Woolgoolga to Ballina Pacific Highway upgrade

Water Quality Monitoring Program

Transport for New South Wales | October 2019

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Table of Contents

1. Introduction 1
1.1 Objectives 2
1.2 Minister's Conditions of Approval 2
1.3 Risk to Surface Waters 3
1.3.1 Construction Stage 4
1.3.2 Operational Stage 4
1.4 Risk to Groundwater 5
1.4.1 Construction Stage 5
1.4.2 Operational Stage 6
1.5 Risk to Groundwater Dependent Ecosystems 6
1.6 Sensitive Receiving Environments and High Risk Areas 7
1.7 Updates to this Plan 10
1.7.1 Surface Water Monitoring Locations 10
1.7.2 Groundwater Monitoring Locations 10
1.7.3 Monitoring Frequency 11
1.7.4 Monitoring Parameters 11
1.7.5 Groundwater Quality Data Analysis Approach 11
2. Monitoring Locations 12
2.1 Surface Water Monitoring Locations 12
2.2 Groundwater Monitoring 12
3. Summary of Pre-Construction Monitoring 18
3.1 Surface Water Monitoring 18
3.1.1 Number of Monitoring Events 18
3.1.2 Number of Monitoring Locations 18
3.1.3 Surface Water Monitoring Parameters 20
3.2 Groundwater Monitoring 21
3.2.1 Groundwater Levels 21
3.2.2 Groundwater Quality 21
4. Sampling Regime and Parameters 23
4.1 Monitoring Duration 23
4.2 Surface Water 23
4.2.1 Construction Phase 23
4.2.2 Operational Phase 24
4.3 Groundwater 25
4.3.1 Groundwater Level Monitoring Regime 25
4.3.2 Groundwater Quality Sampling Regime 26

4.4 Rainfall Data 27

5. Sampling Methodology 28

5.1 Pre-Monitoring Tasks 28

5.1.1 Rainfall Monitoring 28
5.1.2 Calibration 28
5.1.3 Preparation of Sample Containers 28
5.1.4 Sampling equipment 28

5.2 Surface Water Sampling 29

5.2.1 Field Observations 29
5.2.2 Collection of In-Situ Water Quality Data 29
5.2.3 Collection of Water Samples for Laboratory Analysis 30

5.3 Groundwater Sampling 30

5.3.1 Field Observations 30
5.3.2 Collection of Groundwater Standing Water Levels 30
5.3.3 Collection of Field Groundwater Quality Data 31
5.3.4 Collection of Groundwater Samples for Laboratory Analysis 31
5.3.5 Replicate Samples 32

6. Quality Management 33

6.1 Sample Identification and Records 33
6.2 Sample Collection 33
6.3 Sample Preservation and Transport 33
6.4 Chain of Custody 33
6.5 Laboratory Analysis 34
6.6 Quality Control Samples 34

7. Data Analysis and Management 35

7.1 Surface Water 35

7.1.1 Comparison of Sampling Data and Baseline Data 35
7.1.2 Adding to Surface Water Quality Baseline Data 37
7.1.3 In-field Notifications Protocol 37

7.2 Groundwater Quality 37
7.3 Groundwater Levels 38
7.4 Data Interpretation 38

7.4.1 Construction Stage 38
7.4.2 Operational Stage 39

7.5 Reporting 39

7.5.1 Construction Stage 39
7.5.2 Operational Stage 40

8. Management Actions 41

8.1 Construction Phase - Surface Water Management Actions 41
8.2 Construction Phase - Groundwater Management Actions 42
8.3 Operational Phase - Surface Water Management Actions 43
8.4 Operational Phase - Groundwater Management Actions 43
8.5 Adaptive Management Framework 43

Tables

Table 1.1 MCoA Requirements for the Water Quality Monitoring Program 2
Table 2.1 Surface Water Monitoring Point Locations 13
Table 2.2 List of Bores for Groundwater Monitoring 16
Table 3.1 Surface Water / GDE Quality Monitoring Locations 19
Table 4.1 Surface Water Sampling Parameters – Construction Phase 23
Table 4.2 Surface Water Sampling Parameters – Operational Phase 24
Table 4.3 Groundwater Quality Sampling Parameters 26
Table 6.1 Chain of Custody Documentation 34
Table 7.1 Tolerances for Comparing Upstream and Downstream Results 36

Figures

Figure 1.1 Overview of Sections 3-11 of the W2B Pacific Highway Upgrade 1
Figure 7.1 Example Control Chart 36

Appendices

Appendix A Maps of Monitoring Locations – Surface Water and Groundwater
Appendix B Section 3 – Glenugie to Tyndale: Pre-Construction Monitoring Results
Appendix C Section 4 – Tyndale to Maclean: Pre-Construction Monitoring Results
Appendix D Section 5 - Maclean to Iluka Road: Pre-Construction Monitoring Results
Appendix E Section 6 - Iluka Road to Devils Pulpit: Pre-Construction Monitoring Results
Appendix F Section 7 - Devils Pulpit to Trustums Hill: Pre-Construction Monitoring Results
Appendix G Section 8 - Trustums Hill to Broadwater National Park: Pre-Construction Monitoring Results
Appendix H Section 9 - Broadwater National Park to Richmond River: Pre-Construction Monitoring Results
Appendix I Section 10 - Richmond River to Coolgardie Road: Pre-Construction Monitoring Results
Appendix J Section 11 - Coolgardie Road to Ballina Bypass: Pre-Construction Monitoring Results
Appendix K ANZECC Criteria
Appendix L Consultation with Government Authorities

1. Introduction

This Water Quality Monitoring Program (WQMP) outlines monitoring requirements for surface waters and groundwater for the construction and post-construction phases of Sections 3-11 of the Woolgoolga to Ballina (W2B) Pacific Highway Upgrade. There are 37 surface water locations (71 sampling sites) and 59 groundwater monitoring bores spread over the 124.5 km of upgrade works.

Source: http://www.rms.nsw.gov.au/documents/projects/northern-nsw/woolgoolga-to-ballina/woolgoolga-to-ballina-section-map.pdf

Figure 1.1 Overview of Sections 3-11 of the W2B Pacific Highway Upgrade

1.1 Objectives

The objective of the WQMP is to monitor and manage the construction and operation impacts of the highway upgrade on surface water bodies and groundwater resources.

The key surface water quality objective of the overall Woolgoolga to Ballina (W2B) Pacific Highway Upgrade Program is to protect downstream environments from the potential impacts of surface runoff during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012c:58). Similarly, the key groundwater objectives of the W2B project are to protect environmental receivers of groundwater flows, and groundwater users from the potential impacts on groundwater levels and quality during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012d:10).

The WQMP will play a crucial role in ensuring construction and operation of the W2B project does not have a negative impact on sensitive receiving environments such as Marine Parks, State Environmental Planning Policy (SEPP) No. 14 wetlands, threatened species habitat, drinking water catchments, or endangered ecological communities.

The outcomes of the WQMP will assist with achieving water quality and hydrology related management objectives for the W2B project including:

- mitigating impacts to surface water quality in order to protect aquatic ecology and ecosystem characteristics in adjacent catchments; and
- mitigating impacts to groundwater hydrology in order to protect licensed bores and dams, water bodies and groundwater dependant ecosystems.

1.2 Minister's Conditions of Approval

The Minister's Conditions of Approval (MCoA) granted by the Minister for Planning on 24 June 2014 for the Woolgoolga to Ballina Pacific Highway Upgrade includes the following Condition D12 with respect to soil, water quality and hydrology.

> D12. The Applicant shall prepare and implement a **Water Quality Monitoring Program** to monitor the construction and operation impacts of the SSI on surface and groundwater quality and resources and wetlands, prior to construction. The Program shall be prepared in consultation with the EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields), to the satisfaction of the Secretary, and shall include but not necessarily be limited to [the items in **Table 1.1**].

Table 1.1 MCoA Requirements for the Water Quality Monitoring Program

Item	*Details*	*Addressed in*
a)	identification of surface and groundwater quality monitoring locations (including watercourses, waterbodies and SEPP14 wetlands) which are representative of the potential extent of impacts from the State Significant Infrastructure (SSI).	Section 2
b)	the results of any groundwater modelling undertaken.	Section 3 and Appendices B to J
c)	identification of works and activities during construction and operation of the SSI, including emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and known Oxleyan Pygmy Perch habitat.	Section 1.3, 1.4 and 1.5

Item	Details	Addressed in
d)	development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (Australian and New Zealand Environment Conservation Council, 2000) or relevant baseline data.	Section 7
e)	representative background monitoring of surface and groundwater quality parameters for a minimum of twelve months (considering seasonality) prior to the commencement of construction, to establish baseline water conditions, unless otherwise agreed by the Secretary.	Section 3 and Appendices B to J
f)	a minimum monitoring period of three years following the completion of construction or until the affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales).	Section 4
g)	contingency and ameliorative measures in the event that adverse impacts to water quality are identified.	Section 8
h)	reporting of the monitoring results to Department of Planning and Environment (DPE), Environment Protection Authority (EPA), Department of Primary Industries (DPI) (Fisheries), NSW Office of Water (NOW), Department of Environment (DoE) and Rous Water (in relation to the Woodburn borefields).	Section 7.5

The Federal Minister for the Environment's Conditions of Approval granted on 14 August 2014 includes the following Condition D21 with respect to reporting.

21. Within three months of every 12 month anniversary of the **commencement** of the action, the **approval holder** must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any Frameworks, Strategies, Plans, or Packages as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the **Department** [of the Environment] at the same time as the compliance report is published. The **approval holder** must continue to publish the report until such time as agreed in writing by the **Minister**.

Consultation with the government authorities is detailed in **Appendix L** of this WQMP. In accordance with the Staging Report submitted for the project, the WQMP for the Woolgoolga to Glenugie section of the project was submitted to the Department and approved on 8 May 2015. This report addresses the requirements of the remaining sections of the project.

1.3 Risk to Surface Waters

The following provides background information regarding the general risks to surface waters posed by the highway upgrade. The information is largely based on the environmental impact statement documents for the W2B highway upgrade. Refer also to **Section 1.5** and **1.6** in regard to Groundwater Dependent Ecosystems (GDEs) and sensitive receiving environments and high risk areas.

1.3.1 Construction Stage

During construction, the highest risk of impacts on water quality would be associated with:

- Exposure of soils during earthworks (including stripping of topsoil, excavation, stockpiling and materials transport), which may result in soil erosion and off-site movement of eroded sediments by wind and/or stormwater to receiving waterways, resulting in increased nutrients, metals and other pollutants.
- Accidental leaks or spills of chemicals, fuels, oils and/or greases from construction plant and machinery, which may result in pollution of receiving waterways.
- Exposure of acid sulfate soils (as a result of earthworks or dewatering), which may result in generation of sulfuric acid and subsequent acidification of waterways and mobilisation of heavy metals in the environment.
- Disturbance of contaminated land causing contamination of downstream waterways, impacting on aquatic and riparian habitats.
- Removal of riparian vegetation, which may result in soil and stream bank erosion and increased sediment loads in nearby creeks.
- Direct disturbance of waterway beds and banks during culvert and bridge construction and temporary or permanent creek diversions, which may lead to high volumes of sediment entering and polluting the waterways.
- Changes to flow regimes, which can change the volumes and flow rates of water, leading to stagnation of a waterway and changes in turbidity, nitrogen and phosphorus levels. Reduction in flow regimes also has the potential to expose potential acid sulfate soils if it results in a reduction to groundwater levels.
- Leaching of tannins from stockpiles of cleared vegetation, which may have a number of adverse effects on receiving waters, including:
    - Increased biological oxygen demand, with consequent decreases in dissolved oxygen.
    - Reduced water clarity and light penetration.
    - Decreased pH.
- Increase in pH from concreting and lime stabilisation works.
- Pollution by hydrocarbons during or following sealing or asphalting works.

During construction and operation, changes to water velocities and disturbance to riparian and instream habitats have the potential impact on successful fish passage. This is relevant to both permanent waterway crossings (such as bridges and culverts), as well as temporary waterway crossings (such as causeways, fords). Short-term impacts include localised disturbance to riparian and instream habitats such as increased sedimentation and shading (RMS, Aurecon, SKM, 2012e:388).

1.3.2 Operational Stage

Once the highway upgrade is operating, there would be potential for impacts on soils, water quality and groundwater. However, the likelihood and severity of these potential impacts would be minimised by incorporating management and mitigation measures into the design of the highway upgrade, as described in **Section 8**. These measures would protect soils, receiving waters and groundwater.

During operation, the main potential impact on water quality would be associated with runoff from stormwater and direct deposition of airborne particles, causing acute or chronic contamination of water quality in downstream waterways that receive discharged stormwater during rainfall events.

Pollutants from stormwater runoff include sediments, hydrocarbons, metals, and microbials. These deposits build up on road surfaces and pavement areas (including rest areas and truck checking stations) during dry weather and get washed off and transported to downstream waterways when it rains. Other pollutants in the atmosphere, derived from local and regional sources, would also be deposited and build up on the widened road pavement and contribute to impacts on water quality.

In addition, accidental spills of petroleum, chemicals and hazardous materials as a result of vehicle leaks or accidents, and waste discarded by motorists, could pollute downstream waterways and groundwater sources.

The potential impacts of reduced water quality on sensitive receiving environments have also been considered. Because the project includes design measures to minimise the likelihood of impacts on water quality, operation of the project would be unlikely to have an adverse impact on sensitive receiving environments and high risk areas.

As noted in **Section 1.3.1**, changes to water velocities and disturbance to riparian and instream habitats have the potential impact on successful fish passage at permanent waterway crossings (such as bridges and culverts). Long-term impacts include the impediment of fish movements within their natural range, habitat changes or pollution (RMS, Aurecon, SKM, 2012e:388).

1.4 Risk to Groundwater

This section provides background information regarding the general risks to groundwater posed by the highway upgrade. The information is largely based on the environmental impact statement documents for the Woolgoolga to Ballina highway upgrade. Refer also to **Section 1.5** and **1.6** in regard to Groundwater Dependent Ecosystems (GDEs) and sensitive receiving environments and high risk areas such as the Rous Water borefields.

1.4.1 Construction Stage

The main risks to groundwater during construction of the project would be from:

- Cuttings changing surface flows, groundwater flow regimes and ‘draw down’ of the water table as a result of intersection of groundwater and subsequent groundwater discharge.
- Fill embankments changing surface flows and groundwater recharge and compacting soft soils and thereby restricting near-surface groundwater flow.
- Groundwater contamination, which may occur if construction activities are not adequately managed, particularly in areas of shallow groundwater.

Risks to Groundwater from Cuttings

Localised draw down of the groundwater table can occur around cutting sites where the design profile of the proposed highway cuttings is below the level of the groundwater table. This may impact on groundwater flow to local creeks, streams, springs, local water resources and Groundwater Dependent Ecosystems.

Risks to Groundwater from Fill Embankments

Construction and use of embankments will preferentially direct surface runoff and concentrate recharge to groundwaters. On soft soils, compaction may also occur restricting near-surface groundwater flow resulting in discharge and waterlogging (RMS, Aurecon, SKM, 2012d:69).

Risks to Groundwater Quality from Surface Water

The potential risks to groundwater quality during construction would include contamination by hydrocarbons from accidental fuel and chemical spills, refuelling or through storage facilities, and contamination by contaminants contained in turbid runoff from unpaved surfaces.

In addition, site runoff can infiltrate groundwater sources. The process of infiltration is generally effective in filtering polluting particles and sediment. Hence, the risk of contamination to groundwater from any pollutants bound in particulate form in surface water, such as heavy metals, is generally low. Similarly, low-density pollutants such as insoluble hydrocarbons (oils, tars and petroleum products) would be preferentially retained in the soil profile and would not penetrate to the groundwater table. However, soluble pollutants, such as acids and alkalis, salts and nitrates, and soluble hydrocarbons, would be able to infiltrate through soils into the groundwater source and would pose a risk to that groundwater source. Under certain pH conditions, metals may also become soluble and infiltrate groundwater. In these areas, chemical treatments may be necessary. There is potential for long-term contamination risk to groundwater sources from the long-term accumulation of contaminants in the upper soil profile.

1.4.2 Operational Stage

The main hazard to groundwater quality during the operational phase would be pollutant runoff from the road surface infiltrating groundwater. The risks of groundwater pollution depend on the depth to groundwater and the permeability of the soils and geology that overlay groundwater reservoirs. Where groundwater is shallow or not protected from direct infiltration, the risks of pollution would vary depending on the nature of the pollutants of concern. The process of infiltration is generally effective in removing insoluble substances and contaminants that are readily bound to sediment particles, including heavy metals and hydrocarbons like oils, tars and petroleum. Therefore, runoff or spills of these substances have a relatively low risk of causing groundwater contamination. In contrast, soluble pollutants, such as acids, alkalis, salts and nitrates are less readily removed by the infiltration process and have a greater chance of reaching groundwater.

In areas where cuttings penetrate water tables, ongoing seepage would occur unless measures are put in place. Cuttings in areas of naturally high groundwater would see a reduced risk over time as groundwater pressures relax and re-equilibrate under the elevated discharge regime. In areas cut into rocks of low permeability (such as fractured rocks and porous sediments), the risk would remain high as groundwater pressures would not relax and seepage may continue throughout the life of the road.

1.5 Risk to Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) occur in nearly all sections of the W2B upgrade. GDE's include ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater.

The Woolgoolga to Ballina – Pacific Highway Upgrade Environmental Impact Statement (EIS) documents identify several vegetation communities and habitats as GDEs which comprise vegetation occurring on waterways and floodplains which are reliant on groundwater. They include:

- Freshwater wetlands;
- Sub-tropical coastal floodplain forest;
- Swamp sclerophyll forest;
- Swamp oak floodplain forest; and

- Lowland rainforest.

Construction of the W2B upgrade may potentially impact on these GDEs by blocking or altering subsurface flows and drainage paths. Development associated with future highway construction has the potential to affect GDEs function and viability by alteration of surface and subsurface conditions which are outside the physiological tolerance range or dispersal capabilities of groundwater reliant communities (Serov *et al* 2012 cited in Coffey Geotechnics 2014).

Potential impacts to GDEs may include changes in groundwater reliant communities due to changes in local water tables from over extraction or drainage, exposure and subsequent oxidation of potential acid sulfate soils, and resulting changes to groundwater and surface water quality or from saline intrusion. Potential impacts on groundwater recharge rates from highway construction have been assessed in the EIS to be generally greatest in areas where significant road cuttings are required as excavations may potentially intersect the water table and affect groundwater levels downstream (RMS, Aurecon, SKM, 2012a).

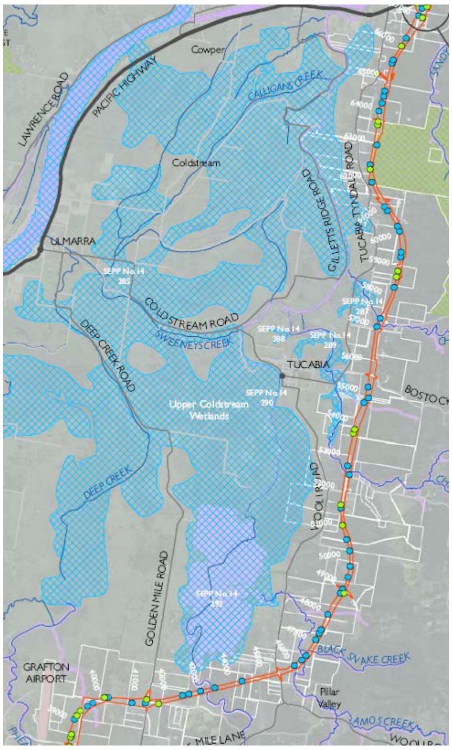
1.6 Sensitive Receiving Environments and High Risk Areas

Sensitive receiving environments include: nationally important wetlands and State Environmental Planning Policy No 14 (SEPP); national parks, marine parks, nature reserves and state conservations areas; threatened ecological communities associated with aquatic ecosystems; and known and potential habitats for threatened fish. Where a number of sensitive receiving environments are located in a single region and where there would be severe implications from changes in surface water quality to the receiving environment, the region has been defined as a high risk area (RMS, Aurecon, SKM, 2012c:74). High risk areas along highway sections 3-11 are:

- Upper Coldstream Wetlands in Section 3
- Tabbimoble Swamp Nature Reserve in Section 7
- The Rous Water borefields in Section 8
- The Broadwater National Park and associated wetlands in Sections 8 and 9
- Wardell Heath in Section 10
- Various areas where the project would discharge to or within 50 m of a known or potential habitat of a threatened aquatic species.

The proposed monitoring locations in Section 2 have been selected with consideration of these sensitive receiving environments and high risk areas.

Upper Coldstream Wetlands in Section 3



The wetlands are a key fish habitat (but not for any listed threatened fish species), are listed as National Important and contain a number of listed as SEPP 14 wetlands. The Wetlands receive flows from the Coldstream River, Pillar Valley Creek, Black Snake Creek, Chaffin Creek, Champions Creek a number of unnamed waterways. All these waterways cross the project.

There is a high probability of acid sulfate soils occurring around the waterway crossings of these creeks. The construction of bridge piers at these waterways will require work within potential acid sulfate soils. Likewise, the construction of sediment basins and areas of cut may expose acid sulfate soils around these waterways.

The construction of bridges (nine in total within the region) poses a risk to the water quality of the immediate waterway and the downstream Wetlands, as activities may disturb the bed and banks.

Large excavations and stockpile sites also present a risk of sediment runoff to the waterways and Wetlands.

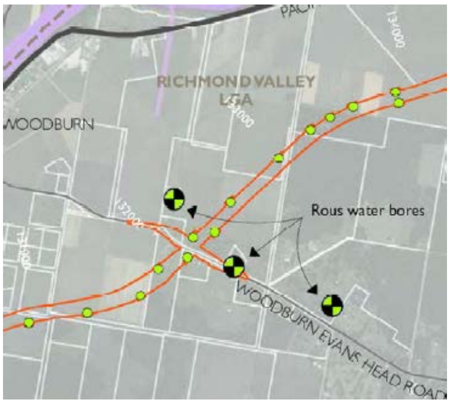
Tabbimoble Swamp Nature Reserve in Section 7

Tabbimoble Swamp is a mapped Oxleyan pygmy perch (OPP) habitat and a SEPP 14 wetland.

There is no known occurrence of acid sulfate soils in the area, however the soil conditions along the alignment within the region are mapped as highly erodible, posing an increased risk of sedimentation to the swamp.

It is noted that monitoring specifically associated with OPP is addressed in the Threatened Fish Management Plan.

The Rous Water borefields in Section 8



In Section 8 of the project, there are three groundwater bores east of Woodburn operated by Rous Water Regional Water Supply. This drinking water supply source draws raw water from the Woodburn Sands aquifer system. The water table is typically located within two metres of the ground surface.

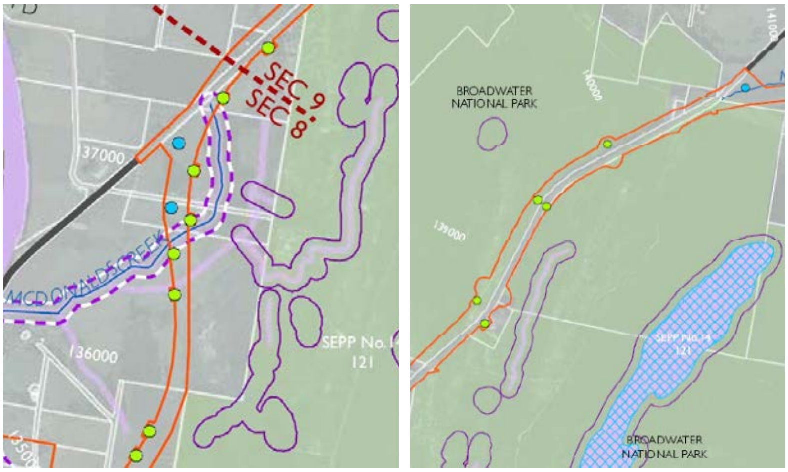
The region is a floodplain and contains a number of cane drains but does not include any named or mapped waterways.

If unmitigated, construction between chainages 131 km and 134 km may result in contamination of this groundwater source with a range of pollutants including sediments, nutrients, hydrocarbons, metals, and pathogens, through direct intersection or infiltration.

Furthermore, the setting of the borefield is in a high risk area for the presence of acid sulfate soils. Any decrease in pH of the groundwater, either through de-watering leading to acid production or allowing infiltration of acid water into the ground water system, would create an elevated risk of dissolved metal contaminants in the Woodburn Sand aquifer system. The implication of any contamination would be that water drawn from the bores may not be suitable for use by Rous Water without additional treatment to what is currently provided.

The Broadwater National Park and associated wetlands in Section 8 and 9

Broadwater National Park is east of the project and close to the proposed alignment between chainages 135 km and 141 km in Sections 8 and 9. Wetlands in the park, a number of which are listed SEPP 14 wetlands, are OPP habitat.

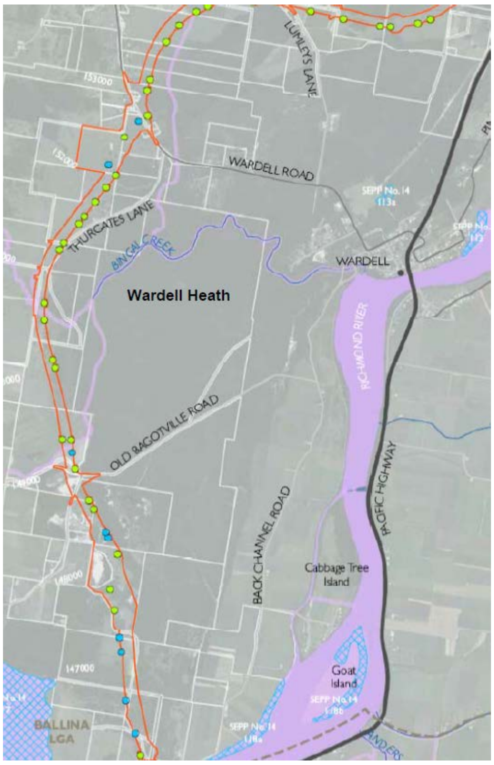


There are two waterways crossing the project in this region – Macdonalds Creek at chainage 136.7 km and an unnamed tributary of Macdonalds Creek at chainage 136.5 km.

Risks to water quality are increased by the presence of highly erodible soils along the project alignment. Around Macdonalds Creek there is a high probability of acid sulfate soils. As noted previously, specific monitoring relating to OPP is addressed in the Threatened Fish Management Plan.

Wardell Heath in Section 10

Wardell Heath is located to the east of the project between chainages 146 km and 157 km in Section 10. It is deemed to be region of high ecological value. There are three unnamed waterways that cross the alignment in this region (at chainages 149.3 km, 150.6 km and 153.9 km), all of which flow to Bingal Creek, which passes through Wardell Heath.



Risks to water quality from construction in this area are increased by highly erodible soils. There is low probability of acid sulfate soils in the area, no major works within waterways and the alignment is not steep, thus limiting risks to water quality from such factors during construction.

Areas within 50 m of a known or potential habitat of a threatened aquatic species

Areas throughout the project where surface water from the construction site or operational highway would discharge to or within 50 m distance from a known or potential habitat of a threatened fish are considered to be sensitive receiving environments as well as high risk areas. In particular, a borrow source site (Lang Hill) has been identified adjacent to OPP habitat at chainage 134.7 km.

1.7 Updates to this Plan

The WQMP takes an adaptive management approach (as described in **Section 8.6)** in order to identify and implement opportunities for improvement and to ensure the WQMP is meeting its objectives. Accordingly, this document is a working document and the WQMP has been subject to ongoing review since construction phase monitoring commenced in July 2016. Annual reports (refer **Section 7.5.1**) for years 1 and 2 of the construction phase monitoring have included recommended changes to the monitoring program. These changes have been presented to relevant agencies within W2B Environmental Review Group (ERG) meetings and the changes have subsequently been approved and implemented.

This version of the plan therefore reflects the changes that have been implemented in years 1 and 2 of the construction phase of the WQMP. A summary of the changes follows.

1.7.1 Surface Water Monitoring Locations

To improve the effectiveness and relevance of the monitoring program, a number of amendments to surface water monitoring locations have been implemented. Amendments comprised either the removal of persistently dry sites or the relocation of sites to ensure the upstream site was not impacted by the Project. The maps of monitoring locations in **Appendix A** and the details in **Section 2.1** reflect these changes.

1.7.2 Groundwater Monitoring Locations

The groundwater monitoring bore locations have been reviewed on an annual basis, including consultation with the ERG. The focus has been to ensure that any proposed changes would still allow the project WQMP objectives to be achieved.

In response to the annual reviews, some groundwater bores have been removed from the program for the following reasons:

- Bores (including their matching pairs) that had been observed to be persistently dry.
- Bores that were in close proximity to other bores.
- Bores that did not have a matching ‘pair’ and therefore could not be assessed using the data analysis approach described in **Sections 7.2 and 7.3**.
- Bores that were impacted by construction.
- Bore that had access issues – particularly private/ adjacent land.

The maps of monitoring locations in **Appendix A** and details in **Section 2.2** have been updated to reflect these changes.

1.7.3 Monitoring Frequency

The WQMP formerly stipulated that the automatic groundwater level recorders (loggers) were to be set to take readings at a maximum of one-hour intervals. However, this frequency of readings resulted in the logger batteries running out of charge relatively quickly. Therefore, loggers are now set to take readings at six-hour intervals to increase the battery life of the loggers. This change is reflected in **Section 4.3.1.1**. Increasing the frequency of readings to six-hour intervals does not compromise the ability to achieve the WQMP objectives.

1.7.4 Monitoring Parameters

This document formerly listed Total Petroleum Hydrocarbons as one of the water quality parameters to be monitored. This parameter has been updated to Total Recoverable Hydrocarbons in line with industry best practice.

1.7.5 Groundwater Quality Data Analysis Approach

The WQMP formerly stipulated that groundwater quality monitoring results be assessed using comparisons to the P80 and P20 values from the baseline data. However, there is no baseline data for some parameters and only limited baseline data for the remainder. Therefore, an alternative approach has been adopted which is now described in **Section 7.2**.

2. Monitoring Locations

There are 37 surface water monitoring locations including groundwater dependent ecosystems. Most locations include an upstream and downstream sampling site resulting in a total of 71 sampling sites. The sampling sites are listed in **Table 2.1** and mapped in **Appendix A**.

There are 59 groundwater bores monitoring significant cuts and fill embankments. Groundwater levels will be monitored at each bore, and water quality will be monitored at 39 of the 59 bores. The water quality sites have been selected for sites close to sensitive receiving environments, and to provide an even spread along the works. The monitoring bores are listed in **Table 2.2** and mapped in **Appendix A**.

2.1 Surface Water Monitoring Locations

The objective of the surface water monitoring is to assess potential impacts of the highway upgrade on water quality and its beneficial uses. These beneficial uses can include: protect aquatic ecosystems; agricultural uses including stock watering; recreational uses; and drinking water supplies.

The selected waterways are generally the same as the monitoring sites from the pre-construction monitoring phase but with the addition of an upstream or downstream monitoring site. However, some sites have been removed from the WQMP or relocated as described in **Section 1.7.1**.

The selected waterways are associated with sensitive receiving environments, groundwater dependent ecosystems (GDE's) and Oxleyan Pygmy Perch (OPP) habitat. The type of sensitive receiving environment and designation of high-risk areas (refer to **Section 1.3**) is indicated in the 'Waterway' column in **Table 2.1**. This information is based on Section 2 of the Water Quality Working Paper (RMS, Aurecon, SKM, 2012c). Refer to **Appendix B** to **Appendix J** for the respective highway sections (3 to 11) for descriptions of the sensitive receiving environments associated with the nominated monitoring locations.

The pre-construction sampling locations at each waterway were generally located on the downstream side of the proposed highway alignment at a location near the project boundary. The proposed sampling locations for the construction and post-construction phases are generally located both upstream and downstream of the highway alignment, within proximity to pre-construction sampling locations. This has been done to allow for a direct comparison between upstream and downstream conditions as well as a comparison with pre-construction monitoring results.

2.2 Groundwater Monitoring

There is a total of 59 groundwater bores to be monitored for groundwater levels. The bores are generally associated with significant cuts ('Type A' cuts) and significant fill embankments. There are also four bores monitoring the Rous Water borefields (refer to **Section 1.6**). **Table 2.2** indicates the purpose of each bore in terms of whether it is monitoring a significant cut, fill or the Rous Water borefields. Of the 59 bores, 39 will be monitored for water quality. The bores are listed in **Table 2.2** and mapped in **Appendix A**.

The objectives of the groundwater monitoring are to:

- Assess the potential impact of the highway upgrade cut structures on groundwater levels and groundwater quality.
- Assess the potential impact of the highway upgrade on groundwater in order to protect licenced bores, waterways and watercourses, and groundwater dependent ecosystems.

Table 2.1 Surface Water Monitoring Point Locations

Highway Section	*Waterway/ (type of sensitive receiving environ't - refer to table notes)*	*Site Identifier*	*High Risk Area*	*Identifier from Pre-Const'n*	*Approx. Chainage*	*Easting*	*Northing*
Section 3 - Glenugie to Tyndale	Picanny Creek / Pheasant Creek (A)	SW3-01		SW01	36200	503336	6704937
		SW3-02		SW02	36400	503147	6705334
	Unnamed tributary of Glenugie Creek (A)	SW3-03		SW03	36600	504445	6708191
		SW3-04				504200	6708469
	Unnamed tributary of Coldstream River (A, B, C, D)	SW3-05	✓	SW04	42600	507255	6708458
		SW3-06	✓			507329	6708595
	Coldstream River (A, B, C, D)	SW3-07	✓	SW05	43350	507950	6708628
		SW3-08	✓			508008	6708765
	Pillar Valley Creek (A, B, C, D)	SW3-09	✓	SW06	46400	510880	6709589
		SW3-10	✓			510847	6709710
	Black Snake Creek (A, B, C, D)	SW3-11	✓	SW07	46700	511113	6709869
		SW3-12	✓			510979	6709887
	Unnamed Creek tributary of Ellis Swamp (A, D)	SW3-13	✓	SW22	50350	512238	6713228
		SW3-14	✓			512152	6713216
	Chaffin Creek (A, B, C, D)	SW3-15	✓	SW08	52450	512179	6715305
		SW3-16	✓			512057	6715355
	Champions Creek (A, B, C, D)	SW3-19	✓	SW10	57100	513210	6719732
		SW3-20	✓			513083	6719842
	Unnamed bodies of water (A, D)	SW3-21	✓	SW11	58700	513778	6721250
		SW3-22	✓			513653	6721287
	South Arm Clarence River (A)	SW3-23		SW12	67950	514434	6730050
Section 4 - Tyndale to Maclean	Shark Swamp overflow	SW4-01		SW23	73400	518903	6732813
		SW4-02				518796	6732827
	Shark Creek (A, C)	SW4-03		SW13	74950	519244	6734336
		SW4-04				519109	6734316
	Edwards Creek	SW4-05		SW14	80200	520106	6739393
		SW4-06				519907	6739434

Highway Section	***Waterway/ (type of sensitive receiving environ't - refer to table notes)***	***Site Identifier***	***High Risk Area***	***Identifier from Pre-Const'n***	***Approx. Chainage***	***Easting***	***Northing***
Section 5 - Maclean to Iluka Road	Unnamed tributary of James Creek (A, C)	SW5-03		SW15	85500	523678	6743214
		SW5-04				523645	6743284
	Clarence River (A, B)	SW5-05		SW16	86800	523335	6744623
		SW5-06				523507	6744641
	Serpentine Channel (A)	SW5-07		SW17	89350	523513	6747097
		SW5-08				523598	6747096
	North Arm (Clarence River) (A, B, C)	SW5-09		SW18	94200	524306	6751477
		SW5-10				524438	6751489
	Mororo Creek (South) (A)	SW5-11		SW19	94950	523928	6752187
Section 6 - Iluka Road to Devils Pulpit	Tabbimoble Creek (A, B, C)	SW6-03		SW21	101650	521092	6758080
		SW6-04				521269	6758168
	Tabbimoble Overflow (A, B, C)	SW6-05		SW25	102850	520522	6759162
		SW6-06				520697	6759323
Section 7 - Devils Pulpit to Trustums Hill	Unnamed tributary of Tabbimoble Swamp (A, B)	SW7-01		SW01	114050	525617	6769018
		SW7-02			113900	525747	6768772
	Tabbimoble Floodway No.1 (A, B)	SW7-03		SW02	115300	526348	6770159
		SW7-04				526395	6770003
	Oakey Creek (A, B)	SW7-05		SW03	1218750	529640	6775311
		SW7-06			122250	529942	6775734
	South of the intersection with the existing Pacific Highway and Norton's Road (A, B)	SW7-07		SW04	124500	531315	6777327
		SW7-08				531223	6777369
Section 8 - Trustums Hill to Broadwater National Park	Tuckombil Canal (becomes Evans River) (A, B)	SW8-01		SW05	130100	533366	6782359
		SW8-02				533465	6782226
	Unnamed watercourse at CH 134 700 m	SW8-03		SW06	134600	537232	6784414
		SW8-04			134900	537136	6785112
	Unnamed tributary of McDonald's Creek CH 136 450 m (A, B)	SW8-05		SW07	135500	537954	6784929
		SW8-06				537912	6785047
	McDonald's Creek (A, B, D)	SW8-07	✓	SW08	136600	538158	6786141
		SW8-08	✓			538057	6786078
Section 9 - Broadwater National Park	Montis Gully (A, B, C)	SW9-01A		SW09	141900	541818	6789129
		SW9-01B				541827	6789224
		SW9-02		SW10	143400	543207	6790014

Highway Section	***Waterway/ (type of sensitive receiving environ't - refer to table notes)***	***Site Identifier***	***High Risk Area***	***Identifier from Pre-Const'n***	***Approx. Chainage***	***Easting***	***Northing***
to Richmond River	Everson's Creek (A, B, C)	SW9-03				543409	6790332
Section 10 - Richmond River to Coolgardie Road	Richmond River (A, B, C)	SW10-01		SW11	146000	542708	6792345
		SW10-02				542801	6792343
	Pond / wetland	GDE07		GDE07	148800	542202	6795080
	Unnamed tributary Bingal Creek CH 149 250 m (A, D)	SW10-03	✓	SW12	149300	541901	6795398
		SW10-04	✓			542052	6795483
	Saltwater Creek	SW10-05		SW13	157500	545928	6800596
		SW10-06				546332	6800231
	Randles Creek	SW10-07		SW14	157800	546289	6800832
		SW10-08				546357	6800700
Section 11 - Coolgardie Road to Ballina Bypass	Duck Creek (A, C)	SW11-01		SW15	164200	548168	6807018
		SW11-02				548847	6806576

Notes: A = key fish habitats
B = mapped, recorded or potential habitat of threatened aquatic species
C = SEPP 14 and Nationally important wetlands
*D = high risk areas (refer to **Section 1.6**)*

Table 2.2 List of Bores for Groundwater Monitoring

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Sensitivity[1] (see notes)	Monitoring for	
							Level	Quality[2]
Section 3 - Glenugie to Tyndale	GWB3-05	PZ09	39800	504540	6708366	A	Y	Y
	GWB3-06	PZ10	39800	504575	6708258	A	Y	Y
	GWB3-07	PZ13	42950	507650	6708670	Fill	Y	Y
	GWB3-08	PZ14	42950	507664	6708562	Fill	Y	Y
	GWB3-13	PZ19	46200	510796	6709494	Fill	Y	Y
	GWB3-14	PZ20	46200	510692	6709581	Fill	Y	Y
	GWB3-21	PZ27	48350	511892	6711361	A	Y	Y
	GWB3-22	PZ28	48350	511777	6711419	A	Y	Y
	GWB3-28	PZ35	53200	512373	6715987	A	Y	Y
	GWB3-29	PZ36	53200	512253	6716011	A	Y	Y
	GWB3-32	PZ39	55400	512966	6718146	A	Y	Y
	GWB3-33	PZ40	55400	512830	6718165	A	Y	Y
	GWB3-37	BH1139	59650	513924	6722241	A	Y	Y
	GWB3-38	PZ45	59600	513768	6722169	A	Y	Y
	GWB3-43	BH1159	66600	514247	6728732	A	Y	Y
	GWB3-45	PZ50	66850	514199	6729026	A	Y	Y
	GWB3-46	PZ51	67700	514778	6729714	A	Y	Y
	GWB3-47	BH1187	67650	514551	6729679	A	Y	Y
	GWB3-48	BH1197	68300	514866	6730253	A	Y	-
	GWB3-49	PZ52	68250	514688	6730300	A	Y	-
	GWB3-50	BH1200	68500	514995	6730479	A	Y	Y
	GWB3-51	PZ53	68550	514804	6730578	A	Y	Y
Section 4 - Tyndale to Maclean	GWB4-01	BH1206	69250	515435	6730961	A	Y	Y
	GWB4-02	PZ54	69200	515291	6731062	A	Y	Y
Section 5 - Maclean to Iluka Road	GWB5-01	PZ71	85800	523248	6743591	Fill	Y	Y
	GWB5-02	PZ72	85650	523430	6743441	Fill	Y	Y
Section 6 - Iluka Road to Devils Pulpit	Section 6 does not contain significant cuttings or areas of extensive fill for construction of the Pacific Highway Upgrade.							
Section 7 – Devils Pulpit to Trustums Hill	The monitoring bores in Section 7 have been removed from the program (refer to **Section 1.7.2**)							
Section 8 – Trustums Hill to Broadwater National Park	GWB8-01	BH1228	128450	533112	6780661	Fill	Y	-
	GWB8-02	BH1229	128450	532755	6780701	Fill	Y	-
	GWB8-07	BH1234	130100	533420	6782235	Fill	Y	Y

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Sensitivity[1] (see notes)	Monitoring for	
							Level	Quality[2]
	GWB8-08	BH1235	130100	533327	6782335	Fill	Y	Y
	GWB8-14	BH1241	132100	535160	6783127	Rous	Y	Y
	GWB8-15	BH1242	132150	535405	6783070	Rous	Y	Y
	GWB8-16	BH1243	132200	535228	6783278	Rous	Y	Y
	GWB8-17	BH1244	132250	535078	6783427	Rous	Y	Y
	GWB8-18	BH1245	132750	535589	6783650	Fill	Y	-
	GWB8-19	BH1246	132800	535726	6783620	Fill	Y	-
	GWB8-22	BH1249	134850	537334	6784727	Fill	Y	Y
	GWB8-23	BH1250	134800	537458	6784493	Fill	Y	Y
	GWB8-24	BH1251	136600	538171	6786034	Fill	Y	-
	GWB8-25	BH1252	136600	538072	6786029	Fill	Y	-
Section 9 - Broadwater National Park to Richmond River	GWB9-01	BH1254	137650	538513	6787003	Fill	Y	Y
	GWB9-02	BH1255	137700	538424	6787105	Fill	Y	Y
	GWB9-03	BH1256	140300	540252	6788872	Fill	Y	Y
	GWB9-07	BH1260	141400	541379	6789029	Fill	Y	Y
	GWB9-08	BH1261	141400	541359	6789098	Fill	Y	Y
	GWB9-09	BH1262	141900	541900	6789172	Fill	Y	-
	GWB9-10	BH1263	141950	541870	6789292	Fill	Y	-
	GWB9-11	BH1264	142950	542767	6789776	Fill	Y	-
	GWB9-12	BH1265	143100	542988	6789746	Fill	Y	-
	GWB9-13	BH1266	143900	543275	6790473	Bridge	Y	-
	GWB9-14	BH1267	144000	543437	6790525	Bridge	Y	-
	GWB9-17	N/A	142500	542500	6789416	A	Y	-
	GWB9-18	N/A	142500	542483	6789485	A	Y	-
	GWB9-19	N/A	142700	542591	6789635	A	Y	-
	GWB9-20	N/A	142700	542555	6789727	A	Y	-
Section 10 – Richmond River to Coolgardie Road	GWB10-03	BH1272	148300	542337	6794530	A	Y	-
	GWB10-04	BH1273	148350	542218	6794549	A	Y	Y
	GWB10-05	BH1274	148450	542255	6794684	A	Y	-
Section 11 – Coolgardie Road to Ballina Bypass	GWB11-03	BH1285	163000	547664	6805746	Fill	Y	Y

Note: 1. "A" = Type A cuts that have potential high impact on groundwater. The final design surface of these cuts will either: sit below the current groundwater table and hence instigate ingress of groundwater onto the pavement; or the watertable is likely to be at or very close to the road design surface.
"Fill" = potential impacts from impediments to groundwater flow, such as deep fill in areas of shallow groundwater tables
"Rous" = Rous Water borefields – refer to **Section 1.6**
2. Pre-construction water quality monitoring consisted of EC, pH and temperature for the nominated bores in Sections 3-6 and only pH readings for the nominated bores in Sections 7-11.

3. Summary of Pre-Construction Monitoring

Pre-construction monitoring of surface waters and groundwater was undertaken between January 2013 and January 2014 by:

- Coffey Geotechnics Pty Ltd for Sections 3 to 6 (referred to as Glenugie to Devils Pulpit - G2DP) and
- Golder Associates Pty Ltd for Sections 7 to 11 (referred to as Devils Pulpit to Ballina - DP2B).

A total of 43 surface water sampling sites were monitored. The construction monitoring will continue monitoring at each of these sites with the exception of two ponds that will be filled by the highway works.

A total of 142 groundwater bores were monitored. Each bore was monitored for groundwater levels, and 113 of the bores were monitored for basic water quality parameters. Three bores adjoining the Rous Water Woodburn borefield in Section 8 were also monitored for a large range of water quality parameters.

Details of the pre-construction monitoring results for each highway section (3 to 11) are contained in **Appendix B** to **Appendix J**.

3.1 Surface Water Monitoring

The surface water locations monitored in the pre-construction phase are listed in **Table 3.1**.

Appendix B to **Appendix J** provide the following surface water monitoring data for highway sections 3 to 11 respectively:

- List of the monitoring locations and associated sensitive receiving environments.
- An overview of the water quality monitoring results in regard to physical properties, chemical properties, hydrocarbons, nutrients, and heavy metals.
- A summary of the visual observations and sampling results for each monitoring site.
- A summary of the water quality statistics (median, minimum, maximum etc) for each monitoring site.

3.1.1 Number of Monitoring Events

Surface water quality monitoring for Sections 3 to 6 involved a total of 15 monitoring events - 11 dry weather events and four wet weather events. Surface water quality monitoring for Sections 7 to 11 involved a total of 13 monitoring events in 2013 (approximately monthly).

3.1.2 Number of Monitoring Locations

Sections 3 to 6

A total of 25 sites were monitored for Sections 3 to 6 which included some groundwater dependent ecosystems (GDE's) as described for each section in the details provided in **Appendix B** to **Appendix E**.

Sections 7 to 11

A total of 25 sites were monitored for Sections 7 to 11 which included:

- nine SW sites (SW04, SW05, SW06, SW07, SW09, SW10, SW11, SW12, SW14).
- three GDE sites (GDE04, GDE05, GDE07).
- six combined SW / GDE sites (SW01 / GDE01, SW02 / GDE02, SW03 / GDE03, SW08 / GDE06, SW13 / GDE08, SW15 / GDE09).

Table 3.1 Surface Water / GDE Quality Monitoring Locations

Highway Section	***Waterway / Type of sensitive receiving environment (refer to table notes for descriptors)***	***Identifier from Pre- Construction Phase***	***Approx. Chainage***
Section 3	Picanny Creek (A)	SW01	35700
	Pheasant Creek (A)	SW02	36300
	Unnamed tributary Glenugie Creek (A)	SW03	36900
	Unnamed tributary of Coldstream River (A, B, C, D)	SW04	42400
	Coldstream River (A, B, C, D)	SW05	43350
	Pillar Valley Creek (A, B, C, D)	SW06	46400
	Black Snake Creek (A, B, C, D)	SW07	46600
	Unnamed Creek tributary of Ellis Swamp (A, D)	SW22	50400
	Chaffin Creek (A, B, C, D)	SW08	52450
	Unnamed tributary of Chaffin Creek (A, B, C, D)	SW09	54700
	Champions Creek (A, B, C, D)	SW10	57100
	Unnamed bodies of water (A, D)	SW11	58700
	South Arm Clarence River (A)	SW12	67950
Section 4	Shark Swamp overflow	SW23	73400
	Shark Creek (A, C)	SW13	74950
	Edwards Creek	SW14	80200
Section 5	Yaegl Wetland (A)	SW24	84400
	Unnamed tributary of James Creek (A, C)	SW15	85100
	Clarence River (A, B)	SW16	86300
	Serpentine Channel	SW17	89350
	North Arm (Clarence River) (A, B, C)	SW18	94200
	Mororo Creek (South) (A)	SW19	94950
Section 6	Unnamed tributary of Mororo Creek (North) (A, B)	SW20	96700
	Tabbimoble Creek (A, B, C)	SW21	101650
	Tabbimoble Overflow (A, B, C)	SW25	102850
Section 7	Unnamed tributary of Tabbimoble Swamp (A, B)	SW01 / GDE01	114000

Highway Section	Waterway / Type of sensitive receiving environment (refer to table notes for descriptors)	Identifier from Pre- Construction Phase	Approx. Chainage
	Tabbimoble Floodway No.1 (A, B)	SW02 / GDE02	115300
	Oakey Creek (A, B)	SW03 / GDE03	122400
	South of the intersection with the existing Pacific Highway and Norton's Road (A, B)	SW04	124400
Section 8	Tuckombil Canal (becomes Evans River) (A, B)	SW05	130100
	Small pond / wetland. Generally dry. Located in footprint of highway upgrade	GDE04	130300
	Large pond / wetland. Located in footprint of highway upgrade	GDE05	133350
	Unnamed watercourse	SW06	134700
	Unnamed tributary of McDonald's Creek (A, B)	SW07	136450
	McDonald's Creek (A, B, D)	SW08 / GDE06	136600
Section 9	Montis Gully (A, B, C)	SW09	140950
	Everson's Creek (A, B, C)	SW10	143400
Section 10	Richmond River (A, B, C)	SW11	145900
	Large pond / wetland.	GDE07	148830
	Unnamed tributary Bingal Creek (A, D)	SW12	149250
	Saltwater Creek	SW13 / GDE08	157200
	Randles Creek	SW14	157800
Section 11	Duck Creek (A, C)	SW15 / GDE09	164400

Notes: A = key fish habitats
B = mapped, recorded or potential habitat of threatened aquatic species
C = SEPP 14 and Nationally important wetlands
D = high risk areas (refer to **Section 1.6**)

3.1.3 Surface Water Monitoring Parameters

Sections 3 to 6

The following parameters were monitored were measured in the field during each monitoring event:

- pH.
- Dissolved oxygen (DO).
- Electrical conductivity (EC).
- Temperature.
- Turbidity.

Samples were also tested for the following laboratory analysis parameters:

- Total Suspended Solids.
- Oil and Grease.
- Total Phosphorous and Total Nitrogen.

- Cations (Ammonia, Calcium, Magnesium).
- Metals (Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver and Zinc).

Sections 7 to 11

The following parameters were monitored were measured in the field:

- pH.
- Dissolved oxygen (DO).
- Electrical conductivity (EC).
- Redox potential.
- Temperature.
- Turbidity.

Samples were also tested for the following laboratory analysis parameters (please note that not all sites were tested for all the following parameters):

- Total Suspended Solids.
- Oil and Grease.
- Total Petroleum Hydrocarbons.
- Total Phosphorous and Total Nitrogen.
- Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen.
- Cations (Calcium, Magnesium).
- Metals (Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver and Zinc).

The Groundwater Dependent Ecosystem monitoring locations were also tested for major cations and anions in addition to the above parameters.

3.2 Groundwater Monitoring

The groundwater locations monitored in the pre-construction phase are listed in **Table 2.2** under the column heading “Identifier from Pre-Construction” with the exception of BH1257, 1268 and 1269 in Section 9 which had not been constructed during the pre-construction phase.

3.2.1 Groundwater Levels

Groundwater level monitoring was undertaken for all groundwater bores. The automatic data loggers recorded at one hour intervals for Sections 3 to 6 and 15 minute intervals for Sections 7 to 11. Plots of the groundwater level at each bore are shown in **Appendix B** to **Appendix J**.

3.2.2 Groundwater Quality

Statistics for the groundwater quality for each bore are shown in **Appendix B** to **Appendix J**.

In both Sections 3 to 6 and Sections 7 to 11 groundwater quality was monitored four times (quarterly) in 2013.

Number of Monitoring Locations

- 77 bores in Sections 3 to 6 (essentially all the bores in Sections 3 to 6 excluding PZ06 and PZ07 which were dry).
- 36 bores in Sections 7 to 11 as nominated in **Table 2.2** which are located in areas of proposed fill embankments.

Monitoring Parameters

In Sections 3 to 6, the bores were monitored for in-situ parameters of pH, EC and temperature. In Sections 7 to 11, the bores were monitored for pH only, with the exception of three bores in Section 8 (BH1242, BH1243 and BH1244) which were monitored for pH, EC, TDS, hydrocarbons, nutrients, major cations and anions, and heavy metals.

4. Sampling Regime and Parameters

4.1 Monitoring Duration

The minimum monitoring period for the construction and operational phases of the project are:

- Construction phase: for the duration of the construction period. Commencement of construction is defined by approval by NSW Department of Planning and Environment of the Construction Environmental Management Plan for the main construction activities on-site; and
- Operational phase: a minimum of three years following completion of Construction as defined in the project approval or until the affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales) (refer to infrastructure approval Condition D12 in **Section 1.2** of this report).

4.2 Surface Water

4.2.1 Construction Phase

Sampling over the construction monitoring period will comprise:

- one wet event sampling round per month <u>except for 'high risk areas' where two wet event sampling rounds will be undertaken</u> (refer to **Table 2.1** for high risk areas):
  - Type A parameters every month (<u>every round for 'high risk areas'</u>); plus
  - Type B parameters every second month (<u>every second round for 'high risk areas'</u>)
- one dry event sampling round per month for all sites:
  - Type A parameters every month; plus
  - Type B parameters every second month.

Table 4.1 Surface Water Sampling Parameters – Construction Phase

Parameter		***Type A Parameters***	***Type B Parameters***
pH	(measured in the field)	X	
Temperature	(measured in the field)	X	
Electrical Conductivity (EC)	(measured in the field)	X	
Dissolved Oxygen (DO)	(measured in the field)	X	
Turbidity	(measured in the field)	X	
Total Suspended Solids (TSS)			X
Total Oils and Grease (include as Type A parameter if oil/grease is visible)		*	X
Total Phosphorous, Total Nitrogen			X
Total Recoverable Hydrocarbons (TRH) (include as Type A parameter if oil/grease is visible)		*	X

* Note: Oils and Grease and TRH to be analysed as a Type A parameter if oil/ grease is visible

Wet events are defined as 15mm or more of rain within 24 hours. Wet event sampling is to be undertaken within 48 hours of the rain event. Refer to **Section 4.4** regarding rainfall information.

Annual reviews of the surface water monitoring program have resulted in changes to analytes and locations as described in **Section 1.7**. These changes are reflected throughout this version of the WQMP.

The sampling regime will continue to be reviewed in consultation with the ERG. The reviews shall consider:

- if the frequency of some of the sampling can be reduced or needs increasing; or
- if some analytes/ parameters/ locations can be omitted from the sampling.

4.2.2 Operational Phase

After the first year of operation, it is assumed that revegetation will have generally established and stabilised. After the first year of operation, the Project independent water quality expert would review the first 12 months of results and determine if any changes to the sampling regime are warranted.

4.2.2.1 Operational Phase – First Year of Operation

Sampling over the first year of the operational phase will comprise:

- one **wet event** sampling round per quarter:
  - Type A parameters every quarter (refer to **Table 4.2**); plus
  - Type B parameters every second quarter (refer to **Table 4.2**).
- one **dry event** sampling round every six months (two rounds in the first year of operation):
  - Type A and Type B parameters.

Table 4.2 Surface Water Sampling Parameters – Operational Phase

Parameter		*Type A Parameters*	*Type B Parameters*
pH	(measured in the field)	X	
Temperature	(measured in the field)	X	
Electrical Conductivity (EC)	(measured in the field)	X	
Dissolved Oxygen (DO)	(measured in the field)	X	
Turbidity	(measured in the field)	X	
Total Suspended Solids (TSS)			X
Total Oils and Grease (include as Type A parameter if oil/grease is visible)		*	X
Total Phosphorous, Total Nitrogen			X
Total Recoverable Hydrocarbons (TRH) (include as Type A parameter if oil/grease is visible)		*	X
Heavy Metals (Total): Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Zinc			X

* Note: Oils and Grease and TRH to be analysed as a Type A parameter if oil/grease is visible

4.2.2.2 Operational Phase – Second and Third Year of Operation

Sampling over the second and third years of the operational phase will comprise:

- one **wet event** sampling round every six months assessing both Type A and Type B parameters
- one **dry event** sampling round every six months assessing both Type A and Type B parameters.

4.3 Groundwater

4.3.1 Groundwater Level Monitoring Regime

Groundwater level monitoring will be undertaken at each of the 59 groundwater bores nominated in **Table 2.2** using automatic water level recorders.

4.3.1.1 Construction Phase

The automatic water level recorders will be set to take readings at a maximum of six-hour intervals with data downloaded quarterly.

Quarterly downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

Annual reviews of the groundwater monitoring program have resulted in changes to the water level monitoring frequency as described in **Section 1.7**. This change is reflected throughout this version of the WQMP.

The groundwater level recording/ download frequency will continue to be reviewed in consultation with the ERG to determine if any further changes are warranted.

4.3.1.2 Operational Phase – First Year of Operation

The automatic water level recorders will be set to take readings at a maximum of six-hour intervals with data downloaded quarterly.

Quarterly downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

4.3.1.3 Operational Phase – Second and Third Year of Operation

The automatic water level recorders will be set to take readings at a maximum of six-hour intervals. The maximum period between downloading and calibration will be six months.

Downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

4.3.2 Groundwater Quality Sampling Regime

4.3.2.1 Construction Phase

Sampling over the construction monitoring period will comprise:

- quarterly sampling of Type A parameters (field analysis parameters - refer to **Table 4.3**) plus
- six-monthly sampling of Type B parameters (laboratory analysis parameters - refer to **Table 4.3**).

Sampling will be conducted on the 39 groundwater bores nominated in **Table 2.2** for quality monitoring.

Annual reviews of the groundwater monitoring program have resulted in changes to monitoring locations as described in **Section 1.7**. These changes are reflected throughout this version of the WQMP. The sampling regime will continue to be reviewed in consultation with the ERG and . shall consider:

- if the frequency of some of the sampling can be reduced or needs increasing; or
- if some analytes/ parameters/ locations can be omitted from the sampling.

4.3.2.2 Operational Phase – First Year of Operation

Sampling over the first year of the operational phase will comprise six-monthly monitoring of both Type A and B parameters. The number/ location of the bores and the sampling parameters shall be based on the construction sampling regime described in this WQMP (and any changes adopted as a result of future reviews of the WQMP).

4.3.2.3 Operational Phase – Second and Third Year of Operation

Sampling over the second and third year of the operational phase will comprise annual monitoring of both Type A and B parameters. The number/ location of the bores and the sampling parameters shall be based on the construction sampling regime described in this WQMP (and any changes adopted as a result of future reviews of the WQMP).

Table 4.3 Groundwater Quality Sampling Parameters

Parameter/Analytical Group	*Analytes*	*Type A Parameters (Field analysis)*	*Type B Parameters (Laboratory analysis)*
Physical and chemical properties	pH	X	
	Temperature	X	
	Electrical Conductivity (EC)	X	
Hydrocarbons	Total Recoverable Hydrocarbons (TRH)		X
Nutrients	Total Phosphorous, Total Nitrogen		X
Major Cations	sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+})		X
Major Anions	chloride (Cl^-), sulfate (SO_4^{2-}), bicarbonate (HCO^{3-})		X
Heavy Metals (Dissolved)	Aluminium, Cadmium, Copper, Lead, Zinc		X

4.4 Rainfall Data

For the construction phase rainfall data shall be collected from a range of weather stations including existing BoM stations and site construction weather stations where available. As noted previously, 'wet events' are defined as 15mm or more of rain within 24 hours.

It is noted that the pre-construction monitoring utilised daily rainfall figures from the following Bureau of Meteorology (BoM) sites:

- Grafton Airport – Station No. 058130: Lat. 29.68 ºS, Long. 152.93 ºE, Elevation 9m.
- Yamba Pilot Station – Station No. 058012: Lat. 29.43 ºS, Long. 153.36 ºE, Elevation 27m.
- Evans Head Station – Station No. 058164: lat. 29.133 ºS, Long. 153.45 ºE, Elevation 31m.

5. Sampling Methodology

5.1 Pre-Monitoring Tasks

5.1.1 Rainfall Monitoring

Daily records of rainfall will be obtained from the construction site weather stations (refer to **Section 4.4**). This information will be checked/ reviewed daily to determine if local rainfall events may trigger a wet weather surface water sampling event as required in **Section 4.2**.

5.1.2 Calibration

The field water quality probe used for surface and groundwater monitoring is to be calibrated in accordance with the manufacturer's recommendations. Any pre-sampling equipment and calibration checks recommended by the manufacturer are to be completed prior to each sampling round. Where sampling extends beyond one day, the probe is to be rechecked in accordance with manufacturer's recommendations for each subsequent day of use. Calibration record sheets are to be completed and retained on the project file.

5.1.3 Preparation of Sample Containers

Sample containers suitable for the required laboratory analysis will be sourced from the laboratory prior to the commencement of monitoring rounds. Sample containers will be labelled prior to field sampling to reduce the potential for labelling errors made in the field.

5.1.4 Sampling equipment

Testing equipment required for surface water monitoring consists of the following:

- Water quality probe.
- Sampling pole.
- Sample bottles supplied by the laboratory.
- Chilled insulated container/ esky and ice.
- Additional sampling equipment (e.g. Bucket) for ex-situ field measurements where required (refer to **section 5.2.2**).
- Camera.
- GPS.
- Field sheets (or equivalent on electronic device).

Testing equipment required for the groundwater monitoring component will include:

- Water quality probe.
- Electronic dip (water level) meter.
- Tape measure for measuring depth of bores.
- Laptop/ notebook with software loaded and operational, water level logger licence key and USB cable.
- Sample bottles supplied by the laboratory.
- Chilled insulated container/ esky and ice.

- Camera.
- GPS.
- Field sheets (or equivalent on electronic device).

5.2 Surface Water Sampling

5.2.1 Field Observations

Observations will be recorded in field sheets at each sampling location upon arrival at the site. This will include:

- Date and time of sampling.
- Weather conditions including rainfall and cloud cover.
- General observations on the condition of the water body such as water colour, stream flow, evidence of recent flooding, any odour, any visible signs of oil/ grease on the water surface, gross pollutants, other pollution or other disturbances including relevant adjacent land use activity.
- Photographic records where it is considered that photos would assist with understanding the context of surface water quality measurements.

5.2.2 Collection of In-Situ Water Quality Data

The following parameters are to be measured in the field for each monitoring round using a calibrated water quality probe:

- pH.
- Temperature.
- Electrical Conductivity (EC).
- Dissolved oxygen (DO).
- Turbidity (NTU).

The field measurements are to be made prior to the collection of samples for laboratory analysis. The measurements are to be noted on the field sheets for each surface water monitoring site and/or captured and stored on the water quality probe.

The water quality probe is to be placed approximately 0.5 m below the water surface or mid-depth in the water column for shallow sites. The water quality readings will be allowed to stabilise before reading/ recording in accordance with the manufacturer's instructions.

Where safety concerns do not allow for sampling in-stream (or depth is too shallow for effective probe deployment), a sample may be collected using an appropriate sampling device (e.g. a metal bucket) and measurements undertaken on the stream bank. Where this methodology is employed it will be recorded on the field sheets. To avoid contamination of samples, field measurements are to be made on samples of water separate to samples collected for laboratory analysis.

Any sampling device used to obtain samples (to allow measurements on the bank) will be decontaminated between sampling sites.

5.2.3 Collection of Water Samples for Laboratory Analysis

Water samples will be collected by immersion of a sample bottle to 0.5 m below the water surface or mid-depth in the water column for shallow sites. The sample bottle will be rinsed three times with sample water prior to obtaining sample. Rinse water will be emptied downstream of the sampling location to avoid contamination of the sample.

Where safety concerns do not allow for sampling in-stream (or depth is too shallow to obtain a sample), a sample may be collected using an appropriate sampling device (e.g. a metal bucket) and a sub-sample then transferred to appropriate sample bottles. Any sampling device used to obtain samples will be decontaminated between sampling sites.

All samples will be stored in a chilled esky and transported to the laboratory as soon as practical.

5.2.3.1 Replicate Samples

One blind replicate water sample will be collected for every 10 samples every monitoring round for laboratory analysis. Blind replicate samples will be submitted to the laboratory as individual samples without any indication to the laboratory that they are replicates.

5.3 Groundwater Sampling

5.3.1 Field Observations

Observations will be recorded in field sheets at each sampling location upon arrival at the site. This will include:

- Date and time of sampling.
- Weather conditions including rainfall and cloud cover.
- General observations on the condition of the groundwater bore, any visible signs of contamination or other disturbances.
- Photographic records where it is considered that photos would assist with understanding the context of ground water measurements.

5.3.2 Collection of Groundwater Standing Water Levels

Prior to extracting the automatic water level recorders or any purging/ sampling, each monitoring well will be gauged by measuring:

- Depth to standing water level with an electronic dip (water level) meter.
- Total depth of the bore. The total depth of the bore is required as the base of the monitoring bores can silt up, and this can occur to the top of the slotted/ screened interval. Comparing the measured total depth reading with the depth documented at the time of construction can be useful to determine the status of the bore (Sundaram et. Al., 2009:24).

The above measurements will be made from a standard reference point on each of the well casings which will be noted on the field sheets. The readings will be recorded as depth from the Top of Casing (TOC).

The automatic water level recorder will then be extracted at each monitoring well for transfer of data to a laptop/ notebook. At the completion of the monitoring event, the laptop/ notebook will be downloaded and data collected from each well will be stored in a Microsoft Excel spread sheet. The field level data for each monitoring well will be corrected for barometric pressure and converted to a standing water level (SWL). This converted data will then be used to plot the SWL over time for each monitoring well.

5.3.3 Collection of Field Groundwater Quality Data

The following parameters are to be measured in the field for each monitoring round using a calibrated water quality probe:

- pH.
- Temperature.
- Electrical conductivity (ec).
- Dissolved oxygen (do).
- Turbidity (ntu).

The field measurements are to be made following purging of the wells and prior to the collection of samples for laboratory analysis. The measurements are to be noted on the field sheets and/or captured and stored on the water quality probe for each groundwater monitoring site.

All equipment will be decontaminated between sampling sites.

5.3.4 Collection of Groundwater Samples for Laboratory Analysis

Groundwater samples can be obtained by either a passive sampling approach or purging – either method is considered appropriate.

5.3.4.1 Passive Sampling

A passive sampling approach will utilise a “Hydrasleeve” or similar. The Hydrasleeve is a tool used for passive groundwater sampling that has been specifically designed to capture a “core” sample of water from a user-defined interval/ portion of the well.

A one-way reed valve allows the Hydrasleeve to be lowered into the well (with the use of a weight and string cut to the desired length) as a thin empty plastic sleeve, thereby preventing the mixing of fluid from higher up the water column. The groundwater sample collection process will involve the placement of Hydrasleeves at a depth of three meters below the top of the screen (or in the case of low yield wells, to the bottom of the well). Once lowered to the desired depth, the Hydrasleeve will be left for a minimum period of one week before being withdrawn and the required groundwater sample retrieved for laboratory analysis. Note that this lag time of one week is a precautionary measure to allow the water in the well to re-equilibrate, should any mixing have occurred.

The condition of each Hydrasleeve will be assessed at each monitoring round to confirm effective operation and that they are capturing a representative groundwater sample. Hydrasleeves that are deemed not to be operating effectively or are otherwise unsuitable for future deployment (for example Hydrasleeves that are unable to be thoroughly cleaned) will be disposed of appropriately upon withdrawal from the well and replaced with a new Hydrasleeve. After the sample has been retrieved from the Hydrasleeve it will be transferred to the corresponding laboratory supplied bottles for analysis. By taking this passive groundwater sampling approach, the bore does not require purging prior to every sampling event.

5.3.4.2 Purging

Prior to the collection of water samples for analysis each well will be purged. The wells will be purged using either an electric purge pump or a decontaminated stainless steel bailer until the following criteria is met:

- a minimum of three well volumes have been removed from the well; or
- the well has been purged dry.

The purging method will be recorded on the field sheet.

Collection of groundwater samples for laboratory analysis will be undertaken following purging and field measurements. All equipment will be decontaminated between sampling sites.

5.3.5 Replicate Samples

One blind replicate water sample will be collected for every 10 samples every monitoring round for laboratory analysis. Blind replicate samples will be submitted to the laboratory as individual samples without any indication to the laboratory that they are replicates.

6. Quality Management

6.1 Sample Identification and Records

Sample containers will be labelled clearly and include the following information:

- Job reference number.
- Sample location name (e.g. Sw01).
- Time and date sampled.

A field sheet will be completed for each surface water and groundwater sampling location. The field sheet will include the following details:

- Sample location name.
- Date and time of sampling.
- Sample equipment used.
- Name of field personnel.
- Weather conditions.
- Water level details including depth to water and total depth within groundwater monitoring bores.
- Visual and odour observations – refer to **section 5.2.1** and **5.3.1**.
- QA/QC sample collection details – refer to **section 6.6.**

Field water quality parameter measurements are to be captured and stored on the water quality probe.

6.2 Sample Collection

To ensure the integrity of all samples taken, the sampling protocol includes the following basic precautions for avoiding contamination during sample collection:

- Containers supplied by the analytical laboratory will be utilised.
- All field equipment will be pre-cleaned.
- Sample bottles suitable for each parameter will be used.
- Containers will be uncapped or removed from their transport bags for minimum amounts of time.

6.3 Sample Preservation and Transport

Water samples are to be collected in laboratory supplied containers and will be kept on ice in a chilled insulated container. Samples are to be couriered to the laboratory under chain of custody protocol within one day of sampling.

6.4 Chain of Custody

Chain of custody documentation to be recorded as part of the sampling program is detailed in **Table 6.1**.

Table 6.1 Chain of Custody Documentation

Process Step	***Quality Assurance Procedure***
Field sampling	Field register of sample number, site, type/ technique, time, date, technician, field data sheet
Sample storage and transport	Field register of transport container number and sample numbers, time, date
Laboratory receipt of samples	Laboratory register of transport container number and sample numbers, time, date
Laboratory storage of samples	Laboratory register of storage location, type, temperature, time, date
Sample preparation	Analysis register of sample (laboratory) number, pre-treatment, date, technician
Sample analysis	Analysis register of instrument, calibration, technician, standard method, date, result

6.5 Laboratory Analysis

During laboratory analysis of samples, standard laboratory analytical procedures are employed and all analyses are undertaken by laboratories with NATA-accredited methods.

6.6 Quality Control Samples

Replicate samples will be collected and submitted to the laboratory for analysis as described in **Sections 5.2.3.1** and **5.3.5**. The results for the replicate samples will be compared against the corresponding routine samples and any potential quality control issues will be discussed with the laboratory.

7. Data Analysis and Management

The proposed method in this WQMP for inferring something from the monitoring results is based on the *Australian and New Zealand guidelines for fresh and marine water quality - Volume 1* (ANZECC ARMCANZ, 2000a) and the *Australian guidelines for water quality monitoring and reporting* (ANZECC ARMCANZ, 2000b). The Water Quality Guidelines (ANZECC ARMCANZ, 2000a) advocate that for physical and chemical (non-toxicant) parameters, the median quality values of fresh and marine waters should be lower than the 80th percentile of concentration values of a suitable reference site (above the 20th percentile for parameters such as dissolved oxygen where low values are the problem). Thus, where available, the 80th and 20th percentiles from the baseline monitoring (pre-construction monitoring) have been adopted in this WQMP as trigger values.

The pre-construction monitoring data provides an indication of baseline conditions and the degree of variation for a range of water quality parameters. This provides the initial baseline data for comparison with the construction/ operational sampling results. However, it is noted there will likely be different climatic factors such as rainfall and drought and potentially land use changes across the project stages that will produce variations from the baseline data, particularly in respect to surface water quality data. Therefore, the baseline data for surface water quality from the pre-construction stage shall be supplemented with data collected from upstream monitoring locations over the construction and operational stages to provide a more robust baseline data set.

For comparative purposes, relevant ANZECC criteria for surface water quality and groundwater quality are provided in **Appendix K** of this WQMP.

7.1 Surface Water

7.1.1 Comparison of Sampling Data and Baseline Data

Comparison of sampling data with baseline data will utilise 80^{th} (P80) and 20^{th} (P20) percentile values from baseline data for trigger values (ANZECC ARMCANZ, 2000b:6-17) and comparison of upstream and downstream data at each sampling location.

The P80 is applicable to parameters where high values are potentially an issue (e.g. turbidity), while the P20 is applicable to parameters where low values are potentially an issue (e.g. dissolved oxygen), and both figures are relevant for parameters where either a high value or a low value are potentially an issue (e.g. pH).

Where a downstream result is greater than the P80 value (or is less than the P20 value, where relevant) then further comparison with the upstream result collected at the same time is to be undertaken. Where the downstream result is also greater than (or less than, where relevant) the corresponding upstream result by more than the tolerance listed in **Table 7.1**, it is to be considered to be a 'result of interest'. That is, the result has potentially been influenced by project activities and further investigation is to be undertaken.

Where the downstream result exceeds the upstream result by less than the tolerance listed in **Table 7.1**, it is considered unlikely to have been influenced by project activities. The tolerances listed in **Table 7.1** take into consideration spatial and temporal variation that is observed when taking water quality measurements in waterways that typically exhibit significant variance within short distances and timeframes. The tolerances also account for instrument error ranges.

Table 7.1 Tolerances for Comparing Upstream and Downstream Results

Parameter	*Downstream result is considered to be a 'result of interest' if it exceeds the upstream result by more than:*
Electrical Conductivity	The standard deviation from the baseline data
pH	The standard deviation from the baseline data
Dissolved Oxygen	0.5 mg/L
Turbidity	10 NTU
Total Suspended Solids	10 mg/L
Oil and grease	2 mg/L
Total Phosphorous	0.02 mg/L
Total Nitrogen	0.2 mg/L

The technique for comparing sampling results and baseline data/ trigger values will use either tabulated results or control charts (or a combination of both). An example of the use of control charts for the comparison of downstream sampling results with the corresponding 80th percentile figure (P80 figures) from the baseline data is shown in **Figure 7.1**. Here, the monthly results for a test parameter for a monitoring location are graphed in a control chart. The results at the downstream or 'impact' site are compared to the trigger value (P80 figures) from the baseline data. It is noted that the baseline data shall be continually adjusted/ supplemented with data collected from upstream monitoring locations over the construction and operational stages.

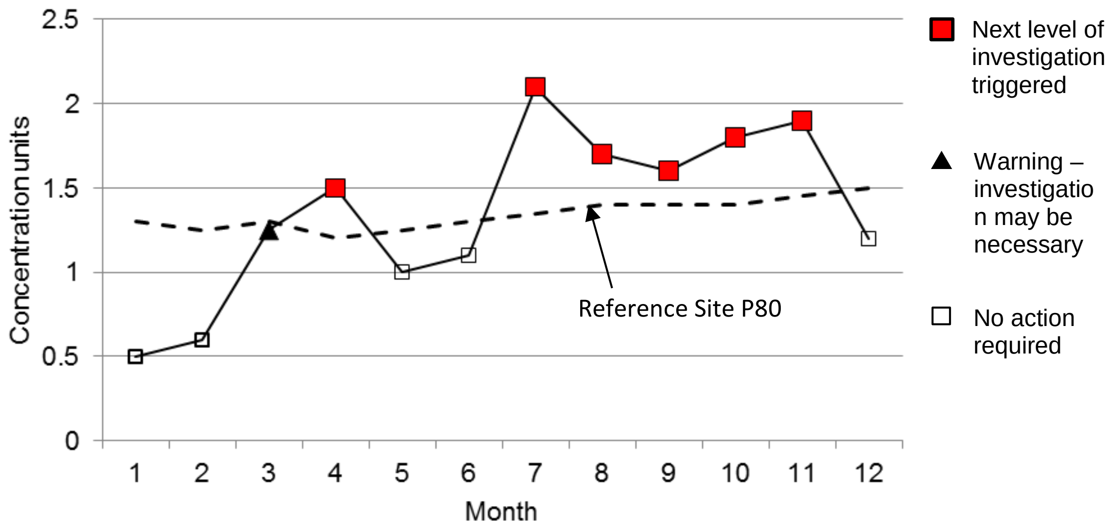


Figure 7.1 Example Control Chart

7.1.2 Adding to Surface Water Quality Baseline Data

The baseline data for surface water quality established from the pre-construction monitoring period will be supplemented with the upstream monitoring data collected during the construction and operational phases of the project. The upstream monitoring sites represent sites not impacted by the highway upgrade and therefore reflect ‘baseline’ data. This process will provide a more robust set of baseline data over the course of the project.

The baseline data shall be supplemented with the upstream monitoring data on a:

- Monthly basis during the construction phase; and
- Six-monthly basis during the operational phase.

7.1.3 In-field Notifications Protocol

In response to advice provided by the EPA during the construction phase, additional in-field notification protocols have been implemented. As suggested by the EPA, relevant RMS personnel are to be notified by the field monitoring team whenever one (or more) of the following occurs:

- Changes of pH of greater than one unit;
- Turbidity changes greater than 50 NTU;
- Any visual oil and grease; and/or
- Any observable construction related impacts.

In instances where no comparison can be made between upstream and downstream monitoring sites (e.g. due to the lack of an upstream monitoring site, insufficient water at the time of monitoring, or access issues), the following criteria are to be utilised as a trigger for notification:

- pH is outside of the range 6.5 to 8.5; or
- Turbidity is greater than 50 NTU.

Should any of these scenarios be observed during the monitoring event, the construction contractors would be advised and investigations into potential impacts would occur. Potential management actions would be undertaken in accordance with **Section 8**.

7.2 Groundwater Quality

Groundwater quality monitoring results are to be assessed using comparisons to the P80 and P20 values from the baseline data, similar to the surface water quality approach described above.

The baseline data set is the pre-construction data collected between February 2013 and January 2014.

During baseline monitoring in Sections 3 to 6, the bores were monitored for the in-situ parameters of pH, EC and temperature. In Sections 7 to 11, the bores were monitored for pH only, with the exception of three bores in Section 8 (GWB8-15, GWB8-16 and GWB8-17), which were monitored for pH, EC, TDS, hydrocarbons, nutrients, major cations and anions, and heavy metals.

Because there is no baseline data for some parameters and only limited baseline data for the remainder, each bore has been classified as either ‘up gradient’ or ‘down gradient’. For a pair of bores, the ‘down gradient’ bore is the one that typically has the lower groundwater level, indicating that the direction of groundwater flow is from the ‘up gradient’ bore to the ‘down gradient’ bore. P80 values (and P20 values, where relevant) have been calculated using any available pre-construction data, as well as the construction phase data for the 'up gradient' bore. These P80 and P20 values are to be used to assess the groundwater quality results for the corresponding 'down gradient' bore.

Where the down gradient result is greater than the P80 value (or is less than the P20 value, where relevant), it is considered to be a 'result of interest'. That is, the result has potentially been influenced by project activities and further investigation is undertaken.

7.3 Groundwater Levels

The construction phase groundwater level data is to be assessed by comparing the difference in groundwater levels between a pair of bores to the P80 of the difference in groundwater level between the same pair of bores during the pre-construction monitoring period. This is to be implemented in the following manner:

- The difference in the groundwater level between a pair of bores is calculated at each time interval for the pre-construction monitoring period.
- The P80 of these groundwater level differences is calculated to determine the baseline P80.
- During the construction phase, the difference in the groundwater level between a pair of bores is calculated at each time interval.
- If the difference in the groundwater level exceeds the baseline P80, it is considered to be a 'result of interest'. That is, the result has potentially been influenced by project activities and further investigation is undertaken which will include consideration of:
  - The timing of the cutting excavation works at the specific site.
  - Site observations that indicate interception of groundwater levels.
  - Climatic conditions such as rainfall/ extended dry period which may influence one of the groundwater bores more than the other.

7.4 Data Interpretation

After the data analysis, the results will be collated into a concise statistical summary and assessed in the context of the monitoring objectives below.

7.4.1 Construction Stage

Data interpretation for the construction stage monitoring will address:

- Surface water quality:
  - refinement of baseline surface water quality data for the project by supplementing pre-construction data with upstream monitoring data;
  - identification of potential impacts of the highway upgrade construction on surface water quality;
  - recommendations for any refinements of construction surface water management measures.
- Groundwater quality:
  - identification of potential impacts of the highway upgrade construction on groundwater quality;
  - recommendations for any refinements of construction groundwater quality management measures.

- Groundwater levels:
  - identification of potential impacts of the highway upgrade construction on groundwater levels;
  - recommendations for any refinements of construction groundwater level management measures.

7.4.2 Operational Stage

Data interpretation for the operational stage monitoring will address:

- Surface water quality:
  - refinement of baseline surface water quality data for the project by supplementing pre-construction data with upstream monitoring data;
  - identification of potential impacts of the highway upgrade operation on surface water;
  - recommendations for any refinements of operational surface water management strategies and stabilisation works.
- Groundwater quality:
  - identification of potential impacts of the highway upgrade operation on groundwater quality;
  - recommendations for any refinements of operational groundwater management strategies.
- Groundwater levels:
  - identification of potential impacts of the highway upgrade operation on groundwater levels;
  - recommendations for any refinements of operational groundwater level management measures.

7.5 Reporting

7.5.1 Construction Stage

Reporting during the construction stage will include annual reports and a final report at the completion of the construction stage.

The reports will include any relevant discussion of the results to inform the ongoing management of the surface water and groundwater management measures and the results will be discussed and minutes taken at the Environmental Review Group meetings.

Annual reports will be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), Department of Industry (Water)DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval (MCoA) – refer to **Section 1.2** and **Table 1.1** in this WQMP. Annual reporting will also be published in accordance with Condition 21 of the Federal Minister for the Environment's Conditions of Approval – refer to **Section 1.2**. Annual reports will include:

- introduction and background: description of the program and objectives and defining the extent of the highway upgrade works;
- experimental detail, describing the sampling regime and parameters including detail of the sampling locations so they can be unambiguously identified, e.g. GPS directions and descriptions of methods of sampling and analysis;
- presentation, interpretation and discussion of the results addressing the items outlined in **Section 7.4**;

- review and recommendations for the monitoring program for the construction and operational stages; and
- appendices, providing laboratory reports, data tables or other relevant information.

Similarly, the final report at the completion of the construction stage will be of a similar format to that outlined above and will include recommendations for the operational monitoring program. The final report will also be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), Department of Industry (Water), DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the MCoA.

7.5.2 Operational Stage

Reporting during the operation stage will also include annual reports and a final report at the completion of the first three years of operation.

Annual reports will be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), Department of Industry (Water), DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval – refer to **Section 1.2** and **Table 1.1** in this WQMP. Annual reporting will also be published in accordance with Condition 21 of the Federal Minister for the Environment's Conditions of Approval – refer to **Section 1.2**. Annual reports will be of a similar format to that outlined in **Section 7.5.1**.

Similarly, the final report at the completion of the first three years of operation will be of a similar format to that outlined in **Section 7.5.1** and will also be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), Department of Industry (Water), DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the MCoA.

8. Management Actions

This section provides an overview of potential contingency and ameliorative measures that could be implemented in the event that adverse impacts are identified. The following contingency and ameliorative measures are largely based on potential measures outlined in the environmental impact assessment for the project. It is noted that alternative measures may be more suitable. This would be determined when adverse impacts are identified and in full consideration of relevant factors and site specific circumstances.

The development of mitigation measures and specific actions should consider related management plans such as the Threatened Frog Management Plan (RMS *et. al.*, 2014) and Threatened Fish Management Plan (RMS *et. al.*, 2013) to ensure measures are complimentary or to avoid conflicting measures/ outcomes. The Contractors environment team involved in soil and water management should also be aware of these related plans.

Updated monitoring data is to be provided to RMS on a regular basis to provide the data in a timely manner so that it can be used to inform environmental management of the project. This allows the project to respond as follows:

1. The water monitoring data is reviewed, with particular focus on the results of interest that have been identified in accordance with **Sections 7.1** to **7.3.**
2. The results assist with setting the focus for the project's environmental management inspections.
3. During these inspections, environmental controls are checked and reviewed against the relevant environmental plans (e.g. Progressive Erosion and Sediment Control Plans) for adequacy and any required actions (e.g. maintenance, replacement or upgrade) are identified.
4. The aforementioned actions are tracked and implemented.

When reviewing a result of interest, the first step is to determine whether construction activities with the potential to influence the result were underway at the time of (or prior to) the monitoring event. For example, if the result of interest is an elevated turbidity value, the first step is to check whether construction activities with the potential to mobilise sediment were occurring at the time of (or prior to) the monitoring event.

Where construction activities are considered a potential contributor to the result of interest, existing management measures are reviewed and, where appropriate, additional management measures are considered. If it is determined that additional management measures are warranted, they are implemented and monitored for efficacy.

With regard to surface water monitoring, sometimes the downstream monitoring site is not connected by continuous water to the upstream monitoring site. In such instances, the waterway may be a series of isolated pools. The review of a result of interest and consideration of the adequacy of the management measures takes into account the lack of connectivity at the time of the monitoring event.

8.1 Construction Phase - Surface Water Management Actions

The key mitigation measures for the construction stage will be sediment basins and additional erosion and sediment controls to intercept run-off and retain the associated sediments and pollutants. Maintenance and monitoring of these measures by the Contractor will form a key component of the mitigation measures. The measures will address the relevant CoA and the safeguards detailed in the EIS and Submission/ Preferred Infrastructure Report (SPIR). Construction activities will also be managed to meet water quality objectives in the Environmental Protection Licence (EPL) conditions. The measures are detailed within the project Construction Soil and Water Management Plan (CSWMP) within the CEMP which is approved by the Department of Planning and Environment. The plan includes water quality monitoring at the outlet of the sediment basins. General water quality criteria for discharges from sediment basins comprise:

- pH between 6.5 - 8.5.
- TSS < 50mg/L.
- No visible oil and grease.

The measures integrate with related plans such as the Threatened Fish Management Plan where there are specific requirements for monitoring or treatment of captured water.

Management actions are also triggered by assessment of water surface water quality data collected during the construction phase as outlined above and in **Section 7**. If the sampling results indicate a possibility of the highway impacting on surface water quality (as outlined in **Section 7.1**), the project is to investigate existing water quality control measures to determine any maintenance requirements or additional measures to be implemented at that location.

8.2 Construction Phase - Groundwater Management Actions

Similar to surface water management, some of the key mitigation measures for the construction stage are erosion and sediment controls. Other measures include best practice management for siting and bunding of storage areas where appropriate. There are also additional site-specific measures such as in the drinking water catchment of the Rous Water Woodburn Sands borefield where: the design of the basins may be shallower than standard to avoid penetration of the natural clay layer; and certain construction activities may be restricted such as refueling, washdown, and storage of chemicals. Section 5.4 of the Water Quality Working Paper (RMS, Aurecon, SKM, 2012c) includes design criteria for mitigation measures for the Rous Water borefield. Measures are detailed in the CEMP which is approved by the Department of Planning and Environment.

The following is a non-prescriptive list of potential contingency and ameliorative measures that could be implemented in the event that adverse impacts are identified:

- Where sites used for stockpiles, washdown, batch plants, refuelling and chemical storage are located in areas of sensitive/ shallow water table, best practice management for siting, erosion and sediment controls, and bunding of storage areas in combination should be employed.
- Dewatering of excavations shall be undertaken in line with RMS' Technical Guideline – Environmental Management of Construction Site Dewatering (RMS, 2011c), and in accordance with any licence conditions.
- Where groundwater is released, recharge of the water table is the preferred option of managing groundwater. This shall be facilitated by collecting groundwater in grassed swales for infiltration back to the groundwater source. Where possible, these swales shall divert the groundwater around the construction area so that the groundwater does not further mix with construction runoff. Recharge could also include the collection of seepage from the cut face in the drainage system which would be diverted to absorption trenches or to water quality ponds to be tested and possibly treated before being released back to the creek or natural drainage system at some point downstream. Any diversion of groundwater intercepted during construction activities into existing water quality/ sediment basins will consider existing design capacity of the basins and any Environmental Protection License requirements that may be impacted by receipt of additional groundwater.

Management actions will also be triggered by assessment of groundwater water quality and groundwater level data collected during the construction phase as outlined in **Section 7**.

8.3 Operational Phase - Surface Water Management Actions

Permanent water quality management and protection measures would be installed to protect adjacent waterways and sensitive receiving environments such as the Rous Borefield from pollutants generated by operation of the project. These would include:

- Water quality ponds; and
- Grassed swales.

Details of the treatment methods will be reviewed and confirmed through the detailed design process. For the Rous Borefield the Water Quality Working Paper (RMS, Aurecon, SKM, 2012c:83) recommends adopting a similar standard of stormwater treatment controls to those used for the T2E project within the constraints of the site.

In the event that adverse impacts are identified from the monitoring, the following procedure should be implemented:

- Identify potential pollutant source based on the parameters that were exceeded (e.g. sediment for high TSS reading, or fuel spill/ leak for high hydrocarbon reading); and
- Inspect and rectify water quality ponds and grassed swales in area where adverse impacts are identified. This would include inspection of water quality ponds to assess available water storage capacity, water quality, sediment build-up, structural integrity and debris levels.

8.4 Operational Phase - Groundwater Management Actions

In the event that adverse impacts are identified from the monitoring, the procedures outlined in **Section 8.3** should be implemented.

8.5 Adaptive Management Framework

RMS acknowledges the importance of undertaking environmental management using an adaptive management approach and as such the WQMP will be a working document. Given the nature of environmental monitoring, an adaptive management approach is considered appropriate to deliver an effective monitoring program during construction and operation. Following review of results and data, improvements and refinements of the WQMP may be identified. The monitoring program will be reviewed and updated accordingly based on this ongoing review process in order to provide a robust monitoring framework in response to the CoA requirements.

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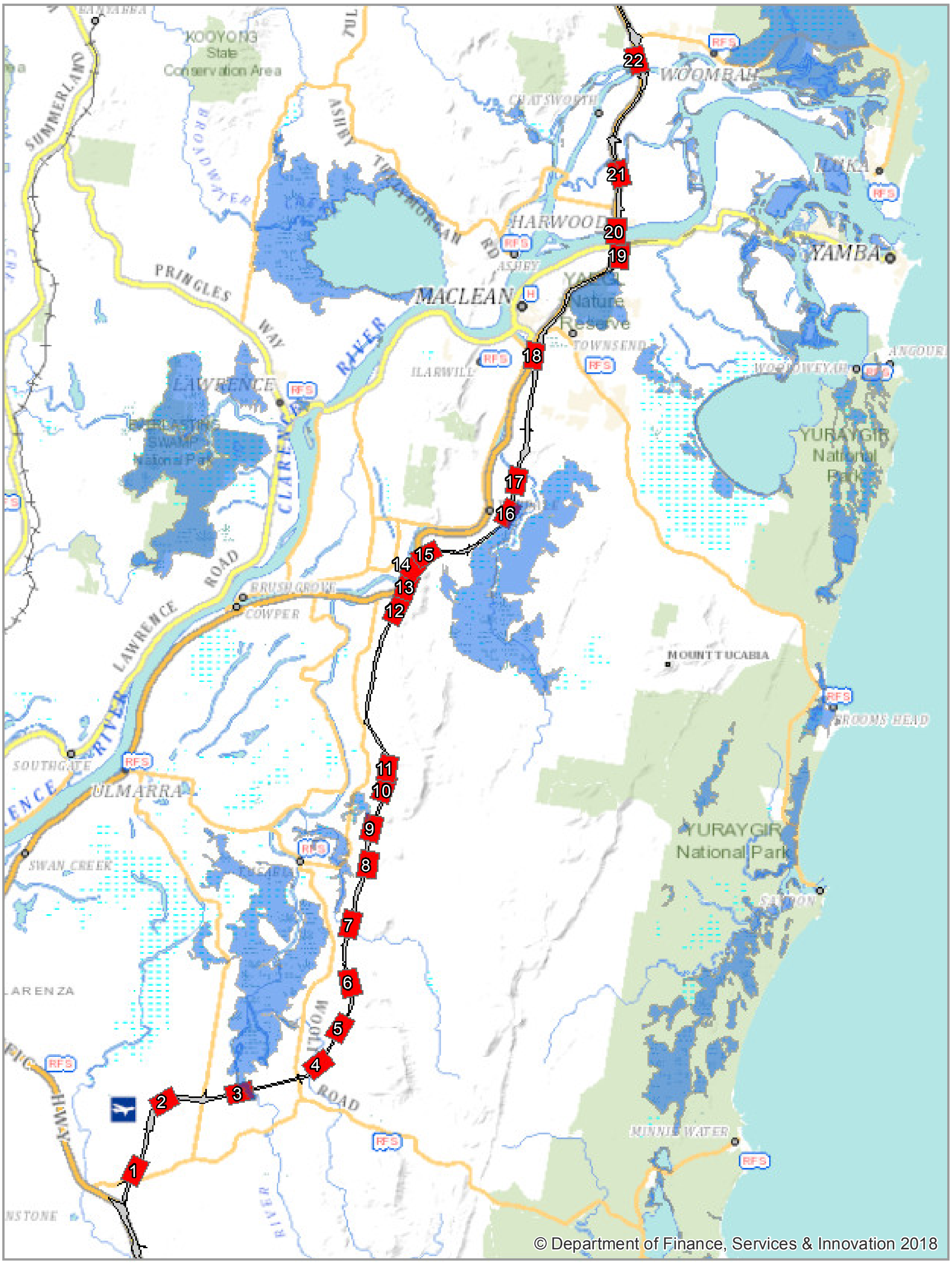
Appendix A

Maps of Monitoring Locations – Surface Water and Groundwater

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JC Date: 23/05/2019
Source of base data: DFS&I and Pacific Complete



LEGEND

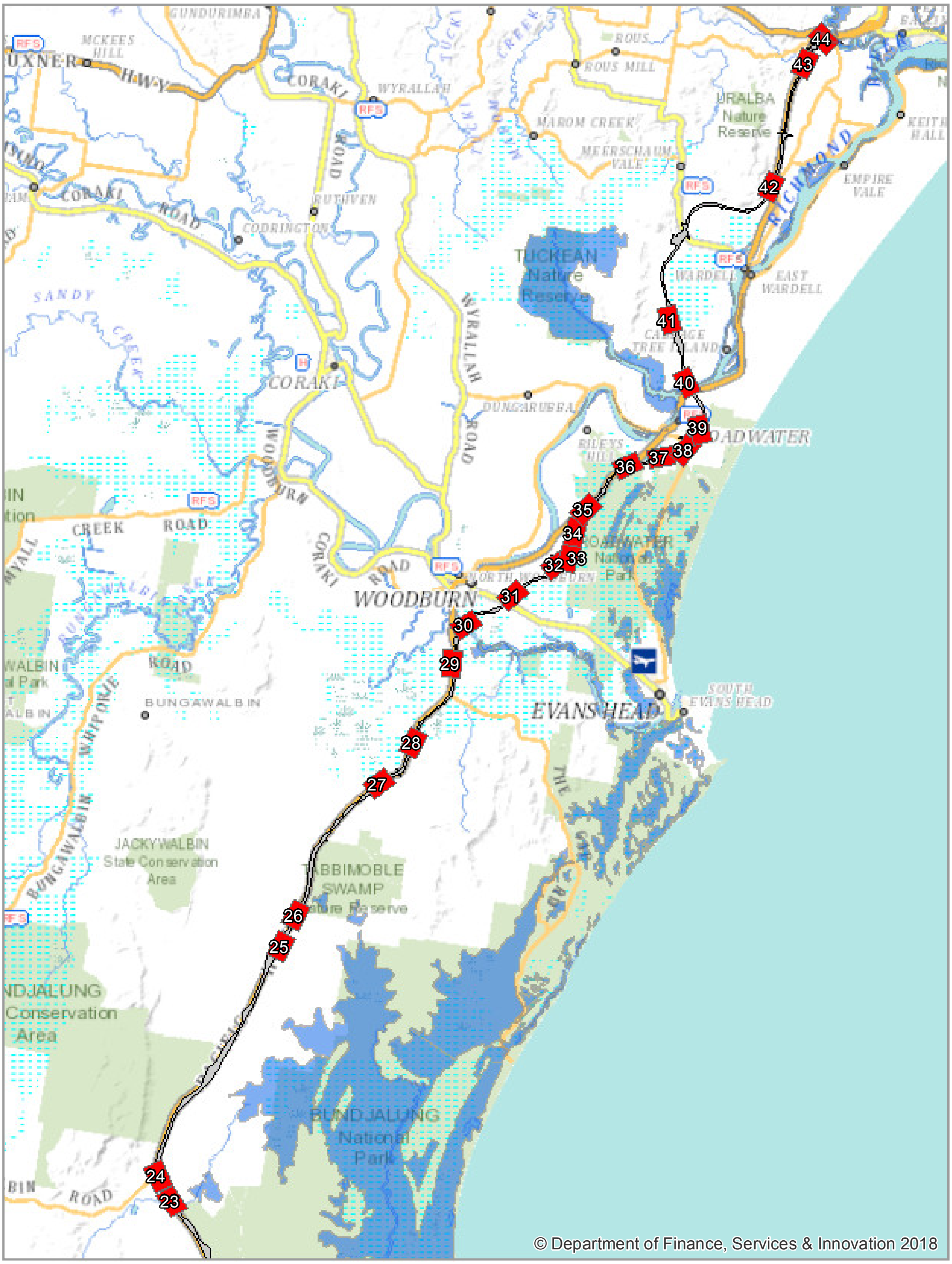
- Approved Project Boundary
- Map sheet
- Coastal wetland

0 5 Km

Map Key
Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JC Date: 23/05/2019
Source of base data: DFS&I and Pacific Complete

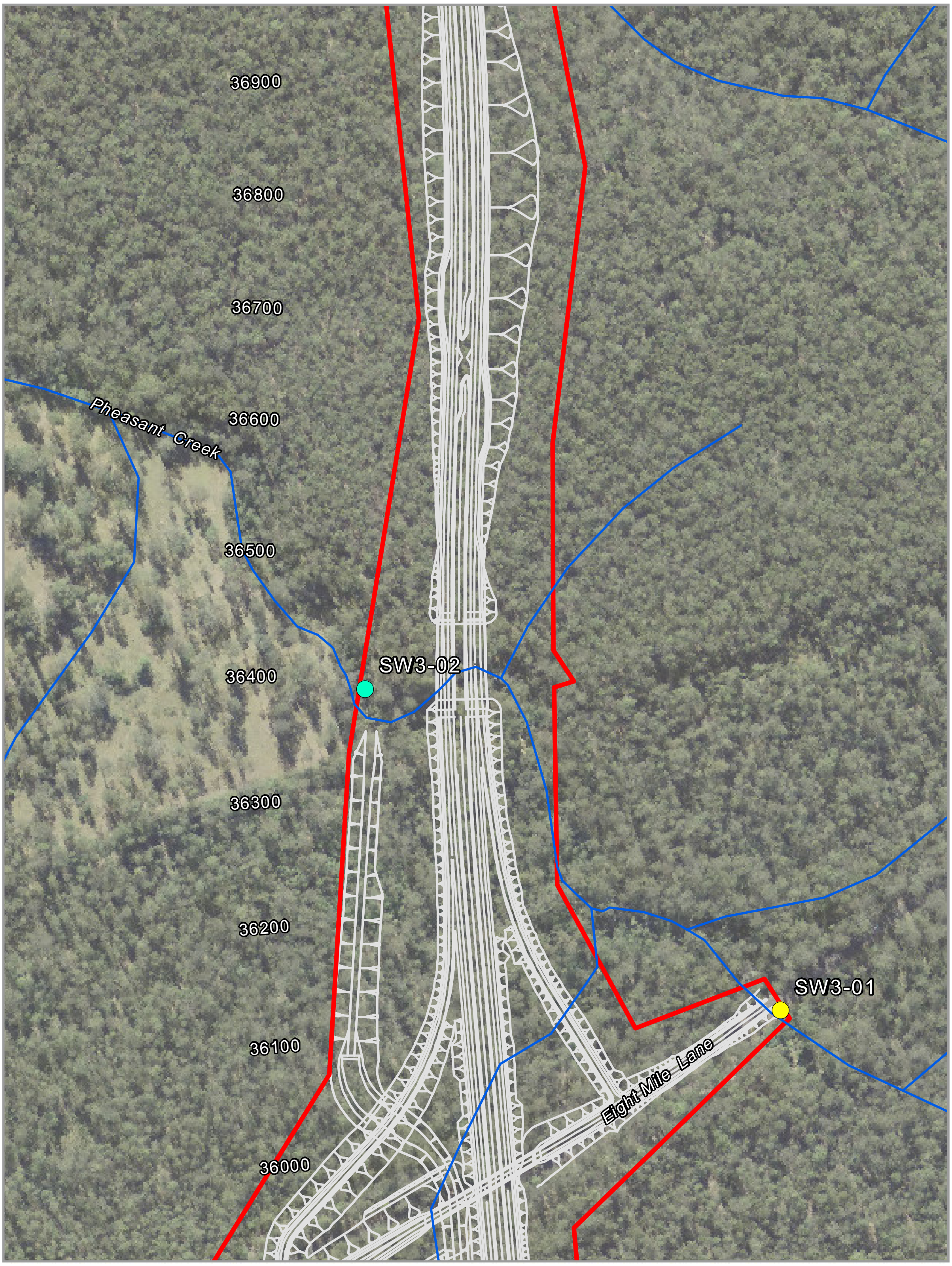


LEGEND

- Approved Project Boundary
- Map sheet
- Coastal wetland

0 5 Km

Map Key
Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

- Approved Project Boundary
- Watercourse
- Downstream surface water monitoring point
- Upstream surface water monitoring point

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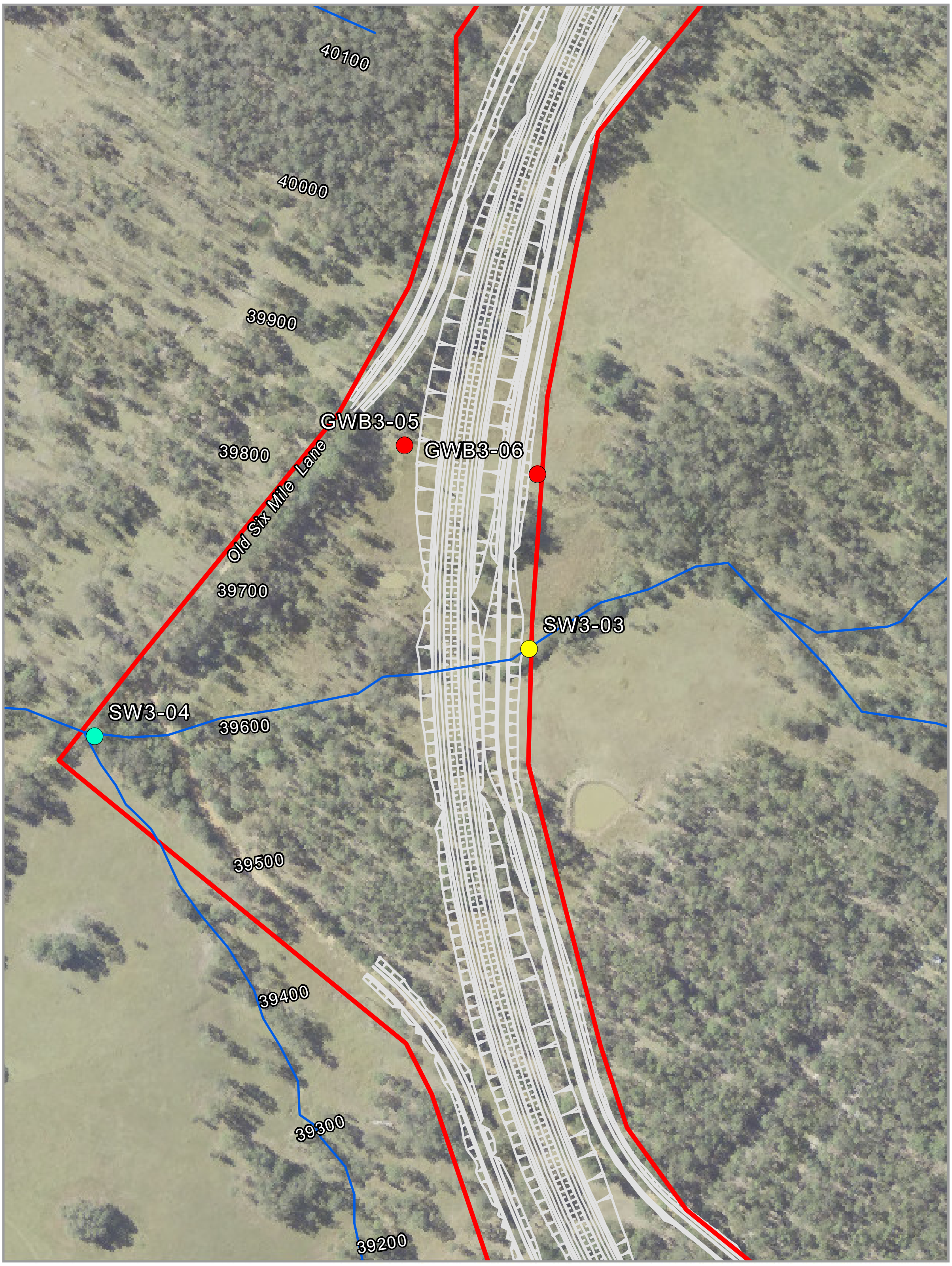
Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels and quality
- Downstream surface water monitoring point
- Upstream surface water monitoring point

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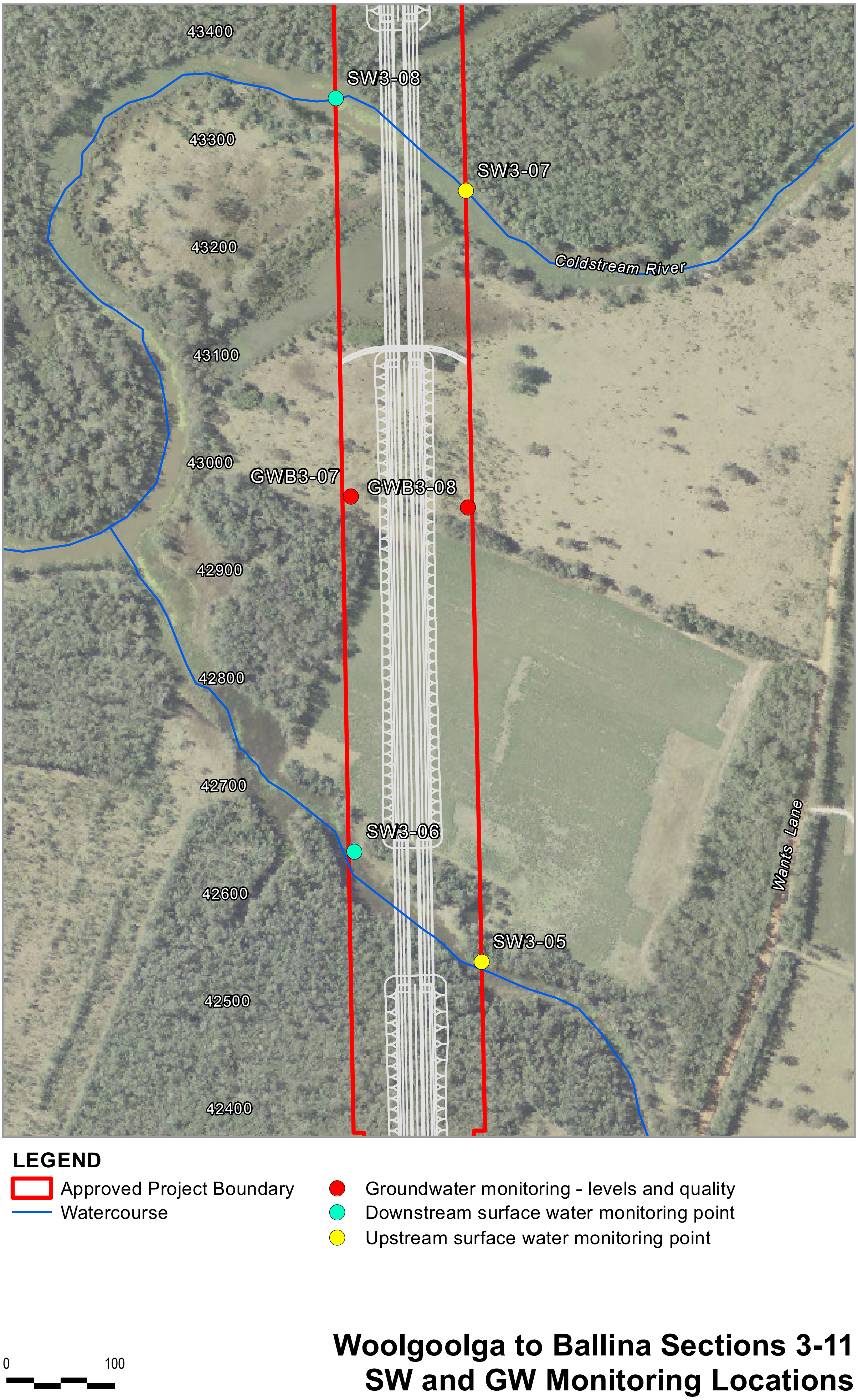
Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

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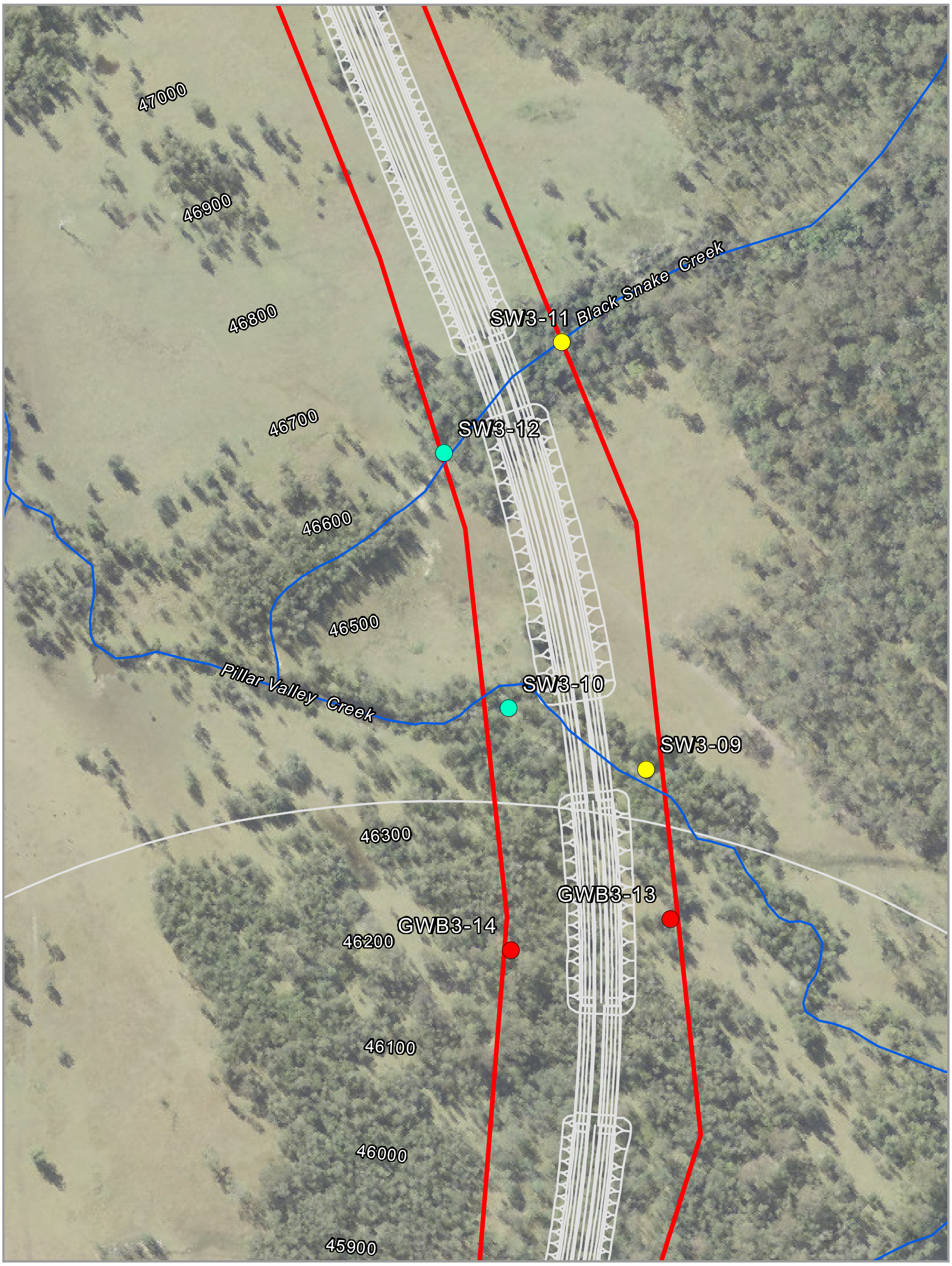

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- Downstream surface water monitoring point
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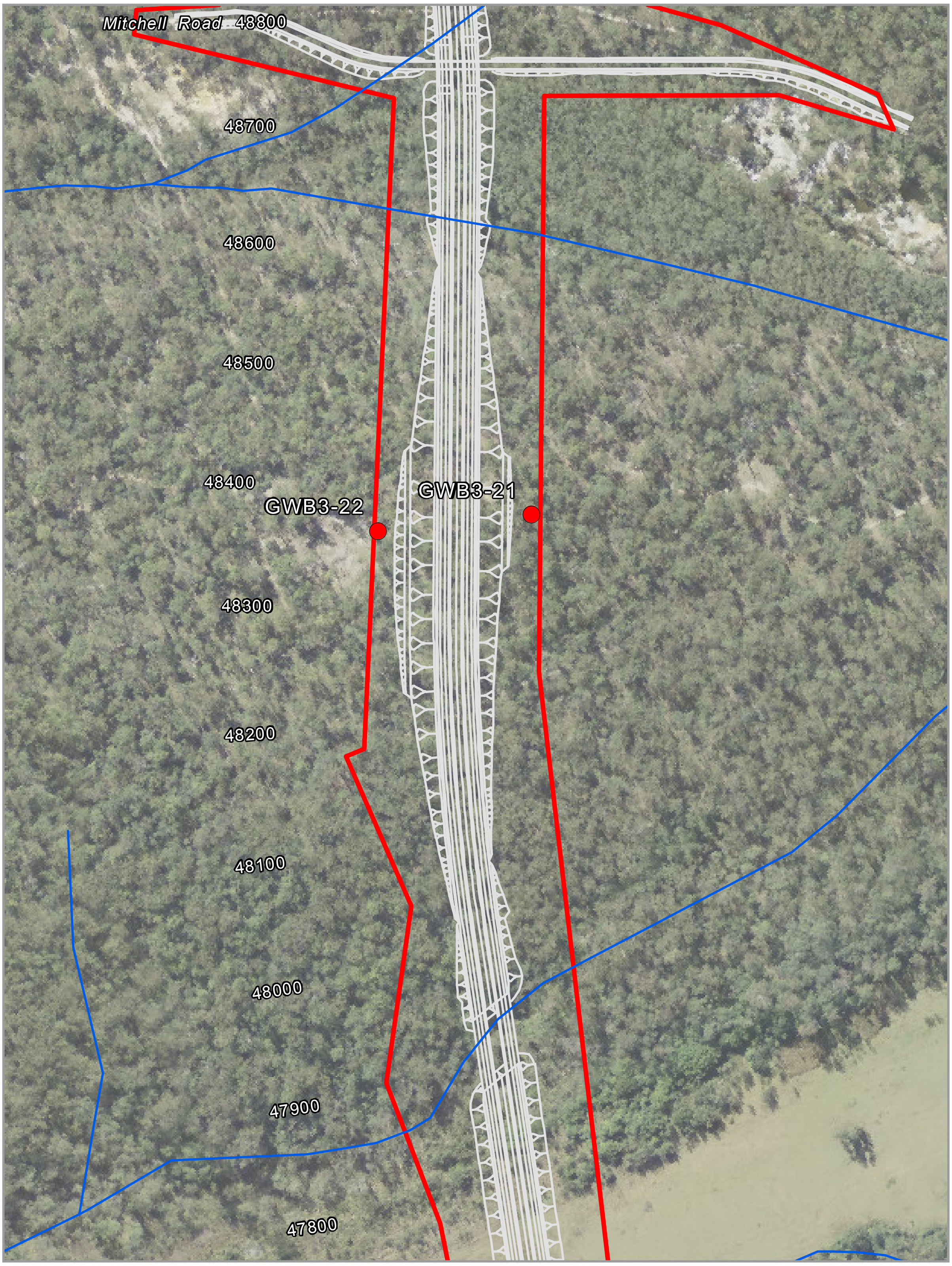
SW and GW Monitoring Locations



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Groundwater monitoring - levels and quality

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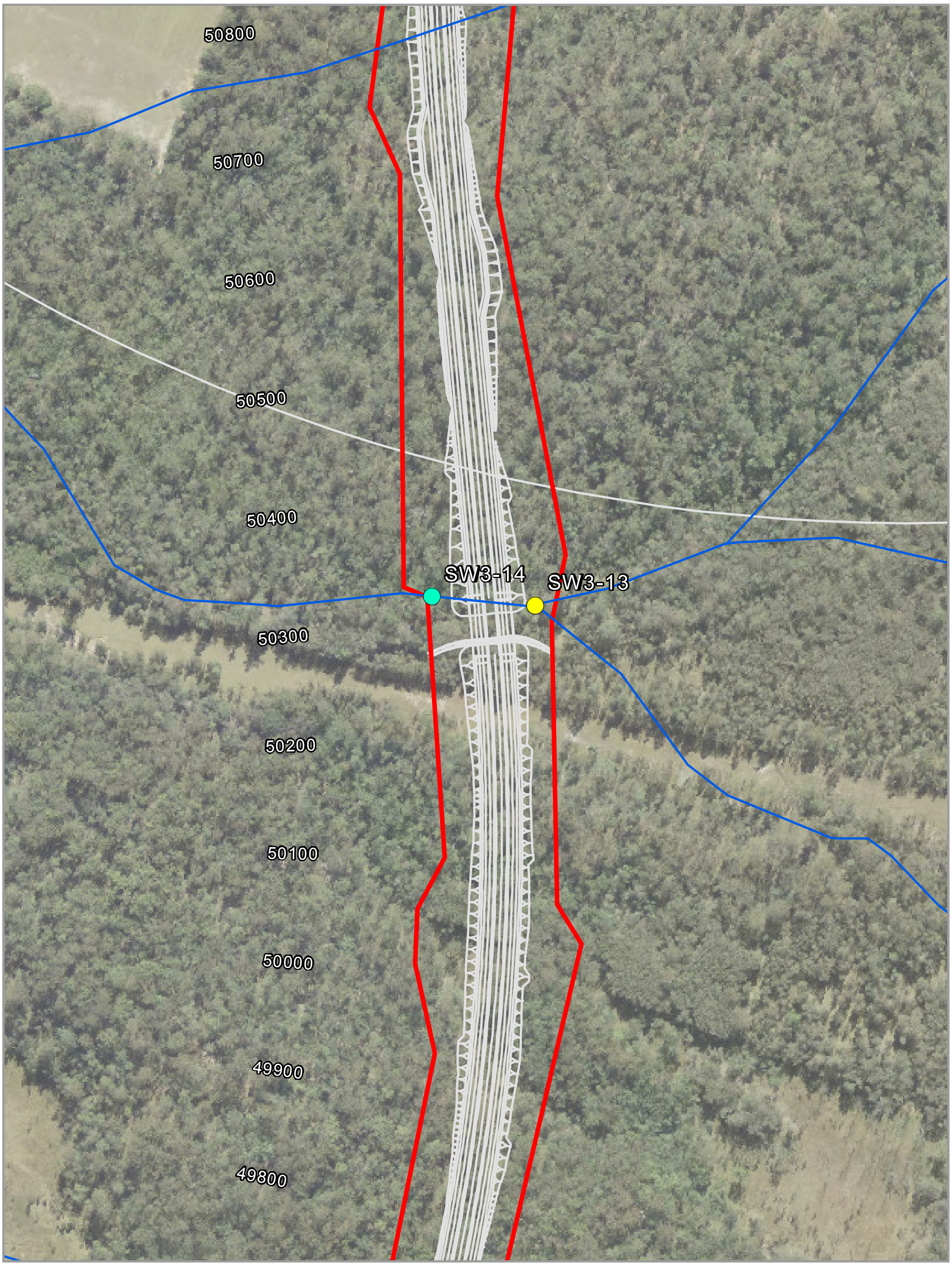
SW and GW Monitoring Locations



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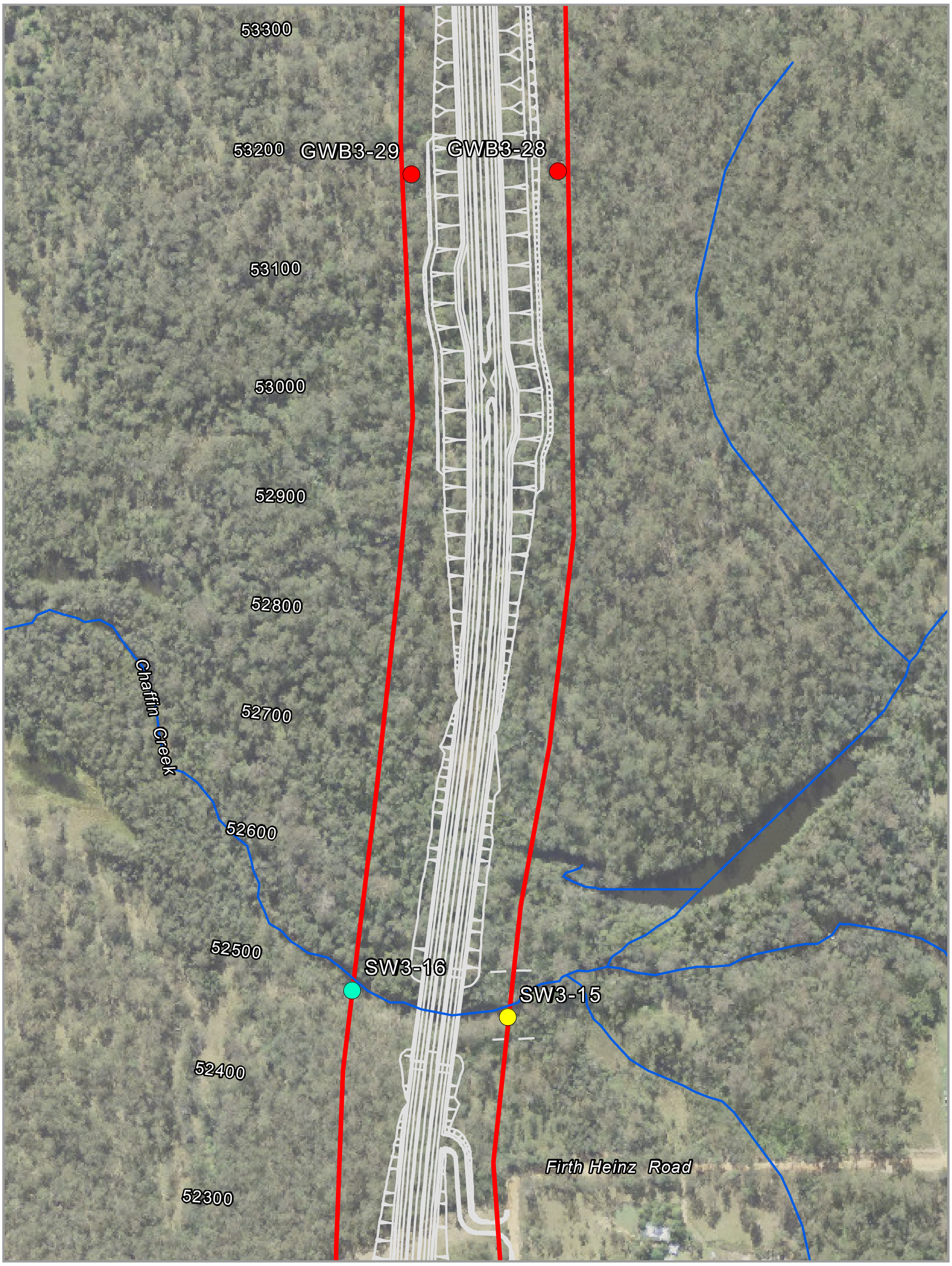
SW and GW Monitoring Locations



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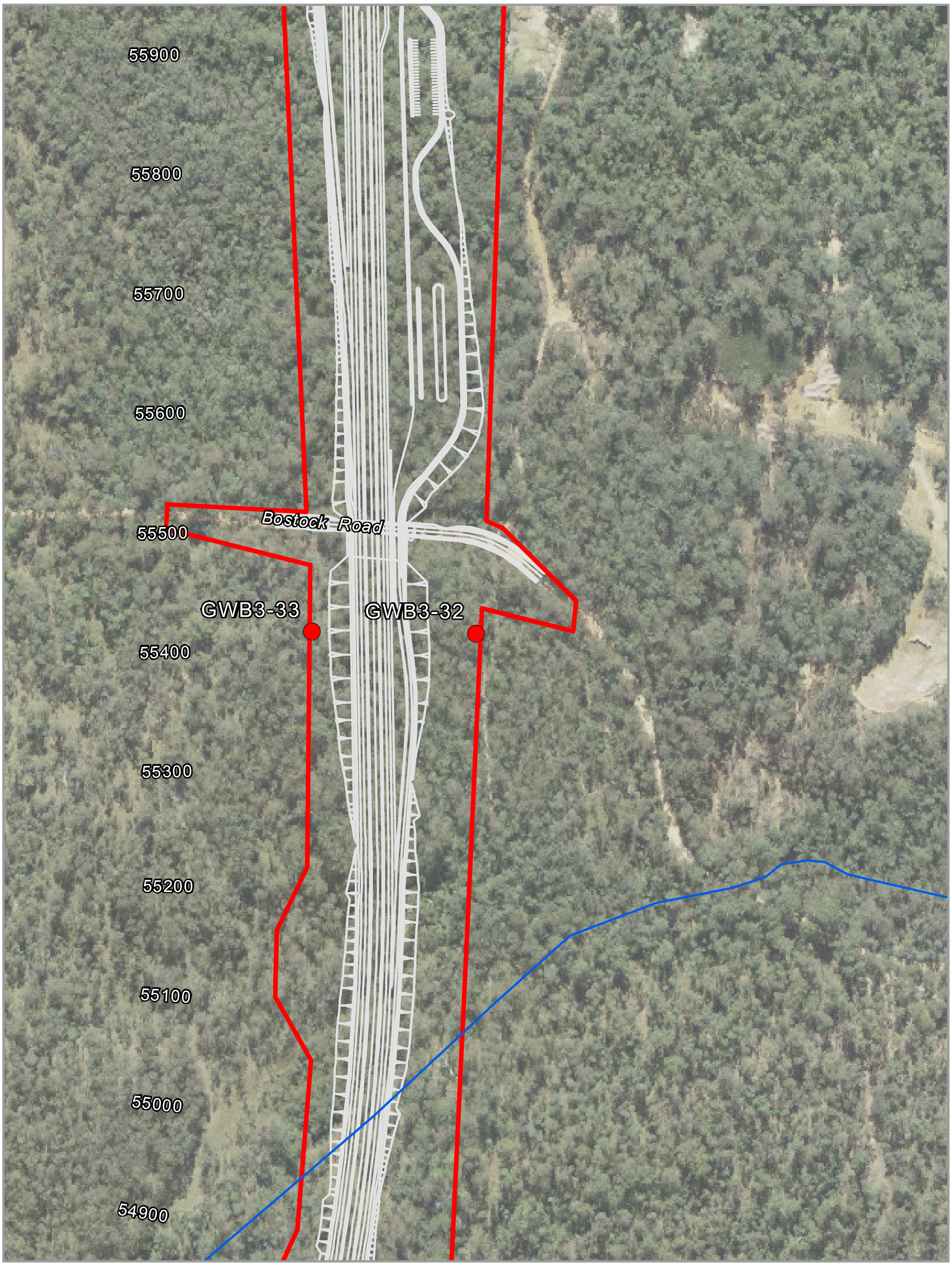

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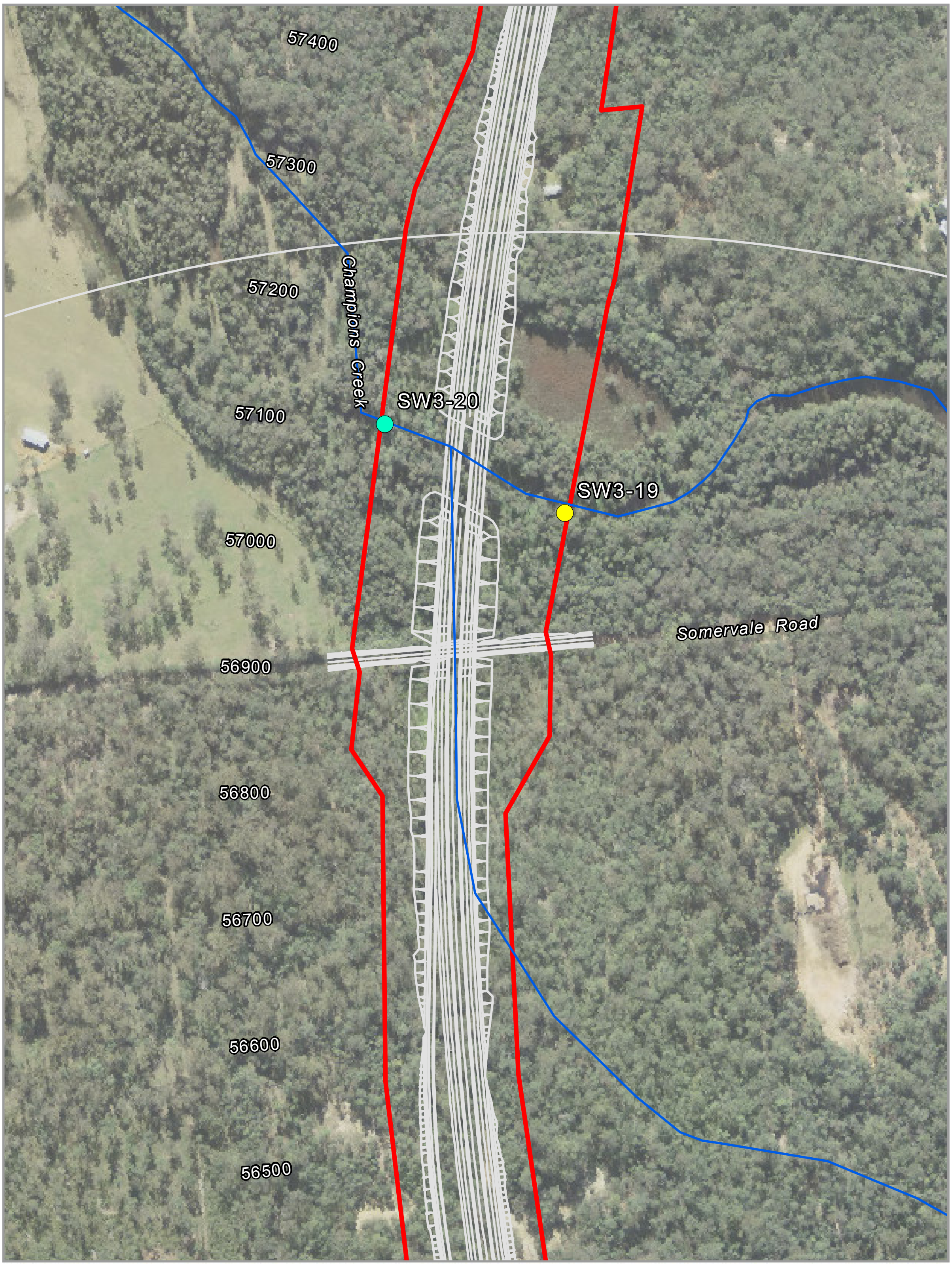
SW and GW Monitoring Locations



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- Upstream surface water monitoring point

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Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

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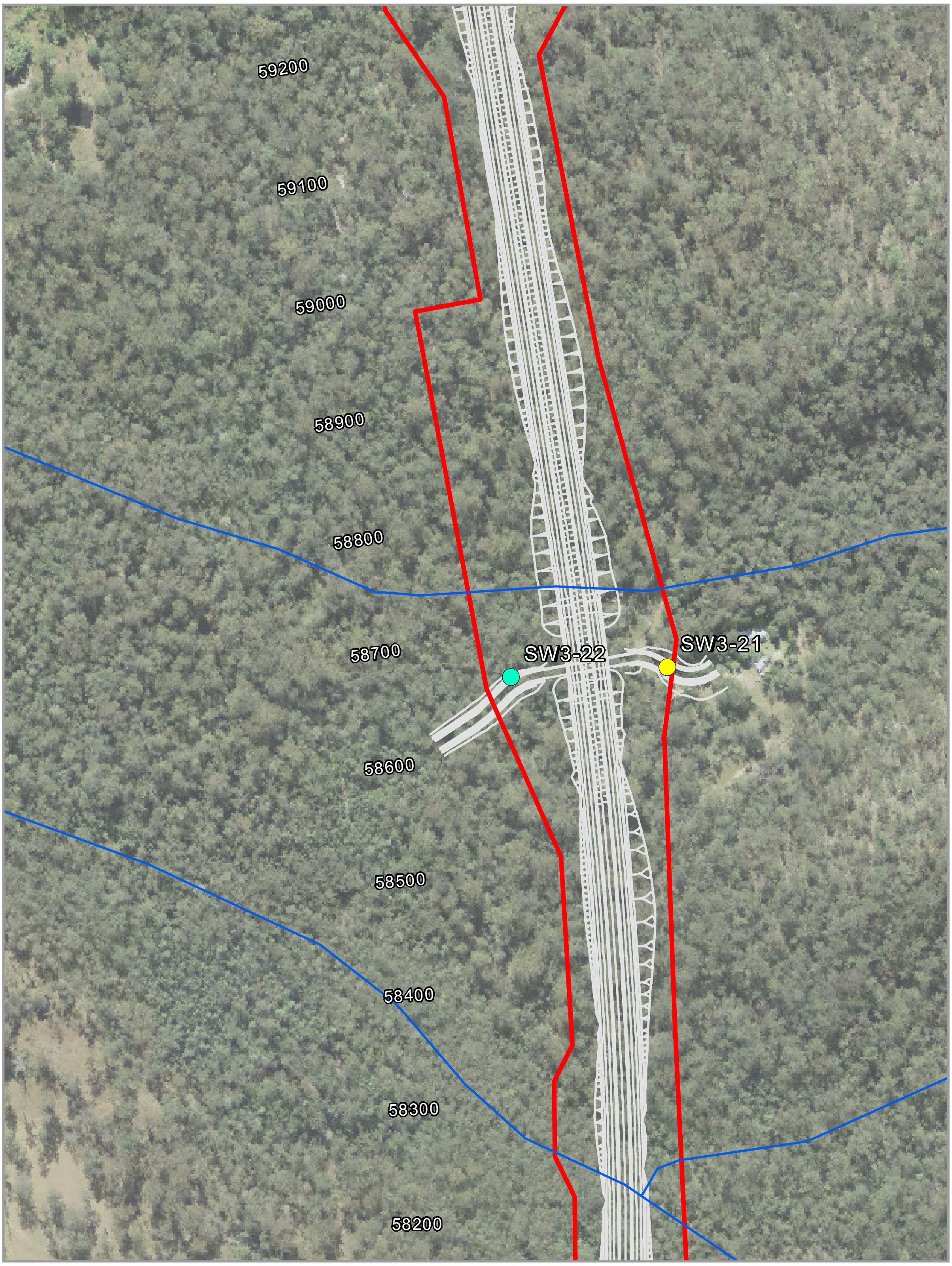

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Downstream surface water monitoring point
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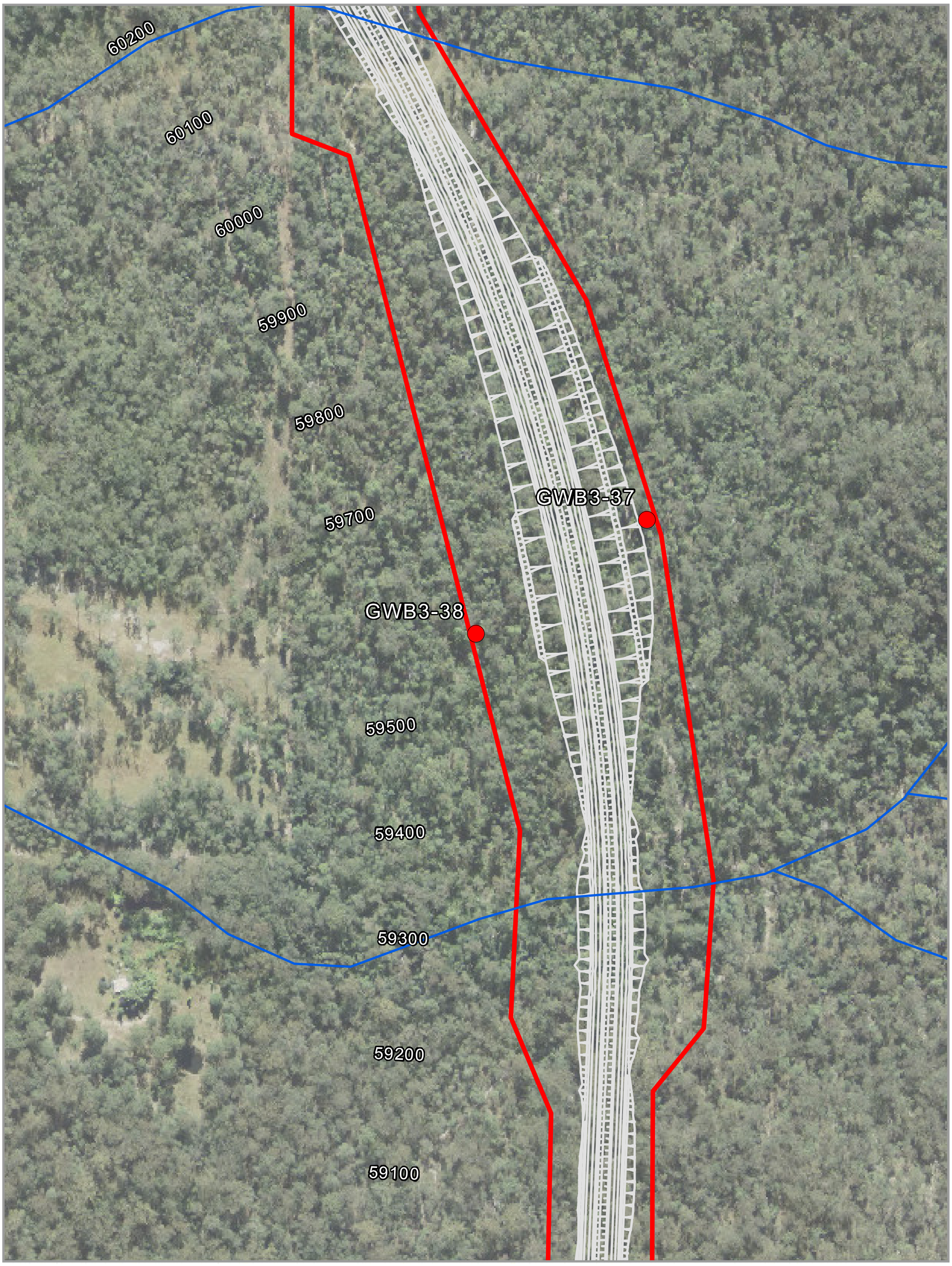
Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



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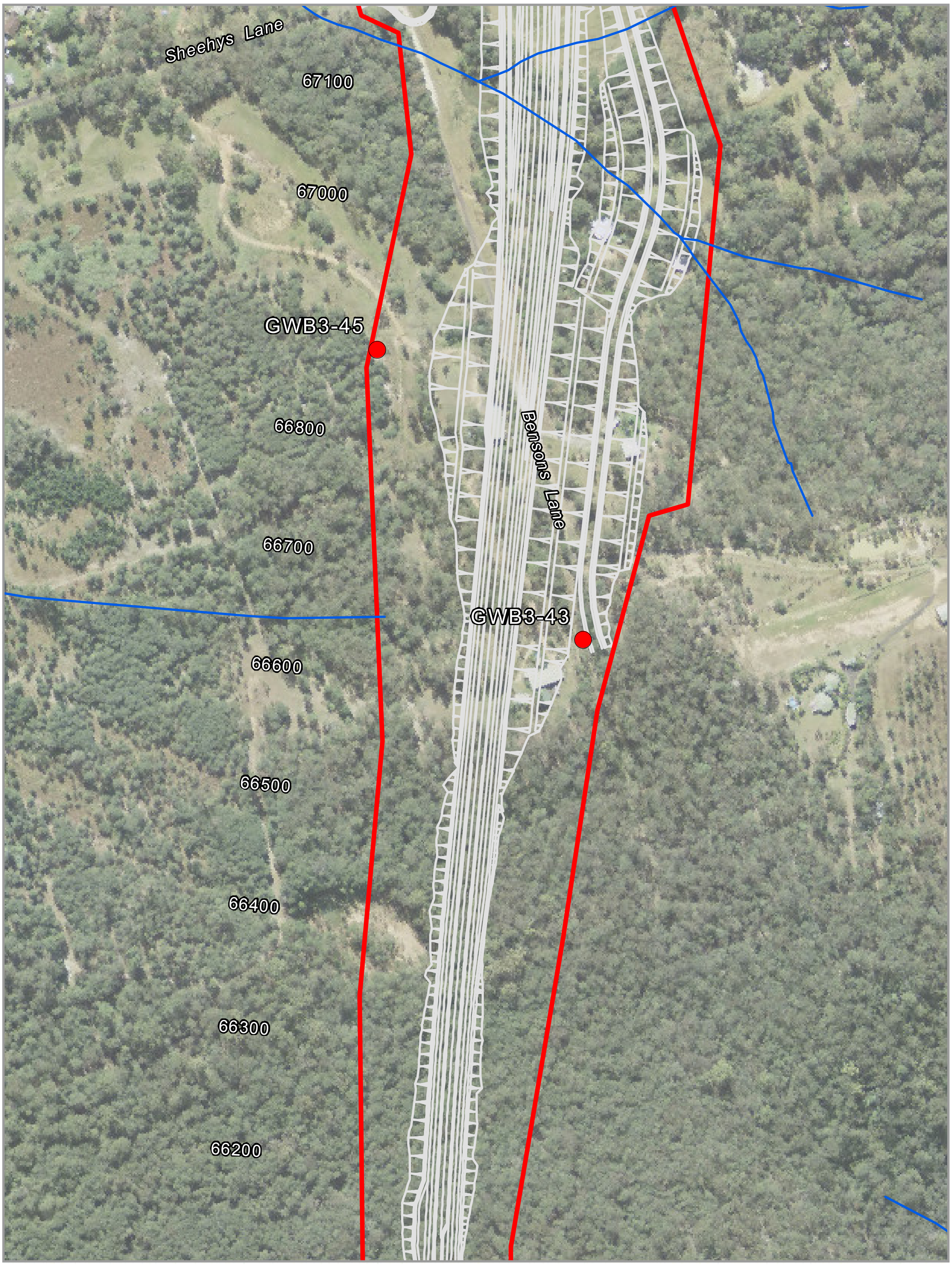
SW and GW Monitoring Locations



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Woolgoolga to Ballina Sections 3-11
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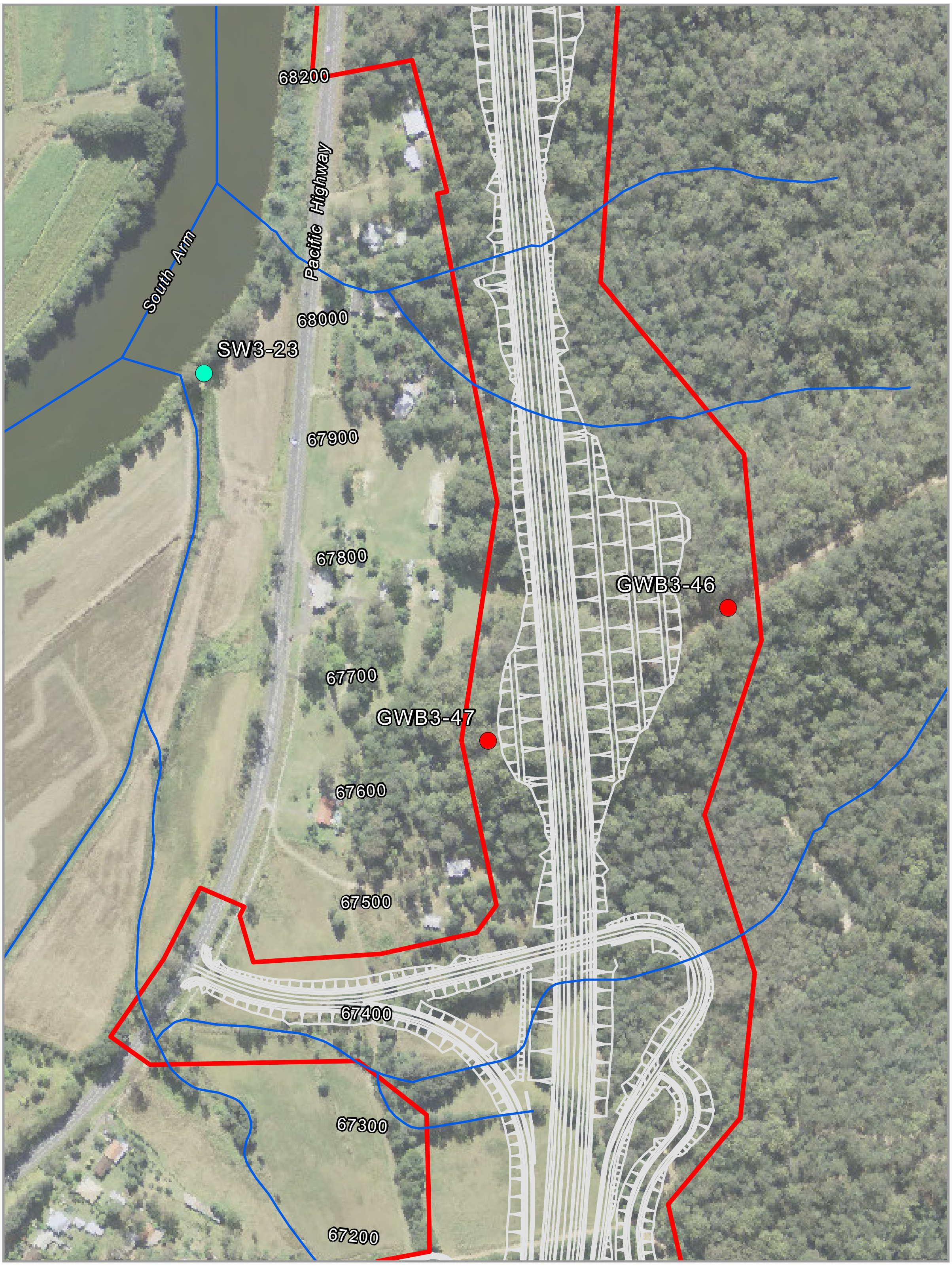

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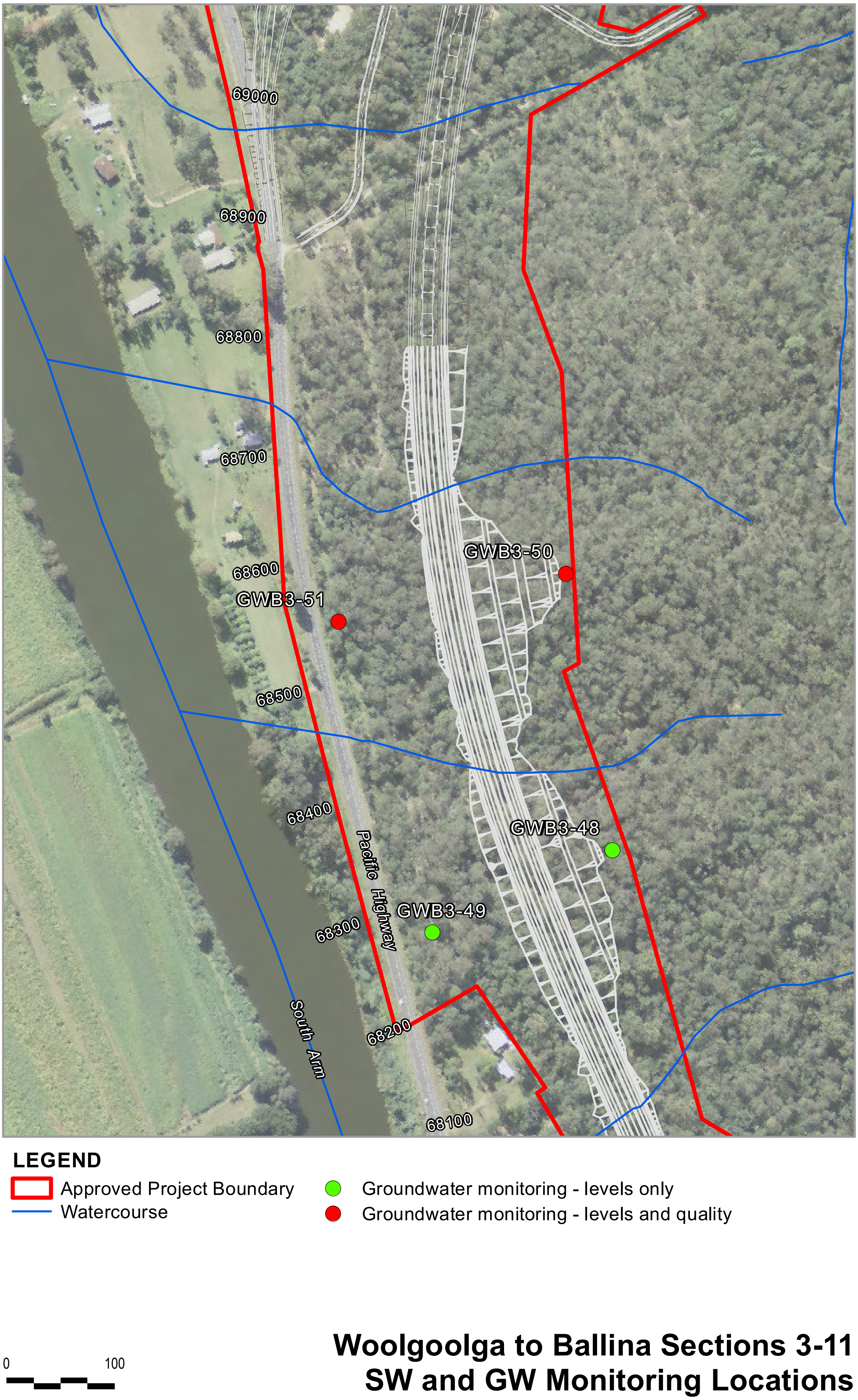
Woolgoolga to Ballina Sections 3-11 SW and GW Monitoring Locations



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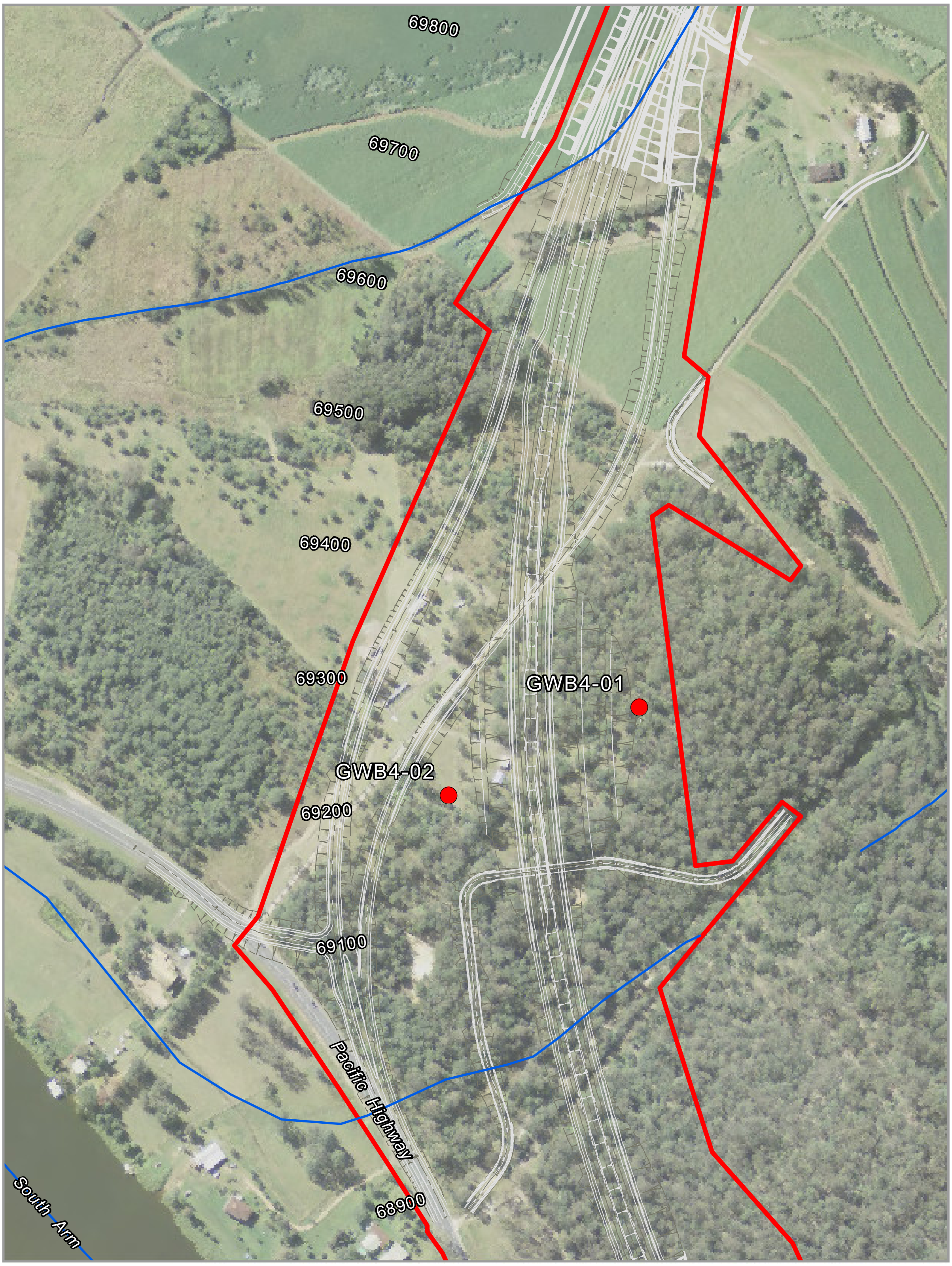
SW and GW Monitoring Locations



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Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

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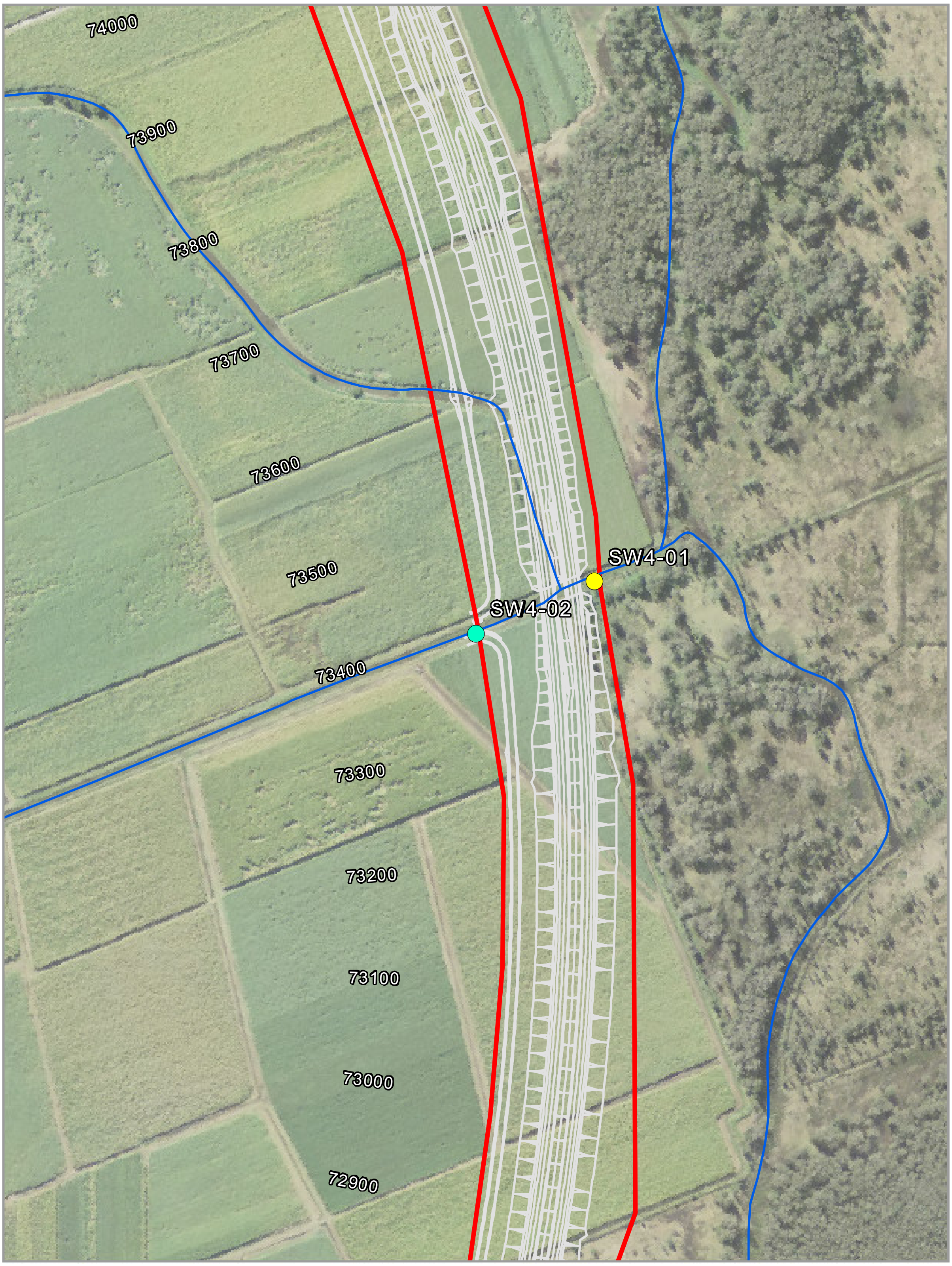

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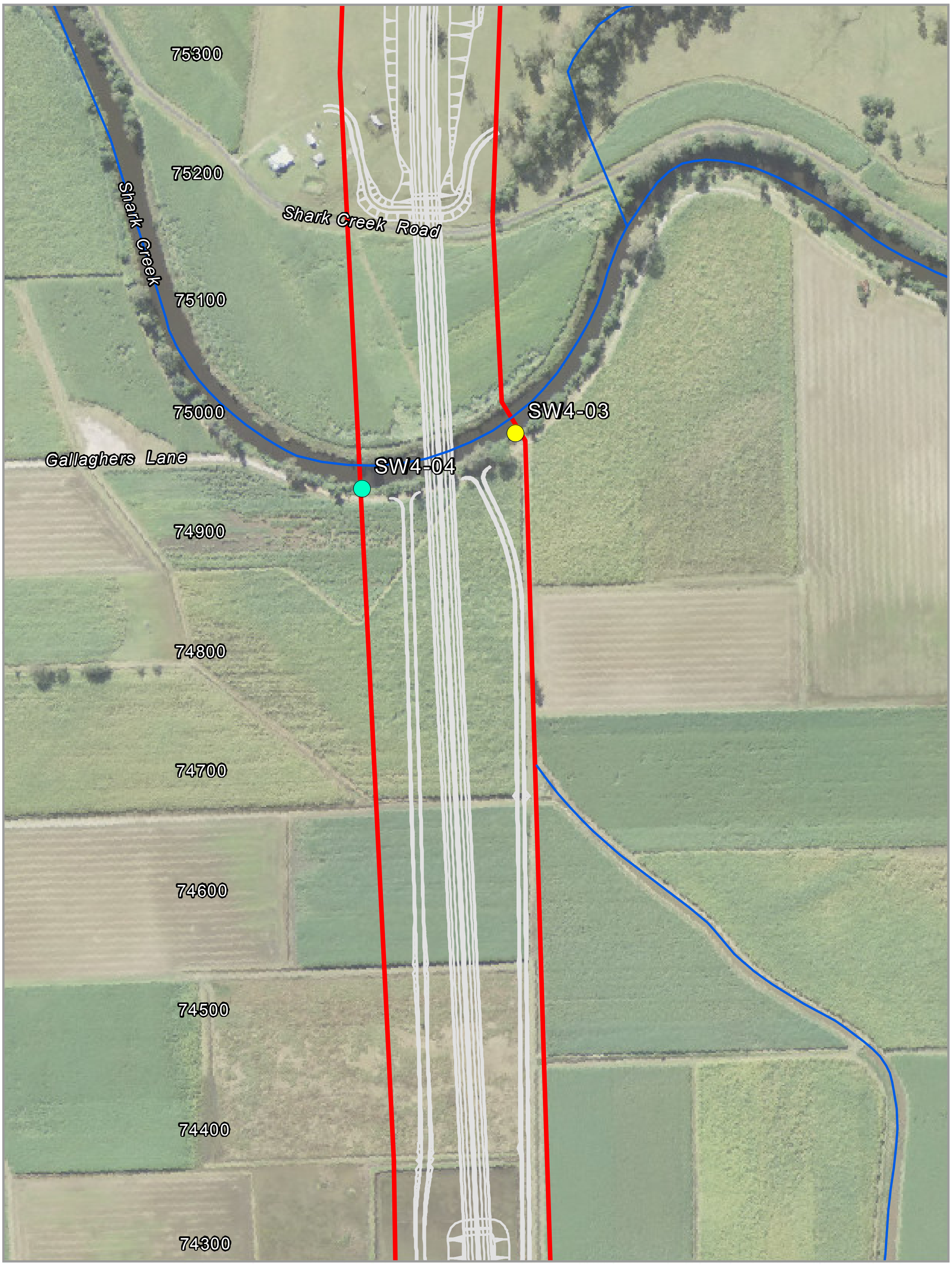
Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



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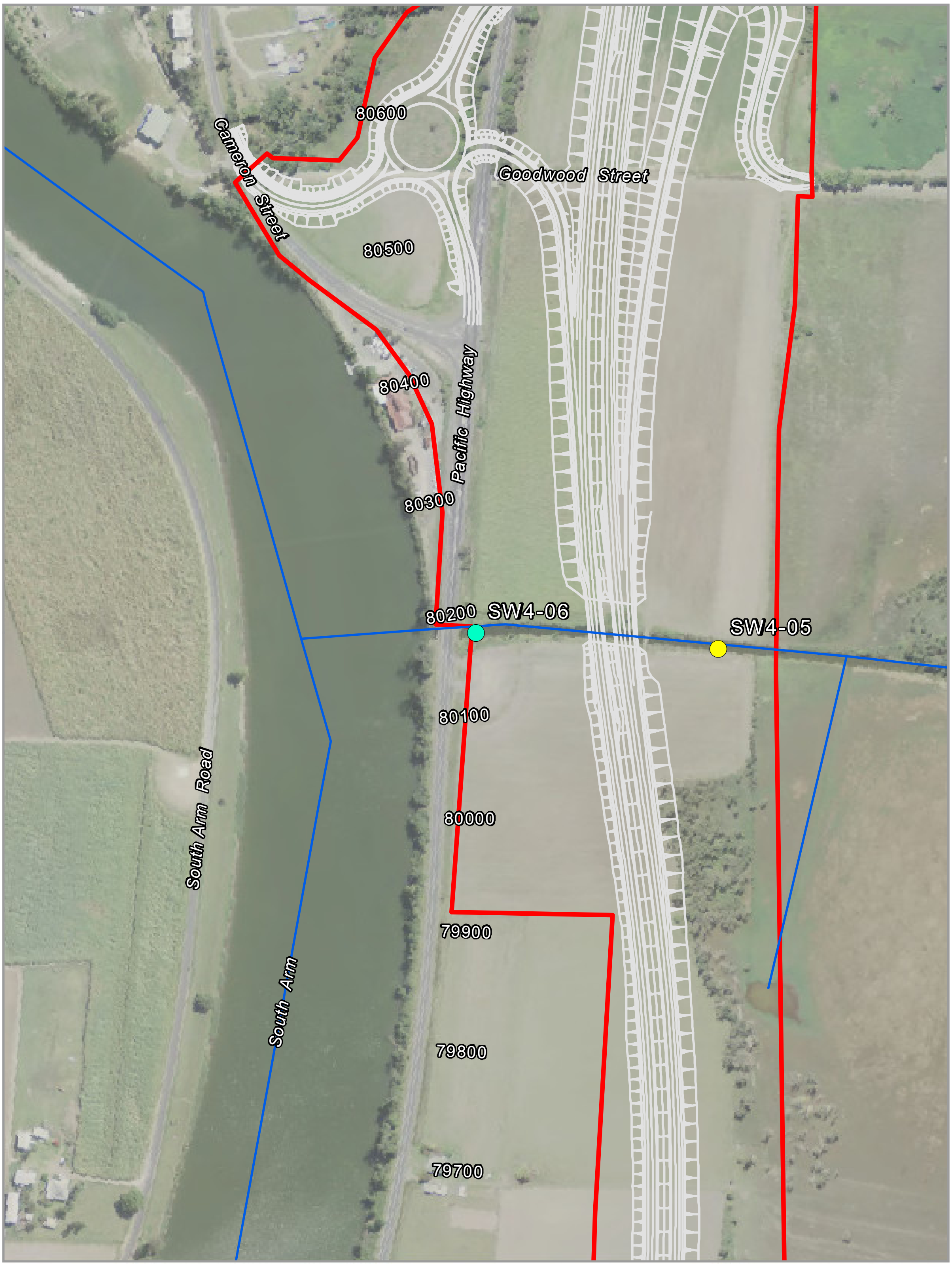

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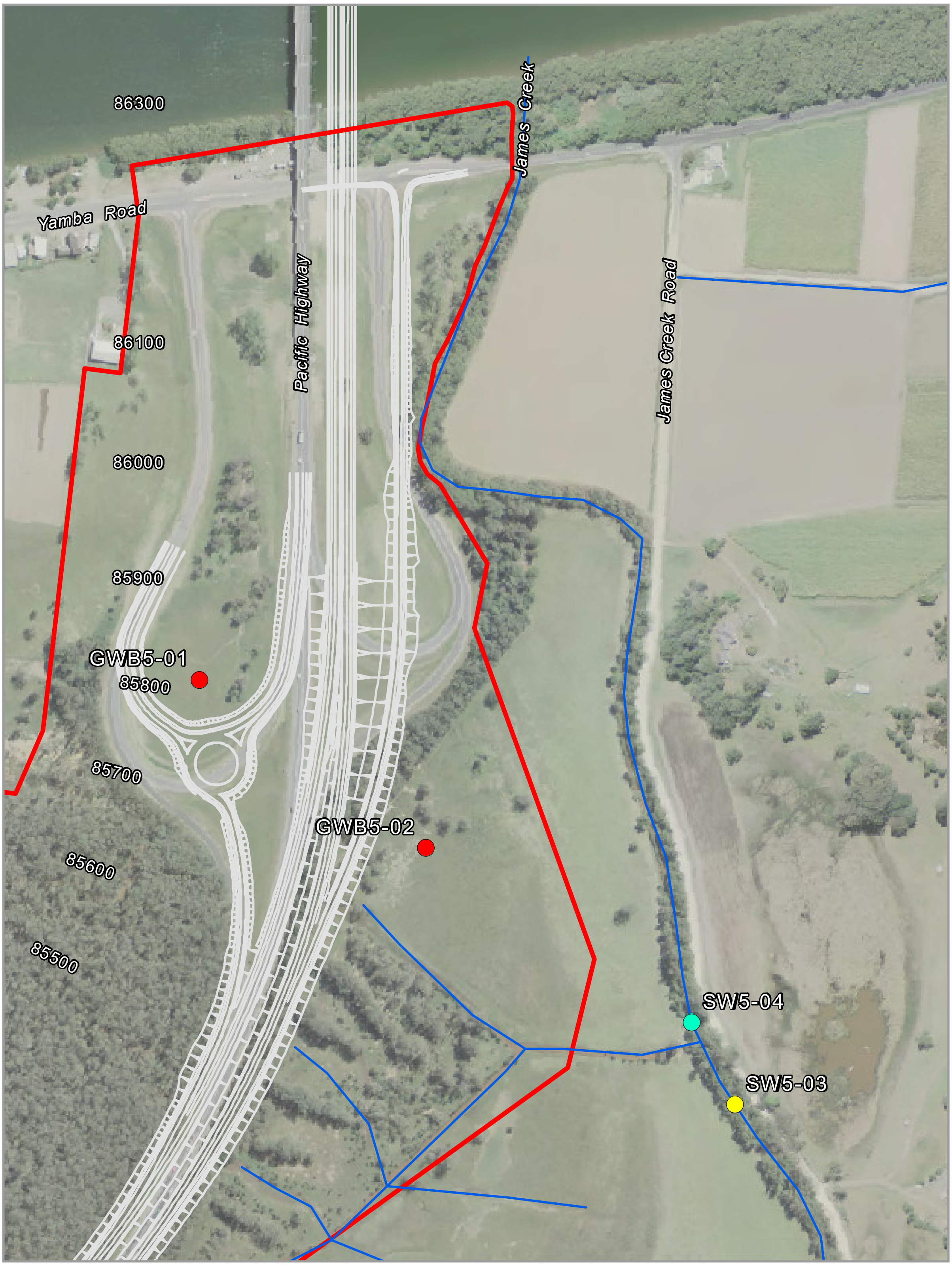

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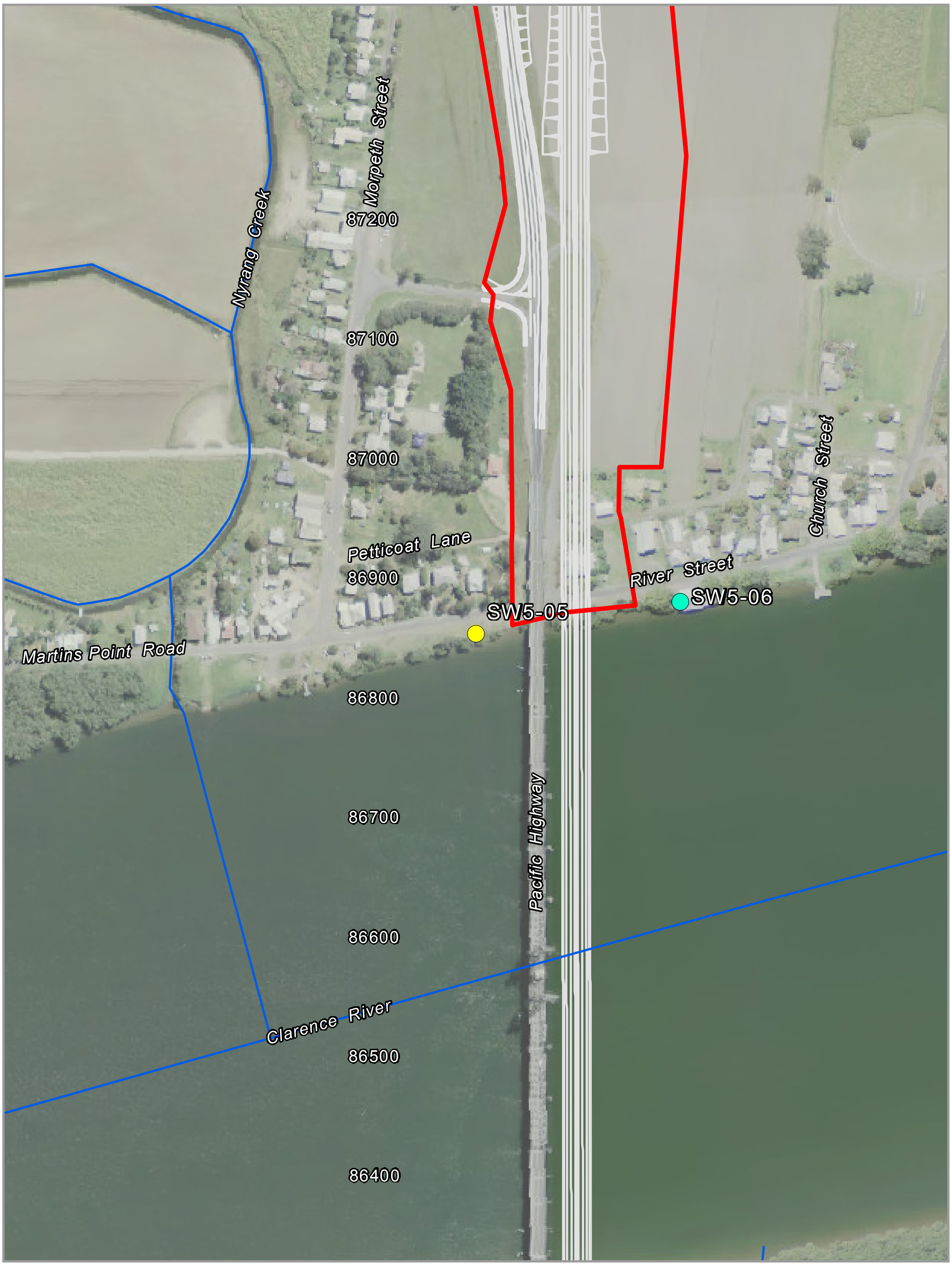

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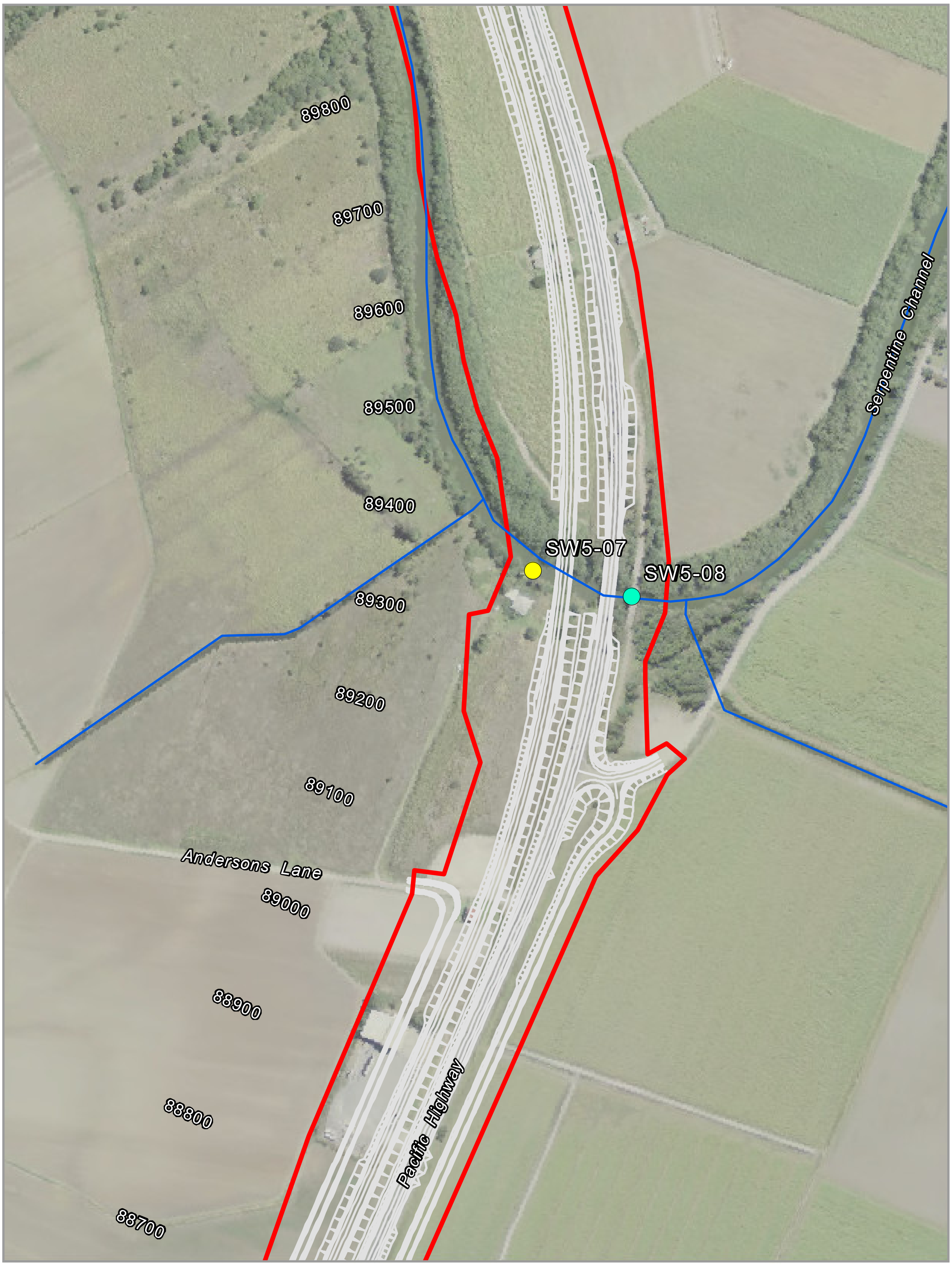

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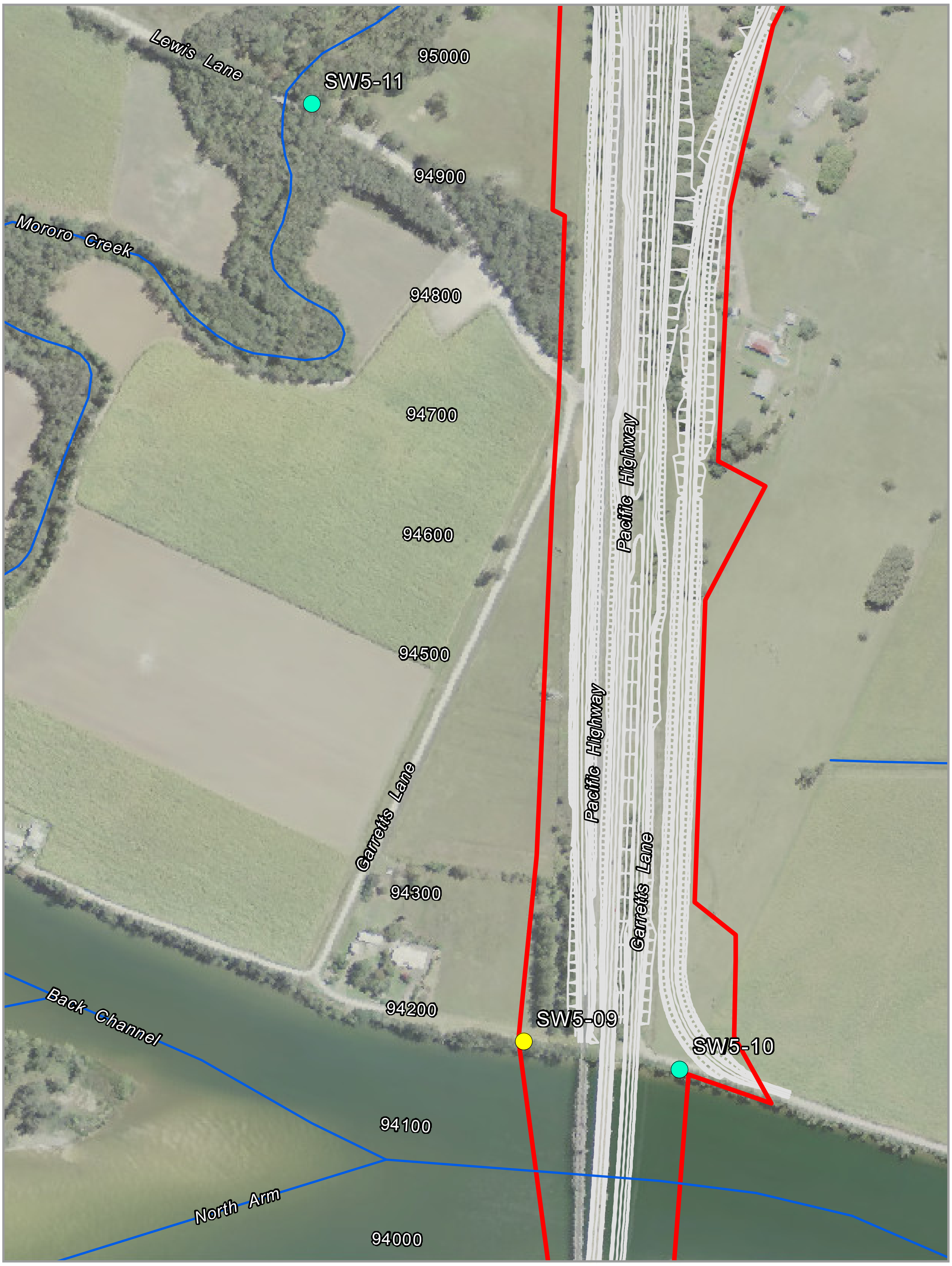

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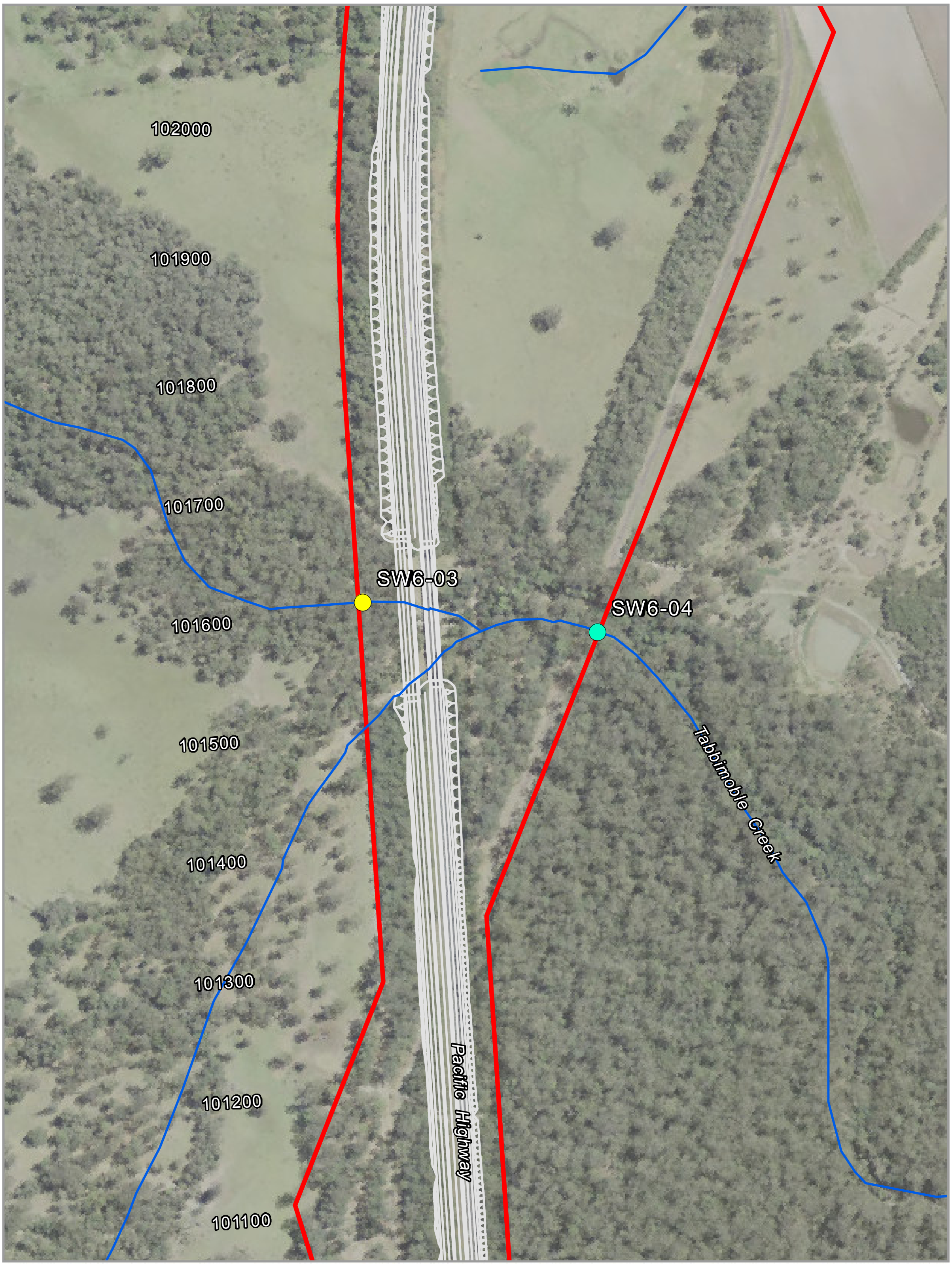

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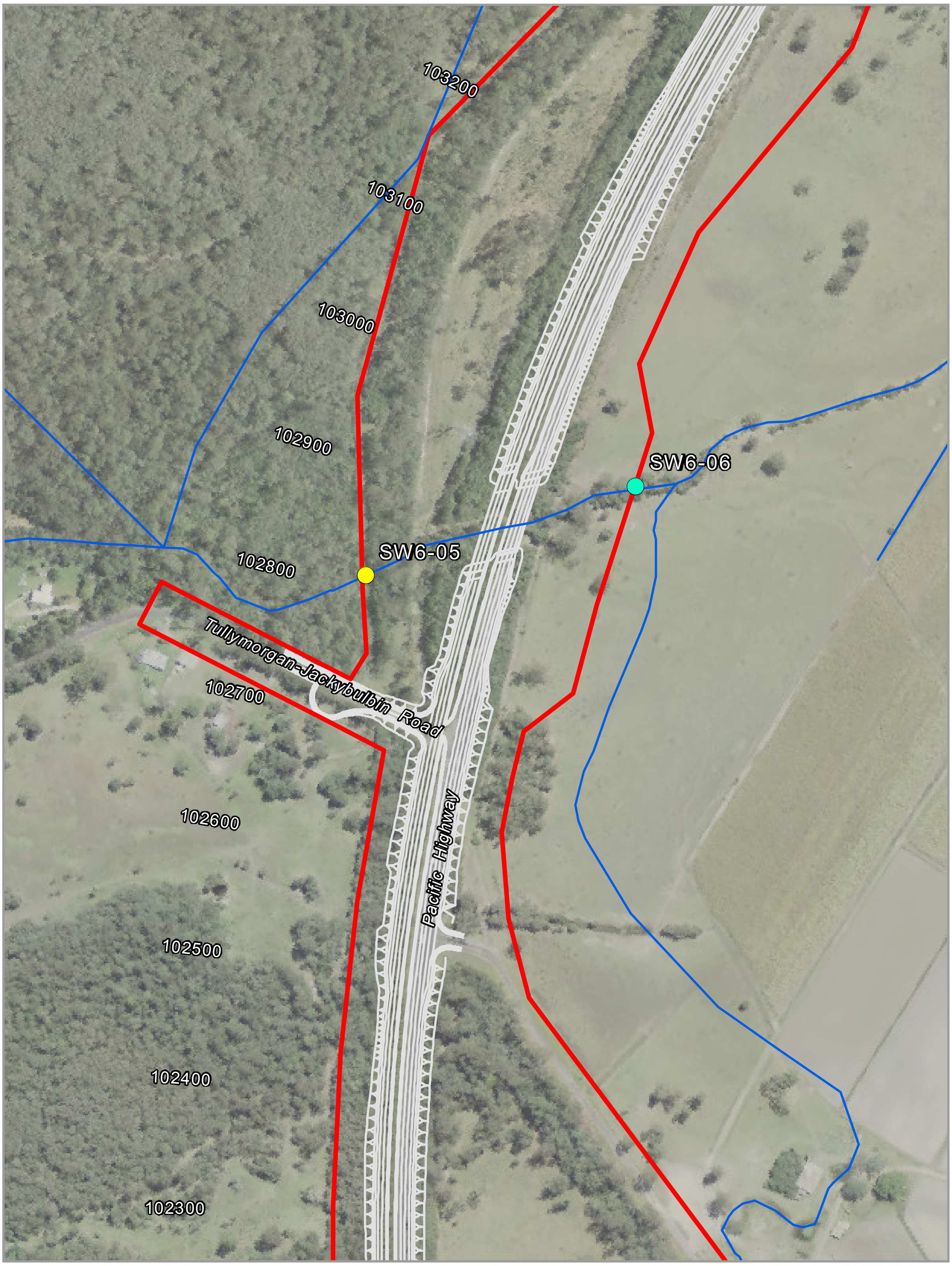

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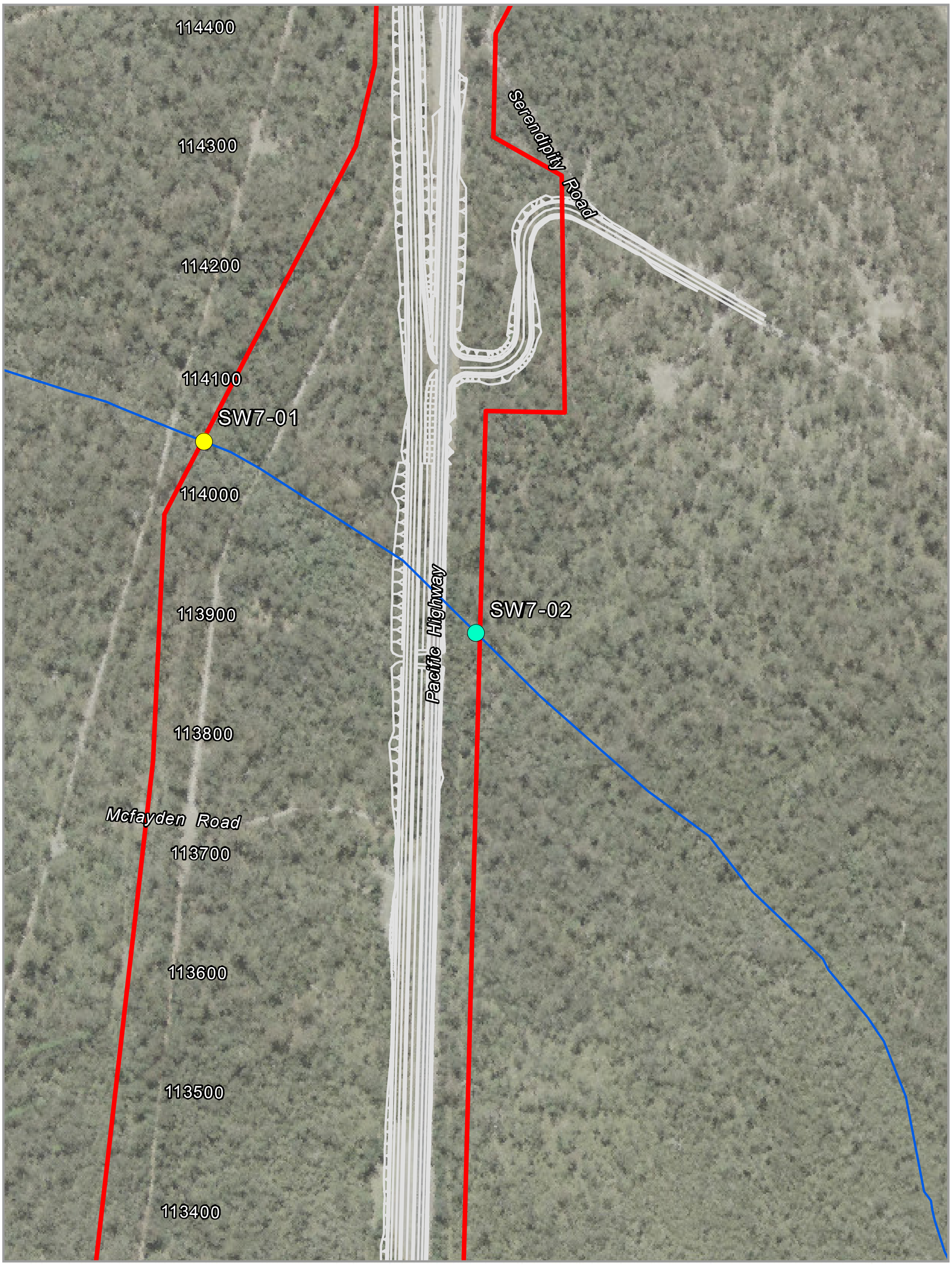

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Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

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Source of base data: DFS&I and Pacific Complete

LEGEND

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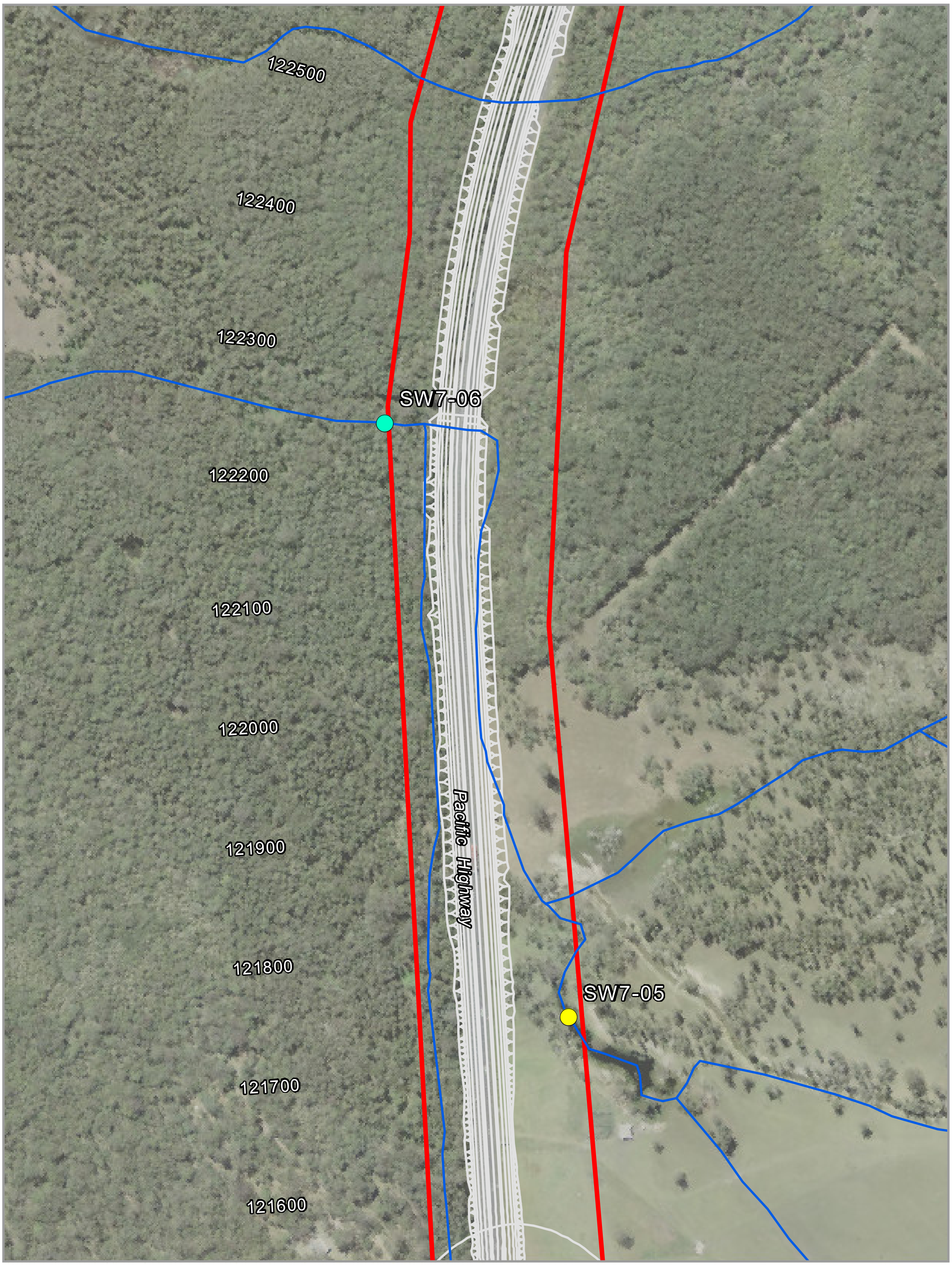
Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



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Woolgoolga to Ballina Sections 3-11
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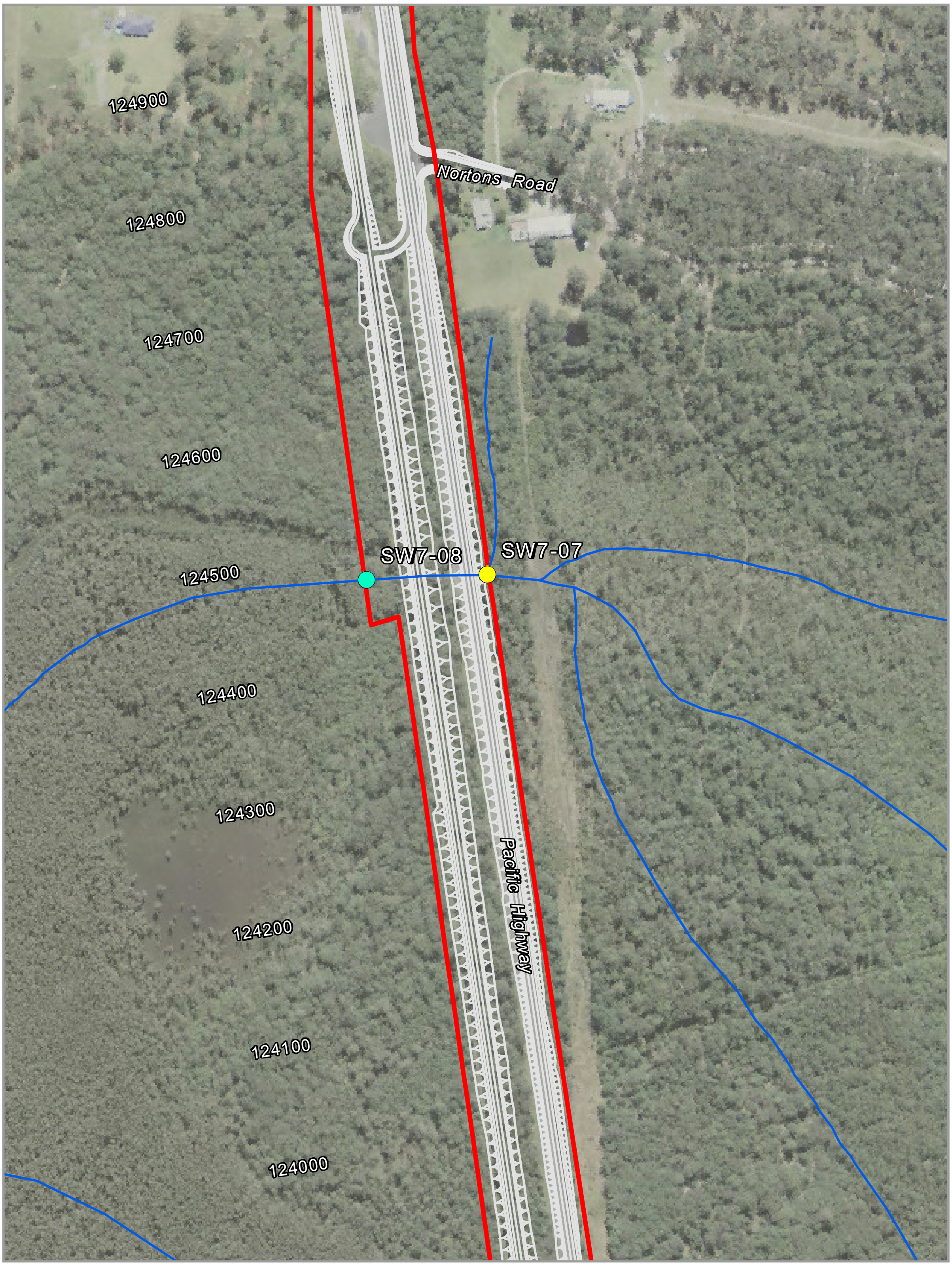

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Woolgoolga to Ballina Sections 3-11
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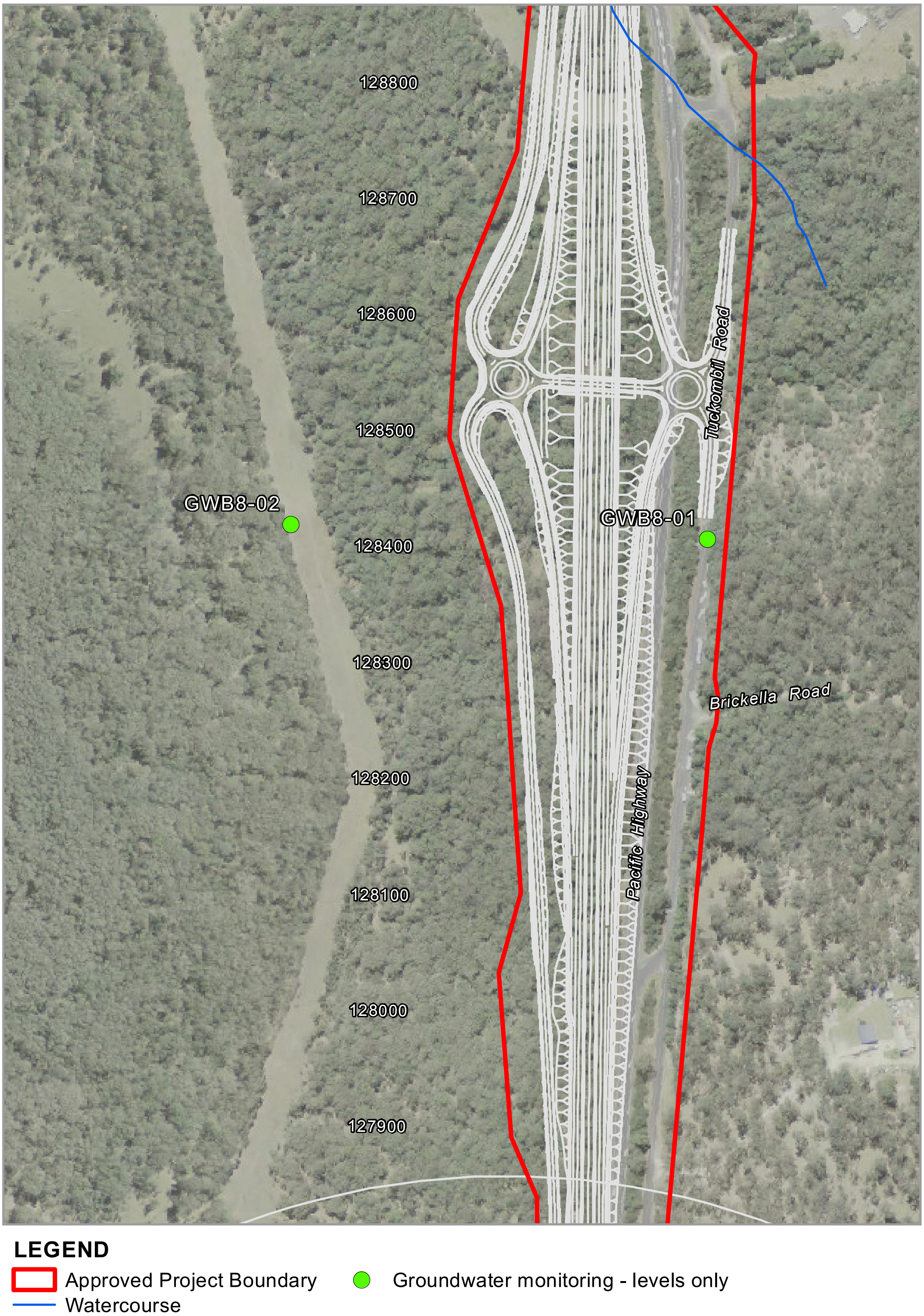
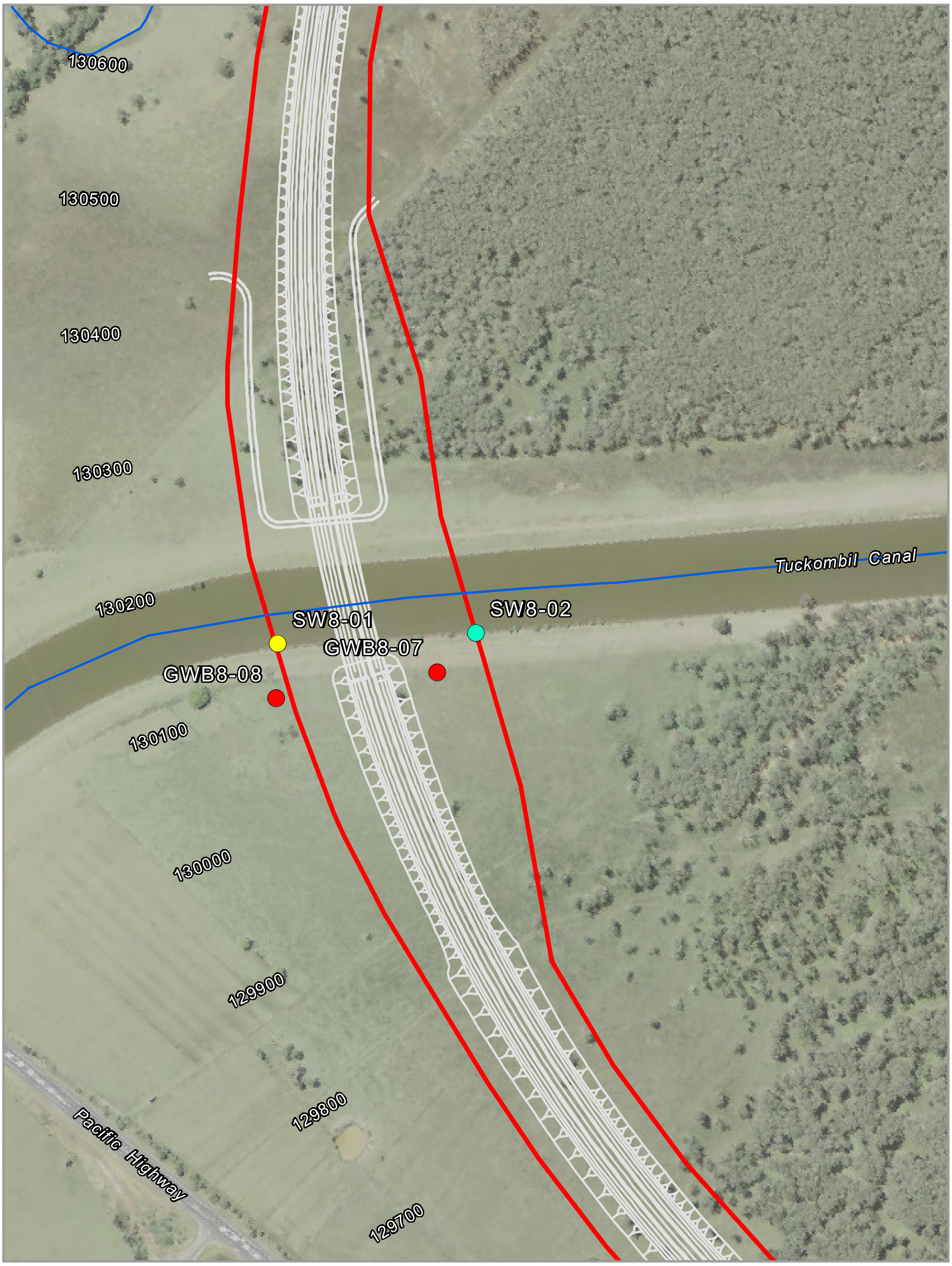


Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

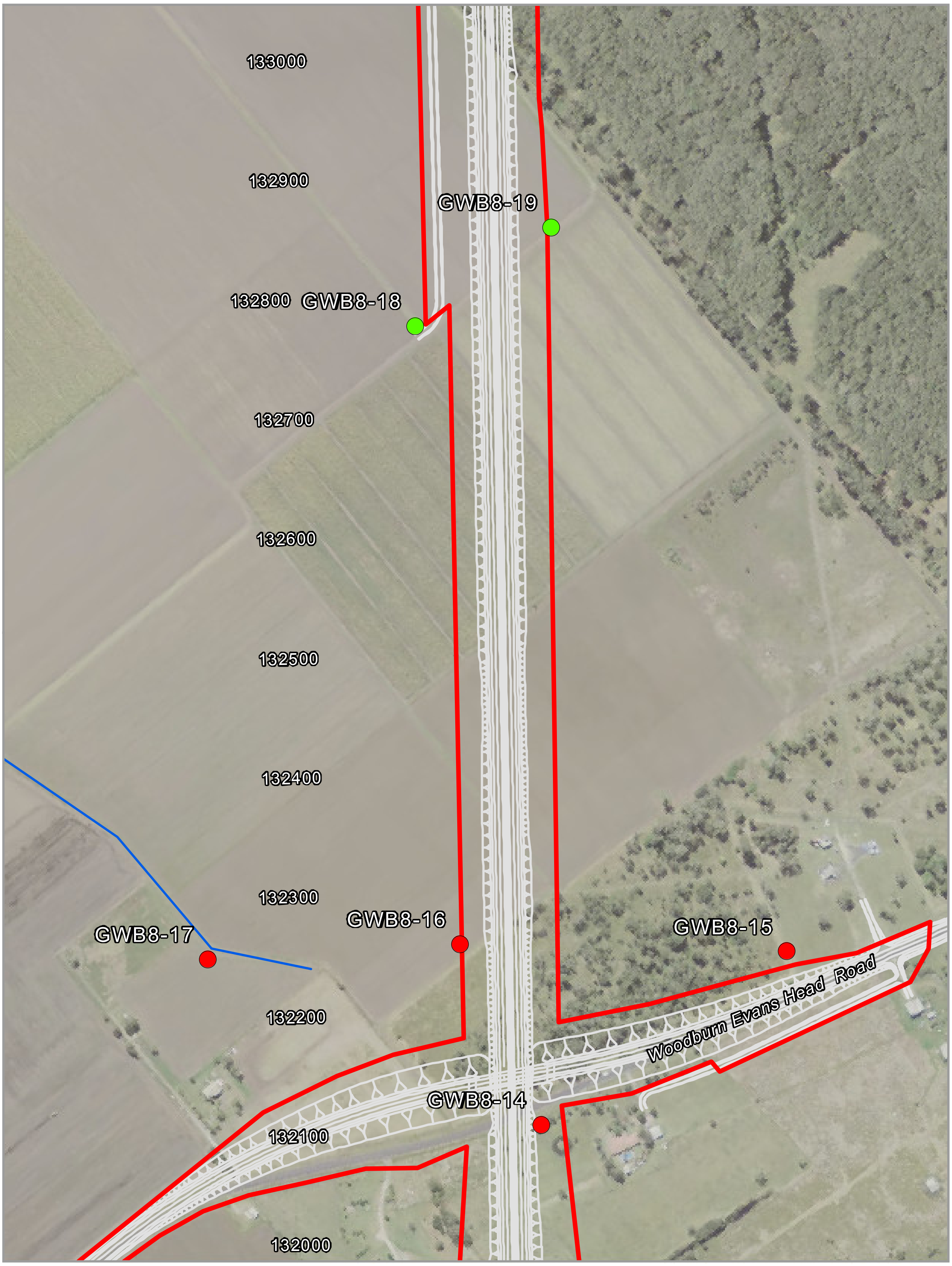
- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels and quality
- Downstream surface water monitoring point
- Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JC Date: 20/06/2019
Source of base data: DFS&I and Pacific Complete

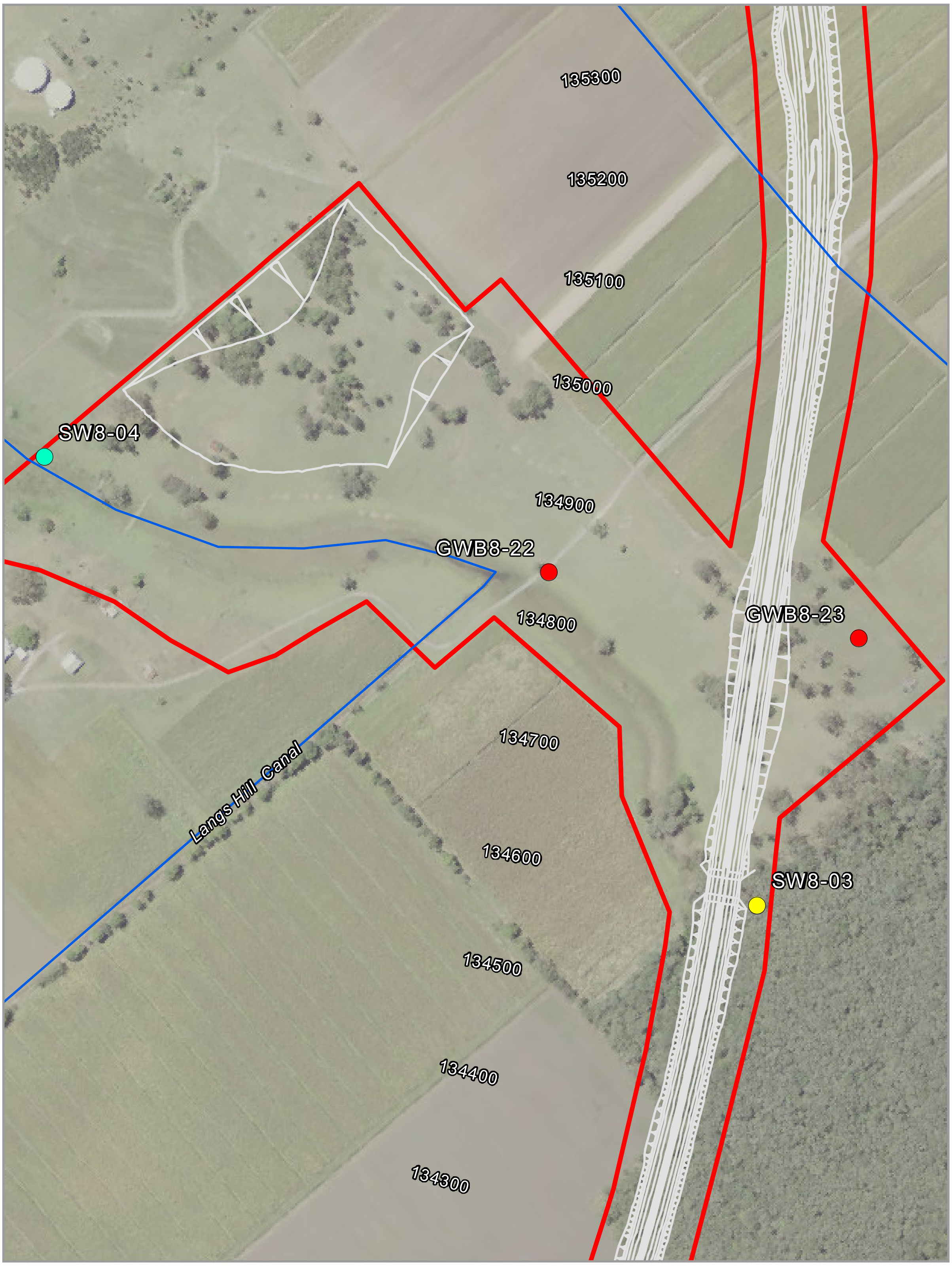


LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels only
- Groundwater monitoring - levels and quality

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

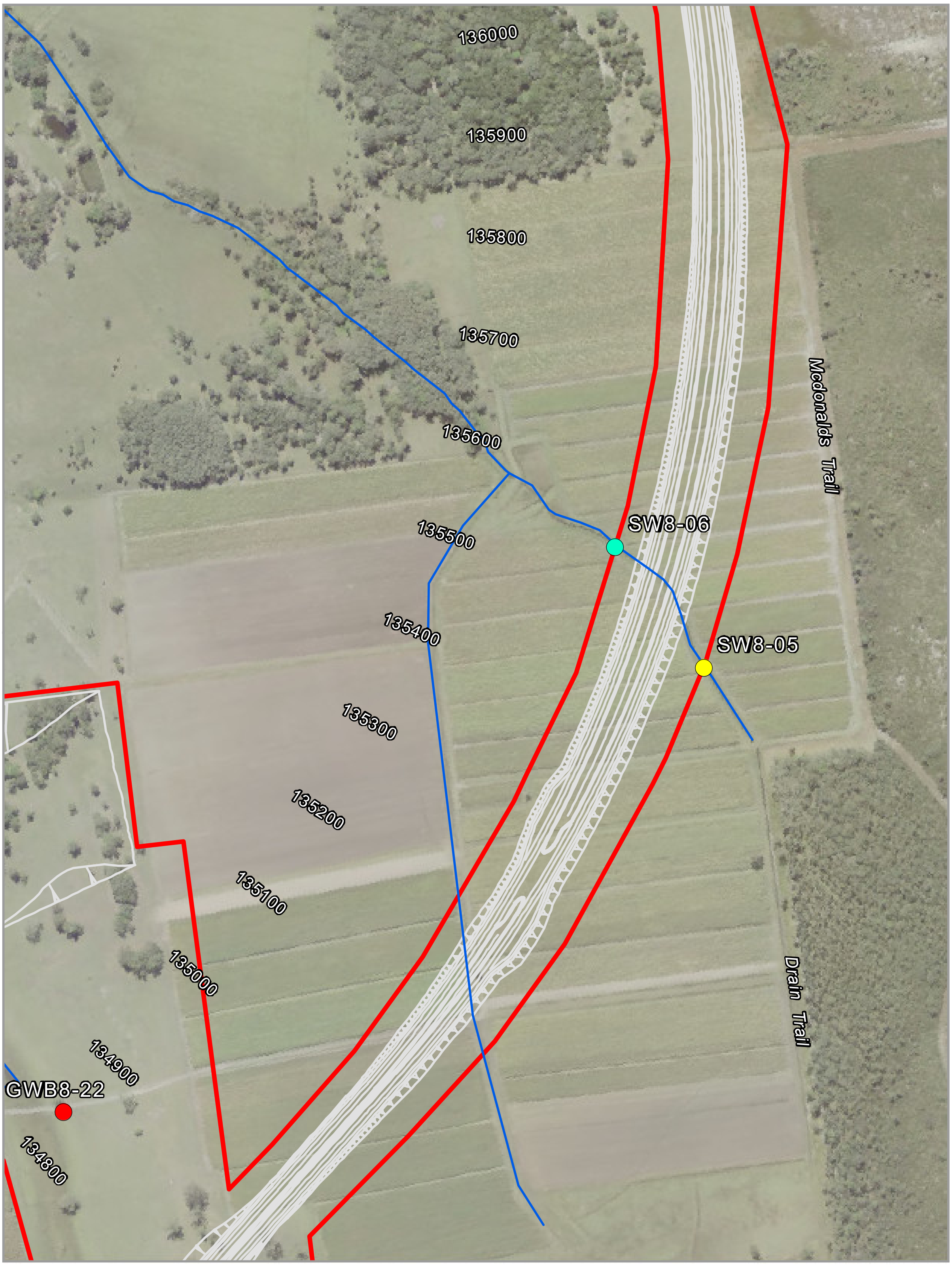


LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels and quality
- Downstream surface water monitoring point
- Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels and quality
- Downstream surface water monitoring point
- Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

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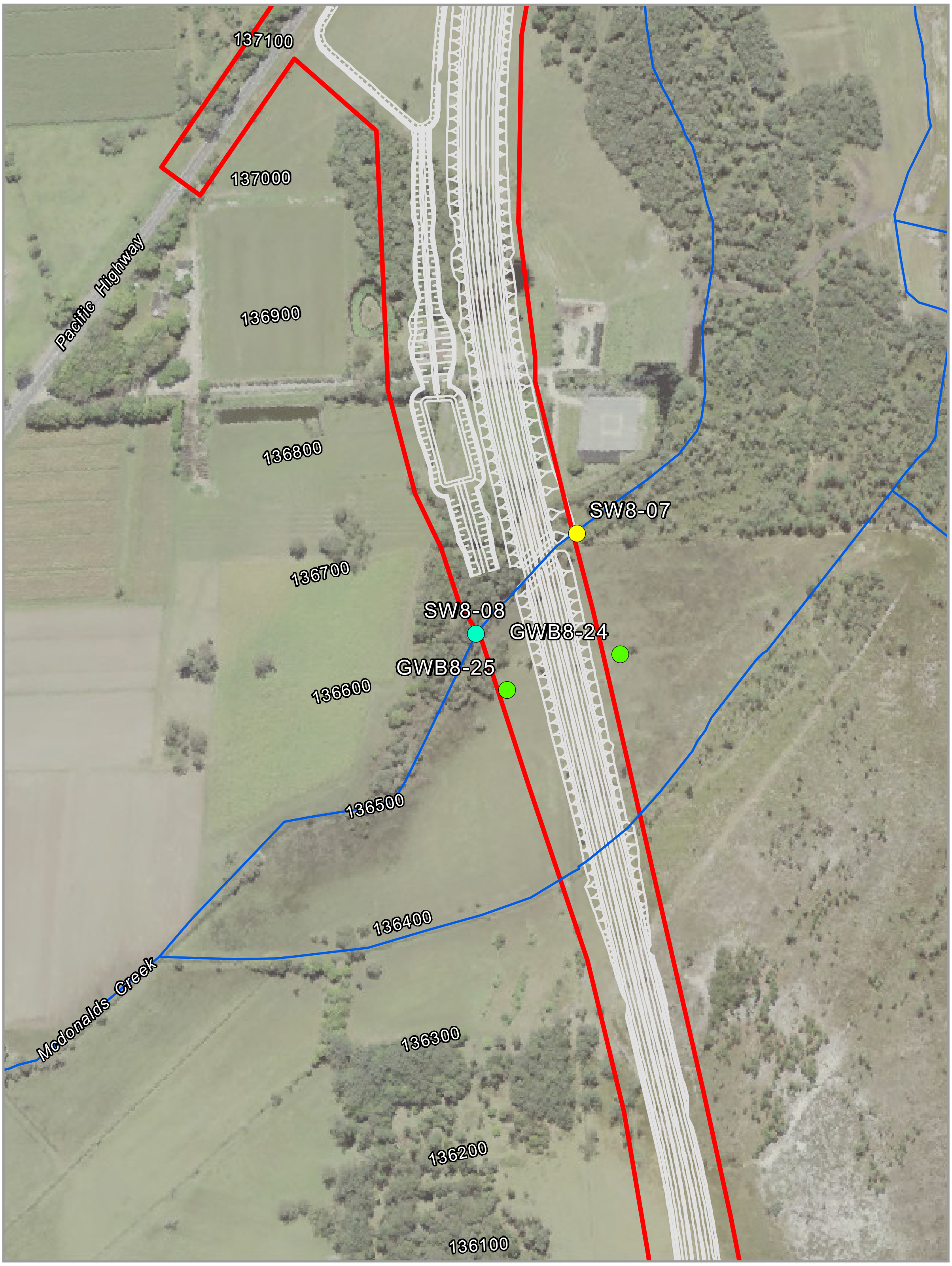
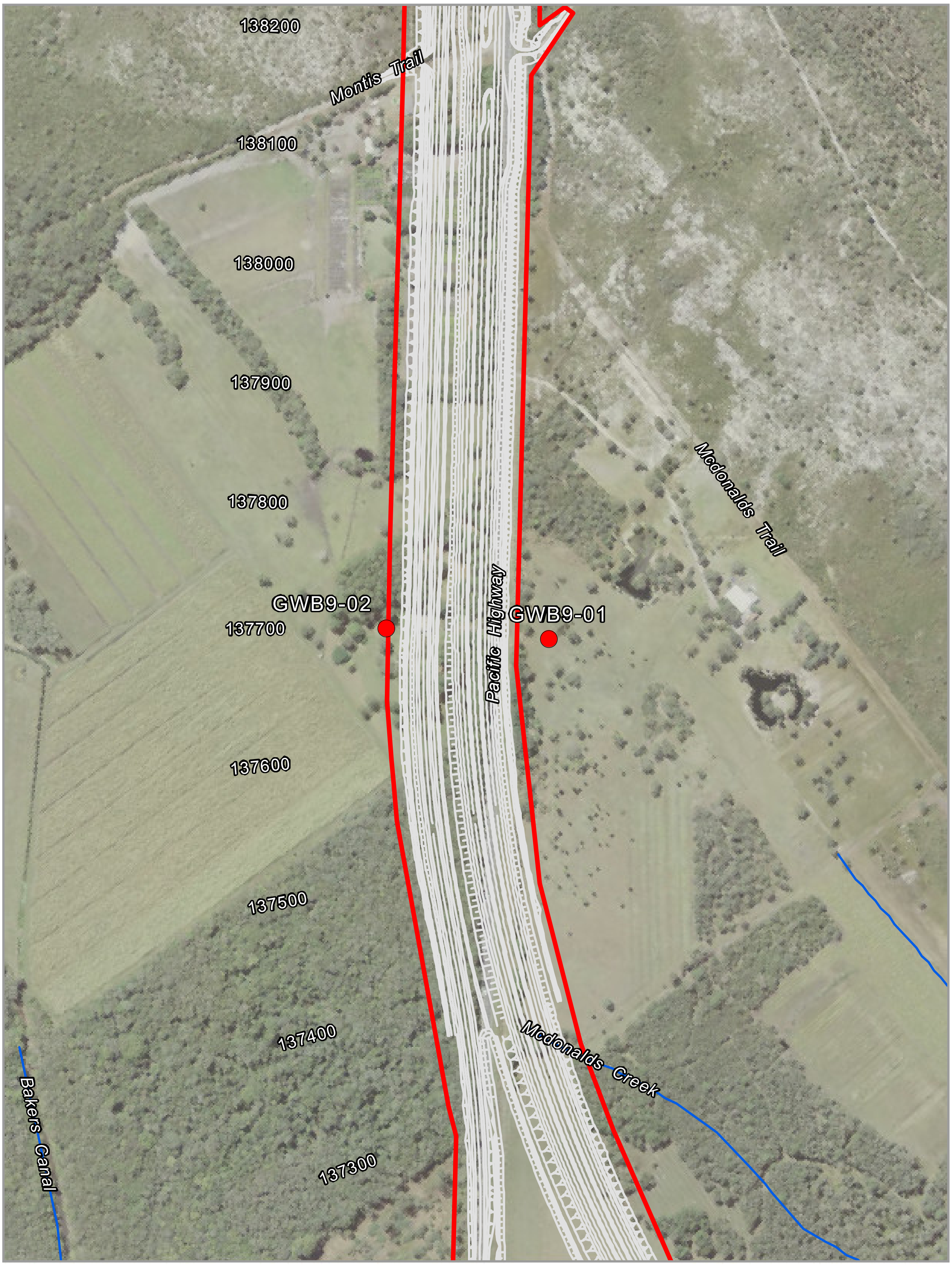


LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels only
- Downstream surface water monitoring point
- Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

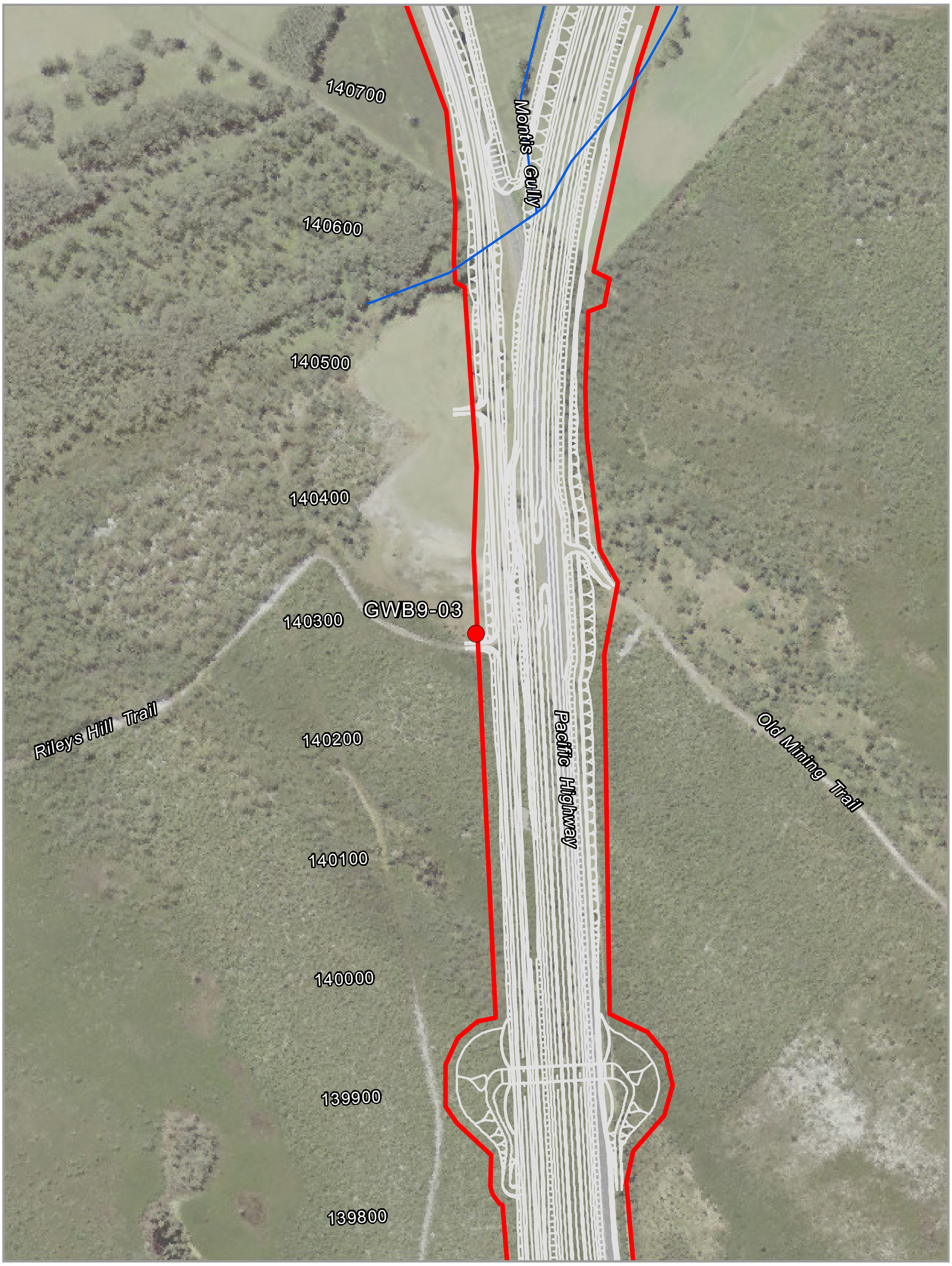
- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels and quality

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JC Date: 20/06/2019
Source of base data: DFS&I and Pacific Complete



LEGEND

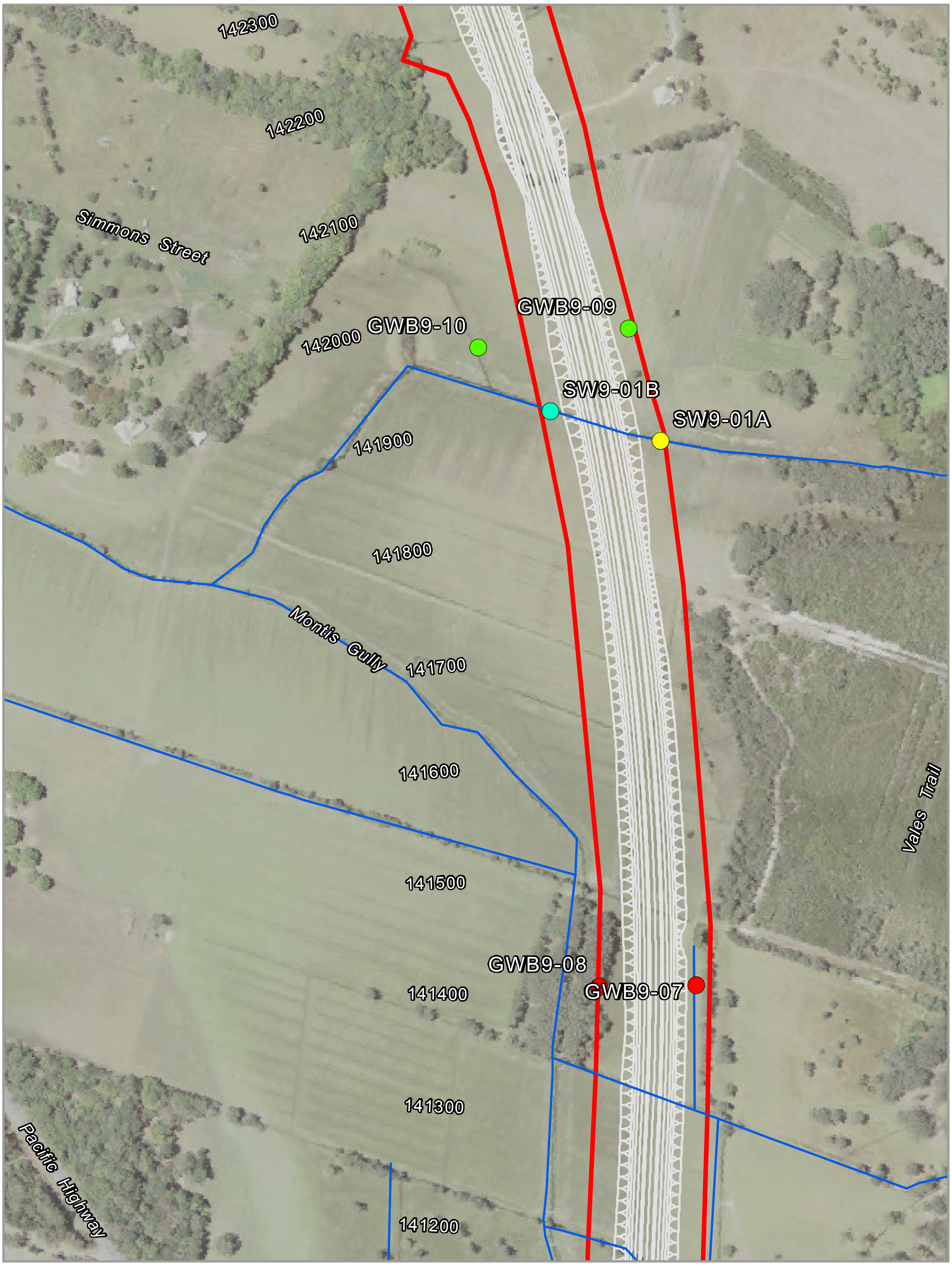
Approved Project Boundary
Watercourse
Groundwater monitoring - levels and quality

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

W2B – Sections 3 to 11 - Water Quality Monitoring Program
2476-1027 - Rev A

Sheet 36 of 44



LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels only
- Groundwater monitoring - levels and quality
- Downstream surface water monitoring point
- Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

Information shown is for illustrative purposes only

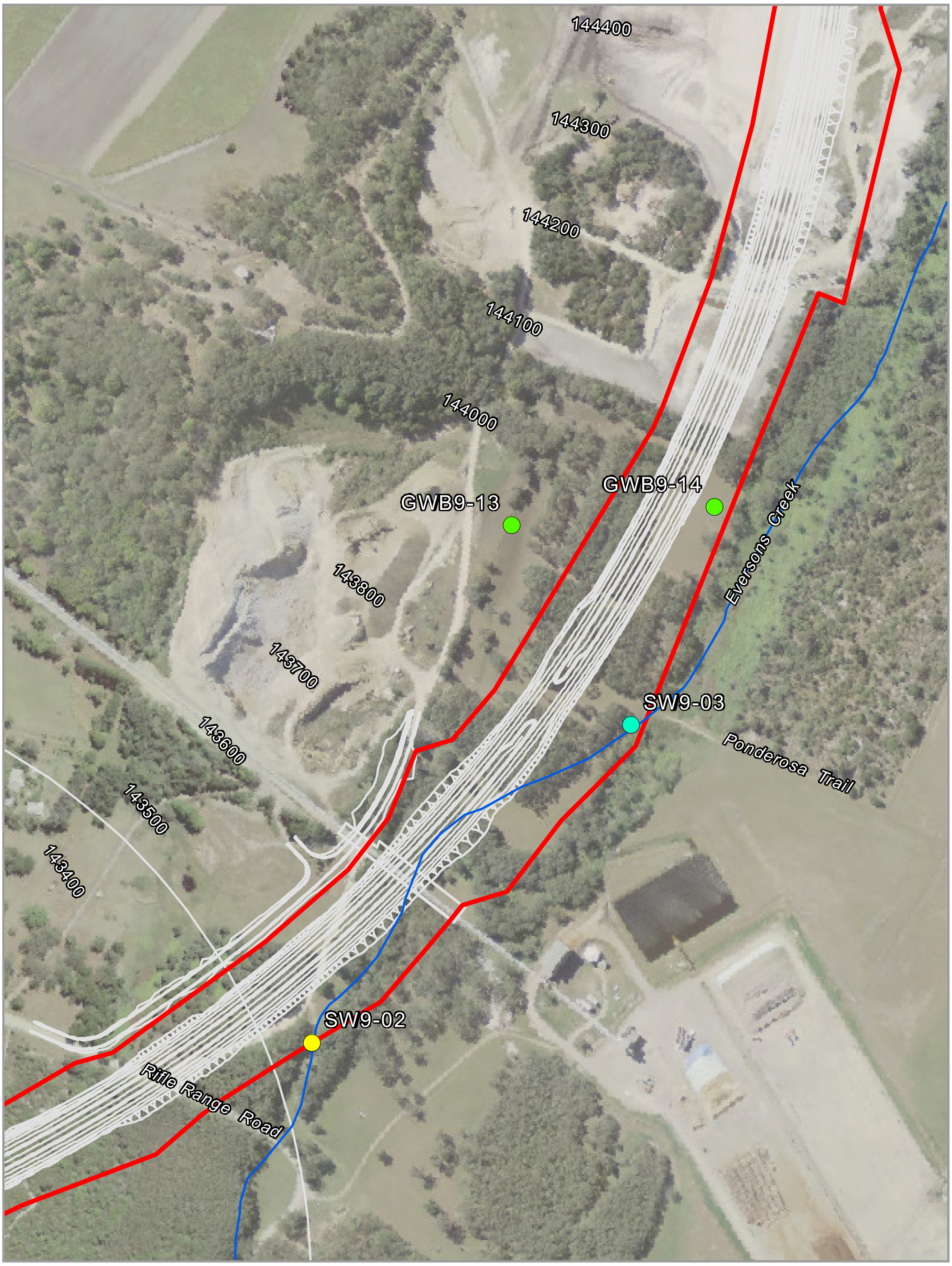
Drawn by: AB Checked by: RE Reviewed by: JC Date: 20/06/2019
Source of base data: DFS&I and Pacific Complete

LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels only

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

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- Watercourse
- Groundwater monitoring - levels only
- Downstream surface water monitoring point
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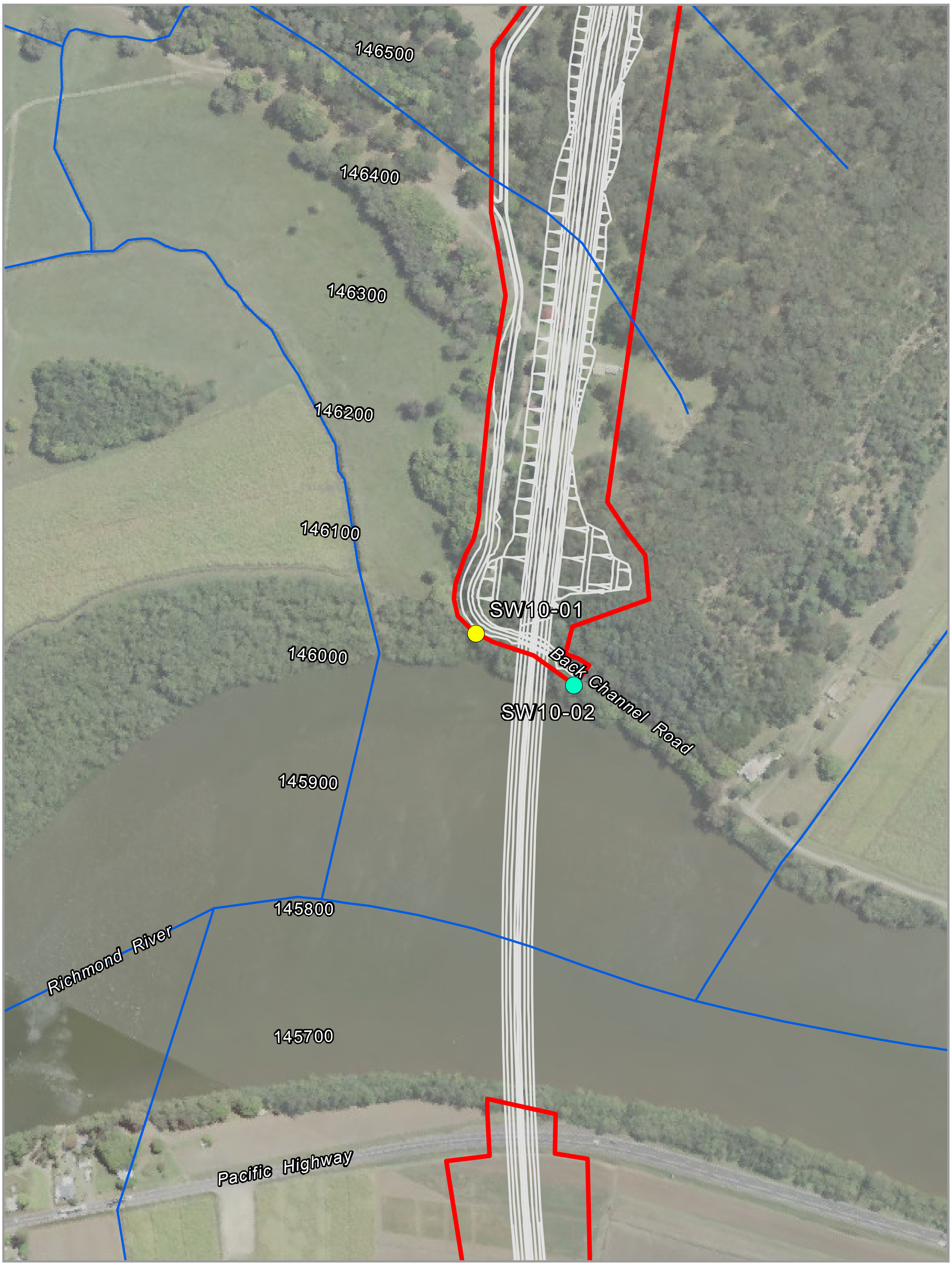
0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

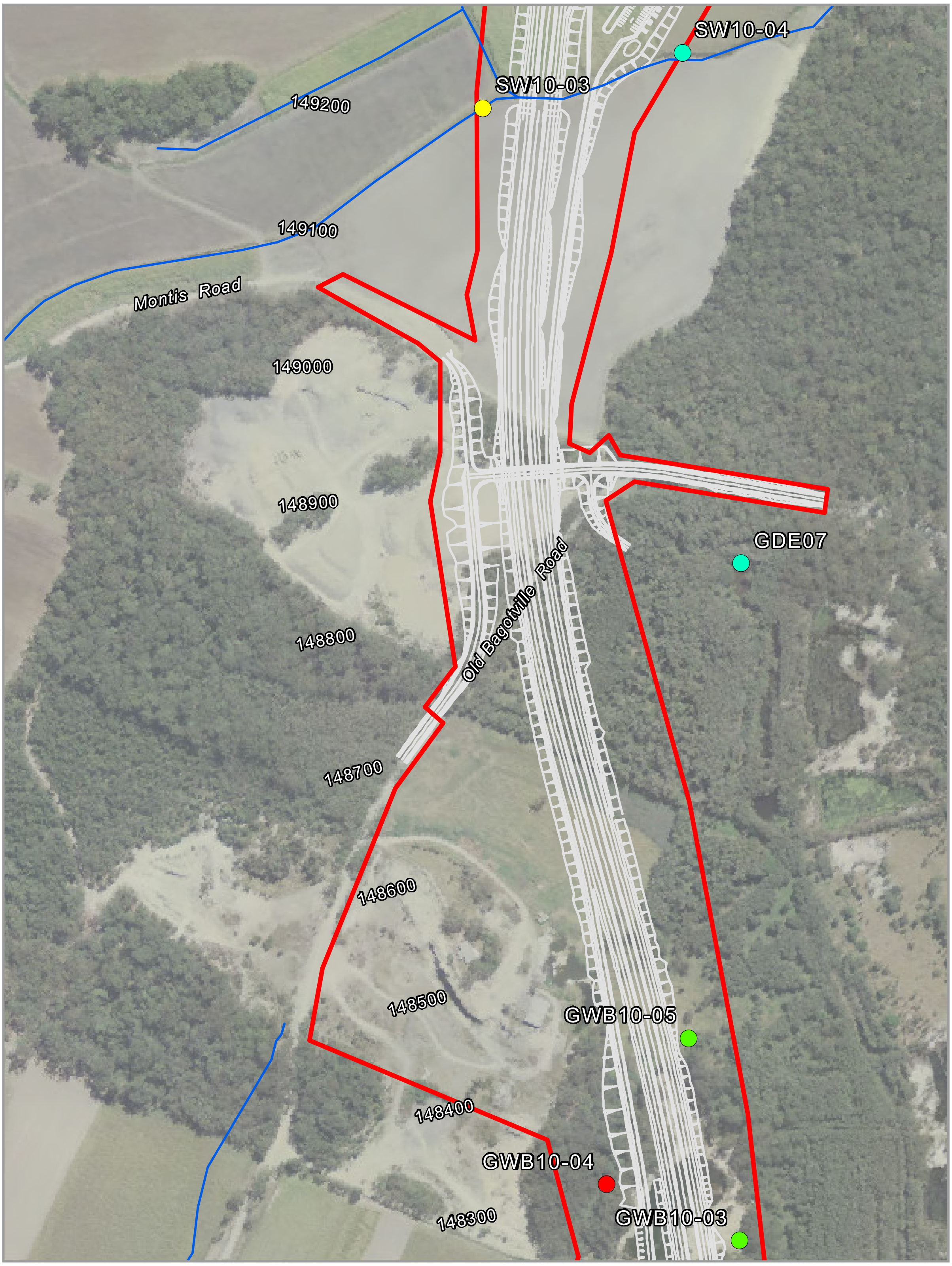


LEGEND

Approved Project Boundary
Watercourse
Downstream surface water monitoring point
Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

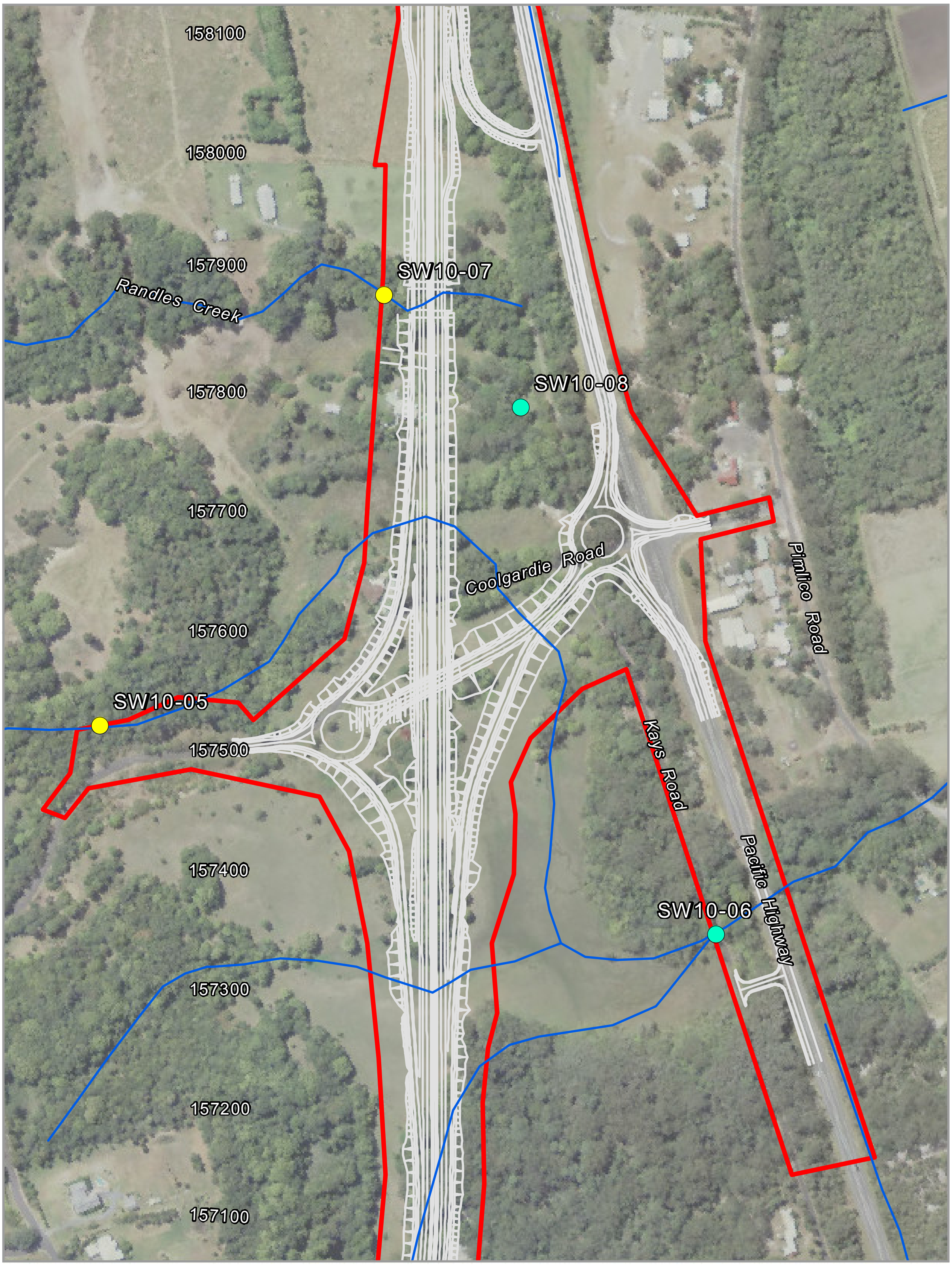
- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels only
- Groundwater monitoring - levels and quality
- Downstream surface water monitoring point
- Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JC Date: 20/06/2019
Source of base data: DFS&I and Pacific Complete

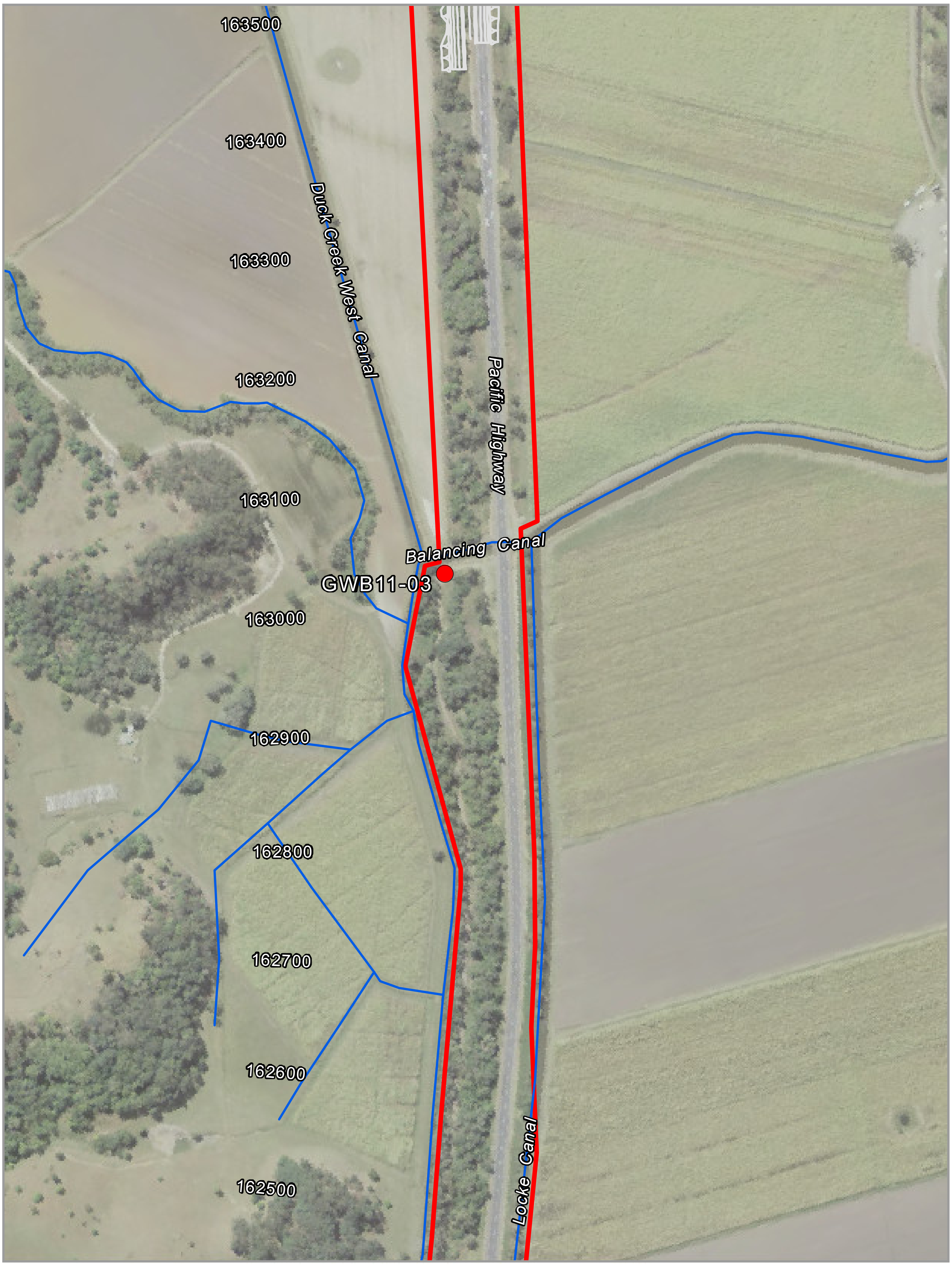


LEGEND

Approved Project Boundary
Watercourse
Downstream surface water monitoring point
Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

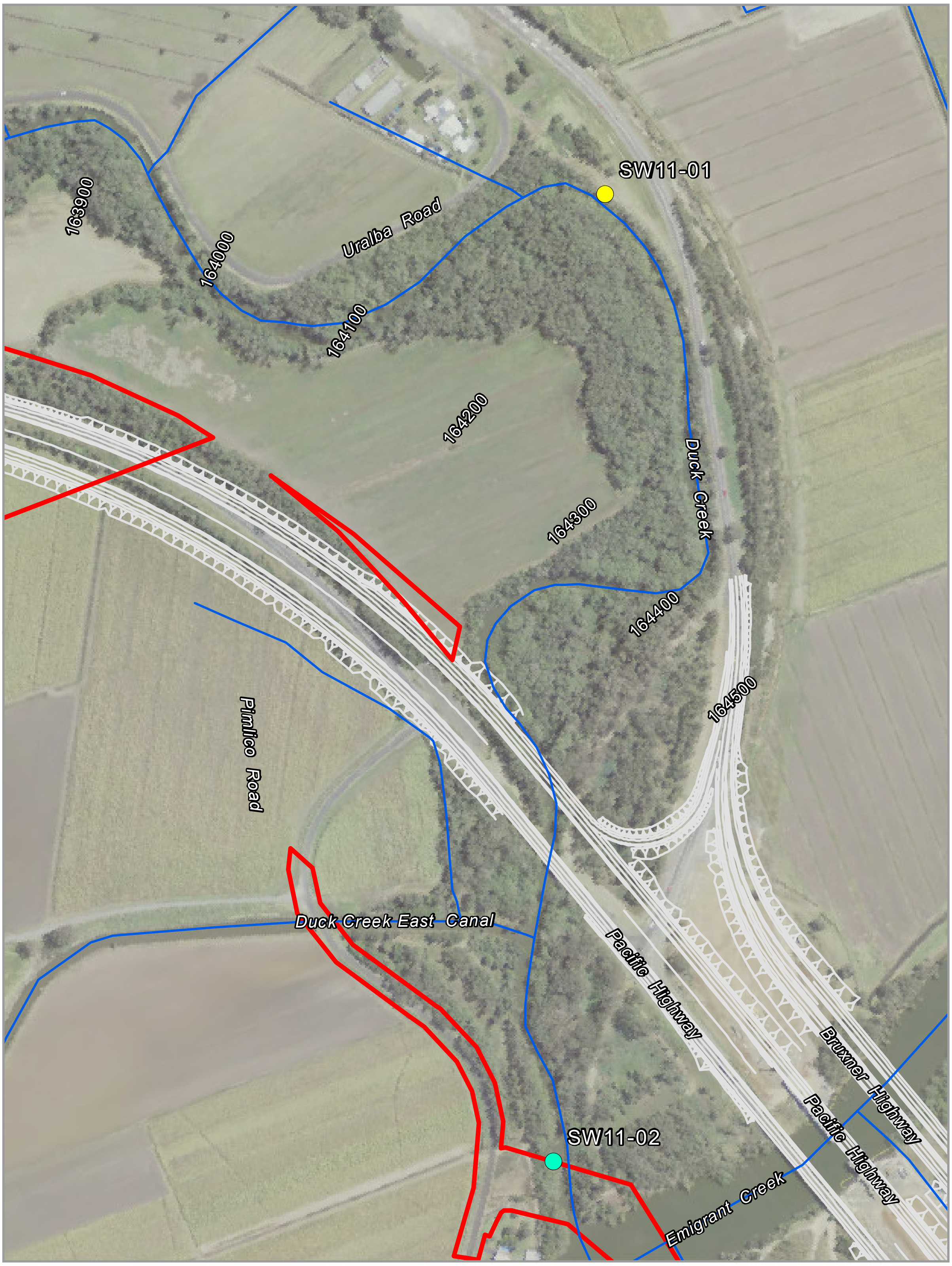


LEGEND

- Approved Project Boundary
- Watercourse
- Groundwater monitoring - levels and quality

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations



LEGEND

- Approved Project Boundary
- Watercourse
- Downstream surface water monitoring point
- Upstream surface water monitoring point

0 100

Woolgoolga to Ballina Sections 3-11
SW and GW Monitoring Locations

Appendix B

Section 3 – Glenugie to Tyndale:

Pre-Construction Monitoring Results

Section 3: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	Waterway Description	Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems
SW01 – Picanny Creek SW02 – Pheasant Creek SW03 – Unnamed tributary Glenugie Creek SW04 and SW05 – Coldstream River SW06 – Pillar Valley Creek SW07 – Black Snake Creek SW22 – Unnamed Creek tributary of Ellis Swamp SW08 – Chaffin Creek SW09 – Unnamed tributary of Chaffin Creek SW10 – Chaffin Creek SW11 – Unnamed bodies of water	The waterways in Section 3 are described as being primarily lowland freshwater systems, particularly in upstream areas. The downstream areas of Coldstream Creek, Chaffin creek and Champions Creek were assessed to have estuarine properties.	▪ Crows Nest Swamp located adjacent to the project ▪ SEPP 14 Coastal Wetland No. 287 located 600 m downstream of highway crossing Champions Creek ▪ SEPP 14 Coastal Wetland No.289 associated with Chaffin Creek is located 450m to west of the project ▪ SEPP 14 Wetland No. 292 is part of the Upper Coldstream wetlands, associated with Coldstream River and Pillar Valley Creek, located downstream and to the west of the project. ▪ Key fish habitats are assessed to be present for all named waterways and some smaller unnamed tributaries. Known and potential threatened aquatic species habitat is assessed to be present in Coldstream River, Black Snake Creek, Pillar Valley Creek and Chaffin Creek.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 3: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the low teens (13-15°C) in winter up to middle 20s (around 25-27°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks and tidal waterways.

Turbidity and total suspended solids (TSS) data varied greatly with no obvious correlation between high results and wet weather as would normally be anticipated. There was also a generally weak correlation between turbidity and TSS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 5 to 7.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.05 to 0.08 mg/L. Total Nitrogen values were generally less than 1.0 mg/L.

Heavy Metals

Heavy metals were generally below detection limits in all samples for all waterways.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	***Summary of Visual Observations***	***Overview of Water Quality Sampling Results***
SW01 Picanny Creek (Downstream) Section 3 Ch. 35,800	▪ Pheasant Creek is a small permanent water course, within the State Forest, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with slow flows to stagnant water generally observed. Moderate flows were observed during Round 2 (February) of the monitoring program. ▪ Water levels were high in Round 1 and 2 (January and February) and at low levels during Round 10 (October). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: 260-14mg/L ▪ TP: 0.01-0.07mg/L ▪ TN: 0.63-4.8mg/L ▪ DO: 4.16-9.12mg/L ▪ EC: 135-400µS/cm ▪ pH: 3.4-7.22 ▪ Temp: 10.8-27.2ºC ▪ NTU: 36-400
SW02 Pheasant Creek (Downstream) Section 3 Ch. 36,400	▪ Pheasant Creek is a small permanent water course, within the State Forest, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow flows observed. Stagnant water was recorded following dry weather in August - October (Round 8 – 10). There were moderate flows also observed during Round 2 of the monitoring program. Water levels were high January - February (Round 1 – 2) and low levels during the dry periods of August - October (Round 8 – 10). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5 -96mg/L ▪ TP: <0.01-0.11mg/L ▪ TN: 0.3-1.4mg/L ▪ DO: 4.12-8.97mg/L ▪ EC: 128.4-356µS/cm ▪ pH: 3.27-7.24 ▪ Temp: 25.7-14.2ºC ▪ NTU: 40.1-140
SW03 Unnamed tributary of Glenugie Creek (Downstream) Section 3 Ch. 39,700	▪ Unnamed tributary of Glenugie Creek is a small permanent water course, within private (Lot 7DP793765) rural grazing land property, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with generally slow flows to stagnant water recorded in August – October (Round 8 – 10). There were moderate flows observed during Round 2 (February) of the monitoring program. ▪ Water levels were high Round 1 and 2 (February) and low levels during August - October (Round 8 –	▪ O&G:<5 mg/L ▪ TSS: 7.4-130mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: <0.2-1.4mg/L ▪ DO: 2.36-8.06mg/L ▪ EC: 218µS/cm-5.37mS/cm ▪ pH: 5.84-7.57 ▪ Temp: 12.3-24.9ºC ▪ NTU: 4.8-145

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
	10). The remaining months were observed as normal water levels.	
SW04 Coldstream River (Upstream) Ch. 42,400	▪ Coldstream River is a small permanent water course, adjacent to Want Lane in the road reserve, up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow flows to stagnant water recorded. ▪ Water levels were high during February (Round 1 – 2) and low levels during the dry periods of August - October (Round 8 – 10). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-50mg/L ▪ TP: 0.02-0.21mg/L ▪ TN: 0.3-2.5mg/L ▪ DO: 3.2-11.99mg/L ▪ EC: 7.82µs/cm-2.34mS/cm ▪ pH: 5.41-6.78 ▪ Temp: 12.8-26ºC ▪ NTU: 7.52-35.1
SW05 Coldstream River (Upstream) Ch. 43,000	▪ Permanent water course sampled beneath Sandy Crossing Bridge within the road reserve, up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with generally slow flows observed. Moderate flows were also observed during Round 2, 11a and 11b (February and November) of the monitoring program. ▪ Water levels were high in Round 1, 2 and 11a (February and November). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-35mg/L ▪ TP: <0.01-0.11mg/L ▪ TN: 0.24-0.9mg/L ▪ DO: 3.15-8.37mg/L ▪ EC: 115.3-935µS/cm ▪ pH: 5.36-7.27 ▪ Temp: 12.9-25.2ºC ▪ NTU: 5.38-44.1
SW06 Pillar Valley Creek (Downstream) Ch. 46,400	▪ Pillar Valley Creek was a small permanent water course, within rural grazing land (private property, Lot 15 DP751378), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with slow flows to stagnant water generally observed. There were periods of moderate flows observed during Round 5b, 6b and 11a, which were all wet weather sampling events (May, July and November). ▪ Water levels were high from February to March and July (Round 1 – 4 and 6b) and low levels during Round 10 (October). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-16mg/L ▪ TP: <0.01-0.06mg/L ▪ TN: 0.015-2.1mg/L ▪ DO: 6.01-9.82mg/L ▪ EC: 120.4-458µS/cm ▪ pH: 3.11-7.09 ▪ Temp: 14.8-29.5ºC ▪ NTU: 11.428.2
SW07 Black Snake Creek (Downstream) Ch. 46,700	▪ Black Snake Creek was a small ephemeral water course, within rural grazing land (private property, Lot 1 DP751378), down gradient of the proposed G2DP highway alignment. The Creek was dry during the Round 10 monitoring event (October). ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with slow flows to stagnant water generally observed. There were also	▪ O&G: <5mg/L ▪ TSS: <5-56mg/L ▪ TP: <0.01-0.04mg/L ▪ TN: >0.1-0.47mg/L ▪ DO: 7.98-10.15mg/L ▪ EC: 124.9-381µS/cm ▪ pH: 4.56-7.47 ▪ Temp: 14.5-27ºC ▪ NTU: 6.37-84.1

Site Identifier/ Waterway	Summary of Visual Observations	Overview of Water Quality Sampling Results
	moderate flows observed during Round 2-4, 6b and 11a. ▪ Water levels were high from February – April, July and November (Round 1 – 4, 6b and 11a), the Creek was low in Round 8 and 9 (August and September) and dry during Round 10 (October). The remaining months were observed as normal water levels.	
SW22 Unnamed Creek tributary of Ellis Swamp (Downstream) Ch. 50,300	▪ The small Creek was an ephemeral water course, sampled from the road reserve down gradient of the proposed G2DP highway alignment. The Creek was dry for the monitoring event in October (Round 10). ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during monitoring with slow flows to stagnant water generally observed. There were also moderate flows observed during Round 2-4, 6b and 11a. ▪ Water levels were high from February – April, July and November (Round 1 – 4, 6b and 11a), low in Round 8 and 9 (August and September) and dry during Round 10 (October). Normal water levels were observed in remaining months.	▪ O&G: <5-6.4mg/L ▪ TSS: <5-40mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: 0.3-1.1mg/L ▪ DO: 2.55-9.70mg/L ▪ EC: 105.9-296µS/cm ▪ pH: 3.54-6.79 ▪ Temp: 12.5-25.5ºC ▪ NTU: 7.2-36.1
SW08 Chaffin Creek (Downstream) Ch. 52,500	▪ Chaffin Creek is a permanent water course, within rural grazing land (private property, Lot 44 DP751365), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity during the monitoring program with generally slow flows observed, with stagnant water recorded following the dry weather August to October (Round 8 - 10). ▪ Water levels were high during February and July (Round 2 and 6b) and low levels during the dry periods of August to October (Round 8 - 10). The remaining months were observed as normal water levels.	▪ O&G: <5-5mg/L ▪ TSS: <5-13mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: 1.5-0.3mg/L ▪ DO: 3.04-7.94mg/L ▪ EC: 104.4-336-µS/cm ▪ pH: 5.32-6.82 ▪ Temp: 14.8-30.3ºC ▪ NTU: 4.08-32.8
SW09 Unnamed tributary of Chaffin Creek (Downstream) Ch. 54,600	▪ Unnamed tributary of Chaffin Creek is a small permanent water course, within rural grazing land (private property Lot 108 DP751365), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity throughout the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 1 - 4 and 6b (February - April and July). ▪ Water levels were high from February - April (Round 1 - 4), the Creek was low in Round 5, 8 - 10 (May and Aug - Oct). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-33mg/L ▪ TP: <0.01-0.05mg/L ▪ TN: 0.3-1.3mg/L ▪ DO: 1.92-8.77mg/L ▪ EC: 110.2-430µS/cm ▪ pH: 3.48-6.85 ▪ Temp: 12.9-24.9ºC ▪ NTU: 4.33-39.00

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW10 Champions Creek (Upstream) Ch. 57,200	▪ The small Creek was an ephemeral water course located within bush land (private property), up gradient of the proposed G2DP highway alignment. The Creek was dry for the monitoring event in October (Round 10) ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 6b (July). ▪ Water levels were high from February – April and July (Round 1 – 4 and 6b), the Creek was normal in Round 5b and 11b (July and November) and dry during Round 10 (October). The remaining months were observed as low water levels	▪ O&G: <5mg/L ▪ TSS: <5-29mg/L ▪ TP: <0.01-0.12mg/L ▪ TN: 0.61-1.3mg/L ▪ DO: 2.46-6.74mg/L ▪ EC: 79.4-500µS/cm ▪ pH: 2.99-6.1 ▪ Temp: 11.4-25.2ºC ▪ NTU: 30.8-41.2
SW11 Unnamed body of water (Downstream)	▪ Unnamed body of water is a small permanent water course located within private property bushland (Lot 124 DP751365), down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow flows observed. Stagnant water was recorded in August to October (Round 8 – 10). ▪ Water levels were high in February (Round 1 – 2) and low levels during the dry periods of August to October (Round 8 – 10). The remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-16mg/L ▪ TP: <0.01-0.04mg/L ▪ TN: 0.15-0.6mg/L ▪ DO: 2.34-7.95mg/L ▪ EC: 119.3-290µS/cm ▪ pH: 5.17-6.46 ▪ Temp: 11-22.3ºC ▪ NTU: 4.04-25.3
SW12 South Arm Clarence River (Tidal)	▪ South Arm Clarence River was sampled from within private property, to the west of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. Moderate flows during the wet weather event in July (Round 6b). ▪ Water levels were high in February and the remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-32mg/L ▪ TP: <0.01-0.15mg/L ▪ TN: 0.31-1.1mg/L ▪ DO: 0.49-10.64mg/L ▪ EC: 132.5µS/cm-6.26mS/cm ▪ pH: 2.7-7.42 ▪ Temp: 27.4-16.2ºC ▪ NTU: 3.95-48.1

Note: * Ch. = Highway Chainage

Section 3: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 3							
				SW01 (SW3-01)					
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	52.40	65.34	14	260	21	57.20	-	
Total Phosphorus as P	mg/l	0.04	0.01	0.01	0.07	0.03	0.04	-	
Total Nitrogen as N	mg/l	1.09	1.07	0.19	4.8	0.8	1.10	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.17	1.38	4.16	9.12	7.6	8.16	6.30	
Conductivity	µs/cm	234.50	76.27	135.1	444	228	269.00	178.84	
pH		6.66	0.95	3.4	7.22	6.94	7.18	6.59	
Temperature	°C	20.17	4.83	10.8	27.2	20.8	24.20	-	
Turbidity	NTU	97.89	89.20	36.1	400	69.9	123.00	-	
				SW02 (SW3-02)					
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	38.83	28.30	2.5	96	28	60.00	-	
Total Phosphorus as P	mg/l	0.06	0.06	0.005	0.25	0.04	0.07	-	
Total Nitrogen as N	mg/l	0.83	0.37	0.21	1.4	0.86	1.22	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.95	1.47	4.12	8.97	7	8.14	5.96	
Conductivity	µs/cm	186.38	60.98	128.4	356	167.1	221.36	141.86	
pH		6.51	1.01	3.27	7.24	6.89	7.05	6.26	
Temperature	°C	19.46	4.85	8.9	25.7	21.5	23.62	-	
Turbidity	NTU	91.21	31.23	40.1	140	95.3	117.80	-	
				SW03 (SW3-03 AND SW3-04)					
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	45.53	41.96	7.4	130	42	67.80	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.02	0.06	-	
Total Nitrogen as N	mg/l	0.69	0.32	0.1	1.4	0.7	0.92	-	
Dissolved Oxygen	mg/l	6.05	2.06	2.36	9.4	6.66	7.79	3.82	
Conductivity	µs/cm	792.30	526.45	204.4	1766	735	1286.00	278.00	
pH		7.03	0.43	5.84	7.57	7.01	7.36	6.80	
Temperature	°C	19.53	4.44	12.3	24.9	20.6	23.54	-	
Turbidity	NTU	69.54	53.43	4.8	145	74.8	123.20	-	
				SW04 (SW3-05 and SW3-06)					
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	14.10	11.99	2.5	50	10	16.80	-	
Total Phosphorus as P	mg/l	0.06	0.07	0.02	0.25	0.03	0.05	-	
Total Nitrogen as N	mg/l	1.13	0.61	0.3	2.5	0.82	1.52	-	

	Units	SECTION 3							
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.20	2.45	2.17	11.99	6.44	7.27	3.92	
Conductivity	µs/cm	736.49	564.46	7.82	1812	492.5	1115.60	297.60	
pH		6.15	0.40	5.41	6.78	6.15	6.48	5.83	
Temperature	°C	19.85	4.99	12.8	26	20.4	24.82	-	
Turbidity	NTU	16.73	6.62	7.25	35.1	16.5	19.16	-	
SW05 (SW3-07 and SW3-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	8.27	10.01	2.5	35	2.5	10.80	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.03	0.06	-	
Total Nitrogen as N	mg/l	0.64	0.33	0.24	1.6	0.6	0.74	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.59	1.64	3.15	8.37	7.11	8.15	6.22	
Conductivity	µs/cm	264.02	202.22	115.3	935	188.9	336.00	15.18	
pH		6.48	0.47	5.36	7.27	6.57	6.80	7.26	
Temperature	°C	19.85	4.89	12.9	27	20.3	24.18	-	
Turbidity	NTU	15.03	9.92	5.38	44.1	13	17.80	-	
SW06 (SW3-09 and SW3-10)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	8.23	4.48	2.5	16	7.5	11.60	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.03	0.04	-	
Total Nitrogen as N	mg/l	0.63	0.45	0.015	2.1	0.6	0.72	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.33	1.35	6.01	9.82	8.55	9.66	7.33	
Conductivity	µs/cm	233.88	112.09	120.4	522	182.6	257.40	172.78	
pH		6.18	0.95	3.11	7.09	6.4	6.76	5.93	
Temperature	°C	21.07	4.91	14.7	29.5	22.2	25.76	-	
Turbidity	NTU	16.34	5.79	7.46	28.2	16.3	19.82	-	
SW07 (SW3-11 and SW3-12)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	16.29	17.20	2.1	56	8.75	29.80	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.03	0.04	-	
Total Nitrogen as N	mg/l	0.27	0.11	0.05	0.4	0.3	0.35	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.92	0.92	7.74	10.15	8.585	9.98	8.14	
Conductivity	µs/cm	173.44	64.90	113.2	381	160.55	183.26	134.28	
pH		6.30	0.77	4.56	7.47	6.505	6.81	5.79	
Temperature	°C	20.51	4.28	14.5	27	21.4	24.40	-	
Turbidity	NTU	23.80	20.62	6.37	84.1	14.85	33.92	-	
SW22 (SW3-13 and SW3-14)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	

	Units	SECTION 3							
Laboratory data									
Oil and Grease	mg/l	2.78	1.04	2.5	6.4	2.5	2.50	-	
Suspended Solids	mg/l	11.96	10.27	2.5	40	9.75	16.80	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.025	0.05	-	
Total Nitrogen as N	mg/l	0.64	0.26	0.3	1.1	0.555	0.94	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.06	2.42	1.89	9.7	6.46	7.90	3.74	
Conductivity	µs/cm	176.71	51.55	105.9	296	173.65	203.52	134.16	
pH		5.94	0.86	3.54	6.79	6.315	6.51	5.41	
Temperature	°C	19.74	4.64	12.5	25.5	20.4	24.10	-	
Turbidity	NTU	12.14	7.93	7.2	36.1	9.185	13.44	-	

SW08 (SW3-15 and SW3-16)

Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.67	0.65	2.5	5	2.5	2.50	-	
Suspended Solids	mg/l	6.62	2.97	2.5	13	6	7.90	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.03	0.06	-	
Total Nitrogen as N	mg/l	0.68	0.28	0.3	1.5	0.62	0.81	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.21	1.54	3.04	7.94	6.43	7.76	5.25	
Conductivity	µs/cm	203.01	60.63	104.4	336	190.3	244.60	160.80	
pH		6.19	0.49	5.32	6.82	6.31	6.72	5.73	
Temperature	°C	21.77	5.61	14.8	30.3	23.2	26.26	-	
Turbidity	NTU	14.75	7.71	4.08	32.8	14.1	19.72	-	

SW09 (SW3-17 and SW3-18)

Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	11.80	11.54	2.5	33	6.5	25.00	-	
Total Phosphorus as P	mg/l	0.03	0.06	0.005	0.25	0.02	0.02	-	
Total Nitrogen as N	mg/l	0.56	0.27	0.3	1.3	0.51	0.72	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.10	1.91	1.92	8.77	6.53	7.81	4.71	
Conductivity	µs/cm	216.01	90.73	110.2	430	204.6	286.00	143.86	
pH		5.65	0.79	3.48	6.85	5.65	6.17	5.30	
Temperature	°C	19.36	4.13	12.9	24.9	20.5	22.92	-	
Turbidity	NTU	14.33	9.95	4.33	39	13.2	17.90	-	

SW10 (SW3-19 and SW3-20)

Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	16.54	7.98	2.5	29	17	23.60	-	
Total Phosphorus as P	mg/l	0.05	0.06	0.005	0.25	0.035	0.05	-	
Total Nitrogen as N	mg/l	0.90	0.18	0.61	1.3	0.91	1.00	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.91	1.41	2.46	6.74	5.035	6.16	3.30	
Conductivity	µs/cm	232.77	116.47	79.4	500	206.2	314.20	142.36	

	Units	SECTION 3							
pH		5.15	0.97	2.99	6.1	5.46	5.84	4.58	
Temperature	°C	19.26	4.84	11.4	25.2	21.5	23.16	-	
Turbidity	NTU	19.53	10.27	3.08	41.2	20.15	26.10	-	

SW11 (SW3-21 and SW3-22)

Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	4.79	4.25	2.5	16	2.5	8.26	-	
Total Phosphorus as P	mg/l	0.03	0.06	0.005	0.25	0.02	0.02	-	
Total Nitrogen as N	mg/l	0.38	0.13	0.15	0.6	0.4	0.50	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.74	1.60	2.34	7.95	6.05	7.26	4.19	
Conductivity	µs/cm	188.82	45.99	119.3	290	188.2	212.20	158.00	
pH		5.98	0.42	5.17	6.46	6.05	6.31	5.66	
Temperature	°C	18.40	4.09	11	22.3	20.8	21.84	-	
Turbidity	NTU	9.43	5.48	4.04	25.3	7.05	11.26	-	

SW12 (SW3-23)

Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	13.40	9.30	2.5	32	10	19.60	-	
Total Phosphorus as P	mg/l	0.07	0.06	0.005	0.25	0.06	0.09	-	
Total Nitrogen as N	mg/l	0.63	0.24	0.31	1.1	0.6	0.80	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.67	2.68	0.49	10.64	8.43	9.43	5.83	
Conductivity	µs/cm	366.75	315.33	132.5	1232	257	396.40	172.00	
pH		6.50	1.14	2.7	7.42	6.76	7.14	6.37	
Temperature	°C	22.12	4.50	16.2	27.4	23.1	26.36	-	
Turbidity	**NTU**	**15.29**	**11.72**	**3.95**	**48.1**	**11.5**	**21.82**	**-**	

Section 3: Groundwater Monitoring – Water Quality Overview

Of the 51 bores monitored, two bores, PZ06 and PZ07, remained dry throughout the monitoring program with no data collected.

Electrical Conductivity

Values are indicative of freshwater to brackish/ saline groundwater conditions with an average salinity ranging between 91 µS/cm (PZ21) to 9,108 µS/cm (PZ09). Generally well locations with shallower water levels (<5.0m below ground level) showed larger standard deviations than wells with standing water levels at greater depths.

pH

pH of groundwater in Section 3 show average values ranging from 3.8 to 7.69. A total of 28 locations had an average pH < 6.0 which suggests that acidic to slightly acidic groundwater is present in about half of the monitoring well locations in Section 3. Little variation occurs in pH with 10 of the 50 wells reporting a standard deviation value > 1 pH unit.

Temperature

The average temperature values for the monitoring locations in Section 3 ranged between 20.03°C to 23°C. The variation in water average temperature values throughout Section 3 likely to be attributable to seasonal temperature changes and the variable depth of groundwater from the ground surface.

Summary Statistics for Groundwater Physico-Chemical Monitoring

Cut/Fill Number	Borehole Identifier	Electrical Conductivity (µS/cm)				pH				Temp. (°C)
		Med.*	SD**	P80	P20	Med.*	SD**	P80	P20	Med.*
Cut 3-5	PZ05	8175	657	8684	8046	6.86	0.16	6.98	6.78	20.05
	PZ06	Dry								
Cut 3-6	PZ07	Dry								
	PZ08	6490	335	6660	6320	7.02	0.14	7.10	6.95	22.60
Cut 3-7	PZ09	9175	408	9326	8916	6.86	0.19	7.02	6.78	21.95
	PZ10	8695	849	9270	7968	6.78	0.15	6.88	6.72	22.15
Fill F3-10B	PZ13	947	587	1325	412	6.63	0.30	6.87	6.44	20.90
	PZ14	1821	1858	3410	235	6.39	0.53	6.80	6.01	21.75
Fill F3-10C	PZ15	3580	2255	5140	1953	6.32	2.40	8.29	5.51	20.80
	PZ16	1624	1571	2932	240	6.24	0.76	6.95	5.78	20.70
Fill F3-11A	PZ17	424	114	528	375	5.40	0.31	5.61	5.22	20.80
	PZ18	1313	231	1475	1141	5.88	0.51	6.33	5.45	22.05
Fill F3-11B	PZ19	437	196	514	265	6.65	0.31	6.80	6.39	21.30
	PZ20	831	384	1123	488	6.56	2.59	8.67	6.20	21.60
Fill F3-11C	PZ21	81	29	106	72	5.48	0.75	5.89	4.94	22.15
	PZ22	219	94	294	193	6.22	1.45	7.38	5.56	21.85
Fill F3-11D	PZ23	184	25	193	167	6.47	1.40	7.44	5.81	23.00
	PZ24	516	92	598	493	5.52	0.60	5.86	5.18	22.15
Fill F3-11E	PZ25	217	55	262	190	5.64	0.50	5.79	5.30	20.00
	PZ26	272	36	300	253	5.59	0.79	6.14	5.08	20.20
Cut C3-11	PZ27	143	29	156	117	5.13	0.72	5.47	4.53	20.60
	PZ28	172	11	179	165	4.38	0.41	179.22	165.98	21.15
Cut C3-15	PZ29	325	24	341	302	5.18	0.64	5.38	4.60	20.45
	PZ30	2855	592	3216	2350	5.59	0.34	5.88	5.46	21.35
Fill F3-16A	PZ31	116	32	131	88	5.59	0.89	6.17	4.96	20.80
	PZ32	2205	869	2970	1949	4.72	1.02	5.46	4.26	21.80
Fill F3-16B	PZ34	1137	541	1367	727	6.05	0.36	6.18	5.77	21.40
Cut C3-16	PZ35	177	15	190	169	5.05	0.57	5.17	4.59	21.40
	PZ36	1061	319	1281	940	5.22	0.53	5.62	4.89	21.40
Cut C3-17	PZ37	1103	179	1161	987	6.25	0.33	6.31	5.98	21.50
	PZ38	2172	480	2330	1795	6.75	0.18	6.85	6.60	21.80
Cut C3-18	PZ39	275	141	290	160	3.96	0.46	4.07	3.60	20.40
	PZ40	663	481	837	488	5.23	3.03	5.37	5.08	20.90
Fill F3-19C	PZ41	409	104	413	324	6.38	0.49	6.66	6.01	20.85
Cut C3-19	PZ43	592	39	622	559	4.66	0.39	4.74	4.32	21.25
	PZ44	132	26	150	108	4.98	0.65	5.29	4.43	21.55
Cut C3-21	BH1139	231	6	234	226	4.94	0.40	5.08	4.64	20.70
	PZ45	249	32	258	220	5.01	0.45	5.35	4.80	20.60
Cut C3-26	PZ46	408	109	499	368	5.97	0.75	6.17	5.33	20.30

Cut/Fill Number	Borehole Identifier	Electrical Conductivity (µS/cm)				pH				Temp. (°C)
		Med.*	SD**	P80	P20	Med.*	SD**	P80	P20	Med.*
	PZ47	861	167	967	767	6.53	0.40	6.64	6.17	20.65
Cut C3-28	PZ48	762	201	823	592	6.54	0.45	6.75	6.16	20.30
	PZ49	187	4	190	184	4.06	0.49	4.30	3.73	20.00
Cut C3-30	BH1159	1472	175	1611	1434	3.95	0.35	4.24	3.67	23.10
	BH1170	261	37	292	249	7.62	1.14	8.32	7.03	22.75
	PZ50	830	104	858	750	6.84	0.24	6.93	6.68	22.10
Cut C3-31	PZ51	963	512	1086	744	5.66	2.87	5.79	5.65	21.50
	BH1187	438	126	539	421	5.00	0.56	5.22	4.64	21.50
Cut C3-32	BH1197	387	83	457	363	6.40	0.44	6.49	6.06	20.95
	PZ52	478	90	544	407	6.44	0.56	6.51	5.98	21.00
Cut C3-33	BH1200	592	234	180	146	5.73	2.81	5.68	5.56	20.75
	PZ53	172	85	807	456	5.52	2.78	6.09	5.66	20.40

Note: * Med. = Median
** DS = Standard Deviation

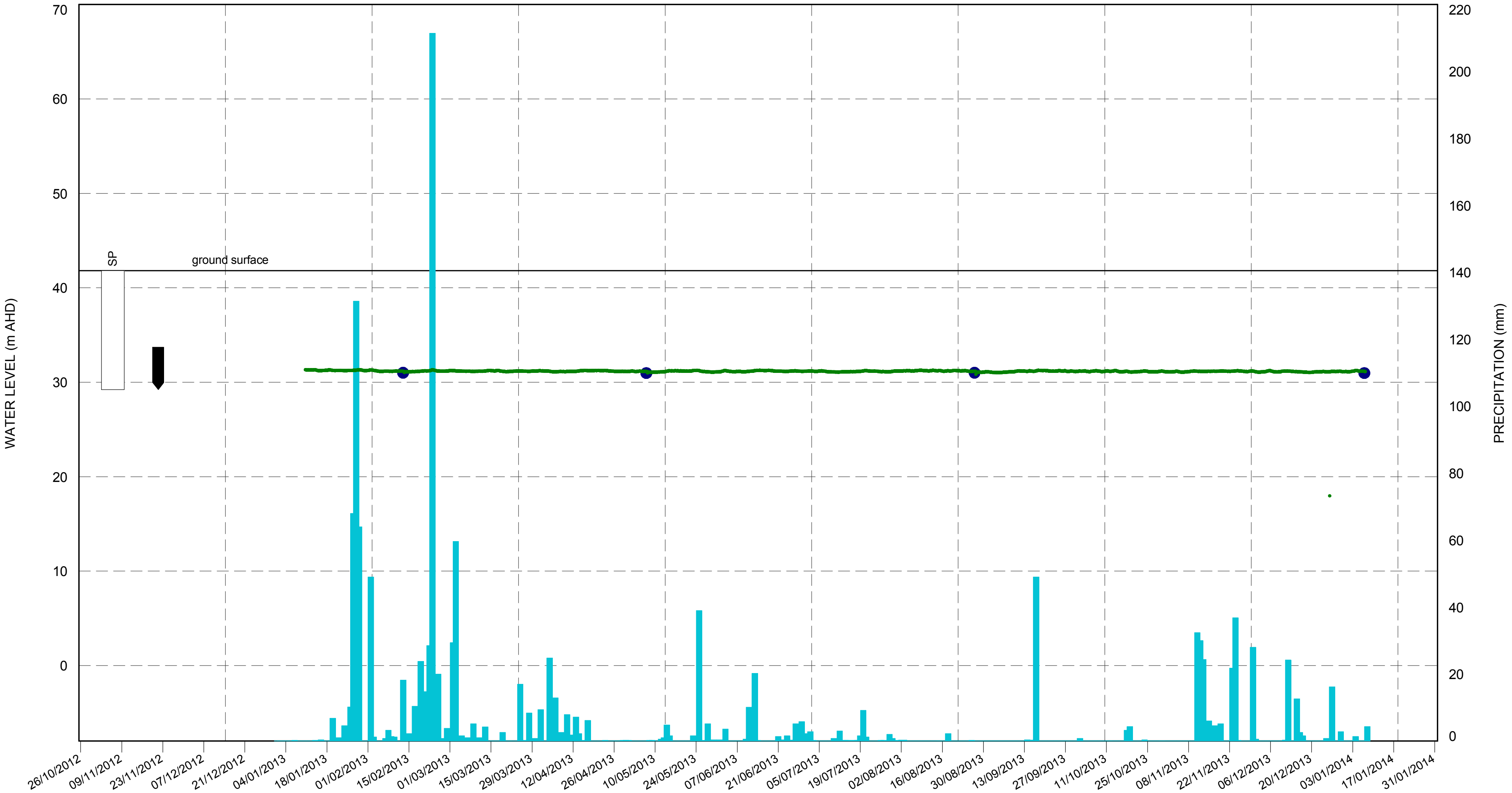
Section 3: Groundwater Monitoring – Levels

The standing water level (SWL) values averaged between 0.04m above the ground surface (PZ26) and 27.21m below ground surface (PZ51). In general, the SWLs observed within the planned fill areas monitored within Section 3 were noted to be close to the ground surface indicating shallow groundwater (<5m bgs – below ground surface) while the SWLs observed within the planned cut areas were noted at >5m bgs depth. The long-term monitoring data indicates that the groundwater levels throughout much of Section 3 are influenced by large rainfall events (e.g. over 100mm rainfall event in January 2013). It should be noted the SWLs are relative to the topography of the monitoring location.

Summary of Groundwater Level Monitoring – Section 3 G2DP Upgrade

Cut/Fill Number	Monitoring Location	Borehole Depth	Typical SWL (m below ground level)		
			AVG	MED	SD
Cut 3-5	PZ05	12.6	10.84	10.84	0.02
	PZ06	16		Dry	
Cut 3-6	PZ07	8		Dry	
	PZ08	12	11.40	11.40	0.04
Cut 3-7	PZ09	13.95	11.62	11.63	0.05
	PZ10	13.83	11.84	11.81	0.20
Fill F3-10B	PZ13	6	1.07	1.06	0.46
	PZ14	6	0.75	0.66	0.28
Fill F3-10C	PZ15	6.16	1.54	1.39	0.40
	PZ16	6.1	1.74	1.62	0.37
Fill F3-11A	PZ17	6.11	2.92	2.80	0.28
	PZ18	6	0.24	0.27	0.29
Fill F3-11B	PZ19	6.14	1.06	1.12	0.47
	PZ20	6.06	1.48	1.58	0.57
Fill F3-11C	PZ21	6.09	1.34	1.52	0.57
	PZ22	6	0.50	0.55	0.20

Cut/Fill Number	*Monitoring Location*	*Borehole Depth*	*Typical SWL (m below ground level)*		
			AVG	MED	SD
Fill F3-11D	PZ23	6.07	0.69	0.69	0.27
	PZ24	6.04	0.47	0.57	0.29
Fill F3-11E	PZ25	6	1.08	1.11	0.27
	PZ26	5.9	-0.04 (SWL above ground level)	-0.08 (SWL above ground level)	0.26
Cut C3-11	PZ27	19	8.69	8.61	0.55
	PZ28	15.27	8.80	8.85	0.39
Cut C3-15	PZ29	16.1	3.62	3.66	0.62
	PZ30	12.18	6.72	6.62	0.26
Fill F3-16A	PZ31	6	0.69	0.71	0.18
	PZ32	6.05	4.03	4.10	0.14
Fill F3-16B	PZ34	6	1.35	1.74	1.16
Cut C3-16	PZ35	17	8.93	8.94	0.25
	PZ36	15.92	11.81	11.77	0.36
Cut C3-17	PZ37	20	16.90	16.96	0.28
	PZ38	18.1	14.63	14.65	0.13
Cut C3-18	PZ39	13.05	7.26	7.21	0.65
	PZ40	11	9.89	9.89	0.74
Fill F3-19C	PZ41	6	0.48	0.47	0.26
Cut C3-19	PZ43	15.15	11.91	11.89	0.31
	PZ44	9	4.02	3.90	1.13
Cut C3-21	BH1139	22	7.62	7.87	1.61
	PZ45				
Cut C3-26	PZ46	17.05	9.17	12.20	6.15
	PZ47	15.3	10.39	10.38	0.07
Cut C3-28	PZ48	14	11.34	11.27	0.27
	PZ49	15	11.27	11.32	0.36
Cut C3-30	BH1159	15.1	9.03	8.98	0.68
	BH1170	24.25	8.88	8.88	0.24
	PZ50	25	13.68	13.55	0.49
Cut C3-31	PZ51	28	27.21	26.99	0.53
	BH1187	25	17.37	17.42	0.22
Cut C3-32	BH1197	26.5	6.70	7.06	1.16
	PZ52	12	9.23	9.12	0.39
Cut C3-33	BH1200	37	26.37	26.73	0.99
	PZ53	6	4.19	4.43	1.69



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

Surface RL: 41.82 m AHD
Borehole Depth: 12.60 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.60 m bgl
RL of Tip: 29.22 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.60 m bgl
RL of Tip: 29.69 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

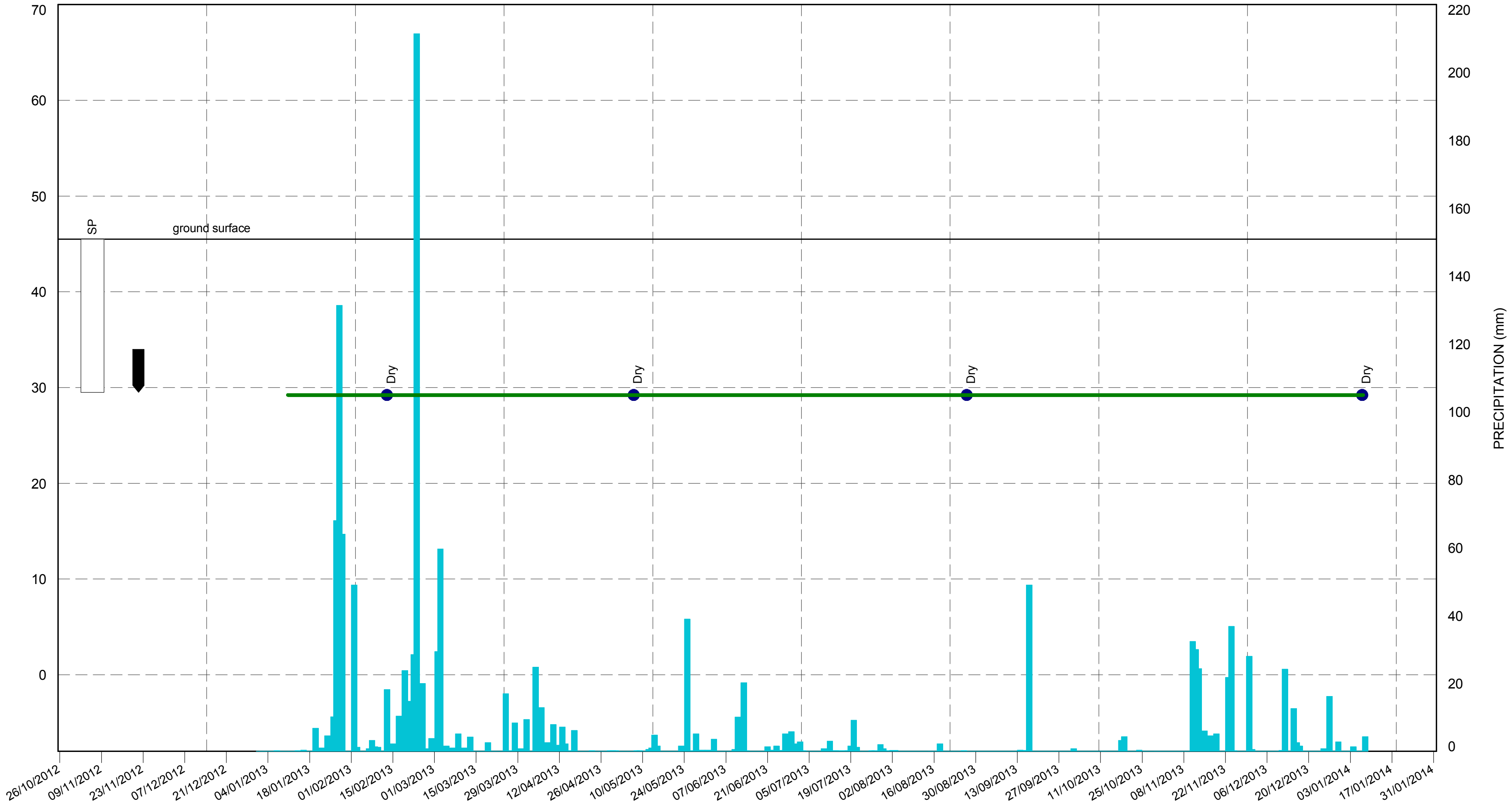
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ5**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H13** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:01



Bentonite Gravel
Concrete Grout
Cuttings Sand

Surface RL: 45.49 m AHD
Borehole Depth: 16.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 16.00 m bgl
RL of Tip: 29.49 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 16.00 m bgl
RL of Tip: 29.22 m AHD

■: Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

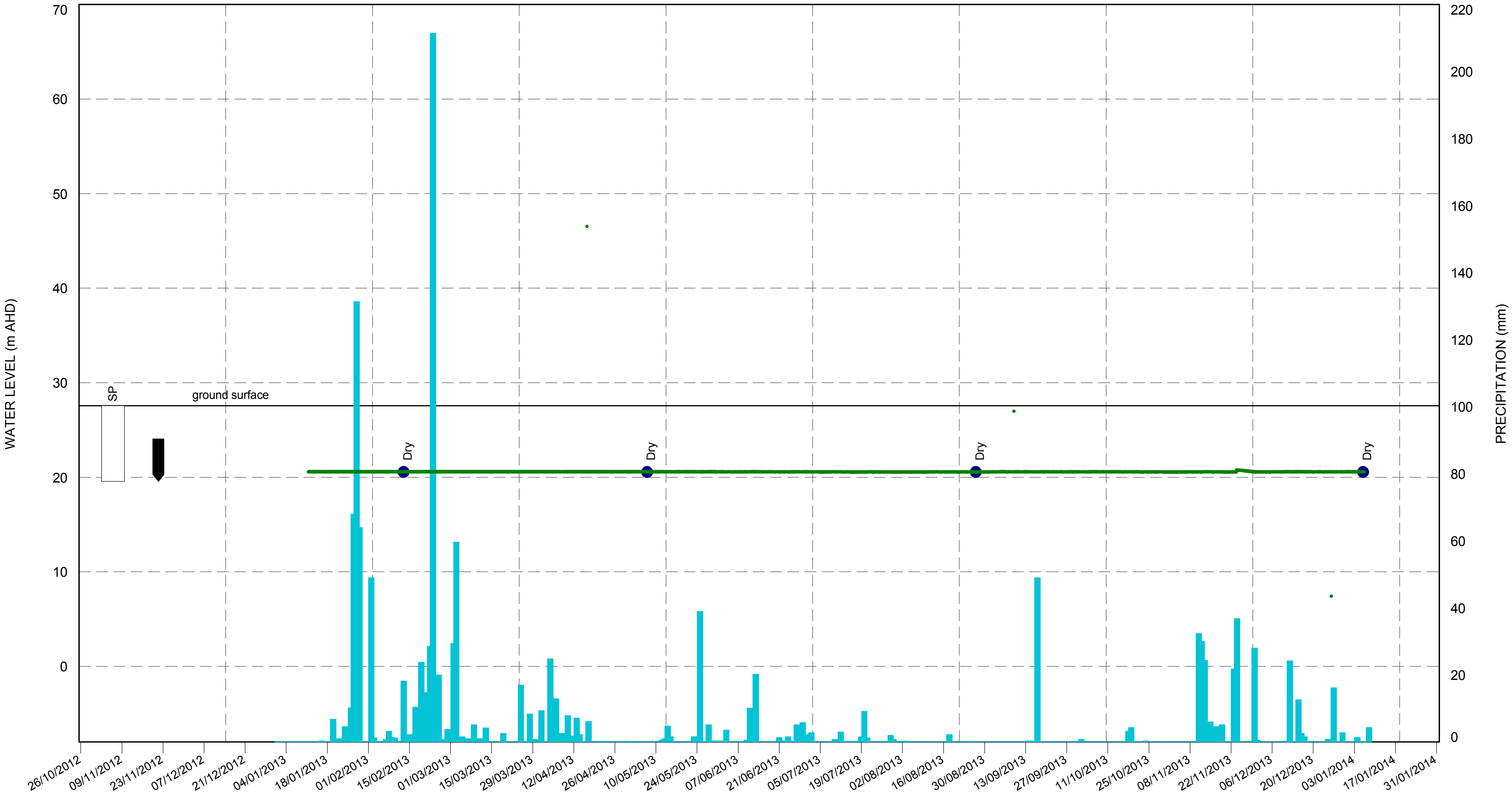
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME**
PZ6

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H14** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 27.56 m AHD
Borehole Depth: 8.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 8.00 m bgl
RL of Tip: 19.56 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 8.00 m bgl
RL of Tip: 20.56 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

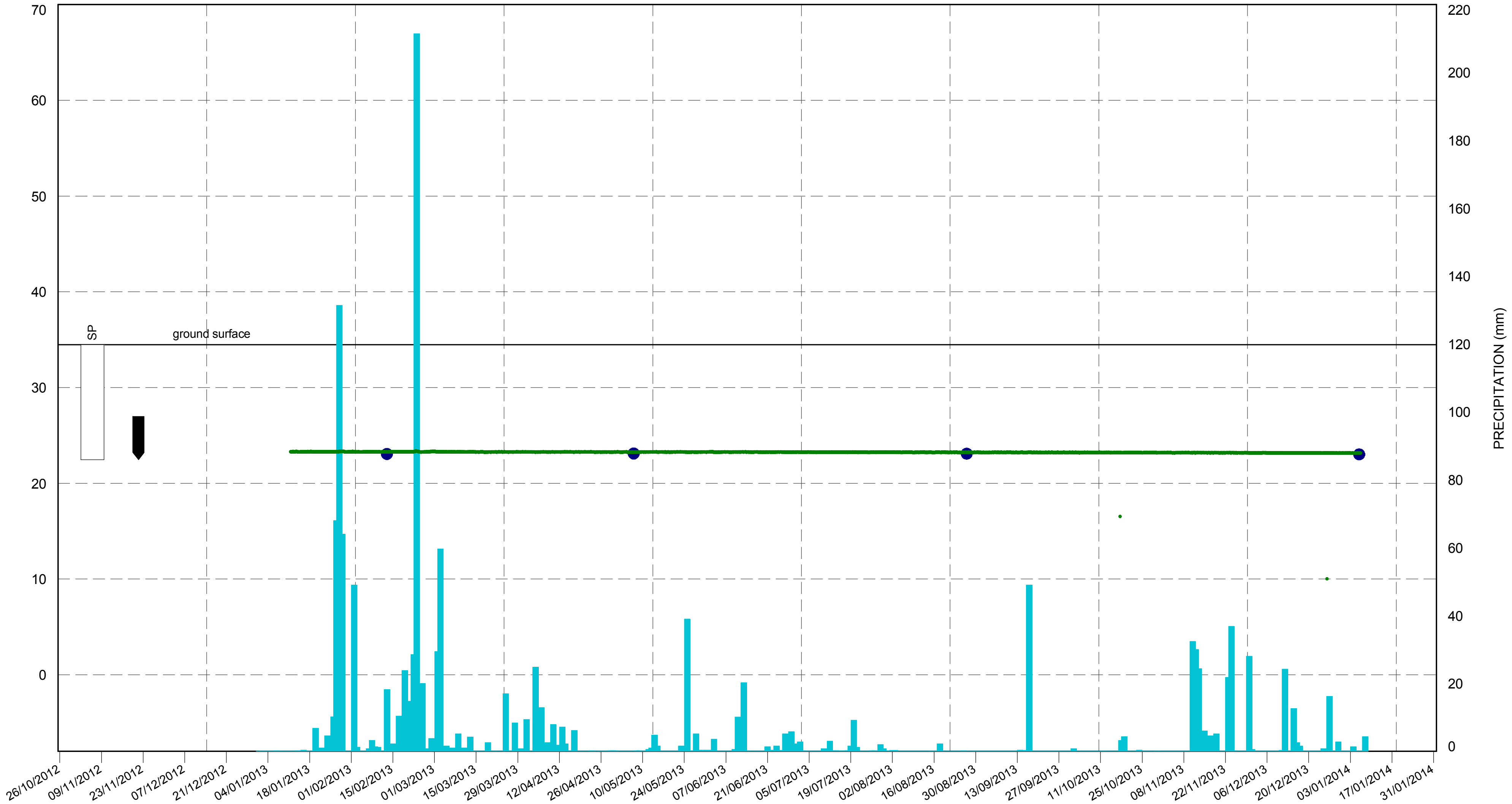
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ7**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H15** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:04



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:05

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 34.47 m AHD
Borehole Depth: 12.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 22.47 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 22.84 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

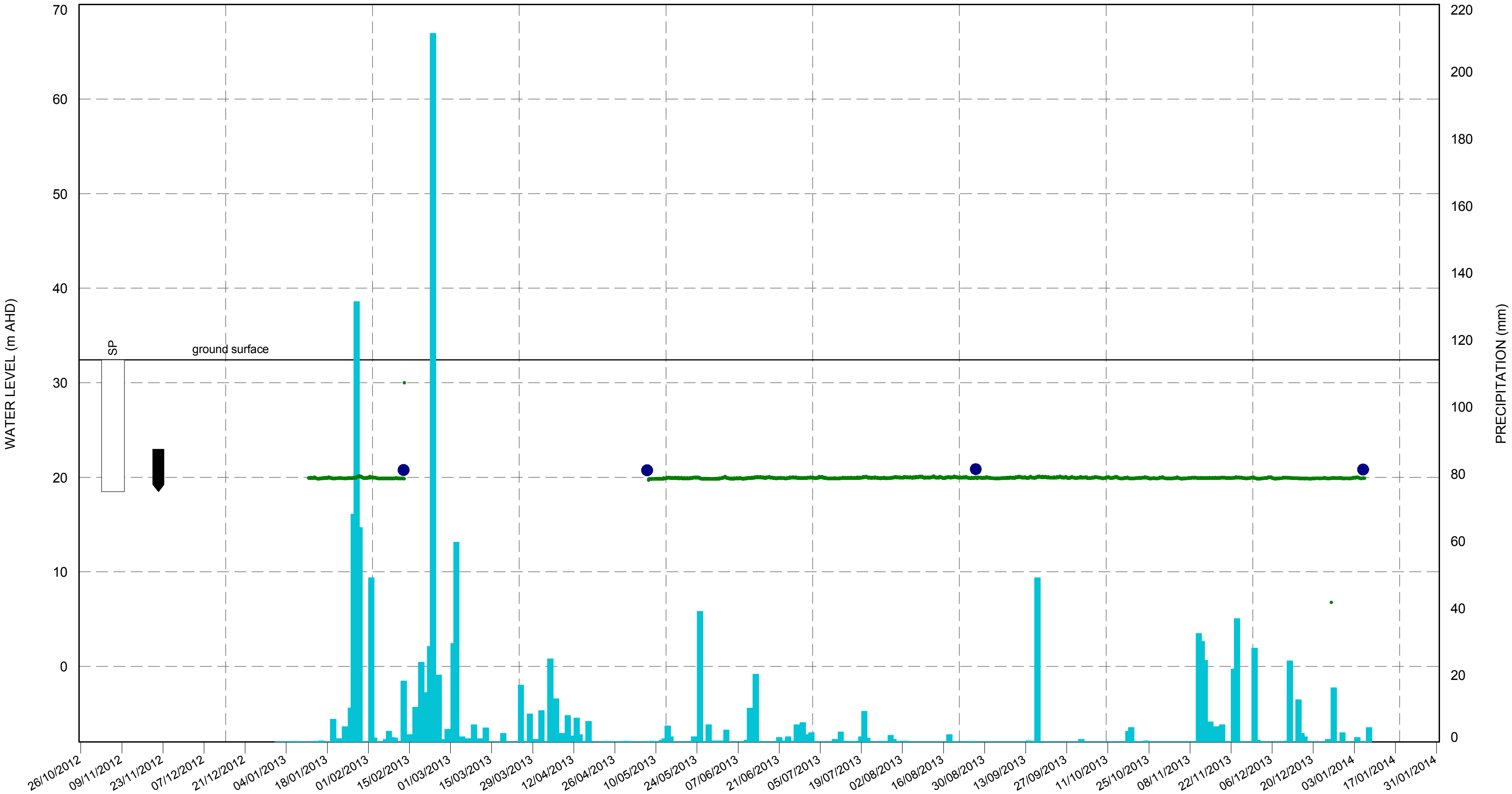
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ8**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H16** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:06



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 32.42 m AHD
Borehole Depth: 13.95 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.95 m bgl
RL of Tip: 18.47 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.95 m bgl
RL of Tip: 17.59 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

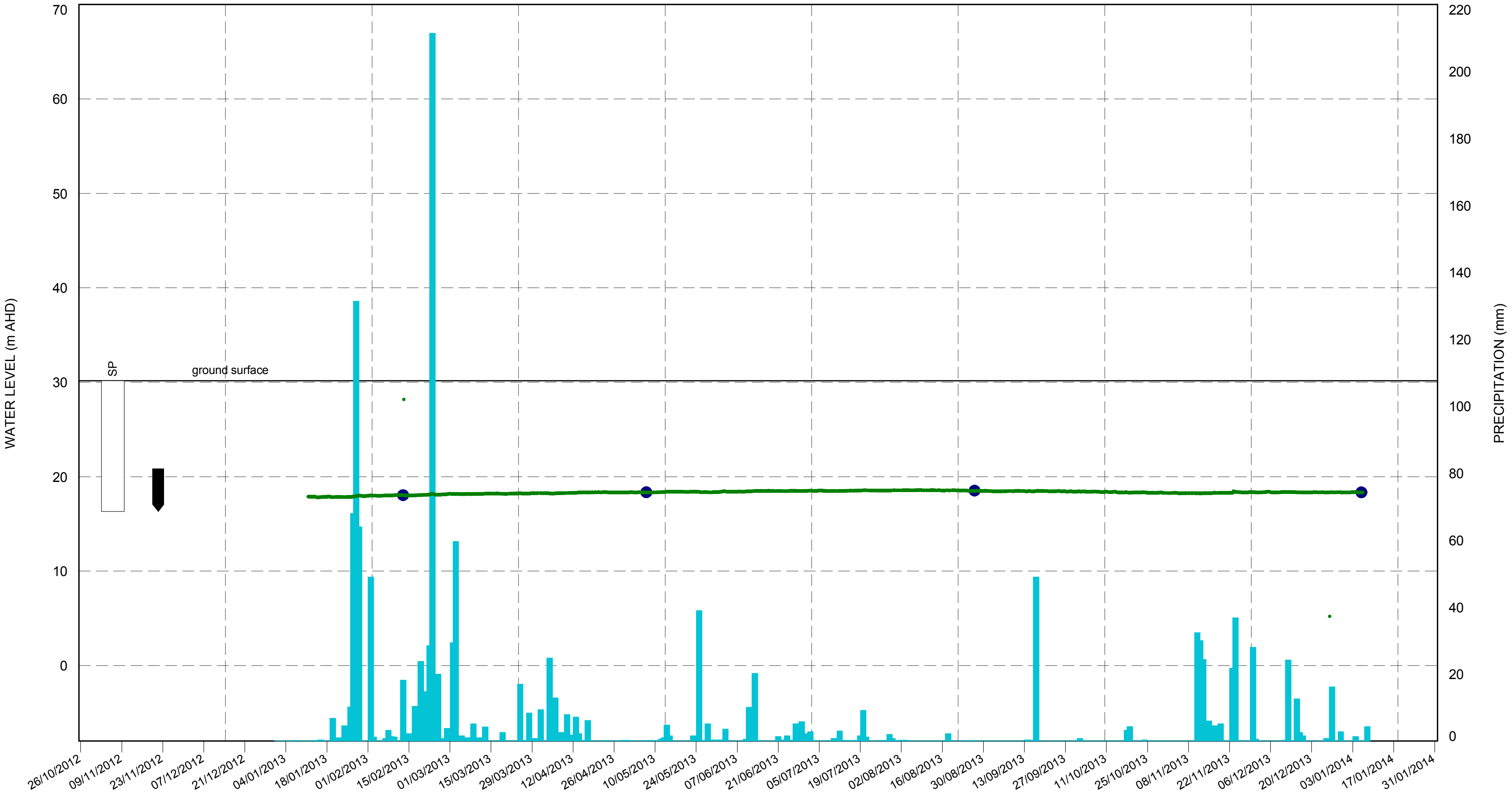
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ9**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H17** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:07

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 30.15 m AHD
Borehole Depth: 13.83 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.83 m bgl
RL of Tip: 16.32 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.83 m bgl
RL of Tip: 16.74 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

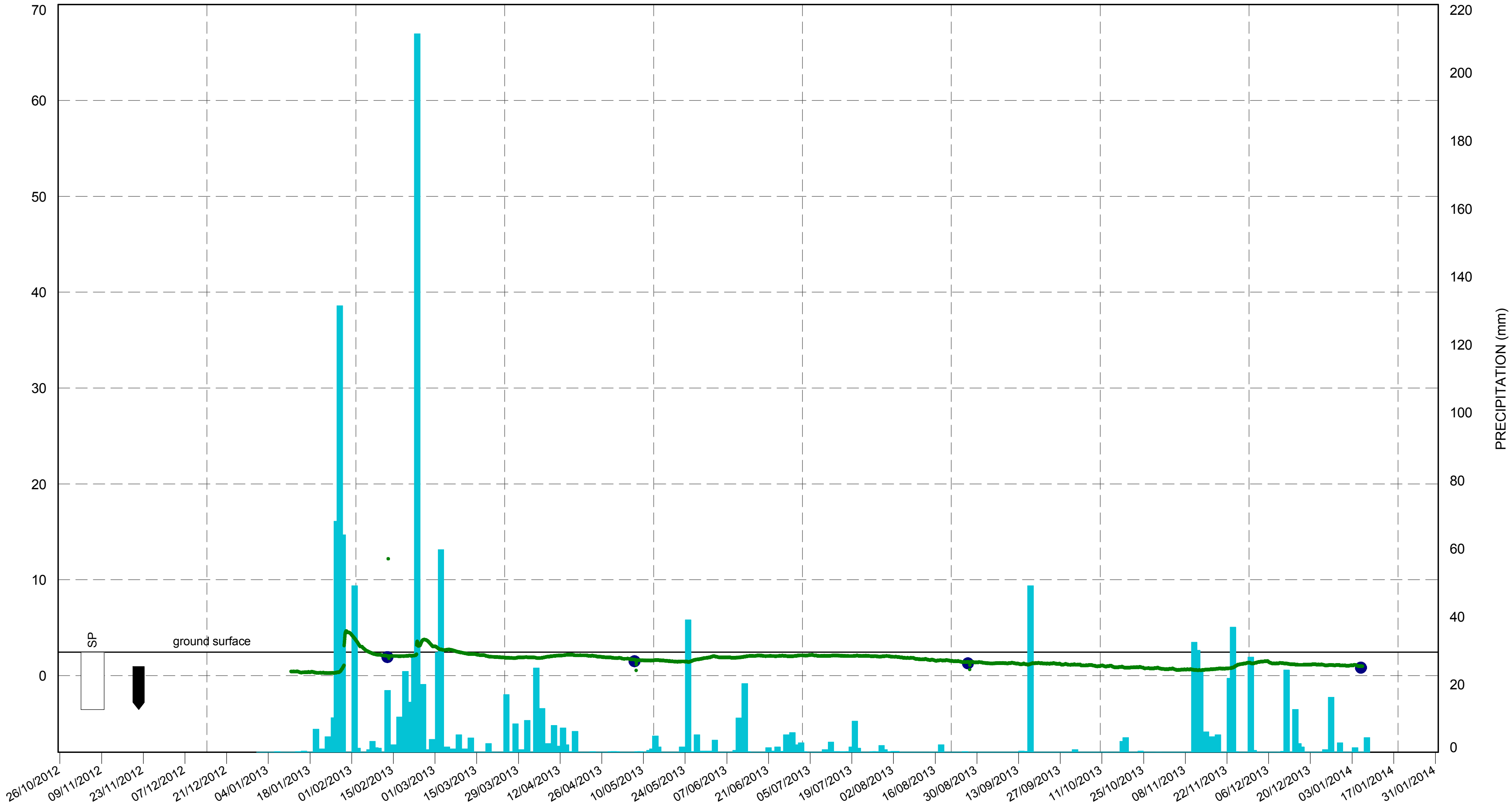
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ10

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H18 | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:09

Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 2.45 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.55 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.94 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

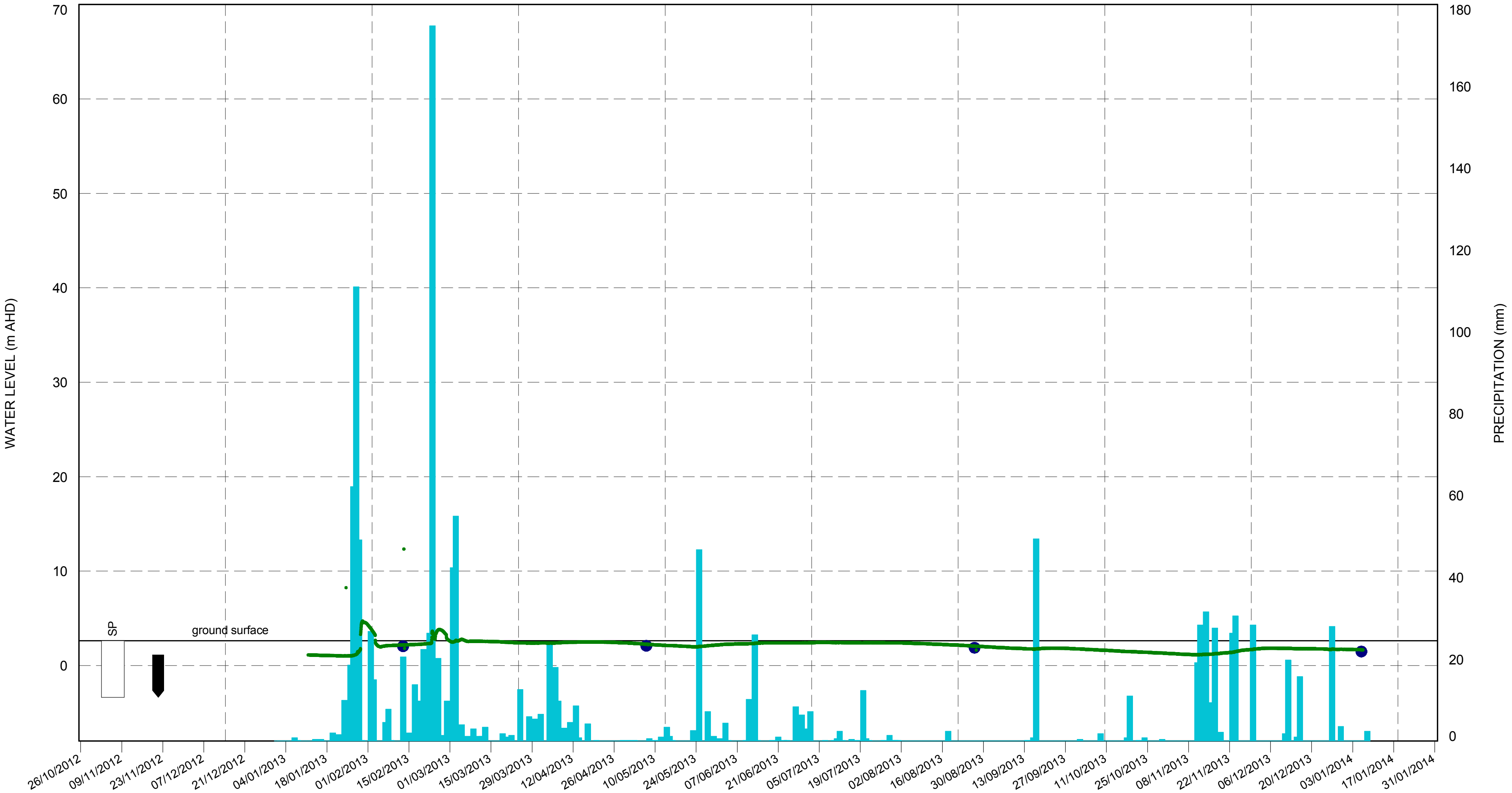
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ13**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H19** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 2.62 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.38 m AHD

━: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.81 m AHD

■: Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

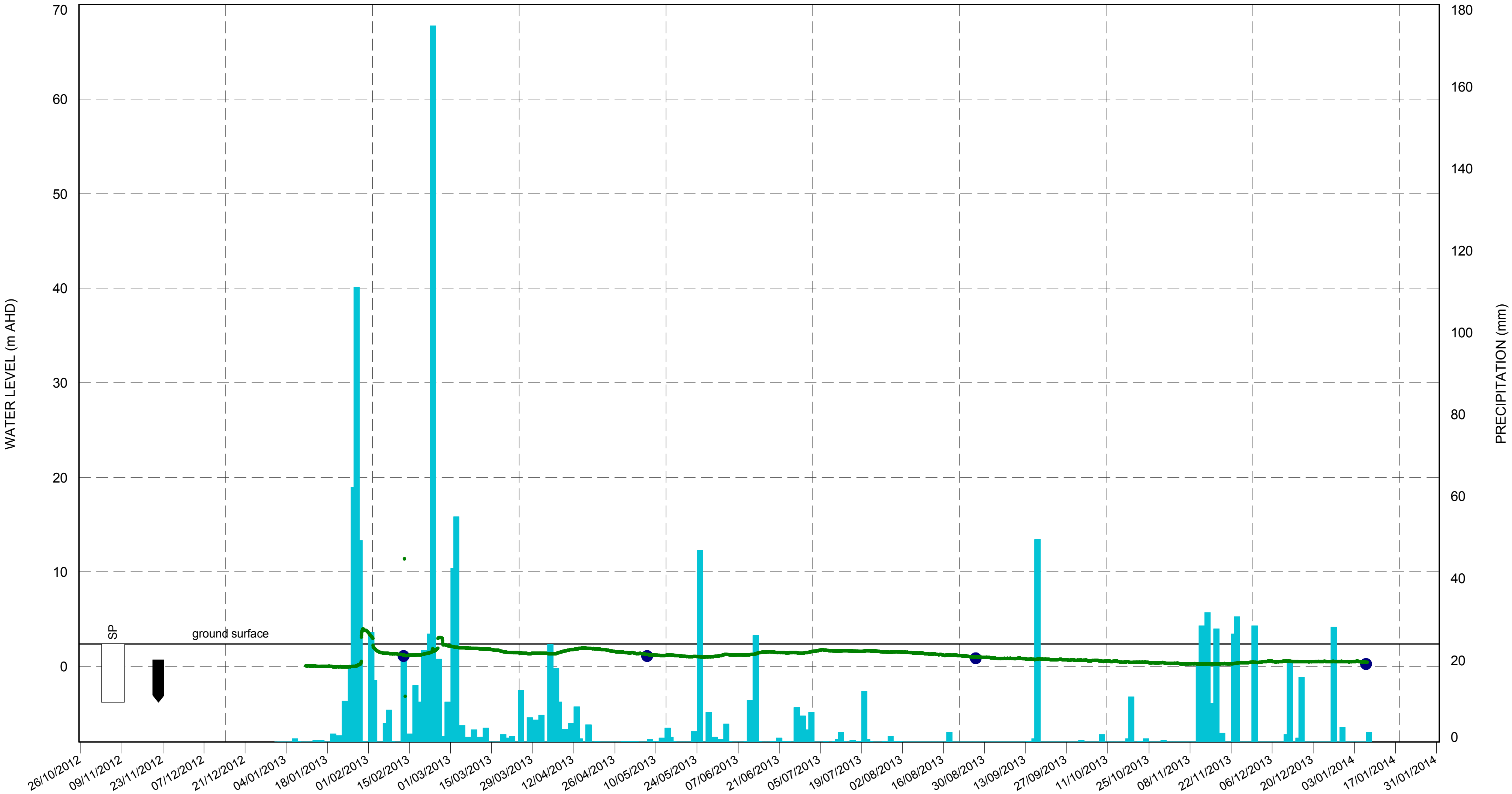
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME
PZ14

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H20 | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:12

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 2.36 m AHD
Borehole Depth: 6.16 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.16 m bgl
RL of Tip: -3.80 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.16 m bgl
RL of Tip: -3.22 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

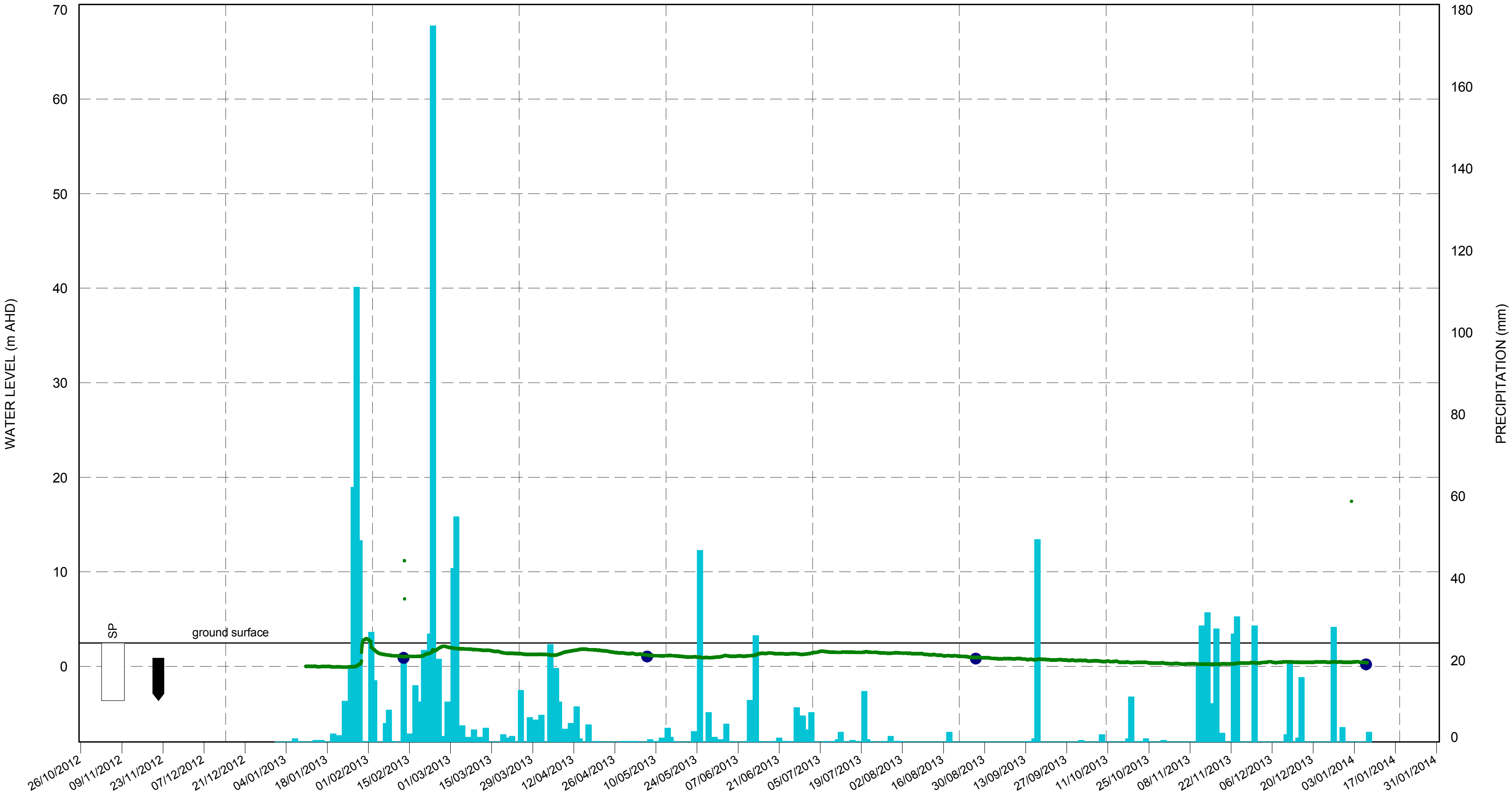
drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ15**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H21** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 2.48 m AHD
Borehole Depth: 6.10 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.10 m bgl
RL of Tip: -3.62 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.10 m bgl
RL of Tip: -3.07 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

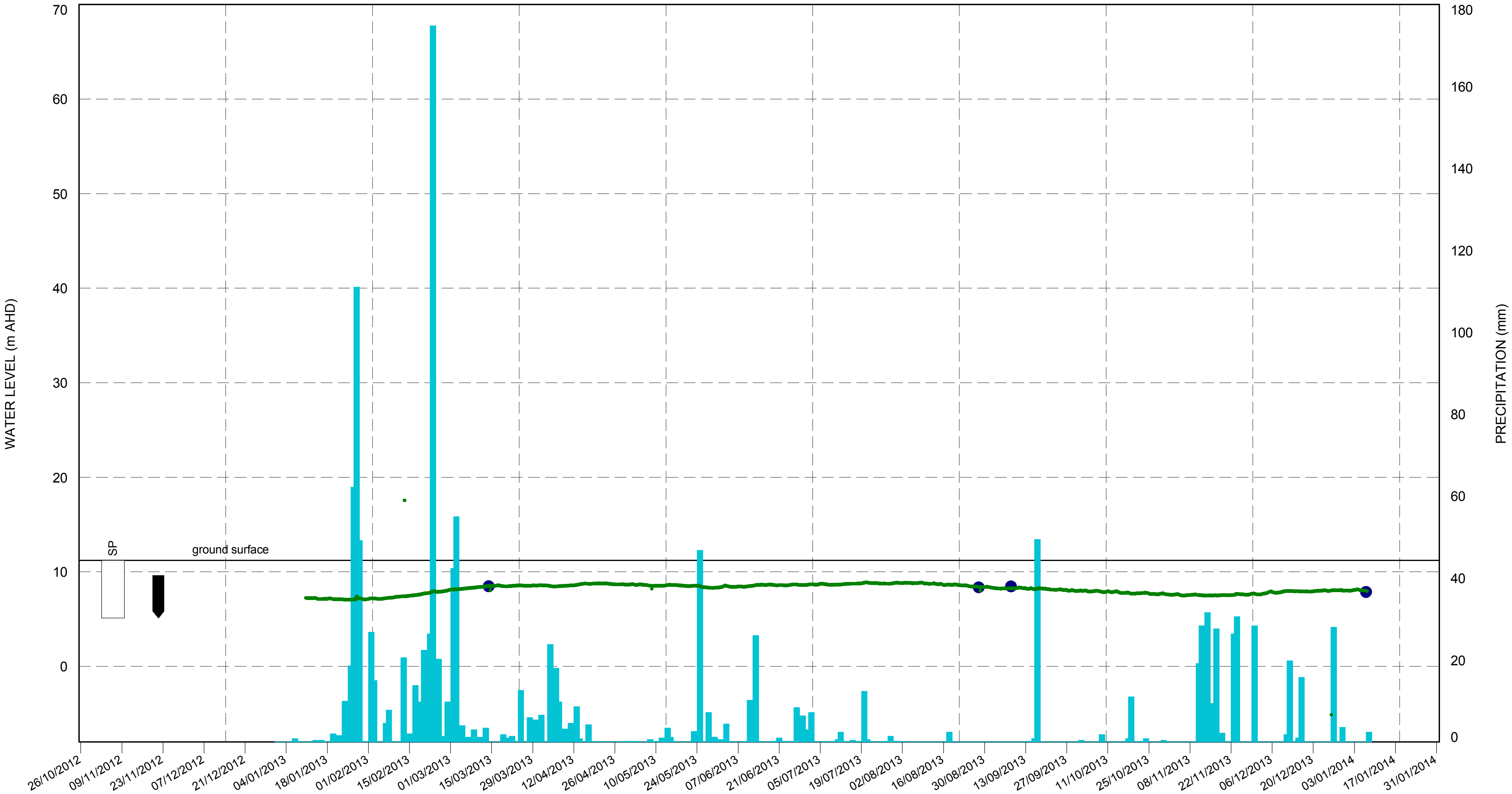
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ16

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H22 | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 11.21 m AHD
Borehole Depth: 6.11 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.11 m bgl
RL of Tip: 5.10 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.11 m bgl
RL of Tip: 5.53 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

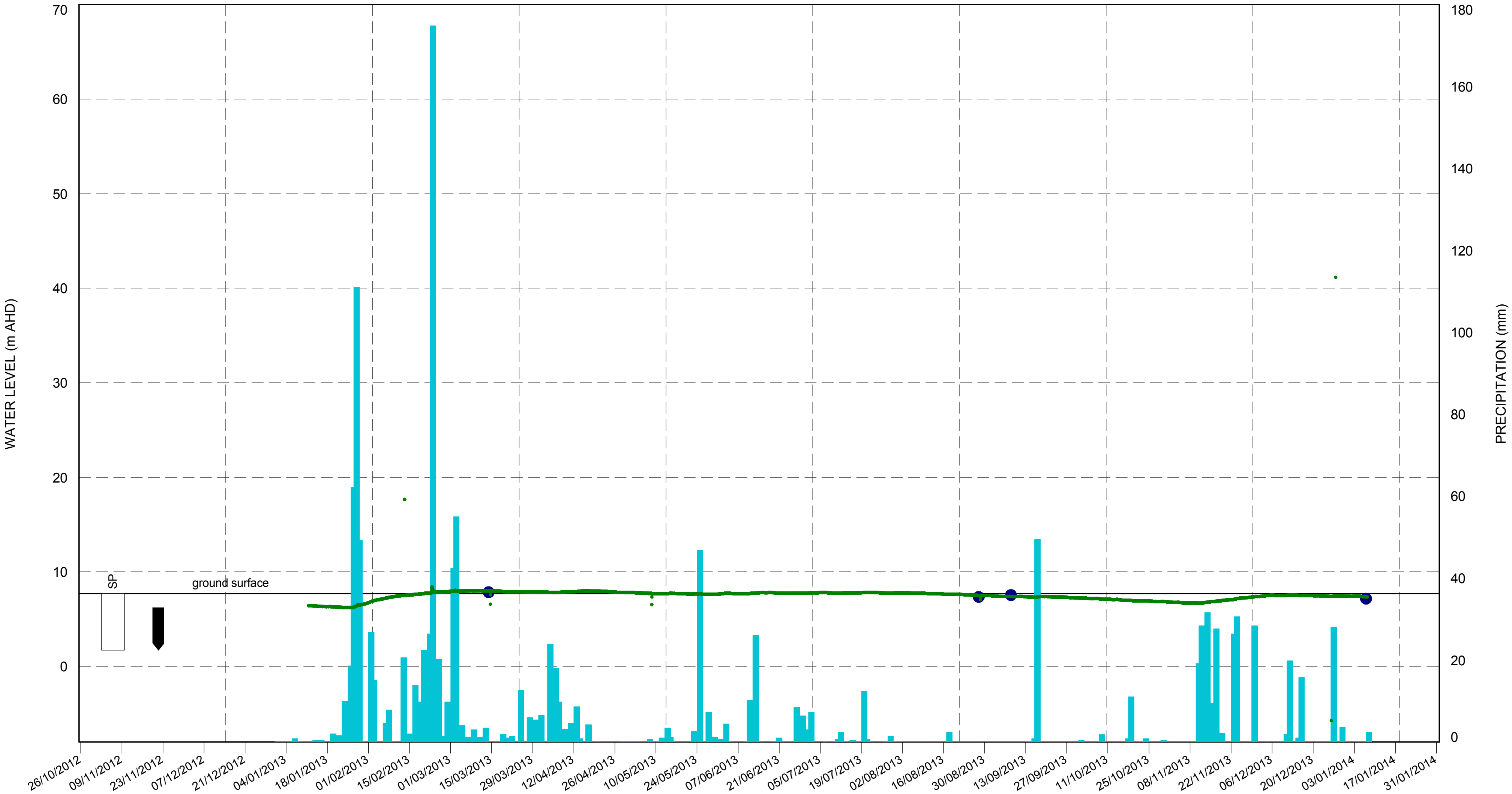
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ17**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H23** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:15

Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 7.71 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.71 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 2.24 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

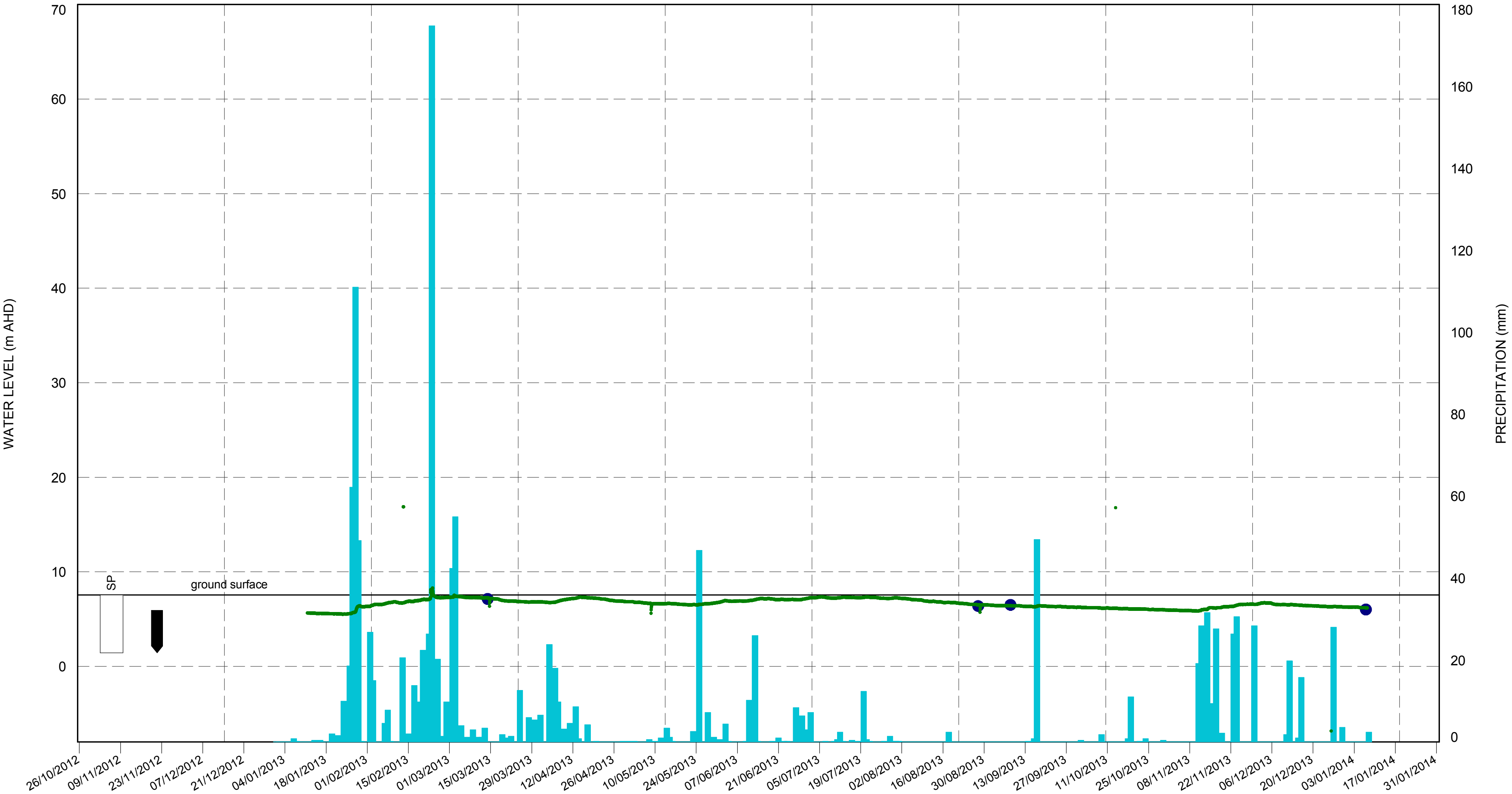
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ18**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H24** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:17

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.56 m AHD
Borehole Depth: 6.14 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.14 m bgl
RL of Tip: 1.42 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.14 m bgl
RL of Tip: 2.04 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

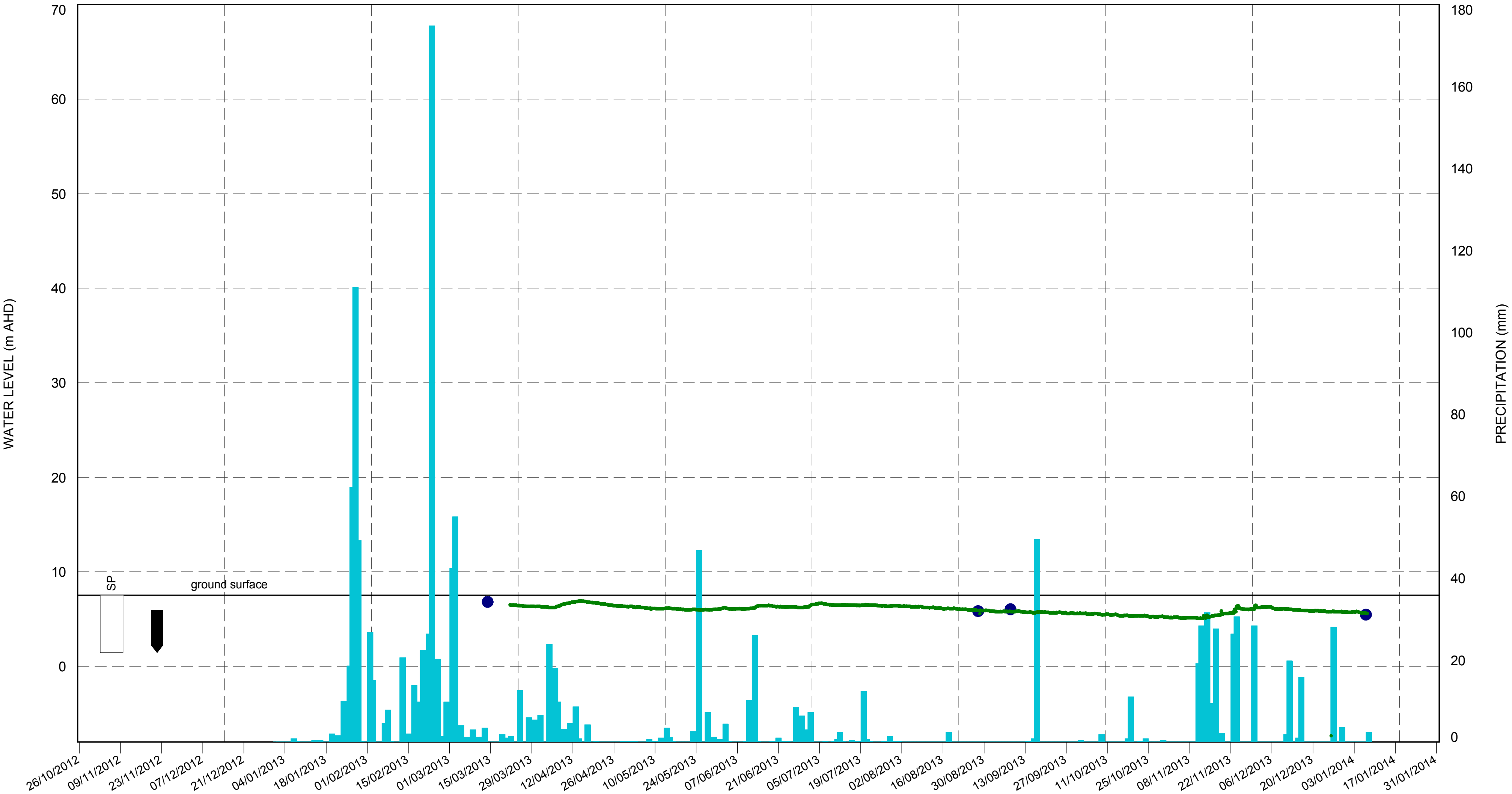
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ19**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H25** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.52 m AHD
Borehole Depth: 6.06 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.06 m bgl
RL of Tip: 1.46 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.06 m bgl
RL of Tip: 1.86 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

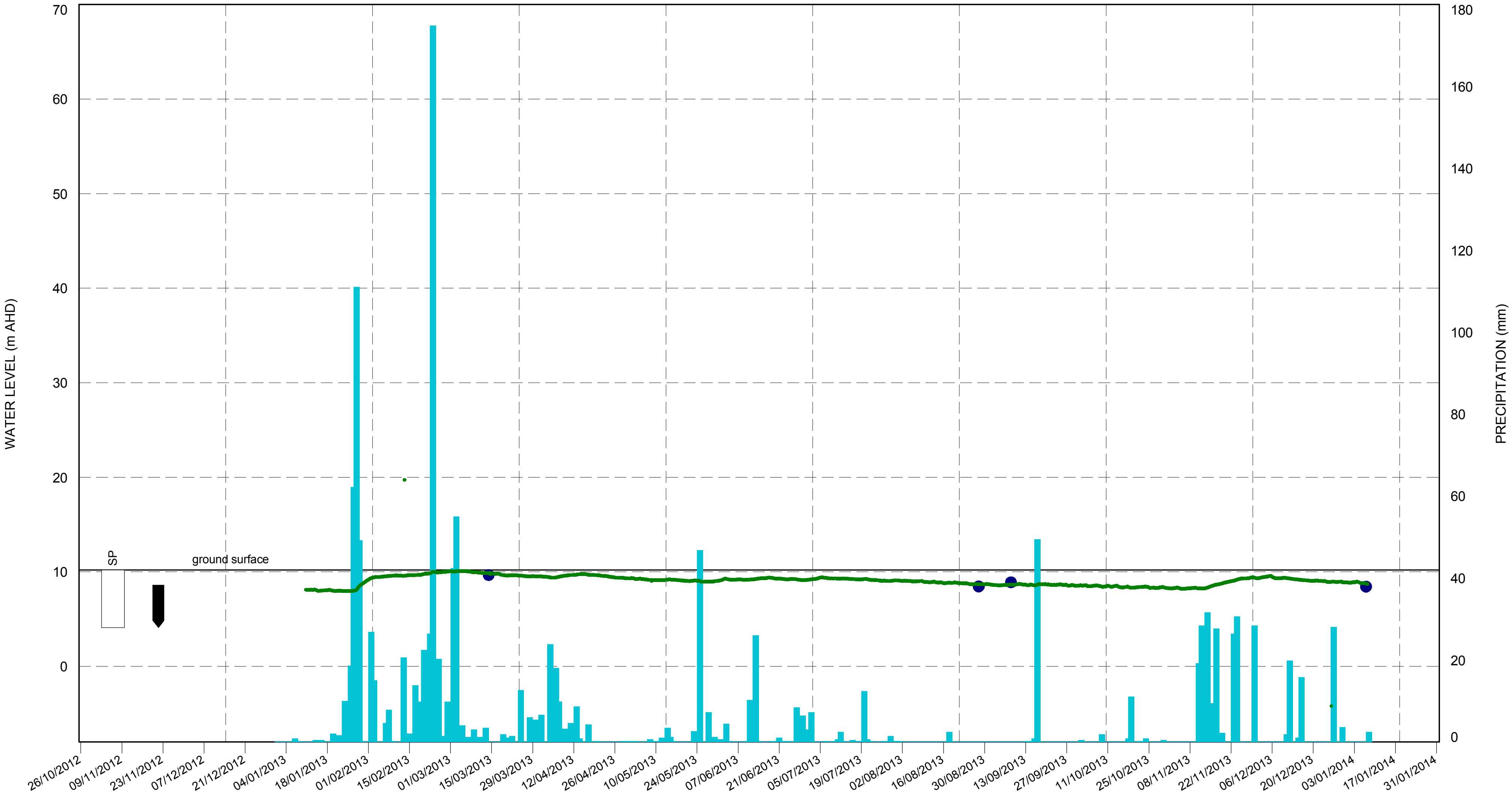
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title:
GROUNDWATER LEVEL AND RAINFALL VERSUS TIME
PZ20

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H26** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:18



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:19

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 10.19 m AHD
Borehole Depth: 6.09 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.09 m bgl
RL of Tip: 4.10 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.09 m bgl
RL of Tip: 4.40 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

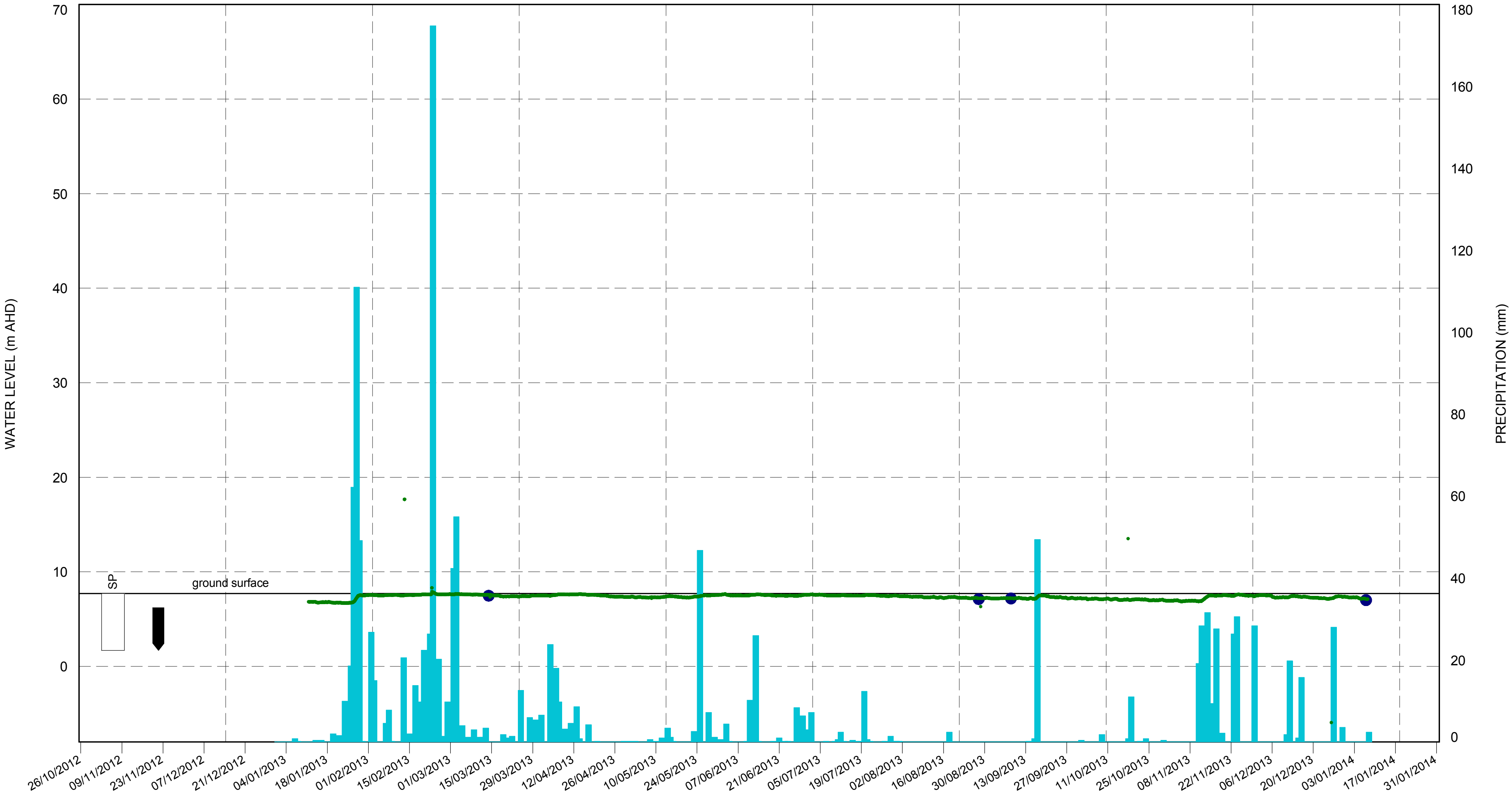
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ21**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H27** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

■ : Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Yamba Pilot Station

Surface RL: 7.69 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.69 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 2.02 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

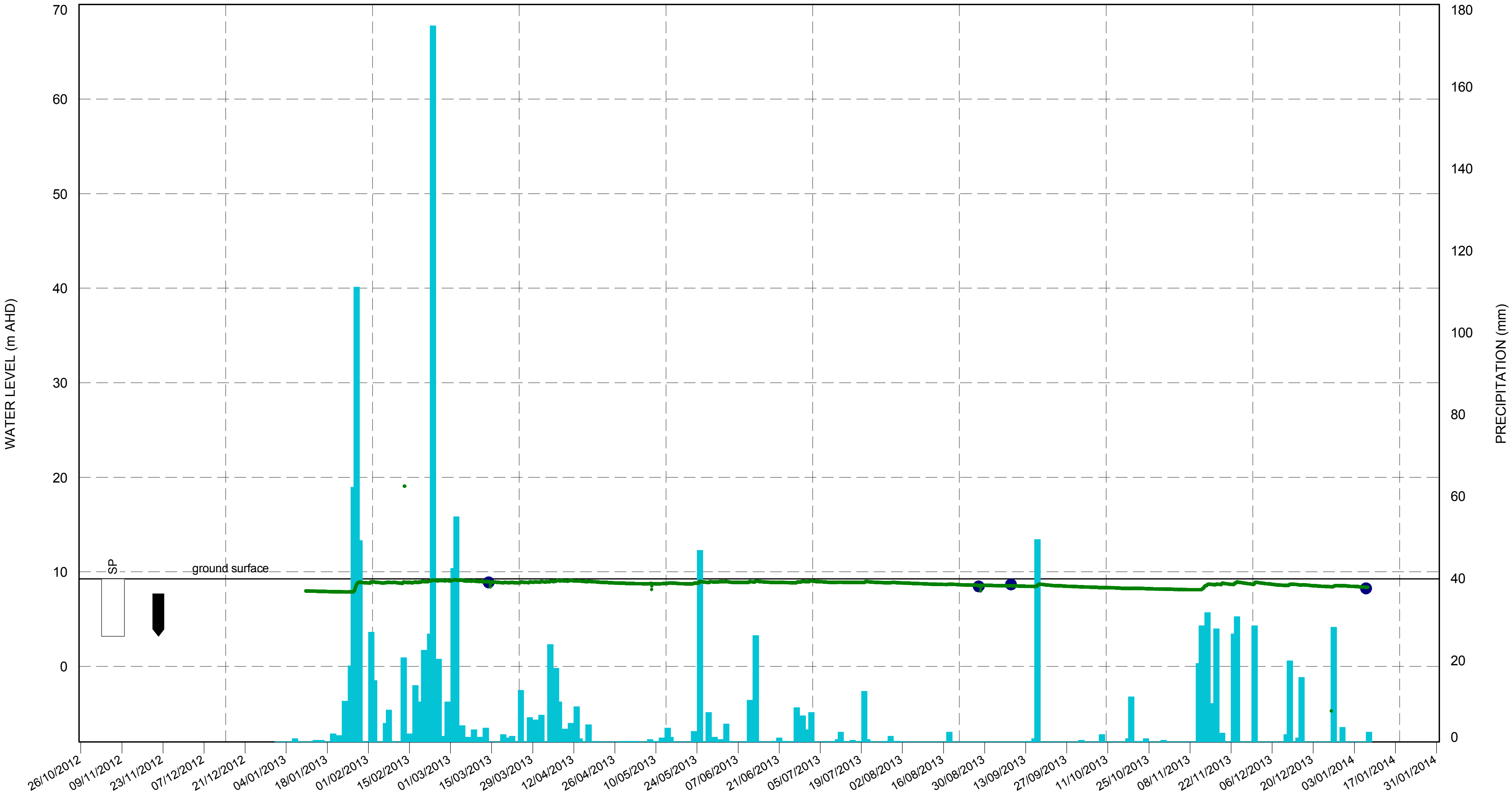
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ22**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H28** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:20



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:21

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 9.25 m AHD
Borehole Depth: 6.07 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.07 m bgl
RL of Tip: 3.18 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.07 m bgl
RL of Tip: 3.54 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

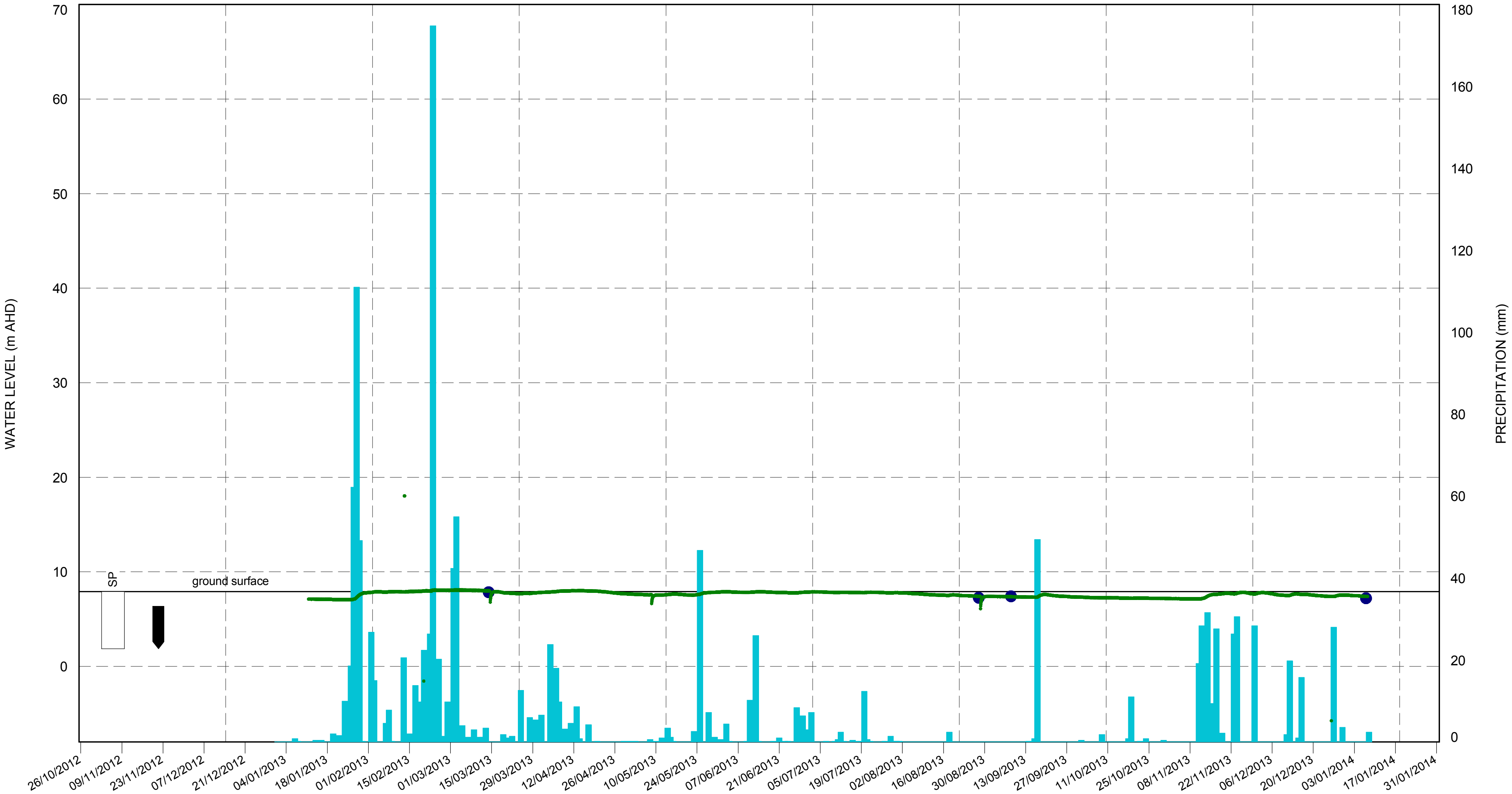
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ23**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H29** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 7.90 m AHD
Borehole Depth: 6.04 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.04 m bgl
RL of Tip: 1.86 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.04 m bgl
RL of Tip: 2.63 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

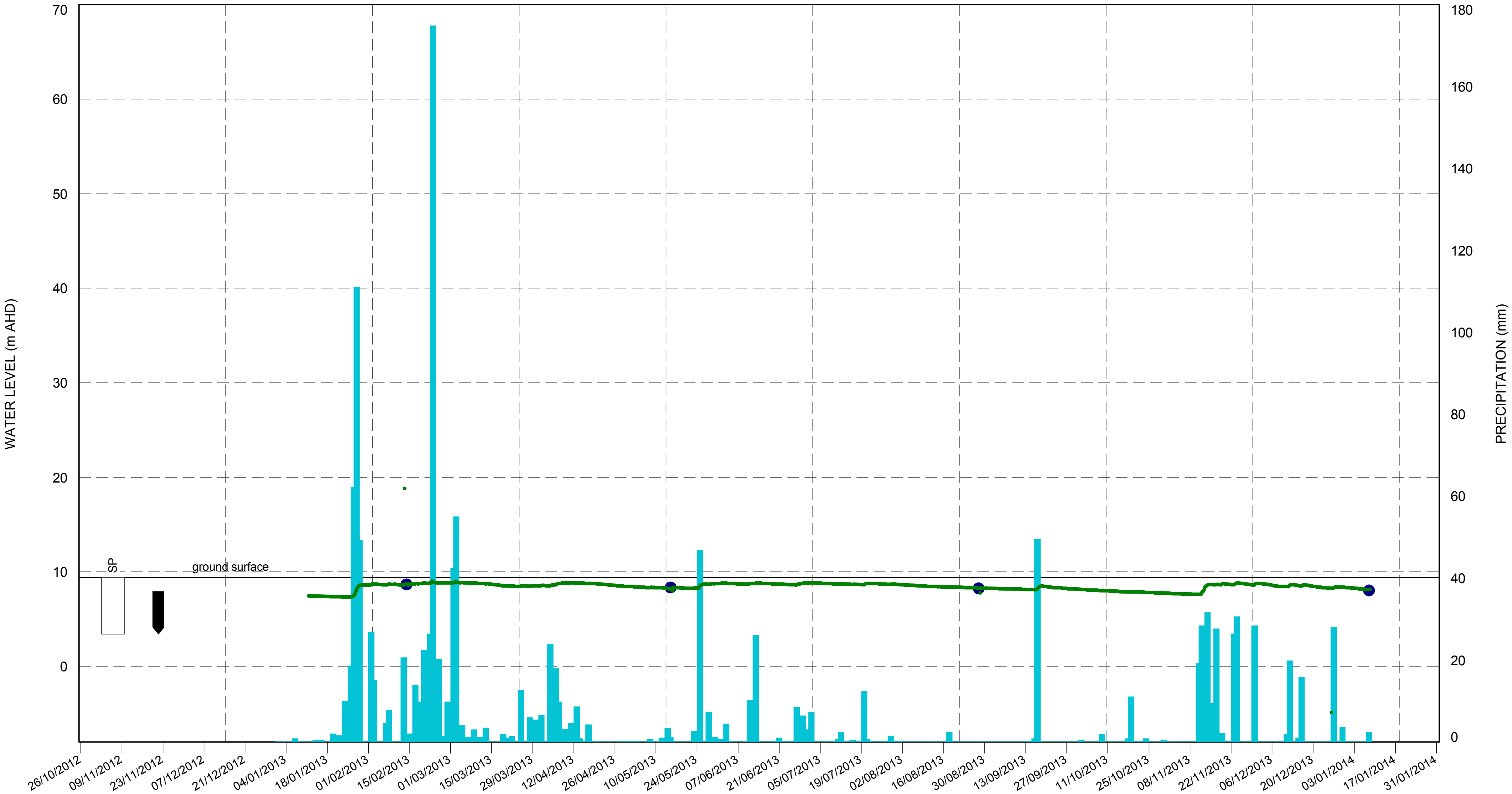
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ24**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H30** | rev:



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 9.40 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 3.40 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 3.74 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

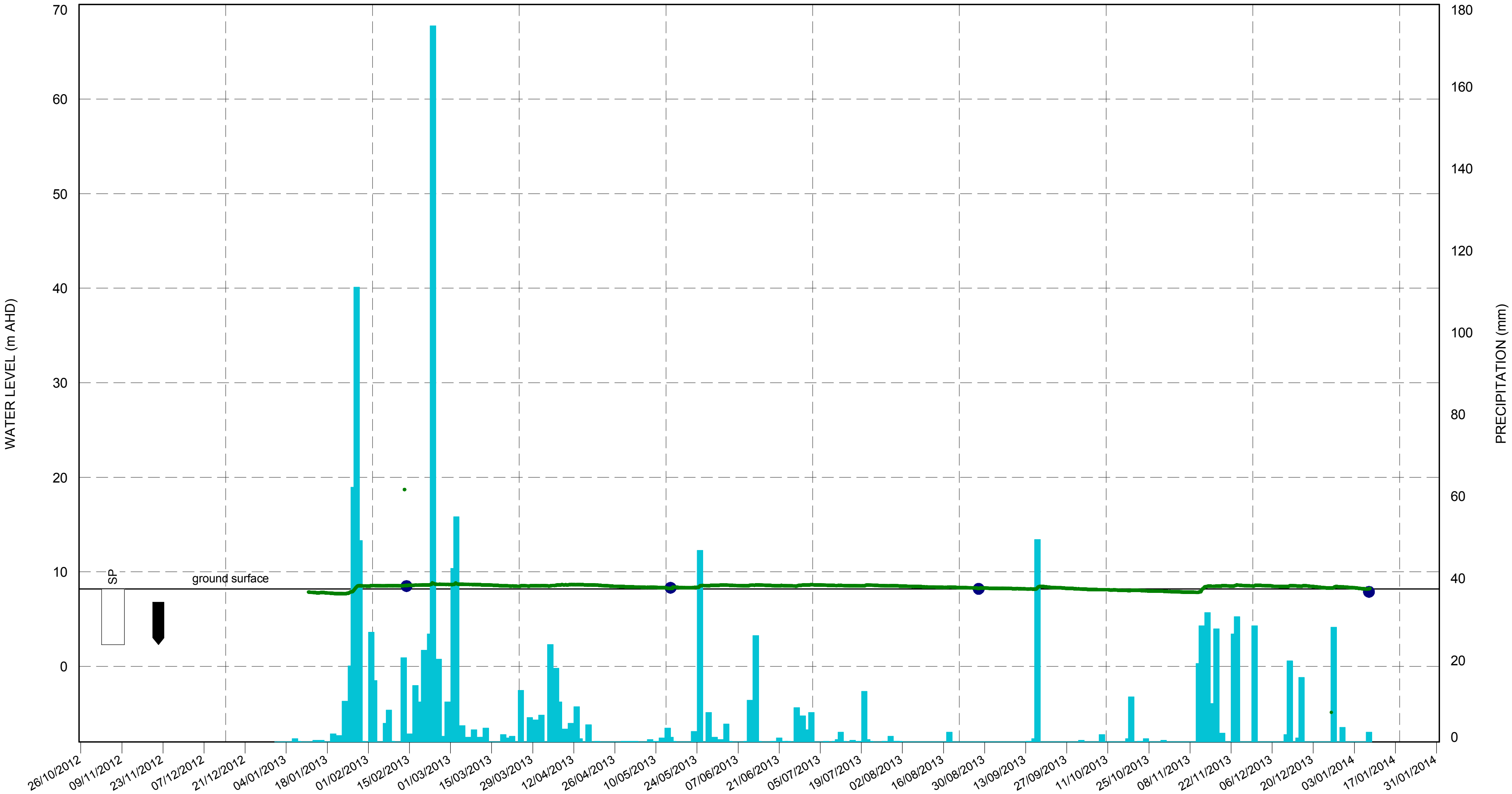
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ25**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H31** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:25

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 8.18 m AHD
Borehole Depth: 5.90 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 5.90 m bgl
RL of Tip: 2.28 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 5.90 m bgl
RL of Tip: 2.60 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

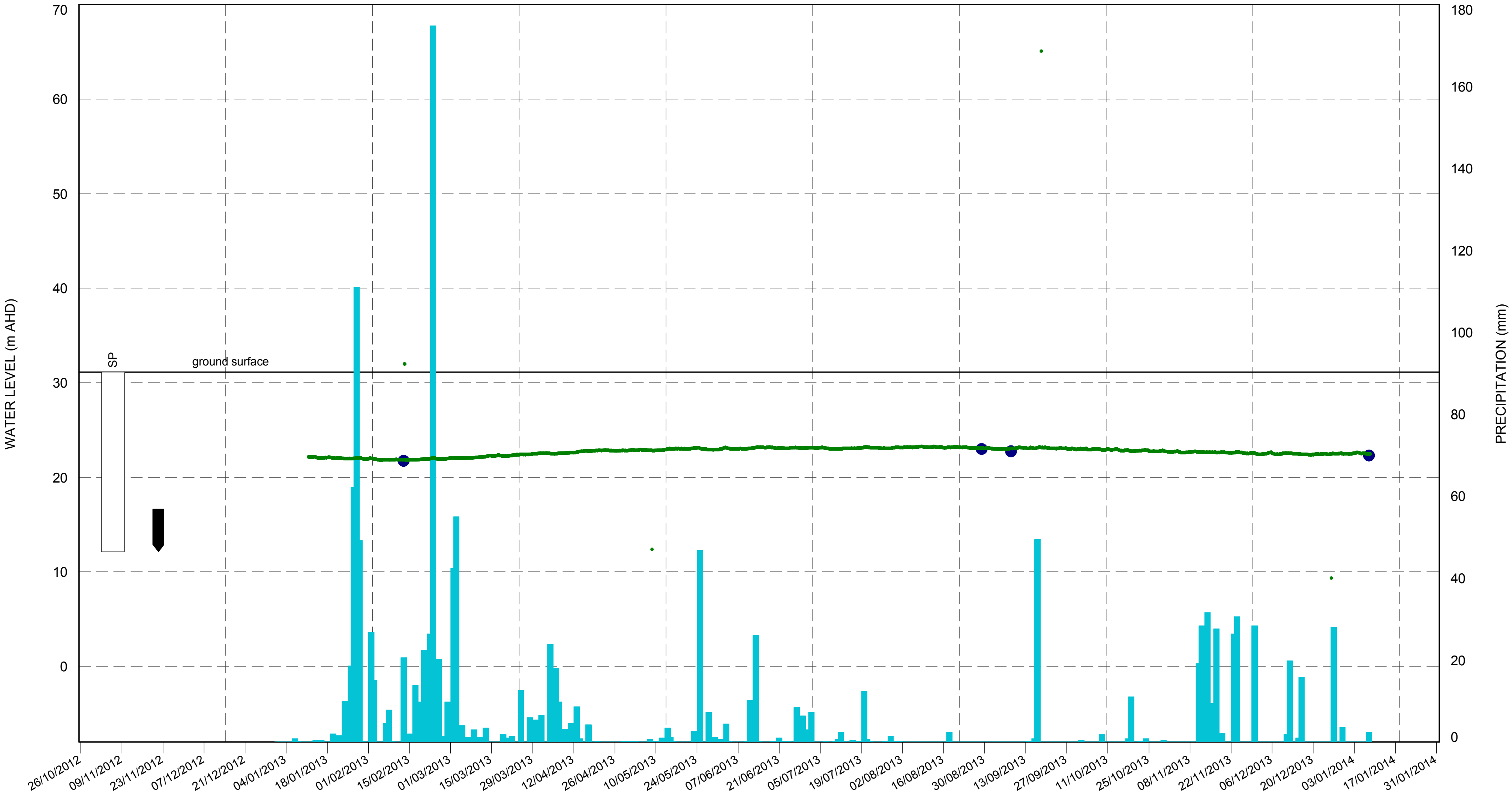
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ26**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H32** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:26

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 31.13 m AHD
Borehole Depth: 19.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 19.00 m bgl
RL of Tip: 12.13 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 19.00 m bgl
RL of Tip: 12.37 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

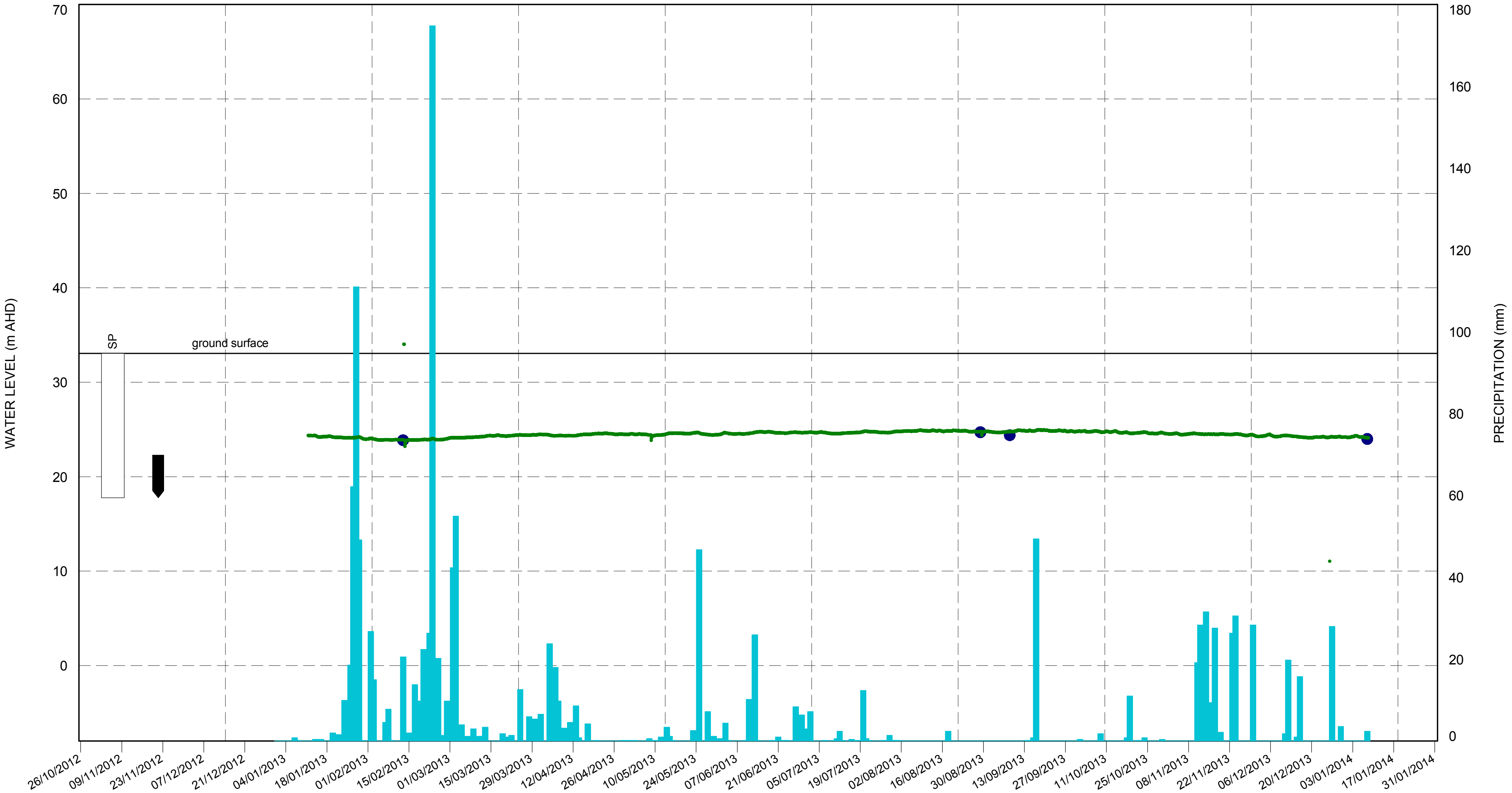
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ27**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H33** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 33.04 m AHD
Borehole Depth: 15.27 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.27 m bgl
RL of Tip: 17.77 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.27 m bgl
RL of Tip: 18.70 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

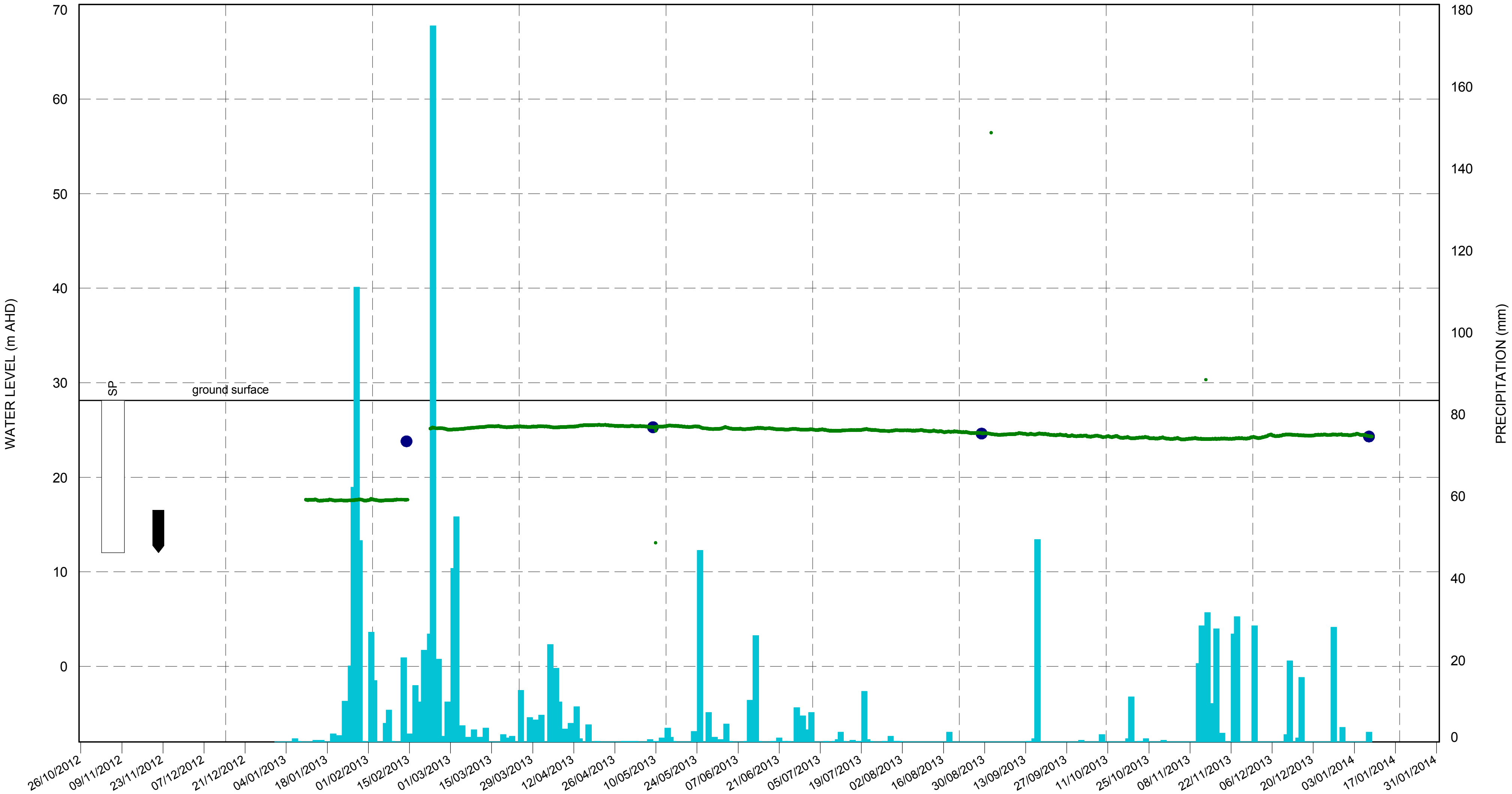
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ28**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H34** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 28.12 m AHD
Borehole Depth: 16.10 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 16.10 m bgl
RL of Tip: 12.02 m AHD

━: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 16.10 m bgl
RL of Tip: 13.02 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

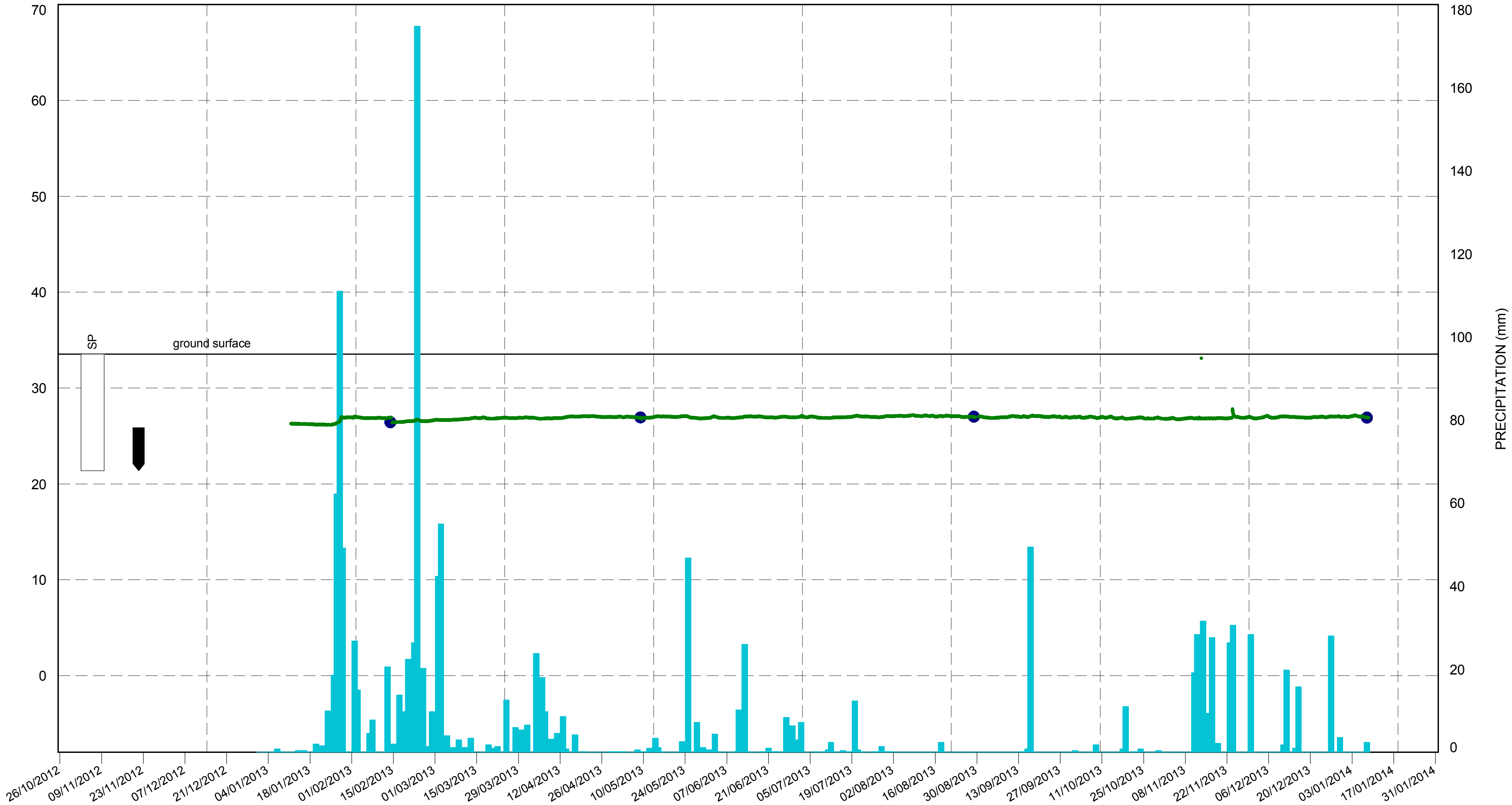
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ29

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H35 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:29



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:30

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 33.54 m AHD
Borehole Depth: 12.18 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.18 m bgl
RL of Tip: 21.36 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.18 m bgl
RL of Tip: 21.78 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

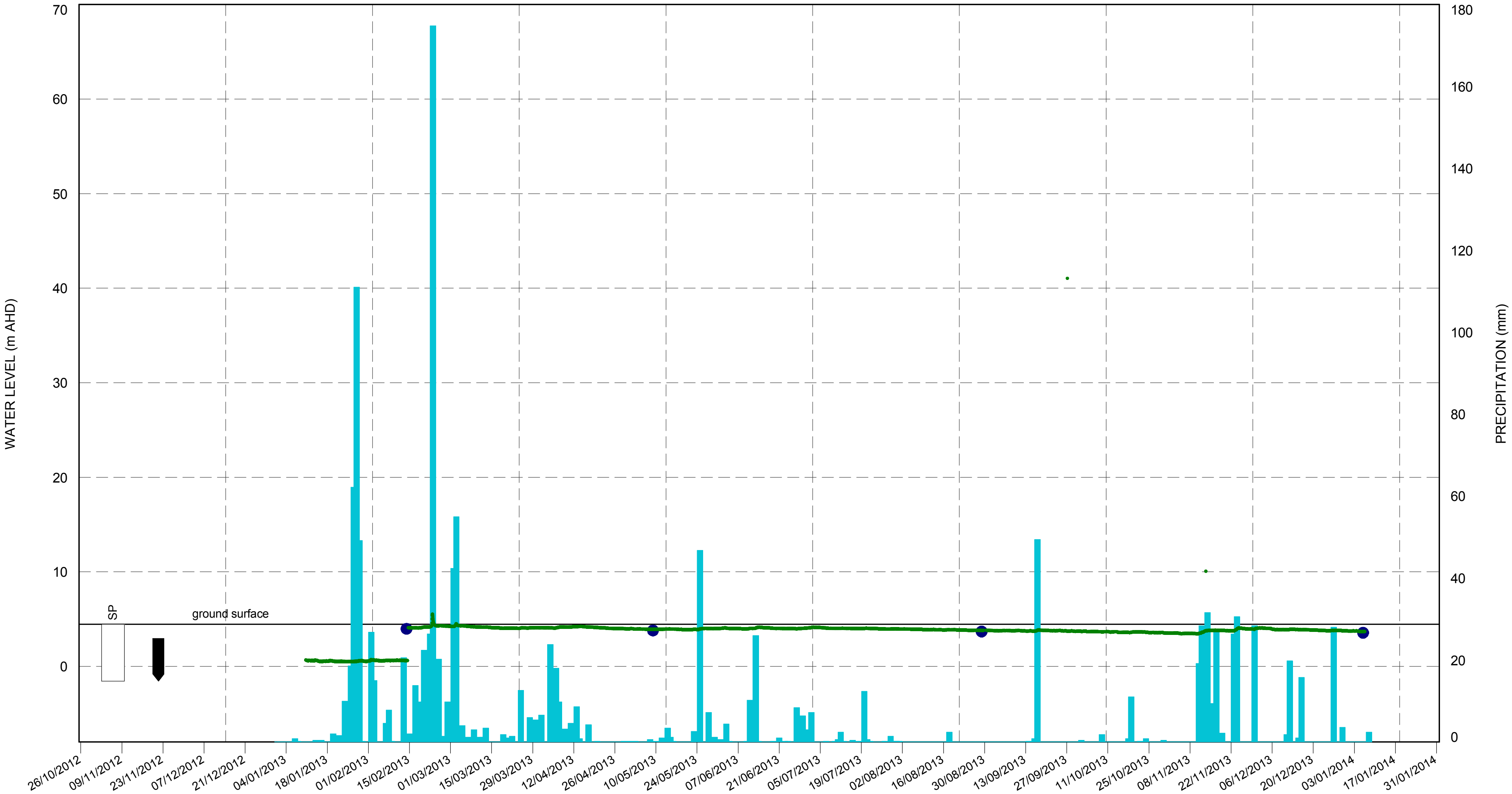
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ30**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H36** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:32

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 4.44 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -1.56 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -1.07 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

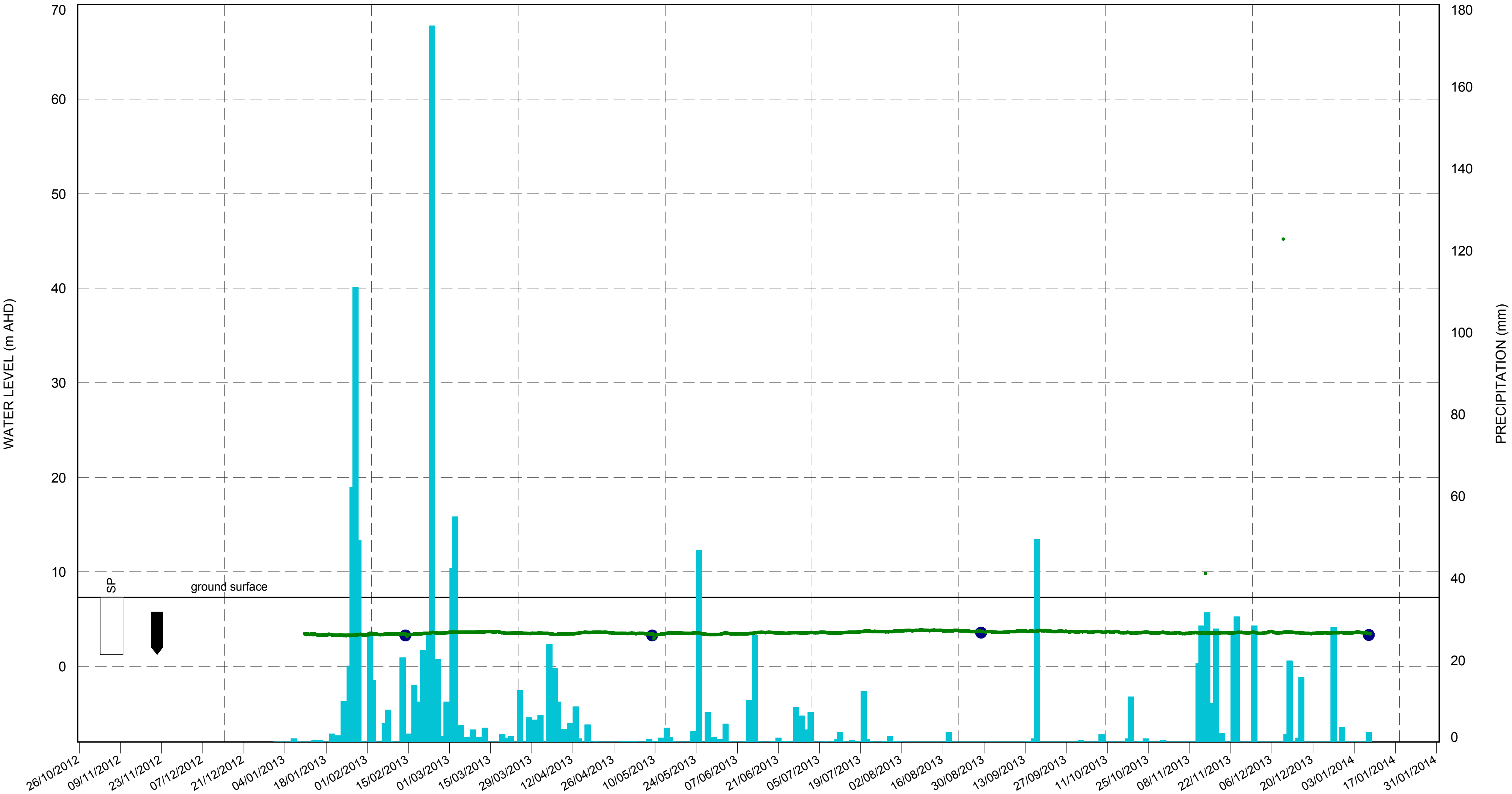
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ31**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H37** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:33

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.30 m AHD
Borehole Depth: 6.05 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.05 m bgl
RL of Tip: 1.34 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.05 m bgl
RL of Tip: 1.71 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

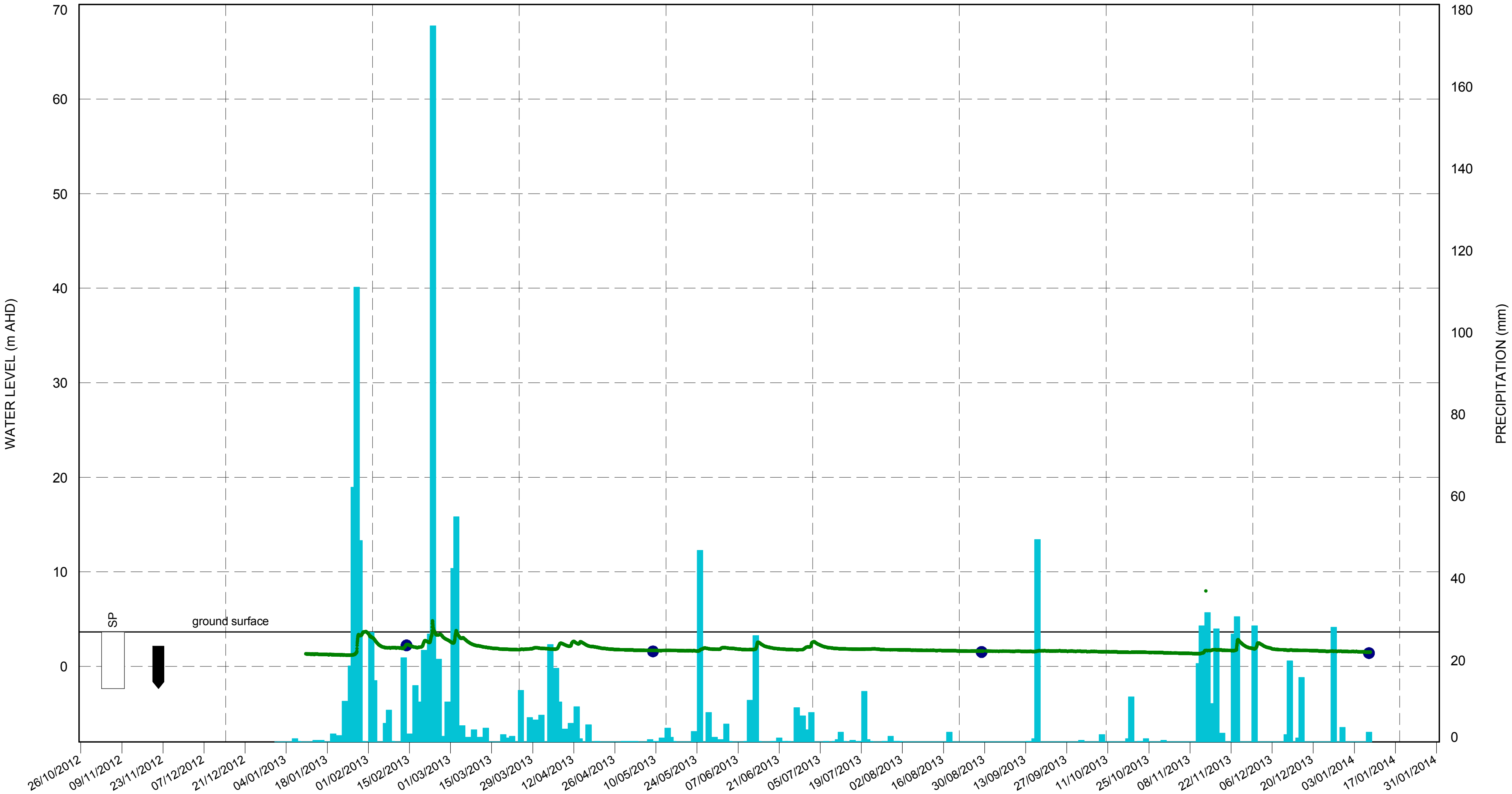
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ32**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H38** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 11:34



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 3.64 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.36 m AHD

━: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.16 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

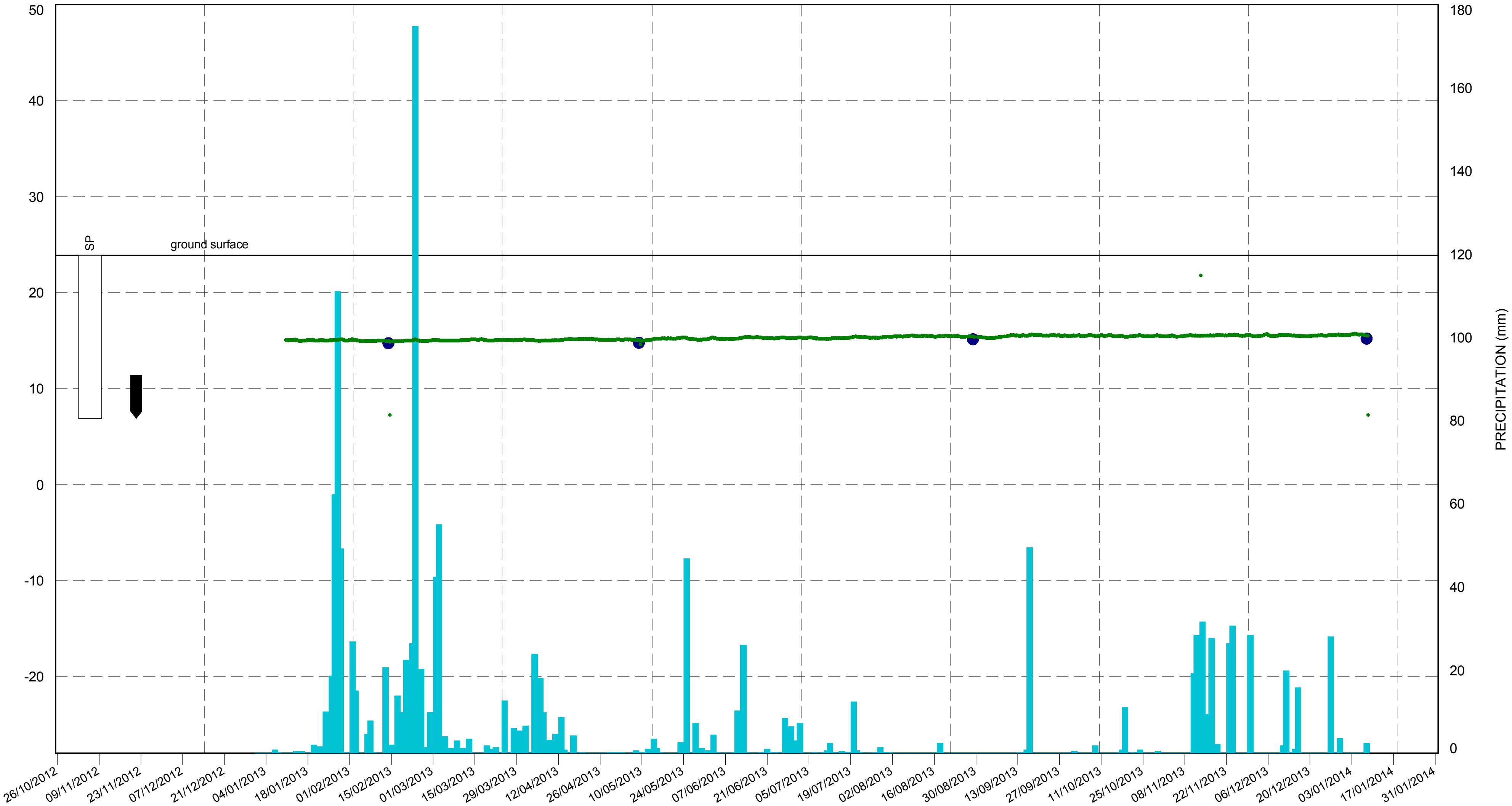
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ34**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H39** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:41

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

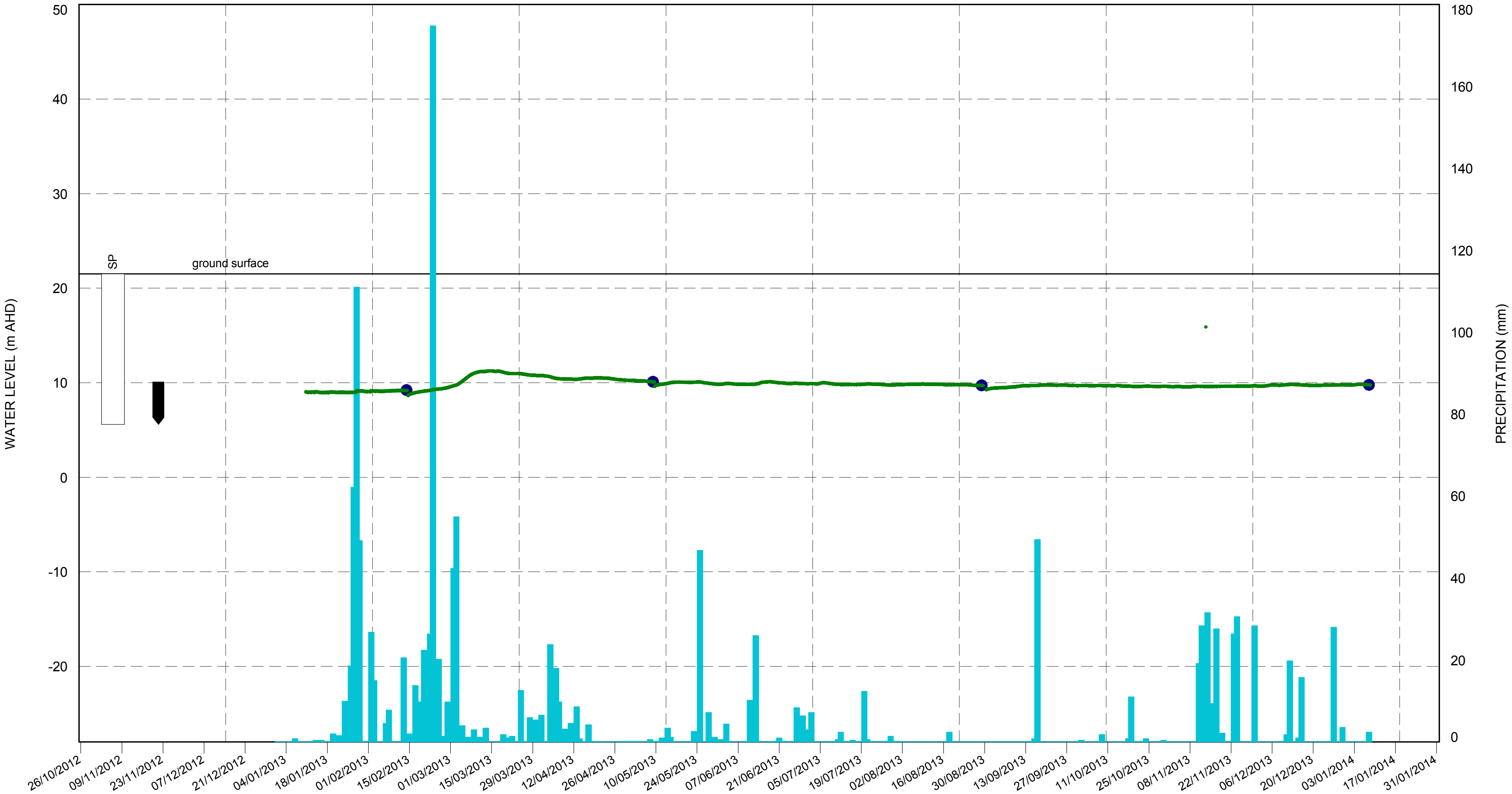
: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 23.88 m AHD
Borehole Depth: 17.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 17.00 m bgl
RL of Tip: 6.88 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 17.00 m bgl
RL of Tip: 7.21 m AHD

drawn	OH	coffey	client: Roads and Maritime Services
approved	AB		project: Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014		title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ35
scale	AS SHOWN		
original size	A4		project no: GEOTCOFH03059AA-AO fig no: FIGURE H40 rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:42

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 21.51 m AHD
Borehole Depth: 15.92 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.92 m bgl
RL of Tip: 5.59 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.92 m bgl
RL of Tip: 5.51 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

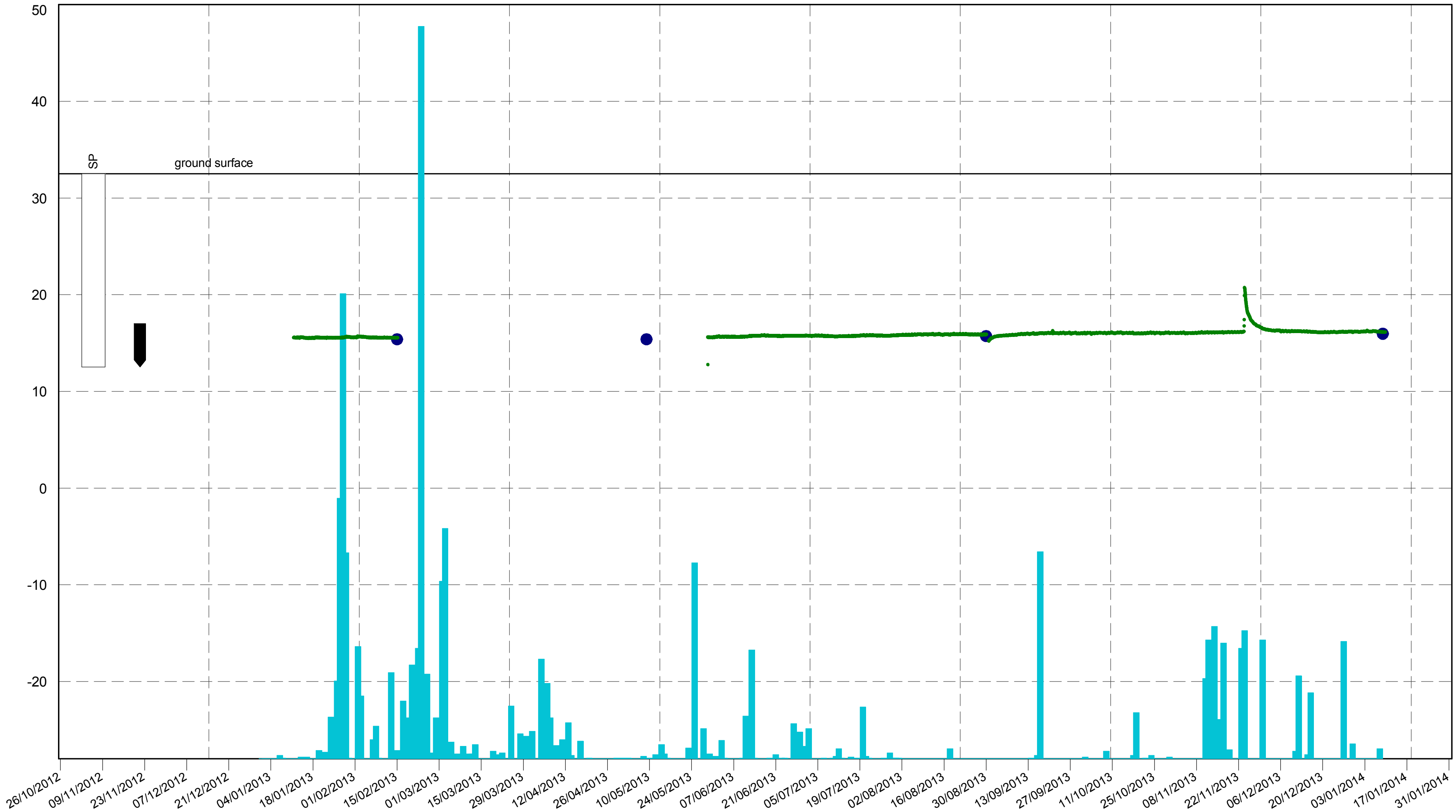
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ36**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H41** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 32.51 m AHD
Borehole Depth: 20.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 20.00 m bgl
RL of Tip: 12.51 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 20.00 m bgl
RL of Tip: 12.75 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

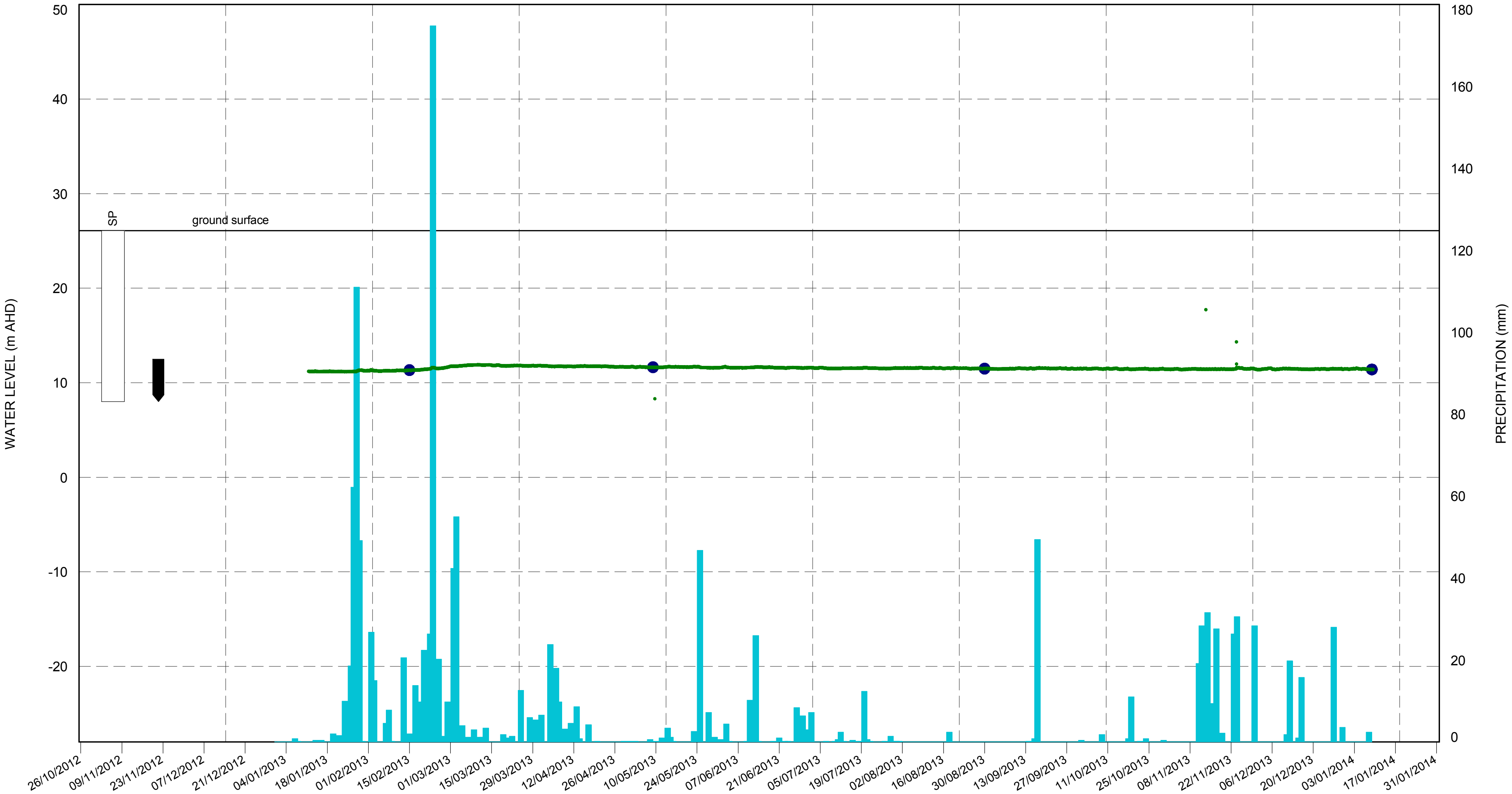
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ37**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H42** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:43



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:45

Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 26.09 m AHD
Borehole Depth: 18.10 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 18.10 m bgl
RL of Tip: 7.99 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 18.10 m bgl
RL of Tip: 8.29 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

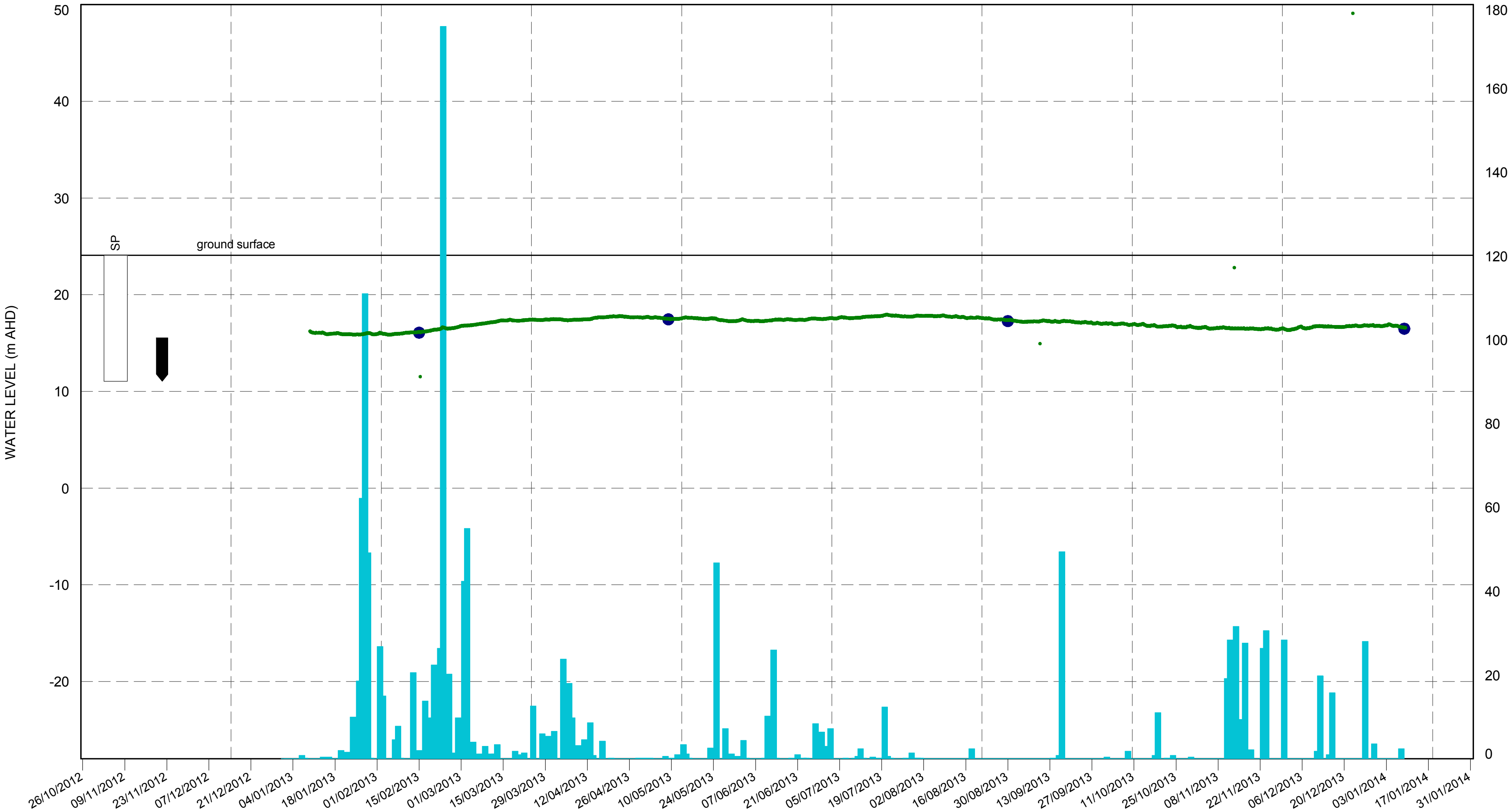
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ38**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H43** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:46

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 24.08 m AHD
Borehole Depth: 13.05 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.05 m bgl
RL of Tip: 11.03 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.05 m bgl
RL of Tip: 11.50 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

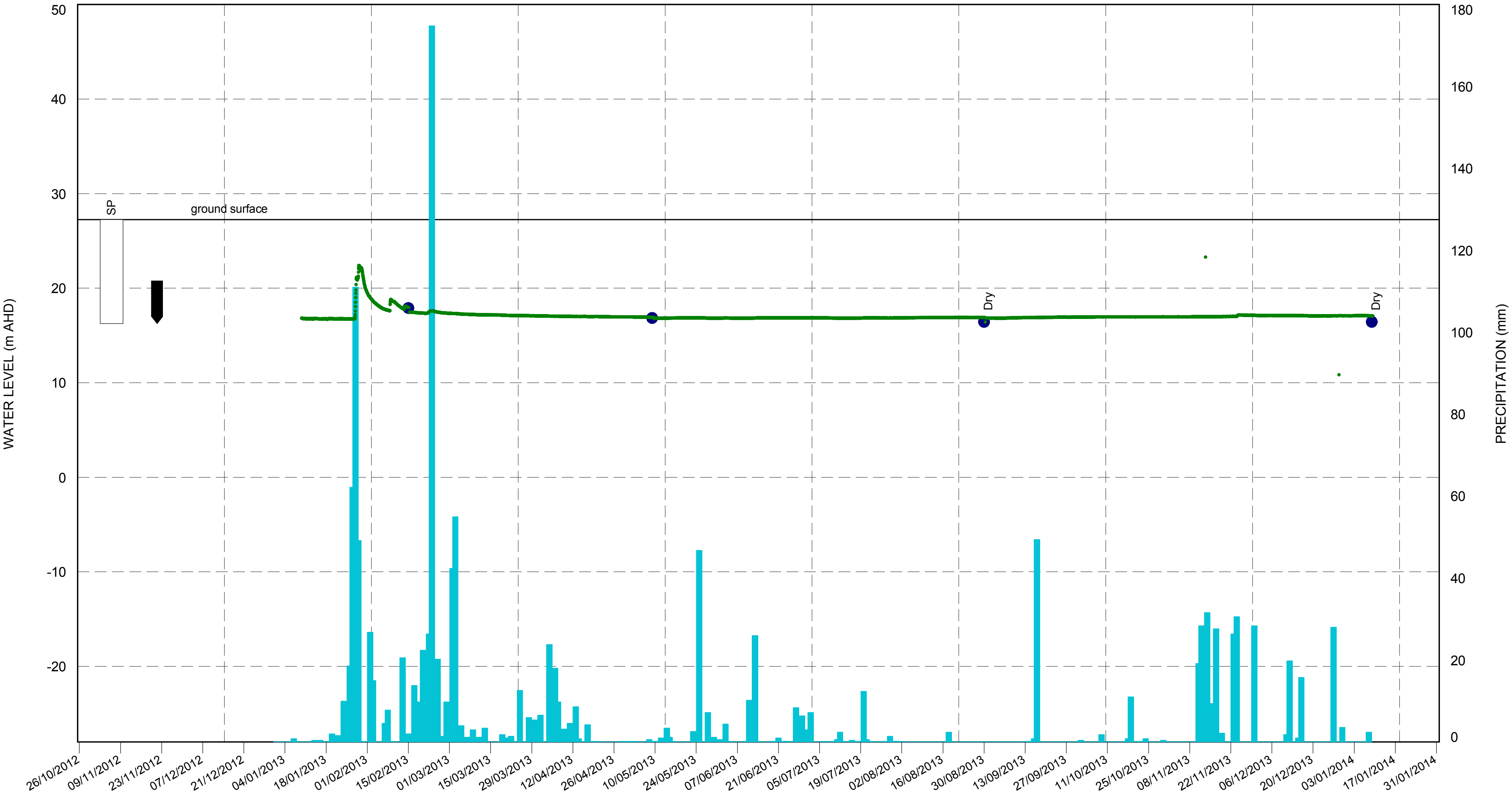
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ39**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H44** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 27.26 m AHD
Borehole Depth: 11.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 16.26 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 16.44 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

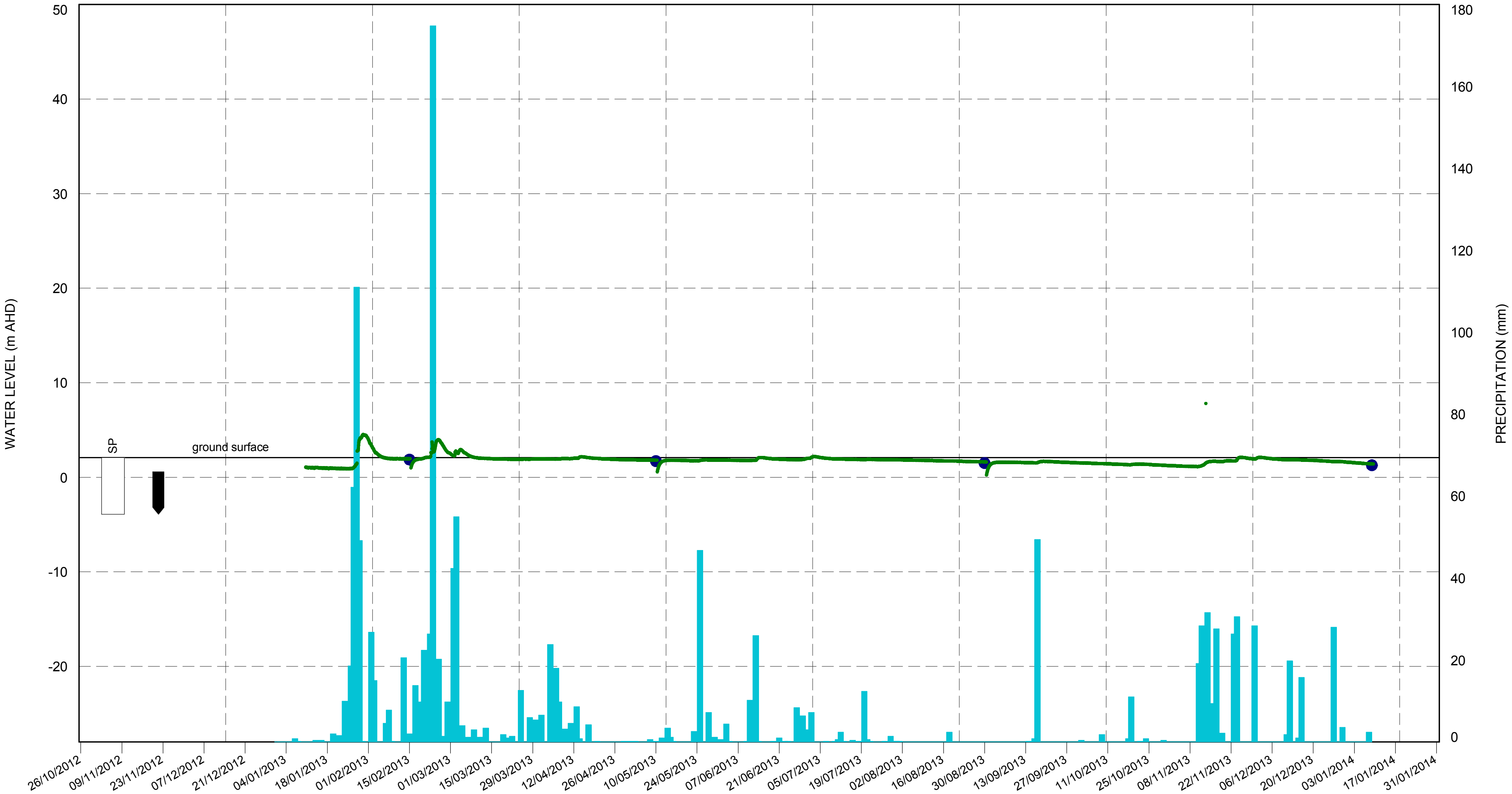
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ40

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H45 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:47



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 2.07 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.93 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.60 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

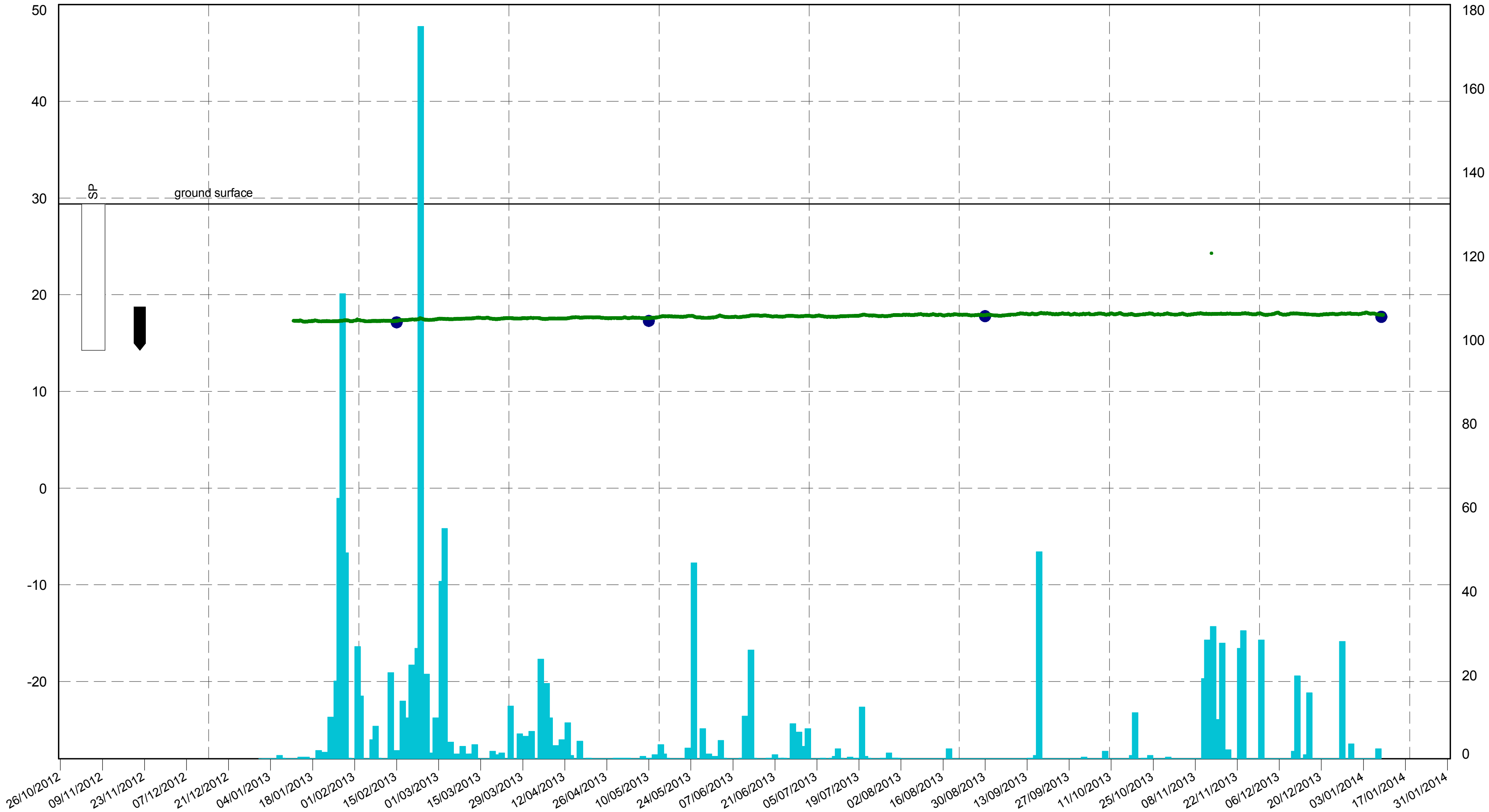
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ41**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H46** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:49

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 29.39 m AHD
Borehole Depth: 15.15 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.15 m bgl
RL of Tip: 14.24 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.15 m bgl
RL of Tip: 14.53 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

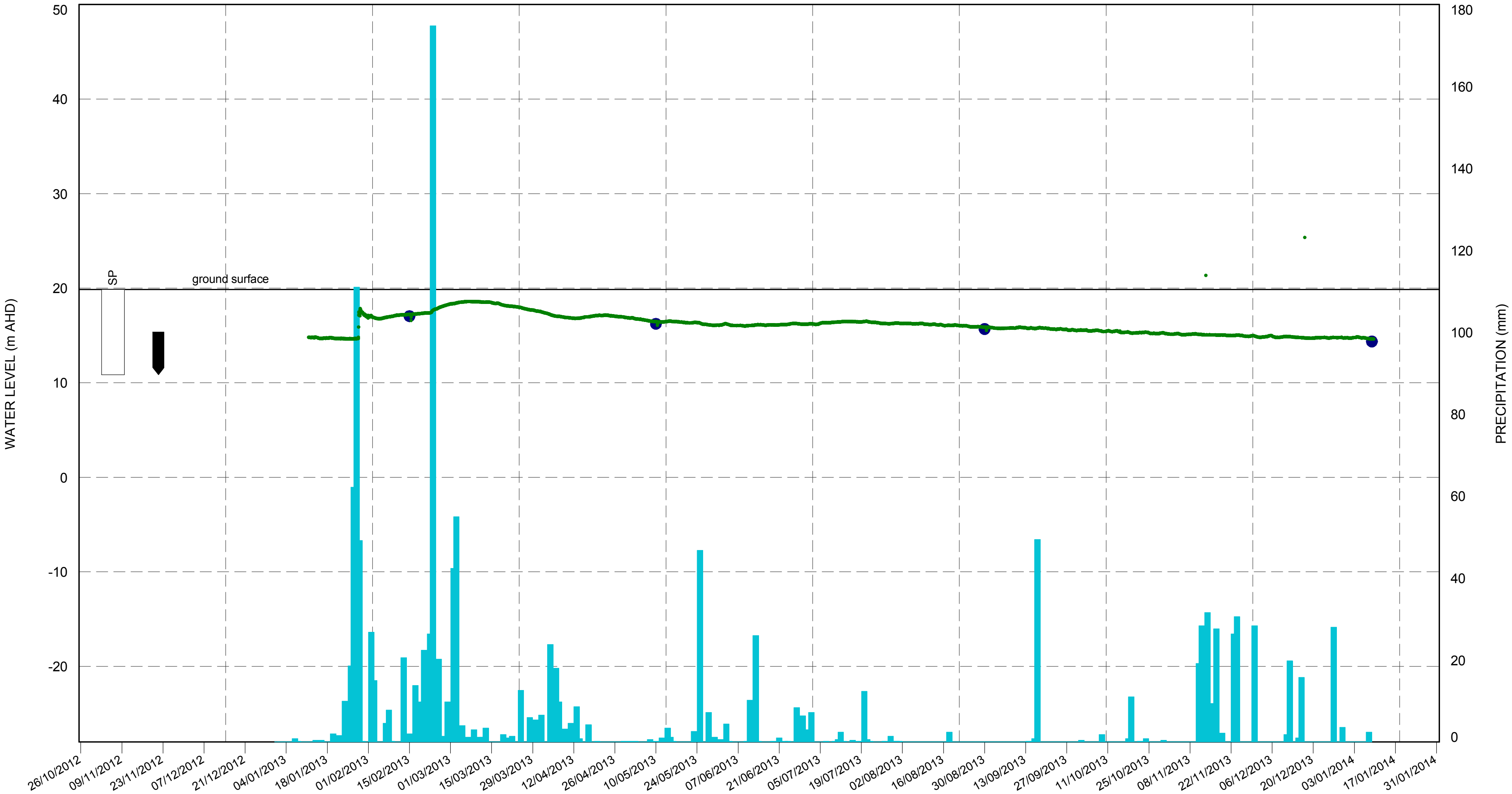
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ43**

project no: GEOTCOFH03059AA-AO

fig no: **FIGURE H47**

rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 19.85 m AHD
Borehole Depth: 9.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 9.00 m bgl
RL of Tip: 10.85 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 9.00 m bgl
RL of Tip: 11.21 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

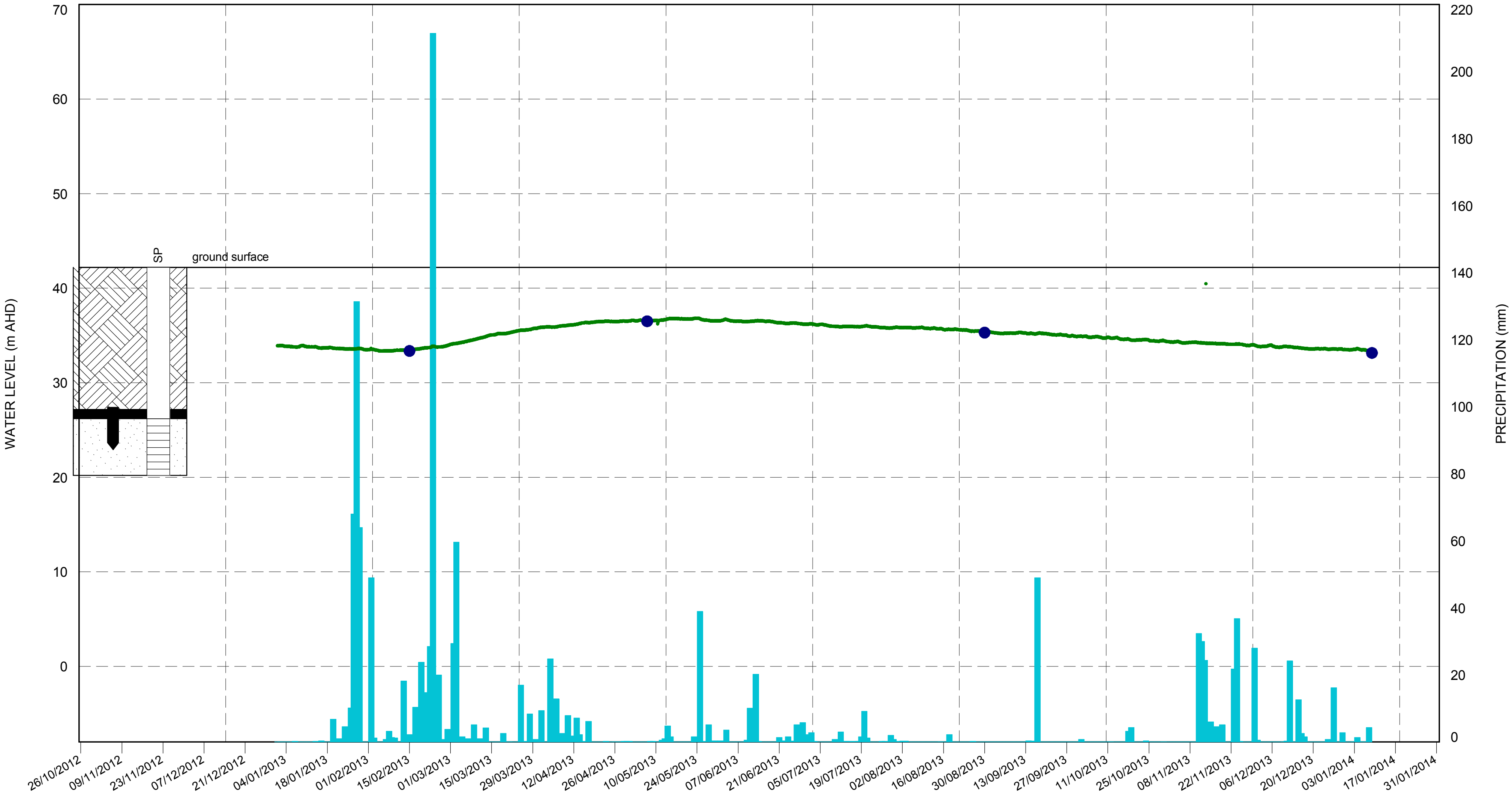
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ44**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H48** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:50

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:47



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 42.20 m AHD
Borehole Depth: 22.00 m

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date: 01/12/2012
Tip Depth: 19.30 m bgl
RL of Tip: 22.90 m AHD

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date: 01/12/2013
Tip Depth: 22.00 m bgl
RL of Tip: 20.20 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

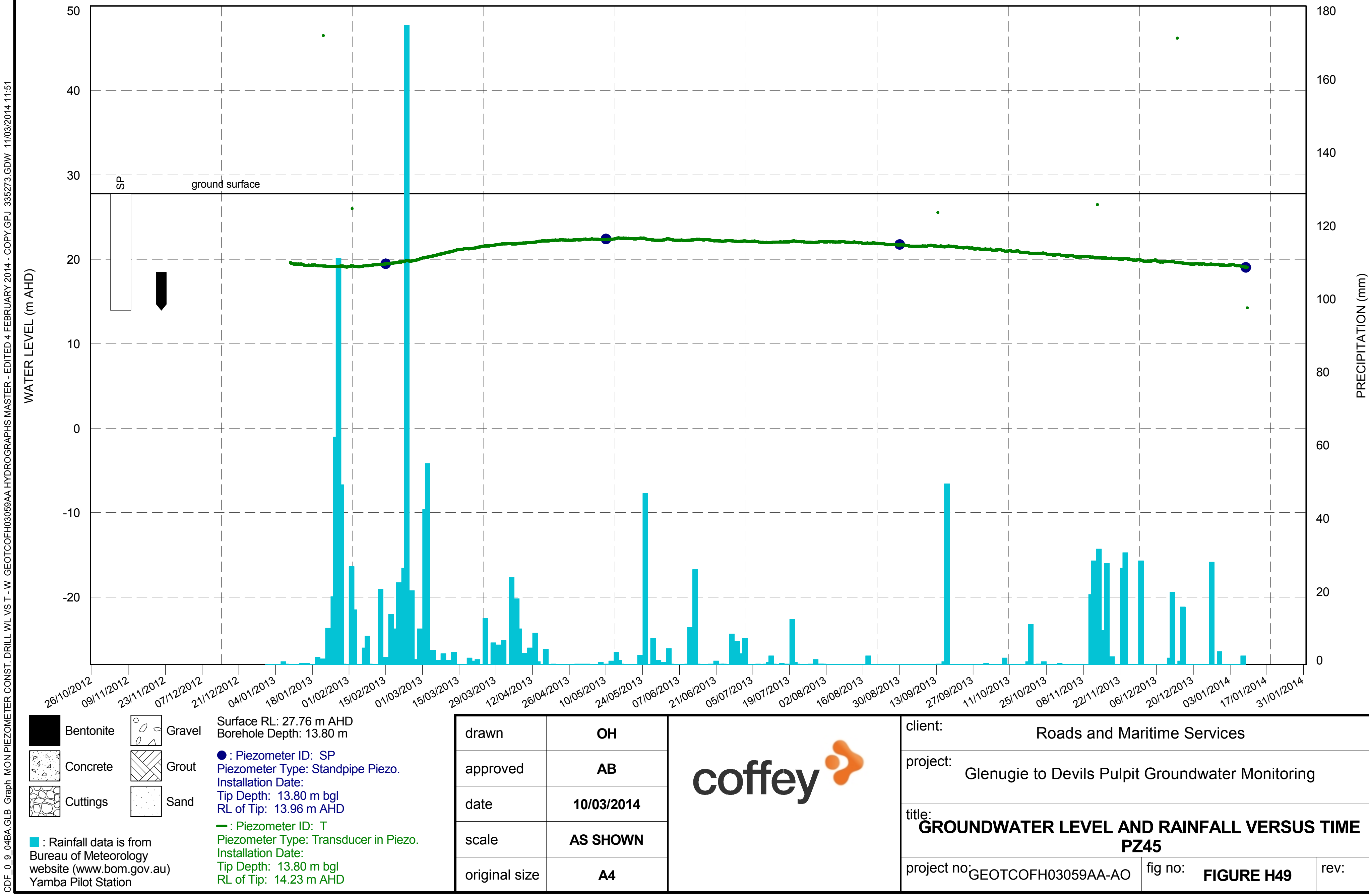
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1139**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H1** | rev:



Surface RL: 27.76 m AHD
Borehole Depth: 13.80 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 13.80 m bgl
RL of Tip: 13.96 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 13.80 m bgl
RL of Tip: 14.23 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

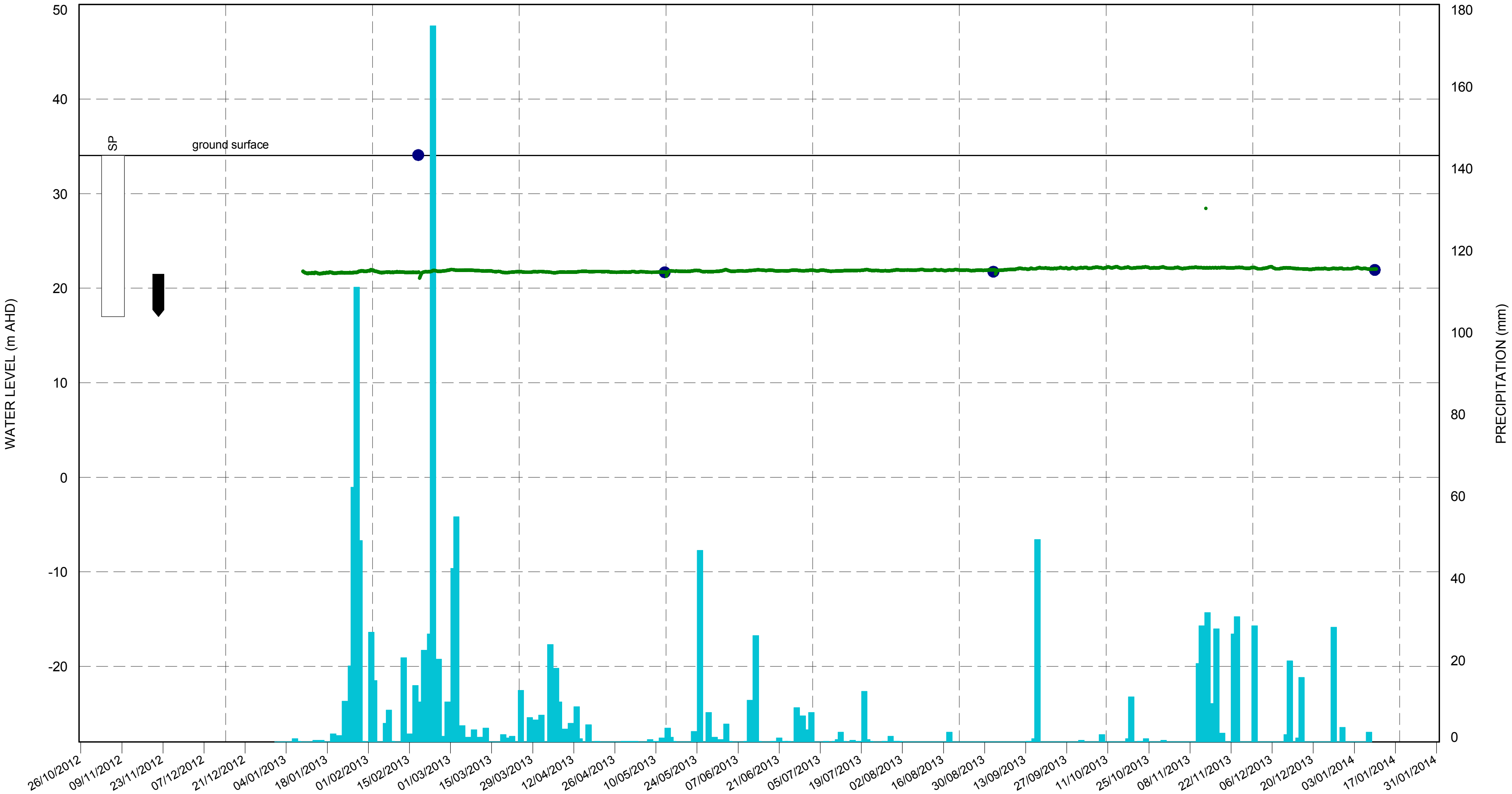
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ45**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H49** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 34.03 m AHD
Borehole Depth: 17.05 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 17.05 m bgl
RL of Tip: 16.98 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 17.05 m bgl
RL of Tip: 16.96 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

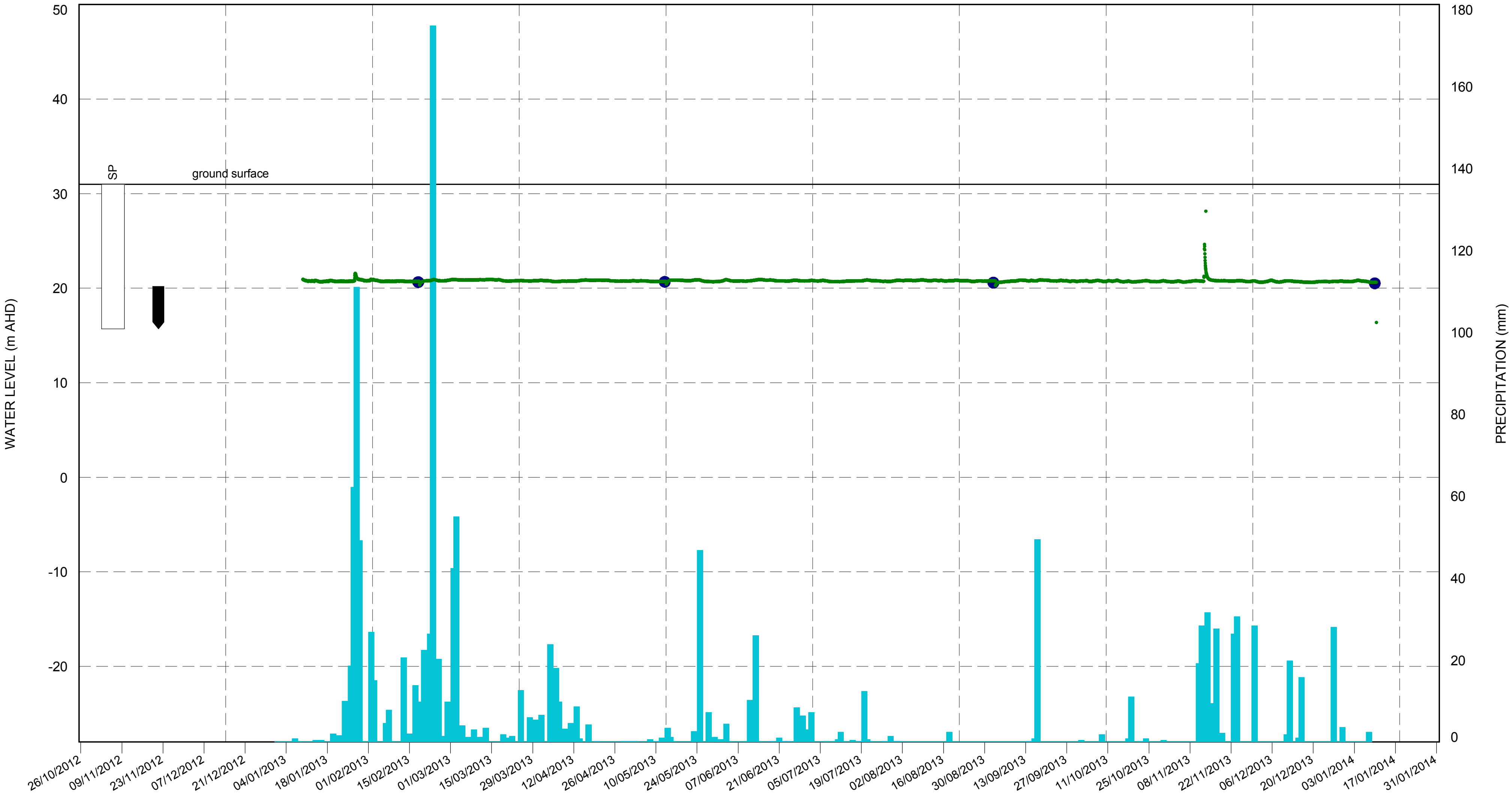
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ46**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H50** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:52



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 30.99 m AHD
Borehole Depth: 15.30 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.30 m bgl
RL of Tip: 15.69 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.30 m bgl
RL of Tip: 16.36 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

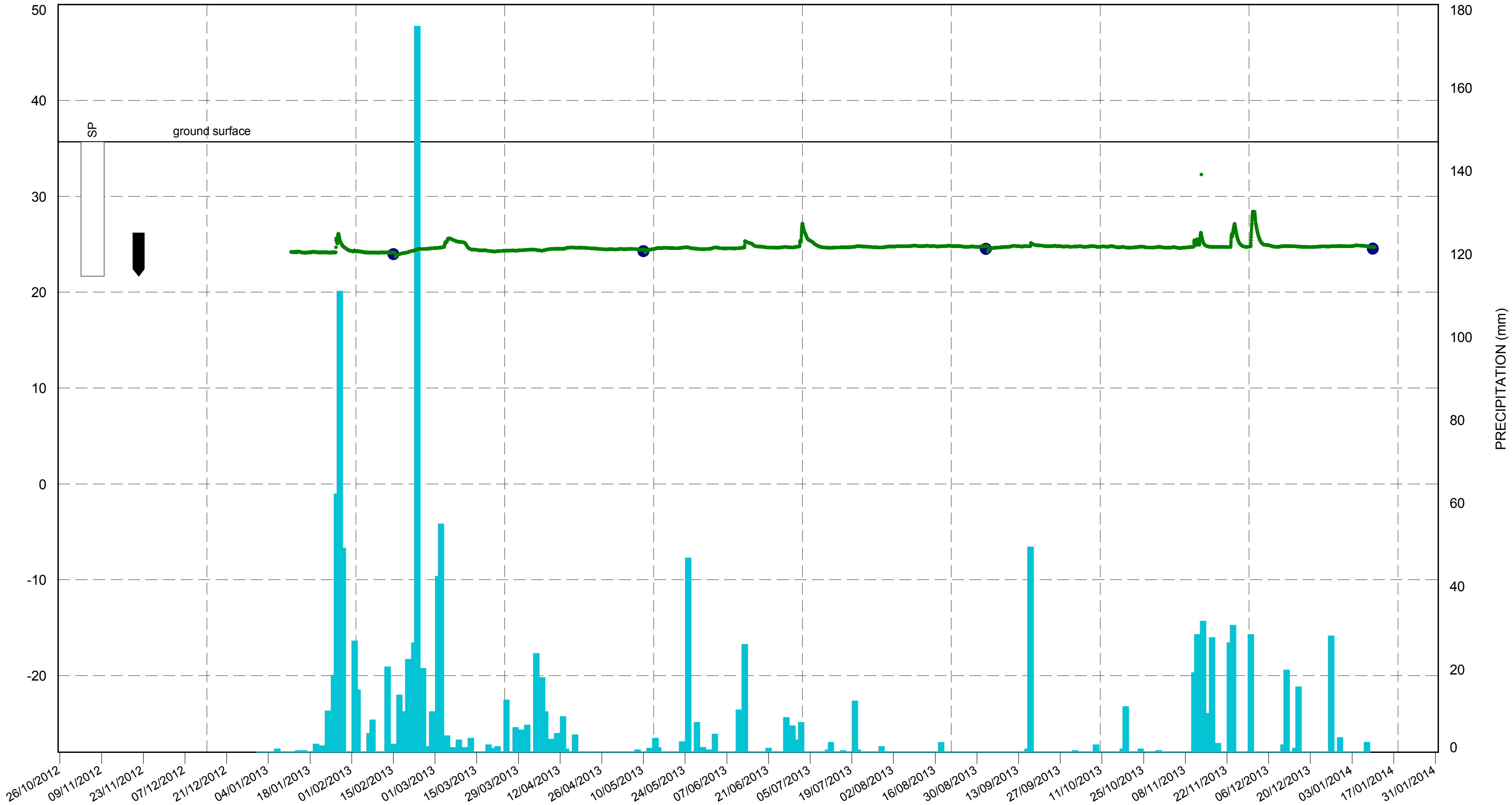
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ47**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H51** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 35.67 m AHD
Borehole Depth: 14.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 21.67 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 22.29 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

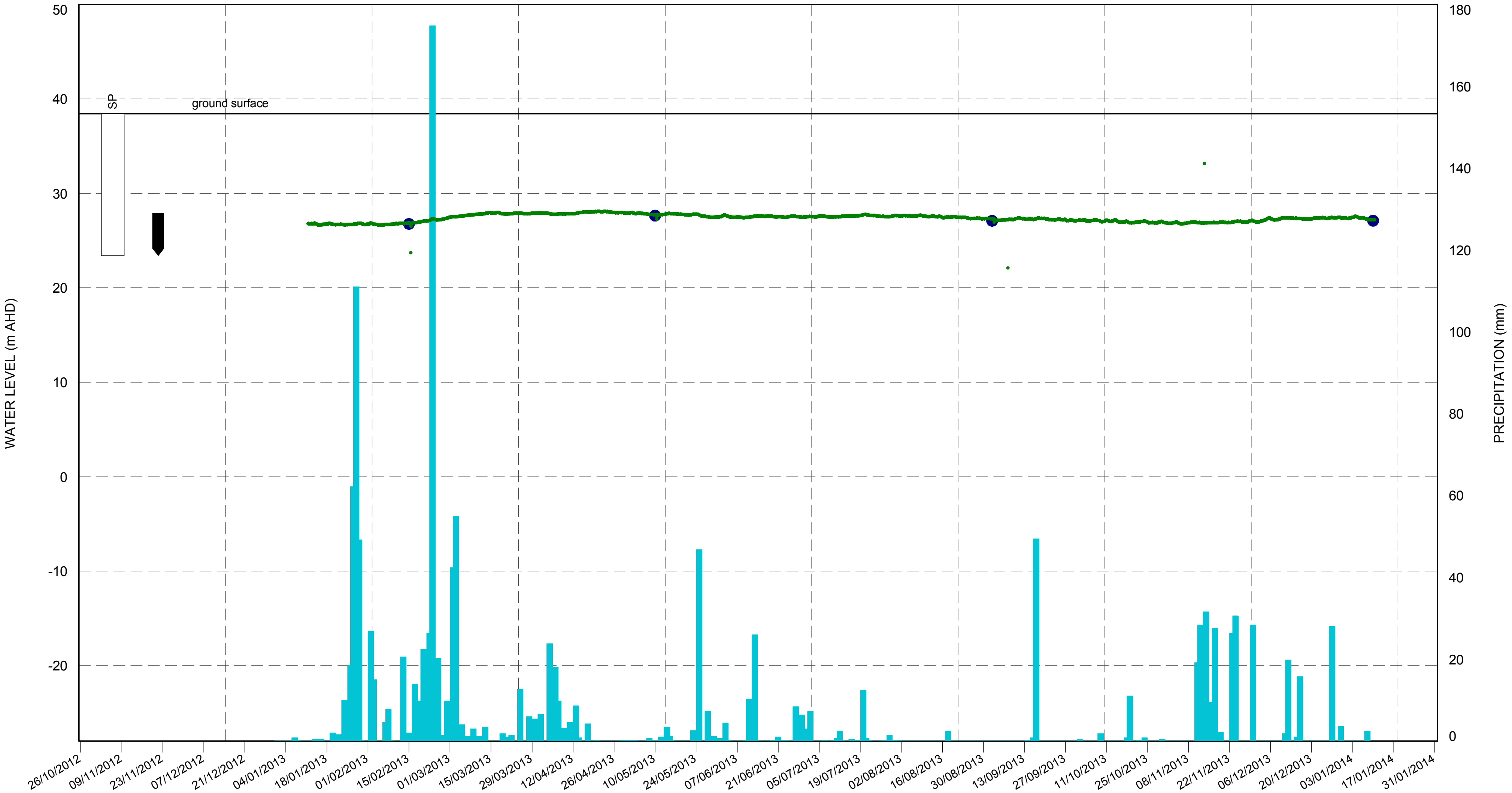
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ48**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H52** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:54



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 38.42 m AHD
Borehole Depth: 15.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.00 m bgl
RL of Tip: 23.42 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.00 m bgl
RL of Tip: 23.72 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

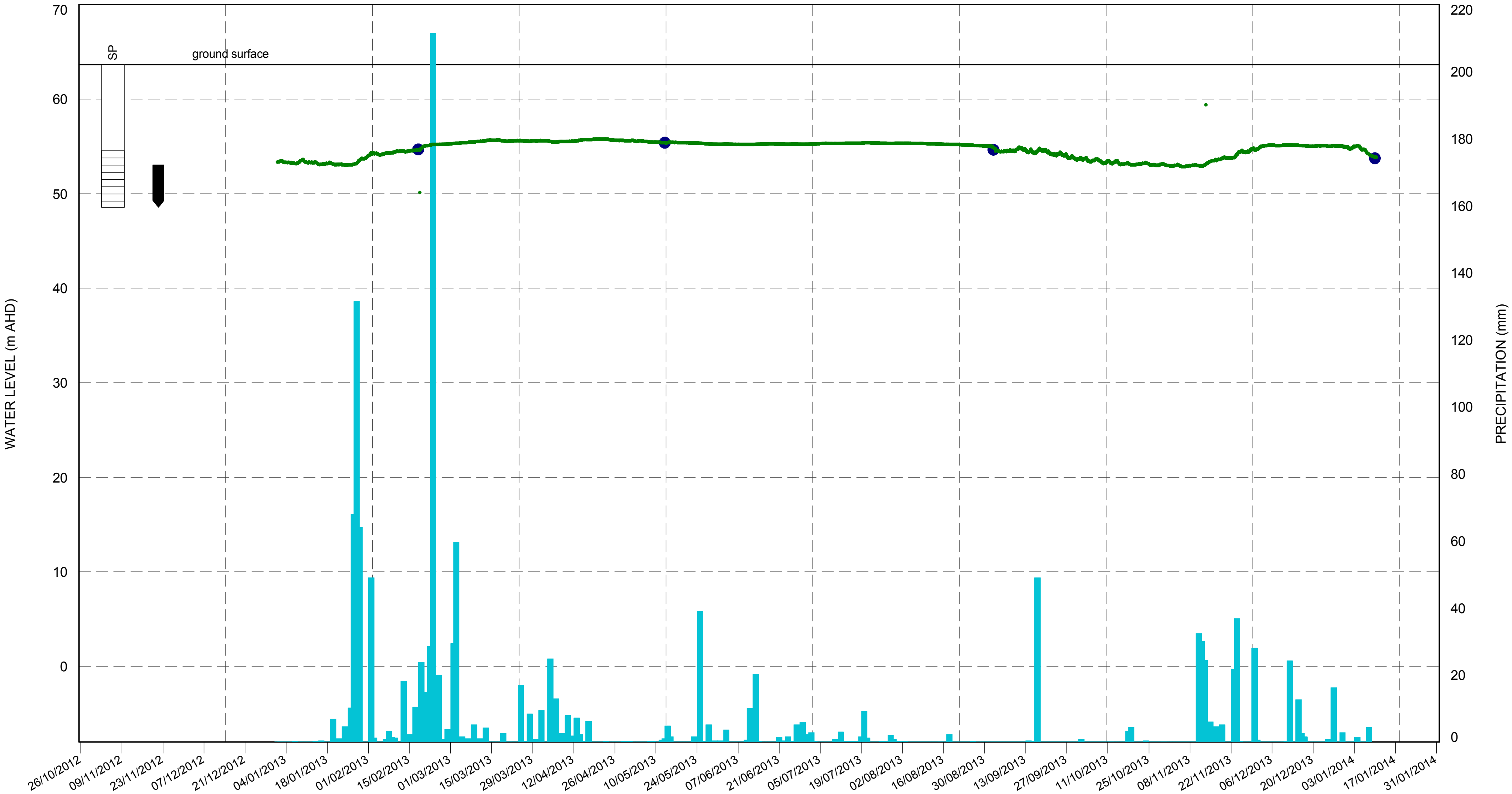
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ49

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H53 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:55



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 63.64 m AHD
Borehole Depth: 15.10 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.10 m bgl
RL of Tip: 48.54 m AHD

━: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.10 m bgl
RL of Tip: 50.15 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

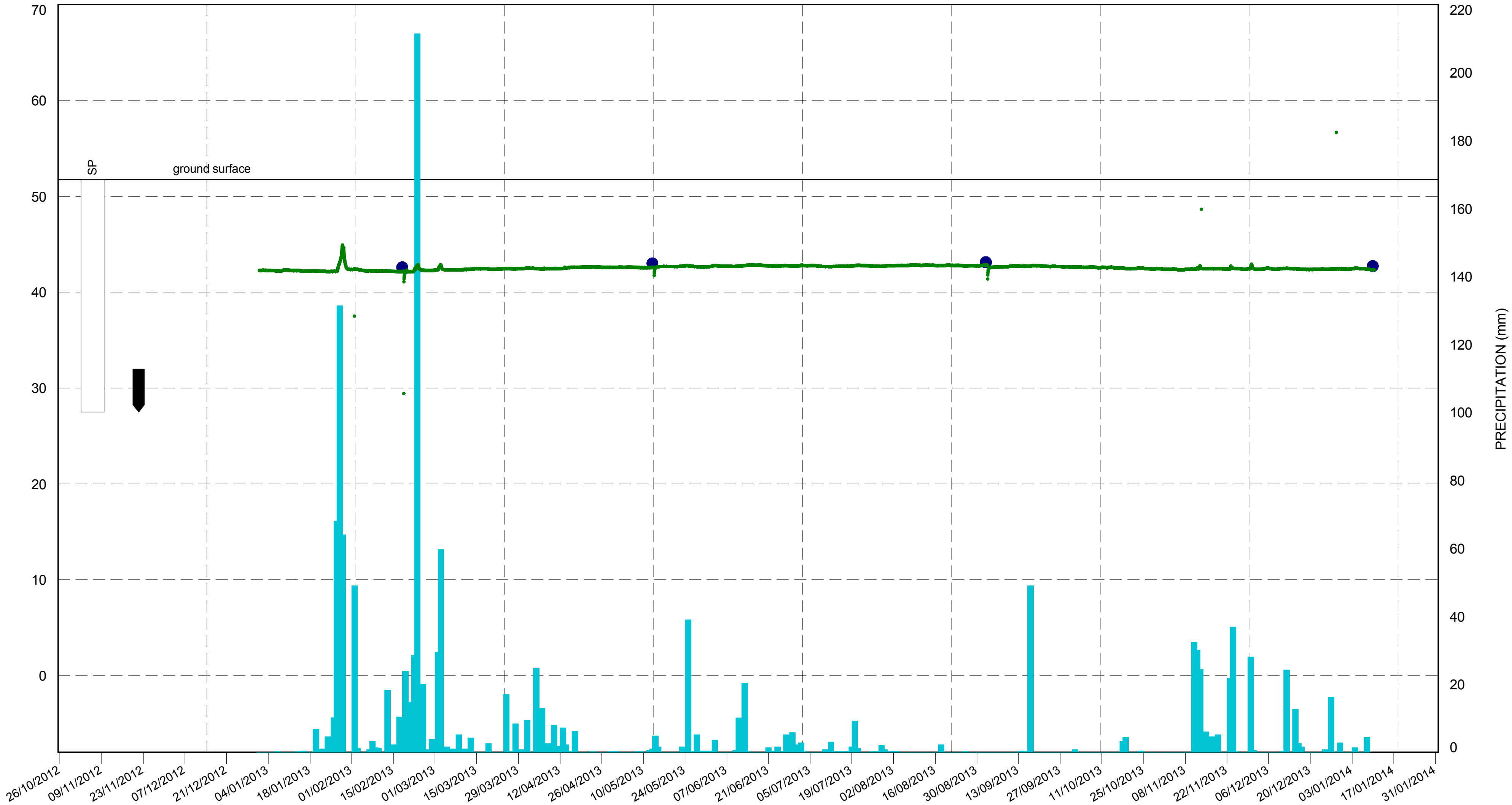
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1159**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H2** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:48



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:48

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 51.74 m AHD
Borehole Depth: 24.25 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 24.25 m bgl
RL of Tip: 22.34 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 24.25 m bgl
RL of Tip: 29.40 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

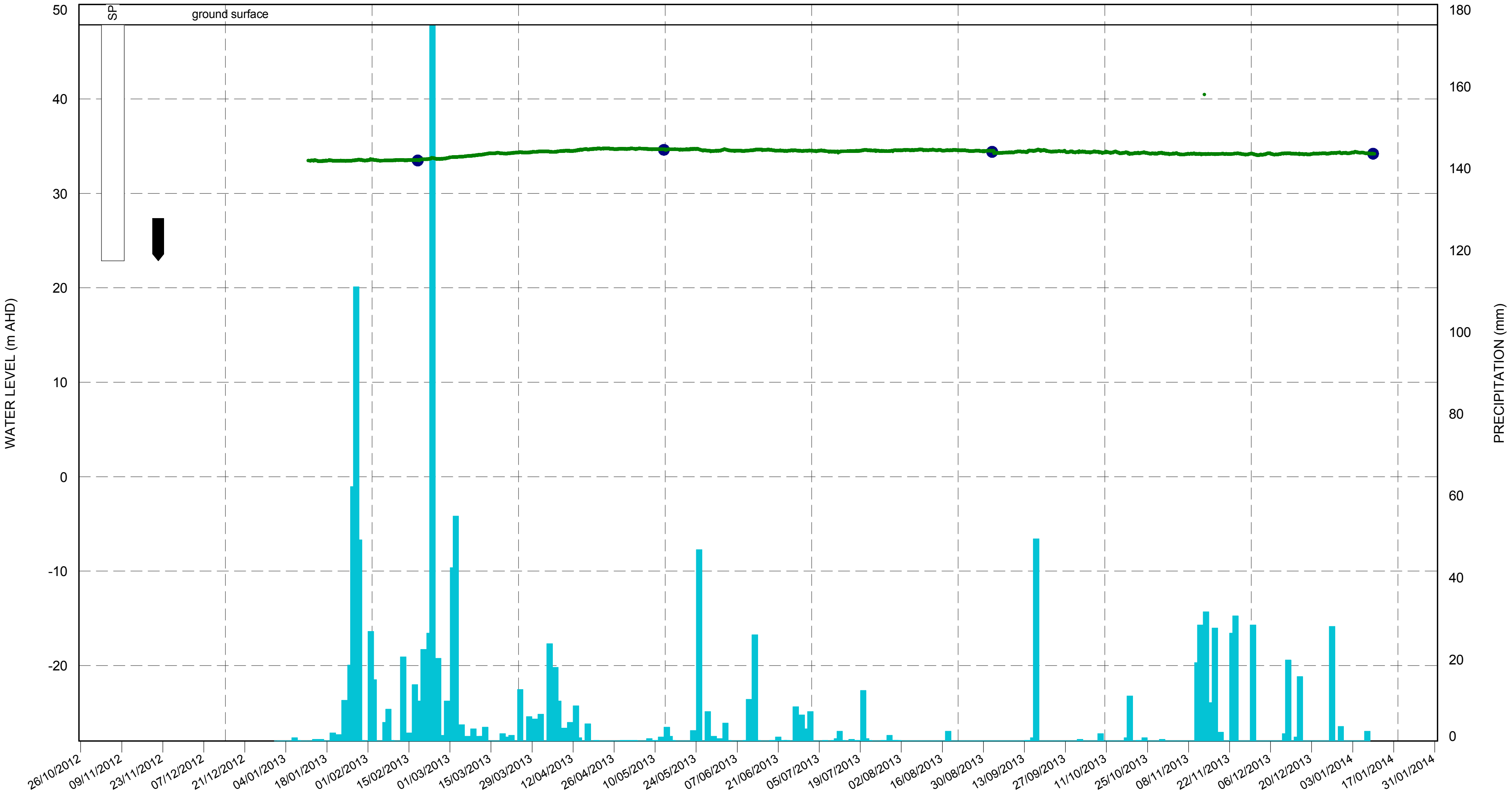
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1170**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H3** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 11:56

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 47.85 m AHD
Borehole Depth: 25.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 22.85 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 25.25 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

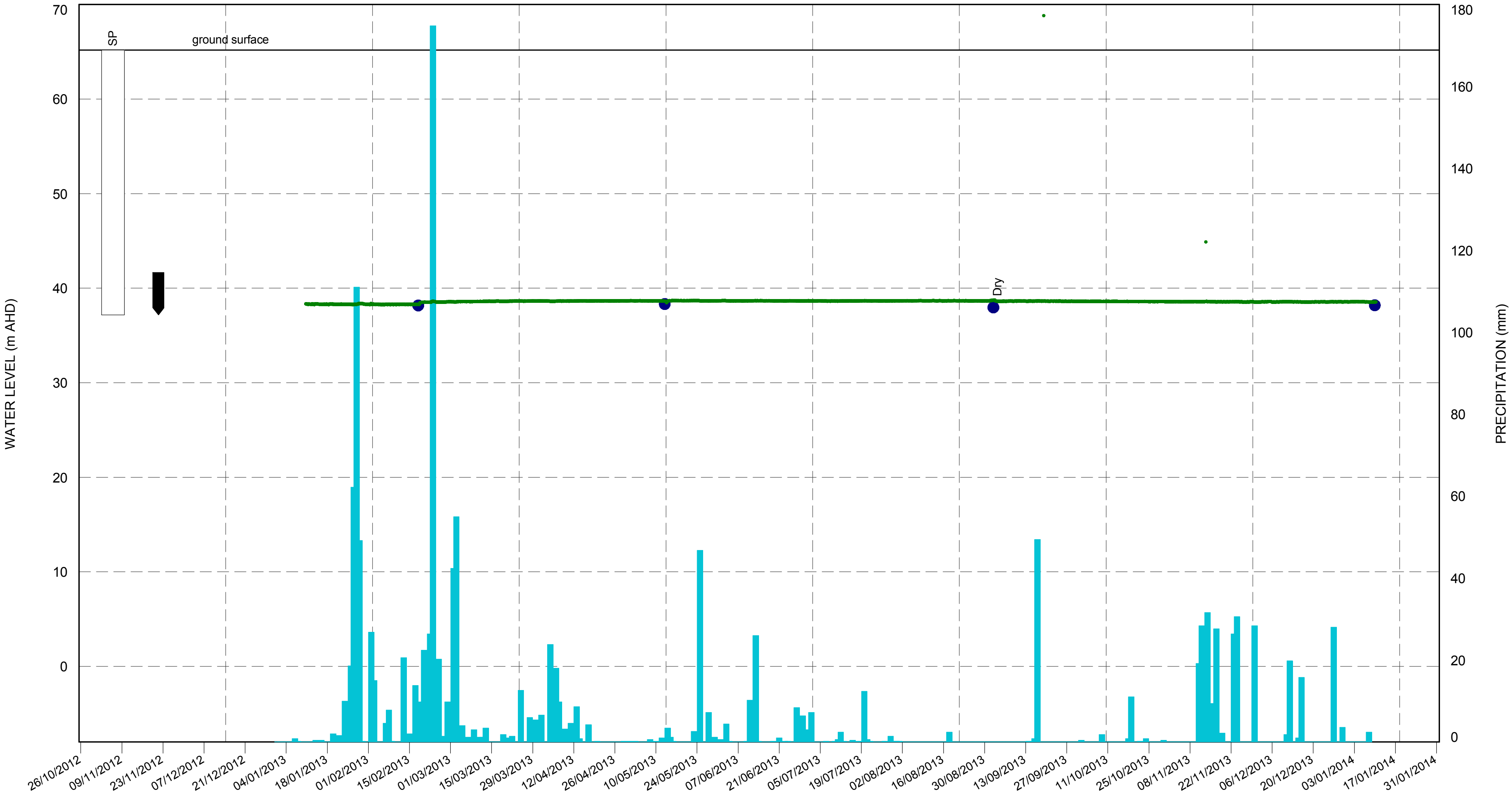
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ50**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H54** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 65.17 m AHD
Borehole Depth: 28.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 28.00 m bgl
RL of Tip: 37.17 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 28.00 m bgl
RL of Tip: 37.96 m AHD

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

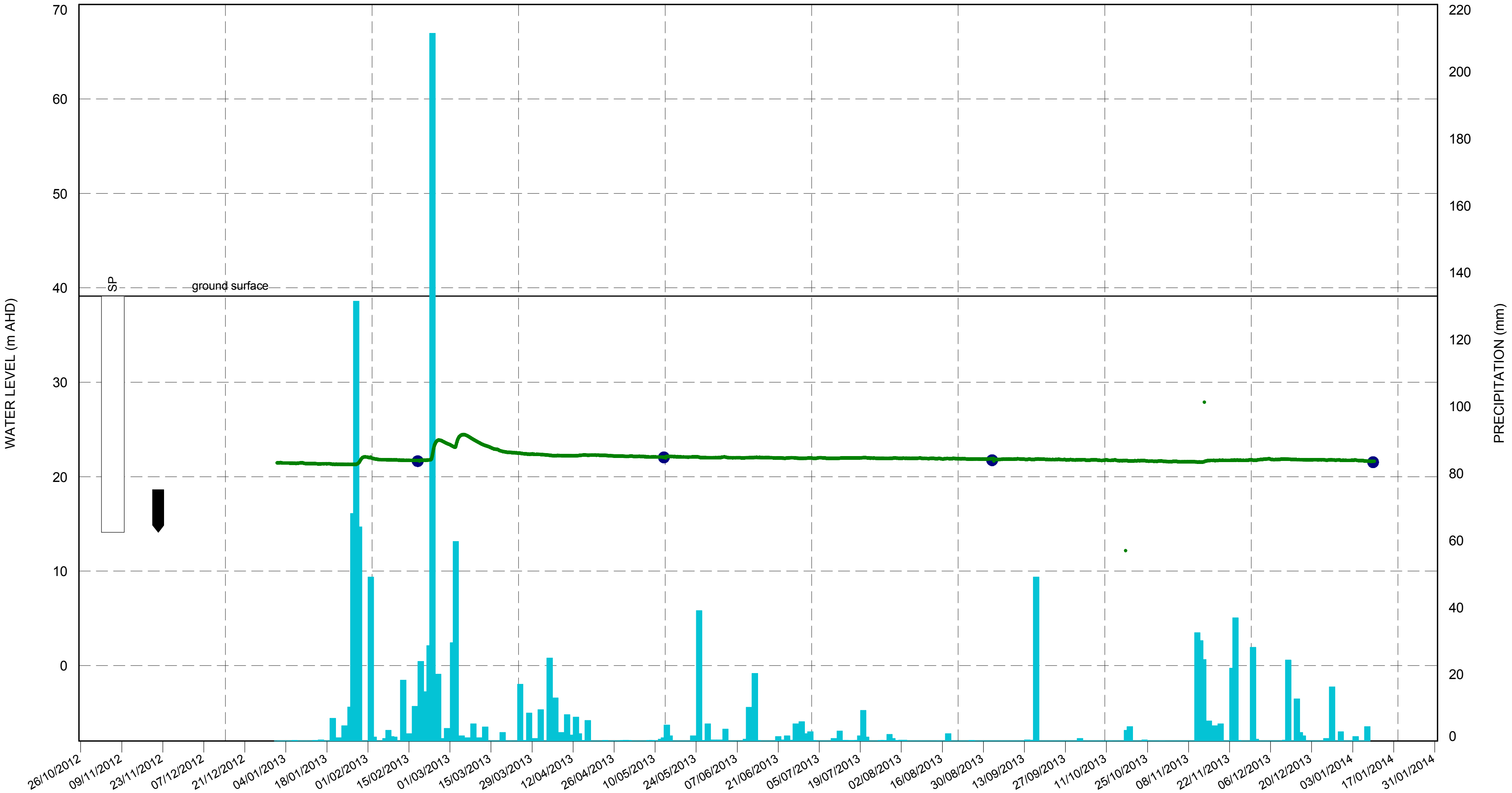
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ51**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H55** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 39.11 m AHD
Borehole Depth: 25.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 14.11 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 25.00 m bgl
RL of Tip: 17.20 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

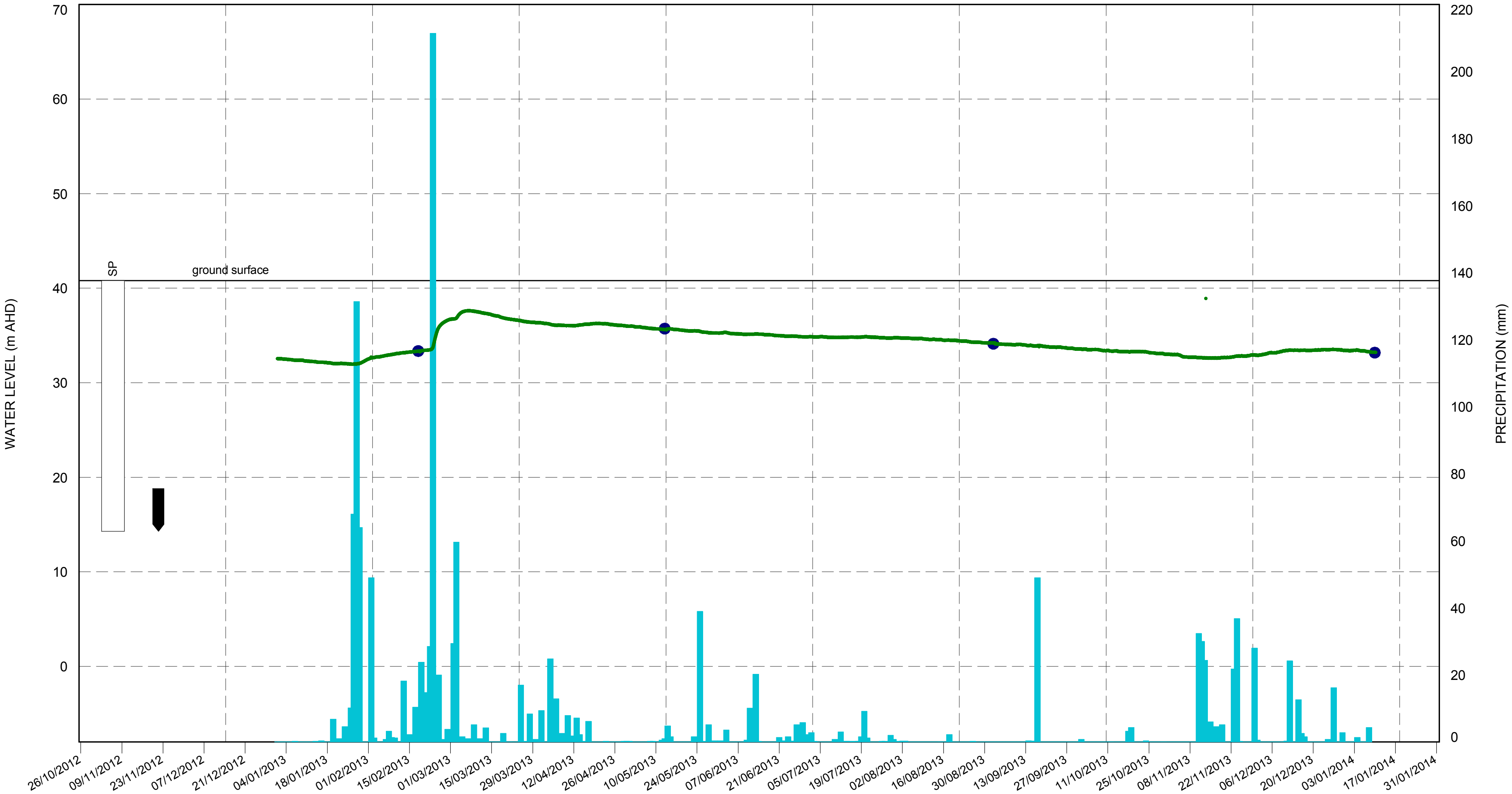
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1187**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H4** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:50



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 40.79 m AHD
Borehole Depth: 26.50 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 26.50 m bgl
RL of Tip: 14.29 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 26.50 m bgl
RL of Tip: 17.86 m AHD

■ : Rainfall data is from
Bureau of Meteorology
website (www.bom.gov.au)
Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

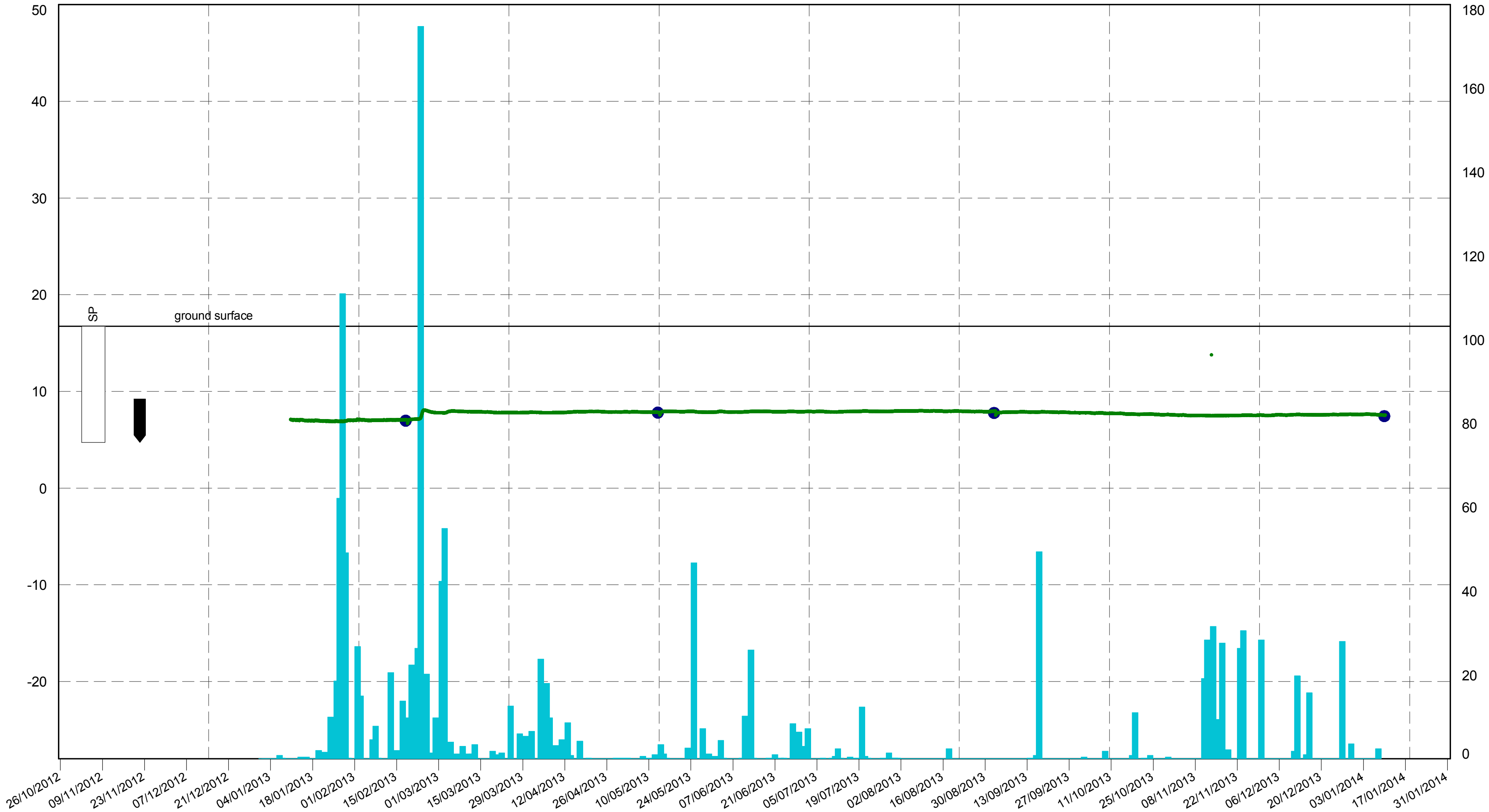
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME**
BH1197

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H5** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:51



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 16.72 m AHD
Borehole Depth: 12.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 4.72 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 12.00 m bgl
RL of Tip: 5.48 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

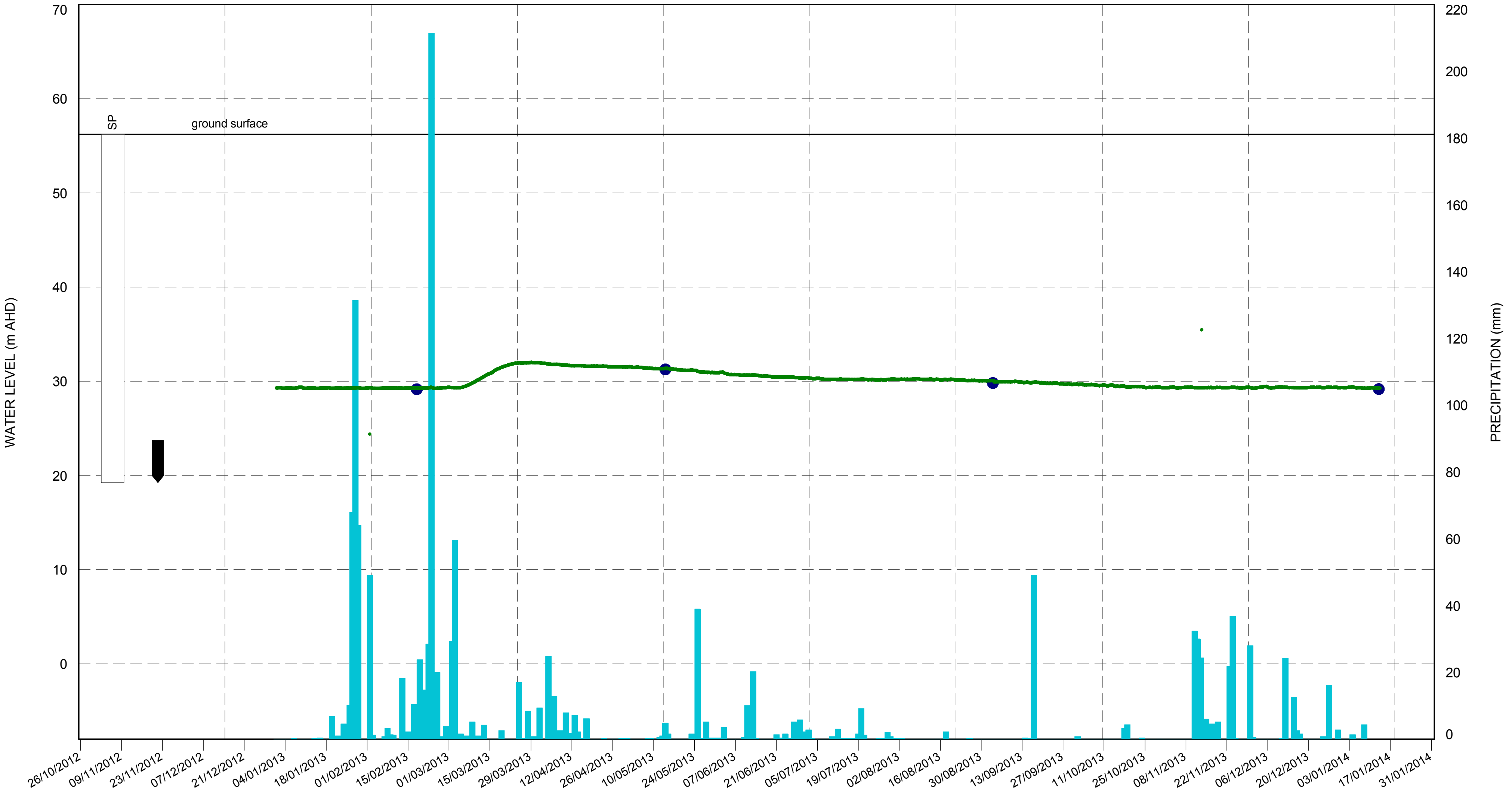
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ52**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H56** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 56.22 m AHD
Borehole Depth: 37.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 37.00 m bgl
RL of Tip: 19.22 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 37.00 m bgl
RL of Tip: 22.53 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

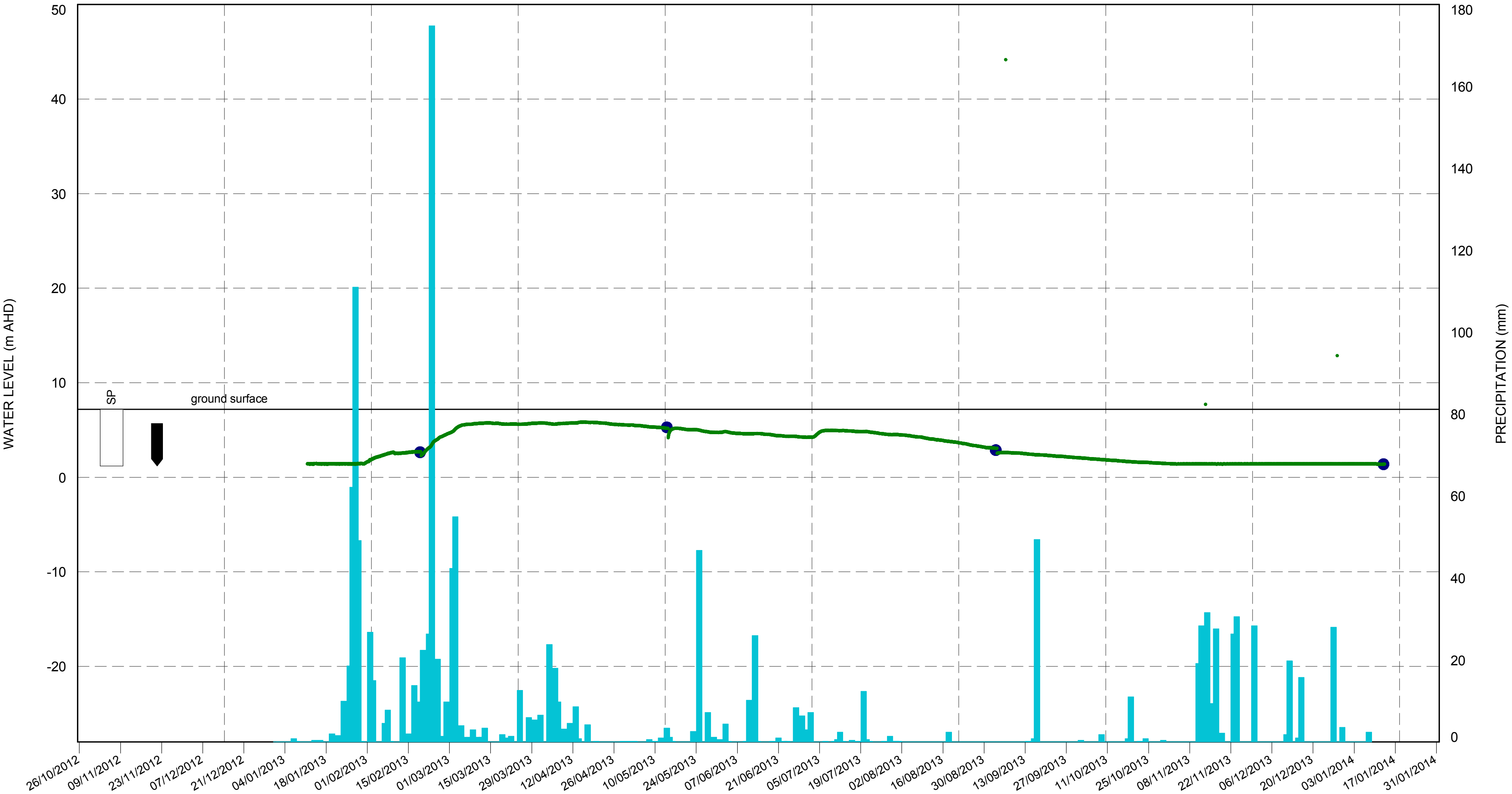
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1200

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H6 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:52



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:00

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 7.19 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.19 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: 1.38 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ53**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H57** | rev:

Appendix C

Section 4 – Tyndale to Maclean:

Pre-Construction Monitoring Results

Section 4: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	*Waterway Description*	*Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems*
SW12 – South Arm Clarence River SW23 – Shark Swamp Overflow SW13 – Shark Creek SW14 – Edwards Creek	The waterways in Section 4 are tidally influenced estuarine systems dominated by saline conditions. The exception is the upstream margins of Shark Creek which are assessed to be a lowland freshwater ecosystem.	▪ The highway upgrade alignment at Shark Creek is nearby to SEPP 14 Wetland No. 232, located on the eastern side and upstream of the project. ▪ Key fish habitats are assessed to be present in South Arm (Clarence River), and Shark Creek.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 4: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the mid-teens (15-16°C) in winter up to the high 20s (around 26-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks and tidal waterways.

Turbidity and total suspended solids (TSS) data varied greatly with some correlation between high TSS results and wet weather as would normally be anticipated. There was also a generally weak correlation between turbidity and TSS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 4.5 to 6.7.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period. With the exception of level spikes caused by rainfall.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 0.18 mg/L. Total Nitrogen values were generally less than 1.0 mg/L. However higher Nitrogen values were recorded at sample point SW23

Heavy Metals

Heavy metals were generally below detection limits for all sample locations.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW23 Shark Swamp Overflow (Downstream) Ch. 73,400	▪ Shark swamp overflow is a permanent water course (cane drain) located within private property (Lot 24 DP1007618). There was some variation in the sampling point due to flooding of the cane paddocks following heavy rainfall events. The sample point varied from the outlet adjacent to the Pacific Highway to 700m down along the cane drain. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity with generally slow flows to stagnant water. There were moderate flows in Round 1 and 11a and fast flows observed in Round 2 (February). ▪ Water levels were high during February (Round 1 and 2) and low during Round 8 – 10 and 12. Normal water levels remaining months.	▪ O&G: <5-6.5mg/L ▪ TSS: <5-170mg/L ▪ TP: <0.01-0.21mg/L ▪ TN: 0.3-9.1mg/L ▪ DO: 1.52-11.89mg/L ▪ EC: 119.3-2158µS/cm ▪ pH: 3.38-6.49 ▪ Temp: 15.90-30.7ºC ▪ NTU: 4-46.6
SW13 Shark Creek (Tidal) Ch. 75,000	▪ Shark Creek is a large Creek system, adjacent to Gallaghers Lane with the sample location within the road reserve up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. There were moderate flows during the wet weather event in February (Round 2). ▪ Water levels were high in February (Round 2) and the remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: <5-38mg/L ▪ TP: <0.01-0.07mg/L ▪ TN: 0.33-1.2mg/L ▪ DO: 1.3-9.84mg/L ▪ EC: 123.5µS/cm-7.40mS/cm ▪ pH: 3.78-7.16 ▪ Temp: 15.1-26.8ºC ▪ NTU: 4.18-62.1
SW14 Edwards Creek (Downstream) Ch. 80,200	▪ Edwards Creek is a tidal creek system, adjacent to the Pacific Highway with the sample location within the road reserve down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity during the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 1, 3 and 4 (February, March and April). ▪ Water levels were high in February (Round 2), the Creek was low during the Round 8, 10 and 12 (August, October and December). The remaining months were observed as normal water levels.	▪ O&G: <5-8.5mg/L ▪ TSS: <5-34mg/L ▪ TP: <0.01-0.18mg/L ▪ TN: 0.14-2mg/L ▪ DO: 1.03-9.65mg/L ▪ EC: 159.2µS/cm-7.96mS/cm ▪ pH: 3.71-7.18 ▪ Temp: 16.3-28.0ºC ▪ NTU: 3.61-32.30

Note: * Ch. = Highway Chainage

Section 4: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 4							
		SW23 (SW4-01 and SW4-02)							
Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.77	1.03	2.5	6.5	2.5	2.50	-	
Suspended Solids	mg/l	21.91	41.98	2.5	170	9	23.00	-	
Total Phosphorus as P	mg/l	0.10	0.13	0.005	0.5	0.05	0.12	-	
Total Nitrogen as N	mg/l	1.53	2.27	0.3	9.1	0.7	1.34	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.15	2.57	1.52	11.89	7.54	8.51	5.10	
Conductivity	µs/cm	1008.03	627.95	119.3	2158	1144	1467.20	234.00	
pH		4.81	1.03	3.38	6.49	4.54	5.90	3.93	
Temperature	°C	22.70	4.98	15.9	30.7	22.7	26.36	-	
Turbidity	NTU	36.57	82.52	4	331	10.5	29.54	-	
		SW13 (SW4-03 and SW4-04)							
Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	16.59	12.42	2.5	38	11	31.00	-	
Total Phosphorus as P	mg/l	0.07	0.13	0.005	0.5	0.02	0.06	-	
Total Nitrogen as N	mg/l	0.60	0.25	0.33	1.2	0.51	0.72	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.05	2.77	1.3	9.84	7.05	8.06	3.15	
Conductivity	µs/cm	673.95	518.34	123.5	1548	447.5	1156.20	328.20	
pH		6.05	1.10	3.78	7.16	6.24	7.13	5.40	
Temperature	°C	21.99	3.93	15.1	26.8	22.8	25.74	-	
Turbidity	NTU	16.09	16.11	4.18	62.1	11.1	15.86	-	
		SW14 (SW4-05 and SW4-06)							
Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.90	1.55	2.5	8.5	2.5	2.50	-	
Suspended Solids	mg/l	13.37	9.71	2.5	34	13	19.40	-	
Total Phosphorus as P	mg/l	0.17	0.44	0.005	1.75	0.03	0.15	-	
Total Nitrogen as N	mg/l	0.69	0.46	0.14	2	0.53	1.00	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.18	2.90	1.03	9.65	8.63	9.63	4.97	
Conductivity	µs/cm	1258.51	1640.13	159.2	4670	332	1728.40	199.12	
pH		6.31	1.07	3.71	7.18	6.72	6.96	5.65	
Temperature	°C	22.70	3.91	16.3	28	22.4	26.26	-	
Turbidity	**NTU**	**13.79**	**9.68**	**3.61**	**32.3**	**10.9**	**22.96**	**-**	

Section 4: Groundwater Monitoring – Water Quality Overview

Electrical Conductivity

Values are indicative of freshwater to brackish/ saline groundwater conditions with average salinity values ranging between 200 µS/cm (PZ21) to 9,320 µS/cm (PZ09). Generally the 12 well locations with shallower water levels (<5.0m below ground level) found within areas of fill or the bridge locations near Edwards Creek of the south bank of the Clarence River showed larger standard deviations than wells with standing water levels at greater depths located in cuts. The observed variation may be due to these locations proximity to tidal waterways and the influence of wet weather events on groundwater conductivity.

pH

pH, of groundwater in Section 4 show average values ranging from pH 5.68 (PZ55) to pH 10.29 (BH1206). The majority, 19 of 20 locations, had an average pH >6 which indicates a slightly acidic to neutral pH in groundwater throughout Section 4. Little variation occurs in pH with 4 of the 20 wells reporting a standard deviation value >1 pH unit.

Temperature

The average temperature values for the monitoring locations in Section 4 ranged between 20.8°C to 23.4°C. The variation in groundwater average temperature values throughout Section 4 is likely to be attributable to seasonal temperature changes and the variable depth of groundwater from the ground surface.

Summary Statistics for Groundwater Physico-Chemical Monitoring

Cut/Fill Number	*Borehole Identifier*	*Electrical Conductivity (µS/cm)*				*pH*				*Temp. (°C)*
		Med.*	**SD****	**P80**	**P20**	**Med.***	**SD****	**P80**	**P20**	**Med.***
Cut 4-2	BH1206	239	100	297	189	10.54	0.63	10.62	10.05	21.60
	PZ54	556	255	568	352	7.13	1.12	7.22	6.25	21.25
Fill F4-2A	PZ55	1831	1269	2774	702	5.84	1.69	7.07	4.35	22.75
	PZ56	22.75	2.20	23	21	6.23	0.67	6.61	5.70	22.75
Fill F4-2B	PZ57	1496	3755	4912	186	6.78	0.53	7.26	6.55	21.65
	PZ58	5565	3404	6744	3233	6.81	0.48	7.08	6.45	21.55
Fill F4-2C	PZ59	506	423	827	333	7.25	0.99	7.95	6.54	22.10
	PZ60	1536	938	1876	982	6.85	0.67	7.44	6.59	22.20
Cut 4-4	BH1251	308	29	323	283	7.16	0.32	7.32	6.91	20.85
	BH1259	2068	668	2351	1784	6.73	0.16	6.79	6.66	21.20
Cut 4-5	BH1261	1663	2066	3558	132	7.42	0.32	7.53	7.14	22.40
	PZ61	7600	323	7772	7456	6.36	0.53	6.77	6.17	22.15
Fill F4-5	PZ62	2775	1363	3020	1681	6.31	1.62	7.62	6.19	21.80
	PZ63	4500	366	4818	4362	6.59	0.29	6.81	6.36	21.55
Cut C4-6	PZ64	4675	1126	5168	3658	6.61	0.07	6.67	6.56	22.30
	PZ65	Dry								

Cut/Fill Number	*Borehole Identifier*	*Electrical Conductivity (µS/cm)*				*pH*				*Temp. (°C)*
		Med.*	**SD****	**P80**	**P20**	**Med.***	**SD****	**P80**	**P20**	**Med.***
Cut C4-7	PZ66	Dry								
	BH1359	399	329	639	246	6.68	0.54	6.98	6.33	22.10
Bridges - Edwards Creek	PZ67	1395	1209	1908	882	7.07	0.91	7.45	6.68	22.70
	PZ68	1169	440	1182	719	6.86	0.45	6.98	6.46	22.40
Maclean Int' change	PZ69	2845	2237	4564	876	7.46	1.02	8.13	7.10	21.20
	PZ70	9320	1245	9848	8792	7.17	0.33	7.31	7.02	21.20

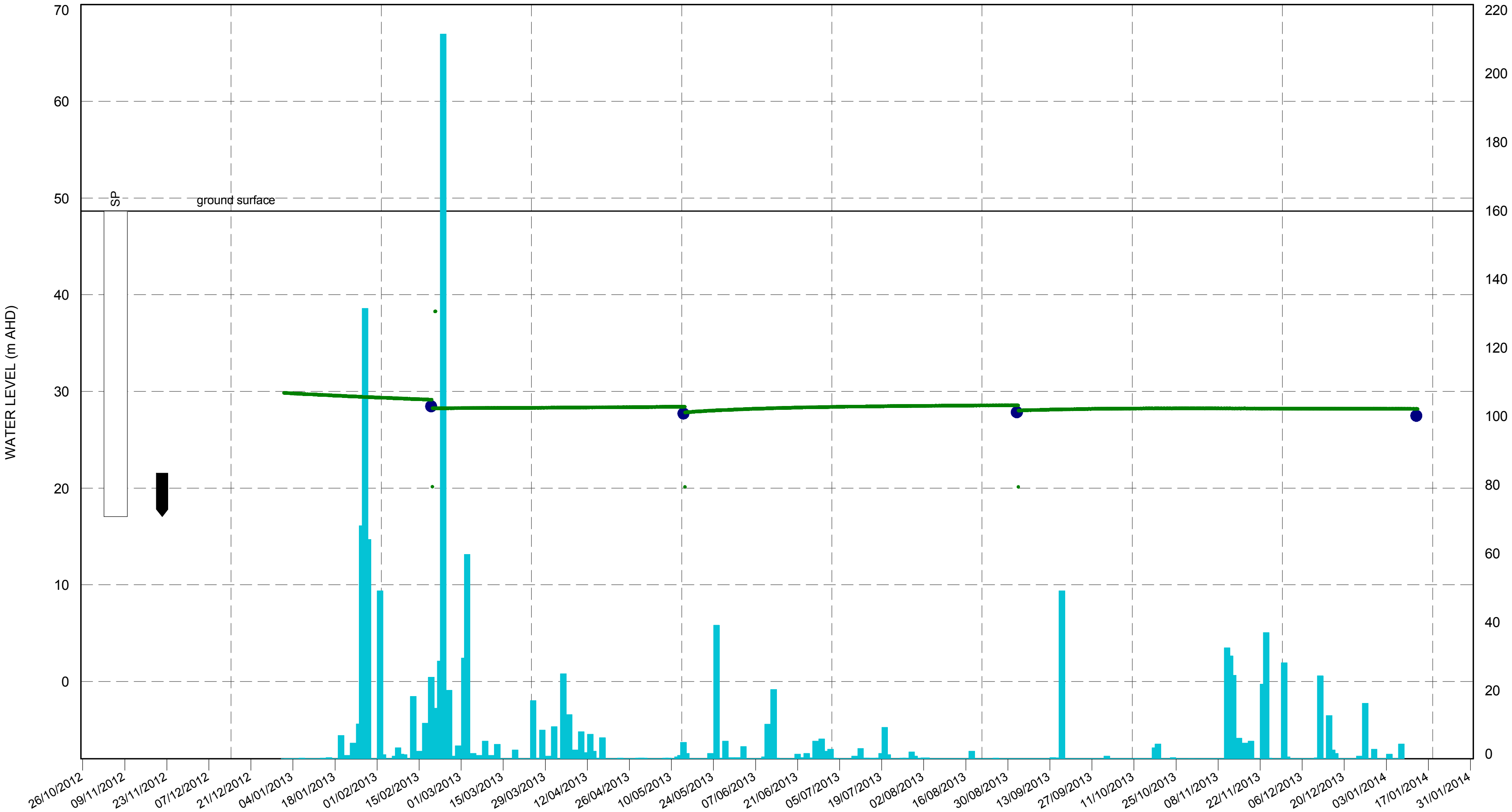
Note: * Med. = Median
** DS = Standard Deviation

Section 4: Groundwater Monitoring – Levels

The typical standing water levels in Section 4 averaged between 0.07m (PZ67) and 22.78m (BH1251) below ground surface. In general, the SWLs observed in areas of proposed fill or bridges in Section 4 were noted to be close to the ground surface (<2m bgs) indicating shallow groundwater. The long-term monitoring data indicates that the groundwater levels throughout much of Section 4 are influenced by large rainfall events (e.g. over 100mm rainfall event in January 2013). It should be noted the SWLs are relative to the topography of the monitoring location.

Summary of Groundwater Level Monitoring – Section 4 G2DP Upgrade

Cut/Fill Number	*Monitoring Location*	*Borehole Depth*	*Typical SWL (m below ground level)*		
			AVG	*MED*	*SD*
Cut 4-2	BH1206	31.6	20.78	20.87	0.42
	PZ54	14	6.91	6.14	2.68
Fill F4-2A	PZ55	6	0.57	0.69	0.40
	PZ56	6	1.26	1.29	0.31
Fill F4-2B	PZ57	6	0.62	0.64	0.30
	PZ58	6	0.58	0.84	0.75
Fill F4-2C	PZ59	6	0.62	0.66	0.48
	PZ60	6	0.64	0.63	0.54
Cut 4-4	BH1251	40.2	22.78	23.08	0.97
	BH1259	15.25	14.75	14.75	0.52
Cut 4-5	BH1261	21	13.22	13.27	0.11
	PZ61	8.8	6.81	6.88	0.19
Fill F4-5	PZ62	6	0.64	0.63	0.50
	PZ63	6	0.55	0.54	0.51
Cut C4-6	PZ64	10	7.63	7.65	0.26
	PZ65	11	Dry	Dry	Dry
Cut C4-7	PZ66	14	Dry	Dry	Dry
	BH1359	16.12	5.70	5.67	6.58
Bridges Over Edwards Creek	PZ67	6	0.07	0.00	0.14
	PZ68	6	1.64	2.08	1.11
Maclean Interchange	PZ69	6	0.70	0.69	0.51
	PZ70	6	0.09	0.00	0.17



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 48.65 m AHD
Borehole Depth: 31.60 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 31.60 m bgl
RL of Tip: 17.05 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 31.60 m bgl
RL of Tip: 20.11 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

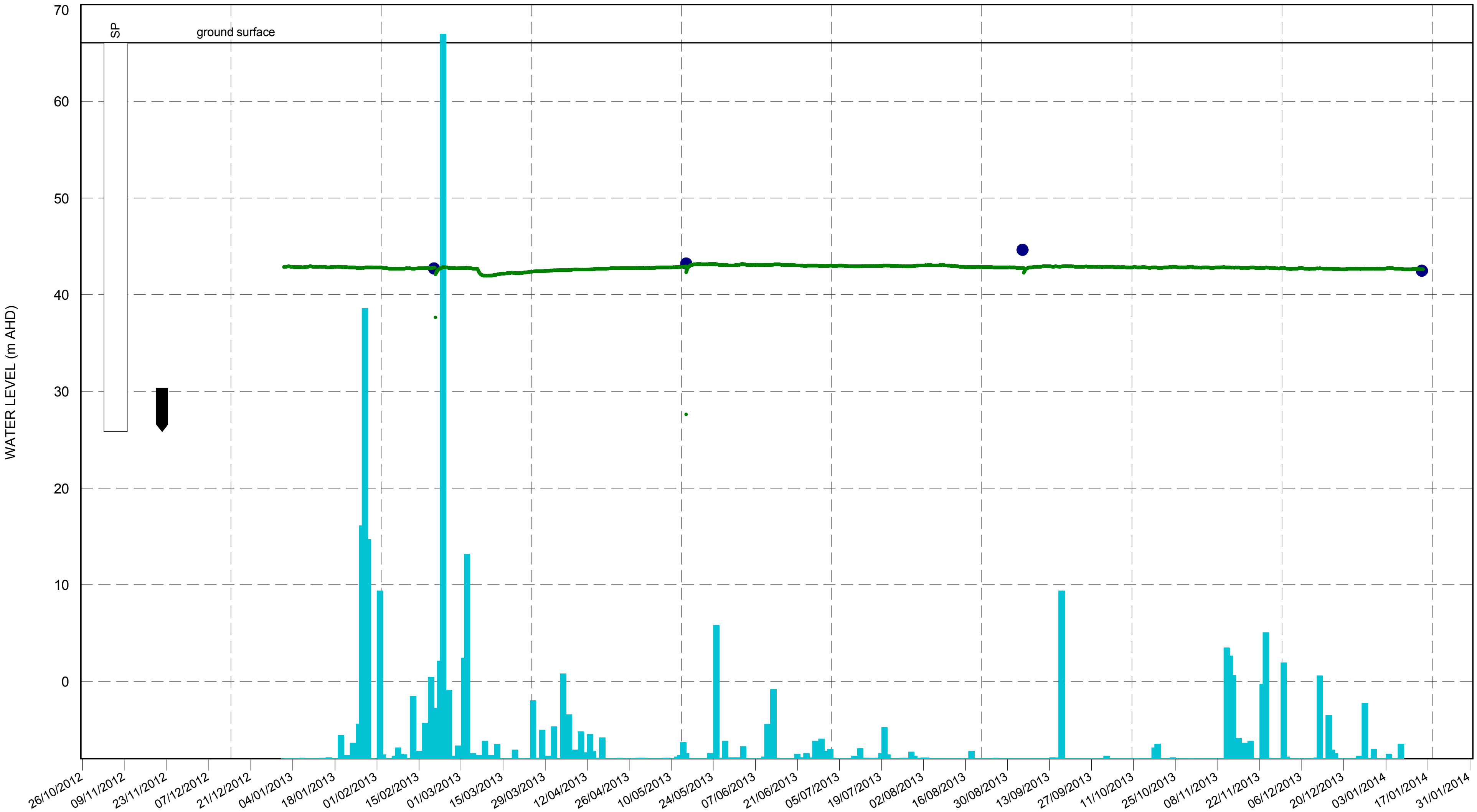
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1206

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H7 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:54



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

Surface RL: 66.04 m AHD
Borehole Depth: 40.20 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 40.20 m bgl
RL of Tip: 25.84 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 40.20 m bgl
RL of Tip: 27.61 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1251**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H8** | rev:

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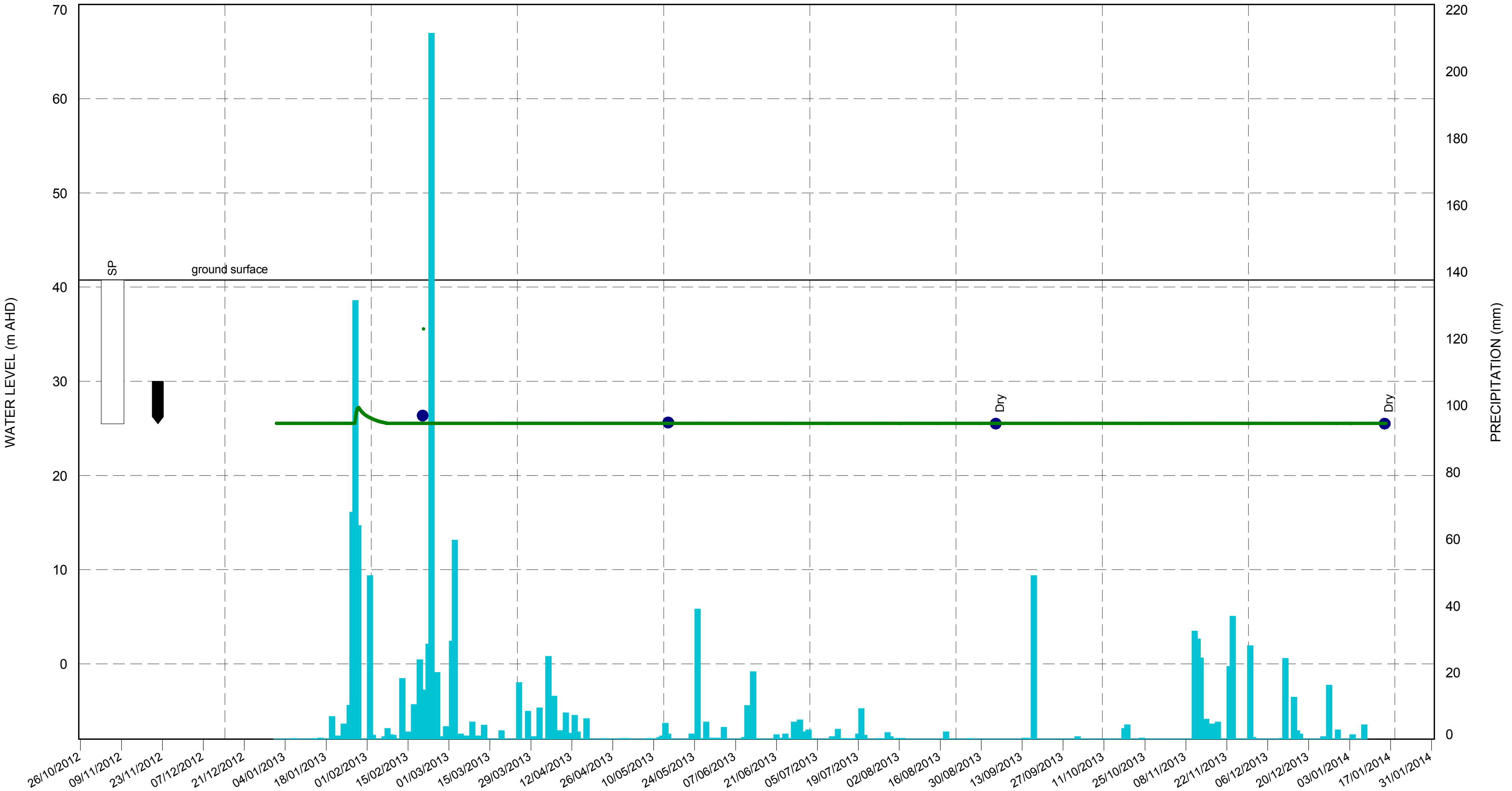
CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:57



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 40.74 m AHD
Borehole Depth: 15.25 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 15.25 m bgl
RL of Tip: 25.49 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.25 m bgl
RL of Tip: 25.50 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

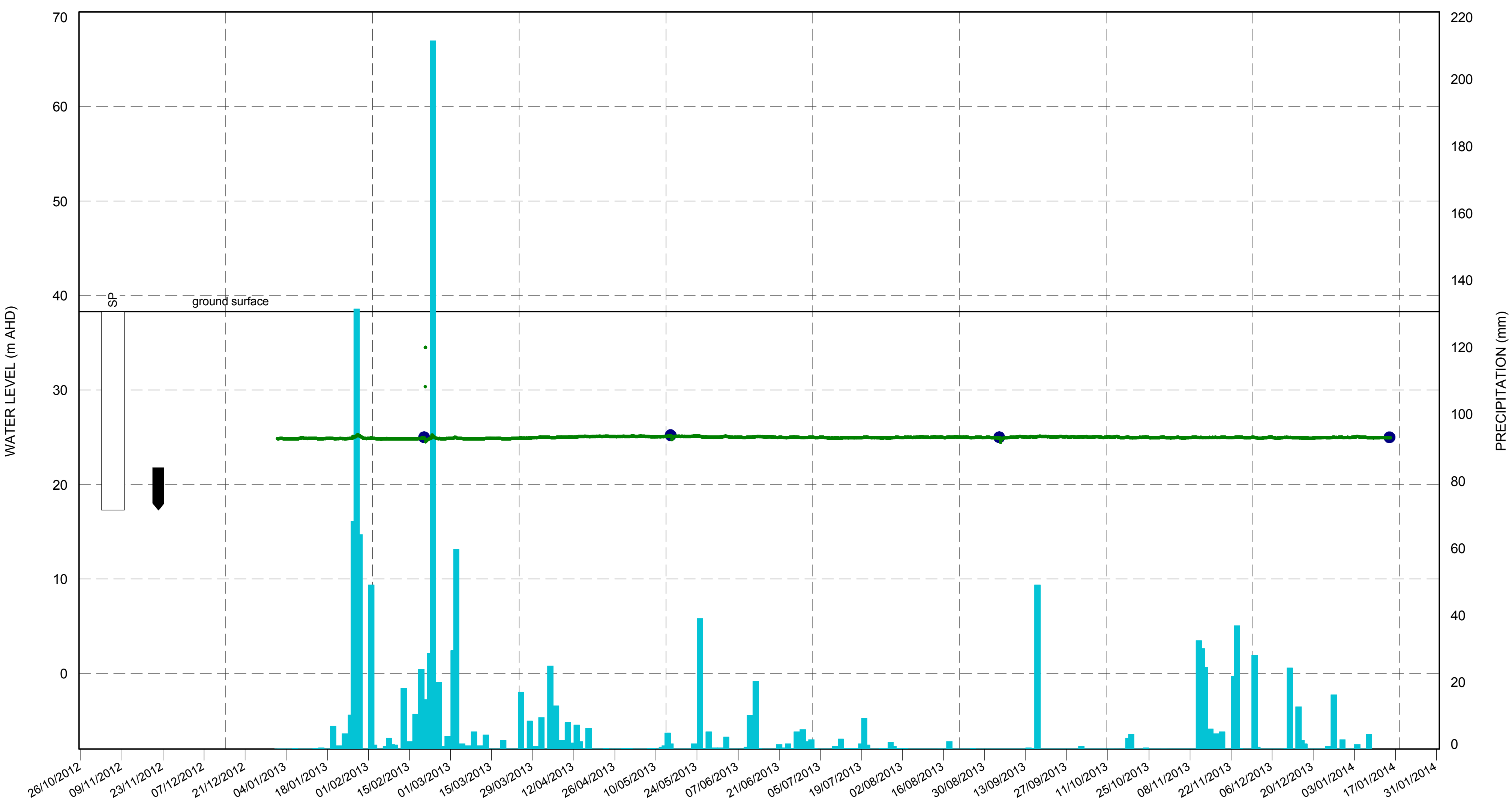
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1259**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H9** | rev:



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Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 38.27 m AHD
Borehole Depth: 21.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 21.00 m bgl
RL of Tip: 17.27 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 21.00 m bgl
RL of Tip: 20.30 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

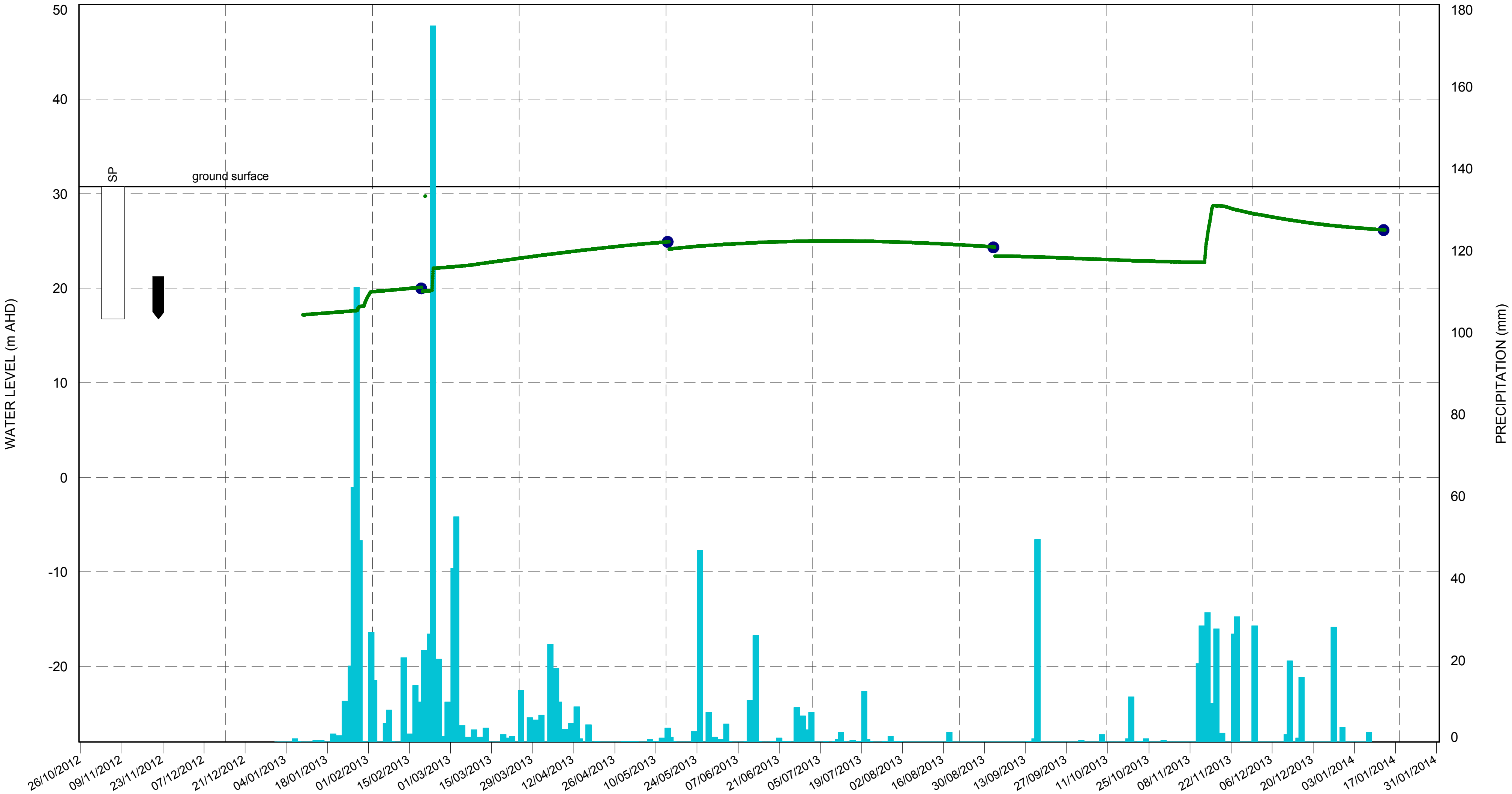
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1261**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H10** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:01

Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 30.74 m AHD
Borehole Depth: 14.00 m

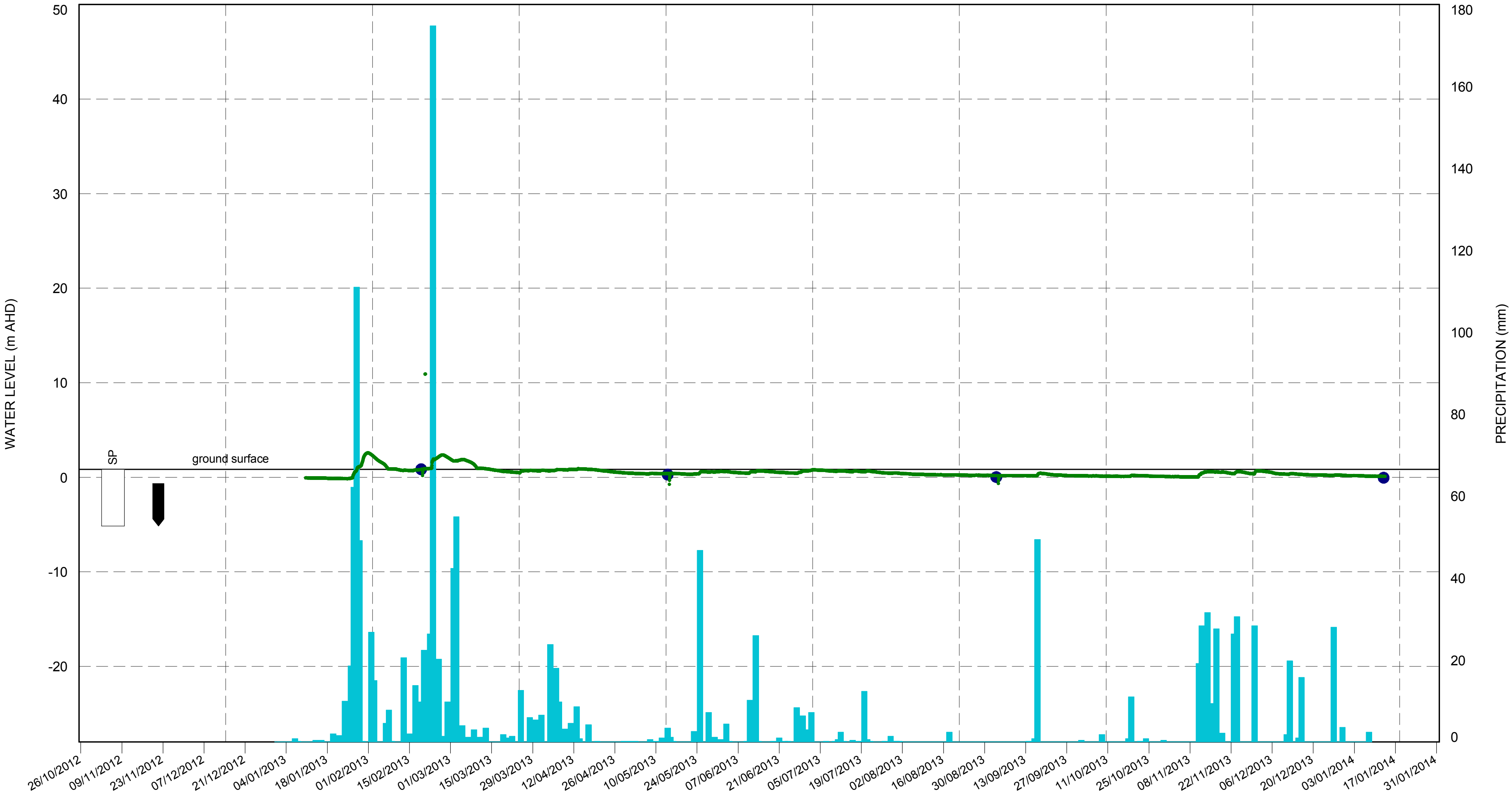
: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 16.74 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 17.12 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client:	Roads and Maritime Services
project:	Glenugie to Devils Pulpit Groundwater Monitoring
title:	GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ54
project no: GEOTCOFH03059AA-AO	fig no: FIGURE H58	rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.84 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.16 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.67 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

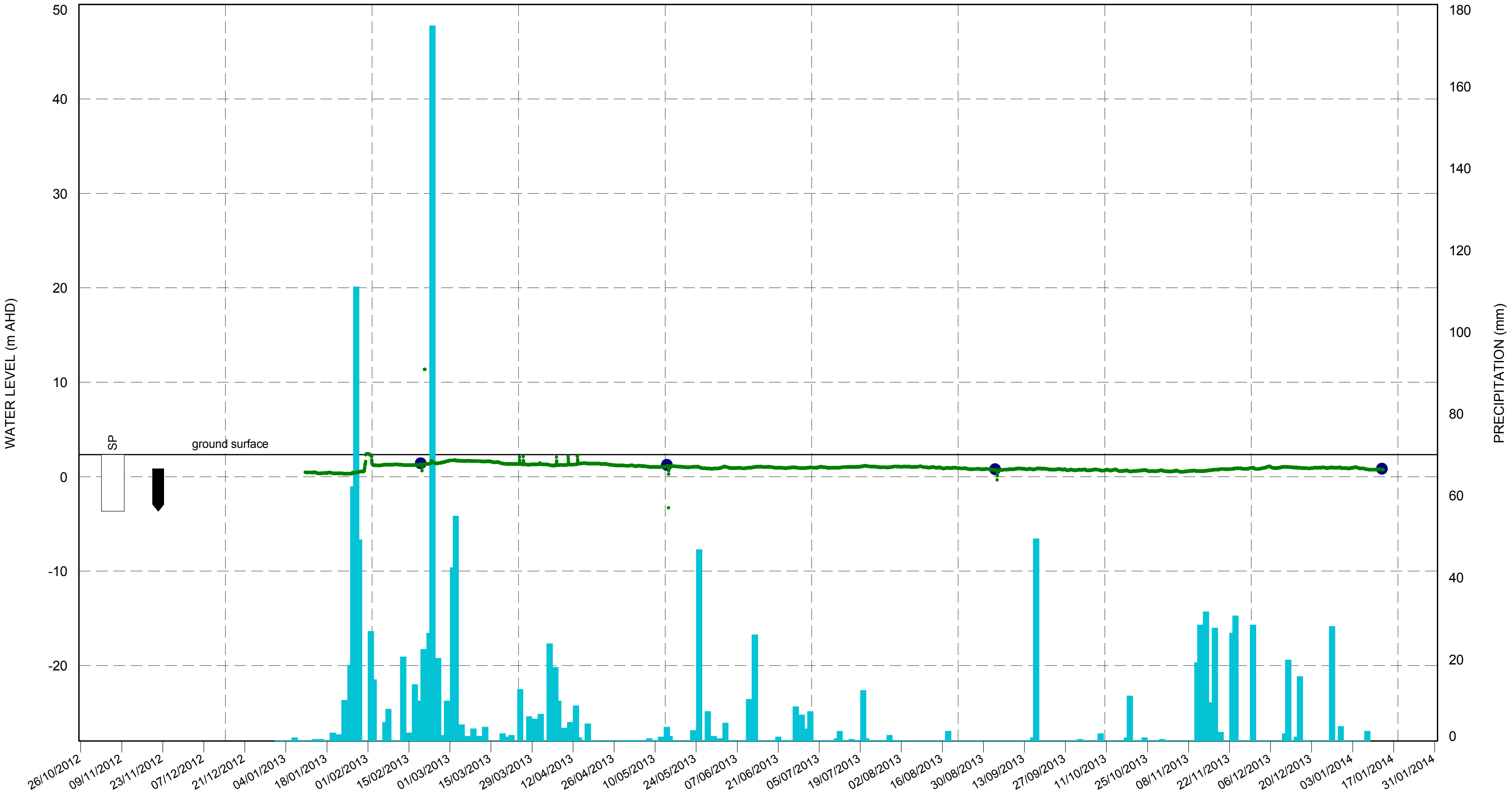
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ55**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H59** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:04



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 2.33 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.67 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.36 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

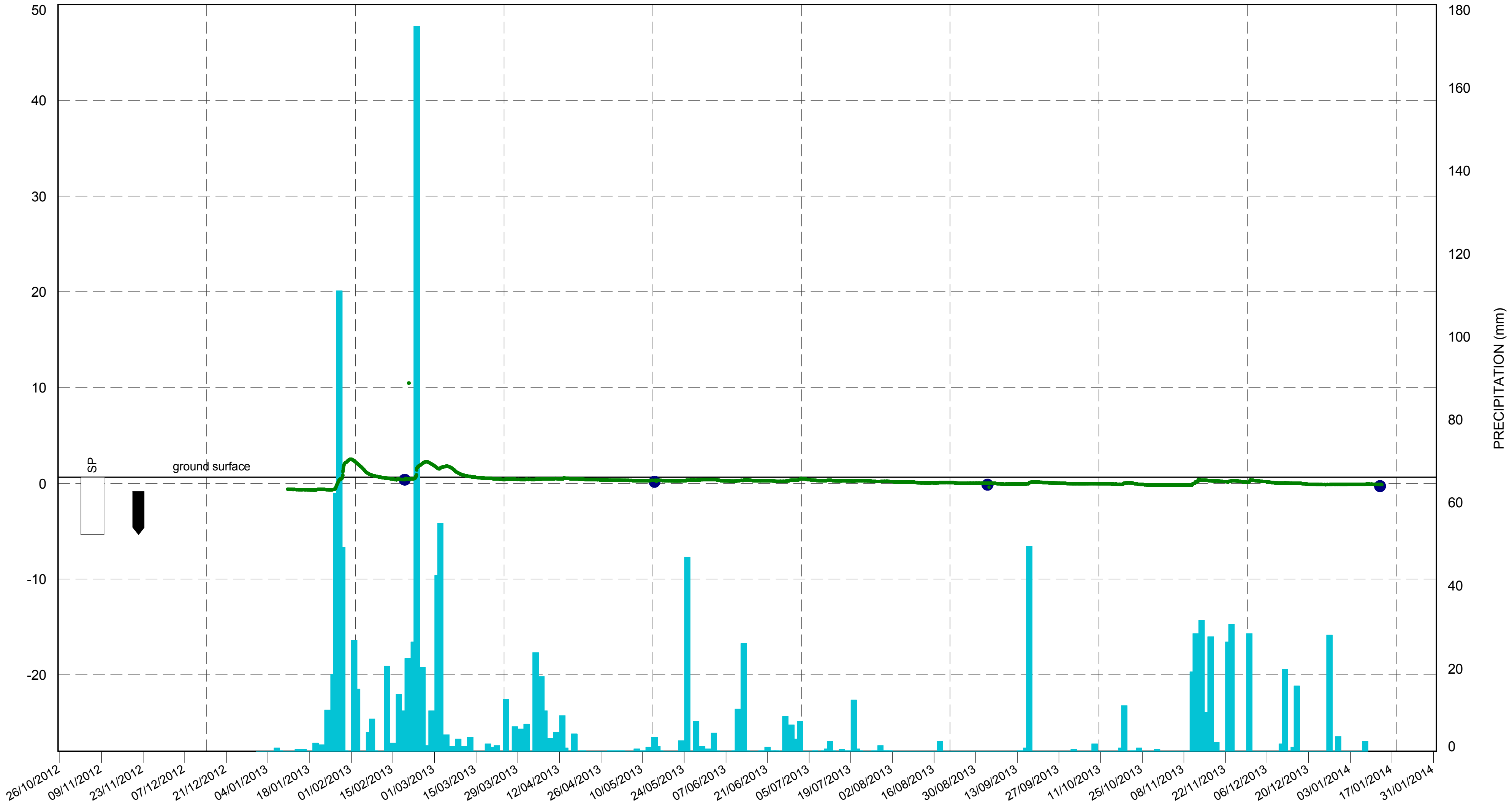
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ56**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H60** | rev:



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Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.64 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.36 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.16 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

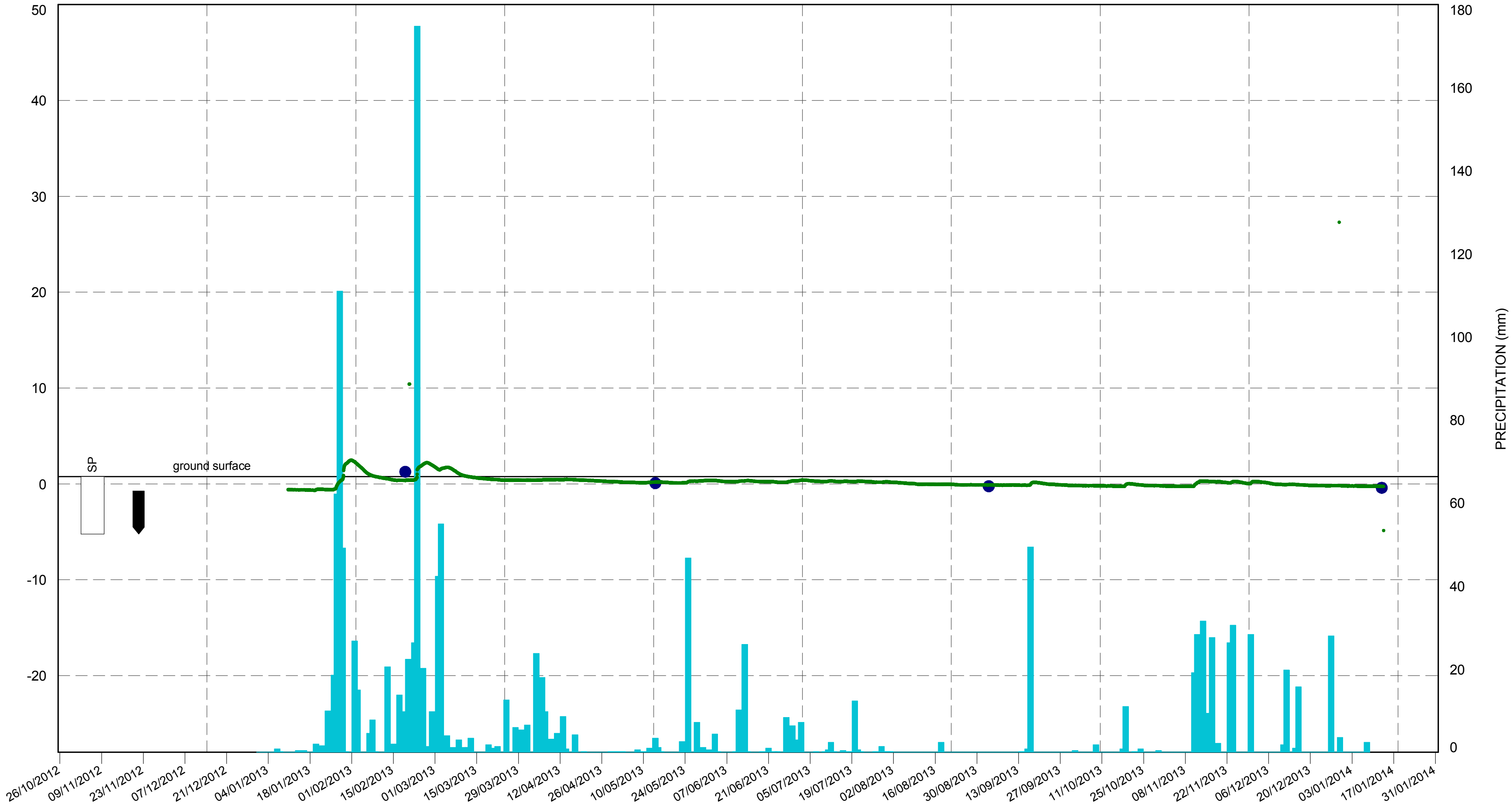
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ57**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H61** | rev:



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Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 0.75 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.25 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.94 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

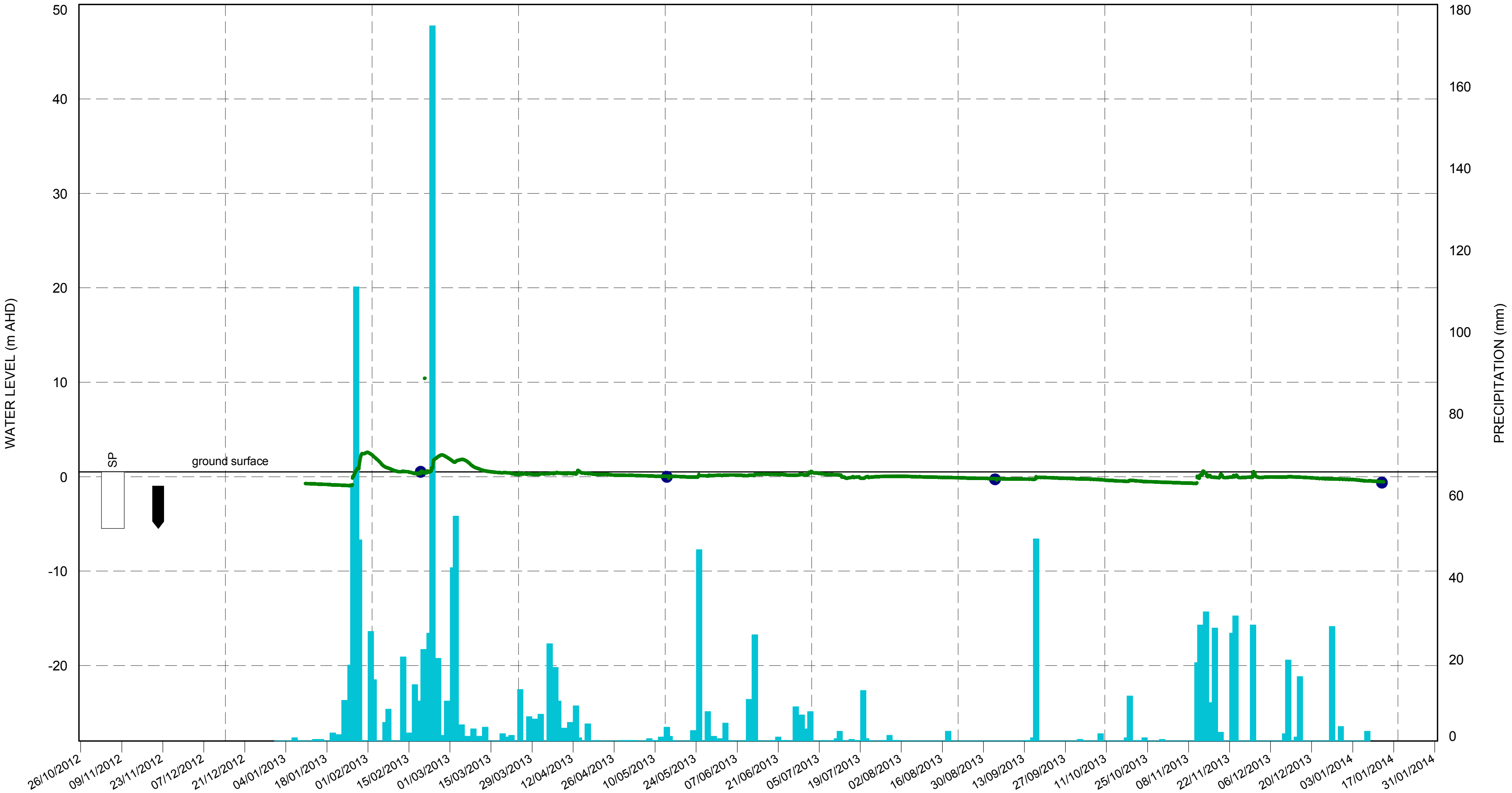
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ58**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H62** | rev:



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.51 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.49 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.82 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

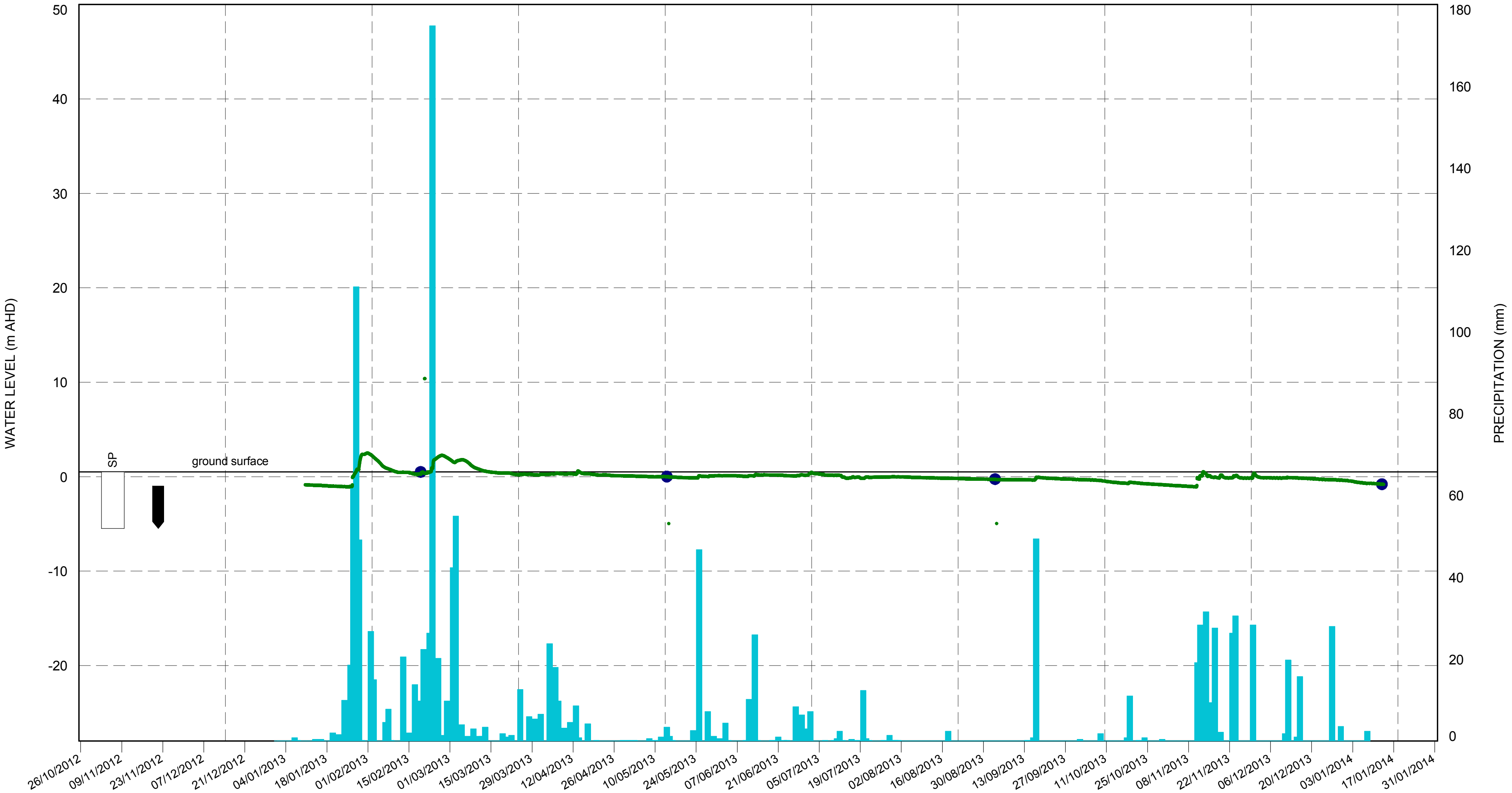
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ59**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H63** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:07



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:08

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 0.50 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.50 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.04 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

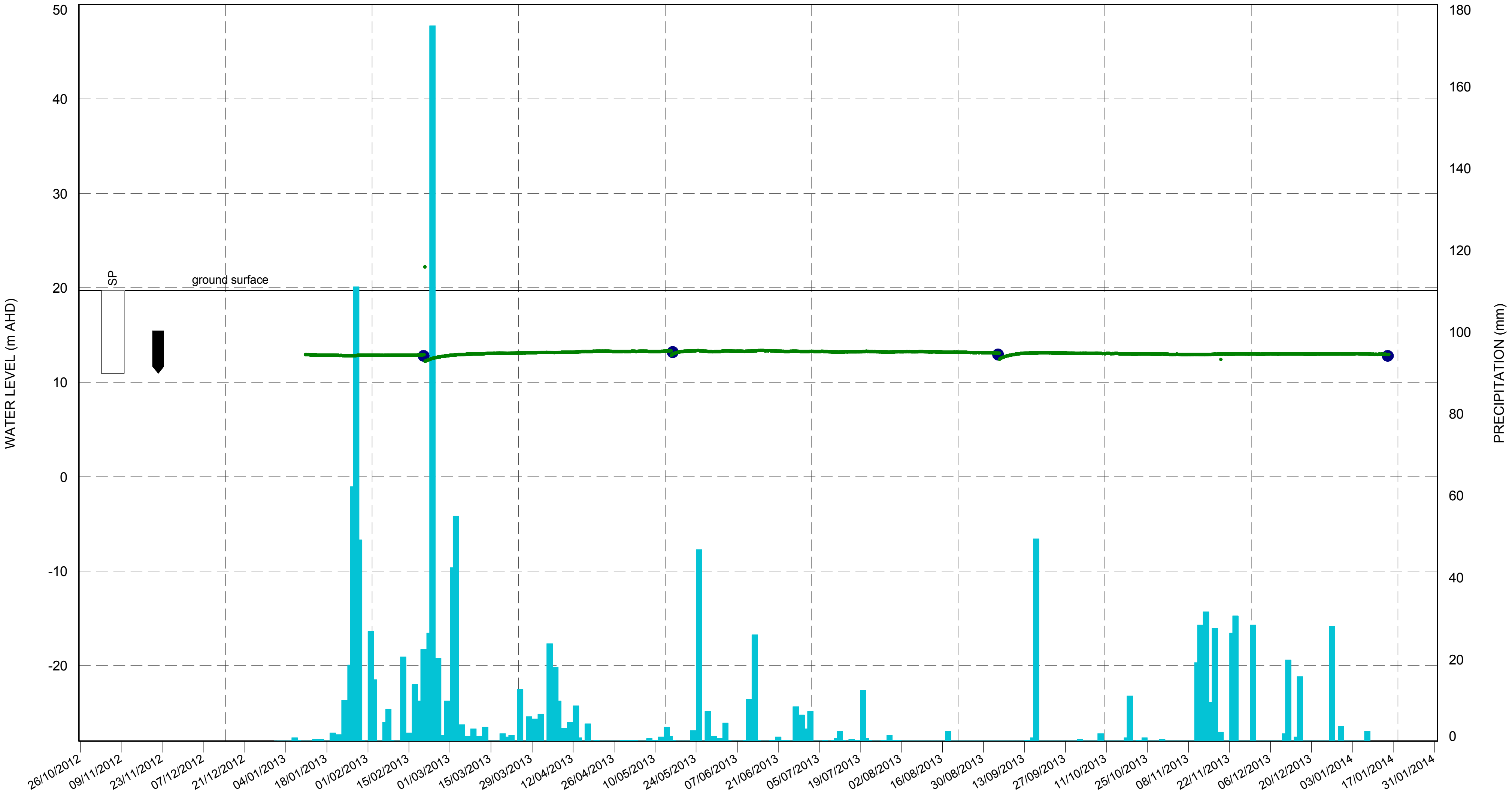
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ60**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H64** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 19.74 m AHD
Borehole Depth: 8.80 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 8.80 m bgl
RL of Tip: 10.94 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 8.80 m bgl
RL of Tip: 11.04 m AHD

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

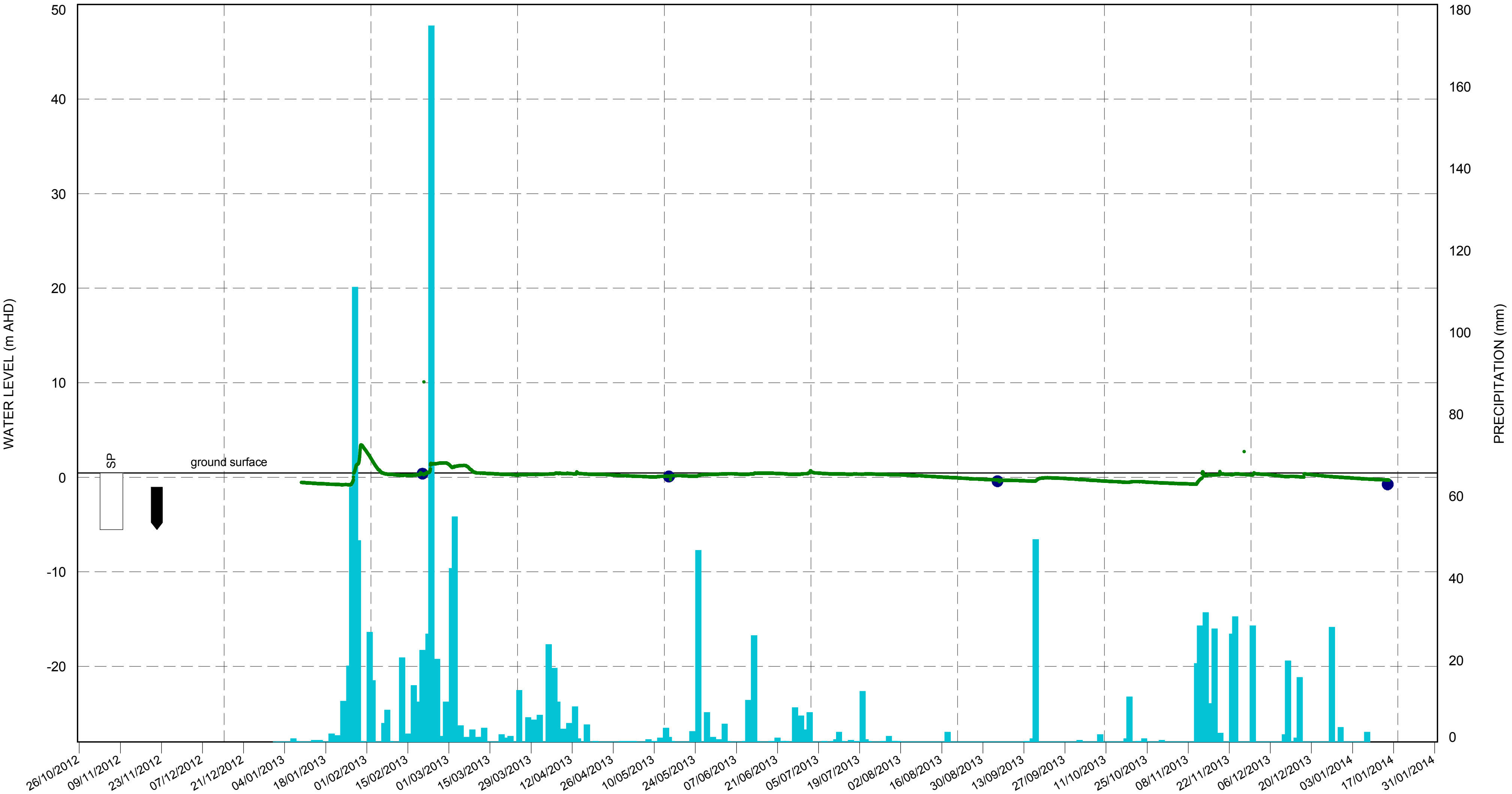
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ61**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H65** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:09



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:10

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.46 m AHD
Borehole Depth: 6.00 m

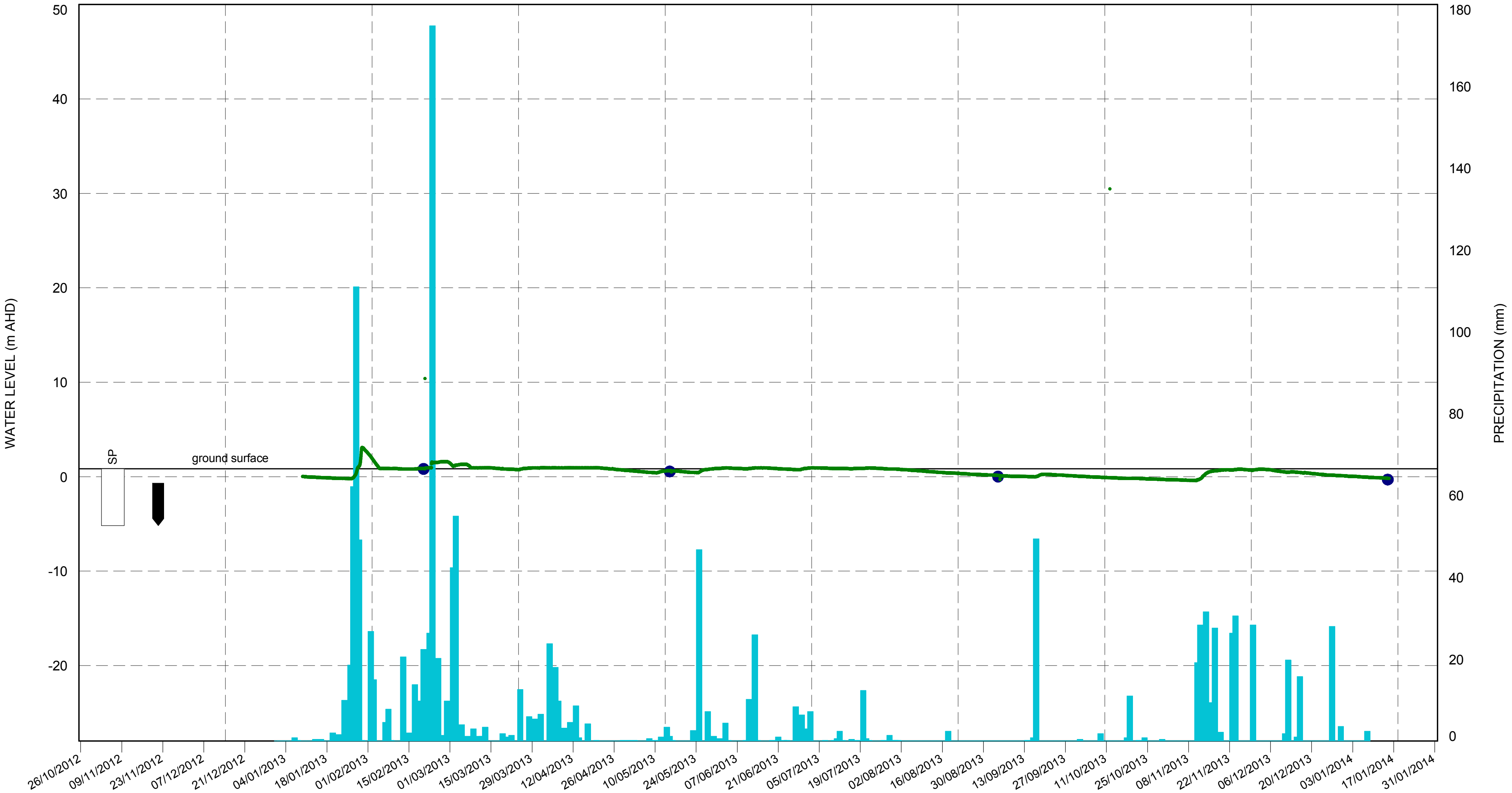
: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.54 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.04 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client:	Roads and Maritime Services		
project:	Glenugie to Devils Pulpit Groundwater Monitoring		
title:	GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ62		
project no: GEOTCOFH03059AA-AO	fig no:	FIGURE H66	rev:



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 0.82 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.18 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.59 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

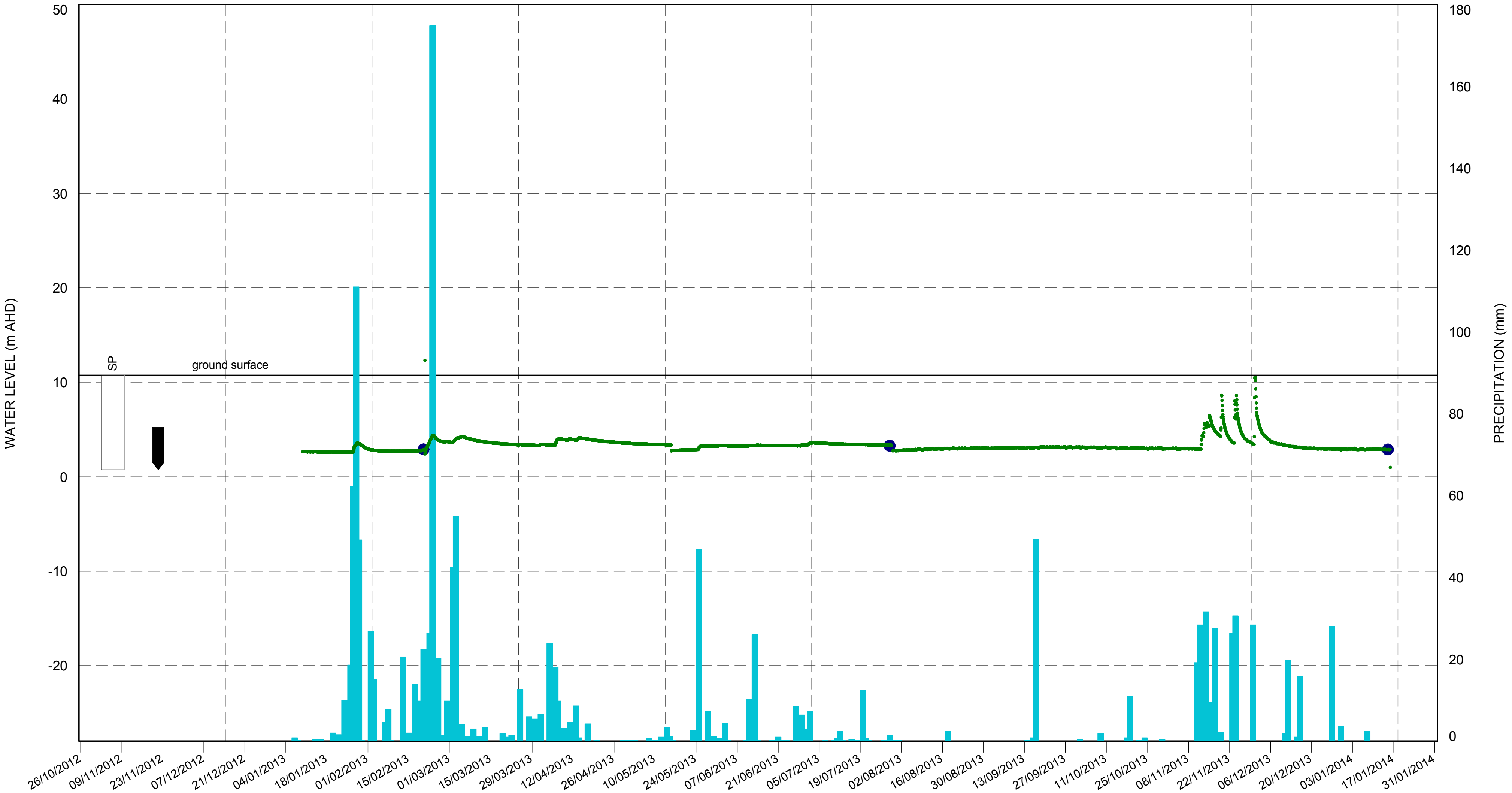
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ63**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H67** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:11



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 10.73 m AHD
Borehole Depth: 10.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 10.00 m bgl
RL of Tip: 0.73 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 10.00 m bgl
RL of Tip: 0.93 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

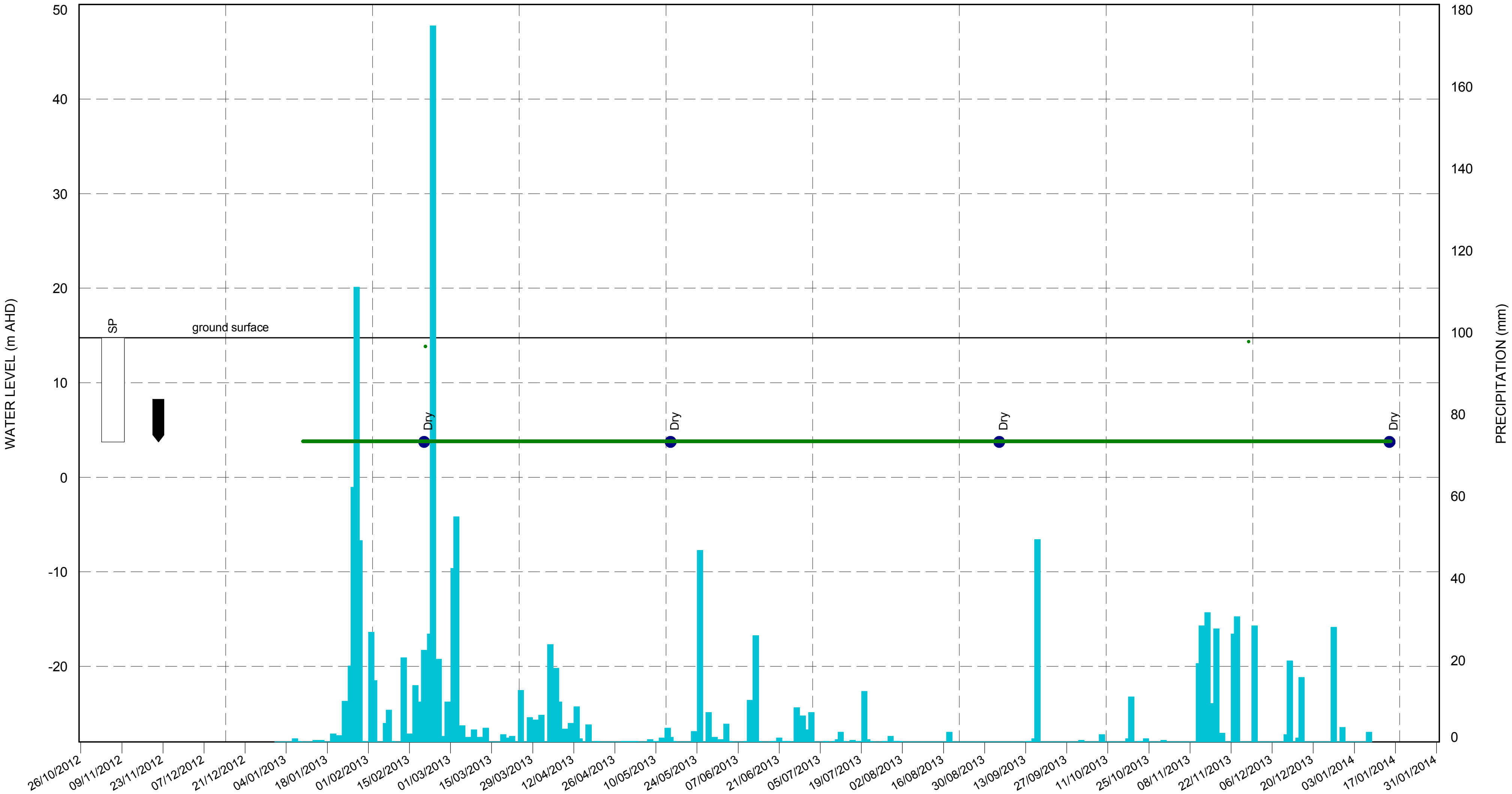
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ64**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H68** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 14.74 m AHD
Borehole Depth: 11.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 3.74 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 11.00 m bgl
RL of Tip: 3.74 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

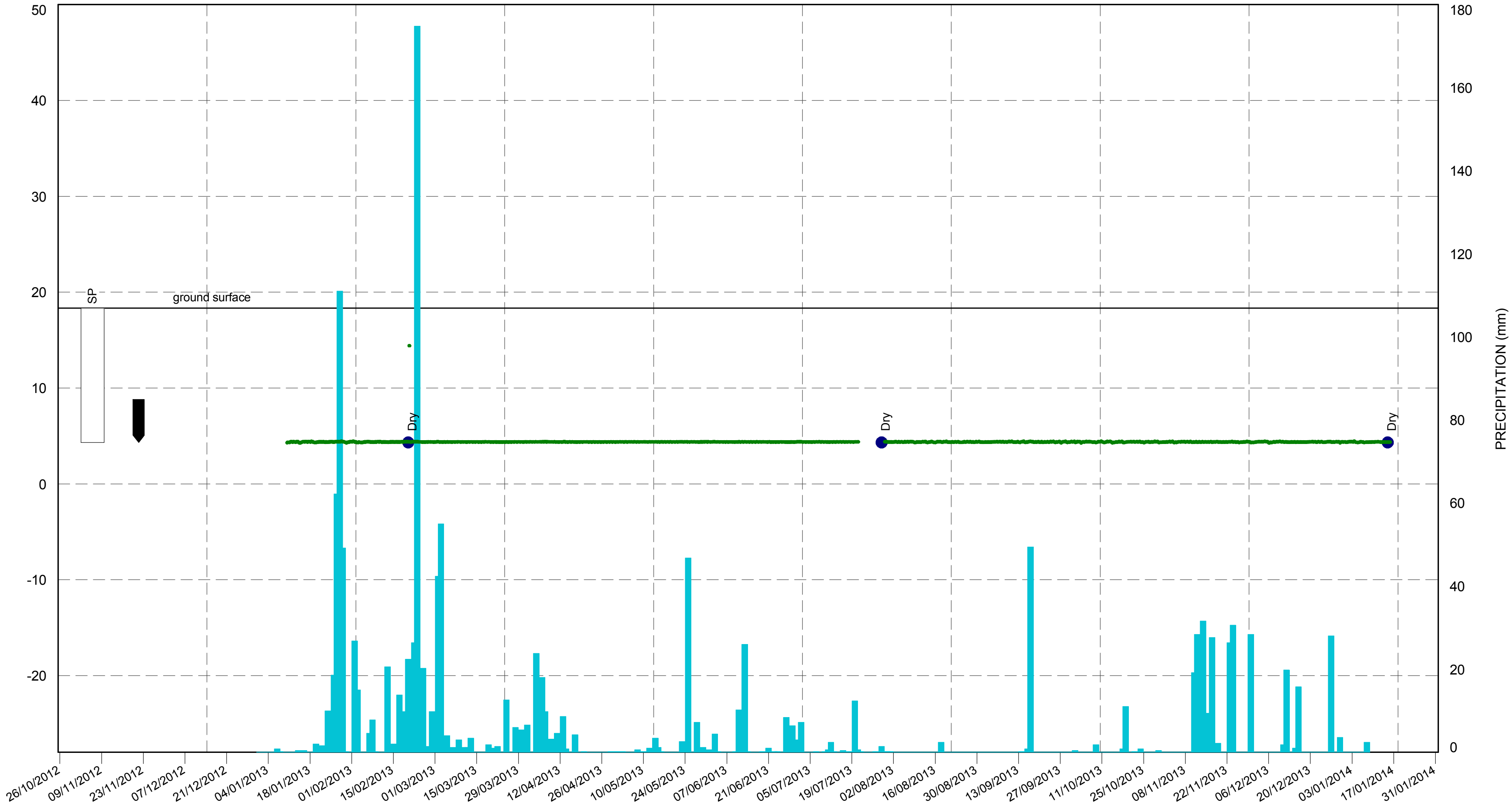
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ65**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H69** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:15

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 18.32 m AHD
Borehole Depth: 14.00 m

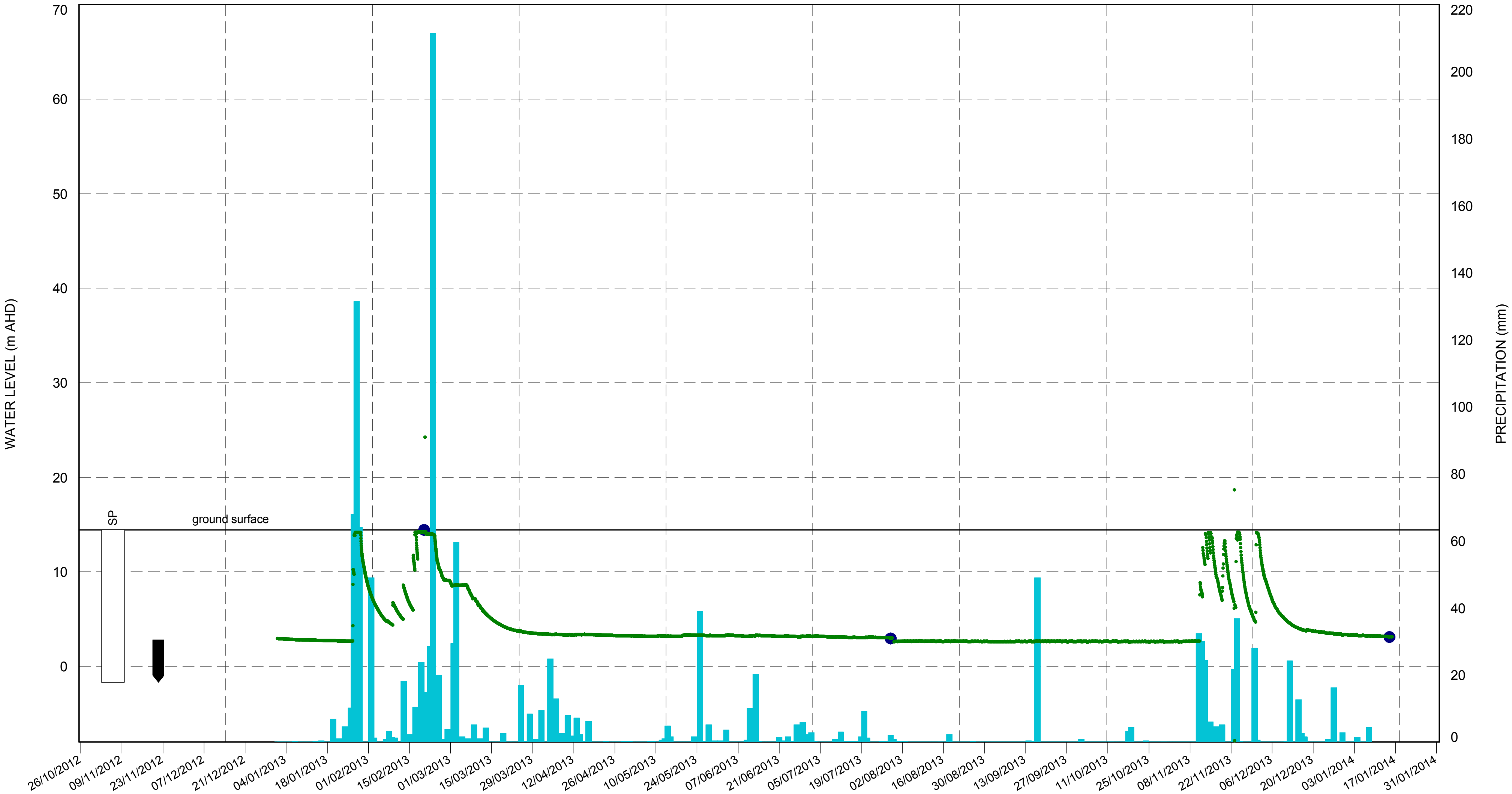
● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 4.32 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 14.00 m bgl
RL of Tip: 4.32 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client:	Roads and Maritime Services
project:	Glenugie to Devils Pulpit Groundwater Monitoring
title:	**GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ66**
project no: GEOTCOFH03059AA-AO	fig no: **FIGURE H70** rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 313630.GDW 11/03/2014 10:59

Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 14.43 m AHD
Borehole Depth: 16.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 16.12 m bgl
RL of Tip: -1.69 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 16.12 m bgl
RL of Tip: 0.79 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Grafton Airport AWS

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

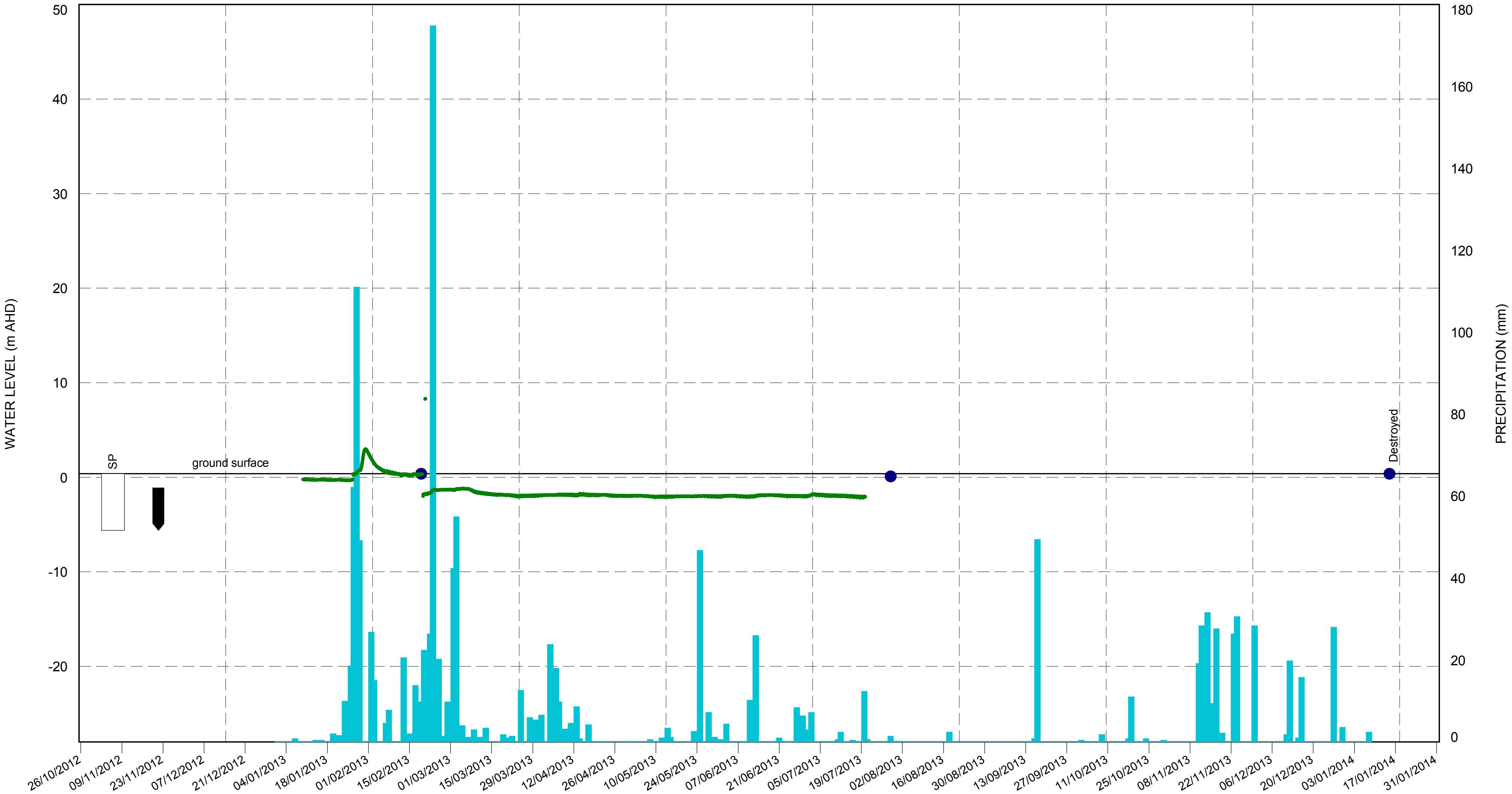
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME BH1359**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H11** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 0.37 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.63 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.17 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

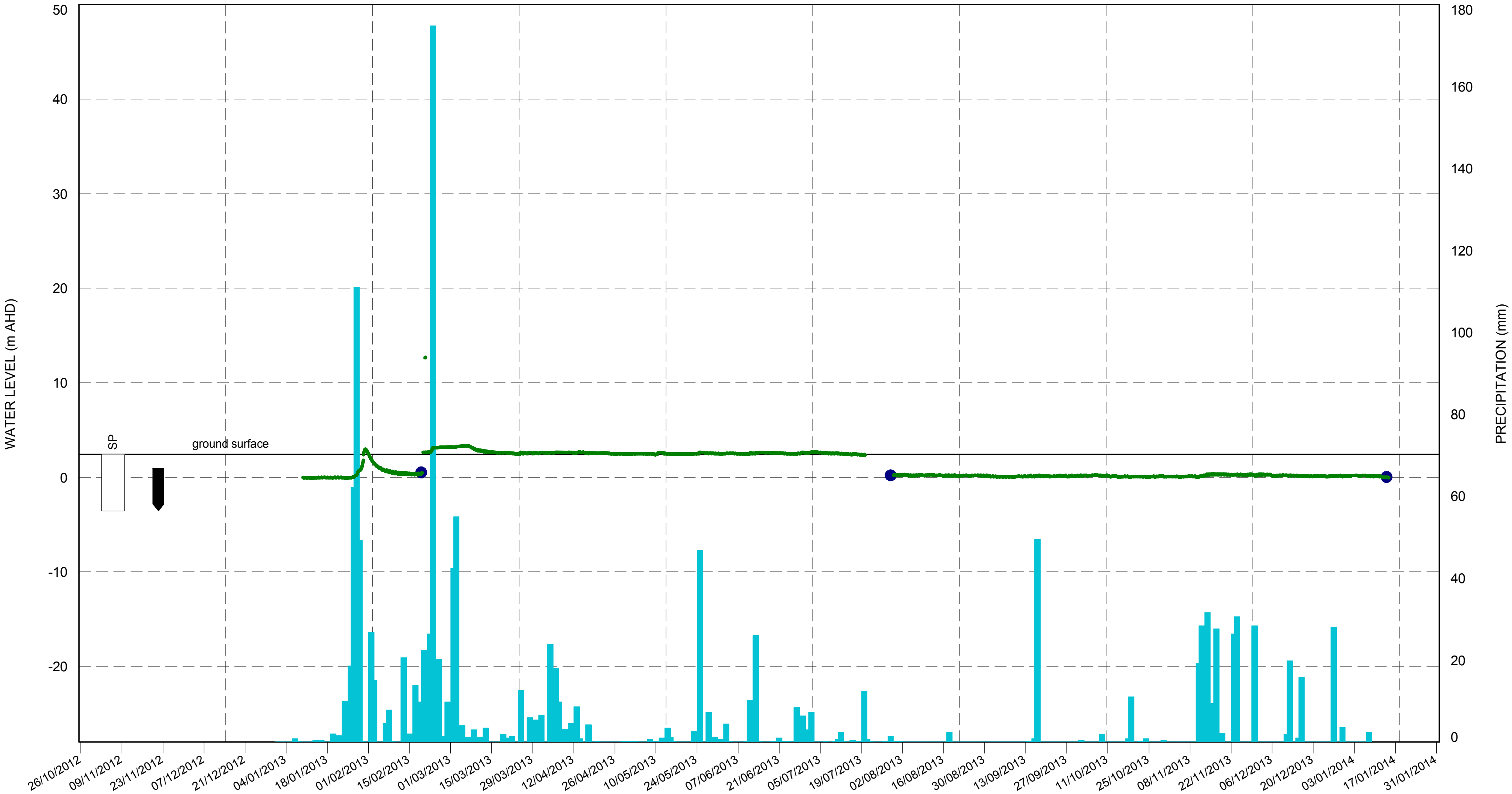
client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ67**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H71** | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:15



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 2.43 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -3.57 m AHD

▬: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -2.88 m AHD

■: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

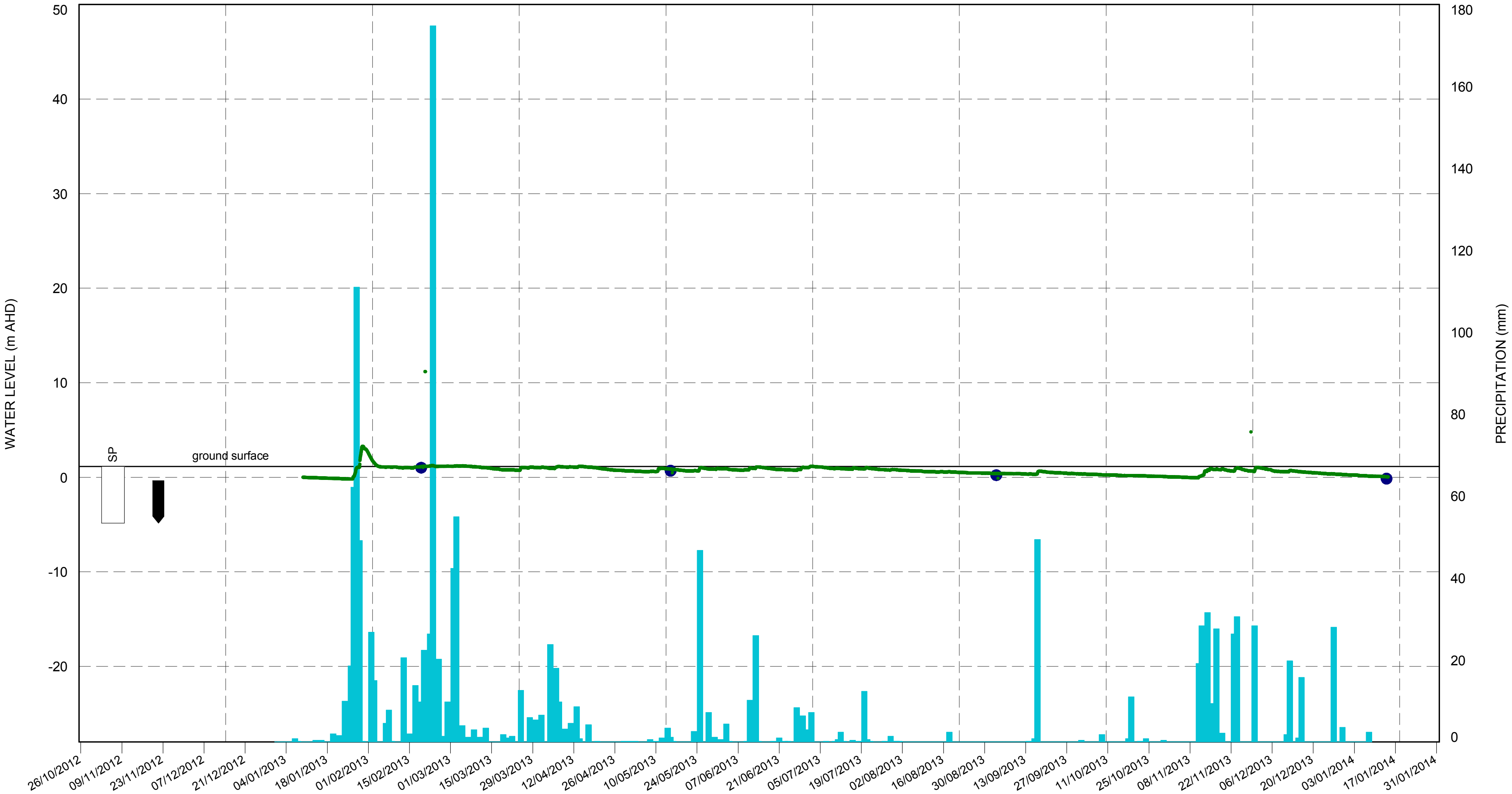
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ68

project no: GEOTCOFH03059AA-AO

fig no: FIGURE H72

rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:17

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 1.14 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.86 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.70 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

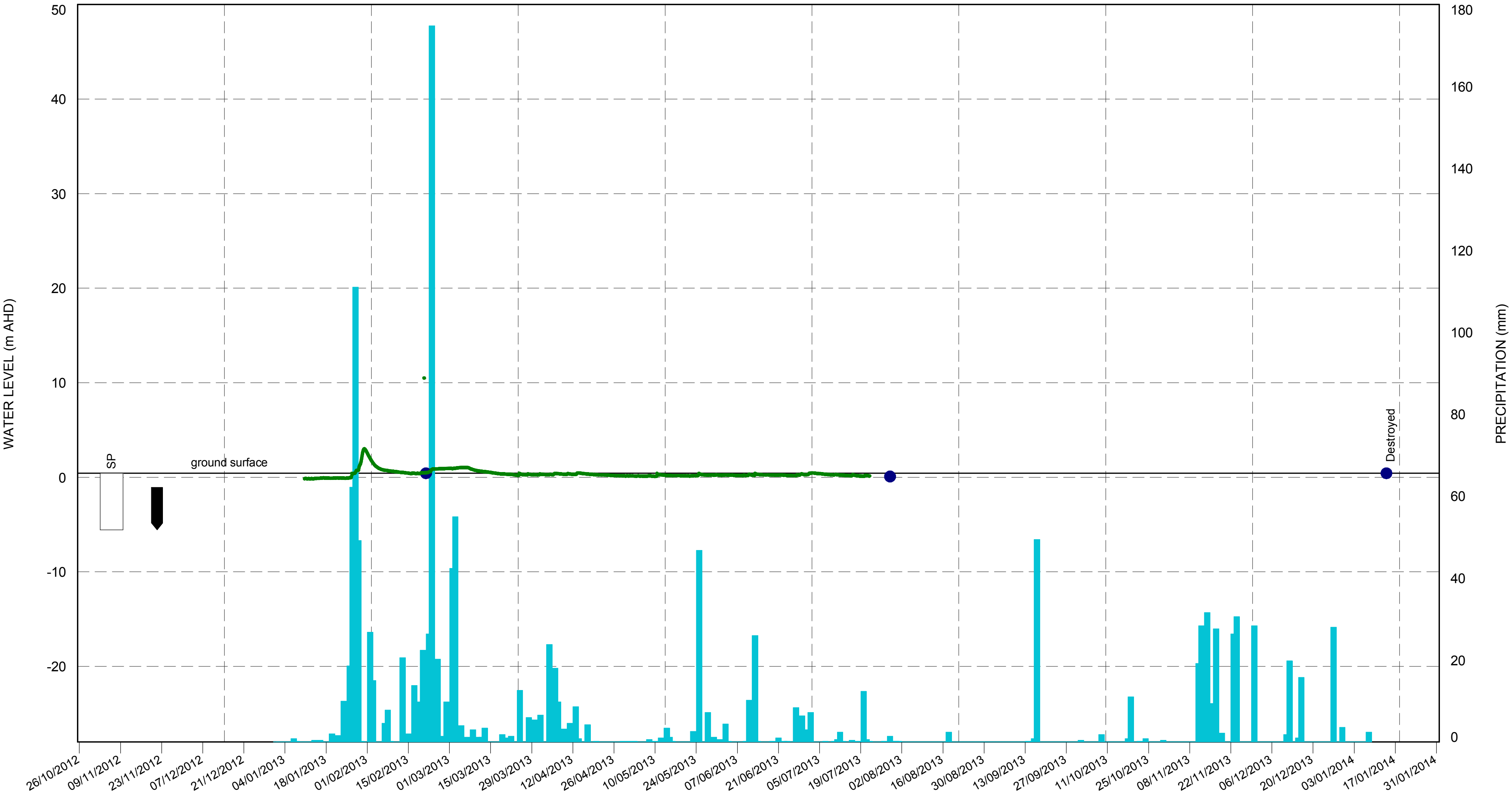
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ69**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H73** | rev:



CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:19

Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.42 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.58 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.14 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ70

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H74 | rev:

W2B-RMS-0-ES-PLN-00040-8.0

Appendix D

Section 5 - Maclean to Iluka Road:

Pre-Construction Monitoring Results

Section 5: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	*Waterway Description*	*Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems*
SW24 – Yaegl Wetland SW15 – Unnamed tributary of James Creek SW16 – Clarence River SW17 – Serpentine Channel SW18 – North Arm (Clarence River) SW19 – Mororo Creek (South)	Waterways within Section 5 are tidally influenced estuarine systems.	▪ SEPP 14 Coastal Wetland No. 220a is located to the south-east of the project and extends into Yaegl Nature Reserve. James Creek flows through the wetland into the nature reserve. ▪ SEPP 14 Coastal Wetland No. 153c is located about 400m west of the crossing of North Arm. ▪ All waterways are assessed to be key fish habitats with the potential for threatened aquatic species habitat to be present in the Clarence River.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 5: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the low-teens (12-16°C) in winter up to the high 20s (26-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks and tidal waterways.

Turbidity and total suspended solids (TSS) data varied greatly with some variable correlation between high TSS results and wet weather as would normally be anticipated. There was no clear correlation between turbidity and TSS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 4.25 to 7.15.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 2.5 mg/L. Total Nitrogen values were generally less than 1.0 mg/L. However higher values were recorded at sample points; SW24, SW15 and SW17.

Heavy Metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	***Summary of Visual Observations***	***Overview of Water Quality Sampling Results***
SW24 Yaegl Wetland (Downstream) Ch. 84,400	▪ The small watercourse within Yaegl Wetland was ephemeral with the sample location varying due to the watercourse drying out. The sample location in the dry periods moved further north up into the water course. The water course was located to the north of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant water observed. The water course was dry in October (Round 10). ▪ Water levels were high in February to April and July (Round 1 - 4 and 6b), normal in May (Round 5b) and the remaining months were observed as low water levels.	▪ O&G: <5-6.1mg/L ▪ TSS: <5-94mg/L ▪ TP: <0.01-0.42mg/L ▪ TN: 0.5-3.6mg/L ▪ DO: 0.63-8.66mg/L ▪ EC: 249-2016µS/cm ▪ pH: 3.11-6.12 ▪ Temp: 12.4-28.4ºC ▪ NTU: 6.51-59.7
SW15 Unnamed tributary of James Creek (Downstream) Ch. 85,200	▪ Unnamed tributary of James Creek was dry several times during the monitoring program and the sample location varied with the sampling location moving further north up the water course during the periods of dry weather. The water course was located to the north of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant water observed. The water course was dry from August to October (Round 8 to 10) and December (Round 12). ▪ Water levels were high in February to April (Round 1 - 4); normal in July (Round 6) and the remaining months were observed as low water levels or dry.	▪ O&G: <5-6mg/L ▪ TSS: 5-430mg/L ▪ TP: <0.02-0.8mg/L ▪ TN: 0.5-18mg/L ▪ DO: 2.5-8.64mg/L ▪ EC: 10.07µS/cm-5.44mS/cm ▪ pH: 3.21-6.68 ▪ Temp: 11.7-30.9ºC ▪ NTU: 9.36-648
SW16 Clarence River (Tidal) Ch. 86,300	▪ Clarence River is a large tidal estuary system and this site is where the proposed G2DP highway alignment will pass over the river. The sample location was on the southern bank of the River. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. Moderate flows in May (Round 5). ▪ Water levels were high in February and December (Round 2 and 12) and the remaining months were observed as normal water levels.	▪ O&G: <5mg/L ▪ TSS: 7-1100mg/L ▪ TP: <0.01-0.28mg/L ▪ TN: <0.2-0.96mg/L ▪ DO: 3.41-10.05mg/L ▪ EC: 85.4µS/cm-26.2mS/cm ▪ pH: 6.44-7.42 ▪ Temp: 15.7-25.9ºC ▪ NTU: 6.55-544
SW17 Serpentine Channel (Tidal)	▪ Serpentine Channel is a tributary of the Clarence River and this site is east of where the proposed G2DP highway alignment passes over.	▪ O&G: <5mg/L ▪ TSS: 12-62mg/L ▪ TP: 0.03-0.35mg/L

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
Ch. 89,400	▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ No variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. ▪ Water levels were high in February (Round 2) and the remaining months were observed as normal water levels.	▪ TN: 0.32-5.3mg/L ▪ DO: 1.9-9.44mg/L ▪ EC: 141-µS/cm-30.3mS/cm ▪ pH: 6.44-7.58 ▪ Temp: 15.4-28.5ºC ▪ NTU: 7.26-166
SW18 North Arm of the Clarence River (Tidal) Ch. 94,000	▪ North Arm Clarence is a large tributary of the Clarence River where the proposed G2DP highway alignment passes over. The sample location was on the northern banks of the River ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ No variation in flow velocity throughout the monitoring program with generally slow tidal movements observed. ▪ Water levels were high in February (Round 2) the remaining months were observed as normal water levels.	▪ O&G: <5-11mg/L ▪ TSS: <5-190mg/L ▪ TP: <0.01-0.07mg/L ▪ TN: <0.2-0.8mg/L ▪ DO: 3.73-26.3mg/L ▪ EC: 136.4µS/cm-32.1mS/cm ▪ pH: 6.6-7.54 ▪ Temp: 16.0-28.6ºC ▪ NTU: 3.11-110
SW19 Mororo Creek (Downstream) Ch. 95,1000	▪ Mororo Creek is small Creek system, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was minimal variation in flow velocity during the monitoring program with generally slow flows to stagnant water observed. There were moderate flows observed during Round 6b (July). ▪ Water levels were high in February and July (Round 2 and 6b), the Creek was low in Rounds 5, 6 and 7 (May, June and July). The remaining months were observed as normal water levels.	▪ O&G: <5-7.2mg/L ▪ TSS: <5-26mg/L ▪ TP: <0.01-0.22mg/L ▪ TN: 0.421.3mg/L ▪ DO: 2.81-9.23mg/L ▪ EC: 229µS/cm-23.6mS/cm ▪ pH: 5.46-6.93 ▪ Temp: 14.1-27.6ºC ▪ NTU: 4.32-57.4

Note: * Ch. = Highway Chainage

Section 5: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 5							
		SW24 (SW5-01 and SW5-02)							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.76	0.96	2.5	6.1	2.5	2.50	-	
Suspended Solids	mg/l	24.00	27.59	2.5	94	11	42.00	-	
Total Phosphorus as P	mg/l	0.15	0.13	0.005	0.42	0.14	0.25	-	
Total Nitrogen as N	mg/l	1.28	0.83	0.5	3.6	0.95	1.78	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.24	2.62	0.63	8.66	5.145	7.84	3.36	
Conductivity	µs/cm	1071.93	536.21	249	2016	984	1472.60	659.60	
pH		4.67	1.17	3.11	6.21	4.25	5.98	3.65	
Temperature	°C	20.43	4.59	12.4	28.4	20.75	23.94	-	
Turbidity	NTU	21.84	19.26	6.51	59.7	11.45	40.12	-	
		SW15 (SW5-03 and SW5-04)							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.79	1.01	2.5	6	2.5	2.50	-	
Suspended Solids	mg/l	89.08	120.94	5	430	37.5	120.00	-	
Total Phosphorus as P	mg/l	0.17	0.21	0.01	0.8	0.115	0.15	-	
Total Nitrogen as N	mg/l	7.24	5.83	0.5	18	6	12.60	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.93	2.17	2.5	8.64	4.67	6.99	2.70	
Conductivity	µs/cm	800.71	964.91	10.07	2300	336	1443.20	104.81	
pH		5.81	1.16	3.21	6.7	6.36	6.50	5.17	
Temperature	°C	20.68	6.41	11.7	30.9	19.65	26.74	-	
Turbidity	NTU	156.02	224.20	9.36	648	31.6	259.60	-	
		SW16 (SW5-05 and SW5-06							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	120.60	276.66	7	1100	25	90.40	-	
Total Phosphorus as P	mg/l	0.18	0.44	0.005	1.75	0.04	0.11	-	
Total Nitrogen as N	mg/l	0.48	0.23	0.1	0.96	0.45	0.57	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.14	1.63	3.41	10.05	8.46	9.22	7.43	
Conductivity	µs/cm	1394.10	1361.14	85.4	2760	1365.5	2520.00	256.76	
pH		6.93	0.30	6.44	7.6	6.92	7.13	6.72	
Temperature	°C	21.30	3.86	15.7	25.9	22.6	24.86	-	
Turbidity	NTU	73.88	141.07	6.55	544	17.9	92.32	-	
		SW17 (SW5-07 and SW5-08)							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0.00	2.5	2.5	2.5	2.50	-	
Suspended Solids	mg/l	27.60	13.83	12	62	25	33.60	-	

	Units	SECTION 5							
Total Phosphorus as P	mg/l	0.21	0.44	0.03	1.75	0.05	0.20	-	
Total Nitrogen as N	mg/l	1.23	1.23	0.32	5.3	1.1	1.62	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.78	2.17	1.9	9.44	6.81	8.83	5.32	
Conductivity	µs/cm	3934.67	7358.67	141	18890	960.5	2146.00	510.00	
pH		7.03	0.33	6.44	7.58	7.02	7.34	6.81	
Temperature	°C	21.91	4.53	15.4	28.5	22	26.30	-	
Turbidity	NTU	28.87	40.73	6.38	166	12.6	38.12	-	

SW18 (SW5-09 and SW5-10)

Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	3.07	2.19	2.5	11	2.5	2.50	-	
Suspended Solids	mg/l	27.42	46.51	2.5	190	13	28.20	-	
Total Phosphorus as P	mg/l	0.15	0.44	0.005	1.75	0.03	0.07	-	
Total Nitrogen as N	mg/l	0.49	0.22	0.1	0.8	0.42	0.76	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	9.31	4.91	3.73	26.3	8.57	9.11	7.82	
Conductivity	µs/cm	4754.88	9809.49	136.4	22300	457	4929.60	262.48	
pH		7.10	0.27	6.6	7.54	7.15	7.30	6.89	
Temperature	°C	22.75	4.06	16	28.6	24.8	26.06	-	
Turbidity	NTU	19.37	28.44	3.11	110	8.66	20.64	-	

SW19 (SW5-11)

Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.81	1.21	2.5	7.2	2.5	2.50	-	
Suspended Solids	mg/l	12.30	8.03	2.5	26	13	19.40	-	
Total Phosphorus as P	mg/l	0.17	0.44	0.005	1.75	0.04	0.10	-	
Total Nitrogen as N	mg/l	0.87	0.24	0.42	1.3	0.9	1.02	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.26	2.18	2.81	9.23	6.52	8.60	4.54	
Conductivity	µs/cm	973.23	1350.16	134.9	4860	551	1091.00	229.00	
pH		6.33	0.38	5.46	6.93	6.48	6.61	5.98	
Temperature	°C	21.08	4.45	14.1	27.6	21.8	24.92	-	
Turbidity	**NTU**	**16.52**	**15.32**	**4.32**	**57.4**	**10.8**	**27.66**	**-**	

Section 5: Groundwater Monitoring – Water Quality Overview

Electrical Conductivity

Values are indicative of freshwater to brackish/ saline groundwater conditions with average salinity values ranging between 200 µS/cm (PZ21) to 9,320 µS/cm (PZ09). Generally the 12 well locations with shallower water levels (<5.0m below ground level) found within areas of fill or the bridge locations near Edwards Creek of the south bank of the Clarence River showed larger standard deviations than wells with standing water levels at greater depths located in cuts. The observed variation may be due to these locations proximity to tidal waterways and the influence of wet weather events on groundwater conductivity.

pH

pH of groundwater in Section 4 show average values ranging from pH 5.68 (PZ55) to pH 10.29 (BH1206). The majority, 19 of 20 locations, had an average pH >6 which indicates a slightly acidic to neutral pH in groundwater throughout Section 4. Little variation occurs in pH with 4 of the 20 wells reporting a standard deviation value >1 pH unit.

Temperature

The average temperature values for the monitoring locations in Section 4 ranged between 20.8°C to 23.4°C. The variation in groundwater average temperature values throughout Section 4 is likely to be attributable to seasonal temperature changes and the variable depth of groundwater from the ground surface.

Cut/Fill Number	Borehole Identifier	Electrical Conductivity (µS/cm)				pH				Temp. (°C)
		Med.*	SD**	P80	P20	Med.*	SD**	P80	P20	Med.*
Fill 5-3	PZ71	18425	6720	21280	12662	7.30	0.09	7.38	7.23	21.60
	PZ72	3393	4245	7226	400	7.47	0.47	7.83	7.04	22.30
Serpentine Channel Bridge	GBH110	26850	2766	28480	24300	7.20	0.15	7.33	7.14	23.10
	PZ73	5040	434	5362	4798	7.34	0.69	7.90	7.23	21.55
Fill 5-5	PZ74	614	2220	2521	236	6.78	0.23	6.97	6.61	22.70
	PZ75	4023	5218	8782	371	7.57	0.66	8.04	7.27	22.30

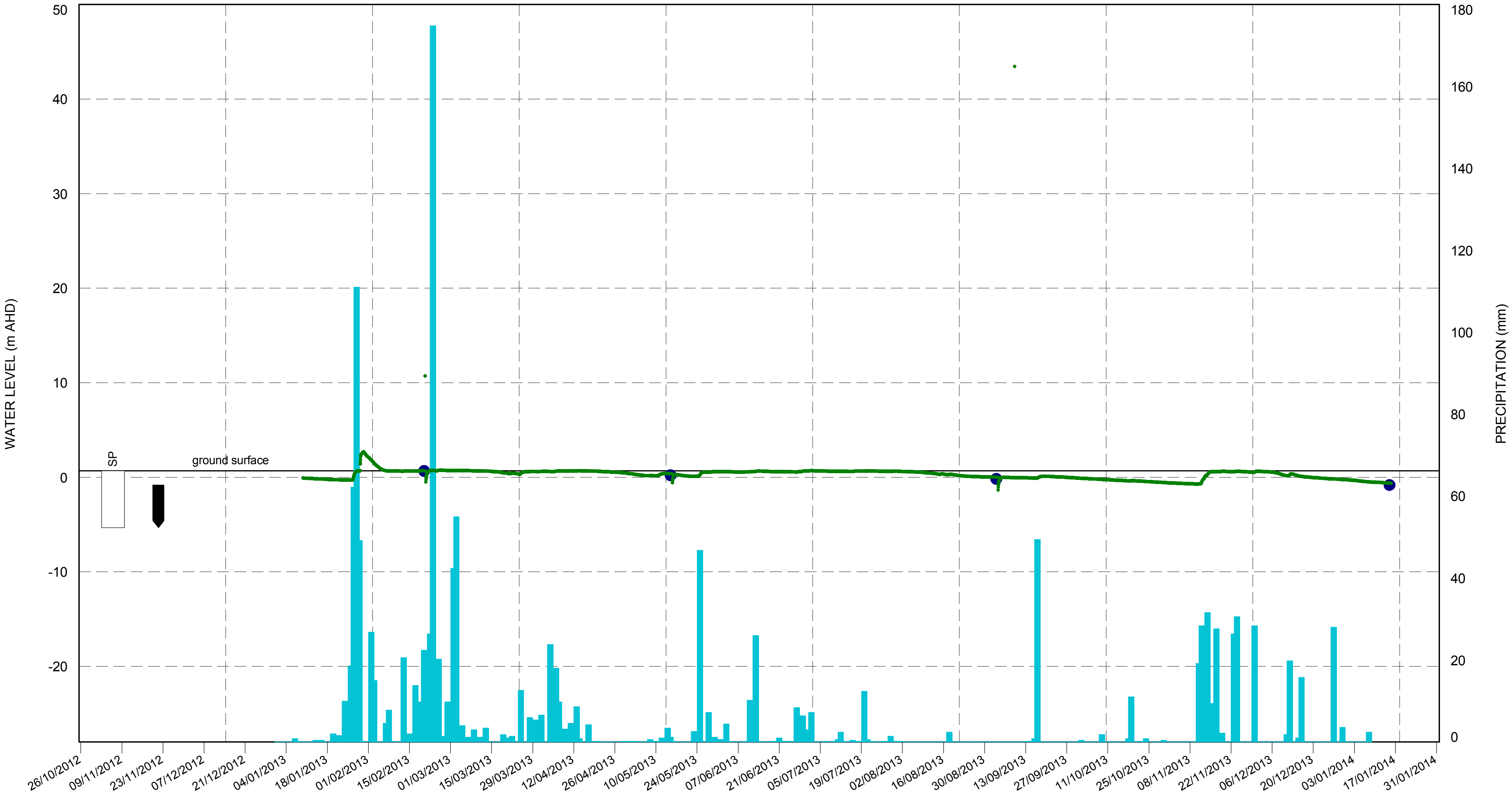
Note: * Med. = Median
** DS = Standard Deviation

Section 5: Groundwater Monitoring – Levels

The typical standing water levels in Section 4 averaged between 0.07m (PZ67) and 22.78m (BH1251) below ground surface. In general, the SWLs observed in areas of proposed fill or bridges in Section 4 were noted to be close to the ground surface (<2m bgs) indicating shallow groundwater. The long-term monitoring data indicates that the groundwater levels throughout much of Section 4 are influenced by large rainfall events (e.g. over 100mm rainfall event in January 2013). It should be noted the SWLs are relative to the topography of the monitoring location.

Summary of Groundwater Level Monitoring – Section 5 G2DP Upgrade

Cut/ Fill Number	Monitoring Location	Borehole Depth	Typical SWL (m below ground level)		
			AVG	MED	SD
Fill 5-3	PZ71	6	0.70	0.65	0.63
	PZ72	6	1.37	1.42	0.49
Serpentine Channel Bridge	GBH110	41	4.11	4.11	0.16
	PZ73	6	1.09	1.20	0.55
Fill 5-5	PZ74	6	0.67	0.79	0.37
	PZ75	6	0.75	0.82	0.50



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Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 0.67 m AHD
Borehole Depth: 6.00 m

●: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.33 m AHD

—: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.08 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

client: Roads and Maritime Services

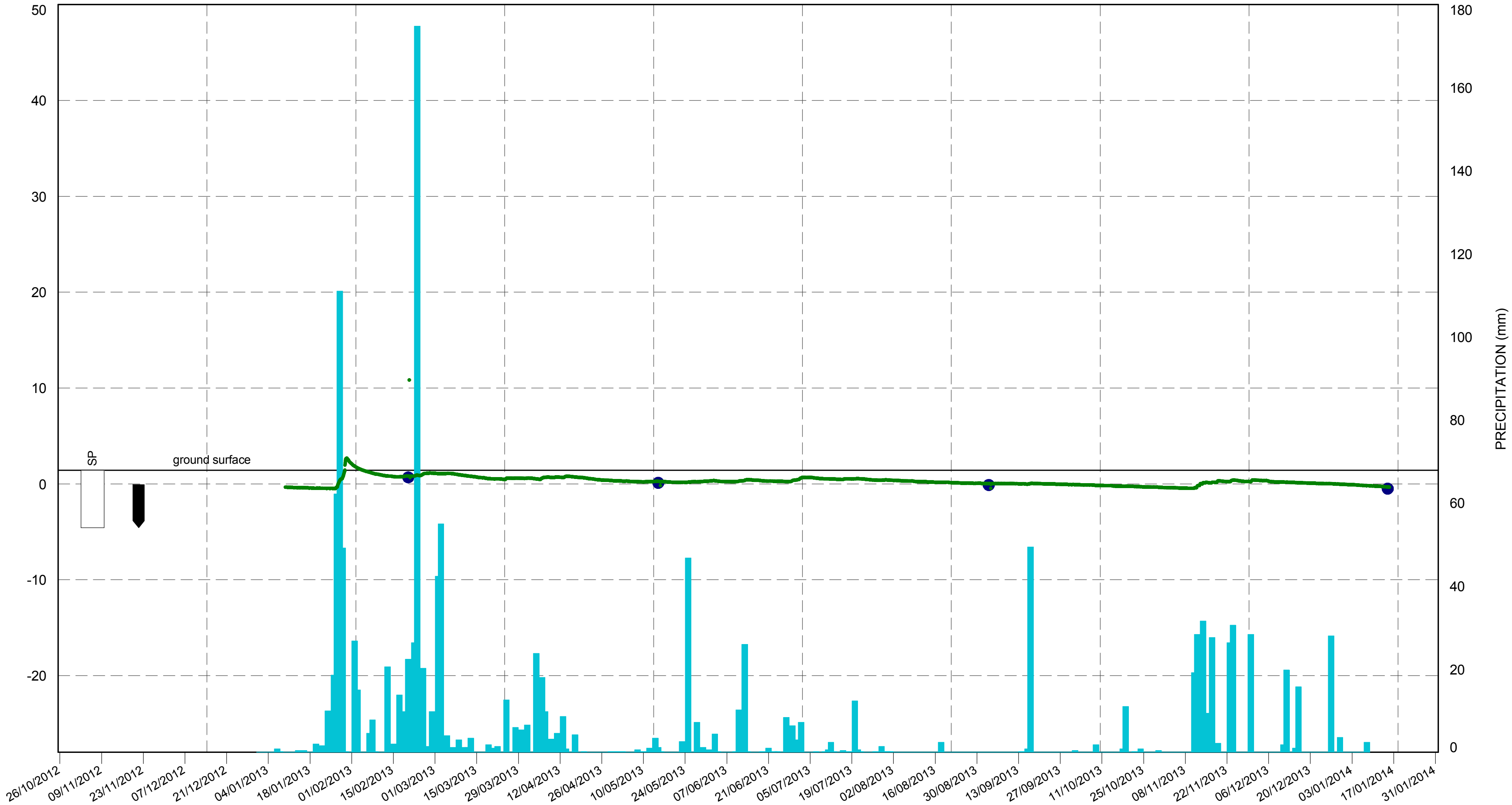
project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ71**

project no: GEOTCOFH03059AA-AO

fig no: **FIGURE H75**

rev:



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Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

Surface RL: 1.41 m AHD
Borehole Depth: 6.00 m

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.59 m AHD

: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.41 m AHD

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

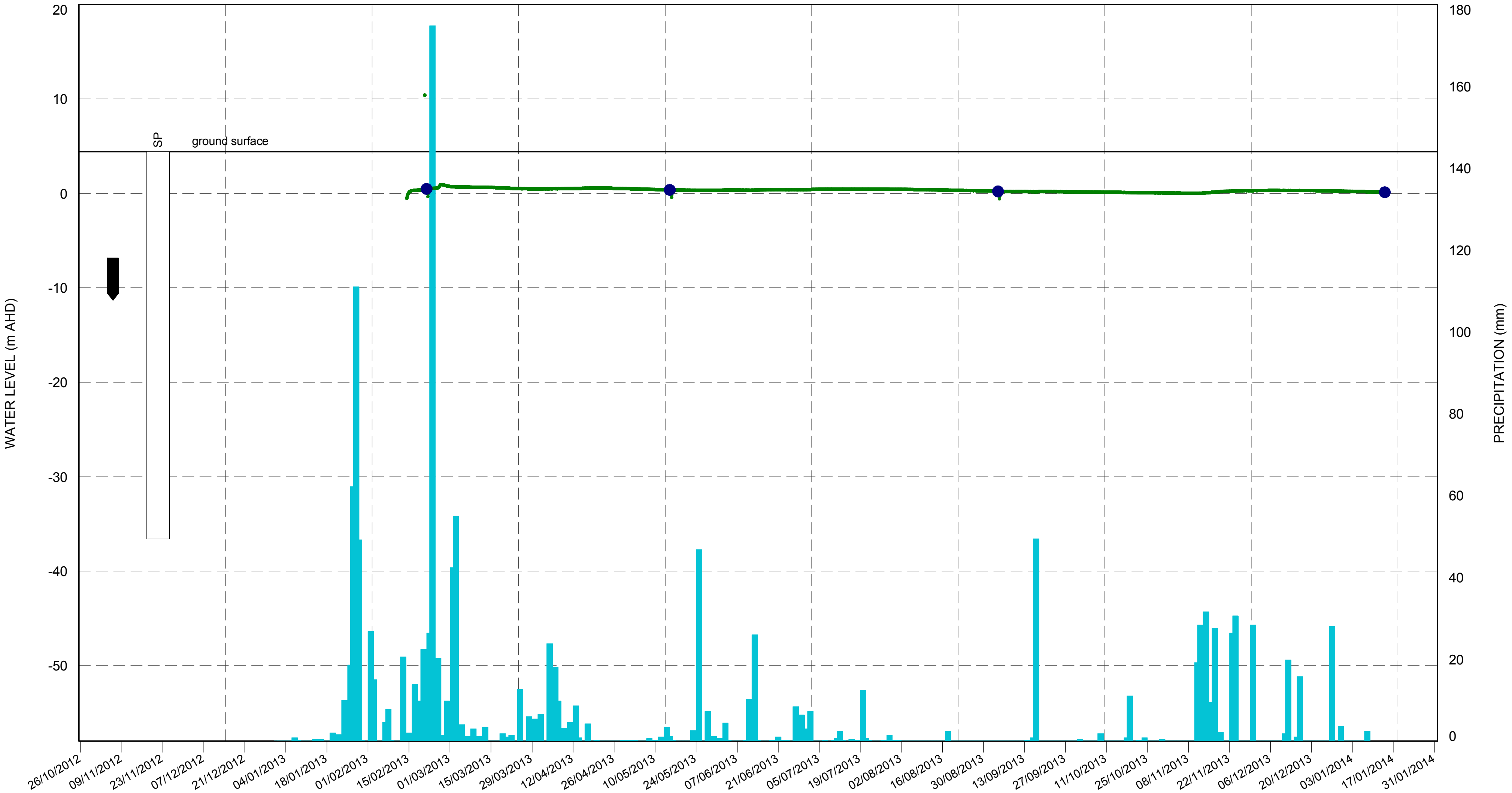
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ72**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H76** | rev:



Bentonite | Gravel
Concrete | Grout
Cuttings | Sand

Surface RL: 4.40 m AHD
Borehole Depth: 41.76 m

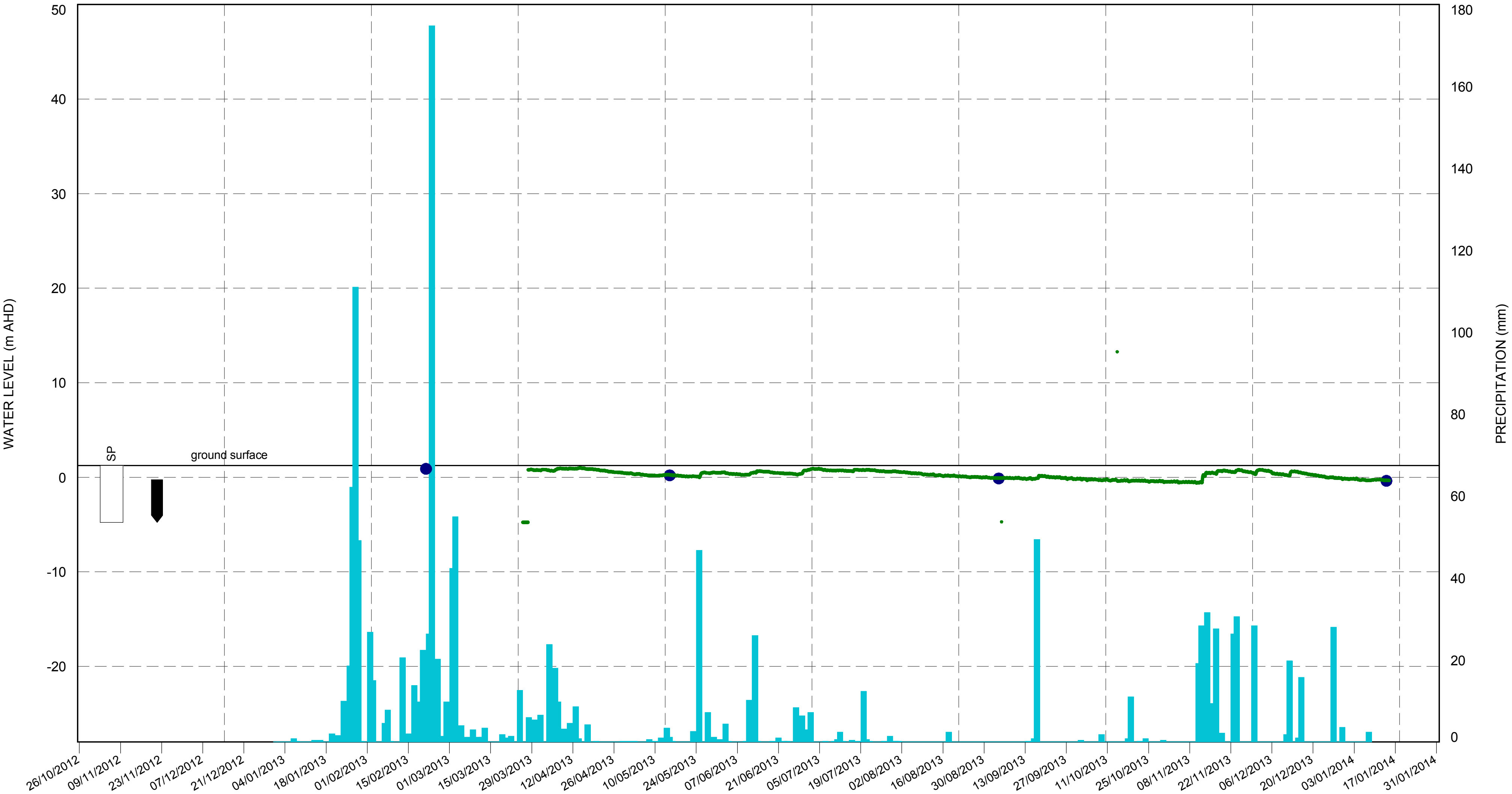
: Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 15.73 m bgl
RL of Tip: -11.33 m AHD

: Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 41.00 m bgl
RL of Tip: -36.60 m AHD

: Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH	client:	Roads and Maritime Services
approved	AB	project:	Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014	title:	GROUNDWATER LEVEL AND RAINFALL VERSUS TIME GBH110
scale	AS SHOWN		
original size	A4	project no: GEOTCOFH03059AA-AO	fig no: FIGURE H12 rev:

coffey



Bentonite | Gravel | Concrete | Grout | Cuttings | Sand

Surface RL: 1.23 m AHD
Borehole Depth: 6.00 m

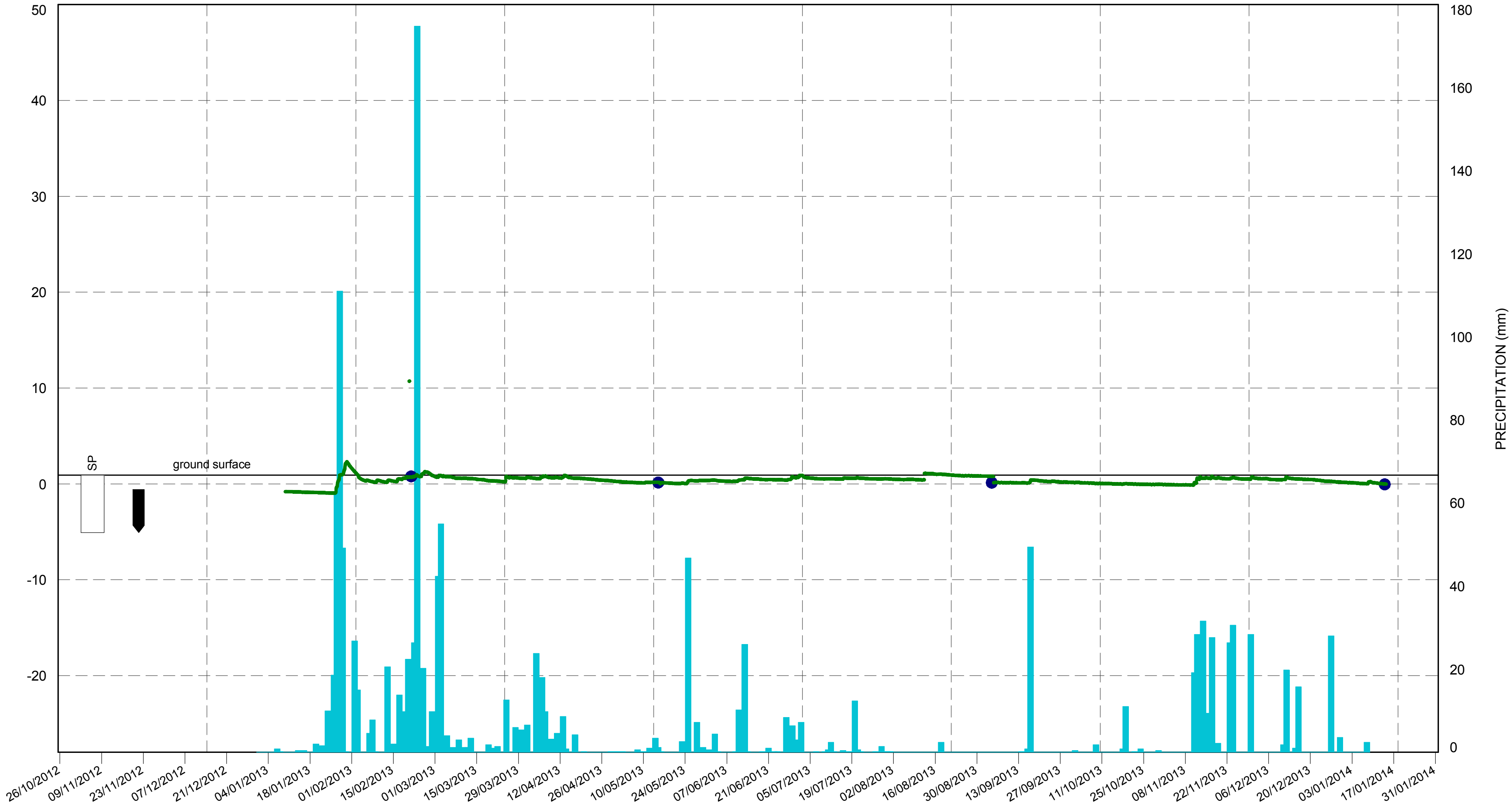
● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.77 m AHD

▬ : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.81 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH	client:	Roads and Maritime Services
approved	AB	project:	Glenugie to Devils Pulpit Groundwater Monitoring
date	10/03/2014	title:	GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ73
scale	AS SHOWN		
original size	A4	project no: GEOTCOFH03059AA-AO	fig no: FIGURE H77 rev:

coffey



Bentonite
Concrete
Cuttings
Gravel
Grout
Sand

Surface RL: 0.92 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.08 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.38 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

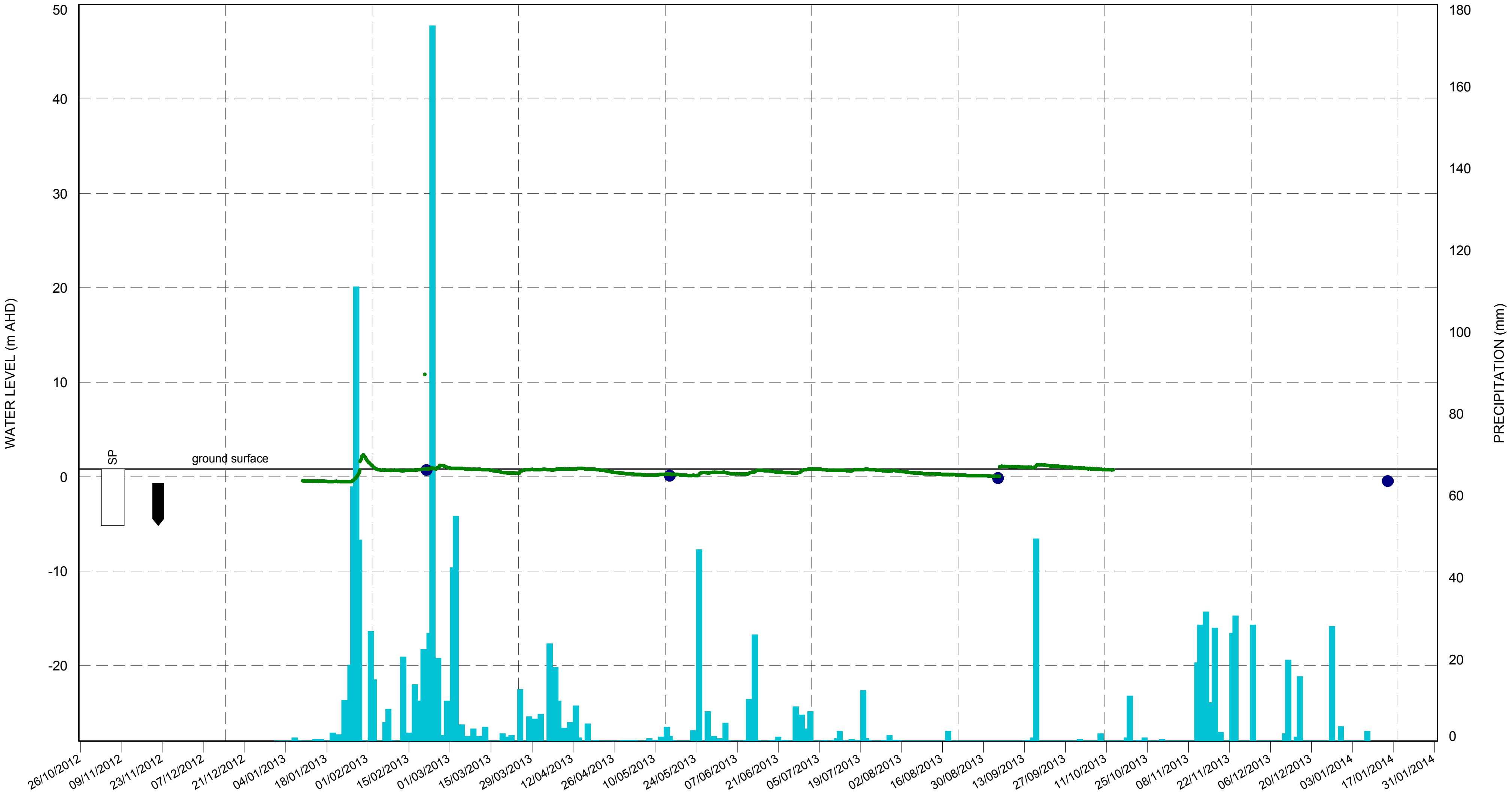
coffey

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: **GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ74**

project no: GEOTCOFH03059AA-AO | fig no: **FIGURE H78** | rev:



Bentonite
Gravel
Concrete
Grout
Cuttings
Sand

Surface RL: 0.80 m AHD
Borehole Depth: 6.00 m

● : Piezometer ID: SP
Piezometer Type: Standpipe Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -5.20 m AHD

— : Piezometer ID: T
Piezometer Type: Transducer in Piezo.
Installation Date:
Tip Depth: 6.00 m bgl
RL of Tip: -4.02 m AHD

■ : Rainfall data is from Bureau of Meteorology website (www.bom.gov.au) Yamba Pilot Station

drawn	OH
approved	AB
date	10/03/2014
scale	AS SHOWN
original size	A4

client: Roads and Maritime Services

project: Glenugie to Devils Pulpit Groundwater Monitoring

title: GROUNDWATER LEVEL AND RAINFALL VERSUS TIME PZ75

project no: GEOTCOFH03059AA-AO | fig no: FIGURE H78 | rev:

CDF_0_9_04BA.GLB Graph MON PIEZOMETER CONST. DRILL WL VS T - W GEOTCOFH03059AA HYDROGRAPHS MASTER - EDITED 4 FEBRUARY 2014 - COPY.GPJ 335273.GDW 11/03/2014 12:25

Appendix E

Section 6 - Iluka Road to Devils Pulpit: Pre-Construction Monitoring Results

Section 6: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	Waterway Description	*Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems*
SW20 – Mororo Creek (North) SW21 – Tabbimobile Creek SW25 – Tabbimobile Overflow	Mororo Creek is ephemeral freshwater waterway at the Pacific Highway and may only flow after wet weather. Tabbimobile Creek is assessed to be estuarine downstream of the weir and freshwater upstream.	▪ SEPP 14 Coastal Wetland No. 153a is located on Tabbimobile Creek about 1km to the east of the project. ▪ SEPP 14 Coastal Wetland No. 153 is located 4.5km to the east of the project, within Bundjalung National Park and Devils Pulpit State Forest, and extends between North Arm in the south and the Evans River in the north. All waterways are assessed to be key fish habitats with the potential for threatened aquatic species habitat.

Source: Table 1 in Coffey Geotechnics (2014c).

Section 6: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the low-teens (11-14°C) in winter up to the mid-20s (25-26°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks.

Turbidity and total suspended solids (TSS) data varied greatly with some correlation between high TSS results and wet weather as would normally be anticipated. There was some correlation evident between turbidity and TSS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. Median pH levels were generally in the range of 6.37 to 6.57.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 0.5 mg/L. Total Nitrogen values were found to be in the range of 0.13 to 2.4 mg/L.

Heavy Metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW20 Mororo Creek (Downstream) Ch. 96,650	▪ Mororo Creek at this location is small Creek system, down gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant flows observed. Moderate flows during the wet weather event in July (Round 6b). ▪ Water levels were high in February, July and November (Round 2, 6b, 11a and 11b) and low in May, June and August (Round 5, 6 and 8). The remaining months observed normal water levels.	▪ O&G: <5-6.6mg/L ▪ TSS: <5-82mg/L ▪ TP: <0.02-0.11mg/L ▪ TN: 0.3-2.4mg/L ▪ DO: 3.18-8.72mg/L ▪ EC: 231-1619µS/cm ▪ pH: 3.74-7.02 ▪ Temp: 13.7-25.1ºC ▪ NTU: 3.67-154
SW21 Tabbimoble Creek (Upstream) Ch. 101,600	▪ Tabbimoble Creek was a permanent water course, within rural bushland (Crown Land), up gradient of the proposed G2DP highway alignment. ▪ No signs of visible hydrocarbon sheens, unusual odours or rubbish observed throughout the monitoring program. ▪ There was some variation in flow velocity throughout the monitoring program with generally slow to stagnant flows observed. Moderate flows during the wet weather in February, April, July and November (Round 2, 4, 6b, 11a and 11b). ▪ Water levels were high in February and March (Round 2 and 6b) and low in August to October (Round 8 - 10). The remaining months were observed as normal water levels.	▪ O&G: <5-5mg/L ▪ TSS: <5-50mg/L ▪ TP: <0.01-0.05mg/L ▪ TN: 0.13-0.9mg/L ▪ DO: 3.41-10.30mg/L ▪ EC: 86.6-543µS/cm ▪ pH: 5.93-7.33 ▪ Temp: 12.7-25.6ºC ▪ NTU: 11-47.9
SW25 Tabbimoble Overflow (Downstream) Ch. 102,900	▪ Tabbimoble Overflow was a permanent water course, within bushland (private property), down gradient of the proposed G2DP highway alignment. ▪ No visual signs of sheens, odours or rubbish observed throughout the monitoring program. ▪ Minimal variation in flow velocity throughout the monitoring program with generally slow to stagnant flows observed. Moderate flows were observed during the wet weather in February and July (Round 2 and 6b). ▪ Water levels were high in February to April and July (Round 2, 3, 4 and 6b) and low in August to October (Round 8 - 10). The remaining months were observed as normal water levels.	▪ O&G: <5-5mg/L ▪ TSS: <5-180mg/L ▪ TP: <0.01-0.36mg/L ▪ TN: 0.3-1.8mg/L ▪ DO: 1.94-9.23mg/L ▪ EC: 100.5-423µS/cm ▪ pH: 5.32-7.04 ▪ Temp: 24.9-11.2ºC ▪ NTU: 12.5-36.7

Note: * Ch. = Highway Chainage

Section 6: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 6							
SW20 (SW6-01 and SW6-02)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.77	1.06	2.5	6.6	2.5	2.50	-	
Suspended Solids	mg/l	14.41	21.25	2.5	82	6.5	13.40	-	
Total Phosphorus as P	mg/l	0.06	0.06	0.01	0.25	0.04	0.07	-	
Total Nitrogen as N	mg/l	0.80	0.53	0.3	2.4	0.7	0.96	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.52	1.50	3.18	8.72	4.93	6.67	4.67	
Conductivity	µs/cm	924.13	459.92	231	1619	966	1324.60	481.40	
pH		6.40	0.77	3.74	7.02	6.55	6.75	6.29	
Temperature	°C	19.99	4.23	13.7	25.1	21	24.02	-	
Turbidity	NTU	30.71	39.43	3.67	154	14.9	32.18	-	
SW21 (SW6-03 and SW6-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.67	0.65	2.5	5	2.5	2.50	-	
Suspended Solids	mg/l	14.68	14.30	2.5	50	8.5	25.00	-	
Total Phosphorus as P	mg/l	0.04	0.06	0.005	0.25	0.02	0.04	-	
Total Nitrogen as N	mg/l	0.46	0.18	0.13	0.9	0.4	0.60	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.90	1.63	3.41	10.3	7.72	9.32	7.18	
Conductivity	µs/cm	262.71	136.48	86.6	543	200.9	360.80	174.56	
pH		6.64	0.51	5.93	7.33	6.57	7.15	6.18	
Temperature	°C	19.66	4.28	12.7	25.6	20.3	23.54	-	
Turbidity	NTU	18.70	9.70	11	47.9	14.2	22.80	-	
SW25 (SW6-05 and SW6-06									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.67	0.65	2.5	5	2.5	2.50	-	
Suspended Solids	mg/l	25.03	44.36	2.5	180	11	19.80	-	
Total Phosphorus as P	mg/l	0.06	0.10	0.005	0.36	0.03	0.03	-	
Total Nitrogen as N	mg/l	0.94	0.34	0.3	1.8	0.81	1.12	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.78	1.90	1.94	9.23	4.74	6.40	3.27	
Conductivity	µs/cm	194.65	87.56	100.5	423	164.7	251.40	139.74	
pH		6.27	0.48	5.32	7.04	6.37	6.61	5.85	
Temperature	°C	20.01	4.21	11.2	24.9	20.6	23.96	-	
Turbidity	**NTU**	**22.09**	**7.55**	**12.5**	**36.7**	**19**	**30.36**	**-**	

Section 6: Groundwater Monitoring

RMS did not nominate any groundwater wells to be monitored for Section 6 which does not contain significant cuttings or areas of extensive fill for construction of the Pacific Highway Upgrade.

Appendix F

Section 7 - Devils Pulpit to Trustums Hill: Pre-Construction Monitoring Results

Section 7: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	*Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems (GDE's)*
SW01 - Unnamed at CH 114 000 m SW02 - Tabbimoble floodway no. 1 SW03 - Oaky Creek SW04 - South of the intersection with the existing Pacific Highway and Norton's Road	▪ potential habitat for threatened fish species / GDE ▪ potential habitat for threatened fish species / GDE ▪ potential habitat for threatened fish species / GDE ▪ potential habitat for threatened fish species

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 7: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the low-teens (13-15°C) in winter up to the mid-20s (22-26°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 3.7 to 7.2.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 0.5 mg/L. Total Nitrogen values were found to be in the range of 0.13 to 2.4 mg/L.

Heavy Metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW01/GDE01 (Golder) Unnamed Ch. 113,950	▪ No record of visual observations provided.	▪ O&G: <5mg/L ▪ SS: <5-42mg/L ▪ TP: <0.01-0.09mg/L ▪ TN: 0.5-1.8mg/L ▪ DO: 5.9-10mg/L ▪ EC: 33-371µS/cm ▪ pH: 5-6.9 ▪ Temp: 13.3-23.6ºC ▪ NTU: 13-91
SW02/GDE02 (Golder) Tabbimoble Floodway No.1 Ch. 115,250	▪ As above.	▪ O&G: <5-5mg/L ▪ SS: <5-36mg/L ▪ TP: <0.01-0.13mg/L ▪ TN: 0.6-2mg/L ▪ DO: 1.3-8.1mg/L ▪ EC: 70-113µS/cm ▪ pH: 3.7-7.2 ▪ Temp: 12.8-26ºC ▪ NTU:10-88
SW03/GDE03 (Golder) Oaky Creek Ch. 122,400	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-22mg/L ▪ TP: <0.01-0.11mg/L ▪ TN: 0.3-0.8mg/L ▪ DO: 0.4-7.6mg/L ▪ EC: 133-187µS/cm ▪ pH: 4.0-6.7 ▪ Temp: 14.8-26ºC ▪ NTU: 3.1-47
SW04 (Golder) Unnamed Ch. 124,400	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-39mg/L ▪ TP: <0.01-0.08mg/L ▪ TN: 0.6-1.3mg/L ▪ DO: 0.5-7.8mg/L ▪ EC: 110-259µS/cm ▪ pH: 4.0-7.1 ▪ Temp: 13.7-22.2ºC ▪ NTU: 1.5-16.0

Note: * Ch. = Highway Chainage

Section 7: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 7							
SW01 (SW7-01 and SW7-02)									
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.75	0.79	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	16.20	15.40	42.00	2.5	10.0	31.8	-	
Total Phosphorus as P	mg/l	0.04	0.03	0.09	0.0	0.0	0.064	-	
Total Nitrogen as N	mg/l	2.66	2.63	8.60	0.5	1.7	4.4	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.68	1.09	10.00	5.9	7.8	8.1	6.988	
Conductivity	µs/cm	171.90	116.88	368.00	9.0	191.0	247.8	72.8	
pH		5.94	0.53	6.90	5.0	5.8	6.4	5.696	
Temperature	°C	20.23	3.21	23.60	13.3	21.7	22.52	-	
Turbidity	NTU	47.99	37.42	118.00	0.9	52.1	71.3	-	
SW02 (SW703 and SW7-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.69	0.69	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	15.31	9.01	36.00	2.5	16.0	18.6	-	
Total Phosphorus as P	mg/l	0.05	0.03	0.13	0.0	0.0	0.066	-	
Total Nitrogen as N	mg/l	0.92	0.35	2.00	0.6	0.9	1	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.91	2.42	8.10	1.3	6.8	7.8	3.2	
Conductivity	µs/cm	101.85	31.33	196.00	70.0	95.0	109	41	
pH		5.47	0.89	7.20	3.7	5.6	5.9	4.94	
Temperature	°C	19.08	4.06	25.90	12.8	18.9	22.4	-	
Turbidity	NTU	46.28	22.14	97.10	18.9	40.1	54.3	-	
SW03 (SW7-05 and SW7-06)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	5.12	5.73	22.00	2.5	2.5	5	-	
Total Phosphorus as P	mg/l	0.03	0.03	0.11	0.0	0.0	0.046	-	
Total Nitrogen as N	mg/l	0.63	0.26	1.20	0.4	0.5	0.76	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.96	2.52	7.60	0.4	5.8	7.2	2.24	
Conductivity	µs/cm	206.91	143.20	464.00	33.0	150.0	377	104	
pH		5.72	0.83	6.70	4.0	5.9	6.44	5.34	
Temperature	°C	19.38	4.00	26.00	14.2	19.1	23.4	-	
Turbidity	NTU	17.59	14.18	46.30	6.2	10.0	28.82	-	
SW04 (SW7-07 and SW7-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.86	0.94	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	13.00	14.69	39.00	2.5	2.5	24	-	
Total Phosphorus as P	mg/l	0.03	0.03	0.08	0.0	0.0	0.038	-	
Total Nitrogen as N	mg/l	0.79	0.25	1.30	0.6	0.7	0.88	-	

	Units	SECTION 7							
Field Physico-chemical data									
Dissolved Oxygen	mg/l	3.39	3.12	7.80	0.5	2.3	6.63	0.9	
Conductivity	µs/cm	110.67	52.97	190.00	52.0	109.0	140	64	
pH		4.90	1.11	7.10	4.0	4.6	4.8	4.3	
Temperature	°C	17.98	3.60	22.20	13.7	17.8	21.16	-	
Turbidity	**NTU**	**9.87**	**6.02**	**18.20**	**1.8**	**10.0**	**13.24**	**-**	

Section 7: Groundwater Monitoring – Water Quality Overview

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

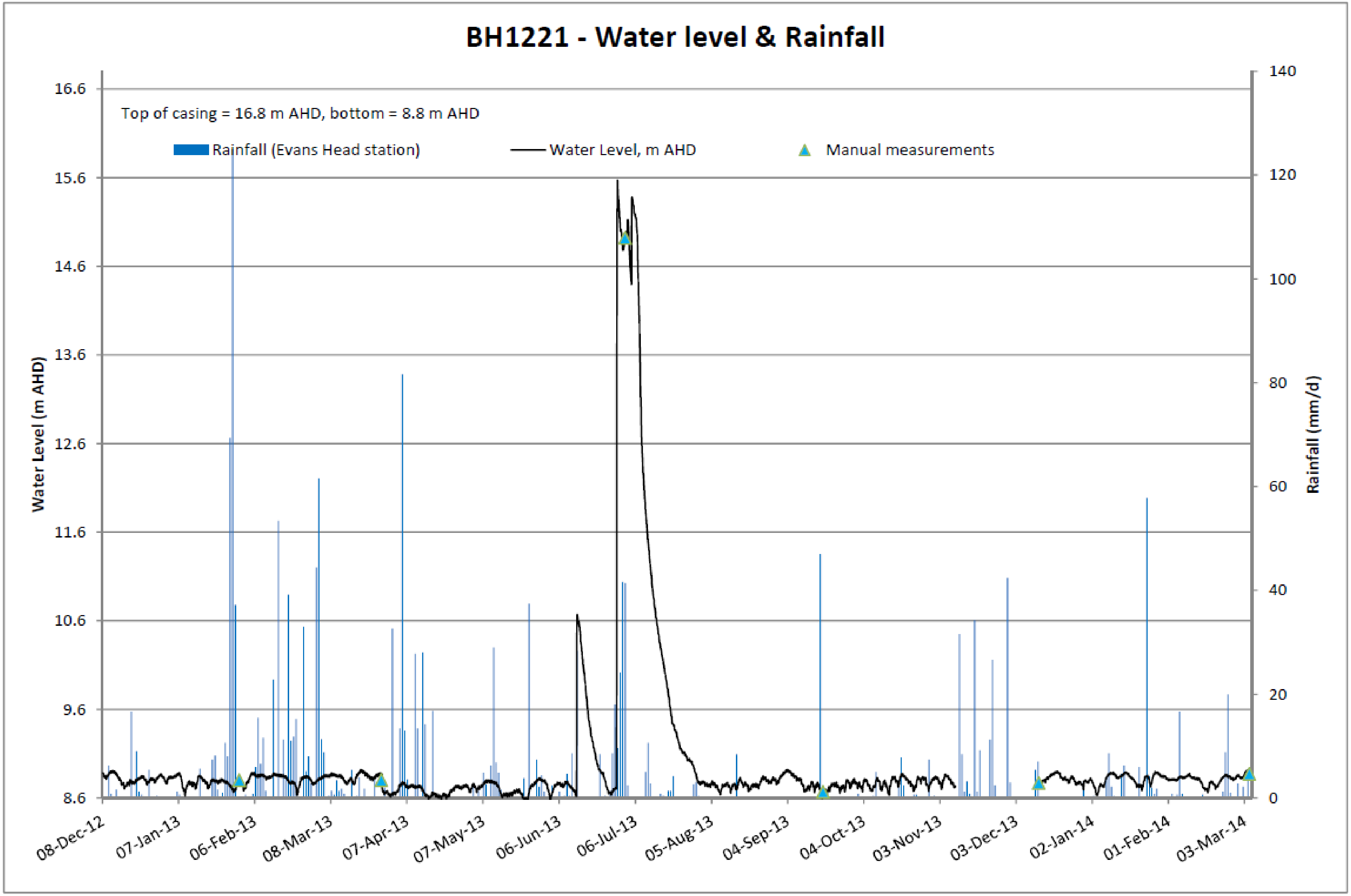
pH Statistics from Boreholes in Areas of Fill

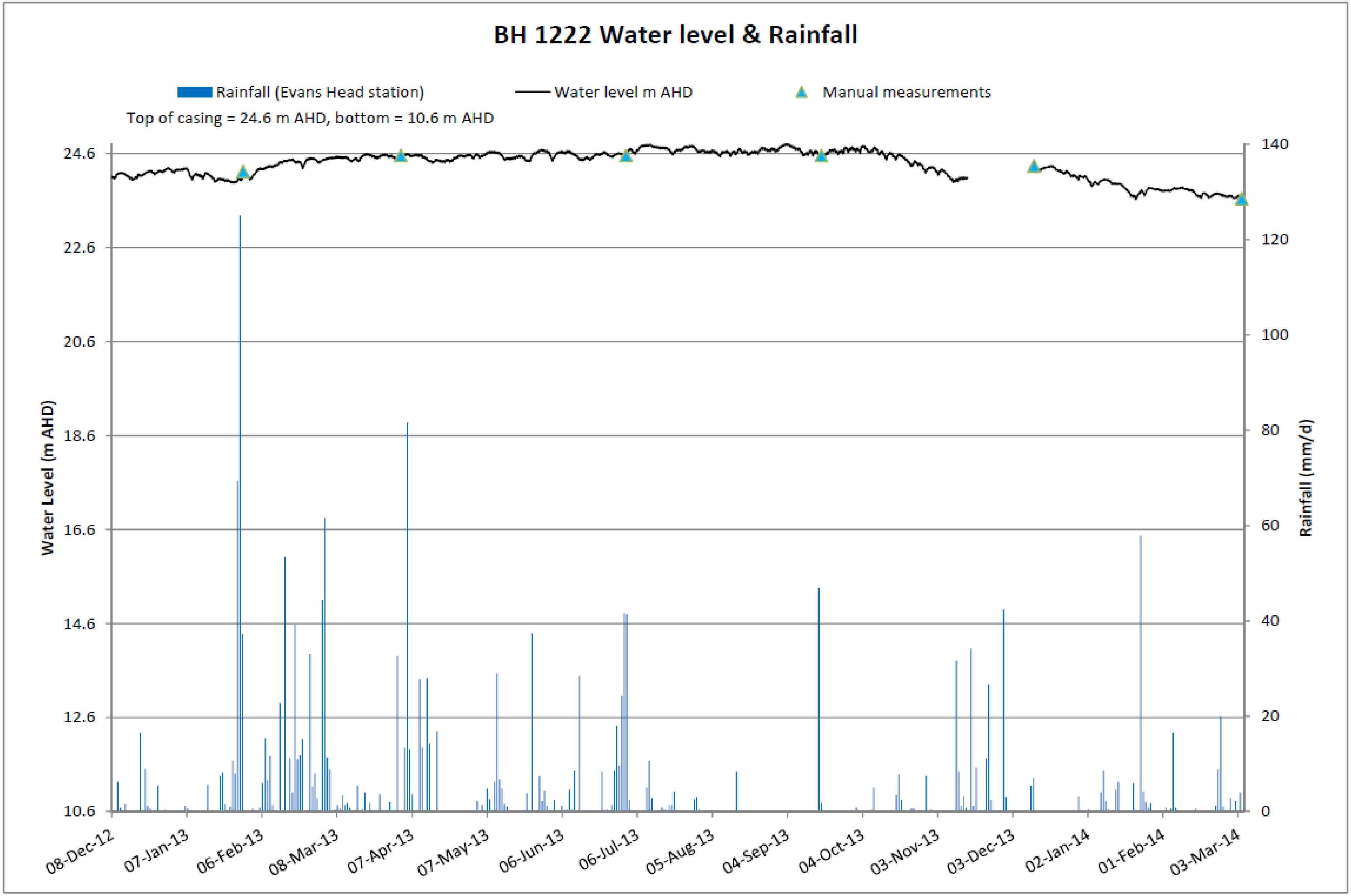
Borehole Identifier	Mean (Total)	Standard Deviation	Min	Max	Percentile	
					P80	P20
BH1223	5.43	0.42	4.80	5.70	5.60	5.64
BH1224	4.88	0.54	4.30	5.60	4.80	5.12

Section 7: Groundwater Monitoring – Levels

Summary of Groundwater Level Monitoring – Section 7 DP2B Upgrade

Borehole Identifier	Typical SWL (m below ground level)		
	Average	Median	Standard Deviation
BH1221	-	-	-
BH1222	-	-	-
BH1223	9.18	9.20	0.107
BH1224	11.01	11.19	3.37
BH1225	6.75	7.01	1.07
BH1226	9.94	10.4	1.15
BH1227	6.7	6.74	0.64


BH1221 - Water level & Rainfall
Top of casing = 16.8 m AHD, bottom = 8.8 m AHD
Rainfall (Evans Head station)
Water Level, m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
16.6
15.6
14.6
13.6
12.6
11.6
10.6
9.6
8.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1222 Water level & Rainfall
Rainfall (Evans Head station)
Water level m AHD
Manual measurements
Top of casing = 24.6 m AHD, bottom = 10.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
24.6
22.6
20.6
18.6
16.6
14.6
12.6
10.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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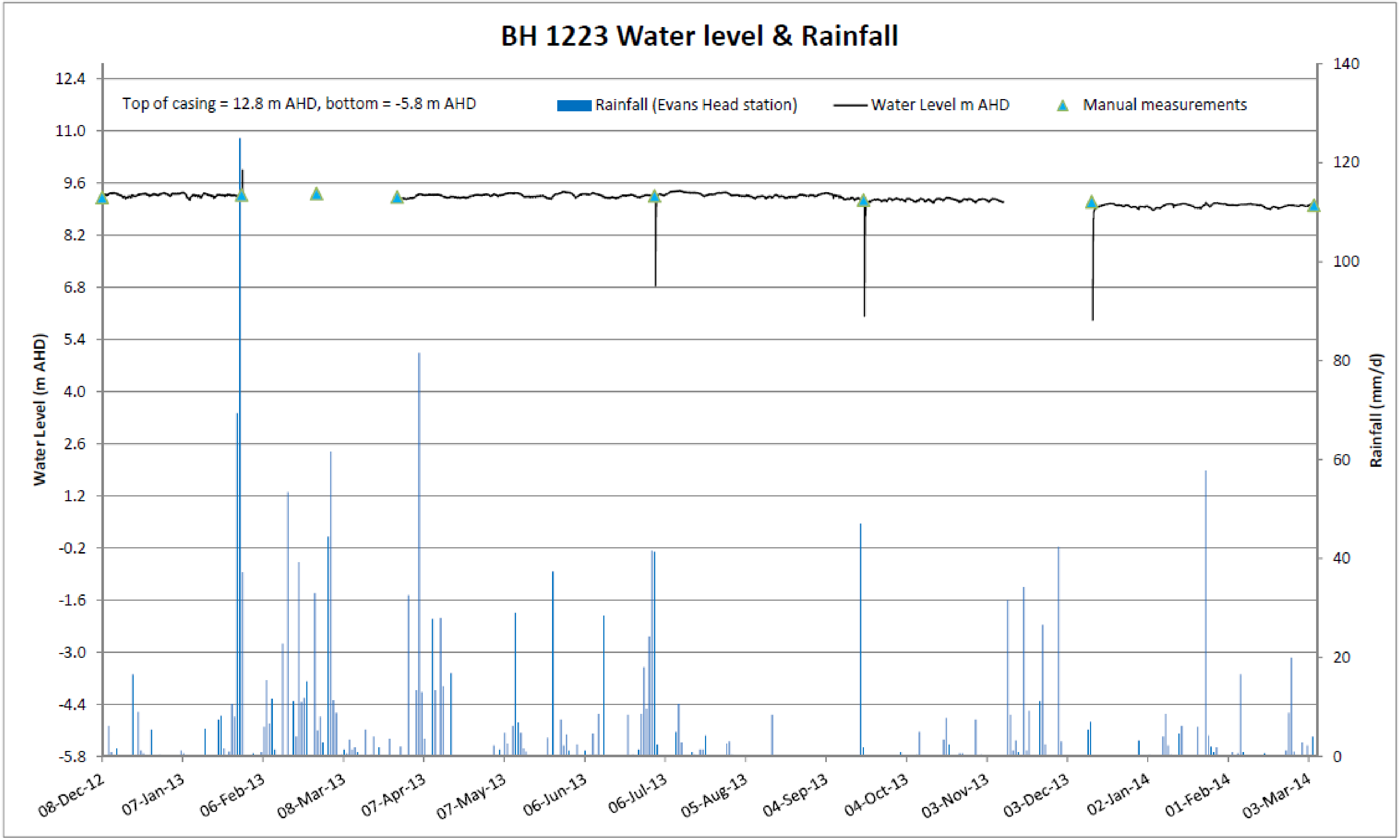
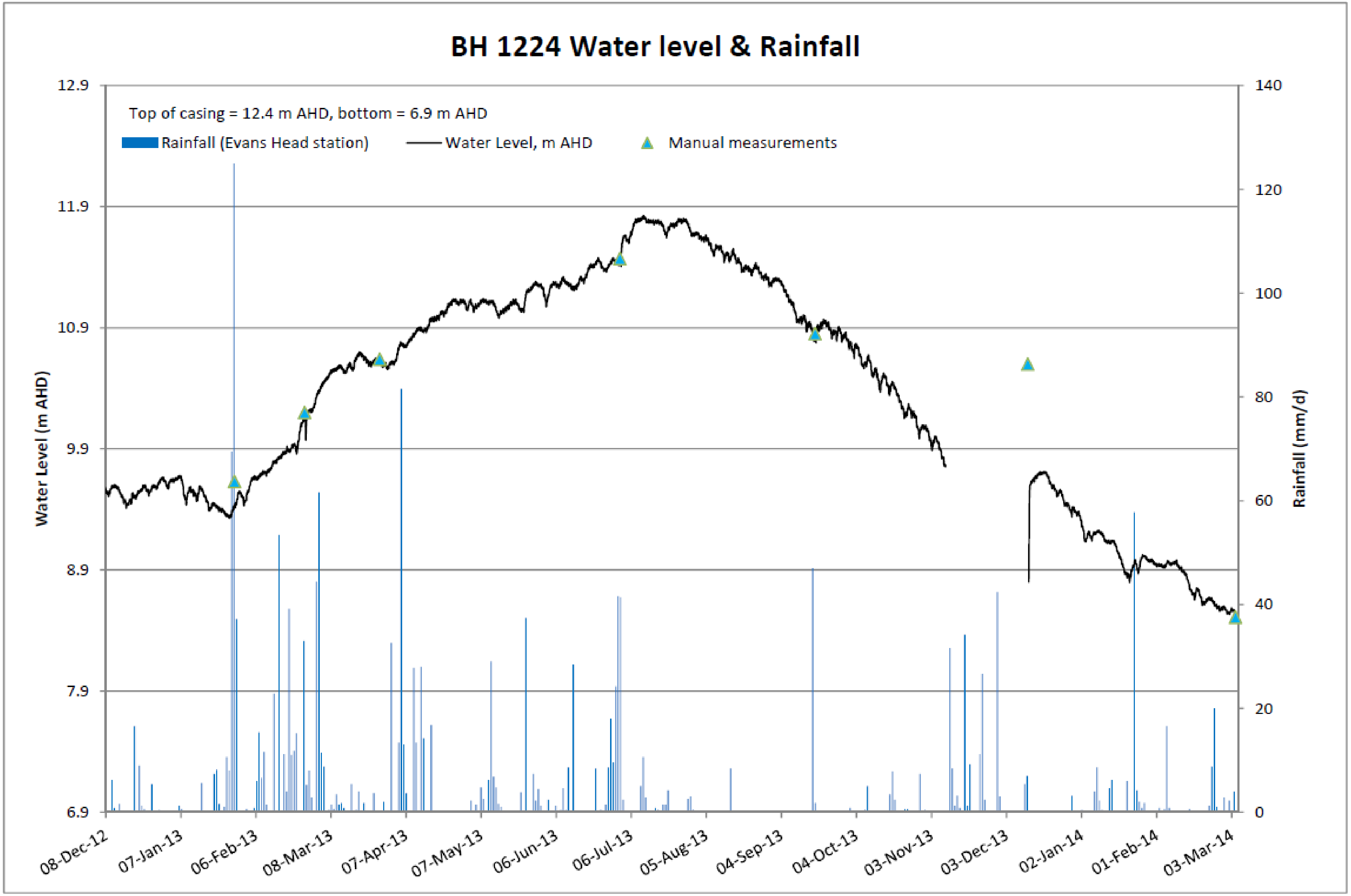
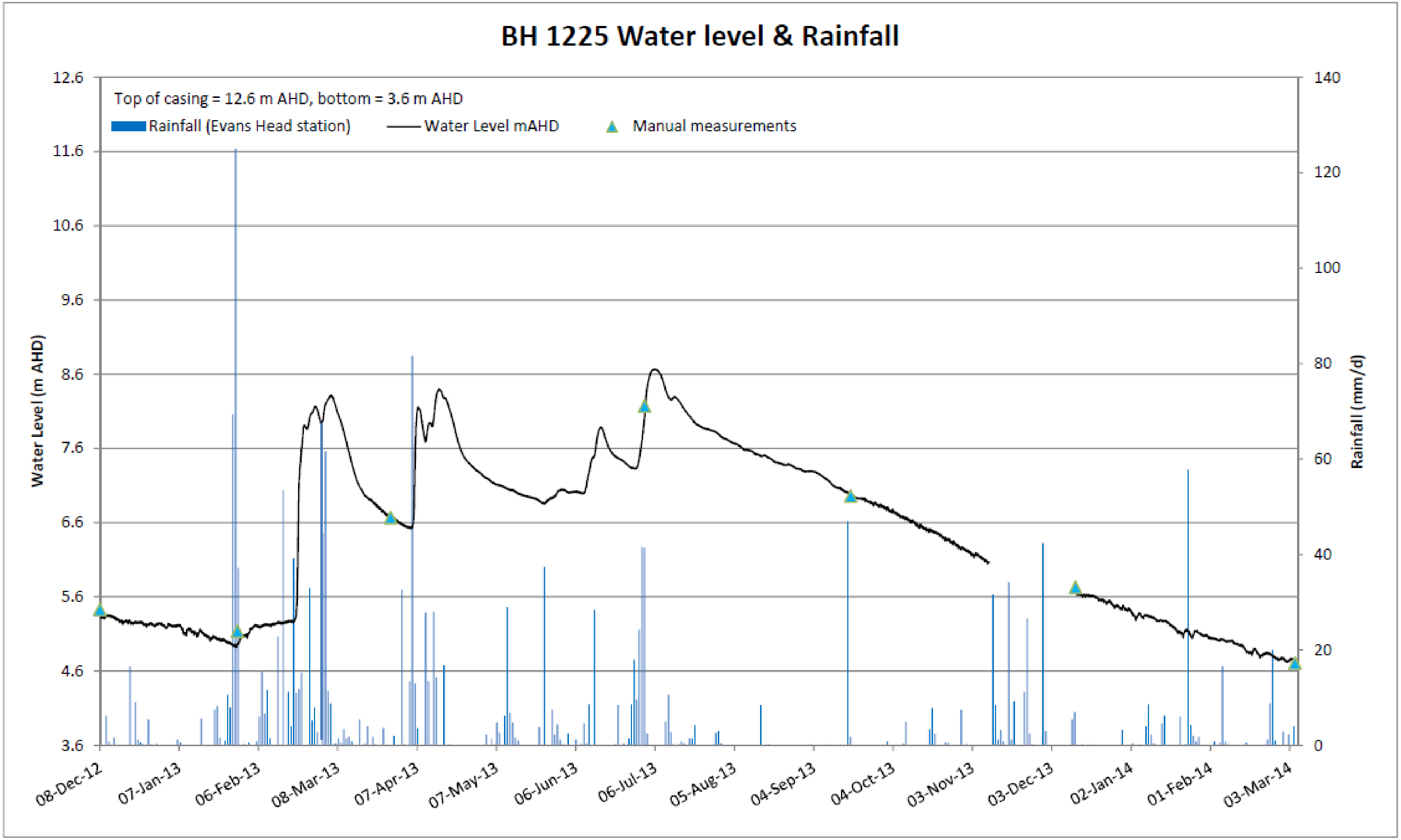
01-Feb-14
03-Mar-14



BH 1223 Water level & Rainfall
Top of casing = 12.8 m AHD, bottom = -5.8 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.4
11.0
9.6
8.2
6.8
5.4
4.0
2.6
1.2
-0.2
-1.6
-3.0
-4.4
-5.8
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1224 Water level & Rainfall
Top of casing = 12.4 m AHD, bottom = 6.9 m AHD
Rainfall (Evans Head station)
Water Level, m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.9
11.9
10.9
9.9
8.9
7.9
6.9
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1225 Water level & Rainfall
Top of casing = 12.6 m AHD, bottom = 3.6 m AHD
Rainfall (Evans Head station)
Water Level mAHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.6
11.6
10.6
9.6
8.6
7.6
6.6
5.6
4.6
3.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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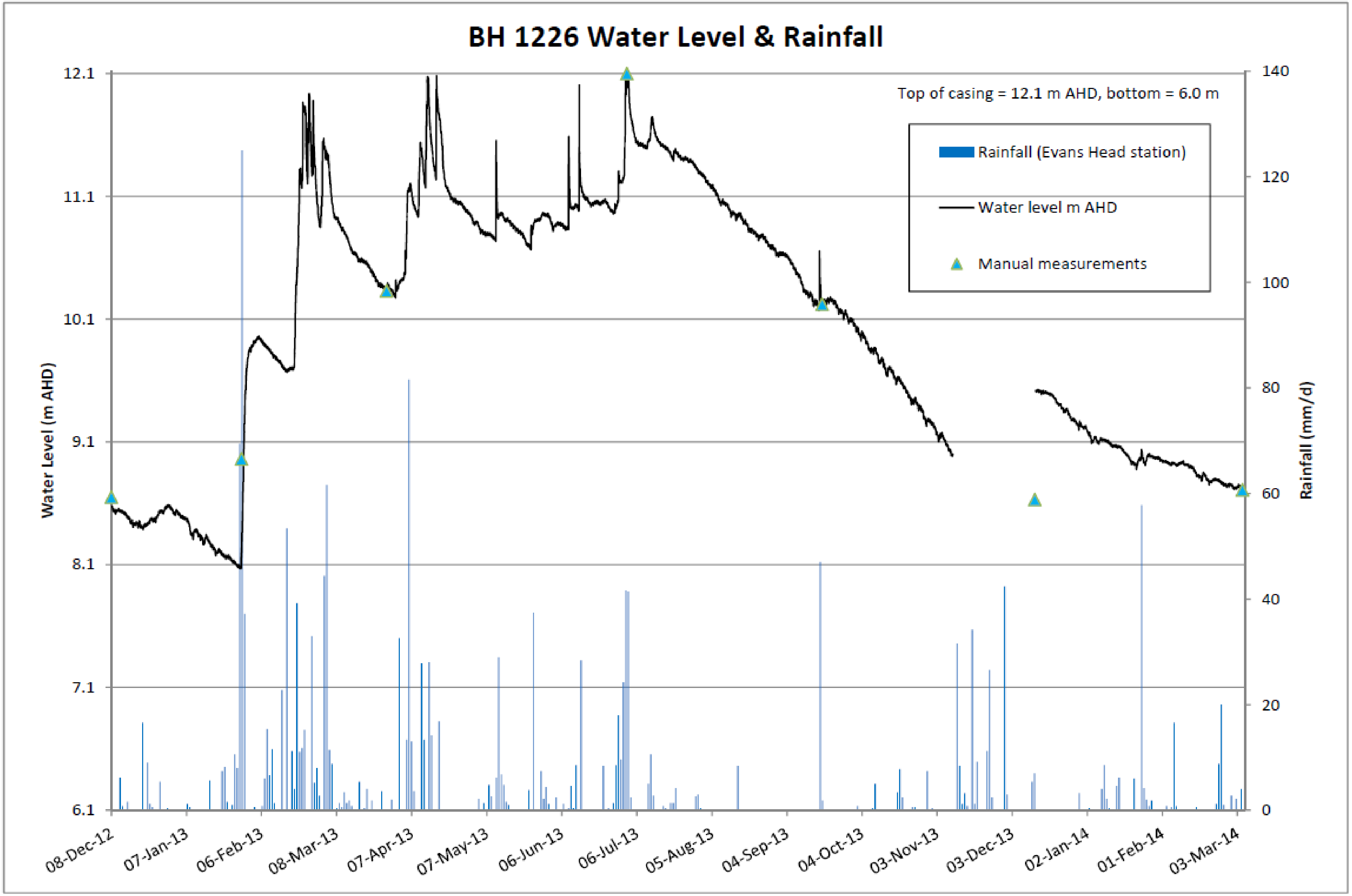
01-Feb-14
03-Mar-14



BH 1226 Water Level & Rainfall
Top of casing = 12.1 m AHD, bottom = 6.0 m
Rainfall (Evans Head station)
Water level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.1
11.1
10.1
9.1
8.1
7.1
6.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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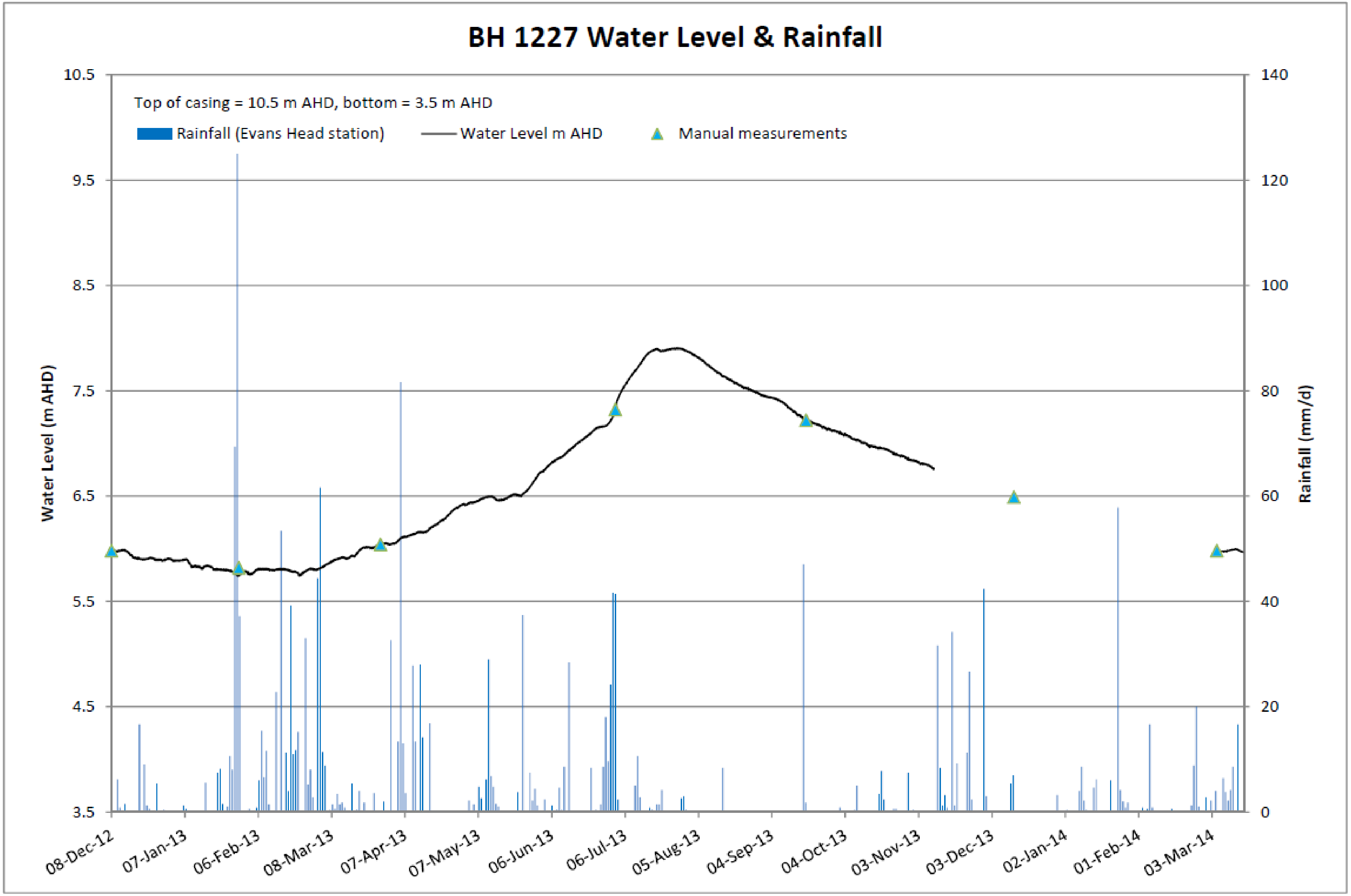
01-Feb-14
03-Mar-14


BH 1227 Water Level & Rainfall
Top of casing = 10.5 m AHD, bottom = 3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

Appendix G

Section 8 - Trustums Hill to Broadwater National Park: Pre-Construction Monitoring Results

Section 8: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	***Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems (GDE's)***
SW05 - Tuckombil Canal (becomes Evans River) SW06 - Unnamed watercourse at CH 134 700 m SW07 - Unnamed tributary of MacDonald's Creek, CH 136 450 m SW08 - MacDonald's Creek	▪ potential habitat for threatened fish species / Rous Water catchment ▪ potential habitat for threatened fish species / Rous Water catchment ▪ potential habitat for threatened fish species / Rous Water catchment ▪ potential habitat for threatened fish species / Rous Water catchment / GDE

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 8: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the high-teens (15-19°C) in winter up to the high-20s (26-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical Properties

pH values were generally experienced a fair degree of variation for each water body. pH levels fell within the range of 3.5 to 9.3.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of 0.01 to 3.31 mg/L. Total Nitrogen values were found to be in the range of <0.1 to 6.0 mg/L.

Heavy Metals

Heavy metals were generally below detection limits.

Summary of Visual Observations and Sampling Results (Note: * Ch. = Highway Chainage)

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
GDE04 Swamp Area Ch. 130,350	▪ No record of visual observations provided.	▪ O&G: <5-5mg/L ▪ SS: 19-240mg/L ▪ TP: 0.14-3.31mg/L ▪ TN: 2.1-6.0mg/L ▪ DO: 3.5-11.3mg/L ▪ EC: 135-2620µS/cm ▪ pH: 3.5-6.1 ▪ Temp: 19.4-31.4°C ▪ NTU: 7.5-58
GDE05 Swamp Area Ch. 133,300	▪ As above.	▪ O&G: <0.5mg/L ▪ SS: <0.5-25mg/L ▪ TP: 0.04-0.14mg/L ▪ TN: 0.8-1.7mg/L ▪ DO: 2.1-10mg/L ▪ EC: 104-292µS/cm ▪ pH: 5.1-8.3 ▪ Temp: 17.4-30°C ▪ NTU: 3.3-12
SW05 Tuckombil Canal (becomes Evans River) Ch. 130,000	▪ As above.	▪ O&G: <5mg/L ▪ SS: 14-149mg/L ▪ TP: <0.01-0.21mg/L ▪ TN: <0.1-1.6mg/L ▪ DO: 2-10.8mg/L ▪ EC: 41-38,600µS/cm ▪ pH: 5.5-7.5 ▪ Temp: 18.1-27.1°C ▪ NTU: 5.2-104
SW06 Unnamed watercourse Ch. 134,800	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-168mg/L ▪ TP: <0.01-0.61mg/L ▪ TN: 5.1-0.5mg/L ▪ DO: 3.4-10mg/L ▪ EC: 116-578µS/cm ▪ pH: 4.0-9.3 ▪ Temp: 16.6-29°C ▪ NTU: 1.0-54.0
SW07 Unnamed tributary of Macdonald's Creek Ch.135,350	▪ As above.	▪ O&G: <5-6mg/L ▪ SS: <5-56mg/L ▪ TP: <0.01-0.21mg/L ▪ TN: 0.2-3.4mg/L ▪ DO: 1.9-8.9mg/L ▪ EC: 122-600µS/cm ▪ pH: 3.8-8.9 ▪ Temp: 15.4-26.7°C ▪ NTU: 1.9-79
SW08/GDE06 Macdonald's Creek Ch. 136,630	▪ As above.	▪ O&G: 0.23-2.97mg/L ▪ SS: <5-13mg/L ▪ TP: <0.01-1.15mg/L ▪ TN: 0.6-0.8mg/L ▪ DO: 1.7-8.1mg/L ▪ EC: 110-654µS/cm ▪ pH: 3.6-6.3 ▪ Temp: 14.9-26°C ▪ NTU: 0.8-8.6

Section 8: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 8							
SW05 (SW8-01 and SW8-02)									
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	40.58	35.92	149.00	14.0	31.0	39.6	-	
Total Phosphorus as P	mg/l	0.24	0.29	1.07	0.0	0.2	0.21	-	
Total Nitrogen as N	mg/l	0.78	0.50	1.60	0.1	0.8	1.18	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.66	2.12	10.80	2.0	7.9	8.7	6.92	
Conductivity	µs/cm	15337.08	13268.43	38600.00	41.0	13100.0	29848	3321.2	
pH		6.76	0.59	7.50	5.5	6.8	7.36		
Temperature	°C	23.80	2.99	27.10	18.1	24.7	26	-	
Turbidity	NTU	40.42	64.20	232.00	10.4	18.9	35	-	
GDE04									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	3.13	1.25	5.00	2.5	2.5	3.5	-	
Suspended Solids	mg/l	87.50	102.94	240.00	19.0	45.5	130.8	-	
Total Phosphorus as P	mg/l	2.14	1.45	3.31	0.1	2.5	3.184	-	
Total Nitrogen as N	mg/l	4.38	1.64	6.00	2.1	4.7	5.34	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.74	4.06	11.30	3.5	5.4	8.94	4.266	
Conductivity	µs/cm	846.33	1145.21	2153.00	17.0	369.0	1439.4	157.8	
pH		4.64	1.33	6.10	3.5	4.3	5.38	3.826	
Temperature	°C	25.40	8.49	31.40	19.4	25.4	29	-	
Turbidity	NTU	108.60	137.74	206.00	11.2	108.6	167.04	-	
GDE05									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	9.18	6.57	25.00	2.5	8.0	10	-	
Total Phosphorus as P	mg/l	0.08	0.03	0.14	0.0	0.1	0.09	-	
Total Nitrogen as N	mg/l	1.13	0.31	1.70	0.8	1.0	1.4	-	
Dissolved Oxygen	mg/l	7.29	2.49	9.70	2.1	8.1	8.76	6.592	
Conductivity	µs/cm	598.80	379.61	1408.00	145.0	642.0	786.8	190.2	
pH		6.75	1.07	8.30	5.1	6.8	7.62	5.92	
Temperature	°C	24.06	4.04	30.00	17.4	25.0	26.68	-	
Turbidity	NTU	8.77	1.77	11.70	5.7	9.2	9.98	-	
SW06 (SW8-03 and SW8-04)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile 80**	**Percentile 20**	**No.**
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	28.86	48.67	168.00	2.5	14.0	37	-	
Total Phosphorus as P	mg/l	0.14	0.18	0.61	0.0	0.1	0.16	-	
Total Nitrogen as N	mg/l	1.39	1.31	5.10	0.5	1.0	1.7	-	

	Units	SECTION 8							
Field Physico-chemical data									
Dissolved Oxygen	mg/l	8.10	1.98	10.00	3.4	8.7	9.36	7.1	
Conductivity	µs/cm	266.00	172.36	537.00	102.0	183.0	473.2	133.2	
pH		5.18	1.77	9.30	4.0	4.3	6.22	4.132	
Temperature	°C	23.80	4.37	29.00	16.6	25.1	27.82	-	
Turbidity	NTU	21.13	38.41	122.00	1.3	9.1	16.24	-	
SW07 (SW8-05 and SW8-06)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.79	1.01	6.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	16.92	18.69	56.00	2.5	6.8	34	-	
Total Phosphorus as P	mg/l	0.05	0.07	0.21	0.0	0.0	0.088	-	
Total Nitrogen as N	mg/l	1.02	0.96	3.40	0.2	0.5	1.74	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.05	1.96	8.90	3.1	6.1	8.2	4.11	
Conductivity	µs/cm	217.92	149.25	606.00	92.0	154.0	313.2	113	
pH		5.00	1.38	8.90	3.8	4.5	5.26	4.3	
Temperature	°C	22.50	3.81	26.70	15.4	22.5	26.32	-	
Turbidity	NTU	25.15	41.38	138.00	2.4	11.4	24.9	-	
SW08 (SW8-07 and SW8-08)									
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	5.45	3.83	13.00	2.5	4.3	7	-	
Total Phosphorus as P	mg/l	0.16	0.37	1.15	0.0	0.0	0.048	-	
Total Nitrogen as N	mg/l	0.67	0.07	0.80	0.6	0.7	0.7	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	4.58	2.49	8.10	1.7	4.4	6.86	2.136	
Conductivity	µs/cm	329.90	150.63	527.00	164.0	284.0	515.2	183	
pH		4.43	0.82	6.25	3.4	4.4	4.78		
Temperature	°C	20.57	3.31	25.60	14.9	21.7	22.76	-	
Turbidity	**NTU**	**4.24**	**4.14**	**14.20**	**0.7**	**3.1**	**6.492**	**-**	

Section 8: Groundwater Monitoring – Water Quality

Water Quality for Bores Next to the Rous Water Extraction Borefield

The following three tables show the water quality monitoring statistics for bores BH1242, BH1243 and BH1244.

		BH1242						
Parameter	***Units***	***Mean (Total)***	***Standard Deviation***	***Minimum***	***Maximum***	***Median***	***Percentile***	
							80	***20***
pH Value (field)	pH Unit	5.23	0.31	4.80	5.50	5.30	5.44	5.04
pH Value (lab)	pH Unit	6.89	0.49	6.54	7.60	6.72	7.13	6.58
Temperature (field)	ºC	19.20	0.67	18.60	20.00	19.10	19.70	18.66
Electrical Conductivity @ 25°C (lab)	µS/cm	286.25	7.85	276.00	295.00	287.00	290.80	282.00
Electrical Conductivity (field)	µS/cm	268.50	44.32	223.00	329.00	261.00	291.20	242.80
Total Dissolved Solids @180°C	mg/L	183.00	17.80	165.00	202.00	182.50	197.20	168.60
Suspended Solids (SS)	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Turbidity (field)	NTU	3.10	0.56	2.60	3.70	3.00	3.42	2.76
Turbidity (lab)	NTU	6.88	1.51	4.70	7.90	7.45	7.90	6.08
Redox Potential (field)		50.90	61.80	10.60	143.00	25.00	73.40	18.04
Redox Potential (lab)	mV	-7.30	61.77	-69.20	66.00	-13.00	38.40	-55.28
pH Redox	pH Unit	6.15	0.07	6.10	6.20	6.15	6.18	6.12
Hydroxide Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Carbonate Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Bicarbonate Alkalinity as CaCO3	mg/L	38.50	3.11	36.00	43.00	37.50	40.00	36.60
Total Alkalinity as CaCO3	mg/L	38.50	3.11	36.00	43.00	37.50	40.00	36.60
Sulfate as SO4 - Turbidimetric	mg/L	12.25	1.71	10.00	14.00	12.50	13.40	11.20
Chloride	mg/L	55.50	2.89	52.00	59.00	55.50	57.20	53.80
Calcium	mg/L	2.50	0.58	2.00	3.00	2.50	3.00	2.00
Magnesium	mg/L	4.00	0.00	4.00	4.00	4.00	4.00	4.00
Sodium	mg/L	46.00	1.41	45.00	48.00	45.50	46.80	45.00
Potassium	mg/L	2.25	0.50	2.00	3.00	2.00	2.40	2.00
Aluminium	mg/L	0.04	0.01	0.03	0.04	0.04	0.04	0.03
Antimony	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	mg/L	0.05	0.00	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	mg/L	0.06	0.03	0.03	0.09	0.06	0.08	0.04
Molybdenum	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Silver	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	mg/L	0.01	0.01	0.00	0.01	0.01	0.01	0.00
Boron	mg/L	0.03	0.00	0.03	0.03	0.03	0.03	0.03
Iron	mg/L	6.34	0.56	5.51	6.72	6.56	6.67	6.09
Mercury	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fluoride	mg/L	0.18	0.22	0.05	0.50	0.08	0.26	0.05
Ammonia as N	mg/L	0.07	0.05	0.04	0.14	0.06	0.09	0.05

Parameter	Units	BH1242 Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile 80	Percentile 20
Nitrite + Nitrate as N	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.28	0.05	0.20	0.30	0.30	0.30	0.26
Total Nitrogen as N	mg/L	0.28	0.05	0.20	0.30	0.30	0.30	0.26
Total Phosphorus as P	mg/L	0.07	0.05	0.04	0.14	0.06	0.09	0.05
Total Anions	meq/L	2.59	0.10	2.48	2.73	2.58	2.65	2.53
Total Cations	meq/L	2.51	0.07	2.46	2.62	2.49	2.54	2.47
Oil and Grease	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Dissolved Oxygen (lab)	mg/L	4.30	2.07	1.90	6.80	4.25	5.66	2.92
Dissolved Oxygen (field)	mg/L	3.23	1.22	1.40	4.00	3.75	3.88	2.78
Benzene	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Toluene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Ethylbenzene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
meta- and para-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
ortho-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Total Xylenes	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Sum of BTEX	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Naphthalene	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C6 - C9 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C10 - C14 Fraction	µg/L	31.88	58.75	2.50	120.00	2.50	49.50	2.50
C15 - C28 Fraction	µg/L	392.50	430.92	120.00	1030.00	210.00	580.00	132.00
C29 - C36 Fraction	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C10 - C36 Fraction (sum)	µg/L	422.50	424.61	120.00	1030.00	270.00	652.00	132.00
C6 - C10 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C6 - C10 Fraction minus BTEX (F1)	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
>C10 - C16 Fraction	µg/L	370.00	392.68	110.00	940.00	215.00	568.00	110.00
>C16 - C34 Fraction	µg/L	67.75	82.75	0.50	170.00	50.25	128.00	0.50
>C34 - C40 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C40 Fraction (sum)	µg/L	437.50	471.55	110.00	1110.00	265.00	696.00	110.00
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	110.00	0.00	110.00	110.00	110.00	110.00	110.00
1.2-Dichloroethane-D4	%	92.20	5.15	86.30	98.50	92.00	95.56	88.76
Toluene-D8	%	94.28	5.65	87.30	100.00	94.90	98.50	90.30
4-Bromofluorobenzene	%	90.03	4.79	83.50	94.50	91.05	93.30	87.16
Faecal Coliforms	**CFU/ 100mL**	**5.88**	**10.75**	**0.50**	**22.00**	**0.50**	**9.10**	**0.50**

Parameter	Units	BH1243 Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile 80	Percentile 20
pH Value (lab)	pH Unit	6.82	0.45	6.53	7.49	6.63	7.00	6.56
pH Value (field)	pH Unit	5.33	0.05	5.30	5.40	5.30	5.34	5.30
Temperature (field)	ºC	19.00	0.54	18.40	19.70	18.95	19.28	18.70
Electrical Conductivity @ 25°C (lab)	µS/cm	402.25	24.19	367.00	421.00	410.50	416.80	391.00
Electrical Conductivity (field)	µS/cm	379.00	53.99	324.00	447.00	372.50	415.80	339.60
Total Dissolved Solids @180°C	mg/L	225.75	17.23	201.00	238.00	232.00	237.40	216.60
Suspended Solids (SS)	mg/L	16.00	8.72	11.00	29.00	12.00	19.40	11.00
Turbidity (field)	NTU	12.90	2.91	10.70	16.20	11.80	14.44	11.14
Turbidity (lab)	NTU	19.30	13.50	6.60	35.00	17.80	29.60	8.40

Parameter	Units	BH1243						
		Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
Redox Potential (field)	mV	72.10	52.02	26.40	141.00	60.50	106.20	33.36
Redox Potential (lab)	mV	12.58	53.60	-46.90	77.30	9.95	49.46	-25.36
pH Redox	pH Unit	6.00	0.14	5.90	6.10	6.00	6.06	5.94
Hydroxide Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Carbonate Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Bicarbonate Alkalinity as CaCO3	mg/L	27.25	4.50	21.00	31.00	28.50	30.40	24.60
Total Alkalinity as CaCO3	mg/L	27.25	4.50	21.00	31.00	28.50	30.40	24.60
Sulfate as SO4 - Turbidimetric	mg/L	24.25	0.50	24.00	25.00	24.00	24.40	24.00
Chloride	mg/L	87.75	9.43	77.00	99.00	87.50	94.20	81.20
Calcium	mg/L	3.75	0.50	3.00	4.00	4.00	4.00	3.60
Magnesium	mg/L	4.50	0.58	4.00	5.00	4.50	5.00	4.00
Sodium	mg/L	65.50	6.03	60.00	74.00	64.00	68.60	61.80
Potassium	mg/L	3.00	0.00	3.00	3.00	3.00	3.00	3.00
Aluminium	mg/L	0.01	0.01	0.01	0.02	0.01	0.02	0.01
Antimony	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	mg/L	0.04	0.01	0.03	0.05	0.05	0.05	0.04
Cadmium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	mg/L	0.06	0.01	0.05	0.07	0.06	0.07	0.06
Molybdenum	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Silver	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	mg/L	0.01	0.00	0.00	0.01	0.00	0.01	0.00
Boron	mg/L	0.03	0.02	0.03	0.06	0.03	0.04	0.03
Iron	mg/L	8.56	0.62	7.72	9.20	8.66	8.92	8.24
Mercury	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fluoride	mg/L	0.14	0.18	0.05	0.40	0.05	0.19	0.05
Ammonia as N	mg/L	0.07	0.08	0.01	0.18	0.05	0.11	0.02
Nitrite + Nitrate as N	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.30	0.12	0.20	0.40	0.30	0.40	0.20
Total Nitrogen as N	mg/L	0.30	0.12	0.20	0.40	0.30	0.40	0.20
Total Phosphorus as P	mg/L	0.03	0.02	0.01	0.05	0.03	0.04	0.01
Total Anions	meq/L	3.53	0.22	3.31	3.83	3.48	3.63	3.41
Total Cations	meq/L	3.49	0.29	3.30	3.91	3.37	3.59	3.33
Ionic Balance	%	1.13	0.70	0.24	1.82	1.23	1.64	0.66
Oil and Grease	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Benzene	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Toluene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Ethylbenzene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
meta- and para-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
ortho-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Total Xylenes	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Sum of BTEX	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Naphthalene	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Dissolved Oxygen (lab)	mg/L	4.95	1.53	3.20	6.80	4.90	5.96	3.92

Parameter	Units	BH1243						
		Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
Dissolved Oxygen (field)	mg/L	3.23	1.08	1.80	4.20	3.45	4.02	2.52
C6 - C9 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C10 - C14 Fraction	µg/L	14.38	23.75	2.50	50.00	2.50	21.50	2.50
C15 - C28 Fraction	µg/L	62.75	72.00	0.50	130.00	60.25	124.00	0.50
C29 - C36 Fraction	µg/L	14.38	23.75	2.50	50.00	2.50	21.50	2.50
C10 - C36 Fraction (sum)	µg/L	88.75	106.15	2.50	220.00	66.25	166.00	2.50
C6 - C10 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C6 - C10 Fraction minus BTEX (F1)	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
>C10 - C16 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C16 - C34 Fraction	µg/L	35.38	69.75	0.50	140.00	0.50	56.30	0.50
>C34 - C40 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C40 Fraction (sum)	µg/L	35.38	69.75	0.50	140.00	0.50	56.30	0.50
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
1.2-Dichloroethane-D4	%	93.38	8.77	86.30	105.00	91.10	99.18	86.66
Toluene-D8	%	96.48	5.52	90.00	102.00	96.95	100.80	92.34
4-Bromofluorobenzene	%	91.28	9.93	79.00	103.00	91.55	97.30	85.36
Faecal Coliforms	**CFU/ 100mL**	**6.88**	**12.75**	**0.50**	**26.00**	**0.50**	**10.70**	**0.50**

Parameter	Units	BH1244						
		Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
pH Value (lab)	pH Unit	6.78	0.45	6.50	7.30	6.54	7.00	6.52
pH Value (field)	pH Unit	5.33	0.06	5.30	5.40	5.30	5.36	5.30
Temperature (field)	ºC	19.33	0.70	18.60	20.00	19.40	19.76	18.92
Electrical Conductivity (field)	µS/cm	354.00	58.23	293.00	409.00	360.00	389.40	319.80
Electrical Conductivity @ 25°C (lab)	µS/cm	366.67	8.33	360.00	376.00	364.00	371.20	361.60
Total Dissolved Solids @180°C	mg/L	210.00	9.54	201.00	220.00	209.00	215.60	204.20
Suspended Solids (SS)	mg/L	3.67	2.02	2.50	6.00	2.50	4.60	2.50
Turbidity (field)	NTU	2.43	0.23	2.30	2.70	2.30	2.54	2.30
Turbidity (lab)	NTU	2.97	1.15	2.30	4.30	2.30	3.50	2.30
Redox Potential (field)	mV	72.33	43.10	31.00	117.00	69.00	97.80	46.20
Redox Potential (lab)	mV	40.73	32.16	20.30	77.80	24.10	56.32	21.82
pH Redox	pH Unit	6.00	#DIV/0!	6.00	6.00	6.00	6.00	6.00
Hydroxide Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Carbonate Alkalinity as CaCO3	mg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Bicarbonate Alkalinity as CaCO3	mg/L	26.33	2.08	24.00	28.00	27.00	27.60	25.20
Total Alkalinity as CaCO3	mg/L	26.33	2.08	24.00	28.00	27.00	27.60	25.20
Sulfate as SO4 - Turbidimetric	mg/L	30.67	1.15	30.00	32.00	30.00	31.20	30.00
Chloride	mg/L	72.67	3.06	70.00	76.00	72.00	74.40	70.80
Calcium	mg/L	1.67	0.58	1.00	2.00	2.00	2.00	1.40
Magnesium	mg/L	3.33	0.58	3.00	4.00	3.00	3.60	3.00
Sodium	mg/L	62.00	2.00	60.00	64.00	62.00	63.20	60.80
Potassium	mg/L	2.67	0.58	2.00	3.00	3.00	3.00	2.40
Aluminium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Antimony	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Parameter	Units	BH1244						
		Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile	
							80	20
Barium	mg/L	0.04	0.01	0.04	0.05	0.05	0.05	0.04
Cadmium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	mg/L	0.02	0.01	0.01	0.03	0.02	0.03	0.02
Molybdenum	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Silver	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uranium	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	mg/L	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Boron	mg/L	0.03	0.01	0.03	0.05	0.03	0.04	0.03
Iron	mg/L	7.21	0.28	7.00	7.53	7.09	7.35	7.04
Mercury	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fluoride	mg/L	0.05	0.00	0.05	0.05	0.05	0.05	0.05
Ammonia as N	mg/L	0.15	0.06	0.08	0.18	0.18	0.18	0.12
Nitrite + Nitrate as N	mg/L	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.40	0.17	0.30	0.60	0.30	0.48	0.30
Total Nitrogen as N	mg/L	0.40	0.17	0.30	0.60	0.30	0.48	0.30
Total Phosphorus as P	mg/L	0.02	0.01	0.02	0.03	0.02	0.03	0.02
Total Anions	meq/L	3.22	0.08	3.14	3.29	3.22	3.26	3.17
Total Cations	meq/L	3.12	0.09	3.04	3.21	3.12	3.17	3.07
Ionic Balance	%	1.48	0.17	1.29	1.62	1.52	1.58	1.38
Oil and Grease	mg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Benzene	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Toluene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Ethylbenzene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
meta- and para-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
ortho-Xylene	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Total Xylenes	µg/L	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Sum of BTEX	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
Naphthalene	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
Dissolved Oxygen (lab)	mg/L	4.27	2.10	2.20	6.40	4.20	5.52	3.00
Dissolved Oxygen (field)	mg/L	3.30	0.75	2.50	4.00	3.40	3.76	2.86
C6 - C9 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C10 - C14 Fraction	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C15 - C28 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
C29 - C36 Fraction	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C10 - C36 Fraction (sum)	µg/L	2.50	0.00	2.50	2.50	2.50	2.50	2.50
C6 - C10 Fraction	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
C6 - C10 Fraction minus BTEX (F1)	µg/L	10.00	0.00	10.00	10.00	10.00	10.00	10.00
>C10 - C16 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C16 - C34 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C34 - C40 Fraction	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C40 Fraction (sum)	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	0.50	0.00	0.50	0.50	0.50	0.50	0.50
1.2-Dichloroethane-D4	%	95.80	8.41	87.20	104.00	96.20	100.88	90.80
Toluene-D8	%	100.70	8.33	91.10	106.00	105.00	105.60	96.66

		BH1244						
Parameter	*Units*	*Mean (Total)*	*Standard Deviation*	*Minimum*	*Maximum*	*Median*	*Percentile*	
							80	*20*
4-Bromofluorobenzene	%	97.40	5.39	91.20	101.00	100.00	100.60	94.72
Faecal Coliforms	**CFU/ 100mL**	**0.50**	**0.00**	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**

pH Statistics

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

pH Statistics from Boreholes in Areas of Fill

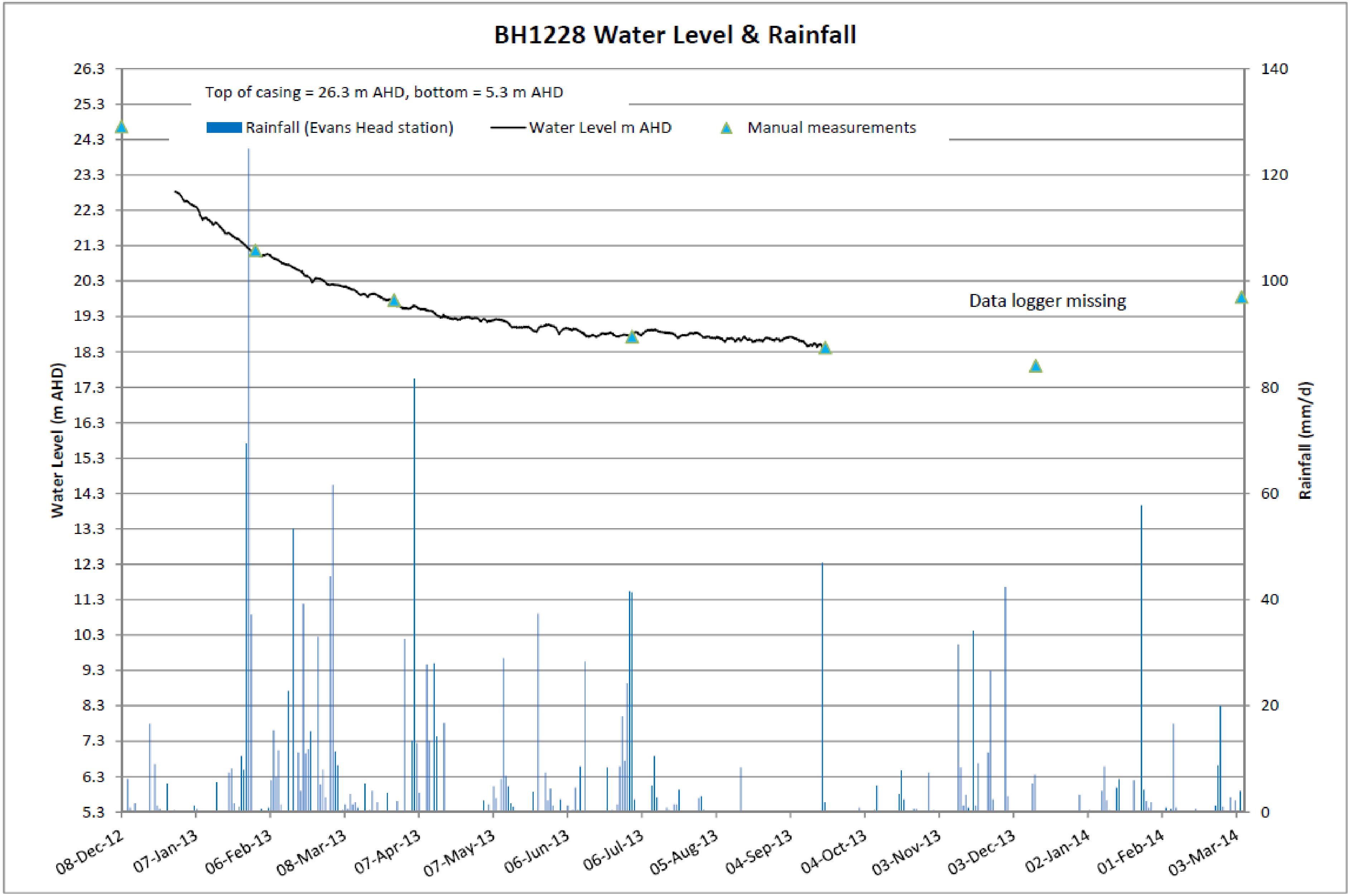
Borehole Identifier	Mean (Total)	Standard Deviation	Min	Max	Percentile	
					P80	P20
BH1230	5.28	0.35	4.90	5.70	5.25	5.52
BH1231	5.45	0.44	5.00	6.00	5.40	5.76
BH1232	4.25	0.65	3.80	5.20	4.00	4.54
BH1233	4.10	0.24	3.90	4.40	4.05	4.28
BH1234	4.98	0.68	4.10	5.60	5.10	5.48
BH1235	5.48	0.79	4.40	6.20	5.65	6.02
BH1236	6.63	0.24	6.30	6.80	6.70	6.80
BH1237	6.55	0.21	6.30	6.80	6.55	6.68
BH1238	6.05	0.69	5.10	6.60	6.25	6.54
BH1239	6.15	0.69	5.20	6.70	6.35	6.64
BH1240	5.53	0.75	4.40	6.00	5.85	5.94
BH1241	5.00	0.81	3.80	5.60	5.30	5.42
BH1242	5.30	0.18	5.10	5.50	5.30	5.44
BH1243	5.33	0.05	5.30	5.40	5.30	5.34
BH1244	5.33	0.06	5.30	5.40	5.30	5.36
BH1245	N/A	N/A	N/A	N/A	N/A	N/A
BH1246	5.43	0.31	5.00	5.70	5.50	5.64
BH1247	5.00	0.36	4.50	5.30	5.10	5.24
BH1248	5.45	0.66	4.50	5.90	5.70	5.90
BH1251	4.70	1.08	3.30	5.90	4.80	5.36
BH1252	4.98	1.09	3.50	5.90	5.25	5.78
BH1253	5.30	0.51	4.60	5.80	5.40	5.62

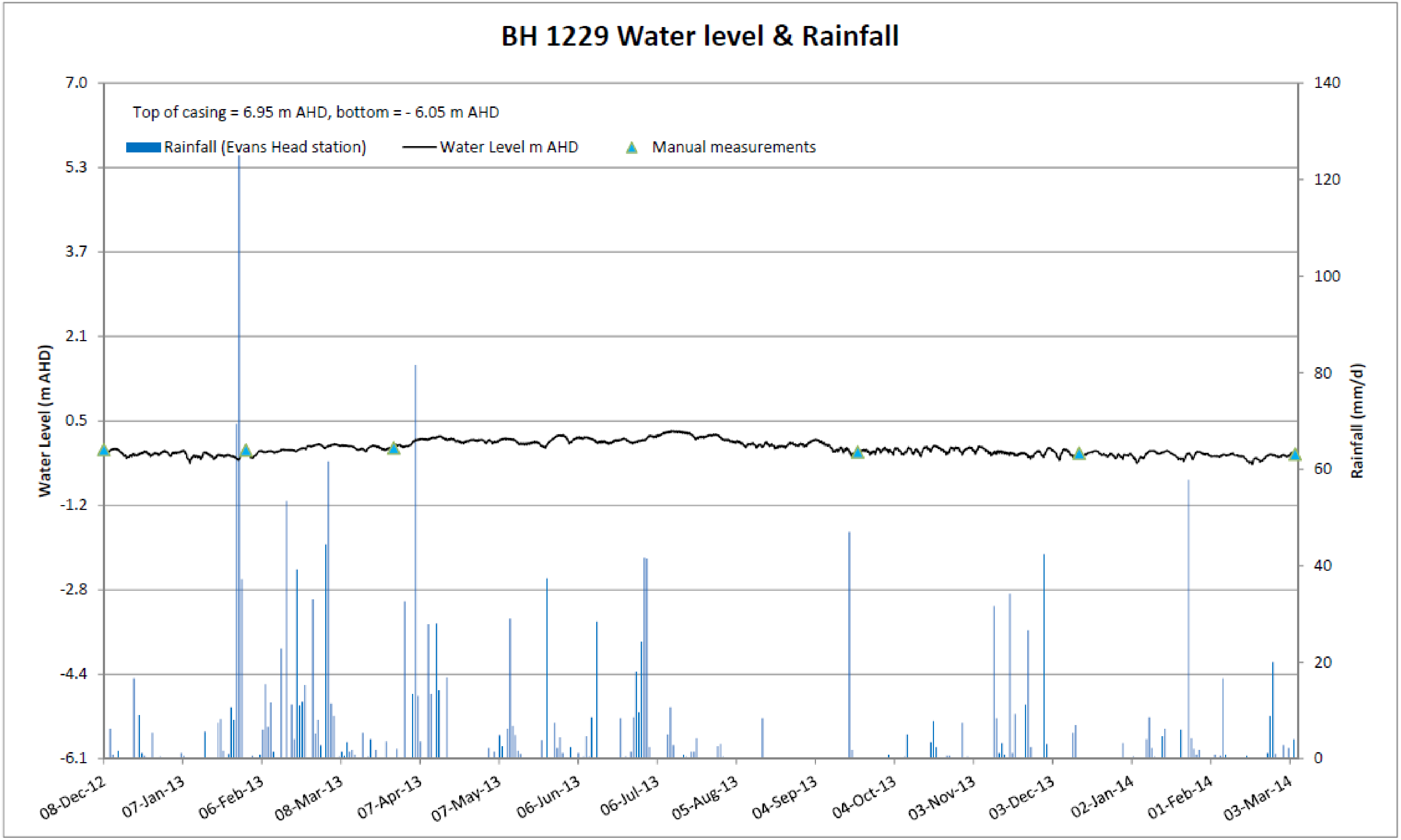
Section 8: Groundwater Monitoring – Levels

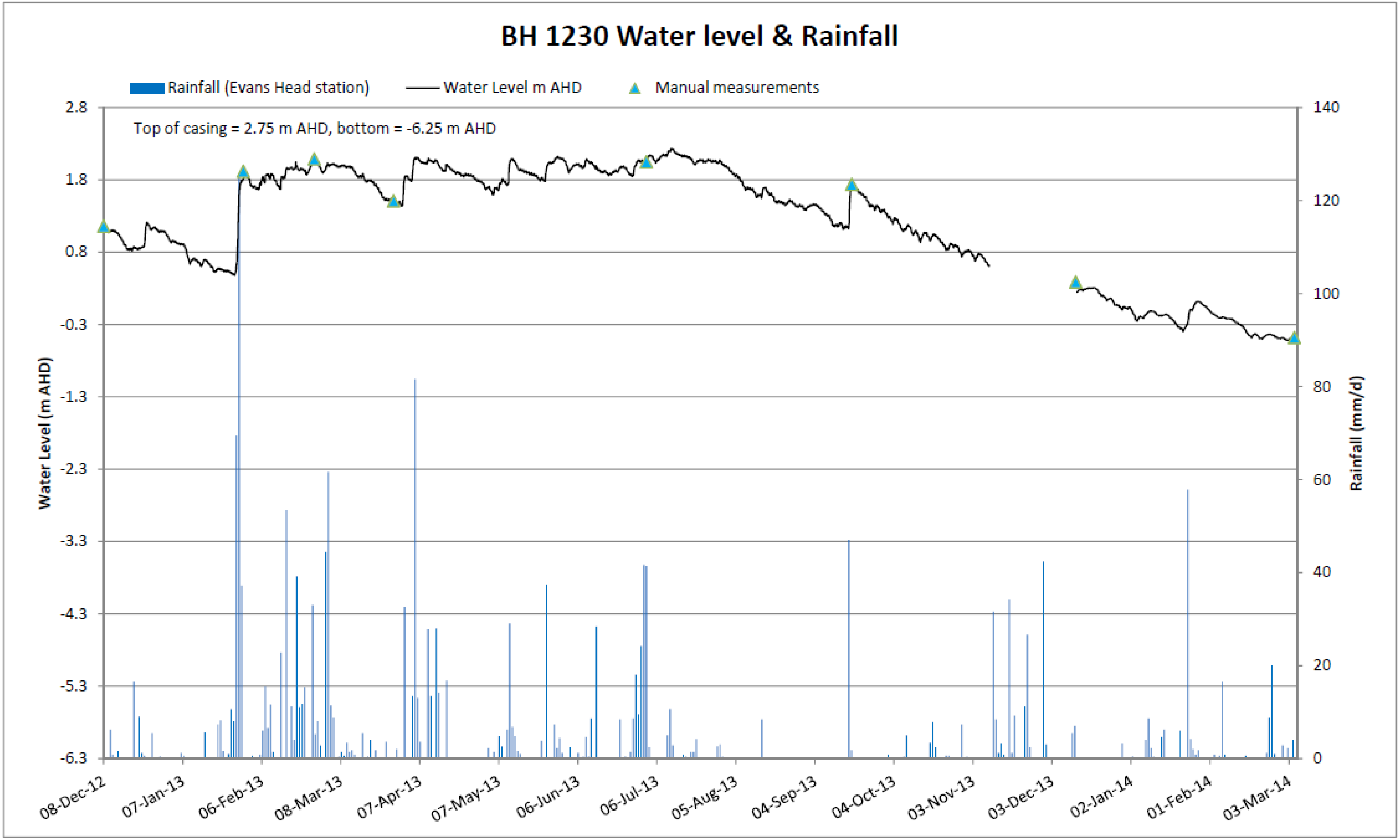
Summary of Groundwater Level Monitoring – Section 8 DP2B Upgrade

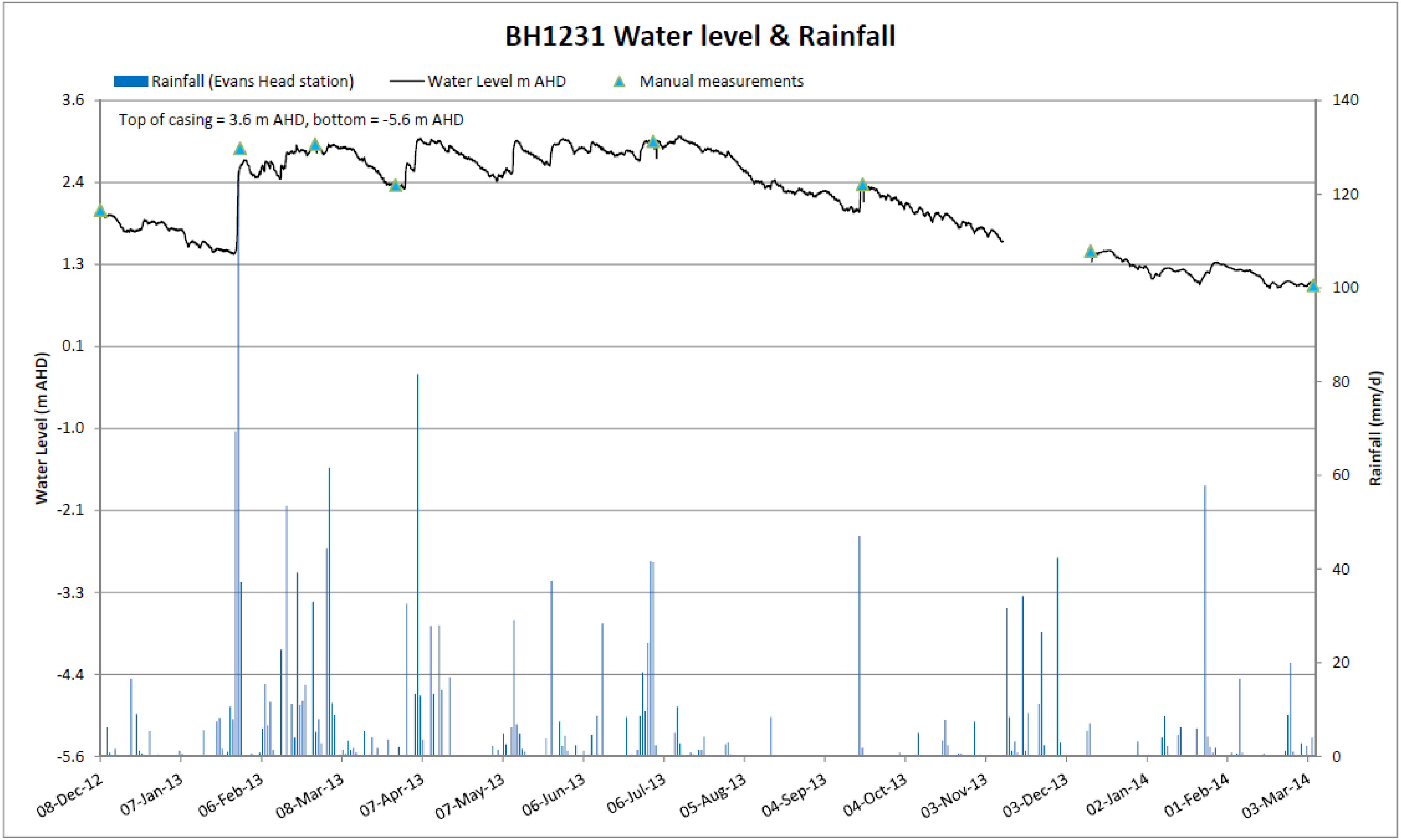
Borehole Identifier	Typical SWL (m below ground level)		
	Average	Median	Standard Deviation
BH1229	-0.1	-0.1	0.03
BH1230	1.7	1.61	0.63
BH1231	2.66	2.51	0.62
BH1232	0.64	0.88	0.42
BH1233	0.79	0.93	0.44
BH1234	0.68	0.62	0.61
BH1235	0.74	0.62	0.53
BH1236	0.72	0.82	0.58
BH1237	0.66	0.8	0.45
BH1238	-	-	-
BH1239	0.22	0.17	0.25
BH1240	1.15	1.03	0.38
BH1241	1.59	1.61	0.27
BH1242	1.56	1.39	0.56
BH1243	1.41	1.28	0.51
BH1244	0.33	0.34	0.07

Borehole Identifier	**Typical SWL (m below ground level)**		
	Average	**Median**	**Standard Deviation**
BH1245	1.4	1.47	0.46
BH1246	1.58	1.71	0.46
BH1247	0.22	0.17	0.25
BH1248	-	-	-
BH1249	-	-	-
BH1250	-	-	-
BH1251	1.63	1.72	0.28
BH1252	1.15	1.14	0.17
BH1253	1.23	1.22	0.16

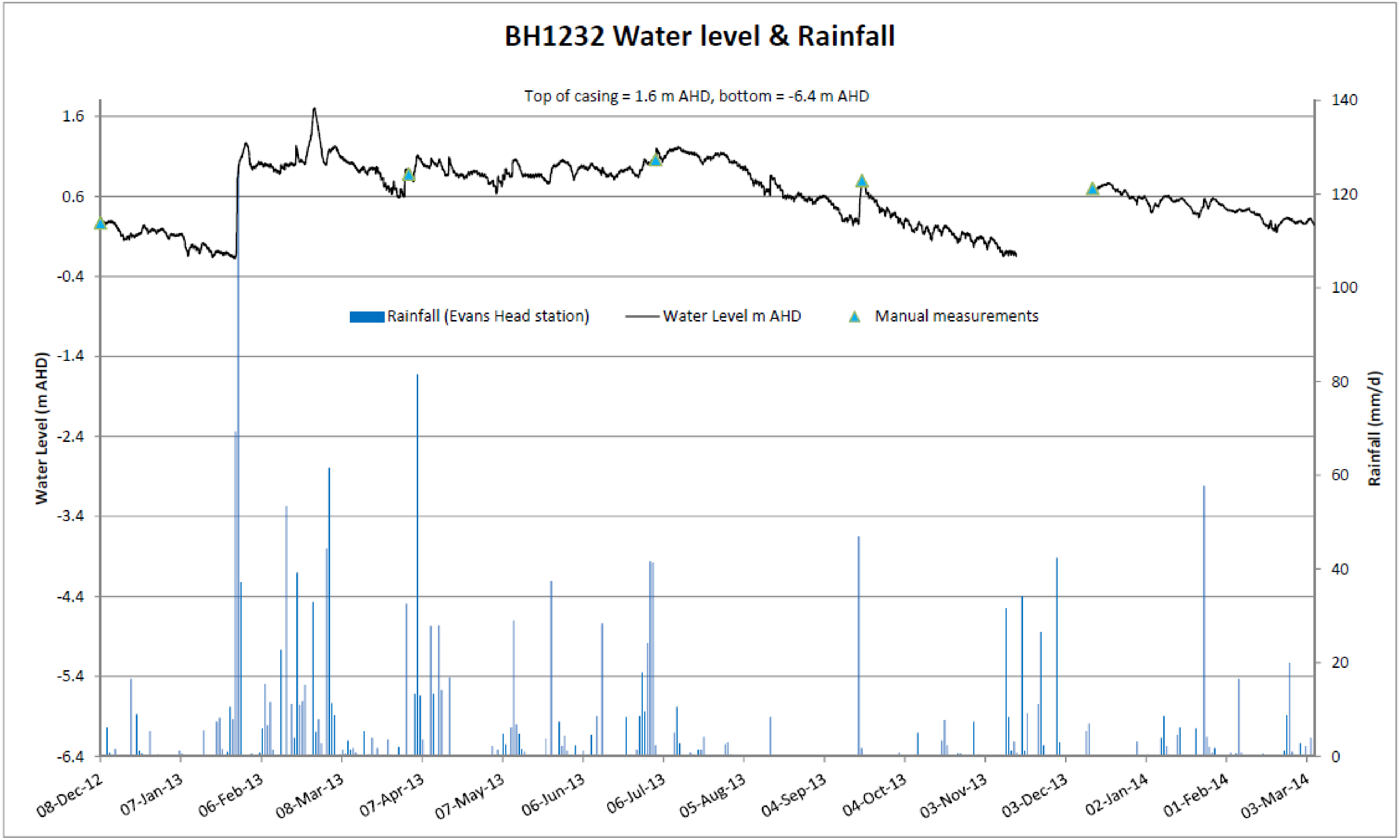

BH1228 Water Level & Rainfall
Top of casing = 26.3 m AHD, bottom = 5.3 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Data logger missing
Water Level (m AHD)
Rainfall (mm/d)
26.3
25.3
24.3
23.3
22.3
21.3
20.3
19.3
18.3
17.3
16.3
15.3
14.3
13.3
12.3
11.3
10.3
9.3
8.3
7.3
6.3
5.3
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

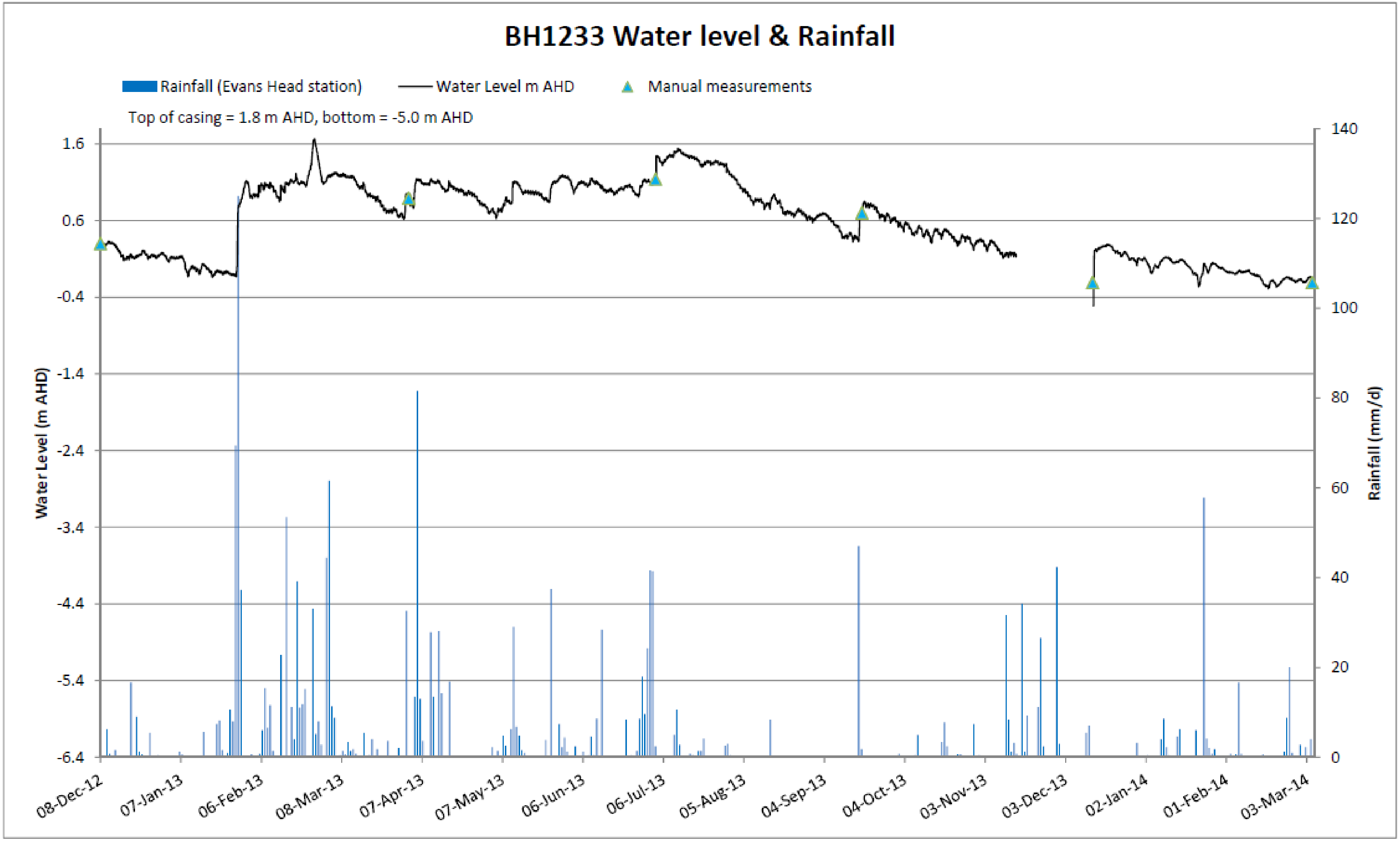

BH 1229 Water level & Rainfall
Top of casing = 6.95 m AHD, bottom = - 6.05 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
7.0
5.3
3.7
2.1
0.5
-1.2
-2.8
-4.4
-6.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1230 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.75 m AHD, bottom = -6.25 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.8
1.8
0.8
-0.3
-1.3
-2.3
-3.3
-4.3
-5.3
-6.3
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

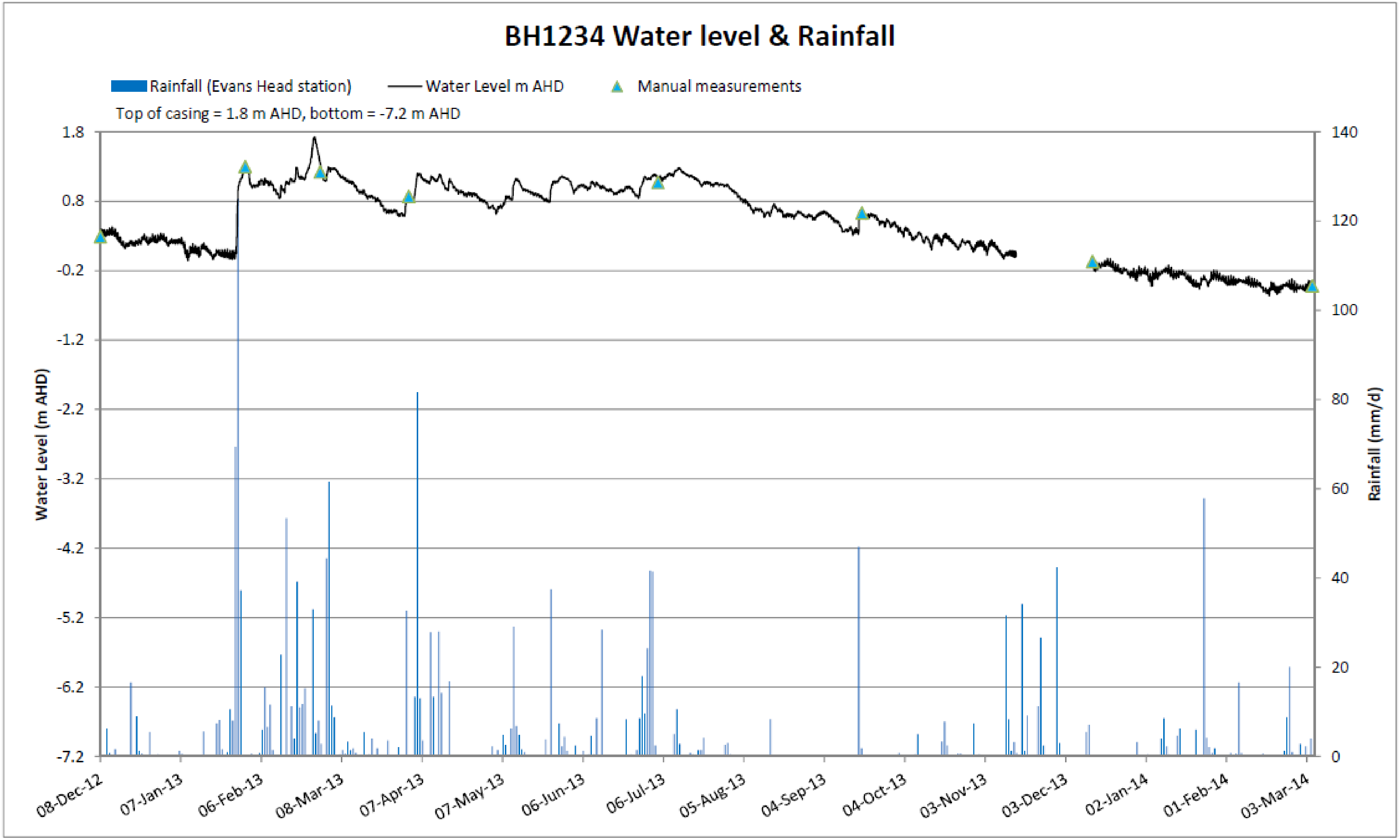


BH1231 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.6 m AHD, bottom = -5.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.6
2.4
1.3
0.1
-1.0
-2.1
-3.3
-4.4
-5.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1232 Water level & Rainfall
Top of casing = 1.6 m AHD, bottom = -6.4 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH1233 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.8 m AHD, bottom = -5.0 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1234 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.8 m AHD, bottom = -7.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
-5.2
-6.2
-7.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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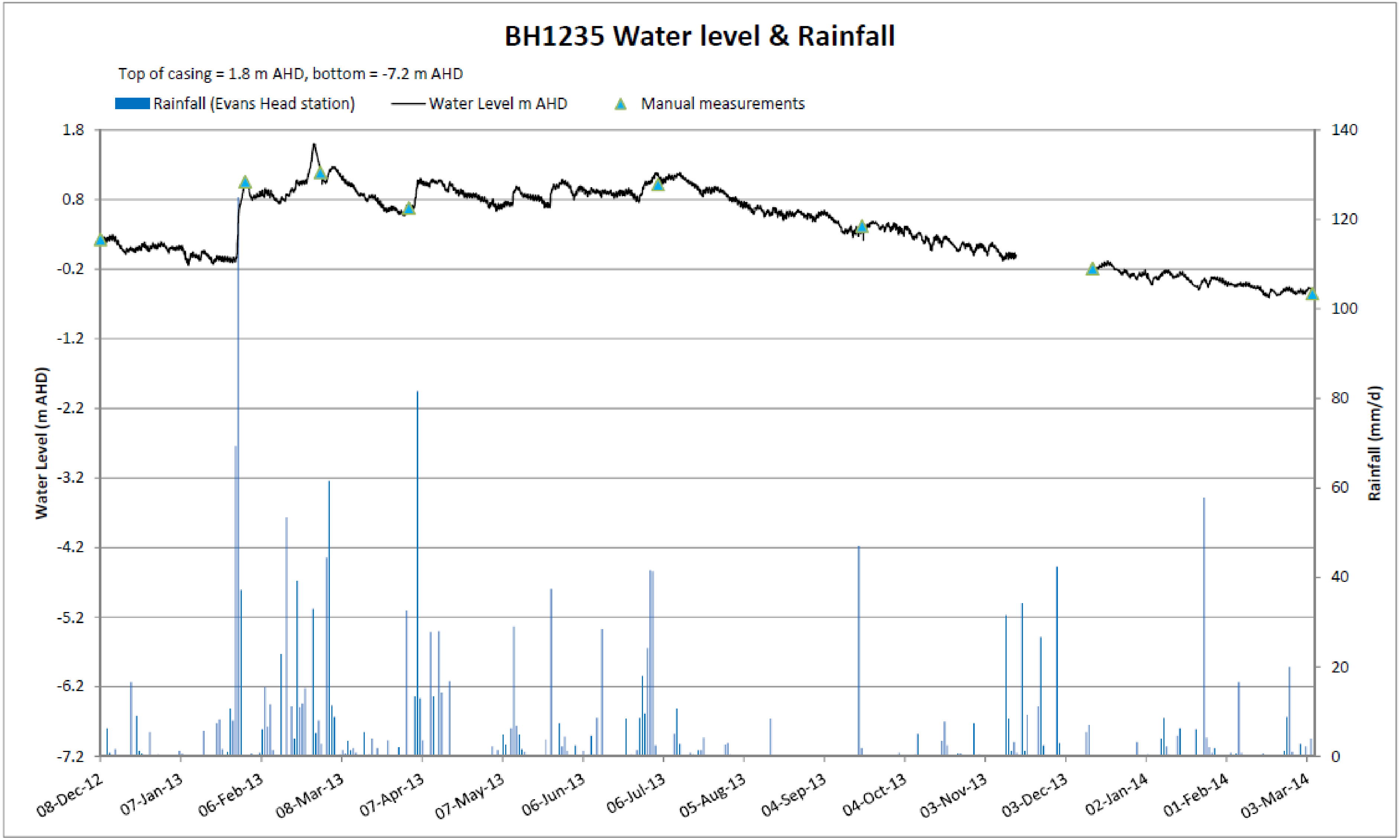
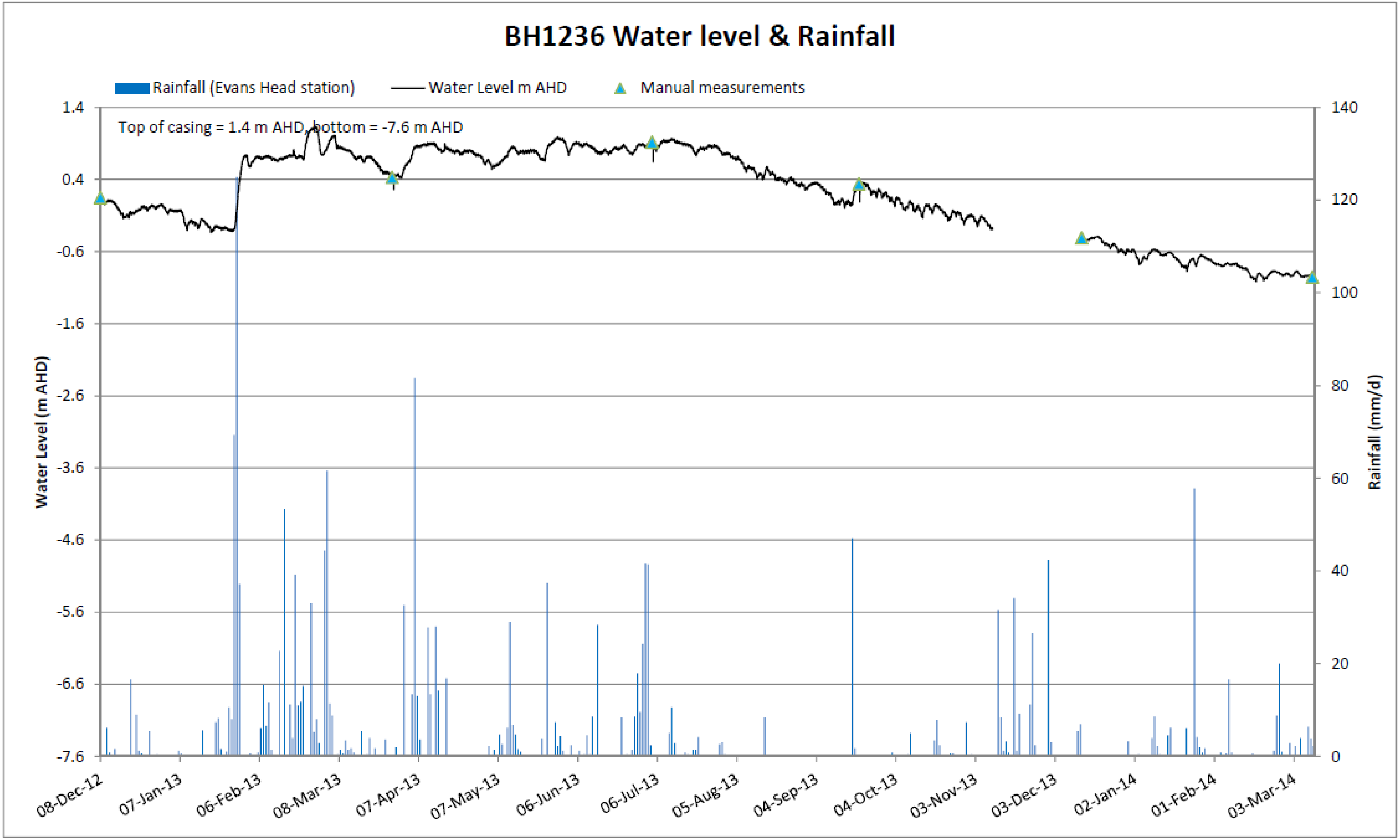
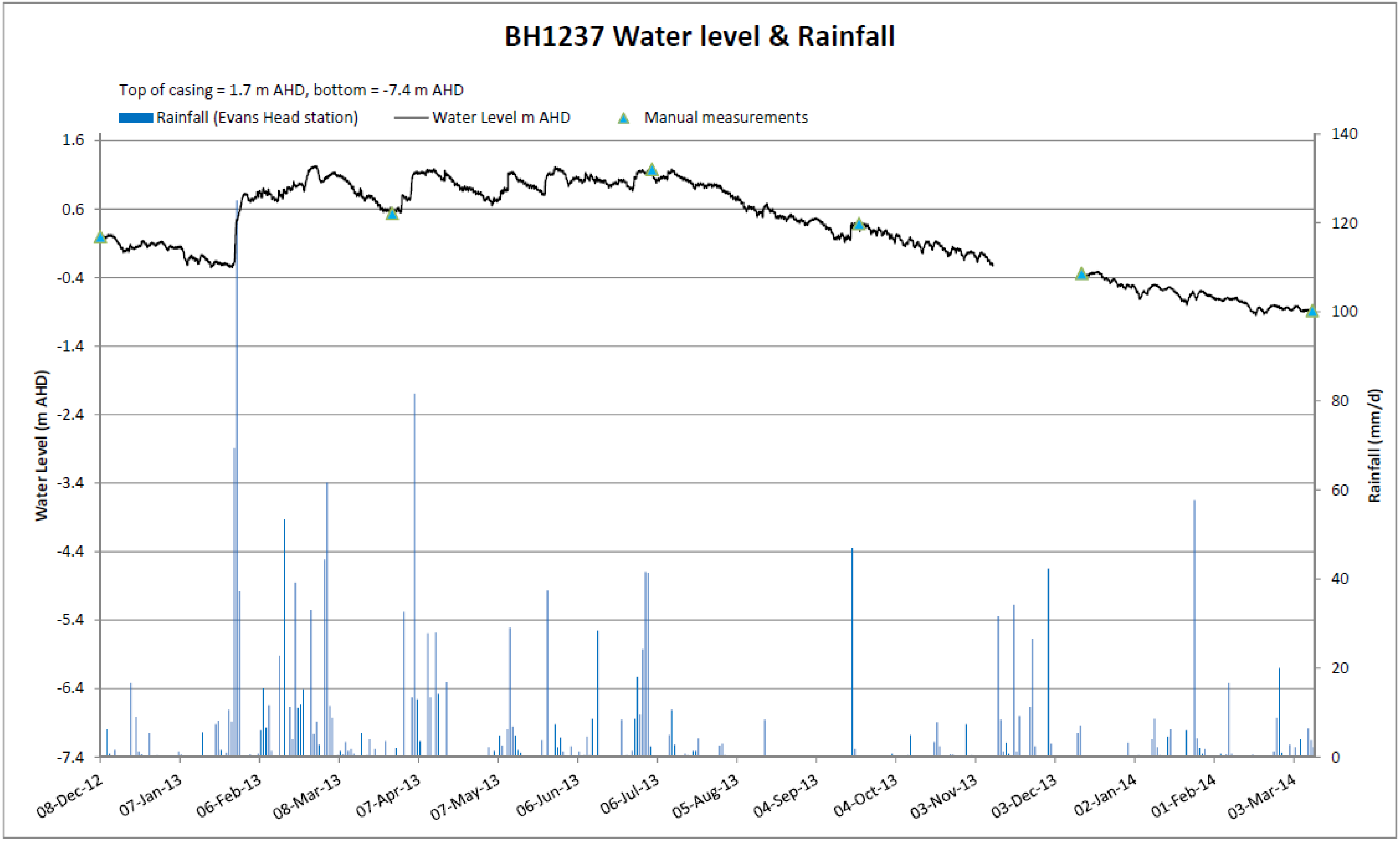
01-Feb-14
03-Mar-14

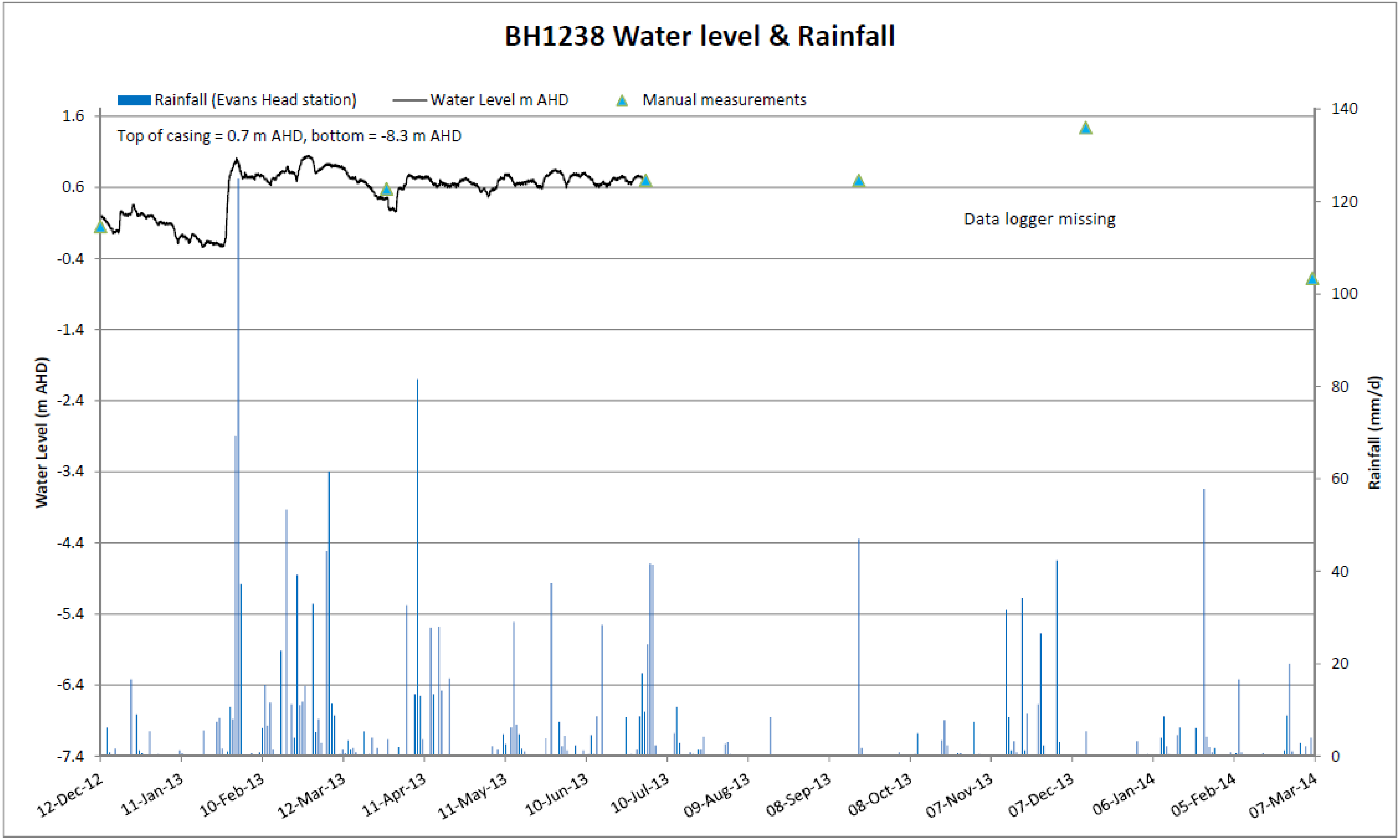


BH1235 Water level & Rainfall
Top of casing = 1.8 m AHD, bottom = -7.2 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
-5.2
-6.2
-7.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

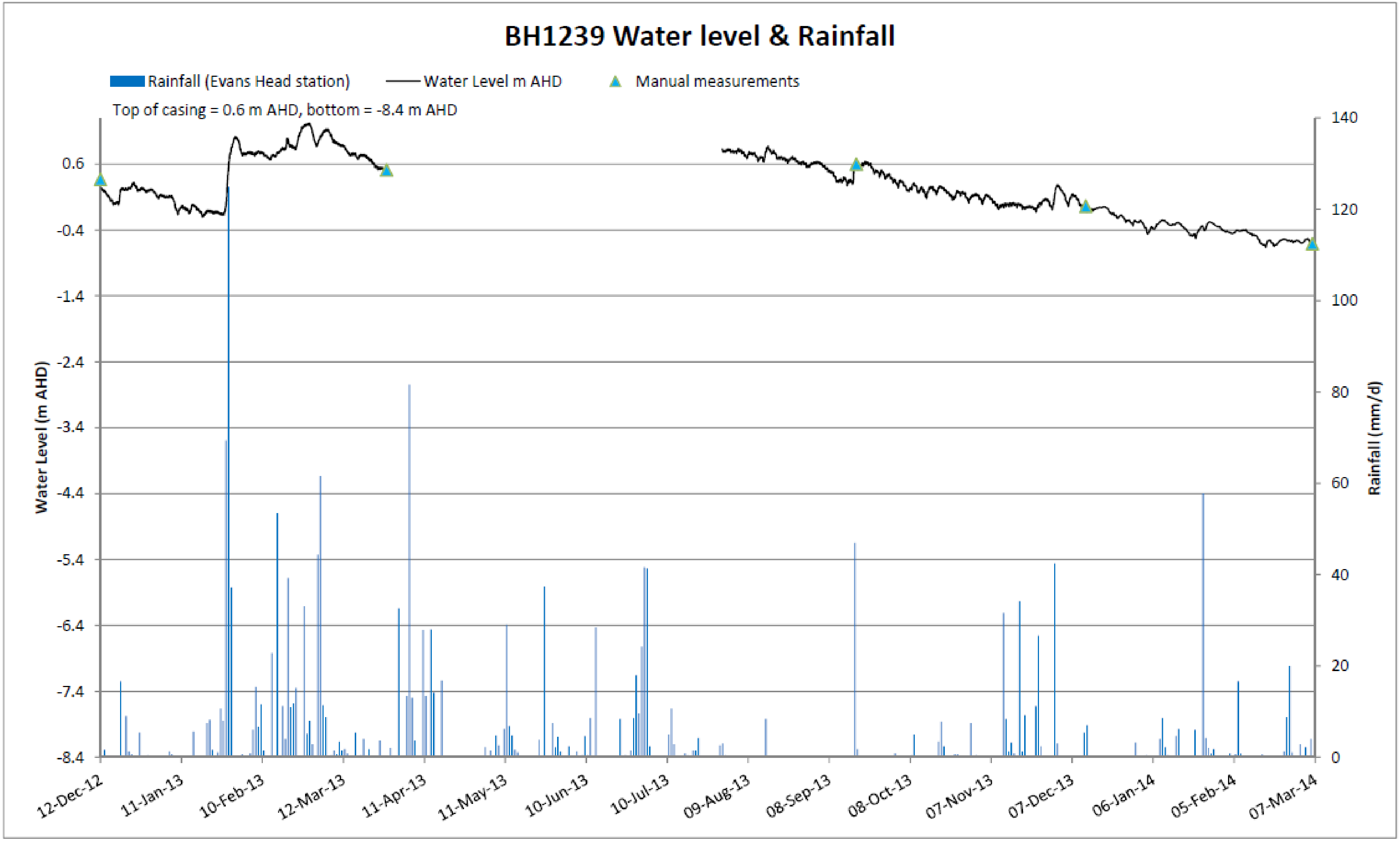


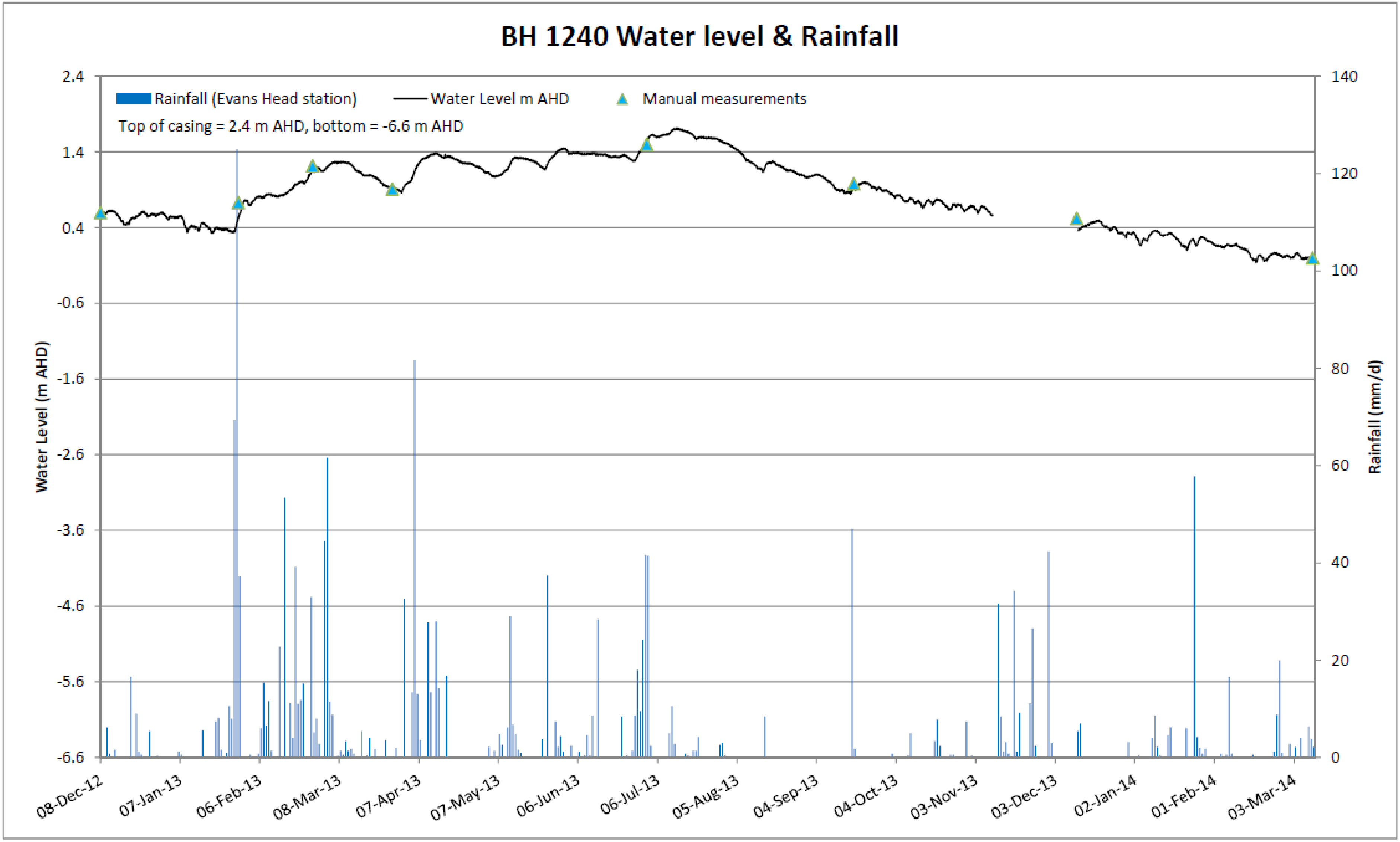
BH1236 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.4 m AHD, bottom = -7.6 m AHD
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
-6.6
-7.6
Water Level (m AHD)
140
120
100
80
60
40
20
0
Rainfall (mm/d)
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH1237 Water level & Rainfall
Top of casing = 1.7 m AHD, bottom = -7.4 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
-7.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH1238 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 0.7 m AHD, bottom = -8.3 m AHD
Data logger missing
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
-7.4
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14


BH1239 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 0.6 m AHD, bottom = -8.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
-6.4
-7.4
-8.4
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14



BH 1240 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.4 m AHD, bottom = -6.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.4
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
-6.6
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
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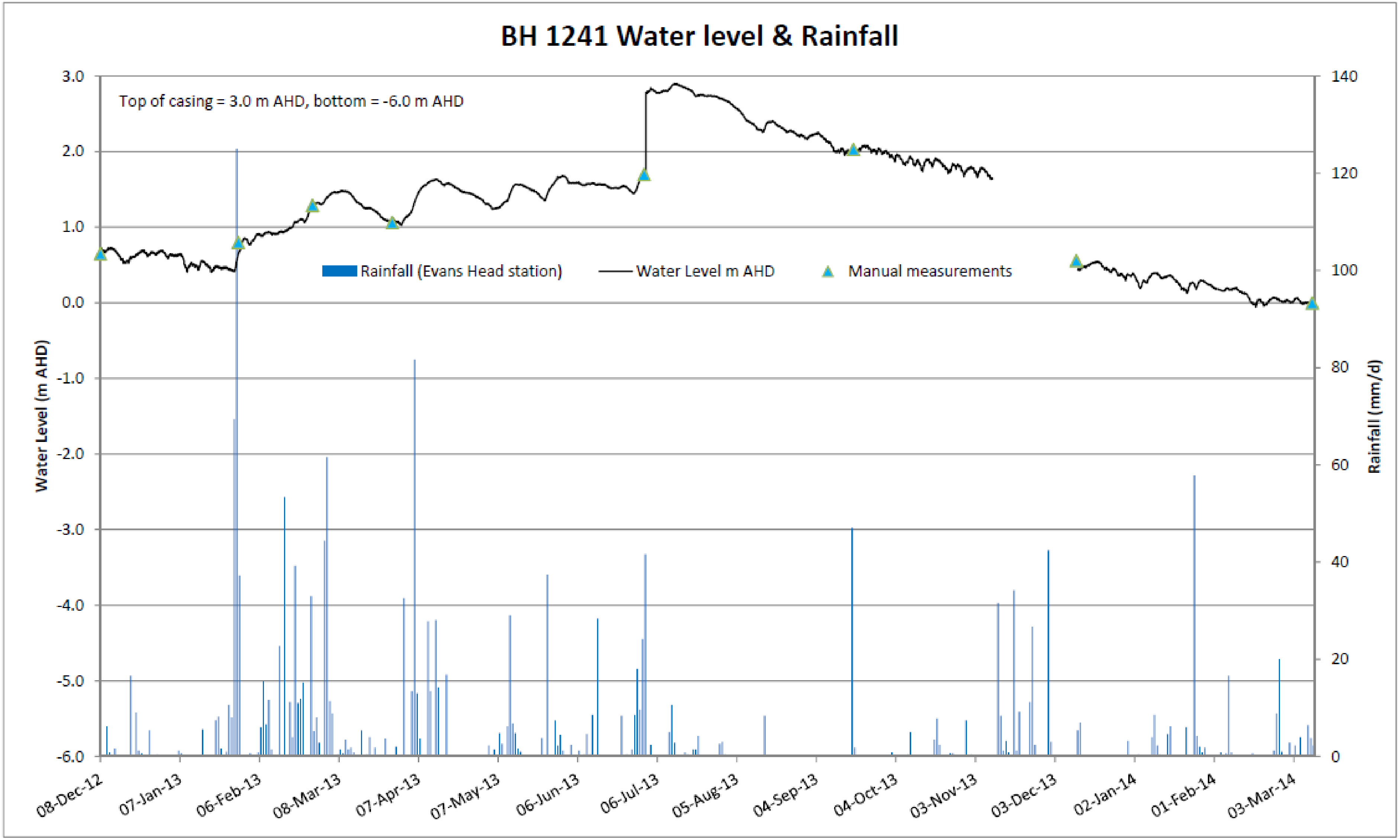
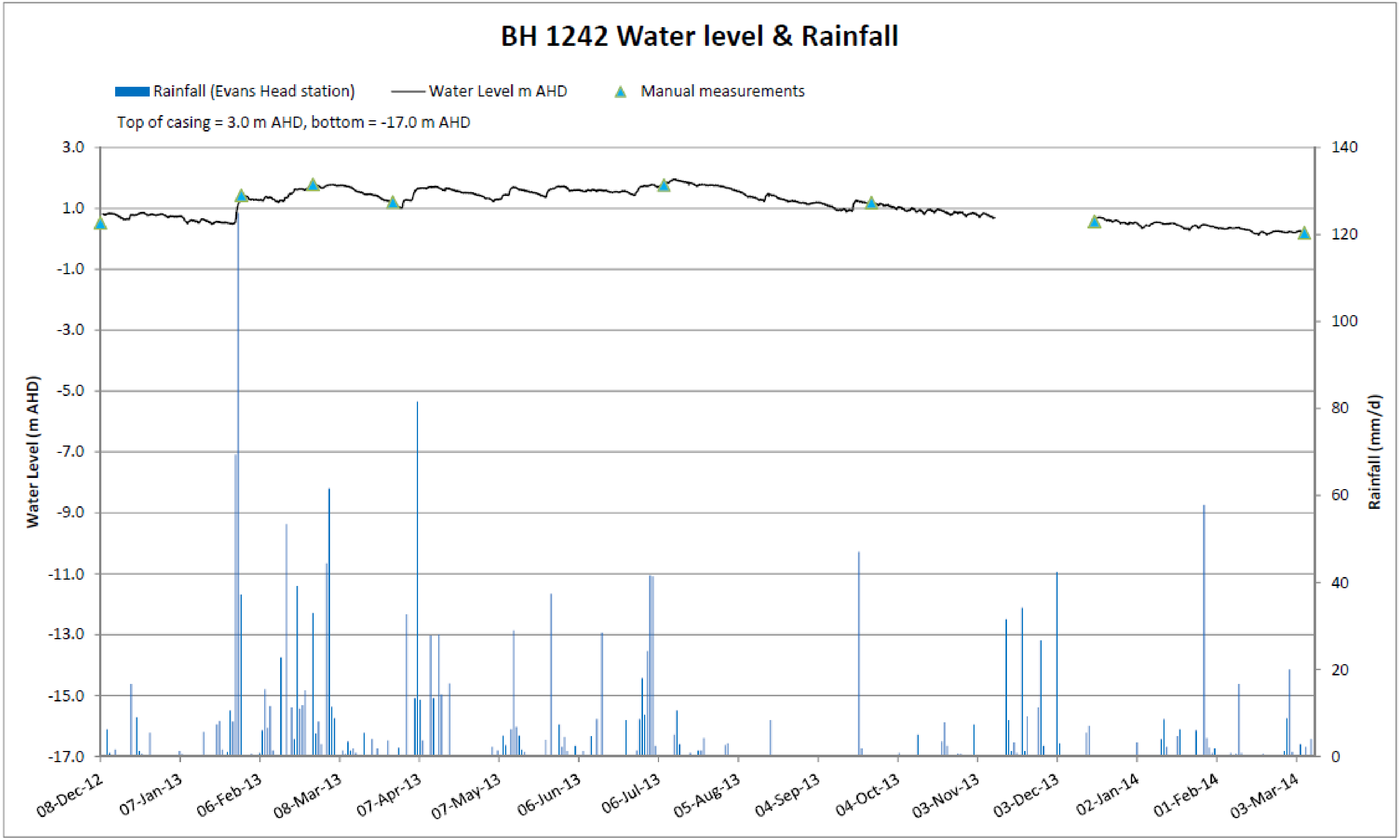
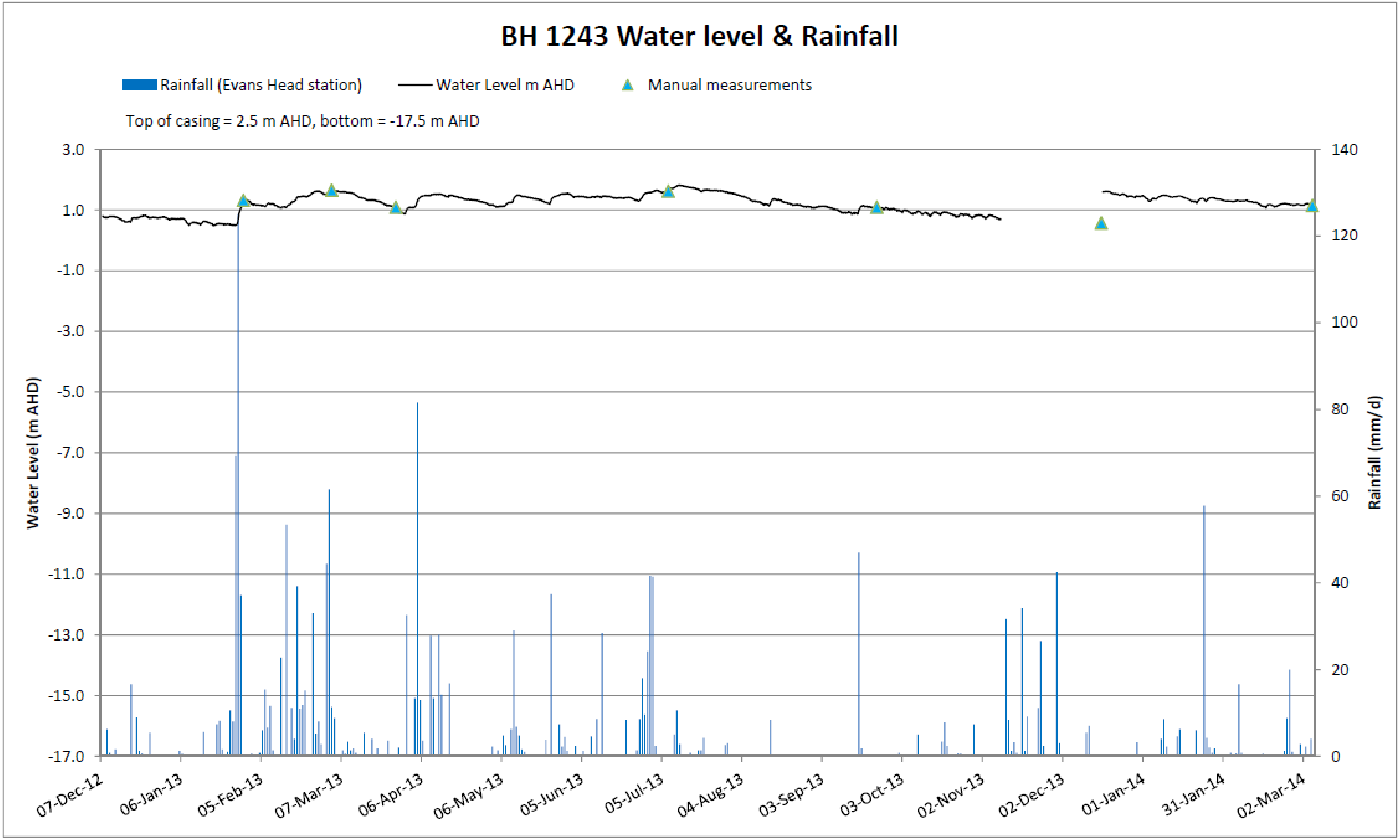
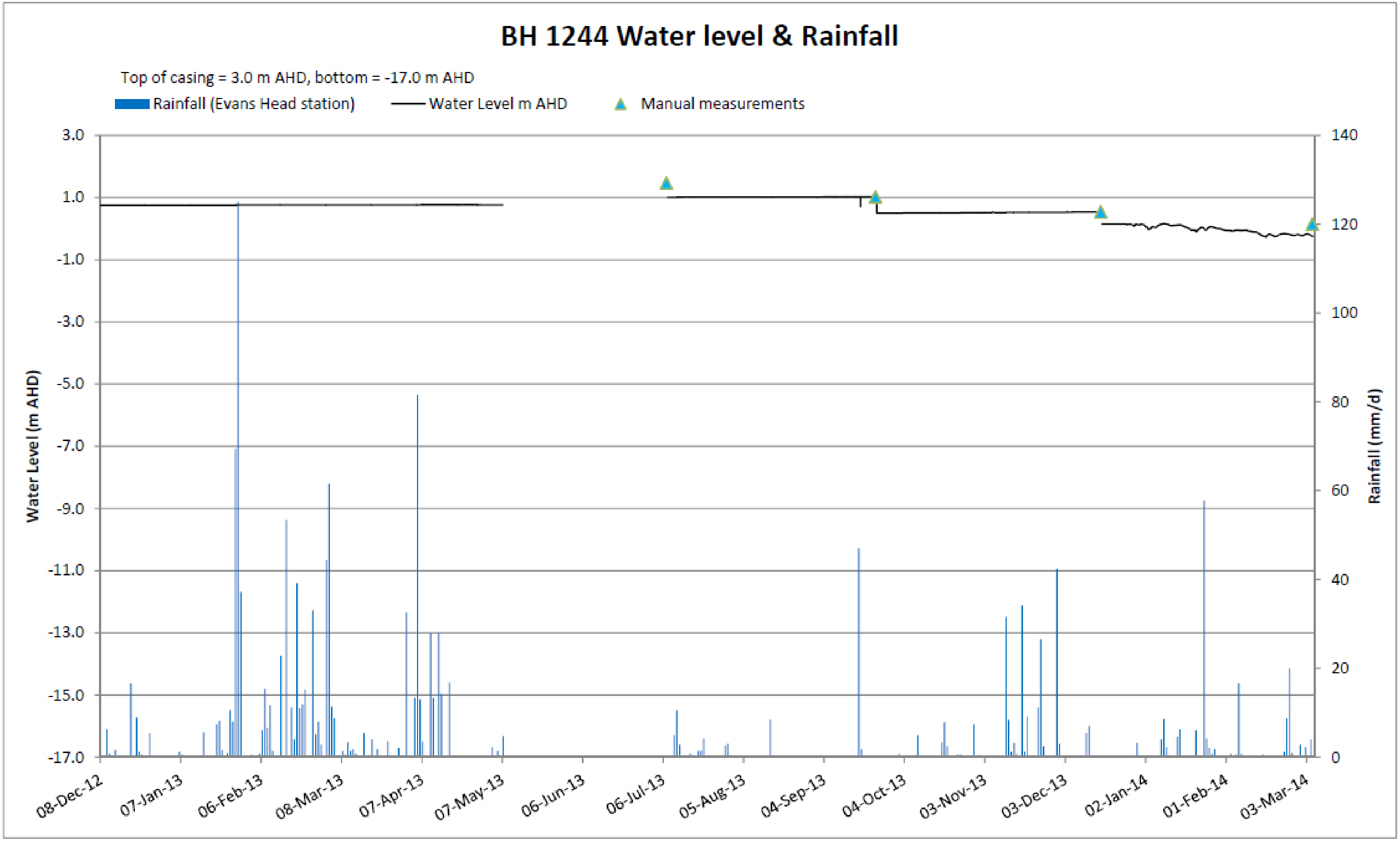
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

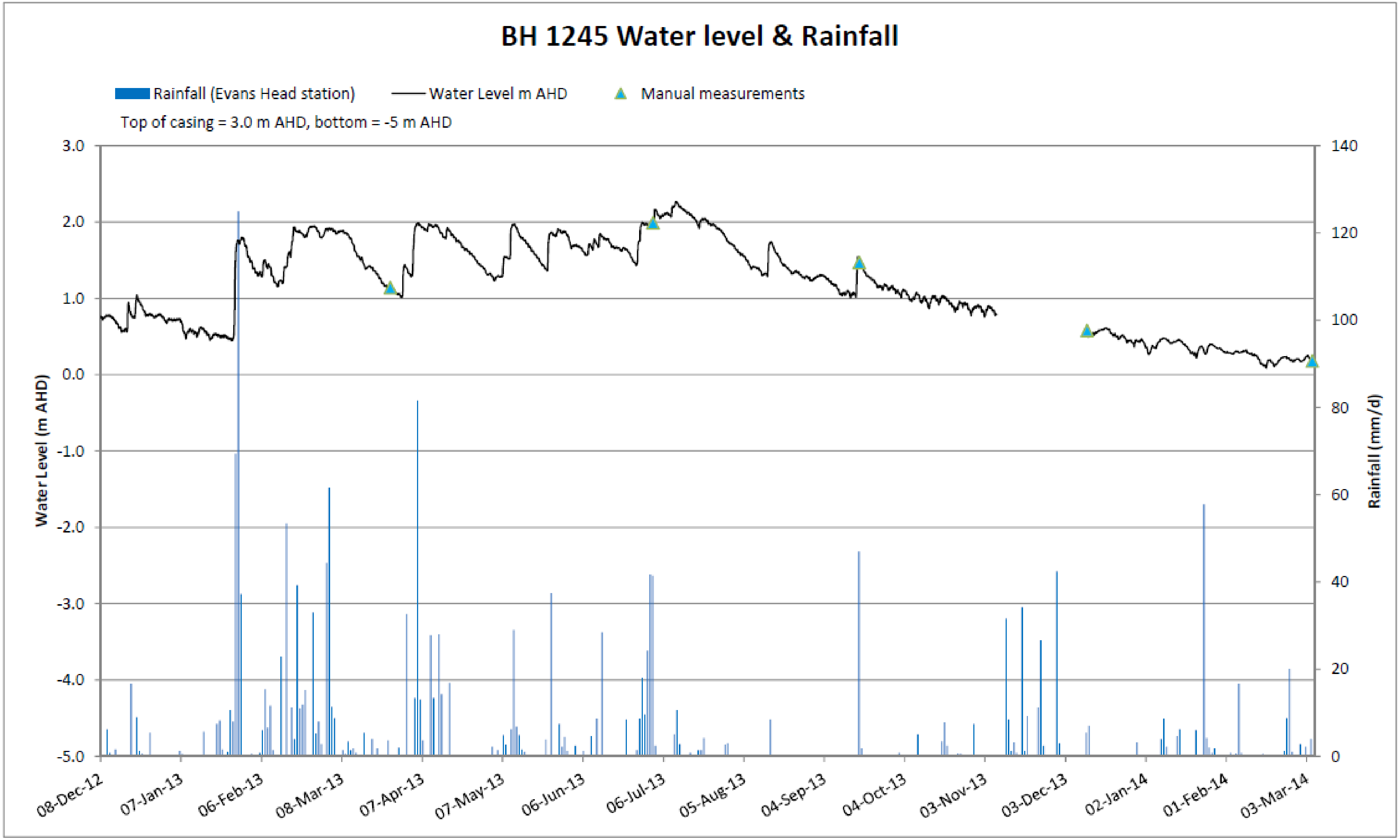

BH 1241 Water level & Rainfall
Top of casing = 3.0 m AHD, bottom = -6.0 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH 1242 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -17.0 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
1.0
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
-17.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1243 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.5 m AHD, bottom = -17.5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
1.0
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
-17.0
140
120
100
80
60
40
20
0
07-Dec-12
06-Jan-13
05-Feb-13
07-Mar-13
06-Apr-13
06-May-13
05-Jun-13
05-Jul-13
04-Aug-13
03-Sep-13
03-Oct-13
02-Nov-13
02-Dec-13
01-Jan-14
31-Jan-14
02-Mar-14


BH 1244 Water level & Rainfall
Top of casing = 3.0 m AHD, bottom = -17.0 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.0
1.0
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
-17.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH 1245 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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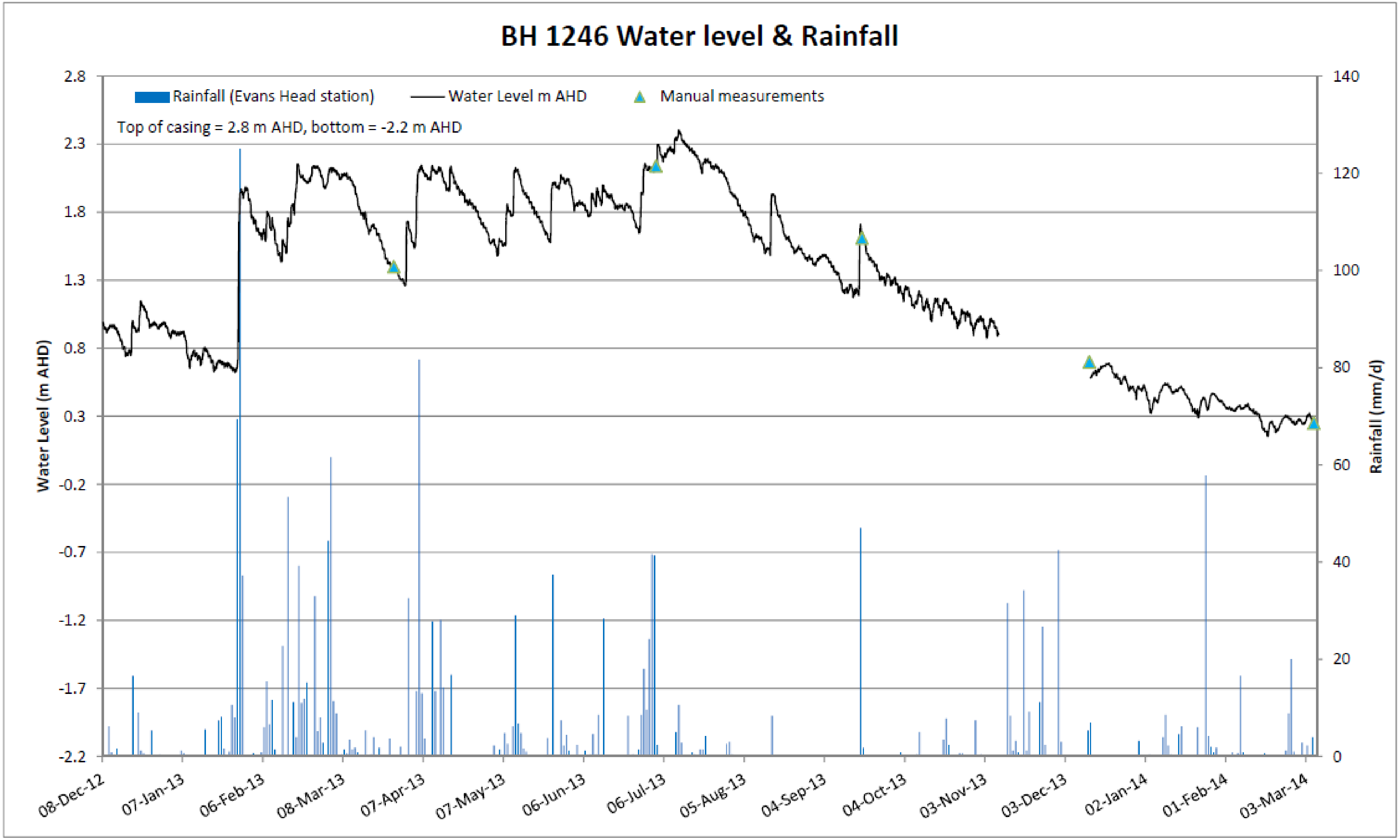
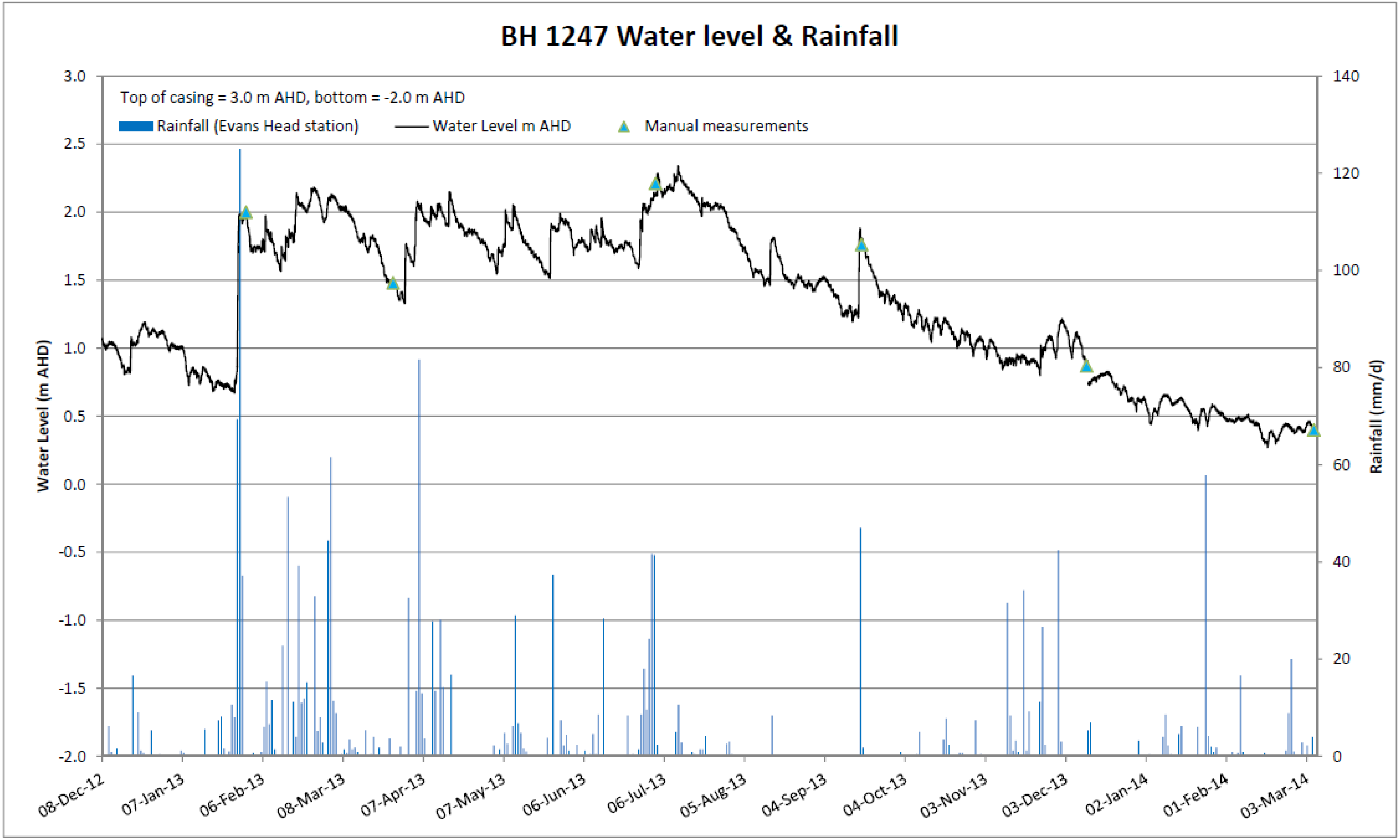
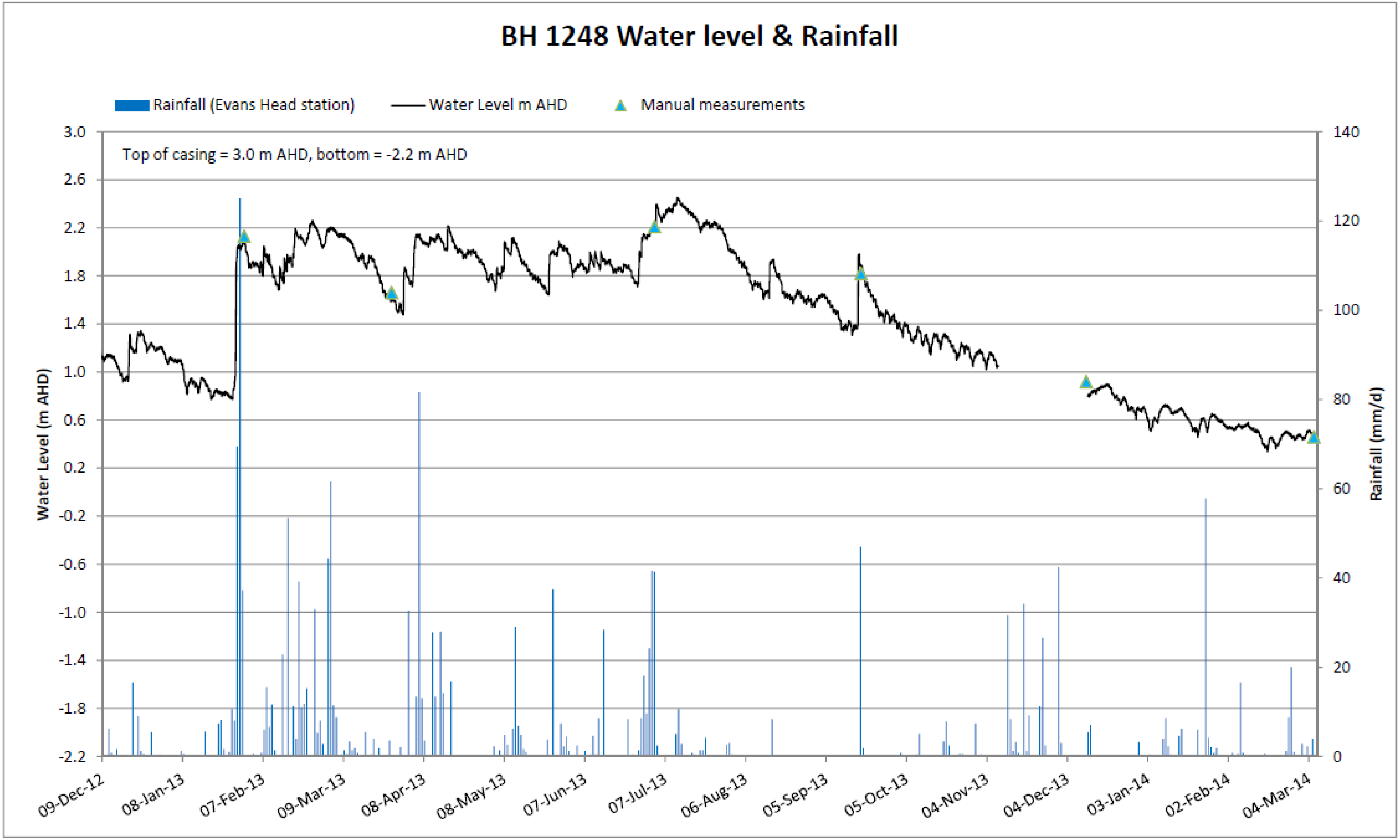
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

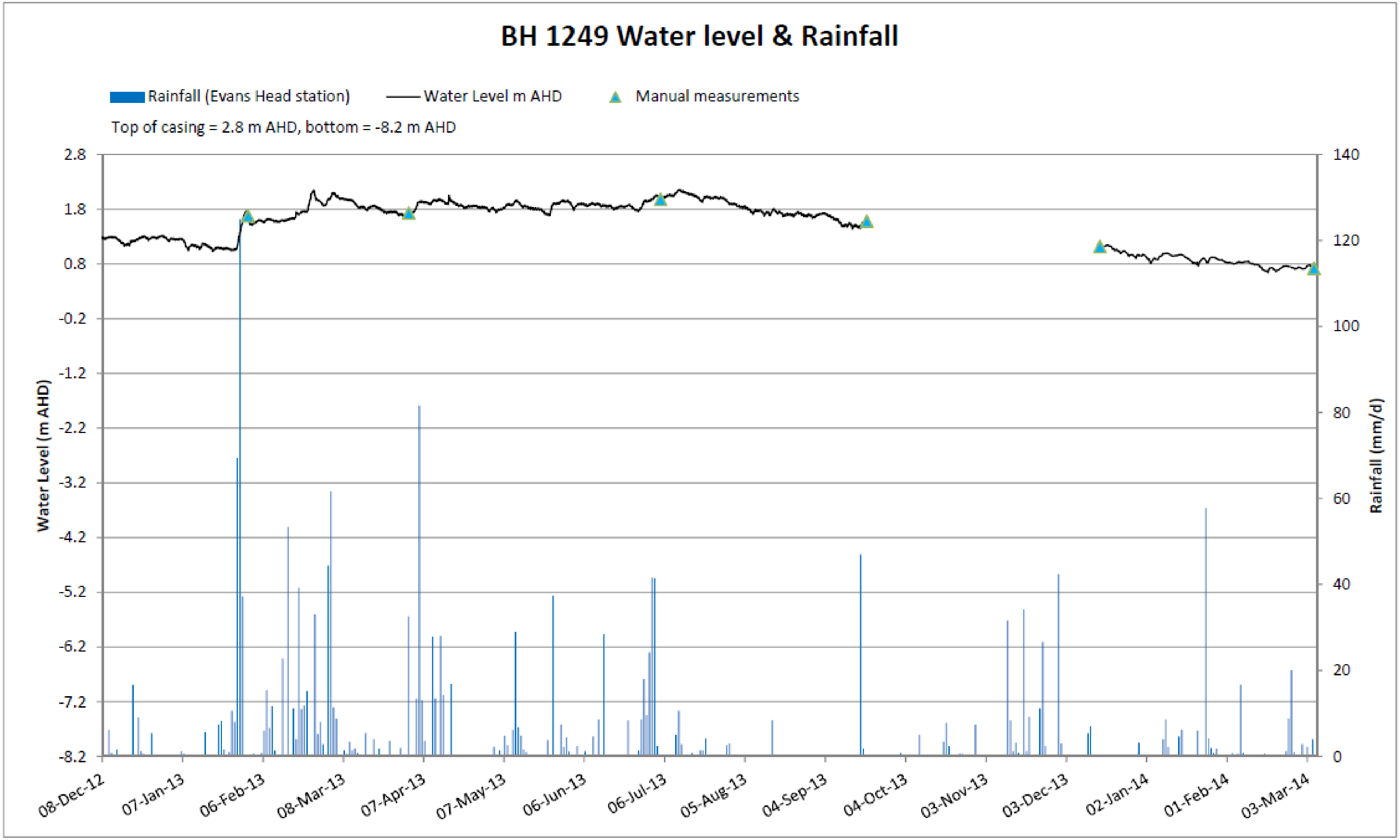


BH 1246 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.8 m AHD, bottom = -2.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.8
2.3
1.8
1.3
0.8
0.3
-0.2
-0.7
-1.2
-1.7
-2.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

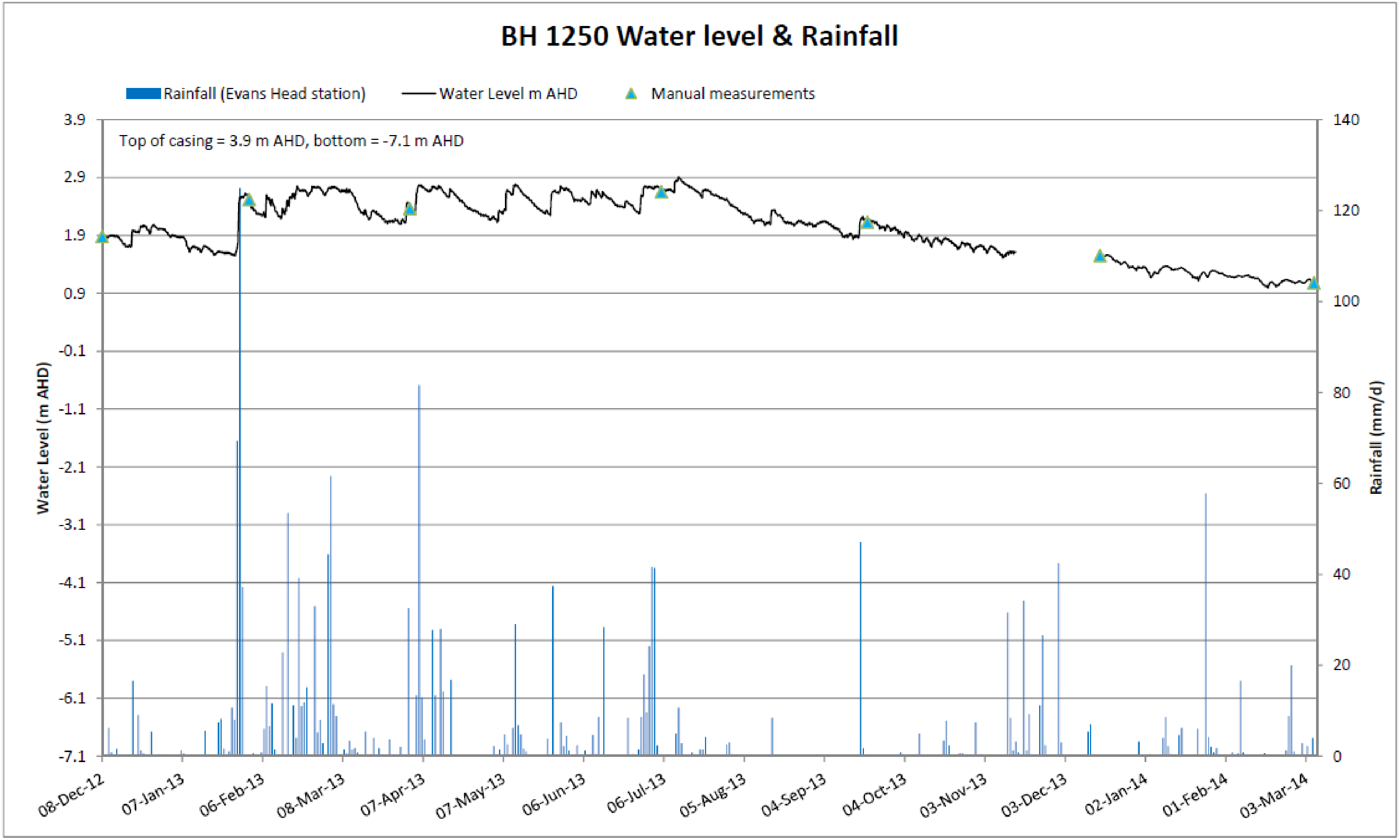


BH 1247 Water level & Rainfall
Top of casing = 3.0 m AHD, bottom = -2.0 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

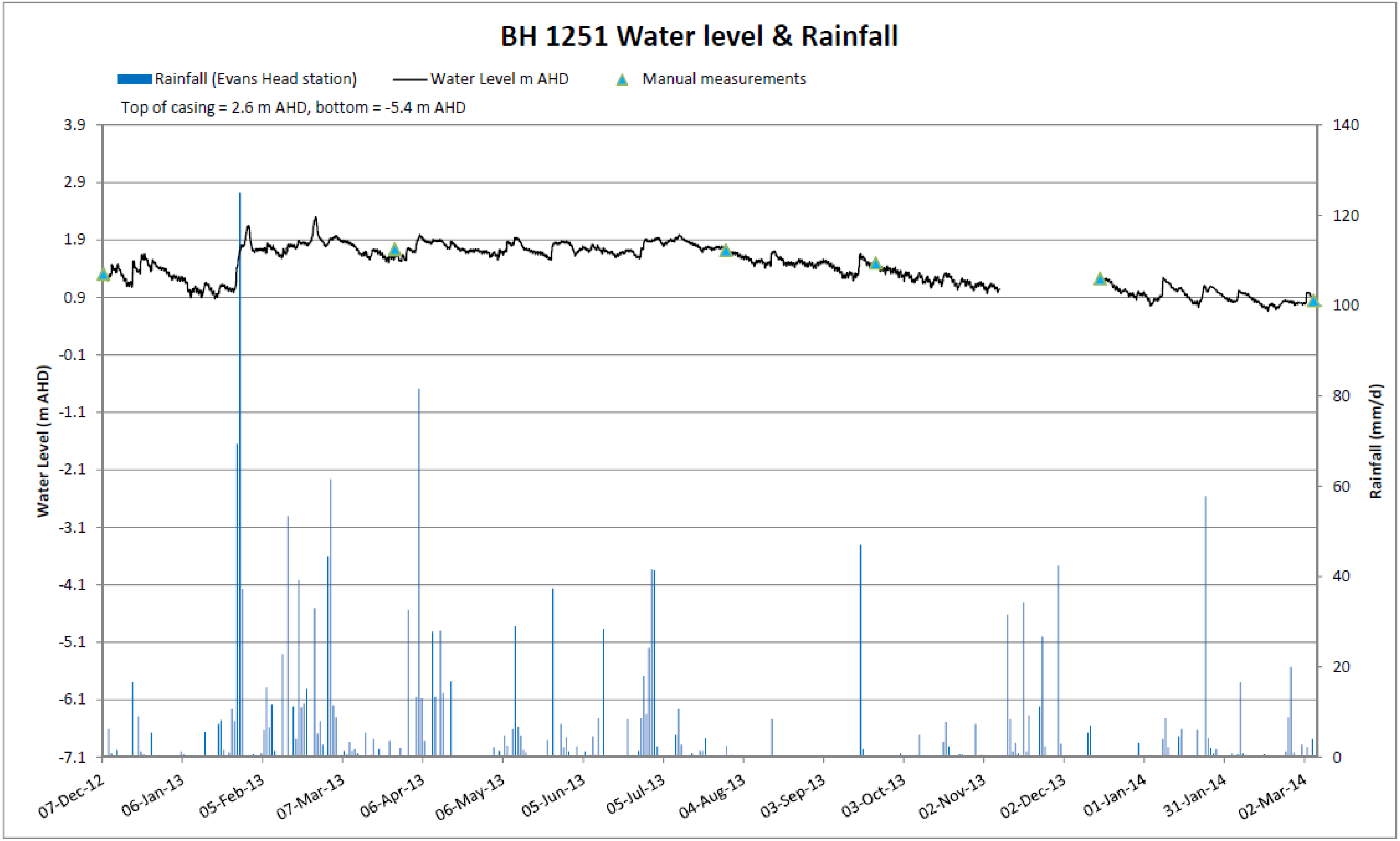

BH 1248 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -2.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-2.2
140
120
100
80
60
40
20
0
09-Dec-12
08-Jan-13
07-Feb-13
09-Mar-13
08-Apr-13
08-May-13
07-Jun-13
07-Jul-13
06-Aug-13
05-Sep-13
05-Oct-13
04-Nov-13
04-Dec-13
03-Jan-14
02-Feb-14
04-Mar-14



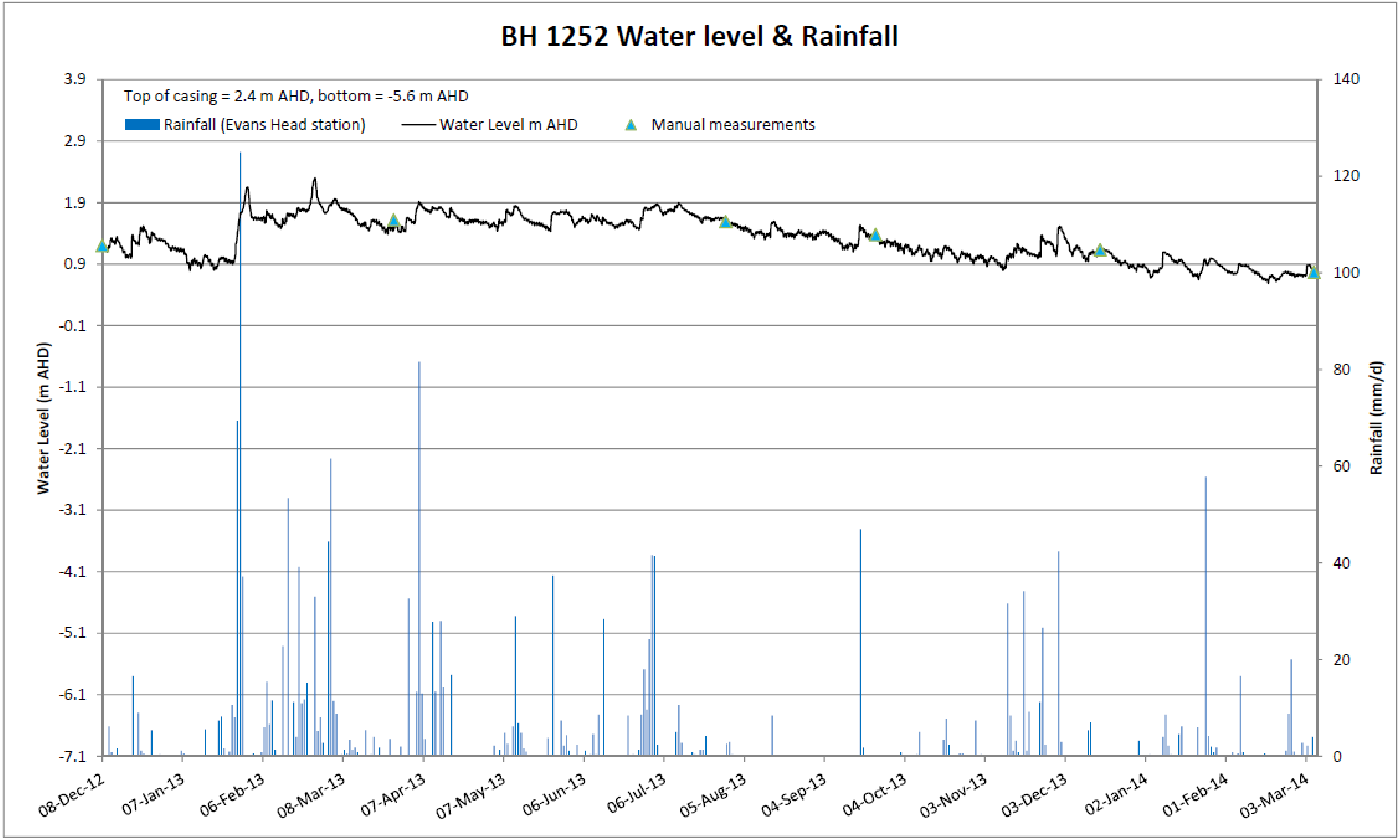
BH 1249 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.8 m AHD, bottom = -8.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.8
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
-5.2
-6.2
-7.2
-8.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH 1250 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.9 m AHD, bottom = -7.1 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
-4.1
-5.1
-6.1
-7.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH 1251 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.6 m AHD, bottom = -5.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
-4.1
-5.1
-6.1
-7.1
140
120
100
80
60
40
20
0
07-Dec-12
06-Jan-13
05-Feb-13
07-Mar-13
06-Apr-13
06-May-13
05-Jun-13
05-Jul-13
04-Aug-13
03-Sep-13
03-Oct-13
02-Nov-13
02-Dec-13
01-Jan-14
31-Jan-14
02-Mar-14


BH 1252 Water level & Rainfall
Top of casing = 2.4 m AHD, bottom = -5.6 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
-4.1
-5.1
-6.1
-7.1
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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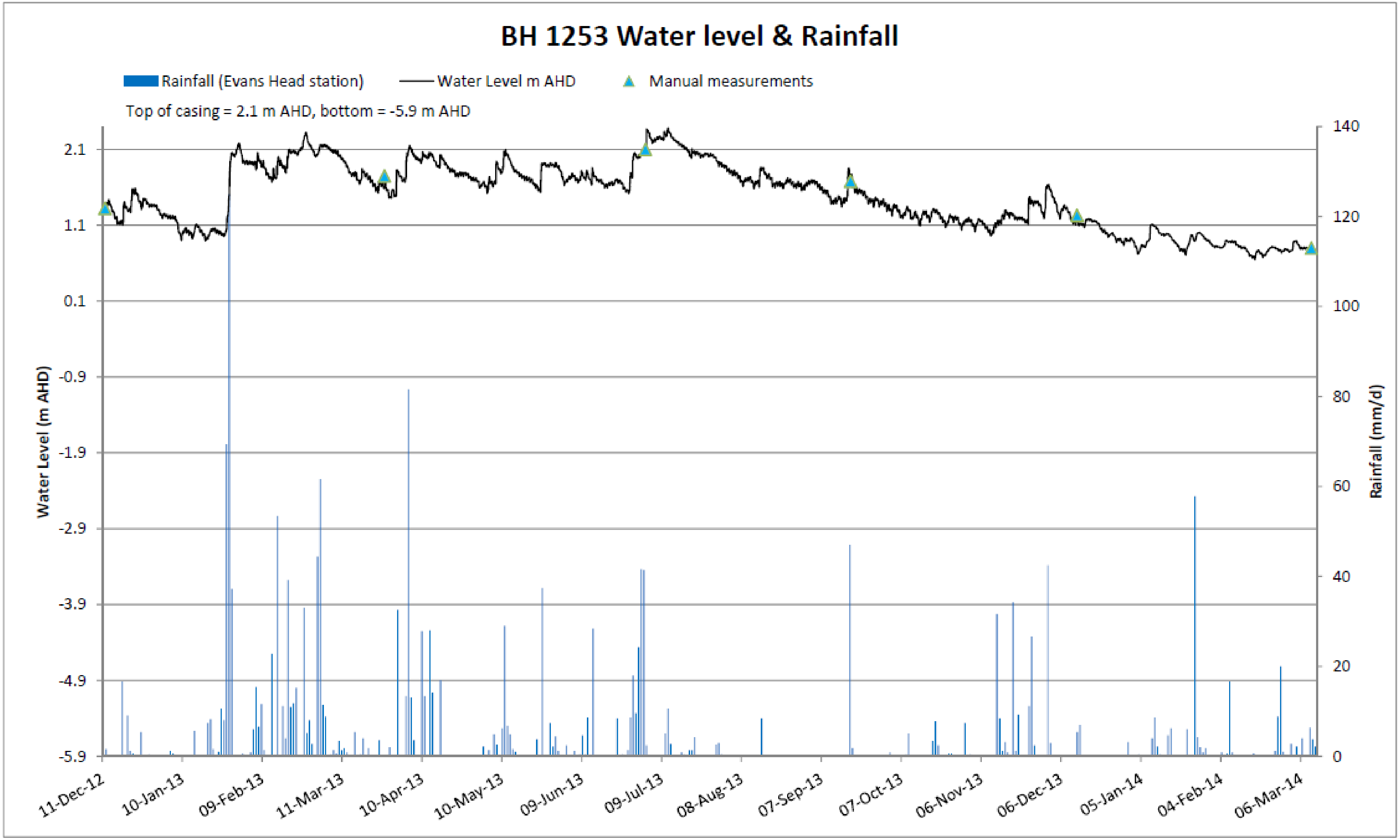
02-Jan-14
01-Feb-14
03-Mar-14



BH 1253 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 2.1 m AHD, bottom = -5.9 m AHD
Water Level (m AHD)
Rainfall (mm/d)
2.1
1.1
0.1
-0.9
-1.9
-2.9
-3.9
-4.9
-5.9
140
120
100
80
60
40
20
0
11-Dec-12
10-Jan-13
09-Feb-13
11-Mar-13
10-Apr-13
10-May-13
09-Jun-13
09-Jul-13
08-Aug-13
07-Sep-13
07-Oct-13
06-Nov-13
06-Dec-13
05-Jan-14
04-Feb-14
06-Mar-14

Appendix H

Section 9 - Broadwater National Park to Richmond River: Pre-Construction Monitoring Results

Section 9: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	*Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems (GDE's)*
SW09 - Montis Gully SW10 - Everson's Creek	▪ No significant sensitive receiving environment ▪ No significant sensitive receiving environment

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 9: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the mid-teens (15-17°C) in winter up to the high-20s (27-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 4.0 to 7.0.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were within the range of <0.01 to 2.46 mg/L. Total Nitrogen values were found to be in the range of 0.3 to 4.2 mg/L.

Heavy Metals

No testing for heavy metals was conducted.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW09 Montis Gully Ch. 140,950	▪ No record of visual observations provided.	▪ O&G: <5-23mg/L ▪ SS: 5-165mg/L ▪ TP: <0.01-0.32mg/L ▪ TN: 0.3-1.5mg/L ▪ DO: 2.1-9.4mg/L ▪ EC: 98-170µS/cm

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
		▪ pH: 4.0-7.0 ▪ Temp: 17.6-30.9ºC ▪ NTU: 1.1-31.0
SW10 Everson's Creek Ch. 143,400	▪ As above.	▪ O&G: <5-5mg/L ▪ SS: <5-255mg/L ▪ TP: 0.26-2.46mg/L ▪ TN: 1.4-4.2mg/L ▪ DO: 1.0-10.7mg/L ▪ EC: 128-288µS/cm ▪ pH: 4.5-5.7 ▪ Temp: 15.3-27.4ºC ▪ NTU: 2.1-42

Note: * Ch. = Highway Chainage

Section 9: Surface Water Monitoring – Sampling Statistics

	Units	*SECTION 9*							
		SW09 (SW9-01 and SW9-02)							
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	4.21	5.92	23.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	48.08	55.05	165.00	5.0	17.0	91.6	-	
Total Phosphorus as P	mg/l	0.09	0.08	0.32	0.0	0.1	0.106	-	
Total Nitrogen as N	mg/l	0.74	0.33	1.50	0.3	0.7	0.9	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.73	2.69	9.40	2.1	7.9	8.66	3.7	
Conductivity	µs/cm	97.93	35.33	159.00	26.0	98.5	116.56	79.4	
pH		5.19	0.74	7.00	4.0	5.2	5.46	4.76	
Temperature	°C	23.30	4.53	30.90	17.6	22.6	28.02	-	
Turbidity	NTU	23.12	30.61	108.00	2.3	14.0	24.2	-	
		SW10 (SW9-03 and SW9-04)							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.73	0.75	5.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	42.64	72.39	255.00	2.5	24.0	40	-	
Total Phosphorus as P	mg/l	1.21	0.79	2.46	0.3	0.7	2.09	-	
Total Nitrogen as N	mg/l	2.33	0.98	4.20	1.4	2.0	3.5	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.17	3.08	10.70	1.0	5.6	7.26	2.516	
Conductivity	µs/cm	140.80	46.13	214.00	67.0	139.0	183.6	105	
pH		4.86	0.59	5.70	4.0	4.7	5.44	4.36	
Temperature	°C	21.09	4.26	27.40	15.3	20.9	24.96	-	
Turbidity	**NTU**	**47.07**	**87.43**	**274.00**	**3.6**	**10.7**	**46.68**	**-**	

Section 9: Groundwater Monitoring – Water Quality Overview

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

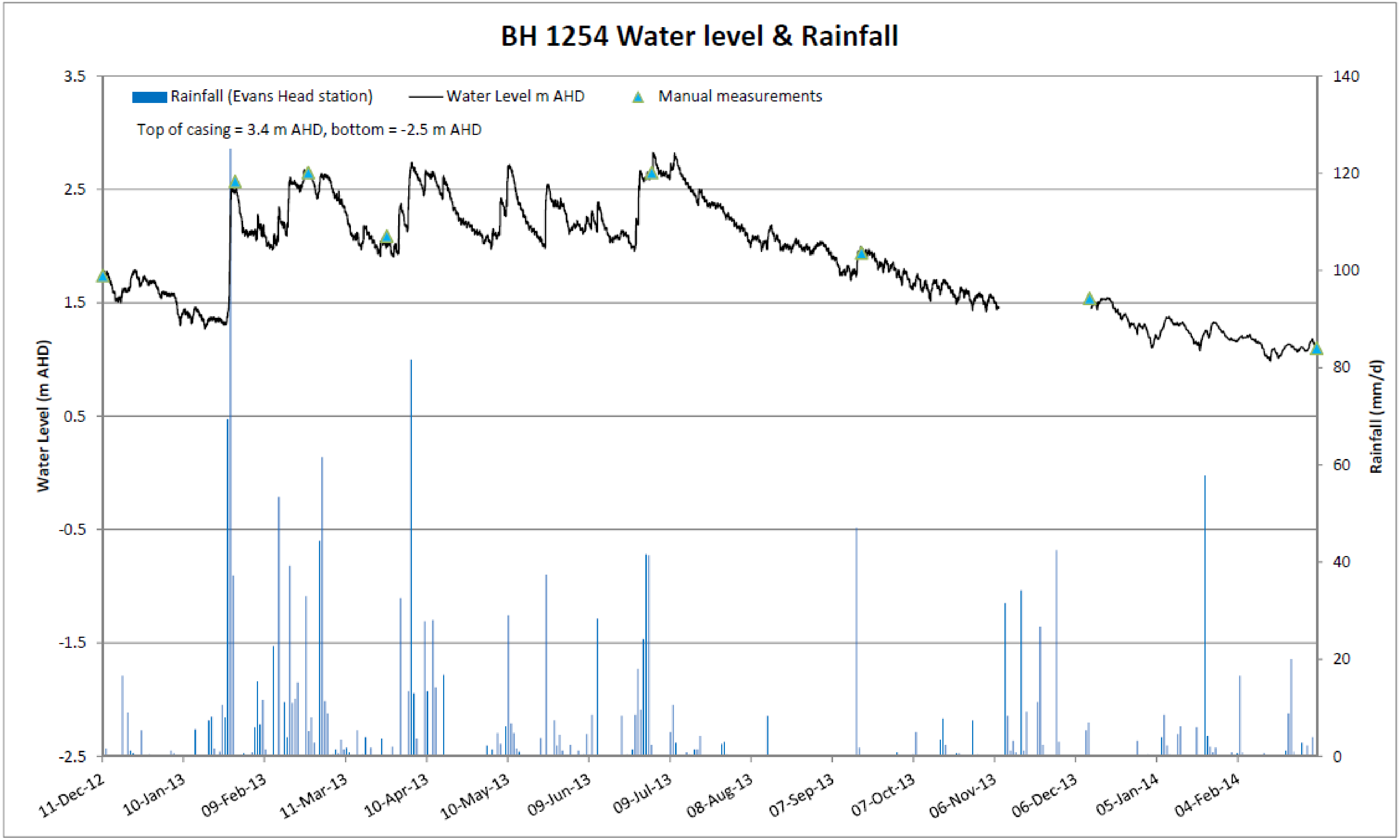
pH Statistics from Boreholes in Areas of Fill

Borehole Identifier	*Mean (Total)*	*Standard Deviation*	*Min*	*Max*	*Percentile*	
					P80	*P20*
BH1254	5.05	0.98	3.60	5.70	5.45	5.64
BH1255	5.98	1.69	4.10	8.20	5.80	6.82
BH1258	5.18	0.61	4.30	5.70	5.35	5.52
BH1259	5.75	0.37	5.30	6.10	5.80	6.04
BH1260	5.25	0.44	4.80	5.80	5.20	5.56
BH1261	6.33	0.25	6.00	6.60	6.35	6.48
BH1262	5.63	0.49	4.90	5.90	5.85	5.90
BH1263	5.80	0.41	5.40	6.20	5.80	6.14

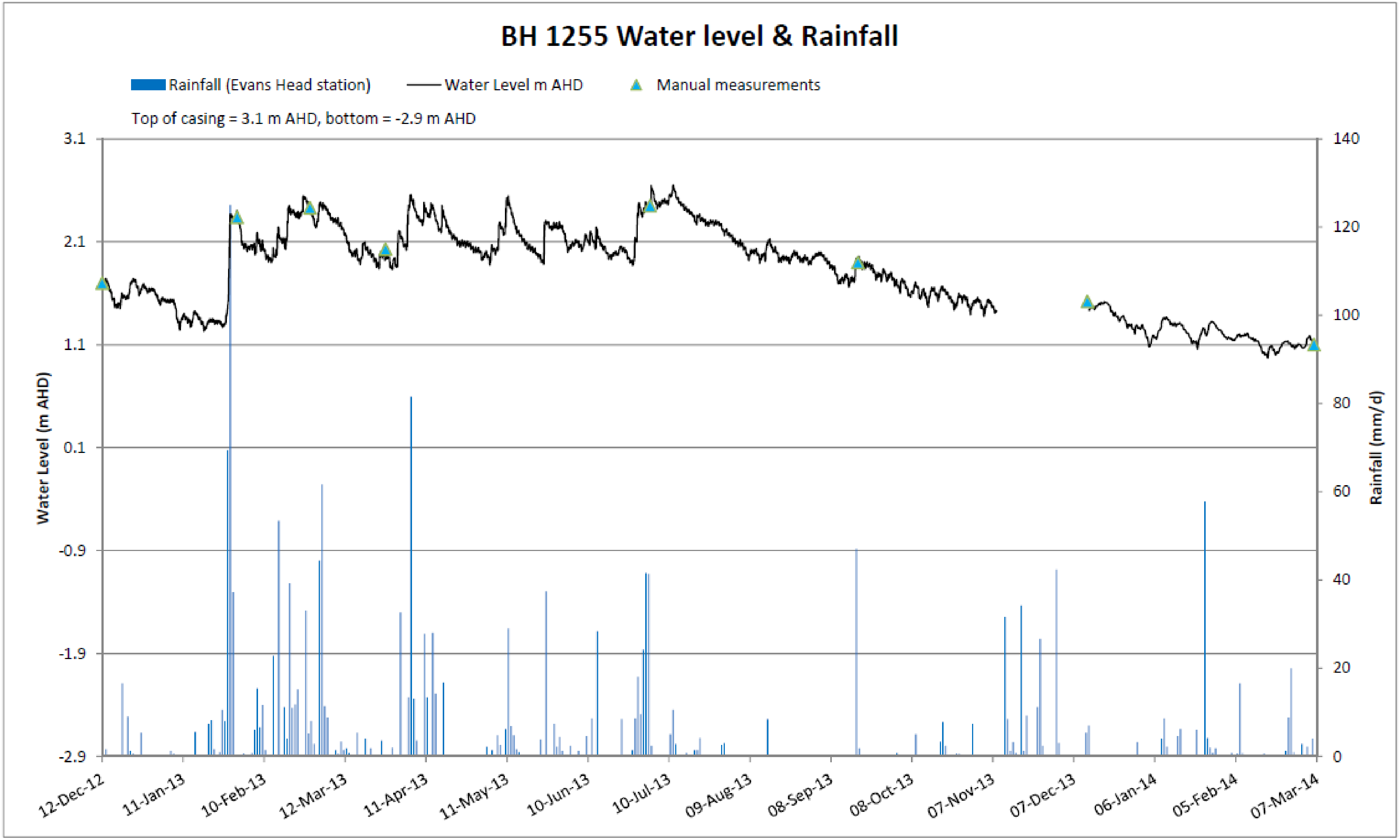
Section 9: Groundwater Monitoring – Levels

Summary of Groundwater Level Monitoring – Section 9 DP2B Upgrade

Borehole Identifier	*Typical SWL (m below ground level)*		
	Average	*Median*	*Standard Deviation*
BH1255	-	-	-
BH1256	-	-	-
BH1257	-	-	-
BH1258	0.88	0.81	0.42
BH1259	0.51	0.58	0.27
BH1260	-	-	-
BH1261	0.36	0.49	0.40
BH1262	2.83	2.93	0.27
BH1263	0.88	0.8	0.42
BH1264	-	-	-
BH1265	-	-	-
BH1266	-	-	-
BH1267	-	-	-
BH1268	-	-	-
BH1269	-	-	-



BH 1254 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.4 m AHD, bottom = -2.5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
140
120
100
80
60
40
20
0
11-Dec-12
10-Jan-13
09-Feb-13
11-Mar-13
10-Apr-13
10-May-13
09-Jun-13
09-Jul-13
08-Aug-13
07-Sep-13
07-Oct-13
06-Nov-13
06-Dec-13
05-Jan-14
04-Feb-14


BH 1255 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.1 m AHD, bottom = -2.9 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.1
2.1
1.1
0.1
-0.9
-1.9
-2.9
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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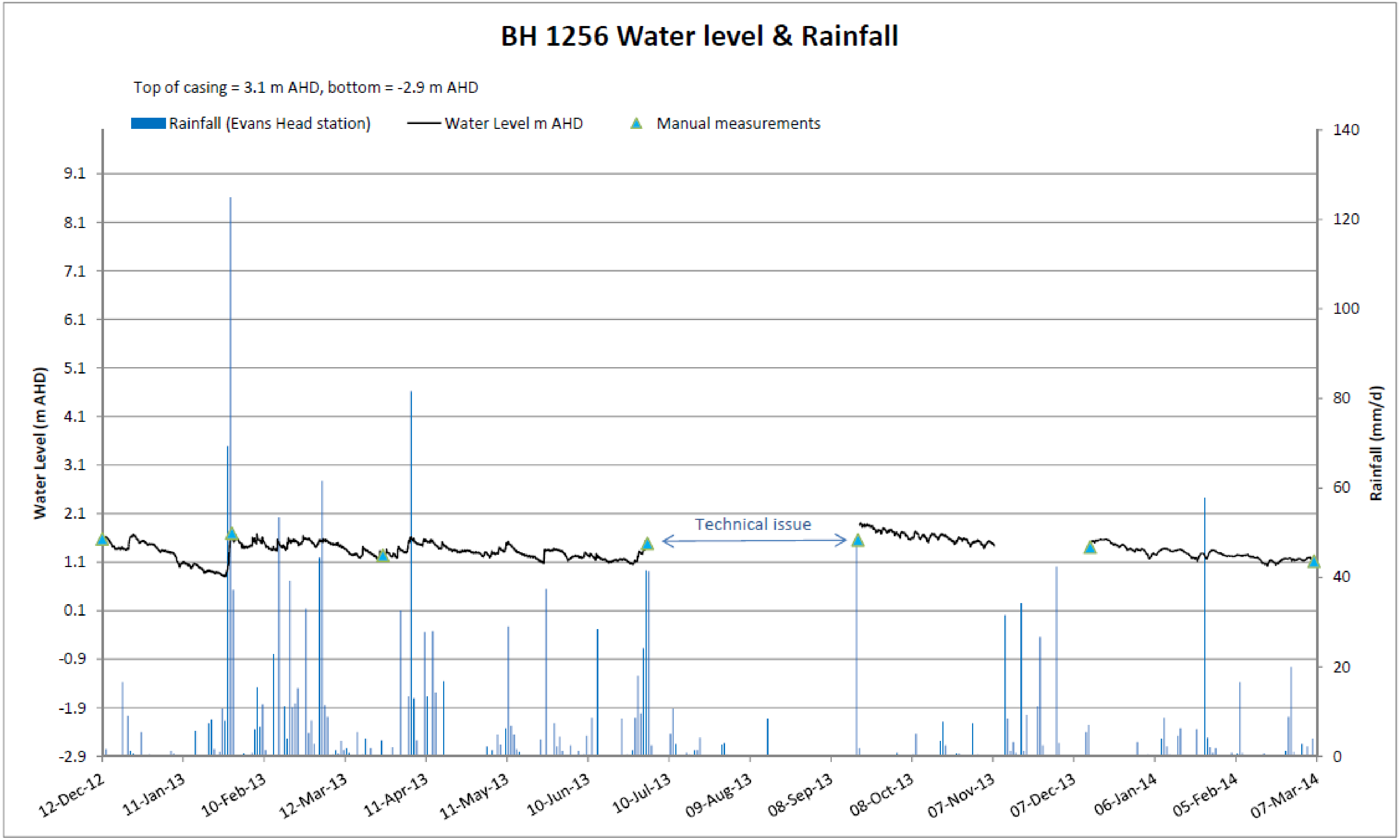
05-Feb-14
07-Mar-14


BH 1256 Water level & Rainfall
Top of casing = 3.1 m AHD, bottom = -2.9 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
Technical issue
9.1
8.1
7.1
6.1
5.1
4.1
3.1
2.1
1.1
0.1
-0.9
-1.9
-2.9
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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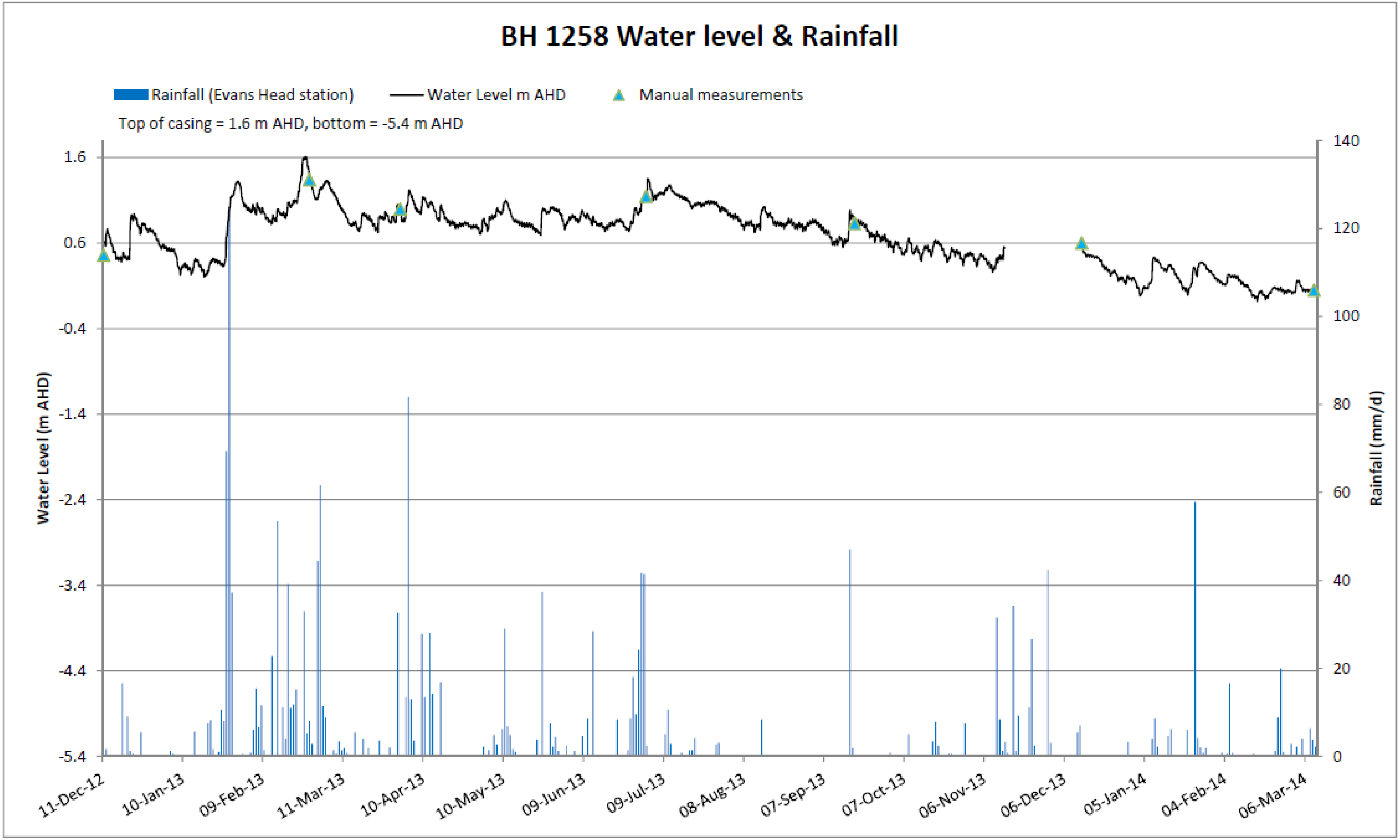
05-Feb-14
07-Mar-14



BH 1258 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.6 m AHD, bottom = -5.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
-5.4
140
120
100
80
60
40
20
0
11-Dec-12
10-Jan-13
09-Feb-13
11-Mar-13
10-Apr-13
10-May-13
09-Jun-13
09-Jul-13
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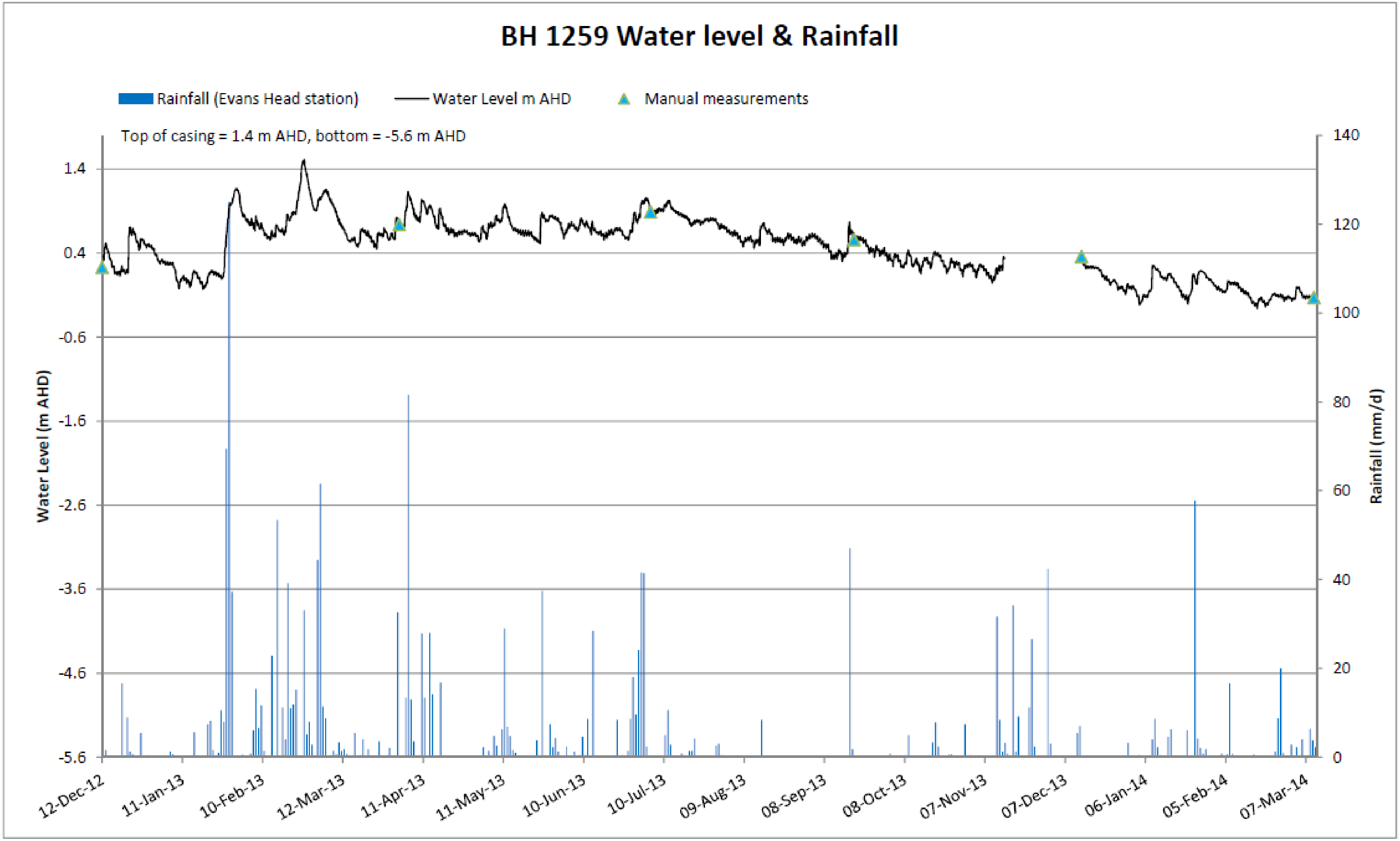
04-Feb-14
06-Mar-14


BH 1259 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.4 m AHD, bottom = -5.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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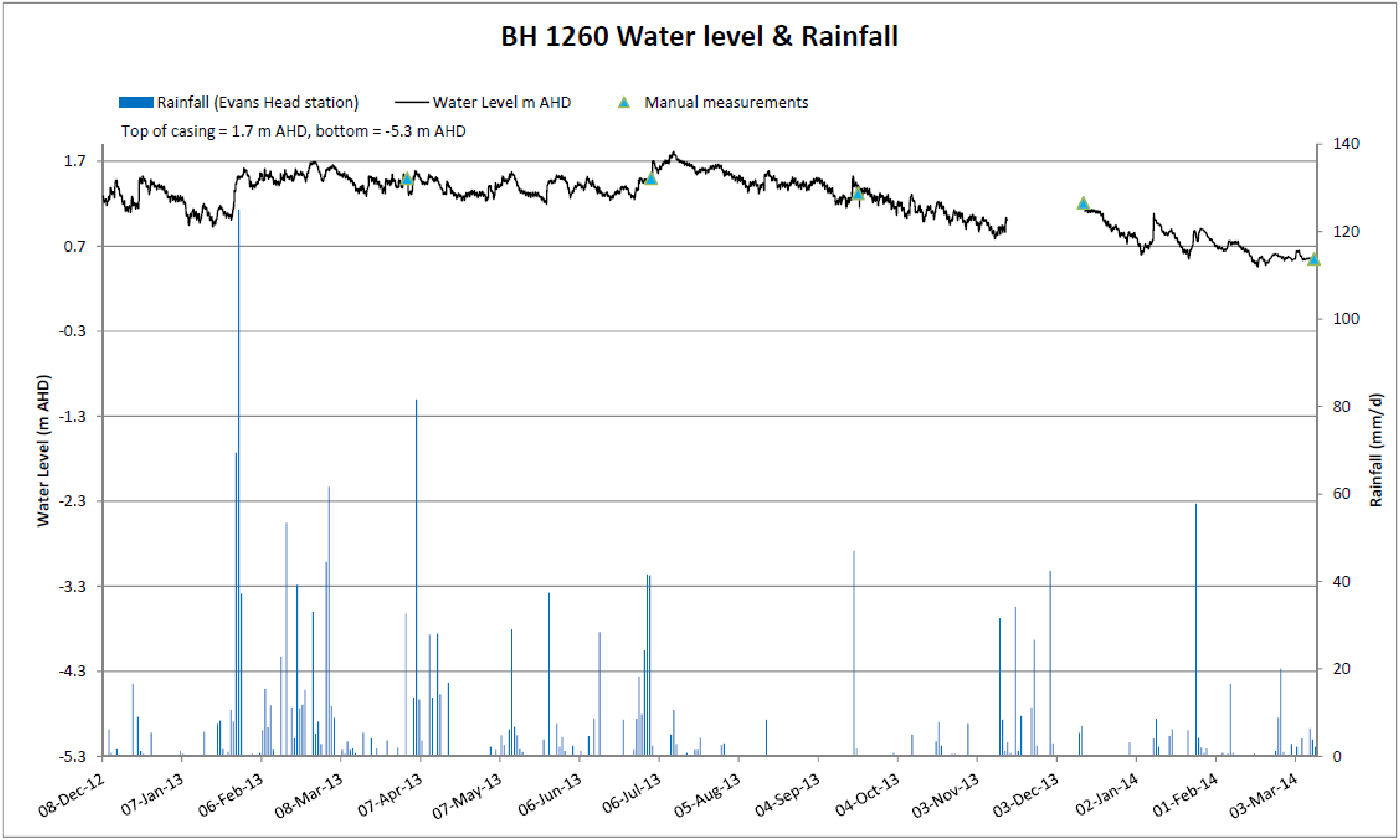
05-Feb-14
07-Mar-14


BH 1260 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.7 m AHD, bottom = -5.3 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.7
0.7
-0.3
-1.3
-2.3
-3.3
-4.3
-5.3
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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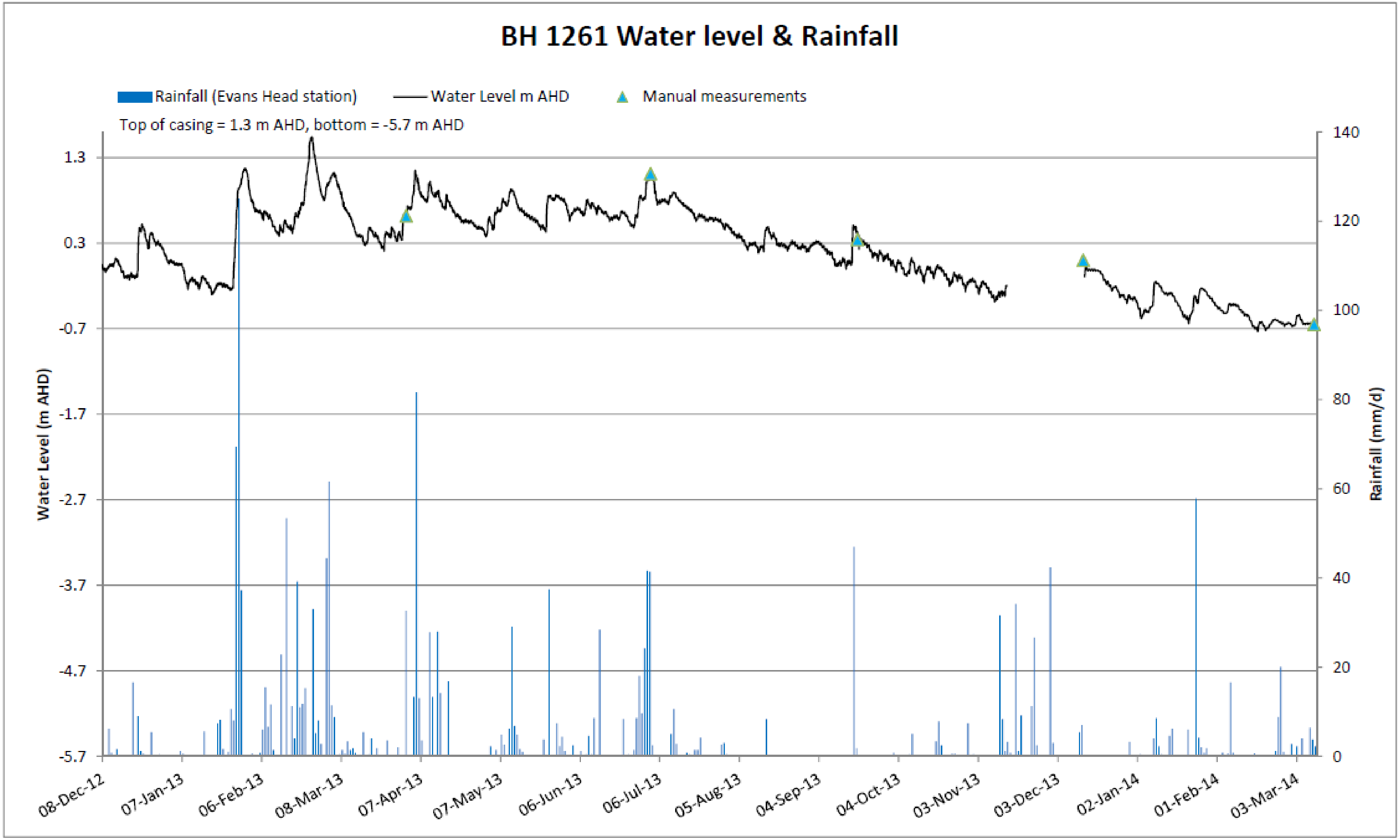
02-Jan-14
01-Feb-14
03-Mar-14


BH 1261 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.3 m AHD, bottom = -5.7 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.3
0.3
-0.7
-1.7
-2.7
-3.7
-4.7
-5.7
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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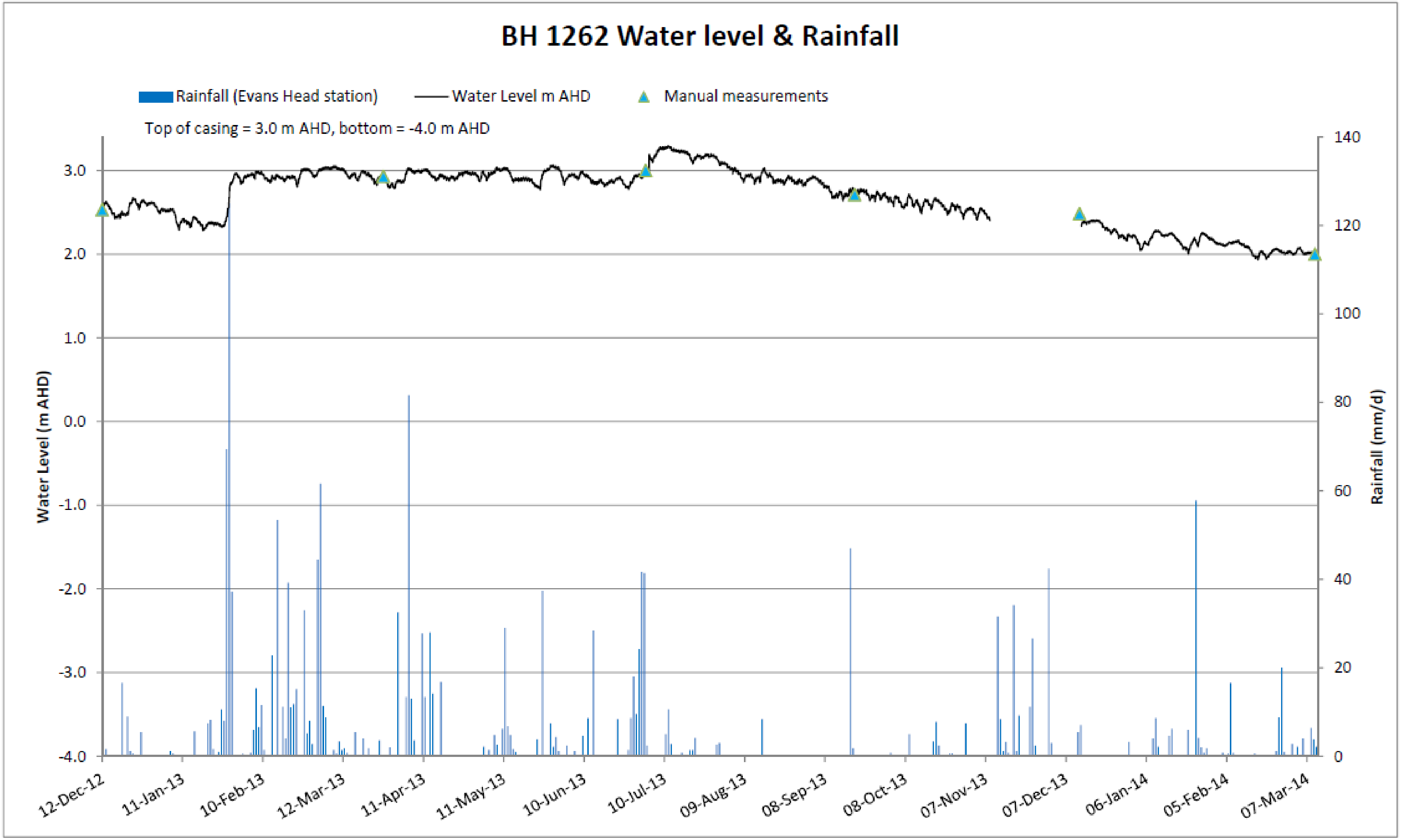
01-Feb-14
03-Mar-14



BH 1262 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 3.0 m AHD, bottom = -4.0 m AHD
Water Level (m AHD)
Rainfall (mm/d)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
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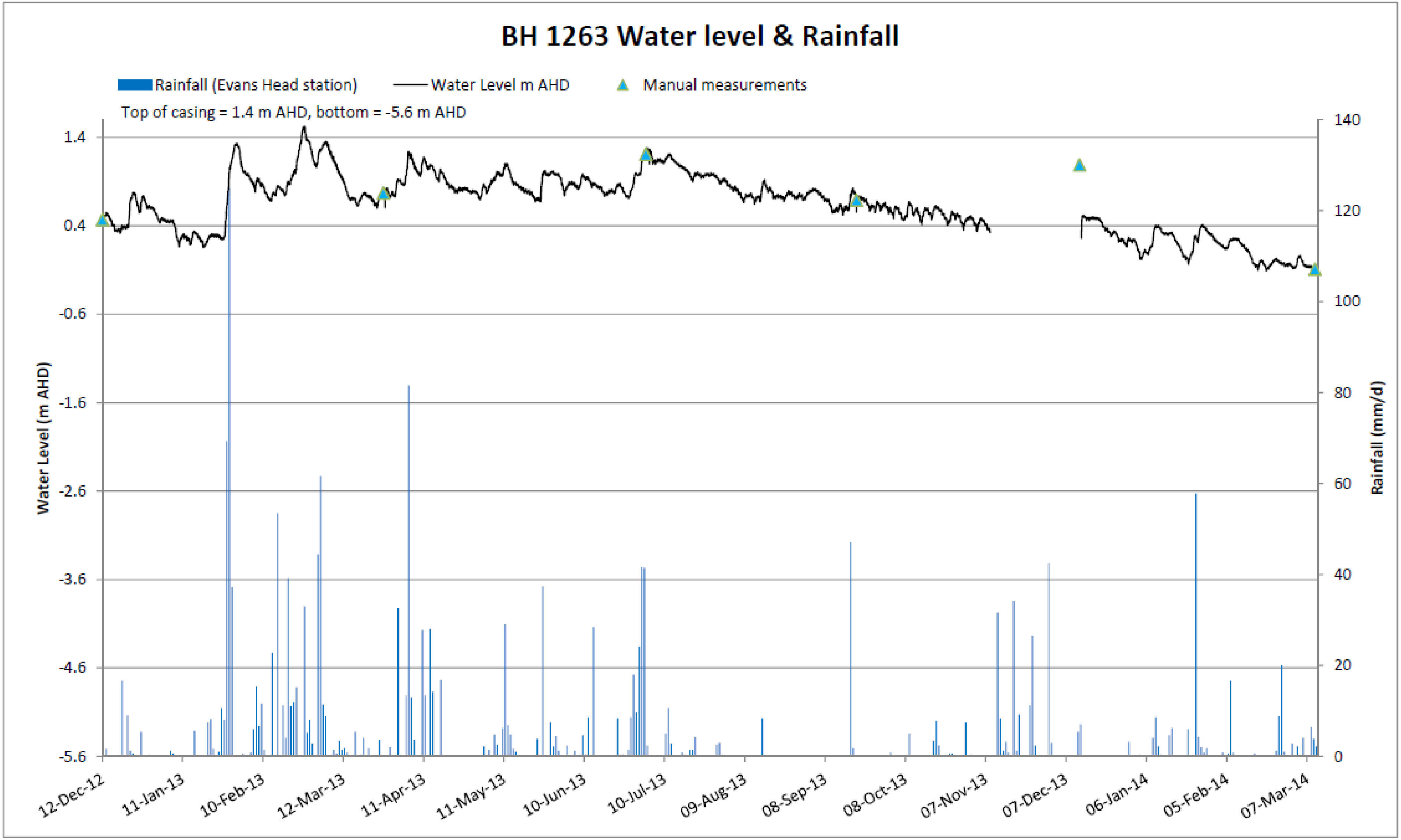
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14


BH 1263 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.4 m AHD, bottom = -5.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.4
0.4
-0.6
-1.6
-2.6
-3.6
-4.6
-5.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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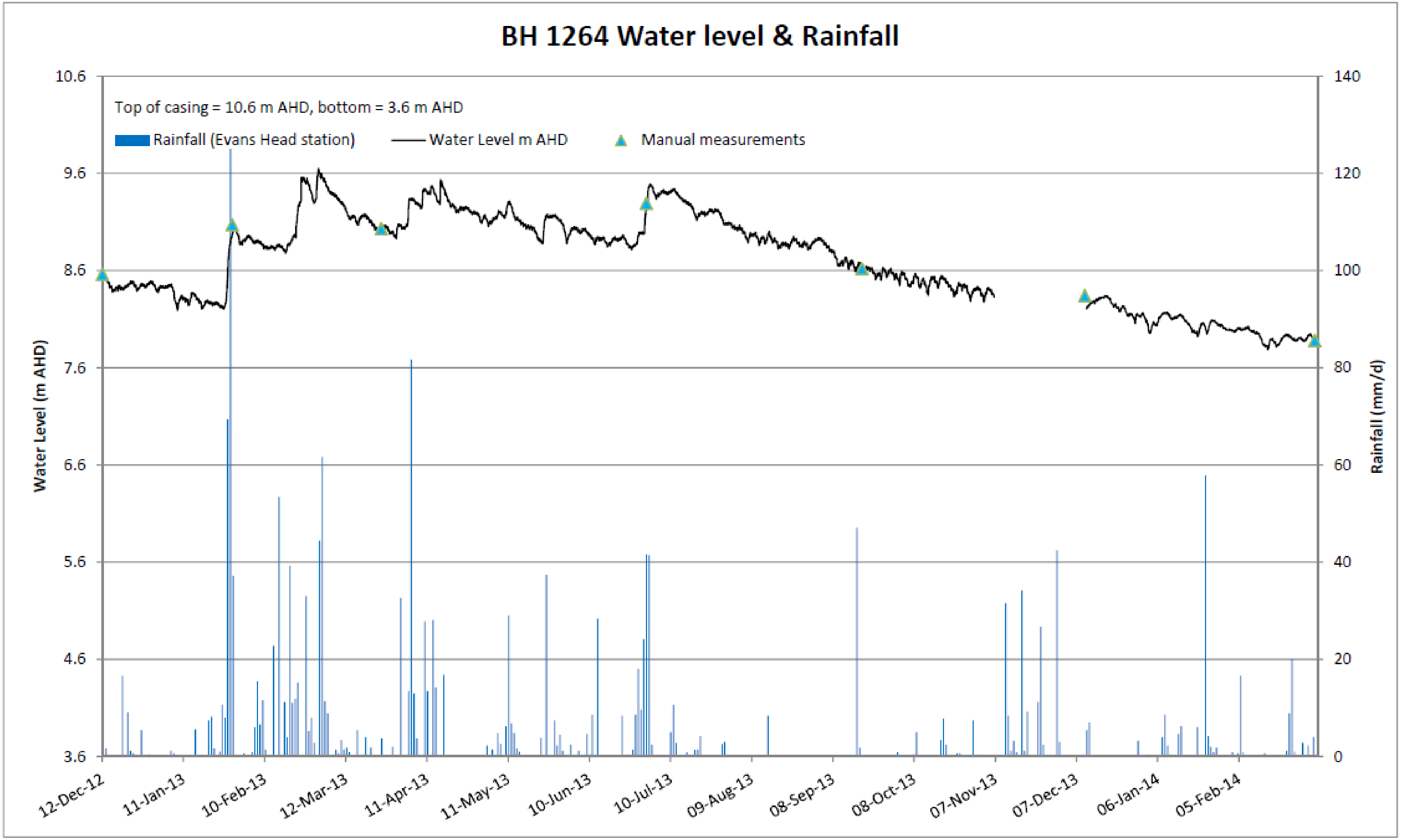
06-Jan-14
05-Feb-14
07-Mar-14


BH 1264 Water level & Rainfall
Top of casing = 10.6 m AHD, bottom = 3.6 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
10.6
9.6
8.6
7.6
6.6
5.6
4.6
3.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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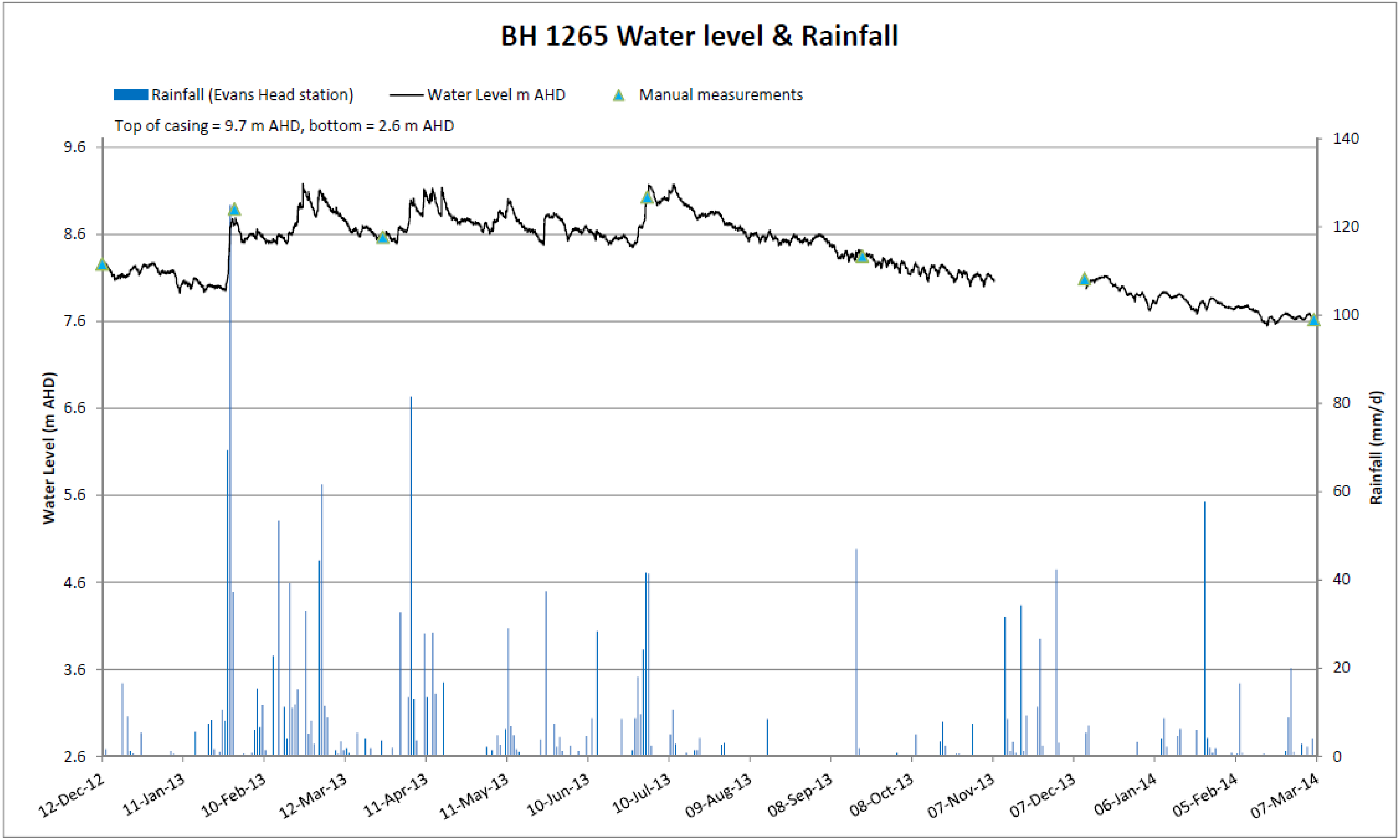
06-Jan-14
05-Feb-14



BH 1265 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 9.7 m AHD, bottom = 2.6 m AHD
Water Level (m AHD)
Rainfall (mm/d)
9.6
8.6
7.6
6.6
5.6
4.6
3.6
2.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
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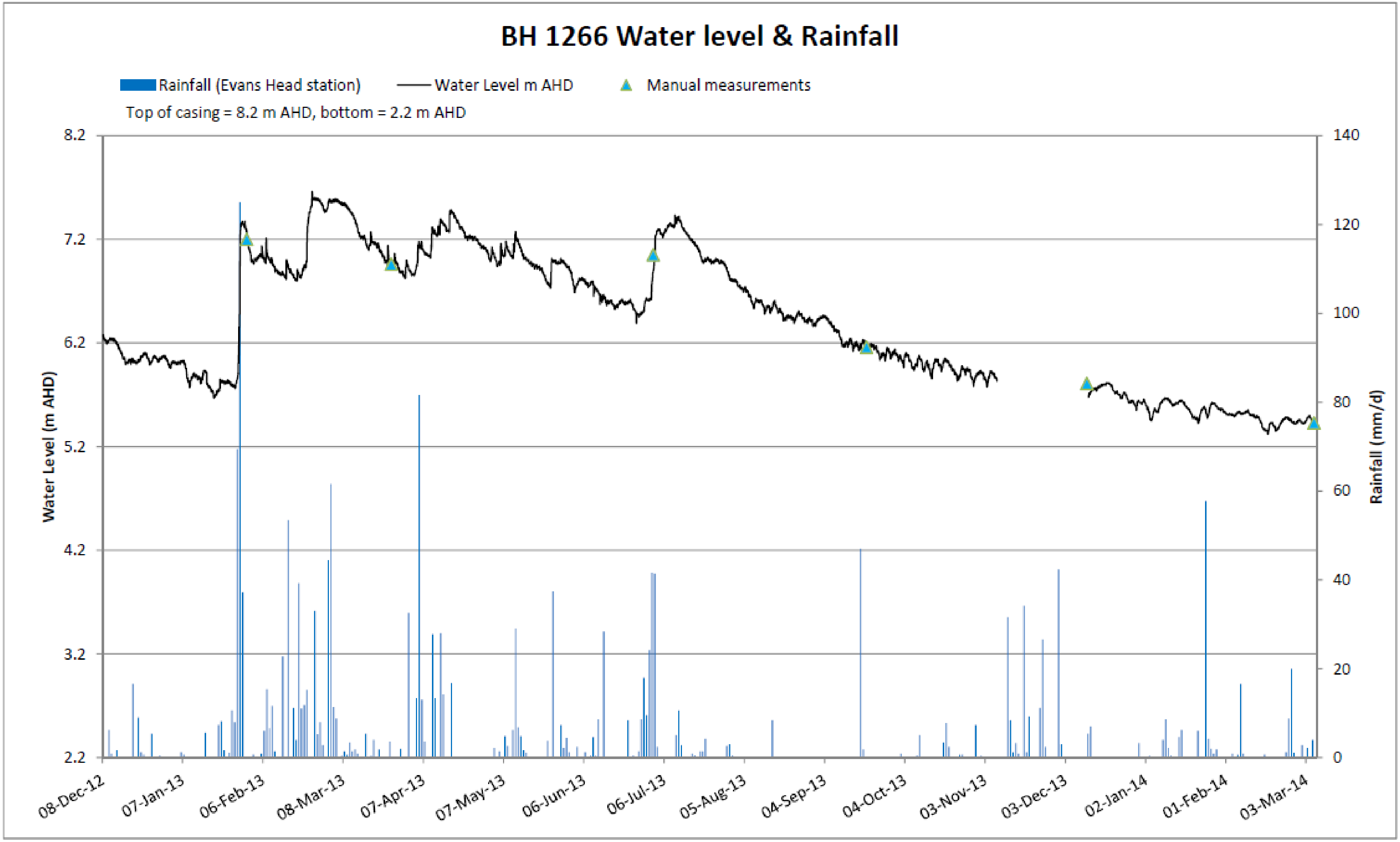
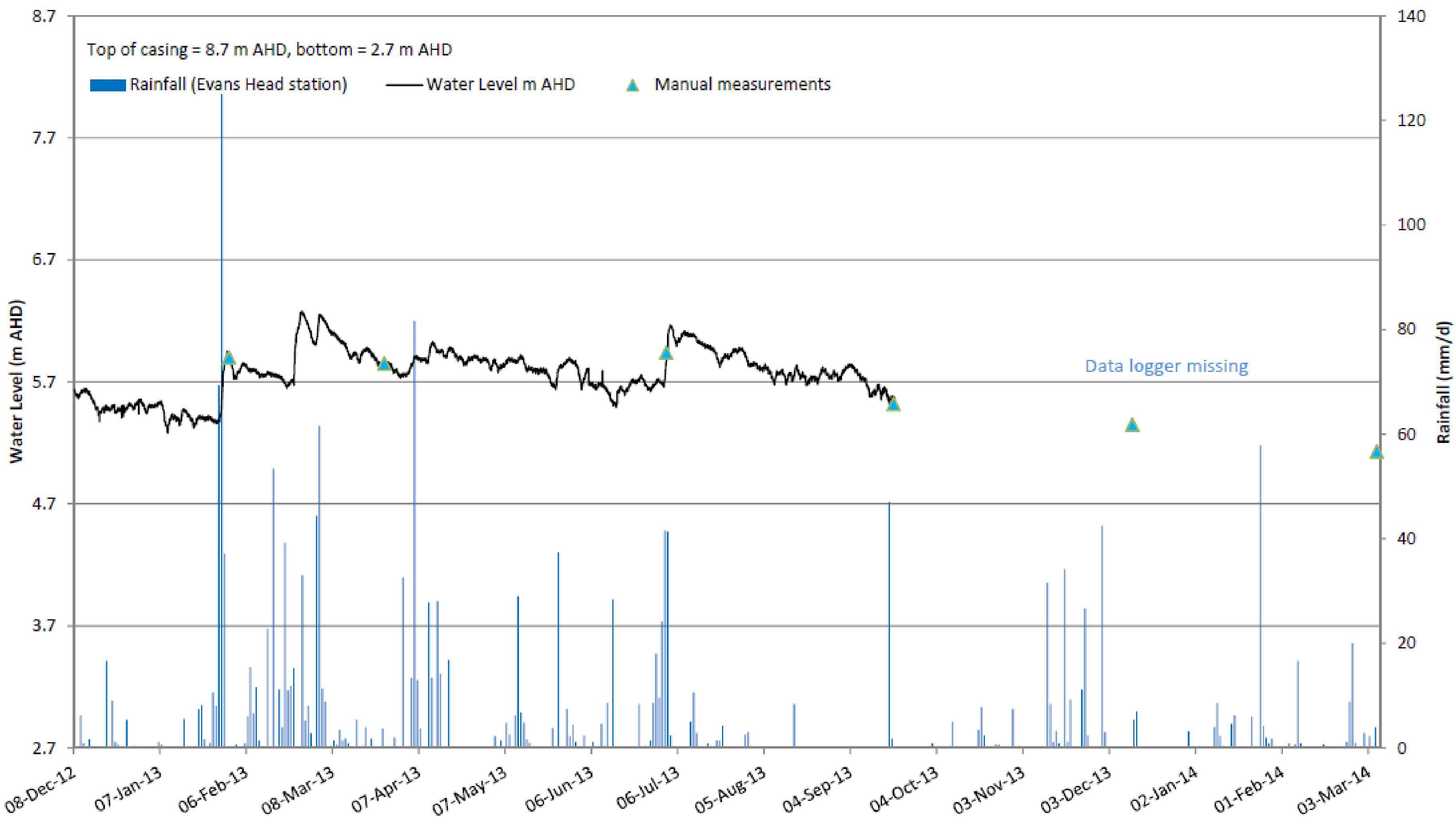
05-Feb-14
07-Mar-14


BH 1266 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 8.2 m AHD, bottom = 2.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
8.2
7.2
6.2
5.2
4.2
3.2
2.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14

BH 1267 Water level & Rainfall



Appendix I

Section 10 - Richmond River to Coolgardie Road: Pre-Construction Monitoring Results

Section 10: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	*Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems (GDE's)*
SW11 - Richmond River	▪ No significant sensitive receiving environment
SW12 - Unnamed tributary Bingal Creek, CH 149 250 m	▪ No significant sensitive receiving environment
SW13 - Saltwater Creek	▪ GDE
SW14 - Randal's Creek	▪ No significant sensitive receiving environment

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 10: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the high-teens (15-18°C) in winter up to the high-20s (25-30°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 4.1 to 9.2.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of <0.01 to 2.02 mg/L. Total Nitrogen values were found to be in the range of <0.1to 2.6 mg/L.

Heavy Metals

Heavy metals were not sampled for most points within section 10.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	Summary of Visual Observations	Overview of Water Quality Sampling Results
GDE07 Unnamed Swamp Ch. 148,900	▪ No record of visual observations provided.	▪ O&G: <5mg/L ▪ SS: <5-275mg/L ▪ TP: <0.01-0.63mg/L ▪ TN: 0.5-2.9mg/L ▪ DO: 1.6-8.1mg/L ▪ EC: 95-275µS/cm ▪ pH: 4.8-8.3 ▪ Temp: 15.6-29.0ºC ▪ NTU: 3.7-259
SW11 Richmond River Ch. 145,900	▪ As above.	▪ O&G: <5mg/L ▪ SS: 28-158mg/L ▪ TP: 0.02-0.38mg/L ▪ TN: <0.1-0.9mg/L ▪ DO: 1.7-9.9mg/L ▪ EC: 122-19,300µS/cm ▪ pH: 5.7-7.9 ▪ Temp: 16.3-29ºC ▪ NTU: 4.9-111
SW12 Unnamed tributary of Bingal Creek Ch. 149,300	▪ As above.	▪ O&G: <5mg/L ▪ SS: 16-158mg/L ▪ TP: 0.02-0.38mg/L ▪ TN: <0.1-0.9mg/L ▪ DO: 1.7-9.9mg/L ▪ EC: 122-19,800µS/cm ▪ pH: 5.7-7.9 ▪ Temp: 16.3-29.0ºC ▪ NTU: 4.9-111
SW13/GDE08 Saltwater Creek Ch. 157,200	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-218mg/L ▪ TP: 0.02-2.02mg/L ▪ TN: 0.3-2.6mg/L ▪ DO: 0.8-16.4mg/L ▪ EC: 120-597µS/cm ▪ pH: 4.1-9.2 ▪ Temp: 18.3-30.5ºC ▪ NTU: 4.3-77.0
SW14 Randal's Creek Ch. 157,800	▪ As above.	▪ O&G: <5mg/L ▪ SS: <5-217mg/L ▪ TP: <0.01-0.19mg/L ▪ TN: <0.1-1.2mg/L ▪ DO: 0.2-8.7mg/L ▪ EC: 94-197µS/cm ▪ pH: 4.3-7.0 ▪ Temp: 15.3-24.7ºC ▪ NTU: 8.4-49.0

Note: * Ch. = Highway Chainage

Section 10: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 10							
		SW11 (SW10-01 and SW10-02)							
Sample ID Date of Sampling Weather		**Mean (Total)**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	62.92	51.75	158.00	16.0	35.0	116.2	-	
Total Phosphorus as P	mg/l	0.17	0.11	0.38	0.0	0.2	0.294	-	
Total Nitrogen as N	mg/l	0.54	0.30	0.90	0.1	0.6	0.8	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.58	2.26	9.90	1.7	8.0	9.08	6.818	
Conductivity	µs/cm	2006.83	3002.41	10800.00	132.0	922.0	2985.6	182.6	
pH		6.82	0.62	7.90	5.7	6.9	7.182	6.54	
Temperature	°C	22.48	3.86	29.00	16.3	23.3	25.1	-	
Turbidity	NTU	62.99	40.47	130.00	8.2	52.1	107	-	
		GDE07							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	37.50	73.03	275.00	2.5	14.0	35.4	-	
Total Phosphorus as P	mg/l	0.12	0.17	0.63	0.0	0.1	0.12	-	
Total Nitrogen as N	mg/l	0.92	0.67	2.90	0.5	0.7	1.12	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	5.74	2.37	9.00	1.6	6.7	7.18	3.19	
Conductivity	µs/cm	263.25	214.24	648.00	67.0	174.0	509.6	84	
pH		6.43	1.06	8.30	4.8	6.5	7.24	5.36	
Temperature	°C	43.17	71.37	258.00	15.6	22.3	25.7	-	
Turbidity	NTU	45.15	83.17	295.00	8.6	19.9	30.9	-	
		SW12 (SW10-03 and SW10-04)							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	129.08	102.17	334.00	33.0	92.0	218.8	-	
Total Phosphorus as P	mg/l	0.20	0.13	0.41	0.0	0.2	0.306	-	
Total Nitrogen as N	mg/l	1.32	1.02	3.60	0.2	0.9	2	-	
Dissolved Oxygen	mg/l	8.58	1.56	10.20	4.5	8.9	9.56	8	
Conductivity	µs/cm	161.02	97.09	383.00	38.0	146.0	217	74.56	
pH		6.90	1.02	8.50	5.1	7.2	7.56	5.944	
Temperature	°C	24.80	5.47	32.70	16.2	24.4	29.3	-	
Turbidity	NTU	358.55	231.43	697.00	63.0	292.0	668	-	
		SW13 (SW10-05 and SW10-06)							
Sample ID Date of Sampling Weather		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**Percentile**		**No.**
							80	**20**	
Laboratory data									
Oil and Grease	mg/l	2.77	0.97	6.00	2.5	2.5	2.5	-	
Suspended Solids	mg/l	32.58	58.03	218.00	2.5	15.0	34	-	
Total Phosphorus as P	mg/l	0.23	0.54	2.02	0.0	0.1	0.148	-	

Total Nitrogen as N	mg/l	0.72	0.63	2.60	0.3	0.5	0.78	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	7.40	3.82	16.40	0.8	7.5	8.56	4.656	
Conductivity	µs/cm	141.67	37.98	187.00	82.0	149.0	176	102.8	
pH		6.28	1.20	9.20	4.1	6.1	6.66	5.9	
Temperature	°C	24.62	4.06	30.50	18.3	22.8	29.06	-	
Turbidity	NTU	27.03	11.69	50.90	11.1	23.2	33	-	

SW14 (SW10-07 and SW10-08)

Sample ID Date of Sampling Weather		Mean	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	39.42	63.37	217.00	2.5	13.0	32.4	-	
Total Phosphorus as P	mg/l	0.06	0.05	0.19	0.0	0.0	0.08	-	
Total Nitrogen as N	mg/l	0.44	0.33	1.20	0.1	0.4	0.46	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.12	2.55	8.70	0.2	6.6	7.68	5.6	
Conductivity	µs/cm	103.88	46.03	154.00	1.6	108.5	142.8	77.4	
pH		5.80	0.83	7.00	4.3	5.8	6.5	5.21	
Temperature	°C	20.77	3.18	24.70	15.3	21.0	23.54	-	
Turbidity	**NTU**	**21.45**	**10.38**	**51.40**	**13.7**	**19.2**	**22.7**	**-**	

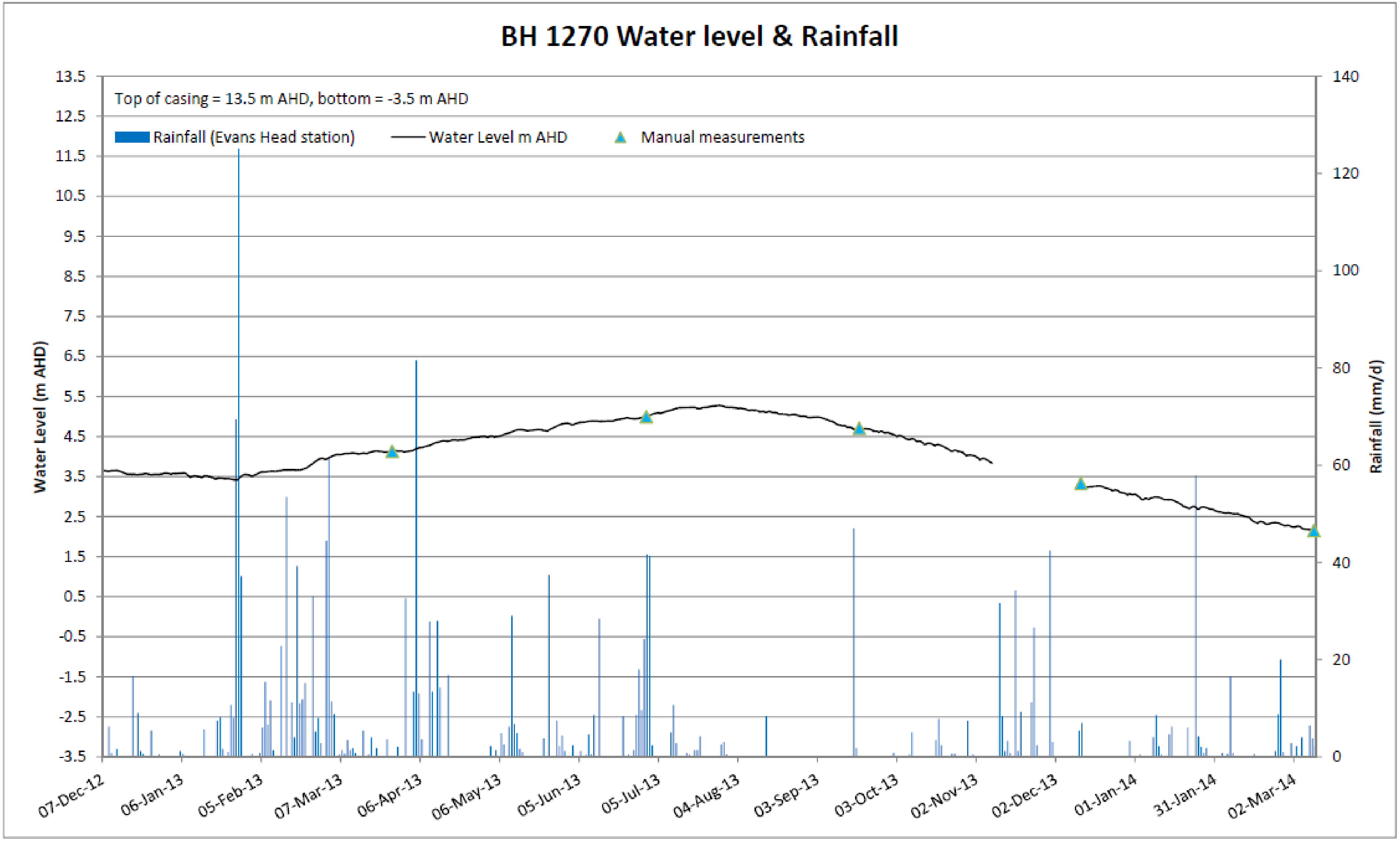
Section 10: Groundwater Monitoring – Water Quality Overview

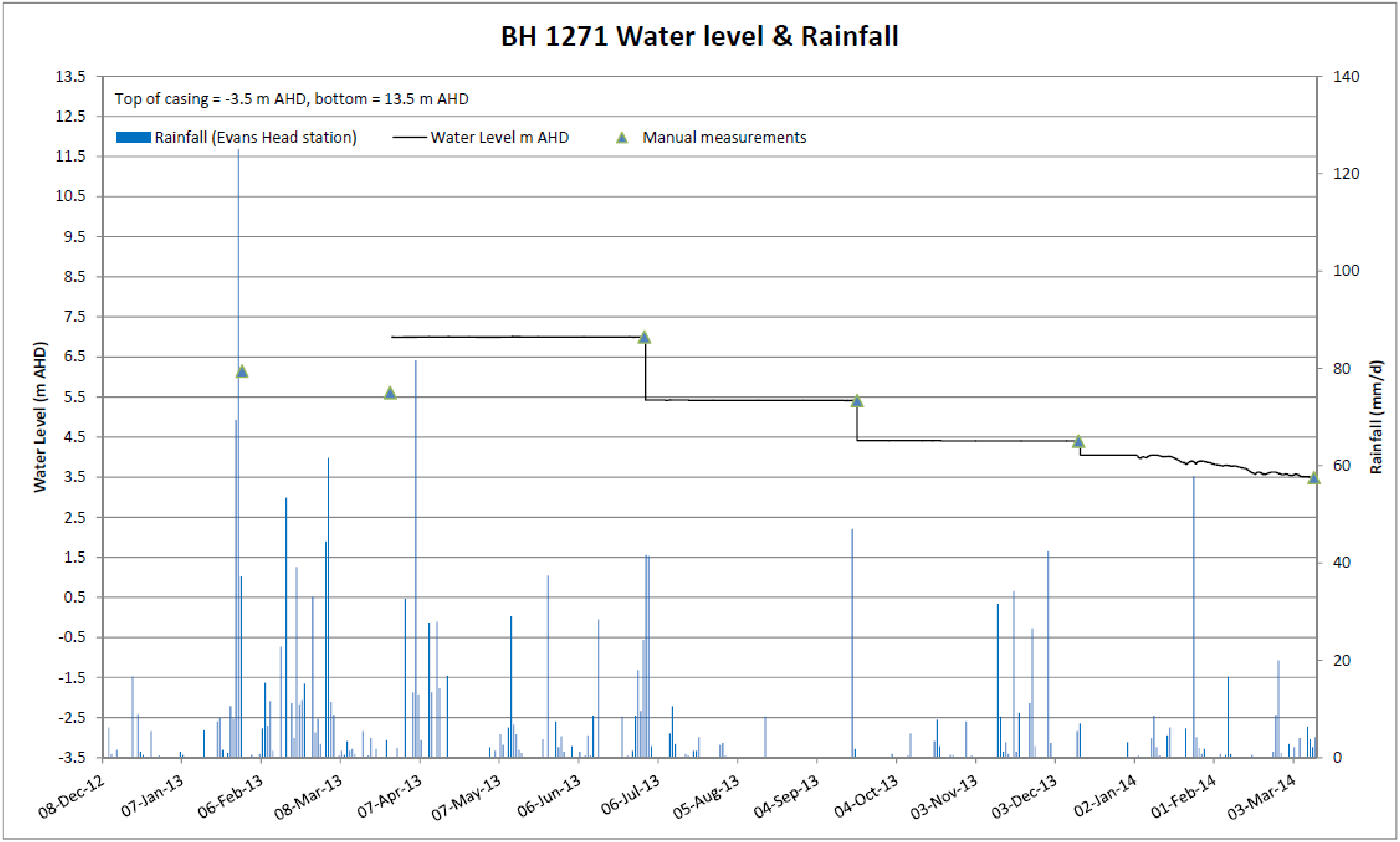
Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. No boreholes were measured in Section 10.

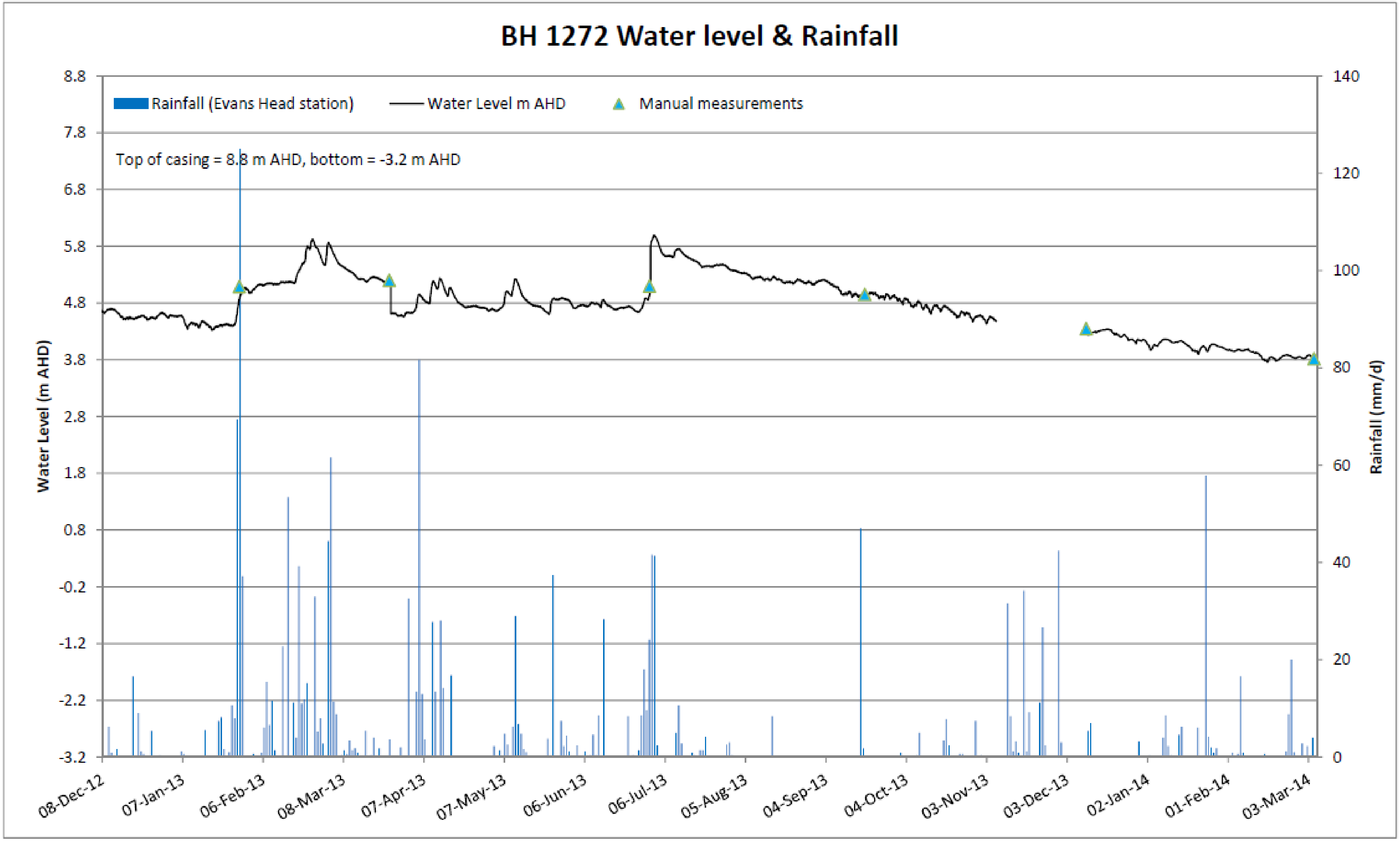
Section 10: Groundwater Monitoring – Levels

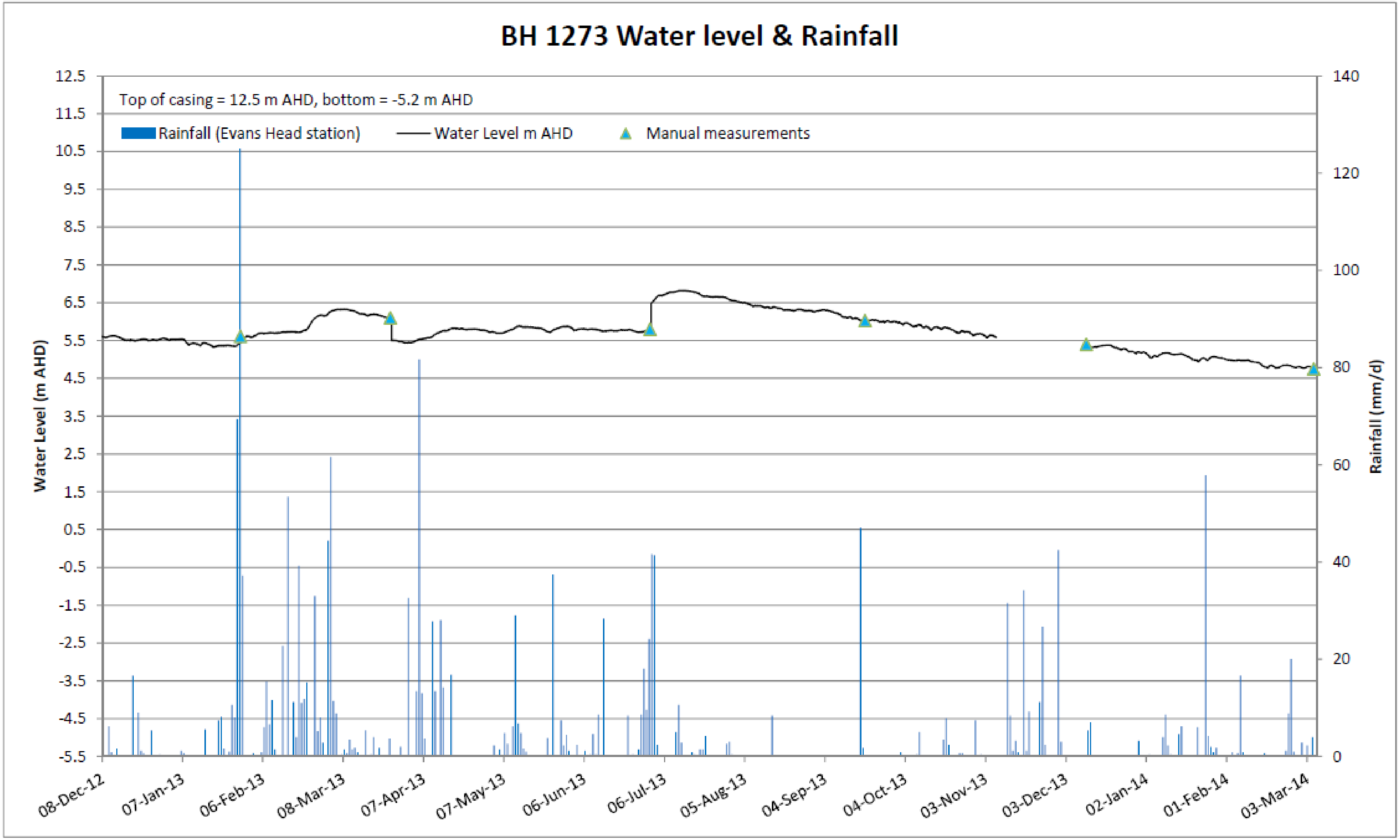
Summary of Groundwater Level Monitoring – Section 10 DP2B Upgrade

Borehole Identifier	*Typical SWL (m below ground level)*		
	Average	*Median*	*Standard Deviation*
BH1271	-	-	-
BH1272	-	-	-
BH1273	-	-	-
BH1274	-	-	-
BH1275	-	-	-
BH1276	-	-	-
BH1277	-	-	-
BH1278	-	-	-
BH1279	-	-	-
BH1280	-	-	-
BH1281	-	-	-
BH1282	-	-	-


BH 1270 Water level & Rainfall
Top of casing = 13.5 m AHD, bottom = -3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
13.5
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
140
120
100
80
60
40
20
0
07-Dec-12
06-Jan-13
05-Feb-13
07-Mar-13
06-Apr-13
06-May-13
05-Jun-13
05-Jul-13
04-Aug-13
03-Sep-13
03-Oct-13
02-Nov-13
02-Dec-13
01-Jan-14
31-Jan-14
02-Mar-14


BH 1271 Water level & Rainfall
Top of casing = -3.5 m AHD, bottom = 13.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
13.5
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1272 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 8.8 m AHD, bottom = -3.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
8.8
7.8
6.8
5.8
4.8
3.8
2.8
1.8
0.8
-0.2
-1.2
-2.2
-3.2
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1273 Water level & Rainfall
Top of casing = 12.5 m AHD, bottom = -5.2 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-4.5
-5.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
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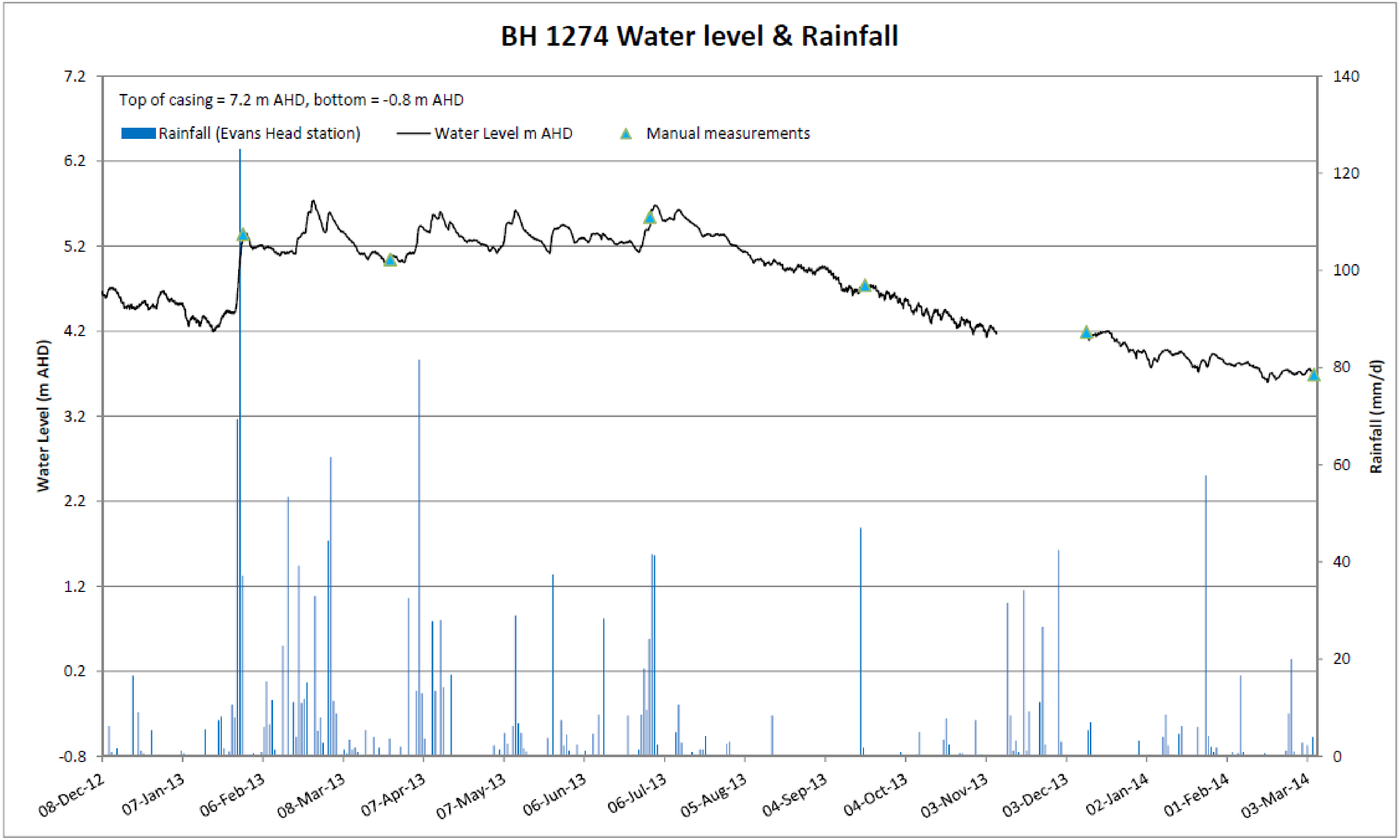
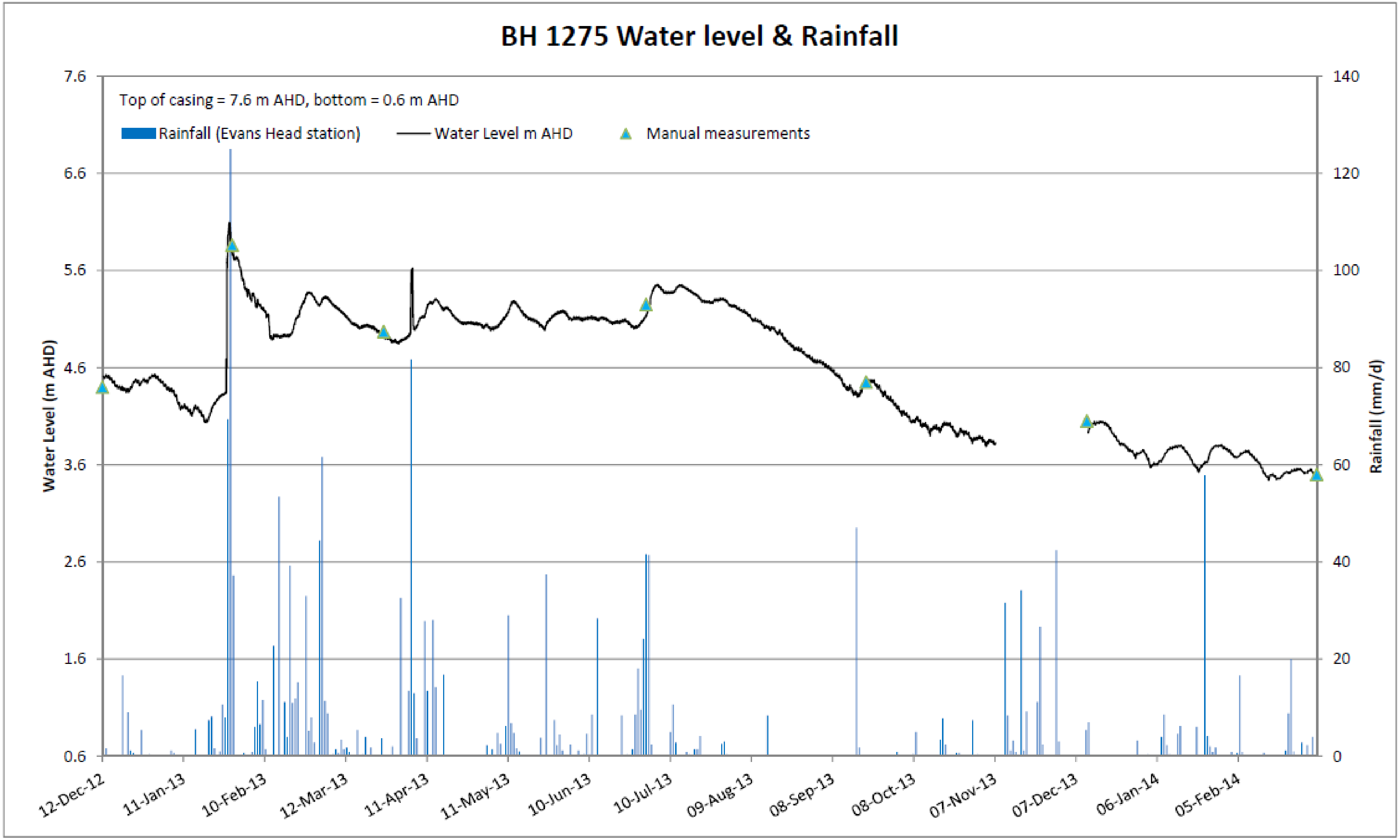
02-Jan-14
01-Feb-14
03-Mar-14



BH 1274 Water level & Rainfall
Top of casing = 7.2 m AHD, bottom = -0.8 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
7.2
6.2
5.2
4.2
3.2
2.2
1.2
0.2
-0.8
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1275 Water level & Rainfall
Top of casing = 7.6 m AHD, bottom = 0.6 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
7.6
6.6
5.6
4.6
3.6
2.6
1.6
0.6
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
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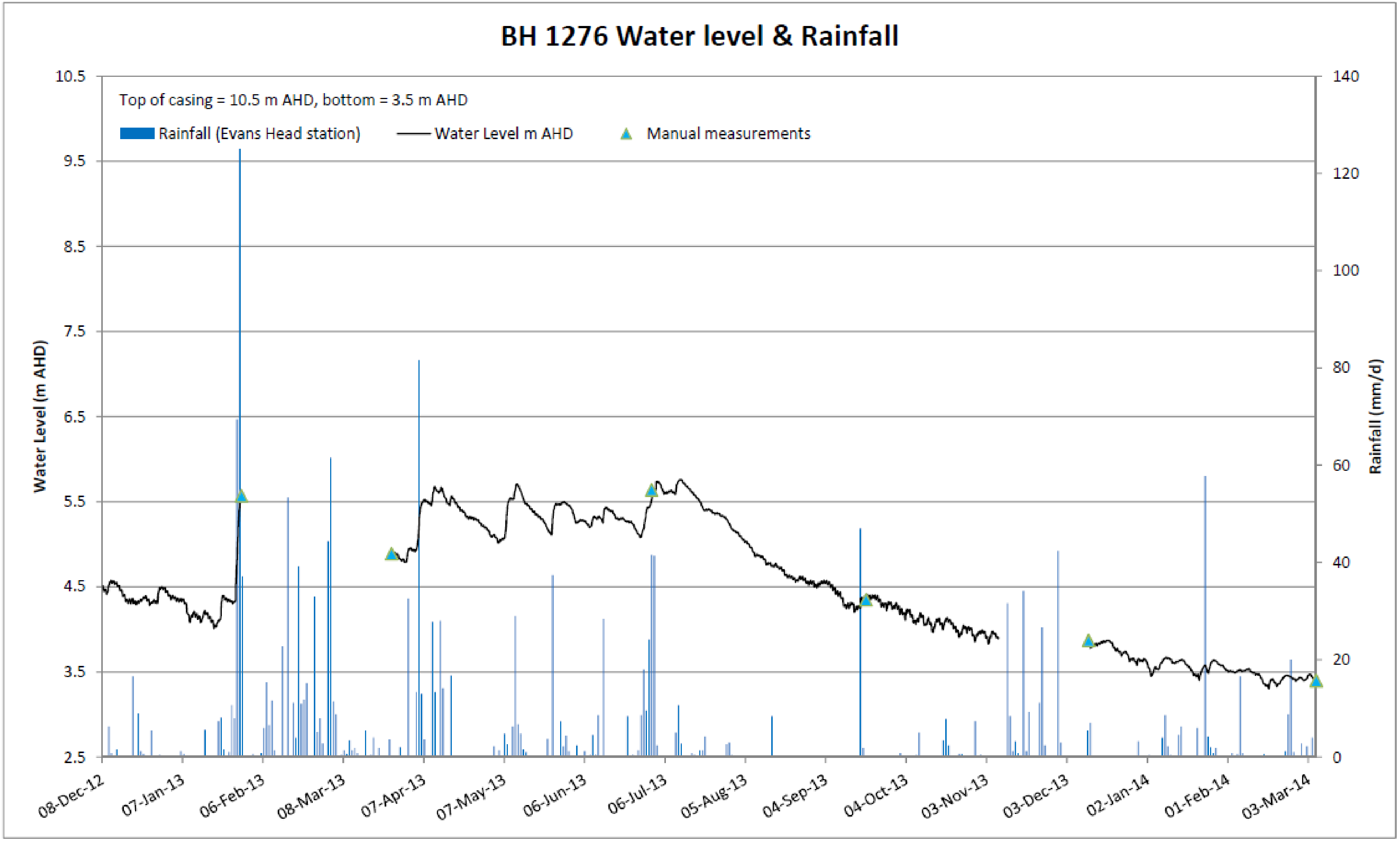
07-Dec-13
06-Jan-14
05-Feb-14


BH 1276 Water level & Rainfall
Top of casing = 10.5 m AHD, bottom = 3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
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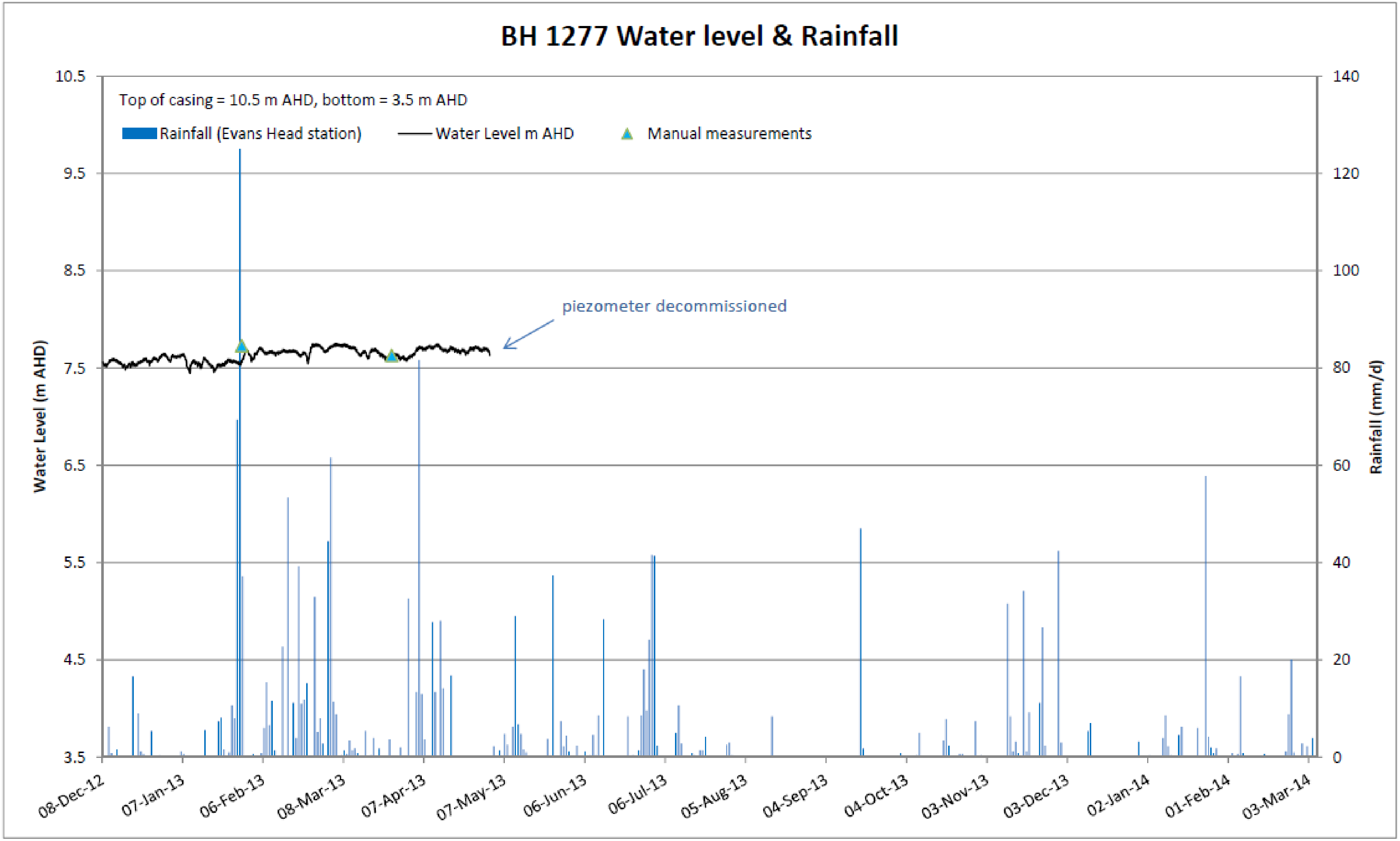
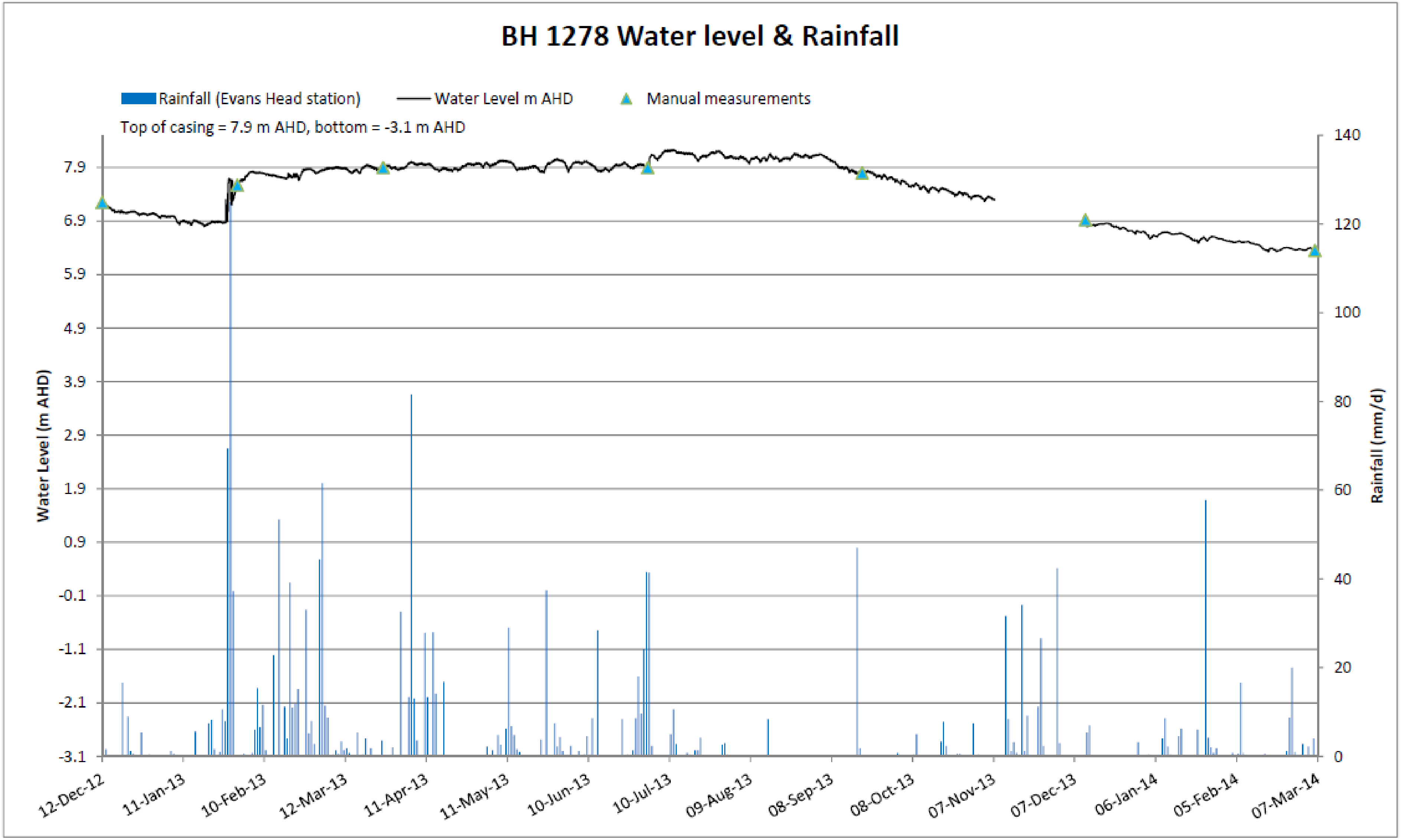
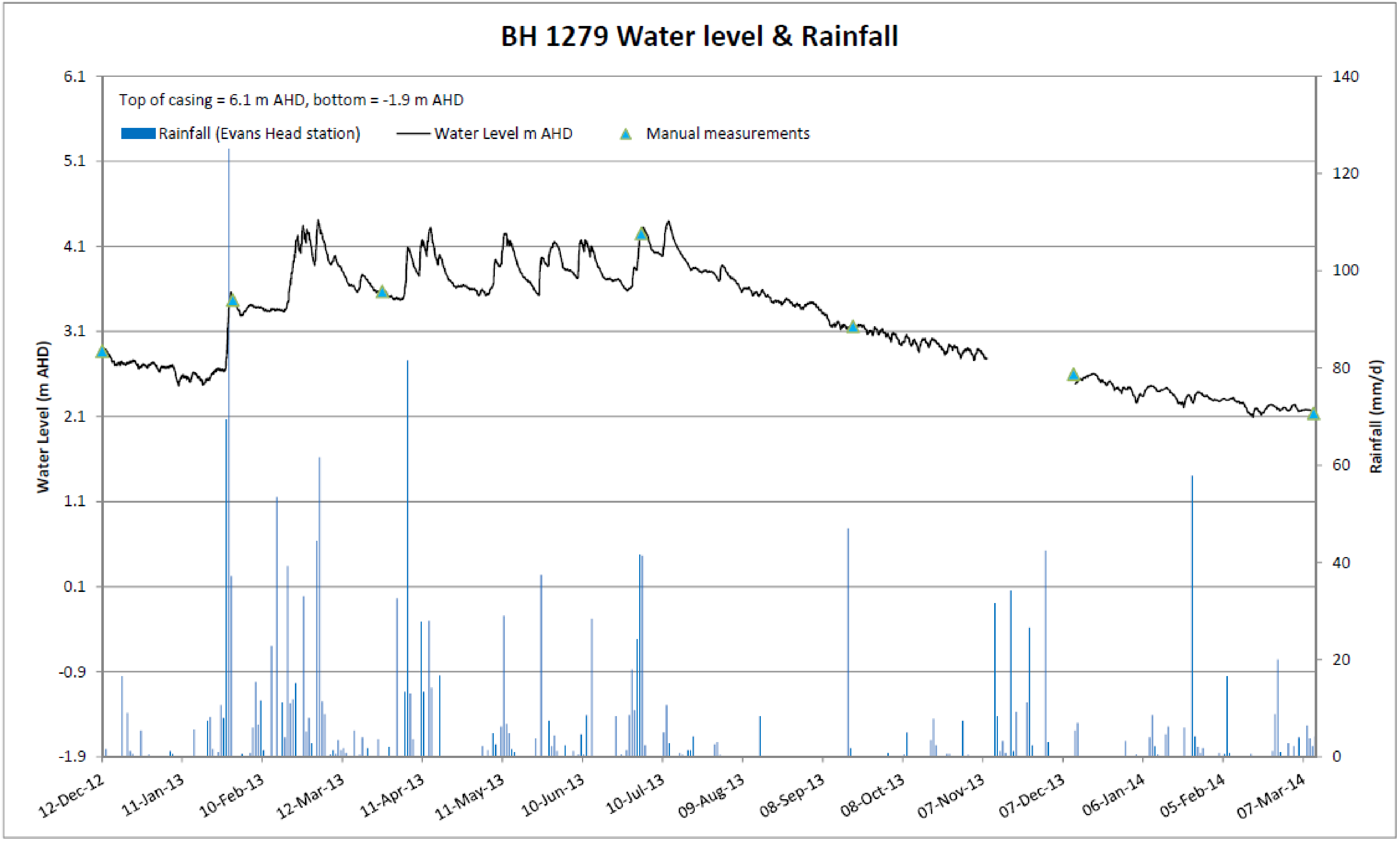
02-Jan-14
01-Feb-14
03-Mar-14

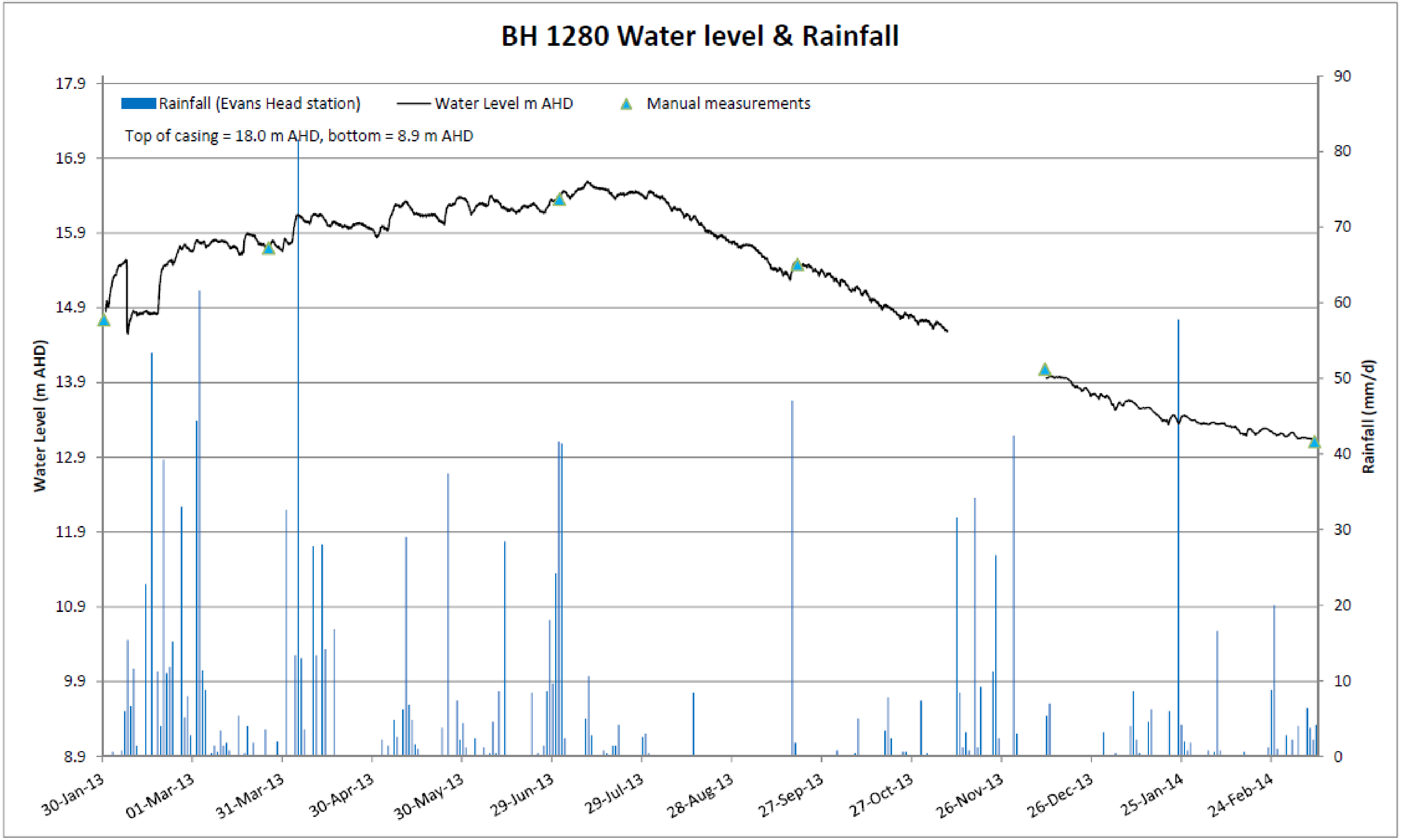


BH 1277 Water level & Rainfall
Top of casing = 10.5 m AHD, bottom = 3.5 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
piezometer decommissioned
Water Level (m AHD)
Rainfall (mm/d)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14



BH 1278 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 7.9 m AHD, bottom = -3.1 m AHD
Water Level (m AHD)
Rainfall (mm/d)
7.9
6.9
5.9
4.9
3.9
2.9
1.9
0.9
-0.1
-1.1
-2.1
-3.1
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14


BH 1279 Water level & Rainfall
Top of casing = 6.1 m AHD, bottom = -1.9 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
6.1
5.1
4.1
3.1
2.1
1.1
0.1
-0.9
-1.9
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14



BH 1280 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 18.0 m AHD, bottom = 8.9 m AHD
Water Level (m AHD)
Rainfall (mm/d)
17.9
16.9
15.9
14.9
13.9
12.9
11.9
10.9
9.9
8.9
90
80
70
60
50
40
30
20
10
0
30-Jan-13
01-Mar-13
31-Mar-13
30-Apr-13
30-May-13
29-Jun-13
29-Jul-13
28-Aug-13
27-Sep-13
27-Oct-13
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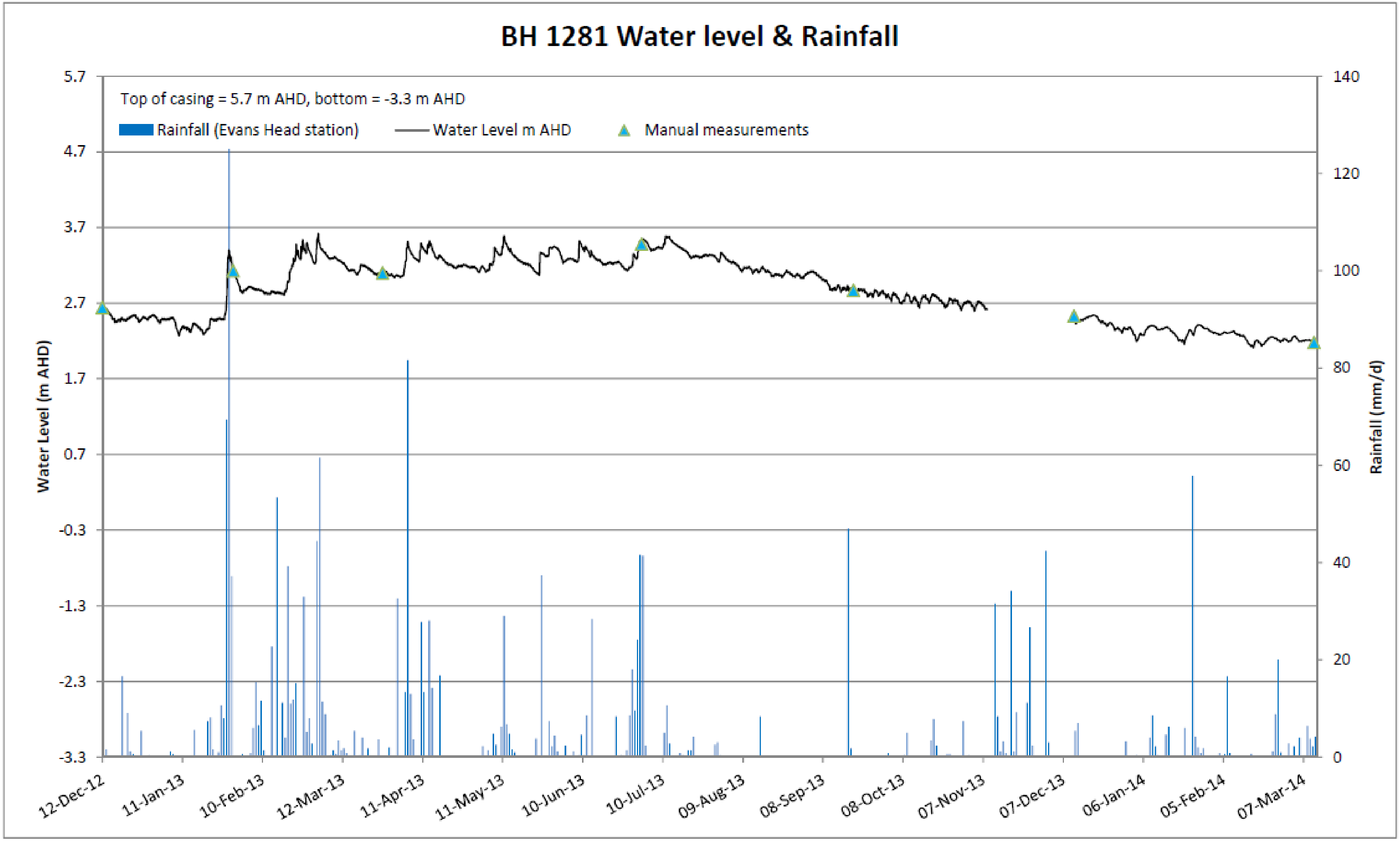
25-Jan-14
24-Feb-14


BH 1281 Water level & Rainfall
Top of casing = 5.7 m AHD, bottom = -3.3 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
5.7
4.7
3.7
2.7
1.7
0.7
-0.3
-1.3
-2.3
-3.3
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
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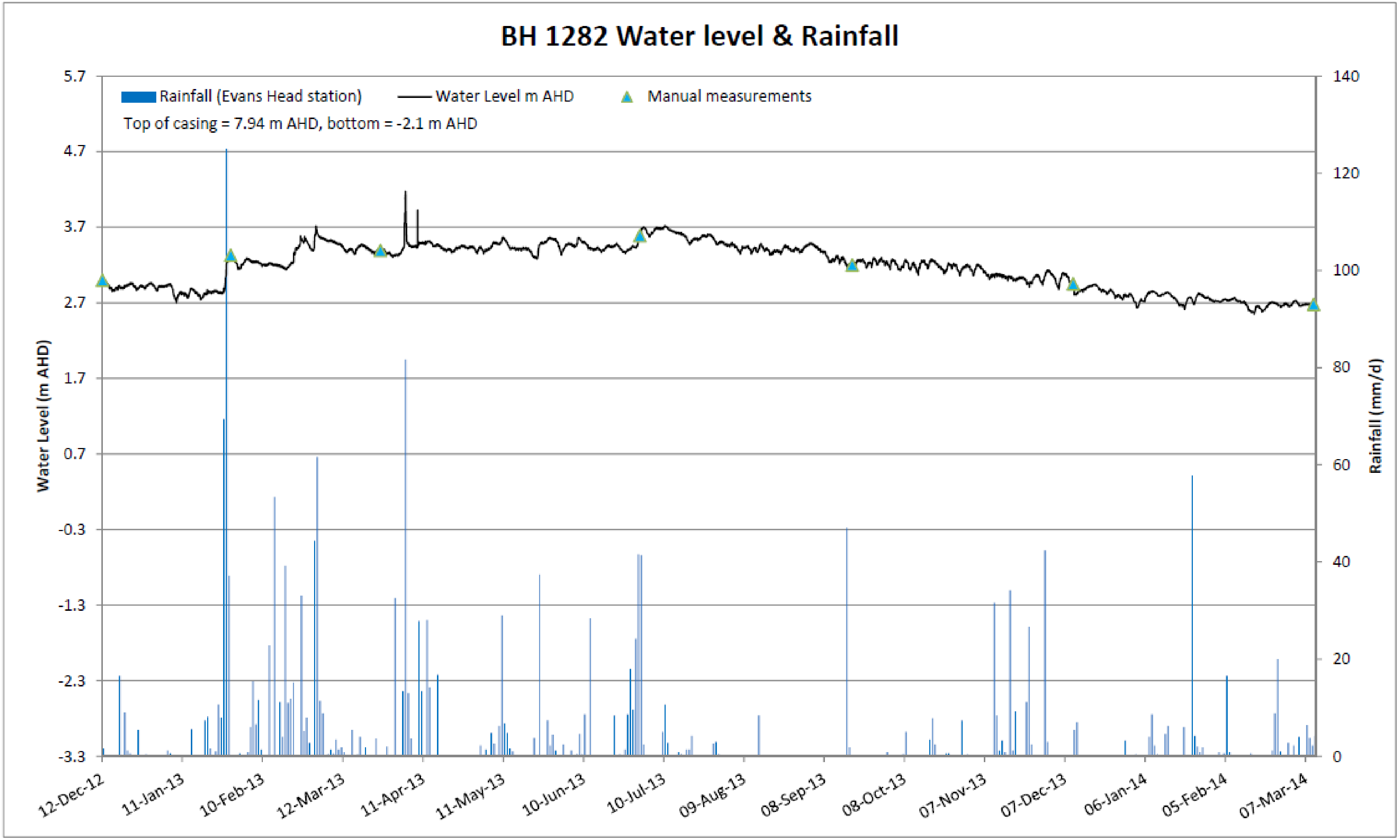
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14



BH 1282 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 7.94 m AHD, bottom = -2.1 m AHD
Water Level (m AHD)
Rainfall (mm/d)
5.7
4.7
3.7
2.7
1.7
0.7
-0.3
-1.3
-2.3
-3.3
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14

Appendix J

Section 11 - Coolgardie Road to Ballina Bypass: Pre-Construction Monitoring Results

Section 11: Surface Water Monitoring Locations and Associated Sensitive Receiving Environments

Surface Water Sample Locations/ Waterway	*Sensitive Aquatic Receiving Environments and Groundwater Dependent Ecosystems (GDE's)*
SW15 - Duck Creek	▪ GDE

Source: Table 4 and Table 9 in Golder Associates, (2014a)

Section 11: Surface Water Monitoring – Overview of Results

Physical Properties

Temperature generally exhibited a gradual increase generally from the mid-teens (around 16°C) in winter up to the high-20s (around 29°C) in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water.

Turbidity and suspended solids (SS) data varied somewhat. There was some correlation evident between turbidity and SS.

Chemical Properties

pH values were generally fairly consistent for each water body with a few outlying sampling results. pH levels fell within the range of 4.1 to 9.2.

The dissolved oxygen (DO) levels exhibit generally lower levels in the summer months of the monitoring period with higher concentrations occurring over winter.

Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

Nutrients

Phosphorus values were typically in the range of <0.01 to 0.46 mg/L. Total Nitrogen values were found to be in the range of <0.1to 0.7 mg/L.

Heavy Metals

Heavy metals were not sampled within section 10.

Summary of Visual Observations and Sampling Results

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW15/GDE09 Duck Creek Ch. 164,400	▪ No record of visual observations provided.	▪ O&G: <5mg/L ▪ SS: <5-107mg/L ▪ TP: <0.01-0.46mg/L ▪ TN: <0.1-0.7mg/L ▪ DO: 0.5-8.9mg/L ▪ EC: 145-29,500µS/cm ▪ pH: 5.6-7.7

		▪ Temp: 16.2-29.2ºC ▪ NTU: 2.5-38

Note: * Ch. = Highway Chainage

Section 11: Surface Water Monitoring – Sampling Statistics

	Units	SECTION 11							
		SW15 (SW11-01 and SW11-02)							
Sample ID Date of Sampling Weather		Mean (Total)	Standard Deviation	Minimum	Maximum	Median	Percentile		No.
							80	20	
Laboratory data									
Oil and Grease	mg/l	2.50	0	2.50	2.5	2.5	2.5	-	
Suspended Solids	mg/l	23.62	28.91	107.00	2.5	12.0	25.6	-	
Total Phosphorus as P	mg/l	0.16	0.23	0.81	0.0	0.1	0.192	-	
Total Nitrogen as N	mg/l	0.51	0.27	0.80	0.1	0.6	0.7	-	
Field Physico-chemical data									
Dissolved Oxygen	mg/l	6.80	2.45	8.90	0.5	7.6	8.56	6	
Conductivity	µs/cm	12746.73	11165.23	31150.00	3.8	10611.0	22188	1216.4	
pH		6.66	0.63	7.50	5.6	6.8	7.22	5.998	
Temperature	°C	23.16	3.58	29.20	16.2	23.1	26.22	-	
Turbidity	**NTU**	**13.96**	**9.50**	**38.60**	**5.8**	**12.2**	**17.6**	**-**	

Section 11: Groundwater Monitoring – Water Quality Overview

Groundwater pH was measured each quarter in boreholes located in areas of proposed fill embankments. Prior to measurement, approximately three times the borehole volume of groundwater was purged from each bore. The results for each quarter are shown in the table below.

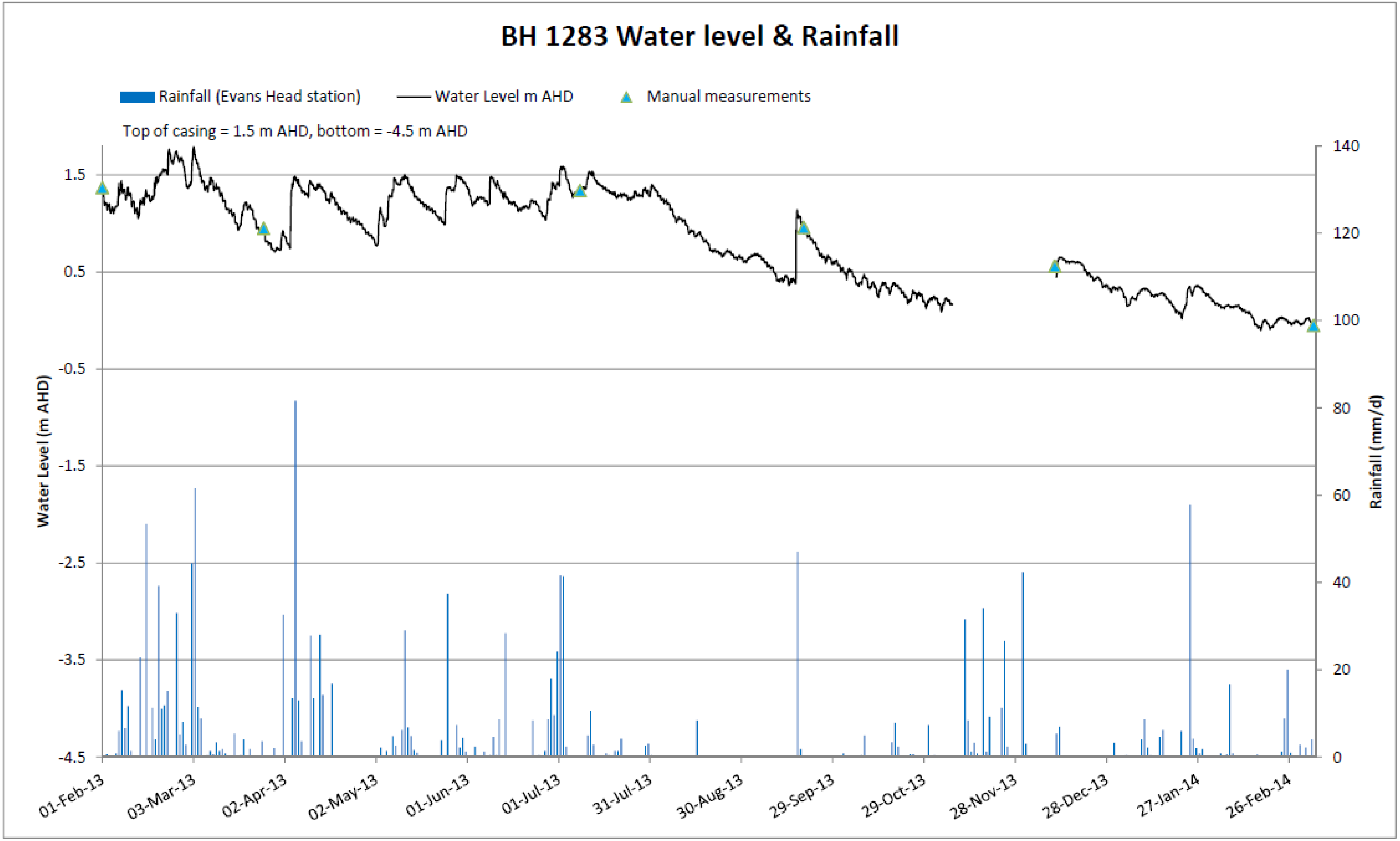
pH Statistics from Boreholes in Areas of Fill

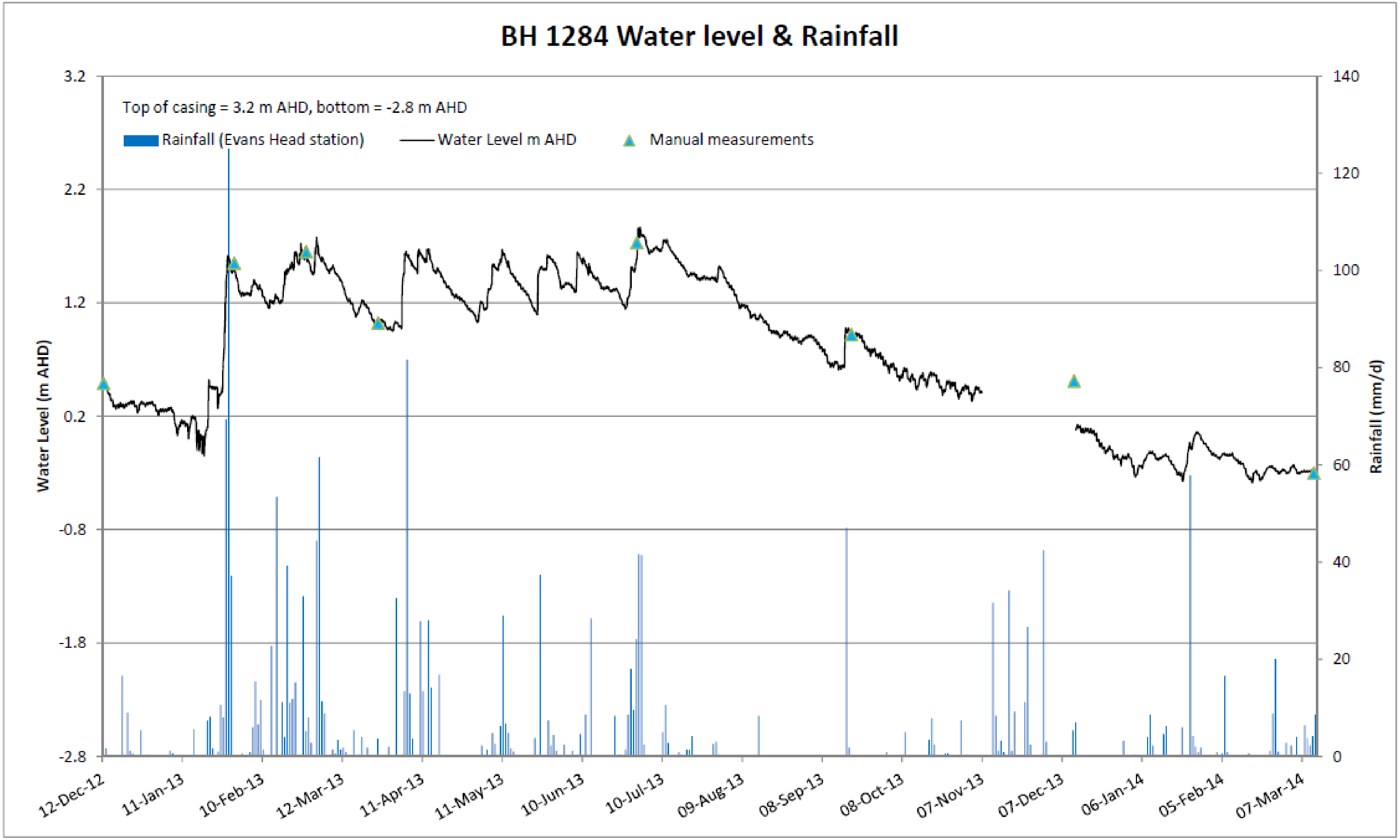
Borehole Identifier	Mean (Total)	Standard Deviation	Min	Max	Percentile	
					P80	P20
BH1283	6.13	0.28	5.80	6.40	6.15	6.34
BH1284	5.73	0.49	5.00	6.00	5.95	6.00
BH1285	7.40	0.59	6.80	8.20	7.30	7.72
BH1286	7.28	0.50	6.90	8.00	7.10	7.52

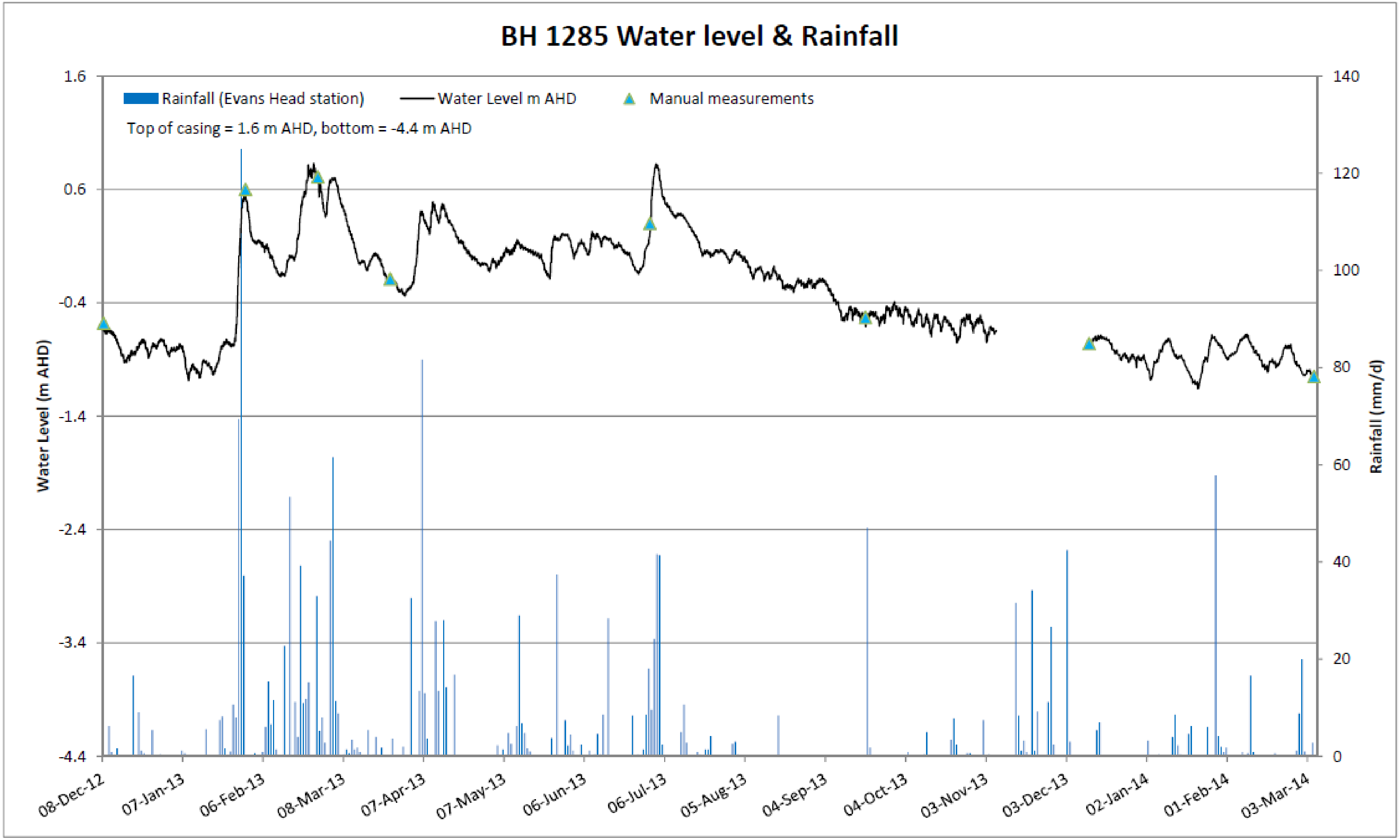
Section 11: Groundwater Monitoring – Levels

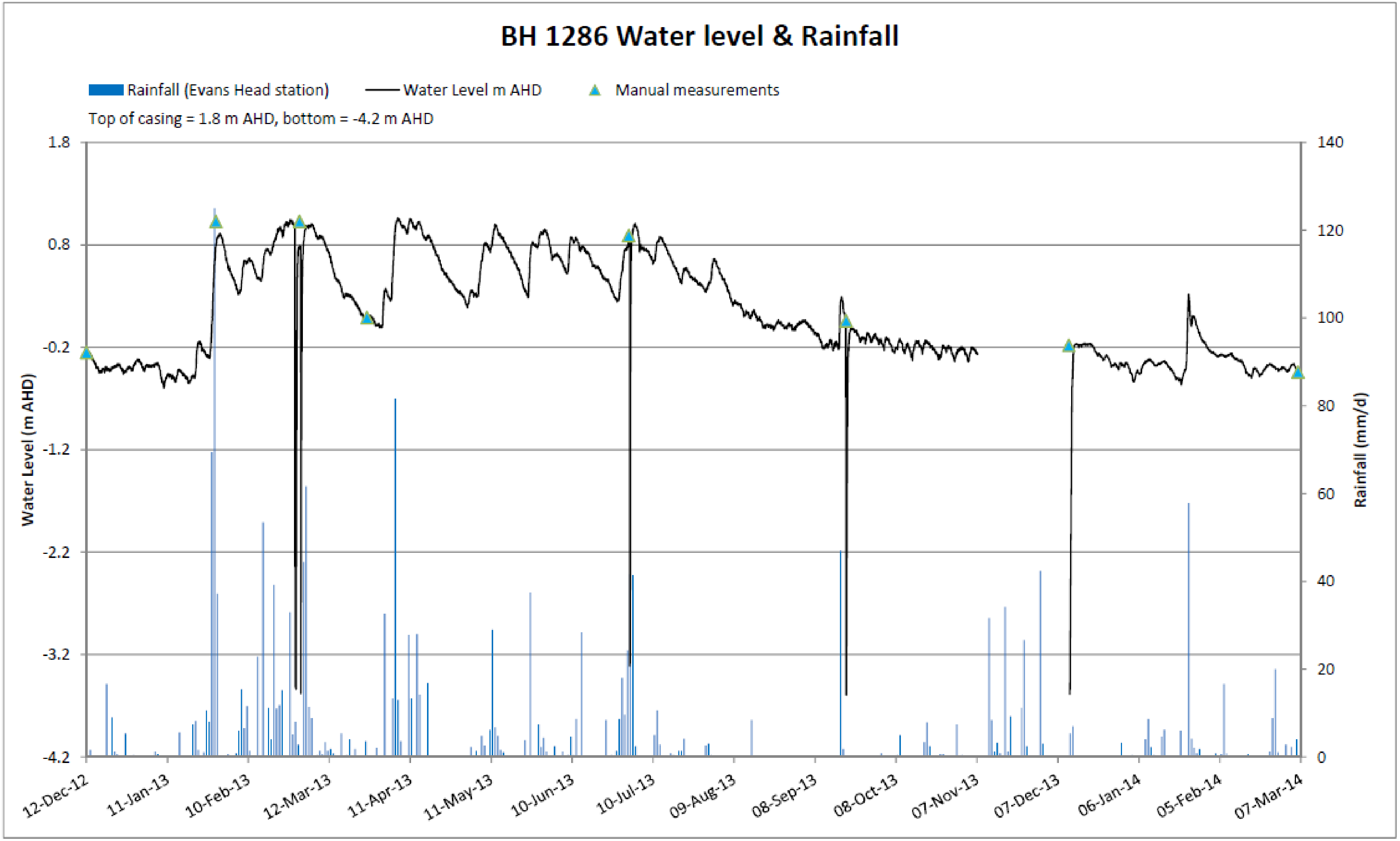
Summary of Groundwater Level Monitoring – Section 11 DP2B Upgrade

Borehole Identifier	*Typical SWL (m below ground level)*		
	Average	*Median*	*Standard Deviation*
BH1284	-	-	-
BH1285	0.21	0.15	0.64
BH1286	0.68	0.6	0.74


BH 1283 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.5 m AHD, bottom = -4.5 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-4.5
140
120
100
80
60
40
20
0
01-Feb-13
03-Mar-13
02-Apr-13
02-May-13
01-Jun-13
01-Jul-13
31-Jul-13
30-Aug-13
29-Sep-13
29-Oct-13
28-Nov-13
28-Dec-13
27-Jan-14
26-Feb-14


BH 1284 Water level & Rainfall
Top of casing = 3.2 m AHD, bottom = -2.8 m AHD
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Water Level (m AHD)
Rainfall (mm/d)
3.2
2.2
1.2
0.2
-0.8
-1.8
-2.8
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14


BH 1285 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.6 m AHD, bottom = -4.4 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.6
0.6
-0.4
-1.4
-2.4
-3.4
-4.4
140
120
100
80
60
40
20
0
08-Dec-12
07-Jan-13
06-Feb-13
08-Mar-13
07-Apr-13
07-May-13
06-Jun-13
06-Jul-13
05-Aug-13
04-Sep-13
04-Oct-13
03-Nov-13
03-Dec-13
02-Jan-14
01-Feb-14
03-Mar-14


BH 1286 Water level & Rainfall
Rainfall (Evans Head station)
Water Level m AHD
Manual measurements
Top of casing = 1.8 m AHD, bottom = -4.2 m AHD
Water Level (m AHD)
Rainfall (mm/d)
1.8
0.8
-0.2
-1.2
-2.2
-3.2
-4.2
140
120
100
80
60
40
20
0
12-Dec-12
11-Jan-13
10-Feb-13
12-Mar-13
11-Apr-13
11-May-13
10-Jun-13
10-Jul-13
09-Aug-13
08-Sep-13
08-Oct-13
07-Nov-13
07-Dec-13
06-Jan-14
05-Feb-14
07-Mar-14

Appendix K

ANZECC Criteria

Surface Water Investigation Levels

Contaminants of Concern	***ANZECC 2000[1] 95% species protected***		***ANZECC 2000 Physico-chemical stressors***	
	Freshwater	***Marine water***	***Freshwater***	***Saltwater/ Estuarine***
Metals				
Arsenic	0.024	0.0023[5]		
Cadmium	0.0002	0.0055		
Chromium	0.001	0.0044		
Copper	0.0014	0.0013		
Lead	0.0034	0.0044		
Mercury	0.0006	0.0004		
Nickel	0.011	0.07		
Zinc	0.008	0.015		
Total Recoverable Hydrocarbons				
Naphthalene	0.016	0.07		
TRH >C10-C16	-	-		
TRH >C10-C16 less Naphthalene	-	-		
TRH >C16-C34	-	-		
TRH >C34-C40	-	-		
TRH C6-C10	-	-		
TRH C6-C10 less BTEX (F1)	-	-		
BTEX				
Benzene	0.95	0.7		
Ethylbenzene	0.08[5]	-		
m&p-Xylenes	-	-		
o-Xylene	0.35	-		
Toluene	0.18[5]	-		
Xylenes - Total	-	-		
Nutrients				
Nitrogen (Total)	-	-	0.5[3]	0.3[3]
Suspended Solids	-	-	< 40[2]	< 10[2]
Phosphorus	-	-	0.05[3]	0.03[3]
Physico-chemical				
Dissolved Oxygen	-	-	> 5[2]	> 5[2]
Electrical conductivity (µS/cm)	-	-	125 – 2,200[4]	-
pH (pH units)	-	-	6.5 - 8[3]	7 – 8.5[3]
Turbidity (NTU)	**-**	**-**	**50[4]**	**10[4]**

1. Based on ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Fresh and Marine water, South Eastern Australia, slightly to moderately disturbed systems 95 per cent of species protected, see Table 3.4.1).
2. Based on ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Table 4.4.2 Physico-chemical stressor guidelines for the protection of aquaculture species).
3. Based on ANZECC (2000), Australian and New Zealand Guidelines For Fresh and Marine Water Quality (Table 3.3.2 Default trigger values for physical and chemical stressors for south-east Australia)
4. Based on ANZECC (2000) Table 3.3.3 Ranges of default trigger values for conductivity and turbidity indicative of slightly disturbed ecosystems in south east Australia. Note. The maximum values have been adopted for this project.
5. ANZECC (2000) Low reliability trigger values

\- No guideline value is specified.

NB. All units in mg/L unless otherwise stated.

Groundwater Investigation Levels

Contaminants of Concern	ANZECC 2000[1] 95% species	Laboratory Limit of reporting	Adopted GILs
Metals			
Antimony	0.009[2]	0.005	0.009
Arsenic	0.024	0.001	0.024
Beryllium	-	0.001	-
Boron	0.37	0.01	0.37
Cadmium	0.0002	0.0001	0.0002
Chromium	0.001	0.001	0.001
Cobalt	-	0.001	-
Copper	0.0014	0.001	0.0014
Lead	0.0034	0.001	0.0034
Manganese	-	0.001	-
Mercury	0.0006	0.0001	0.0006
Molybdenum	-	0.001	-
Nickel	0.011	0.001	0.011
Selenium	-	0.005	-
Silver	0.00005	0.0001	< LOR
Tin	0.003[2]	0.005	0.005
Zinc	0.008	0.005	0.008
Inorganics			
Cyanide	0.007	0.005	0.007
Total Recoverable Hydrocarbons			
TRH C6-C10	-	0.002	< LOR
TRH C6-C10 less BTEX (F1)	-	0.002	< LOR
TRH >C10-C16	-	0.05	< LOR
TRH >C10-C16 less Naphthalene (F2)	-	0.05	< LOR
TRH >C16-C34	-	0.1	< LOR
TRH >C34-C40	-	0.1	< LOR
BTEX			
Benzene	0.95	0.001	0.95
Ethylbenzene	0.08[2]	0.001	0.08
m&p-Xylenes	-	0.002	-
o-Xylene	0.35[2]	0.001	0.35
Toluene	0.18[2]	0.001	0.18
Xylenes - Total	-	0.003	-
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	-	0.001	-
Acenaphthylene	-	0.001	-
Anthracene	-	0.001	-
Benz(a)anthracene	-	0.001	-
Benzo(a)pyrene	0.0002[2]	0.001	< LOR
Benzo(b)fluoranthene and Benzo(k)fluoranthene	-	0.001	-
Benzo(g.h.i)perylene	-	0.001	-
Chrysene	-	0.001	-

Contaminants of Concern	*ANZECC 2000[1] 95% species*	*Laboratory Limit of reporting*	*Adopted GILs*
Dibenz(a.h)anthracene	-	0.001	-
Fluoranthene	0.0014[2]	0.001	0.0014
Fluorene	-	0.001	-
Indeno(1.2.3-cd)pyrene	-	0.001	-
Naphthalene	0.016	0.001	0.016
Phenanthrene	0.002[2]	0.001	0.002
Pyrene	-	0.001	-
Total PAH	-	0.001	< LOR
Phenols			
Phenolics (Total)	0.32	0.002	0.32
Organochlorine Pesticides			
4.4'-DDD	-	0.0001	-
4.4'-DDE	-	0.0001	-
4.4'-DDT	0.00001	0.0001	< LOR
a-BHC	-	0.0001	-
Aldrin	-	0.0001	-
b-BHC	-	0.0001	-
Chlordanes - Total	0.00008	0.001	< LOR
d-BHC	-	0.0001	-
Dieldrin	-	0.0001	-
Endosulfan I	-	0.0001	-
Endosulfan II	-	0.0001	-
Endosulfan sulphate	-	0.0001	-
Endrin	0.00002	0.0001	< LOR
Endrin aldehyde	-	0.0001	-
Endrin ketone	-	0.0001	-
g-BHC (Lindane)	0.0002	0.0001	0.0002
Heptachlor	0.00009	0.0001	< LOR
Heptachlor epoxide	-	0.0001	-
Hexachlorobenzene	-	0.0001	-
Methoxychlor	-	0.0001	-
Toxaphene	-	0.0001	-
Polychlorinated Biphenyls			
Aroclor-1016	-	0.005	-
Aroclor-1232	-	0.005	-
Aroclor-1242	0.0006	0.005	< LOR
Aroclor-1248	-	0.005	-
Aroclor-1254	0.00003	0.005	< LOR
Aroclor-1260	-	0.005	-
Total PCB	**-**	**0.005**	**< LOR**

1. Based on ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Fresh and Marine water, South Eastern Australia, slightly to moderately disturbed systems 95 per cent of species protected, see Table 3.4.1).
ANZECC (2000) Low reliability trigger values

NB. All units in mg/L unless otherwise stated.

Appendix L

Consultation with Government Authorities

Agency: Commonwealth Department of the Environment – 24/6/15				
No.	**CoA**	**Requirement / Plan reference**	**Comments**	**RMS Response**
EPBC 14g	Develop and implement the Water Quality Monitoring Program (WQMP) required by NSW approval condition D12	This Plan for sections 3-11 of the highway	EPBC condition 14g does not require approval of this plan by the Minister.	Noted.
D12	Prepare and implement a WQMP to monitor construction and operational impacts on surface and groundwater quality and resources and wetlands prior to construction.	This Plan		Noted.
D12 (a)	Identification of surface and groundwater quality monitoring locations – representative of the potential extent of impacts from the SSI	2, Appendices A – J Tables 2-1 & 2-2	The Plan lacks sufficient information to indicate the correlation between sensitive environmental areas and proposed monitoring locations.	Document has been updated to include additional information in Section 1.3 on sensitive receivers for the project, based on information provided and assessed in the EIS and SPIR. Additional information has also been included as to why locations were chosen to be monitored as part of the monitoring plan. Table 2.1, 2.2 and 3.1 have also been updated to reflect correlation between cut and fill areas, sensitive environmental areas and water quality monitoring locations.

Agency: Commonwealth Department of the Environment – 24/6/15				
No.	**CoA**	**Requirement / Plan reference**	**Comments**	**RMS Response**
D12(b)	The results of any groundwater modelling undertaken	3, Appendices B - J	compliant	Noted.
D12(c)	Identify activities with potential impacts on surface and groundwater quality in affected waterways and known Oxleyan Pygmy Perch (OPP) habitat.	1.3, 1.4 and 1.5	Oxleyan Pygmy Perch has been recorded in sections 7, 8 and 9. The figures do not indicate the relative locations of monitoring sites to OPP recorded locations. The Plan should identify impact activities, OPP locations and relative monitoring locations etc. The information must be consistent with the monitoring proposed in the OPP Management Plan.	Noted – information is included in the Threatened Fish Management Plan. Additional wording has been included in Section 1.6 to clarify this approach.
D12(d)	Parameters and standards against which any changes to water quality will be assessed including ANZ Guidelines for Fresh and Marine Water Quality 2000 or relevant baseline data.	7	The proposed construction phase water quality monitoring frequency appears inadequate (once/month for the first 12 years to make an informed review of results within the proposed 12 moth period.	RMS believe that the proposed frequency for monitoring in both construction and operation is adequate to address the objectives of the WQMP. Annual reporting periods provide opportunity to detail results and discussion around any potential changes to sampling methodology.
D12 (e)	Representative background monitoring of surface and groundwater quality parameters for a minimum 12 months prior to the commencement of construction to establish baseline water conditions (unless otherwise agreed by the Secretary).	3, Appendices B - J	Background monitoring for surface and groundwater at identified locations have been undertaken between January 2013 and January 2014. However representativeness of this samples to environmentally sensitive areas, other than wetland areas, is not described.	Document has been updated to include additional information in Section 1.3 on sensitive receivers for the project, based on information provided and assessed in the EIS and SPIR. Additional information has also been included as to why locations were chosen to be monitored as part of the monitoring plan. A note has been added to relevant items in Table 2.1, 2.2 and 3.1 to identify which sites are considered adjacent to high-risk areas. In addition the high-risk sensitive areas have been included on the maps in Appendix A.
D12(f)	A minimum monitoring period of 3 years following the completion of construction or until the affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable	4	Section 4.1 states this requirement	Noted.

Agency: Commonwealth Department of the Environment – 24/6/15				
No.	**CoA**	**Requirement / Plan reference**	**Comments**	**RMS Response**
	condition. The monitoring shall also confirm the establishment of operational water control measures (sediment basins, vegetation swales).			
D12(g)	Contingency and ameliorative measures in the event that adverse impacts to water quality are identified.	8		Noted.
D12(h)	Reporting of the monitoring results to DPE, OEH, EPA, DPI, NOW, DOE and Rous Water (in relation to the Woodburn borefields).	7.5	As required by EPBC approval condition 21 results and summary of outcomes must be included in the annual compliance report	Noted, additional wording included in this section.

Agency: NSW Department of Planning & Environment – 16/7/15			
Comment number	**Document section/Ref CoA**	**Comments**	**RMS Response**
1.	Figure 1.1	Please update as Devils Pulpit upgrade project has been completed.	Noted – map updated.
2.	Section 1.3	Include risks to water quality from stream diversions (permanent and temporary).	Comment noted, this measure is already included under Section 1.3.1
3.	Add Section 1.6	Include specific section on risk to Woodburn bores from construction and operation of the project.	Additional text included in Section 1.6 to detail risk to Woodburn bores from construction and operation of the project.
4.	Section 3	This section should include summary of pre-construction monitoring results contained in Appendices B to E/B to J – provide context to existing water quality.	Comment noted. Information on background monitoring undertaken is included in the Appendices to the plan. This includes summary information for each of the project Sections. It is considered that these summaries are appropriate given the level of information gathered during the pre-construction sampling period.

Agency: NSW Department of Planning & Environment – 16/7/15			
Comment number	**Document section/Ref CoA**	**Comments**	**RMS Response**
5.	Section 4.2.1	Change wet weather sampling round to two events per month, to be consistent with the Water Quality Monitoring Program for sections 1 and 2 (WQMP 1 & 2). Wet weather events are defined as 15mm or more of rain within 24 months. However, in the WQMP 1 & 2, wet weather events are 10mm or more of rain. The definition of a wet weather event should be consistent with the WQMP 1 & 2.	RMS considers that one wet and one dry sample per month as detailed in Section 4.2.1 is appropriate to meet the objectives of the water quality monitoring plan. In order to address the specific high-risk areas identified eg Rous borefield, Coldstream River, an additional wet weather sample will be undertaken at these locations during the construction period. The document has been updated to reflect this change. RMS considers that a 15mm rainfall within 24 hours is more representative of a wet weather event for the purposes of water quality sampling. In addition this is the trigger value that has been used in the Threatened Fish Management Plan. This section has not been updated.
6.	Table 4.1	The frequency of monitoring of some Type A and Type B parameters is different to the sampling frequency in the WQMP 1 & 2: • Total suspended solids (TSS), total phosphorous and total nitrogen are now classified as Type B parameters and would be sampled every second month. These are Type A parameters in the WQMP 1 & 2. • Phosphate, Ammonia, Nitrate and Nitrite will not be sampled. These are Type B parameters in the WQMP 1 & 2. Justification must be provided for the change in the sampling parameters. This Plan must be consistent with the WQMP 1 & 2.	RMS notes the changes in some Type A and B parameters. The Type A and B parameters in the WQMP 3-11 have been updated and are considered appropriate for the purposes of the monitoring plan. In addition the Type A parameters are defined as purely field gathered measurements with Type B also requiring lab testing. RMS believes that the sampling regime and parameters are appropriate. This view is also supported by Rous Water.
7.	Section 4.2.2.1	The operational sampling frequency in the first year of operation should be every month for Type A parameters and every second month for Type B parameters instead of quarters – to be consistent with the WQMP 1 & 2. No justification has been provided of the difference in monitoring frequency.	As detailed in comment 6, RMS believes that sampling regime in operation is appropriate for the water quality risks that are present in this phase of the project. This section has not been updated.
8.	Table 4.2	Same comments as Table 4.1 apply to the operational sampling parameters (see comment 6 above). The sampling parameters must be the same as the WQMP 1 & 2.	As detailed in comment 6, this section has not been updated.

Agency: NSW Department of Planning & Environment – 16/7/15			
Comment number	**Document section/Ref CoA**	**Comments**	**RMS Response**
9.	Section 4.2.2.2	The sampling frequency for operational years 2 and 3 must be the same as WQMP 1 & 2 (sections 4.2.2.2 and 4.2.2.3).	As detailed in comment 7, this section has not been updated.
10.	Section 4.3.2 and Table 4.3	The groundwater sampling frequency and parameters sampled must be consistent with those in the WQMP 1 & 2. No justification for the changes to the frequency and parameters monitored has been provided. Construction monitoring will be reviewed (and may be changed) by the ERG after 12 months of monitoring during construction. Condition D12(f) requires minimum of three years operational monitoring, which can be changed on the advice of an independent expert. This also applies to surface water monitoring.	Refer to responses above. As detailed in Section 8.5, RMS has adopted an adaptive management approach and as such the WQMP will be a working document. Improvements or refinements of the WQMP may be identified throughout the project based on review of results and data. RMS notes that the operational monitoring requirements for a minimum three years has been captured in the plan.
11.	Section 4.4	See comment 5 regarding definition of a wet weather event.	Refer to above responses.
12.	Section 5.3.5	The WQMP 1 & 2 requires the collection of two blind replicate water samples. This is changed to one sample – no justification has been provided. The Plan should be consistent with the WQMP 1 & 2.	The WQMP 3-11 proposes one blind replicate for every 10 samples / round which is the same as WQMP 1 & 2 (the latter equated this to 2 blind replicate samples / round for the 13 sample sites). This section has not been updated.
13.	Section 7.7.1	Second dot point – notification must be made to the EPA (within 48 hours of receiving the result) if downstream result is greater than the upstream result. To be consistent with the WQMP 1 & 2.	Notification to the EPA has been included however the 48 hours criteria has been removed based on consideration of a number of factors. RMS has reviewed the notification requirements that were included in the WQMP for Section 1&2 and consider that there are a number of other documents and management mechanisms that appropriately address the agency notification requirements. The process of water quality monitoring for the plan includes a number of steps: • Collection of sample • Issue to lab for analysis • Receive results • Undertake statistical analysis • Determine results • Identify any potential management measures or further investigations required. Given the number of steps involved in this process, it may take a

Agency: NSW Department of Planning & Environment – 16/7/15			
Comment number	**Document section/Ref CoA**	**Comments**	**RMS Response**
			few weeks between taking sample and determining results. There are also Construction monitoring mechanisms such as CEMP, Emergency Response Plans, EPL, POEO Act incident reporting requirements that are appropriate and relevant to promptly notify EPA should an issue be identified. RMS has committed in Section 7.5.1 to have ongoing discussion of results at regular Environmental Review Group meetings. These ERGs are considered the most appropriate forum to discuss any of the water quality monitoring results. Notwithstanding this, a mechanism for notify the EPA has been included outside of the ERG forum.
14.	Section 7.2	As with comment 13 above, notification must be made to EPA of downstream results higher than upstream results.	Refer to above comments and response to NSW Environment Protection Authority.
15.	Section 7.3	Point 3 and 4 must include notification to the EPA, similar to the requirement in the WQMP 1 & 2.	Refer to above comments and response to NSW Environment Protection Authority.
16.	Section 8	Ensure references are made to the approved Threatened Frog and Threatened Fish Management Plans.	Noted, these plans are included and referenced in Section 8.
17.	Section 8.1	Add notification to the EPA in the event impacts to surface water quality are found – to be consistent with the WQMP 1 & 2.	Refer to above comments and response to NSW Environment Protection Authority.
18.	Section 8.2	See comment 17 regarding notification to the EPA.	Refer to above comments and response to NSW Environment Protection Authority.

<table>
<tr><th colspan="3">Agency: NSW Department of Planning and Environment – email 20/7/15</th></tr>
<tr><th>Comment number</th><th>Comments</th><th>RMS Response</th></tr>
<tr><td>1.</td><td>There are differences in the frequency of surface water quality monitoring for the project. The table below summarises the approved and proposed monitoring programs:
<table>
<tr><td>Project phase</td><td>WQMP (sections 1 & 2) Approved 8/5/15</td><td>Draft WQMP (sections 3-11</td><td>Draft Threatened Fish Management Plan</td></tr>
<tr><td>Construction</td><td>2 wet events/month
1 dry event/month</td><td>1 wet event/month
1 dry event/month</td><td>Weekly</td></tr>
<tr><td>Operation Y1</td><td>1 wet event/month
1 dry event every 6 months</td><td>1 wet event/quarter
1 dry event every 6 months</td><td>Quarterly</td></tr>
<tr><td>Y2</td><td>1 wet event every second month
1 dry event every 6 months</td><td>1 wet and 1 dry event/every 6 months</td><td>Quarterly</td></tr>
<tr><td>Y3</td><td>1 wet and 1 dry event/every 6 months</td><td>1 wet and 1 dry event/every 6 months</td><td>Quarterly</td></tr>
</table>
The Department considers that the monitoring program for water quality in sections 3-11 must be the same as that approved for sections 1 and 2 (see email of 16 July 2015.</td><td>Refer to above comments.</td></tr>
<tr><td>2.</td><td>In relation to water quality monitoring of OPP waterways in the Threatened Fish Management Plan the Department supports weekly monitoring during construction. However, monitoring during operation (in the first and second years) should be the same as the monitoring for sections 1 and 2, monthly and bimonthly. The Department considers that quarterly monitoring for OPP waterways during operation is too infrequent. Quarterly monitoring in year 3 is appropriate for OPP waterways.</td><td>Refer to above comments.

RMS has separately updated the Threatened Fish Management Plan as required.</td></tr>
<tr><td>3.</td><td>The sections 3-11 water quality monitoring program and the threatened fish management plan should be revised accordingly.</td><td>Refer to above comments.</td></tr>
</table>

Agency: NSW Department of Primary Industries - Fisheries – 14/7/15		
Comment number	**Comments**	**RMS Response**
4.	NSW DPI is generally satisfied with the proposed Water Quality Management Plan for sections 3 to 11 of the Woolgoolga to Ballina Pacific Highway Upgrade with the exception of some critical OPP management areas.	Noted.
5.	NSW DPI would like to see the water quality monitoring extended to include all agreed upon OPP structures and particularly at chainages 134600, 141180, 141450 and 141890. Map 50 has not been updated to show these structures and no map has been provided for chainage 134600. It is important to detect and immediately remediate any construction impacts on water quality in OPP habitat. Including an upstream and downstream monitoring point at these chainages will assist this aim.	Noted – as detailed above, the relevant information is included in the Threatened Fish Management Plan. This plan does not duplicate the water quality monitoring inclusions in this Threatened Fish Plan.

Agency: NSW Department of Primary Industries - Water – 21/7/15		
Comment number	**Comments**	**RMS Response**
1.	Roads and Maritime Services (RMS) has suitably identified potential impacts to groundwater, proposed a suitable monitoring regime to monitor for potential impacts, and proposed mitigation measures should monitoring show a breach of identified impact thresholds.	Noted.
2.	Groundwater levels Groundwater level monitoring will be undertaken at 132 groundwater bores (as reported in Section 2.2 and 4.3.1 or 142 bores as reported in section 3.2.1), using automatic water level recorders. It is reported in Section 2.2 that the locations of "bores are associated with significant cuts and fill embankments", however there is no identification of the assessment for how a "significant cut and fill embankment" is classified, or for expected water levels relative to the cut.	Noted. Additional information has been included in Section 2 of the document to reflect the type of cuts and fills encountered on the project.
3.	Groundwater quality Groundwater quality sampling will be undertaken in 64 of the monitoring bores. Groundwater quality sampling will be undertaken using either passive (hydrosleeve), or purging methods, however there is no justification for when one method will be used in preference to the other.	Either method is appropriate – it's up to the Contractors preference. No changes to the document

Agency: NSW Department of Primary Industries - Water – 21/7/15		
Comment number	**Comments**	**RMS Response**
4.	RMS has suitably identified the potential impacts to groundwater and proposed an appropriate monitoring regime and mitigation measures should a breach of identified impact thresholds occur. The following is recommended: 1) Any groundwater works where water is extracted, or supplementary groundwater collected, for the purpose of water supply for the development are licensed. 2) The Water Quality Monitoring Plan be endorsed by the Department of Primary Industries - Water with the following alterations: i) The criteria for the use of the "Hydrasleeve" sampler in preference to purging should be outlined in Section 5.3.4.1. ii) The number of bores to be monitored for water levels should be consistent in Sections 2.2, 4.3.1, and 3.2.1. iii) Information for the determination of bore locations should be included (as a minimum in the appendices). This has been undertaken in previous RMS reports in the form of an assessment of cut depths relative to expected water table depth, resulting in Type A, B or C cuts being high, low to moderate, and low impact potential respectively.	Support for monitoring program noted. As detailed in EIS, RMS will apply for all relevant licences required for the project. See above response Inconsistent numbering of bores noted. This has been updated. Additional information has been included in Table 2.2 to identify the nature of cut and how this relates to the monitoring locations chosen.

Agency: NSW Environment Protection Authority – 5/8/15		
Comment number	**Comments**	**RMS Response**
1.	An important function of the WQMP is to highlight locations at which construction activity may be impacting upon waterways. An ERG for a traditional highway project that is up to 20km in length provides a good opportunity for discussion of results prior to a site inspection. As W2B sections 3 to 11 become busy the ERGs may not always provide an appropriate forum to adequately discuss these results. I'm not suggesting that the EPA needs an email each time a TSS result increases from 10 to 15mg/L but I do see a need for a mechanism to be in place (outside of the ERG forum) to notify the EPA of variations beyond 20% in some circumstances. For example I want to be notified of significant increases in NTU downstream of construction activity such as an increase from 50 to 200. I think that the field results for NTU provide an adequate indication of a potential construction impact. With this in mind I ask that that you consider putting a process in place that provides notification to the EPA when significant changes in water quality are detected as part the program.	A notification procedure has been incorporated in Sections 7.1, 7.2 and 7.3 of the WQMP – requiring EPA to be notified when water quality results or groundwater levels show a significant variation. Refer also to response to NSW Department of Planning & Environment Comment No. 13.

Agency: Rous Water – 22/7/15			
Comment number	**Document section/Ref CoA**	**Comments**	**RMS Response**
1.		Overall, I think the draft document provides a sound basis for monitoring impacts on surface water and groundwater resources associated with the construction and operation of the Pacific Highway upgrade, between Woolgoolga and Ballina. Rous Water notes the comments of the other agencies that have been provided. However, as you are aware, Rous Water's comments are focussed on issues associated with the Woodburn Sands aquifer system, which represents a significant water source for the regional water supply.	Noted.
2.	Section 8.1	Section 8.1 states: Construction activities will also be managed to meet water quality objectives in the Environmental Protection Licence (EPL) conditions. Whilst monitoring to demonstrate compliance with EPL conditions is outside of the scope of the monitoring that is the purpose of the draft WQMP, there may be an ability of the data collected in relation to EPL compliance to assist in interpretation of surface water/groundwater monitoring results, particularly in relation to the adaptive management framework described in Section 8.5. The draft WQMP should describe the ability for monitoring conducted for EPL compliance to contribute to the adaptive management of surface and groundwater resources, and potentially assisting in interpretation of results.	RMS notes that the EPL monitoring requirements will be focussed on compliance with EPL discharge criteria from sediment basins during construction. This monitoring is undertaken in water within sediment basins during construction rather than in surrounding creeks. As a result it is not considered that this data will assist interpretation of water quality impacts as part of the WQMP. Notwithstanding this, any discharge from basins and ongoing construction activities will be considered when reviewing data and results from the WQMP monitoring program.
3.	Section 8.2	Section 8.2 states: There will also be site specific measures such as in the drinking water catchment of the Rous Water Woodburn Sands borefield where: the design of the basins may be shallower than standard to avoid penetration of the natural clay layer; and certain construction activities may be restricted such as refueling, washdown, and storage of chemicals. The clay layer was identified in the groundwater working paper as an 'intermittently impermeable barrier' in the vicinity of the borefield, and this has been confirmed through subsequent research by Southern Cross University which has found that this clay layer does not prevent local recharge, with macropores and cracks acting as a conduit for local recharge. Therefore, whilst avoiding penetration of the clay layer may be an appropriate risk management measure, there should be no inference that this measure on its own would act as a protection mechanism for the aquifer from potentially contaminated stormwater runoff.	Noted. Additional text has been included in Section 8.2 to reflect these risks.

Agency: Rous Water – 22/7/15			
Comment number	**Document section/Ref CoA**	**Comments**	**RMS Response**
4.	Section 8.3	Section 8.3 states: Permanent water quality management and protection measures would be installed to protect adjacent waterways and sensitive receiving environments such as the Rous Borefield from pollutants generated by operation of the project. These would include: • Water quality ponds; • Grassed swales; Whilst there is no issue with this text per se, there should be a qualification/additional statement identifying that details of the treatment methods will be confirmed through the detailed design process, and shall address the requirements described below. Section 5.4 of the water quality working paper commits to same standard of treatment as that provided at T2E (extract provided with comment), and this should be referenced.	Noted. Additional text has been included in Section 8.3 to reflect these requirements.
5.	General	Section 2.8 of the surface water working paper identifies sensitive receiving environments. Section 2.8.7 of the working paper clearly identifies that the Woodburn Sands aquifer is a sensitive location: Project areas overlying the Woodburn Sand aquifer, between station 131.1 and 134.0 are deemed to be within sensitive receiving environments. In addition, the groundwater working paper identifies this location as a "Local Area Management Zone associated with the route." Therefore, Rous Water's main comment on the draft WQMP is that it has not really provided any specific consideration of the Woodburn Sands aquifer as a 'sensitive receiving environment' or 'Local Area Management Zone' associated with the route. Given that the working paper clearly identifies that the Woodburn Sands aquifer between station 131.1 and 134.0 is deemed to be a sensitive receiving environment, it would seem that there would be a specific section of the draft WQMP that focuses on this management unit.	Noted. Additional text has been included in Section 1.3, and 1.6 about the sensitivities and specific risks to the Rous Water borefield.
6.	General	Inclusive of the changes suggested in the comments of the other agencies referenced above, Rous Water considers that the draft WQMP provides an appropriate coverage of parameters, sites and sampling frequency.	Noted.

Agency: Rous Water – 22/7/15			
Comment number	**Document section/Ref CoA**	**Comments**	**RMS Response**
7.	General	However, whilst there appears to be adequate coverage of monitoring, Rous Water considers that consistent with the coverage provided in the working papers, there needs to be specific treatment afforded for the Woodburn Sands aquifer in the draft WQMP. In doing so, the draft WQMP should: • Provide a background to this water resource (sensitive receiving environment/Local Area Management Zone) • Revisit the risks to this zone • Characterise the prevailing water quality based on summary analysis and assessment of the sampling included in Appendix G – at the moment this is just listed and no interpretation or discussion of prevailing conditions provided • Highlight how the parameters being included relate to these risks • Confirm the sample program and how it will be reported for the Woodburn Sands aquifer It is understood that this cannot be done in detail given that the draft WQMP is for the overall project. However given that this content is available in the referenced documents, it would seem appropriate that – whilst forming part of the overall monitoring framework – that the specific risks, monitoring and reporting (and hence informing management) of sensitive receiving environments/Local Area Management Zones be provided for through this plan. This will then provide an excellent and informed basis for the management of the Woodburn Sands aquifer throughout the project, and a well defined focus for the overall engagement of Rous Water in the project – this management process could even be included as an appendix for easy reference. This type of treatment may also be appropriate for the other sensitive receiving environments identified.	Noted. Additional text included in Section 1.3 and 1.6 about Rous Water borefield. Information has been summarised from the details provided during the EIS phase of the project. The EIS and Working Paper is the appropriate documents to contain discussion potential impacts and assessment of those impacts, prior to the project receiving approval. Summaries of water quality results collected to date, and interpretation of the prevailing conditions has not been provided. RMS consider that this comparison against baseline will be undertaken progressively throughout the project in the annual reports which are provided to each regulatory agency. Rous Water support for parameters, sites and sampling regime is noted. RMS notes that additional sampling has been included for the high-risk areas on the project including Rous Water borefields. RMS consider that these parameters adequately inform the WQMP and information collected during the monitoring program will be reported in the annual reports and informal updates at the regular ERG meetings. There will not be a specific report on the Woodburn Sands aquifer however it will be included in dedicated section in the Annual Reports.