WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

# Expert Report on Drainage/Hydrology

## Craigieburn West PSP

19 April 2021

| | |
|---|---|
| **Report Author:** | Warwick Bishop |
| **Title:** | Expert Report on Drainage/Hydrology |
| **Address of Property:** | Criagieburn West |
| **Report Prepared For:** | Hume City Council |
| **Instructed By:** | Maddocks |
| **Date of Report** | 19 April 2021 |
| **Document Name** | 21010410_R01v01b.docx |

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365
ACN 093 377 283
ABN 60 093 377 283

# CONTENTS



# APPENDICES

# LIST OF FIGURES

# 1 STATEMENT OF ENGAGEMENT, QUALIFICATION, EXPERIENCE AND EXPERTISE

1. I, Warwick Bishop, have prepared this report at the request of Maddocks.
2. I am a Director and a Senior Principal Engineer of Water Technology Pty Ltd. I have over 25 years experience as a consulting water engineer.
3. A copy of my Curriculum Vitae is provided in Appendix A.
4. The report is prepared as an independent and impartial report.
5. I have read and understood the Planning Panels Victoria Guide to Expert Evidence and agree to be bound by the Rules.
6. This report is given independently to assist the Standing Advisory Committee in relation to the matter. I accept my paramount duty is to the Standing Advisory Committee and not to any individual party who is liable to pay my fees or otherwise.
7. I have relied upon many documents in formulating my opinion. A list of the key documents is included in the reference section of this report.
8. With my qualifications and experience, I believe I am well qualified to provide an expert opinion in this matter.

# 2 REPORT AUTHOR

**Warwick Bishop**
Director and a Senior Principal Engineer

15 Business Park Drive
Notting Hill VIC 3168

### Qualifications

- B.E. (Hons), University of Melbourne, 1993
- MEngSci, Monash University, 2000

### Affiliations

- Chartered Member, Institution of Engineers, Australia
- Member, Engineers Australia, Victorian Water Engineering Panel Committee
- Member, International Association for Hydraulic Research
- Member, Australian Water Association
- Member, River Basin Management Society
- Member, Stormwater Victoria

### Areas of Expertise

Key areas of expertise relevant to this report are summarised below:

- Hydrologic and hydraulic modelling of stormwater and floodplain flows for flooding, drainage and stormwater studies;
- Assessment of surface water related issues associated with residential development, including waterway management;
- Expert witness for surface water management related issues at planning appeals and civil actions.

# 3 GLOSSARY AND ABBREVIATIONS

| TERM | DEFINITION |
|---|---|
| Annual Exceedance Probability (AEP) | The probability of exceedance of a given discharge within a period of one year. Can be expressed as a percentage (e.g. 1% chance in any one year, or a probability of 1 in 100). This report will generally use ARI terminology. |
| Average Recurrence Interval (ARI) | The average or expected period between exceedances of a given discharge expressed in years. This is a another method of expressing the magnitude of a particular event in probabilistic terms (e.g. a “100 year ARI flood” can also be described as a flood with an AEP of “1%” or “1 in 100” or ARI 100 Year). The ARI of a flood event is a statistical estimate that gives no indication of when a flood of that size or larger will occur next. |
| Catchment | The area of land contributing stormwater runoff to a particular site or point under consideration. It always relates to a particular location and includes the catchments of tributary streams as well as the main stream. |
| Consequence | Outcome or impact of an event. |
| Drainage System | A system of gully [street or field] inlets, pipes, overland flow paths, open channels, culverts and detention basins used to convey runoff to its receiving waters. |
| Freeboard | The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation. |
| Flood | The covering of normally dry land by water that has escaped or been released from [i.e. has exceeded the capacity of] the normal confines of any lake, or any river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam. A flood can be caused by excessive rainfall, storm surge, dam break or a tsunami. |
| Floodplain | A floodplain is defined as the extent of land inundated by the Probable Maximum Flood. |
| Hazard | A source of potential harm. |
| Hydraulic Design | The component of drainage design that involves the determination of velocities, heads and water levels as storm runoff passes through the drainage system. |
| Hydrologic Design | The component of drainage design that involves determination of stormwater runoff, either discharge or volume. |
| Local Authority | Any local or regional external authority—whether government or non-government, including local governments and the State Government—that has a legal interest in the regulation or management of a given activity, or the land on which the activity is occurring, or is proposed to occur. Reference to “the local authority” shall also imply the plural. |
| Local Government | The local city or shire council with jurisdiction over the land in which the activity in question is occurring, or is proposed to occur. |
| Manning's ‘n’ Roughness Coefficient | A measure of the surface roughness of a conduit or channel to be applied in the Manning's equation. |

| TERM | DEFINITION |
|---|---|
| Rainfall Intensity | The rate at which rain falls, typically measured in mm/hour. Rainfall intensity varies throughout a storm. This variation is called a temporal pattern. |
| Risk | The chance of something happening that will have an impact on objectives. It is measured in terms of a combination of the consequences of an event and their likelihood. |
| Runoff | That part of rainfall which is not lost to infiltration, evaporation, transpiration or depressions in the ground.<br>For the purposes of investigating or studying a flood it is the amount of rainfall that drains along the surface and into the “drainage system” or directly into receiving waters. Local runoff is that which occurs locally to a point in question (i.e. within a lot) and has not yet reached a drainage system. |
| Sedimentation Basin | A permanent sediment collection basin as opposed to a temporary construction site “sediment basin”. A tank or basin designed for low-velocity, low-turbulent flows suitable for settling coarse sediment particles from stormwater runoff. |
| Stormwater Flooding | Inundation by local runoff caused by heavier than usual rainfall. Stormwater inundation is caused by local runoff before it has entered a watercourse or joined watercourse flow. In a rural setting and within large rural allotments, we define stormwater flooding as sheet flow caused by local runoff before it has concentrated into a watercourse, including a drainage channel, stream, gully, creek, river, estuary, lake or dam, or any associated water holding structure. |
| Surface Water or Inundation | Any water collecting on the ground or in an open drainage system or receiving water body. In this report we use these terms to discuss water before it is categorised into flood, stormwater or other. |
| UGB | Urban Growth Boundary |

# 4 SCOPE OF THIS REPORT

In relation to Craigieburn West PSP, I have been requested by Maddocks on behalf of Council to review the documents supplied to me as relevant to my area of expertise and prepare an expert evidence statement and appear as an expert for Council at the Advisory Committee (to be held on an online platform) on 29 and 30 April 2021.

My expert evidence report should:

1. consider the drainage and hydrology related work underpinning the Draft Amendment and Proposed PSP;
2. consider the matters raised in the Council's submission and provide my opinions in respect of the Council's submission;
3. respond to any others submissions insofar as they relate to my area of expertise as relevant to Council's submission;
4. consider any additional material including the VPA's response to the Council's submission;
5. include my opinion on the Draft Amendment having regard to the documents in the briefing folder relevant to my area of expertise, in particular the proposed PSP;

# 5 BASIS OF THIS REPORT

This report is based on:

- Observations from site visit
- LiDAR, VicMap GIS layers and aerial imagery
- Information provided to me by Maddocks including:
  - VPA Project Standing Advisory Committee Terms of Reference, dated 17 July 2020
  - Letter of Referral, dated 8 March 2021
  - Explanatory-Report-Public-Consultation-November-2020
  - Public Consultation - Incorporated Documents – Craigieburn West PSP 1068 Background Report, Draft for Public Consultation, November 2020
  - Craigieburn West PSP Submissions 1 -42, in particular:
    - Submission 17 - Hume City Council, Submission to draft CWPSP, 18 Dec 2020
    - Submission 24 - 1360 Mickleham Road, Craigieburn - from SMEC on behalf of Porter Davis Projects Pty Ltd, 18 Dec 2020
    - Submission 25 - Melbourne Water, 18 Dec 2020
    - Submission 29 - 1340, 1390, 1430 & 1480 Mickleham Road & 665 Craigieburn Road, Craigieburn - Peet 18 Dec 2020
  - VPA Submission Summary, 15 March 2021
  - CWPSP - Hydrogeogological Salinity Acid Sulphate Soil and Geotechnical Assessment Revised Report - Beveridge Williams, September 2020
  - CWPSP - Integrated Water Management Issues and Opportunities - Alluvium - March 2019
  - CWPSP - Aitken Creek Waterway Values Assessment prepared for Melbourne Water – Jacobs, December 2020
- Stormy Water Solutions Memo - Gap Catchment Required Drainage Reserve for a Singular Asset (for Peet), April 2021

This report has been prepared in accordance with the Guide for Expert Evidence. I have read the Guide and am aware of my overriding duty to assist the Panel on matters relevant to my expertise.

# 6 SITE DESCRIPTION

## 6.1 Locality

The Craigieburn West Precinct is located approximately 30 km north of the Melbourne CBD and approximately 5 km west of the Craigieburn Train Station as shown in Figure 6-1 (reproduced from Alluvium IWM Report 2019). Plan 4 of the Craigieburn West Precinct Structure Plan (CWPSP) is shown in Figure 6-2.

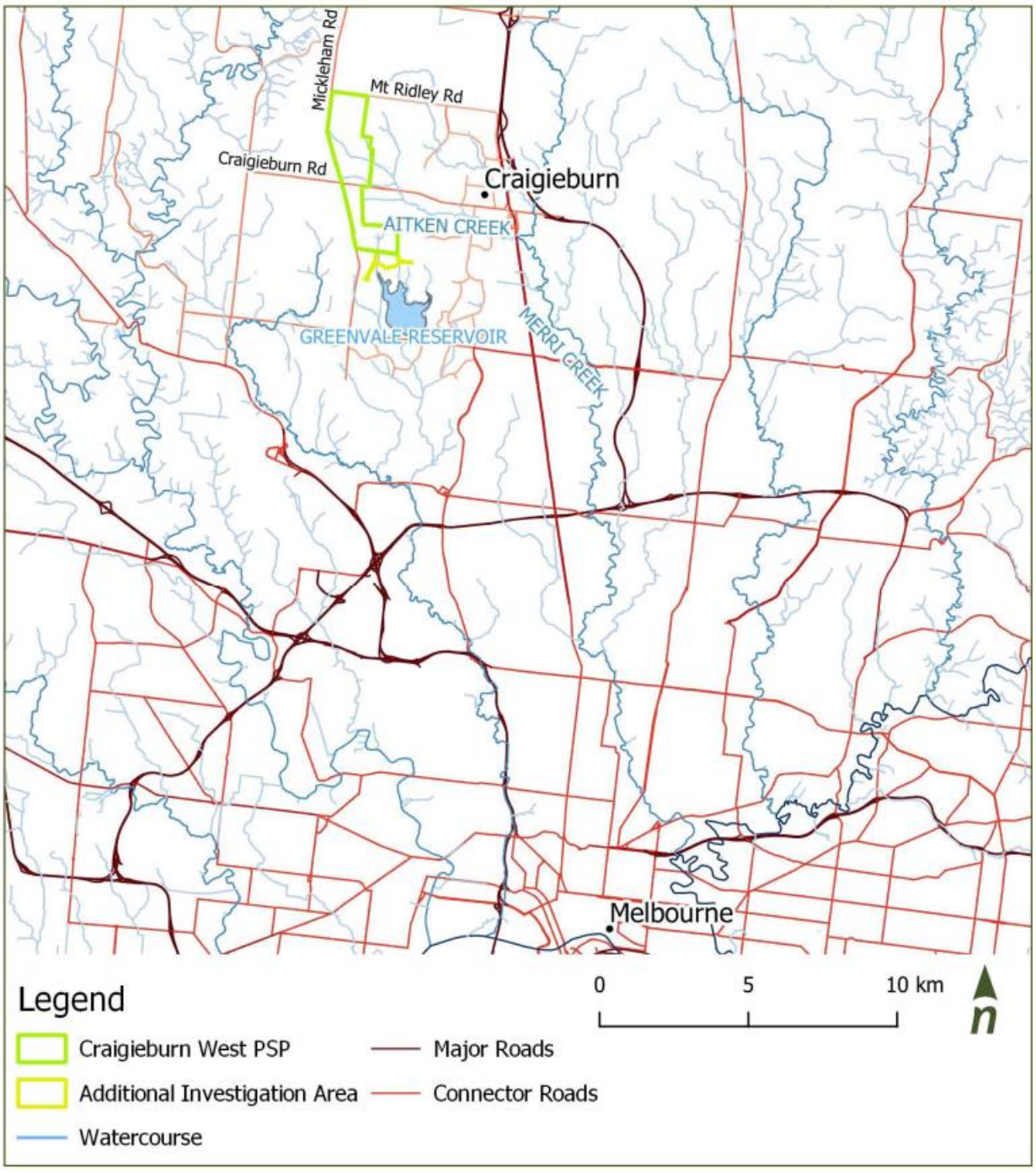


**FIGURE 6-1 CRAIGIEBURN WEST PRECINCT LOCATION (SOURCE ALLUVIUM, 2019)**

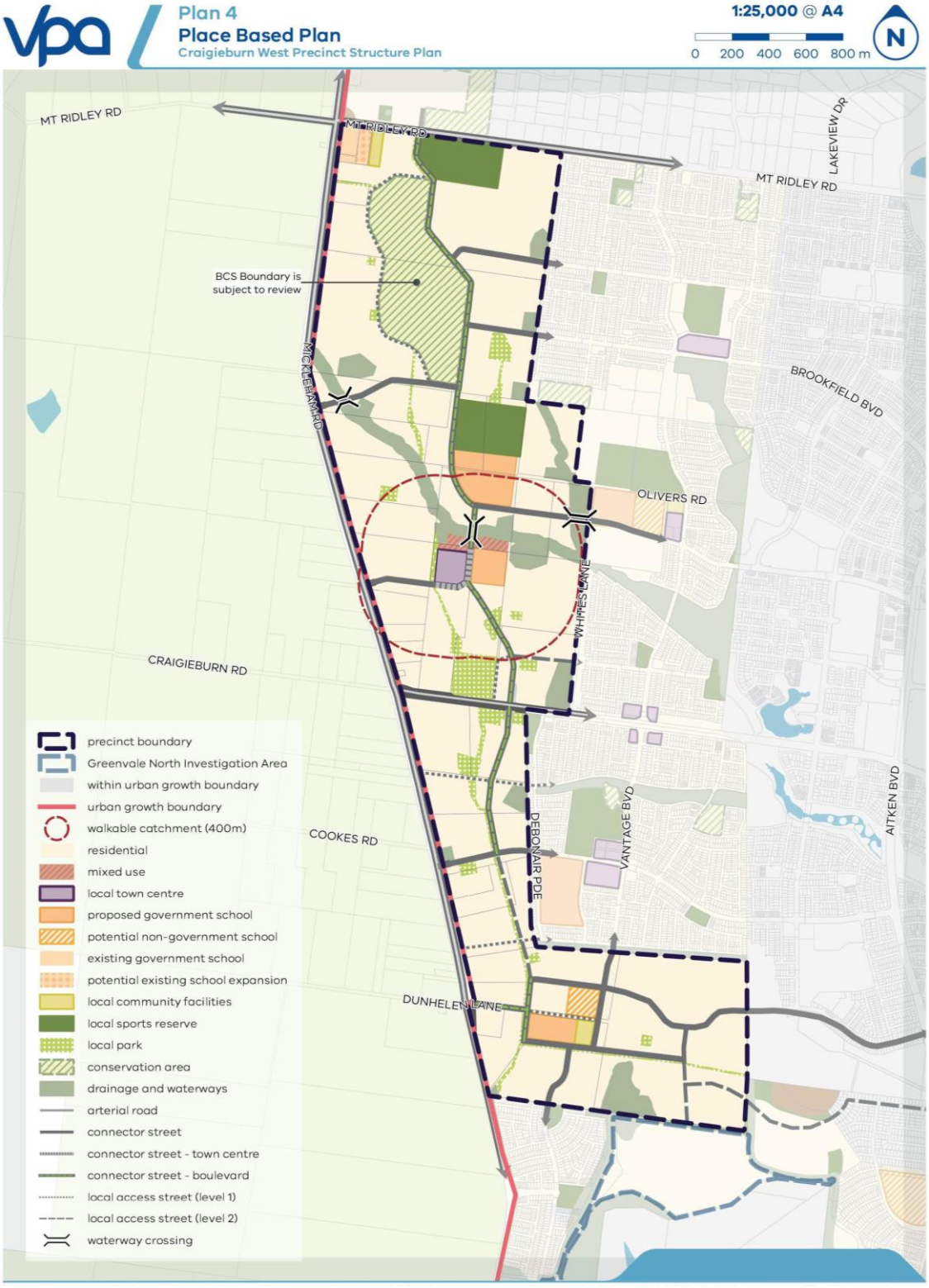


**FIGURE 6-2 CRAIGIEBURN WEST PRECINCT STRUCTURE PLAN (FROM DRAFT PSP, VPA NOV 2020)**

## 6.2 Key Characteristics

### 6.2.1 Topography

The CWPSP covers an area of around 562 hectares. The area is elongated from north to south as shown in Figure 6-2 above and is bounded by existing or approved residential development to the east, Mickleham Road (which defines the urban growth boundary in this area) to the west, rural land to the north and existing development including Greenvale Reservoir to the south.

The land generally slopes gently from north to south and west to east as shown in Figure 6-3. The highest elevations are around 270 m AHD in the north of the CWPSP and the lowest is around 190 m AHD near the southern boundary.

### 6.2.2 Catchments and Drainage

Most of the CWPSP land drains into the Aitken Creek catchment to the east whilst the southern portion of the catchment flows into the upper Moonee Ponds Creek catchment. The CWPSP is covered by 3 Melbourne Water Drainage Scheme (also referred to as a Development Services Scheme, DSS) areas as shown in Figure 6-4. These are:

- 4480 Aitken Creek DS
- 4381 Upper Brodies Creek DS
- 4360 Yuroke Creek DS

The 4368 Greenvale Lakes Strategy scheme does not cover the CWPSP area but abuts a section of the south-west corner.

There is also an area within the CWPSP not covered by any drainage scheme. This is referred to as the “DSS gap” in the CWPSP report. Melbourne Water refer to this area as the “Gap Catchment (Non DSS)”. This gap area is also shown in Figure 6-4 and is located between Debonaire Parade and Mickleham Road (opposite Cookes Road) in the lower third of the CWPSP area. This catchment is approximately 19 ha in area according to the DSS maps. The local topography and background aerial image are shown in Figure 6-5 and Figure 6-6 respectively. These highlight the gap catchment flows to the west across Mickleham Road. There is a large private dam, approximately 1.8 ha in area inside the gap catchment, adjacent to Mickleham Road. This dam has a 2-3 m high earth embankment on the west side.

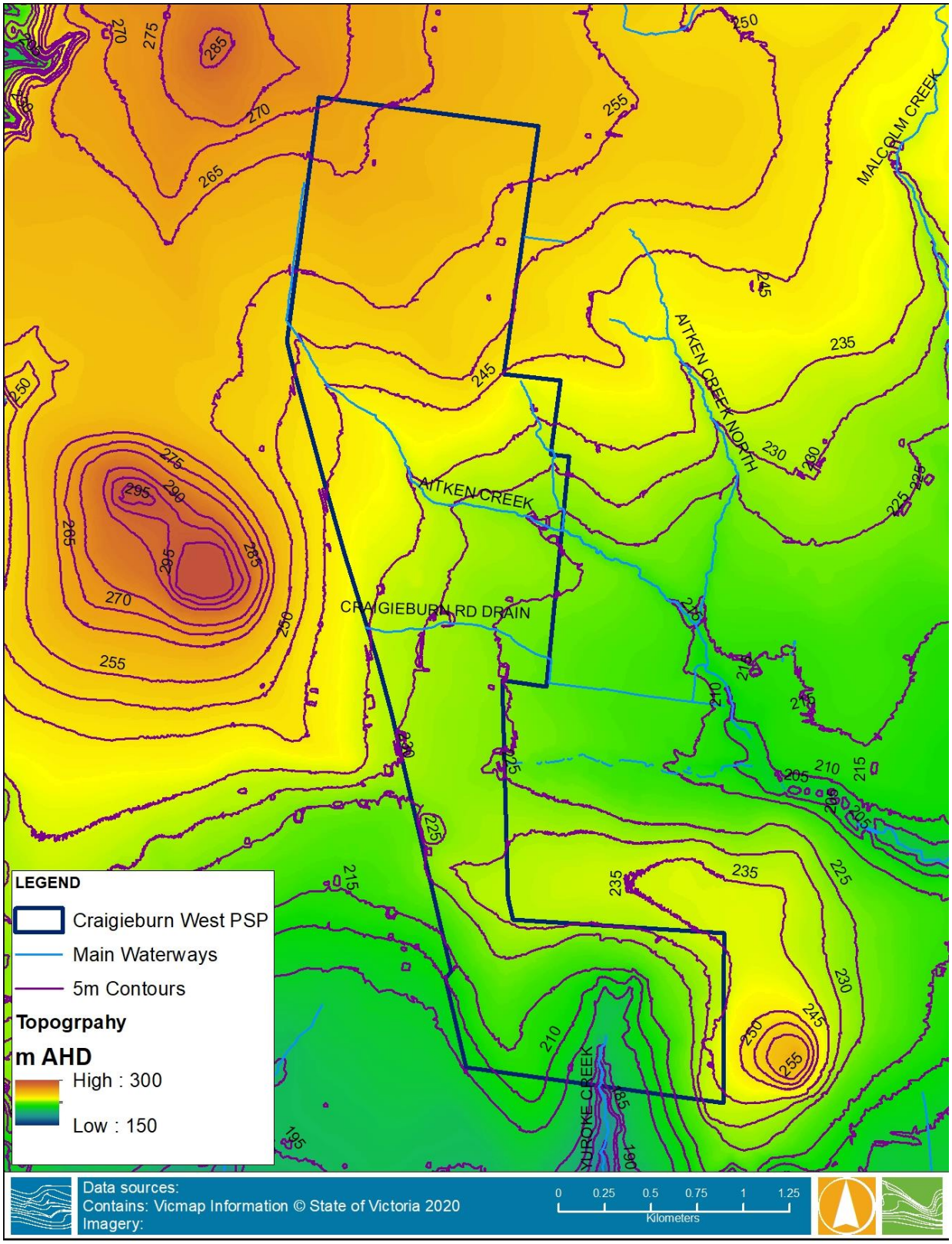


FIGURE 6-3 REGIONAL TOPOGRAPHY

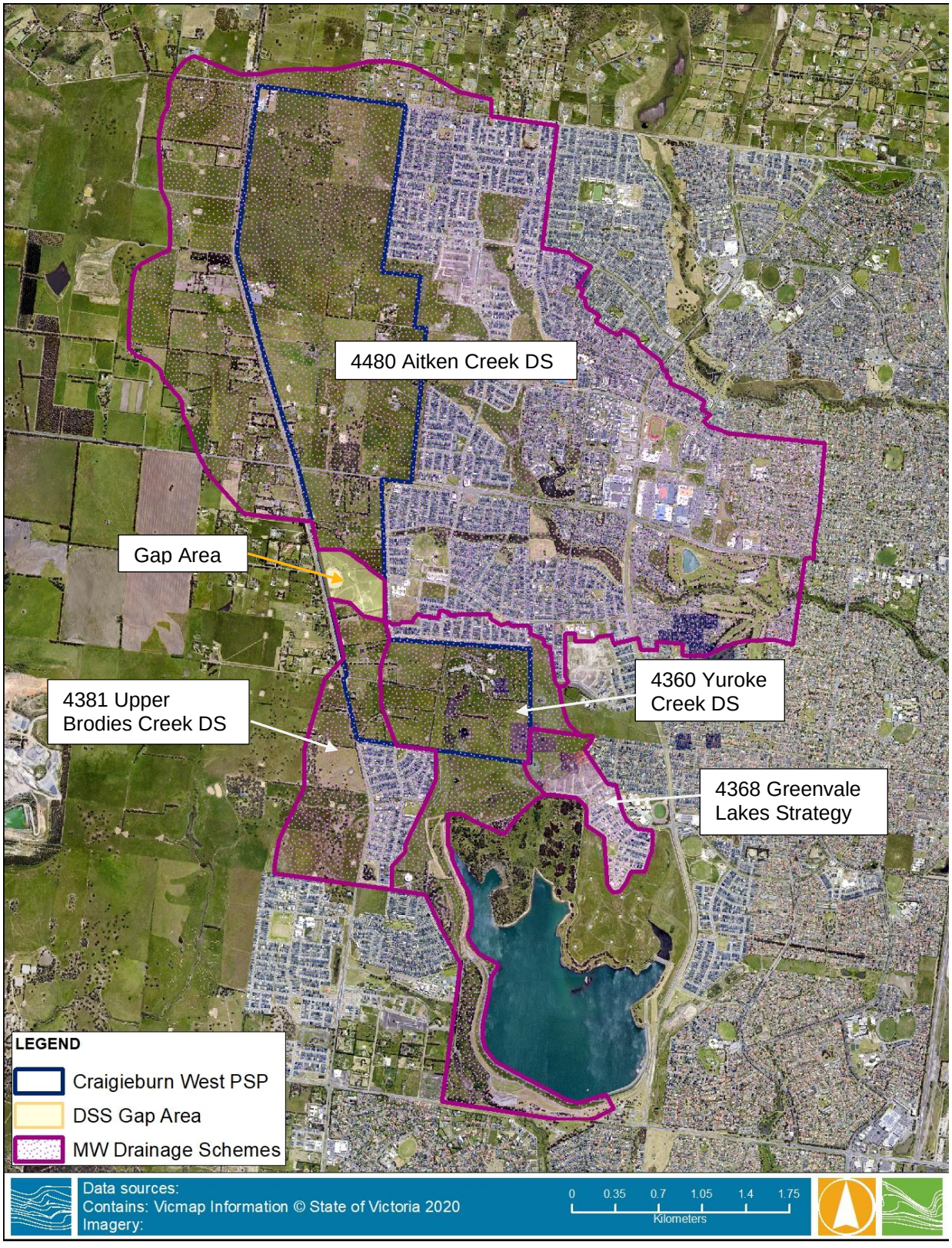


FIGURE 6-4 MELBOURNE WATER DRAINAGE SCHEMES

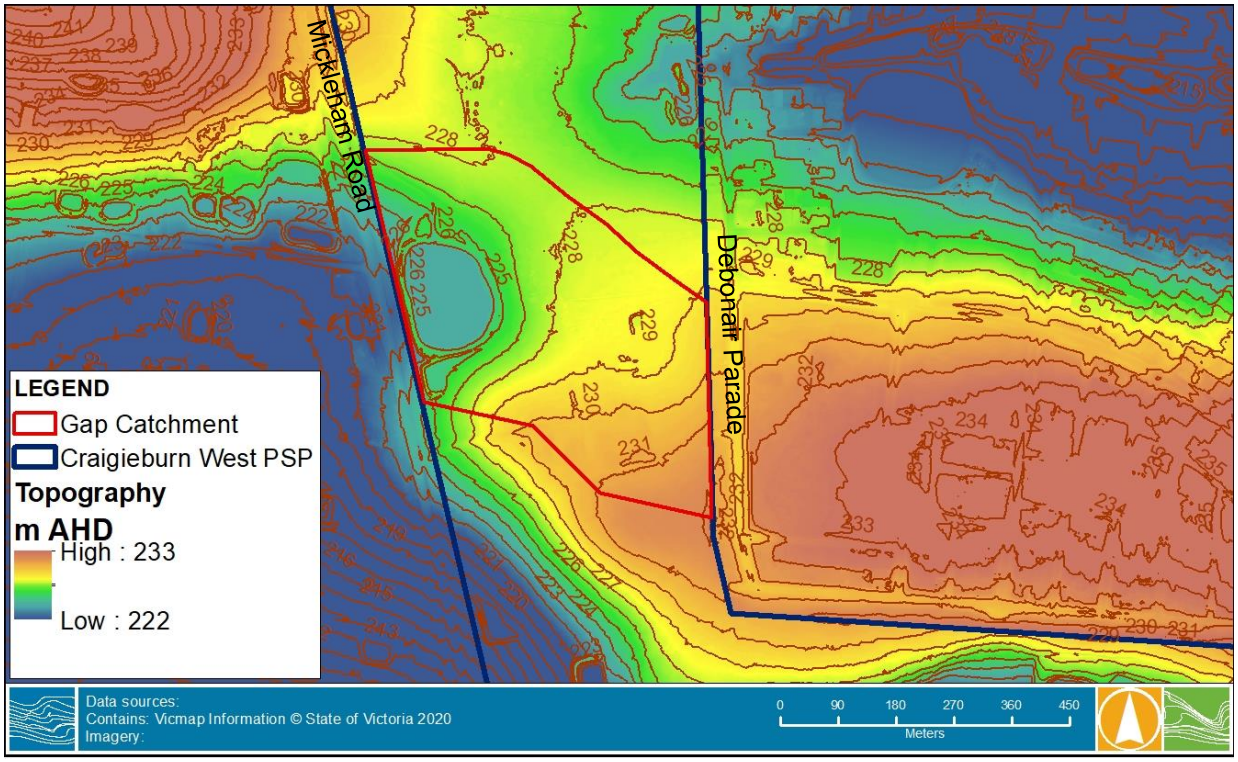


FIGURE 6-5 GAP CATCHMENT AREA TOPOGRAPHY

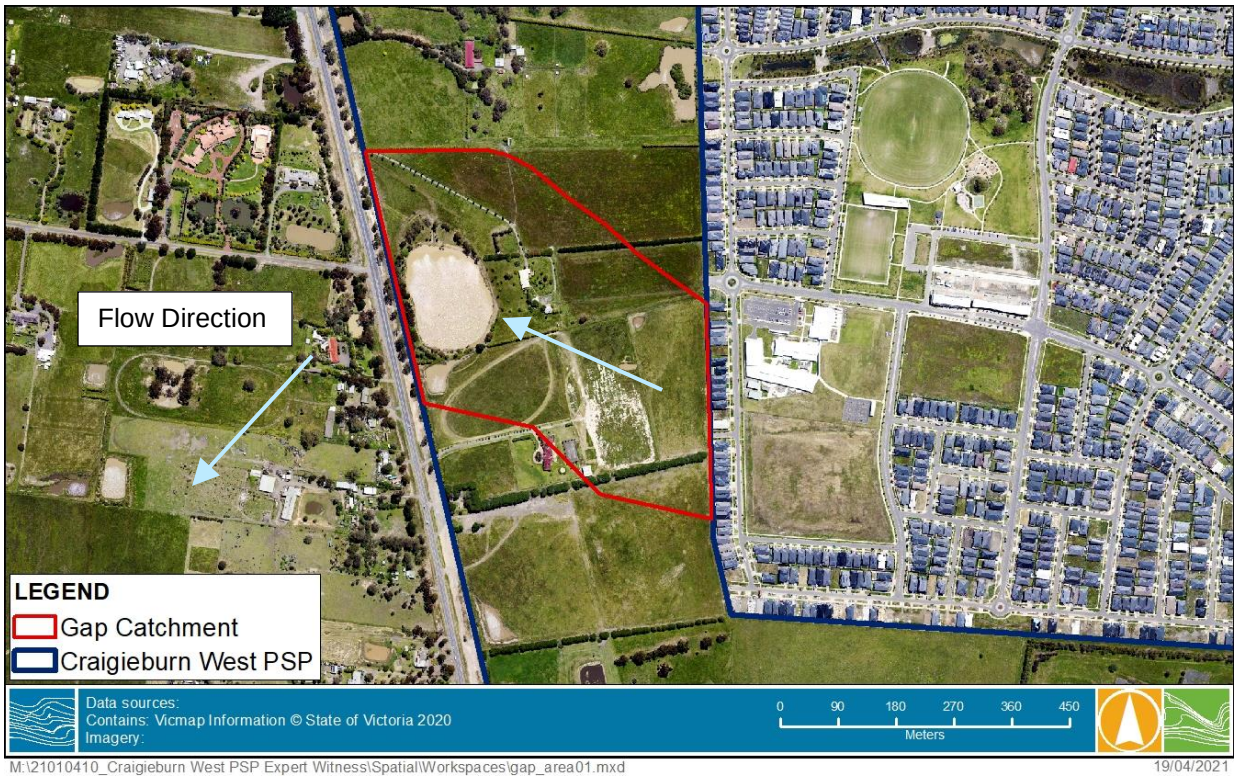


FIGURE 6-6 GAP CATCHMENT AREA BACKGROUND AERIAL IMAGE

# 7 PSP DRAINAGE CONCEPT

## 7.1 Overview

Plan 6 of the CWPSP shows the Integrated Water Management Plan which includes the main drainage infrastructure as proposed in the 3 drainage schemes which cover the area.

The stormwater management approach covered by the DSS plans is typical for Melbourne Water drainage schemes and principally comprises constructed waterways, sediment basins and wetlands/retarding basins. This type of infrastructure is considered appropriate and in line with industry practice as it typically achieves good treatment efficiency and reduces maintenance costs compared to highly distributed systems. I have not looked in detail at the proposed assets, however they appear logically arranged.

As highlighted by Jacobs (2020) the Aitken Creek DSS was originally developed in 2000. Jacobs infer that the DSS was designed to standards that are no longer current. In addition, they raise concerns particularly in relation to sodic soils and potential environmental impacts of deep excavated drainage channels. Whilst drainage schemes are regularly updated, the overall drainage strategy for the CWPSP appears to be subject to further refinement. This is supported by Melbourne Water commissioning Jacobs to review the values of Aitken Creek, presumably so that this can be incorporated in the design of future drainage infrastructure within the CWPSP area to protect and/or enhance those values.

It is clear there is impetus to improve the standard of urban water management in new urban areas. Melbourne Water is investing significant effort in nearby catchments to develop harvesting schemes to minimise the increased volume of runoff associated with urbanisation (Sunbury for example). This serves the goal of protecting waterway health downstream. Alluvium have flagged this in their 2019 report on Integrated Water Management Issues and Opportunities. Without large-scale stormwater reuse schemes, it is likely that further land would be required for additional stormwater storage, to achieve these waterway health objectives. At present it is not clear to what extent such measures are “aspirational” or a requirement of Melbourne Water and the CWPSP. Greater clarity of expectations would give developers more certainty in planning.

I note that the contribution rates for the Aitken Creek Drainage Scheme appear generally low compared to many contemporary schemes (i.e., hydraulic contribution of $77k/ha compared to Upper Brodies Creek DS $160k/ha). There can be many reasons for nearby drainage schemes to vary in rates, however this would support the view that refinement of the scheme to match current expectations and requirements in terms of integrated water management and waterway health is required and this may lead to an increase of the DSS rate.

I note that waterway corridor widths are not specified in the CWPSP. Some assumptions have been made in relation to these for the purposes of land budget calculations. Based on the Jacobs report and the requirements in Section 3.3.1 of the CWPSP, there seems to be some possibility, if not a likelihood, that waterway corridor widths will increase. This is based on the desire to maintain a wider and shallower waterway profile than may typically be the case. The advantages of this approach are to maintain a more natural profile with greater surface storage and avoiding deep excavations that may disturb sodic soils and intercept shallow groundwater. A disadvantage of shallow drainage channels is that piped drainage in adjoining areas may be difficult to achieve without additional fill and raising of lots. This would have an impact on the land take and land development costs.

## 7.2 Functional Design

I note that, as far as I am aware, no overall functional stormwater design has been developed for the CWPSP. In my experience it is helpful if a functional design report(s) is prepared to demonstrate the nominated stormwater management assets will fulfil their desired function and that authorities and land-owners have a reasonable understanding of the constraints and challenges associated with the proposed infrastructure.

Functional designs are helpful to confirm that all drainage elements will work together to provide a practical and efficient stormwater management system. This addresses issues like asset size, taking into account depths and batter slopes, the level and gradient of the land and so on. Typically, it will also address what extent and depth of bulk cut and fill earthworks are required (for drainage).

It is apparent that some elements of the stormwater infrastructure design are unresolved (particularly with respect to the IWM and waterway values reports). Whilst this may not impact the general arrangement or even the number of assets, it could have an impact on land-take for drainage reserves.

I do not consider this should prevent the PSP from being adopted, however it will be important there is a clear understanding that some flexibility will be required around the exact areas and widths of drainage reserves (waterways, sedimentation basins and wetlands/retarding basins). Melbourne Water, Council, VPA and developers will need to work together to resolve these matters as soon as possible to provide greater certainty in the stormwater designs.

## 7.3 Gap Catchment

As noted in Section 6.2.2 (Figure 6-6), there is a gap catchment that is not part of the current DSS areas. Based on the Melbourne Water DSS plans, this area is around 19 ha. Analysis of the LIDAR contours produces a catchment area of approximately 14.5 ha, shown as “Refined Catchment Area” in Figure 7-2. This calculation could be considered to be representative of the current catchment that drains towards the large dam on Mickleham Road. I recognise that Melbourne Water typically adjusts DSS boundaries to align with property boundaries where possible to avoid complications related to DSS charges which explains the difference in area. Figure 7-2 also highlights the alternative gap catchment area proposed by Stormy Water Solutions (for Peet), which I refer to as the “SWS Gap Catchment”. This SWS Gap Catchment area is 11.4 ha. I understand the area of the gap catchment is proposed to be reduced on the basis that:

- Allocating more land to the existing drainage schemes will not have a significant impact on the treatment measures proposed for those schemes.
- Reducing the gap catchment area will minimise the quantum of drainage works required outside of the drainage schemes and the associated costing arrangements.
- Reducing the size of drainage assets in the gap catchment will reduce the future maintenance burden on Council, which will be the responsible authority for any drainage assets in the gap area.
- Reducing the area of the gap catchment will minimise the impacts of development on downstream landowners outside the UGB. Typically, an increase in low, frequent flows from urban runoff has greater impact on downstream rural land-use compared to urban. This is because the downstream drains in rural areas are generally not designed to manage these flows. Common outcomes may be water logging of paddocks, access issues and erosion.

It is noted that an adjustment of the gap catchment area would have a minor impact on the DSS boundaries and detailed cost calculations (rate per hectare for example).

I believe the SWS proposed gap catchment is an appropriate response to the issues highlighted above. There is a small area in the north-west corner that may be difficult to drain without fill of up to 2 m (or slightly more) to achieve grade to the east. This is shown in Figure 7-3, with a longitudinal section along the nominal boundary road shown in Figure 7-4. I do not consider this to be a significant issue and can either be resolved through civil design or the boundary slightly adjusted.

I understand there are two landowners that share approximately 50% ownership of the land covered by the SWS Gap Catchment. The development of drainage infrastructure in the gap catchment will benefit both landholders/developers and hence costs should be equitably shared between them using principles similar to the way drainage schemes are managed.

I have reviewed the proposed Stormy Water Solutions design for a sediment basin, retarding basin and bio-retention system. I believe the design is appropriate and could achieve the desired outcome. There is ample elevation between the current base of the dam and the land surrounding the dam, which rises steadily, to implement the bioretention swale and match the culvert invert levels to achieve outfall.

I understand that two assets were previously proposed, however I believe a single asset in this catchment is a far better design solution. Dual assets in a small catchment are inefficient as they require additional reserve area to accommodate batter slopes, access paths and maintenance areas. The logical position for a treatment asset in this catchment is at the lowest point which is inside the footprint of the existing dam (property 31). A second asset located in property 32 would fall outside the dam and not in the lowest part of the catchment. This would also require excavation of higher ground and filling of a larger portion of the dam which is inefficient from an earthworks perspective.

A shallow bioretention system will minimise excavation at the site and any potential interaction with a shallow groundwater table.

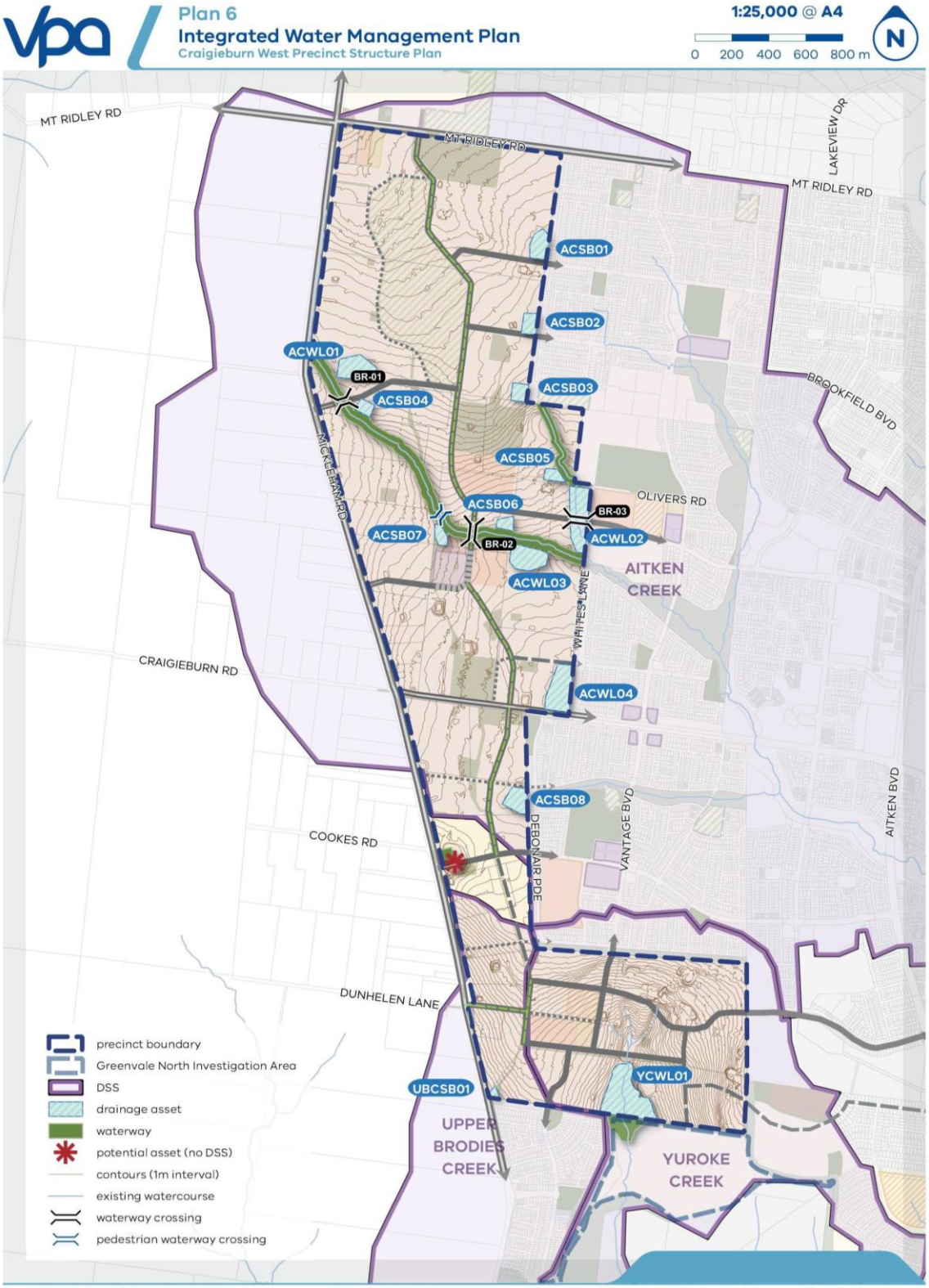


**FIGURE 7-1 CRAIGIEBURN WEST PSP – PLAN 6 INCORPORATING DRAINAGE**

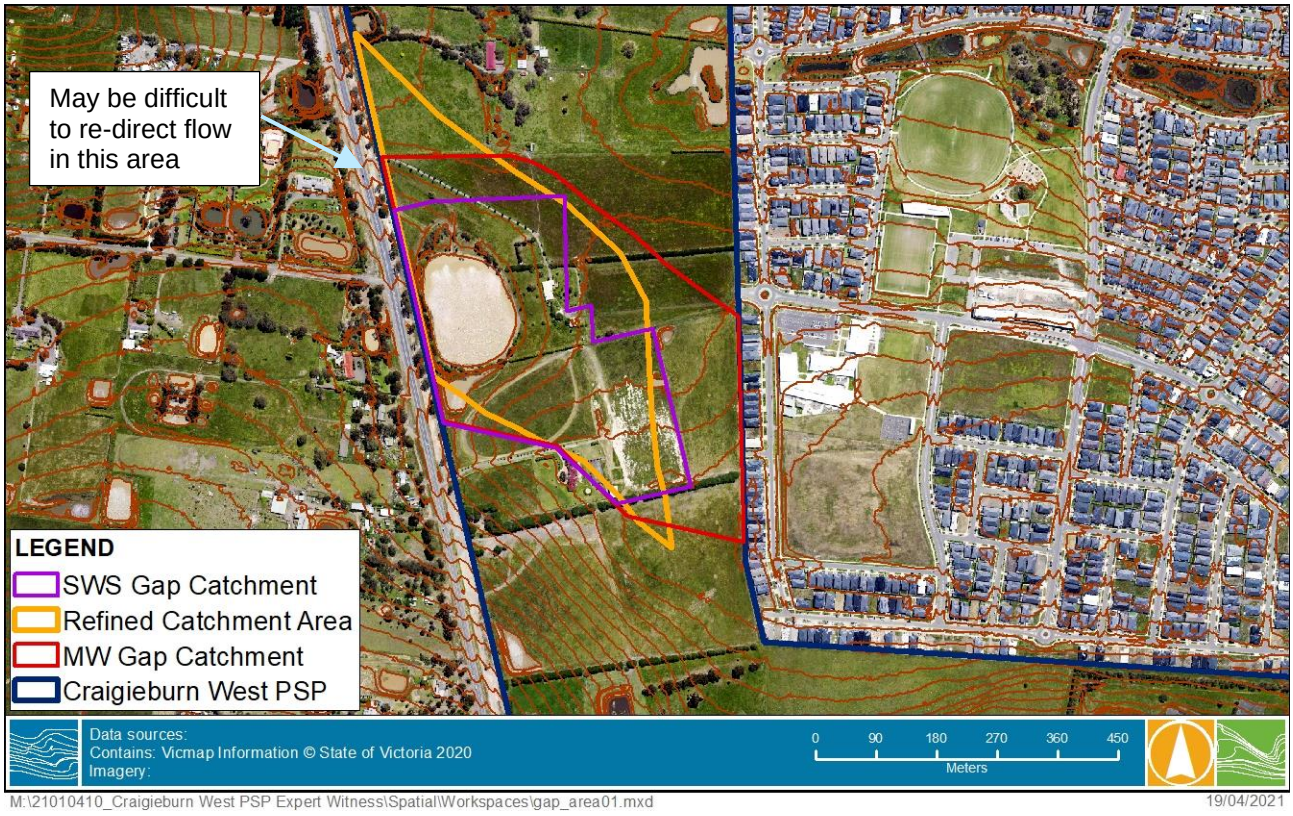


FIGURE 7-2 REFINED GAP CATCHMENT AREAS

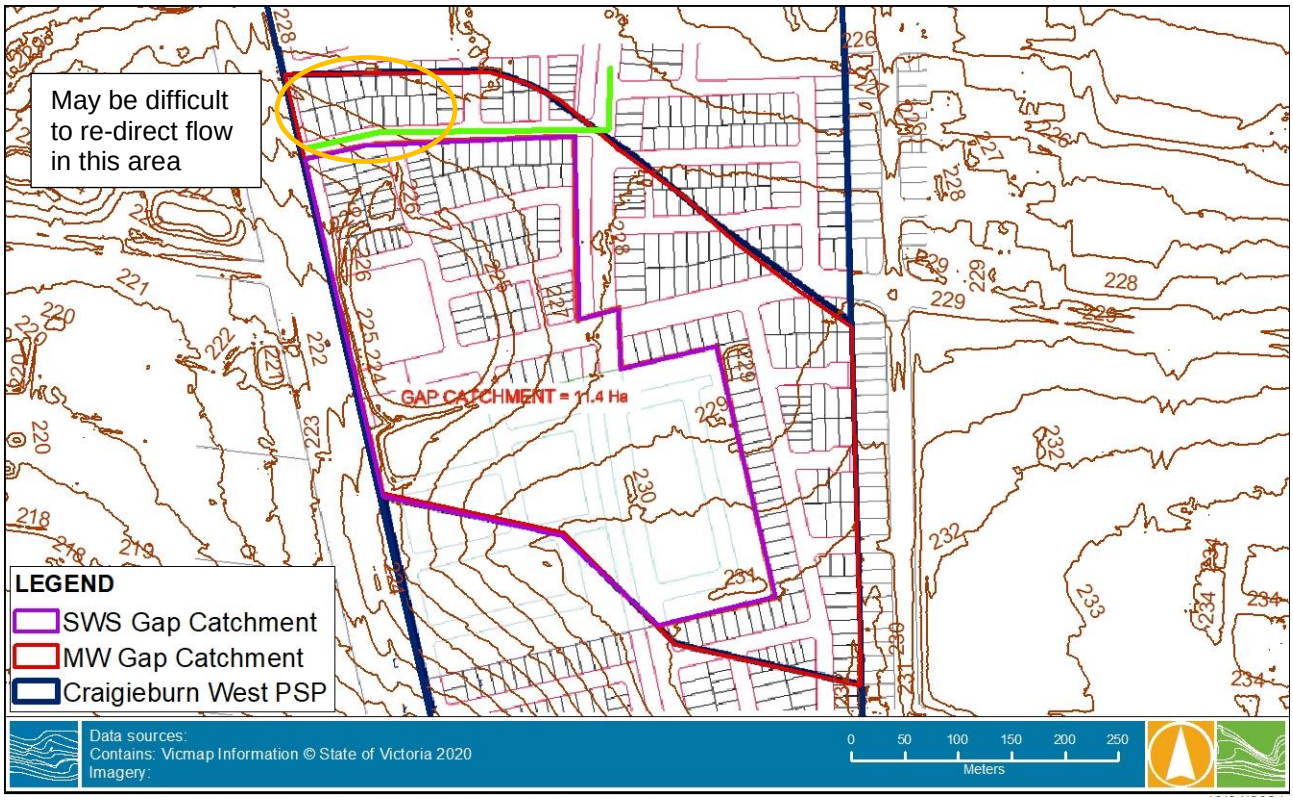


FIGURE 7-3 REFINED GAP CATCHMENT LOCATION OF LONG-SECTION (IN LIGHT GREEN)

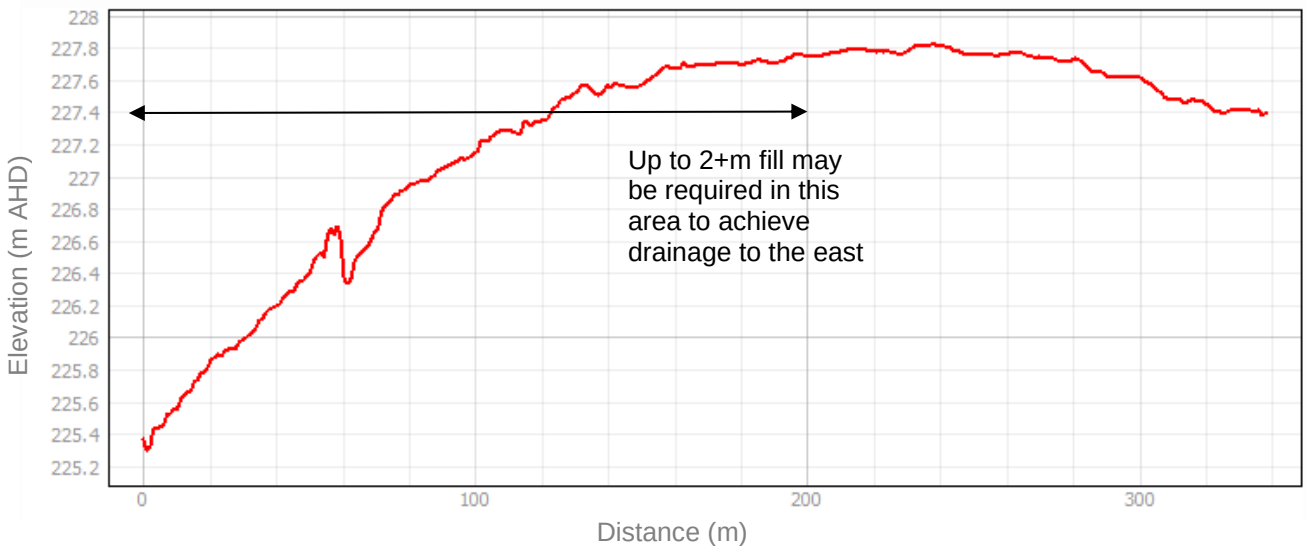


**FIGURE 7-4 LONGITUDINAL SECTION ALONG NORTHERN BOUNDARY OF SWS GAP CATCHMENT**

# 8 RESPONSE TO QUESTIONS

***1. Consider the drainage and hydrology related work underpinning the Draft Amendment and Proposed PSP***

I have reviewed and commented on the drainage and hydrology in the preceding sections of this report.

***2. Consider the matters raised in the Council's submission and provide my opinions in respect of the Council's submission***

I have reviewed Council's submission to the Panel and address the matters relevant to my area of expertise below.

**Hydrology**

*Shallow Groundwater*

The Hydrogeological, Salinity, Acid Sulphate Soil and Geotechnical Assessment Craigieburn West PSP by Beveridge Williams (2020) highlighted some potential groundwater issues. The report concluded that:

- The risk to development from soil, groundwater and geotechnical issues is low.
- The sampling on-site suggested some soils were slightly saline and risk of dryland salinity is low (which also infers that water tables are not extremely shallow).
- Isolated areas of potential shallow groundwater may be present in the central portion of the PSP area.

None of the on-site testing revealed any areas of concern with respect to shallow groundwater. The report acknowledged that development is likely to reduce recharge and lower groundwater levels over time. However, state-based datasets identify the middle section of the CWPSP area as having potential shallow groundwater. The report recommends that precinct scale or development specific investigations are undertaken through areas identified as more at risk by the statewide data. In terms of stormwater treatment asset design, I believe that development specific investigations would be appropriate. The area identified as higher risk does not cover a large portion of the PSP. The gap between major drainage assets is such that design and works at one site are unlikely to have significant impacts on groundwater at other sites. Hence the groundwater investigations can be undertaken independently.

I understand Council recommends that the extension of Elevation Boulevard to Mickleham Road should be adjusted to align with Cookes Road to create a four-way intersection. I do not believe there are any adverse consequences to this change from a drainage perspective.

***3. Respond to any others submissions insofar as they relate to my area of expertise as relevant to Council's submission***

I have not had the opportunity to review all submissions in detail and provide no further comments at this time.

***4. Consider any additional material including the VPA's response to the Council's submission***

I understand that VPA agrees with most of Councils submissions other than the need for additional precinct scale groundwater investigations. I have addressed this, to the extent of my expertise, in my comments above.

***5. Include my opinion on the Draft Amendment having regard to the documents in the briefing folder relevant to my area of expertise, in particular the proposed PSP***

I consider the CWPSP to have taken appropriate consideration of stormwater management requirements. The proposed drainage assets provide an appropriate response. Further details, in terms of functional design reports for stormwater management assets, would be helpful and should be developed in consultation with

MW and Council to provide greater certainty with respect to the required asset foot print, associated land take and refined DSS costs.

# 9 CONCLUSIONS

With respect to surface water management issues related to the Craigieburn West PSP, I am of the opinion that:

- The CWPSP includes an appropriate approach to stormwater management.
- The requirements and guidelines in the PSP should assist developers to produce designs that meet the needs of the community and the receiving environment.
- Groundwater investigations undertaken at permit stage can address concerns in relation to any groundwater-surface water interactions for the drainage infrastructure.
- The size of the gap catchment can be reduced to approximately 11.4 ha in accordance with preliminary designs by Stormy Water Solutions, pending agreement with Melbourne Water on the slight adjustment of existing DSS boundaries.
- A single water treatment asset in the gap catchment is likely to be the most efficient and cost-effective means of managing stormwater.

# 10 DECLARATION

I confirm the following:

a. The factual matters stated in this report are, as far as I know, true;

b. I have made all enquiries that I consider appropriate;

c. The opinions stated in this report are genuinely held by me;

d. The report contains references to all matters I consider significant; and,

e. I understand my duty to the Panel and have complied with that duty.

Warwick Bishop

19 April 2021

# APPENDIX A
# CURRICULUM VITAE

# WARWICK BISHOP

warwick.bishop@watertech.com.au | 15 Business Park Drive, Notting Hill VIC 3168
Phone: 03 8526 0800 | 0403 055 338

***Director***

***BE (Hons), MEng Sci (Water)***

***FIEAust, CPEng, NER***

## QUALIFICATIONS

- Bachelor of Engineering with Honours (Civil), University of Melbourne, 1992
- Masters of Engineering Science (Water), Monash University, 1999

## AFFILIATIONS

- Fellow, Institution of Engineers, Australia, Chartered Professional Engineer
- Member, International Association for Hydraulic Research
- Member, Australian Water Association
- Member, River Basin Management Society
- Member, Stormwater Victoria
- Member, Engineers Australia Victorian Water Engineering Branch Committee

## SUMMARY

Warwick is a Director of Water Technology and has over 25 years' experience in hydrologic and hydraulic investigations, specialising in the development and calibration of rural and urban hydrologic and hydrodynamic models and their application to flooding, water quality, sediment transport and environmental values. He also has extensive experience in coastal and estuary modelling including wave, current and oil spill investigations. He has worked extensively in the Murray Darling Basin, principally on environmental hydraulic investigations for the Living Murray Program. Warwick was contributed to the most recent revision of Australian Rainfall and Runoff, providing input to the reference document on 2D hydraulic modelling of rural and urban areas. Warwick worked in the Flood Intelligence Unit of SES during the 2011 floods and is regularly called on to provided expert evidence in surface water matters at VCAT and planning panels.

## PROFESSIONAL HISTORY

| | |
|---|---|
| 2009 to present | Director, Senior Principal Engineer, Water Technology Pty Ltd |
| 2003-2009 | Senior Engineer, Water Technology Pty Ltd |
| 2001-2003 | Victorian Water Resources Manager, Lawson and Treloar Pty Ltd |
| 1997-2001 | Senior Engineer, Lawson and Treloar Pty Ltd |
| 1993-1997 | Engineer, Lawson and Treloar Pty Ltd |

## SPECIALIST AREAS OF EXPERTISE

- Wetland, WSUD and water quality investigations
- Surface water investigations of urban and rural floodplains, rivers and wetlands
- Modelling of flooding, environmental flows, water quality and sediment transport
- Urban flood mapping, flood mitigation and stormwater treatment
- Integrated Water Management
- Investigations of estuary and coastal hydraulics
- Expert witness reports

## RECENT MAJOR PROJECTS

### STORMWATER PROJECTS (FLOODING, DRAINAGE AND WSUD) WATER TECHNOLOGY

Glen Eira WSUD Opportunities – Project director for an options study looking at the potential effectiveness of WSUD measures for flood mitigation. A local case study was undertaken with preliminary hydrologic and hydraulic modelling.

PNG LNG Condensate Fate Modelling – Project Director for hydrologic and hydraulic assessment of potential condensate spill scenarios for Gas Pipeline Development. One and two-dimensional models as well as mixing zone calculations were performed.

Buckland Park Development, Lower Gawler River – Detailed hydraulic investigation of a large new residential area in a floodplain environment. Development of flood mitigation measures including levees and channels.

Inverloch, Broadbeach Resort – Management of flooding issues related to a coastal development on the South Gippsland Coast. Hydrodynamics of the ocean, estuary, creek and township drainage systems have been taken into account to develop an overall flood risk assessment and appropriate land development level. Also included full drainage and WSUD design for the development.

Hoppers Lane (Werribee) – Development of a surface water management strategy for a mixed-use development including full WSUD treatment.

Keysborough South – Development of surface water management strategy for a large residential rezoning. This strategy has been adopted by Melbourne Water as input to their drainage scheme.

Stamford Park – Floodplain and wetland design for an industrial development adjoining a community park area for Knox Council.

The Strand Traralgon – Development of surface water models and WSUD design (wetlands) to provide treatment for a challenging site, constrained by existing drainage infrastructure and major easements.

Ocean View Lakes Entrance Stormwater Management Plan - Project director for development plan for a residential subdivision. Included design of wetland systems and retarding basin controls.

Cowes WEMP – Project Director in the development of a Water Efficiency Management plan for development in Cowes, use of probabilistic rainfall model PURRS.

Darebin Creek –1d Model (HEC-RAS) construction of waterway and analysis of bridge level assessment for Darebin Creek. Project Director.

Azola Waters, Pakenham – Functional design of Wetlands system for retirement village. Ongoing water quality assessment using various monitoring equipment. Project Manager/Director.

Cuttriss Street Flood investigation, Inverloch – Use of Mike Storm Pipe (Mouse) and two-dimensional (Mike21) linked model for urban storm water flooding. Project Director.

Brookfield Lakes, Bairnsdale, Stormwater Management Plan - Development plan for residential subdivision. Included design of wetland systems and retarding basin controls. Project Director.

Donga Road main drain catchments drainage study (City of Greater Geelong) - GIS analysis and hydraulic modelling of urban floodplain. Use of TUFLOW as predominate 2d/1d modelling package. Project Director.

#### STORMWATER PROJECTS (FLOODING, DRAINAGE AND WSUD) LAWSON AND TRELOAR

Sanctuary Lakes Water Quality – Management of a detailed water quality investigation including complex eutrophication modelling of the large lake system and analysis of the upstream wetlands

Sandhurst Estate – Management of hydrologic, hydraulic and water quality investigations for a large residential and golf course development in Melbourne's SE. This investigation included two-dimensional hydraulic analysis, a dynamic-pump system for lake top-up and eutrophication modelling in order to predict future water quality impacts.

Knox Golf Course – Development, calibration and application of a detailed MIKE 21 model of Monbulk Creek/Ferny Creek floodplain to assess flood impacts of a proposed golf course.

Oyster Cove Development, Coomera River QLD – Development of detailed MIKE 21 sub-models to calibrate roughness over residential developments.

Nerang River Floodplain – Major involvement in the development and application of a large, detailed 2-dimensional model of the Nerang River Floodplain. Analysis of impact of developments on flooding and investigation of mitigation options.

Heritage Golf and Country Club – Development of a MIKE 11 model to assess flood conditions in the Yarra River floodplain for design input.

Graceburn Creek, Healesville – development and application of a two-dimensional numerical model of a floodplain for risk assessment, regarding a proposed development. Believed to be the first application of two-dimensional hydraulic modelling on a floodplain in Victoria (1994).

#### FLOODPLAIN INVESTIGATIONS WATER TECHNOLOGY

Project Director for a hydraulic modelling study of the Pike River floodplain (SA MDB NRM Board). Development and calibration of a MIKE FLOOD model of the floodplain and use to inform the concept design of environmental regulators.

Project Director for a hydraulic modelling study of the South Australian Katfish Demonstration Reach (DEH). Development and calibration of a MIKE FLOOD model of the floodplain. This model was used to test a number of management scenarios.

Lyndhurst Drainage Strategy - Project Director of modelling waterway works for design of Retarding basins and wetlands for the Lyndhurst drainage scheme. Innovative use of linear waterways/wetlands for storage using two-dimensional hydraulic modelling.

Chowilla Floodplain Hydrodynamic Model – Supervision of the provision of detailed modelling services for this important floodplain system on the Murray River in South Australia, near the Victorian/NSW Border.

Port Fairy Flood Regional Study – A comprehensive review of flood risk to the township of Port Fairy and surrounding areas was undertaken. This included detailed hydrologic and hydraulic modelling, mapping and flood damages analysis. In addition, an extensive investigation of the potential impacts of climate change was undertaken.

Boggy Creek Wetland Review – Hydrologic and hydraulic review of translocated high-value wetland plots in Seaford adjacent to major road development. Working with ecologists to determine appropriate hydrologic regime.

Swan Hill Levee Audit – Investigation of the status of the existing town levee around Swan Hill through the use of a detailed two-dimensional hydraulic model. Assessment of levee system performance and recommendations for future flood mitigation works.

Beaufort Flood Study – Management of a comprehensive hydrologic and hydraulic study of the Beaufort township including investigation of 4 creeks that flow through the town. Resolution of complex design hydrology inputs to the township.

Dennington Flood Study – Detailed two-dimensional hydraulic model developed to describe inundation of the Merri River floodplain and provide planning information for future growth area near Warrnambool in south-west Victoria.

Applying Modelling Tools to Investigate Water Management in the Gunbower Forest – Project manager for the development of a detailed hydraulic model of Gunbower Forest. The model has been calibrated against a number of historic flood events and will be used to assess the effectiveness of a number of potential water management options. These options seek to improve the flooding regime of the forest through the use of environmental flow allocations. The required flooding is determined through a set of ecological objectives. Working closely with ecologists to determine hydrologic regime.

Hydraulic Modelling for Lindsay, Mulcra and Wallpolla Islands – This project involves the development of a linked one and two-dimensional model of these important floodplain and wetland environments that are included as one of the significant environmental assets or “icon sites” along the Murray River. This area has significant environmental values that suffer from reduced flooding due to river regulation. The hydraulic model will be used to test different management scenarios for floodplain improvement.

Murray River Regional Flood Study – Cobram to Tocumwal – Specialist modelling input is being provided for this project with an extensive one and two-dimensional model being developed including the Murray River channel and floodplain. The study area features many man-made controls such as levee banks and irrigation supply channels that dominate the topography. Once established the modelling will be used to develop flood management scenarios on a regional scale.

Investigations into Preferred Water Management Options in Gunbower Forest, 2D Modelling - Project management of the hydraulic modelling of the impact and effectiveness of proposed management options to improve watering of the wetlands and floodplain within Gunbower Forest.

Glenelg Hopkins CMA Rural Drainage Areas, Water Quality Impact Studies – Hydrologic and water quality analysis of four rural drainage areas specifically to examine the impacts of rural drainage on stream health of the main receiving waters.

Living Murray Hydraulic Investigation, Environmental flow for Barmah Millewa Wetland System – Project and technical management of this significant study within the Murray River system. The project involves the development and calibration of a detailed one and two-dimensional hydrodynamic model of the Barmah Millewa Forest for the purposes of determining the impact and effectiveness of various environmental flow management scenarios.

Lower Gawler Flood Mitigation Study – Detailed hydraulic modelling of the Lower Gawler River floodplain to investigate the effectiveness of various flood mitigation measures. A combined one and two-dimensional hydraulic model was employed.

Scoping Study for Best Management Options for Rural Drainage, Eumeralla and Nullawarre Drainage Areas – Major rural drainage study covering some 18,000 Hectares in south-west Victoria. Processing of ALS/Lidar survey data to assist in detailed hydrologic and hydraulic modelling. Investigation of water quality and environmental impacts of drainage practices and options for implementation of best management practices.

South Warrnambool Flood Study – Management of an urban hydraulic and flood mapping study of a major coastal township. Integration of a variety of survey data sources and a development of a two-dimensional hydrodynamic model.

Geelong Bypass Hydrology and Hydraulics – Management of the investigations of waterway requirements for this major freeway planning study. Numerous crossings analysed with a variety of techniques ranging from simple one-dimensional to fully two-dimensional models.

#### FLOODPLAIN INVESTIGATIONS LAWSON AND TRELOAR

Point Roadknight Drainage Investigation – Development of a detailed pipe and overland flow model for the assessment of flood extents and investigation of potential mitigation options.

Lake Burrumbeet and Burrumbeet Creek Floodplain Management Plan – Project and technical management of a comprehensive hydrologic and hydraulic modelling study. Assessment of economic, social and environmental impacts also determined.

Morambro Creek Surface Water Allocation – A rigorous hydrological approach was applied to a large catchment in south-east SA utilising a spatially distributed, GIS based hydrologic Model (SWAT). The results will be used in determining future allocation of water rights in the catchment.

Glass's Creek and Bell Street Flood Mitigation Studies – Detailed hydrology and hydraulic modelling has been undertaken in order to develop appropriate mitigation strategies for two densely developed urban areas in Melbourne. The two-dimensional overland flood models are coupled with detailed pipe network modelling to provide a robust and accurate analysis tool.

Princes Freeway (Pakenham Bypass), Cardinia Creek Crossing – Detailed hydrologic and hydraulic investigation of a proposed crossing of a particularly sensitive creek environment was undertaken. This involved fine-grid two-dimensional modelling.

Little Lang Lang River Waterway Mapping – A combined one and two-dimensional hydrodynamic model of this rural catchment was developed and results integrated into Melbourne Water's GIS system.

Albury-Wodonga Bypass Hydrology and Hydraulics – Development of a detailed two-dimensional hydraulic model for the assessment of alignment options. The development of detailed hydraulic performance criteria for alignment assessment was also undertaken.

City of Kingston, Flood Mitigation Assessment – Detailed flood modelling of various mitigation options. Utilising local catchment hydrologic and hydraulic models requiring detailed assessment at the block level combined with complex pump systems.

Breakwater Road Hydrology and Hydraulics – Review of hydrology and detailed hydraulic modelling of a proposed crossing of the Barwon River floodplain. An innovative hydraulic design was necessary in order to provide zero afflux within this sensitive floodplain area.

Shepparton Floodplain Management Investigation for Shepparton City Council – Project management of the hydraulic modelling aspects of the largest rural township flood study undertaken in Victoria.

Princes West Project - Detailed hydrologic and hydraulic assessment of the existing status of the Princes West freeway between Melbourne and Geelong fro VicRoads. Crossing upgrades were designed for varying levels of immunity and various configurations.

Data Consistency Project Stages 7-10 – These projects involved detailed one and two-dimensional urban flood modelling of stormwater surcharges from the various main drain systems.

City of Kingston – Flood Mapping of various locations to supplement Melbourne Water Mapping. Development of local catchment hydrologic and hydraulic models requiring detailed assessment at the block level.

Data Consistency Project Stage 6 – This project involved detailed two-dimensional urban flood modelling of stormwater surcharges from the main drain system. This work formed a pilot study in which Melbourne Water were able to evaluate the benefits of applying two-dimensional modelling to urban areas.

Tambo River Geomorphic Investigation – The 1998 Tambo River event caused significant damage in the floodplain. Specialist two-dimensional hydraulic modelling was undertaken as part of an integrated study approach considering flooding, longer term geomorphological processes and potential waterway management options.

Tuppal and Bullatale Creek Flood Study – Development and calibration of an extensive model of the Tuppal/Bullatale Creek system as well as the Murray and Edward Rivers between Tocumwal and Deniliquin. This model was set-up for the subsequent analysis of floodplain management options through DLWC (NSW).

Strathmerton Route Investigation – Development and calibration of hydraulic models (ranging from steady state backwater to full two-dimensional unsteady models) for subsequent hydraulic design. Both Murray River and floodplain areas have been investigated.

Swan Hill Regional Flood Strategy – Extensive MIKE 11 modelling of Murray/Loddon River system upstream of Swan Hill to assess effects of proposed regional flood strategies.

Traralgon Floodplain Management Study for Shire of Traralgon – As for the Euroa Study, a comprehensive understanding of the flooding mechanisms is being gained through this state of the art fully two dimensional, dynamic flooding investigation.

Euroa Floodplain Management Study for Shire of Strathbogie – This Floodplain Management Study aimed initially at providing a comprehensive understanding of the damaging and complex flooding regime at Euroa, and subsequently at assessing potential flood protection measures (mitigation schemes, both structural and non-structural and flood warning systems). Full two-dimensional hydraulic modelling was undertaken.

Wangaratta Flood Study, Stage 2 – Application of MIKE 11 model to assess various flood mitigation measures.

Cairns Airport Drainage Study – Development and application of a detailed 2-dimensional model of the Cairns Airport and Lower Barron Delta in order to assess flood/cyclone hydrodynamic conditions at the Airport. Analysis of mitigation options.

Wangaratta Flood Study, Stage 1 – Development and calibration of a MIKE 11 model covering the extensive Ovens/King Rivers floodplain.

Yarra River, Melbourne – Development of a detailed MIKE 21 (two-dimensional) model of the Yarra River to investigate the hydraulic features of a small turning basin/wharf.

Gippsland Lakes System – One-dimensional model developed to analyse the potential impact of sea-level rise on lake levels.

Yarra River, Yarra Glen (VicRoads) – Set up and calibration of both one and two-dimensional models to investigate the impact of a proposed bridge replacement on flood levels.

Lower Loddon River Flood Study – development and calibration of MIKE 11 model covering an extensive floodplain network.

**COASTAL/ESTUARINE INVESTIGATIONS WATER TECHNOLOGY**

Gippsland Lakes Coastal Hazard Assessment – Project manager for a major hazard assessment project looking at impacts of sea level rise on coastal vulnerability throughout the Gippsland Lakes and Ninety Mile Beach.

Environmental Water Requirements of the Gippsland Lakes – Managed the input of scientific knowledge around hydrodynamics of the lakes and the freshwater/saltwater interface as well as the impacts of reduced freshwater inputs on these flow mechanisms.

Ecological Characterisation of the Gippsland Lakes – Provided hydrodynamic input to a broader characterisation project looking at the various habitats and bio-dependencies in the Gippsland Lakes.

Numerous Coastal Hazard Vulnerability Risk Assessments – assessing the change in risk to coastal inundation and stability due to sea level rise and the resulting change in coastal processes.

**COASTAL/ESTUARINE INVESTIGATIONS LAWSON AND TRELOAR**

Bass Strait – Three-dimensional model (Delft3D) development and calibration for pipeline design currents prediction.

Tropical Cyclone Thelma, Three-dimensional Current Model – This project involved the set-up and calibration of a three-dimensional hydrodynamic model of the Timor Sea and extraction of currents data.

Mooney Ponds Creek three-dimensional Water Quality Modelling – This project involved modelling of the detailed hydrodynamics of the fresh/salt-water interface in the Yarra River and how this effected the movement of pollutants from storm-water inflows.

Port Catherine Development, W.A. – Detailed three-dimensional hydrodynamic and water quality modelling of a proposed harbour development south of Perth.

Palm Springs Marina, Malaysia – Development of a two-dimensional model to assess effects of marina on local hydraulics.

Corio Bay Sediment Model Verification – Comparison of model predicted and recorded sediment plumes in Corio Bay during channel dredging.

Lake Illawarra/Botany Bay – Application of a two-dimensional water quality model to two large waterways. Long term water quality simulations performed and analysed for risk assessment.

South China Sea – Two and three-dimensional modelling to determine design currents for oil/gas pipelines.

Manila Bay – Analysis of flood behaviour, dredged sediment impacts and flushing characteristics of a proposed area of reclamation in Manila Bay, using one and two-dimensional models.

West Point Wilson hazardous chemicals storage facility – Environmental Effects Statement. Investigation of proposed facilities effect on nearby coastal processes.

East Coast Armaments Complex – Set up of two-dimensional current and wave models to investigate the impacts of proposed port facility.

Port Hedland – Set up and operation of numerical model to investigate Cyclone driven winds and wave set up.

Western Port – Two-dimensional model investigations of the dispersion of pollutants and the flushing characteristics of Western Port under tidal and wind driven currents.

Oil Spill Modelling/Response – Development of oil spill response procedures to perform real-time modelling of oil slick movements in Bass Strait and Western Port.

Western Port – Set up and calibration of a numerical model for the development of tidal and wind driven current fields as input to oil spill modelling.

Port of Geelong – Application of a two-dimensional numerical model to assess impact of a proposed dredging program on suspended sediment loads in Corio Bay.

Bass Strait – Numerical modelling of the flushing characteristics of Bass Strait over a typical year.

**EXPERT WITNESS REPORTS**

Adams Creek, Lang Lang – Expert evidence related to rural flooding and drainage issues

Donald, NW Victoria – Expert evidence and analysis of flooding issues related to channel networks on farmland in the Wimmera area

St Georges Road Northcote - Expert advice and modelling of an apartment development within SBO

Duncans Road South Werribee – Review of hydraulic conditions, flooding and drainage for a horticulture area. Provision of expert evidence report.

Nunawading – Expert evidence on flooding issues including modelling, for a multi-storey apartment building in a floodway zone

Hagen Park Bangholme – Expert advice and modelling of drainage issues in SE Melbourne

Noonan Grove Woodend - Expert advice and report on surface water management for a residential subdivision

Industrial Subdivision Shepparton/Mooroopna – Expert advice on drainage and flooding issues for land valuation purposes

Dandenong Valley, Scoresby – Expert modelling and report on flooding issues and development capability for land valuation

Coastal Development Paynesville – Expert report and evidence at VCAT on coastal hazard vulnerability for a residential subdivision

School Site Monbulk – Expert report on drainage issues in the Dandenong Ranges

Broken River, Stewarton – Expert modelling/report and evident at VCAT for a rural flooding issue

Toorak Road South Yarra – VCAT report and evidence in relation to redevelopment of a site within an urban area subject to flooding

Hopkins River Warrnambool – Flooding and coastal hazard vulnerability export report and VCAT evidence

Apartment Development Port Fairy – Expert report on flooding issues associated with a proposed apartment complex

Port Fairy (2014) – Expert evidence to VCAT on coastal hazard and flooding for a proposed sub-division in Port Fairy.

Kerang East (2014) – Expert evidence to VCAT on flooding issues along Pyramid Creek arising from 2011 floods.

Woodend (2014) – Expert evidence to VCAT regarding flooding from Five Mile Creek and local stormwater impacts at a development site within Woodend.

Port Fairy Planning Scheme Amendment (2014) – Provided Expert Evidence on flooding to Planning Panels Victoria for Moyne Shire.

Victoria Street Richmond (2016) – Expert Evidence to VCAT on flooding issues related to a multi-storey apartment development next to the Yarra River.

Donnybrook/Woodstock PSP (2016) – Expert evidence to panel hearing in relation to drainage issues for a large greenfield development area.

Manningham (2016) – Provision of peer review of modelling and expert advice to City of Manningham regarding a planning scheme amendment to implement SBO layers into their planning scheme.

Amendment C121 Planning Panel - Leneva Baranduda Precinct – expert advice to the City of Wodonga

## PUBLICATIONS

### CONFERENCE PRESENTATIONS

BISHOP, W.A., McCOWAN, A. D., SUTHERLAND, R. J., WATKINSON, R. J. - “Application of Two-Dimensional Numerical Models to Urban Flood Studies”, 2nd International Symposium on Urban Stormwater Management, Melbourne 1995.

SOMES, N.L.G., BISHOP, W.A., WONG, T.H.F. - “Numerical Simulation of Wetland Hydrodynamics”, MODSIM 97 International Congress on Modelling and Simulation, Hobart.

BISHOP, W.A., COLLINS, N. I., CALLAGHAN, D. P., and CLARK, S. Q. - “Detailed Two-Dimensional Flood Modelling of Urban Developments”, 8th International Conference on Urban Storm Drainage, Sydney 1999.

SOMES, N.L.G., BISHOP, W.A., WONG, T.H.F. - “Numerical Simulation of Wetland Hydrodynamics”, Environment International, Vol. 25, No. 6/7 pp. 773-779, 1999.

BISHOP, W.A. – “Two-dimensional Modelling for Urban Flood Mapping and Drainage Analysis”, Proceedings, Victorian Flood Management Conference, 2001.

BISHOP, W.A. and CATALANO, C.L., “Benefits of Two-dimensional Modelling for Urban Flood Projects”, 6th Conference on Hydraulics in Civil Engineering, Hobart 2001.

McCOWAN, A.D., BERTON, F.M. and BISHOP, W.A. – “The Application of a Three-dimensional Variable Density Model to Assess Water Quality in an Urban Waterway”, 6th Conference on Hydraulics in Civil Engineering, Hobart 2001.

REHMAN, H.U., ZHANG, S.Y., BISHOP, W.A., BERKFELD, J., “Water Resources Assessment using Soil Water Assessment Tool - A Case Study”, in Proceedings of ICam Catchment Management Conference, University of Western Sydney, Australian Water ssociation, Sydney, 26-28 November 2003.

McMASTER, M.J., PROVIS, D.G., GRAYSON, R.B. & BISHOP, W.A., “Calibration and testing of a hydrodynamic model of the Gippsland Lakes” in Proceedings of MODSIM 2003, Townsville, Australia 14-17 July 2003.

BISHOP, W.A., WOMERSLEY, T.J. & TIERNEY, G, “Flooding Forests - the Hydraulics of Environmental Flows”, Proceedings, 4th Victorian Flood Management Conference, Shepparton 2005.

MUNCASTER, S.H., BISHOP, W.A. and MCCOWAN, A.D., “Design flood estimation in small catchments using two-dimensional hydraulic modelling –A case study”, 30th Hydrology and Water Resources Symposium, Launceston, TAS, December 2006.

BISHOP, W.A. and WOMERSLEY, T.J., “The use of hydraulic models to inform the management of flood dependent ecosystems on the River Murray, South-Eastern Australia”, 6th International Symposium on Ecohydraulics, Christchurch, February 2007.

MUNCASTER, S. H., BISHOP, W. A. and DUGGAN, S.J., “Making the best with what you have - Design flood estimation with and without observed data”, 5th Victorian Flood Management Conference, Warrnambool, October 2007

BISHOP, W.A., CHARTERIS, A.B., MUNCASTER, S.H., WOMERSLEY, T.J., “Impacts of Climate Change on Floodplain Management in Coastal Communities”, 5th Victorian Flood Management Conference, Warrnambool, October 2007.

BISHOP, W.A. and TATE, B. “The Use of Eco-Hydraulics in Managing the River Murray”, 17th QLD Water Symposium, Griffith University, November 2008.

BISHOP, W.A. and WOMERSLEY, T.J., “Port Fairy Regional Flood Study - Dealing with Risk in a Coastal Floodplain”, Jo int 49th Annual Floodplain Management Authorities Conference (NSW) & 6th Biennial Victorian Flood Conference, Albury, February 2009.

BISHOP, W.A., RUSSELL, K.L. and LITTLE, M.J., “Impacts of Sea Level Rise on Flooding in an Estuarine Environment”, Climate Change 2010: Practical Responses to Climate Change Conference, Melbourne, 2010.

MARTIN, J.C., ARROWSMITH, C.L., and BISHOP, W.A., Hydraulic Implications associated with the Placement of Timber Snags in a Developing Anabranch. Proceedings of the Sixth Australian Stream Management Conference, Canberra, Australian Capital Territory, 2011.

BISHOP, W.A., LAW, S.E., NEWTON, J.L., GODFREY, M., “Integrated Water Management Opportunities for Inner Suburban Areas”, WSUD 2013, 8th International Water Senitive Urban Design Conference, Gold Coast, November 2013.

WOMERSLEY, T.J., LEAHY, C., HUDSON, K., ANDERSON, B., KAZAZIC, E., BISHOP, W.A., & MAWER, J., “Proof of concept hydrodynamic model and marine and atmospheric forecast data integration for flood forecasting in the Gippsland Lakes”, 54th Floodplain Management Association Conference, 20-23 May 2014, Deniliquin RSL Club, Deniliquin, NSW

McCOWAN, A.D., LAUCHLAN-ARROWSMITH, C., BISHOP, W.A., “Estimating Future Coastal Inundation and Erosion Hazards”, Australian Coastal Councils Conference, March 2015

COUSLAND, T.J., and BISHOP, W.A., “Transport modelling to verify constructed wetland residence times”, Stormwater 16 – National Stormwater Association Conference, Gold Coast, QLD, September 2016.

CLARK, S., BISHOP, W., CUNNINGHAM, L., TATE, B., DALY, A., “Utilising Hydraulic Grade Line rather than water surface levels for Flood Planning Levels”, 13th Conference on Hydraulics in Water Engineering, Sydney, Nov 2017.

CLARK, S., CUNNINGHAM, L., TATE, B., DALY, A., BISHOP, W., “Flood Planning Levels: Incorporating residual risk considerations”, 13th Conference on Hydraulics in Water Engineering, Sydney, Nov 2017.

## Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365

## Brisbane

Level 3, 43 Peel Street
South Brisbane QLD 410[illegible]
Telephone (07) 3105 14[illegible]
Fax (07) 3846 5144

## Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000
Fax (08) 8357 8988

## Perth

Ground Floor
430 Roberts Road
Subiaco WA 6008
Telephone 0438 347 968

## Geelong

PO Box 436
Geelong VIC 3220
Telephone 0458 015 664

## Gippsland

154 Macleod Street
Bairnsdale VIC 3875
Telephone (03) 5152 5833

## Wangaratta

[illegible]irst Floor, 40 Rowan Street
[illegible]angaratta VIC 3677
[illegible]elephone (03) 5721 2650

## Wimmera

PO Box 584
Stawell VIC 3380
Telephone 0438 510 240

www.watertech.com.au

info@watertech.com.au