

4 October 2016,  
Brett McLennan  
McLennan & Associates

Greg Freeman  
EGIS Road Services

Dear Greg,

As requested by EGIS Consulting (EGIS), McLennan & Associates (M&A) undertook the September 2016 quarterly groundwater survey of existing monitoring bores along the Legacy Way Tunnel. Monitoring of groundwater levels is required as part of the Coordinator Generals conditions for both the design and construct, as well as the operational phase of the Legacy Way Tunnel.

Field work was undertaken on 22 September 2016. All monitoring locations were sampled. Four data loggers (NL2-02, BH320, NL2-14 and BH312) have corrupted data storage and will require replacement. It is likely that other units will start to fail over the coming year.

BH205 at the ICB continues to have water level less than 10cm and unable to be used for data logging. Current measurements indicate a level of 3cm in the well. It is recommended that this well is re-developed to clear sediment from the well and filter pack to ascertain if water levels have decreased in this location.

NL2-12 has been repaired by Egis in May 2016 and will require redevelopment to remove sediment from the bore.

BH NL5-4 in Sleath Street Toowong is collapsing due to installation on a 50-degree angle with vehicle and soil weight onto the PVC casing causing joints to slip. As degradation of the joints has been noted previously, this well should be decommissioned in accordance with the Minimum Requirement for Water Bores in Australia V3 (2012). Monitoring of groundwater in the surrounding area to NL5-4 is adequately covered with the groundwater bores located in Birdwood Terrace, Thorpe Street and within Toowong Cemetery.

## Groundwater September 2016

Monthly groundwater monitoring has been conducted in compliance with the Hydrogeology and Groundwater Environmental Management Plan (EMP EN-OP-PP0018). Monitoring locations were previously selected due to their location, geology and accessibility along the Legacy Way Tunnel corridor. The monthly groundwater works included measuring standing water levels along the tunnel alignment and downloading data from *in situ* water level loggers. For the purpose of this study the monitoring wells are targeting bedrock (confined) and alluvial (unconfined) aquifers.

## Groundwater Monitoring Locations

The monitoring locations assessed during this month's works are outlined in Table 1.

TABLE 1- GROUNDWATER LOCATIONS

Locality	ID	Reference	Geology	Monitoring
West	NL2-02	Toowong	Bedrock	Groundwater level
	NL3-05S	Toowong	Alluvium	Groundwater level
	NL3-16	Toowong	Alluvium	Groundwater level
Alignment	BH108	Toowong	Bedrock	Groundwater level
	BH320	Toowong	Bedrock	Groundwater level
	NL5-4	Toowong	Bedrock	Groundwater level
	NL2-12	Toowong	Bedrock	Groundwater level
	NL2-14	Auchenflower	Open Bore – Bedrock and Alluvium	Groundwater level
	BH309	Rosalie	Bedrock	Groundwater level
	BH311	Rosalie	Bedrock	Groundwater level
	BH312	Rosalie	Bedrock	Groundwater level
	BH313	Rosalie	Bedrock	Groundwater level
	BH313 A	Rosalie	Alluvium	Groundwater level
	NL4-HG10	Rosalie	Alluvium	Groundwater level
	NL4-HG6A	Paddington	Alluvium	Groundwater level
	NL4-5	Paddington	Bedrock	Groundwater level
	NL4-A2	Rosalie	Bedrock	Groundwater level
	NL2-06	Red Hill	Bedrock	Groundwater level
	NL2-09	Red Hill	Bedrock	Groundwater level
East	BH205	Inner City Bypass	Bedrock	Groundwater level
	BH221	Kelvin Grove	Bedrock	Groundwater level
	BH222	Inner City Bypass	Bedrock	Groundwater level

The groundwater locations in Table 2 had previously been decommissioned during the design and construct phase of the project. It is understood that most have been destroyed since the commencement of the project. The quantity of the remaining monitoring locations is deemed sufficient for the purposes of the groundwater monitoring and no additional replacement wells are planned. Monitoring had previously ceased in the Botanic Gardens following handback of the tunnel conveyor to BCC.

TABLE 2 - DECOMMISSIONED GROUNDWATER LOCATIONS

Locality	ID	Reference	Geology	Monitoring
West	BH503	Botanic Gardens	Bedrock	Conveyor Tunnel no longer in use - no further monitoring to be conducted
	BH502	Botanic Gardens	Bedrock	Conveyor Tunnel no longer in use – no further monitoring to be conducted
	BH104D	Botanic Gardens	Bedrock	Destroyed
	BHSC1A	Botanic Gardens	Alluvium	Destroyed
	BHSC1B	Botanic Gardens	Bedrock	Destroyed
Alignment	BH314	Toowong	Bedrock	Not located – Note NL2-14 located nearby this location
	BH310	Rosalie	Alluvium	Replaced by BH313A
	BH307	Red Hill	Bedrock	Decommissioned, due to proximity to the alignment
East	NL4-HG4	Brisbane Grammar	Bedrock	Destroyed
	NL4-HG5	Brisbane Grammar	Bedrock	Destroyed
	BH203	Brisbane Grammar	Bedrock	Destroyed
	BH220	Kelvin Grove	Bedrock	Decommissioned due to damaged casing

## Groundwater Monitoring Results

### Groundwater Level Monitoring

Groundwater levels below ground surface were collected along the tunnel corridor at 22 locations. All locations monitored were equipped with Solinst Leveltrolls (automated water data) loggers, which were calibrated via the static water groundwater level measurements and corrected for barometric pressure. Static groundwater level measurements are detailed in Table 3.

TABLE 3 – GROUNDWATER ELEVATION

Locality	West	Alignment												East	West	Alignment							
Geology	Bedrock	Bedrock												Bedrock	Alluvium	Alluvium							
Location	NL2-02	BH108	BH320	NL5-4	NL2-12	NL2-14	BH309	BH311	BH312	BH313	NL4-5	NL4-A2	NL2-06	NL2-09	BH205	BH221	BH222	NL3-16	NL3-05S	BH313A	NL4-HG10	NL4-HG6A	
Units	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD
Ground Elevation mAHD	25.78	23.65	47	20.2	26.07	47.7	4.1	4	4.1	3.8	5.6	2.2	63.9	41.4	23.8	29.3	23.9	18.9	25.01	3.8	2.2	5.58	
Water Elevation mAHD Sep. 2016	16.63	18.91	18.76	12.33	17.16	4.03	-1.1	-0.98	0.17	0.24	4.45	0.58	36.335	29.09	18.745	18.045	18.375	15.35	15.09	-1.495	0.29	2.26	

### Groundwater Level Results

Figure 1 and Figure 2 demonstrate water level variations in the bedrock and alluvium respectively.

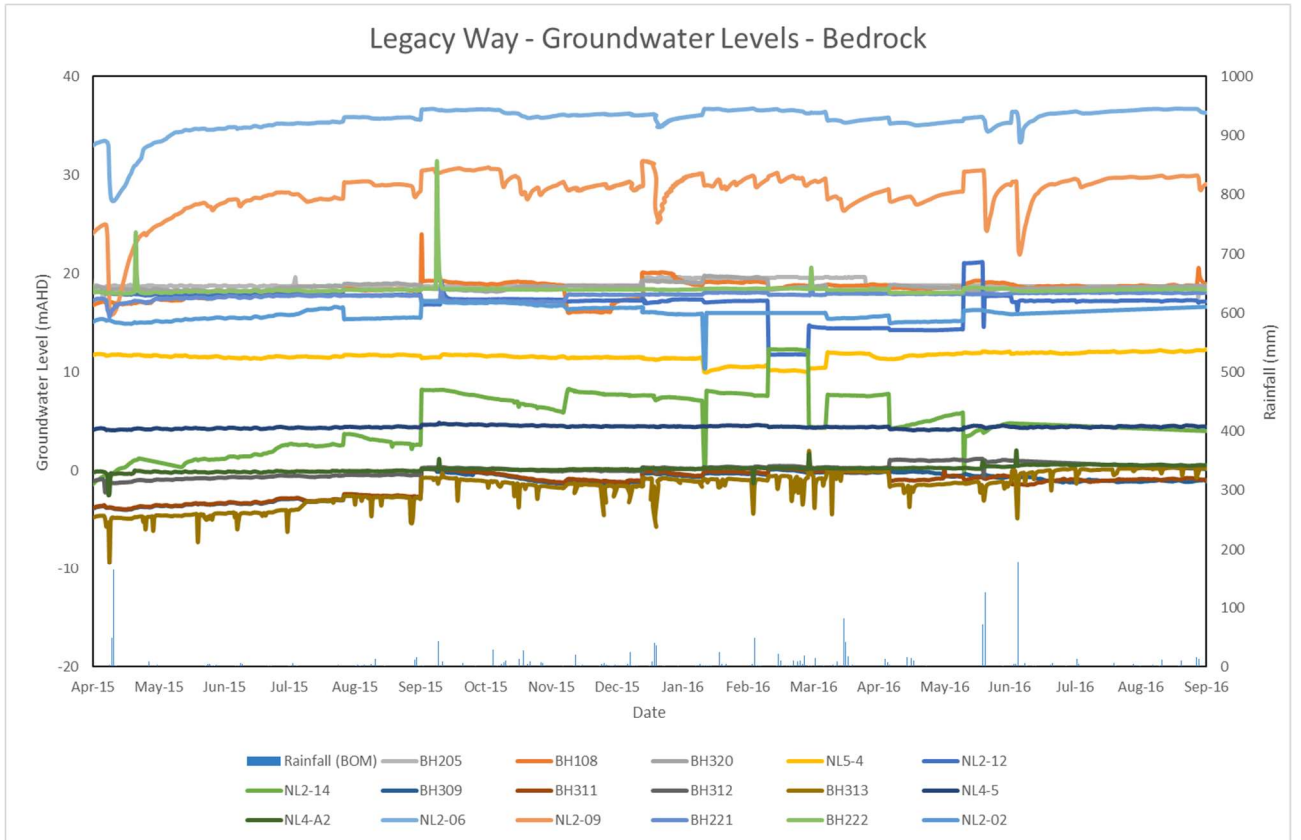


FIGURE 1 - GROUNDWATER LEVELS – BEDROCK

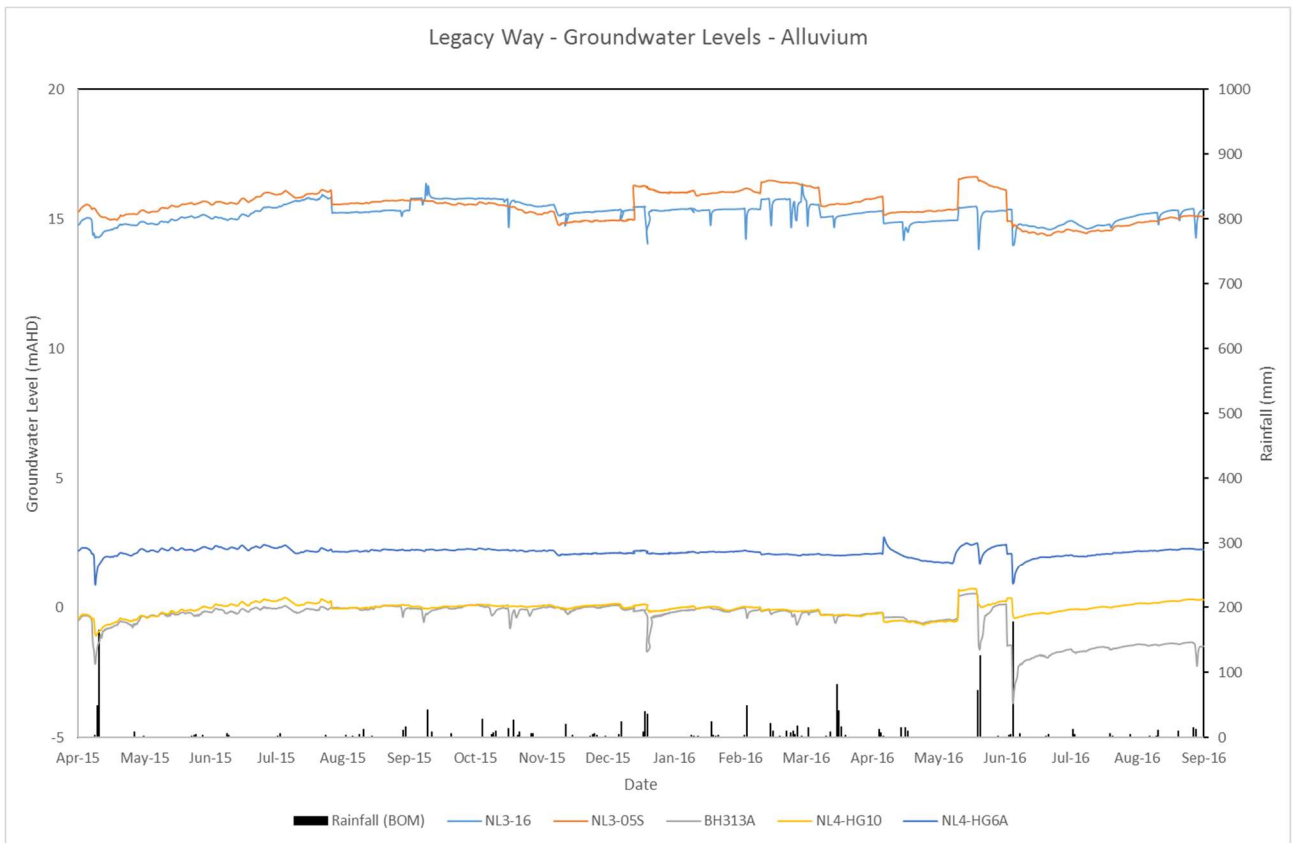


FIGURE 2 - GROUNDWATER LEVELS - ALLUVIUM

The standing water levels continue to follow previous trends displayed during the construction phase i.e. relationship of groundwater fluctuations to rainfall levels, with the following of note:

A large rainfall event of 178mm occurred on 20 June 2016 and dewatering events were noted across the alignment.

Groundwater in the Toowong Cemetery and surrounds, the groundwater level in boreholes BH108, BH320, NL5-4, NL2-14 had historically been reported as exceeding the 200% of the natural variation and was associated with the tunnelling activities in close proximity to the boreholes. BH108 continued to increase since the May 2016 monitoring period and correlates with rainfall events. BH320 dip data indicated a slight increase since the June 2016 monitoring period, and has historically indicated slow recharge following the rainfall events. NL5-4 continues to increase slowly since the January 2016 monitoring round; however, remains within the maximum observed level over the previous 15 months. Groundwater levels in BH 2-14 dip data indicates a decreased in water level. This well has historically displayed a high variation of up to 3.5m since the March 2016 monitoring period. It is expected that this location will continue to recharge until a stable level is achieved.

Along the tunnel alignment in Rosalie and surrounding areas, the groundwater level in boreholes BH309, BH311, BH312, BH313 had previously been reported as historically exceeding the 200% of the natural variation and was associated with tunnelling activities in close proximity to the boreholes. These boreholes are assessing water levels in the bedrock, and drawdown from tunnelling operations was predicted in this area. BH313 indicated an increase of 1.39m since June 2016, with levels in nearby locations decreasing over this period. It is possible that the well might have been compromised due to increased rainfall events with roadway water likely to move towards this well. BH309 and BH311 decreased slightly since the June 2016 monitoring event. BH312 dip data indicated a decrease of 0.86m since the June monitoring period but remains within the established variation.

At the alignment borehole locations monitoring the alluvium adjacent to the tunnel alignment - NL4-HG10 and NL4-HG6A displayed a dewatering event around 20 June 2016 (3 days after the previous round) and increasing to the June 2016 level over the previous three months. NL4-5 NL4-A2 were static.

Groundwater monitoring of the Eastern Portal area continued, with slow recovery noted in the bores. BH205 has continued to have less than 10 cm of water and is considered "dry" for automatic logging. This could be due to the dewatering of the Eastern Portal. BH221 and BH222 appear to have stabilised since the March 2016 monitoring period with no fluctuation noted due to recent rainfall events. Bedrock groundwater in this area appears to have stabilised. NL2-06 in upper Clifton Terrace increased; however, the bore was noted as inundated with water during sampling and surface ingress is noted with spikes correlating with rainfall events. NL2-09 indicated two dewatering events in June 2016 that is likely due to localised residential construction works. This bore has since recovered.

At the Western portal, NL2-02 indicated continued to display increased levels after the recent rainfall events. Levels in this site appear to be impacted by localized rainfall events and has been noted to be potentially influenced from external activities (i.e. Mt Coot-Tha Quarry and the botanic garden ponds). Groundwater in the alluvial bore NL3-16 and NL3-05 indicated that dewatering occurred during rainfall event in June 2016 and have recovered since this event. These wells continue to indicate a relationship with localised dewatering and rainfall events.

It should be noted that at this stage Egis does not propose any mitigation strategies in regards to fluctuations in groundwater levels. However, ongoing monitoring will be undertaken to assess any impacts and stabilisation of water levels.



Brett McLennan

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