



Expert Opinion

Pakenham East Precinct Structure Plan

Earliden Pty Ltd and Auscare Commercial Pty Ltd

Panel Hearing: Amendment C234 to the Cardinia Shire Planning Scheme

May 2018





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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





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1 REPORT AUTHOR

Warwick Alistair Bishop

Senior Principal Engineer, Director
Water Technology Pty Ltd
15 Business Park Drive
Notting Hill, VIC 3168

Qualifications:

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

Affiliations:

- Fellow, Institution of Engineers Australia
- Member, River Basin Management Society
- Member, Engineers Australia, Victorian Water Engineering Branch Committee
- Member, Society for Sustainability and Environmental Engineering of Engineers Australia
- Member, Stormwater Victoria
- Member, Australian Water Association

Area of Expertise

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

- Assessment of drainage and flood related issues associated with Pakenham East Precinct Structure Plan;
- Hydraulic modelling;
- Expert witness for drainage and flood related issues at environmental effects panels, planning panels and civil hearings.

Statement of Expertise

With my qualifications and experience, I believe that I am well qualified to provide an expert opinion on drainage and flood matters for Pakenham East Precinct Structure Plan (PSP).



2 REPORT CONTRIBUTORS

Luke James Cunningham

Principal Engineer

Water Technology Pty Ltd

15 Business Park Drive

Notting Hill, VIC 3168

Qualifications:

- BEnvEng (Hons), Monash University, 2006
- Dip PM, PDMI, 2013

Affiliations:

- Chartered Professional Engineer of Australia
- Registered Practicing Engineer of Queensland
- National Engineer Record
- Member, Australian Water Association
- Member, Stormwater Victoria
- EnviroDeveloper Certified

Areas of Expertise:

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

- Flood hydraulics and establishment of hydraulic models for floodplain areas, particularly urban areas.
- Application of hydraulic models to assess and develop floodplain mitigation options and flood mapping.

Scope of contribution:

Luke assisted in the preparation of the report, including hydraulic modelling, under my supervision.



Bertrand Salmi

Senior Engineer

Water Technology Pty Ltd

15 Business Park Drive

Notting Hill, VIC 3168

Qualifications:

- Bachelor (Hons) of Ecological Sciences (Environmental Sciences), University of Edinburgh 2006
- Master of Sciences, Water Resource Engineering Management, Heriot Watt University 2007

Area of Expertise:

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

- Hydraulic modelling;
- Assessment of flood and stormwater management;
- Application of GIS.

Scope of contribution:

Bertrand assisted in the preparation of the report, including hydraulic modelling and figure preparation, under my supervision.



3 SCOPE OF REPORT

In relation to the Amendment C234 to the Cardinia Shire Planning Scheme and the Pakenham East PSP, I have been engaged to act as an independent expert on drainage and flooding issues relevant to 35 Canty Lane, Pakenham. In particular, I have been asked to:

- Review all relevant background material and underlying technical reports provided to me in relation to the proposed amendments, particularly having regard to the flooding and drainage conditions within Pakenham East PSP;
- Identify alternative waterway designs to reduce waterway corridor, as currently proposed, clearly stating the basis upon which I have arrived at these, including:
 - Hydraulic modelling methodology and limitations;
 - Any facts I have relied upon or assumption; and
 - Risk and opportunities associated with each option considered.
- Prepare an Expert Witness Report incorporating the findings of the review and investigation, specifically to:
 - Analyse the drainage and floodplain management strategy in respect to Deep Creek, and where relevant, how this relates to the drainage and floodplain management strategy for 35 Canty Lane Pakenham, and the broader Pakenham East PSP.
 - Comment on the width and extent of the Deep Creek corridor for drainage, flooding and environmental purposes as currently proposed for Pakenham East PSP and Amendment C234.



4 BASIS OF THIS REPORT

This report is based on:

- Review of Amendment C234 (Pakenham East PSP) supporting information and technical reports, including:
 - PSP 1210 Pakenham East Precinct Structure Plan (December 2017)
 - Pakenham East Precinct Structure Plan Proposed Drainage Strategy (Stormy Water Solutions, 2017)
 - Ryan Road Development Service Scheme (DSS) Wetland/Retarding Basin Functional Design (Stormy Water Solutions, 2016)
- Review of previous Pakenham East PSP documentation, when available;
 - Deep Creek Corridor Proposals (Stormy Water Solutions, 2014)
 - Proposed Drainage Strategy (Stormy Water Solutions, 2015)
- Review of any additional publicly available information, including:
 - LiDAR and VicMap information;
- Review of previous modelling by Melbourne Water, as provided in March 2018:
 - Deep Creek RORB Model (Oct 2014)
 - Dore Road DSS RORB Model (Oct 2016)
 - Deep Creek Hec Ras Models
- Hydraulic Modelling of Deep Creek within Pakenham East PSP
- A site inspection on Wednesday 18 April 2018;

This report has been prepared in accordance with the relevant procedures and practice notes applied by Planning Panels Victoria on Expert Evidence. I have read the “Guide to Expert Evidence” and am aware of my overriding duty to assist the Panel on matters relevant to my expertise.



5 INTRODUCTION

I have been requested by Hall & Willcox on behalf of Earlden Pty Ltd and Auscare Commercial Pty Ltd to provide expert evidence at the upcoming Panel Hearing in relation to relevant drainage and flooding matters associated with the development of Pakenham East PSP and Amendment C234 to the Cardinia Shire Planning Scheme.



6 BACKGROUND

6.1 Site Description

The site is located at 35 Canty Lane Pakenham, within Cardinia Shire Council. The site locality is shown in Figure 6-1. The parcel is approximately 24.7 ha in area and is predominantly grassed paddocks used for grazing of livestock. The Deep Creek watercourse traverses the site near its western boundary. The site is bounded by Princes Highway to the north and Canty Lane to the south. There is rural farmland to the east and rural residential lots to the east of the subject site.



Figure 6-1 – Subject Site Locality

The site is located within the Pakenham East Precinct Structure Plan (PSP Property No. 28) and is identified for standard residential development. The PSP includes a waterway corridor reserve along the eastern floodplain of Deep Creek, located on the subject. The PSP shows a minimum corridor width of 100 m for most of the site, reducing to 50 m near Ryan Road, as shown in Figure 6-2. Additionally, a 30 m buffer zone is shown around all edges of the Deep Creek Conservation Reserve which must exclude buildings but may include roads, paths, nature strips, public open space and drainage infrastructure (R57).



Figure 6-2 –Pakenham East PSP Integrated Water Management Plan (extract).

The subject site is covered by Floodway Overlay, as shown in Figure 6-3.

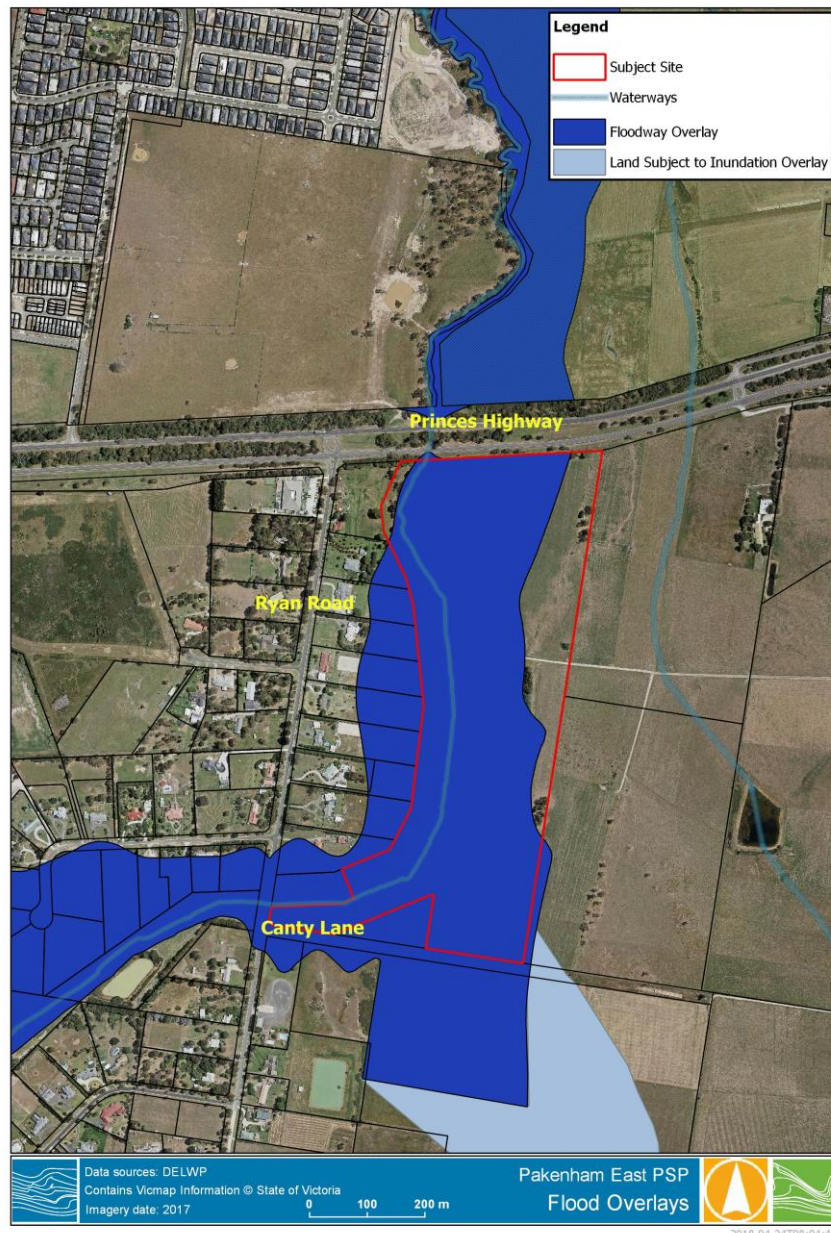


Figure 6-3 – Flood Overlays

6.1.1 Waterway Corridor

The proposed drainage strategy (Stormy Water Solutions, Dec 2017) for the Pakenham East PSP provides initially for a 100 m corridor along Deep Creek (east bank) within the site reducing to a 50 m corridor near Canty Lane. We understand, that the proposed waterway corridor setback has been determined by flood flows and flood levels within the 1% AEP floodplain. It is noted that the original strategy concept contained a 50 m corridor on the eastern side.

Physical modifications within the proposed waterway corridor are proposed to facilitate floodplain conveyance. These are outside the existing vegetated riparian corridor but within the broader waterway corridor, with cut proposed to reduce levels by 400 mm below existing natural surface levels, as shown in Figure 6-4.

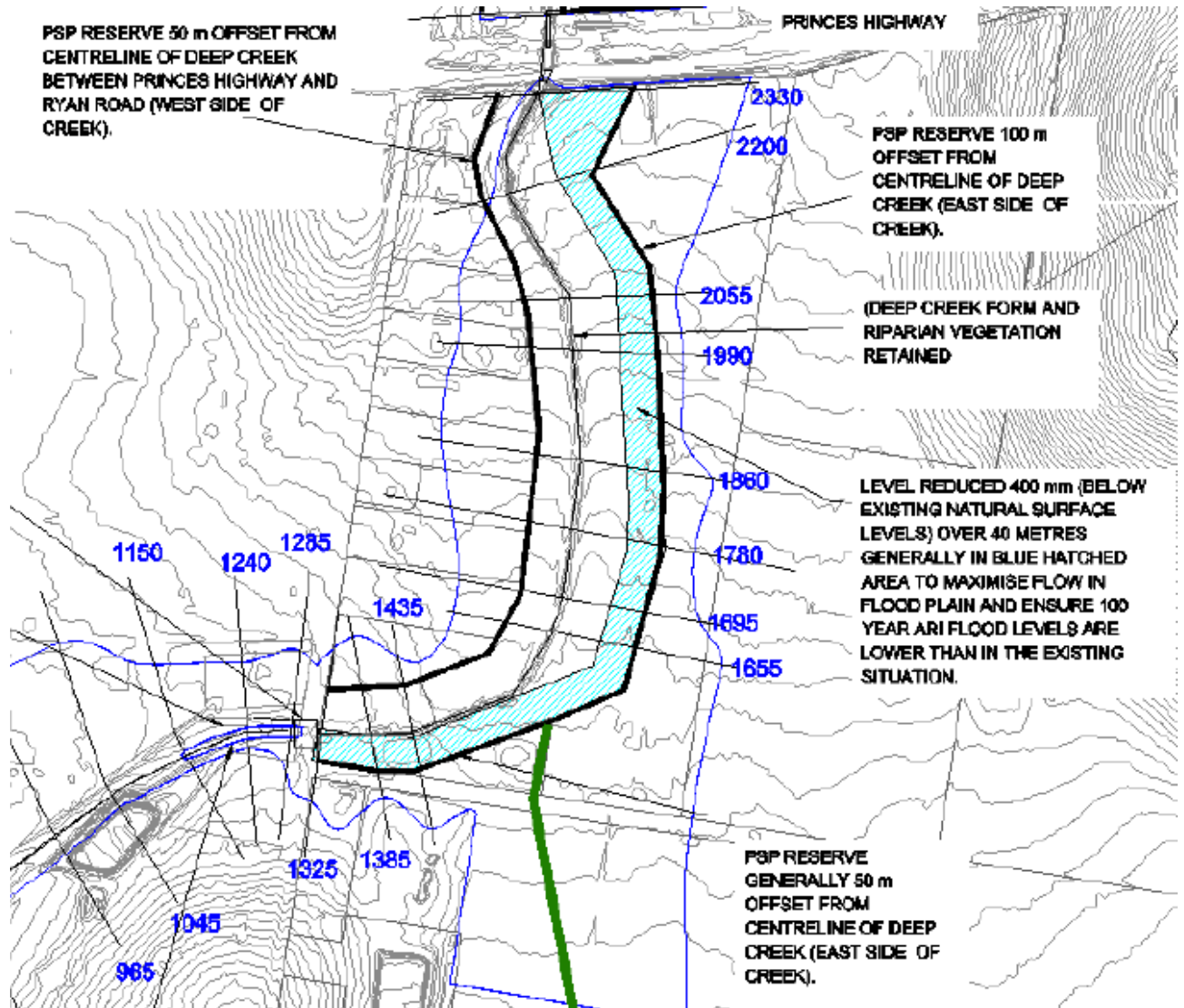


Figure 6-4 – Possible Deep Creek Corridor Works (source: Stormy Water Solutions, 2014)

Compared to the current situation, these earthworks aim to;

- Convey local runoff from future development to the east and excess flow from Deep Creek.
- Maximise flow in the eastern floodplain;
- Lower 1% AEP flood levels; and
- Reduce 1% AEP flood extent.



7 INITIAL SUBMISSION

In January 2018, Water Technology was engaged by Earlden Pty Ltd and Auscare Commercial Pty Ltd to prepare a submission in respect of the Cardinia Shire Council Planning Scheme Amendment C234. Whilst not opposing the future development of this land, they have questioned the extent of the proposed waterway corridor within their property (PSP Property No. 28).

Having reviewed the exhibited documentation for the proposed Amendment C234 to the Cardinia Planning Scheme, I believe the 100 m waterway corridor on the east side of Deep Creek through the subject site is not well justified. The main conclusions from our review were as follows:

- Deep Creek is a highly modified waterway and its floodplains have limited natural values;
- It is possible to modify the current 1% AEP Deep Creek channel, levees and floodplain to:
 - improve flood conveyance;
 - reduce erosion and geomorphic risk within Deep Creek in the long-term;
 - maximise the land within the PSP (increase Net Developable Area).
- A 50 m corridor is likely to be sufficient, as this is what has been allowed for at the downstream end of Deep Creek within the PSP.
- Given the existing flood behaviour in the area and corresponding waterway buffers required in other places, the 100 m requirement appears to be somewhat arbitrary without a clear case that it is necessary.

Importantly, Earlden and Auscare Commercial's submission acknowledged that:

- Changes to the Deep Creek channel and adjacent levees may result in loss of native vegetation (which would need to be off-set); and
- Any modification to the Deep Creek riparian corridor would need to be supported by a detailed hydraulic study and, possibly, vegetation off-set.

Whilst matters related to vegetation management are outside my area of expertise, additional modelling of Deep Creek has been undertaken. The following section details the findings of this modelling and discusses possible implications for the Deep Creek corridor for flooding and environmental purposes as currently proposed for Pakenham East PSP and Amendment C234.

7.1 Adopted Modelling Approach

The width and extent of the corridor was assessed for the PSP using the one-dimensional version of Hec Ras. I believe there would be additional value in modelling the flooding behaviour of Deep Creek using a two-dimensional (2D) hydrodynamic model. It is considered that a 2D model is likely to provide a better representation of the hydraulic behaviour of Deep Creek and its floodplain in this vicinity. This is because of the relatively unconstrained nature of the Deep Creek waterway. There is no distinct valley floor or clear delineation of the edge of the floodplain. These types of circumstances are ideally suited to a 2D approach.

We also noted that:

- Separate Hec Ras models were constructed to assess three reaches of Deep Creek within the PSP. Culvert influence on flood levels was assessed separately, to inform boundary conditions within each model. It is possible to model these reaches in a consolidated 1D hydraulic model.



We consider that this would provide a more accurate representation of interactions between the three reaches and influence from culverts;

- Whilst Hec Ras is still widely used, there are 2D software packages available that are more appropriate to capture and reproduce floodplain interactions in areas of poor lateral floodplain definition. Floodplain management agencies (including Melbourne Water) generally favour the use of 2D models for hydraulic impact assessment.



8 EVALUATION OF WATERWAY CORRIDOR

This section documents the findings of my evaluation of Stormy Water Solutions' Drainage Strategy (December 2017), in particular the extent of the proposed waterway corridor.

8.1 Existing Flood Extent

Our hydraulic model results confirm that Deep Creek breaks its banks during the critical 1% AEP design flood event (9hr) through the site, with major floodways east and west of the main channel, as shown in Figure 8-1 and Figure 8-2. The flood extent and flood levels from the TUFLOW model are generally similar to those from Stormy Water Solutions' Hec Ras model. However, it is noted that the flood extent is wider to the west, through the existing rural residential area. Additionally, the Hec Ras model (and declared flood plain extent) may under-estimate the importance of the break-away flow to the south. Figure 8-3 shows the split of flows in the deep Creek floodplain at the downstream boundary of the site predicted by the 2D model. This suggests that, during extreme floods, a significant portion of Deep Creek flow (around 50%) may break away from Deep Creek and flow south under existing conditions.

It is also evident that properties on the north side of Deep Creek and west of Ryan Road are potentially subject to flood risk under existing conditions. It should be noted that this 2D flood modelling is preliminary and would benefit from further refinement and validation.

The modelling highlights that on both the western and eastern floodplain, inundation generally extends more than 100 m from the Deep Creek channel, although depths are mostly quite shallow. Works within the floodplain and/or riparian zones are therefore required to accommodate the flood flows within a reduced waterway corridor for the works currently proposed under the PSP.

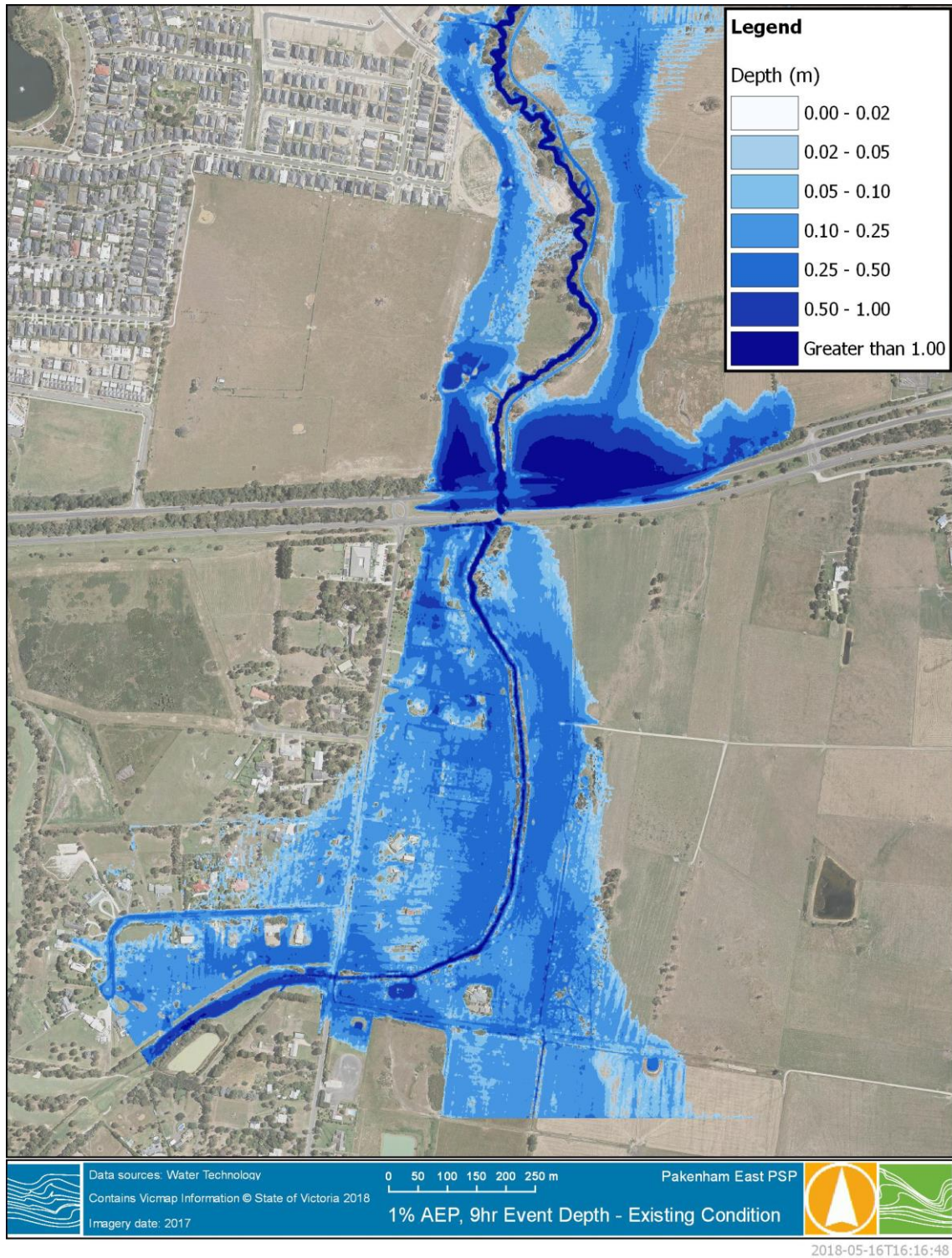


Figure 8-1 – Existing Flood Depths within the Subject Site

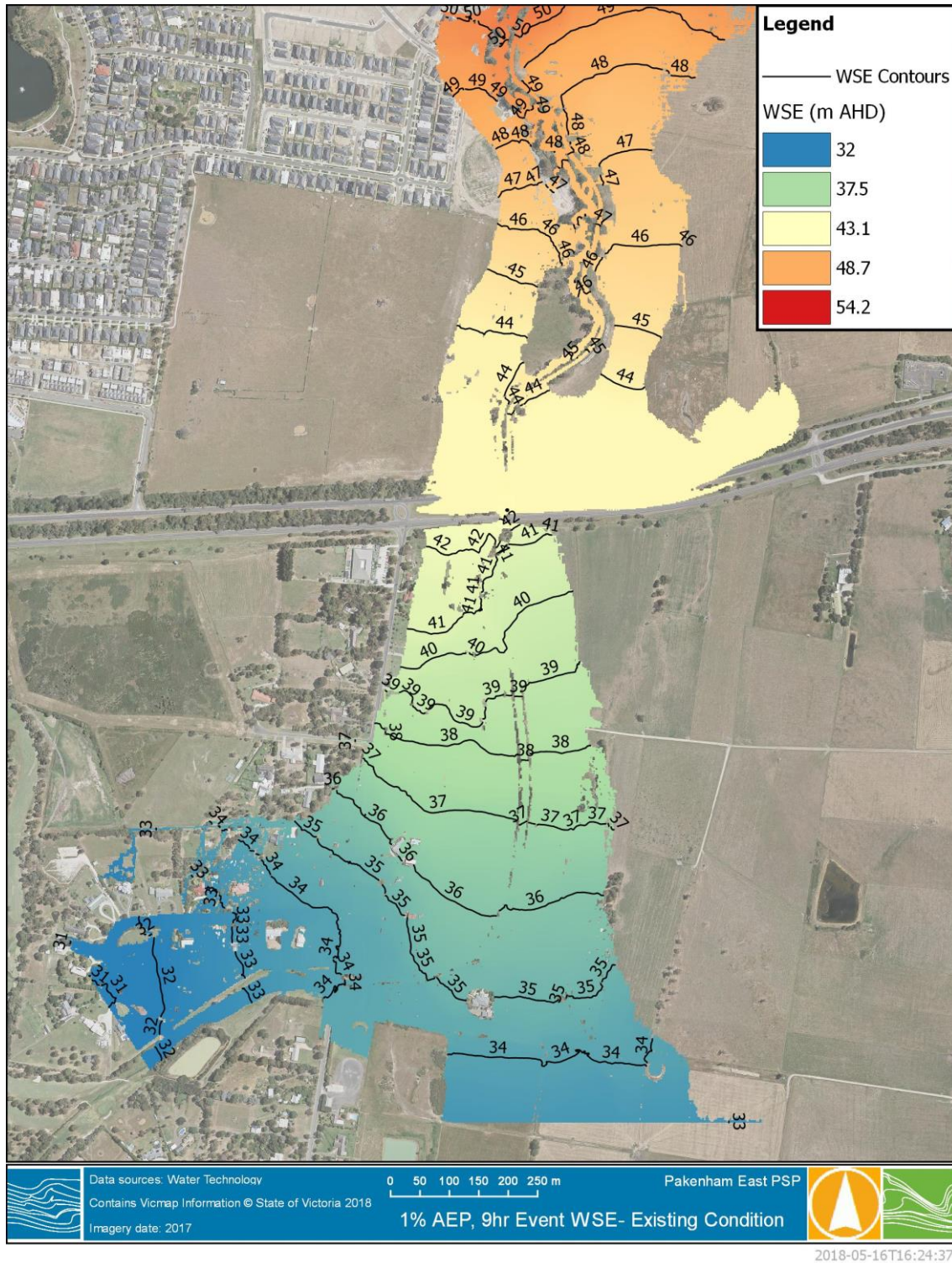


Figure 8-2 – Flood Levels within the Subject Site

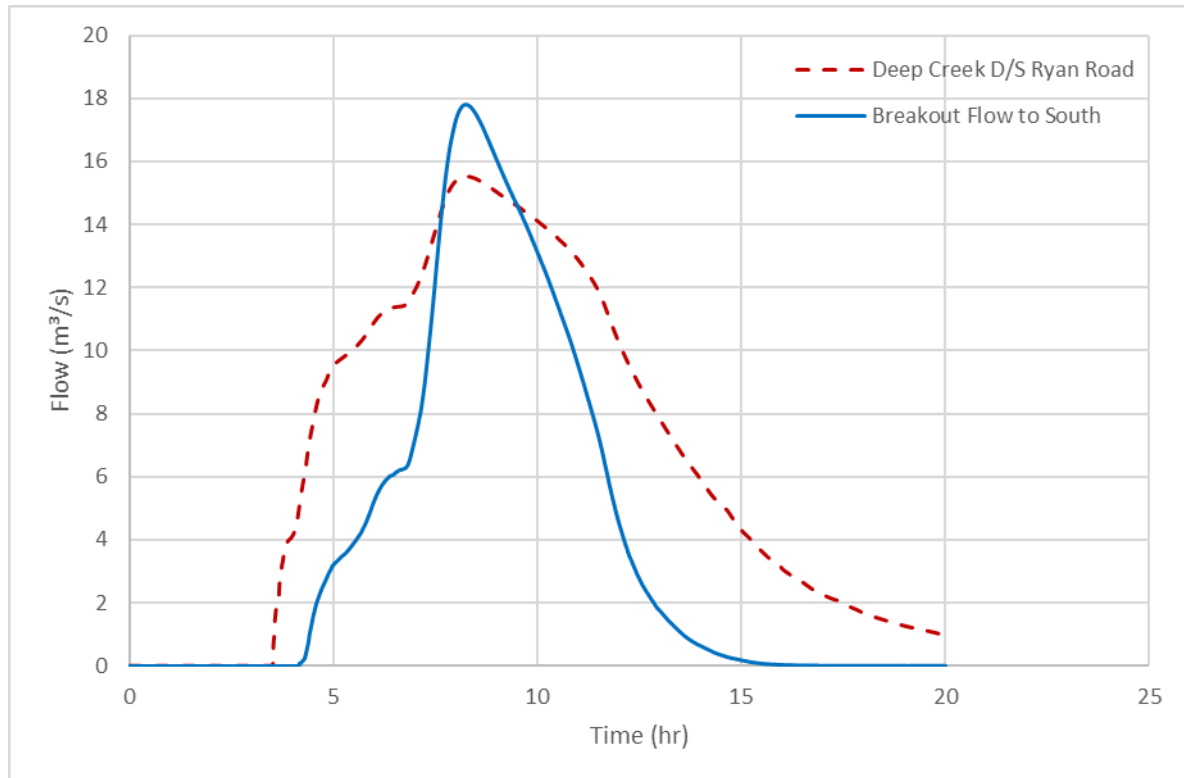


Figure 8-3 – Deep Creek flow split at downstream boundary of site

8.2 Proposed Waterway Corridor

The Deep Creek reach within the Subject Site is expected to have a Strahler stream order of 2, which, according to the Melbourne Water Waterway Corridors - Guidelines for greenfield development areas (2013), implies the following may be appropriate:

- a minimum setback of 20 m from top of bank on both banks; and
- incorporates a 10 m wide vegetated buffer immediately adjacent and parallel to the core riparian zone (10 m).

Melbourne Water has advised that the corridor is greater than the above setback to accommodate the entire 1% AEP flood extent. This is generally a reasonable position to take and is consistent with the guidelines above. However, the Deep Creek waterway and floodplain is highly modified. This is evident from the limited extent of riparian vegetation along the creek (Native Vegetation Precinct Plan, Ecology & Heritage Partners, Dec 2017) and low-lying pasture prevalent across its floodplain (Pakenham East Precinct Landscape Assessment, Hansen, May 2013).

Amendment C51 of the Wyndham Planning Scheme in 2005 addressed a similar issue regarding the waterway corridors in that municipality. The Panel supported the use of the 1% AEP floodplain as a basis for further investigation to assess the extent and nature of the waterway corridor but acknowledged that “a more detailed level of analysis would be required to comprehensively identify environmental values”. In the Panel’s view, “how a waterway might be defined is less important than identifying the values that need to be protected”.



The Planning Hearing Panel for Amendment C51 of the Wyndham Planning Scheme also recognised that “situations may arise where it is appropriate to modify the extent of the 1:100 year floodplain”, provided that the proponent demonstrates that the “environmental values of the waterway will not be compromised”. We consider that past and current agricultural land use have altered the natural values of the floodplain in this area. As a result, we consider that the riparian buffer width should be dependent on values to be protected as determined from environmental studies.

As currently detailed in the Native Vegetation Precinct Plan (Ecology & Heritage Partners, Dec 2017), the vegetation to be retained within the proposed 100 m corridor is limited to the existing riparian zone. This suggests that the proposed waterway corridor does not need to match the current 1% AEP extent to meet floodplain or environmental management best practice objectives. Existing planning controls (i.e. Floodway Overlay) are already in place, ensuring new developments consider overland flows and flooding.

The current DSS is supported by hydraulic modelling, which includes details of the proposed works within the Deep Creek corridor. I consider that there would be additional value in modelling the flooding behaviour of Deep Creek using a two-dimensional (2D) hydrodynamic model. I believe the adopted methodology by Stormy Water Solutions for the PSP has been appropriate up to this point, however further refinement requires a more sophisticated approach to resolving the details of floodplain hydraulics along Deep Creek.

Based on the modelling undertaken, it may be possible to reduce the eastern waterway corridor width to 50 m, as is currently proposed near Canty Lane. It is noted that a 50 m easement either side of the creek was considered sufficient for the approval of the 1990’s low density subdivision located on the western side of Deep Creek downstream of the Princes Highway. Any changes to the 1% AEP flood corridor would need to be supported by detailed hydraulic modelling, demonstrating there is no adverse impact on adjacent and downstream properties.

The feasibility of reducing the waterway corridor (i.e., less than the 100 m currently proposed) is discussed in further detail in Section 9.

8.3 Proposed Conservation Buffer

Within the PSP, a 30 m buffer zone is shown around all edges of the Deep Creek Conservation Reserve and must exclude buildings but may include roads, paths, nature strips, public open space and drainage infrastructure (R57). As previously mentioned, the Planning Panel for Amendment C51 of the Wyndham Planning Scheme recognised that “situations may arise where it is appropriate to modify the extent of the 1:100 year floodplain”, provided that the proponent demonstrates that the “environmental values of the waterway will not be compromised”. The areas within the proposed 30 m conservation buffer for the Pakenham East PSP generally have minimal vegetation to be retained, as shown in the Native Vegetation Precinct Plan (Ecology & Heritage Partners, Dec 2017). This buffer, if in addition to the 100 m water corridor, should be determined and based on existing environmental values.



9 ALTERNATIVE WATERWAY DESIGN

9.1 Approach

This section is informed by detailed hydraulic modelling of Deep Creek (within Pakenham East). A hydraulic model (TUFLOW) of Deep Creek was developed to model flooding under existing conditions and test alternative waterway design options. The adopted modelling methodology is detailed in Appendix A.

The TUFLOW model routes flows overland across the topographic surface (2D Domain) to create flood extents, depths and velocities. It is widely used, industry standard software that is suitable for flood studies. Floodplain management authorities (including Melbourne Water) generally recommend 2D models to be used for hydraulic impact assessment. From a hydraulic perspective there are three potential options that could be a variation to the current PSP proposal for flood capacity through the Deep Creek at the subject site. These are:

- Option 1 - Reduce the width and increase the depth of the currently proposed eastern floodway.
- Option 2 - As for Option 1 but also provide an excavated floodway on the west side of Deep Creek to balance flow capacity across the floodplain.
- Option 3 - Recognise the Deep Creek waterway channel has been highly modified, and that a wider, shallower profile would provide a more functional and practical waterway geometry in the local context. Based on this, reconstruct the channel, broadly in its current location with a series of pools and meandering low-flow channel with floodplain capacity for high design flows. In the longer term, I expect this geometry would provide greater social and environmental values and amenity than retaining the Deep Creek channel in its current form. Presently the waterway corridor is not particularly accessible, and the steepness of the channel presents a potential safety issue for pedestrian access.

Options 1 and 2 are effectively modifications of the present strategy, maintaining the present Deep Creek channel and riparian corridor. Option 3 is a significant departure from this approach and would require the removal of a significant amount of native vegetation. I believe the current form of Deep Creek is not a desirable or long-term stable geometry and it is possible that future channel works may be required that would result in significant loss of vegetation anyway. If there was no significant riparian vegetation along Deep Creek, this would be a desirable hydraulic option.

9.2 Reduced Waterway Corridor

I have modelled a preliminary version of Option 2 to demonstrate the potential for this to function hydraulically. It should be noted that the scenario was modelled as a proof-of-concept and further refinement of the modelling/design would be required to demonstrate the effectiveness of this approach. Figure 9-1 shows the depths for the Option 2 configuration in a 1% AEP design flood event. Figure 9-2 shows the model predicted water level difference which is calculated by subtracting the existing peak water surface from the developed peak water surface. This shows positive values where the developed conditions levels are higher and negative values where the developed conditions levels are lower.



The magenta area in Figure 9-2 shows areas that were previously flooded and are now dry. The areas that are yellow to red show that levels have increased. This is particularly evident at the downstream end of the site and downstream of Ryan Road. There is a corresponding reduction in levels to the east. The main cause of the increases downstream is that the reduced levels in Deep Creek through the subject site have resulted in a significant decrease in breakout flow to the south. The flow down the Deep Creek channel is predicted to be 26 m³/s compared to 16 m³/s under existing conditions. The extra flow in Deep Creek downstream of Ryan Road causes levels to be elevated. This impact could be mitigated through optimisation and refinement of the channel geometry.

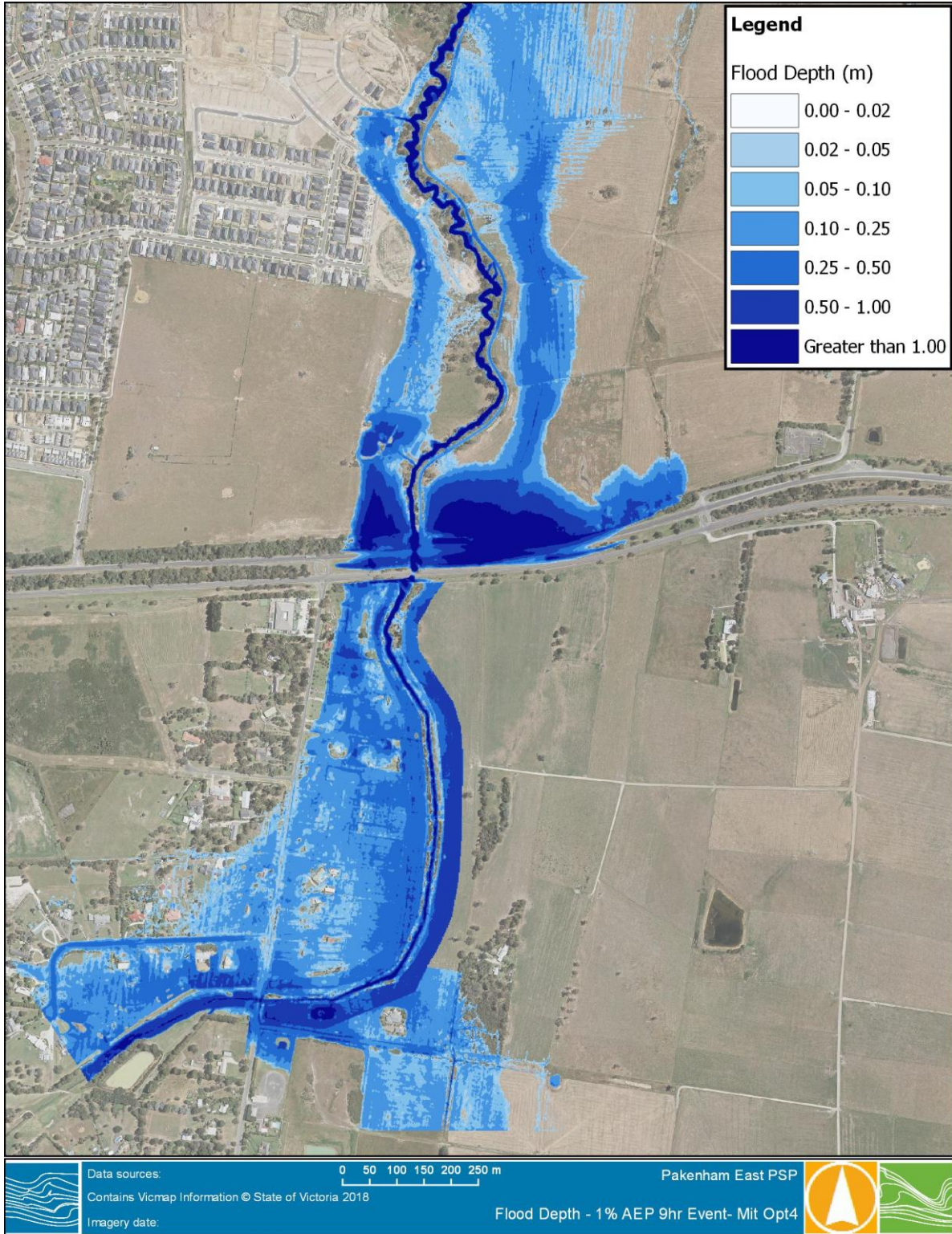


Figure 9-1 – 1% AEP - Post-Development Flood Depths

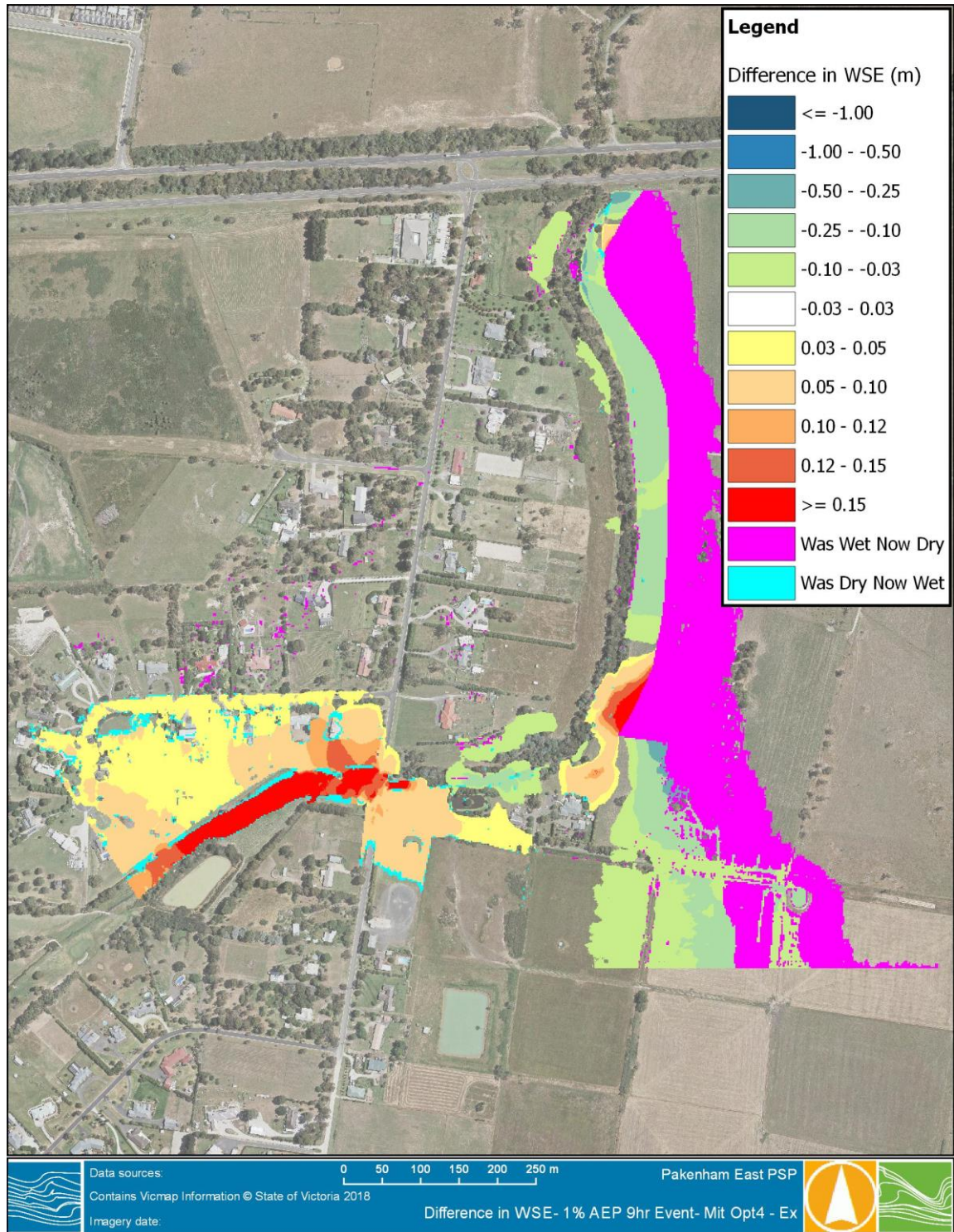


Figure 9-2 – 1% AEP - Water Surface Elevation Difference Plot (Developed minus Existing Conditions)



9.3 Melbourne Water's Flood Criteria

Melbourne Water's *Guidelines for Development in Flood-prone Areas* (2008) outlines guiding principles in relation to proposed development. The principles aim to:

- Minimise risk to people and property;
- Prevent potential for adverse impacts on adjacent, upstream or downstream areas;
- Ensure that development within a flood-prone area is appropriate and designed accordingly; and,
- Reduce reliance on emergency service personnel when flooding events occur.

These principles are reflected in 5 core requirements, these are:

- Flood Flow
- Flood Storage
- Freeboard
- Site Safety
- Access Safety

Proposed development within flood-prone areas must demonstrate compliance with the core requirements from these guidelines. A description of how development of 35 Canty Lane and the above rehabilitated waterway may perform against each of these above requirements is shown in Table 9-1.

Table 9-1 - Melbourne Water Core Flood-Prone Requirements Application

MW Core Flood-prone land requirement	How it applies to 35 Canty Lane, Pakenham	Likely Requirement
Flood Flow	The proposed infill area would be partially located within the 1% AEP flood extent of Deep Creek. The design of the waterway would therefore need to be designed to convey peak 1% AEP flood flows and ensure there is no adverse impact on adjacent and downstream properties.	Shaping of the Deep Creek floodway to ensure that a balance between conveyance and levels is achieved to mitigate any flood level impacts. This will require the maintenance of existing breakout flows to the south.
Flood Storage	The proposed fill is located within the 1% AEP floodplain of Deep Creek and the development should not reduce floodwater storage capacity. As discussed in Section 8.2, the proposed waterway corridor does not need to match the current 1% AEP extent to meet floodplain objectives. Loss of flood storage must however, be minimised if possible.	Present inundation over the floodplain is shallow. A narrower, deeper profile should be able to maintain flood storage.
Freeboard	Any development within the site must be constructed with finished floor levels having appropriate freeboard above applicable flood levels. The development must therefore incorporate filling to required Melbourne Water's (i.e. 600 mm	Applicable flood levels, which will inform Finished Flood Levels will be confirmed by Melbourne Water. The development will be raised relative to the



	for dwellings) standards adjacent to Deep Creek to ensure adequate flood protection.	Deep Creek floodplain and sufficient freeboard will therefore be provided. Interface between development and waterway corridor, allowing for safe batters and access, will need to be designed for.
Site Safety	Flood hazard is generally assessed in terms of flood depth and flood velocity. The product of flood depth and flood velocity is often referred to as the flood hazard, with flood depth also being considered to drive the hazard if above the velocity and depth product.	The proposed residential development will be raised relative to Deep Creek floodplain, the site will be flood-free.
Access Safety	Existing vehicular and pedestrian access to the site would be maintained as Princes Highway is flood-free to the east. Provided that the development layout maintains flood free entrance and exit points, the site access safety requirement will be met.	Maintain flood free access.

9.4 Waterway Corridor Requirements

The rehabilitated Deep Creek waterway corridor will need to be designed to meet the objectives of Melbourne Water's *Waterway Corridors in Greenfield Development* (2013). Whilst the modelling undertaken as part of the preparation of this report aimed to demonstrate the feasibility of a narrower waterway corridor compared to the 100 m currently proposed, further design and modelling would be required to obtain Melbourne Water's approval.

A risk matrix has been prepared to identify design and operational risk, possible mitigation measures; and to assess residual risks. This risk assessment (Table 9-2) is considered to be 'high-level' and provides preliminary indication of potential risks associated with the proposed, modified waterway corridor. It is based on current modelling and available information and could be reviewed and updated as the design progresses.



Table 9-2 - Risk Matrix

Description of Risk / Key design considerations		Rating without mitigation measures			Potential Mitigation Measure	Residual Rating	
		Likelihood	Consequence	Risk Rating		Likelihood	Risk Rating
WATER QUALITY	Avulsion and erosion risk.	Unlikely	Moderate	Medium	<p>Include natural features such as pools and riffles or a series of on-line ponds separated by a continuous channel to ensure long term channel stability.</p> <p>Hydraulic modelling to assess erosion and avulsion risk and design protection measures (e.g. rip rap) accordingly.</p>	Rare	Low
	Long term channel stability and flood behaviour.	Unlikely	Moderate	Medium	<p>Conduct detailed environmental and geomorphic investigations.</p> <p>Increase in-channel geomorphic diversity (e.g. pools, riffles, bars etc.).</p> <p>Design (informed by TUFLOW modelling) to ensure peak design flows are conveyed within waterway and its floodplain, allowing for mostly vegetated or rock banks.</p> <p>Hydraulic modelling to assess erosion and avulsion risk and design protection measures (e.g. rip rap) accordingly.</p>	Rare	Low

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Description of Risk / Key design considerations		Rating without mitigation measures			Potential Mitigation Measure	Residual Rating	
		Likelihood	Consequence	Risk Rating		Likelihood	Risk Rating
	Loss of established environmental values and functions of the existing waterway.	Possible	Moderate	Medium	Earthworks and planting program to increase riparian vegetation cover. Provision of vegetation off-set. Improve floodplain connectivity	Rare	Low
	Loss of existing vegetation, including established trees.	Likely	Moderate	Medium	Older trees present, but limited remnant trees in the existing riparian corridor. To be confirmed via arborist survey. Design to protect remnant trees, where possible. Provision of vegetation off-set.	Rare	Low
WATER QUALITY	Water quality within Deep Creek.	Unlikely	Moderate	Medium	Pre-treatment (including tertiary treatment processes) to best practice standards upstream of outlet to Deep Creek (e.g. Dore Road DSS).	Rare	Low
	Entry and exit points of the new channel and floodway	Possible	Moderate	Medium	Analysis of shear stress and appropriate design of the entry/exit points of the floodway. Design of appropriate rockworks.	Rare	Low



Description of Risk / Key design considerations		Rating without mitigation measures			Potential Mitigation Measure	Residual Rating	
		Likelihood	Consequence	Risk Rating		Likelihood	Risk Rating
	Access to waterway.	Likely	Major	High	<p>Batters on approaches to waterways, to be designed to current safety standards (refer to Melbourne Water's <i>Constructed Waterways in Urban Developments Guidelines</i>), allowing for landscape constraints.</p> <p>Maintenance access areas to be signed, fenced and gated to discourage access where the basic safety measures (as per relevant guidelines and standards) are not met.</p> <p>Shared paths to be designed to current safety standards (refer to Melbourne Water's <i>Shared Pathways Guidelines</i>).</p>	Rare	Medium
WATER QUALITY	Proliferation of pests (e.g. Alligator weed) and consequent impact on fauna and flora.	Possible	Moderate	Medium	Prepare a plant establishment and maintenance schedule (first 12 months) and an ongoing maintenance schedule.	Unlikely	Medium



10 SUMMARY AND CONCLUSIONS

The main conclusions from the review and analysis, described above, are as follows:

- The existing hydraulic analysis does not appear to have fully resolved the significant break-out of floodplain flow to the south of Canty Lane in the 1% AEP design flood.
- Deep Creek downstream of the Princes Highway is a narrow, deep, steep-sided and relatively straight channel that, whilst not experiencing significant erosion or bank stability issues at present is likely to migrate laterally in the future, particularly as the pressures of urban development upstream begin to impact the flow regime experienced by the waterway.
- There is no clear hydraulic justification for the provision of additional waterway width on the east side of Deep Creek compared to the west side through the subject site.
- The 1% AEP design flood flows can be accommodated through a modified floodway geometry in a corridor less than 100 m wide on the east side of Deep Creek.
- A 2D modelling approach is the most appropriate means of refining the existing and future flood behaviour along Deep Creek and the rest of the Pakenham East PSP area.



11 DECLARATION

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance (save those covered by legal professional privilege) which I regard as relevant have, to my knowledge, been withheld from the Tribunal.

Warwick A Bishop

B.E. (Hons), MEngSci, FIEAust

18 May 2018



APPENDIX A

Key Modelling Parameters – Hydraulic Modelling	
Terrain	The model's base terrain was created using 2012 mosaic LiDAR from DELWP. A 1m grid resolution data is used in the model.
Inflow boundary	Direct rainfall methodology was employed in this investigation.
Inflow storm duration	Critical storm duration of 9hr was used in the model.
Downstream boundary	2D HQ slope boundary was employed along the downstream boundary of the model. Slopes were adjusted to match localised topography.
1D Structures	Culverts under Princess Hwy and Ryan Rd are represented as 1D elements in the model.
Model type	TUFLOW 1D-2D linked model
Model build	2018-03-AA-iSP-w64 , HPC GPU
Hydraulic Roughness	<p>Manning's 'n' values were attributed to different land use or surface types. The adopted manning 'n' values are as follows:</p> <p>Urban residential areas – 0.35</p> <p>Rural residential areas – 0.15</p> <p>Open Space or Waterway, minimal vegetation – 0.04</p> <p>Open Space or Waterway, moderate vegetation – 0.06</p> <p>Open Space or Waterway, heavy vegetation – 0.09</p>
Model timestep (2d)	1 second
Model timestep (1d)	Adaptive
Model start time	0 hour
Model cell size	2 x 2 m
Total 1D negative depths	0
Total 2D negative depths	0
HPC NaN Repeated Timesteps	0

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