Length of Sump (m): 0.33

Finished Depth of Well (m): 21.33

Screen NB Dia
(mm): 125

Ground Level

Steel Casing
Length (m): 9.00

PVC Casing
Length (m):

Total Screen
Length (m): 12.00

Remarks:

This log is reproduced from the original drillers log. No test pumping carried out on this well back in those days. The test pumping figures on this log are from a short pump test carried out on the 2/4/2008. Per Woody.

27/06/2011 12:37:26 p.m.

Page 1 of 2

PLEASE NOTE:

This well log report is subject to being edited (eg. A down hole flow test may be carried out at any time).
Test pumping flow rates, static levels, and water level draw down are as recorded at the time of test pumping. These figures could change at a later time due to influences beyond our control (e.g. seasonal variations).

Waimea Drilling Co Ltd

Drillers Water Well Log Form

MEMBER OF
N.Z.D.F.

WDC Log No 6789

Well Owner [REDACTED]

Contact [REDACTED]

Map Sheet No

Altitude (m): 84.00

Grid Ref East 0

North 0

Driller [REDACTED]

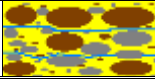
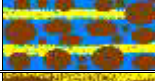
GPS Easting 25-15-153

GPS Northing: 59-97-999

Drilling Date 29/12/2015

Council Consent No:

Locality [REDACTED]

Depth To Strata Top (m)	Strata Bottom (m)	Strata Thickness (m)	Static Level (m)	Strata Description	Strata Picture
0.00	3.00	3.00		Yellow clay and brown medium gravels	
3.00	56.00	53.00		Brown coarse gravels, yellow clay bound	
56.00	95.00	39.00		Brown and grey coarse gravels, yellow clay bound	
95.00	106.00	11.00		Brown and grey coarse gravels to fine sand ,yellow clay bound.	
106.00	106.20	0.20	25.00	Brown and grey coarse gravel to medium sand, yellow clay, poor water bearing	
106.20	117.50	11.30		Brown cobble to medium sand yellow clay bound	
117.50	117.70	0.20	25.00	Brown and grey coarse gravel to medium sand, yellow clay, poor water bearing	
117.70	129.00	11.30		Brown cobble to medium sand yellow clay bound	
129.00	129.80	0.80		Yellow clay	
129.80	133.00	3.20		Brown cobble to medium sand yellow clay bound	
133.00	133.20	0.20	25.00	Brown coarse gravels, some yellow clay, water bearing	
133.20	137.00	3.80		Brown cobble to medium sand yellow clay bound	
137.00	137.20	0.20	25.00	Brown coarse gravels, some yellow clay, water bearing	
137.20	154.00	16.80		Brown cobble to medium sand yellow clay bound	
154.00	154.20	0.20	25.00	Brown coarse gravels, some yellow clay, water bearing	
154.20	158.00	3.80		Brown cobble to medium sand yellow clay bound	

Finished Static
Water Level: 30.00

Test Pumping: 2.00 Hours

Draw Down (m): 20.00 Below Static Water Level

Flow Rate: 3.00 cubic mph

Step Test By:

No: 0 Screen Type Open hole

Casing above ground (mm): 300

Casing NB Dia
(mm): 150

Ground Level

Screen NB Dia
(mm): 0

Steel Casing
Length (m): 60.00

Top of Screen Leader (m): 0.00

Top Of Screen (m): 60.00

From:	To:	Slot Size	Length
60.00	158.00	0.00	98.00

PVC Casing
Length (m):

Bottom Of Screen (m) 158.00

Length of Sump (m) 0.00

Total Screen
Length (m): 98.00

Finished Depth of Well (m) 158.00

Remarks:

PLEASE NOTE:

This well log report is subject to being edited (eg. A down hole flow test may be carried out at any time).
Test pumping flow rates, static levels, and water level draw down are as recorded at the time of test pumping.
These figures could change at a later time due to influences beyond our control (e.g. seasonal variations).

Waimea Drilling Co Ltd

Drillers Water Well Log Form

MEMBER OF
N.Z.D.F.

WDC Log No 6827

Well Owner [REDACTED]
[REDACTED]
[REDACTED]

Map Sheet No

Altitude (m): 93.00

Grid Ref East 0

North 0

Driller [REDACTED]

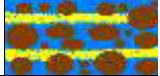
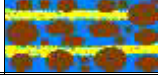
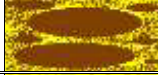
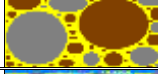
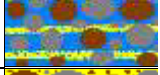
GPS Easting: 25-14-234

GPS Northing: 59-97-487

Drilling Date 18/02/2019

Council Consent No:

Locality [REDACTED]

Depth To Strata Top (m)	Strata Bottom (m)	Strata Thickness (m)	Static Level (m)	Strata Description	Strata Picture
0.00	0.10	0.10		Brown grass and brown topsoil.	
0.10	3.00	2.90		Yellow clay	
3.00	8.00	5.00		Brown coarse gravels, yellow clay bound	
8.00	68.00	60.00		Brown coarse gravels to medium sand yellow clay bound	
68.00	82.00	14.00		Brown cobble to medium sand yellow clay bound	
82.00	82.20	0.20	34.00	Brown coarse gravels, some yellow clay, water bearing	
82.20	95.00	12.80		Brown cobble to medium sand yellow clay bound	
95.00	95.30	0.30	34.00	Brown coarse gravels, some yellow clay, water bearing	
95.30	106.00	10.70		Brown cobble to medium sand yellow clay bound	
106.00	121.50	15.50		Brown and grey cobble to medium sand, yellow clay bound	
121.50	121.70	0.20	34.00	Brown and grey coarse gravel, yellow clay, poor water bearing	
121.70	136.00	14.30		Brown and grey cobble to medium sand, yellow clay bound	
136.00	136.30	0.30	34.00	Brown and grey coarse gravel, some yellow clay, water bearing	
136.30	150.00	13.70		Brown and grey cobble to medium sand, yellow clay bound	

Finished Static
Water Level: 33.90

Test Pumping: 4.00 Hours

Draw Down (m): 24.00 Below Static Water Level

Flow Rate: 3.00 cubic mph

Step Test By:

No: 0 Screen Type slotted pvc

Casing above ground (mm): 400

Casing NB Dia
(mm): 150

Ground Level



Leader Length
(m): 6.00

Screen NB Dia
(mm): 100

Top of Screen Leader (m): 54.00

Steel Casing
Length (m): 0.00

Top Of Screen (m): 60.00

PVC Casing
Length (m):

From:	To:	Slot Size	Length
60.00	150.00	3.00	90.00

Bottom Of Screen (m): 150.00

Length of Sump (m):



Total Screen
Length (m): 90.00

Remarks:

Finished Depth of Well (m): 150.00

PLEASE NOTE:

This well log report is subject to being edited (eg. A down hole flow test may be carried out at any time). Test pumping flow rates, static levels, and water level draw down are as recorded at the time of test pumping. These figures could change at a later time due to influences beyond our control (e.g. seasonal variations).

Waimea Drilling Co Ltd

Drillers Water Well Log Form

MEMBER OF
N.Z.D.F.

WDC Log No 6830

Well Owner

Map Sheet No

Altitude (m): 67.00

Grid Ref East 0

North 0

Driller

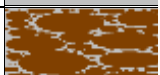
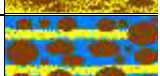
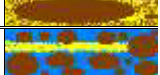
GPS Easting: 25-15-055

GPS Northing: 59-97-630

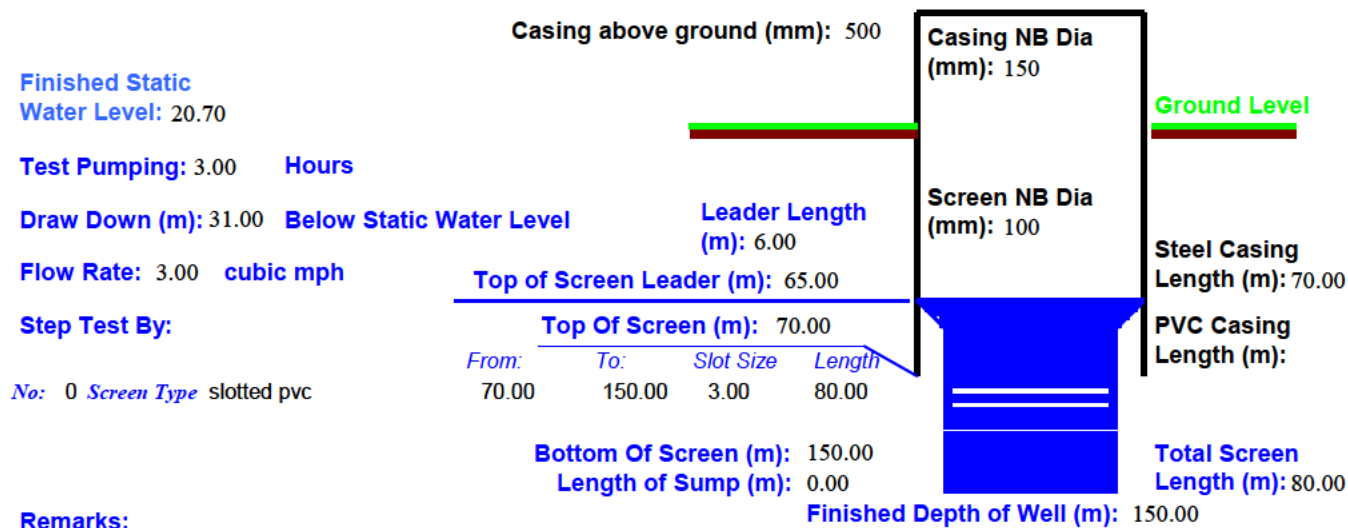
Drilling Date 18/03/2019

Council Consent No: RM 190186

Locality

Depth To Strata Top (m)	Strata Bottom (m)	Strata Thickness (m)	Static Level (m)	Strata Description	Strata Picture
0.00	0.10	0.10		Green grass and brown topsoil	
0.10	65.00	64.90		Brown coarse gravels, yellow clay bound	
65.00	66.00	1.00		Grey clay	
66.00	69.50	3.50		Brown coarse gravel to medium sand, grey clay bound	
69.50	85.00	15.50		Brown coarse gravels to medium sand yellow clay bound	
85.00	85.20	0.20	20.70	Brown coarse gravels, some yellow clay, water bearing	
85.20	92.00	6.80		Brown cobble, coarse gravels, yellow clay bound	
92.00	97.00	5.00		Brown and grey cobble to medium sand, yellow clay bound	
97.00	98.50	1.50		Brown cobble to medium sand yellow clay bound	
98.50	98.70	0.20	20.70	Brown coarse gravels, some yellow clay, water bearing	
98.70	108.70	10.00		Brown cobble to medium sand yellow clay bound	
108.70	108.90	0.20	20.70	Brown coarse gravels, some yellow clay, water bearing	
108.90	109.50	0.60		Brown cobble to medium sand yellow clay bound	
109.50	110.50	1.00		Yellow clay	
110.50	125.30	14.80		Brown and grey cobble to medium sand, yellow clay bound	
125.30	125.80	0.50		Yellow clay	
125.80	133.00	7.20		Brown and grey cobble to medium sand, yellow clay bound	

133.00	133.20	0.20	20.70	Brown and grey cobble to medium sand, some yellow clay, water bearing	
133.20	141.50	8.30		Brown and grey cobble to medium sand, yellow clay bound	
141.50	142.00	0.50		Yellow clay	
142.00	150.00	8.00		Brown and grey cobble to medium sand, yellow clay bound	



PLEASE NOTE:

This well log report is subject to being edited (eg. A down hole flow test may be carried out at any time). Test pumping flow rates, static levels, and water level draw down are as recorded at the time of test pumping. These figures could change at a later time due to influences beyond our control (e.g. seasonal variations).

Bouwer & Rice (1976) Slug Test Analysis Sheet

PATTLE DELAMORE PARTNERS

Project: Tahimana - Falling Head Test 1

Job No: C04732500

Bore ID: WWD24683

Test date: 5/10/2023

Test time: 15:08

Performed by: EW

Analysed by: RN

Reviewed by: NL

Test type: Falling head

Bore depth: 19.8 mBGL

SWL: 2.18 mBGL

Screen radius (rc): 0.016 m

Borehole radius (Re): 0.075 m

Saturated screen length (Le): 14.8 m

Aquifer sat. thickness (h): 20 m

Piezo sat. thickness (Lw): 17.62 m

Slugs used: 3

Slug length: 0.5 m

Slug radius: 0.025 m

Displacement vol: 0.00295 m³

Expected displ: 3.66 m

Obs displacement: 0.85 m

Eff. casing radius: 0.033 m

Correct for displacement: FALSE

Well screened across water table: FALSE

GWL measurement: Depth to water

Static GWL (m): 2.18

Displaced GWL (m): 1.333

Curve fitting:

Y-intercept shift: 0.53 m

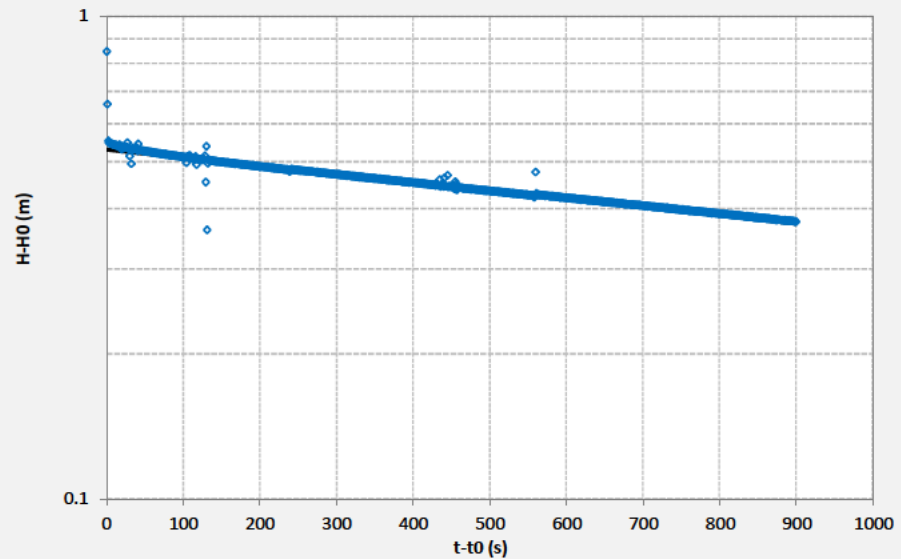
Hydraulic conductivity (K): 1.35E-08 m/s

1.17E-03 m/d

Test duration: 900 s

Observed data

t (s)	GWL (m)	H-H0 (m)
0.0	1.333	0.847
1.0	1.522	0.658
2.0	1.628	0.552
3.0	1.633	0.547
4.0	1.634	0.546
5.0	1.634	0.546
6.0	1.635	0.545
7.0	1.636	0.544
8.0	1.636	0.544
9.0	1.637	0.543
10.0	1.638	0.542
11.0	1.639	0.541
12.0	1.639	0.541
13.0	1.639	0.541
14.0	1.640	0.540
15.0	1.641	0.539
16.0	1.637	0.543
17.0	1.642	0.538
18.0	1.640	0.540
19.0	1.650	0.530
20.0	1.645	0.535
21.0	1.642	0.538
22.0	1.646	0.534
23.0	1.643	0.537
24.0	1.644	0.536
25.0	1.644	0.536
26.0	1.643	0.537
27.0	1.632	0.548
28.0	1.647	0.533
29.0	1.646	0.534
30.0	1.666	0.514
31.0	1.642	0.538
32.0	1.685	0.495
33.0	1.652	0.528
34.0	1.650	0.530
35.0	1.649	0.531
36.0	1.649	0.531
37.0	1.648	0.532
38.0	1.650	0.530
39.0	1.644	0.536
40.0	1.653	0.527
41.0	1.636	0.544
42.0	1.650	0.530
43.0	1.651	0.529
44.0	1.652	0.528
45.0	1.652	0.528
46.0	1.653	0.528
47.0	1.653	0.527
48.0	1.653	0.527
49.0	1.653	0.527
50.0	1.654	0.526
51.0	1.654	0.526
52.0	1.654	0.526
53.0	1.655	0.525
54.0	1.655	0.525
55.0	1.655	0.525
56.0	1.656	0.524
57.0	1.656	0.524
58.0	1.656	0.524
59.0	1.657	0.523
60.0	1.657	0.523
61.0	1.657	0.523
62.0	1.658	0.522
63.0	1.658	0.522



Notes:

$$K = 1.35 \times 10^{-8} \text{ m/s}$$

Bouwer & Rice (1976) Slug Test Analysis Sheet

PATTLE DELAMORE PARTNERS

Project: Tahimana - Falling Head Test 2

Job No: C04732500

Bore ID: WWD24683

Test date: 5/10/2023

Test time: 15:08

Performed by: EW

Analysed by: RN

Reviewed by: NL

Test type: Falling head

Bore depth: 19.8 mBGL

SWL: 2.25 mBGL

Screen radius (rc): 0.016 m

Borehole radius (Re): 0.075 m

Saturated screen length (Le): 14.8 m

Aquifer sat. thickness (h): 20 m

Piezo sat. thickness (Lw): 17.55 m

Slugs used: 3

Slug length: 0.5 m

Slug radius: 0.025 m

Displacement vol: 0.00295 m³

Expected displ: 3.66 m

Obs displacement: 0.73 m

Eff. casing radius: 0.036 m

Correct for displacement: FALSE

Well screened across water table: FALSE

GWL measurement: Depth to water

Static GWL (m): 2.25

Displaced GWL (m): 1.525

Curve fitting:

Y-intercept shift: 0.53 m

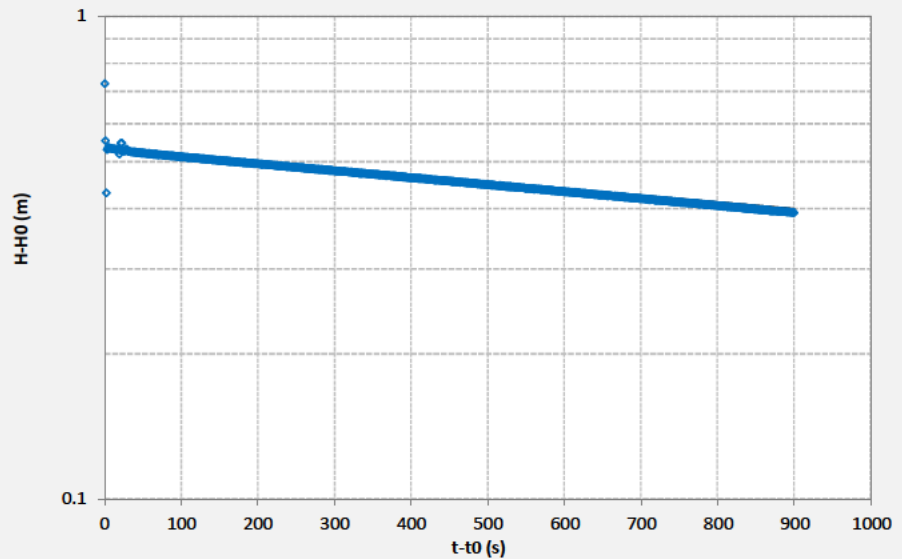
Hydraulic conductivity (K): 1.10E-08 m/s

9.47E-04 m/d

Test duration: 900 s

Observed data

t (s)	GWL (m)	H-H0 (m)
0.0	1.525	0.725
1.0	1.697	0.553
2.0	1.819	0.431
3.0	1.720	0.530
4.0	1.715	0.535
5.0	1.715	0.535
6.0	1.716	0.534
7.0	1.716	0.534
8.0	1.717	0.533
9.0	1.717	0.533
10.0	1.718	0.532
11.0	1.718	0.532
12.0	1.719	0.531
13.0	1.719	0.531
14.0	1.719	0.531
15.0	1.720	0.530
16.0	1.720	0.530
17.0	1.720	0.530
18.0	1.718	0.532
19.0	1.731	0.519
20.0	1.721	0.529
21.0	1.704	0.546
22.0	1.703	0.547
23.0	1.723	0.527
24.0	1.722	0.528
25.0	1.723	0.527
26.0	1.724	0.526
27.0	1.722	0.528
28.0	1.721	0.529
29.0	1.719	0.531
30.0	1.724	0.526
31.0	1.724	0.526
32.0	1.725	0.525
33.0	1.725	0.525
34.0	1.726	0.524
35.0	1.726	0.524
36.0	1.726	0.524
37.0	1.726	0.524
38.0	1.726	0.524
39.0	1.727	0.523
40.0	1.727	0.523
41.0	1.727	0.523
42.0	1.727	0.523
43.0	1.727	0.523
44.0	1.728	0.522
45.0	1.728	0.522
46.0	1.728	0.522
47.0	1.729	0.521
48.0	1.728	0.522
49.0	1.729	0.521
50.0	1.729	0.521
51.0	1.729	0.521
52.0	1.729	0.521
53.0	1.729	0.521
54.0	1.730	0.520
55.0	1.730	0.520
56.0	1.730	0.520
57.0	1.730	0.520
58.0	1.730	0.520
59.0	1.730	0.520
60.0	1.731	0.519
61.0	1.731	0.519
62.0	1.731	0.519
63.0	1.732	0.518



Notes:

$$K = 1.1 \times 10^{-8} \text{ m/s}$$

Bouwer & Rice (1976) Slug Test Analysis Sheet

PATTLE DELAMORE PARTNERS

Project: Tahimana - Rising Head Test 1

Job No: C04732500

Bore ID: WWD24683

Test date: 5/10/2023

Test time: 15:08

Performed by: EW

Analysed by: RN

Reviewed by: NL

Test type: Rising head

Bore depth: 19.8 mBGL

SWL: 2.24 mBGL

Screen radius (rc): 0.016 m

Borehole radius (Re): 0.075 m

Saturated screen length (Le): 14.8 m

Aquifer sat. thickness (h): 20 m

Piezo sat. thickness (Lw): 17.56 m

Slugs used: 3

Slug length: 0.5 m

Slug radius: 0.025 m

Displacement vol: 0.00295 m³

Expected displ: 3.66 m

Obs displacement: 0.57 m

Eff. casing radius: 0.041 m

Correct for displacement: FALSE

Well screened across water table: FALSE

GWL measurement: Depth to water

Static GWL (m): 2.24

Displaced GWL (m): 2.809

Curve fitting:

Y-intercept shift: 0.52 m

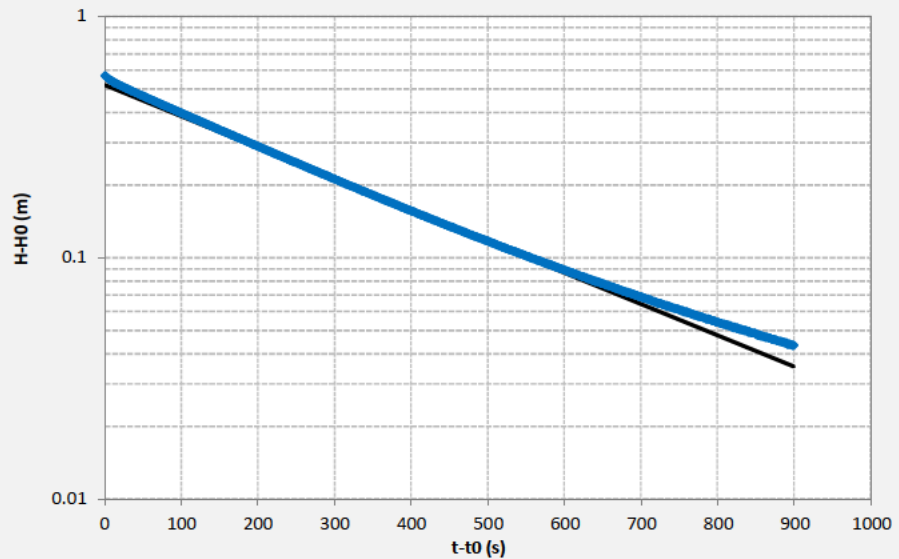
Hydraulic conductivity (K): 1.02E-07 m/s

8.84E-03 m/d

Test duration: 900 s

Observed data

t (s)	GWL (m)	H-H0 (m)
0.0	2.809	0.569
1.0	2.806	0.566
2.0	2.803	0.563
3.0	2.796	0.556
4.0	2.794	0.554
5.0	2.791	0.551
6.0	2.788	0.548
7.0	2.785	0.545
8.0	2.783	0.543
9.0	2.782	0.542
10.0	2.777	0.537
11.0	2.775	0.535
12.0	2.769	0.529
13.0	2.772	0.532
14.0	2.769	0.529
15.0	2.768	0.528
16.0	2.764	0.524
17.0	2.764	0.524
18.0	2.762	0.522
19.0	2.760	0.520
20.0	2.758	0.518
21.0	2.756	0.516
22.0	2.755	0.515
23.0	2.753	0.513
24.0	2.751	0.511
25.0	2.748	0.508
26.0	2.748	0.508
27.0	2.745	0.505
28.0	2.743	0.503
29.0	2.742	0.502
30.0	2.740	0.500
31.0	2.739	0.499
32.0	2.737	0.497
33.0	2.735	0.495
34.0	2.733	0.493
35.0	2.732	0.492
36.0	2.730	0.490
37.0	2.729	0.489
38.0	2.727	0.487
39.0	2.725	0.485
40.0	2.724	0.484
41.0	2.722	0.482
42.0	2.720	0.480
43.0	2.719	0.479
44.0	2.717	0.477
45.0	2.715	0.475
46.0	2.714	0.474
47.0	2.712	0.472
48.0	2.711	0.471
49.0	2.709	0.469
50.0	2.708	0.468
51.0	2.706	0.466
52.0	2.705	0.465
53.0	2.704	0.464
54.0	2.702	0.462
55.0	2.700	0.460
56.0	2.699	0.459
57.0	2.697	0.457
58.0	2.696	0.456
59.0	2.694	0.454
60.0	2.693	0.453
61.0	2.692	0.452
62.0	2.690	0.450
63.0	2.688	0.448



Notes:

$$K = 1.02 \times 10^{-7} \text{ m/s}$$

Bouwer & Rice (1976) Slug Test Analysis Sheet

PATTLE DELAMORE PARTNERS

Project: Tahimana - Rising Head Test 2

Job No: C04732500

Bore ID: WWD24683

Test date: 5/10/2023

Test time: 15:08

Performed by: EW

Analysed by: RN

Reviewed by: NL

Test type: Rising head

Bore depth: 19.8 mBGL

SWL: 2.24 mBGL

Screen radius (rc): 0.016 m

Borehole radius (Re): 0.075 m

Saturated screen length (Le): 14.8 m

Aquifer sat. thickness (h): 20 m

Piezo sat. thickness (Lw): 17.56 m

Slugs used: 3

Slug length: 0.5 m

Slug radius: 0.025 m

Displacement vol: 0.00295 m³

Expected displ: 3.66 m

Obs displacement: 0.57 m

Eff. casing radius: 0.041 m

Correct for displacement: FALSE

Well screened across water table: FALSE

GWL measurement: Depth to water

Static GWL (m): 2.25

Displaced GWL (m): 2.82

Curve fitting:

Y-intercept shift: 0.54 m

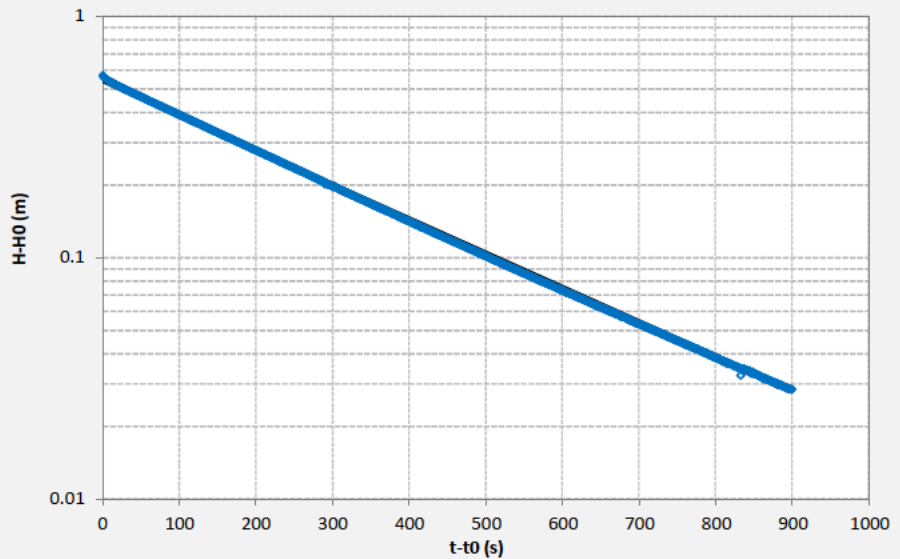
Hydraulic conductivity (K): 1.12E-07 m/s

9.69E-03 m/d

Test duration: 900 s

Observed data

t (s)	GWL (m)	H-H0 (m)
0.0	2.820	0.570
1.0	2.811	0.561
2.0	2.808	0.558
3.0	2.803	0.553
4.0	2.801	0.551
5.0	2.799	0.549
6.0	2.796	0.546
7.0	2.793	0.543
8.0	2.791	0.541
9.0	2.788	0.538
10.0	2.786	0.536
11.0	2.784	0.534
12.0	2.782	0.532
13.0	2.779	0.529
14.0	2.778	0.528
15.0	2.776	0.526
16.0	2.774	0.524
17.0	2.771	0.521
18.0	2.769	0.519
19.0	2.767	0.517
20.0	2.766	0.516
21.0	2.764	0.514
22.0	2.762	0.512
23.0	2.760	0.510
24.0	2.758	0.508
25.0	2.756	0.506
26.0	2.755	0.505
27.0	2.753	0.503
28.0	2.751	0.501
29.0	2.749	0.499
30.0	2.748	0.498
31.0	2.746	0.496
32.0	2.744	0.494
33.0	2.742	0.492
34.0	2.741	0.491
35.0	2.739	0.489
36.0	2.737	0.487
37.0	2.736	0.486
38.0	2.734	0.484
39.0	2.732	0.482
40.0	2.730	0.480
41.0	2.729	0.479
42.0	2.727	0.477
43.0	2.726	0.476
44.0	2.724	0.474
45.0	2.722	0.472
46.0	2.721	0.471
47.0	2.719	0.469
48.0	2.718	0.468
49.0	2.716	0.466
50.0	2.714	0.464
51.0	2.713	0.463
52.0	2.711	0.461
53.0	2.710	0.460
54.0	2.708	0.458
55.0	2.706	0.456
56.0	2.705	0.455
57.0	2.703	0.453
58.0	2.701	0.451
59.0	2.700	0.450
60.0	2.698	0.448
61.0	2.697	0.447
62.0	2.696	0.446
63.0	2.694	0.444



Notes:

$$K = 1.12 \times 10^{-7} \text{ m/s}$$

Bouwer & Rice (1976) Slug Test Analysis Sheet

PATTLE DELAMORE PARTNERS

Project: Tahimana - Falling Head

Job No: C04732500

Bore ID: Standpipe 1

Test date: 5/10/2023

Test time: 15:08

Performed by: EW

Analysed by: RN

Reviewed by: NL

Test type: Falling head

Bore depth: 2.4 mBGL

SWL: 1 mBGL

Screen radius (rc): 0.016 m

Borehole radius (Re): 0.016 m

Saturated screen length (Le): 1.8 m

Aquifer sat. thickness (h): 2.4 m

Piezo sat. thickness (Lw): 1.4 m

Slugs used: 1

Slug length: 0.5 m

Slug radius: 0.02 m

Displacement vol: 0.00063 m³

Expected displ: 0.78 m

Obs displacement: 0.17 m

Eff. casing radius: 0.034 m

Correct for displacement: TRUE

GWL measurement: Depth to water

Static GWL (m): 1

Displaced GWL (m): 0.831

Curve fitting:

Y-intercept shift: 0.159 m

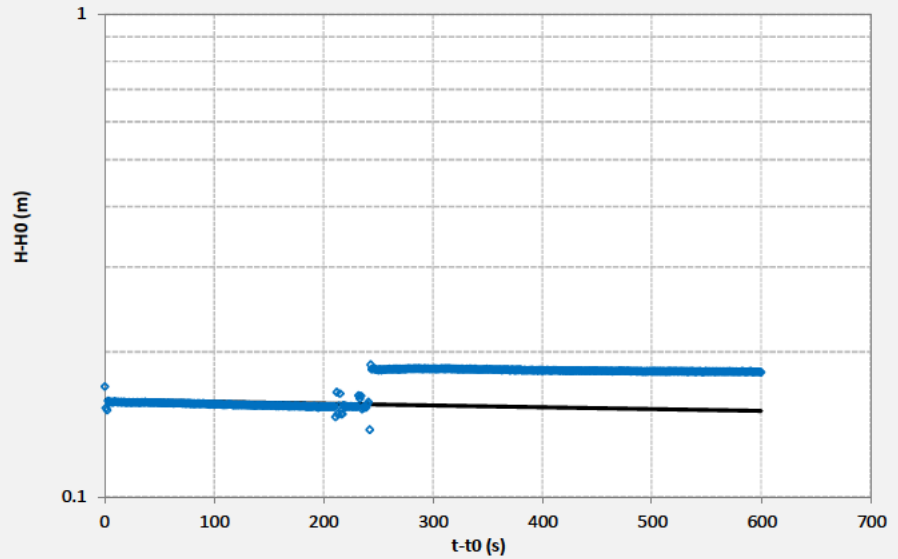
Hydraulic conductivity (K): 9.12E-08 m/s

7.88E-03 m/d

Test duration: 600 s

Observed data

t (s)	GWL (m)	H-H0 (m)
0.0	0.831	0.169
1.0	0.847	0.153
2.0	0.849	0.151
3.0	0.842	0.158
4.0	0.842	0.158
5.0	0.842	0.158
6.0	0.843	0.157
7.0	0.843	0.157
8.0	0.843	0.157
9.0	0.842	0.158
10.0	0.842	0.158
11.0	0.843	0.157
12.0	0.843	0.157
13.0	0.843	0.157
14.0	0.843	0.157
15.0	0.843	0.157
16.0	0.843	0.157
17.0	0.842	0.158
18.0	0.843	0.157
19.0	0.843	0.157
20.0	0.843	0.157
21.0	0.843	0.157
22.0	0.843	0.157
23.0	0.843	0.157
24.0	0.843	0.157
25.0	0.843	0.157
26.0	0.843	0.157
27.0	0.843	0.157
28.0	0.843	0.157
29.0	0.843	0.157
30.0	0.843	0.157
31.0	0.843	0.157
32.0	0.843	0.157
33.0	0.843	0.157
34.0	0.843	0.157
35.0	0.843	0.157
36.0	0.843	0.157
37.0	0.843	0.157
38.0	0.843	0.157
39.0	0.843	0.157
40.0	0.843	0.157
41.0	0.843	0.157
42.0	0.843	0.157
43.0	0.843	0.157
44.0	0.843	0.157
45.0	0.843	0.157
46.0	0.843	0.157
47.0	0.843	0.157
48.0	0.843	0.157
49.0	0.843	0.157
50.0	0.843	0.157
51.0	0.843	0.157
52.0	0.844	0.156
53.0	0.843	0.157
54.0	0.843	0.157
55.0	0.843	0.157
56.0	0.844	0.156
57.0	0.843	0.157
58.0	0.843	0.157
59.0	0.843	0.157
60.0	0.843	0.157
61.0	0.843	0.157
62.0	0.843	0.157
63.0	0.844	0.156



Notes:

K calculation corrected for expected displacement using a mass balance approach (Eq. 3.2 in Butler, 1996)

$$K = 9.12 \times 10^{-8} \text{ m/s}$$

Bouwer & Rice (1976) Slug Test Analysis Sheet

PATTLE DELAMORE PARTNERS

Project: Tahimana - Falling Head

Job No: C04732500

Bore ID: Standpipe 2

Test date: 5/10/2023

Test time: 15:08

Performed by: EW

Analysed by: RN

Reviewed by: NL

Test type: Falling head

Bore depth: 1.4 mBGL

SWL: 0.71 mBGL

Screen radius (rc): 0.016 m

Borehole radius (Re): 0.016 m

Saturated screen length (Le): 1.1 m

Aquifer sat. thickness (h): 1.4 m

Piezo sat. thickness (Lw): 0.69 m

Slugs used: 1

Slug length: 0.5 m

Slug radius: 0.02 m

Displacement vol: 0.00063 m³

Expected displ: 0.78 m

Obs displacement: 0.43 m

Eff. casing radius: 0.022 m

Correct for displacement: TRUE

GWL measurement: Depth to water

Static GWL (m): 0.71

Displaced GWL (m): 0.284

Curve fitting:

Y-intercept shift: 0.37 m

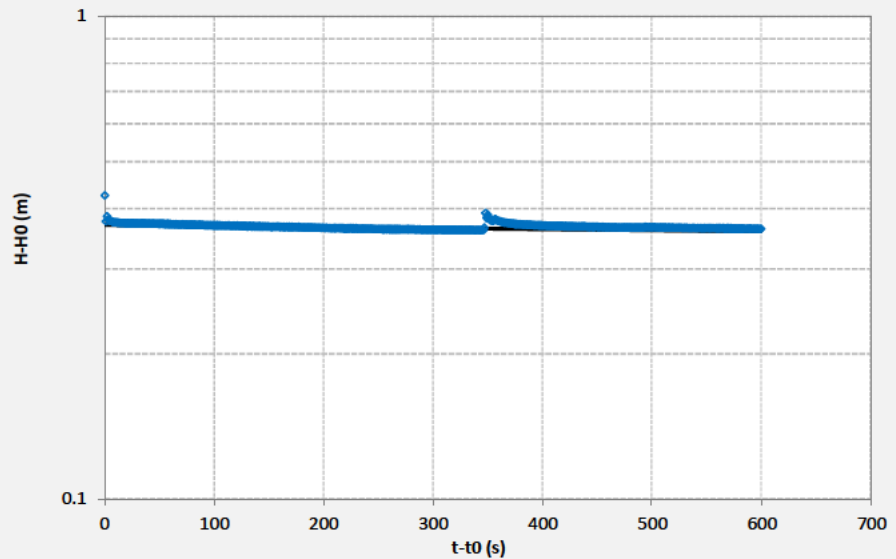
Hydraulic conductivity (K): 2.88E-08 m/s

2.49E-03 m/d

Test duration: 600 s

Observed data

t (s)	GWL (m)	H-H0 (m)
0.0	0.284	0.426
1.0	0.334	0.376
2.0	0.325	0.385
3.0	0.330	0.380
4.0	0.332	0.378
5.0	0.333	0.377
6.0	0.333	0.377
7.0	0.335	0.375
8.0	0.335	0.375
9.0	0.335	0.375
10.0	0.335	0.375
11.0	0.336	0.374
12.0	0.336	0.374
13.0	0.336	0.374
14.0	0.336	0.374
15.0	0.337	0.373
16.0	0.337	0.373
17.0	0.336	0.374
18.0	0.337	0.373
19.0	0.337	0.373
20.0	0.337	0.373
21.0	0.337	0.373
22.0	0.337	0.373
23.0	0.337	0.373
24.0	0.337	0.373
25.0	0.337	0.373
26.0	0.337	0.373
27.0	0.337	0.373
28.0	0.337	0.373
29.0	0.337	0.373
30.0	0.337	0.373
31.0	0.337	0.373
32.0	0.337	0.373
33.0	0.337	0.373
34.0	0.337	0.373
35.0	0.337	0.373
36.0	0.337	0.373
37.0	0.337	0.373
38.0	0.338	0.373
39.0	0.338	0.372
40.0	0.337	0.373
41.0	0.338	0.372
42.0	0.338	0.372
43.0	0.338	0.372
44.0	0.337	0.373
45.0	0.338	0.372
46.0	0.338	0.372
47.0	0.338	0.372
48.0	0.338	0.372
49.0	0.338	0.372
50.0	0.338	0.372
51.0	0.338	0.372
52.0	0.338	0.372
53.0	0.338	0.372
54.0	0.338	0.372
55.0	0.338	0.372
56.0	0.338	0.372
57.0	0.338	0.372
58.0	0.338	0.372
59.0	0.338	0.372
60.0	0.339	0.371
61.0	0.339	0.371
62.0	0.339	0.371
63.0	0.339	0.371



Notes:

K calculation corrected for expected displacement using a mass balance approach (Eq. 3.2 in Butler, 1996)

$$K = 2.88 \times 10^{-8} \text{ m/s}$$

Appendix E: Excavation depth maps (provided by Staig and Smith)



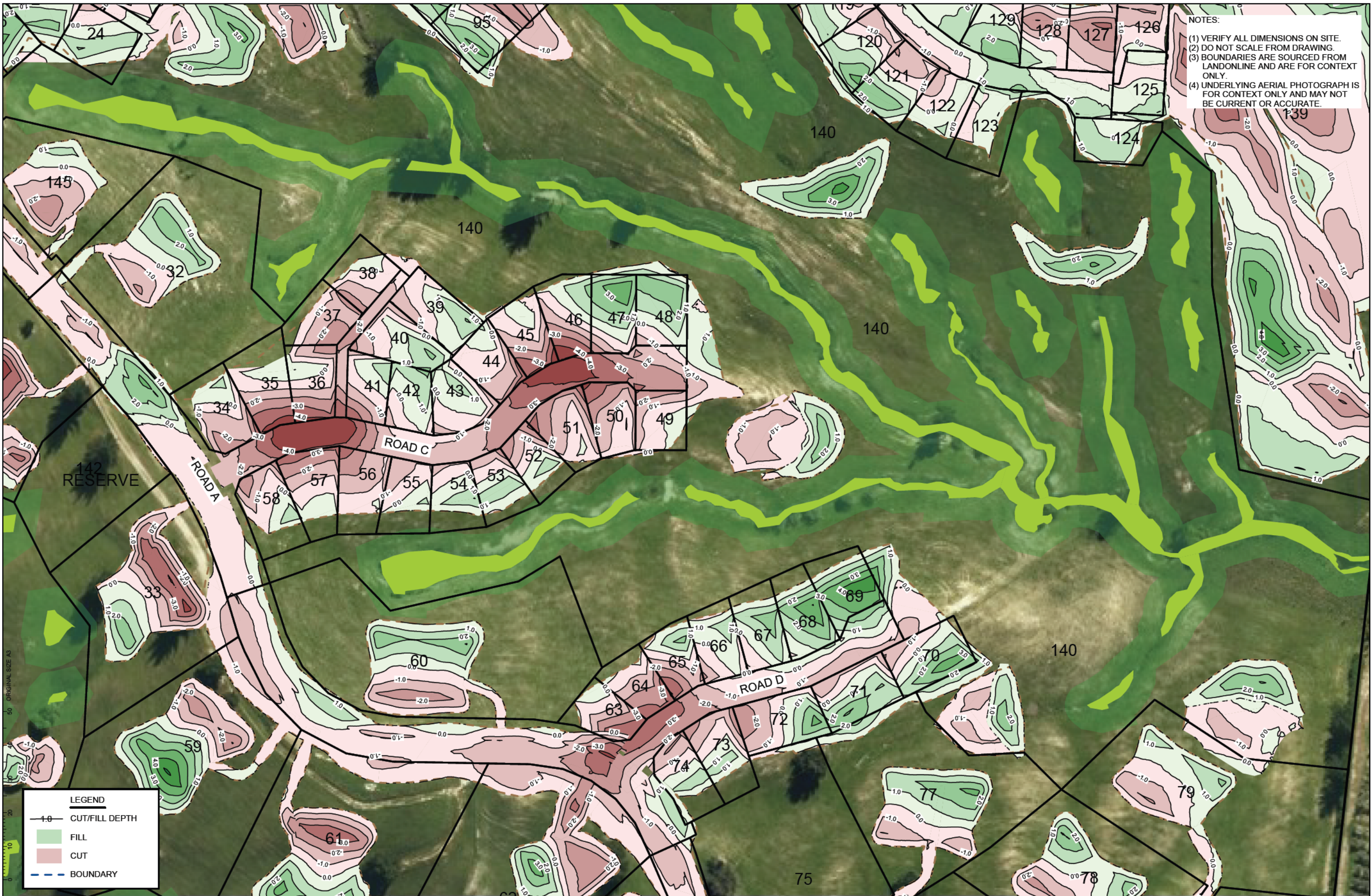


NOTES:

- (1) VERIFY ALL DIMENSIONS ON SITE.
- (2) DO NOT SCALE FROM DRAWING.
- (3) BOUNDARIES ARE SOURCED FROM LANDONLINE AND ARE FOR CONTEXT ONLY.
- (4) UNDERLYING AERIAL PHOTOGRAPH IS FOR CONTEXT ONLY AND MAY NOT BE CURRENT OR ACCURATE.

LEGEND

- 1.0 CUT/FILL DEPTH
- FILL
- CUT
- BOUNDARY



NOTES:
(1) VERIFY ALL DIMENSIONS ON SITE.
(2) DO NOT SCALE FROM DRAWING.
(3) BOUNDARIES ARE SOURCED FROM LANDONLINE AND ARE FOR CONTEXT ONLY.
(4) UNDERLYING AERIAL PHOTOGRAPH IS FOR CONTEXT ONLY AND MAY NOT BE CURRENT OR ACCURATE.

LEGEND

1.0 CUT/FILL DEPTH

FILL

CUT

BOUNDARY



NOTES:
(1) VERIFY ALL DIMENSIONS ON SITE.
(2) DO NOT SCALE FROM DRAWING.
(3) BOUNDARIES ARE SOURCED FROM LANDONLINE AND ARE FOR CONTEXT ONLY.
(4) UNDERLYING AERIAL PHOTOGRAPH IS FOR CONTEXT ONLY AND MAY NOT BE CURRENT OR ACCURATE.

LEGEND

- 1.0 CUT/FILL DEPTH
- FILL
- CUT
- BOUNDARY