Expert Evidence (Groundwater)

North East Link Project Environment Effects Statement (EES)

Prepared for:

Manningham City Council
Banyule City Council
Boroondara City Council
Whitehorse City Council

Prepared by:

Christopher Smitt

July 2019

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Expert Evidence Information

This report has been prepared in accordance with the Planning Panels Victoria (PPV) "Guide to Planning Expert Evidence". The content requested is outlined below:

(a) Name and address

Christopher Smitt
c/o EHS Support Pty Ltd
17/31 Queen Street,
Melbourne VIC 3000

(b) Expert's qualifications, experience and area of expertise

Qualifications

BSc (Honours) Majoring in Hydrogeology and Geophysics

Certificate in Advanced GIS Analysis and Modelling (Hydrology and Groundwater Modelling with GIS)

Experience

I have 19 years of experience as a Hydrogeologist. My CV (**Appendix A**) details my experience.

Area of expertise

Hydrogeology (**refer to 1(c)**)

(c) Expertise to make this report

My areas of expertise relevant to my instructions include:

- Hydrogeology;
- Catchment health and water quality;
- Numerical modelling to determine the impacts of groundwater extraction for both the Natural Resource Management and heavy industry sector (including water resource assessment and well field design); and
- Investigating the role of climate change/variability on Australia's groundwater resources.

In addition to having expertise in the above areas, I have had considerable experience in developing hydrogeological conceptual and numerical models, as well as developing environmental performance requirements (EPRs) for a range of projects. Most recently was the review of the Mordialloc Bypass (Freeway) – Environmental Effects Statement (EES). Other relevant projects include the M80 Freeway Upgrade and developing closure criteria and performance metrics for the closure and rehabilitation of the Anglesea Coal Mine.

I have also undertaken and reviewed many risk assessments as part of (and member of), the ISA Superbasin and Cooper Basin Geological and Bioregional Assessment (GBA) Technical Working Groups (TWGs). The working group assists the Federal members of the Australian Government GBA

Program (primarily the Department of the Environment and Energy (DoEE); Geoscience Australia (GA) and CSIRO) to assess the potential impacts of selected unconventional hydrocarbon plays on water and the environment and provide independent scientific advice to governments, landowners and the community, business and investors.

(d) Reference to any private or business relationship between the expert witness and the party for whom the report is prepared

Nil, other than the current engagement.

(e) All instructions that define the scope of the report (original and supplementary and whether in writing or oral)

All instructions that define the scope of the report are written. These are presented in **Section 2** and attached in **Appendix B**.

(f) The facts, matters and all assumptions upon which the report proceeds

Provided in **Section 2** to **Section 4** of this report.

In addition, on 4 July 2019, at the North East Link Project (NELP) office, I met with Tim Anderson, Rikito Gresswell and Hugh Middlemis (whom attended via phone hook-up) to discuss aspects of a data request memorandum (refer **Appendix C**). The outcome of this meeting has not changed my position as numerous reports and data requested were unavailable. Most of this data will be provided at a later date in the form of a "factual report".

(g) Reference to those documents and other materials the expert has been instructed to consider or take into account in preparing his or her report and the literature or other material used in making the report

Referenced within **Section 3 of this report.**

(h) The identity and qualifications of the person who carried out any tests or experiments upon which the expert relied in making the report.

I have relied on the published materials presented in **Section 3 of this report**.

(i) Statement of the expert

Provided in **Section 4** of this report.

(j) A signed declaration by the expert

See **Section 5** of this report.

2 Instructions

I have been instructed by Harwood Andrews (acting for Manningham City Council) and Maddocks (acting for Banyule City Council, Boroondara City Council and Whitehorse City Council) collectively, "the Councils" to undertake the following:

(a) Review the exhibited documents relevant to your area of expertise and each of the Councils' municipal areas, in particular:

  a) The EES:

    i) Volume 1 (Chapters 1 to 8);

    ii) Volume 4 (Chapters 21 'Ground movement', 22 'Groundwater', 23 'Contamination and soil', 24 'Surface water', 25 'Ecology', 27 'Environmental management framework');

  b) Technical Report N: Groundwater;

  c) EES Map Book;

  d) Attachment III: Risk Report;

  e) Attachment V: Draft Planning Scheme Amendment.

(b) Review:

  a) The Ministerial Guidelines for assessment of environmental effects under the Environmental Effects Act 1978 (2006);

  b) Manningham City Council's public submission on the EES dated 5 June 2019;

  c) Banyule City Council, Boroondara City Council and Whitehorse City Council's joint public submission on the EES dated 7 June 2019;

  d) IAC tabled document no. 5 titled Preliminary Matters and Further Information Request, dated 20 June 2019;

  e) IAC tabled document no. 14 being the Maddocks further information request on behalf of Banyule, Boroondara and Whitehorse City Councils;

  f) Clayton Utz initial response to Maddocks further information request dated 26 June 2019;

  g) Harwood Andrews further information request to Clayton Utz on behalf of Manningham City Council dated 26 June 2019;

  h) the draft Yarra River Bulleen Precinct Land Use Framework Plan 2019 and Manningham City Council's public submission on this dated 6 June 2019;

(c) Prepare a single expert witness report on behalf of the Councils for circulation that contains your opinion on the following matters, as relevant to groundwater:

  1. Does the EES adequately document and assess the nature and extent of the environmental effects of the Project;

  2. Can the Project as described in the EES achieve a level of environmental performance which is consistent with relevant legislation, documented and endorsed policy or acknowledged best practice;

3. If the Project, as described in the EES cannot achieve a level of environmental performance which is consistent with relevant legislation, documented and endorsed policy or acknowledged best practice, are there any recommendations that you would make as to specific measures which you consider necessary and/or appropriate to prevent, mitigate and/or offset adverse environmental effects;
4. How does the Project as described in the EES respond to the principles and objectives of "ecologically sustainable development" as defined in the IAC's Terms of Reference;
5. Are there any recommendations that you would make as to specific measures which you consider necessary and/or appropriate to improve the response of the Project to the principles and objectives of "ecologically sustainable development"; and
6. To the extent that the content of the draft planning scheme amendment, works approval and environmental protection requirements lies within your expertise, do you have any recommendations for changes that should be made to the draft planning scheme amendment, works approval or planning approval and/or draft environmental performance requirements in order to improve the environmental outcome of the Project.

(d) In due course, review and comment on other parties' expert evidence (groundwater);

(e) Attend any conclave of groundwater experts requested by the IAC;

(f) Present your expert evidence at the hearing.

Refer to **Appendix B** for a full copy of my instructions.

3 Documents Reviewed

In constructing this advice, I have reviewed the project specific documents listed below:

1. North East Link Project Environment Effects Statement chapters:
    a. Chapter 1 Introduction
    b. Chapter 2 Project-Rationale
    c. Chapter 3 Legislative Framework
    d. Chapter 4 EES Assessment Framework
    e. Chapter 5 Communications and Engagement
    f. Chapter 6 Project-Development
    g. Chapter 7 Urban Design
    h. Chapter 8 Project Description
    i. Chapter 21 Ground movement
    j. Chapter 22 Groundwater
    k. Chapter 23 Contamination and Soil
    l. Chapter 24 Surface water
    m. Chapter 25 Ecology
    n. Chapter 27 Environmental Management Framework
2. EES Chapters, Technical Appendices and Attachments:
    a. Technical Report N: Groundwater;
    b. EES Map Book;
    c. Attachment III: Risk Report; and
    d. Attachment V: Draft Planning Scheme Amendment.

I have also been supplied with or had access to the below documents, where additional background information was sought:

1. EES Public Submissions:
    a. Manningham City Council's public submission 316 dated 5 June 2019;
    b. Manningham City Council's public submission S13 dated 7 June 2019; and
    c. Banyule City Council, Boroondara City Council and Whitehorse City Council's joint public submission 716 dated 7 June 2019.
2. Other Documents:
    a. Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978 (Seventh edition, 2006)
    b. IAC tabled document no. 5 titled Preliminary Matters and Further Information Request, dated 20 June 2019
    c. IAC tabled document no. 14 being the Maddocks further information request on behalf of Banyule, Boroondara and Whitehorse City Councils
    d. Clayton Utz initial response to Maddocks further information request, dated 26 June 2019
    e. Harwood Andrews further information request to Clayton Utz on behalf of Manningham City Council, dated 26 June 2019
    f. Draft Yarra River Bulleen Precinct Land Use Framework Plan 2019 and Manningham City Council's public submission on this, dated 7 June 2019
    g. Ministerial Guidelines for assessment of environmental effects under the Environmental Effects Act 1978 (2006)
    h. (DELWP 2015). Ministerial Guidelines for Groundwater Licensing and the Protection of High Value GDEs

i. Barnett et al., 2012 (Australian Groundwater Modelling Guidelines)
j. Yarra River Protection (Wilip-gin Birrarung murron) Act 2017
k. National Environment Protection Council (Victoria) Act 1995
l. National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999)
m. U.S. Environmental Protection Agency, 2000a. Guidance for the Data Quality Objectives Process (EPA QA/G4)
n. U.S. Environmental Protection Agency, 2000b. Policy and Program Requirements for the Mandatory Agency-Wide Quality System, EPA Order 5360.1 A2
o. U.S. Environmental Protection Agency, 2006a. Data Quality Assessment: A Reviewer's Guide (EPA QA/G-9R)
p. Rural Water Corporation (1993). Groundwater Management Strategy.

4 Findings

As per my instructions, I have presented my findings in accordance to the questions outlined in **Section 2(c)**.

4.1 Does the EES adequately document and assess the nature and extent of the environmental effects of the Project?

4.1.1 Introduction

The Environment Effects Act 1978 provides for assessment of proposed projects (works) that are capable of having a significant effect on the environment. The Act does this by enabling the Minister administering the Environment Effects Act to decide that an Environment Effects Statement (EES) should be prepared.

On 2 February 2018, the Minister for Planning declared North East Link to be 'public works' under Section 3(1) of the Environment Effects Act, which was published in the *Victorian Government Gazette* on 6 February 2018 (No. S 38 Tuesday 6 February 2018). This declaration triggered the requirement for the preparation of an EES to inform the Minister's assessment of the project and the subsequent determinations of other decision-makers.

In addition, on 13 April 2018, the Australian Government's Minister for the Environment decided that the North East Link is a 'controlled action' under section 75 of the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) ('EPBC Act') (EPBC 2018/8142) because of the potential for significant impact on matters of national environmental significance and on the environment of Commonwealth land, requiring assessment and approval under the EPBC Act.

As outlined in the Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978 (p3), the specific objective of the EES assessment process are:

- *to provide for the transparent assessment of potential environmental effects of proposed projects, in the context of applicable legislation and policy, including principles and objectives of ecologically sustainable development*
- *to provide timely and integrated assessments of proposed projects to inform relevant decisions, in the context of coordinated statutory processes*
- *to ensure proponents are accountable for investigating potential environmental and related effects of proposed projects, as well as for implementing effective environmental management measures*
- *to provide public access to information regarding potential environmental effects as well as fair opportunities for participation in assessment processes by stakeholders and the public*
- *to provide a basis for monitoring and evaluating the effects of works to inform environmental management of the works and improve environmental knowledge.*

As part of the EES process, the Minister for Planning issued ten (10) EES scoping requirements: These are:

1. ***Transport capacity, connectivity and traffic management*** *– To increase transport capacity and improve connectivity to, from and through the northeast of Melbourne, particularly freight movement via the freeway network instead of local and arterial roads, while managing the effects of the project on the broader and local road, public transport, cycling and pedestrian transport networks*

2. ***Health, amenity and environmental quality*** *– To minimise adverse air quality, noise and vibration effects on the health and amenity of nearby residents, local communities and road users during both construction and operation of the project.*
3. ***Social, business, land use and infrastructure*** *– To manage effects of the project on land use and the social fabric of the community with regard to wellbeing, community cohesion, business functionality and access to goods, services and facilities.*
4. ***Landscape, visual and recreational values*** *– To minimise adverse effects on landscape values, visual amenity, recreational and open space values and to maximise the enhancement of these values where opportunities exist.*
5. ***Habitat and biodiversity*** *– To avoid or minimise adverse effects on vegetation (including remnant, planted and regenerated) listed rare and threatened species and ecological communities, habitat for listed threatened species, listed migratory species and other protected flora and fauna, and address offset requirements for residual environmental effects, consistent with relevant State policies.*
6. ***Cultural heritag****e – To avoid or minimise adverse effects on Aboriginal and historical cultural heritage values.*
7. ***Land stability*** *– To avoid or minimise adverse effects on land stability from project activities, including tunnel construction and river and creek crossings.*
8. ***Waste management*** *– To manage excavated spoil and other waste streams generated by the project in accordance with the waste hierarchy and relevant best practice principles.*
9. ***Catchment values*** *– To avoid or minimise adverse effects on the interconnected surface water, groundwater and floodplain environments.*
10. ***Greenhouse gases*** *– To demonstrate the project will contribute to the need for an effective, integrated and climate change-resilient transport system that provides a wide range of travel choices for all Victorians****.***

With respect to my area of expertise (hydrogeology), my analysis presented in **Section 4.1.2** addresses the adequacy of the EES to address scoping requirement 9 (**catchment values**) and partially 5 (***Habitat and biodiversity).***

4.1.2 Analysis

Through my analysis, I have focused on fundamental aspects that are required when developing an EES to meet the scoping objectives listed in **Section 4.1.1** (item 9). That is:

- Data
  - The data collected and how it was used.
  - The transparency and accuracy of the data.
- Data uncertainty of key areas within the project area, namely;
  - Bolin Bolin Billabong
  - Simpson Barracks
  - Banyule Swamp.
- The use of predictive tools (such as analytical and numerical models).
- The development and application of a risk assessment.
- Defining and understanding the feasibility of project environmental performance indicators (EPRs).

4.1.2.1 Data

My analysis began with an understanding of the data because if there is an issue identified with the data, its collection (or lack thereof) and application, the ramifications can propagate through all aspects of the project.

Firstly, with the exception of groundwater level data used to create Figure 6-9 on Page 80 of EES Technical Report N (reproduced as **Figure 4-2**), no data was made available despite a memorandum requesting additional data to support this review. This memorandum along with the response from North East Link Project (NELP) can be viewed in **Appendix C**. Simply, the response to the data requested was "*a groundwater factual report is under preparation*" (refer **Appendix C, Page 5, Row No 13 to 15**).

Further, it is typical of EES projects to present a stand-alone chapter regarding the data and if contamination is identified or likely to be found, the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999) requires Data Quality Objective (DQO) to be set (also refer (USEPA 2000a, 2000b and 2006a)). This EES does not provide any data transparency (such as bore logs, construction details) or state any DQOs despite contamination such as hydrocarbons and poly-fluoroalkyl substances (PFAS) being present.

I find it difficult to comprehend that an EES of such importance does not contain such data.

The only dataset that was obtained for review was supplied from Melbourne Water. This is graphically shown in **Figure 4-1**. The chain of communication and data can be provided on request. When comparing this dataset with that presented in EES Technical Report N, errors were immediately discovered. I believe the data supplied form Melbourne Water to be correct, meaning I do not believe the data shown in Figure 6-9 on Page 80 of EES Technical Report N, (reproduced as **Figure 4-2**).

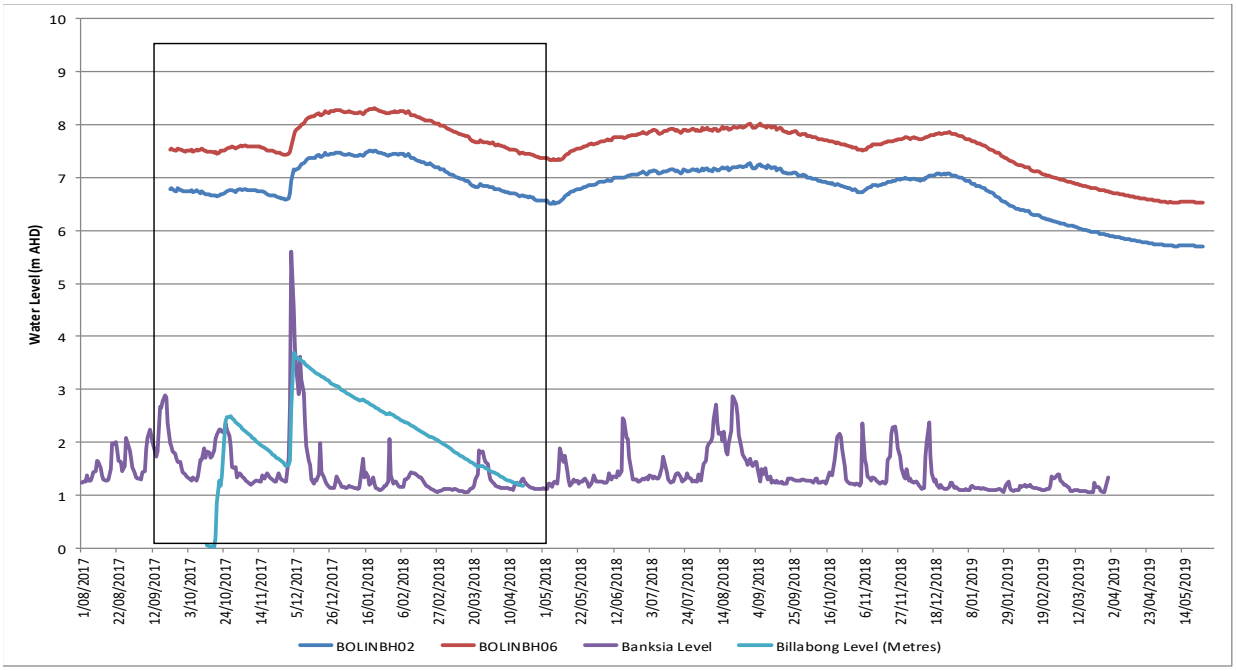


Figure 4-1 Melbourne Water Data for Bolin Bolin Billabong

The error was identified when reviewing Figure 6-9 on Page 80 of EES Technical Report N (reproduced as **Figure 4-2**). This figure depicts surface water and groundwater levels in the vicinity of Bolin Bolin Billabong between August 2017 and May 2018.

Bolin Bolin Billabong is a high value ox-bow lake on the floodplain of the Yarra River in Bulleen, and contains vegetation that is potentially reliant on groundwater to meet some of its water requirements.

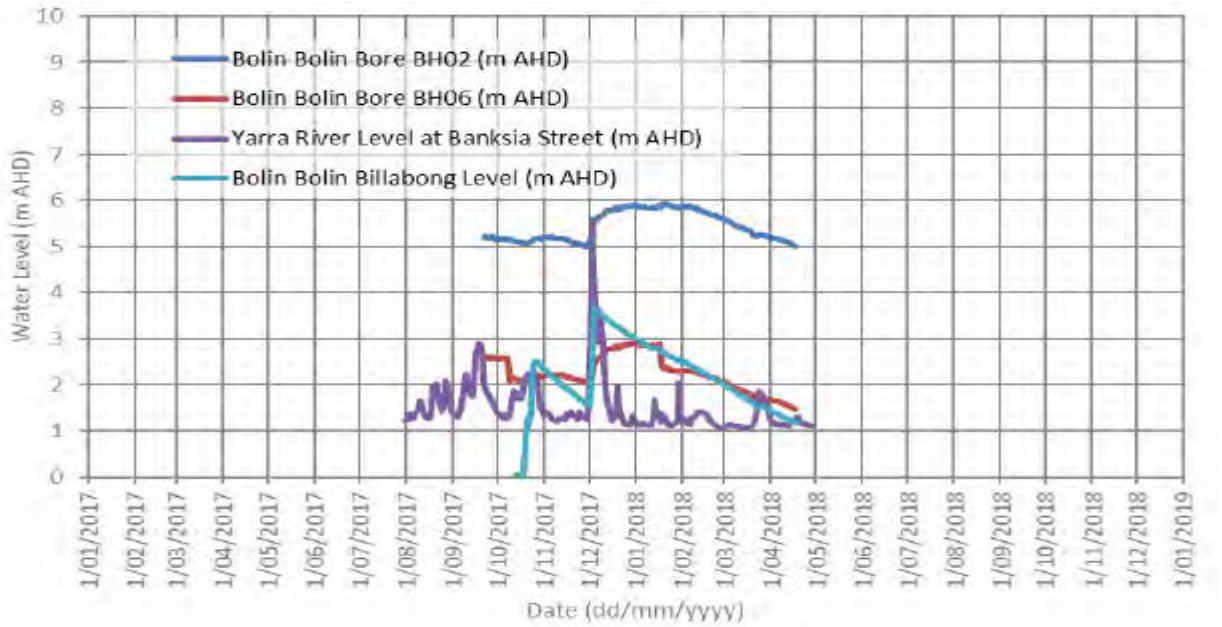


Figure 4-2 Surface water and groundwater levels as indictated in Figure 6- 9 of EES Technical Report N

The data within the black box on **Figure 4-1** represents the same time period as the data represented on **Figure 4-2**. As can be clearly seen, groundwater elevations monitored within BH02 and BH06 do not match. **Figure 4-2** (i.e. Figure 6-9 of EES Technical Report N) suggests that groundwater levels are found between 1.5 and 6 metres Australian Height Datum (mAHD), however the data provided directly by Melbourne Water (refer **Figure 4-1**) indicates water levels are much higher and fluctuates between 6.5 and 8.2 mAHD for the same corresponding period. For Bore BH06, this difference can be up to 6.7 metres (m) with Figure 6-9 of EES Technical Report N placing the depth to groundwater several metres below the Yarra River invert. This conceptually is wrong.

As Bolin Bolin Billabong (shown in cross section on **Figure 4-3**) is regarded as a high value ox-bow lake, the ramification of using or reporting incorrect data can be serious. For example, model predictions or setting design environmental performance requirements (EPRs) to protect/maintain the ecosystem could be wrong. It also raises concerns over the quality assurance (QA) and quality checking (QC) process that has (or has not) been undertaken.

In addition to the potential error or mis-representation of this data, in the vicinity of this location, the groundwater model predicts up to 0.5 m of drawdown to occur (refer page 44 [Figure 26], Appendix C of EES Technical Report N). If adequate QA/QC processes have not been adopted, this value could be much larger. Nevertheless, the significance of what a 0.5m drawdown may mean is visualised and quantified on **Figure 4-4.** This figure adopts the conceptualisation shown in **Figure 4-3**

with the analytical solution of Darcy's Law (represented as **Equation 1**) applied. Darcy's Law is one of the fundamental governing equations that describes the flow of a fluid through a porous medium.

$$Q = kiA \quad (\mathbf{1})$$

Where Q = Groundwater flux or volumetric flowrate through a porous medium (cubic metres per day [m^3/d]), K = Hydraulic conductivity (metres per day[m/d]), A = Cross sectional area (m^2) and i = hydraulic gradient.

Assuming the water levels provided by Melbourne Water are correct, I have calculated the groundwater flux from the permanent pool in to the aquifer based on the following:

- The cross-sectional area (as measured on Google Earth Pro) indicated that the "permanent pool" has a diameter of 240 m and a depth of 2 m (page 98, of EES Technical Report N), therefore the available cross-sectional area for which water to flow out is 960 m^2.
- The hydraulic gradient has been measured using the height difference between the water in the permanent pool and the average water level in bore BH02 (approximately 7 m).
- A hydraulic conductivity ranging between 0.1 m/d to 25 m/d (page 21, Appendix C, EES Technical Report N). Note a calibrated K of 13 m/d was chosen (Table 3, page 25, Appendix C, EES Technical Report N).

Excluding loss of water through evaporation, the results indicate for a 0.5 m drop in groundwater water level at Bolin Bolin Billabong, between 76,000 litres (L) (using K = 0.1 m/d) and 19,000,000 L (using K = 25 m/d) of water would be required every year to keep Bolin Bolin Billabong with water.

Using the calibrated K of 13 m/d, the results suggest a 0.5 m decline would result in an additional 4,950,000 L per year (~5 ML) to maintain a pool height equivalent of predevelopment conditions. This is the equivalent (at minimum) of trucking in 2 Olympic sized swimming pools every year. This also excludes the effect of evaporation. Inclusive of evaporation, the number would increase.

In addition to the modelled drawdown effect, Table 5-3 within EES Technical Report N (page 34) states acceptable levels of drawdown as "Acceptable interference limits for existing bores are set out in a strategy recommended by the Rural Water Corporation (1993). The acceptable limits for poorly defined aquifer systems are 10% of the available drawdown in the neighbouring bore". EES Technical Report N then states: "this drawdown is within the 10 per cent licensing guidelines recommended by Southern Rural Water (pg. 141)". However, this conclusion is incorrect.

As shown on EES Technical Report N Figure 6-16 (reproduced in **Figure 4-3**), the standing water level is approximately 5 m below ground level and the bore has a depth of 10 m. Therefore, the **available drawdown** is 5 m (not 10 m as implied in EES Technical Report N). This means that a 0.5 m drop in water level results in a 10 percent loss of available drawdown. Considering uncertainty and the precautionary principle, this is an unacceptable drawdown.

In addition, the Ministerial guidelines to determine acceptable limits of drawdown for Groundwater Dependent Ecosystems (GDEs) (DELWP [2015], **Appendix D**) state "Water table decline of 0.1 m to 2 m results in a moderate consequence". The guidelines then state, if greater than 10 megalitres (ML) of water is required for management and mitigation purposes, the application is referred to the authorised Catchment Management Authority (CMA), in this case Port Phillip and Westernport CMA.

As the project development period will likely run for between 2 and 5 years, its highly probable in excess of 10ML of water for management provisions would be required.

An additional error that can potentially have significant project impacts is also found in Table 8.5 (page 123) of EES Technical Report N. Table 8.5 shows the use of a variant of Darcy's Law (represented as **Equation 2**) to calculate linear groundwater velocity (V):

$$V = \frac{Ki}{n_e} \qquad (\mathbf{2})$$

where K = hydraulic conductivity (m/d), I = hydraulic gradient (-) and ne = effective porosity (-).

The EES calculated the velocity (V) to be 0.002 m/d and goes on to state "The construction timeframe (an estimated two to three years) does not provide time for migration of a groundwater plume over significant distances". Again, this conclusion is incorrect.

Using the input parameters provided in the EES, V = 0.01 m/d (calculated by (0.1x0.005)/0.05. This is an order of magnitude faster than the report calculated (0.002 m/d).

Under a dewatering scenario where the hydraulic gradient (i) is increased to 0.083 (calculated from EES Technical Report N Figure 8- 13 (page 143), it would take less than 2 years for a particle of water to travel 120 m (this the distance from the mined tunnel to Bolin Bolin Billabong). Adopting the precautionary principle and using the upper modelled value of hydraulic conductivity for bedrock (K = 0.5 m/d, refer page 21 Appendix C of EES Technical Report N), it would take 144 days for a particle of water to travel 120 m. In alluvial sediments, where the calibrated K = 13 m/d, this travel time becomes 5.5 days.

All of these scenarios show that its entirely possible for a particle of water (and potentially contaminated water) to migrate in either the bedrock or alluvium (the 2 aquifers present) in less than the construction period where dewatering would be occurring (estimated between 2 and 5 years). Therefore, the identification of all (and potential) known sources of contamination (which is acknowledged to be lacking, refer **Appendix C**), needs to be thoroughly risk assessed as the proposed EPR's have been developed based on incorrect data.

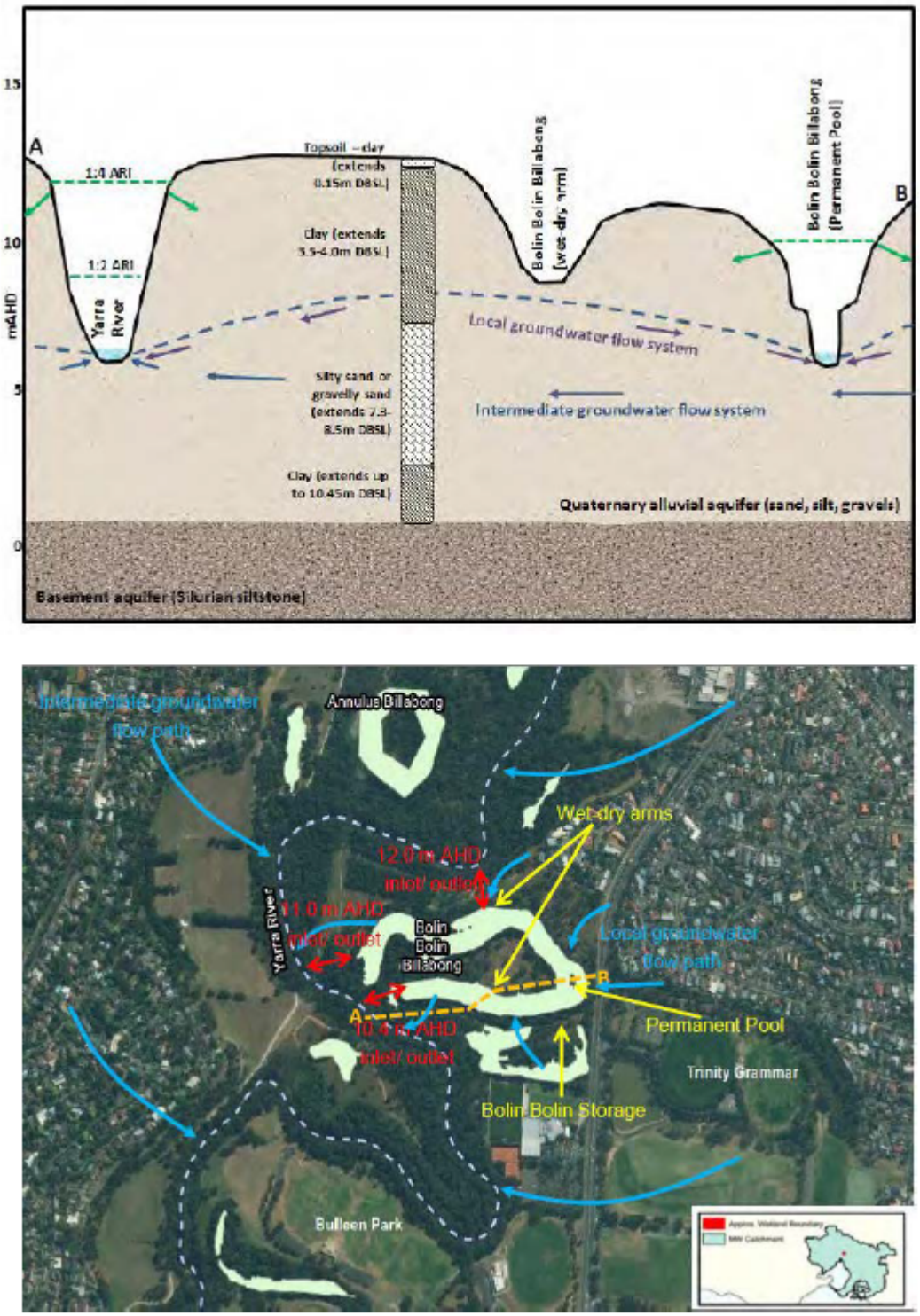


Figure 4-3 Conceptualisation of Bolin Bolin Billabong (taken from page 98; EES Technical Report N)

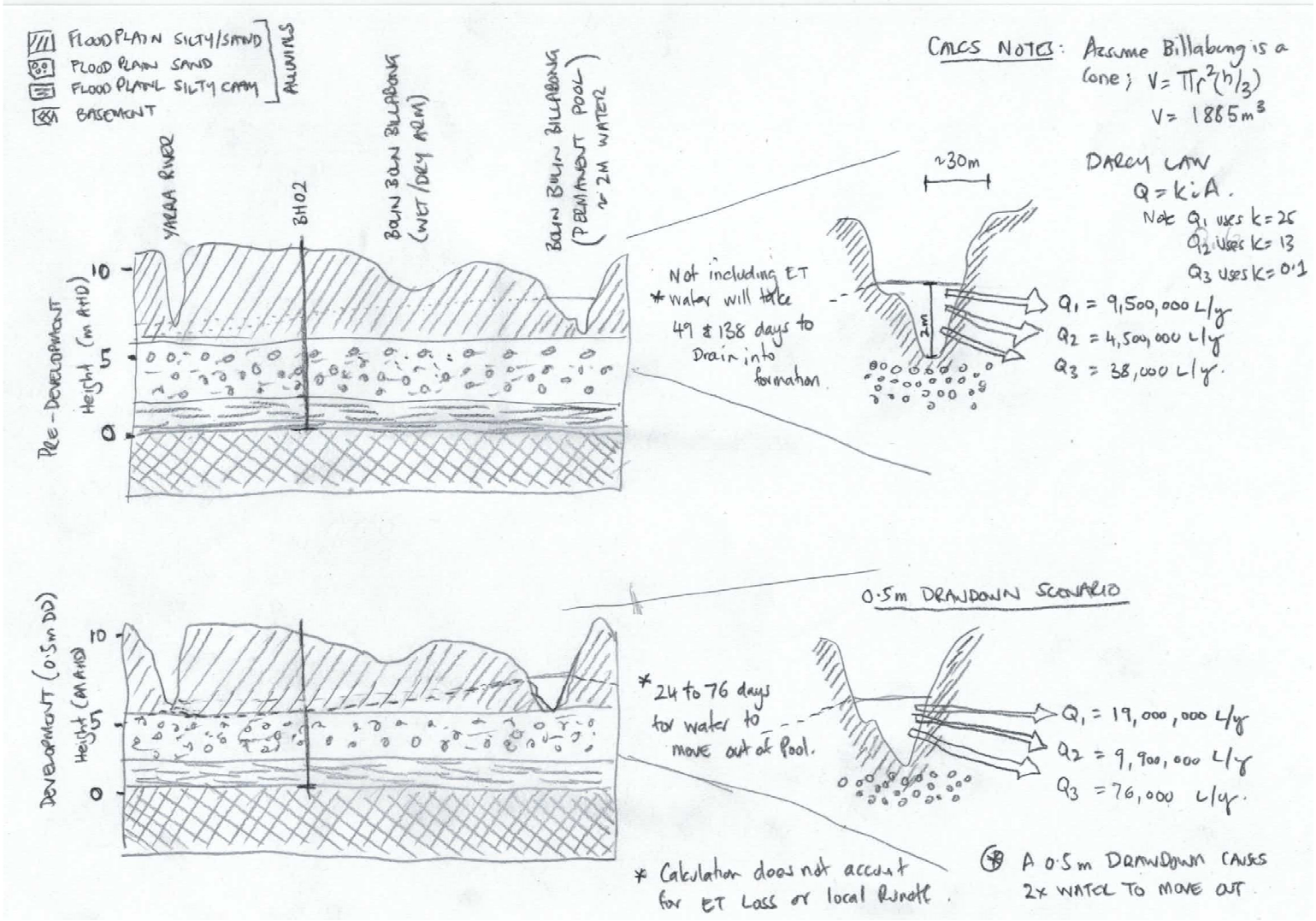


Figure 4-4 Conceptualisation and Part Water Balance of Bolin Bolin Billabong (Analytical Calculatios by C Smitt)

4.1.2.2 Data Uncertainty

Whilst in the preceding section (**4.1.2.1**) data uncertainty is implied, the project also provides the following statements or assumptions, which only increase uncertainty in the predicted outcomes:

- EES Technical Report N (page 96) states: "*there is a limited understanding of connectivity between surface and groundwater throughout the study area*". Whilst groundwater dependent ecosystems (GDEs) have been mapped in the area, no confidence is given regarding the behaviour of surface water and groundwater interactions.
    - For example, the draft PER acknowledges that GDEs exist around Banyule Creek and surrounds (Simpson Barracks). The report the states (page 13); "*On the lower to mid slopes of Simpson Barracks (east of the project boundary) where depth to groundwater is 10 to 20 metres (based on groundwater depth contours), it is assumed that River Red Gums may be accessing subsurface groundwater for at least part of the year (such as during summer) or during drought conditions. On the upper slopes of Simpson Barracks where depth to groundwater is greater than 20 metres (based on groundwater depth contours), it is assumed that River Red Gum and Yellow Box do not access subsurface groundwater*".

      Reviewing the above statement makes its clear that no groundwater levels were measured at or near these GDEs otherwise these more discrete values would be reported as opposed to using interpreted groundwater levels with 10 m intervals. The above statement is also not discussed within the EES Technical Report N.
- The report then states (page 48): "*some monitoring bores do not screen the first water intersection*". This may result in:
    - The use of incorrect water levels being adopted for use within the groundwater model.
    - Highly erroneous results if these bores are used when applying analytical solutions to determine hydraulic parameters (such as Hvorslev [1951]).
    - Water level and quality information obtained from these bores may not be representative of conditions in the zone of water table fluctuation/shallow part of the aquifer where contamination is most commonly identified.
    - Vertical groundwater flow (upward or downward) may be mis-calculated which not only has significant hydrogeological repercussions, but geotechnical as well, such as design assumptions for the use of a Tunnel Boring Machine (TBM).
- No hydrogeological conceptualisation of Koonung Creek has been presented. Rather, similarities are drawn to the heavily urbanised Banyule Creek. Considering these creeks are separated by approximately 10 km and the groundwater flow direction of Banyule Creek is from the north to south and for Koonung Creek is south to north, this is inappropriate.
- The EPRs make no mention of the detailed requirements (and therefore feasibility) to meet objectives under the State Environment Protection Policies (SEPPs). For example:
    - EES Chapter 3 (Contamination and Soil), reveal that petroleum hydrocarbons were identified in groundwater south of the service station at the intersection of Yallambie Road and Greensborough Road and per- and poly-fluoroalkyl substances (PFAS) at the former Bulleen Drive-in. The modelling also suggests that petroleum hydrocarbon and PFAS contamination may migrate towards environmental receptors due to groundwater dewatering associated with construction.

- As a result of this contamination, SEPP (Waters) and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000) will require the 99% ecosystem protection values to be adopted, as 99% protection applies to "high conservation/ecological value" (such as Bolin Bolin Billabong) or if the aquatic ecosystem is classified as "slightly to moderately disturbed ecosystems". In addition, ANZECC 2000 States "*For those chemicals that have the potential to bioaccumulate, a higher level of protection is recommended (e.g. 99% protection for slightly–moderately disturbed systems instead of 95%)*". PFAS is a bioaccumulator and known to be present, other examples are cadmium, Polychlorinated Biphenyls (PCBs) and Dioxins.

It should be noted that at the time of writing, a "groundwater factual report" was in development (refer **Appendix C**). During an informal meeting between experts held on 08 July 2019 (refer **Section 1 (f)**), to discuss the information requested, no further information regarding this "factual report" was forthcoming. I find it difficult to comprehend that an EES of such importance does not have the basic data attached to back up some of the conclusions made. For example, bore completion or lithological records are not presented, not even for the 69 newly installed monitoring bores.

4.1.2.3 Groundwater Numerical Model

A groundwater model is any computational method that represents an approximation of an underground water system (Barnett et al., 2012). Due to the vast array of requirements for a groundwater model, in June 2012, Australian groundwater modelling guidelines were released to promote a consistent and sound approach to the development of groundwater flow and solute transport models in Australia.

Within these guidelines, the concept of "model classification" is introduced (i.e. the models confidence in its predictions), and generally reflects the level of data available. The guidelines present 3 types of classification ranging from Class 1 to Class 3 and the objectives of the project are usually the starting point in determining what classification of model is required.

Class 1 models are usually developed where there is insufficient data to support conceptualisation and calibration and thus have the lowest level of confidence in prediction. Class 3 models on the other hand are seen as providing the highest confidence in prediction.

The groundwater model developed for this EES has been independently reviewed as conforming to a Class 1 model (with a few Class 2 aspects).

A review of the Australian groundwater modelling guidelines (Barnett et al., 2012. page 18) states: "*A Class 1 model, for example, has relatively low confidence associated with any predictions and is therefore best suited for managing low-value resources (i.e. few groundwater users with few or low-value groundwater dependent ecosystems) for assessing impacts of low-risk developments or when the modelling objectives are relatively modest*".

In addition to this, (SKM 2012), presented these guidelines to the International Association of Hydrogeologists (IAH) Groundwater Modellers Forum where they stated: "*Class 1: simple models, either developed on few or sparse data sets that do not provide confidence in the hydrogeological conceptualisation*". This presentation is attached in **Appendix E** and provides a good high level summary and interpretation of these guidelines.

SKM (2012) also states: "*Example of Use for a Class 1 model:*

- *Predicting long-term impacts of proposed developments in low value aquifers*
- *Designing observation bore arrays for pumping tests*
- *Designing observation bore arrays for pumping tests*
- *A starting point from which to develop higher class models".*

This compares to the example of use for a Class 2 model:

- *"Prediction of impacts of proposed developments in medium value aquifers*
- *Estimating dewatering requirements for mines/excavations and the impacts*
- *Designing groundwater management schemes such as MAR, salinity management schemes and infiltration basins*
- *Estimating distance of travel of contamination through particle-tracking methods and defining water source protection zones"*.

With respect to the model objectives for this EES, Section 1.2 of Technical Report N (page 1) states: "*The project is located adjacent to environmentally sensitive areas, with groundwater connected water bodies and groundwater-dependent ecosystems that are potentially sensitive to changes in the elevation of water table, groundwater fluxes and water quality. These include water bodies such as the Bolin Bolin Billabong, a high value ox-bow lake on the floodplain of the Yarra River in Bulleen, and vegetation that is potentially reliant on groundwater to meet some of its water requirements. The primary objective of numerical groundwater model is to inform potential impacts and risks of the project on these sensitive receptors. To meet this objective, the groundwater model must be capable of predicting potential changes to existing groundwater levels and fluxes arising from interactions with the project*."

Therefore, according to the objectives of the project and the EES scoping requirements set by the Minister, in my opinion a Class 2 or higher model is required for the model to meet the objectives of the project. Additional rationale for this is provided below:

- The current model uses a minimum water level contour of 0.1 m to inform the groundwater impact assessment. However, for a Class 1 model, this level of accuracy can be misleading as changes of less than 0.5 m are generally considered beyond the threshold of accuracy expected of a regional model. This Statement is also acknowledged in the EES Technical Report N (page 42).
- At the time of model development, a groundwater baseline has not been established. The purpose of a baseline assessment is to "establish a point from which future measurements and predictions can be calculated". If a baseline is not established, the model outputs become unreliable. Typically, a baseline period is considered as seasonal monitoring over 3 years or more, or where Mann-Kendall test becomes valid. It appears that the majority of bores have only been sampled once (April 2018 in 69 monitoring bores).
- Climate change is not adequately assessed in the model outputs. This is because:
    - The model used climatic data and behaviour from observation points in Kinglake (30 km to the north) and Tarneit (approximately 40 km West) because no long-term monitoring data was available within the model domain. However, upon review, closer State Observation Bores (SOB) are available such as ID 126149 (approximately 20 km away) screened in the same geology (basalt) as those used in the model and covers the Millennial drought to capture the impacts of drought on water levels.

    - Recharge (i.e. rainfall that infiltrates in to an aquifer) is only calibrated in steady state. This means seasonal fluctuations as a result of recharge cannot be rigorously assessed through calibration to existing data.
- Calibration statistics claims of scaled root mean square (SRMS) error of less than 10 percent (i.e. numerical difference between model outputs and observed data) with respect to hydraulic heads or mass balance error of less than 1 percent are easily obtained when the model has only a few datapoints to calibrate against.
- The calibrated hydrographs presented on Figure 18 (Appendix C of EES Technical Report N) and reproduced in **Figure 4-5**, show a relatively poor fit in most bores that had a pump test performed.

I appreciate that it may be difficult to obtain a complete Class 2 model or higher for a project of this nature. For example, for a model that is required to predict water levels 50 years into the future, a Class 2 model would need to have observation data in numerous locations within the model domain that contain at least 5 years of good quality data. In many development/feasibility projects, this level of infrastructure is not readily available. However, where aspects of the model domain contain, high value environmental receptors and or aspects of the project that have a human safety element (geotechnical related), a Class 2 (or more elements conforming to a Class 2) should be the minimum requirements.

In addition, I do form the opinion that the current model setup is too complicated for the dataset it is using and that improvement in conceptual understanding in surface water and groundwater interactions, along with continual model validation, is required to bring the model closer to a Class 2 status.

Using a detailed model setup with limited data, can often introduce uncertainty or establish a false sense of security. For example, in the alluvial sediments, a hydraulic conductivity (K = 13 m/d) was uniformly applied across the model domain. This value was derived by analysing 8 data points (bores). It was acknowledged during the meeting discussed in **Section 1 (f)**, that that these bores target more permeable parts of the alluvium near where geotechnical work for construction will be undertaken (e.g. tunnelling, piling, etc). As such, the modelling objective should have been "to inform design parameters for the geotechnical program", as opposed to "inform potential impacts and risks of the project on sensitive environmental receptors".

Whilst the calibration process used "PEST" (a useful and popular software to automate parameter estimation), this initial data input was limited and consisted of steady state calibration using few data points (i.e. April 2018 groundwater levels [heads]), followed by transient calibration to drawdown observed during pumping tests. The result of which often showed poor fit in environmentally sensitive areas. This is shown in **Figure 4-5** where up to ~1m (at NEL-BH107) or 300% (at NEH-BN106) difference between model performance and real-world test are observed.

Therefore, whilst the model may be fit for purpose to initially inform hydrogeological design parameters for the use of TBMs etc., applying the "calibrated" K to floodplains and billabongs/swamps associated within waterways (i.e. areas where sensitive environmental receptors are found) may not reflect the true hydro-dynamics within these areas. In fact, a high K (which I believe has been used), will often dampen any potential impacts. As presented earlier (refer **Figure 4-4**), if the predictions are only out by 0.5m, this can conservatively equate to an increase in leakage of ~5,000,000 L (every year) for the permanent pool at the Bolin Bolin Billabong.

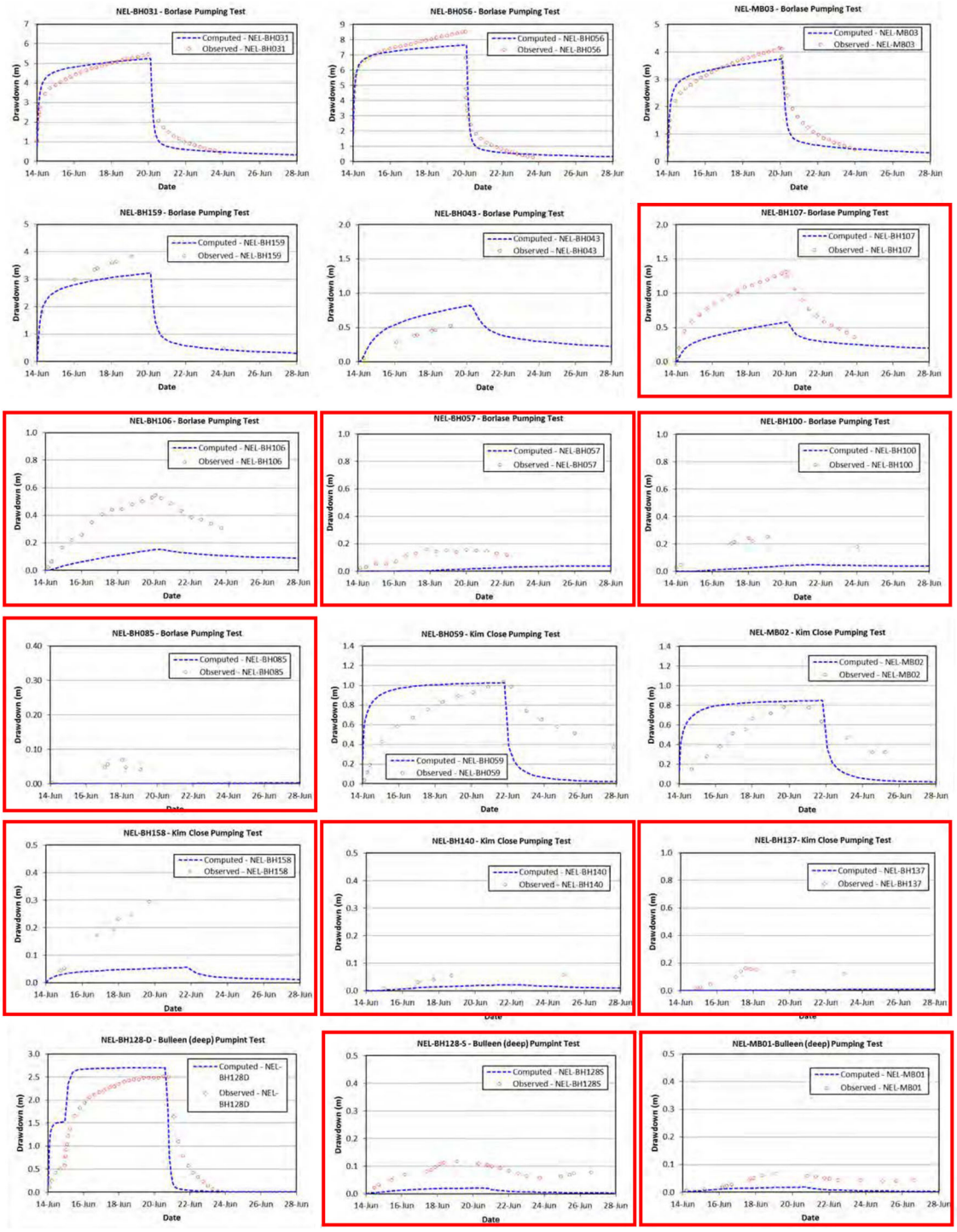


Figure 4-5 Calibrated Hydrographs (modified from Figure 18, Page 32, Appendix C of EES Technical Report N). Graphs highlighted by a red box demonstrate poor calibration (i.e. model prediction not well aligned to real world data).

4.1.2.4 Risk Assessment

Whilst my stated area of expertise is "hydrogeology", this also includes risk assessments as discussed in **Section 1 (c)**.

In my opinion, the adopted risk assessment process is very subjective and tried to assess all aspects of the EES scoping requirements against the same criteria (for example, dewatering impacts on vegetation are assessed against the same criteria as impacts on local business). Furthermore, the severity of consequence has no reference point. For example, a medium consequence is inferred to be "moderate degree of impact" however there is no definition of what a moderate impact is.

In my opinion, I believe this has caused the risk assessment to undervalue certain items. To demonstrate this, I will reference a risk that has been identified as Medium "drawdown related impacts on GDEs".

This risk was identified as a medium risk based in the following conditions (refer page 3, Technical Report Q Appendix A):

- "possible likelihood" of a local impact
- "2-7-year duration" of impact; and
- "medium severity" if the impact were to occur.

Again note: there is no definition of "consequence = medium severity" in either EES Technical Report N (groundwater), EES Technical Report Q (ecology) or EES Chapter 04 (EES Assessment Framework).

However, considering:

1. A watering regime as part of the Bolin Bolin rehabilitation works (https://www.melbournewater.com.au/what-we-are-doing/works-and-projects-near-me/all-projects/bolin-bolin-billabong-rehabilitation), where water is diverted from the Yarra River is already in place for Bolin Bolin Billabong, the likelihood should have been upgraded to "likely" (meaning "*The event is likely to occur several times within a five-year timeframe*"
2. Steady state post construction groundwater modelling does indicate some level of drawdown, post construction, therefore the Characterisation of consequence should be changed to "*Permanent (>7 years) duration of impact*".
3. Whilst there is no definition of severity of consequence, as discussed previously, available drawdown is likely to exceed 10 percent at Bolin Bolin Billabong, therefore a "high" severity impact can be argued based on Acceptable interference limits (RWC, 1993).

If the above is taken into consideration, the residual risk is "high". Another example is Risk CT08 "Abstraction of groundwater causes migration of contamination onto sites that otherwise may not have been impacted, resulting in soil impact off site and causes an impact to human health and the environment" refer EES Technical Appendix O (page 88). This is classified as "low", however when the corrected groundwater velocities are applied (refer page 11 and 12 of this statement), the time for potential contaminants reduces from years to days.

4.1.3 Conclusion

Through the analysis above, in my opinion, the EES **DOES NOT** adequately assess the potential nature and extent of the environmental effects of the Project. A summary of my rationale is provided below:

1. The limited data collected to date and its application have led to incorrect statements, calculations and assumptions that have been used to develop environmental performance requirement (EPRs).
2. Potential impacts on sensitive environmental receptors based in the alluvium (such as Bolin Bolin Billabong, Simpson Barracks, Banyule Swamp and Trinity Grammar Sports Ground wetlands) have been estimated using 8 data points (bores) where these data points target more permeable parts of the alluvium near where geotechnical work for construction will be undertaken (e.g. tunnelling, piling, etc).
3. The objectives of the model are more aligned to initially informing design parameters for the geotechnical program, as opposed to "inform potential impacts and risks of the project on sensitive environmental receptors".
4. The model has been classified as a "Class 1" model which according to the Australian groundwater modelling guidelines (Barnett et al., 2012. page 18) states: "A Class 1 model, for example, has relatively low confidence associated with any predictions and is therefore best suited for managing low-value resources (i.e. few groundwater users with few or low-value groundwater dependent ecosystems)".
5. The model uses a minimum water level contour of 0.1 m to inform the groundwater impact assessment. However, for a Class 1 model, this level of accuracy can be misleading as changes of less than 0.5 m are generally considered beyond the threshold of accuracy expected of a regional model.
6. A groundwater baseline has not been established.
7. Climate change is not adequately assessed in the model outputs as the model used climatic data and behaviour from observation points in Kinglake (30 km to the north) and Tarneit (approximately 40 km West).
8. Current and predicted migration of contaminated groundwater have been underestimated.
9. No hydrogeological conceptualisation of Koonung Creek has been presented. Rather, similarities are drawn to the heavily urbanised Banyule Creek. Considering these creeks are separated by approximately 10 km and the groundwater flow direction of Banyule Creek is from the north to south and for Koonung Creek is south to north, this is inappropriate.
10. The project does not conform to the data quality aspects under National Environment Protection Council (Victoria) Act 1995 and National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999).

4.2 Can the Project as described in the EES achieve a level of environmental performance which is consistent with relevant legislation, documented and endorsed policy or acknowledged best practice

I believe when a project is properly researched and considers relevant environmental factors with a degree of confidence to satisfy the project's objectives and scoping requirements, it can achieve an acceptable level of environmental performance.

However, I must state that in its current form, and with respect to Clause 2 of SEPP (Waters) which refers to the principles of environment protection in the Environment Protection Act 1970 (Sections 1B to 1L), I believe there will be unacceptable impacts on some environmental receptors within the project areas. These are attributed around drawdown levels and the ability and or feasibility to manage these impacts.

For example, it is clear that there will be de-watering impacts at Bolin Bolin Billabong and this will require additional water to maintain water levels in the permanent pool. However, the application of the SEPP (Waters) (which define water quality criteria) and potentially application for a temporary sustainable diversion limit (SDL) within the Yarra River basin. In my experience with SDL in Victoria, this will likely need Ministerial approval as I understand no further allocations will be issued in the Yarra River or any of its tributaries under the SDL application process and Section 40 of the Water Act 1989.

4.3 If the Project, as described in the EES cannot achieve a level of environmental performance, are there any recommendations that you would make?

Refer to previous answer and recommendations in **Table 4-1.**

4.4 How does the Project as described in the EES respond to the principles and objectives of "ecologically sustainable development" as defined in the IAC's Terms of Reference

Under Section 3(3) of the Environment Effects Act 1978, the EES is required to document potential environmental effects of the proposed works (including the feasibility of design alternatives and relevant environmental mitigation and management measures).

From the information reviewed, the project does not assess the feasibility of design alternatives and relevant environmental mitigation and management measures. For example, in EES Technical Report Q (Ecology), the project identified impacts of GDE as a medium residual risk (although I argue this will be high). To manage this risk, the project states it would conform to EPR FF6 (Implement a groundwater dependent ecosystem monitoring and mitigation plan). However, no details regarding the feasibility of meeting this objective are stated. In my opinion, it is likely the Minister for water will be required to sign off on certain management actions to off-set potential impacts.

4.5 Are there any recommendations that you would make as to specific measures which you consider necessary and/or appropriate to improve the Project objectives of "ecologically sustainable development"?

The project lists numerous EPR's, however some contain very little information (other than a headline) on what will be achieved or targeted, and therefore whilst it may be listed as an ERP, it may simply not be technically feasible or possibly to achieve an acceptable outcome under the current regulatory environment. **Table 4-1** outlines recommendations for additional work whilst **Table 4-2** outlines additional EPSs.

Table 4-1 Recommendations for additional Work (EPR)

Action/Item	Recommended Additional Work
Establishment of a groundwater baseline not achieved	It is understood that only one groundwater quality monitoring event (GME) has been undertaken. This is woefully inadequate to characterise a baseline assessment and define EPRs and their feasibility. It should reasonably be expected that quarterly GMEs be undertaken on the groundwater monitoring infrastructure. Furthermore, after the informal meeting with NELP hydrogeologists (refer Section 1(f)), I believe the groundwater was not sampled in accordance to EPA 2000, Publication 669, Groundwater sampling guidelines, as numerous samples were believed to have been undertaken immediately following drilling and development. However, without bore development records or a QA/QC summary table, this cannot be verified. It is also understood that (where practical), monthly water level results are obtained from the monitoring network (although only a small sub set if this information has been used in the initial model). Whilst this is an acceptable frequency, considering deficiencies in the numerical model to classify recharge, groundwater loggers should be installed in all observation bores. The small capital expenditure for a data logger would be offset with the efficiencies gained with reliable continuous data. Note: It is acknowledged that EPR GW2 outlines a requirement to improve baseline data, however the additional details above should be incorporated in to this EPR.
Introduction of a data chapter to the EES	It is typical of EES projects to present a stand-alone chapter regarding the data (if it is not a part of the relevant technical chapter). Currently, the project does not conform to the data quality aspects under National Environment Protection Council (Victoria) Act 1995 and National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999). As contaminated data has been found and is also likely to be encountered, the NEPM 1999 recommends the USEPA seven-step Data Quality Objective (DQO) (USEPA 2000a, 2000b and 2006a). The DQO process is recommended when data is being relied on to make a risk-based decision as part of a detailed site investigation, though a simplified planning process may be appropriate for straightforward screening assessments. Currently the EES does not provide any data quality objectives. Furthermore, the EES does not provide any compilation of all data which can be used or referenced to define minimum data requirements and quality control procedures. By undertaking this, potential data limitations or data uncertainties can be documented and/or quantified. Where limitations or uncertainties exist, water management, monitoring and a contingency plan can be developed to present the approach for where, when and how additional data and supplemental assessments will be completed.

<table>
<tr><th>Action/Item</th><th>Recommended Additional Work</th></tr>
<tr><td>Risk assessment process</td><td>The adopted Risk assessment process is very subjective, and the severity of consequence has no reference point. For example, a medium consequence is inferred to be “moderate degree of impact’ however there is no definition of what a moderate impact is. It is recommended that “consequence” criteria for each technical discipline be re-evaluated. An example is provided below for groundwater. This will ensure risks are weighted appropriately with respect to its technical discipline. When this is undertaken, a review of the current list of EPRs is required.
<table>
<tr><th>Consequence Category</th><th>Description</th></tr>
<tr><td>Critical
Severe, widespread long-term effect</td><td>Destruction of sensitive environmental features. Severe impact on ecosystem. Impacts are irreversible and/or widespread. Regulatory and high-level government intervention/action. Community outrage expected. Prosecution likely. Financial loss in excess of $X.</td></tr>
<tr><td>Major
Wider spread, moderate to long-term effect</td><td>Long term impact of regional significance on sensitive environmental features (e.g. wetlands). Likely to result in regulatory intervention/action. Environmental harm either temporary or permanent, requiring immediate attention. Community outrage possible. Prosecution possible. Financial loss from $X to $Y.</td></tr>
<tr><td>Moderate
Localised, short-term to moderate effect</td><td>Short term impact on sensitive environmental features (e.g. gibber plain). Triggers regulatory investigation. Significant changes that may be rehabilitated with difficulty. Repeated public concern. Financial loss from $X to $Y.</td></tr>
<tr><td>Minor
Localised short-term effect</td><td>Impact on fauna, flora and/or habitat but no negative effects on ecosystem. Easily rehabilitated. Requires immediate regulator notification. Financial loss from $X to $ Y million.</td></tr>
<tr><td>Negligible
Minimal impact or no lasting effect</td><td>Negligible impact on fauna/flora, habitat, aquatic ecosystem or water resources. Impacts are local, temporary and reversible. Incident reporting according to routine protocols. Financial losses up to $X.</td></tr>
</table></td></tr>
<tr><td>Groundwater Impacts on upgradient side of diaphragm walls.</td><td>Risks of a shallowing water table on the up hydraulic gradient side have not been well considered. In some areas, the water table is forecast to rise by 5m or more (20m in areas near the tunnel). This would bring the water table close to the surface. If this water table gets within 2 meters, during the summer months, capillary rise can cause the water table to reach the surface and water salinization will be the results. This full acknowledgement of this risk is missing. Not only can higher salinity water devastate ecosystems, corrosive or aggressive water has the potential to impact the integrity and lifespan of materials that would be used to construct North East Link.
Note: Figure 8-4 Impact to existing users in EES Technical Report N (page 113) is conceptually wrong and may be the reason this risk was not identified. The water table on the up-gradient side should be closer to the land surface.</td></tr>
</table>

Action/Item	Recommended Additional Work
Groundwater model Improvements	The current model needs to be re-run and calibrated using the data collected to date (assuming it is fit for purpose). The model should also adopt spatially variable hydraulic parameters that are reflective of the key environmental receptors within the model domain; namely: • Bolin Bolin Billabong • Simpson Barracks • Banyule Swamp • Trinity Grammar Sports Ground wetlands It is noted that EPR GW1 mentions the development of a predictive and numerical groundwater model, informed by field investigations, to predict changes in groundwater levels and flow and quality, as they are affected by construction, and develop mitigation strategies. This is a somewhat confusing EPR as this effectively makes the model used in this EES redundant. Nevertheless, it is recommended that this model meets the majority of Class 2 characteristics and those words should be incorporated in to this EPR.

Table 4-2 Additional Environmental Performance Requirements (EPR)

Action/Item	Suggested EPR/Additional Work
Groundwater quality and adoption of protection levels	As the project area includes aquatic reserves/wetlands with a high conservation value (e.g. Bolin Bolin Billabong), the 99% ecosystem protection values should be adopted. Currently there is a lack of detail mentioned in the EPR or other performance metrics. Therefore, to assure these are captured, a recommendation is to monitor water quality results against these levels. If levels exceed the criteria, the establishment of a background dataset (discussed above) is crucial, as under the SEPP, background takes priority over exceedances against protection values; e.g. if the system naturally has a low pH, the SEPP will not request the proponent to increase pH to the levels listed.
Environmental Compliance	Appoint an Independent Reviewer and Environmental Auditor (IREA) to review and approve the construction and operational environmental management plan (EMP) and other plans approved under the EPRs, to ensure compliance with the Environmental Management Strategy and EPRs with the approved Environmental Management Strategy. The IREA must produce six monthly audit reports which the Major Transport Infrastructure Authority must forward to the Minister for Planning during construction. Audit reports must be made publicly available.
PFAS Management Plan	Prior to the commencement of works (other than preparatory works referred to in the Incorporated Document), a site-specific PFAS management plan must be prepared in accordance with EPA Publication 1669.2 Interim position statement on PFAS (EPA Victoria 2018) and the Heads of EPAs Australia and New Zealand PFAS National Environmental Management Plan (PFAS NEMP) (HEPA 2018).

4.6 Do you have any recommendations for changes that should be made to the draft planning scheme amendment, works approval or planning approval and/or draft environmental performance requirements

Refer to **Table 4-1.**

5 Declaration by the Expert

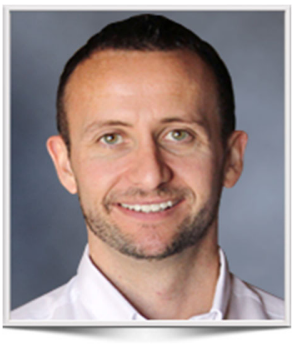
With respect to my instructions, I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the PPV.

Sincerely,

Chris Smitt,
Principal Hydrogeologist | Director
EHS Support Pty Ltd

Appendix A CV

PROFESSIONAL PROFILE



CHRIS SMITT, B.SC (HONS) HYD & GEO

Director | Principal Hydrogeologist

chris.smitt@ehs-support.com

+61 3 9646 8615

Melbourne, VIC, Australia

Search Chris Smitt

EDUCATION

Bachelor of Science (Honours, Hydrogeology and Geophysics), Flinders University, Adelaide

PROFESSIONAL AFFILIATIONS

- International Association of Hydrogeologists
- Australian Institute of Geoscientists
- Australian Institute of Company Directors

CERTIFICATION & TRAINING

- Certificate of Advanced GIS Analysis & Modelling, Adelaide University, 2002
- Certificate of competency for German language studies, Adelaide University, 2003
- Advanced Resuscitation and Senior Occupational First Aid

EXPERTISE

- Managed aquifer recharge
- Analytical and numerical groundwater modelling
- Expert witness / Evidence statements
- Deep bore installation supervision
- Inter-aquifer communication and petroleum activities
- Coal seam/shale gas water management
- Mine rehabilitation
- Project management

Chris is currently the Australian Managing Director for EHS Support Pty Ltd and a principal hydrogeologist with over 19 years' experience in both private and public sector within Australia, North America and the Middle East. Chris has a degree in Physics and Earth Science, majoring in Hydrogeology & Geophysics (obtained in year 2000) from the Flinders University of South Australia

Chris began his career as a hydrogeologist and hydro-climatologist with CSIRO Land & Water where he gained a detailed understanding of surface water and groundwater interactions in complex basaltic aquifers in Victoria. Chris also developed Murray-Darling Basin End of Valley salinity targets and installed more than 200 groundwater observation bore along the River Murray floodplain.

Since 2006, Chris worked as a hydrogeologist in private industry and has been responsible for and/or worked on critical aspects of, numerous technical and complex projects including;

- Catchment and groundwater impacts assessments (e.g. Mordialloc Bypass Project, Victorian Index of Groundwater Condition and numerous development and review of State groundwater management plans)
- CSG and shale gas resource development projects in Australia and North America (e.g. Cooper Basin, Isa Superbasin, Beetaloo sub-Basin, Gunnedah Basin, Great Artesian Basin, Surat and Bowen Basins);
- Mine rehabilitation (e.g. rehabilitation of the Anglesea Coal Mine).
- Managed aquifer recharge projects (e.g. Canberra Integrated Water Management Program and Roma (GAB) pressurization scheme).
- Sustainable groundwater development projects (e.g. Aspire Zone Development, Doha, Qatar and Warrion Water Supply Protection Area),

Chris is also experienced in preparing and delivering expert witness statements for VCAT and PPV acting on-behalf of both public and private industry.

Clifton StrengthsFinder identifies natural strengths and is used to build high performance, well-balanced teams that maximize productivity, efficiency, harmony and engagement.

EMPLOYMENT HISTORY

EHS Support (based in Melbourne)

Director and Principal Hydrogeologist

February 2013 - Present

On the technical side, my role involved providing technical expertise in the following fields;

- CSG and shale gas water management
- Mine site rehabilitation
- Groundwater resource management studies incl:
- Groundwater flow and well hydraulics
- Conceptual site model development
- Regulatory Interaction—Federal, State, Local;

On the business side, my role involves;

- Developing business plans Liaising with the board and other senior management (globally)
- Developing high quality business strategies and plans
- Overseeing all operations and business activities
- Maintain a deep knowledge of the markets and industry of the company

Halocom International (Global)

Director and Chief Financial Officer

September 2001 - September 2016 (15 years 1 month)

Halocom International is a sms permission-based marketing company. Chris and his colleague started the company and his role primarily involved Financial control and planning as well as business development Marketing.

URS Corporation (based in Melbourne)

Principal Hydrogeologist | Project Manager

February 2010 - February 2013 (3 years 1 month)

My role involved the following:

- Executing managed aquifer recharge projects
- Analytical and numerical groundwater modelling
- Expert witness / Evidence statements
- Deep bore installation supervision
- Assessment of inter-aquifer communication
- Coal seam/shale gas water management; and
- Mentoring for project teams

Hyder Consulting

Senior Hydrogeologist

June 2006 - January 2010 (3 years 8 months)

My role involved the following:

- Analytical and numerical groundwater modelling
- mentoring project teams and developing business
- Geoscience business line leader - including business plan & sales strategy development

CSIRO Land and Water (based in Melbourne)

Research Scientist (Hydrogeology and Hydroclimatology)

December 2000 - June 2006 (5 years 7 months)

My role involved the following:

- Numerical modelling,
- Strategic salinity policy,
- Surface water / groundwater processes, Floodplain storage
- Climate change

KEY EXPERIENCE

EXPERT WITNESS STATEMENTS

1. Mordialloc Bypass (Freeway) Environment Effects Statement (EES) Inquiry - Planning Panel Victoria; Advisory Committee Hearing, January to March, 2019.
2. Peninsula Hot Springs and Southern Rural Water and St Andrews Beach Country Club Golf Course - VCAT Proceeding No. P2730/2015
3. 320 Mooleric Road, Ombersley (Colal Otway Shire Council and MCG Quarries Pty Ltd) – VCAT Proceeding No. P281/2015
4. Max Castle vs Southern Rural Water - VCAT proceeding no p1348/2007
5. O'Keefe and Brimin Sands Groundwater License Application – Expert report VCAT appeal P205/2008

HYDROGEOLOGICAL ASSESSMENTS AND AUDITS

Anglesea Coal Mine Rehabilitation | Anglesea Victoria

Project Manager and Lead Hydrogeologist

The long-term objective is the development of a pit lake with a self-sustaining circum-neutral stratified water body and discharges from the pit lake which can potentially improve downstream beneficial users in the Lower Anglesea River.

However, within the mine catchment, the geological profile consisting of the Eastern View Formation (EVF) is dominated by a coal lithological unit containing a pyritic siltstone, a form of iron sulfide. As a result, the catchment naturally generates acid when its shallow coal seams (which contain high a sulfur content) come in and out of contact with water and oxygen.

Due to the elevated dissolved metals and acidity within the surface water, active and passive treatment methods have been developed to be incorporated in the Mine Closure Plan to increase alkalinity and reduce dissolved metal concentrations. These methods are summarized in a surface water and groundwater management and monitoring plan and are a critical component of water quality management during the early stages of pit lake development to ensure the long-term objectives are achieved.

The hydrogeological technical studies that formed the basis behind the Mine Closure Activities were:

- Sub Catchment Scale Geochemical Modelling
- Numerical Groundwater Modelling
- Water Quality Baseline sampling and Analysis
- Pit and Spoil pH Balance Assessment
- Risk assessment in accordance with AS/NZ ISO 31000:2009; and
- Management of civil design engineers tasked with works on waterways, surface water diversion structures and dam analysis

Rehabilitation of the Point Henry Refinery | Geelong, Victoria

Technical Hydrogeologist

Chris was tasked with peer reviewing 3rd party hydrogeological reports as well as developing regional and site hydrogeological models. This led to the development of a groundwater monitoring network in which Chris assisted in supervising the installation of over 200 groundwater and soil gas monitoring bores.

Residential Development Impact Assessment, New Gisborne | Colanz Pty

Project Engineer

Project engineer involving a desktop assessment, site visit and field investigations to provide Colanz Pty Ltd with technical advice upon the impact of a residential development on the racecourse reserve Marshlands. The project involved drilling, instillation and sampling of 6 licensed groundwater investigation bores. A short-term pumping test and analysis was also performed.

Securing Sustainable Groundwater for Aspire Zone | Aspire Zone Doha, Qatar

Project Manager

The Leisure Land precinct adjacent to Aspire Zone in Doha, Qatar was irrigated with potable water supplied by Khara-Maa. Due to high costs and the possibility of Khara-Maa tightening supply, Aspire Zone wished to replace or augment this supply with a suitable supply of groundwater. As such, a hydrogeological study was undertaken to characterise the quality and quantity of groundwater that can be extracted and to design an extraction regime. Chris project managed a series of hydrogeological investigations on the proposed site. This included a desktop analysis of the characteristics and history of the aquifer and surrounding area. Drilling, completion and sampling of 13 boreholes. Pumping tests and analysis to determine optimum well yield and aquifer parameters; Development of a numerical model of the physical resource and to test various well-field configurations that may be used in the development of the groundwater resource.

LGL Ballarat Groundwater Monitoring System | Lihir Gold Limited

Assistant Auditor

Assistant auditor to conduct an audit of the groundwater monitoring system at LGL Ballarat as part of EPA Works Approval No WA63536. The works approval is to allow LGL Ballarat Pty Ltd to store recycled brine within the Terrible Gully Tailings Storage Facility (TSF) at the Woolshed Gully Site in Ballarat. The audit objectives were to the assess the adequacy of the groundwater monitoring program, and to provide recommendations for any additional measures required

Canberra Managed Aquifer Recharge Scheme, Federal Treasury

Project Manager and Technical Hydrogeologist

Project manager and technical hydrogeologist to assist the ACT Government to reduce the demand on the mains water supply, by 12% by 2013 and 25% by 2023. This was partly achieved by stormwater harvesting, storage and recovery as a means to help the ACT Government achieve these targets.

In order to identify suitable areas for this type of MAR scheme to occur, the project involved exploratory geophysics, groundwater bore design and installation, geochemical modelling and other hydraulic information to assist in the procurement and detailed design of surface infrastructure to trial a MAR scheme in the northern suburbs of Canberra. The project found one of the highest yielding parts of the Canberra Formation investigated to date (>50 l/s) which allowed the ACT Government to store and recover more water than anticipated.

Western Metropolitan Melbourne MAR Feasibility, Melbourne Water

Project Manager

Project manager for a regional review on the feasibility for a 1-2GL/year type MAR schemes across western metropolitan Melbourne for irrigation and third pipe in new suburb developments. The initial phase was to complete a desktop assessment of the groundwater conditions at a number of strategic distribution locations in the region, including the presence, quality and depth of groundwater (both in the shallow and deeper aquifers and movement between these aquifers) and to assess the suitability of these aquifers for the storage and extraction of captured water. The desktop assessment was undertaken in accordance with the National Water Quality Management Strategy guidelines for Managed Aquifer Recharge (MAR), published in July 2009. The final phase of the project focused on the most promising locations, based on the outcomes of the Entry Level and Stage 1 Risk Assessment, and collecting site specific data and conceptualising the potential MAR scheme with the groundwater conditions to develop an understanding of the key data gaps and work required to progress a MAR scheme in the area.

to ensure the risk to the beneficial uses is minimised and maintained at an acceptable level.

Development of an Victorian Index of Groundwater Condition | Dept of Sustainability and Environment

Project Manager

Project manager and lead hydrogeologist for developing the Victorian Index of Groundwater Condition (IGC). An online user friendly tool which identified which aquifers within Victoria were under stress from either human or environmental factors. The project involved a trial in six aquifers assessing their beneficial use and "naturalness" for groundwater quality, quantity, environmental support and physical characteristics.

Determining Victoria Groundwater Age for Management Options | Dept of Sustainability and Environment

Project Manager

In Southern Australia, groundwater became a significant freshwater resource since the onset of the drought in the (mid 1990's to late 2000's), with the rates of bore installation and extraction of water from aquifers increasing during this time. Whilst the drought has led to many declining groundwater levels across the State of Victoria, it has also facilitated studies involving isotope hydrogeochemistry to better understand surface water / groundwater interactions, groundwater flow paths and age of the resource. Chris was the project manager and lead hydrogeologist to conduct a desktop literature review and collect additional field data involving carbon-14 (14C), tritium (3H), chloride-36, (36Cl) and chlorofluorocarbons (CFCs) dating to determine the ages of the groundwater in "key areas" of Victoria. The results helped set sustainable future allocation limits for groundwater extraction.

Yarra Valley Water Hydrogeological and Geophysical Assessment | Coca-Cola Amitil

Project Manager

Project manager of a desktop study followed by on-site investigations in the Yarra Valley region of Victoria to identify a new groundwater source which will supplement existing bottled spring water supplies and assist in making amendments to the existing groundwater extraction license on the site. The hydrogeological assessment involved geophysics, baseflow impact calculations into the Don River and surrounding rivers as well as analysis of isotope geochemistry.

Impacts of the Donald Wastewater Treatment Plant | Grampians Wimmera Mallee Water

Project Manager

The Donald Wastewater Treatment Plant (WWTP) is situated near the Donald township and the Richardson River and came under question by the Donald Neighbourhood Environment Improvement Plan (NEIP) that operations at the WWTP are having a negative effect on water quality in the Richardson River via leaching of nutrients and contaminants to the watertable, with contaminated groundwater discharging to the river as baseflow. Chris project managed and undertook an investigation whether the WWTP and its operations are resulting in adverse impacts on the river. The project involved the collation of data and site history. A review of the monitoring program, including the sampling methodology to determine reliability of the monitoring results was undertaken and soil infiltration potential was calculated. The assessment concluded that there has been no evidence of treated wastewater impacting the Richardson River via baseflow, however, localised contamination could be identified in other areas of the landscape. Suggested improvements to the current monitoring programs and remedial actions which may mitigate any identified or potential environmental impacts to the River in the future were made.

Development of a Groundwater and Irrigation Drainage Monitoring, Evaluation and Reporting (MER) Plan | Mallee Catchment Management Authority

Project Manager

Project manager who was responsible the development of a groundwater and irrigation drainage Monitoring, Evaluation and Reporting (MER) plan to help identify which parts of the landscape are sufficiently being monitored and those where threats related to groundwater and irrigation drainage are deficient. The project was a large Microsoft Access and GIS database which was accepted by the Mallee CMA in 2006.

Lake Corangamite Groundwater Modelling | Corangamite CMA

Project Manager

Lake Corangamite is a terminal lake within the Corangamite River Basin in south western Victoria. In the past, water has been diverted away from the lake to the Barwon River via the Woady Yaloak diversion scheme. This resulted in relatively low water levels and increased salinity which in part has been exacerbated by drought conditions over the past decade. Chris project managed and developed a steady-state numerical groundwater model (Modflow) for the target region, encompassing Lakes Corangamite, Weering, Gnarpurt, Beeac, Colac, Murdeduke and Cundare Pool. The model was calibrated to best represent the naturally occurring conditions associated with the major lakes and rivers in the area. A number of scenarios trialing the effects of drought, extraction, land-use and lake level were then run. Scenario modelling highlighted the changes to groundwater systems, under a number of different environmental conditions. For drought and extraction scenarios recharge was altered to show the effect on groundwater flow conditions by removing/adding water to the system. The effect of lake level modelling found that changing lake levels altered capture zones and flow paths, as well as changing groundwater divides between lake systems.

Critical Review of the Warrion WSPA Groundwater Management Plan | SRW

Project Manager

In 2002 the Consultative Committee developed the Warrion Water Supply Protection Area (WSPA) (Groundwater) Management Plan to be submitted to the Minister. The plan acknowledged that the PAV was estimated with a low level of confidence and adopted a PAV of 16,500 ML/yr which is greater than the recommended level set out in 2001. On behalf of the Department of Sustainability and Environment, Chris developed a decisions paper detailing recommendations as to any consequent changes to the plan or the plan prescriptions. The paper provided an assessment of the key technical issues related to the development of the Warrion WSPA groundwater management plan. In particular the assessment focused on technical studies related to Groundwater Dependent Ecosystems; Surface water and groundwater connectivity; Acid Sulfate Soil potential; and Groundwater level trends.

Determine a New Method for Assessing the Status of Dryland Salinity Across Victoria | Dept of Sustainability and Environment

Project Manager

The 2000 National Land and Water Resources Audit estimated that 670,000 ha of land was at high risk from shallow water tables (equivalent of high dryland salinity risk) in Victoria. The Audit then predicted that by the year 2050, the risk of dryland salinity in Victoria would increase by over 450%. However, by 2008 only 256,194 ha of mapped dryland salinity existed (this equates to a 76% reduction of the Audit's prediction for 2008. With this new evidence, Chris project managed a review that assessed the extent and nature of the current dryland salinity risk, identifying and discuss the major factors influencing this and describe the likely future outlook to the year 2015 and 2050 for two areas in Victoria these being the Corangamite Catchment Management Area (CCMA) and the North Central Catchment Management Area (NCCMA). The outcomes of the review provided recommendations to DSE on future policy directions for dryland salinity management across the areas and eventually across the State. These were then later adopted in the 2008 Biodeversity white paper.

Determining Water and Salt Balances for the Murray-Darling Basin End-of-Valley Target Sites | Murray Darling Basin Authority

Project Engineer

The project involved collation of all available flow and electrical conductivity (EC) data for the 32 Murray-Darling Basin End-of-Valley target stations for the benchmark period (1975-2000). Various statistical methodologies were then used to explore the raw data with the use of flow, EC, and saltload exceedance curves. Estimation of historical stream salinity trends for the benchmark period using the GENSTAT statistical software, and Estimation of historical catchment salt balances for the last 15 years of the benchmark period (1985-2000) was then undertaken. The results were used as a basis for policy development for environmental flow and water allocation issues throughout the Murray-Darling Basin.

Defining Groundwater Flow Systems (GFSs) on the Victorian Volcanic Plains to Accurately Assess the Risks of Salinity and Impacts of Changed Land Use | Corangamite Catchment Management Authority

Project Engineer

The project involved the development a 3D geological and hydrological numerical model using GMS MODFLOW and ARC Hydro to produce images of the lithology and groundwater chemistry under the Victorian Volcanic Plains (VVP) of western Victoria. The model was then calibrated using water level and chemistry data. The model improved our understanding of the hydrological processes across the VVP and helped delineate where local, intermediate and regional GFS dominate the salinity processes. The model also helped establish the cause(s) of rising salinity trends in the VVP as described in the Corangamite Regional Salinity Action Plan and enabled new targets to be established on saline land to measure the risk to the ecology from either increasing or decreasing salinity as described in the Corangamite Regional Salinity Action Plan.

COAL SEAM GAS EXPERIENCE

Tier 1-3 Groundwater and Soil Gas Risk Assessments | South West Queensland

Technical Hydrogeologist and PM 2

The project involved management and coordination for a major Oil and Gas Company to undertake a soil gas investigation and risk assessment works in the relevant parts of the regulator-imposed "Excavation Caution Zone (ECZ)" close to Chinchilla (QLD).

The over-arching strategic objectives were to undertake a phased approach to:

- Undertake a risk assessment and develop control measures to mitigate identified risks; and
- To demonstrate that CSG development in the relevant overlapping parts of the ECZ can be conducted safely with acceptable and mitigated risk to employees, the community and the environment.

More specific project objectives include:

- Assess and characterise shallow geology and delineate the likelihood of potential UCG combustion gases in the shallow soil/weathered rock profile being present within the study area;
- Assess human health and environmental risk exposure pathways and risks associated with the identified likely combustion gases within the ECZ/Orana gas field overlap area;
- Assess the potential for contaminants associated with the UCG site to be mobilised due to CSG development operations.

Roma Managed Aquifer Recharge Scheme, Santos

Senior Project Manager and Technical Lead

Senior project manager and technical lead for the Roma Managed Aquifer Recharge Scheme valued at $18M over 2 years. The project initially involved drilling design, supervision and pump testing deep (>250m) groundwater observation bores and injection wells used to trial water injection into the Great Artesian Basin (South-East Queensland). Results from the trial (which included hydrochemical analysis and numerical modelling) lead to the development of detailed design requirements for the installation of large scale MAR scheme consisting of up to 8 injection wells and 12 observation bores targeting deep (up to 600m) beneficial use aquifers capable of receiving up to 20-30ML/d of treated CSG water.

Multiple Irrigation and Groundwater Assessments, Origin Energy South West Queensland

Technical Lead and Project Manager

Origin wished to expand the areas of irrigation using treated coal seam Gas water at several locations, however it is understood that irrigation rates that exceed the internal drainage capacity could potentially lead to seepage and discharge of saline irrigation water to surfacewater systems. As a result, for each area, Chris undertook a study that involved a hydrogeological investigation and development of a numerical groundwater model to assess the potential for seepage and associated impacts of irrigation.

Santos GLNG Well and Bore Integrity Risk Assessment, Santos

Project Manager and Technical Lead

Santos GLNG has expended considerable effort in the management and maintenance of the aquifers and the prevention of aquifer interconnectivity. However, to date all of this work has not been integrated into a single plan or report. This project provided a systematic review of the well installation processes, the management and assessments completed by Santos GLNG to date, and an assessment of the potential risks posed by existing and proposed wells. Through this process, Santos GLNG demonstrated that aquifer interconnectivity arising from well or bore failure has been adequately considered in the development program, and the methodologies used for drilling, completion and abandonment of CSG wells are sufficient for management of long term risks.

Well Integrity Risk Assessment, Confidential Client

Project Manager and Technical Lead

Chris undertook a risk assessment for a proponent which evaluated common mechanism of failure for historic conventional oil and gas wells, CSG wells, and private landholder water bores. The likelihood and consequence of failure was also addressed, and the methodology used is adaptable to future development areas.

The risk assessment demonstrated that historical conventional oils and gas wells posed the highest risk relative to CSG production wells for gas migration to surface and inter-aquifer interaction. Private landholder water bores were also considered in terms of gas and fluid migration. While the majority of these bores were constructed in a relatively unregulated industry (during the early 20th century), they pose a low risk of cross aquifer flow being low. These bores are generally located above potential coal seam or conventional gas targets resulting in low risk of gas migration.

By using this desktop approach, the proponent can satisfy community, State and Federal environmental concerns, as well as recognizing significant cost or cash flow reduction (multi millions) as management actions including risk-based monitoring, inspection and plug and abandonment decisions could be implemented and prioritized based on the relative magnitude of risk.

Armour Energy, Identifying Sources of Sustainable Water for 2014/15 Shale Gas Drilling Program

Project Manager and Technical Lead

Chris undertook the following tasks:

1. Reviewed existing environmental values and surface water characteristics
2. Assesses groundwater characteristics within the project area with a view to completing a baseline assessment
3. Summarise the system's capability to take water from either the surface or the groundwater system.

The results found across the eastern half of ATP 1087, water is likely to be available from both surface water (Nicholson River) and groundwater options.

Across the western half of ATP 1087 no perennial surface water systems exist with only intermittent and ephemeral river systems being available for potential water extraction. Water in this region should focus on groundwater within the Walford Dolomite which known to contain water bearing lenses.

Bibblewindi Study, Santos

Technical Lead

The study involved an assessment of the potential impacts of brine seepage and development of remedial alternatives for groundwater. A detailed hydrogeologic conceptual model was developed using hydrogeologic and geochemical analyses to assess the magnitude of impacts and leakage and the fate and transport in groundwater. Using information on groundwater and soil/bedrock chemistry the maximum lateral extent of impacts was determined and a groundwater extraction system designed and installed.

Tintsfield Study, Santos

Technical Lead

Hydrogeologic and geochemical assessment of coal seam water storage ponds. The study involved a detailed assessment of hydrogeologic data and groundwater geochemistry to assess the potential for pond leakage and impacts in the perimeter groundwater monitoring network. The study demonstrated that the pond was not significantly impacting groundwater and a long-term monitoring program, better focused on groundwater geochemistry, was developed to assess the potential for leakage.

Development of an EMP for an Underground Coal Gasification Pilot Trial, Confidential Client

Hydraulics Technical Lead

This project involved completion of a risk assessment and development of an EMP for an Underground Coal Gasification Pilot Trial in South East QLD. An underground gas storage risk assessment was conducted to determine the adequacy of geological strata for the trial. The project also involved understanding contaminants of concern and undertaking a toxicology risk assessment. A fate and transport model was also undertaken as well as risk-based rehabilitation and remediation plan.

Gunnedah Managed Aquifer Recharge Scheme, Santos

Project Manager and Technical Hydrogeologist

Project manager and technical hydrogeologist to assess the viability and risks of a proposed managed aquifer recharge scheme in the Gunnedah-Oxley basin, NSW. The project involved assessing the hydrogeological properties of the region, developing a numerical model to estimate impacts, and undertaking a risk assessment and priority matrix to define priority areas for MAR.

Narrabri Managed Aquifer Recharge Scheme | Santos

Project Director

Project director of a proposed MAR scheme where treated CSG water would be discharged in to the base of a deep alluvial creek system in the Narrabri region, NSW. The project involved geophysical transect to determine the storage capacity of the system as well as laboratory analysis of core samples to determine geochemical compatibilities and surface water / groundwater interactions. Liaison with the NSW Office of Water was also a key consideration of the project with all approved outputs being used to assist in the procurement and detailed design of surface infrastructure to trial a MAR.

Scotia Managed Aquifer Recharge Scheme, Santos

Senior Project Manager and Technical Lead

Senior project manager and technical lead for the Scotia Managed Aquifer Recharge Scheme. The project involved an assessment of the groundwater conditions underneath the site, including, coring 500m of aquifer material with XRD/XRF analysis, design and supervision of large diameter, deep injection wells, pumping tests, geochemical compatibility modeling, and detailed design criteria for the procurement of surface infrastructure. The project was undertaken in accordance with the National Water Quality Management Strategy guidelines for Managed Aquifer Recharge (MAR), published in July 2009.

Surat Basin Flow and Solute Transport Numerical Model, Santos

Project Manager

Project manager for the development of a flow and solute transport numerical model. The model was designed to simulate cumulative impacts of a proposed MAR scheme in the Roma CSG field and its potential impact on surrounding landholders and town water supply bores. The model was also used to inform injection pressure calculations and pipe diameter sizing for the EPCM contractor to factor in to the engineering detail design.

Arrow Energy MAR Feasibility Options Analysis, Arrow Energy

Project Manager

A review up to 50 Managed Aquifer Recharge (MAR) schemes from around the world, its objectives and results (if a trial has occurred) was undertaken. The results were then used to guide Arrow Energy's water management strategy involving MAR.

Publications and Presentations

Smitt, C., Goulding, N., and Silverman, T., (2014). Surat Basin Well Integrity Risk Assessment. In Proceedings of the American Society of Civil Engineers (ASCE) Shale Engineering Energy Conference, Pittsburgh, Pennsylvania, July 21-24.

Smitt, C., Vanderzalm, J., Dillon, P., Ife., D and Davidge, S., (2012). Aquifer Recharge to Assist in the Management of Produced CSG Water. in Proceedings of 2012 Annual APPEA Conference, Adelaide.

Smitt, C., Vanderzalm, J., Dillon, P., Ife., D and Davidge, S., (2011). Aquifer Recharge to Assist in the Management of Produced Coal Seam Gas Water. in Proceedings of 2011 National Groundwater Association Spring Meeting, Baltimore, Maryland.

Dahlhaus, P., Cox, J., Simmons, C., Smitt, C., (2007). Beyond hydrogeologic evidence: challenging current salinity models in the Corangamite region, Australia. Hydrogeology Journal HJ-2007-0621

Smitt, C. M., Cox, J. W., Herczeg, A., Wilford, J., Henschke, C., Liddicoat, C., and Walker, G., (2006). The origins, mobilisation and management of salt in the Eastern Mt Lofty Ranges of South Australia. Australian Journal of Earth Sciences.

Smitt, C., Herczeg, A., Davies, P., and Cox, J (2005). Identifying sources of salt and its mobilisation processes in the Eastern Mt Lofty Ranges, South Australia. in Proceedings of "Where Waters Meet" NZHS-IAH-NZSSS Auckland Conference, New Zealand, 28th November to 2nd December

Smitt, C., Gilfedder, M., Dawes, W., Petheram, C., Stauffacher, M., and Walker, G., (2001). Modelling the Effectiveness of Recharge Reduction for Salinity Management: Sensitivity to Catchment Characteristics, in Proceedings of Murray-Darling Basin Groundwater Workshop, September, Victor Harbor

Appendix B Instructions

HARWOOD ANDREWS
Our ref: 3TED 21900952
Contact: Tessa D'Abbs
Direct Line: 03 9611 0117
Direct Email: tdabbs@ha.legal
Principal Lawyer: Kate Morris

MADDOCKS
Our ref: TGM:7849160
Contact: Sophie Jacobs
Direct Line: 03 9258 3546
Direct Email: sophie.jacobs@maddocks.com.au
Partner: Terry Montebello

28 June 2019

Chris Smitt
EHS Support
Email: Chris.Smitt@ehs-support.com

Subject to legal professional privilege

Dear Chris,

North East Link Environment Effects Statement process

Harwood Andrews act for Manningham City Council and Maddocks act for Banyule City Council, Boroondara City Council and Whitehorse City Council (collectively, the **Councils**) in relation to the North East Link Environment Effects Statement (**EES**) process, the draft planning scheme amendment and the works approval application prepared to facilitate the North East Link Project (**Project**).

We are instructed to engage you to provide expert evidence in the area of groundwater.

An Inquiry and Advisory Committee (**IAC**) has been appointed by the Minister for Planning under section 9(1) of the *Environmental Effects Act* to hold an enquiry into the environmental effects of the Project. The role of the IAC in this regard is set out in paragraph 1 of the Terms of Reference (**TOR**).

The IAC has also been appointed as an advisory committee under section 151 of the *Planning and Environment Act 1987* to review the draft planning scheme amendment prepared to facilitate the Project. The role of the IAC in this regard is set out in paragraph 2 of the TOR.

The IAC is a multi-disciplinary committee. The biography of each committee member is available here.

The IAC will hold a public hearing from **25 July 2019** to approximately 6 September 2019.

A summary of key dates is set out below.

Instructions

We request that you provide a fee proposal to:

1. Review the exhibited documents relevant to your area of expertise and each of the Councils' municipal areas, in particular:
    a) The EES:
        - Volume 1 (Chapters 1 to 8);
        - Volume 4 (Chapters 21 'Ground movement', 22 'Groundwater', 23 'Contamination and soil', 24 'Surface water', 25 'Ecology', 27 'Environmental management framework');
    b) Technical Report N: Groundwater;
    c) EES Map Book;
    d) Attachment III: Risk Report;
    e) Attachment V: Draft Planning Scheme Amendment.

2. Review:

a) The Ministerial Guidelines for assessment of environmental effects under the *Environmental Effects Act 1978* (2006);
b) Manningham City Council's public submission on the EES dated 5 June 2019;
c) Banyule City Council, Boroondara City Council and Whitehorse City Council's joint public submission on the EES dated 7 June 2019;
d) IAC tabled document no. 5 titled *Preliminary Matters and Further Information Request*, dated 20 June 2019;
e) IAC tabled document no. 14 being the Maddocks further information request on behalf of Banyule, Boroondara and Whitehorse City Councils;
f) Clayton Utz initial response to Maddocks further information request dated 26 June 2019 (**attached**);
g) Harwood Andrews further information request to Clayton Utz on behalf of Manningham City Council dated 26 June 2019 (**attached**);
h) the *draft Yarra River Bulleen Precinct Land Use Framework Plan 2019* and Manningham City Council's public submission on this dated 6 June 2019*;* and
i) any other submission or document we subsequently refer to you.

3. Prepare a single expert witness report on behalf of the Councils for circulation that contains your opinion on the following matters, as relevant to your area of expertise:

    a) Does the EES adequately document and assess the nature and extent of the environmental effects of the Project? In addressing this question please explain where you are satisfied with the content of the EES and why, and if not, what if any deficiencies exist in the documentation and/or assessment of the nature and extent of environmental impacts contained in the EES;

    b) Can the Project as described in the EES achieve a level of environmental performance which is consistent with relevant legislation, documented and endorsed policy or acknowledged best practice;

    c) If the Project, as described in the EES cannot achieve a level of environmental performance which is consistent with relevant legislation, documented and endorsed policy or acknowledged best practice, are there any recommendations that you would make as to specific measures which you consider necessary and/or appropriate to prevent, mitigate and/or offset adverse environmental effects? If so, please explain your reasoning in detail. To the extent that it is within your expertise to comment upon the feasibility of any of your recommendations, please state whether or not any recommendations are feasible, explaining your reasoning;

    d) How does the Project as described in the EES respond to the principles and objectives of "ecologically sustainable development" as defined in the IAC's Terms of Reference;

    e) Are there any recommendations that you would make as to specific measures which you consider necessary and/or appropriate to improve the response of the Project to the principles and objectives of "ecologically sustainable development"? If so, please explain your reasoning in detail. To the extent that it is within your expertise to comment upon the feasibility of any of your recommendations, please state whether or not any recommendations are feasible, explaining your reasoning; and

    f) To the extent that the content of the draft planning scheme amendment, works approval and environmental protection requirements lies within your expertise, do you have any recommendations for changes that should be made to the draft planning scheme amendment, works approval or planning approval and/or draft environmental performance requirements in order to improve the environmental outcome of the Project?

4. In due course, review and comment on other parties' expert evidence (groundwater);

5. Attend any conclave of groundwater experts requested by the IAC;

6. Present your expert evidence at the hearing. You should anticipate preparing a short (no more than 30 minutes) presentation to facilitate this. The presentation is to be drawn from your expert witness report and may respond to other expert reports (as relevant).

Please ensure you carefully read and comply with both Planning Panels Guide to expert evidence (DOCX, 81.8 KB), April 2019 and all of the IAC's directions set out in tabled document 15 here (the **IAC's directions**).

Key Dates

Please note the following key dates:

- NELP has offered for its experts to meet with other experts (outside the formal expert conclave process) prior to **5pm Friday 12 July 2019** to discuss issues, view models etc. The IAC has encouraged parties to take up offer in the IAC Directions (orders 4-7). If you would like to take up this offer and meet with a NELP expert before you finalise your expert evidence, please let us know as soon as possible and we will arrange for this to occur.

- Your expert witness statement will need to be circulated by **9.00 am on Monday 15 July**. We kindly ask that you provide us with a copy of the report by **10.00 am on 11 July**.

- A conclave of surface water experts is likely occur (as per order 14 of the IAC Directions). A time and date for this meeting has not yet been scheduled but we expect it to occur during the week of 15 July. We will confirm this as soon as possible;

- Presentation of the proponent's case is scheduled to commence on Thursday 25 July; and

- Presentation of the Councils' case is likely to be scheduled to commence in mid-August. We are waiting on a timetable for hearings to be circulated so will confirm this as soon as possible.

Documents

The exhibited EES documents may be accessed at: https://northeastlink.vic.gov.au/environment/environment-effects-statement-ees/environment-effects-statement-documentation.

Confidentiality

Please keep our engagement of you and the preparation of your expert witness statement confidential until we have notified you that we have circulated your evidence externally or made it publicly available.

If you have any queries, please contact Tessa D'Abbs on 9611 0117 or at tdabbs@ha.legal (acting for Manningham) or Sophie Jacobs on 9258 3546 or at sophie.jacobs@maddocks.com.au (acting for Banyule, Boroondara and Whitehorse).

Yours sincerely,

HARWOOD ANDREWS **MADDOCKS**

Appendix C Request for Clarification

CLAYTON UTZ

Email letter

Mr Terry Montebello
Partner
Maddocks

terry.montebello@maddocks.com.au

26 June 2019

Dear Mr Montebello

RE: North East Link EES - Further information request

We refer to your letter dated 19 June 2019 together with its enclosure.

We confirm that we continue to act for the North East Link Project (**NELP**) in relation to the Joint Inquiry and Advisory Committee (**IAC**) for the North East Link Environment Effects Statement (**EES**), draft planning scheme amendment (**PSA**) and EPA works approval application.

NELP does not accept the assertion contained in your letter that the EES materials released by our client contain significant deficiencies and is inadequate to enable submitters, including your clients, to appropriately assess and understand the impacts of the proposal. Our client is of the view that the EES material is full and comprehensive, and more than sufficient to enable your clients to participate in the EES inquiry process.

Notwithstanding, our client is happy to provide your clients with additional information reasonably requested. Please now find enclosed our client's initial response to your request, and note our client's offer to inspect relevant microsimulation, groundwater and surface water models prior to or as part of any expert witness meeting.

We will provide you with further information in response to your request as soon as it becomes available.

We also await the IAC's directions prior to sending this correspondence to the IAC.

Please don't hesitate to let us know if you have any queries.

Yours sincerely

Sallyanne Everett, Partner
+61 3 9286 6965
severett@claytonutz.com

Enc Sophie Jacobs
Copy sophie.jacobs@maddocks.com.au

Your ref TGM: SAJ:7849160
Our ref 965/21512/80184879

NELP: Additional information request from Maddocks dated 19 June 2019

No.	Information Required	Reason why information necessary	NELP Initial Response
1	Updated horizontal design sheets to a standard scale (e.g. 1:2000, 1:2500); Chainages for all horizontal and vertical alignments; and Vertical alignments for all existing and proposed ramps, busway, C-D roads and intersecting arterial roads (only those for freeway mainline have been shown) with measurements.	This missing information is essential to allow for the proper review of the Reference Design to ensure that issues impacting local governments can be identified and addressed. The Reference Design for the West Gate Tunnel Project included the information requested and it is industry standard to provide requested details on the designs.	Designs are shown in the EES Map Book. Maps in the exhibited material are of the same detail and scale relied upon throughout the process, including through the TRG process. Preparation of plans at the scale requested is not expected to occur until the design and construction phase, and no plans of that scale have been generated at this time. Request for plans at that scale for the whole of the project is an unreasonable request and is not being requested by the IAC. It is also noted that the reason for this request is inaccurate as the West Gate Tunnel Project did not include a reference design.
2	AM and PM peak hour simulated flows on all separate segments (i.e. mainline mid-blocks, all ramps, all C-D roads and connecting arterials), as well as all intersection turning movements for the 2036 no project and project cases. Some of the ramp and mid-block volumes have been provided in the microsimulation result tables but significant gaps exist.	Additional data is needed evaluate sufficiency of the proposed designs, identify likely congestion areas and assess effectiveness/impacts of the proposed interchange and intersection arrangements.	Flows on the freeway mainline and CD's are already presented within the TTIA (see section 9.3.1). Exit ramp volumes are provided within the tables in Appendix D of the TTIA. Approaches to intersections on the arterial roads are also provided within Appendix D. Intersection turning movement details are not provided in the TTIA and have not been provided for previous EES assessments of a similar scale ie West Gate Tunnel and EWL. The level of service analysis provided already provides sufficient insight into the operation of the intersections, as is industry practice. The microsimulation models can be inspected prior to or as part of any expert witness meeting upon request.
3	Calibration/validation report for traffic microsimulation model.	To understand the strengths and weaknesses of the model.	The calibration and validation report was provided and assessed by the peer reviewer. The peer reviewer was satisfied with the level of calibration and the performance of the microsimulation model as outlined in their report in

No.	Information Required	Reason why information necessary	NELP Initial Response
			Appendix A of the TTIA. The microsimulation models can also be inspected prior to or as part of any expert witness meeting upon request.
4	Existing conditions traffic performance outputs from the micro-simulation model.	Given that the existing conditions models have been prepared for the corridor, some level of results should be included to allow interpretation and sense checking of the results and how conditions change in the future	Assessment of traffic performance under existing conditions is not within the scope of the EES because the EES assesses the impacts of the project and not existing traffic performance. The peer reviewer has reviewed the model and its calibration against existing conditions (refer to Appendix A of the TTIA). The microsimulation models can also be inspected prior to or as part of any expert witness meeting upon request.
5	Demand modelling sensitivity tests to show the impact of Suburban Rail Loop and East West Link on traffic demands for NEL. This should be provided in the form of volume difference plots.	Suburban Rail Loop and East West Link were excluded from transport demand modelling, yet if they proceed, they potentially both could have material effects during the life of the project.	The TTIA has relied upon forecast traffic volumes estimated by a strategic transport model. In accordance with demand forecasting guidance published by the State, forecasting assumptions have been sourced from the State's Transport Modelling Reference Case. This document sets out assumptions relating to future land use and demographics, road and public transport networks and cost parameters, the details of which are outlined in Appendix B of the TTIA. The Reference Case at the time of preparation of the EES did not include the Suburban Rail Loop (SRL) project or East West Link. The section of SRL adjacent to NEL is not planned to be opened until beyond 2036 which is the EES assessment year, while EWL does not appear within the reference case.
6	Detailed breakdown of travel time savings by section for key trips.	Travel time savings are mostly given between specific points on the network (i.e. the extremities of the project itself). The effects of traffic redistribution beyond the project physical limits are not included. Key movements that use the NEL should be identified and end-to-end travel time comparisons given for them.	Travel time savings have been provided in two forms, for specific key routes within the study area (for example Figure 9-88) and at a strategic network level for distinct origins (for example Figure 9-92) in Section 9.4 of the TTIA. The strategic network level plots show the impact on travel times of the project well beyond the study area.
7	Comparison of historic traffic data showing how current peak spreading	This information is required to allow better understanding of the effects of peak spreading on	The peak spreading assessment is based on capacity of roads rather than a historical trend. The assessment is based on the two hour peak period and how much traffic can

No.	Information Required	Reason why information necessary	NELP Initial Response
	trends (peak vs shoulder peak) relates to the forecast modelled peak spreading.	congestion.	travel through the network during this time. The assessment in the TTIA is based on the worst two hour peak period. Traffic travelling in the shoulders would be lower than this peak. The microsimulation models can also be inspected prior to or as part of any expert witness meeting upon request.
8	Volume difference plot or histogram showing distribution of change on links to describe the impact of the peak spreading and constraining process.	The modelling approach has applied a constraining process to represent future year peak spreading. The impact that this process has had on the forecast demand is not clear.	Histograms are provided in Figure 4-11 and 4-12 showing the impact of the constraining process of all assessed links within the study area. The microsimulation models can also be inspected prior to or as part of any expert witness meeting upon request.
	Ecological		
9	Results of additional NELP survey following DELWP feedback, showing locations and detail of additional Studley Park Gums *Eucalyptus X studleyensis* identified on Simpson Army Barracks and surrounds.	Required for adequate and holistic assessment of impact on FFG advisory list species.	A Technical Note responding to this issue will be prepared and provided to the IAC. A copy of the draft report that has been provided to DELWP is attached. A key outcome from this report is that a management plan be prepared.
10	Shapefile of: • the project area; • vegetation polygons (habitat zones and 'amenity planting') in Figure 11 of the 'Ecology' technical report; and • areas where stormwater	The PDF maps are too poor in resolution to accurately determine impact. The Shapefiles are requested to accurately determine: • the exact location of the boundary in situations such as on the steep slope between the Eastern Freeway and the Main Yarra Trail immediately west of Willsmere Park; • the amount and other	Consideration is being given to this request and a response will be provided shortly.

No.	Information Required	Reason why information necessary	NELP Initial Response
	treatment wetlands or other Water-Sensitive Urban Design works or Integrated Water Management projects may occur	statistics of 'amenity planting'; and • where flora or fauna may be affected by these stormwater or WSUD/IWM works and make associated assessments.	
11	Any mapping (or failing that, quantification) of how much of the 'amenity planting' contains native vegetation (as defined in the Victoria Planning Provisions (VPPs)), and how much of the native vegetation is subject to the 'planted vegetation' exemption under clause 52.17 of the VPPs.	Some of the 'amenity planting' performs ecological functions and was planted for that purpose with public funds. Clause 52.17 and overlays regulate removal of such vegetation. Overlays also affect other planted vegetation. This will allow assessment of the ecological and regulatory implications of removing the vegetation.	This is addressed at Section 5.4.5 of the Ecology Technical Report Q.
12	Any information obtained by NELP about what compensation the applicable planning overlays (e.g. SLO, ESO) would require for removal of vegetation, whether native or otherwise.	This request is made on the basis that there does not appear to be any reference to providing compensation for the loss of tens of hectares of 'amenity planting' vegetation despite the protection the vegetation is meant to receive from overlays. There also does not appear to be any reference to meeting the requirements (e.g. decision guidelines) of ESOs that go beyond clause 52.17.	This is addressed at Section 12.1.1 of the Ecology Technical Report Q.
	Groundwater		

No.	Information Required	Reason why information necessary	NELP Initial Response
13	Completion details of the 70 groundwater monitoring bores shown in Figure 5-3. At a minimum this should include: • Easting • Northing • Date completed • Surveyed elevation • Screen depths • Completed depth • Standing water level In addition to the completion detail, soil and geotechnical logs are requested	The groundwater Appendix (N) makes numerous mention that some monitoring bores do not screen the first water intersection. Water level and quality information obtained from these bores may not be representative of conditions in the zone of water table fluctuation/shallow part of aquifer where contamination is most commonly identified. This increases the uncertainty in the model. In addition, on Page 96, **GHD State** "there is a limited understanding of connectivity between surface and groundwater throughout the study area". Having this data will allow an independent qualification of this statement. For example, the report does not indicate a vertical groundwater flow (upward or downward). This understanding is essential in determining water balances and aquifer storage. Furthermore, it will allow some conclusions to be made with respect to: — What are the potential effects on water environments and related beneficial uses. What are the potential effects resulting from disturbance or mobilisation of anthropogenic soil contaminants or potential acid sulfate soils.	A groundwater factual report is under preparation, incorporating the results of groundwater investigations that supported the EES groundwater assessment and information gathered subsequently in support of future detailed design development. The groundwater investigation program has targeted conditions influencing tunnel construction as well as regional groundwater quality. It is acknowledged that shallow groundwater contamination may not have been characterized and therefore a series of shallow contaminated land monitoring bores (BH-ENV-series) were installed to target such. Council's expert is invited to inspect the model prior to or as part of the expert witness meeting.
14	Groundwater monitoring	This information is necessary to	This information will be contained in the groundwater factual

No.	Information Required	Reason why information necessary	NELP Initial Response
	details (water level and water quality (Field Parameters, EC, pH, Temperature and Redox) of the 70 groundwater monitoring bores shown in Figure 5-3.	determine beneficial use proposed by the Project, to confirm accuracy of statements made and to assist in groundwater model classification statements.	report. In addition, Council's expert is invited to inspect the model prior to or as part of the expert witness meeting.
15	Output graphs used to analyse the slug test data (30 mores). This should include which method (Bouwer Rice (1976) or Hvorslev (1951) were used to determine the parameter.	Several methods were used to determine the hydraulic conductivity presented in Table 6-6 however the data is not shown. The response of the curves (from the pumping test) give an indication on the reliability of the data. Furthermore, the text mentions use of Hvorslev (1951) which should only be used for Confined Aquifers. We are unlikely to have a confined setting here.	This information will be contained in the groundwater factual report. In addition, Council's expert is invited to inspect the model prior to or as part of the expert witness meeting.
16	Details with time stamps regarding how the proposed vertical (and horizontal) alignment of the Tunnel has changed as the project has evolved.	It has been noted that vertical alignment of the tunnel has evolved during the course of the geotechnical and groundwater investigations. Therefore, if the tunnel has moved in to a different hydrogeological environment or towards an environment receptor, environmental risks may not consider the current proposed alignment	The EES contains an assessment of the North East Link reference project. Any other tunnel designs pursued during project implementation must meet the requirements of the key approvals if obtained and the associated environmental performance requirements.
17	Map of Potential Acid Sulfate Soil (PASS) including along the widening of the Eastern Freeway	Figure 6-13 is meant to show the PASS locations however, none are indicated on the Figure. Having this information would allow some statement to be concluded regarding dewatering	The bore locations where PASS materials were identified from sampling have been shown in Figure 6-13. Further information on where PASS may exist more widely in the vicinity of the project is provided in Figure 6-13 of Technical Report O Contamination and soil.

No.	Information Required	Reason why information necessary	NELP Initial Response
		impacts. For example, if the soil/geology is dewatered (i.e. exposed to Oxygen), soils and water can become acidic (low pH). This may impact deep-rooted vegetation, aquatic flora and fauna. In addition, the water can be aggressive to reactive materials (such as concrete, steel) of foundations, underground structures (such as piles, pipes, basements) or buried services in contact with groundwater.	
18	Hydrogeological cross sections of mapped GDE's: • Banyule Swamp • Bolin Bolin Billabong • Kew Billabong • Koonung Creek floodplain • Plenty River floodplain • Banyule Creek • Salt Creek	This information is required to determine potential drawdown or other impacts as a result of tunnelling and deep excavations. Information can be combined using rooting depths and salinity tolerances which are provided in Technical report Q – Ecology.	The EES groundwater assessment report includes some hydrogeological cross sections, e.g. Bolin Bolin Billabong, however, cross-sections are not included for all of the locations specified in the request. It is noted that some of these GDEs e.g. Salt Creek, Plenty River, Kew Billabong, and Koonung Creek are remote from where tunneling or deep excavations are proposed in the reference project and are therefore beyond areas with a reasonable chance to be affected by groundwater drawdown. The IAC has asked a number of questions about the hydrogeological data. Council's attention is drawn to the IAC's request which we are preparing responses to.
19	Melbourne Water Cross Sections of the Bolin Bolin Billabong and surrounding area (references in Page 15 (Appendix C, groundwater modelling report (of Appendix N).	This will verify the setup of the numerical model in this area.	The Melbourne Water survey plan is available and can be requested from Melbourne Water but wasn't included in the EES / modelling report. Data from the plan was incorporated directly into the numerical model.
20	Geotechnical investigations used in Table 5-7 to conclude there is connectivity	Table 5-7 (Appendix N) qualifies that surface water and groundwater connectivity exists, however this is not quantified	The geotechnical investigations upon which the lines of evidence for connectivity between surface water and groundwater are contained in Appendix A of the EES groundwater assessment.

No.	Information Required	Reason why information necessary	NELP Initial Response
	between surface water and groundwater.		
21	Data and description behind Figure 14 (Page 25 of Appendix C, groundwater modelling report (of Appendix N).	This Figure is not referenced in the text and the descriptors on the x-axis cannot be matched to a geological unit. This needs to be clarified with the data provided to determine aquifer behaviour and conformance with the proposed CSM.	Aquifer test information is documented in the groundwater factual report described in 13 above. Council's expert is also invited to make inquiries of the model prior to, or as part of, the expert witness meeting.
22	Description and consideration of the groundwater impacts of the proposed widening of the Eastern Freeway	Whilst the widening of the Eastern Freeway may not directly impact groundwater, over time, changes to the surface water system, recharge processes and ground water flow dynamics may cause changes to the groundwater flow regime. This has not been taken into consideration in the EES as it was considered low risk to groundwater. How it was concluded that it is low risk and how it is concluded that it does not need to be assessed is not set out in the EES.	The impacts of freeway widening elements present a low risk. Nevertheless, the groundwater EPRs developed provide suitable protection for groundwater systems.
23	Results of any additional NELP groundwater investigations in the vicinity of Borlase Reserve and Banyule Swamp, not included in the EES.	Required for adequate assessment of all potential groundwater impacts.	Additional groundwater investigations are proposed in Borlase Reserve including a pumping test to support future detailed design activities. No additional groundwater investigations are currently proposed at Banyule Swamp, apart from water level monitoring in bores in the regional network.
	Groundwater		
24	Flood hazard mapping / modelling outputs	To assess and understand the impact of the reference design with respect to flood hazard.	The EES contains mapping of both changes in depth and changes in velocity which are considered to provide a good indication of potential changes to flood hazard. See section 9 (operation impact assessment) of Technical report P –

No.	Information Required	Reason why information necessary	NELP Initial Response
			Surface water for mapping of impacts during operation of North East Link. Council's expert is also invited to inspect the model prior to or as part of the expert witness meeting.
25	All flood models (hydrological and hydraulic) and results / outputs for assessment of base case / existing flooding and impact of reference design	To assess if the Project has been appropriately represented within the flood models and compared to base case models.	Council's expert is invited to inspect the model prior to or as part of the expert witness meeting.
26	Details of why differences in modelling approach exist across catchment areas	The best available information does not appear to have been used as has been suggested.	Council's expert is invited to inspect the model prior to or as part of the expert witness meeting.
27	Details of the proposed augmentation of the existing retarding basin in AK Lines Reserve	This is a Council asset and Council need to assess the impact of the proposal on the function of the basin particularly when it proposed to contain a wetland in the base of the basin.	The reference design is a concept that has been developed to understand the issues and constraints. The EES includes some discussion of AK Lines reserve in section 9.1.1 of Technical Report P – Surface water. There have also been discussions with Council. The final design is a matter for the detailed design and construction phase. The EPRs requires this to be done in association with the Council.
28	Full details of blockage considerations	There is little detail provided regarding blockage considerations and it appears that this has not been assessed in any detail.	Blockage has been specifically referred to within EPR SW6 in recognition that it may be more relevant for alternative design outcomes.
29	All proposed drainage assets including locations where proposed drainage will be discharged to and proposed ownership of drainage assets	To assess flooding, drainage capacity and water quality impacts associated with reference design.	Details and ownership of potential assets has been discussed at length with Councils and other drainage authorities. The reference design is appropriate to establish the acceptability of drainage impacts.
30	WSUD asset details including: • Confirmation of WSUD asset	To enable a more detailed assessment of the land that will be occupied by and the impact of the proposed WSUD assets at an	The EES includes a relevant amount of detail for this stage of design development. Importantly it has established that there is considerable flexibility in achieving the desired treatment objectives. The EES concept recognizes that with

No.	Information Required	Reason why information necessary	NELP Initial Response
	locations • Confirmation if the footprints make appropriate allowance for ongoing and maintenance provisions (e.g. sediment laydown areas for wetlands • Confirmation of pre-treatment arrangements (e.g. upstream of bioretention assets are GPT's proposed?) • Anticipated ownership of each of the possible WSUD assets • MUSIC modelling inputs and results for each proposed WSUD assets (existing and developed conditions) • have existing WSUD assets been considered in the MUSIC modelling to understand impacts on those asset	individual asset level. No details are provided in the EES with respect to water quality treatment effectiveness at a sub-catchment level nor impact on existing WSUD assets. There are also inconsistencies in what is shown across various documents with respect to WSUD locations. Map books identify locations but are inconsistent with surface water report, e.g. no WSUD at M80 interface but there is WSUD identified immediately south of Lower Plenty Rd on map books which is contradictory to surface water report. Need to understand where assets are proposed to be located to assess and confirm impact.	further design development and negotiation some potential sites may become more challenging or constrained and may need to be downsized or removed. The final location and detail of WSUD features is not known at the EES stage and is likely to continue to evolve throughout the design process. The EES documentation provides an indication of potential outcomes it is unlikely to be the final design solution. MUSIC modelling has considered both existing and potential WSUD assets. Given the early conceptual nature of the WSUD features, it is appropriate that the EES includes a high level discussion of these modelling results. It is not normal for high level concepts to be detailed to any greater degree at and EES stage particularly when the performance objectives are so easily met. Whole of life cycle costing and ownership has not been detailed in the EES as this will be dependent on the final details

No.	Information Required	Reason why information necessary	NELP Initial Response
	• Whole of life cycle costing (e.g. construction, maintenance, renewal) for each WSUD asset.		
31	Any recorded water quality data that has been collated either during the preparation of the EES or since finalisation of EES	To gain a greater appreciation for current / baseline water quality conditions.	No additional water quality information has been collated either during the preparation of the EES or since finalisation of EES.
32	Details of the flood walls required to protect the tunnel entrance northern end from the Probable Maximum Flood (PMF). This includes location, extent, height etc.	To understand the scope / significance of the works and whether alternatives are possible.	The EES provides information regarding the concept and potential features of the northern portal recognizing that a range of design alternatives are possible. Section 5.6.1 item 2(i) contains the following text which may assist with your understanding of likely project outcomes. "*For the northern portals, the flows are generally small enough that the barriers protecting the portals would be higher than needed for the PMF for other reasons such as excluding pedestrian, cars and bicycles. This same relatively high barrier to flood level height generally also applies to the adjacent northern sections of the open cut roads.*" Further information is also provided in Section 9.1.4.
33	All functional details of the proposed retardation asset on the northern side of Lower Plenty Road. Who will own this asset?	This asset has not been presented in any visual imagery at this location. There are concerns how this will fit in amongst the proposed road works and serve the required function.	The EES provides information regarding the concept and potential features of the storage to the north of Lower Plenty Road recognising that a range of design alternatives are possible refer discussion in Section 9.1.4. Ownership of this asset or its equivalent will be agreed at a suitable time once there is sufficient detail of the actual asset to enable meaningful discussions.
34	Confirmation of how much storage within the Yarra River floodplain is lost as a result of the proposed works	To understand the volume of flood storage that should be offset to avoid cumulative impacts	In the context of storage within the Yarra River floodplain (specifically the Chandler Basin) the reference design has no impact on small events and modelling shows no noticeable impact on larger events. The potential for cumulative impacts is discussed in Section 11 of the EES. The need for and extent of any mitigation will be dependent on the final design and discussions with Melbourne Water regarding the potential for impact.

No.	Information Required	Reason why information necessary	NELP Initial Response
35	All surveyed drainage asset details	To ensure that the flood models have used this data and to confirm that assets requiring survey (where data gaps may exist) have been surveyed	Relevant data has been used in the flood model and Council's expert is invited to make inquiries of the model prior to, or as part of, the expert witness meeting.
36	The level of protection achieved for the Bulleen Road tunnel entrance.	To understand for which storm event the tunnel entrance is at risk of inundation.	The flood maps show an exceedance of a 1% AEP event in the reference project.
37	Intended operation of spill containment assets. Will they be manually operated or operated without human intervention?	To understand the risk to water quality if spill containment assets are not operated appropriately.	The designs adopted for North East Link would be determined during the detailed design phase for the project in accordance with EPRs SW1, SW2 and SW3.
38	Confirm how the impacts of the ARR16 sensitivity runs were identified. Were the results for mitigation conditions compared to the same temporal pattern for existing conditions and selected as being the closest to the mean?	It is possible that the reference design could change the critical storm duration and temporal pattern across the project area. Need to understand how this assessment accounted for this.	Existing and proposed conditions were assessed individually and then compared as indicated in the heat maps provided in Appendix F of Technical report P – Surface water . Council's expert is invited to make inquiries of the model prior to, or as part of, the expert witness meeting.
39	Spill risk assessment for the project	We need to understand if appropriate mitigation measures are proposed to address the risk of spills.	The requirements for spill containment are defined in EPR SW2. This EPR requires a risk assessment as part of the detailed design process.
40	All stormwater quality and water balance modelling (e.g. MUSIC models, spreadsheets and supporting information) demonstrating changes in runoff volumes as a result of the project	Require a greater understanding of the impact of the proposed works with respect to volumes being discharged into downstream waterways. It is expected that this information would have been created to assess geomorphology impacts	Council's expert is invited to make inquiries of the model prior to, or as part of, the expert witness meeting.

No.	Information Required	Reason why information necessary	NELP Initial Response
41	Further details regarding compensating Flood Storage Locations (CFSL). What target level of service are they designed for? What form will they take?	Need to understand the extent of these works, how they will operate and what benefit they provide such that there impact can be assessed.	The provision of CFSL is a preliminary allowance to understand the potential requirements for attenuation. The preliminary sizing was based on retarding peak flows from the road catchment to predeveloped conditions for the 10 % AEP event.
42	Further details of potential mitigation works for Kempston Street Main Drain and Koonung Creek	The surface water Technical report suggests ***"The effects and potential*** *mitigation mechanism are still being refined for Kempston Street Main Drain and for Koonung Creek, with the expectation that design development and modelling would verify that downstream impacts can be* ***mitigated."*** An understanding of these refinements needs to be understood to assess the impact.	At the time of publishing the EES the modelling provided an indication of the potential impacts. The impact assessment for Kempston Street Main Drain and Koonung Creek and proposed mitigation measures are presented in section 9 of technical report P – Surface water. The EPRs have been written with an understanding that the EES is based on a reference design.
43	Confirm impact of project on performance of existing wetland adjacent to Koonung Creek	Technical Report outlines that ***"project assets may directly impact the*** *performance of an existing water quality asset such as the wetlands south* ***of the Eastern Freeway adjacent to Koonung Creek."*** The impact needs to be quantified to provide an understanding of what works will be required to offset the impact	The reference design requires the relocation of some existing water quality assets, the final design may be similar or different. The MUSIC modelling confirms that the performance objectives are achievable with replacement assets. There are a number of supporting EPRs however the dominant project requirement in this regard is EPR SW14.
44	Details of non-potable water use for construction activities. Does the use of non-potable water for the project meet VicRoads objectives?	Need to understand if non-potable water will be used for construction activities. Other large road infrastructure projects have detailed an approach to non-potable water use. It is also a requirement of VicRoads IWM Guidelines as follows "*To this end, VicRoads objectives are*	These objectives are referenced in EPR SW11. A detailed assessment of how they may be achieved is typically undertaken during the detailed design phase of a project.

No.	Information Required	Reason why information necessary	NELP Initial Response
		*that, by the end of 2015, 80% (by volume) of all water used during road construction, and 40% of all water used for regional projects and maintenance, is non-**potable.**"* Does the project achieve this objective?	
45	All details of climate change assessment as part of water quality and flow regime impact assessment	It appears that only climate change has been considered in the flooding impact assessment. Details are required for the assessment undertaken to assess impact on water quality and flow regime.	The EES includes climate change requirements in both EPR SW13 and EPR SW14. Due to the uncertainties of future conditions, climate change impacts are generally assessed using sensitivity analysis and by adopting conservative design criteria as appropriate.
46	Any information relied upon to assess the performance / condition of WSUD assets	This information is needed to understand what assumptions have been to enable an impact assessment of the project on these assets	The EES has adopted industry standard approaches and using these demonstrates that the objectives can be met refer Section 9.2.1 and to a lesser extent other parts of Section 9.2.
47	Any available information to confirm the groundwater connection between the Banyule Swamp and Banyule Billabong	**The Groundwater Technical Report suggests "Connection betwee**n Banyule Swamp and Banyule Billabong with groundwater is not known (Melbourne Water *date unknown*)**.". To assess impact of project at this** location it is expected that further investigations would have been undertaken.	Consideration is being given to preparing a relevant technical note for the purposes of the IAC.

Appendix D Ministerial Guidelines for Groundwater Licensing and the Protection of High Value GDEs (DELWP, 2015)

MINISTERIAL GUIDELINES FOR GROUNDWATER LICENSING AND THE PROTECTION OF HIGH VALUE GROUNDWATER DEPENDENT ECOSYSTEMS

I, **Lisa Neville MP**, as Minister administering the *Water Act 1989*, issue the following Guidelines.

Hon Lisa Neville MP
Minister for Environment, Climate Change and Water

Date: 13/4/15

PART 1 GENERAL

1. CITATION

These Guidelines may be cited as the Guidelines for Groundwater Licensing and the Protection of High Value Groundwater Dependent Ecosystems.

2. COMMENCEMENT

These Guidelines come into operation seven days after the date they are signed.

3. DEFINITIONS & INTERPRETATION

"the Act" means the *Water Act 1989*.

"approved groundwater management plan" means:

a. a groundwater management plan approved under section 33A of the Act; or
b. a local groundwater management plan.

"confined" means an aquifer that is separated from land surface by 40 metres or more of aquitard thickness.

"delegate" means the Minister for Water or delegate responsible for issuing licences under section 51 and their transfer under section 62 of the Act.

"drawdown" means is the change in head or water level relative to background condition.,

"feature" means any physical feature that groundwater is a part of, or interacts with, such as an aquifer, discharge to spring, rivers or wetlands.

"gaining" means the process whereby groundwater is flowing into surface water, whether on a temporal or permanent basis.

"**groundwater dependent ecosystems**" means those ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain the communities of plants and animals and ecological processes they support, and ecosystem services they provide.

"**groundwater level**" is defined for unconfined and confined aquifers as follows:

a. For an unconfined aquifer it is the depth below the surface where the groundwater pressure equals the atmospheric pressure.
b. For a confined aquifer it is the potentiometric pressure, the level to which a column of water rises within a bore intersecting the aquifer.

"**groundwater licence**" means a licence issued under section 51 of the Act for taking and using water from a bore.

"**Guidelines**" means the Ministerial Guidelines for Groundwater Licensing and the Protection of High Value Groundwater Dependent Ecosystems (this document).

"**high value ecosystems**" means those ecosystems that are recognised by State and National Governments as being significant for their environmental values; including but not limited to:

a. Ramsar listed wetlands as identified in the Australian Wetlands database of the Commonwealth Government wetlands listed in the Directory of Important Wetlands in Australia of the Commonwealth Government
b. Heritage river areas under Schedule 1 of the *Heritage Rivers Act 1992*
c. species and communities listed under the *Flora and Fauna Guarantee Act 1988* of the Victorian Government or the *Environment Protection and Biodiversity Act 1999* of the Commonwealth Government
d. priority environmental values set by waterway managers, including those identified in Regional Waterway Strategies (or previously, Regional River Health Strategies) or their relevant sub-strategies.

"**hydraulic gradient**" means the gradient or difference between two or more measurements of hydraulic head over the length of a groundwater flow path.

"**Hydraulic head**" means a measurement of water pressure, or depth to water table, commonly level of water based on surface elevation.

"**local groundwater management plan**" means any management plan prepared and approved by a delegate for managing groundwater in an area.

"**licence application area**" means the area within which measurable groundwater drawdown occurs.

"**perched water table**" means an aquifer that occurs above the regional water table, in the unsaturated zone. This occurs when there is an impermeable layer of rock or sediment or

relatively impermeable layer above the main water table/aquifer but below the surface of the land.

"Q90" is a reference to a flow frequency curve; a Q90 flow rate means that 90% of the time, the flow exceeds the stated flow.

"unconfined aquifer" means an aquifer that is at or connected to the land surface, including via other overlying aquifers. An unconfined aquifer has a vertical connection to the surface, unlike a confined aquifer.

4. SCOPE

4.1 These Guidelines apply to an application made under:

a. section 51 (1) of the Act for a licence to take and use groundwater in an area that is not managed under an approved management plan; or

b. section 62 of the Act to transfer a groundwater licence for use at a different location, in an area that is not managed under an approved management plan.

4.2 These Guidelines shall be applied where an application is made under section 51 (1) of the Act for a licence to take and use groundwater or its transfer under section 62 of the Act in an area that is managed under an approved groundwater management plan insofar as they are not inconsistent with the requirements of that management plan.

4.3 These Guidelines do not apply to an application made under section 67 of the Act for a licence to construct, alter, remove or decommission a bore identified on an existing groundwater licence.

Part 2 POLICIES

5. RISK ASSESSMENT

5.1 A delegate should assess the risk of the groundwater licence application to high value ecosystems dependent on groundwater, having regard to the need to protect those ecosystems. Schedule 1 provides guidance to the delegate on undertaking a risk assessment.

5.2 If all other matters relevant to the application have been considered and found acceptable, then on the basis of the risk assessment the delegate may:

a. **if the risk is low**, approve the groundwater licence application; or

b. **if the risk is medium**, develop risk treatment options to manage risk and approve the groundwater licence application with conditions; or

c. **if the risk is high**, develop risk treatment options to reduce the risk to medium, or decide to accept the risk and fully document the reasons, or refuse the groundwater licence application.

6. REFERRAL

6.1 A groundwater licence application shall be referred to the relevant Catchment Management Authority in line with Schedule 2.

7. DECISION MAKING

7.1 The delegate should consider the advice provided by the relevant Catchment Management Authority prior to making a final decision on the groundwater licence application.

SCHEDULE 1 A GUIDE TO RISK ASSESSMENT

A. PURPOSE

The purpose of Schedule 1 is to provide guidance on assessing the risk posed by a groundwater licence application to high value ecosystems that depend on groundwater.

B. RISK ASSESSMENT PROCESS

The assessment of a licence application's risk to high value ecosystems that depend on groundwater requires the following steps:

STEP 1. Determine the licence application area and identify high value ecosystems. Determine that the aquifer is unconfined and identify any features within that area, such as rivers, springs, soaks or terrestrial vegetation containing high value ecosystems. If the aquifer is unconfined and high value ecosystems are identified, go to step 2, otherwise assess the risk as low.

STEP 2. Determine the likelihood that the proposed groundwater extraction will interact with the feature.

STEP 3. Determine the consequence of the proposed groundwater extraction on the feature.

STEP 4. Determine the risk to the high value ecosystems dependent on groundwater.

STEP 5. Determine how risk will be managed for groundwater licence applications with a risk assessment of medium or high.

STEP 6. Consult with relevant Catchment Management Authority in line with Schedule 2.

STEP 7. Make final decision.

STEP 1. Determine the licence application area and identify high value ecosystems

i. The licence application area is determined by the areal extent of drawdown arising from the proposed groundwater extraction and the adjacent licensed entitlement. The application area will extend to the point at which a drawdown of less than 0.1m, which is considered the limit for measurable impact, is estimated.

ii. The delegate will assess whether or not the aquifer is unconfined and identify features including rivers, springs, soaks, wetlands or terrestrial vegetation containing high value ecosystems within the licence application area. Identification can occur through a desktop GIS search of the area, any field investigation conducted as part of

the application process, information and comment provided by a CMA and/or local knowledge, or features identified in a management plan.

iii. If the aquifer is unconfined and a high value ecosystem is identified, go to step 2, otherwise assess the risk as low.

STEP 2. Determine the likelihood that groundwater will interact with the feature

i. The likelihood the proposed groundwater extraction will interact with a feature is to be determined by delegates using Table 1 and Table 2.

Table 1 Likelihood – Depth to water table

Likelihood	Description	Feature	Measures
Unlikely	A disconnected ecosystem	Aquifer	The groundwater is "confined"
		Terrestrial vegetation	Depth to water table > 6m from surface
		Rivers	"Disconnected" or intermittent or naturally cease to flow regularly during summer (Q_{90}=0.0)
Possible	A poorly connected ecosystem	Terrestrial vegetation	Depth to water table between 2m-6m from surface
		Rivers	Assessed as losing or variably gaining stream
Certain	A well-connected ecosystem	Terrestrial vegetation	Depth to Water Table <2 m from surface
		Rivers	Assessed as a gaining or strongly gaining stream

Table 2 Likelihood – Surface flow

Likelihood	Description	Feature	Measures
Unlikely	A disconnected ecosystem	Rivers	>12 months' time lag until 60% of extraction comes from river
		Floodplain or non-floodplain wetlands	Perched water table in all conditions
		Springs or soaks	None identified; or identified and only discharge intermittently in wet climate
Possible	A poorly connected ecosystem	Rivers	Between 3 and 12 months' time lag until 60% of extraction comes from river
		Floodplain or non-floodplain wetlands	Perched water table in summer / dry conditions
		Springs or soaks	Identified and discharges in average or wet climate
Certain	A well-connected ecosystem	Rivers	<3 months' time lag until 60% of extraction comes from river
		Floodplain or non-floodplain wetlands	Water table at or above base of wetland in summer / dry conditions
		Springs or soaks	Perennial springs or soaks identified and discharge in dry conditions

STEP 3. Determine the consequence of the proposed groundwater extraction on the feature

i. Delegates shall use Table 3, Table 4 and Table 5 to determine consequence.

ii. The consequence table used should be consistent with the relevant likelihood table above.

Table 3 Conditions considered to have no consequences

Consequence	Description	Measures
NONE	No high value ecosystems affected	No high value ecosystems in the application area
	Area is managed for salinity or drainage	The licence application does not impact management objectives set for the area
	Trade reduces risk to high value ecosystems	A trade of an existing licence reduces risk of impact on high value ecosystems

Table 4 Consequences – Depth to water table

Consequence	Description	Measures
MINOR	Proposed extraction is small with respect to the aquifer's ability to supply	Water table decline of <0.1m
		Hydraulic gradient at wetland boundary remains positive
MODERATE	Proposed extraction impacts measurably with respect to the aquifer's ability to supply	Water table decline 0.1m to 2m
		Hydraulic gradient at wetland may fall to zero at boundary in dry conditions
SIGNIFICANT	Proposed extraction is large with respect to the aquifer's ability to supply	Water table decline >2m at boundary
		Hydraulic gradient at wetland reverses direction at boundary

Table 5 Consequences – Surface flow

Consequence	Description	Measures
MINOR	Proposed extraction impacts on natural or current streamflow are small	Licence application is less than 1% of minimum average seasonal baseflow
		Less than 1% reduction in the Q90 flow rate
MODERATE	Proposed extraction impacts measurably on natural or current streamflow	Licence application is between 1% and 10% of lowest seasonal baseflow
		Between 1% and 10% reduction in the Q90 flow rate
		The minimum recommended environmental flow remains above the Q90 flow rate

SIGNIFICANT	Proposed extraction impacts significantly on natural or current streamflow	Maximum reduction in seasonal baseflow is greater than 10% of minimum average seasonal flow
		More than 10% reduction in the Q90 flow rate
		The minimum recommended environmental flow falls below the Q90 flow rate

STEP 4. Determine the risk to the high value ecosystems dependent on groundwater

i. The risk shall be evaluated by delegates using Table 6.

Table 6 Risk evaluation

		Consequence		
		Minor	Moderate	Significant
Likelihood	Unlikely	Low	Low	High
	Possible	Low	Medium	High
	Certain	Medium	High	High

STEP 5. Risk management

i. Risk treatment options will be developed for licence applications evaluated as medium or high risk.

ii. If risk is evaluated as medium or high, the delegate may consider refusal of the application, licence conditions or further hydrogeological, hydrological or ecological study. Any further investigation should address parameters in the risk assessment in order to inform risk treatment options. The level of risk should inform the scope of any further study.

iii. Risk treatment options can include actions such as:

- Altering the area of impact (e.g. reducing the entitlement volume, locating the bore in a deeper aquifer, re-siting the bore, undertaking investigations to improve information on the local aquifer).
- Changing the likelihood (e.g. increasing the set back distances, modifying the pumping schedule).
- Changing the consequence (e.g. modifying the pumping schedule, developing offsets, developing options for supplementing surface water flows).
- Reducing the risk evaluation through licence conditions.
- Deciding to undertake further analysis to gain better information and improve the risk analysis.
- Providing alternative supply to "at-risk" areas to maintain the high value ecosystem.

iv. In certain circumstances the delegate may decide to accept a high level of risk to pursue a special need or opportunity. In this circumstance the delegate should fully document the reasons for accepting the risk.

STEP 6. Consultation

i. Prior to making a final decision(s) the delegate shall provide to the relevant Catchment Management Authority a copy of the licence application, the risk assessment, and information relevant to the risk assessment, as required under Schedule 2.

STEP 7. Make final decision

i. The delegate should consider any information and comment provided by the Catchment Management Authority when finalising its risk assessment and making its decision on the licence application.

ii. If the proposed risk treatment (for example licence conditions) is unacceptable to either the proponent or the delegate, the application is to be refused.

SCHEDULE 2 Consultation with Catchment Management Authority

A. PURPOSE

i. To provide a delegate with a guide to referring an application to the relevant Catchment Management Authority for additional information and comment.

B. REFERRAL REQUIREMENT

i. An application for a licence entitlement greater or equal to 20ML that requires a risk assessment, or greater than 10ML if the risk assessment is medium or high, shall be referred to the relevant Catchment Management Authority for comment, unless:
ii. If the application is to trade an existing entitlement that results in the point of extraction moving further from a feature (eg. more distant in the same aquifer or deeper, or into a confined aquifer) there is no need to refer the application to the Catchment Management Authority.
iii. If the application is for a temporary transfer of less than 20ML and the application is approved, any subsequent temporary transfer equal to or less than this volume will not require a referral.

C. INFORMATION TO BE PROVIDED BY DELEGATE

The delegate will provide information to the Catchment Management Authority including:

i. the licence application,
ii. any site inspection report,
iii. licence application area,
iv. high value ecosystems identified,
v. any modelled impact to high value ecosystems dependent on groundwater; and
vi. its risk assessment.

D. CONSULTATION PERIOD

The Catchment Management Authority shall have 28 clear working days to respond by providing:

i. information about any additional high value ecosystems dependent on groundwater, their water resource requirements if known, any recognised threats and any current assessment of risks to those additional high value ecosystems; and
ii. comments on the risk assessment and proposed licence conditions.

E. CONSIDERATION OF ADVICE FROM CATCHMENT MANAGEMENT AUTHORITY

i. Information and comment provided by the Catchment Management Authority shall be considered by the delegate when making its final decisions.

Appendix E SKM (2012) Australian Groundwater Modelling Guidelines

achieve outstanding client success

Australian Groundwater Modelling Guidelines

Doug Weatherill
dweatherill@globalskm.com

IAH Groundwater Modellers Forum
21 February 2013

Background

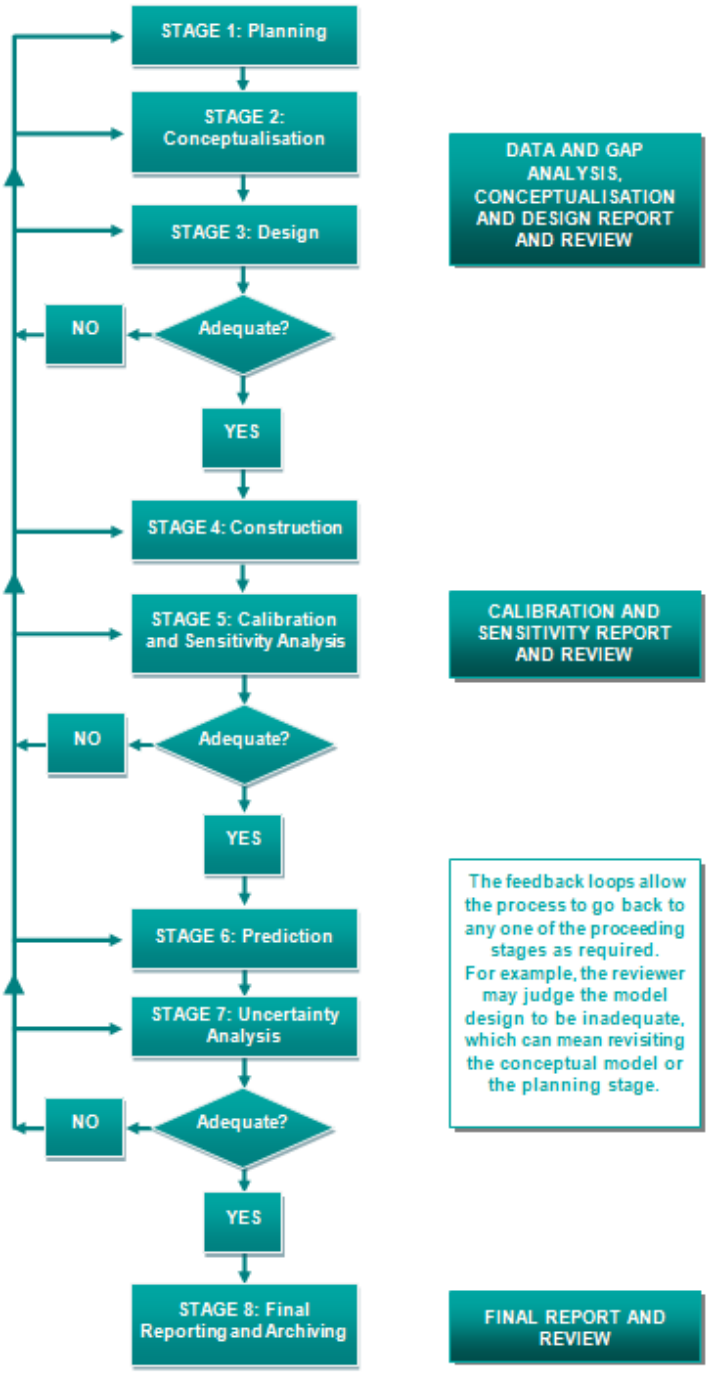
- Commissioned as part of the NWC Waterlines series
- In the absence of a national guideline, MDBC (2001) Groundwater Flow Modelling Guideline adopted as a de-facto Australian ‘standard’
- NWC identified need to update and expand in line with current best practice and for use on projects with a variety of model applications and environments encountered in Australia

Development of the Guidelines

- Collaborative team with members from SKM, NCGRT, CSIRO, NTEC Environmental Technology, NRETAS, USGS, AWE and SS Papadopulos & Associates
- Two national workshops held during development with consultants, researchers, miners and regulators

Overview

- Objective is to promote a consistent and sound approach to the development of groundwater flow and solute transport models in Australia
- Builds on existing MDBA (2001) Guideline
- Point of reference, not a rigid standard
- Promotes model development as a series of interdependent stages with feedback loops


STAGE 1: Planning
STAGE 2: Conceptualisation
STAGE 3: Design
Adequate?
NO
YES
STAGE 4: Construction
STAGE 5: Calibration and Sensitivity Analysis
Adequate?
NO
YES
STAGE 6: Prediction
STAGE 7: Uncertainty Analysis
Adequate?
NO
YES
STAGE 8: Final Reporting and Archiving
DATA AND GAP ANALYSIS, CONCEPTUALISATION AND DESIGN REPORT AND REVIEW
CALIBRATION AND SENSITIVITY REPORT AND REVIEW
The feedback loops allow the process to go back to any one of the proceeding stages as required. For example, the reviewer may judge the model design to be inadequate, which can mean revisiting the conceptual model or the planning stage.
FINAL REPORT AND REVIEW

Major changes from MDBA (2001)

- ‘Solute transport’ added as a distinct chapter
- ‘Surface water-groundwater interaction’ added as a distinct chapter
- ‘Calibration and sensitivity analysis’ and ‘Uncertainty’ chapters now promote the use of powerful parameter optimisation software to aid calibration and quantification of sensitivity and predictive uncertainty

Model confidence classification

- Intended to provide an indication as to the relative confidence with which a model can be used in predictive mode. Three classifications are described.
- Most models will not have all the defining characteristics of a particular class. The modelling team and key stakeholders should agree on the most relevant criteria for the project and set the target classification accordingly. During development this should be reviewed and, if necessary, revised.

Model confidence classification

- Class 1: simple models, either developed on few or sparse data sets that do not provide confidence in the hydrogeological conceptualisation and/or provide little or no data on which the model can be calibrated. Alternatively, data may be available but a decision has been made not to undertake an exhaustive calibration and validation procedure.

Model confidence classification

- Class 2: more complex models that are generally based on a sound understanding of the local and regional hydrogeology and have been calibrated to appropriate data sets and to a reasonable level (as defined by agreed quantitative and qualitative metrics).

Model confidence classification

- Class 3: the highest confidence models, that are based on extensive data sets that provide a good understanding of the regional and local hydrogeology and have been extensively calibrated to data sets that include both groundwater head and flux observations or estimates. Typically calibrated in steady state and transient modes, validated to illustrate the model's ability to replicate observed behaviour outside the data used for calibration and predictions are formulated in a manner that do not stray significantly from the calibration, in terms of both temporal scale and applied stresses.

Model confidence classification

- Generic models: not given a classification, these are models developed primarily to understand processes and not to provide quantitative outcomes for any particular aquifer or physical location. They can be considered to provide a high level of confidence when applied in a general, non-specific sense.

Model confidence classification

- There has been some confusion regarding requirements of models following release of the Guidelines.
- A Class 3 model is NOT necessary in all, or even most, cases.

Classification	Examples of use
Class 3	•Predicting arbitrary groundwater responses to arbitrary changes in applied stress of hydrological conditions anywhere within the model domain •Provide information for sustainable yield assessments for high value regional aquifer systems •Designing complex mine-dewatering schemes, salt interception schemes or water allocation plans •Simulating interaction between surface water bodies and groundwater to a level required for dynamic linkage to surface water models •Assessment of complex large-scale solute transport processes
Class 2	•Prediction of impacts of proposed developments in medium value aquifers •Estimating dewatering requirements for mines/excavations and the impacts •Designing groundwater management schemes such as MAR, salinity management schemes and infiltration basins •Estimating distance of travel of contamination through particle-tracking methods and defining water source protection zones.
Class 1	•Predicting long-term impacts of proposed developments in low value aquifers •Designing observation bore arrays for pumping tests •Understanding groundwater flow processes under hypothetical conditions •A starting point from which to develop higher class models

References

Barnett et al., 2012. Australian groundwater modelling guidelines, Waterlines report 82, National Water Commission, Canberra.

Available at: http://archive.nwc.gov.au/library/waterlines/82

MDBA, 2001. Groundwater flow modelling guideline. Report prepared by Aquaterra Consulting Pty Ltd, January 2001.