Memorandum

To	Amber Tsang & Tim Hegarty (Jacobs) Victor Romero (McMillan-Jacobs)	**Date**	17 April 2019
From	Jon Williamson & Jake Scherberg (Williamson Water & Land Advisory)	**Project No**	WWA0047
Subject	**Grey Lynn Interceptor Resource Consent Application: RMA Section 92 Responses Pertaining to Groundwater Assessments**		

1. Introduction

This document is a response to the S92 Request items primarily pertaining to the groundwater modelling assessment, specifically RC 35 through RC 40 dated 21 March, 2019.

2. Responses

RC35: *The application for consents describes the construction of the tunnel and the Main and Secondary shafts, together with ancillary structures at the Tawariki Street site including two control chambers and a grit trap. The features at the Tawariki Street are to be installed at substantial depth below both the ground surface and below the ambient groundwater level. The groundwater drawdown effects related to the two shafts have been assessed through Ref. 1 and Ref. 4.*

However, there does not appear to be an assessment of the groundwater drawdown and mechanical settlement effects arising from the ancillary structures in the documents reviewed. The ground settlements arising from the ancillary structures are not presented in Appendix A of the settlement assessment report (Ref. 1).

The Tawariki Street shaft site layout plan (Ref. 8) indicate the proposed control chambers and grit trap will be between 5 m and 13 m depth. The proposed 5 m deep control chamber in the north-western portion of the site is in relatively close proximity to the existing building at 42 Tawariki Street.

Please provide an assessment of the ground settlement effects (due to groundwater drawdown and retaining wall deflections) arising from construction of the ancillary structures planned for the Tawariki Street site.

Response (RC35): see response below for RC36.

RC36: *Please provide an assessment of the ground settlement effects (due to groundwater drawdown and retaining wall deflections) arising from construction of the ancillary structures planned for the Tawariki Street site.*

Response (RC35 & RC36): The comment refers to drawdown and settlement resulting from ancillary structures, specifically two control chambers and a grit trap, that are not directly included in the groundwater model.

The ancillary structures referred to in RC35 and RC36 will be sealed waterproofed structures by necessity. As such, once completed, they will not impact groundwater beyond the area occupied by the structures themselves and will not increase the cumulative effects predicted from the main shaft on a long-term basis.

Some drainage can be expected over the construction period, expected to be 6 to 9 months, where the excavations will be supported by temporary sheetpiles through near surface soils and shotcrete/nails in the underlying ECBF.

The ancillary structures will be installed at 5 to 13 m BGL, corresponding to model Layer 1. **Table 1** (based on Table 13 in the Groundwater Effects Assessment) shows that 0.1 and 0.2 m is the maximum drawdown outside of the shaft expected in Scenario and Scenario 6, respectively.

During construction of the ancillary structures, some leakage into the excavation will occur, hence the Layer 1 drawdown contours predicted as currently shown can be expected to shift such that they encompass the ancillary structures excavation area. Given that maximum drawdown will occur immediately adjacent to the shaft and decline rapidly with distance, the difference in the maximum extent of drawdown with the ancillary structures will be negligible compared to that currently shown.

Deeper model layers will not be impacted by the ancillary structures therefore drawdown predicted for model Layers 2 through 4 will be the same as what is provided in the Groundwater Effects Assessment report.

Table 1. Lateral extent and maximum predicted drawdown in model Layer 1 for Scenario 4 and Scenario 6.

Model Layer	Extent of Drawdown (m)		Maximum drawdown outside of shaft (m)	
	Scenario 4	Scenario 6	Scenario 4	Scenario 6
1	300	300	0.1	0.2

RC37: Groundwater inflows to the proposed tunnel are planned to be controlled through lining the tunnel and using an Earth Pressure Balance ("EPB") tunnel boring machine. "The EPB TBM must be able to apply a positive pressure to the tunnel face, balancing the earth and groundwater pressures at all times to effectively control the ground and prevent groundwater inflows into the tunnel" (Ref. 1). On this basis, groundwater inflows and therefore "the potential groundwater impacts of the Grey Lynn Tunnel construction are considered to be negligible." (Ref. 4) The flows into the tunnel have been described as:

a. *"Groundwater inflows through the tunnel lining during construction are expected to be limited to less than 0.5 litres per square metre of tunnel lining per day, which is 13 m^3 per day for the 1.6 km length of the tunnel." (Ref. 5)*
b. *"Approximately 0.006 L/s per meter of tunnel (Ref 4). This equates to approximately 52 m^3/day per 100 m length of tunnel"*

Please clarify what the groundwater inflows to the tunnel at the operational face and along the lined length are expected to be.

Response: We did not address drainage into the tunnel because previous tunnel construction experience using earth pressure balance machines in Auckland within the ECBF (e.g. Waterview

Tunnel, Hobson Bay Tunnel) resulted in no groundwater inflow. Furthermore, the assessment of effects for the Central Interceptor Tunnel concluded the same, hence it was not considered further here.

However, the inference from Ref. 4 and Ref. 5 above is that the majority of the seepage would occur at or near the tunnel face. The 52 m^3/day quotes in Ref. 4 refers to the temporary state associated with the moving cutting head and TBM itself. Once the concrete lining is locked in place and the TBM progresses down the tunnel, any leakage will be manually grouted (sealed) to reduce the seepage to the longer term rate of no more than 13 m^3/day.

RC38: *A sub-regional scale model has been developed and used appropriately and acceptably to assess the effects of the proposed Tawariki Street shafts on the surrounding environment. Potential effects on stream baseflows, wetlands, lakes, existing groundwater takes and saline water intrusion assessed in this report. Groundwater drawdown derived from the model documented in Ref. 4 has been used to support the assessment of ground settlement around the Tawariki Street site documented in Ref. 1.*

Please provide cross sections aligned parallel and perpendicular to Tawariki Street showing the geological materials modelled, the static groundwater table and the and the drawn down groundwater table for the construction scenarios considered in the settlement report. The cross sections should focus on the areas within 200 m of the Tawariki Street site.

Response: Cross sections through the groundwater model showing the model layer structure, geological materials and groundwater pressure equipotential have been prepared. The location of the cross sections are shown in **Figure 1.**

Figure 2 and **Figure 3** show the expected depressurisation following shaft construction for the east-west transect (A-A') from Scenario 4 (lined shaft) and Scenario 6 (lined shaft to 7 mBGL), respectively[1]. **Figure 4** and **Figure 5** show expected depressurisation following shaft construction for the north-south transect in Scenario 4 and Scenario 6, respectively. Both figures show the long-term condition once the shaft has been completed and groundwater conditions have stabilised.

The figures show that depressurisation will primarily occur at depth, near the base of the shaft while minimal impact will be realised near the ground surface where softer sediments reside.

[1] Scenario 4 was considered to be the most representative of long-term conditions while Scenario 6 was considered to represent a potential worst case temporary condition during the construction period prior to the installation of the full shaft lining.

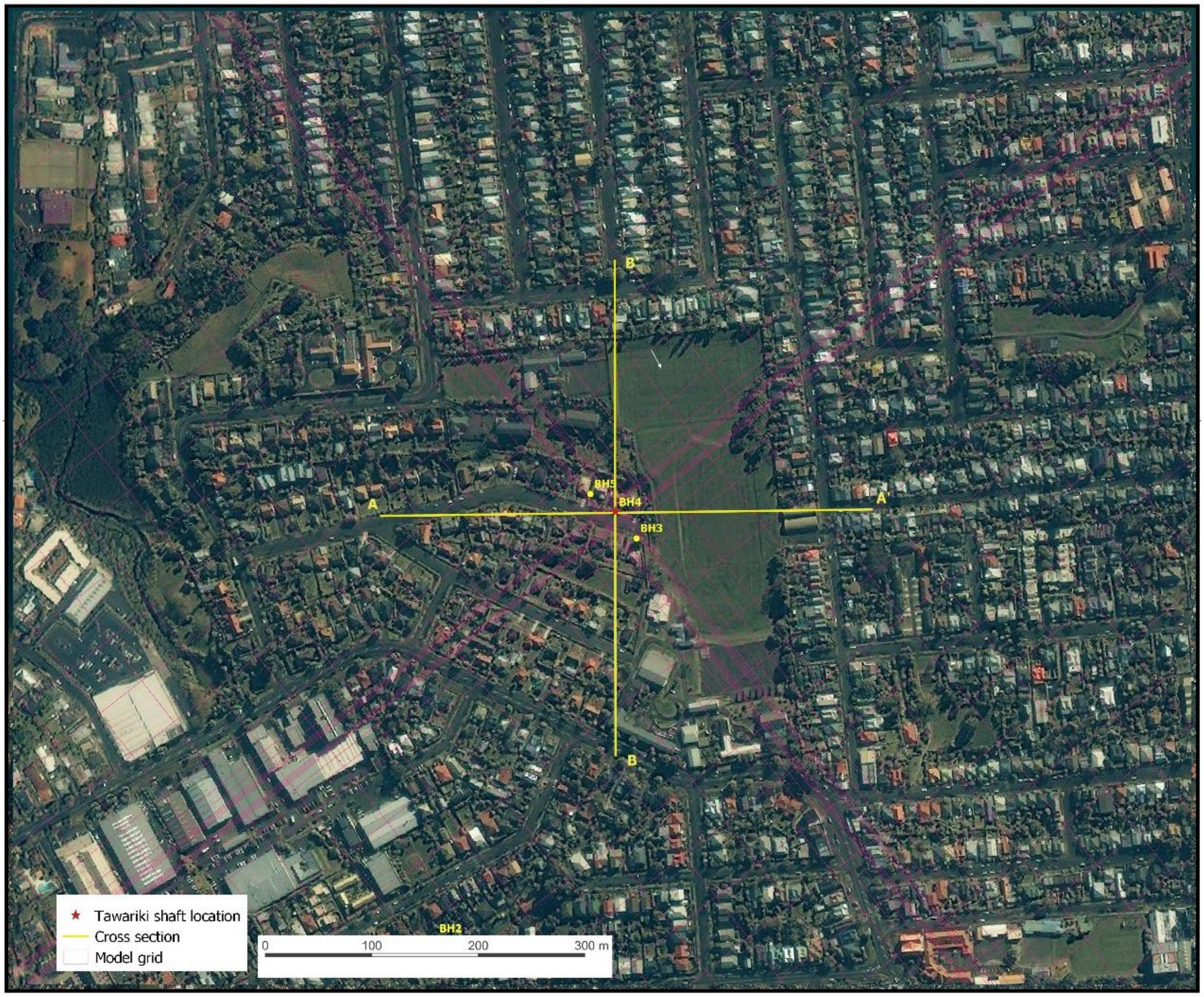


Figure 1. Location of east-west and south-north cross sections referred to in Figure 2 through 5.

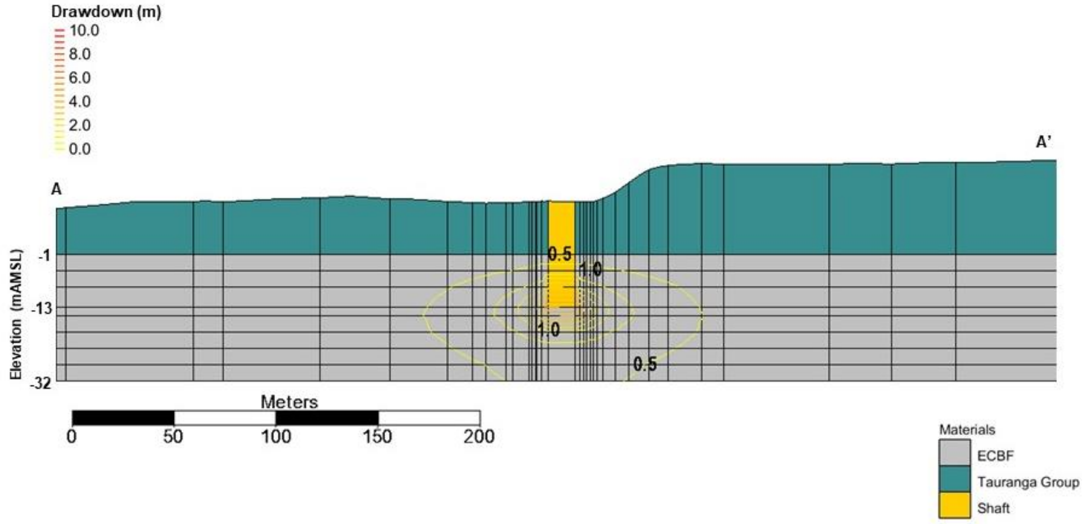


Figure 2. East-west cross-section of predicted drawdown under Scenario 4 conditions.

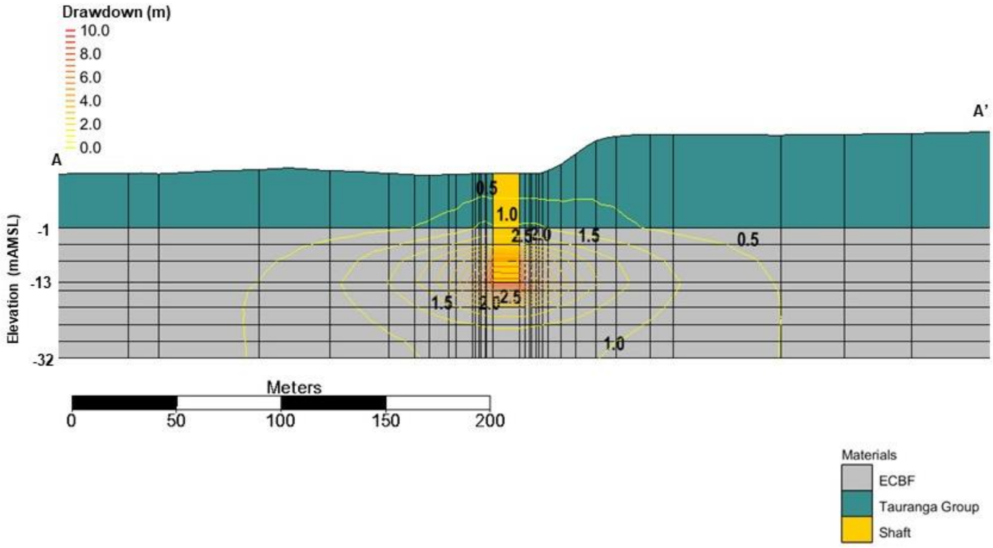


Figure 3. East-west cross-section of predicted drawdown under Scenario 6 conditions.

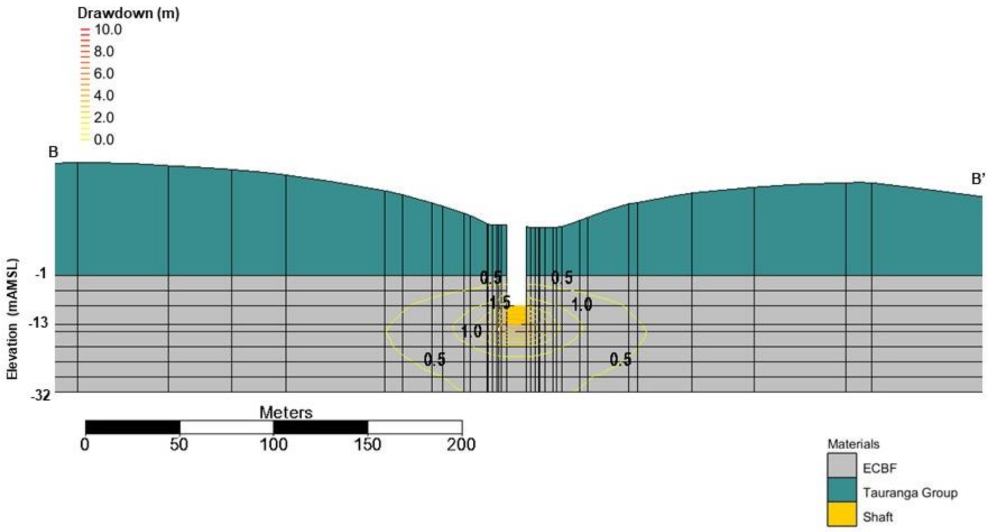


Figure 4. South-north cross-section of predicted drawdown under Scenario 4 conditions.

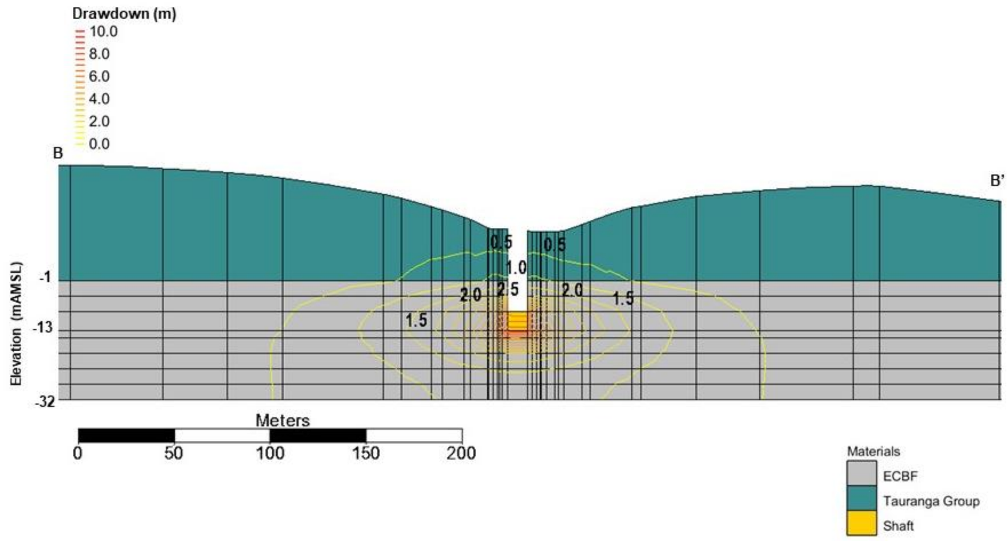


Figure 5. South-north cross-section of predicted drawdown under Scenario 6 conditions.

RC39: *Taking into consideration the model structure and cell definition, please provide an assessment of the uncertainty regarding the extent and magnitude of groundwater drawdown within the residual soils and highly weathered ECBF in the area within 200 m of the Tawariki Street site. Please take specific account of the groundwater drawdown potentially affecting sites adjacent to the Tawariki Street site.*

Response: Model cell size surrounding the shaft comprises an array of five 1.5 m wide cells, which increase in width away from the array using a 1.5 multiplier, hence the area of maximum groundwater impact is simulated at an appropriate level of accurately through this high cell resolution.

Maximum drawdown occurs in model Layer 4 where the base of the shaft is located, and as shown in the cross sections (**Figure 2** to **Figure 5**) the extent of significant drawdown in Layer 4 is limited to less than 25 m of the shaft.

Uncertainty has been addressed through the development of a range of model scenarios. The shaft liner, which is the key limiting factor for drawdown, was simulated with permeabilities ranging from 10^{-8} m/s to 10^{-10} m/s (a permeability characteristic of concrete) and the model was also tested with no impermeable lining on the shaft wall.

The maximum drawdown in Layer 4 was 9.7 m, which was predicted in the scenarios with no shaft liner and where the shaft liner only extended 7 m BGL, such that there was effectively no liner once shaft construction reached that depth. This is a conservative estimate given that the shaft wall is going to be lined.

The least permeable barrier produced a predicted drawdown of 1.4 m.

The permeability of the ECBF material was not varied in the simulations because hydraulic testing results were consistent within a narrow range of low permeability. It was also considered that drawdown will be controlled by the shaft liner so uncertainty in the permeability of the ECBF will not impact the level of predicted drawdown.

RC40: *Please provide a localised east-west cross section from the groundwater model through the simulated shaft showing the model grid, materials simulated and the boundary conditions applied to the shaft under Scenario 6.*

Response: The requested east-west cross-section of the groundwater model showing 200 m in each direction form the shaft and including the model grid, materials, and boundary conditions is provided below in **Figure 6**. The cross-section location is the same as transect A-A’ in **Figure 1**.

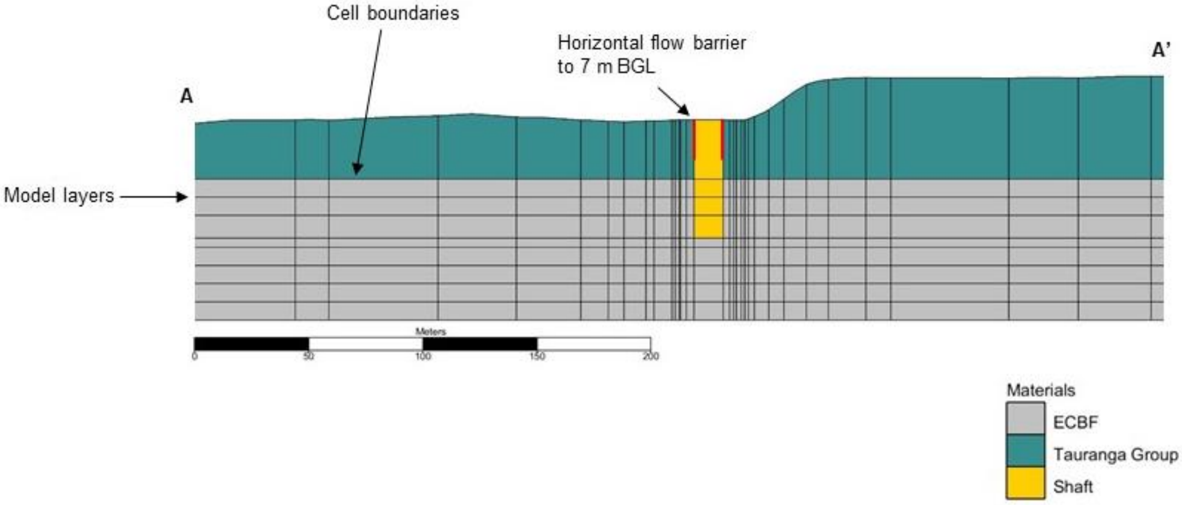
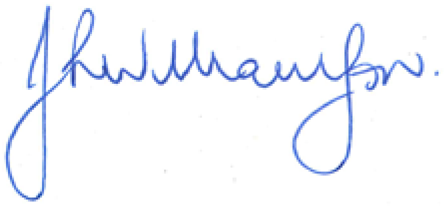


Figure 6. Model grid cross section showing shaft and boundary conditions

Yours sincerely,



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