Appendix E – Groundwater Issues Memorandum

The following memorandum, exploring the potential issues associated with implementing distributed storages in areas with high groundwater levels, was developed to inform a key workshop in the project.

Two key additional items, discussed further since the workshop, are important to note:

- The decision to assume storages would not be used below a certain elevation was used for the purpose of strategy development at the whole of Fishermans Bend scale. It is however technically feasible to use storages in areas with high groundwater, albeit there are additional challenges that need to be addressed, and potentially therefore additional costs. If needed, storage in such areas can be considered in future more detailed planning that considers solutions at the local level.
- Furthermore, not all stakeholders were in agreement on the decision to not consider storages in low-lying areas as a general rule. For example noting "*Groundwater contamination is highly varied in the project area and design responses will differ depending on this. Furthermore, there are many landscape design options that can be utilised to prevent community contact of waterbodies including the use of dense plantings and riparian furniture. Thus, avoiding storages that are at or close to the groundwater level is only one of a number of responses.*"
- The groundwater memo which is an appendix to this strategy refers to 1.8m AHD as the minimum level at which storages are proposed. This had an allowance for 'freeboard' between bottom of the storage and future groundwater level. Following the workshop, it was agreed to remove this freeboard component and reduce the minimum elevation for storages from 1.8m AHD to 1.4m AHD. This was a key change, as there is very little area that is below 1.4m AHD.

Memorandum

15 November 2018

To	Fishermans Bend Drainage Working Group		
Copy to			
From	Ryan Brotchie	Tel	+61 3 8687 8827
Subject	Impact of future groundwater conditions on drainage strategy	Job no.	3136555

1 Introduction

This document provides a discussion on future groundwater conditions at Fishermans Bend resulting from the impacts of climate change, and the impact that this may have on the drainage strategy.

2 Purpose

The purpose of this memorandum is to provide the *Fishermans Bend Drainage Working Group* high-level background information on the issues relating to future groundwater conditions. Because of the timing associated with the delivery of the *Water Sensitive Drainage and Flood Management Strategy*, it is not likely that the required information will be made available in time to make an informed decision as to the viability of infrastructure construction in or around groundwater. As such, certain assumptions will need to be made as part of the Strategy.

This issue was discussed at the *Fishermans Bend Drainage Working Group* meeting on 15.11.2018 where it was decided a stand-alone meeting to deal with the issue was required. This meeting has been scheduled for 21.11.2018 and this memorandum is simply meant to provide information ahead of that meeting.

3 Objectives

The objective of the memorandum is to briefly discuss:

1. Existing groundwater conditions (e.g. level, salinity, contamination, etc.)
2. Future groundwater conditions by 2100 (i.e. considering impacts of climate change, particularly sea level rise)
3. Impact of future groundwater conditions on infrastructure, drainage, etc.
4. Possible future groundwater management responses (e.g. dewatering).
5. Implications for the Water Sensitive Drainage and Flood Management Strategy.

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 **F** 61 3 8687 8522 **E** melmail@ghd.com **W** www.ghd.com

4 Groundwater Studies for Fishermans Bend

Groundwater studies for Fishermans Bend were conducted between 2015 and 2017 for EPA. The studies focused on confirming the depth of groundwater and the regional groundwater quality. The studies can be found at https://www.epa.vic.gov.au/fishermansbend#Studies.

5 Existing groundwater conditions

The EPA's *Fact sheet: Fishermans Bend groundwater studies 2015–2017 (publication 1674)* and *Summary of groundwater studies (2015–2017)* (AECOM, 2017) contain useful summaries of the key findings from the various studies. Relevantly for this memorandum this included:

- The groundwater in Fishermans Bend is shallow, with a depth of approximately 1 – 3.5 meters below ground level (mBGL). The variation in groundwater depth is due to the presence of former landfills/quarries, extensive underground sewer networks, former wetland areas and proximity to the Yarra River and Hobsons Bay.
- Groundwater contamination has been identified which may trigger further assessment during future development. The main contaminants found on a regional scale include: Metals (Aluminium, Arsenic, Total Chromium, Iron, Lead, Manganese, Nickel); Ammonia; Nitrate; Chloride; Fluoride, Sodium; Sulfate; Total Recoverable Hydrocarbons (TRH); and PFAS.
- The salinity levels are between 124 and 30,300 mg/L. That groundwater was sampled at the lower end of this salinity range means drinking water is a protected beneficial use; however other contaminants may preclude this use.
- Some contaminant levels were elevated above drinking water and recreational guidelines. EPA will consider these further, with the aim of identifying a groundwater quality restricted use zone where groundwater is polluted.
- Volatile organic compounds were identified in a small number of groundwater bores, indicating localised impacts.
- There were no obvious groundwater contaminants that would constrain buildings and structures on a regional scale, however, localised impacts of chloride and sulfate do exist in parts of Fishermans Bend and will need to be considered by developers.
- Groundwater north of the Westgate Freeway is likely to discharge to the Yarra River while groundwater south of the Westgate Freeway is likely to discharge to Hobsons Bay. The groundwater may impact those surface waters.

The EPA notes that the results of this investigation will be used by EPA to identify a groundwater quality restricted use zone, which indicates an area of polluted groundwater unsuitable for some uses.

As individual sites are developed, the Capital City Zone planning scheme means that those developed for sensitive uses will undergo environmental audits in accordance with the Environment Protection Act 1970 requirements, and be cleaned up as necessary.

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 F 61 3 8687 8522 E melmail@ghd.com W www.ghd.com

Groundwater Levels

The existing groundwater table in Fishermans Bend has a depth of approximately 1 – 3.5 meters below ground level (mBGL). The depth varies in relation to distance from the river/coast, local surface elevation and other physical

At the River Yarra (adjacent to Fishermans Bend), and along the edge of the bay, the groundwater level is expected to correlate with mean sea level, which is currently at about 0m AHD. Figure 1 below presents the groundwater levels within Fishermans Bend. Attachments 1 and 2 further detail existing groundwater levels across the Fishermans Bend precinct and locally across Lorimer, Sandridge & Montague Precincts.

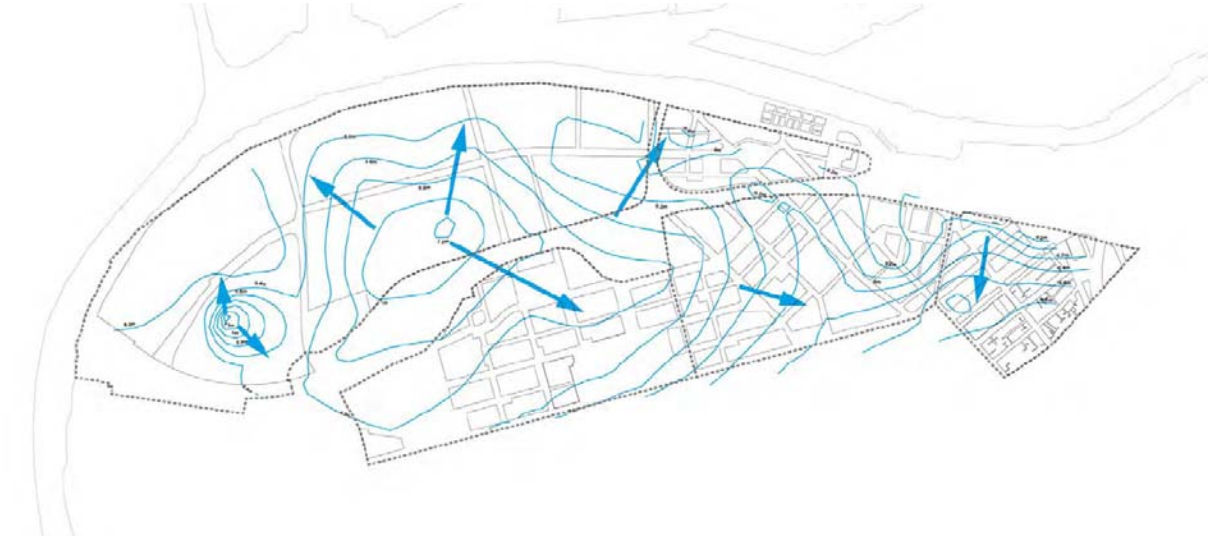


Figure 1: Groundwater levels (mAHD) ['Groundwater Monitoring Event Fishermans Bend Urban Renewal Area'. 2016. AECOM for EPA.]

Figure 1 and Attachments 1 and 2 indicate that, even across the lower Lorimer, Sandridge & Montague Precincts, there is expected to be variations in the local groundwater level. Further site-specific investigations are recommended before finalising any assumptions that rely on understanding groundwater levels.

Tidal Influence on Groundwater Levels

Due to the expected permeability of the ground beneath Fishermans bend, it is likely that there will be a degree of dampened tidal influence on groundwater levels – most significantly adjacent to the Yarra River. AECOM, in their 2015 Desktop Study and Preliminary Regional Conceptual Site Model drew the following conclusions regarding tidal influences:

"There is expected to be significant tidal influence on the shallow groundwater. This tidal influence is expected to be greater particularly closer to the Yarra River to the north of the site and is likely to become damped towards the south. Further consideration of this on the regional groundwater quality

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 F 61 3 8687 8522 E melmail@ghd.com W www.ghd.com

including the impacts of regular flushing of water, salinity and migration pathways needs to be further assessed as part of future investigations". (AECOM, *Desktop Study and Preliminary Regional Conceptual Site Model*, 2015, p13).

6 Future groundwater conditions

Groundwater Level

Groundwater conditions are expected to change over time, predominantly due to the sea level rise resulting from global climate change. However, we are not aware of any specific consideration of this issue across any of the Fishermans Bend planning studies.

For flood management, current planning requirements and practice are to plan for a sea level rise of 0.8m by 2100. Given the "significant tidal influence on the shallow groundwater" as identified by AECOM (2015), it is reasonable to expect that groundwater levels will increase at a comparable rate to the sea level rise in proximity to the Yarra River. That is an increase of approximately 0.8m by 2100.

If the general groundwater level (noting there are local fluctuations) is approximately 0.0m AHD today, then by the year 2100 it may be in the order of 0.8m AHD. This increase may become less pronounced in general as you get further from the river, but detailed investigations and modelling are again recommended before any firm decisions are made as to future levels and impacts.

Uncertainty

Although current planning requirements and practice are to plan for a sea level rise of 0.8m by 2100, this is only one scenario, and by no means is 0.8m an end point for sea level rise. Best practice planning should consider a range of scenarios acknowledging that this level may be reached some time before or after 2100, and that sea level will continue to rise beyond this point. To the extent that groundwater levels at Fishermans Bend are dependent on the sea level, then the same considerations should apply.

7 Impact of future groundwater conditions

If future groundwater levels at Fishermans Bend approach 0.8m AHD (or higher), then this raises a critical issue for infrastructure and development within the Fishermans Bend. This is because there would be areas where the groundwater level is at, or close to, ground level (see red areas on map below), and reasonably large areas in the North-Eastern part of Fishermans Bend where groundwater is less than 500mm below ground level (see orange areas) or less than 1000mm below ground level (see yellow areas).

Note that the elevation map below provides just an approximate idea of spatially how much area would be impacted, and doesn't actually reflect groundwater levels or consider local fluctuations in groundwater levels.

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 F 61 3 8687 8522 E melmail@ghd.com W www.ghd.com

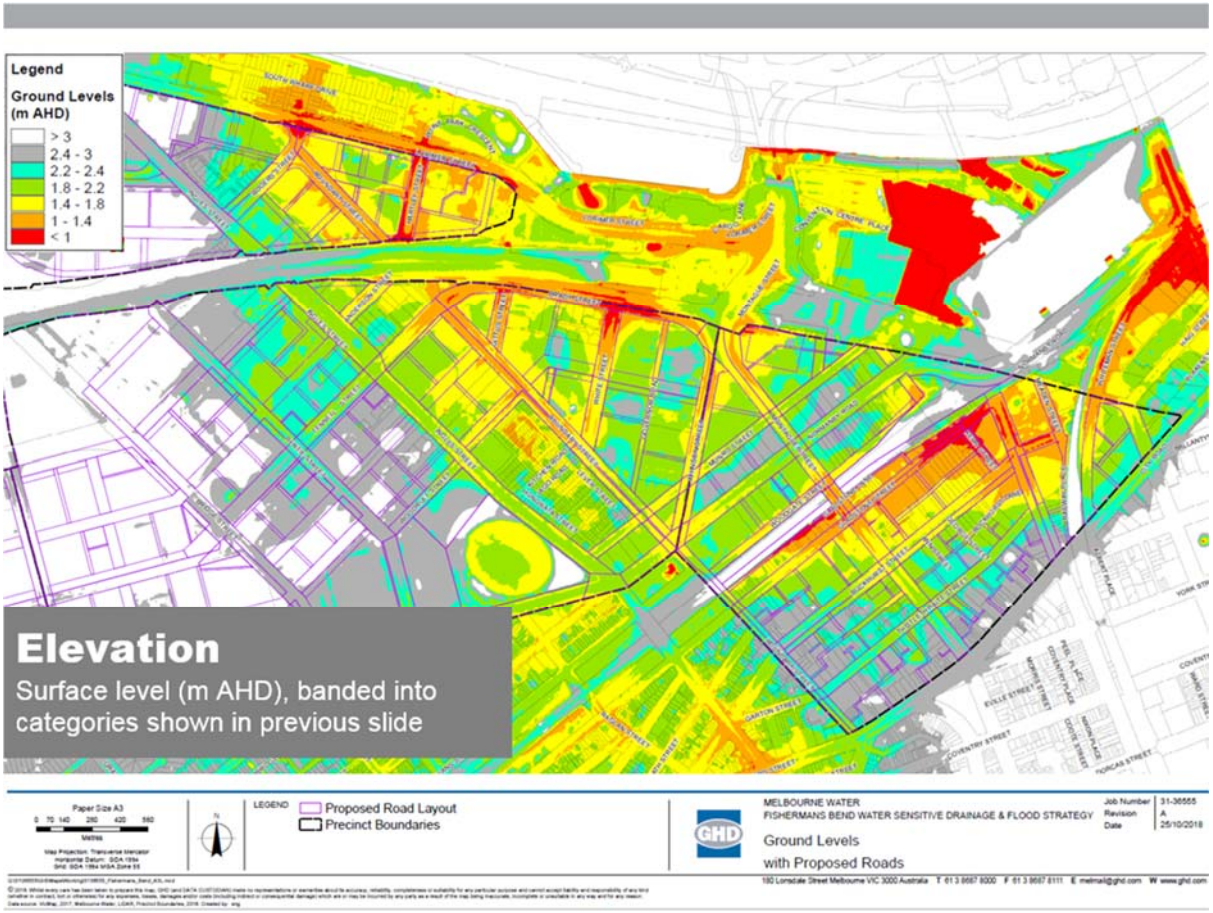


Figure 2. Ground levels

8 Possible future groundwater management responses

If future groundwater conditions are as predicted in the previous sections (eg ground water levels being at approximately ground level in some areas by 2100), it is highly likely that groundwater levels would need be actively managed at some point in the future. For example, groundwater levels could be maintained at a certain level through de-watering (pumping out groundwater). This is likely to be required independently of any drainage solution, to manage amenity and functionality of the precinct as it is currently proposed.

9 Implications for the Drainage and Flood Management Strategy

Future groundwater conditions have significant implications for the *Water Sensitive Drainage and Flood Management Strategy*. If there are high groundwater levels, then this will likely influence the possible depth of infrastructure.

If groundwater levels are actively managed in the future (eg through dewatering) then the impacts of this issue may be avoided or minimised. There is considerable uncertainty about this though. For

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 **F** 61 3 8687 8522 **E** melmail@ghd.com **W** www.ghd.com

the purposes of this strategy, it would be imprudent to assume that this will occur, because it appears that the issue hasn't been considered yet at Fishermans Bend, let alone there being a commitment to that particular management approach.

Additionally, groundwater suppression through dewatering may not be desirable if avoidable. Environmental impacts of disposal might necessitate costly decontamination measures.

Alternative suppression approaches have been raised by stakeholders in the Working Group (eg through strategic plantings), however it is unlikely that this would provide a long term solution and whether it could even be effective in the short term.

If groundwater levels are not actively managed in the future, then there is a question to consider about the allowable depth of infrastructure, and in particular for this strategy, whether we should consider excavated storages in the low lying areas as part of the drainage plan.

Based on discussions to date within the Drainage Working Group, GHD has assumed that excavated storages may not be suitable in areas where the surface level is lower than 1.8m AHD (this assumes groundwater generally at 0.8m AHD by 2100, allowance for storage depths of up to 0.5m, and allowance for a further 0.5m to enable a suitable formal invert to be established). *See the image below.*

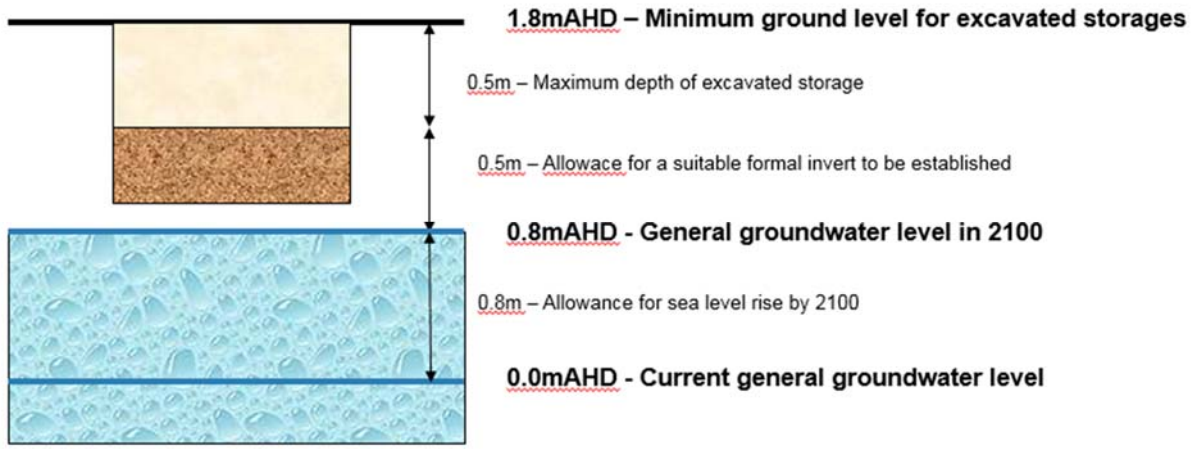
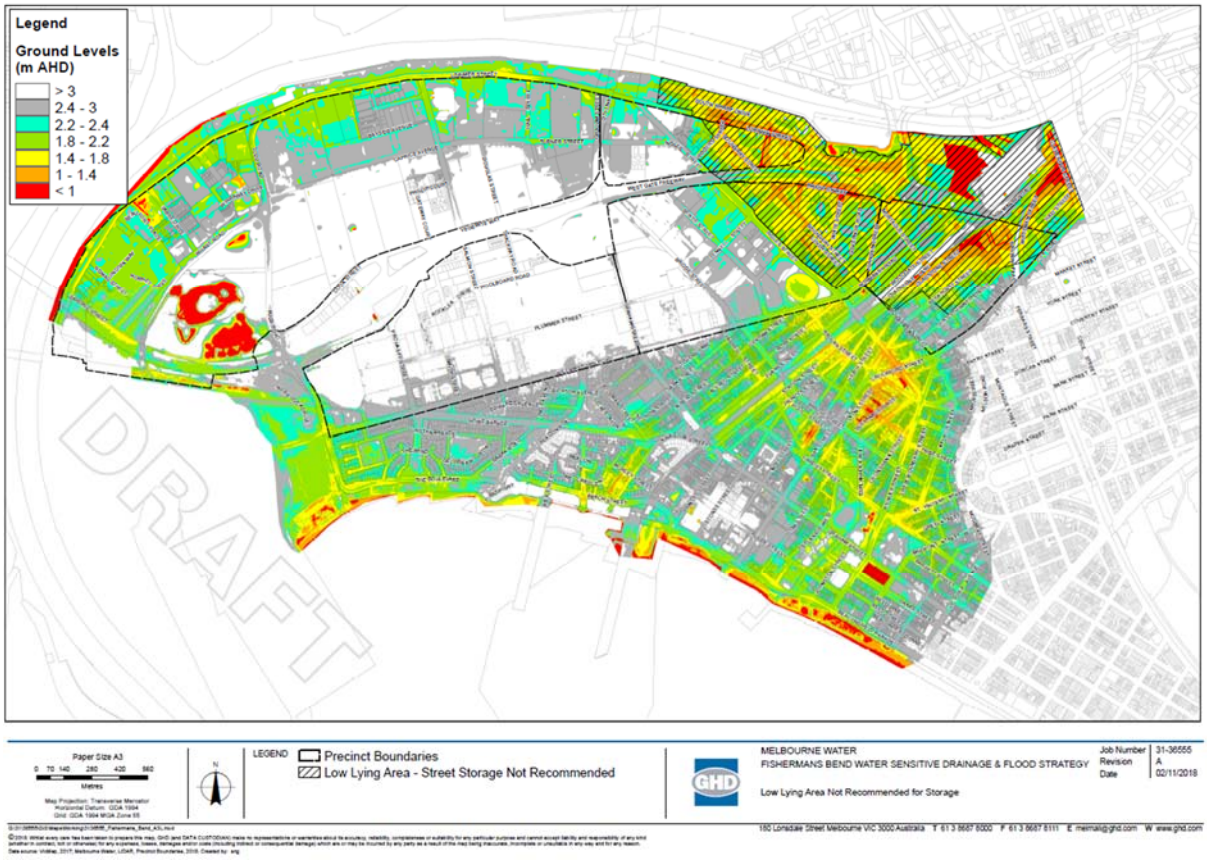


Figure 3. Storage level assumptions allowing for impact of climate change on groundwater

GHD previously understood that in principle there was agreement with this approach described above, but that the exact level of 1.8m AHD needed further consideration. We now understand that this requires further discussion before agreement is reached.

Below is a plan providing an indication of the area within Fishermans Bend that is generally below 1.8m AHD (see yellow, orange & red areas).

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 **F** 61 3 8687 8522 **E** melmail@ghd.com **W** www.ghd.com



In areas that CoM has identified for flood detention storage, the CoM has suggested that these could be excavated below the ground water level to maximise the storage in the air space above and leave them as a permanent water body. The question of how these spaces would work from an urban design perspective is still to be worked through by CoM.

Additionally, we note that groundwater salinity and groundwater contamination both need to carefully considered if allowing any infrastructure below the groundwater level and in particular if creating any permanent water bodies. It is unlikely that it would be desirable to have (untreated) groundwater in open water bodies where there is a risk of community contact.

It is noted that if you let a storage fill with groundwater (and presumably the pipe below it), then the only active storage area you have is the air space above the storage, so groundwater level controls your invert level. This means you either have to pump the groundwater out, or put storages higher, or keep the groundwater out (eg through contained/lined storages). Given all of the above, keeping the groundwater out seems attractive, but that will require sealing/lining the storage which will be expensive (e.g. sheet piles etc.).

Water Sensitive City Solutions

It is worth noting that one of the CRCWSC's five current national research project is *Integrated Research Project 5: Water Sensitive City Solutions for Groundwater Impacted Development.* This

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 **F** 61 3 8687 8522 **E** melmail@ghd.com **W** www.ghd.com

research project specifically explores the unique issues of providing water sensitive city solutions in developments impacted by high groundwater tables. The project is still underway, but we have reviewed the draft Stage 1 Report (GHD and Water Technology, prepared for CRCWSC, October 2018) for any potentially relevant ideas or solutions for this project.

The report concludes that there are numerous methods potentially available to predict future groundwater impacts, and measures such as rainwater tanks may actually assist in lowering the water table in areas less impacted by sea ingress. The lower areas across Fishermans Bend are likely see minimal impact as a result of such measures.

Potential impacts to structures as a result of reductions to footing strength were also noted, but no strong mitigation measures were noted that are likely to substantially limit the impacts of sea level rise (aside from conventional mechanical dewatering measures).

10 References

EPA, *Fact sheet: Fishermans Bend groundwater studies 2015–2017* (publication 1674)

AECOM, 2017, *Summary of groundwater studies (2015–2017) Fishermans Bend*, prepared for Environment Protection Authority Victoria.

GHD and Water Technology, 2018, *Integrated Research Project 5 Stage 1 Report* Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Regards

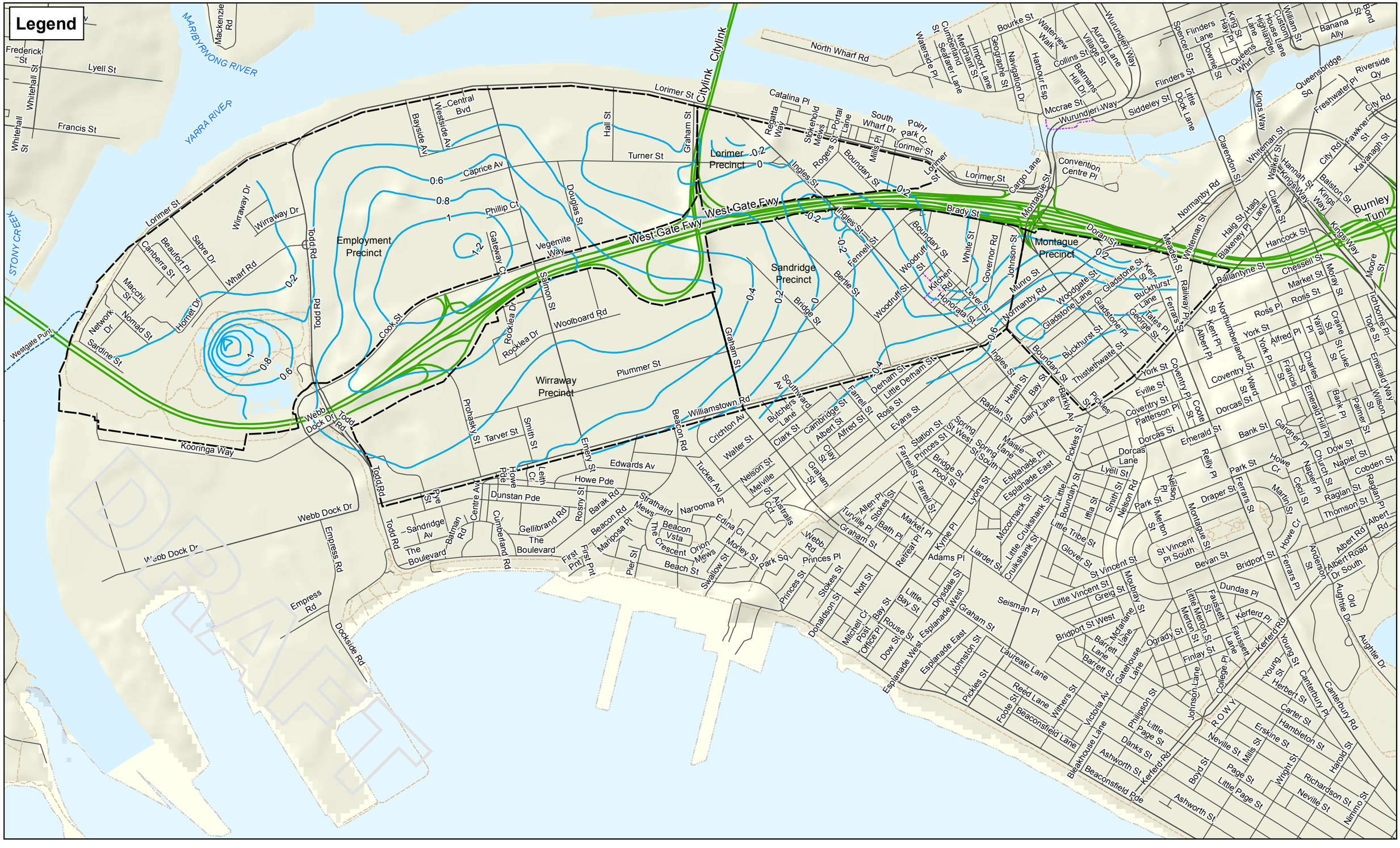
Ryan Brotchie
Service Line Leader Integrated Water Management

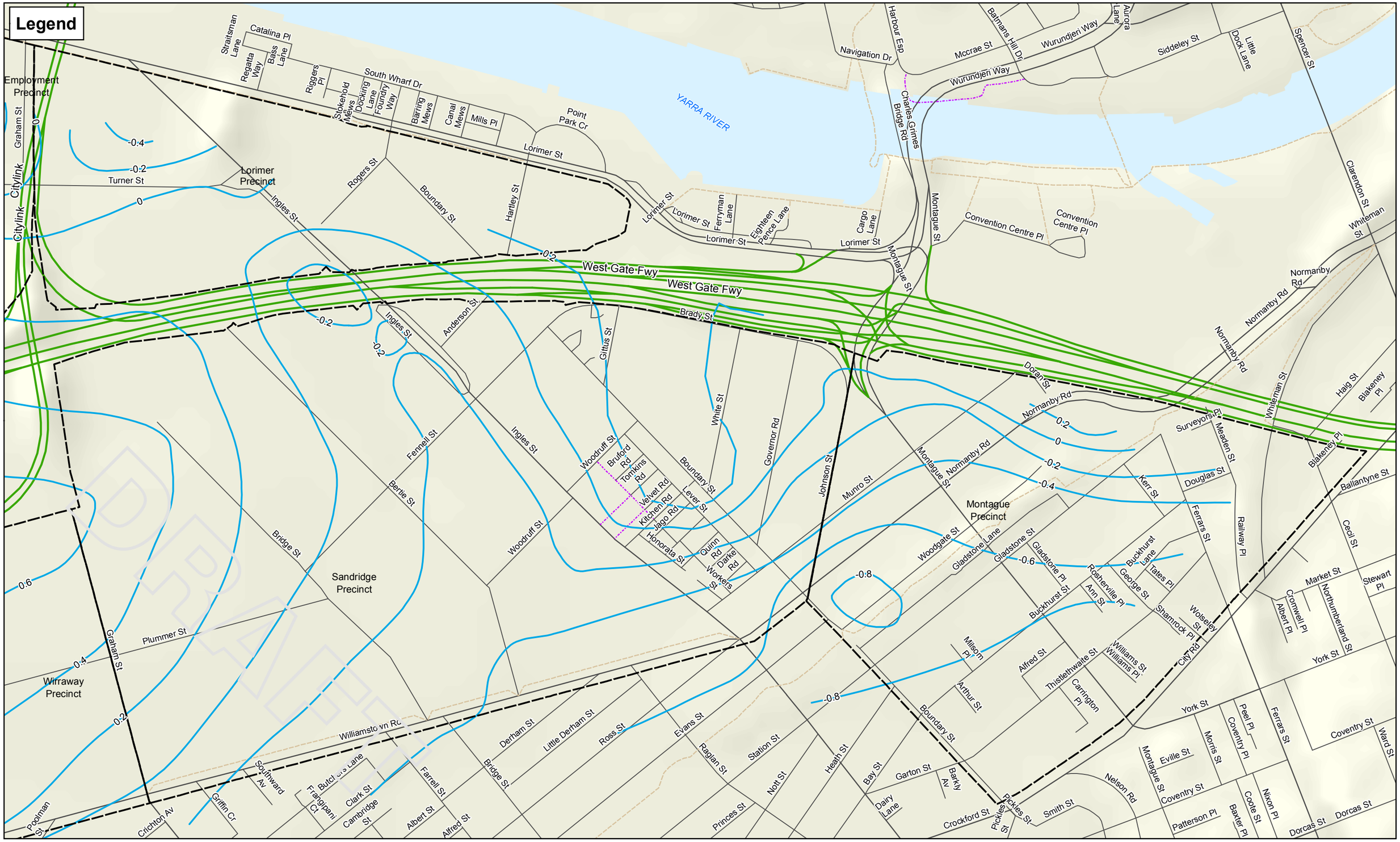
Attachments:

Existing Groundwater Level –Fishermans Bend (m AHD)

Existing Groundwater Level – Lorimer, Sandridge & Montague (m AHD)

GHD
Level 8 180 Lonsdale Street Melbourne VIC 3000 Australia
T 61 3 8687 8000 **F** 61 3 8687 8522 **E** melmail@ghd.com **W** www.ghd.com


Legend
MARIBYRNONG RIVER
YARRA RIVER
STONY CREEK
Citylink
West Gate Fwy
Lorimer Precinct
Employment Precinct
Wirraway Precinct
Sandridge Precinct
Montague Precinct
Burnley Tunl
Lorimer St
Graham St
Hall St
Turner St
Bayside Av
Westside Av
Central Blvd
Caprice Av
Phillip Ct
Gateway Ct
Vegemite Way
Douglas St
Wirraway Dr
Todd Rd
Sabre Dr
Wharf Rd
Beaufort Pl
Canberra St
Macchi St
Network Dr
Nomad St
Hornet Dr
Sardine St
Westgate Punt
Cook St
Rocklea Dr
Woolboard Rd
Salmon St
Plummer St
Graham St
Bridge St
Bertie St
Fennell St
Boundary St
Ingles St
Rogers St
Mills Pl
Lorimer St
Catalina Pl
Regatta Way
Stokehold Mews
Portal Lane
South Wharf Dr
Point Park Cr
Cargo Lane
Montague St
Brady St
Dorans St
Convention Centre Pl
North Wharf Rd
Waterside Pl
Cumberland St
Seafarer Lane
Merchant St
Import Lane
Geographe St
Navigation Dr
Harbour Esp
Waterview Walk
Bourke St
Collins St
Batmans Hill Dr
Aurora Lane
Village St
Wurundjeri Way
Mccrae St
Siddeley St
Flinders St
Little Dock Lane
Spencer St
Flinders Lane
Downie St
King St
Hay Pl
Queens Whrf
Highlander Lane
House Lane
Custom St
William St
Bond St
Banana Ally
Kings Way
Queensbridge Sq
Freshwater Pl
Riverside Qy
City Rd
Fawkner St
Kavanagh St
Balston St
Whiteman St
Walker St
Hannah St
Kingsway
Clarendon St
Normanby Rd
Haig St
Haig Lane
Blakeney Pl
Clarke St
Hancock St
Meeden St
Railway Pl
Ballantyne St
Chessell St
Market St
Moray St
Moore St
Ross St
Ross Pl
York St
Alfred Pl
Yarra Pl
Crane St
St Luke St
Tichborne Pl
Tobe St
Emerald Way
Wilson St
Northumberland St
Kent Pl
Albert Pl
Coventry St
Ward St
Francis St
Charles St
Emerald Hill Pl
Bank Pl
Palmer St
Gardner Pl
Dow St
Napier St
Cobden St
Raglan St
Raglan Pl
Albert Rd
Albert Road Dr South
Howe Cr
Church St
Cecil St
Martin St
Thomson St
Ferrars St
Anderson St
Augthie Dr
Old Augthie Dr
Dundas Pl
Kerferd Pl
Kerferd Rd
Young St
Canterbury Pl
Canterbury Rd
Herbert St
Carter St
Hambleton St
Harold St
Erskine St
Wright St
Richardson St
Nimmo St
Ashworth St
Little Page St
Page St
Neville St
Mills St
Boyd St
R O W Y
Johnson Lane
College Pl
Fausset St
Fausset Lane
Little Merton St
Merton St
Ograde St
Gatehouse Lane
Barrett Lane
Mcfarlane Lane
Bridport St West
Seisman Pl
Esplanade West
Esplanade East
Graham St
Dysdale St
Little Bay St
Bay St
Mitchell Ct
Post Office Pl
Rouse St
Dow St
Donaldson St
Stokes St
Nott St
Princes St
Princes Pl
Webb Rd
Park Sq
Beach St
Swallow St
Morley St
Edina Ct
Beacon Vsta
The Crescent
Orion Mews
Beacon Rd
Mariposa Pl
Pier St
First Pnt
First Pnt
Strathaird Mews
Narooma Pl
Australis Cct
Barak Rd
Rosny St
Howe Pde
Dunstan Pde
Gellibrand Rd
The Boulevard
Cumberland Rd
Batman Rd
Centre Av
Sandridge Av
Pye St
Howe Pde
Leith Cr
Emery St
Edwards Av
Tucker Av
Beacon Rd
Williamstown Rd
Crichton Av
Walter St
Clark St
Butchers Lane
Southward Av
Cambridge St
Albert St
Alfred St
Farrell St
Ross St
Evans St
Derham St
Little Derham St
Nelson St
Melville St
Graham St
Tarver St
Smith St
Prohasky St
Webb Dock Dr
Empress Rd
Dockside Rd
Kooringa Way
Todd Rd
Webb Dock Dr
Lyons St
Esplanade East
Esplanade West
Johnston St
Pickles St
Laureate Lane
Reed Lane
Foote St
Beaconsfield Lane
Withers St
Victoria Av
Bleakhouse Lane
Beaconsfield Pde
Ashworth St
Kerferd Rd
Danks St
Little Page St
Philipson St
Station St
Princes St
Spring St
West
South
Bridge St
Pool St
Maisie Lane
Esplanade Pl
Esplanade East
Mccormack St
Little Cruikshank St
Cruikshank St
Little Boundary St
Ifla St
Smith St
Nelson Rd
Park St
Nelson Pl
Merton St
Draper St
Montague St
St Vincent Pl South
Bevan St
Bridport St
Little Tribe St
Glover St
St Vincent St
Little Vincent St
Greig St
Moubray St
Dysdale St
Adams Pl
Liardet St
Kyme Pl
Market Pl
Refuge Pl
Bath Pl
Graham St
Turville Pl
Allen Pl
Stokes St
Farrell St
Pickles St
Coote St
Dorcas Lane
Lyell St
Dorcas St
Emerald St
Eville St
Coventry St
Patterson Pl
Coventry Pl
York St
Eville St
Thistlethwaite St
Buckhurst St
Gladstone Pl
Gladstone Lane
Woodgate St
Normanby Rd
Leveson St
Honorata St
Kitchener Rd
Woodruff St
Boundary St
Governor Rd
White St
Johnson St
Munro St
Railway Pl
Ferrars St
Buckhurst Lane
Kerr St
Gladstone St
Yates Pl
George St
Barkly Av
Barkly St
Pickles St
Heath St
Bay St
Dairy Lane
Raglan St
Ingles St
Derham St
Little Derham St
Ross St
Evans St
Southward Av
Butchers Lane
Cambridge St
Albert St
Alfred St
Farrell St
Williamstown Rd
Crichton Av
Walter St
Clark St
Tucker Av
Nelson St
Melville St
Graham St
Beacon Rd
Tarver St
Smith St
Prohasky St
Howe Pde
Dunstan Pde
Edwards Av
Emery St
Leith Cr
Howe Pde
Pye St
Centre Av
Sandridge Av
Batman Rd
Cumberland Rd
Gellibrand Rd
The Boulevard
Barak Rd
Rosny St
Strathaird Mews
Narooma Pl
Beacon Rd
Mariposa Pl
Beacon Vsta
The Crescent
Orion Mews
Edina Ct
Morley St
Park Sq
Webb Rd
Princes Pl
Princes St
Stokes St
Nott St
Donaldson St
Mitchell Ct
Post Office Pl
Bay St
Rouse St
Dow St
Esplanade West
Esplanade East
Graham St
Seisman Pl
Bridport St West
Barrett Lane
Mcfarlane Lane
Gatehouse Lane
Ograde St
Merton St
Little Merton St
Fausset St
Fausset Lane
College Pl
Johnson Lane
Finlay St
Young St
Herbert St
Canterbury Pl
Canterbury Rd



Paper Size A3

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundaries
- Existing Groundwater Level (m AHD) (Ramboll, 2017)

MELBOURNE WATER
FISHERMANS BEND WATER SENSITIVE DRAINAGE & FLOOD STRATEGY

Existing Groundwater Level (m AHD)
Lorimer / Sandridge

Job Number	31-36555
Revision	A
Date	16/11/2018

G:\31\36555\GIS\Maps\Working\3136555_Fishermans_Bend_A3L.mxd

Data source: VicMap, 2017; Melbourne Water, LiDAR, Precinct Boundaries, 2018.; Ramboll, Groundwater Depth Contours, 2017 Created by: SPLaird

180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com