Public Environment Report

Technical Appendix C: Surface water

North East Link Project

North East Link Public Environment Report

Technical Appendix C – Surface water technical report

Prepared for North East Link

September 2019

Executive summary

This technical report is an appendix to the North East Link Public Environment Report (PER). It has been used to inform preparation of the PER and the Environment Protection and Biodiversity Conservation (EPBC) Act assessments required for North East Link.

Overview

North East Link ('the action') is a proposed new freeway-standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The proponent for the North East Link project is the State of Victoria through the Major Transport Infrastructure Authority (MTIA). The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is the division within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 13 April 2018, a delegate of the Australian Government Minister for the Environment and Energy determined that North East Link is a controlled action due to likely significant impacts on the following matters protected under Part 3 of the EPBC Act:

- Listed threatened species and communities (Sections 18 and 18A)
- Listed migratory species (Sections 20 and 20A)
- The environment on Commonwealth land (Sections 26 and 27A).

The delegate of the Minister also determined that North East Link requires assessment by a PER. The PER allows stakeholders to understand the likely impacts of the action on Matters of National Environmental Significance (MNES) and on the environment on Commonwealth land and how they are proposed to be managed.

The PER was developed in parallel with the reference project development and preparation of the North East Link Environment Effects Statement (EES). The reference project has been assessed in the PER.

GHD was commissioned to undertake a surface water impact assessment for the purposes of the PER.

Surface water context

The following controlling provisions are relevant to the surface water assessment:

- Listed threatened species and communities (Sections 18 and 18A)
- Listed migratory species (Sections 20 and 20A)
- The environment where actions involve Commonwealth land (Sections 26 and 27A).

Changes to surface water have potential to affect the habitat of listed threatened species and communities as well as listed migratory species. The significance of these impacts are addressed in PER Technical Appendix A – Flora and fauna, but the changes to surface water that could cause those impacts are described in this report.

Description of the environment

The description of the environment is summarised as follows:

- North East Link would be located within a predominantly urban section of the Yarra River catchment. It would include twin tunnels that would pass beneath the Yarra River as well as the widening of the Eastern Freeway bridge over the Yarra River. Tributaries of the Yarra River that intersect with the project include Banyule Creek and Koonung Creek.
- An underground storm water system, the Yando Street Main Drain, and its associated overland flow paths also cross beneath the project alignment (and Greensborough Bypass) from west to east before discharging to the Plenty River. A tributary of this drain, the Kempston Street Main Drain, crosses the alignment also from west to east a little further to the south.
- There is an overland flow path associated with an unnamed council drainage system which runs east from Watsonia railway station carpark to Melbourne Water's Watsonia Drain.
- PER Technical Appendix A – Flora and fauna has concluded that any local surface water impact on the Yando Street Main Drain, Kempston Street Main Drain or Watsonia Station drain, which all discharge to the Plenty River, would unlikely have a measurable impact on MNES or Commonwealth land. These drains are therefore not further considered in this report.
- Banyule Creek starts as an ephemeral waterway within Simpson Barracks and flows south to the Yarra River. The project area overlays the current creek alignment from its beginning in the Barracks to Lower Plenty Road (adjacent to Greensborough Road). Banyule Creek was included in the assessment as North East Link would require diversion of the existing creek and connecting drains to accommodate the project alignment to the north of Lower Plenty Road.
- The Yarra River is a major waterway with a catchment area of approximately 4,000 square kilometres. The Yarra River and its floodplain was included in the assessment as due to proposed elements of North East Link including:
  - A new interchange at Manningham Road comprising open cut, cut and cover and mined tunnel sections
  - A tunnel portal and associated ventilation structure located south of the Veneto Club in Bulleen
  - Surface road and elevated ramps connecting to the Eastern Freeway via a new interchange.
- Koonung Creek is a heavily modified creek which runs generally parallel to the Eastern Freeway from Springvale Road, to its outfall into the Yarra River downstream of Bulleen Road. Koonung Creek was included in the assessment as North East Link would require the realignment of sections of the creek, and extensions of undergrounded sections of the creek in culverts.
- Surface water bodies which would be impacted by North East Link include the irrigation storage at Trinity Grammar School Sporting Complex and a number of wetlands along Koonung Creek. A number of other water bodies in the area include Banyule Swamp, Banyule Billabong and Bolin Bolin Billabong would unlikely be affected.

Key findings

This technical report identified the following key findings relating to construction impacts on components of the environment involving Commonwealth land and the means by which they may be mitigated:

- There are no significant residual impacts on runoff volumes or peak flows (flooding) expected on or downstream of the Commonwealth land during the construction of North East Link. Appropriate mitigation would include providing suitable storages and outlet controls designed to attenuate downstream peak flows. These additional storages would be designed to minimise changes to the frequency and magnitude of downstream flows.
- No significant adverse residual impacts are expected on water quality with appropriate design, construction methodologies and risk management including: hazard prevention (such as off-site servicing to reduce potential for spills), wash down areas, bunds around stockpiles, sedimentation and or holding ponds, construction scheduling, careful location and protection of access tracks, stockpiles, plant and sheds. This includes downstream of the Commonwealth land during construction, with some potential improvement in water quality (removing existing erosion sources) possible.
- Using the same mitigation measures to attenuate flooding, there would be no significant change in the erosion potential of the waterways downstream of the Commonwealth land. The stability of waterways on Commonwealth land would likely improve.

During the operation of North East Link, impacts on Commonwealth land may include:

- The small increase in paved surface on Commonwealth land (such as surface roads) would lead to only a small increase in runoff volume, which would likely be fully contained within the pump sump to which most of this area would drain. Other changes to the construction flow paths would be designed to have no increase to local flood peaks.
- The combination of active management, physical spill capture and treatment trains (such as sedimentation ponds and swales) provides a high level of protection, which modelling indicates would be effective in achieving best practice objectives, and an improvement on the performance of the current infrastructure. Residual impacts to water quality on and from Commonwealth land would be low.
- The most significant cause of waterway erosion on Commonwealth land is the drain on the east side of Greensborough Bypass. The operation of North East Link would see the drain replaced by a well-engineered flowpath, removing what is locally a source of erosion impacts on waterway stability, quality and habitat.

This technical report identified the following key findings relating to construction impacts on MNES and the means by which they may be mitigated:

- Construction works have the potential to results in spills and or to expose and mobilise sediment and pollutants which may find their way into the waterways. While the greatest potential for water quality impacts are related to construction works in close proximity to the waterways, adverse water quality outcomes could result from construction works anywhere within the catchments. Mitigation such as scheduling works to avoid interaction with significant flows, spill and sediment control measures, and water quality treatment (such as swales, treatment wetlands) would result in low residual impacts to water quality.

- Changes in flow regime have the potential to affect habitat which may be of significance to MNES. For this to occur there would need to be a change to the flow regime that results in more on less frequent overtopping into the flood plain, increased erosion or deposition, or undergrounding of an open waterway. The greatest potential for changes to surface water associated habitat are related to the expected undergrounding along parts of Banyule Creek upstream of Lower Plenty Road and sections of Koonung Creek where space for widening the Eastern Freeway is limited. The likely loss of attenuation due to the piping of overland flows would be mitigated with additional appropriately designed storages to manage the potential for downstream flooding or erosion which may otherwise occur.

Operation impacts relating to MNES may include:

- Modifications to Koonung Creek with potential to affect the water quality of MNES habitat include changes to the wetlands, and undergrounding or realigning of some sections of the creek. Given the highly modified nature of much of Koonung Creek it is anticipated that, with the exception of locations where open waterways are being undergrounded, the long-term operational impact would be minimal to quality and flow outcomes.
- North East Link has the potential to generate pollutants that may find their way into the waterways. By treating a significant portion of all vehicle pollutants mobilised by stormwater runoff, modelling indicates that North East Link would achieve best practise pollutant reductions and significant reductions in pollutant loads entering downstream waterways.

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Abbreviations

Abbreviation	Term in full
AEP	Annual Exceedance Probability
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average Recurrence Interval
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
BOM	Bureau of Meteorology
BPEMG	Best Practice Environmental Management Guidelines
DCCEE	Department of Climate Change and Energy Efficiency
DELWP	Department of Environment, Land, Water and Planning
DEM	Digital Elevation Model
DOEE	Department of Environment and Energy
DSEWPAC	Department of Sustainability, Environment, Water, Population and Communities
EES	Environment Effects Statement
EPA	Environment Protection Authority
EPBC Act	The Environment Protection and Biodiversity Conservation Act 1999
FO	Floodway Overlay
IRC	Index of River Condition
ISC	Index of Stream Condition
LPPF	Local Planning Policy Framework
LSIO	Land Subject to Inundation Overlay
MNES	Matters of National Environmental Significance according to the EPBC Act
MTIA	Major Transport Infrastructure Authority
NELP	North East Link Project
NHMRC	National Health and Medical Research Council
NWQMS	National Water Quality Management Strategy
PMF	Probable Maximum Flood
SBO	Special Building Overlay
SCEW	Standing Council on Environment and Water
SEPP	State Environment Protection Policies
SPPF	State Planning Policy Framework
UFZ	Urban Floodway Zone
VPP	Victorian Planning Provisions
VWMS	Victorian Waterway Management Strategy

Glossary

Term	Description
Annual Exceedance Probability	Defines the likelihood of a flood occurring in any given year. The most commonly used definition in planning is the '1 in 100 year flood'. This refers to a flood level that has a one in a hundred, or 1%, chance of being equalled or exceeded in any year (1% AEP = 100 year average recurrence interval).
Major Transport Infrastructure Authority (MTIA)	The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.
North East Link Project (NELP)	North East Link Project (NELP) is an organisation within Victoria's Major Transport Infrastructure Authority (MTIA) that is responsible for developing and delivering North East Link. NELP was formerly known as the North East Link Authority prior to 1 January 2019. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.
Probable Maximum Flood (PMF)	The largest flood that could conceivable occur at a particular location, usually estimated from Probable Maximum Precipitation (PMP) and, where applicable, snow melt, coupled with the worst flood-producing catchment conditions.
RORB	A general non-linear runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other catchment inputs
Tail water level	The water surface level, downstream of a pipe, culvert or waterway, which influences upstream flood levels under most flow conditions.
TUFLOW	1D/2D finite difference numerical model used to simulate hydraulic behaviours in rivers, floodplains and urban drainage environments.
Victorian Department of Transport	The Victorian Department of Transport is responsible for delivering the government's transport infrastructure agenda. It was formed on 1 January 2019 when the former Victorian Department of Economic Development, Jobs, Transport and Resources transitioned into the Department of Transport and the Department of Jobs, Precincts and Regions.

1. Introduction

1.1 Purpose of this report

North East Link ('the project') is a proposed new freeway-standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The proponent for the North East Link project is the State of Victoria through the Major Transport Infrastructure Authority (MTIA). The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is the division within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

North East Link was referred to the Australian Government's Department of the Environment and Energy on 17 January 2018. On 13 April 2018 the project was declared a 'controlled action', requiring assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The decision notice requires North East Link to be assessed through a Public Environment Report (PER).

The purpose of this report is to assess the potential surface water impacts associated with North East Link for the purposes of the PER required for the project.

This report describes the surface water resources that may support MNES and provides an assessment of potential surface water-related impacts. It focuses on the key waterways that may result in impacts on Commonwealth land and on the listed threatened species and ecological communities and migratory species (or their habitat) dependent on these water resources, which have been identified in PER Technical Appendix A – Flora and fauna:

- Banyule Creek
- Yarra River
- Koonung Creek.

To the north of Watsonia, the project area contains several other drainage systems that discharge to the Plenty River which itself ultimately joins the Yarra River upstream of the project area. While North East Link has the potential to result in surface water impacts associated with these drainage systems, PER Technical Appendix A – Flora and fauna has identified that it is unlikely any local surface water impact would have a measurable impact on Matters of National Environmental Significance (MNES) at these locations. Therefore, while they have been considered, these drainage systems are not discussed further in this report.

North East Link also requires assessment under Victoria's *Environment Effects Act 1978*. A separate report has been prepared for the purposes of the Environment Effects Statement (EES) required under the Environment Effects Act.

1.2 Why understanding surface water is important

Some changes to surface water resulting directly or indirectly from the construction or operation of North East Link have the potential to result in direct and indirect impacts on MNES and the Commonwealth land environment. More generally, it is important that North East Link is designed to minimise threats to the health of surface water ecosystems and to maintain floodplain functionality.

North East Link lies within the urban waterway reaches of the Yarra River catchment. This highly urbanised part of Melbourne includes long-established residential areas, industrial precincts, parks and reserves, and community and recreation facilities.

There are many locations where the action would intersect with an existing floodplain although only some of these are relevant with respect to the consideration of direct and indirect impacts on MNES and the Commonwealth land environment.

Potential surface water impacts associated with the construction of North East Link that have potential to impact MNES or the Commonwealth land environment relate to:

- Increased risk of property flooding due to flow diversions, loss of floodplain storage or obstruction of drainage paths
- Reduced water quality due to increased release of pollutants to waterways
- Altered geomorphic conditions resulting in changes in erosion, deposition or waterway stability.

Potential surface water impacts associated with the operation of North East Link that have potential to impact MNES or the Commonwealth land environment relate to:

- Increased risk of flooding of property due to installation of project elements within the floodplain
- Reduced water quality due to release of pollutants to waterways
- Altered geomorphic conditions resulting in changes to erosion, deposition or waterway stability
- Flood waters entering the tunnel during a flood event.

The potential extent and magnitude of the surface water impacts as listed have been investigated. To avoid and/or manage the potential for adverse impacts, mitigation measures have been developed.

2. PER Guidelines

2.1 Controlling provisions

The controlling provisions are the matters protected under Part 3 of the EPBC Act which the proposed action may have a significant impact on. These are the focus of the PER assessment.

The controlling provisions relevant to surface water are:

- Listed threatened species and communities (Sections 18 & 18A of the EPBC Act)
- Listed migratory species (Sections 20 & 20A of the EPBC Act)
- The environment on Commonwealth land or on land that is affected by actions on Commonwealth land (Sections 26 & 27A of the EPBC Act).

Changes to surface water have potential to affect the habitat of listed threatened species and communities, and listed migratory species. The significance of these impacts are addressed in PER Technical Appendix A – Flora and Fauna but the changes to surface water that could cause those impacts are described in this report.

This report describes changes to surface water related to the actions that have potential to affect Commonwealth land or to occur on Commonwealth land and affect external environments.

2.2 PER Guideline requirements

The Commonwealth Department of Environment and Energy (DoEE) provided the North East Link Project (NELP) with *Guidelines for the content of a draft Public Environment Report* (PER Guidelines) on 10 July 2018.

The content requirements from the PER Guidelines relevant to surface water are shown in Table 2-1, as well as the location where these items have been addressed in this report.

Table 2-1 PER Guidelines content requirements relevant to surface water

PER Guidelines section	Summary of PER Guidelines content requirements*	Application to this report
2.0 Specific content	Lists the matters protected under the EPBC Act that DoEE considers may be significantly impacted by the proposed action and that therefore must be assessed in the PER.	The matters in this list that are relevant to this report are discussed in Sections 5 to 8.
2.2 Description of the action	Description of the construction and operational components of the action.	Chapter 3 of the PER describes the action. Section 3 of this report describes the specific components of the action relevant to surface water impacts.
2.3 Feasible alternatives	Description and comparison of feasible alternatives	Chapter 4 of the PER describes the feasible alternatives.

PER Guidelines section	Summary of PER Guidelines content requirements*	Application to this report
2.4 Description of the environment	(a) A description of the abundance, distribution, and ecological relationships of threatened species and ecological communities in the study area including maps. A description of the known threats to, and assessment of quality and importance of the habitats of species or communities in the study area. A description of the scope, timing and methodology for studies or surveys including assessment of the adequacy of any surveys undertaken.	This report does not directly discuss threatened species and ecological communities, their distribution, quality and importance, or relevant surveys. These are covered in PER Technical Appendix A – Flora and Fauna. Section 6 of this report provides information relating to surface water resources which may be affected by North East Link.
	(b) A description of the surface and groundwater resources relevant to the action and listed threatened species or communities as well as migratory species.	Section 6 of this report provides a description of the surface water features potentially affected by the action. In some circumstances, changes to these features, may have the potential to affect listed threatened species or communities as well as migratory species.
	(c) A description of the Commonwealth land environment to be affected by the proposal	Section 6.2 of this report describes the surface water features on and around Commonwealth land potentially impacted by the action
2.5 Relevant impacts	(a) Requirements for the assessment of impacts on the Specific content listed in Section 2 of the guidelines. This includes assessment of: • Direct, indirect, cumulative and facilitated impacts. • Long and short-term impacts and if they are reversible. • Analysis of impact significance. • If any impacts are unpredictable or unknown and any additional data that may be needed. • Illustration of impacts using maps. • Description of assessment methodology.	Section 5 of this report summarises the scope of the assessment and describes the impact assessment methodology and limitations. Section 7 of this report details the relevant impacts identified including maps where applicable. Section 9 of this report details the relevant cumulative and facilitated impacts identified including maps where applicable.
	(b) Requirement to address cumulative impacts.	
	(c) Requirement to address ‘facilitated’ impacts at a local, regional, state and national scale.	

PER Guidelines section	Summary of PER Guidelines content requirements*	Application to this report
2.5.1 Listed threatened species and ecological communities; and migratory species	Specific requirements for assessment of the impacts on MNES (threatened species, ecological communities and migratory species). These include: • Number of individuals and area of occupancy affected • Impacts on population and community • Loss, alteration or fragmentation of habitat and breeding sites.	Section 7 of this report provides an assessment of potential changes to aquatic habitats and the availability of water for use by MNES. PER Technical Appendix A – Flora and Fauna describes the impact of these changes on MNES.
2.5.2 Water-related impacts	Requirement to assess impacts to waterways and groundwater that could potentially affect MNES or their habitat.	Section 7 of this report provides an assessment of potential changes to aquatic habitats and the availability of water for use by MNES. PER Technical Appendix A – Flora and Fauna describes the impact of these changes on MNES.
2.5.2.2 Surface water	(a) A surface water quality monitoring program and water quality assessment which should include, but not be limited to: • Recent monitoring data provided from other nearby monitoring sites, including from representative control sites further upstream and downstream from the construction areas. • Baseline data on the water quality of the water channels to be used to determine any changes. (b) A stormwater runoff assessment including quantification of the volume and water quality of the discharge from the proposed project area, estimations of future runoff volumes into the waterways and consideration of risks due to hazardous substance spills. (c) Identification of the monitoring locations for discharge points during development and the ongoing future use of the site. (d) Details of mitigation measures to prevent discharge or runoff into the waterways including an assessment of the expected efficacy of the mitigation measures. (e) Details on the construction of the diversion channels and how they will be designed to minimise potential impacts to MNES. (f) Assessment of risks associated with increased erosion due to changes to the landscape.	Section 3 of this report describes design of diversion channels and other project components specific to surface water management. A full project description can be found in the PER Chapter 3. Section 6 of this report describes the surface water resources potentially affected by the project. Section 7 of this report details the predicted impacts to surface water.

PER Guidelines section	Summary of PER Guidelines content requirements*	Application to this report
2.5.3 Commonwealth land – whole of the environment	Assessment of the whole of the environment affected by actions on (or affecting) Commonwealth land (see Significant Impact Guidelines 1.2 (DSEWPAC, 2013)). The affected environment outside Commonwealth land is taken to be defined both by a stated buffer of '500 m of the disturbance footprint' and by the need to assess impacts on the environmental and ecological services provided by the Commonwealth land at a 'landscape level'. The requirements include a description of resources used for the assessment, description of the matters affected and assessment of: • Flora and fauna • People and communities (including the Defence estate as a distinct community) • Cultural and heritage values • Landscapes and soils • Water resources • Pollutants, chemicals and toxic substances.	Section 5 of this report describes the impact assessment methodology and limitations. Section 6 of this report describes the features potentially affected by the project. Section 7 of this report details the predicted surface water impacts.
2.6 Proposed avoidance and mitigation measures	Description of safeguards and mitigation, including a consolidated list of measures, which include: • Details of the impacts to which measures relate • Maps showing the measures' location • The anticipated effectiveness of the measures and the expected environmental outcomes of their use • Baseline data and/or proposed monitoring to demonstrate achievement of outcomes • Description of habitat rehabilitation including management, methodology and timing • Statutory or policy basis and agency responsible for approval of measures • Cost of the mitigation measures • An overall framework for management, mitigation and monitoring including provision for independent auditing.	Section 10 of this report describes measures to avoid, mitigate and monitor surface water impacts, including description of the likely residual impacts and environmental outcomes following the implementation of the mitigation measures. Section 10 provides a consolidated list of these measures.
2.7 Residual impacts/ environmental offsets	(a) Description of likely residual impacts (the 'Relevant impacts' referred to in Section 2.5 of the PER Guidelines following the implementation of mitigation measures referred to in Section 2.6.	Section 7 and 8 of this report describes the likely residual impacts and environmental outcomes following implementation of the mitigation measures.
2.10 Consultation	Description of any consultation undertaken or proposed.	Section 5.7 of this report describes consultation that has informed the surface water assessment.

PER Guidelines section	Summary of PER Guidelines content requirements*	Application to this report
2.13 Information sources provided in the PER	Information on the source, currency, reliability and uncertainty of data provided in the PER	Section 5.6 of this report describes limitations, uncertainties and assumptions including data sources and reliability.

*A full copy of the guidelines can be found in PER Attachment I – PER Guidelines.

2.3 Linkages to other reports

This report relies on or informs the technical assessments as indicated in Table 2-2.

Table 2-2 Linkages to other technical reports

Specialist report	Relevance to this impact assessment
PER Technical Appendix A *Flora and Fauna Technical Report*	Clarifies which waterways and drainage systems have the potential to impact MNES, providing an input to the surface water assessment in terms of scope of potential MNES impacts. Provides an assessment of North East Link's potential impacts on water sensitive ecological assets/communities as an output from the assessment of surface water. Specifically providing an understanding of the beneficial uses of downstream surface water environments.
PER Technical Appendix B *Groundwater Technical Report*	Provides an assessment of North East Link's potential impacts on groundwater and details locations of groundwater and surface water interaction that are an input to the assessment of surface water. Specifically, the residual effects on short-term or longer-term changes to groundwater conditions, with particular regard to interchange between surface water and ground water, ground subsidence, tunnel drainage, groundwater quality, relevant SEPP (Waters of Victoria) standards and beneficial uses.
PER Technical Appendix D *Commonwealth land Technical Report*	Provides an assessment of North East Link's potential impacts on the Commonwealth land environment based on information and assessments produced in PER Technical Appendix A – Flora and fauna, PER Technical Appendix B – Groundwater and this PER Technical Appendix C – Surface water.

3. Project description

3.1 Overview

The North East Link alignment and its key elements assessed in the PER include:

- **M80 Ring Road to the northern portal** – from the M80 Ring Road at Plenty Road, and the Greensborough Bypass at Plenty River Drive, North East Link would extend to the northern portal near Blamey Road utilising a mixture of above, below and at surface road sections. This would include new road interchanges at the M80 Ring Road and Grimshaw Street.
- **Northern portal to southern portal** – from the northern portal the road would transition into twin tunnels that would connect to Lower Plenty Road via a new interchange, before travelling under residential areas, Banyule Flats and the Yarra River to a new interchange at Manningham Road. The tunnels would then continue to the southern portal located south of the Veneto Club.
- **Eastern Freeway** – from around Hoddle Street in the west through to Springvale Road in the east, modifications to the Eastern Freeway would include widening to accommodate future traffic volumes and new dedicated bus lanes for the Doncaster Busway. There would also be a new interchange at Bulleen Road to connect North East Link to the Eastern Freeway.

An overview of North East Link is provided in Figure 3-1.

North East Link would also improve existing bus services from Doncaster Road to Hoddle Street with the Doncaster Busway as well as pedestrian connections and the bicycle network with connected cycling and walking paths from the M80 Ring Road to the Eastern Freeway.

For a detailed description of the project, refer to PER Chapter 3 – Description of the action.

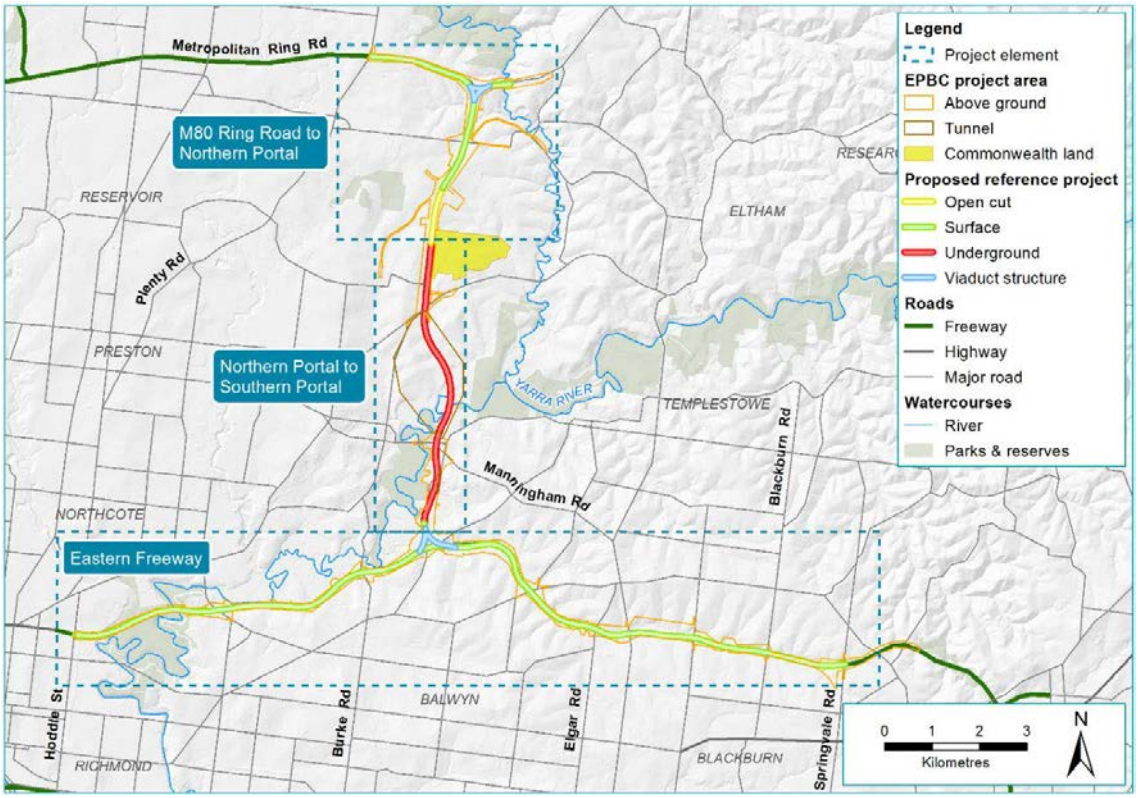


Figure 3-1 Overview of North East Link

3.2 Construction

Key construction activities for North East Link would include:

- General earthworks including topsoil removal, clearing and grubbing vegetation
- Relocation, adjustment or installation of new utility services
- Construction of retaining walls and diaphragm walls including piling
- Ground treatment to stabilise soils
- Tunnel portal and dive shaft construction
- Storage and removal of spoil
- Construction of cross passages, ventilation structures and access shafts
- Installation of drainage and water quality treatment facilities
- Installation of a Freeway Management System
- Tunnel construction using tunnel boring machines (TBMs), mining and cut and cover techniques
- Installation of noise walls
- Restoration of surface areas.

3.3 Operation

Following construction of North East Link, the key operation phase activities would include:

- Operation and maintenance of new road infrastructure
- Operation and maintenance of Freeway Management System

- Operation of North East Link motorway control centre
- Operation and maintenance of the tunnel ventilation system
- Operation and maintenance of water treatment facilities
- Operation and maintenance of the motorways power supply (substations)
- Maintenance of landscaping and water sensitive urban design (WSUD) areas.

3.4 Activities on Commonwealth land

Commonwealth land that would potentially be affected by the action includes:

- Simpson Barracks and adjoining publicly accessible area immediately south-west of the Simpson Barracks fence line. This area is used for informal outdoor recreation purposes. Throughout this report, all of this land is referred to as ‘Simpson Barracks’
- A strip of land located about one kilometre north of the barracks, to the rear of residential properties on Elder Street. This strip of land is an easement for electricity transmission lines, and is referred to throughout this report as the 'War Services easement'.

Key activities on Simpson Barracks would include:

- Construction of North East Link carriageways in a trench between Yallambie Road to just north of Blamey Road, then as a cut and cover tunnel section between Blamey Road and Lower Plenty Road
- Construction of ramps for the Lower Plenty Road interchange
- Construction of a northern portal tunnel ventilation structure
- Construction compounds and laydown areas during construction.

Key activities on the War Services easement would include:

- Construction of surface road components, including a local road connection (Greensborough Road), an upgraded shared use path, new noise wall and stormwater drainage bioretention water treatment pond
- Relocation of electricity transmission lines
- Construction laydown areas and temporary car parking during construction.

3.5 Activities and design considerations relevant to surface water

In addition to the construction and operation items listed in Section 3.2 to Section 3.4, the following design considerations are relevant to surface water on and adjacent to the Commonwealth land:

- The construction and maintenance of floodwalls for the protection of the northern tunnel portal from flooding during construction and operation. During operation, this protection would typically be provided by multi-purpose barriers and designed pavement and landscaping levels.
- The temporary diversion and long-term realignment of Banyule Creek to accommodate construction activities and the project alignment.

4. Legislation, policy, guidelines and criteria

4.1 Legislation, policy, and guidelines

Numerous legislative, policy and guidance documents were found to be relevant to this surface water impact assessment and are discussed further in this report. The key legislation, policy and guidelines that apply to the surface water impact assessment for the project are summarised in Table 4-1.

Victorian legislation has been considered when assessing impacts on Commonwealth land and from works on Commonwealth land to provide a consistent approach to the assessment of impacts across North East Link.

Victorian and other legislation and guidance has also provided criteria for valuing receptors and assessing impacts where none exists under the Commonwealth system, which is particularly the case for receptors that are not MNES.

Table 4-1 Key legislation, policy, and guidelines

Legislation/ Regulation	Policy/Guideline	Relevance to this impact assessment
Commonwealth		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)		The EPBC Act is administered by the Australian Government's Department of Environment and Energy. At a Commonwealth level, the EPBC Act focuses on the protection of the environment, with emphasis on matters of national environmental significance. The EPBC Act also applies to actions that have a significant impact on the environment where the actions affect, or are taken on Commonwealth land or are carried out by a Commonwealth agency. As discussed in Section 1.1 the North East Link project has been determined as a 'controlled action' that requires assessment and approval under the EPBC Act (EPBC 2018/8142).
National Water Quality Management Strategy 1994		The National Water Quality Management Strategy (1994) (NWQMS) is a joint national approach to improving water quality in Australian and New Zealand waterways. It was originally endorsed by two Ministerial Councils – the former Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) and the former Australian and New Zealand Environment and Conservation Council (ANZECC). Since 1992 the NWQMS has been developed by the Australian and New Zealand governments in cooperation with state and territory governments. Ongoing development is currently overseen by the Standing Council on Environment and Water (SCEW) and the National Health and Medical Research Council (NHMRC).

Legislation/ Regulation	Policy/Guideline	Relevance to this impact assessment
		The policy objective of the NWQMS is: 'to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development'. The guiding principles of the NWQMS include: • Decision-making processes should effectively integrate long and short-term economic, environmental, social and equity considerations • Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation • The global dimension of environmental impacts of actions and policies should be recognised and considered • The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised • Decisions and actions should provide for broad community involvement on issues that affect them. The principles identified above have guided the scientific investigations undertaken in the surface water impact assessment as well as the mitigation strategies that may be required to reduce or mitigate environmental impacts of North East Link on surface water.
	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)	The guidelines set the water quality objectives required to sustain current or future environmental values for natural and semi-natural water resources in Australia and New Zealand. Recommended limits to acceptable change in water quality that would continue to protect the associated environmental values are identified in the guidelines. Meeting the guidelines for North East Link would provide a level of certainty there would be no significant impact on water resource values.
	Australian Rainfall and Runoff (ARR): A guide to flood estimation 1987 – 3rd edition (Pilgrim, DH & Institution of Engineers, Australia, 1987)	This guide was last updated in 1997 and is the basis of the methodologies and approach used for all existing and current flood models covering areas within the North East Link project area. It was a significant reference for this assessment.
	Australian Rainfall and Runoff (ARR): A guide to flood estimation 2016 (Commonwealth of Australia (Geoscience Australia) 2016).	The 2016 revised edition of the guide contains many significant changes in approach and data to the previous 1987 edition. Some sensitivity testing has been undertaken using the 2016 edition to assess the potential significance of adopting different versions of the guide. While still a draft with some updates pending, it is expected the 2016 edition will progressively replace the 1987 edition.

Legislation/ Regulation	Policy/Guideline	Relevance to this impact assessment
Victorian		
Water Act 1989		The Water Act is the primary legislation for the resourcing and use of water in Victoria. The Act gives Melbourne Water the responsibility of granting a permit to undertake works on a waterway. North East Link would require works to be undertaken within waterways and Melbourne Water has specified a set of criteria that must be met for each individual waterway.
	By-Law No. 2: Waterways, Land and Works Protection and Management (Melbourne Water, 2018a)	By-law No. 2 was made by Melbourne Water pursuant to its powers under Victoria Water Act in April 2009. The By-law includes specific rules that apply within a specific area of Melbourne Water's responsibility. The objectives of By-law No. 2 include: • Preventing or minimising interference with the flow of water • Preventing or minimising pollution of our waterways • Prohibiting or regulating the removal of materials from our waterways • Regulating certain activities.
	Melbourne Water Standards for infrastructure projects in flood-prone areas	These standards document requirements for North East Link in flood-prone areas under the control of Melbourne Water.
	Improving our Waterways, Victorian Waterway Management Strategy (DEPI, 2013a)	This strategy sets the policy direction for managing Victoria's waterways to 2021. It requires the development and implementation of regional waterway strategies for 10 catchment management regions across Victoria. Compliance with strategy requires that all North East Link works maintain or improve the condition of rivers, estuaries and wetlands so they continue to provide environmental, social, cultural and economic values for all Victorians.
	Healthy Waterways Strategy (Melbourne Water, 2013)	This describes Melbourne Water's role in managing rivers, estuaries and wetlands in the Port Phillip and Westernport region. It identifies priority areas and management actions to improve waterway health over five years from 2013 to 2018. The strategy sets implementation targets to measure progress and effectiveness in implementing its actions. North East Link works should not inhibit Melbourne Water from achieving the longer-term waterway implementation targets set in the Healthy Waterways Strategy.
	Draft Healthy Waterway Strategy (Melbourne Water, 2018)	This draft strategy documents Melbourne Water's 50-year vision for the Port Phillip and Westernport region. It identifies high waterway values and priority management activities for the 10 years to 2028, with objectives to guide activities and indicate progress towards improving the waterway condition.
	Shared Pathways Guidelines (Melbourne Water, 2009)	These guidelines have been developed to document Melbourne Water's standards for paths along waterways and provide details on the most effective way to liaise with the authority to ensure successful construction of a shared path.

Legislation/ Regulation	Policy/Guideline	Relevance to this impact assessment
Environment Protection Act 1970		The Environment Protection Act is Victoria's primary legislation to regulate and control actions relating to the protection of Victoria's environment. The Act is administered by EPA Victoria. The Act covers several aspects of the natural and built environment with a particular focus on air, land, noise, waste and water. In relation to water, the Act provides the basis for protecting Victoria's water environments from pollution. The Act empowers EPA Victoria to administer legislation including, but not limited to Acts, regulations and State Environment Protection Policies (SEPPs). The SEPP (Waters) is summarised in the section below.
	SEPP (Waters)	SEPP (Waters) replaced SEPP (Waters of Victoria) on 19 October 2018. It sets a statutory framework for the protection of the uses and values of Victoria's fresh and marine water environments. The *Urban Stormwater Best Practice Environmental Management Guidelines* (BPEMG) (CSIRO, 1999) establish best practice performance objectives for urban stormwater (for urban development) to assist in determining the level of stormwater management necessary to meet the SEPP (Waters of Victoria) requirements as detailed above. North East Link would be required to comply with the BPEMG in operation (not construction) which would assist in meeting the SEPP (Waters) over the long term for pollutant concentrations in receiving waters.
Planning and Environment Act 1987	Planning schemes (Banyule, Boroondara, Manningham, Nillumbik Whitehorse, Yarra).	Local council planning schemes identify the presence of surface water and control development through the application of overlays and related policies. These include Land Subject to Inundation Overlay (LSIO), Floodway Overlay (FO), Special Building Overlay (SBO), Urban Floodway Zone (UFZ). A permit is required to construct or carry out works (including works for North East Link) within a defined planning scheme.
Climate Change Act 2017	Policy objective 22b	Policy objective (22b) of the Climate Change Act is 'to build the resilience of the state's infrastructure, built environment and communities through effective adaptation and disaster preparedness action'. The guiding principles include 'integrated decision making' to ensure that any decisions made consider all relevant issues relating to climate change. North East Link will assess and provide an allowance for future climate change conditions.
	Yarra River Action Plan (2016)	This action plan outlines the Victorian Government's support of the 30 recommendations made by a Ministerial advisory committee report which followed on from a discussion paper and extensive consultation. The action plan is guided by five objectives which cover: a healthy river; the parklands; cultural diversity; security; and modern governance.

Legislation/ Regulation	Policy/Guideline	Relevance to this impact assessment
Yarra River Protection (Willip-gin Birrarung Murron) Act 2017	Yarra Strategic Plan	Melbourne Water is leading the development of this strategic plan under the Yarra River Protection (Willip-gin Birrarung Murron) Act). The key objectives of the strategic plan are: the overall environmental health of the river (waterway and riparian land); community use, access and amenity of the river and parklands; the river's landscape setting and interface of the river corridor with adjacent land use, cultural and heritage values.
Other standards and guidelines		
	Austroads Guide to Road Tunnels (first edition) (Austroads, 2010)	This guide sets out standards for the planning of road tunnels. It describes important issues and considerations relating to implementation, general planning, regulation, structural and geometric design, drainage, geology, the environment as well as operation, construction and maintenance. The risk management approach identified in the guide has been adopted in the assessment of tunnel flood immunity standards.
	Austroads Guide to Road Design Parts 5, 5A and 5B (Austroads 2013)	This guide sets out standards for road design in relation to hydrology and drainage for aspects including roads surfaces, drainage networks, basins, subsurface drainage, open channels, culverts and floodways.
	Integrated Water Management Guidelines – VicRoads	These guidelines set the direction for the management of water resources during road construction, operation and maintenance activities.
	Water for Victoria (Water Plan) (DELWP, 2017)	This plan recognises the need to better manage Victoria's water resources into the future and the economic benefits of doing so as Victoria responds to a changing climate and growing population. Water for Victoria was the platform for the development of: • The Integrated Water Management Framework for Victoria • Melbourne Water System Strategy.

4.2 State Environment Protection Policy (Waters) 2018

In 2018, the State Environment Protection Policy (SEPP) (Waters) replaced the previous SEPP (Waters of Victoria). SEPP (Waters) combines the two former policies (surface water and groundwater) into a single streamlined policy to better reflect community values, better clarify industry obligations, provide for greater accountability, and applies updated science (Engage Victoria, 2018).

SEPP (Waters) sets a statutory framework for the protection of the uses and values of Victoria's fresh and marine water environments, including:

- The uses and values of the water environment the community and government want to protect (beneficial uses)
- The objectives and indicators which describe the environmental quality required to protect beneficial uses

- Guidance to local councils, catchment management authorities, water authorities and Victorian Government agencies to protect and rehabilitate water environments to a level where environmental objectives are met and beneficial uses are protected.

SEPP (Waters) requires measures to be implemented to control the environmental impact of discharges and to protect the beneficial uses of water. A beneficial use is defined in Victoria's *Environment Protection Act 1970* and includes a current or future environmental value or use of surface waters that communities want to protect. A beneficial use does not prohibit or permit the use of surface waters for any particular purpose, but requires surface waters to be of a suitable quality and quantity to support that use or value.

The following beneficial uses are to be protected:

- Protection of water-dependent ecosystems and species
- Water for human consumption
- Water for agriculture, aquaculture and industry
- Water for recreation
- Cultural and spiritual values
- Other beneficial uses.

To protect the beneficial uses and the aquatic ecosystems, the following indicators are used for rivers and streams:

- Nutrients (phosphorus and nitrogen)
- Turbidity
- Electrical conductivity
- pH
- Dissolved oxygen
- Toxicants in water and sediments.

EPA Victoria has developed a series of Information Bulletins to support and guide the SEPP (Waters). Two of the Information Bulletins relevant to the North East Link surface water assessment include:

- Water Quality Objectives for Rivers and Streams – Ecosystem Protection (EPA Victoria, 2003c)
- Nutrient Objectives for Rivers and Streams – Ecosystem Protection (EPA Victoria, 2003a).

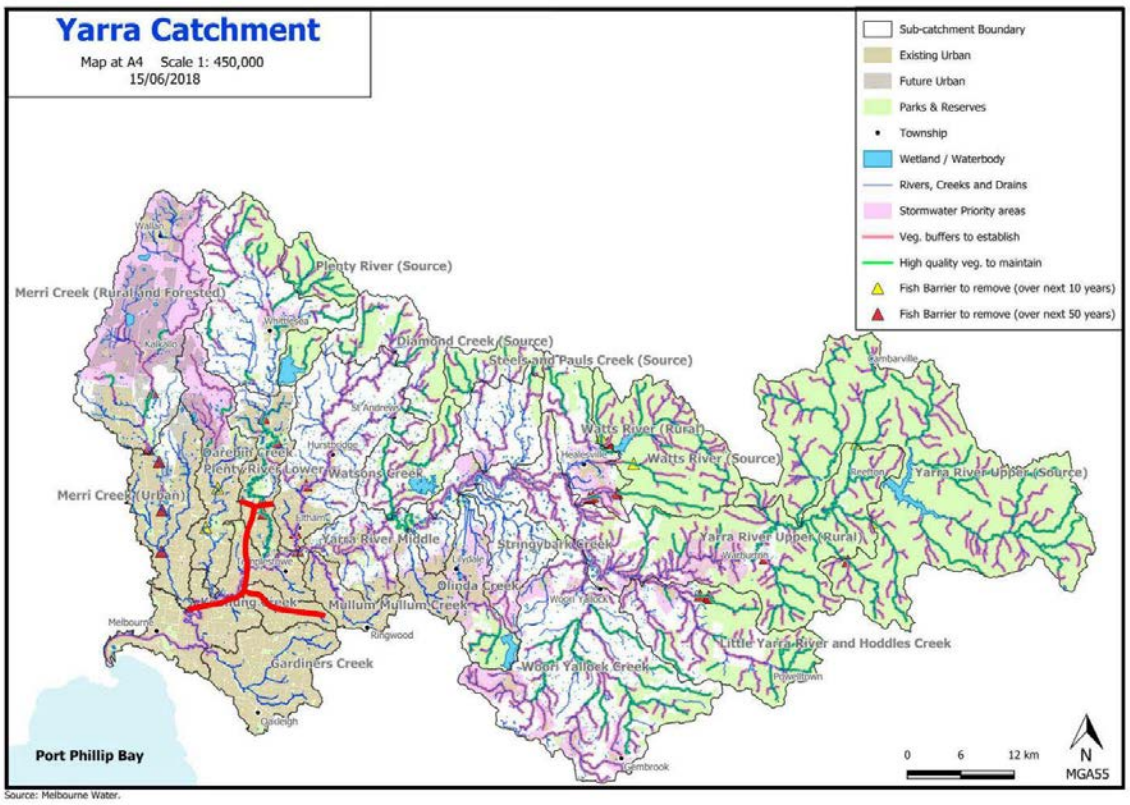


Figure 4-1 North East Link (red) within the Yarra Catchment

The objectives set out in these publications are outlined in Table 4-2.

Table 4-2 SEPP Water quality objectives applicable to North East Link

Policy	SEPP(Waters) (Table 1)			
Segment	Mainstream		Tributaries	
Indicator	Central Foothills and Central Plains (slightly to moderately modified) lowlands of Yarra)		Urban (highly modified) Lowlands of Yarra	
Total phosphorus	<55	75th percentile (µg/L)	<110	75th percentile (µg/L)
Total nitrogen	≤1100	75th percentile (µg/L)	≤1300	75th percentile (µg/L)
Dissolved oxygen (per cent saturation U.N.O.)	≥75 110	25th percentile Maximum	≥70 110	25th percentile Maximum
Turbidity (NTU)	≤25	75th percentile	≤35	75th percentile
Electrical conductivity	≤250	µS/cm @ 25 °C	≤500	µS/cm @ 25 °C
pH (pH units)	≥6.7 ≤7.7	25th percentile 75th percentile	≥6.4 ≤7.9	25th percentile 75th percentile

SEPP (Waters) references the *Urban Stormwater Best Practice Environmental Management Guidelines* (BPEMG) (CSIRO, 1999) which were developed to establish best practice performance objectives for urban stormwater (for urban development). These objectives for stormwater best practice are set out in Table 4-3. The objectives assist in determining the level of stormwater management necessary to meet the SEPP (Waters) requirements as detailed above. The BPEMG sets specific pollutant reduction targets for future development.

Table 4-3 Objectives for environmental management of stormwater (BPEMG: CSIRO, 1999)

Pollutant	Receiving water objective	Current best practice performance objective
Operation		
Suspended solids (SS)	Comply with SEPP (Waters)	80% retention of the typical urban annual load.
Total phosphorus (TP)	Comply with SEPP (Waters)	45% retention of the typical urban annual load.
Total nitrogen (TN)	Comply with SEPP (Waters)	45% retention of the typical urban annual load.
Litter	Comply with SEPP (Waters)	70% retention of typical urban annual load.
Flows	Maintain flows at pre-urbanisation levels	Maintain discharges for the 1.5 year ARI at pre-development levels.
Construction		
Suspended solids	Comply with SEPP (Waters)	Effective treatment of 90% of daily run-off events. Effective treatment equates to a 50 percentile SS concentration of 50 mg/L.
Litter	Comply with SEPP (Waters)	Prevent litter from entering the stormwater system.
Other pollutants	Comply with SEPP (Waters)	Limit the application, generation and migration of toxic substances to the maximum extent practicable.

4.3 Local guidelines

The following local guidelines should be considered with respect to Commonwealth land, particularly in the absence of equivalent Commonwealth guidelines. The City of Banyule is the relevant local government area for Commonwealth land affected by North East Link.

While Melbourne Water is responsible for regional drainage, flood plain and waterway management and for contributing to the protection and improvement of waterway health across greater Melbourne, local councils are the responsible authorities for planning decisions made with reference to planning schemes that control land use and development. Planning schemes contain Victorian Government and local council planning policies, zones and overlays and other provisions that affect how land can be used and developed. Councils are also responsible for managing local drainage infrastructure in catchments of less than 60 hectares, including ownership and maintenance of drainage assets.

Table 4-4 summarises strategy and guideline documents published by Banyule City Council of relevance to North East Link.

Table 4-4 City of Banyule document summary

Relevant documents	Summary
Planet: Water – Water Sustainability Plan 2013 (Banyule City Council, 2013)	The objective of this plan is to improve water quality, to prepare for the likelihood of future dry periods and to constrain rising water costs, this plan has developed specific water sustainability targets. The plan states *'Water quality in Banyule's waterways is generally rated moderate to poor and it is unlikely that there has been significant long term change in this. This has a detrimental impact on waterway health and people's enjoyment of waterways'.*
Stormwater Management Plan (Sinclair Knight Merz for Banyule City Council, 2003)	The purpose of this plan is to guide the council in improving environmental management and quality of stormwater runoff from urban areas throughout the municipality.
Banyule Planet: Environmental Sustainability Policy and Strategy 2013-2017 (Banyule City Council, 2013)	This policy and strategy support the Banyule City Plan 2013-2017 objective to 'conserve water and improve stormwater quality and impact'.
Drainage Policy (Banyule City Council, 1998)	This policy was developed following the amalgamation of local councils and it documents the management of drainage assets.

5. Assessment method

This chapter describes how surface water impacts of North East Link on MNES and the environment on Commonwealth land have been assessed.

While this report considers changes to surface water characteristics of potential importance to the environment on Commonwealth land and on MNES habitat, it makes no assessment regarding the significance of those changes on MNES. The significance of potential impacts on MNES is discussed in the PER Technical Appendix A – Flora and fauna.

5.1 Overview of method

Four technical reports were prepared to inform the PER and assessment of impacts. This surface water technical report is one of those four reports. Impacts and their significance were assessed taking into account relevant EPBC Act Significant Impact Guidelines. Figure 5-1 provides an overview of this process.

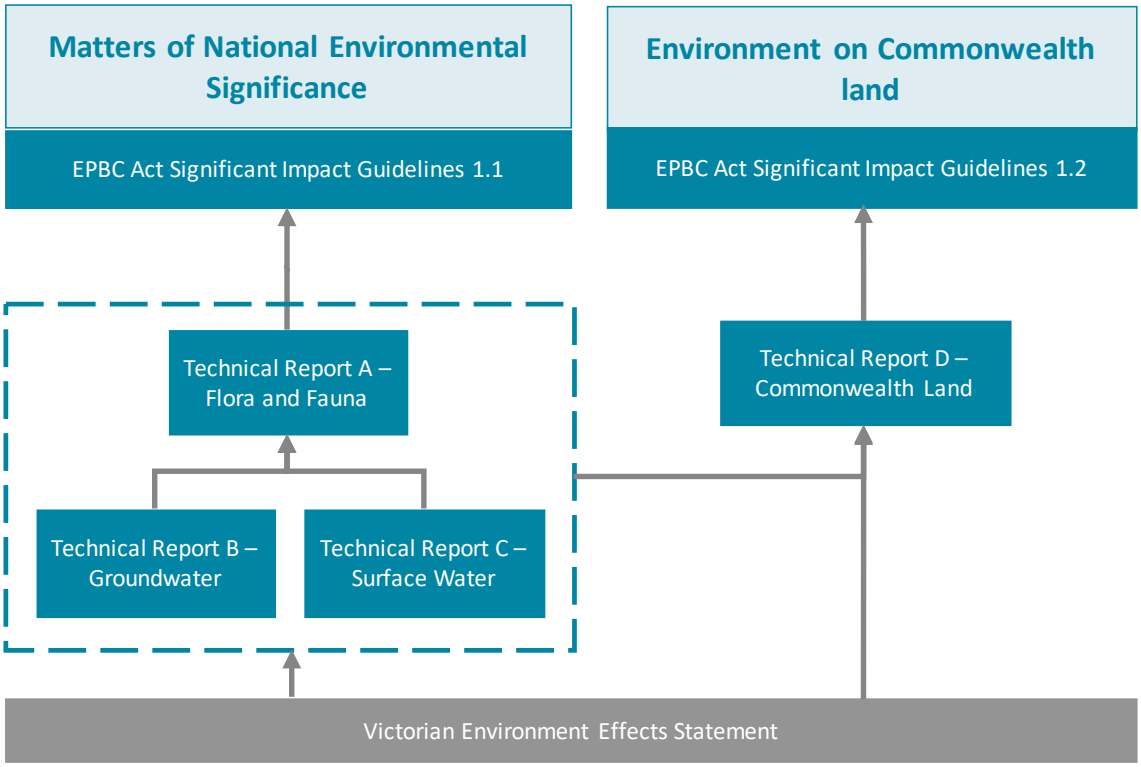


Figure 5-1 Assessment approach

In assessing surface water impacts in this technical report, the following steps were followed:

- The existing surface water environment that would influence impacts on MNES and Commonwealth land was described
- Surface water impacts, either direct or indirect, resulting from construction and operation of North East Link that could directly or indirectly impact MNES and Commonwealth land were identified
- Measures to avoid or mitigate surface water impacts were considered
- The significance of residual impacts were assessed.

The impact assessment process has informed and been informed by community and stakeholder engagement (refer Chapter 14 – Consultation) and development of the reference project (refer Chapter 3 – Description of the action). Figure 5-2 shows this process.

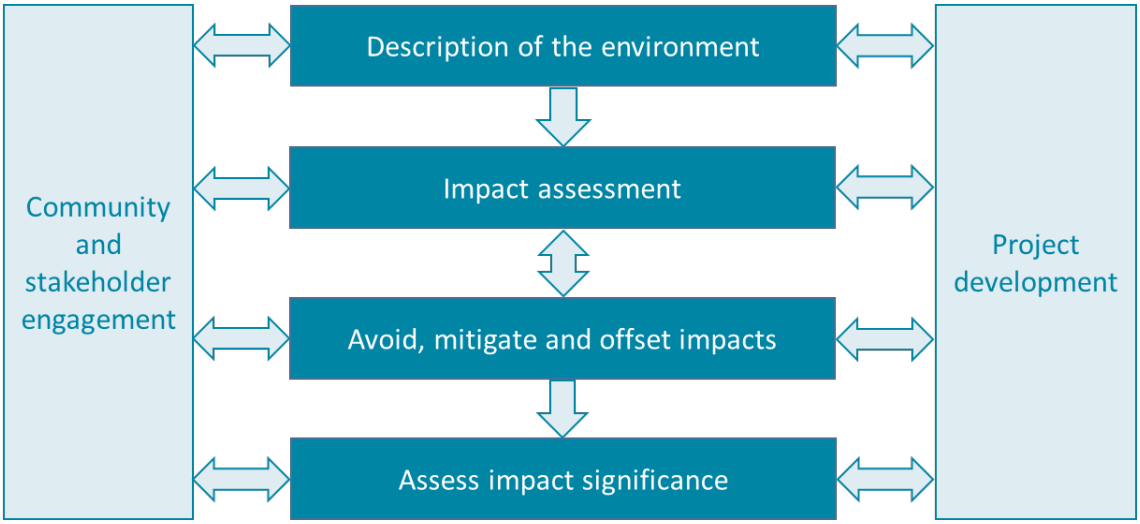


Figure 5-2 Impact assessment process

5.2 Study scope

5.2.1 Study area

North East Link would extend from Watsonia North and Greensborough in the north, through Watsonia, Macleod and Yallambie, before tunnelling beneath parts of Rosanna, Viewbank and Heidelberg. At Bulleen, North East Link is proposed to connect to the Eastern Freeway. Works required for the Eastern Freeway widening and the new Doncaster Busway would occur within the suburbs of Fairfield, Kew, Kew East, Bulleen, Balwyn North, Doncaster, Mont Albert North, Box Hill North, Doncaster East, Blackburn North, Donvale and Nunawading.

A high-level review of surface water features including waterways, drains and other surface water bodies in close proximity to North East Link was undertaken to identify which sites were potentially impacted (refer Appendix B). This review identified that North East Link has the potential to impact the Yando Street Main Drain, Kempston Street Main Drain, Watsonia Station drain, Banyule Creek, the Yarra River and Koonung Creek, as well as their associated floodplains and tributaries. Potential impacts to other water bodies have also been identified and include the wetlands and irrigation storage at Trinity Grammar School Sporting Complex and a number of wetlands along Koonung Creek.

The potential surface water impacts within the study area shown in Figure 5-3 have been considered with respect to their potential to directly or indirectly impact the Commonwealth land environment or MNES. Where there is potential for surface water impacts to impact the Commonwealth land environment or MNES. They have been included in the assessment documented in this report.

PER Technical Appendix A – Flora and fauna has concluded that any local surface water impact on the Yando Street Main Drain, Kempston Street Main Drain or Watsonia Station drain, which all discharge to the Plenty River, would be unlikely to have a measurable impact on MNES or Commonwealth land. These drains are therefore not further considered in this report.

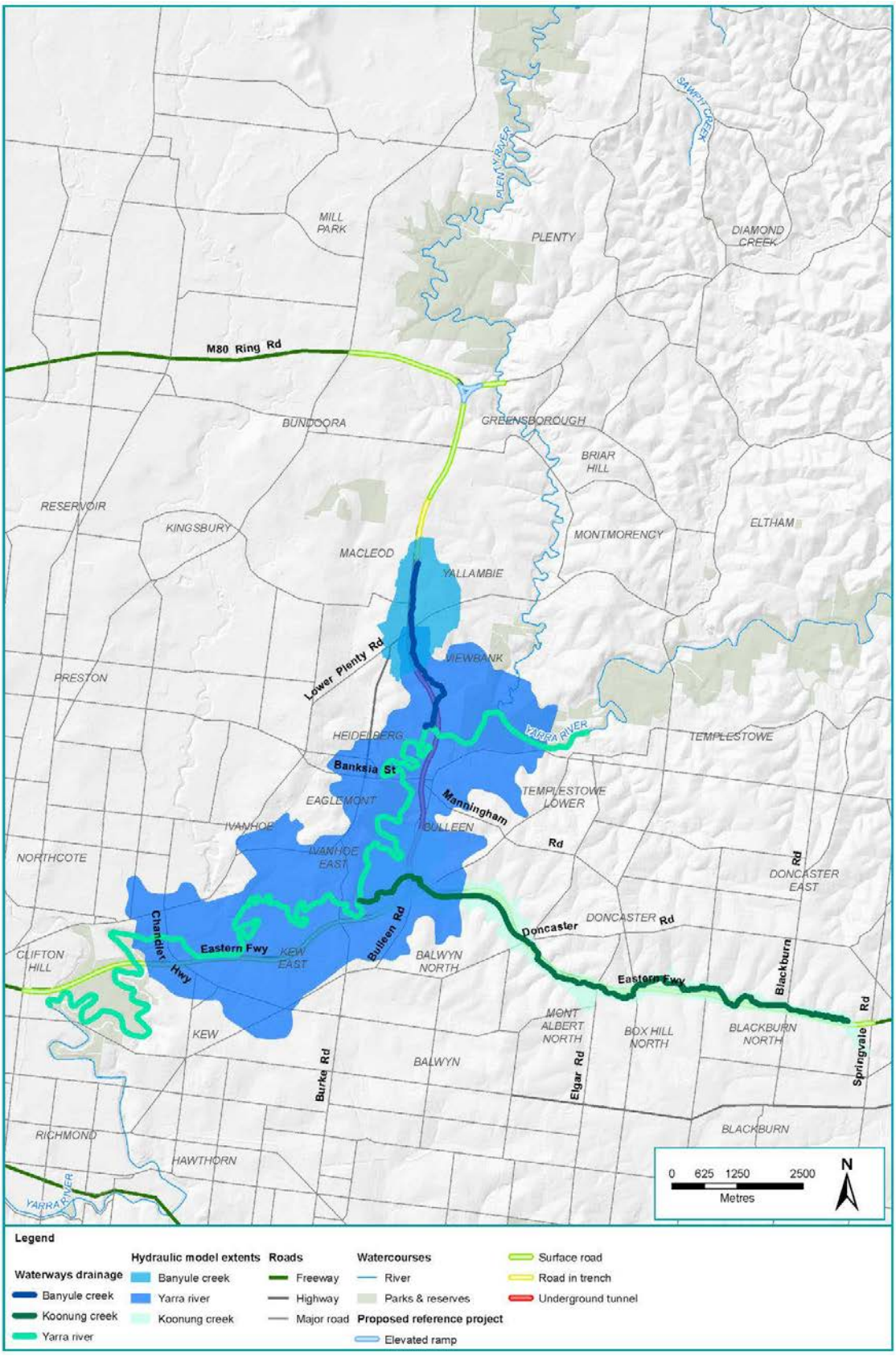


Figure 5-3 PER study area

5.2.2 Scope

As noted in Section 5.2.1, the study area for the assessment includes the intersected waterways and their overland flow paths and associated flood plains. This area covers a much larger area than would need to be considered for impacts on and around Commonwealth land. This is so the assessment can assess impacts further downstream that may affect other MNES – although this assessment does not comment on impacts to MNES, it does comment on impacts to surface water that may in turn affect MNES. As no commentary is made on the potential likelihood or magnitude of impacts to MNES in this report, all waterway and waterbodies information are included as potentially important habitat.

This PER assessment takes a holistic approach to the scope of the surface water impacts, and provides commentary encompassing the whole of the project area to cover off all aspects of the PER Guidelines relating to surface water as noted in Table 2-1.

5.3 Description of the environment

In describing the existing environment, the environmental assets, values and uses that may be affected by North East Link were characterised. This focused on the potential presence of or habitat for MNES, water resources that may support MNES and the environment on Commonwealth land.

This has considered:

- History, current use and condition of environmental assets, values and uses
- Significance of environmental assets, values and uses
- Sensitivity or vulnerability to impacts.

The existing environment of the study area was determined through a series of desktop and field investigations.

5.3.1 Approach

There are four main aspects relating to surface water that have been considered in this assessment: flooding, water quality, geomorphology, and water supply. Existing conditions have been defined for each of these aspects, by waterway where relevant.

The importance of defining the existing conditions for each of these aspects for North East Link is:

- **Flooding** – A key consideration is the potential for project construction and operation to affect waterways and hydrology with respect to flooding and future climate change scenarios (see Table 2-1). An objective for North East Link is to avoid or minimise adverse effects on surface water and groundwater environments.
- **Water quality** – A key consideration is the potential for contaminated run-off or other water to be transported into surface waters or groundwater environments (see Table 2-1). An objective for North East Link is to avoid or minimise adverse effects on surface water and groundwater and floodplain environments.
- **Geomorphology** – Geomorphology is the study of landforms and their origin. This geomorphological assessment is focused on the banks and beds of waterways. A key consideration for North East Link is the potential for project works to contribute to land subsidence or erosion (see Table 2-1). An objective is to avoid or minimise adverse effects of erosion and subsidence on land stability from the works, including constructing the tunnels and the river and creek crossings.

- **Water supply** – A priority for characterising the existing environment is to identify and map the natural and constructed surface water drainage systems and storages relevant to the geographic coverage of project works (see Table 2-1). North East Link works have the potential to impact the water supply for the irrigation of sporting fields.

The method used to establish the existing conditions for each of these aspects is discussed in the following subsections.

5.3.2 Flooding

To establish the existing flooding conditions for North East Link and facilitate subsequent assessment of its impacts under proposed conditions, the following methodology was used:

- A review of the existing planning overlays that indicate existing flood extents was undertaken to identify where North East Link would interacts with creeks, rivers, floodplains, overland flow paths and underground drains – this considered areas covered by a Land Subject to Inundation Overlay (LSIO) and/or a Special Building Overlay (SBO)
- Models provided by Melbourne Water were reviewed for the areas where interactions were identified – this included an assessment of the suitability of the available modelling for the assessment
- Where the available modelling was not appropriate for the assessment updated modelling was developed
- Modelling was undertaken in general accordance with Melbourne Water standards for infrastructure projects in flood-prone areas and Flood Mapping Projects Guidelines and Technical Specifications (Melbourne Water 2016). Modelling has included the assessment of climate change as per Melbourne Water standards for infrastructure projects in flood-prone areas (refer Appendix A). This included additional simulations with increased rainfall intensities to inform an assessment of potential climate change impacts.

Detailed hydrologic and hydraulic modelling has been undertaken for the Banyule Creek, Yarra River and Koonung Creek to identify and map the natural and constructed surface water drainage systems. The modelling was developed using RORB (a hydrologic modelling package) and TUFLOW (a two-dimensional hydraulic modelling package), in general accordance with the Melbourne Water guidelines for flood studies.

Banyule Creek flooding

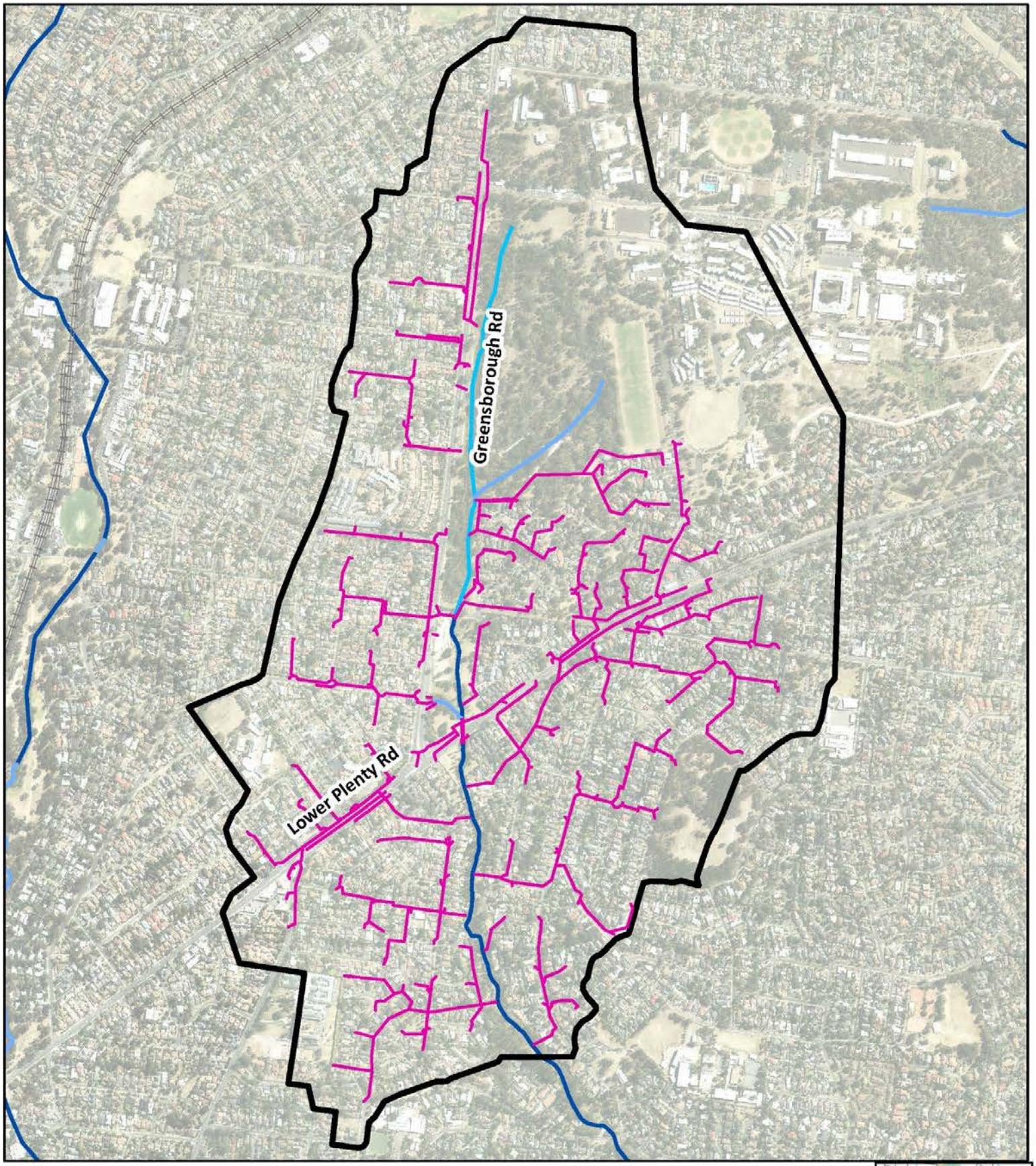
Models for Banyule Creek are based on available information including an existing conditions model recently prepared by Engeny for the Banyule City Council and Melbourne Water.

The key assumptions adopted in the hydrologic and hydraulic analysis were:

- The hydraulic model extent includes the upper catchment and reach of Banyule Creek and associated floodplain area (downstream boundary approximately 800 metres south of Lower Plenty Road) as shown in Figure 5-4.
- Hydraulic model inflows were based on data included with the provided base hydraulic TUFLOW model, although a RORB model was subsequently provided (5/10/2018). These inflows have been consistently applied for the hydraulic modelling of existing as well as proposed conditions.
- In the absence of suitable historical data for calibration or verification, flood flows and resultant levels are estimated based on standard methodologies.
- A range of design events were modelled including small (frequent) and large (rarer) events for a range of durations as shown in Appendix C (C4).

- Inlets were modelled without blockage in existing as well as proposed conditions.
- The potential impacts of climate change have been modelled using an increased rainfall intensity for the 1% AEP design event.
- The major hydraulic connections and local drainage connections and systems were modelled for the upper catchment, based on data provided by Melbourne Water (10 January 2018).
- A downstream boundary rating curve was developed based on the slope of the channel at the downstream boundary.
- The topography of Banyule Creek and surrounds has been developed based on a Digital Elevation Model (DEM) provided by Melbourne Water (10 January 2018); no bathymetric survey was available for Banyule Creek.
- Roughness values have been developed with guidance from the Flood Mapping Projects Guidelines and Technical Specifications (Melbourne Water, 2016) and the data provided by Melbourne Water (10 January 2018).

The Banyule Creek hydraulic model setup is shown in Figure 5-4.



LEGEND

- Hydraulic Model Boundary
- Underground drainage included in model
- River
- Stream
- Channel
- Drain

Paper Size A4

0 85 170 340

Metres

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

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NORTH EAST LINK PROJECT

North East Link Project
Public Environment Report

Job Number 31-35006
Revision C
Date 22/10/2018

Hydraulic model setup
Banyule Creek

Figure 5-4

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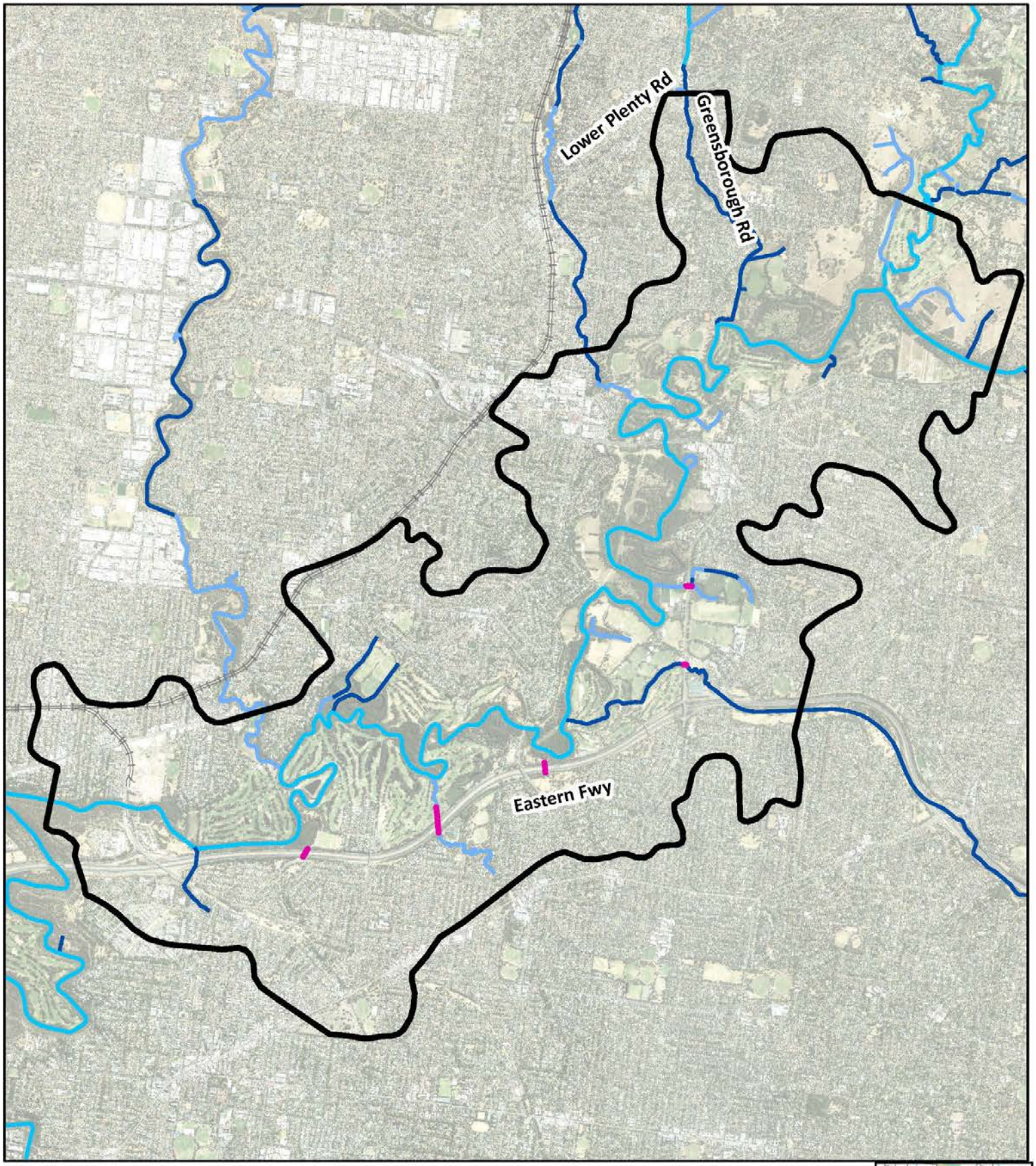
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

Yarra River flooding

Melbourne Water has been consulted through the development of this model.

The key assumptions adopted in the hydrologic and hydraulic analysis are;

- The area of interest for this assessment is outlined in Figure 5-4 as the hydraulic model boundary. Additional modelling using a separate TUFLOW model was prepared downstream to improve the downstream boundary of the main model. A hydraulic model which extended further upstream was also used to better understand the potential propagation of any flooding impacts upstream.
- Flow from the Yarra River catchment upstream has been incorporated along with flows from Plenty River, Banyule Creek, Salt Creek, Koonung Creek and Darebin Creek. These flows were generated from a RORB model provided by Melbourne Water (3 July 2017). These flows were obtained using models adjusted to match Melbourne Water's designated flood levels in the Chandler Basin (referring to the extensive floodplain storage nominally upstream of the Chandler Highway in Fairfield and downstream of Manningham Road West or Banksia Street). Melbourne Water's design flows and levels are largely based on interpretation of observed 1934 flood levels.
- The events modelled included 63.2%, 39.4%, 18.1%, 10%, 5%, 2%, 1%, 0.5%, 0.2%, 0.1%, 0.05% AEPs and Probable Maximum Flood for existing conditions to assist in understanding the potential ponding levels in Chandler Basin. For the proposed conditions the 10%, 5%, 2%, 1% and 0.5% AEP events were modelled. All events were modelled with a 72-hour duration design storm event as shown in Appendix C (C5).
- Assessment of the potential impact of climate change has been informed by modelling with an increase in rainfall intensity.
- The model includes a representation of the new Chandler Highway Bridge currently being constructed.
- Bridges and other structures were modelled without blockage in existing as well as proposed conditions.
- Major hydraulic connections, including various shared use path conduits beneath the Eastern Freeway, Glass Creek, Koonung Creek and the culvert connection to the storage at Trinity Grammar School Sporting Complex were included based on information obtained from the GIS data provided by Melbourne Water (25 October 2017) and VicRoads As-Constructed drawings (3 August 2017).
- A downstream boundary rating curve developed based on modelling of the Yarra River reach downstream of Chandler Highway.
- The topography of floodplain and surrounds has been developed based off supplied DELWP LiDAR (13 July 2017) and Melbourne Water DEM (15 August 2017). Bathymetric survey was utilised to determine the centreline of the Yarra River as provided by Melbourne Water (20 July 2017).



LEGEND

- Hydraulic Model Boundary
- Underground drainage included in model
- River
- Stream
- Channel
- Drain

Paper Size A4

0 280 560 1,120

Metres

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

N

NORTH EAST LINK PROJECT

North East Link Project
Public Environment Report

Job Number 31-35006
Revision C
Date 22/10/2018

Hydraulic model setup
Yarra River

Figure 5-5

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

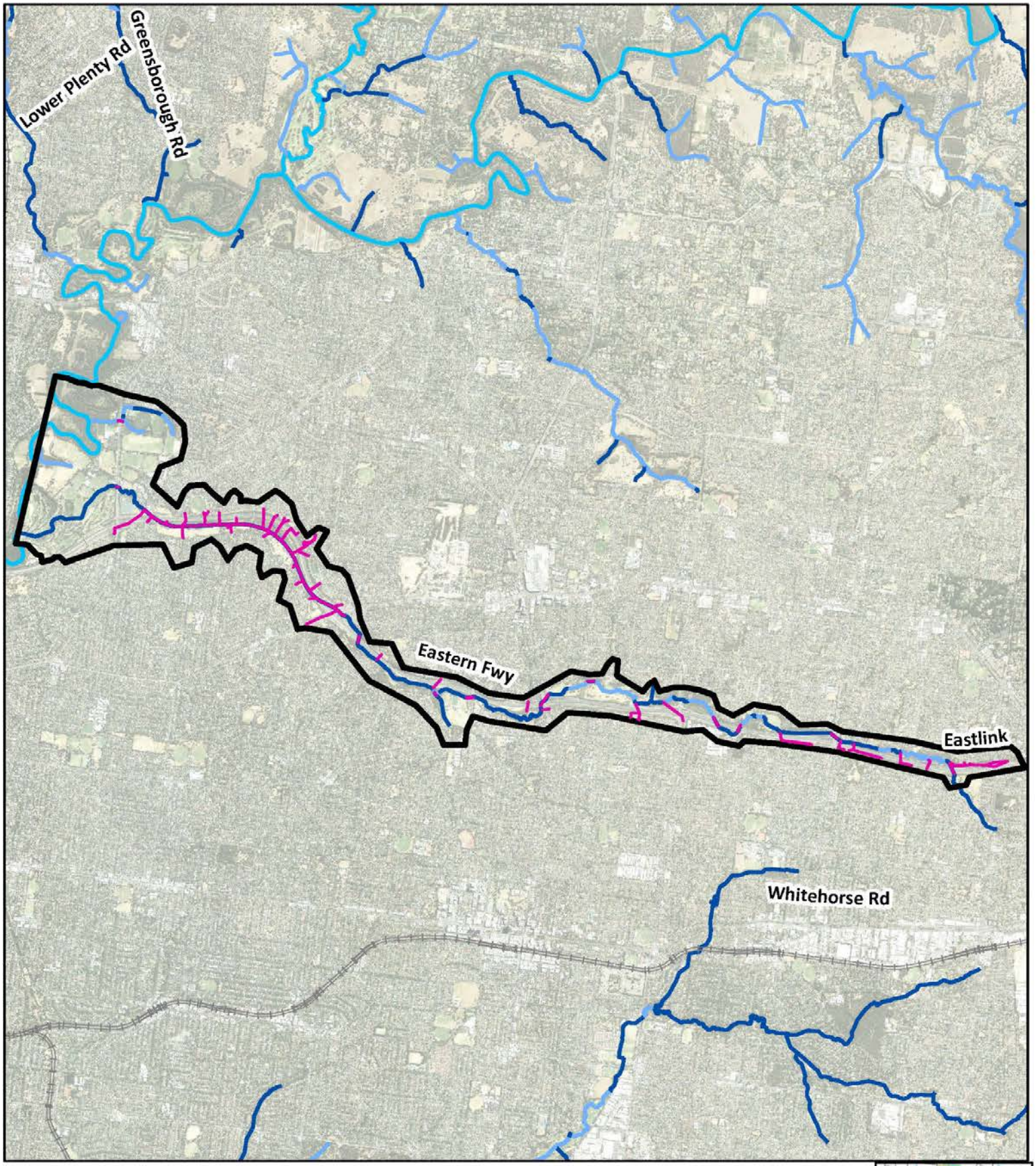
Koonung Creek flooding

Melbourne Water has been consulted throughout the development of this model.

The key assumptions adopted in the hydrologic and hydraulic analysis are:

- The hydraulic model extent includes, the entire 12-kilometre length of Koonung Creek, as shown in Figure 5-6. While inflows have been carefully considered, flooding on the tributary streams (local catchment flooding) has not been explicitly modelled.
- Hydraulic model inflows were estimated using a RORB model of Koonung Creek and have been consistently applied for the hydraulic modelling of existing as well as proposed conditions.
- In the absence of suitable historical data for calibration or verification, flood flows and resultant levels are estimated based on standard methodologies.
- A range of design events were modelled including small (frequent) and large (rarer) events for a range of durations as shown in Appendix C (C6).
- The key hydraulic structures were modelled, based on information obtained from the GIS data provided by Melbourne Water (25 October 2017), and VicRoads drawings (supplied by VicRoads and Melbourne Water on 3 August 2017, 7 September 2017 and 25 January 2018). Data gaps have been filled in a number of locations, based on engineering judgement; these assumptions are expected to be corrected as information becomes available.
- 1% AEP Yarra River and Koonung Creek flood events do not occur concurrently.
- A downstream boundary water level of 11 metres AHD was adopted based on the assumption the Yarra River would be at the top of bank level.
- The topography of Koonung Creek and surrounds has been developed based on a supplied DELWP LiDAR (3 August 2017) and Melbourne Water DEM (15 August 2017); no bathymetric survey was available for Koonung Creek.
- Roughness values have been developed based on different types of land use and ground cover, aerial photography and a site visit with guidance from the Flood Mapping Projects Guidelines and Technical Specifications (Melbourne Water, 2016).

The Koonung Creek hydraulic model setup is shown in Figure 5-6.



LEGEND

- Hydraulic Model Boundary
- Underground drainage included in model
- River
- Stream
- Channel
- Drain

Paper Size A4

0 335 670 1,340

Metres

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

N

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Date 22/10/2018

Hydraulic model setup
Koonung Creek

Figure 5-6

G:\31\35006\GIS\Maps\Working\Specialist Submission\EES\Groundwater and Hydrology\Surface_Water\35006_Hydraulic_Model_Koonung.mxd
GHD 180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

5.3.3 Water quality

The following methodology was used to assess existing water quality:

- Data available from Melbourne Water, EPA Victoria and Waterwatch was reviewed. This data has been compared with water quality objectives as per the draft 2018 SEPP(Waters), and an assessment has been provided.
- An overview of water quality and waterway health in the creeks and waterways that intersect with North East Link has been developed based on information available in Melbourne Water's Port Phillip and Westernport Regional River Health Strategy and Melbourne Waters Index of River Conditions (IRC) ranking (Melbourne Water, 2007).

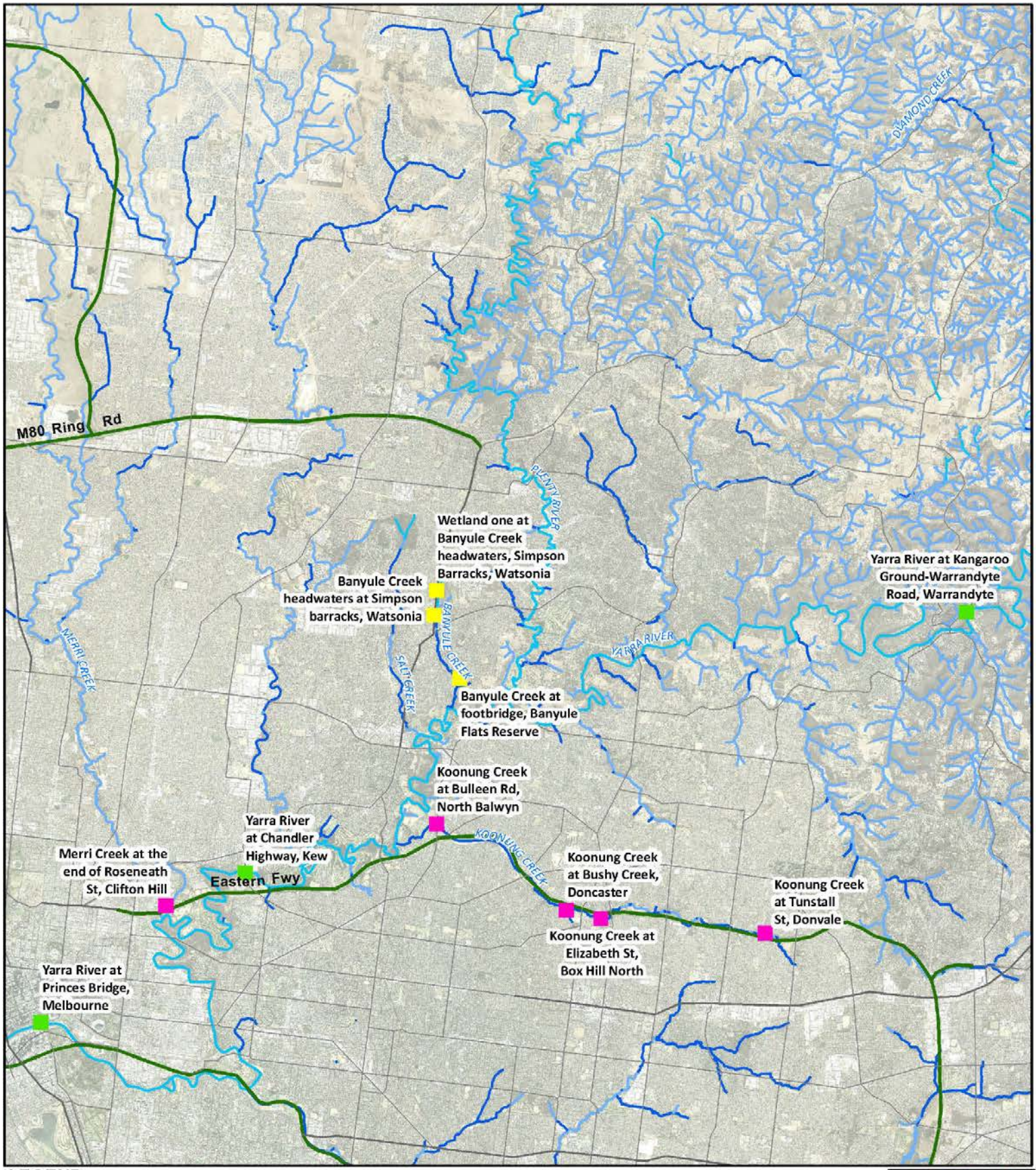
These are discussed in more detail in the following subsections.

Water quality monitoring data

To characterise the existing conditions water quality, monitoring data has been collected and collated for the creeks and rivers within the study area. Figure 5-7 shows the locations of the water quality monitoring sites used in the assessment.

The following water quality data was collected for this assessment:

- Melbourne Water – Melbourne Water has a Water Quality Monitoring Program (WQMP) that covers 136 sites across Greater Melbourne (Melbourne Water, 2015). The most recent published water quality data from Melbourne Water's WQMP is for the 12 months across 2015. Data from three sites has been used to inform this assessment of water quality in the Yarra River. The locations of these sites are shown in Figure 5-7.
- EPA Victoria – historical water quality monitoring data was provided by EPA Victoria (2018). From this data, four sites have been used to inform an assessment of water quality in Koonung Creek. The locations of these sites are shown in Figure 5-7.
- Waterwatch – water quality monitoring data was obtained from Waterwatch for three sites in the study area. From this data, all three sites have been used to inform an assessment of water quality in Banyule Creek.



LEGEND

River
Stream
Channel
Drain

Water Quality Monitoring Sites

EPA
MW
Waterwatch

Paper Size A4

0 800 1,600 3,200

Metres

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

N

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Water quality monitoring sites assessed for North East Link Figure 5-7

G:\31\35006\GIS\Maps\Working\Specialist Submission\EES\Groundwater and Hydrology\Surface_Water\35006_HydraulicBoundaryMap.mxd 180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

Regional River Health Strategy

Melbourne Water's Regional River Health Strategy (2005) was reviewed to obtain an overview of water quality and waterway health in the creeks and waterways that intersect with North East link. The Regional River Health Strategy includes condition assessments for the Yarra River, Koonung Creek and Banyule Creek. The condition descriptions in the Regional River Health Strategy are based on an assessment of five criteria: water quality, aquatic life, habitat and stability, vegetation, and flow.

Index of River Conditions

The Index of River Conditions (IRC) ranking system was developed by Melbourne Water (2007) to provide an overall assessment of the condition and health of the rivers and creeks within its management area. The index has been reviewed to obtain an overview of water quality and waterway health in the creeks and waterways that intersect with North East Link. The IRC has been established using DELWP's Index of Stream Condition (ISC) (DEPI, 2013b). The IRC rankings are different from the ISC rankings as they have been modified to account for the urban rivers and creeks.

5.3.4 Geomorphology

Geomorphology relates to the study of landforms and their origin. The existing condition geomorphological assessment for surface water has focused on the waterway stability. To establish the existing geomorphic conditions for North East Link, the following methodology was adopted:

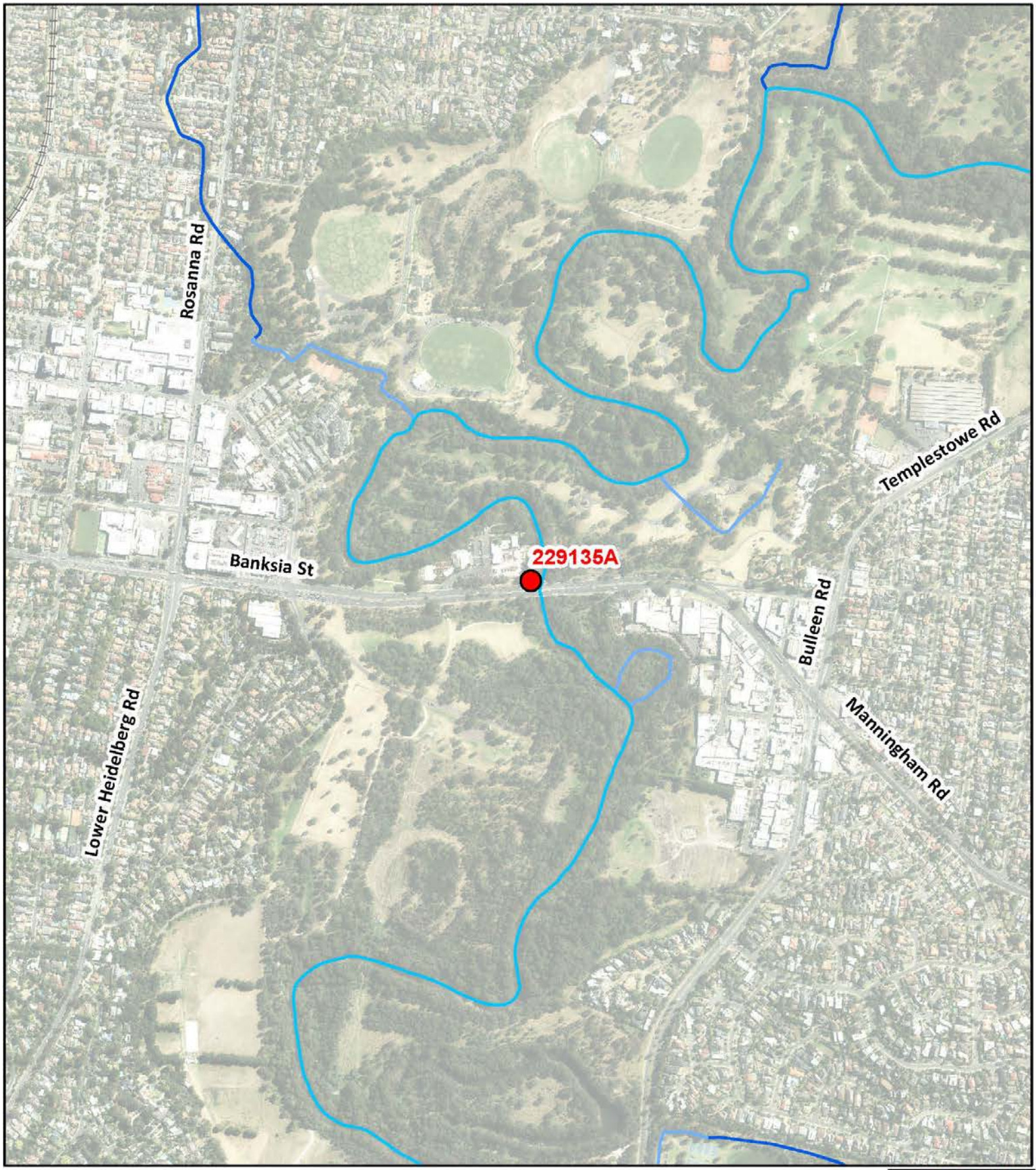
- A review of previous geomorphic assessments (Sinclair Knight Merz, 2005)
- Site inspections undertaken on 17 July 17 and 7 May 18 to provide a series of current geomorphic observations.

Information obtained from these sources has been used to determine the existing geomorphic condition with respect to waterway stability for Banyule Creek, Koonung Creek and the Yarra River.

5.3.5 Flow assessment

A flow assessment has been undertaken to document the low flow conditions for the Yarra River to inform the impact assessment for PER Technical Appendix A – Flora and fauna (see Section 2.3).

Utilising flow gauge data provided by Melbourne Water for the location shown in Figure 5-8, flow duration curves were developed for the Yarra River.



LEGEND

- Melbourne Water gauge location
- River
- Stream
- Channel
- Drain

Paper Size A4

0 65 130 260

Metres

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

N

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Melbourne Water Gauge Location

Figure 5-8

G:\31\35006\GIS\Maps\Working\Specialist Submission\EES\Groundwater and Hydrology\Surface_Water\35006_HydraulicBoundaryMap.mxd 180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

5.4 Impact assessment

5.4.1 Impact assessment approach

Impact assessment

The change that would result from the implementation of North East Link is called an impact. Impacts can be positive or negative. Impacts can be a direct result of an action, or can occur indirectly, such as impacts on habitat for MNES resulting from a change in surface water conditions. The nature and extent of any impact is measured against the current environmental conditions, considering the differences between the project and 'no project' scenarios.

The following factors were considered when assessing potential impacts:

- Severity including the intensity, duration, timing and frequency, and scale or geographic extent of impacts
- The relationship between different impacts on the environment
- The likely effectiveness of measures to avoid and mitigate adverse impacts
- The likelihood that any given environmental impact would occur
- Whether any impacts are likely to be unknown, unpredictable or irreversible
- Benchmarks and requirements set by statutory requirements, policies and guidelines
- Community expectations
- The principles of ecologically sustainable development and objects and requirements of the EPBC Act.

Avoid, mitigate and offset impacts

Measures to avoid and mitigate impacts were developed in response to the impact assessment to reduce surface water impacts and consequent impacts on MNES and the environment of Commonwealth land.

These have included refinements to the reference project and specification of measures to avoid and mitigate environmental impacts during construction and operation of North East Link. The reference project is described in PER Chapter 3 – Description of the action.

Section 10 of this report describes the proposed surface water avoidance and mitigation measures. PER Chapter 10 – Proposed avoidance and mitigation measures provides a consolidated list of all avoidance and mitigation measures and the framework for implementing these.

Where impacts could not be reduced through avoidance and mitigation measures, environmental offsets have been proposed in accordance with the EPBC Act Environmental Offsets Policy (DSEWPAC, 2012). These are described in PER Chapter 11 – Offsets.

Assess impact significance

The significance of relevant impacts took into account the current environmental context and the likely effectiveness of measures to avoid, mitigate and offset potential impacts. Having regard to the assessment in this report, the significance of relevant impacts was also assessed against the EPBC Act Significant Impact Guidelines for each of MNES and the environment on Commonwealth land in PER Technical Appendix A – Flora and fauna and PER Technical Appendix D – Commonwealth land respectively.

5.4.2 Surface water assessment – Commonwealth matters

The impact assessment has considered the potential for significant impacts on the environment to occur as described by the criteria outlined in the EPBC Act Significant Impact Guidelines:

- Matters of National Environmental Significance – Significant impact guidelines 1.1 (DoE, 2013). Relevant surface water impacts which may affect MNES are discussed in Section 8; the actual impact of these effects on MNES are discussed in Per Technical Appendix A – Flora and fauna including:
  - Grassy Eucalypt Woodland of the Victoria Volcanic Plain
  - Matted Flax-lily (*Dianella amoena*)
  - River Swamp Wallaby-grass (*Amphibromus fluitans*)
  - Clover Glycine (*Glycine latobeana*)
  - Swift Parrot (*Lathamus discolour*)
  - Australian Painted Snipe (*Rostratula australis*)
  - Australasian Bittern (*Botaurus poiciloptilus*)
  - Grey-headed Flying-fox (*Pteropus poliocephalus*)
  - Growling Grass Frog (*Litoria raniformis*)
  - Macquarie Perch (*Macquaria australasica*)
  - Australian Grayling (*Prototroctes maraena*)
  - Latham's Snipe (*Gallinago hardwickii*).
- Step 4 of the *Actions on, or impacting upon, Commonwealth land, and actions by* Commonwealth agencies – Significant impact guidelines 1.2 (DSEWPAC, 2013). The remainder of Section 7 summarises these impacts.

5.4.3 Surface water assessment criteria – non-Commonwealth

Table 5-1 sets out the non-Commonwealth assessment criteria used in this assessment.

Table 5-1 Assessment criteria for surface water – non-Commonwealth

Criteria	Legislation and policy	North East Link requirements
Construction		
Flooding	Water Act 1989 (Vic): • By-law No 2: Waterways, Land and Works Protection Management (2009) • Melbourne Water Standards – Infrastructure Projects in Flood-prone Areas (2018) • Guidelines for Development in Flood-prone Areas (Melbourne Water 2008) • Council design standards.	• Maintain existing flood conditions for each receiving drainage or waterway system. • Maintain functional capacity of floodplains.
Water quality	Environment Protection Act 1970 (Vic) • State Environment Protection Policy: Waters of Victoria (1988) • Integrated Water Management Guidelines (VicRoads, 2013) • EPA Victoria Publication 275 (1991), 480 (1996) and 960 (2004)	• No pollution of waterways such that the condition of waterways becomes detrimental to any beneficial use of the waters.

Criteria	Legislation and policy	North East Link requirements
Geomorphology	Water Act 1989 (Vic): • Victorian Waterway Management Strategy (DEPI, 2013a) • Healthy Waterways Strategy (Melbourne Water, 2013) • Constructed Waterways in Urban Developments Guidelines (Melbourne Water, 2009)	• Maintain the existing waterway stability
Water supply	Water for Victoria (Water Plan) (DELWP, 2016) • Integrated Water Management Guidelines (VicRoads, 2013)	• Maintain existing storage and water supply for irrigation.
Operation		
Flooding	Water Act 1989 (Vic): • By-law No 2: Waterways, Land and Works Protection Management (2009) • Melbourne Water Standards – Infrastructure Projects in Flood-prone Areas (2018) • Guidelines for Development in Flood-prone Areas (Melbourne Water, 2008) • Shared Pathways Guidelines (Melbourne Water, 2008) • Council design standards. Climate Change Act 2017 (Vic) Austroads Guide to Road Tunnels (Austroads, 2010)	• Maintain existing flood conditions for each receiving drainage or waterway system. • Maintain function capacity of floodplains. • Flood risk assessment is required for tunnel portal locations. • Consider climate change impacts.
Water quality	Environment Protection Act 1970 (Vic) • State Environment Protection Policy: Waters of Victoria (1988) • Urban Stormwater Best Practice Environmental Management Guidelines (CSIRO, 1999) • Integrated Water Management Guidelines (VicRoads, 2013). Austroads Guide to Road Design Parts 5, 5A and 5B (Austroads, 2013) Climate Change Act 2017	• Meet annual pollutant load reductions in accordance with the Urban Stormwater Best Practice Environmental Management Guidelines (BPEMG) on a project-wide scale. • No pollution of waterways such that the condition of waterways becomes detrimental to any beneficial use of the waters. • Manage the risk of spills on freeway pavements at points of discharge by providing appropriate spill containment. • Consider climate change impacts.

Criteria	Legislation and policy	North East Link requirements
Geomorphology	Water Act 1989 (Vic): • Victorian Waterway Management Strategy (DEPI, 2013a) • Healthy Waterways Strategy (Melbourne Water, 2013) • Constructed Waterways in Urban Developments Guidelines (Melbourne Water, 2009) • Melbourne Water Shared User Path Guidelines. Climate Change Act 2017 (Vic)	• Maintain the existing waterway stability. • Consider climate change impacts.
Water supply	Water for Victoria (Water Plan) (DELWP, 2016): • Integrated Water Management Guidelines (VicRoads, 2013). Climate Change Act 2017 (Vic)	• Maintain existing storage and water supply for irrigation. • Consider climate change impacts.

5.4.4 Construction assessment method

The impact assessment for the construction of North East Link has reviewed the activities that could adversely impact flooding, water quality, geomorphology and water supply within the study area.

Flooding

A qualitative assessment of the potential impacts on flooding during the construction of North East Link has been undertaken. The qualitative assessment has identified activities expected to occur during construction which could adversely impact floodplains and overland flow paths. Impacts on flooding from construction could include obstruction of overland flows, reduction in floodplain storage or changing existing flow conditions downstream of construction sites. Construction activities that could potentially impact floodplains and overland flow paths in the study area are described in Section 7.1.1 and 8.1.2. In exceptional cases where the qualitative assessment indicated that construction activities may have impacts which may be difficult to avoid or mitigate, modelling was undertaken to further inform the assessment.

As a part of Melbourne Water Standards for infrastructure projects in flood-prone areas (refer Appendix A), it is a requirement that temporary construction works are modelled once activities are adequately defined to demonstrate the achievement of Melbourne Water's guiding principles (Appendix A).

Water quality

The assessment of the potential impacts on water quality during the construction of North East Link has been undertaken through a qualitative assessment. The qualitative assessment has identified activities expected to occur during its construction which could adversely impact the water quality of local and receiving waters. Impacts on water quality from construction could include the transportation of pollutants and hazardous materials in stormwater to surface waters. Construction activities identified that could potentially impact water quality in the study area are described in Section 7.1.2 and 8.1.1.

Geomorphology

The assessment of the potential impacts on geomorphic conditions during the construction of North East Link has been undertaken through a qualitative assessment. The qualitative assessment has identified activities expected to occur during construction of the project which could adversely impact erosion and waterway stability. Impacts on waterway stability from construction could include the removal of soil, the changing of soil, and/or temporary diversions altering flow conditions downstream of construction. Construction activities identified that could potentially impact geomorphic conditions in the study area are described in Section 7.1.3 and 8.1.2.

Water supply

The assessment of the potential impacts on water supply during the construction of North East Link has been undertaken through a qualitative assessment. The qualitative assessment has identified activities expected to occur during construction which could adversely impact the water supply of end users. Construction activities identified that could potentially impact water supply in the study area are described in Section 8.1.2.

5.4.5 Operation assessment method

The impact assessment for the operation of North East Link has identified permanent new structures and activities that could potentially impact flooding, water quality, geomorphology and water supply within the study area.

Flooding

The assessment of the potential impacts on flooding during the operation of North East Link has been undertaken through a quantitative assessment. The quantitative assessment has included hydraulic modelling of the proposed design/s using TUFLOW software for Banyule Creek, Koonung Creek and the Yarra River. TUFLOW is a model used to simulate hydraulic behaviours in rivers, floodplains and urban drainage environments to examine potential changes in flood behaviour associated with North East Link.

Modelling of the proposed design/s has been undertaken based on the hydraulic models developed to define the existing conditions (see Section 5.3.2). The proposed design/s has been included in the models to quantify the potential impacts to floodplains and overland flow paths. Modelling has been undertaken in accordance with Melbourne Water requirements for the project (see Table 4-1). Modelling has included the assessment of climate change as per Melbourne Water standards for infrastructure projects in flood-prone areas.

The potential impacts from the operation of North East Link on flooding in the study area are described in Section 7.2.1 and 8.2.2.

Water quality

Additional paved surfaces from new roads and infrastructure associated with the project would increase surface water run-off, with a higher pollutant load which can impact water quality. In addition, North East Link would be located in a metropolitan area with limited land available for retarding basins, wetlands and other drainage features to treat additional surface water run-off. The assessment of the potential impacts on water quality during the operation of North East Link has applied the following methodology:

- A concept drainage strategy was developed to identify where additional paved surfaces would be created due North East Link, and to identify potential locations for retention and treatment of surface water run-off from these additional paved surfaces.

- Modelling was undertaken using MUSIC (developed by eWater) to calculate resulting pollutant loads from the implementation of the proposed treatment locations to determine if these locations provide sufficient space to meet SEPP (Waters of Victoria) and BPEMG objectives for urban stormwater. MUSIC is an industry accepted model in Victoria that enables the representation of surface water pollutant generation and treatment process.

The potential impacts from the operation of North East Link on water quality in the study area are described in more detail in Section 7.2.2 and 8.2.1.

Geomorphology

The assessment of the potential impacts on geomorphic conditions during the operation of North East Link has been undertaken through a qualitative assessment. The qualitative assessment has identified activities expected to occur during the operation of North East Link which could adversely impact waterway stability. Operational activities identified which could potentially impact geomorphic conditions in the study area are described in Section 7.2.3 and 8.2.2.

Water supply

The assessment of the potential impacts on water supply during the operation of North East Link has been undertaken through a qualitative assessment. The qualitative assessment has identified activities expected to occur during the operation of North East Link which could adversely impact the water supply of end users. Operational activities identified which could potentially impact water supply in the study area are described in Section 8.2.2.

5.5 Rationale

5.5.1 Overview

The methodology for the impact assessment has been developed to address the evaluation objectives and key issues within the scoping requirements for North East Link. The range of issues that exist within the scope of surface water for the action has required that different methodologies are adopted for the key aspects of surface water. The rationale for the methodologies adopted is described below:

Flooding – The definition of the existing conditions and impact assessment for flooding has adopted a methodology of hydrologic and hydraulic modelling using industry accepted methods. Hydrologic modelling has been completed using RORB. Hydraulic modelling has been completed using TUFLOW. The modelling approach is generally based on Melbourne Water technical specifications for flood modelling and mapping.

Water quality – The methodology for the definition of the existing conditions for water quality was adopted based on the data availability in the study area. The comparison with SEPP (Waters) water quality objectives (see Section 4.2) was considered an appropriate methodology to determine the existing water quality conditions in the study area.

The methodology for the impact assessment for water quality for the construction of North East Link was adopted based on the scope of water quality issues identified which could adversely impact the water quality of local and receiving waters during construction. A qualitative assessment was considered appropriate for this phase of the action.

The methodology for the impact assessment for water quality for the operation of North East Link was modelling using MUSIC software. The results were assessed against BPEMG (CSIRO, 1999). These treatment objectives as summarised in Table 4-3 were met or exceeded by the selection of treatment opportunities assessed. Although the final treatment arrangements

are likely to vary from those currently assessed, this analysis confirms that the objectives can be realistically met.

Geomorphology: The methodology for the impact assessment was chosen by considering how to adequately characterise the geomorphic conditions with the potential to affect bed and bank stability from the available information. A qualitative assessment was considered appropriate for this phase of the action.

Water supply – The methodology for the assessment for water supply impact was adopted based on the scope of the water supply issues. The approach of a qualitative assessment was considered appropriate for this phase of the action.

5.5.2 Use of Australian Rainfall and Runoff (ARR) Guidelines

Background to the new version

Australian Rainfall and Runoff (ARR) is the industry-recognised guideline for undertaking hydrologic investigations in Australia. For the last 30 years these investigations have adopted methodologies from the 1987 version (last updated in 1997). Around 10 years ago, Engineers Australia commenced a project to update ARR to reflect the additional data and new technologies and science available. Over $15 million has been invested in developing a new guideline for use in Australia. This includes $4 million from the Department of Climate Change and Energy Efficiency (DCCEE), $3 million from the Bureau of Meteorology (BoM), $5.15 million from Geoscience Australia (GA) and $3.5 million from Engineers Australia (EA) and its members.

ARR 2016 was released as a draft for industry comment in November 2016 by Geoscience Australia. The data and methodologies in ARR 2016 are very different to those in ARR 1987 (Pilgrim, DH & Institution of Engineers, Australia 1987). It benefits from a more extensive database of additional rainfall stations and more than 30 years of additional data, analysed with more rigorous methodologies, as well as a greater awareness of uncertainty and variability. The defined methodologies of ARR 1987 for calculating specific flow estimates from a catchment have been largely replaced with more rigorous and computationally intensive methodologies to produce distributions of results which can be analysed and interpreted. Experience to date suggests that while the results will typically vary as a result of applying the new data and methodologies, they are often in fairly good agreement.

At present, ARR 2016 is:

- Still a draft for industry consultation with all sections described as ‘Advanced Draft’ or ‘Working Draft’, noting that ARR 2016 states that *‘where relevant this draft of ARR can be used in practice prior to finalisation’* (<http://book.arr.org.au.s3-website-ap-southeast-2.amazonaws.com/>, accessed 20 June 2018). Updates are progressing, ‘Book 9 – Runoff in Urban Areas’ was updated to ‘Final Draft’ status on the 4 December 2018. (http://www.arr-software.org/arr_pdfs/ARR_Book9_FinalDraft181204.pdf>, accessed on 21 January 2019).
- Still expected to change. In a December 2017 update it was noted that industry feedback is being progressively addressed and that *“A new version of ARR will be released in the first quarter of 2018 with the identified errors corrected”* (<http://arr.ga.gov.au/news>, accessed on 20/6/18). This new release has not yet occurred nor has there been any formal notification of known errors.
- Not readily used with existing models and results – for instance, ARR 2016 includes a disclaimer *‘care should be taken when combining inputs derived using ARR 1987 and methods described in this document’*. Similar statements are also made by the Bureau of Meteorology.

ARR 2016 is significantly different to ARR 1987 and includes processes and philosophies which are in many ways improvements, although many aspects are still being trialled with techniques and understanding still being developed. Industry is thus yet to fully adopt ARR 2016 although this will progressively change.

Application to North East Link

The 1987 version of ARR (Pilgrim, DH & Institution of Engineers, Australia 1987), as last updated in 1997, has been adopted for the PER assessment and as the basis of the reference design. In 2017 shortly after the project commenced, Melbourne Water advised that NELP should proceed on the basis of using ARR 1987. Given this advice from Melbourne Water, the characteristics of North East Link, and the limited experience with and draft status of ARR 2016, the use of ARR 1987 for this PER is considered appropriate.

However, in the near future it is expected that further experience with and updates to ARR 2016 will see its widespread adoption as the dominant guideline, superseding ARR 1987. Accordingly, it is important to investigate the potential implications of ARR 2016. A sensitivity analysis to better understand the implications of ARR 2016 is underway. Some preliminary results of this sensitivity analysis are provided in Appendix E.

Sensitivity testing of the significance of the two guidelines indicates that:

- Estimates of afflux are not significantly affected by the choice of either guideline.
- For ungauged catchments the choice of guideline may affect the estimates of absolute design levels. On this project this is primarily of significance with respect to the tunnel portals:
  - For the northern portal, the flows are generally small enough that the barriers protecting the portals would be higher than needed for the Probable Maximum Flood for other reasons such as excluding pedestrian, cars and bicycles. This same relatively high barrier to flood level height generally also applies to the adjacent northern sections of the open cut sections.
  - For the southern portal, the levels are based on a hydrologic model which has been conservatively adjusted to match historic flood levels and so is not dependent on the choice of ARR guideline.

The above findings indicate the analysis undertaken for the PER is relatively insensitive to the choice of ARR guidelines at least with respect to flooding and cross drainage. There may be implications with respect to water sensitive urban design (WSUD) and longitudinal road drainage, but ARR 2016 is rather limited in its coverage of these aspects. Given the above considerations, the adopted analysis based on ARR 1987 with consideration of climate change in accordance with ARR 2016 recommendations is considered appropriate.

5.6 Assumptions

The following assumptions, limitations and uncertainties apply to the study:

- Although some sensitivity analysis is ongoing, the conclusions and in particular the project-specific requirements are well supported by the completed assessments
- Climate change assessments have been undertaken in accordance with Melbourne Water Standards for infrastructure projects in flood-prone areas
- Hydrologic modelling of all events is based on methods and data outlined in ARR 1987 and existing models except as noted otherwise

- Any use which a third party makes of this document, or any reliance on or decision to be made based on this document, is the responsibility of such third parties. Neither NELP nor GHD accept responsibility for damages, if any, suffered by any third party as a result of decisions or actions made based on this document
- Where information or data has been supplied by NELP other external sources including Melbourne Water, the information has been assumed correct and accurate unless stated otherwise. No responsibility is accepted for incorrect or inaccurate information supplied by other sources.

The following limitations apply to the modelling:

- Modelling results are suitable for informing the PER process and would be subject to further checking, revision and interpretation during subsequent design stages
- The modelling produces results with many significant figures; the precision of these results should not be taken as an indication of their accuracy
- The modelling is generally more reliable in producing comparisons between existing and proposed conditions and less reliable in producing absolute levels
- It should be noted that all models are simplified representations of reality. The following partial extract, from ARR Revision Project 15: Two Dimensional Modelling in Urban and Rural Floodplains (November 2012) summarises as fundamental advice:
  - All models are coarse simplifications of very complex processes. No model can therefore be perfect, and no model can represent all of the important processes accurately
  - Model accuracy and reliability will always be limited by the accuracy of the terrain and other input data
  - Model accuracy and reliability will always be limited by the reliability/uncertainty of the inflow data
  - A poorly constructed model can usually be calibrated to the observed data but will perform poorly in events both larger and smaller than the calibration data set
  - No model is ‘correct’ therefore the results require interpretation
  - A model developed for a specific purpose is probably unsuitable for another purpose without modification, adjustment, and recalibration. The responsibility must always remain with the modeller to determine whether the model is suitable for a given problem (task).

5.7 Stakeholder engagement

Stakeholders and the community were consulted to support the preparation of the North East Link EES and PER and to inform the development of the project and understanding of potential impacts. Table 5-2 lists specific engagement activities that have occurred in relation to surface water, with more general engagement activities occurring at all stages of the project. For further detail relating to submissions received on the draft PER and associated responses, refer to PER Attachment VIII – Submissions report.

Table 5-2 Stakeholder engagement undertaken for surface water

Activity	When	Matters discussed	Outcome
Presentation to Melbourne Water	31 August 2017	Yarra River Strategic Plan	Melbourne Water provided an overview of its approach to the development of the Yarra River Strategic Plan
Presentation to Melbourne Water	29 March 2018	Project overview	A wide range of Melbourne Water teams were briefed on North East Link
Meeting with Melbourne Water	3 July 2018	Yarra River Strategic Plan	Shared and confirmed understanding
Regular meetings with Melbourne Water	Ongoing	Hydrological and hydraulic modelling	Ongoing discussions to confirm that surface water modelling for North East Link is being undertaken to Melbourne Water requirements
Correspondence with EPA Victoria	16 January 2018	Design standards for spill containment on freeways	EPA Victoria confirmed this is a matter for VicRoads
Meeting with Manningham City Council	03 May 2018	Project overview	Exchange of relevant information to support surface water assessment and assist with further design development
Meeting with Boroondara City Council	26 July 2018	Project overview	Exchange of relevant information to support surface water assessment and assist with further design development
Meeting with Whitehorse City Council	4 June 2018	Project overview	Exchange of relevant information to support surface water assessment and assist with further design development
Meeting with Banyule City Council	4 July 2018	Project overview	Exchange of relevant information to support surface water assessment and assist with further design development
Trinity Grammar School Sporting Complex – site visit with Property Manager	20 February 2018	Dam for the irrigation of sporting ovals	Understanding of the operation of the dam and its connection to the Yarra River floodplain. Stormwater management within the complex
Parks Victoria	15 October 2018	Project overview	Improved understanding of project and respective requirements
Wurundjeri	14 November 2018	Project overview	Improved understanding of project and respective requirements

6. Description of the environment

This report describes the surface water resources that may support MNES and provides an assessment of potential surface water-related impacts. It focuses on the key waterways that may result in impacts on Commonwealth land and on the listed threatened species and ecological communities and migratory species (or their habitat) dependent on these water resources, which have been identified in PER Technical Appendix A – Flora and fauna.

North East Link would intersect with a number of waterways as shown in Figure 6-3. These include Banyule Creek, Koonung Creek and the Yarra River. Existing conditions have been defined for each of these waterways with respect to flooding, water quality, geomorphology and water supply. The importance and methodology of defining the existing conditions for these aspects of North East Link is detailed in Section 5.3.

6.1 Summary of key water features

North East Link would be located within a predominantly urban section of the Yarra River catchment. It would include twin tunnels beneath the Yarra River and the widening of the Eastern Freeway bridge over the Yarra River. Tributaries of the Yarra River that would intersect with the project include Banyule Creek and Koonung Creek, as shown in Figure 6-3.

Other tributaries of the Yarra River in this area would be not impacted by the project. These include Merri Creek, Plenty River, Glass Creek and Bushy Creek. These waterways are not discussed further.

The North East Link alignment would intersect with a number of floodplains and overland flow paths. The surface water study area is shown in Figure 6-3 and includes:

- Banyule Creek starts as an ephemeral waterway within Simpson Barracks and flows south to the Yarra River. The project area overlays the current creek alignment from its beginning at the barracks to Lower Plenty Road (adjacent to Greensborough Road). Banyule Creek was included in the assessment as North East Link would require diversion of the existing creek and connecting drains to accommodate the alignment to the north of Lower Plenty Road. A detailed description of the existing conditions of Banyule Creek is provided in Section 6.2.
- The Yarra River is a major waterway with a catchment area of approximately 4,000 square kilometres. The Yarra River and its floodplain was included in the assessment due to proposed elements of North East Link including:
  - A new interchange at Manningham Road comprising open cut, cut and cover and mined tunnel sections
  - A tunnel portal and associated ventilation structure located south of the Veneto Club in Bulleen
  - Surface road and elevated ramps connecting to the Eastern Freeway via a new interchange
  - A description of the existing conditions of the Yarra River is provided in Section 6.3.
- Koonung Creek is a heavily modified creek which runs generally parallel to the Eastern Freeway from Springvale Road, to its outfall into the Yarra River downstream of Bulleen Road. Koonung Creek was included in the assessment as the project would require the realignment of sections of the creek, and extensions of undergrounded sections of the creek in culverts. A description of the existing conditions of Koonung Creek is provided in Section 6.4.

As North East Link would include new sections of road, this means the overall pavement area would increase. This was included in the assessment, as additional impervious area can impact the flow conditions and water quality of receiving waters.

Other drains near North East Link but not directly affected by its construction include Kew Mental Hospital Main Drain 4711, Kew Main Drain 4712 and Glass Creek Main Drain 4720. Peak flood levels for these drains in the lower reaches near the Eastern Freeway are dominated by Yarra River flood levels which inundate parts of the Eastern Freeway. It is unlikely, even considering the potential for blockage, that a local event on any of these catchments would result in overtopping of the Eastern Freeway, so the local catchment flooding for these catchments has not been modelled as part of this PER. The potential of impacts on flooding from local catchments have been considered in developing the mitigation measures (refer to Section 10) and modelled where appropriate (such as some tributaries to Koonung Creek).

Surface water bodies which would be impacted by North East Link include the irrigation storage at Trinity Grammar School Sporting Complex and a number of wetlands along Koonung Creek. A number of other water bodies in the area including Banyule Swamp, Banyule Billabong and Bolin Bolin Billabong would unlikely be affected.

The surface water assessment has evaluated the potential impacts due to construction and operation of North East Link within this study area.

This report focuses on the assessment of potential impacts from the project interacting with waterways, overland flow paths and drainage alignments.

6.2 Banyule Creek

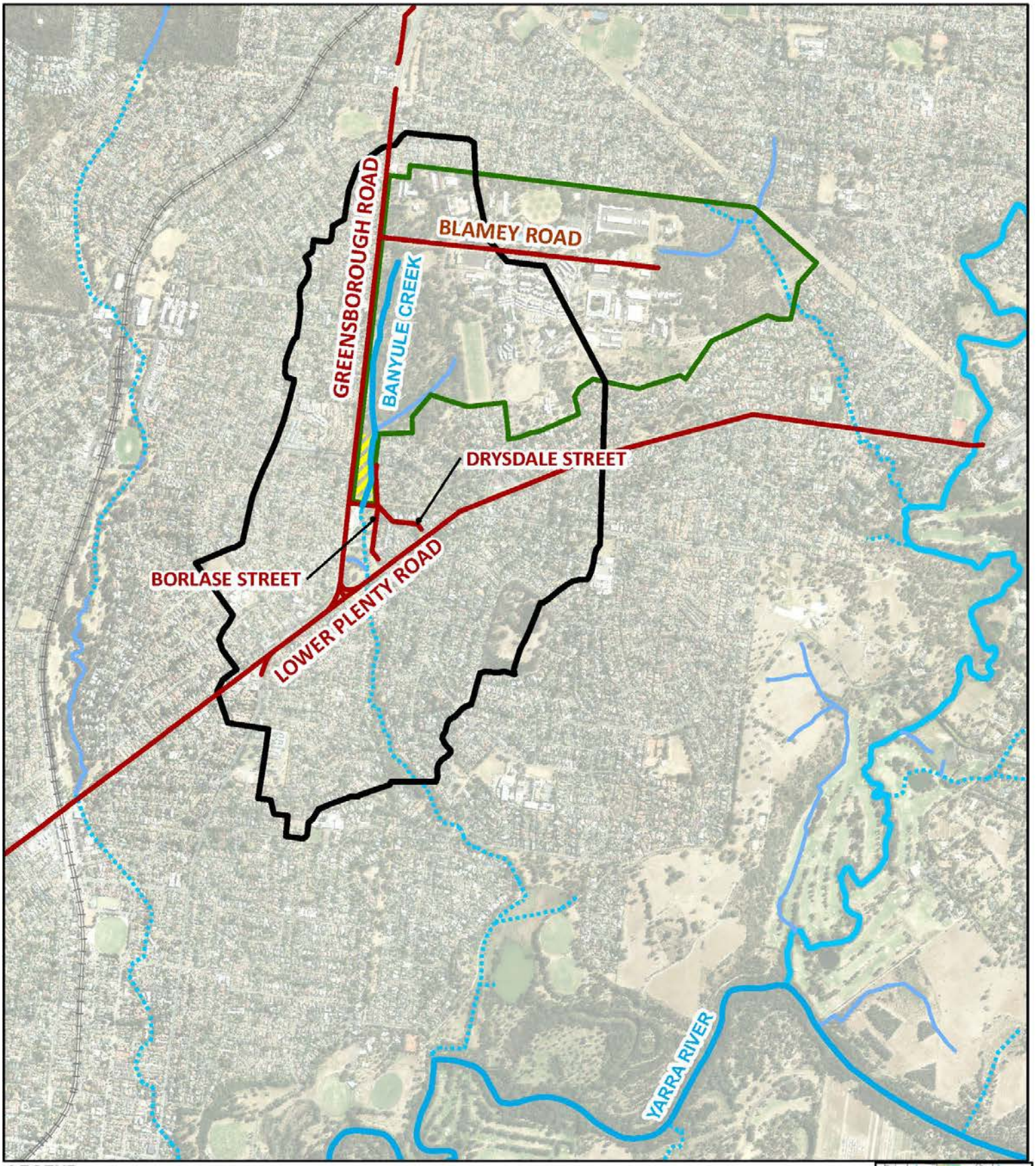
North East Link has the potential to result in surface water impacts along Banyule Creek. These local surface water impacts could occur on Commonwealth land from project activities, or on downstream areas resulting from project activities on Commonwealth land. Without adequate mitigation, there could be limited potential for surface water impacts to affect MNES. Banyule Creek (and the Banyule Drain Main Drain) discharge to the Plenty River, and subsequently to the Yarra River and then Port Philip Bay.

The Friends of Banyule describe Banyule Creek as ‘a small watercourse, with a catchment area of only four square kilometres. Banyule Creek rises in the area of the Simpson Army Barracks just north of Viewbank’ (Friends of Banyule, 2017). The flow regime upstream of Lower Plenty Road Banyule Creek is an ephemeral stream, with no permanent baseflow.

From Simpson Barracks, the creek flows south and outfalls into the Yarra River. The creek is approximately four kilometres long. The extent of Banyule Creek is shown in Figure 6-1.

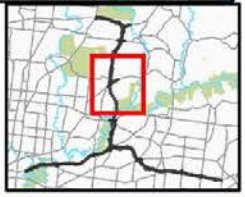
The majority of the catchment is urbanised with the exception of Simpson Barracks, which lies partly within the north-eastern corner of the catchment and is largely vegetated open space. The catchment also includes some other open space areas. The proportion of urbanisation within a catchment influences the volume of stormwater runoff and therefore the volume of surface water flow generated. Additionally, the proportion of urbanisation impacts the amount of contaminants being discharged to waterways.

From Blamey Road, the creek runs parallel to Greensborough Road through Simpson Barracks to an open reserve north of Drysdale Street. At Drysdale Street the creek crosses under the road in a single 0.6-metre diameter circular culvert. In larger storm events, stormwater would flow over the road. The open reserve continues downstream. At Lower Plenty Road the creek crosses under the road in two 1.6-metre diameter circular culverts. South of Lower Plenty Road the creek continues through an open reserve backing onto residential properties until it flows into the open space within Banyule Flats. The creek then continues through Banyule Flats and outfalls into the Yarra River.



LEGEND

- Hydraulic Model Boundary
- Roads of interest
- Simpson Barracks Boundary
- Publicly accessible Commonwealth land south of Simpson Barracks
- River
- Stream
- Channel
- Drain



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Map Projection: Transverse Mercator
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Overview
Banyule Creek

Figure 6-1

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

6.2.1 Commonwealth land environment

The Commonwealth land that would be affected by North East Link is located along Banyule Creek and includes the western side of Simpson Barracks and also a publicly accessible reserve immediately to the south. Any surface water impacts of these works on and immediately adjacent to this Commonwealth land may in the absence of appropriate mitigation extend to downstream receiving waters, including the lower reaches of Banyule Creek and the Yarra River.

6.2.2 Flooding

Detailed hydrologic and hydraulic modelling has been undertaken for Banyule Creek to understand the behaviour of the current flooding. The 1% AEP (1 in 100 year) flood depths for Banyule Creek are shown in Figure 6-2. At Simpson Barracks, the depth of flooding is generally less than 0.5 metres, aside from some isolated locations which are estimated to have depths up to one metre in a 1% AEP event. The elevation of Greensborough Road is higher than the surrounding properties, which results in stormwater flowing south along the western side of the road.

Within the publicly accessible Commonwealth land south of Simpson Barracks and Drysdale Street, Banyule Creek deepens and becomes more confined. Flood depths greater than two metres are estimated in a 1% AEP event. Due to the limited capacity of the council network near Drysdale Street, the 1% AEP flood extent expands onto and over Borlase Street and inundates private property. Stormwater crosses Drysdale Street with a depth of 0.5 metres.

From Drysdale Street to Lower Plenty Road the 1% AEP flood extent is confined to Borlase Reserve. The creek then flows beneath Lower Plenty Road in two 1.6-metre diameter circular culverts. The flow in these culverts is shown in Table 6-1.

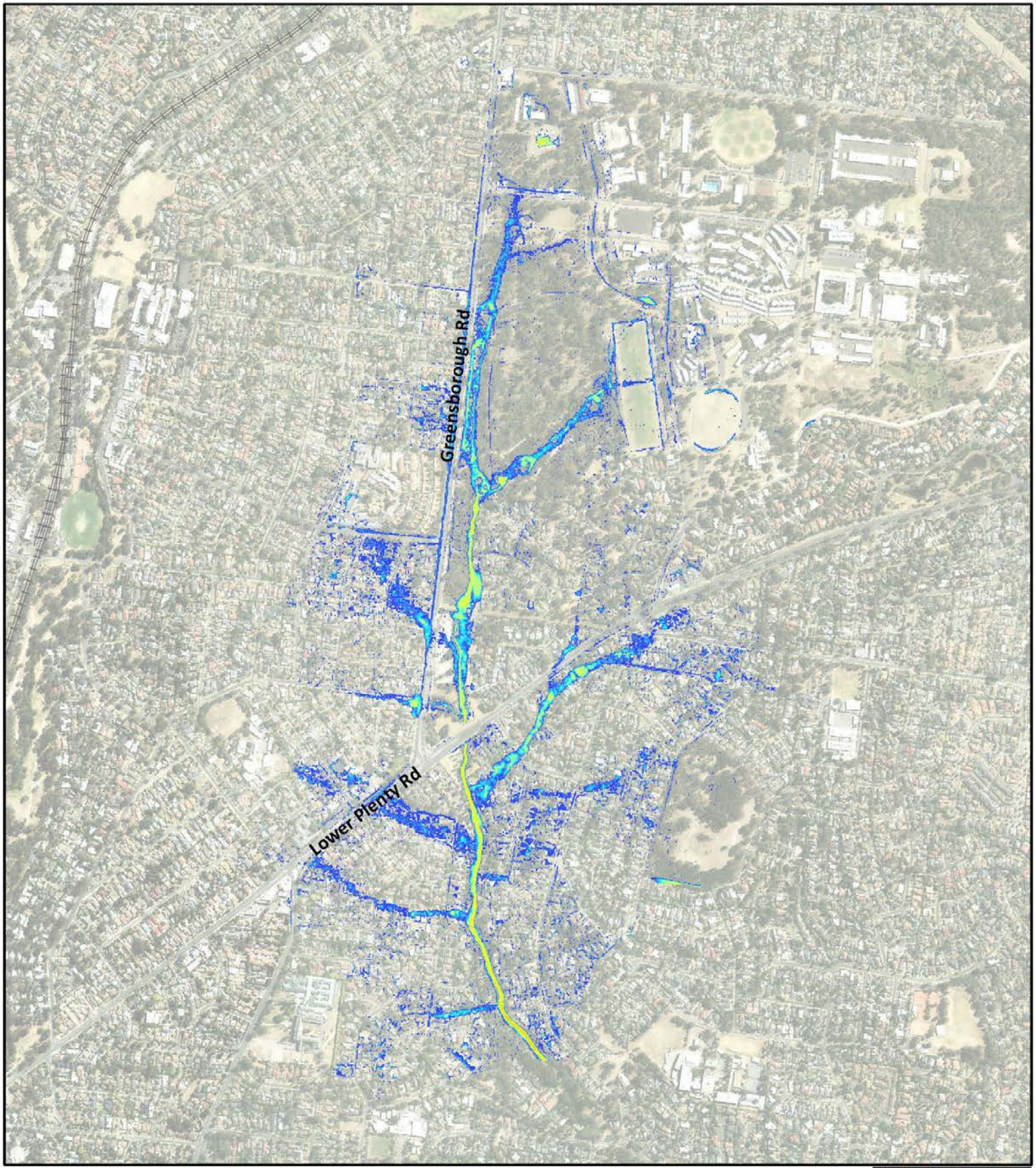
Table 6-1 Banyule Creek flows in culverts under Lower Plenty Road

AEP (%)	Flow (m^3/s)
10%	2.9
5%	4.4
2%	6.8
1%	9.3
1% climate change	12.1
0.2%	15.2
PMP	18.4

Downstream of Lower Plenty Road, the estimated flow is mainly confined to the creek reserve with depths of up to two metres.

The timing of the peak flow and water level influences the nature of the flooding within a catchment. Due to the short reach lengths and steep nature of the catchment, flash flooding occurs within Banyule Creek, with the peak flow and or water level typically occurring within one to two hours of rain starting.

Flood level results for a wider range of design events at selected locations are provided in Appendix C (C1).



Peak Flood Depth (m)

<0.05	0.16 - 0.20	0.51 - 1.20	8.01 - 12.00
0.05 - 0.10	0.21 - 0.25	1.21 - 2.00	12.01 - 18.00
0.11 - 0.15	0.26 - 0.30	2.01 - 4.00	
	0.31 - 0.50	4.01 - 8.00	

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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1% AEP peak flood depth Banyule Creek

Figure 6-2

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

6.2.3 Water quality

To determine the current water quality of Banyule Creek, data was obtained from three monitoring stations (Waterwatch, 2018):

- Wetland one at Banyule Creek headwaters, Simpson Barracks, Watsonia (Site ID: ME_YBA006), 13 readings, recorded April 2007 through October 2008
- Banyule Creek headwaters at Simpson barracks, Watsonia (Site ID: ME_YBA005), 24 readings, recorded April 2007 through November 2008
- Banyule Creek at footbridge, Banyule Flats Reserve (Site ID: ME_YBA500), 44 readings, recorded June 2006 through July 2012.

The water quality results are summarised in Table 6-2.

Table 6-2 Water quality monitoring results for Banyule Creek (Waterwatch, 2018)

Parameter	SEPP (Waters) Objective	ME_YBA006	ME_YBA005	ME_YBA500
Dissolved oxygen (% saturation) (25th percentile)	≥70%	71.7*	52.6*	53.4*
Dissolved oxygen (% saturation) (maximum)	≤110%	76.8*	97.0*	91.7*
Electrical conductivity at 25°C (75th percentile)	≤500 µS/cm	100.0	370.0	750
pH (25th percentile)	≥6.4	7.6	7.5	7.4
pH (75th percentile)	≤7.9	7.8	8.2	7.9
Turbidity (75th percentile)	≤35 NTU	30	40	13
Total nitrogen (75th percentile)	≤1300 µg/l	No recorded data	No recorded data	No recorded data
Total phosphorous (75th percentile)	≤110 µg/l	No recorded data	No recorded data	No recorded data

Table notes: Red numbers do not meet SEPP (Waters) objective

* Waterwatch samples recorded dissolved oxygen in mg/L and were converted to percentage saturation to compare with the SEPP (Waters) objectives.

Water quality at Banyule Creek was assessed against the SEPP(Waters) objectives which seek to protect beneficial uses of waterways. Table 6-2 shows that, from the data available, dissolved oxygen (25th percentile), pH (75th percentile) and turbidity samples exceed SEPP (Waters) objectives at monitoring sites within the investigation area along Banyule Creek. This indicates that water quality in some aspects is worse than the objectives set out in the SEPP (Waters). It is recognised this water quality data only covers the period from 2006 to 2012. These results highlight the trend that electrical conductivity, an indicator of salinity, increases from upstream to downstream.

Banyule Creek is a minor urban tributary of the Yarra River and is not gauged, so no flow data is available.

6.2.4 Geomorphology

The existing geomorphic conditions for river waterway stability within Banyule Creek have been appraised through observations made during site visits. For the purpose of the PER, the distinct reaches of Banyule Creek potentially impacted by North East Link are described in Table 6-3.

Table 6-3 Overview of Banyule Creek existing conditions

Reach	Description)
Simpson Barracks	Low flow channel formation as a small incision within the relatively steep (>1:40) natural valley depression within the confined floodplain. Along the reach there are a number of local drainage connections from the east and west sides of the catchment. The stream form changes to a more defined creek channel where the bed profile locally steepens near the Simpson Barracks boundary, where the channel combines with the tributary flow path from the east.
Simpson Barracks boundary to Drysdale Road	The channel profile flattens (<1:100) and becomes heavily choked with cumbungi reeds, and the surrounding floodplain also heavily vegetated with mature gum trees and understorey. The Drysdale Road culvert is a hydraulic restriction that may be influencing the characteristics of this reach.
Drysdale Road to Lower Plenty Road	Immediately downstream of Drysdale Road within Borlase Reserve the channel profile steepens (>1:50), and becomes more uniform and straightened. The surrounding floodplain becomes predominately-grass (maintained) with scattered mature trees. There are local signs of bank erosion with some placement of large edge rock observed.
Lower Plenty Road to Banyule Swamp Reserve	The formed channel downstream of Plenty Road becomes further incised within the more confined Banyule Creek corridor reserve located through the residential surrounds. The reach includes occasional bed incisions and local bank erosion with some limited and ad-hoc placement of rock protection works, as well as other locations of high energy where local drainage outfalls enter the creek channel.

Banyule Creek at Simpson Barracks effectively commences as a surface flow path immediately downstream of the culvert under Blamey Road. The top of the catchment appears to align with Yallambie Road and there is no defined flow path until downstream of Blamey Road. It is unclear as to the extent of piped network (if any) that discharges via this culvert.

The flow path downstream of Blamey Road has formed a small incised channel through the vegetated depression (typically 100 to 200 millimetres wide, 300 millimetres deep) with localised deeper and wider sections along the reach.

There are a number of overland flow paths and piped connections from the east from the urbanised catchments at Simpson Barracks. From the west there are several local council drainage catchments that discharge under Greensborough Road into the Simpson Barracks site into a formed channel drain that connects to Banyule Creek towards the southern end of the site.

The open drain is steeply graded and attempts at placing erosion control and check dams have suffered damage with evidence of outflanking. Banyule Creek then becomes a larger capacity channel joined by the tributary flow path from the east, fed by the catchments at Simpson Barracks as well as some of the surrounding residential catchments. At the site boundary (immediately downstream of the confluence with the tributary), the channel is intersected by a cyclone fence with a grill extending to the base of the channel for security. This would become an obstruction to flow during large events. This is evident from the localised erosion where turbulent flows have crossed the boundary.

The channel immediately downstream of the site boundary within the publicly accessible Commonwealth land south of Simpson Barracks, is a heavily vegetated channel with an approximate bed width of between one and two metres. The waterway in this area is relatively stable and protected with vegetation/grass. Between Drysdale Street and Lower Plenty Road the creek has cut downward through its bed (incised). Rock armouring is an erosion mitigation measure that has been used along much of Banyule Creek in this region. Bed incision is evident around some of the rock armouring and has the potential to undermine the erosion protection works.

South of Lower Plenty Road there is evidence of significant waterway stability issues including bank erosion, bank undercutting, localised scour pools and channel deepening. An exposed vertical bank between two to three metres high exists immediately downstream of Lower Plenty Road. The erosion identified at this location of Banyule Creek has the potential to lead to land instability. Further downstream, between Lower Plenty Road and Banyule Flats, erosion is already adversely affecting drainage infrastructure and river health.

6.3 Yarra River

While North East Link has the potential to result in surface water impacts within the Yarra River floodplain, it is unlikely these could have a measurable impact on MNES such as Australian Grayling, and certainly not on or from Commonwealth land.

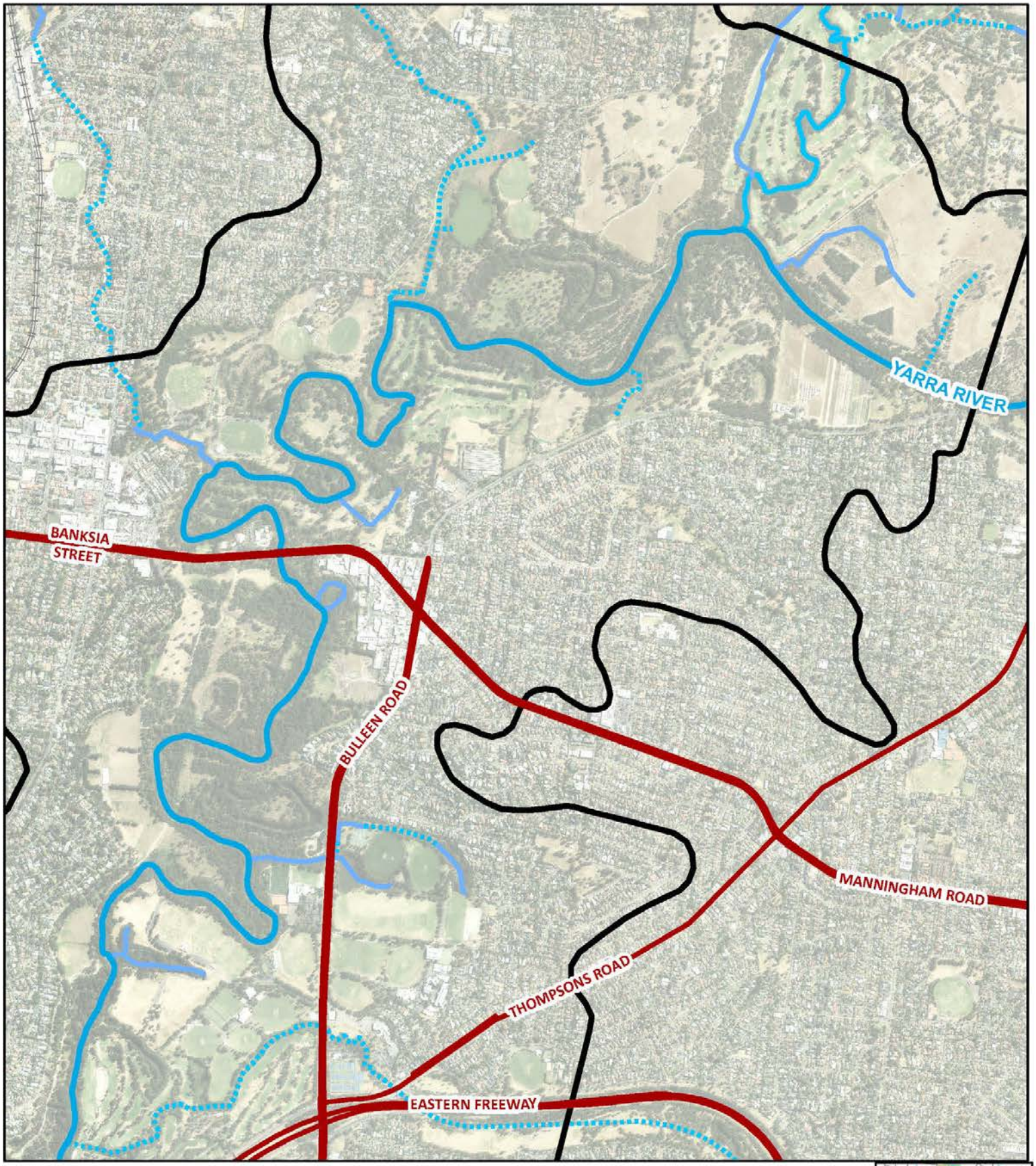
Melbourne Water describes the Yarra River as follows (Melbourne Water and Port Phillip Westernport Catchment Management Authority, 2007):

> *'The Yarra catchment lies north and east of Melbourne, beginning on the southern slopes of the Great Dividing Range in the forested Yarra Ranges National Park. Around two million people, over one-third of Victoria's population, live in the catchment, which has an area approximately 4,000 square kilometres.*
>
> *The upper reaches of the Yarra River and its major tributaries flow through forested, mountainous areas, which have been reserved for water supply purposes for more than 100 years. Around 70% of Melbourne's drinking water comes from these pristine upper reaches. Most of the land along rivers and creeks in the middle and lower sections has been cleared for agriculture or urban development'.*

The section of the Yarra River which has been investigated is shown in Figure 6-3. Most of the flow through this area originates upstream in the Yarra River catchment.

The Yarra River catchment consists of various land uses along its length, including forested, agricultural and urban development. The land use within the catchment impacts the volume of surface water runoff and volume and type of water quality contaminants. As shown in Figure 6-3 the Yarra River floodplain is extensive and comprises a number of land uses including but not limited to public recreation, conservation and special use zones such as golf courses. Between Banksia Street and Chandler Highway the floodplain is generally well vegetated.

Within the study area, there are three bridge crossings of the Yarra River: Manningham Road West, Burke Road and Chandler Highway.



LEGEND

- Hydraulic Model Boundary
- Roads of interest
- River
- Stream
- Channel
- Drain

Paper Size A4

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Map Projection: Transverse Mercator
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Overview
Yarra River 1 of 3

Figure 6-3a

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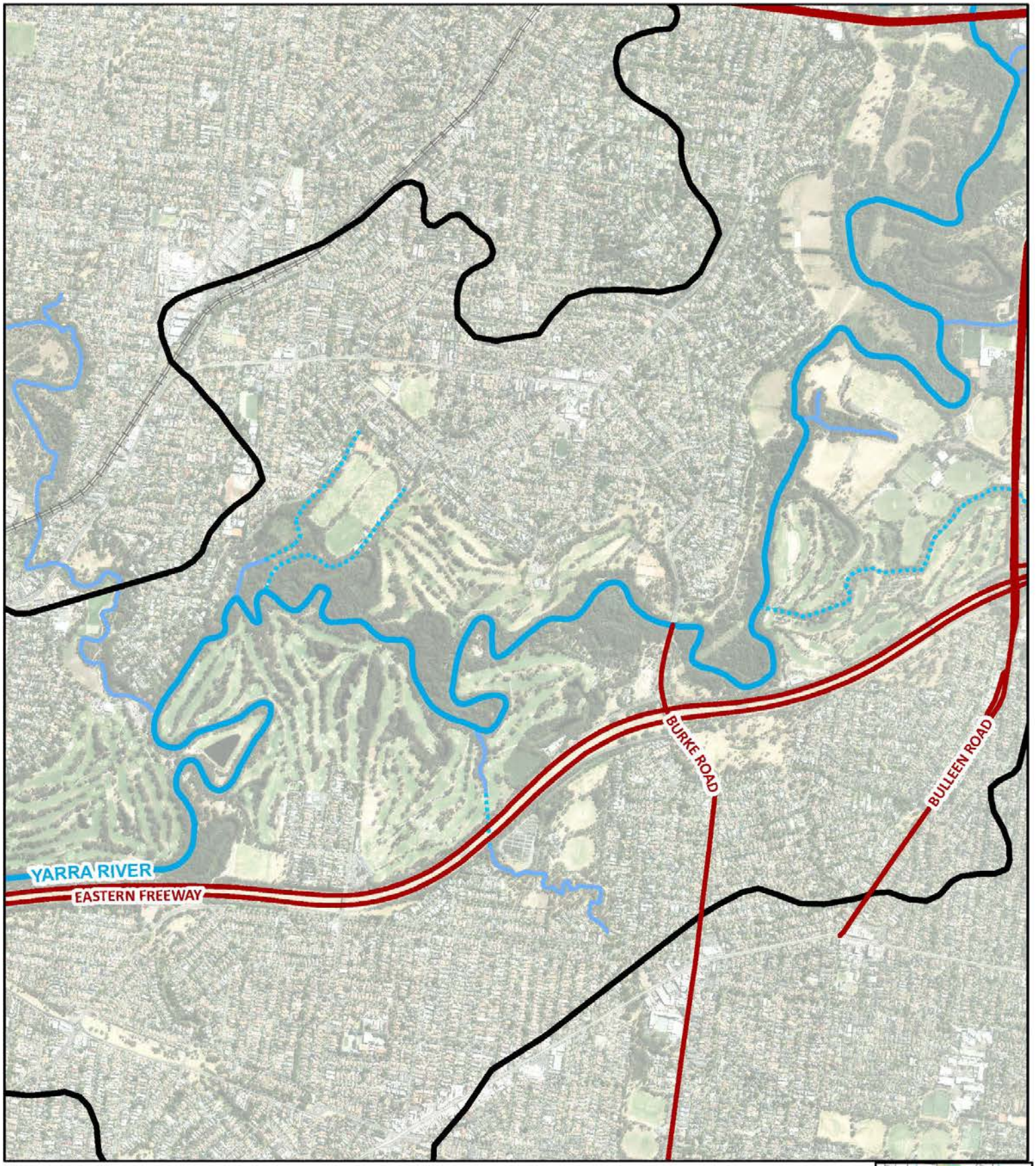

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- Hydraulic Model Boundary
- Roads of interest
- River
- Stream
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Grid: GDA 1994 MGA Zone 55

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Overview
Yarra River 2 of 3

Figure 6-3b

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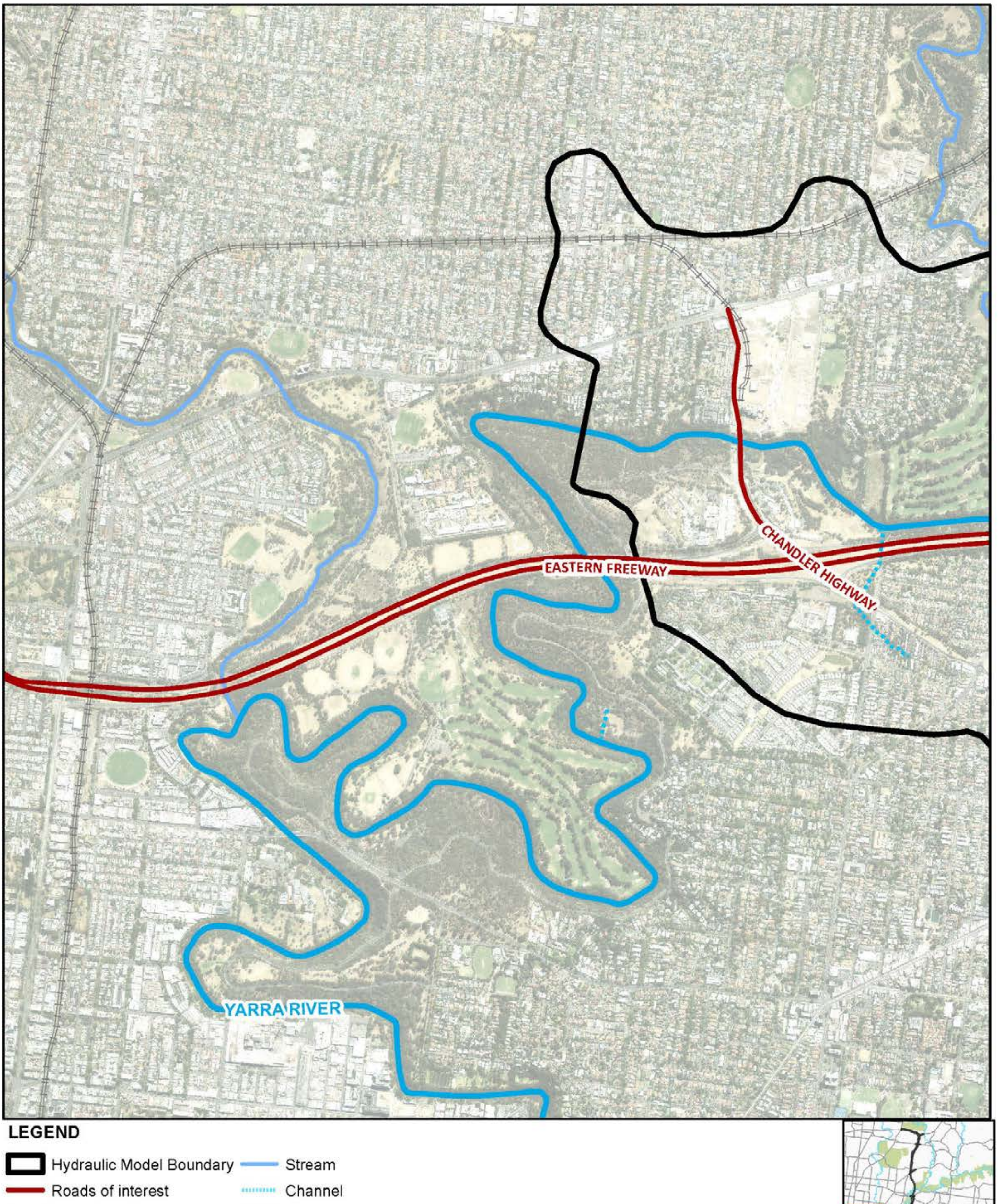

LEGEND

- Hydraulic Model Boundary
- Roads of interest
- River
- Stream
- Channel
- Drain

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

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Date 19/10/2018

Overview
Yarra River 3 of 3

Figure 6-3c

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

6.3.1 Flooding

Modelled existing peak 1% AEP flood depths are shown in Figure 6-4, Figure 6-5 and Figure 6-6. The 1% AEP flood extent covers an extensive area utilised for public open space and recreational facilities as well as some areas of private residential, commercial and industrial properties along the fringes of the floodplain.

The road on both sides of the Manningham Road West Bridge is overtopped in a 1% AEP event by a depth of up to two metres. Bulleen Road between the Trinity Grammar School Sporting Complex and the Eastern Freeway is overtopped by up to six metres of floodwater in the 1% AEP event. The Eastern Freeway is inundated to the west of Burke Road and east of the Chandler Highway.

In a 1% AEP event, flows in the Yarra River at Banksia Street are in the order of 1200 cubic metres per second, as shown in Table 6-4. Between Birrarrung Park and the Chandler Highway, the floodplain provides a significant amount of flood storage and as a result water surface elevations across the floodplain are relatively consistent. Flow from the Chandler Basin is controlled by a relatively confined section of the Yarra River at and downstream of the Chandler Highway.

Table 6-4 Yarra River existing condition results

AEP (%)	Flow at Banksia Street (m^3/s)	Flood levels at industrial park near Manningham Road (mAHD)
1%	1,220	18.43
1% climate change	1,480	19.75
0.5%	1,410	19.38
0.5% climate change	1,720	20.93
0.2%	1,700	20.84
0.2% climate change	2,080	22.62
0.1%	1,950	22.05
0.1% climate change	2,410	23.78
0.05%	2,230	23.24
0.05% climate change	2,780	24.66
PMP	12,070	34.51

The timing of the peak flow and water level influences the nature of the flooding within a catchment. Due to the size of the Yarra River catchment upstream of the study area, the peak flows occur several days following the rain falling in the upper catchment. Smaller local rainfall events may cause local flooding within the catchment however would not typically result in widespread flooding.

Flooding of the billabongs, wetlands and swamps within the Yarra River floodplain provides a mechanism for topping up the levels of many of these surface water bodies including Bolin Bolin Billabong, Banyule Flats and Banyule Swamp. Although the water level in many of these features is variable, some of these standing waterbodies are occasionally topped up with water extracted from the Yarra River.

6.3.2 ARR 2016 sensitivity

The designated 1% AEP Yarra River flood levels adopted by Melbourne Water are based on a range of recorded historic flood levels from the 1934 flood. The hydrologic model and to a lesser extent the hydraulic model adopted for this PER are adjusted to match these designated levels.

A hydrologic analysis of the Yarra River was undertaken using ARR 2016 (Geoscience Australia, 2016) methodologies and data. Even when very low loss values were adopted it predicted lower flood levels within the Chandler Basin.

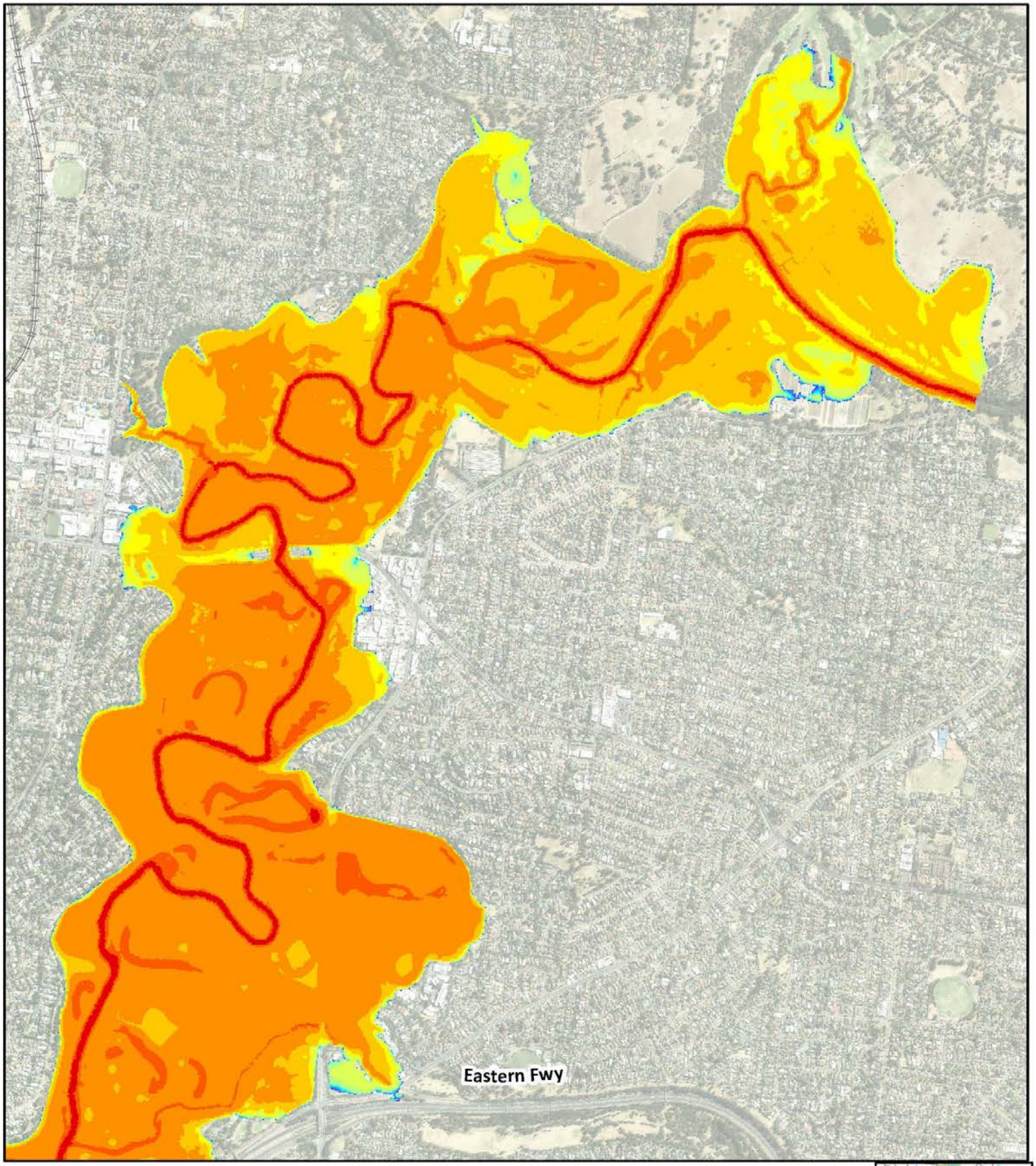
For comparison, a hydrologic analysis of the Yarra River using pre ARR 2016 methodologies for ungauged catchments was also undertaken and results were also lower than those of the models which have been adjusted to match the designated levels and adopted for this PER assessment.

A summary of some comparison hydrographs and long sections is provided in Appendix E.

The apparent discrepancy is likely to be due to a number of significant differences and affected by numerous less significant differences. Reasons for this variation may include:

- Limited hydrologic data for long duration events particularly in the southern states
- Data inaccuracy, potentially in recorded flood levels, hydrologic data and numerous other parameters
- Perhaps the 1934 event was bigger than a 1% AEP event.

These results perhaps indicate the designated flood levels and subsequently, perhaps some of the design levels for North East Link may be conservatively high. However, the designated levels are based on the largest flood on record, and in the absence of new information to the contrary, would generally be considered more reliable than a parameter based hydrologic model regardless of whether it adopted ARR 1987 (Pilgrim, DH & Institution of Engineers, Australia, 1987) or ARR 2016 methodologies.



Peak Flood Depth (m)			
<0.05	0.16 - 0.20	0.51 - 1.20	8.01 - 12.00
0.05 - 0.10	0.21 - 0.25	1.21 - 2.00	12.01 - 18.00
0.11 - 0.15	0.26 - 0.30	2.01 - 4.00	
	0.31 - 0.50	4.01 - 8.00	

Paper Size A4

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

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1% AEP peak flood depth
Yarra River 1 of 3

Figure 6-4

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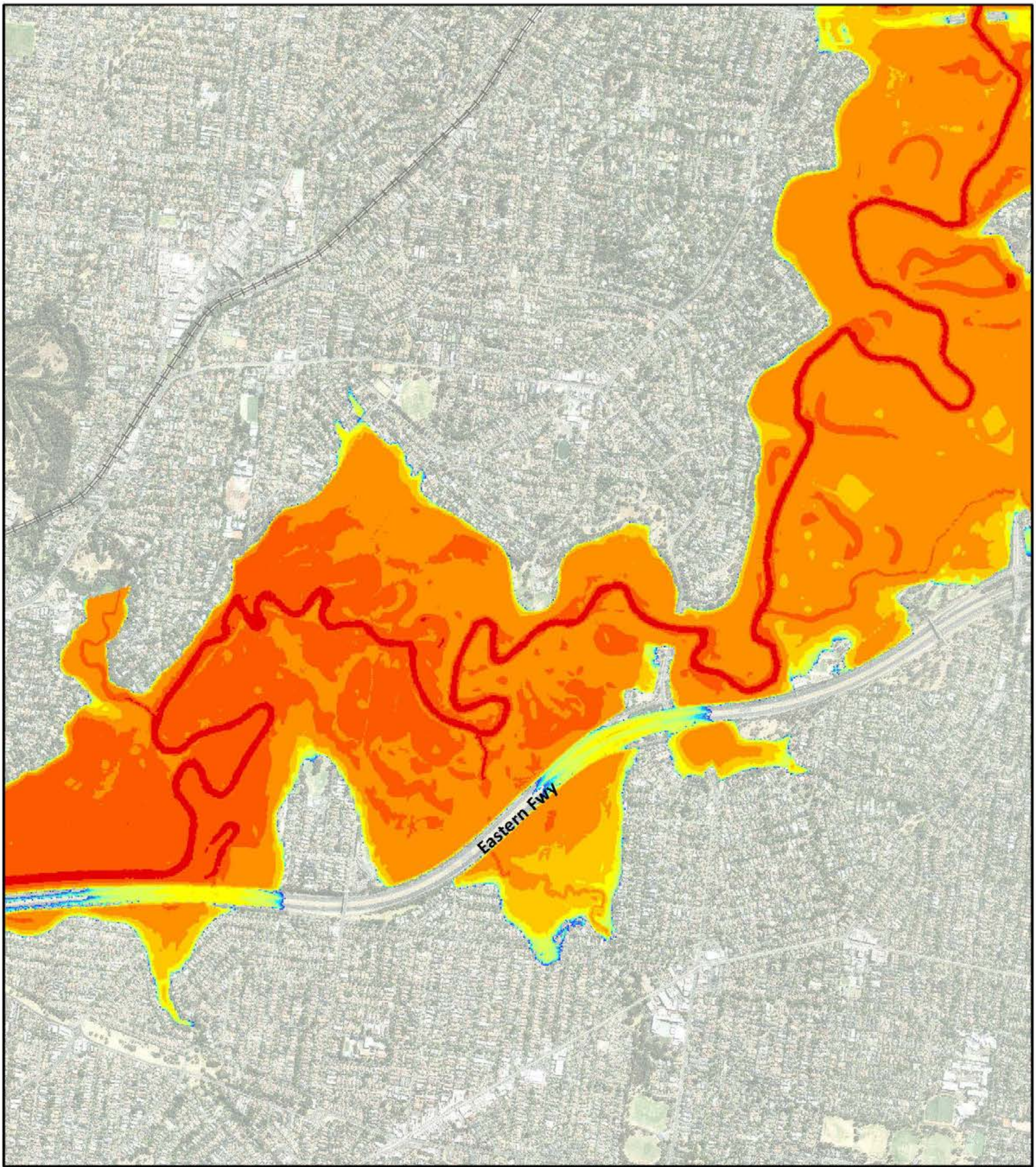

Peak Flood Depth (m)

<0.05	0.16 - 0.20	0.51 - 1.20	8.01 - 12.00
0.05 - 0.10	0.21 - 0.25	1.21 - 2.00	12.01 - 18.00
0.11 - 0.15	0.26 - 0.30	2.01 - 4.00	
	0.31 - 0.50	4.01 - 8.00	

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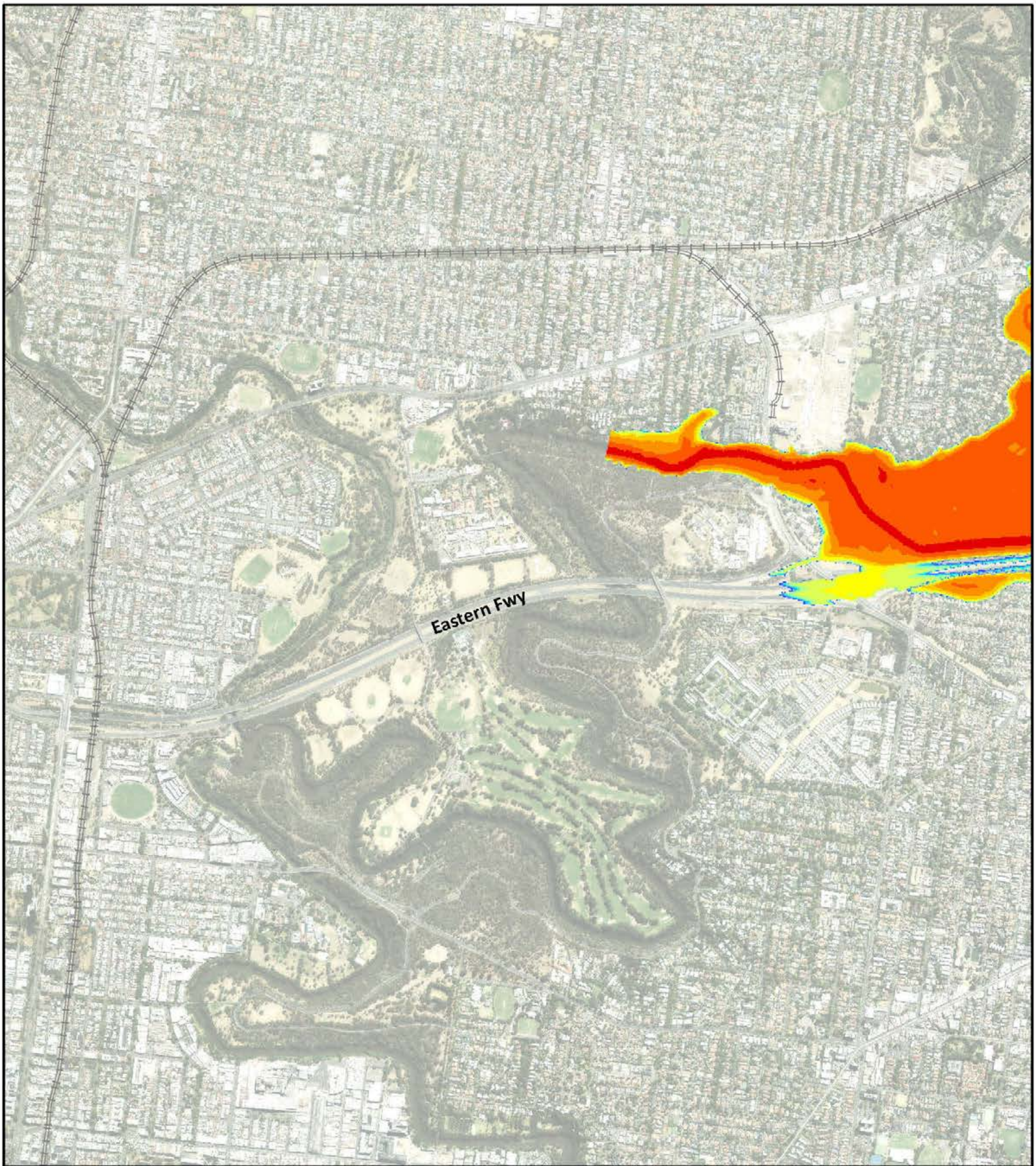
1% AEP peak flood depth
Yarra River 2 of 3

Figure 6-5



Peak Flood Depth (m)

<0.05	0.51 - 1.20
0.05 - 0.10	1.21 - 2.00
0.11 - 0.15	2.01 - 4.00
0.16 - 0.20	4.01 - 8.00
0.21 - 0.25	8.01 - 12.00
0.26 - 0.30	12.01 - 18.00
0.31 - 0.50	

Paper Size A4

0 135 270 540

Metres

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

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1% AEP peak flood depth
Yarra River 3 of 3

Figure 6-6

6.3.3 Water quality

Water quality monitoring data was obtained for two monitoring stations on the Yarra River (Melbourne Water, 2015). The water quality results are summarised in Table 6-5. The following data has been used for this assessment:

- Yarra River at Kangaroo Ground-Warrandyte Road, Warrandyte, six readings, recorded 2015
- Yarra River at Chandler Highway, Kew, six readings, recorded 2015.

Table 6-5 Water quality monitoring results for Yarra River (Melbourne Water 2015)

Parameter	SEPP (Waters) Objective	Yarra River at Kangaroo Ground-Warrandyte Road, Warrandyte	Yarra River at Chandler Highway, Kew
Dissolved oxygen (% saturation) (25th percentile)	≥75%	91.0	81.0
Dissolved oxygen (% saturation) (maximum)	≤110%	100	91
Electrical conductivity at 25°C (75th percentile)	≤250 µS/cm	138	188
pH (25th percentile)	≥6.7	7.4	7.2
pH (75th percentile)	≤7.7	7.6	7.6
Turbidity (75th percentile)	≤25 NTU	12	28
Total nitrogen (75th percentile)	≤1100 µg/l	700	900
Total phosphorous (75th percentile)	≤55 µg/l	30	50

Table notes: Red numbers do not meet SEPP (Waters) objective

Table 6-5 shows that at least for this small data set, the majority of the SEPP (Waters) objectives are met for these Yarra River monitoring sites.

The most recent analysis presented on the Yarra and Bay website (DELWP, 2018b) of the available sampling of Yarra River (2016 to 2017) indicates very good ratings for pH and salinity at Chandler Highway, Kew. In the same timeframe, very poor ratings are noted for water clarity, nutrients and metals due to high concentrations recorded for nitrogen, phosphorus and heavy metals (DELWP, 2018b). DELWP combines the score of individual water quality parameters to produce an overall water quality index. Figure 6-7 shows that from 2000 to 2017, the water quality index for the Yarra River at Chandler Highway at Kew oscillated between very poor and poor. Since 2012 the water quality index has been improving.

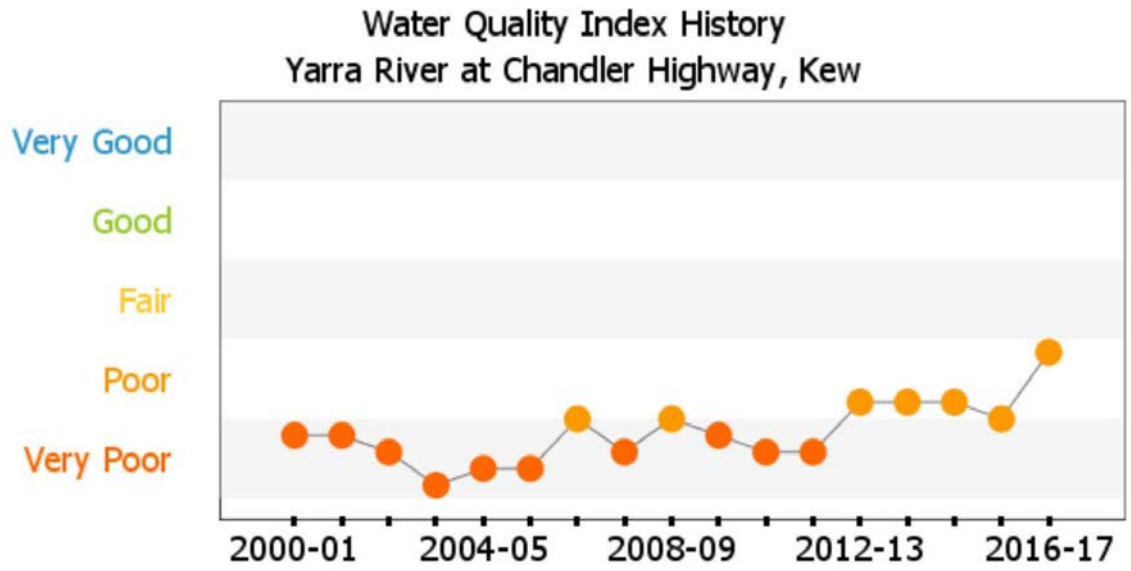


Figure 6-7 Water quality index, Yarra River at Chandler Highway, Kew (YAYAR3331) (DELWP, 2018b)

Table 6-6 and Table 6-7 show the Yarra River existing condition descriptions from the Draft Healthy Waterways Strategy 2018–2028 (Melbourne Water, 2018) and a Yarra River conditions summary (Melbourne Water and Port Phillip Westernport Catchment Management Authority, 2007) respectively. The Yarra River is rated by Melbourne Water as having very high regional importance and its overall current condition is rated as being moderate, with the lowest condition ratings for physical form and hydrology.

Table 6-6 Yarra River conditions – Draft Healthy Waterways Strategy 2018–2028 (Melbourne Water, 2018).

Parameter	Condition/Note
Stormwater condition	Low
Water for the environment	High
Vegetation extent	Moderate
Vegetation quality	Moderate
Water quality – environment	Moderate
Instream connectivity	Very High
Physical form	Very Low
Access	High
Water quality – recreational	Moderate
Litter absence	High
Participation	Low

Table 6-7 Yarra River condition summary (Melbourne Water and Port Phillip Westernport Catchment Management Authority, 2007).

Parameter	Condition
Water quality	Moderate
Aquatic life	Moderate
Habitat and stability	Good
Vegetation	Poor
Hydrology	Poor

6.3.4 Geomorphology

The existing geomorphic conditions within the Yarra River have been appraised through observations made during site visits and desktop assessment.

The Yarra River corridor contains some of the most valued geomorphic assets in metropolitan Melbourne. Indigenous vegetation and remnant riparian vegetation provide habitat and contribute to the protection of water quality and flow regimes. The Yarra River provides a natural landscape and key geomorphic features include river flats and billabongs.

The Yarra River reach between Diamond Creek and Merri Creek confluences has been described as having bed and banks that are relatively stable and well vegetated although somewhat weedy (Sinclair Knight Merz, 2005). The river channel comprises pools with the occasional gravel riffles and runs.

While much of the Yarra River floodplain has been cleared over time due to urbanisation, some billabongs remain relatively intact such as Annulus Billabong and Bolin Bolin Billabong.

6.3.5 Water supply

Various storages exist within the Yarra River floodplain, including a dam within Trinity Grammar School Sporting Complex and irrigation storages owned and operated by Manningham City Council.

The Trinity wetlands get water from a local urban catchment to the east of the site. Stormwater from these wetlands flows into a dam located on the Trinity Grammar School Sporting Complex grounds. Water stored in this dam is used for irrigating sporting ovals at Trinity Grammar as well as the Marcellin College grounds.

Private licences to extract water from the river exist along the Yarra River. Trinity Grammar School Sporting Complex have a current licence to extract water from the Yarra River as part of an agreement with Melbourne Water.

Manningham City Council has a licence to extract water from the Yarra River and has advised this water is stored in above and below ground tanks and used for irrigation of the Freeway Public Golf Course and the Carey Grammar Sports Complex.

On the west side of Bulleen Road, the recently completed Bolin Bolin Integrated Water Management Project collects, stores and transports irrigation water between a 1.5 ML wetland and storage on Crown land at Bolin Bolin Billabong, which primarily collects and treats local stormwater, a 3.3 ML storage at the Freeway Public Golf Course with extraction from the Yarra River and a 0.5 ML of tank storage at Bulleen Park. Water from the integrated water management project is used for the irrigation of sports grounds located at Bulleen Park, the Carey Sports Complex and the Freeway Public Golf Course. The integrated water management project is a partnership between Manningham City Council, the City of Boroondara and Carey Baptist Grammar School, with support from Melbourne Water, the Department of Environment, Land Water and Planning (DELWP) and the Australian Government.

6.3.6 Flow assessment

Flows in the Yarra River are significantly altered from its natural condition due to the existence of water storages along its length and development within the catchment. The flow duration curves shown in Figure 6-8 were developed using recorded gauge data at Banksia Street in Heidelberg (Melbourne Water, 2 August 2017). Significant variability can be seen between a wet year and dry year. In a dry year, flow greater than four cubic metres per second occurred 20 per cent of the time, whereas in a typical wet year, flow greater than 55 cubic metres per second occurred 20 per cent of the time. Across the total period, 18 cubic metres per second was exceeded 20 per cent of the time.

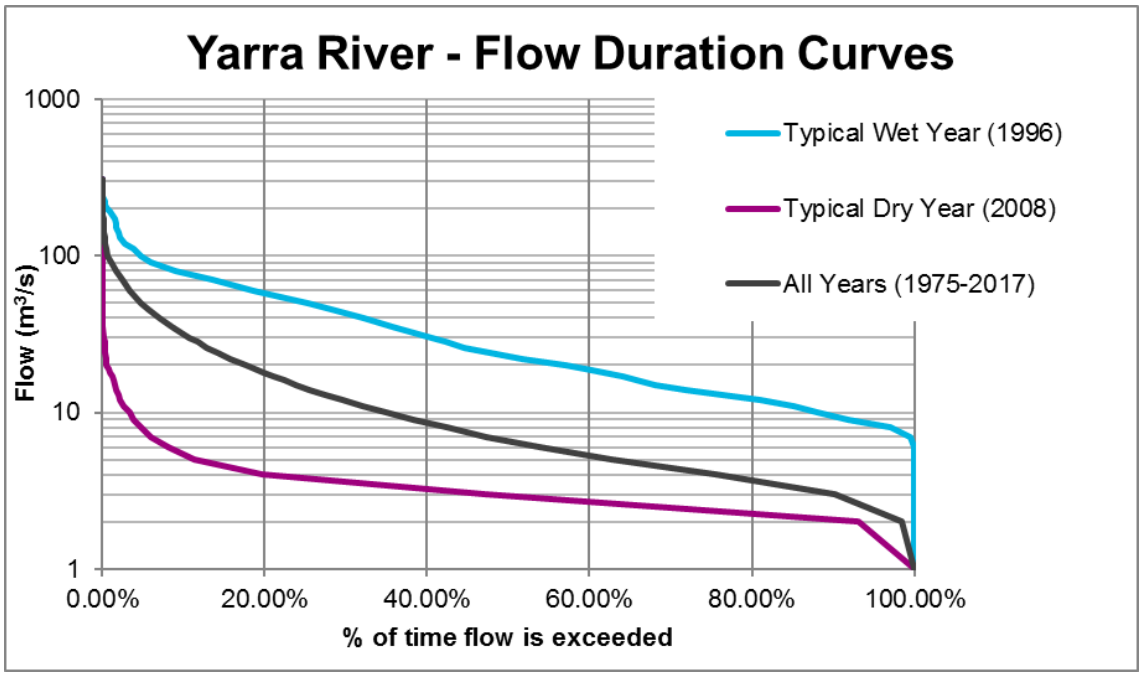


Figure 6-8 Yarra River flow duration curves

6.4 Koonung Creek

While North East Link has the potential to result in surface water impacts along Koonung Creek, it is unlikely that any local surface water impact on Koonung Creek could have a measurable impact on MNES and certainly not on or from Commonwealth land. Koonung Creek discharges to the Yarra River and then Port Philip Bay.

Melbourne Water describes Koonung Creek as (Melbourne Water and Port Phillip Westernport Catchment Management Authority, 2007):

> *'Koonung Creek is a small tributary of the Yarra that arises in Blackburn North and Doncaster. Its catchment is almost entirely urban, however the creek contains major parklands in some of its reaches that have high recreational value. The creek has been heavily modified by realignment and erosion control works, particularly those associated with the Eastern Freeway, however it has retained native fish species, listed water birds, the growling grass frog and the floodplain contains sites of significant Aboriginal heritage.*
>
> *The most significant risks for the creek are associated with altered hydrology, largely as a result of the urbanised catchment, loss of vegetation in the streamside zone, poor water quality, loss of in-stream habitat and barriers to fish movement'.*

Consistent with the above description, there are pre-2007 records documenting the presence of species of ecological value in Koonung Creek, although recent surveys indicate the ecological condition is currently degraded, and no Growling Grass Frog are present (refer to PER Technical Appendix A – Flora and fauna).

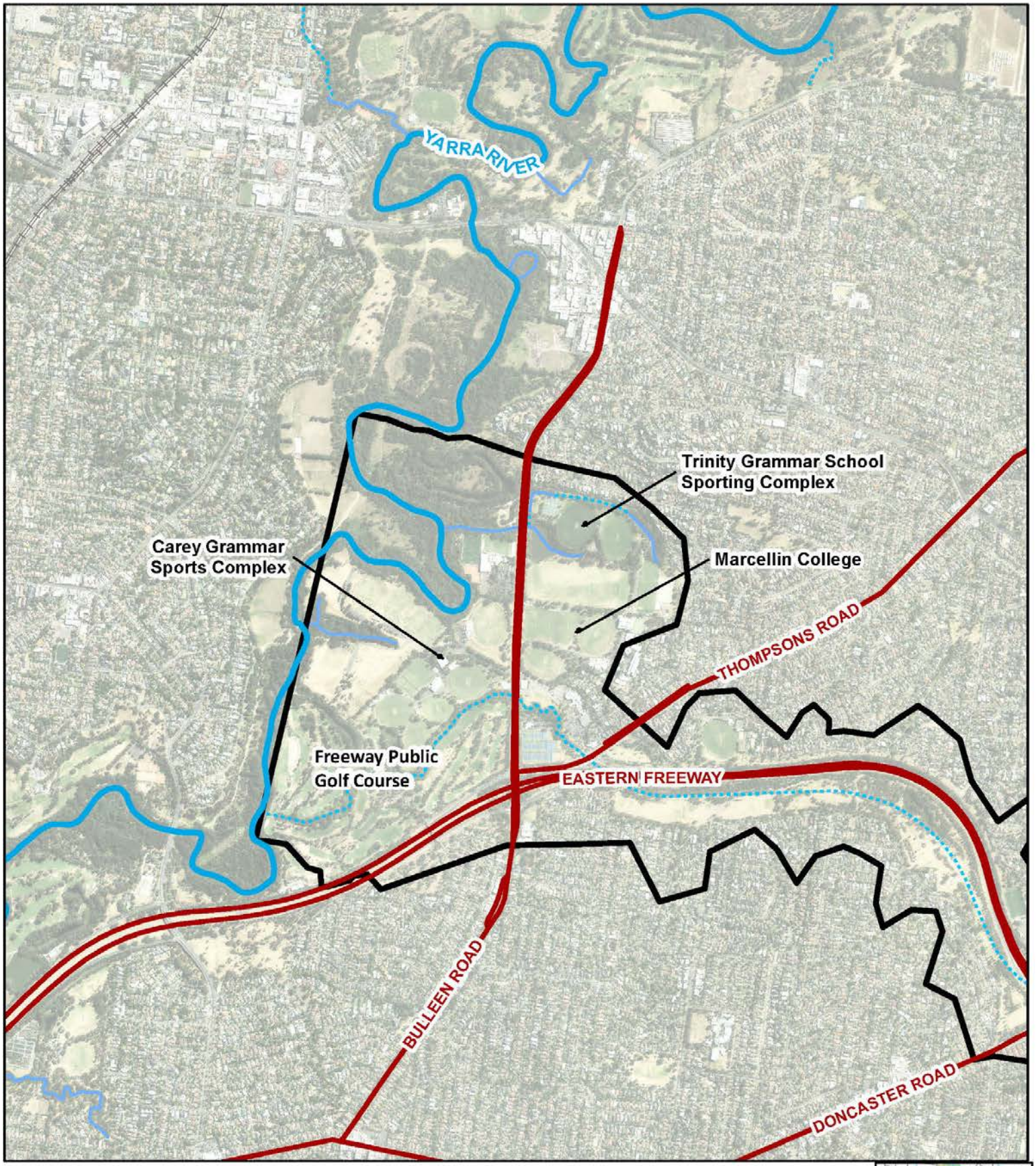
Koonung Creek is approximately 12 kilometres long and begins near Springvale Road in Blackburn North and flows west to join the Yarra River just north of the Freeway Public Golf Course. The creek meanders back and forth either side of the Eastern Freeway for much of its length. The extent of Koonung Creek is shown in Figure 6-9, Figure 6-10 and Figure 6-11.

The catchment is predominantly urban, with dispersed parklands often adjacent to the creek. The proportion of urbanisation within a catchment influences the volume of stormwater runoff and therefore the volume of surface water flow generated. Additionally, the proportion of urbanisation has an impact on the amount of contaminants being discharged to waterways, which may result in poor water quality.

Flows into Koonung Creek enter from local catchment drainage connections including Melbourne Water Drains (Blackburn Road Drain, Leeds Road Drain, Elms Grove Drain, Gardenia Road Drain, Ayr Street Drain and Minerva Avenue Drain), creeks (Brushy Creek) and additional overland flow paths.

In the 1980s, the construction of the Eastern Freeway between Bulleen Road and Doncaster Road resulted in Koonung Creek being 'undergrounded' into a 2.4-kilometre long 'arch drain' (Country Roads Board, 1982). In the 1990s, the construction of the Eastern Freeway extension between Doncaster Road and Springvale Road resulted in heavy modification of Koonung Creek. This included the realignment of Koonung Creek to either side of the Eastern Freeway and the installation of eight 'arch culverts', which provide connections between open channels on either side of the Eastern Freeway beneath the freeway and various intersecting roads (Laybutt, 2007). The realignment works also included significant lengths of erosion control works in some areas including rock armouring of the creek banks, between Doncaster Road and Springvale Road.

Flooding in the lower reaches of Koonung Creek is substantially influenced by flood levels in the Yarra River.



LEGEND

- Hydraulic Model Boundary
- Roads of interest
- River
- Stream
- Channel
- Drain

Paper Size A4

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Metres

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

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Overview
Koonung Creek 1 of 3

Figure 6-9

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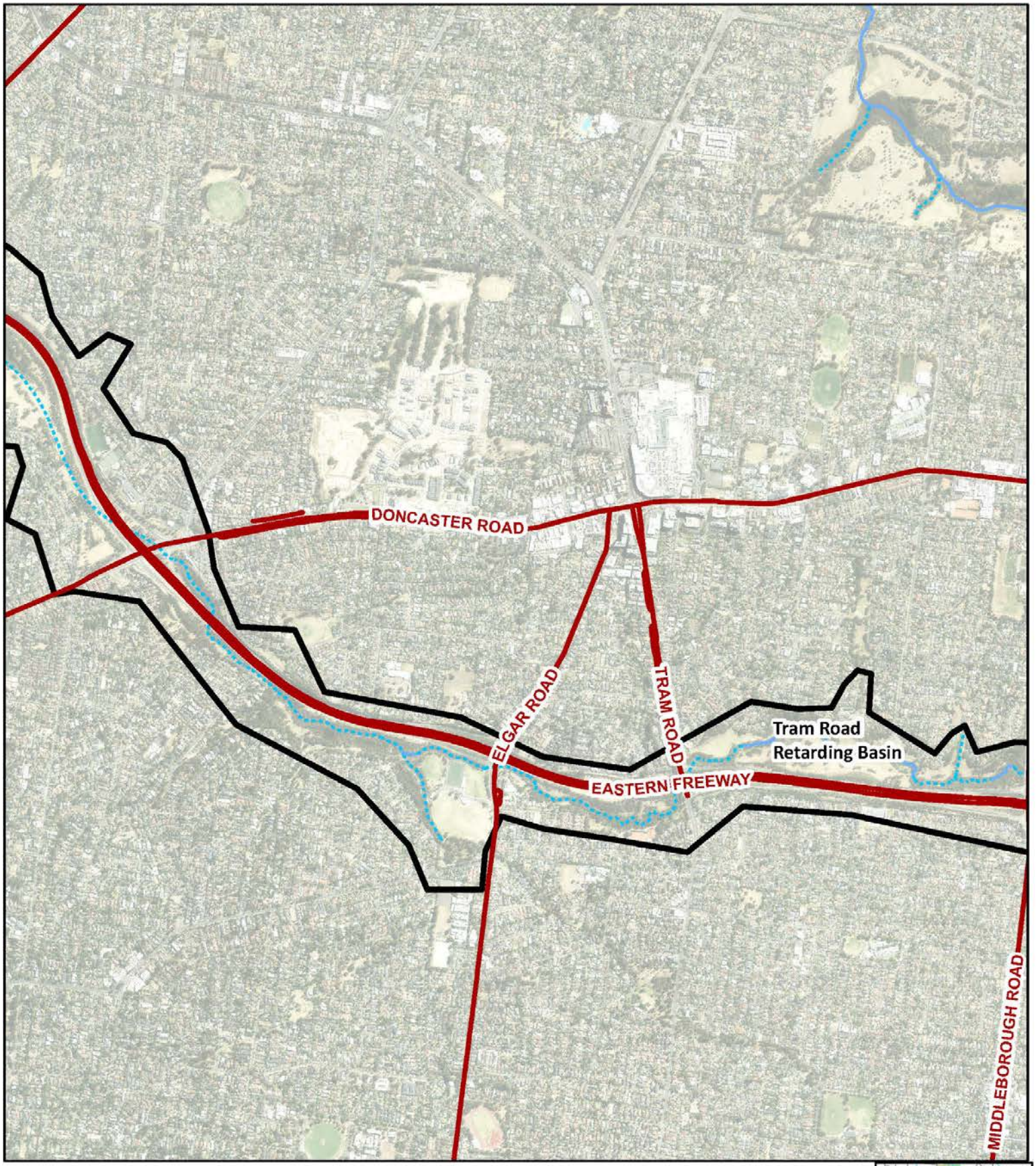
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



LEGEND

- Hydraulic Model Boundary
- Roads of interest
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- Stream
- Channel
- Drain

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Metres

Map Projection: Transverse Mercator
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Overview
Koonung Creek 2 of 3

Figure 6-10

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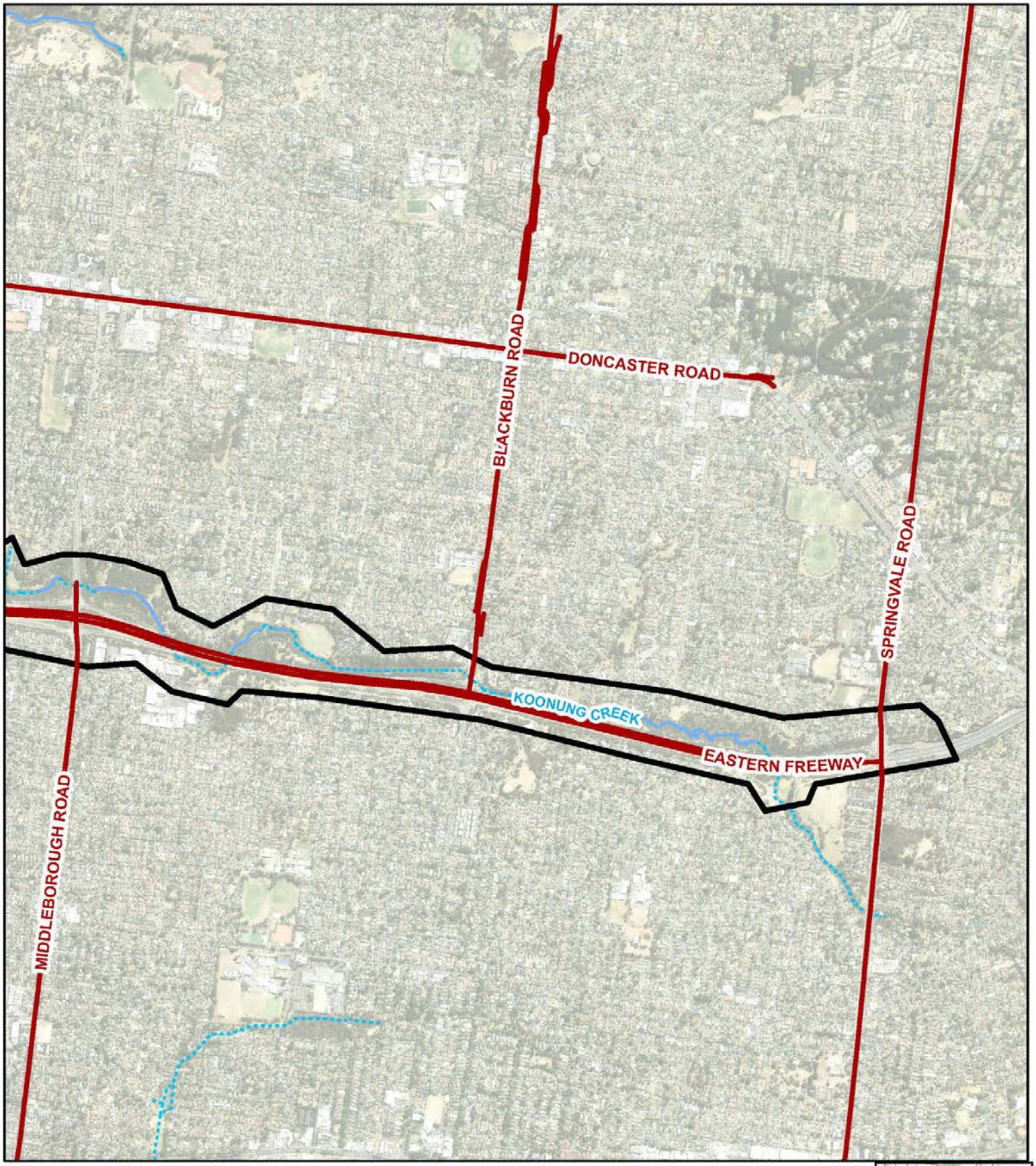

LEGEND

- Hydraulic Model Boundary
- Roads of interest
- River
- Stream
- Channel
- Drain

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Overview
Koonung Creek 3 of 3 Figure 6-11

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

6.4.1 Flooding

The existing flood extents along Koonung Creek as currently shown in the planning scheme are for many areas no longer representative of existing conditions. A new model of Koonung Creek has been used to assess flooding along Koonung Creek. The model includes parts of the local council drainage network and cross drainage across the existing Eastern Freeway for the purpose of appropriately modelling the creek and the impacts of the North East Link reference project. While this would enable an understanding of impacts on local flooding networks, actual flooding on the local drainage system (council drainage) could and will often be greater than what is shown in this report.

The 1% AEP flood depths for Koonung Creek are shown in Figure 6-12, Figure 6-13 and Figure 6-14.

Within the upper reaches of Koonung Creek from Springvale Road to Middleborough Road, the 1% AEP flood extent is confined within the creek channel and surrounding parklands or publicly accessible vegetated area and does not extend to private properties.

Downstream of Middleborough Road, flood extents expand and impact some private properties surrounding the Melbourne Water Tram Road retarding basin. Flood depths of up to eight metres occur within this basin in the 1% AEP event. Additionally, weir flow over the retarding basin wall occurs in the 1% AEP event with a depth up to 0.5 metres.

Upstream of the ‘arch culvert’ under Elgar Road, the Koonung Creek flood extent expands into private properties to the south of the Eastern Freeway. Downstream of Elgar Road, Bushy Creek joins Koonung Creek. The 1% AEP flow inundates various ovals within Elgar Park on the east and private properties on the west. These ovals currently act as retarding basins for Bushy Creek.

The inundation extent resulting from the combined Koonung Creek and Bushy Creek flows extend across a series of wetlands. The flood extent is confined to the creek further downstream through a rock cutting, which was constructed alongside the Eastern Freeway. Downstream of this cutting the flood extent widens, before entering a culvert and crossing to the north of the Eastern Freeway.

A short section of open channel connects into the long ‘arch drain’, beginning near the Doncaster Park and Ride. The peak flow entering into this arch drain for various AEP events is outlined in Table 6-8. Surface inundation above the ‘arch drain’, is evident in Figure 6-12. This surface inundation is from flows which exceeds the capacity of the ‘arch drain’.

Flood extents for the length of the ‘arch drain’ are defined by a variety of issues including the overflow from the ‘arch drain’ and capacity of the local stormwater network entering the arch drain. The Yarra River 1% AEP flood extent intersects with the Koonung Creek 1% AEP flood extent, in the area that includes the Trinity Grammar School Sporting Complex, Marcellin College and the Carey Grammar Sports Complex.

Significant flooding of the Yarra River typically results from prolonged rain events covering large areas of the catchment. In contrast, Koonung Creek is a significantly smaller urbanised catchment that is more likely to be flooded from shorter more intense and more concentrated rainfall events. These different types of critical events do not typically occur in the same general area at the same time. For this reason it is unlikely that a significant flood on Koonung Creek would coincide with a significant Yarra River flood. Additional discussion of the Yarra River flooding can be found in Section 6.3.

The outlet of the ‘arch drain’ is downstream of Thompson Road, where the Koonung Creek flood extent expands across the Trinity Grammar School Sporting Complex and Marcellin College adjacent to Bulleen Road. Three 3.35-metre wide by 3.05-metre high culverts beneath Bulleen Road convey flood waters towards the Yarra River. In the 1% AEP flood event on Koonung Creek, Bulleen Road is overtopped by 0.5 metres.

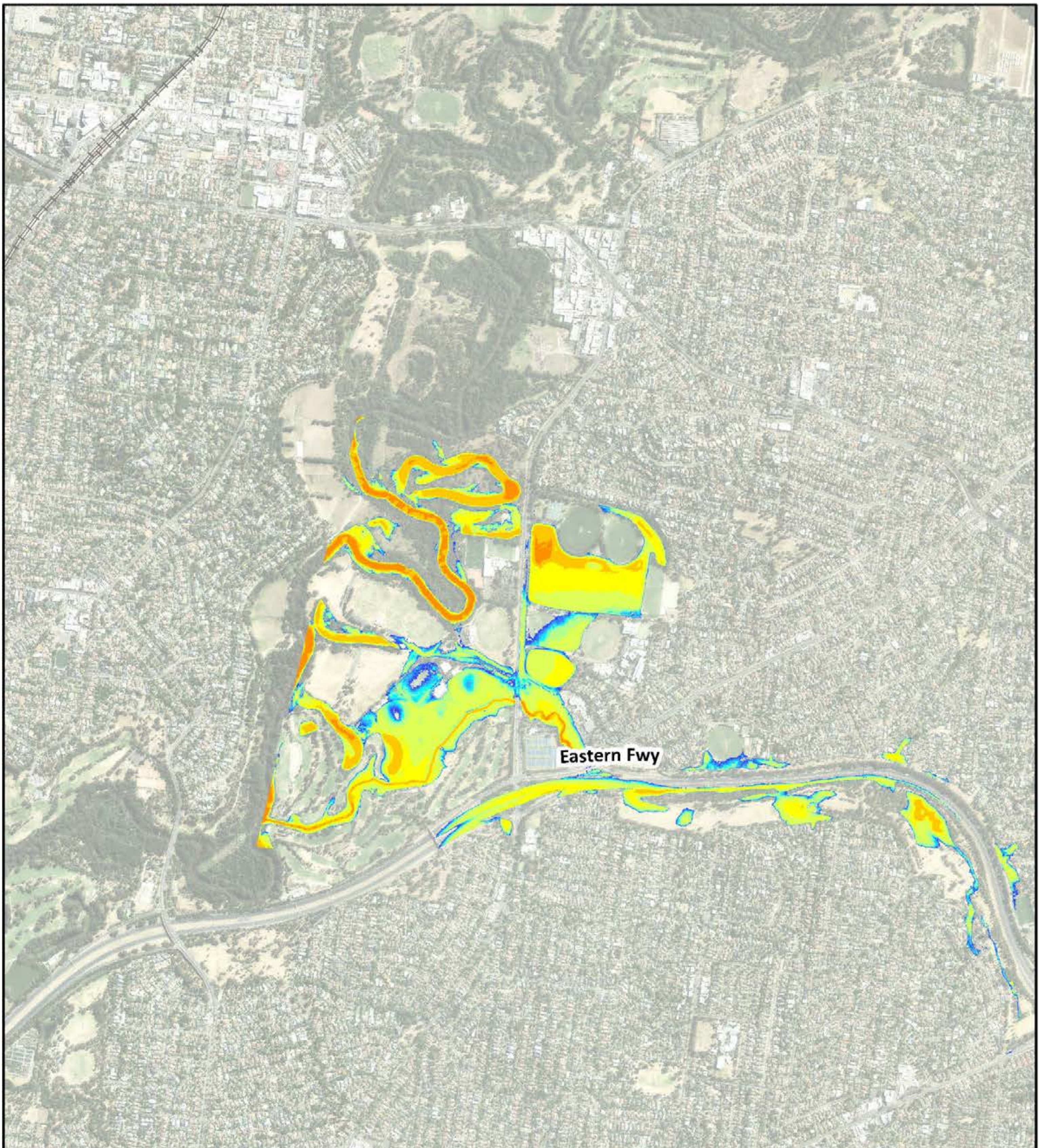
In addition to the Koonung Creek catchment, the local catchment situated to the east of and including the Trinity Grammar School Sporting Complex has been modelled. Floodwaters from the 1% AEP event spread across most of the sporting ovals and water supply dam, before flowing through five 2.4-metre diameter overflow culverts beneath Bulleen Road into a wetland system on the western side of Bulleen Road, which discharges to the Yarra River.

The timing of the peak flow and water level influences the nature of the flooding within a catchment. Due to the short reach lengths and steep nature of the catchment flash flooding (quick rise and fall) occurs within Koonung Creek. Upstream of Thompsons Road, the flood peak might typically occur within one to two hours of rain starting. Further downstream, major flooding would likely result from longer duration storms and the flooding response although still quick relative to a large river system may take several hours.

Koonung Creek is covered by a Land Subject to Inundation Overlay (LSIO) which represents the approximate flood extent for the 1% AEP storm event prior to construction of the Eastern Freeway. The LSIO has not been updated to include the various structures and realignments associated with the Eastern Freeway constructed in the 1990s and is not considered representative of existing (current) flood conditions.

Table 6-8 Koonung Creek existing condition results

AEP (%)	Peak Flow into ‘arch drain’ at Doncaster Road (m^3/s)
10%	66.3
5%	81.5
2%	108.4
1%	121.1
1% climate change	122.1



Peak Flood Depth (m)			
<0.05	0.16 - 0.20	0.51 - 1.20	8.01 - 12.00
0.05 - 0.10	0.21 - 0.25	1.21 - 2.00	12.01 - 18.00
0.11 - 0.15	0.26 - 0.30	2.01 - 4.00	
	0.31 - 0.50	4.01 - 8.00	

Paper Size A4

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Metres

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

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1% AEP peak flood depth
Koonung Creek 1 of 3

Figure 6-12

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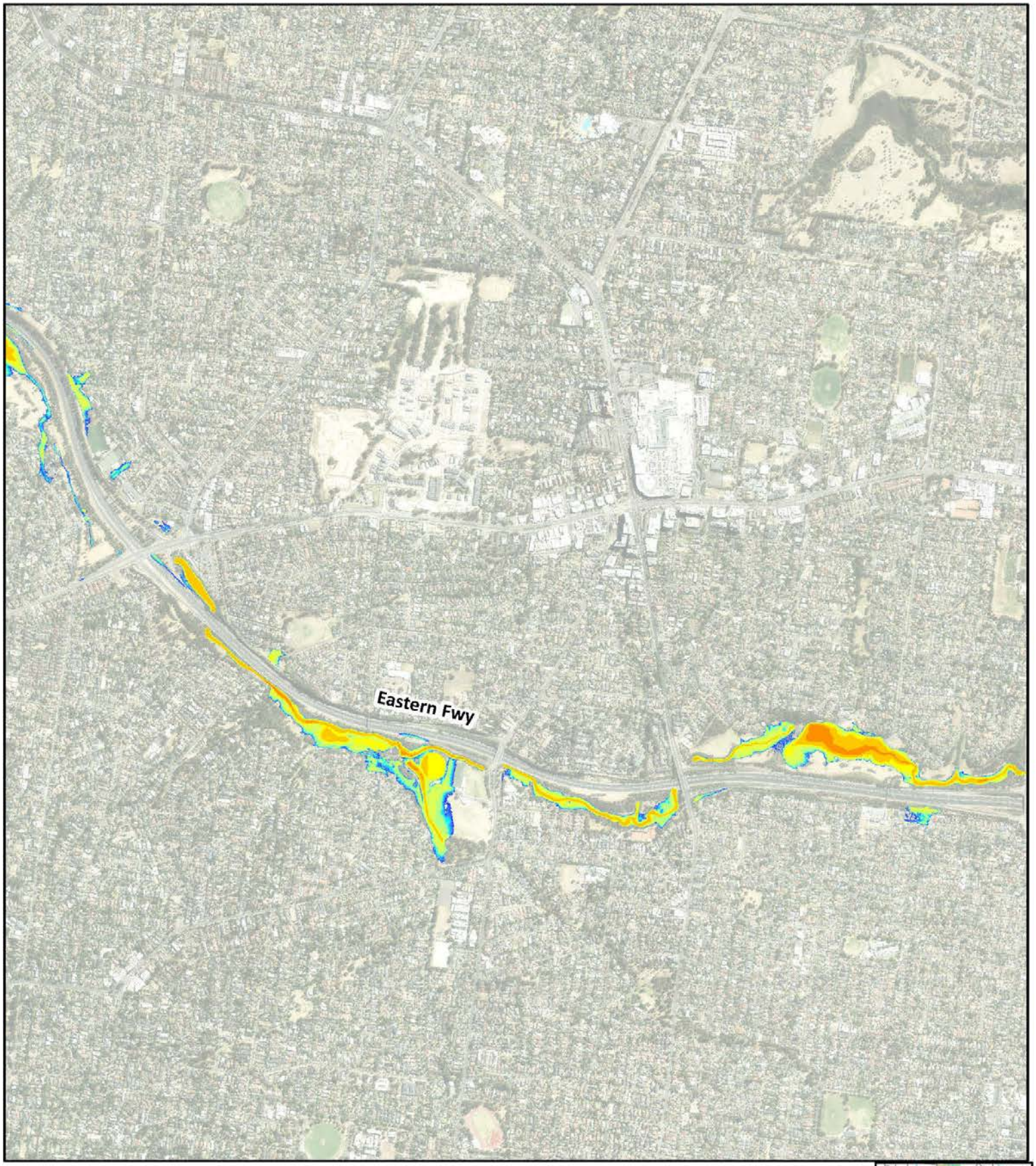
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



Peak Flood Depth (m)

<0.05	0.16 - 0.20	0.51 - 1.20	8.01 - 12.00
0.05 - 0.10	0.21 - 0.25	1.21 - 2.00	12.01 - 18.00
0.11 - 0.15	0.26 - 0.30	2.01 - 4.00	
	0.31 - 0.50	4.01 - 8.00	

Paper Size A4

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Metres

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

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1% AEP peak flood depth Koonung Creek 2 of 3

Figure 6-13

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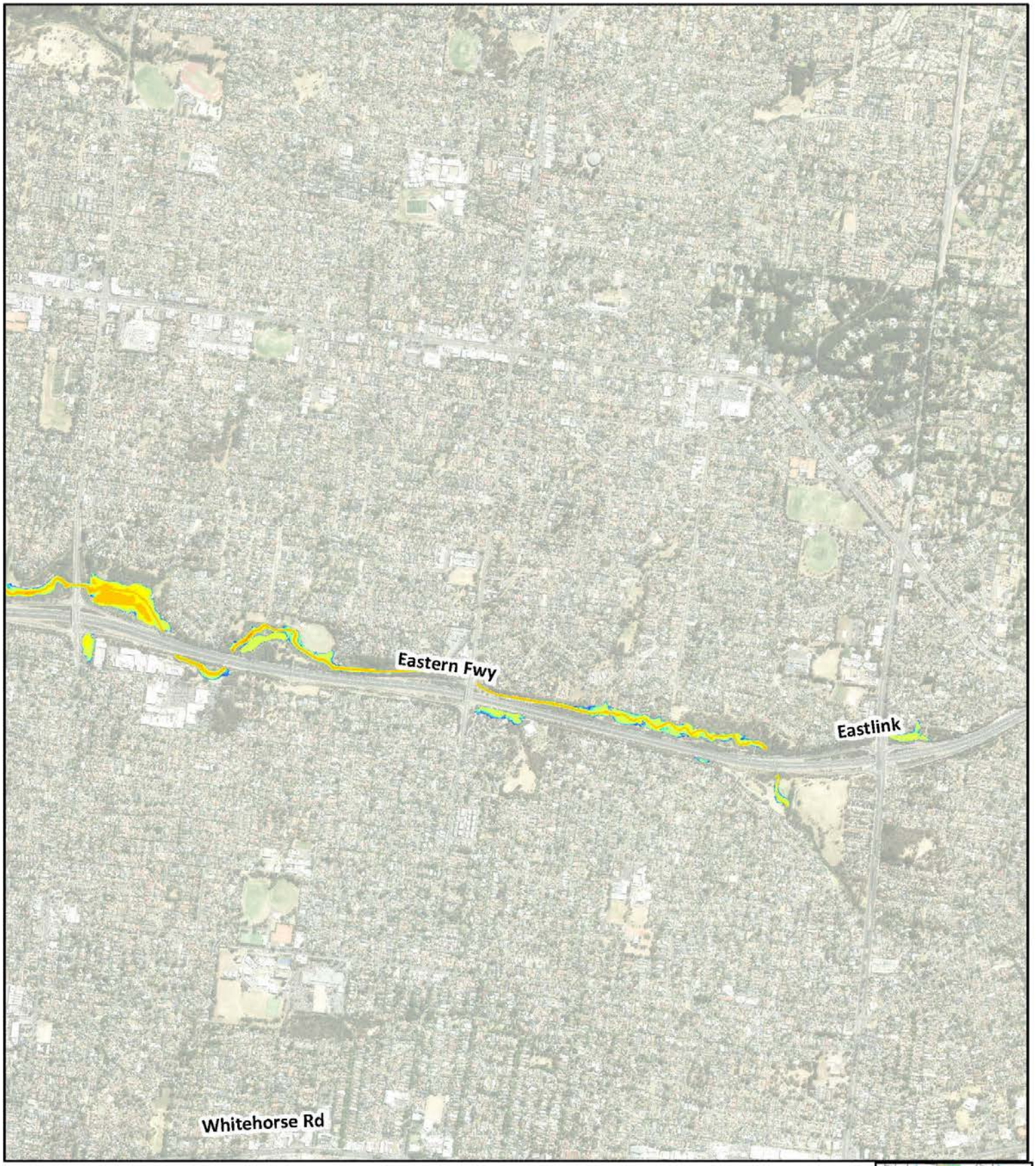
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



Peak Flood Depth (m)

<0.05	0.16 - 0.20	0.51 - 1.20	8.01 - 12.00
0.05 - 0.10	0.21 - 0.25	1.21 - 2.00	12.01 - 18.00
0.11 - 0.15	0.26 - 0.30	2.01 - 4.00	
	0.31 - 0.50	4.01 - 8.00	

Paper Size A4

0 135 270 540

Metres

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1% AEP peak flood depth Koonung Creek 3 of 3

Figure 6-14

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

6.4.2 Water quality

Water quality monitoring data was obtained for four monitoring stations on Koonung Creek (EPA Victoria, 2018; Melbourne Water, 2015). The water quality results are summarised in Table 6-9. The following data has been used for this assessment:

- Koonung Creek at Tunstall Street, Donvale (Site ID: 4402), 12 readings, recorded April 1998 through March 2008
- Koonung Creek at Elizabeth Street, Box Hill North (Site ID: 4400), eight readings, recorded October 1994 through March 1995
- Koonung Creek at Bushy Creek, Doncaster (Site ID: 4450), 10 readings, recorded October 2000 through March 2008
- Koonung Creek at Bulleen Road, Bulleen, 12 readings, recorded 2015.

Table 6-9 Water quality monitoring results for Koonung Creek (EPA Victoria, 2018; Melbourne Water, 2015)

Parameter	SEPP (Waters) Objective	Site ID: 4402	Site ID: 4400	Site ID: 4450	Bulleen Road
Dissolved oxygen (% saturation) (25th percentile)	≥70%	96.8	78.9	97.8	64
Dissolved oxygen (% saturation) (maximum)	≤110%	118	90.1	115	95
Electrical conductivity at 25°C (75th percentile)	≤500 µS/cm	990	No recorded data	846	583
pH (25th percentile)	≥6.4	7.8	7.5	7.4	7.4
pH (75th percentile)	≤7.9	8.3	7.7	7.7	7.7
Turbidity (75th percentile)	≤35 NTU	108	40	216	52
Total nitrogen (75th percentile)	≤1,300 µg/l	1,060	1,063	No recorded data	1,100
Total phosphorous (75th percentile)	≤110 µg/l	54	96	No recorded data	90

Table notes: Red numbers do not meet SEPP (Waters) objective

The small sample size covering the period from 1994 to 2015 shown in Table 6-9 indicates that the SEPP(Waters) objectives are only partially met for the monitoring sites along Koonung Creek.

Water quality recordings at Koonung Creek, Bulleen Road note especially high levels of E.coli with 3,250 organisms per 100 millilitres (50th percentile) (Melbourne Water, 2015) greatly exceeding the SEPP(Waters) objective of under 1,000 organisms per 100 millilitres (EPA Victoria, 2003b). As outlined in the Tracking Sources of Faecal Pollution information bulletin (EPA Victoria 2007), the human faecal biomarker (coprostanol/5a cholestenol ratio) measured from the dry and wet weather samples taken at Koonung Creek indicate human faecal matter contamination (Wangersky, 2006). Potential sources of faecal contamination include sewer blockages, seepage from the sewerage system and cross-connections between sewer and stormwater pipes (EPA Victoria, 2007).

The most recent analysis presented on the Yarra and Bay website (DELWP, 2018a), of the available sampling of Koonung Creek (2016 to 2017) indicates a fair rating for pH at Bulleen Road, Bulleen. In the same timeframe, very poor ratings were noted for water clarity, dissolved oxygen, salinity, nutrients and metals due to high concentrations recorded for nitrogen, phosphorus and heavy metals (DELWP, 2018a). DELWP combines the score of individual water quality parameters to produce an overall water quality index. Figure 6-15 shows that from 2000 to 2017, the water quality index for Koonung Creek at Bulleen Road, Bulleen has consistently remained very poor.

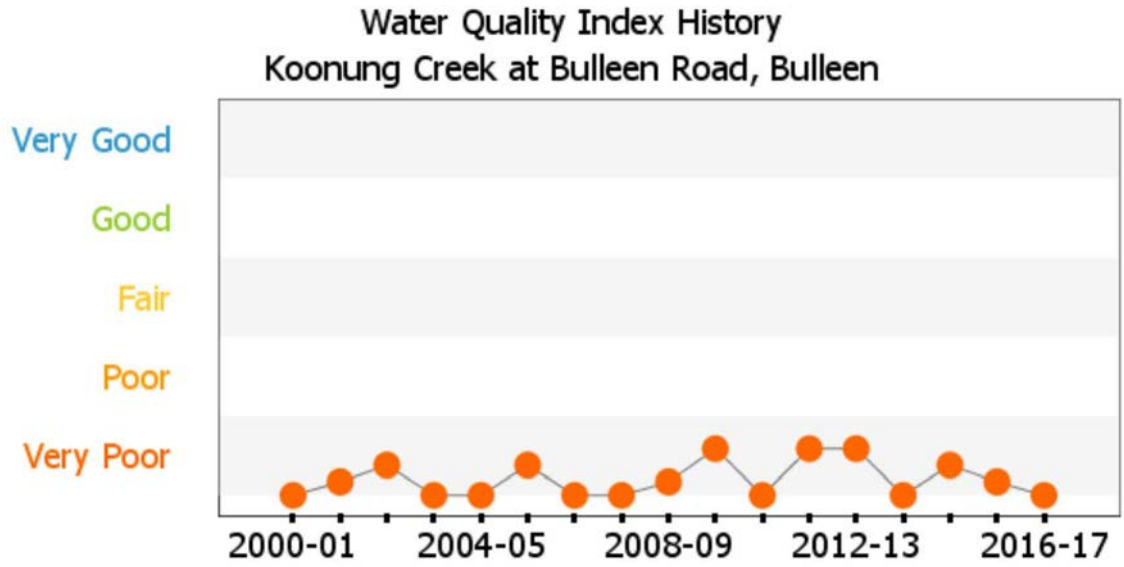

Figure 6-15 Water quality index, Koonung Creek at Bulleen Road, Bulleen (YAKOO0033) (DELWP, 2018a)

Table 6-10 and Table 6-11 show the Koonung Creek existing condition descriptions from the Draft Healthy Waterways Strategy 2018–2028 (Melbourne Water, 2018) and a Koonung Creek conditions summary (Melbourne Water, 2007). Melbourne Water has rated Koonung Creek as of low regional importance and its overall current condition is rated as being very poor, with the lowest condition ratings for physical form and stormwater.

Table 6-10 Koonung Creek condition (Melbourne Water, 2018)

Parameter	Condition/Note
Stormwater condition	Very Low
Water for the environment	High
Vegetation extent	Low
Vegetation quality	Low
Water quality – environment	Moderate
Instream connectivity	Low
Physical form	Very Low
Access	High
Water quality – recreational	Moderate
Litter absence	Very Low
Participation	Moderate

Table 6-11 Koonung Creek condition summary (Melbourne Water, 2007)

Parameter	Condition
Water quality	Very poor
Aquatic life	Very poor
Habitat and stability	Good
Vegetation	Poor
Hydrology	Very poor

Flow data was made available for Koonung Creek but was not used due to poor data quality, and an unreliable rating curve. Therefore no flow assessment was undertaken.

6.4.3 Geomorphology

The existing geomorphic conditions within Koonung Creek have been appraised through observations made during site visits.

Koonung Creek is a heavily modified waterway due to the construction of the Eastern Freeway. The realignment works included significant lengths of erosion control works, consisting of rock armouring of the creek in some areas between Doncaster Road and Springvale Road. Despite some sections of the creek having steep longitudinal grades and confined width, significant erosion protection works along with exposed natural rock cuttings contribute to a relatively stable creek showing minimal signs of erosion.

Approximately 150 metres upstream of Elgar Road, there is evidence of localised bank erosion on the left bank (upstream of the shared use bridge). The erosion is caused by the hydraulic flow conditions upstream of the bridge constriction and the height of the existing bank protection. The bank erosion is located above the rock armouring, and has exposed tree roots, threatening bank stability.

Approximately 80 metres downstream of the Bushy Creek and Koonung Creek confluence, there is evidence of lateral bank migration. The erosion occurs on an inner bend where the waterway has high sinuosity. Straightening of the waterway, to reach an equilibrium state through erosion is not common in this highly modified reach of Koonung Creek. Erosion in Koonung Creek between the arch culvert opposite Clifton Street and crossing following Elgar Road (approximately 1.5 kilometres) is localised in nature and not widespread due to the significant armouring of the creek.

7. Relevant impacts (Commonwealth land)

7.1 Construction impacts

This section describes the potential surface water construction impacts on the environment in relation to actions affecting Commonwealth land.

Construction of North East Link would change many of the surface water characteristics of Banyule Drain and Banyule Creek at Simpson Barracks and the downstream publicly accessible Commonwealth land. The potential for impacts are in part dependent on the construction methodology and the mitigation measures adopted and may vary from the concepts developed for the North East Link reference project which form the basis of the following discussion.

7.1.1 Stormwater runoff volume and flooding

Impact description and proposed avoidance and mitigation measures

This section considers the potential for flooding impacts on people, community, infrastructure and assets.

There is potential for increased runoff volumes due to reductions in the perviousness of the catchment during construction. For instance, the construction of a large shed may locally increase runoff volumes. This type of change could be mitigated with rainwater tanks with sufficient event storage and may potentially provide some opportunity for stormwater reuse. With the exception of site sheds and covered stockpiles, the potential for increased impervious area is generally less during construction than during operation and is conservatively assessed in Section 7.2.1.

Construction works would divert both the existing open drain on the east side of Greensborough Bypass and some of the ephemeral flow paths within Simpson Barracks. This has the potential to reduce flow attenuation leading to increases to peak flows. Mitigation could involve providing suitable storages and outlet controls designed to attenuate downstream peak flows. Additional storage would be designed to minimise changes to the frequency and magnitude of downstream flows. It is likely that at least some of this mitigation would be provided downstream of the Commonwealth land to the north of Lower Plenty Road. With such a solution, larger peak flows may extend at least a short distance downstream of the Commonwealth land. Adverse flooding impacts on either Commonwealth land or downstream would be avoided by providing sufficient conveyance to offset any potential increase in peak flows.

The temporary diversion would likely to comprise a pipe to the east and to the west of the proposed northern portal to pick up the east and west catchments respectively. It is likely that inlet capacity would be reliant at least in part on the ponding within storages and that the inlets would be designed to minimise their potential for blockage. The potential impacts of inlet blockage during a flood event include increased flood levels, velocities and consequently the potential for scour and safety concerns. Although performance of the existing drainage system can be impacted by inlet blockage, the piped diversion is potentially more susceptible to inlet blockage and the design would need to mitigate this risk. Potential mitigation measures may include large inlet grill capacity with downstream orifice to regulate outlet capacity and or design and management of overland bypasses.

Connections with upstream tributary streams and drains would need to be suitably designed to avoid increased tail water levels, which might lead to flooding, or reduced tail water levels, which without appropriate management may lead to headward and or gully erosion.

Specific requirements that relate to the design development of North East Link include the requirement to mitigate flood impacts during construction (and operation) by:

- Assessing overall flood risk by using modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile in accordance with Standards for Infrastructure in Flood-Prone Areas (2019)
- Modelling a range of flood events with varying probabilities and a range of scenarios (such as inlet blockage)
- If significant increases in flood risk are predicted for any events analysed, an overall assessment of flood risk together with proposed mitigation measures would be presented to the relevant drainage authority or asset owner for acceptance, prior to commencement of construction for the relevant section of the works. If there are significant design changes during construction, the model must continue to be updated, as appropriate to represent these changes. Other relevant authorities (eg Simpson Barracks) would be consulted where required.

With these requirements, the design of any pipes or diversions to accommodate surface water flow during construction would need to be sized by the contractor to manage any modelled flooding.

Although likely to be limited by available space, there is sometimes potential for over compensation with respect to providing additional storage and water quality treatment. Given the urban nature of the downstream waterway, a reduction in flooding, particularly overbank flooding may be seen as beneficial. However, in many flood plains there are environmental benefits of overbank flooding, such as the downstream reaches of Banyule Creek where flood flows may occasionally contribute water to Banyule Swamp within Banyule Flats. Although primarily fed from other sources and well over a kilometre downstream, these areas are an example of why mitigation should be thoroughly contemplated and not used to fix existing flooding issues without careful consideration.

Residual impact

With appropriate design and construction management for surface water flow, no significant residual impacts on runoff volumes or peak flows are expected on or downstream of the Commonwealth land. With careful design and construction management, the potential impacts of blockage on the performance of the proposed stormwater system would be substantially controlled and remain comparable with those of the existing stormwater system.

7.1.2 Stormwater runoff quality and spills

Impact description and proposed avoidance and mitigation measures

This section considers the potential for spills, and mobilisation of pollutants or sediment leading to a reduction in water quality.

In the absence of appropriate best practice controls, construction particularly along or adjacent to waterways or drains increases the risk of spills and the exposure and mobilising sediment and other pollutants in stormwater runoff. While this site is no exception, the diversion of the existing open drain would replace an asset which is actively eroding. The replacement of this actively eroding drain in itself is likely to improve water quality. Treatment measures will include standard construction measures and approaches for works of this type. Best practice sediment and erosion control and monitoring, in general accordance with EPA Victoria publications such as:

275 (1991)	Construction techniques for sediment pollution control
480 (1996)	Environmental Guidelines for Major Construction Sites
960 (2004)	Doing It Right On Subdivisions – Temporary Environmental Protection Measures for Subdivision Construction Sites
IWRG 701 (2009)	Industrial Waste Resource Guidelines – Sampling and analysis of waters, wastewaters, soils and wastes
1698 (2018)	Liquid and Storage Handling Guidelines.

Measures to protect water quality could include hazard prevention (such as off-site servicing to reduce potential for spills), wash down areas, bunds around stockpiles, sedimentation and or holding ponds, construction scheduling, careful location and protection of access tracks, stockpiles, plant and sheds, which would be implemented in combination with detailed Construction Environmental Management Plans (CEMPs) and Surface Water Management Plan (SWMP). The project requirements and management plans would require monitoring and as necessary refinement of methodologies and approaches to effectively minimise the potential for impacts due to spills or pollution of stormwater runoff during construction. The selection of monitoring methodologies and locations would consider construction methodologies, locations and risks and be developed in consultation with EPA Victoria and the asset owner/manager.

Construction activities and stockpiling along the banks and flood plains of larger waterways such as the Yarra River and Koonung Creek would adopt an upstream and downstream differential monitoring approach to monitor compliance with environmental objectives. For the ephemeral upstream reaches of Banyule Creek, such an approach is not practical and measurement of the collected site water and any pollutants would be required on site prior to the point of discharge.

Residual impact

It is possible that some water quality treatment measures to manage potential water quality impacts originating on or contributed by works on Commonwealth land would be located downstream of the Commonwealth land so that unmitigated impacts would likely extend at least a short distance downstream of the Commonwealth land. Impacts between the Commonwealth land and the downstream location where they are mitigated would be significantly contained within the construction site that would extend south of the Commonwealth land to Lower Plenty Road.

With appropriate design, construction methodologies and risk management, no significant adverse residual impacts are expected on or downstream of the Commonwealth land during the construction of North East Link, and some improvement in water quality is a possibility.

7.1.3 Erosion impacts on waterway stability, habitat and water quality

Impact description and proposed avoidance and mitigation measures

This section considers the potential for erosion to bed or banks resulting in the undermining of assets, with potential to impact on habitat and water quality.

The most significant erosion currently occurs in the open drain on the east side of Greensborough Bypass which runs parallel to and discharges to Banyule Creek. Minor erosion elsewhere has less potential to destabilise assets. Construction works which divert the eroding open drain are expected to replace it with a properly engineered solution significantly improving waterway stability. Although the duration of the construction phase is likely to be greater than five years, for the majority of this time the diversions, bunding and other ‘temporary’ features would be in place and operating effectively to minimise any adverse impacts. The greatest risks

in terms of waterway stability and water quality would be over a relatively short period while the diversions are being initially constructed and brought into service. There is a potential for perceived impacts on Banyule Creek due to existing bank erosion, particularly a section of bank just downstream of Lower Plenty Road.

Residual impact

With appropriate mitigation measures in place to control flooding related impacts (refer 7.1.1) there would be no significant change in the residual erosion potential to the waterways downstream of the Commonwealth land. The stability of waterways on Commonwealth land would likely improve.

7.2 Operation impacts

This section describes the potential surface water operation impacts on the environment in relation to actions affecting Commonwealth land from the operation of North East Link.

Once completed, North East Link would change many of the surface water characteristics of Banyule Drain and Banyule Creek within Simpson Barracks and the downstream publicly accessible Commonwealth land. The changes are expected to be concentrated along the western side of Simpson Barracks and in the publicly accessible Commonwealth land immediately to the south. The replacement of the existing drain, ephemeral flow paths and creek with new drainage works and associated flow paths, storages and treatment trains would provide a permanent change to the surface water characteristics on Commonwealth land. New drainage works to store and divert flows around the new North East Link road infrastructure including stormwater storages and diversions as well as barrier walls around tunnel portals and various elevated pavements would be located on Commonwealth land and adjacent sites.

7.2.1 Stormwater runoff volume and flooding

Impact description and proposed avoidance and mitigation measures

This section considers the potential for flooding impacts on people, community, infrastructure and assets.

There is minimal potential for increased runoff volumes due to reductions in the perviousness of the catchment during operation. The increased pavement and runoff for road catchments intersecting Commonwealth land were assessed for the North East Link reference project. This indicated an increase in pavement area of approximately 33,000 m^2 with an increase in a 10% AEP design event runoff volume of around 150 m^3. Only a small portion of these increases would be located on Commonwealth land and include surface roads as well as open cut sections. This small volume would likely fully contained within the pump sump to which most of this area would drain.

Taking into account the design requirements discussed in Section 7.1.1, the design of any pipes or diversions to accommodate surface water flow during operation would need to be sized by the contractor to adequately manage flood flows and risks.

Residual impact

During operation, the constructed flow paths including flood barriers and storages would provide performance in accordance with North East Link and drainage authority requirements and so would have a negligible impact on the current flood regime.

7.2.2 Stormwater runoff quality and spills

Impact description and proposed avoidance and mitigation measures

This section considers the potential for spills, and mobilisation of pollutants or sediment leading to reduced water quality.

During operation, a number of controls including emergency response plans and spill collection storages would reduce the potential for adverse water quality impacts from spills. Spill collection would generally be achieved using underground tanks and or appropriately designed surface storages.

During operation, pollutants from vehicles mobilised by stormwater would be treated using wetlands, sedimentation ponds and swales to achieve SEPP (Waters) requirements.

Spill containment storages and water treatment train elements would require ongoing monitoring and maintenance; no additional water quality monitoring of receiving waters is proposed.

Residual impact

The combination of active management, physical spill capture and treatment trains provides a high level of protection, which modelling indicates would be effective in achieving best practice objectives, and an improvement on the performance of the current infrastructure. These controls would be effective in limiting the potential for residual impacts on the Commonwealth land environment as a result of surface water changes resulting from the operation of North East Link.

7.2.3 Erosion impacts on waterway stability, habitat and water quality

Impact description and proposed avoidance and mitigation measures

This section considers the potential for erosion to bed or banks resulting in the undermining of assets, with potential to impact on habitat and water quality.

Under existing conditions, the most significant erosion is currently occurring in the drain on the east side of Greensborough Bypass. Minor erosion elsewhere has less potential to destabilise assets. Once construction was complete and North East Link was operating, the actively eroding drain would be replaced by a well-engineered flowpath. Replacement of this problematic eroding drain in combination with the storages and treatment trains would increase waterway stability, the security of adjacent structures, habitat and improve downstream water quality by reducing sediment loads.

Residual impact

During operation, it is anticipated that bank erosion downstream of Lower Plenty Road would continue until works are undertaken to stabilise this existing issue. Compliance with project requirements would limit the potential for adverse residual impacts on waterway stability along any of the major waterways including Banyule Creek and the Yarra River.

8. Relevant impacts (MNES)

This section describes the potential surface water impacts on MNES. While MNES are described in more detail in Technical Appendix A – Flora and fauna, the following list of MNES helps explain the focus of this section:

- Grassy Eucalypt Woodland of the Victoria Volcanic Plain
- Matted Flax-lily (*Dianella amoena*)
- River Swamp Wallaby-grass (*Amphibromus fluitans*)
- Clover Glycine (*Glycine latobeana*)
- Swift Parrot (*Lathamus discolour*)
- Australian Painted Snipe (*Rostratula australis*)
- Australasian Bittern (*Botaurus poiciloptilus*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Growling Grass Frog (*Litoria raniformis*)
- Macquarie Perch (*Macquaria australasica*)
- Australian Grayling (*Prototroctes maraena*)
- Latham's Snipe (*Gallinago hardwickii*).

Few of these MNES are directly affected by surface water. The Australian Grayling has been observed in the Yarra River and while any impact on the Yarra River from the construction of North East Link would be indirect and significantly diluted, it is the focus of the assessment in this section.

8.1 Construction impacts

8.1.1 Surface water quality impacts on Matters of National Environmental Significance (MNES)

The construction of North East Link has some potential to impact MNES. The potential for changes in water quality sufficient to affect MNES is generally limited, not only by the mitigation measures but also by the urban nature of the existing waterways and the significant dilution of potential pollutants by the time they might have impact MNES.

Impact description

In the absence of adequate controls, construction works have the potential to results in spills and or to expose and mobilise sediment and pollutants which may find their way into the waterways. The potential for pollution of the waterways during construction would be controlled and managed by compliance with the project-specific requirements.

While the greatest potential for water quality impacts are related to construction works in close proximity to the waterways, adverse water quality outcomes could result from construction works anywhere within the catchments. On this basis and ignoring the controls which would be implemented, adverse water quality outcomes may occur along:

- Banyule Creek – more major drain diversion of small ephemeral waterway and construction of storages
- Yarra River – no direct impact on main river channel although construction would locally affect some floodplains and would need appropriate management
- Koonung Creek – earthworks and diversions along a significant length of creek.

The potential for construction works to result in residual impacts on habitat and water quality would be effectively limited by a design and implementation in accordance with the project-specific requirements as well as being limited to the duration of the works.

Proposed avoidance and mitigation measures

Compliance with the project-specific requirements would involve:

- Where practical, works would be scheduled to reduce the likelihood of interaction with significant flows, noting that some aspects of construction would likely exist over a period of several years
- The potential for the mobilisation of sediment or other materials (including hazardous materials) would be appropriately managed
- The likely loss of attenuation due to the piping of overland flows would be offset with additional appropriately designed storages to manage the potential for downstream flooding or erosion which may otherwise result
- Construction risks would be appropriately managed to reduce the potential for adverse water quality outcomes.

Residual impact

With appropriate management and controls, the residual surface water quality impacts on MNES areas during construction would be limited in extent and as predicted by hydrologic and hydraulic modelling. The most significant residual impacts would be associated with the removal and underground diversion of existing open channels, with a lesser and more temporary residual impact associated with the realignment of some sections of waterway. The significance of any loss of this potential MNES habitat is assessed in PER Technical Appendix A – Flora and fauna. With appropriate management measures as mentioned above, the residual impacts on waterways with respect to surface water quality are relatively minor.

8.1.2 Surface water flow impacts on Matters of National Environmental Significance (MNES)

The construction of North East Link has some potential to impact MNES. The potential impacts in terms of changes to stormwater runoff volumes or the frequency, velocity, level and depth of flooding are generally small enough that they would have no direct impact on MNES. However, changes in flow regime may impact habitat that, subject to assessment by relevant ecological specialists, may be significant to MNES.

Impact description

Changes in flow regimes have the potential to affect habitat which may be of significance to MNES. For this to occur there would need to be a change to the flow regime that results in more on less frequent overtopping into the flood plain, increased erosion or deposition, or undergrounding of an open waterway. Compliance with the project-specific requirements would minimise any change to the frequency of flooding and the potential for erosion and deposition. While undergrounding open waterways during construction, surface waterway diversions and associated earthworks would likely be minimised. Undergrounding is expected along parts of Banyule Creek and Koonung Creek, and would subsequently remove some waterway habitat locally in these areas. Some of these waterway and waterbody changes would have a relatively short-term impact on habitat, while vegetation is re-established. Other changes such as the undergrounding of parts of Koonung Creek would have a permanent impact. The significance of this habitat removal on MNES (if any) is assessed in PER Technical Appendix A – Flora and fauna.

The greatest potential for changes to surface water associated habitat are related to the expected undergrounding along parts of Banyule Creek upstream of Lower Plenty Road and sections of Koonung Creek where space for widening the Eastern Freeway is limited. The diversion of parts of Koonung Creek and modifications to wetlands along Koonung Creek may have shorter-term impacts during construction as vegetation is re-established.

The Trinity Grammar School wetlands used for irrigation water storage currently receive flow from a diversion from an urban stormwater system to the east. Construction of North East Link is expected to require the emptying of this irrigation water storage. This dewatering might potentially be assisted by modifying the existing diversion of flows from the urban catchment to the east to reduce flows to the storage. This could change the flows feeding the Trinity Grammar School wetlands which may potentially impact habitat which may be important for MNES.

In the absence of effective controls, adverse habitat outcomes may occur during construction along:

- Banyule Creek – major drain diversion of small ephemeral waterway and construction of storages
- Yarra River – no direct impact on main river channel although construction would locally affect some floodplains and would need appropriate management
- Koonung Creek – earthworks and diversions along a significant length of creek.

The potential for construction works to result in residual impacts on habitat are limited to the duration of the works and would be limited by design and implementation in accordance with the project-specific requirements.

Proposed avoidance and mitigation measures

Compliance with the project-specific requirements would involve:

- Where practical, works would be scheduled to reduce the likelihood of interaction with significant flows, noting that some aspects of construction would likely exist for more that several years
- The potential for the mobilisation of sediment or other materials (including hazardous materials) would be appropriately managed

- The likely loss of attenuation due to the piping of overland flows would be offset with additional appropriately designed storages to manage the potential for downstream flooding or erosion which may otherwise result.

Residual impact

With appropriate management and controls, the residual surface water flow impacts on MNES areas during construction would be limited in extent and as predicted by hydrologic and hydraulic modelling. The potential for construction works to affect water quantity has been identified and substantially mitigated using standard controls. The potential significance of water flow to MNES is documented in PER Technical Appendix A – Flora and fauna.

8.2 Operation impacts

8.2.1 Surface water quality impacts on Matters of National Environmental Significance (MNES)

The operation of North East Link has some potential to impact MNES. The potential for changes in water quality sufficient to affect MNES is generally limited, not just by the mitigation measures but also by the urban nature of the existing waterways and the significant dilution of potential pollutants by the time they might impact MNES.

Impact description

Operational impacts on Koonung Creek with potential to affect MNES include modifications to the wetlands, undergrounding of some sections of creek and realignment of other sections. While these works would be minimised, they would affect some areas permanently and in others take some time to re-establish. Given the highly modified nature of much of Koonung Creek it is anticipated that, with the exception of locations where open waterways are being undergrounded, from a surface water perspective the long-term operational impact would be minimal with respect to the quality of the habitat which may support MNES.

In the absence of adequate controls, the operation of North East Link has the potential to generate pollutants that may find their way into the waterways. Compliance with the project-specific requirements would necessitate that potential for pollution of the waterways during operation would be controlled and managed. By treating a significant portion of all vehicle pollutants mobilised by stormwater runoff, modelling indicates that North East Link would achieve best practise pollutant reductions and achieve significant reductions in pollutant loads entering downstream waterways.

The potential for the operation of North East Link to result in a residual impact on water quality is limited by the level of treatment and spill management requirements as well as the level of dilution and, while less relevant to the Yarra River, the urban nature of the waterways.

Proposed avoidance and mitigation measures

Compliance with the project-specific requirements would involve:

- The potential for the mobilisation of sediment or other materials would be appropriately managed by maintaining existing flow regimes and providing adequate erosion protection to new or modified assets in the floodplain
- The likely loss of attenuation due to the diversion of overland flows would be offset with additional appropriately designed storages to manage the potential for downstream flooding or erosion which may otherwise result

- Operational risks such as generation of pollutants and spills would be appropriately managed to reduce the potential for adverse water quality outcomes – spills would be managed with the implementation of a spill management response plan and the provision of spill containment storages at key locations
- Discharge of seepage, deluge or other collected water would be appropriately managed with appropriate classification, treatment and disposal methods in accordance with authority requirements.

Residual impact

With appropriate management and controls, the residual surface water quality impacts on MNES areas from the operation of North East Link would be limited in extent and minimal as predicted by hydrologic and hydraulic modelling.

8.2.2 Surface water flow impacts on Matters of National Environmental Significance (MNES)

The operation of North East Link has some potential to impact MNES. The potential impacts in terms of stormwater volumes or changes in the frequency, velocity, level and depth of flooding are generally small enough that they would have no direct impact on MNES. However, changes in flow regime may have the potential to affect MNES habitat. The significance of these impacts on MNES is assessed in PER Technical Appendix A – Flora and fauna.

Impact description

Changes in flow regime have the potential to affect habitat which may be of significance to MNES. For this to occur, there would need to be a change to the flow regime that results in more or less frequent overtopping into the flood plain, increased erosion or deposition, or undergrounding of an open waterway. Compliance with the project-specific requirements would minimise any change to the frequency of flooding and the potential for erosion and deposition. The replaced surface water paths along Banyule Creek would have permanently changed characteristics (such as size, location and improved stability). Preliminary discussions with the project ecologists indicate the likely changes in this area would unlikely significantly improve or reduce habitat which supports MNES.

Operational impacts on Koonung Creek with potential to affect MNES include modifications to the wetlands, undergrounding of some sections of creek and realignment of other sections. While these works would be minimised, they would affect some areas permanently and in others take some time to re-establish. Given the highly modified nature of much of Koonung Creek it is anticipated that, with the exception of locations where open waterways would be undergrounded, from a surface water perspective the long-term operational impact would be minimal with respect to the quality of the habitat which may support MNES.

The Trinity Grammar School wetlands used for irrigation water storage currently receive flow from a diversion from an urban stormwater system to the east. On completion of construction, it is likely the flow to the Trinity Grammar School wetlands would revert back to the existing arrangement and so remain unchanged during operation. However, maintaining the irrigation function of the wetlands may be satisfied in a number of ways, which may involve changes to the source and volume of flow to the wetlands

It is expected there would be some residual impacts to surface water-related habitat affected by undergrounding or diversions along parts of Banyule Creek upstream of Lower Plenty Road and sections of Koonung Creek where space for widening the Eastern Freeway is limited. The significance of these areas with respect to MNES are assessed in PER Technical Appendix A – Flora and fauna.

Proposed avoidance and mitigation measures

Compliance with the project-specific requirements would involve the following:

- The potential for the mobilisation of sediment or other materials would be appropriately managed
- The likely loss of attenuation due to the diversion of overland flows would be offset with additional appropriately designed storages to manage the potential for downstream flooding or erosion which may otherwise result
- Where waterway modifications are necessary, they would consider the need for, amongst other things, maximising the environmental conditions including habitat, connectivity, refuge and hydraulic conditions to support aquatic ecosystems of the waterways.

Residual impact

With appropriate management and controls, the residual surface water flow impacts on MNES areas from the operation of North East Link would be limited in extent and as predicted by modelling. It is expected there would be some residual impact to surface water-related habitat associated with the removal and underground diversion of existing open channels. The significance of the loss of this potential MNES habitat is assessed in PER Technical Appendix A – Flora and fauna.

9. Facilitated impacts and cumulative impacts

9.1 Cumulative impacts

There is the potential for surface water related cumulative impacts associated with North East Link, where potential impacts within individual sub-catchments could be cumulative in the wider catchment or in association with other future works. This particularly relates to flood risk and water quality effects associated with stormwater runoff from additional pavement areas.

The potential effects of increased stormwater runoff, changes to flood storage and changes to flood conveyance on flooding risk have been assessed. Based on the assessment undertaken and the proposed project-specific requirements, it is expected that flooding risk could be managed locally and in accordance with the requirements of the applicable drainage authority (typically Melbourne Water or local council). Accordingly, cumulative impacts on flooding risk are unlikely.

With respect to water quality, water sensitive urban design measures are proposed as part of the project design to manage water quality. Wherever possible, this would be undertaken at a sub-catchment level, although in some locations it would be done in the wider catchment, or in some instances through compensatory works in a different catchment. Overall no adverse cumulative impacts on water quality are expected.

With respect to floodplain storage, North East Link has the potential to reduce the available floodplain storage associated Banyule Creek, the Yarra River and Koonung Creek. At Banyule Creek, the only creek with direct interaction with Commonwealth land, modelling indicates that local treatment measures would provide adequate mitigation so that downstream environments would not be adversely affected.

For the Yarra River, potentially a significant receptor in terms of MNES, the expected impacts are proportionally small and in themselves not likely to be significant. However, mitigation works may be required to address the potential for cumulative impacts from numerous projects over time to prevent the incremental reduction in performance of the overall system from lots of small independently insignificant changes. If needed, this mitigation would be designed in consultation with Melbourne Water.

The effects and potential mitigation mechanism are still being refined for Koonung Creek, the expectation is that design development and modelling would verify that local as well as downstream impacts could be mitigated.

There is also the potential for cumulative impacts due to the combined effects of North East Link and other separate upgrades to the M80 Ring Road planned by VicRoads in the immediate vicinity and with respect to the upgrade of the Chandler Highway Bridge across the Yarra River. However, no cumulative impacts have been identified because the construction periods of these projects would not overlap and each project would be designed to meet the relevant flooding and water quality requirements during their operation.

10. Avoidance and mitigation measures

This section presents a consolidated list of the avoidance and mitigation measures proposed to address relevant impacts on MNES, Commonwealth land and surface water values across North East Link. These include measures to mitigate impacts specifically related to impacts on surface water values as well as other measures to avoid and mitigate general construction and operation impacts. Sections 7, 8 and 9 describe the measures in more detail for each relevant impact.

A range of environmental management plans would be developed and implemented for the construction and operation of North East Link. These plans would support implementation of the measures described in this section. An independent environmental auditor would review the environmental management plans and proposed management measures prior to the construction or operation works that were the subject of the plans. The independent environmental auditor would conduct regular audits of compliance with the environmental management plans.

10.1 Surface water specific measures

Key measures to mitigate impacts on surface water values would include:

- Adoption of Urban Stormwater Best Practice Environmental Management Guidelines to comply with SEPP (Waters) during operation
- Adoption of water sensitive urban and road design (WSUD) and integrated water management principles in the design of stormwater treatment, in consultation with the relevant asset owner or land manager and in general accordance with the Urban Design Strategy
- Designing systems to mitigate flood risk at relevant locations to appropriate standards, including considering future scenarios (such as impacts of climate change including increased rainfall intensity and sea level rise as relevant)
- Managing waste water appropriately during construction and operation to prevent unregulated discharges to the environment
- Designing the operational stormwater drainage system for all freeway pavements (including ramps) to manage the risk of hazardous spills and meet AustRoads requirements
- Developing a surface water-monitoring program before and during construction, which would:
  - Assess surface water quality in multiple locations at suitable distances upstream and downstream of works to establish baseline conditions
  - Be developed in consultation with EPA Victoria and Melbourne Water
  - Be used to inform the development and refinement of a Surface Water Management Plan
- Implementation of a Surface Water Management Plan addressing:
  - Best practice management of erosion and sediment control and monitoring
  - Measures to maintain key hydrologic and hydraulic functionality and reliability of existing flow paths and flood plain storage
  - Measures to be undertaken to ensure existing flow characteristics are retained to maintain downstream stability

  - The location of any contaminated material within the project boundary and details of bunding of materials and significant excavations including tunnel portals and interchanges
  - Works scheduling to reduce flood-related risks
  - The existing conditions of all drainage assets potentially affected by works to enable baseline conditions to be established and the potential construction impacts on the assets to be managed
- Development of measures to observe changes in conveyance and flood plain storage. This will be undertaken using modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile in accordance with Standards for Infrastructure in Flood-Prone Areas (2019)
- Development of Flood Emergency Management Plans for construction and operation. The management plans would provide measures to manage flood risk to construction sites, tunnel portals, interchanges and substations as well as emergency management procedures
- Design waterway modifications to mitigate effects from changes in flow and minimise the potential for erosion, sediment plumes, exposure of contaminated material and visual amenity
- Maintaining bank stability through suitable measures to be decided on by the appointed contractor
- Maintaining adequate clearances and access for ongoing maintenance of existing drainage assets
- Maintaining existing storage and available water supply for impacted stakeholders
- Meet or exceed water quality treatment performance as originally designed for that asset.

10.2 Other measures

Other measures that would be developed and implemented to mitigate impacts on surface water quality values throughout North East Link include:

- Construction and Operation Environmental Management Plans (CEMPs) outlining:
  - Management of chemicals, fuels and hazardous substances, including incident and emergency response procedures and provision of spill kits on construction sites
  - Minimising and appropriately managing waste in accordance with Victoria's *Environment Protection Act 1970*
- A Dust and Air Quality Management Plan to minimise dust and air quality impacts during construction, in consultation with EPA.

11. References

ANZECC 2000, *Australian and New Zealand guidelines for fresh and marine water quality*, Volume 1, The guidelines/Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

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Appendices

Appendix A – Melbourne Water standards for infrastructure projects in flood-prone areas

Melbourne Water standards for infrastructure projects in flood-prone areas

1. Purpose

Melbourne Water as the Floodplain Manager for the Port Phillip and Westernport catchments is responsible under the Water Act (1989) to oversee development works that have the potential to change the characteristics of the floodplain. This document provides the minimum requirements for any proposed project works that have the potential to impact on any flood-prone area within Melbourne Water's (MW) area of responsibility.

Melbourne Water requires a proponent to meet these standards or otherwise demonstrate why they cannot and how they have appropriately mitigated or minimised any associated flood risks.

2. Melbourne Water's Guiding Principles

Melbourne Water has five guiding principles for the assessment of development in flood-prone areas:

a) Risk to people and property must not increase as a result of the development.

b) Any development within a flood-prone area must be suitably designed for conditions that might be experienced and to reduce the reliance on emergency service personnel when flood events occur.

c) Climate change must be considered in the design.

d) Proponents must identify existing flood risk and should work with Melbourne Water to identify opportunities to reduce these risks.

e) Flood risk must be assessed at both the local and regional scale.

3. Melbourne Water's Standards

Melbourne Water uses these standards to guide its flood risk assessment:

a) **Flood Flow: Works or structures should not affect floodwater flow capacity.**

This ensures that existing flood levels are not made worse by alterations to the flow characteristics of a floodplain or overland flow path.

b) **Flood Storage: Works or structures should not reduce floodwater storage capacity.**

This prevents higher flood levels that may occur if the available storage volume is reduced.

c) **Freeboard: Works or structures should not reduce minimum freeboard[1].**

This ensures there is no adverse impact on existing property and infrastructure.

[1] For new structures Melbourne Water requires 600mm and 300mm freeboard for Waterway and drainage flood extents respectively; where the structure is designed for 100 years or more, climate change must be included with freeboard.

d) **Site Safety Requirements: Works or structures should not create new hazards or increase existing hazard.**

Development will not be allowed where the depth and flow of floodwaters would create new hazard or increase existing hazards.

e) **Access Safety Requirements: Access safety requirements should be taken into account.**

Development cannot be allowed in circumstances where the depth and flow of floodwater affecting access to the property is hazardous.

f) **Climate Change Requirements: Flood plain impacts of works or structures must be considered, consistent with the approach specified in ARR2016, for the following climate change scenarios:**

i. **Sea-level rise** – An increase of 0.8m by the year 2100 is the current standard for sea level rise assessments.

ii. **Increase in rainfall intensity** – A rainfall intensity increase figure must be derived from either the AR&R 2016 Book or the AR&R Data Hub. The adopted figure must reflect the project's asset life and the project's flood protection technical performance requirements.

4. Other applicable standards and guidelines

Melbourne Water requires the proponent to consider and address, where applicable, any additional requirements specified in Melbourne Water and industry best practice standards and guidelines, including but not limited to:

- Australian Rainfall & Runoff 2016[2].
- Melbourne Water's Land Development Manual.
- Melbourne Water's Guidelines for development in flood-prone areas.
- Melbourne Water's Shared user path guidelines.
- Melbourne Water's Guidelines for Development within the Koo Wee Rup Flood Protection District
- Melbourne Water Corporation Flood Mapping Projects Guidelines and Technical Specifications November 2018

[2] Melbourne Water has adopted the information and approaches defined in the draft Australian Rainfall and Runoff 2016 (ARR2016) guidelines as current best practice for the development and analysis of hydraulic and hydrological models for the purpose of stormwater and flood flows simulations. As stated by Geoscience Australia (Commonwealth of Australia, Geoscience Australia 2016) where relevant the draft ARR2016 can be used in practice prior to finalisation.

5. Deliverables

5.1 Scenarios

Melbourne Water requires the proponent to model or assess the risks of the following scenarios at applicable stages (reference design, preliminary and detailed design/for construction):

a) Pre-existing flood conditions (the 'base case') should be modelled at each stage

b) Project ultimate design flood conditions (the 'proposed' case) including any variation from the 'base case' should be modelled at each stage. Mitigation options should be presented where project works adversely impact flooding.

c) Temporary construction works flood condition (inclusive of the works method steps/staging, site access, haul roads etc.)[3] should be risk assessed at the reference design stage and modelled at each subsequent stage.

Melbourne Water will provide advice through our comments and specified requirements but will not undertake model reviews of structural and methodological changes between major milestones.

5.2 Parameters

The following results must be presented where the effects of the proposed design and temporary works can be assessed against the pre-existing conditions. All pre and post assessments must be done at several locations for at least the following:

- Flows (in m^3/s)
- Velocities (in m/s)
- Product of Velocity and Depth (V x D in m^2/s)
- Flood Levels to m AHD
- Depth in metres (m)
- Any cut and fill balance information
- Clearly showing where the flooding conditions have changed and how much
- All manning's values used in modelling and assessment should be accompanied by justification in a summary modelling note.
- For ease of assessment these must be provided in three separate MapInfo tables representing each scenario.
- Site specific detailed design model should be created for the project. Melbourne Water's regional model should be updated.

[3] At reference design, if the staging of construction is known the risks must be identified through qualitative measures. A flood management plan will be required for any temporary works.

5.3 Hydrology and hydraulic submissions

Hydrology and hydraulic submissions must include:

- A design model. This must include project specific and local detail.
- Melbourne Water's regional model must be updated with the design information. If the design changes during construction the model must be resubmitted incorporating the changes.
- Models must be submitted for the following AEP events (20%, 10%, 5%, 2% and 1% and climate change).
- Where rarer events are run, models and results of these runs.
- Where deemed necessary an independent peer review of submissions must be undertaken. This independent peer review would be managed by Melbourne Water at the expense of the proponent.
- A log file must be submitted detailing model runs/scenarios.
- Modelling assumptions and parameters must be submitted with reference to the standards.
- The submitted model must be error free and stable.
- A report outlining the modelling methodology and results must be provided in a report format.
- Data must be supplied in digital format - MW can provide the proponent with the file types to submit on request.

6. Timeframes

Please allow the following timeframes when submitting information to MW for review:

SUBMISSION	REVIEW PERIOD
Preliminary Advice	28 Business Days or Subject to number of models and size of reports
Detailed Design Reports & Models	28 Business Days
Final Detailed Designs	10 Business Days
General queries (1 – 2 pages)	5 Business Days

Document History

Date	Reviewed/ Actioned By	Version	Action
May 2018	Ruwan Jayasinghe, Principal Flood Modelling & Mapping	1.0	
July 2018	Jean-Michel Benier, Team Leader Flood Information	2.1	
February 2019	Jean-Michel Benier, Team Leader Flood Information	2.2	

Appendix B – High-level preliminary review of surface water features

The table below provides a high-level review of surface water features including waterways, drains and other surface water bodies in close proximity to North East Link. The table was prepared to identify which sites were potentially impacted by North East Link and in particular to help direct focus on areas where additional assessment and controls may be required to investigate and manage these potential impacts.

Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Rivers and creeks (including associated floodplains)							
Banyule Creek	Small ephemeral urban creek upstream of Lower Plenty Road	The entire length of this section of creek would be realigned to either side of the road. Works would include a tunnel portal and a retarding basin.	Changes to flood conveyance, storage and attenuation, water quality treatment and erosion potential	✓	✓	✓	·
	An urban creek downstream of Lower Plenty Road discharging to the Yarra River	Twin tunnels run roughly parallel to the creek occasionally passing at depth beneath it.	None	·	·	✓	·
Yarra River	Major waterway with considerable upstream catchment	Twin tunnels pass beneath the Yarra River at depth.	None	·	·	·	·
		Eastern Freeway bridge over the Yarra River to be widened	Relatively minor bridge widening	✓	·	✓	·
		Tunnel Portals and associated infrastructure within the floodplain	Loss of floodplain storage. Level of flood protection for tunnels	✓	·	✓	·
Merri Creek	Major urban creek which passes beneath the Eastern Freeway before discharging to the Yarra River	Near the western extent of the project. Line marking works only.	None	·	·	·	·
Plenty River	Significant tributary of the Yarra River	No direct interaction, receiving water for Yando Drain	None	·	·	·	·

Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Glass Creek	Yarra River tributary which passes beneath the Eastern Freeway to the west of Burke Road	Additional lanes at this location within the footprint of the existing freeway.	Additional pavement	✓	✓	·	·
Koonung Creek	A significant but highly modified urban tributary of the Yarra River with reaches varying from underground arches to semi-naturalised.	Diversions and realignment along sections of the Eastern Freeway to accommodate road widening	Potential loss of storage, attenuation, treatment and change in flows and waterway stability	✓	✓	✓	·
Main drains (including associated overland flow paths)							
Yando Street	Tributary of Plenty River	Project earthworks would reduce flood storage, extend culverts and change drainage inlets. Shared use bridge and piers would interact with floodplain	Potential increase in flood frequency and levels	✓	·	·	·
Kempston Street	Tributary of Yando Street Main Drain	Provision of the proposed shared use underpass would reduce the storage within the retarding basin immediately upstream (south) of Grimshaw Street. Further floodplain storage may be removed as a result of the northbound entrance ramp from Grimshaw street.	Potential increase in flood frequency and levels	✓	✓	·	·
		Potentially temporary construction compound in vicinity	Potential impact during construction				

Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Banksia Street	Yarra tributary	None	None	·	·	·	·
Alexandra Parade	Merri Creek tributary	None	None	·	·	·	·
Kew Mental Hospital	Yarra River tributary which passes beneath the Eastern Freeway to the west of Burke Road	Additional lanes at this location within the footprint of the existing freeway	Additional pavement	·	✓	·	·
Kew	Yarra River tributary which passes beneath the Eastern Freeway to the west of Burke Road	Additional lanes at this location within the footprint of the existing freeway	Additional pavement	·	✓	·	·
Glass Creek	Yarra River tributary which passes beneath the Eastern Freeway to the west of Burke Road	Additional lanes at this location within the footprint of the existing freeway	Additional pavement	·	✓	·	·
Aqulia St	Yarra River tributary which passes beneath the Eastern Freeway between Burke Road and Bulleen Road	Additional lanes at this location within the footprint of the existing freeway	Additional pavement	·	✓	·	·
Minerva Ave	An urban tributary of Koonung Creek	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected	Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·

Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Ayr Street	An urban tributary of Koonung Creek which passes beneath the Eastern Freeway from the north side	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected. Potential loss of flood storage and afflux.	Potential loss of flood storage and afflux on the north side. Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·
Gardenia Road	An urban tributary of Koonung Creek	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected	Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·
Elms Grove	An urban tributary of Koonung Creek which passes beneath the Eastern Freeway from the north side	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected. Potential loss of flood storage and afflux.	Potential loss of flood storage and afflux on the north side. Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·
Bushy Creek	An urban tributary of Koonung Creek	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected	Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·

Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Box Hill North	An urban tributary of Koonung Creek	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected	Nothing specific. Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·
Lees Road	An urban tributary of Koonung Creek	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected	Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·
Blackburn Road	An urban tributary of Koonung Creek	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected	Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·
Dunlavin Road	An urban tributary of Koonung Creek which passes beneath the Eastern Freeway from the south side	Indirect interaction with project is possible given that downstream connection to Koonung Creek may be affected. Potential loss of flood storage and afflux.	Potential loss of flood storage and afflux on the south side. Any changes would be part of the Koonung Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·

Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Other surface water bodies							
Kalparrin Gardens wetland and retarding basin	Wetlands on Yando St Main Drain, downstream of the works	Upstream works can affect the flows incoming	Could be affected by increased flow or pollutants	·	·	·	·
Grimshaw Street Retarding Basin	RB south and upstream of Grimshaw Street (north of AK Lines Reserve)	Proposed shared path might reduce storage in the basin	Loss of flood storage, possible afflux in the basin and increased flooding over Grimshaw Street	✓	·	·	·
Watsonia Station and rail line	Railway line under Greensborough Highway	Minimal if no extra runoff is directed to the rail corridor	None	·	·	·	·
Simpson Barracks wetlands	Informal wetlands at Simpson Barracks	Minor	Any changes would be part of the Banyule Creek works which would need to consider all tributaries and drainage inflows.	·	·	·	·
Banyule Flats	At the confluence of Banyule Creek and the Yarra River	Tunnelling under	None	·	·	·	·
Annulus Billabong	Billabong south of Manningham Road and north of Bolin Bolin Billabong	Across the river from works and temporary construction compound to be investigated in vicinity	None	·	·	·	·

Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Bolin Bolin Billabong	A billabong of high ecological and cultural significance to the north of the Veneto Club and Bulleen Park to the west of Bulleen Road.	No project interaction from a surface water perspective. Potential groundwater impacts are discussed in the groundwater report.	None	·	·	·	·
Bolin Bolin Storage and Wetland	Recently constructed on Crown land immediately south of Bolin Bolin Billabong to the Bulleen Road	Change in local drainage network upstream of the system	Potential change in flow to stormwater harvesting system.				✓
Trinity Grammar School Sporting Complex irrigation storage	Irrigation dam located on Banyule Road with overflow to Yarra River	Irrigation storage is intersected by the alignment	Loss of irrigation storage	·	·	·	✓
Trinity Grammar School Sporting Complex wetlands	Wetlands upstream of irrigation storage	Potential for changed outlet conditions or modifications to upstream diversion structure.	Potential change in flow regime.				
Chandler Park Wetlands	Proposed wetlands near eastbound entrance to Eastern Freeway from Chandler Highway	Extension of wetlands being investigated to allow for treatment of road runoff from the Eastern Freeway	Improve water quality treatment	·	✓	·	·
The Kew Billabong	North of Eastern Freeway west of Willsmere Park	Being investigated for water quality treatment use	Very minor loss of flood storage or increased pollutants	·	✓	·	·
Kew Golf Club Storage	Located immediately north of where Glass Creek crosses beneath the Eastern Freeway	Being investigated for water quality treatment use		·	✓	·	·

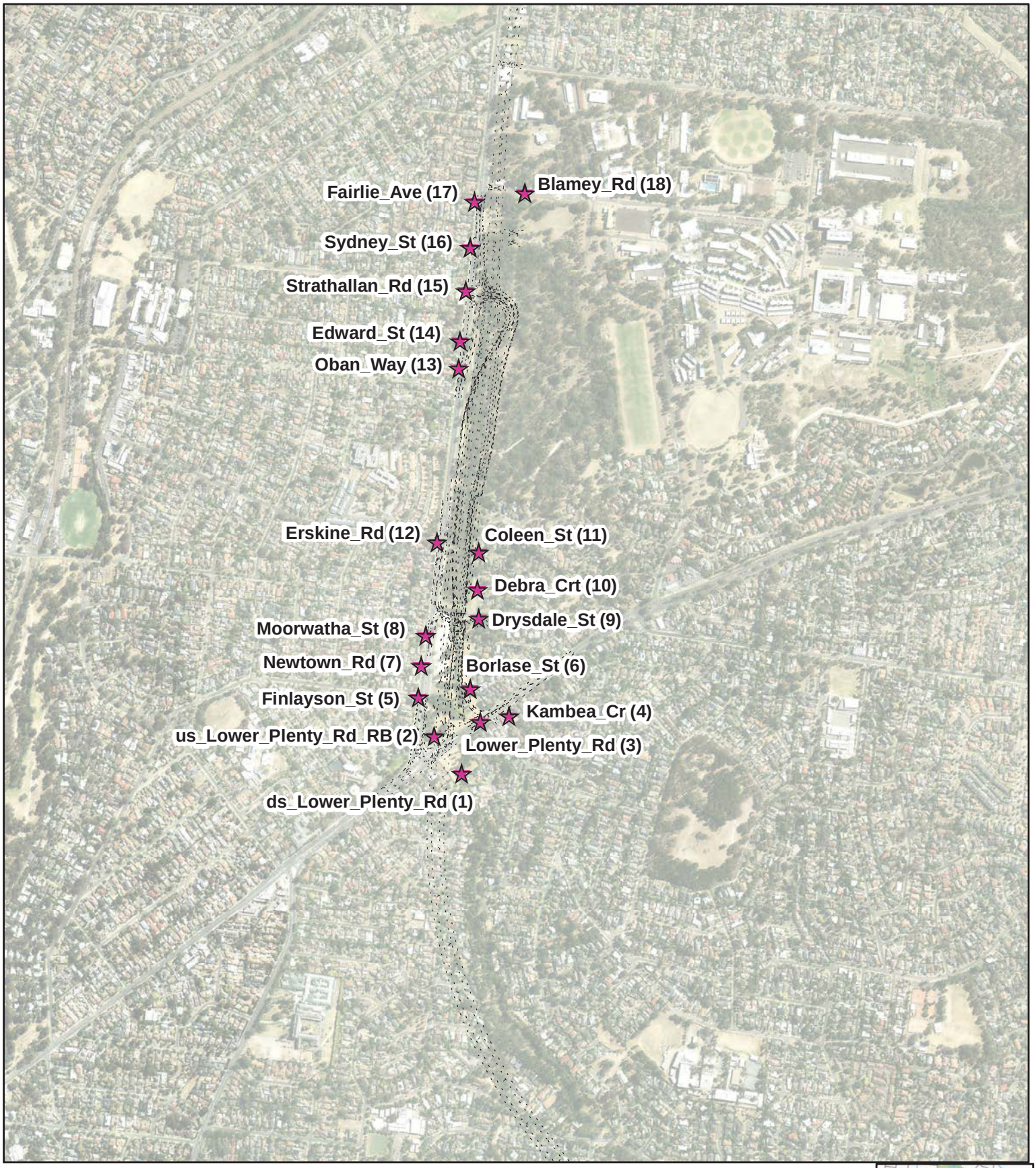
Surface water feature	Brief description	Interaction with project	Potential surface water impact	Further assessment			
				Flooding	Water quality	Geomorphology	Water supply
Burke Road Billabong Reserve	North-west of Burke Road crossing of Eastern Freeway	None	None	·	·	·	·
Freeway Golf Course Wetlands	Immediately north of the Eastern Freeway within the Yarra River floodplain	Being investigated for water quality treatment use		·	✓	·	·
Koonung Creek Wetlands (Wilburton Parade)	Wetlands on Koonung Creek, south of the Eastern Freeway	Relocation of wetland needs to be investigated		·	✓	·	·
Koonung Creek Wetlands (Valda Avenue)	Wetlands on Koonung Creek, south of the Eastern Freeway	Relocation of wetland needs to be investigated		·	✓	·	·
Koonung Creek Wetlands (Middleborough Road)	Wetlands on Koonung Creek, north of the Eastern Freeway	Being investigated for water quality treatment use		·	✓	·	·

Appendix C – Comparison of select model results at select locations.

C1 Banyule Creek

C2 Yarra River

C3 Koonung Creek



LEGEND

★ Selected Locations

Paper Size A4

0 85 170 340

Metres

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

N

NORTH EAST LINK PROJECT

North East Link
North East Link Project

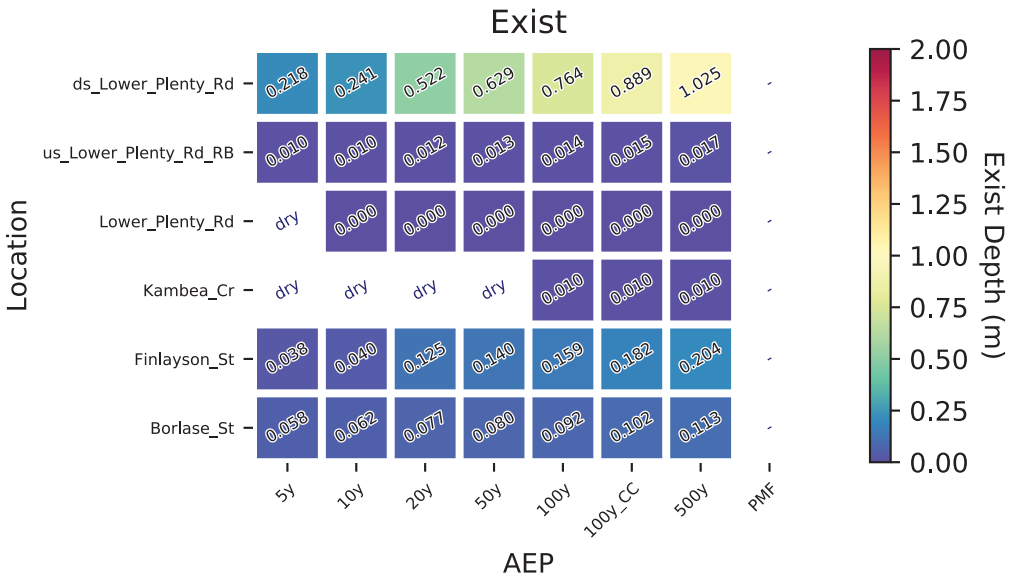
Job Number | 31-35006
Revision | C
Date | 13/11/2018

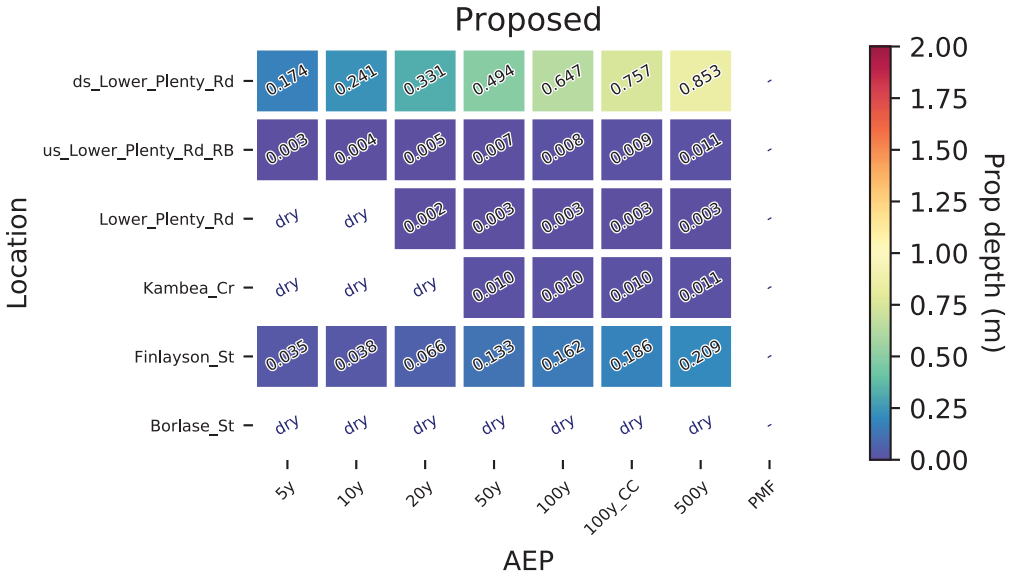
Banyule Creek Comparison Locations Appendix C-1

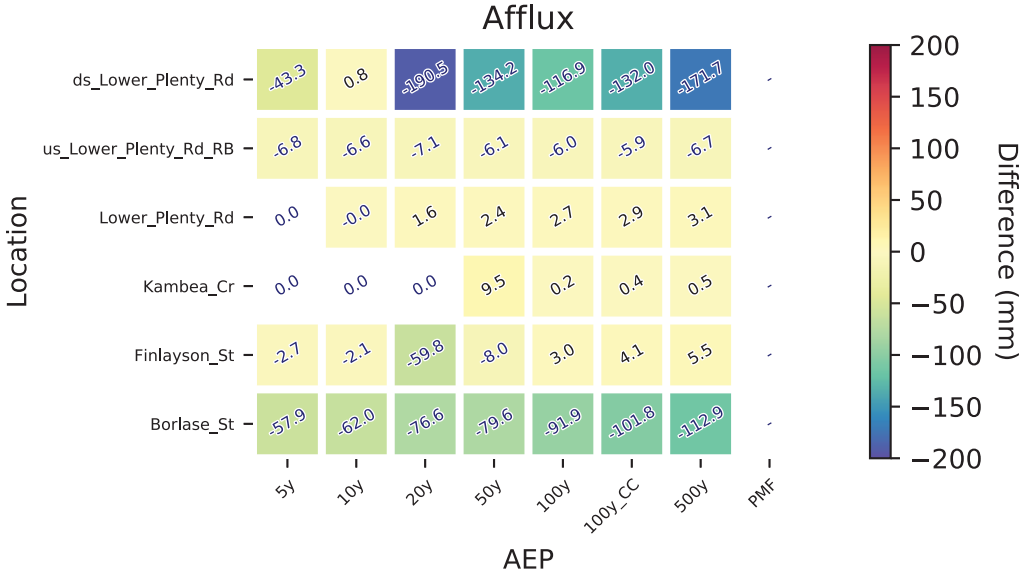
G:\31\35006\GIS\Maps\Working\Specialist Submission\EES\Groundwater and Hydrology\Surface_Water\35006_Hydraulics_KBM_A4P.mxd 180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

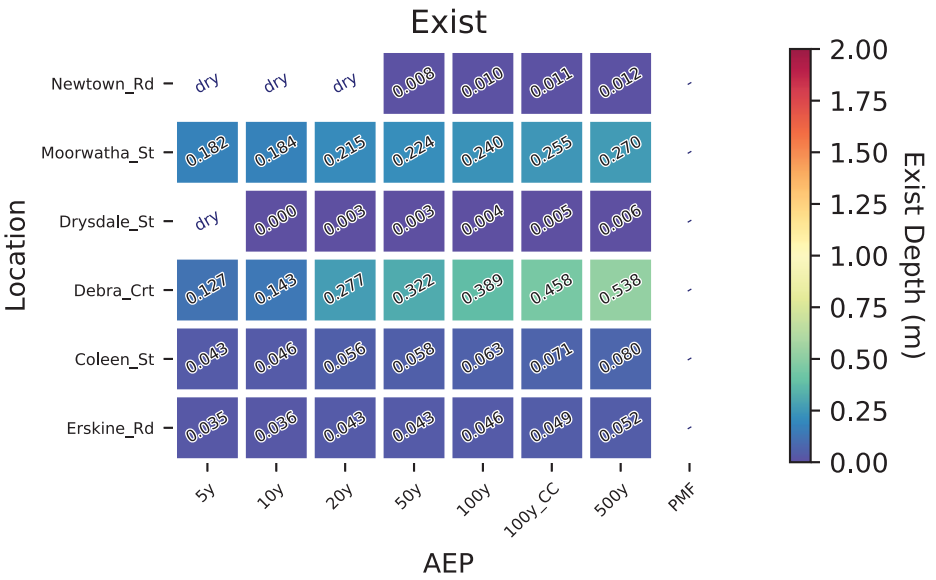
Banyule Creek - Overview

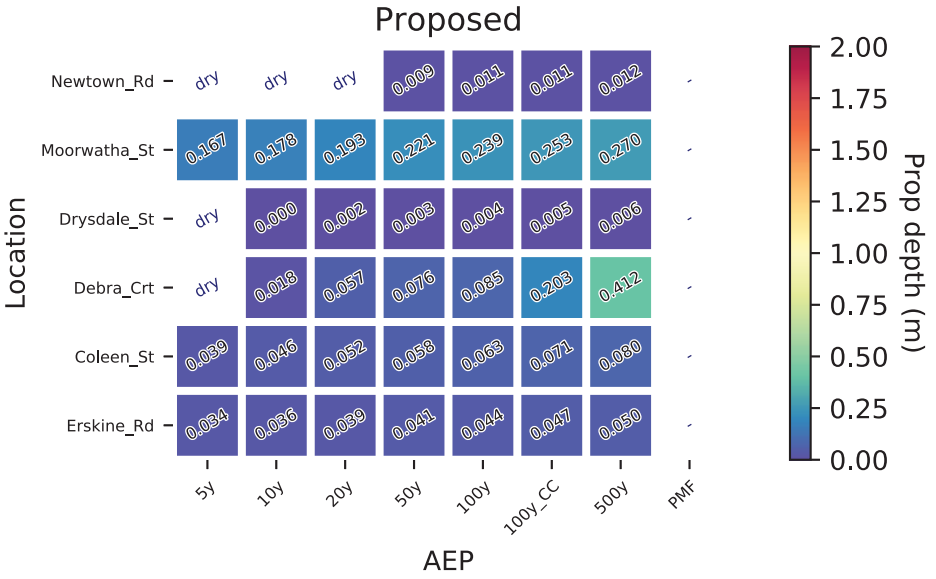


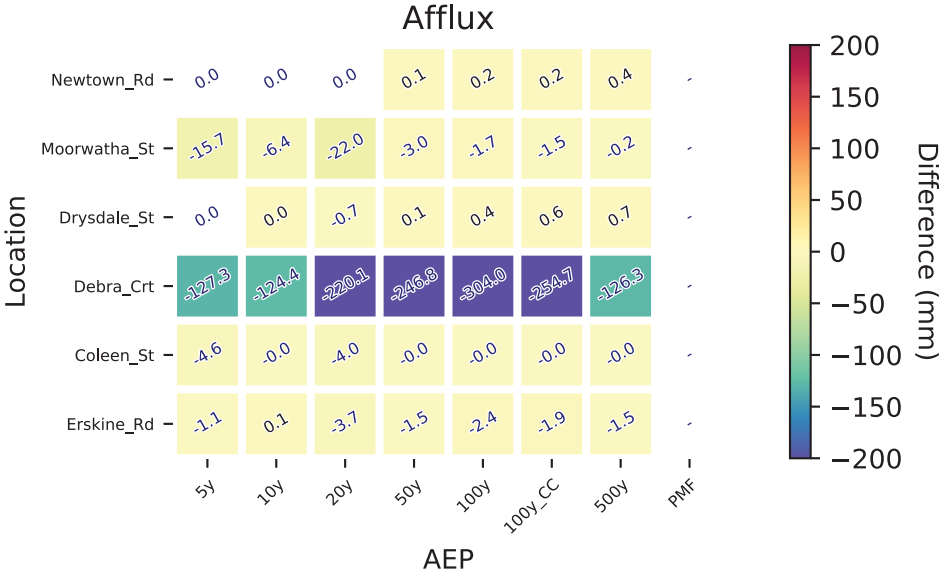




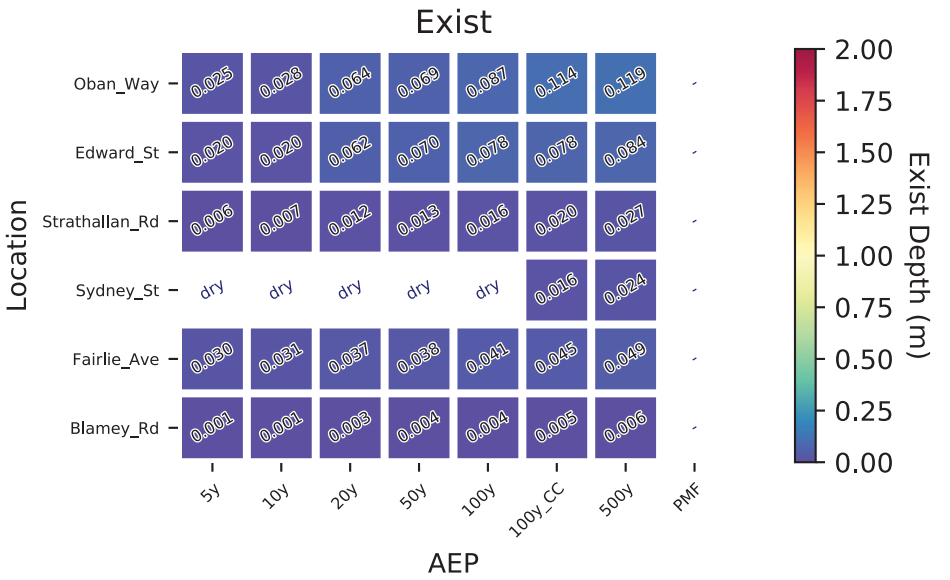
Banyule Creek - Overview

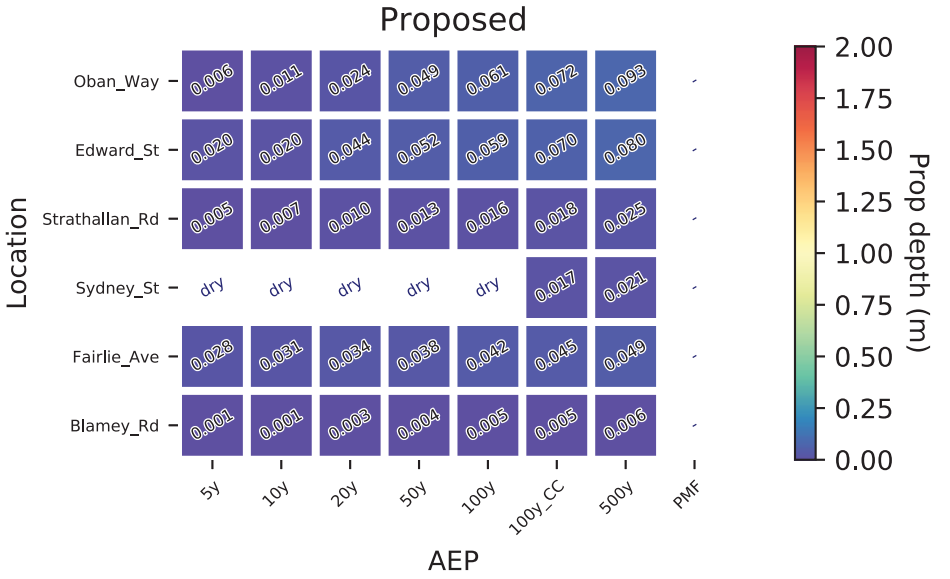


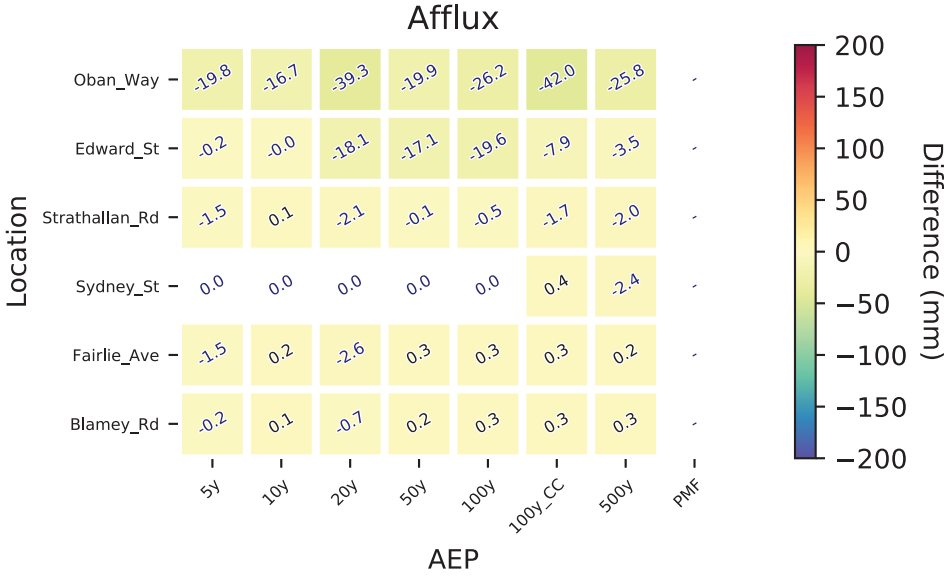




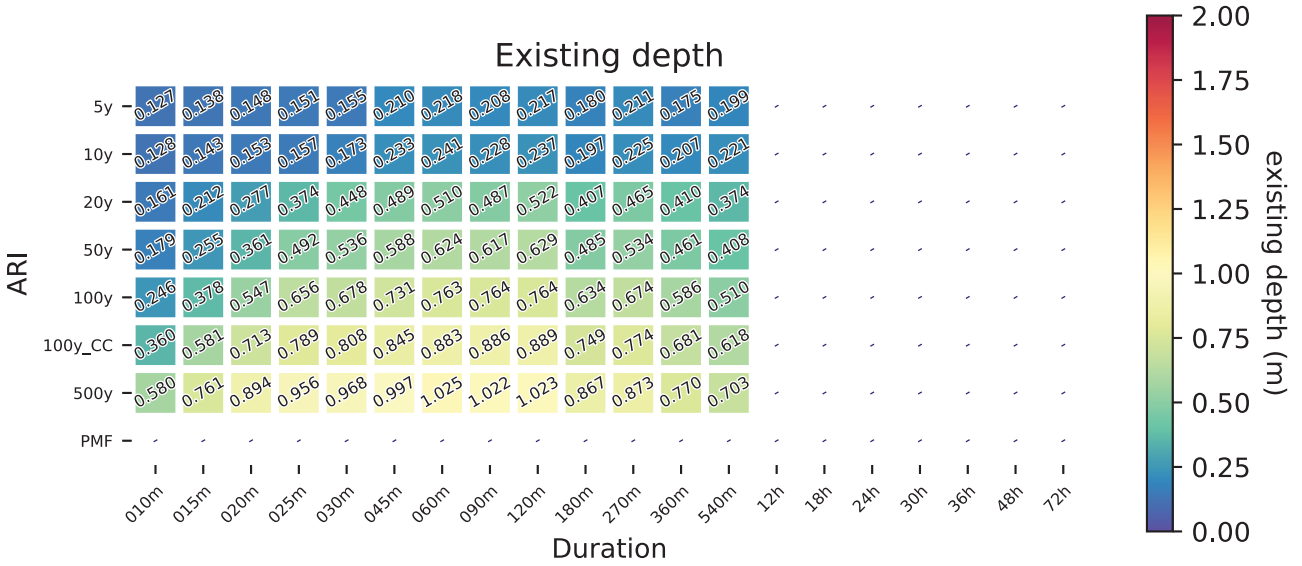
Banyule Creek - Overview

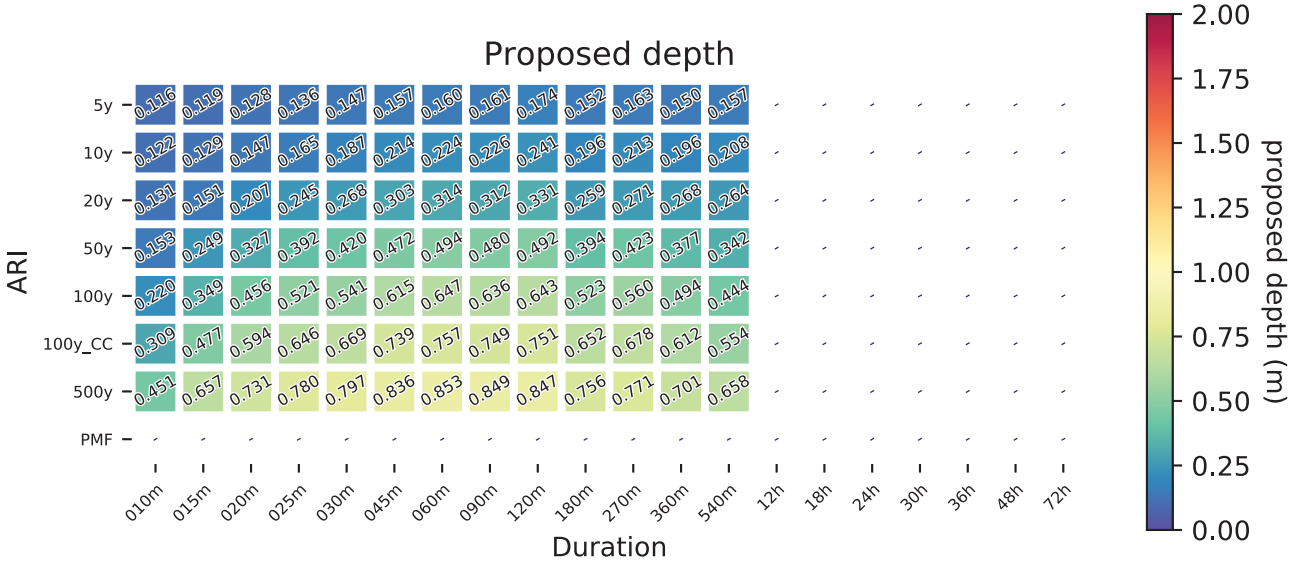


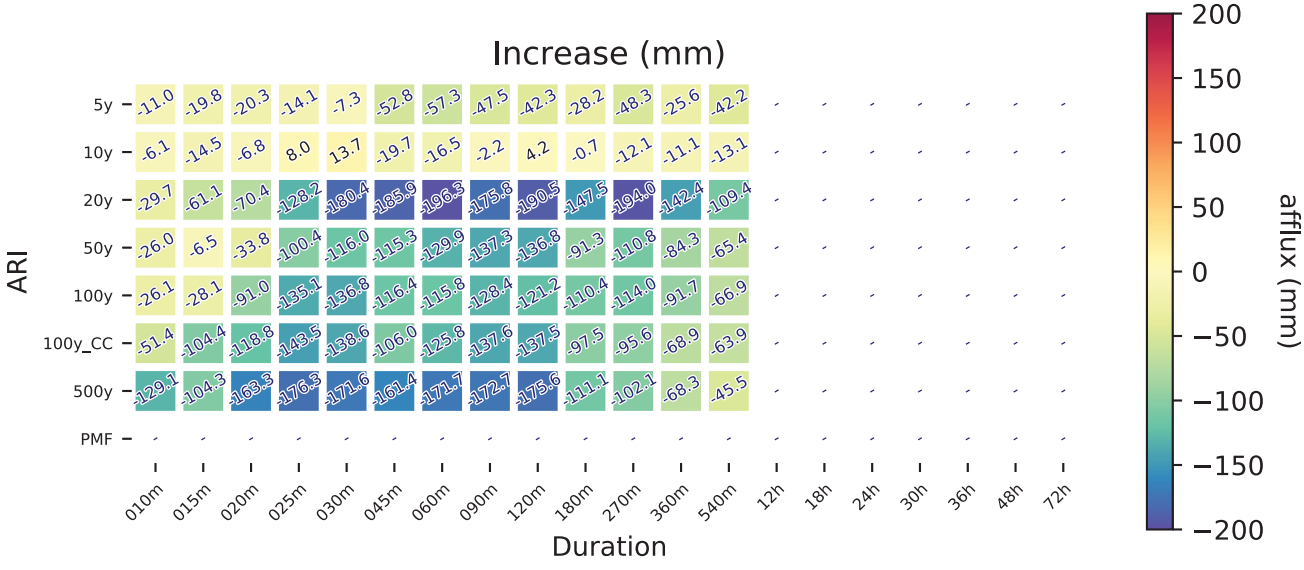




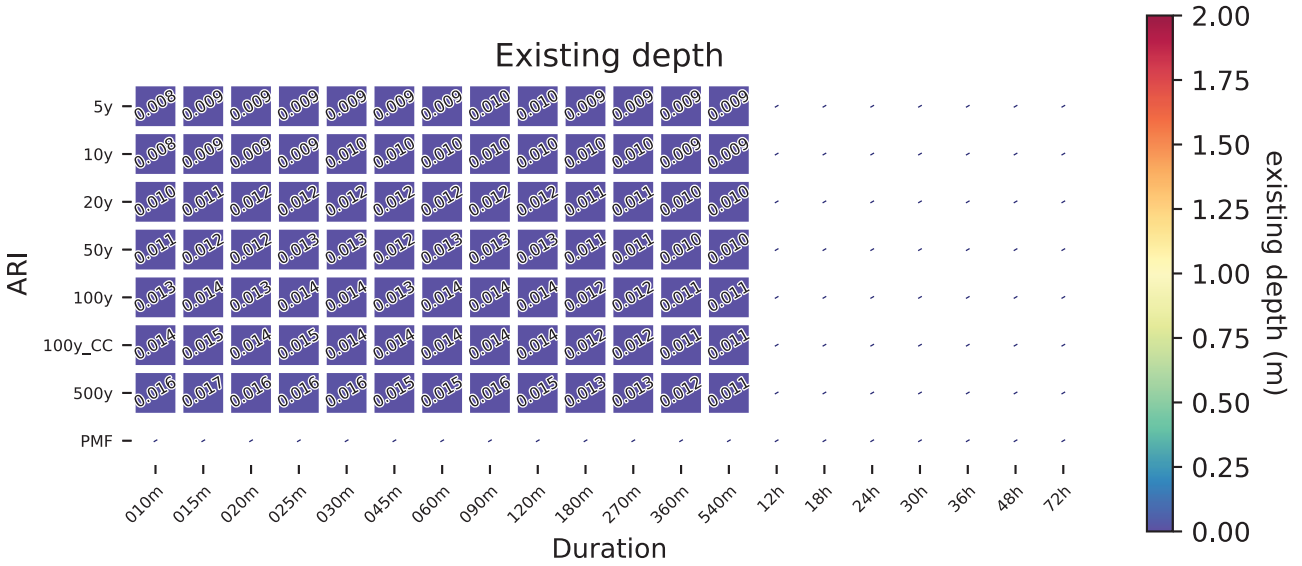
Banyule Creek - ds_Lower_Plenty_Rd

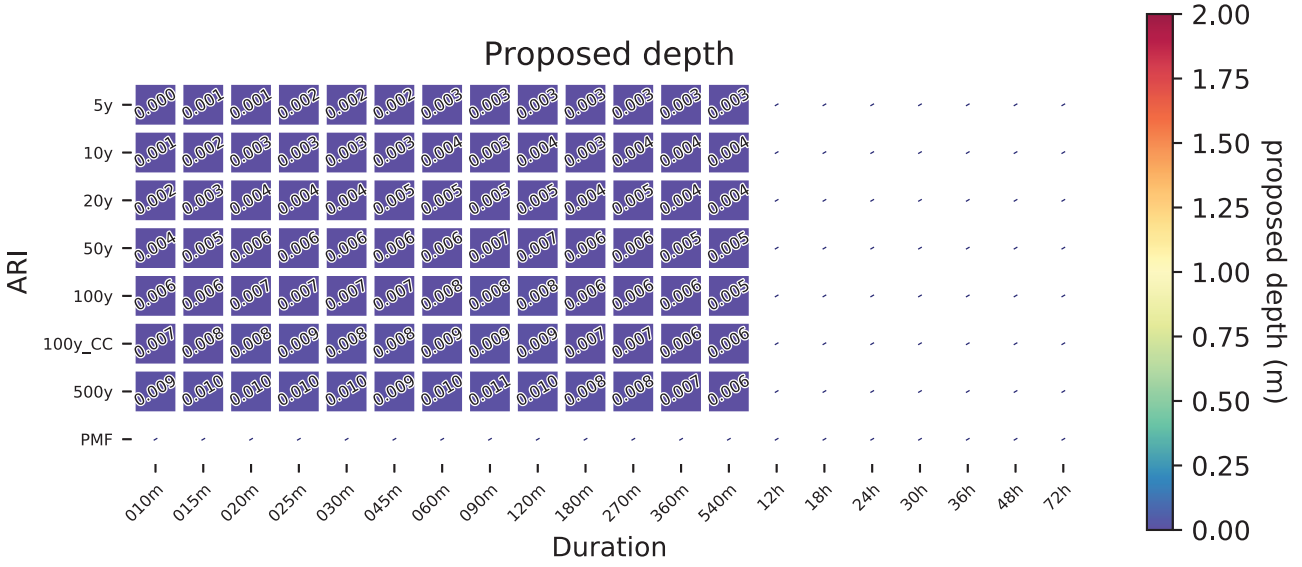


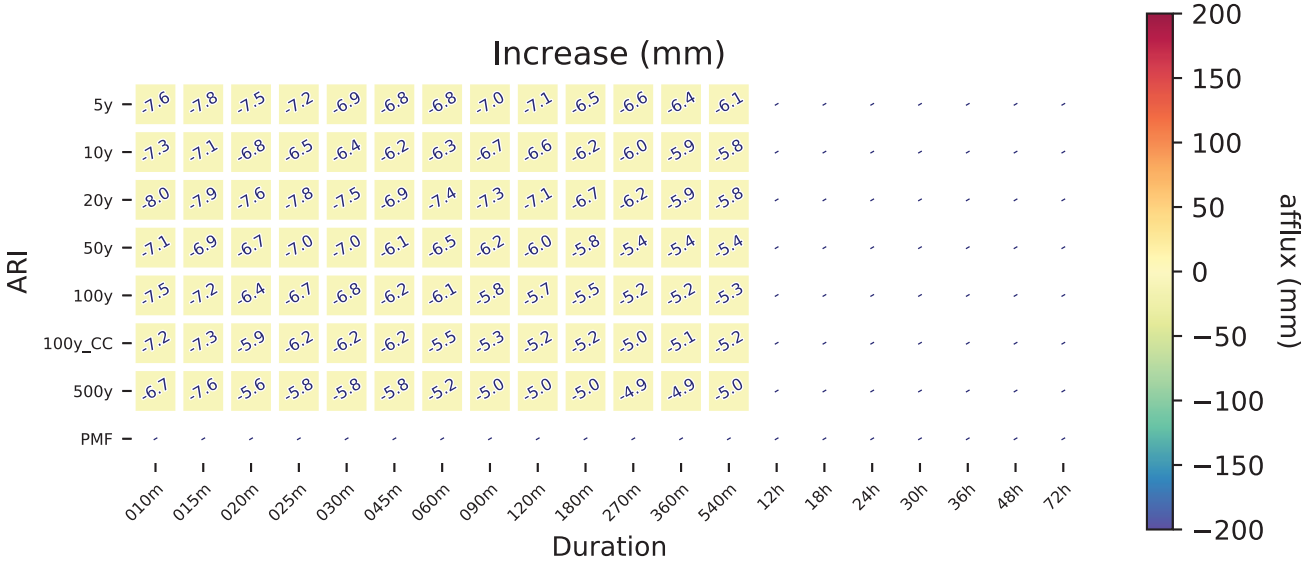




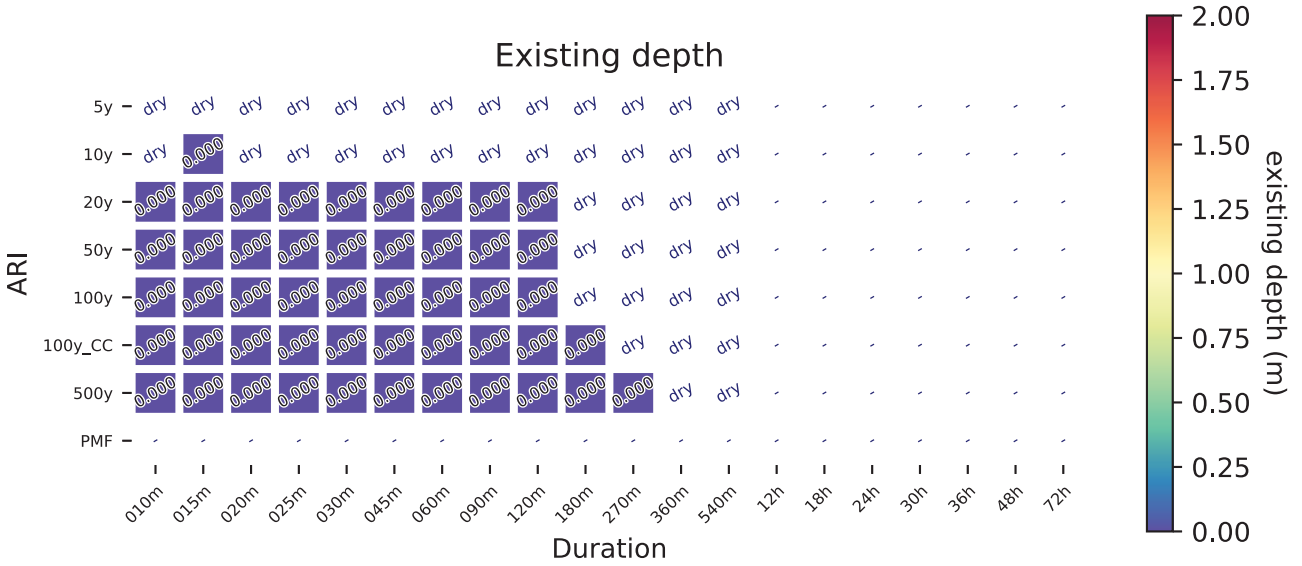
Banyule Creek - us_Lower_Plenty_Rd_RB

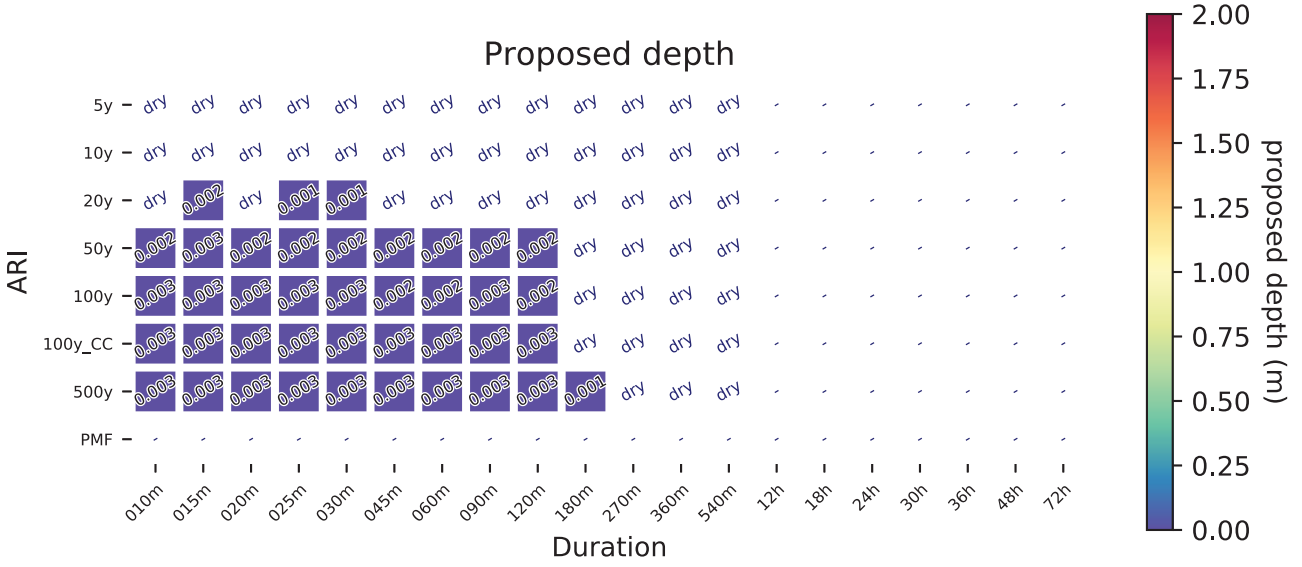


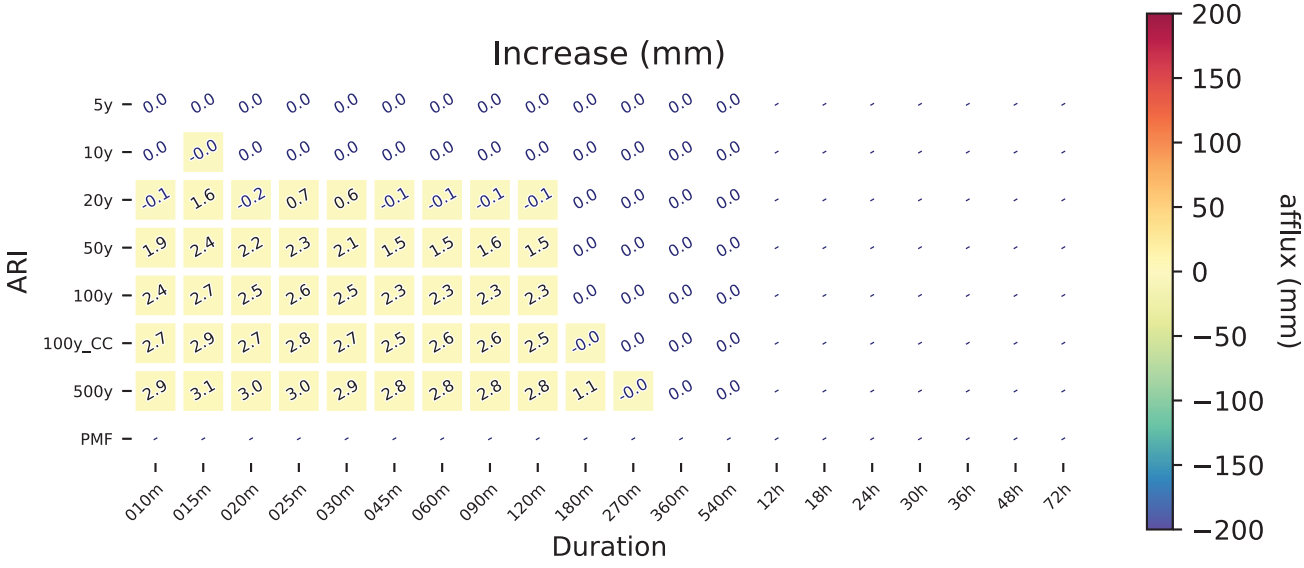




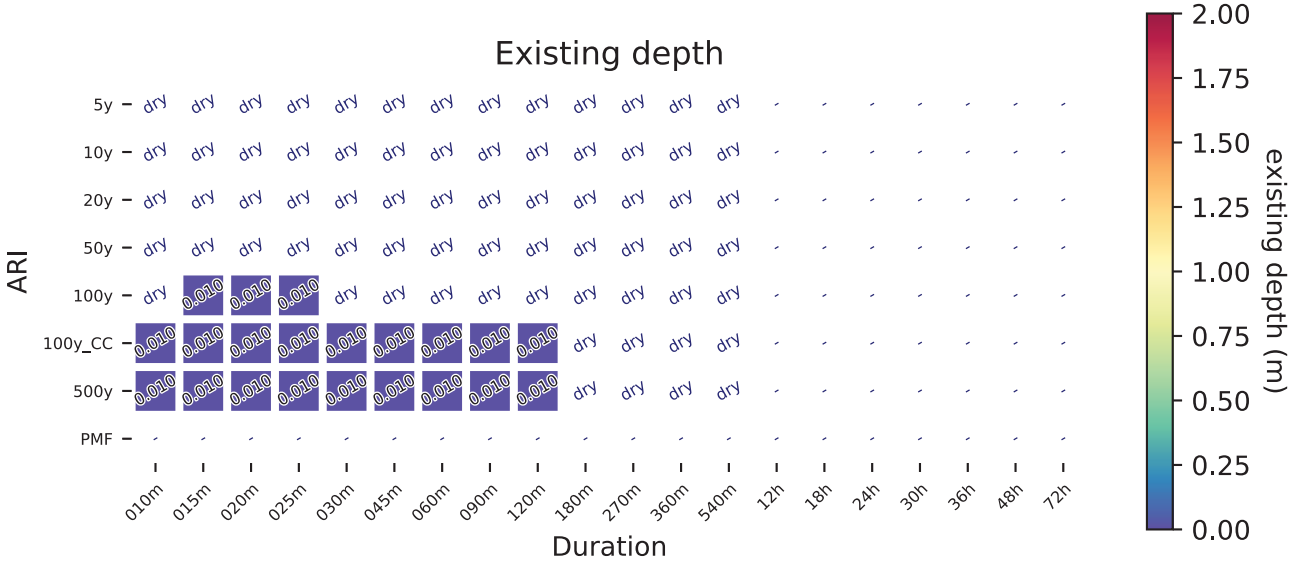
Banyule Creek - Lower_Plenty_Rd

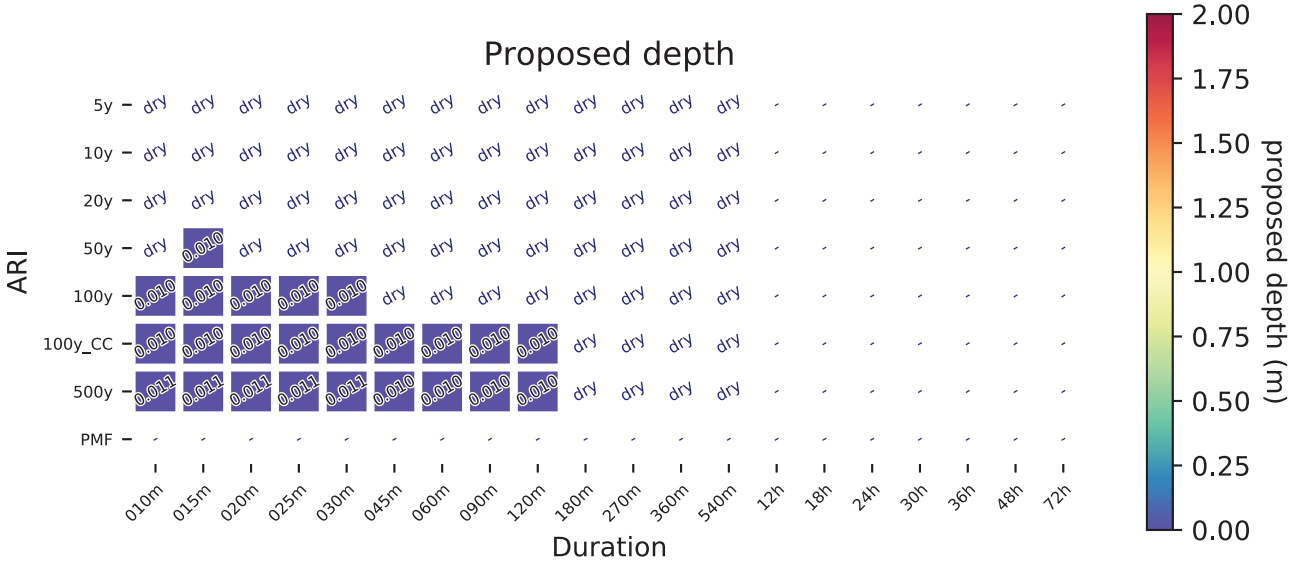


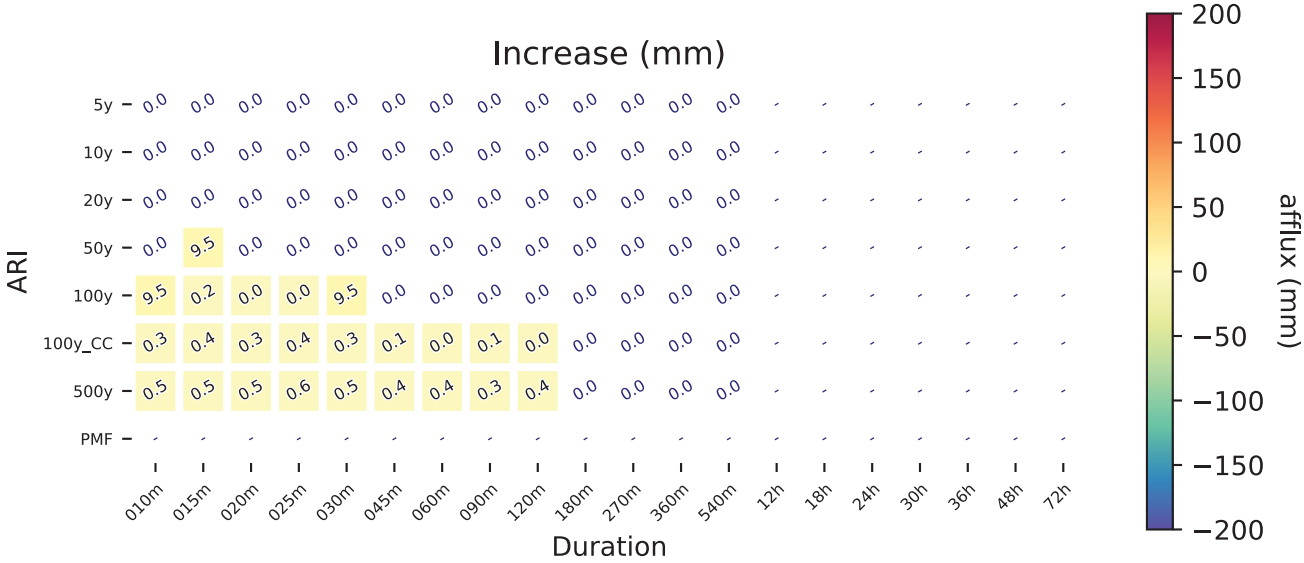




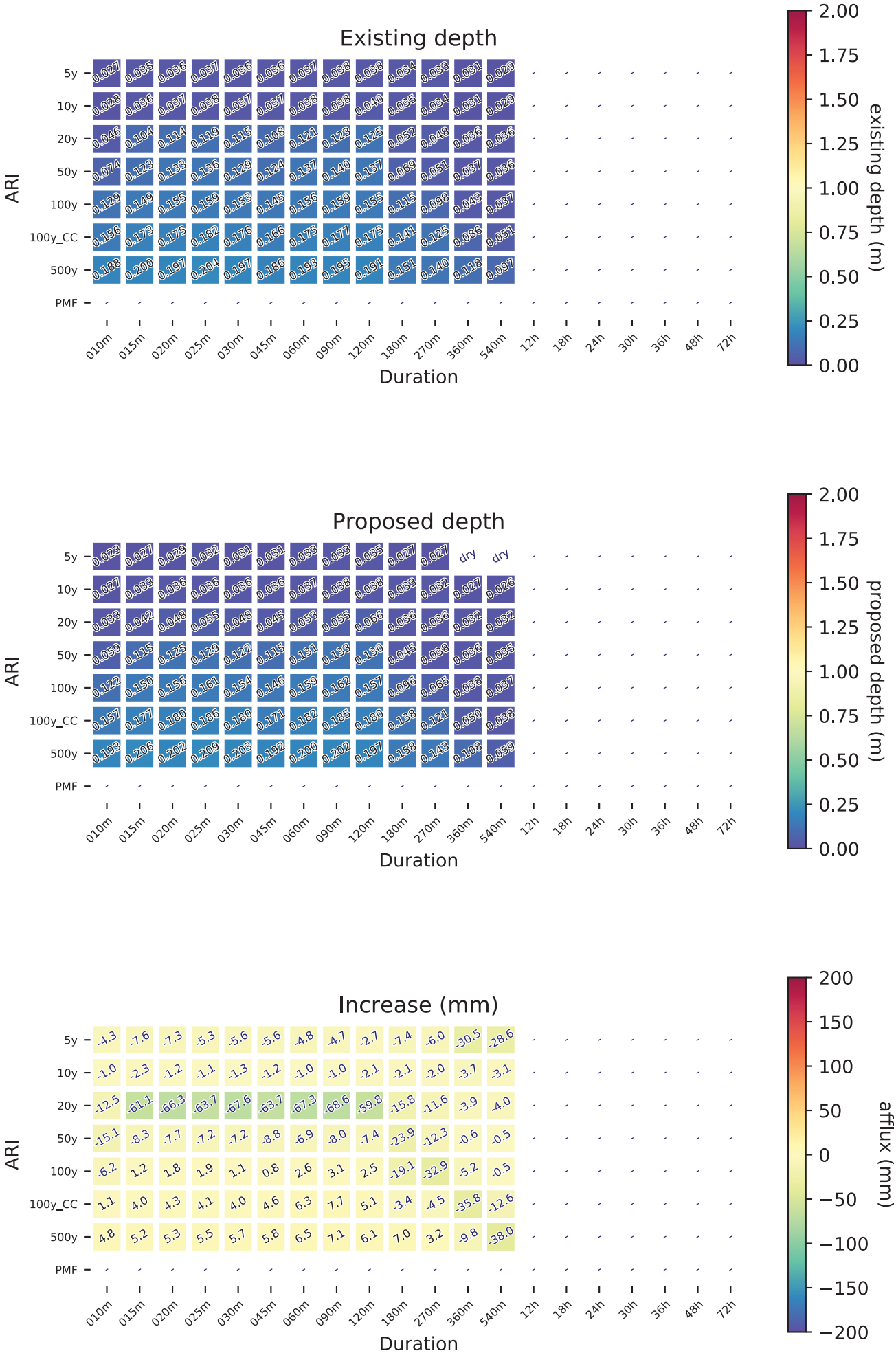
Banyule Creek - Kambea_Cr



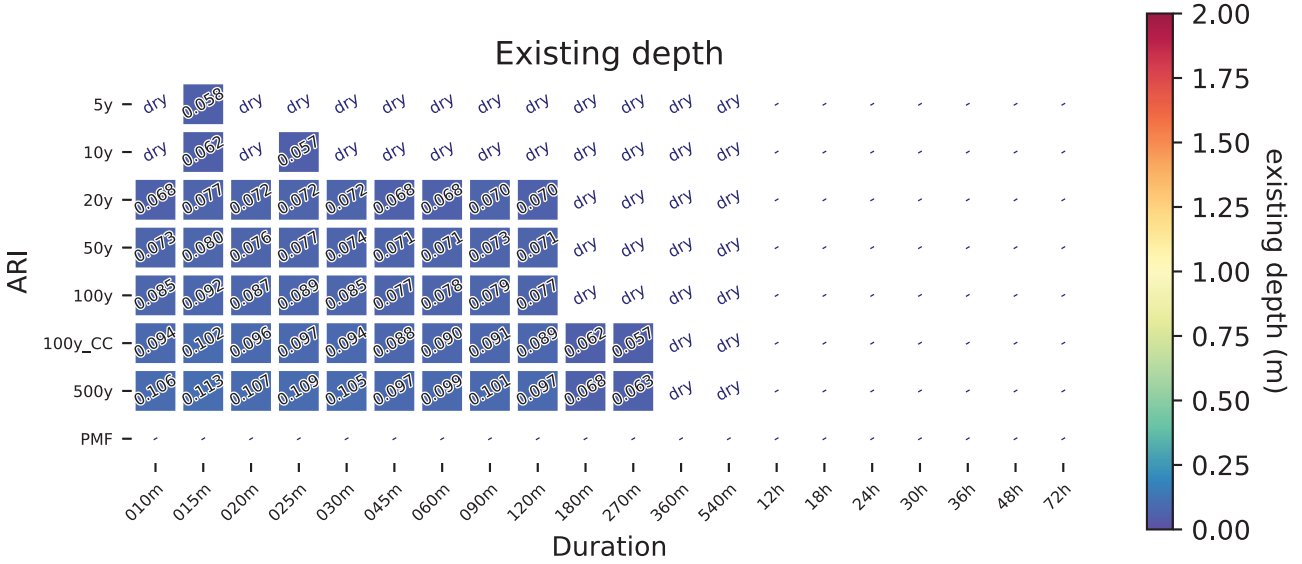


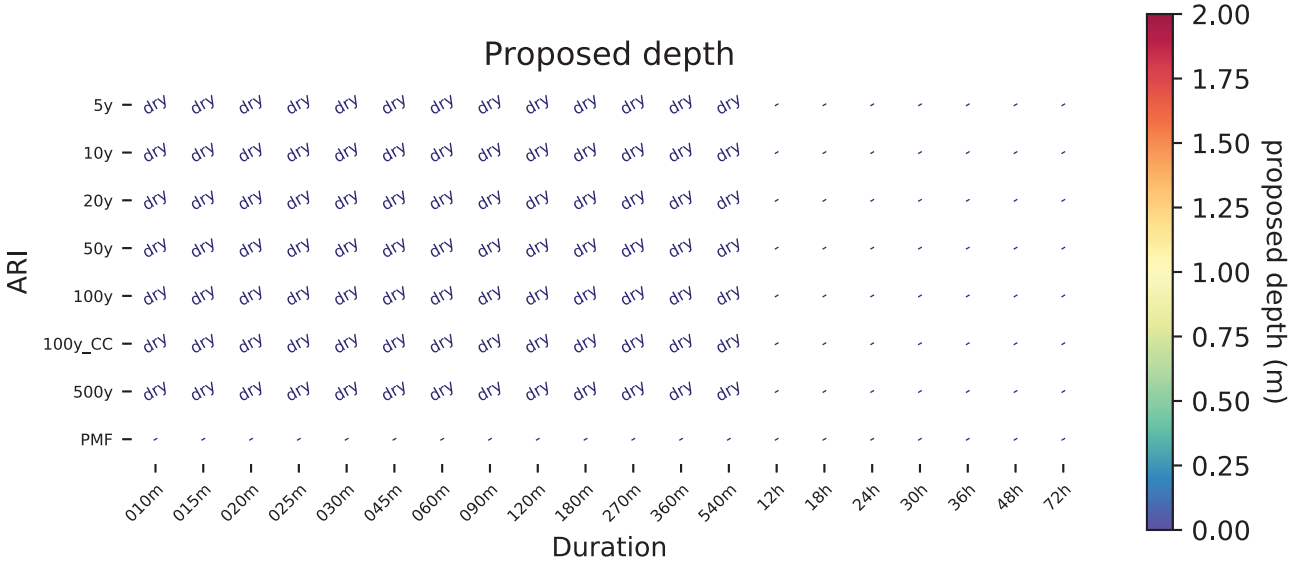


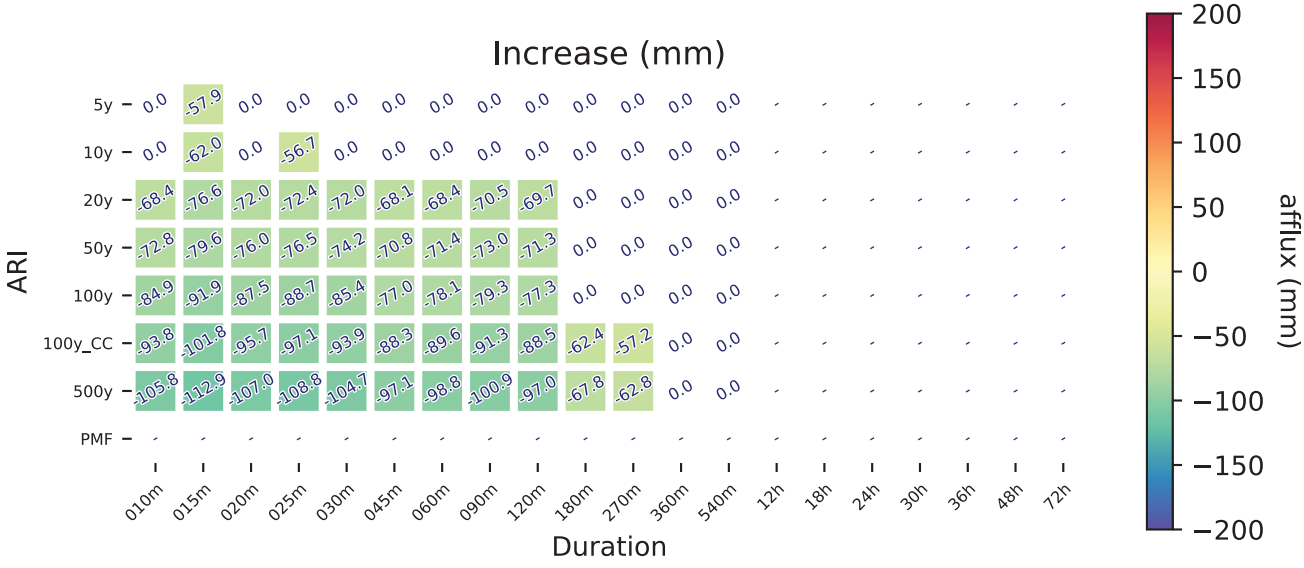
Banyule Creek - Finlayson_St



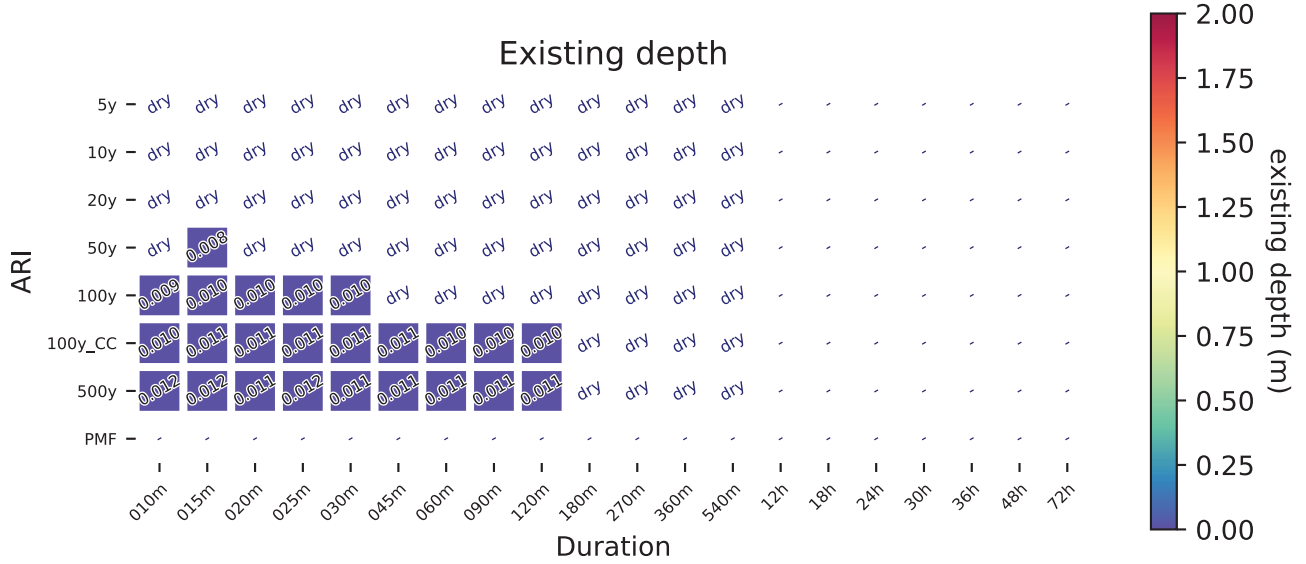
Banyule Creek - Borlase_St

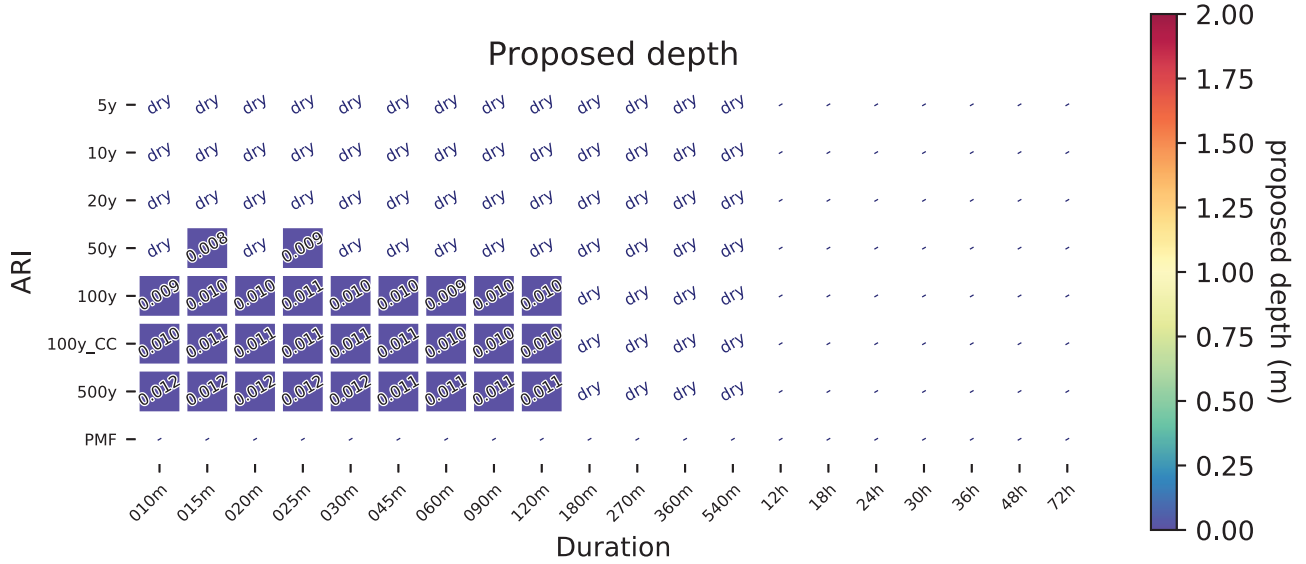


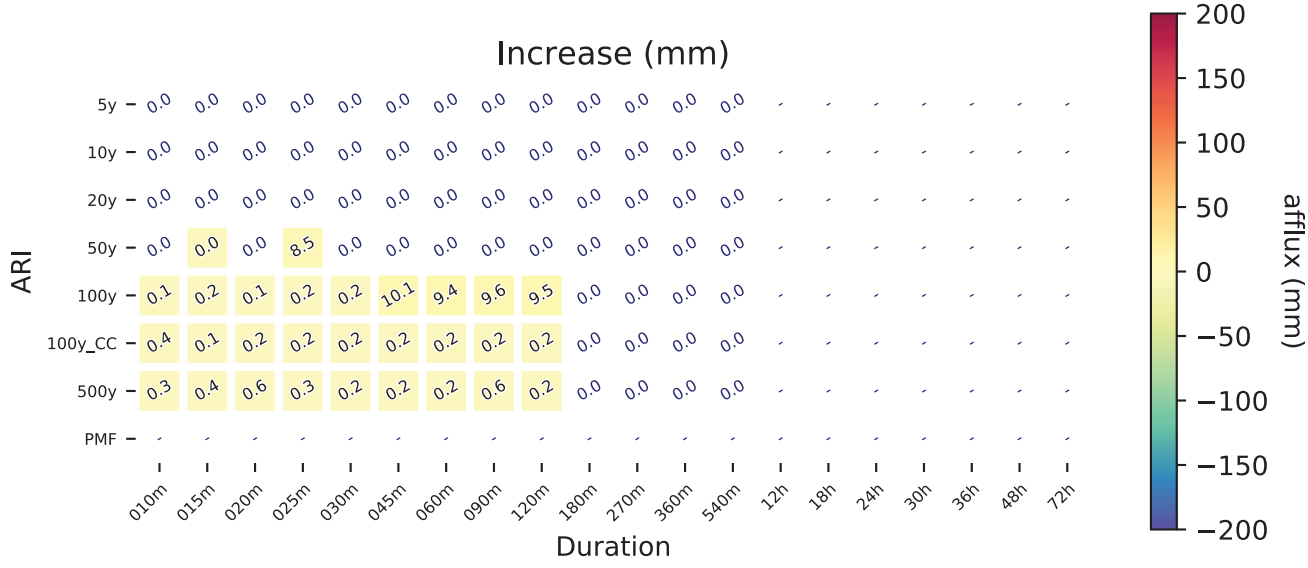




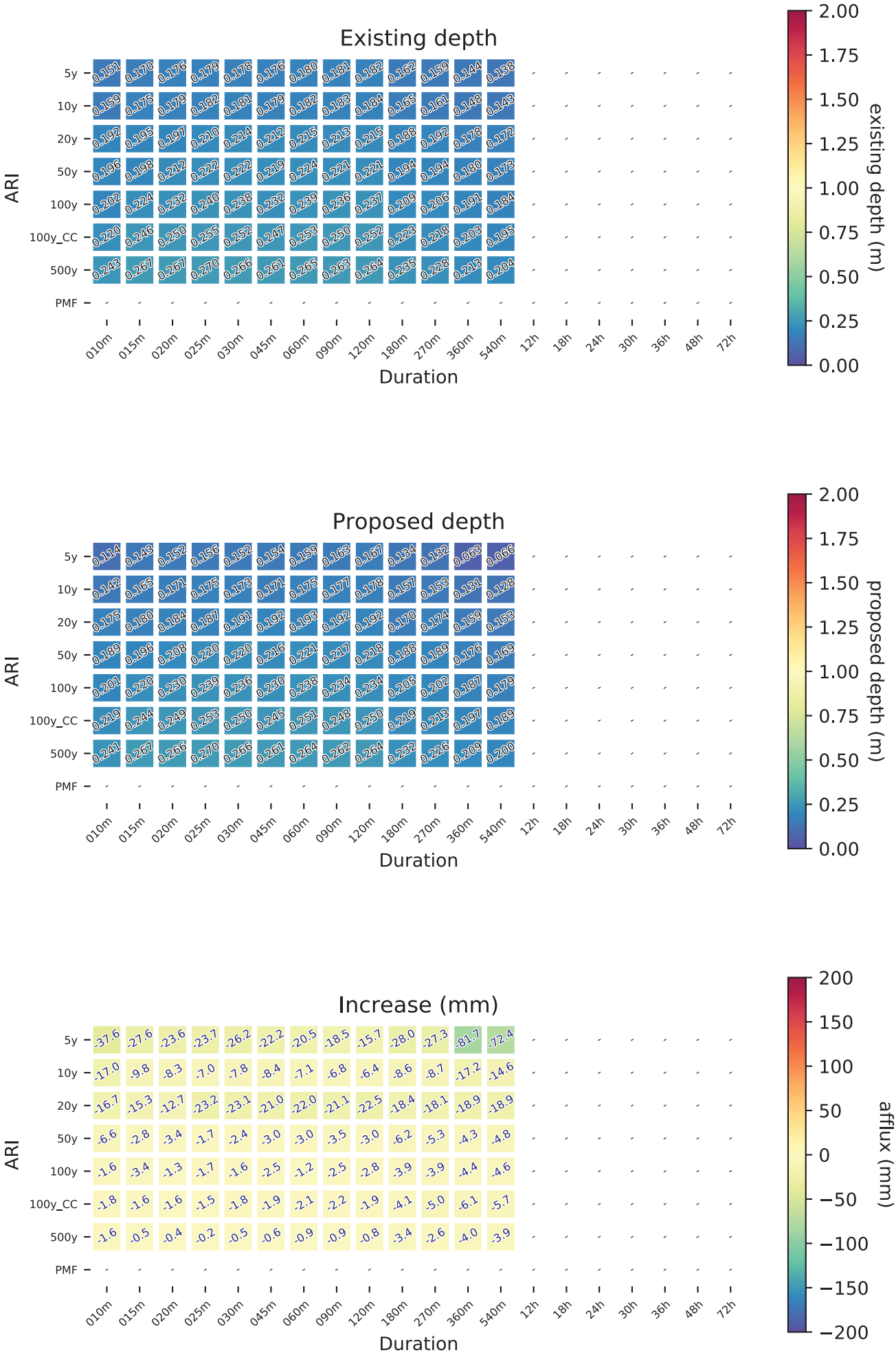
Banyule Creek - Newtown_Rd



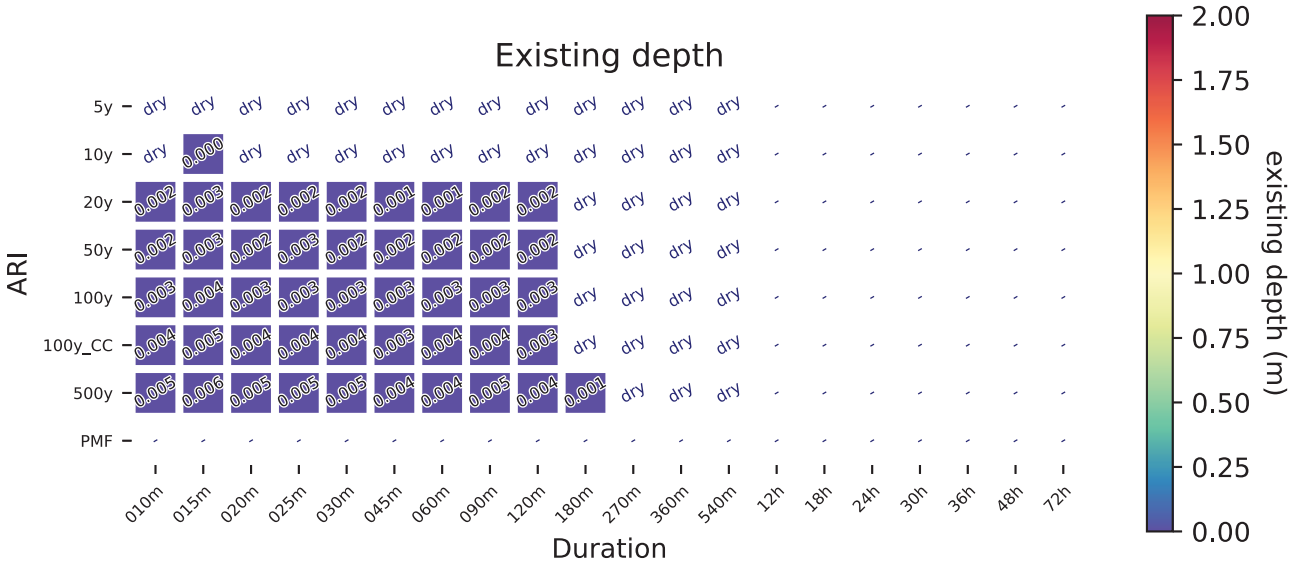


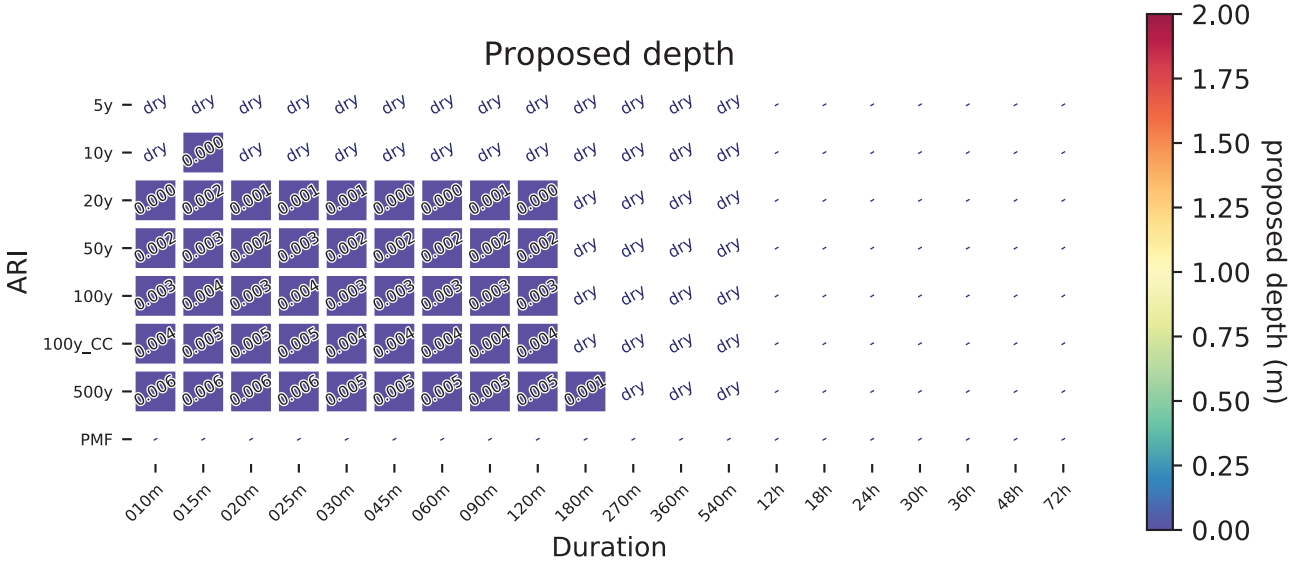


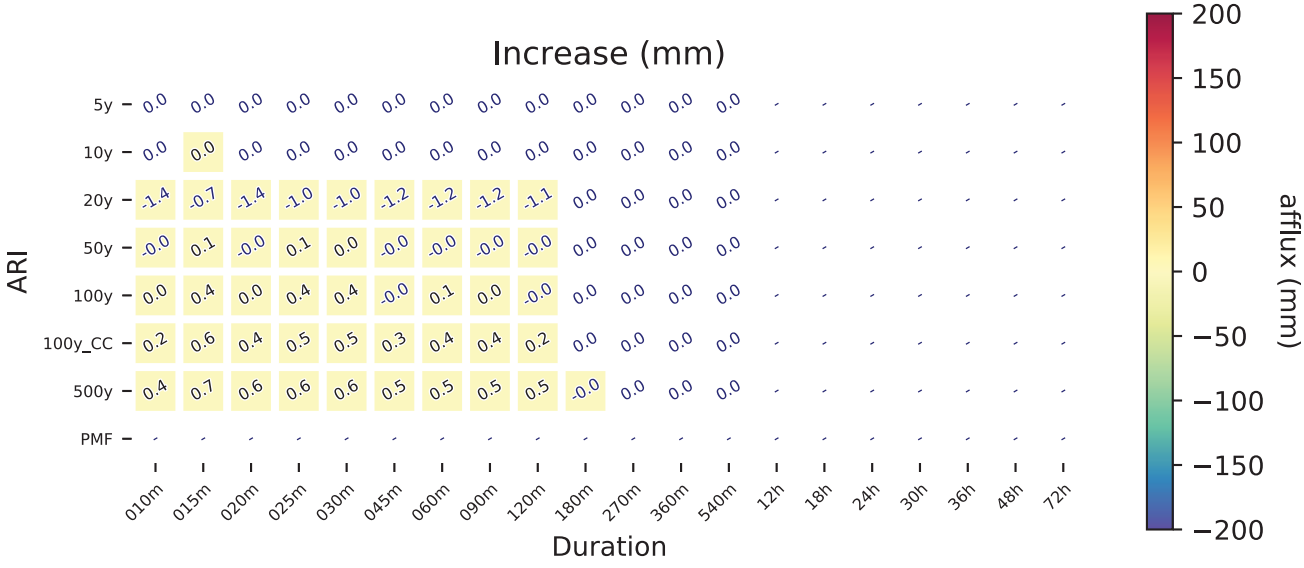
Banyule Creek - Moorwatha_St



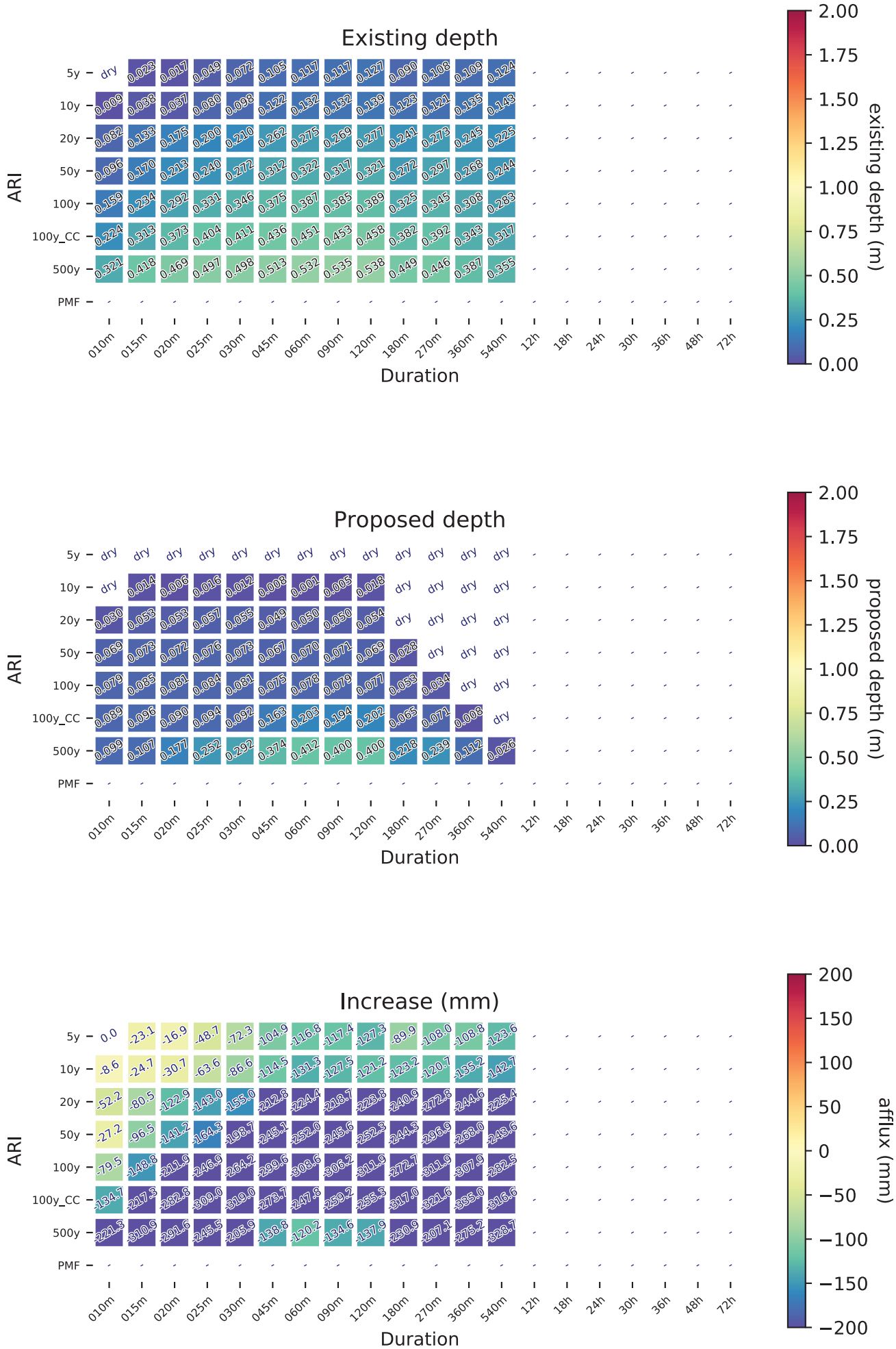
Banyule Creek - Drysdale_St



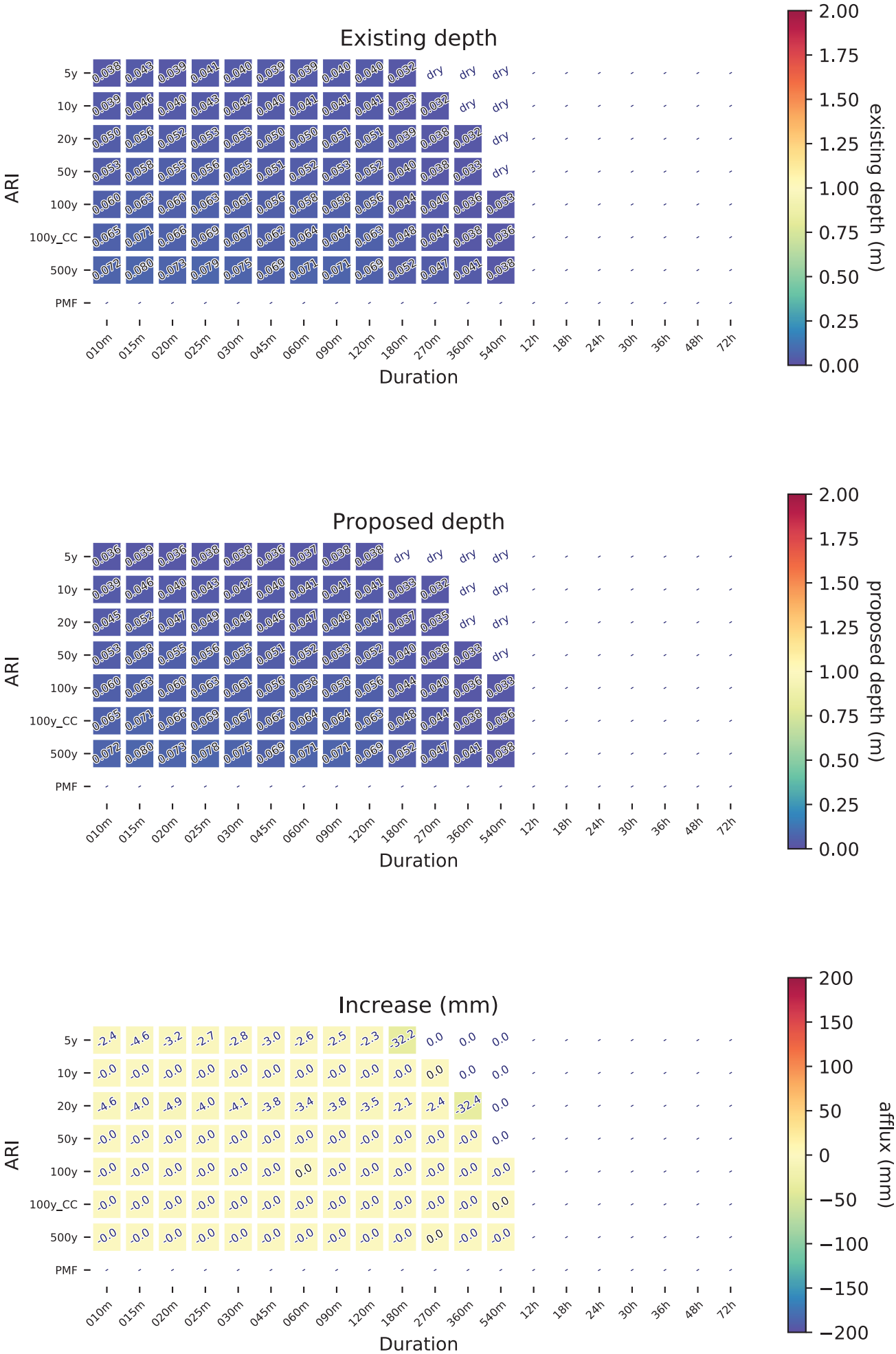




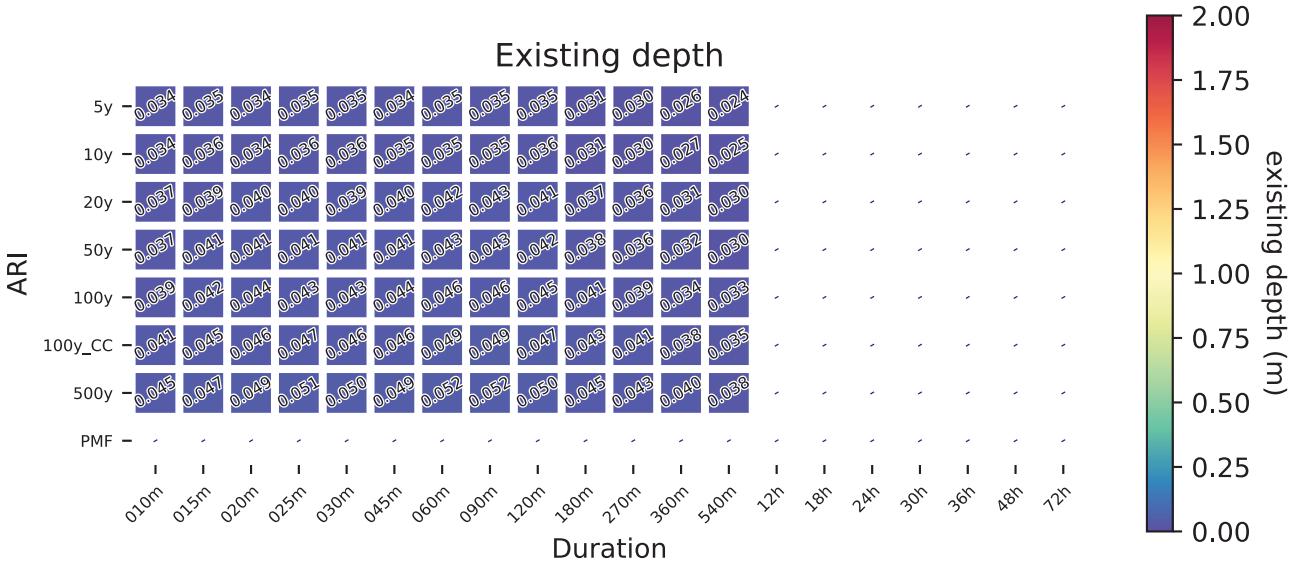
Banyule Creek - Debra_Crt

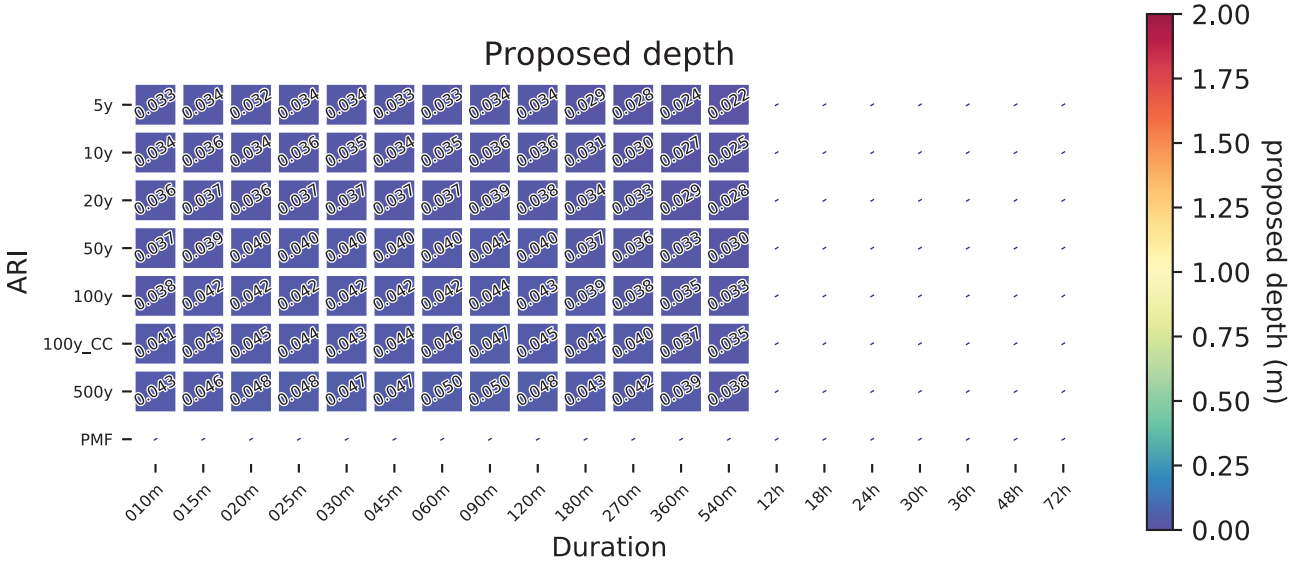


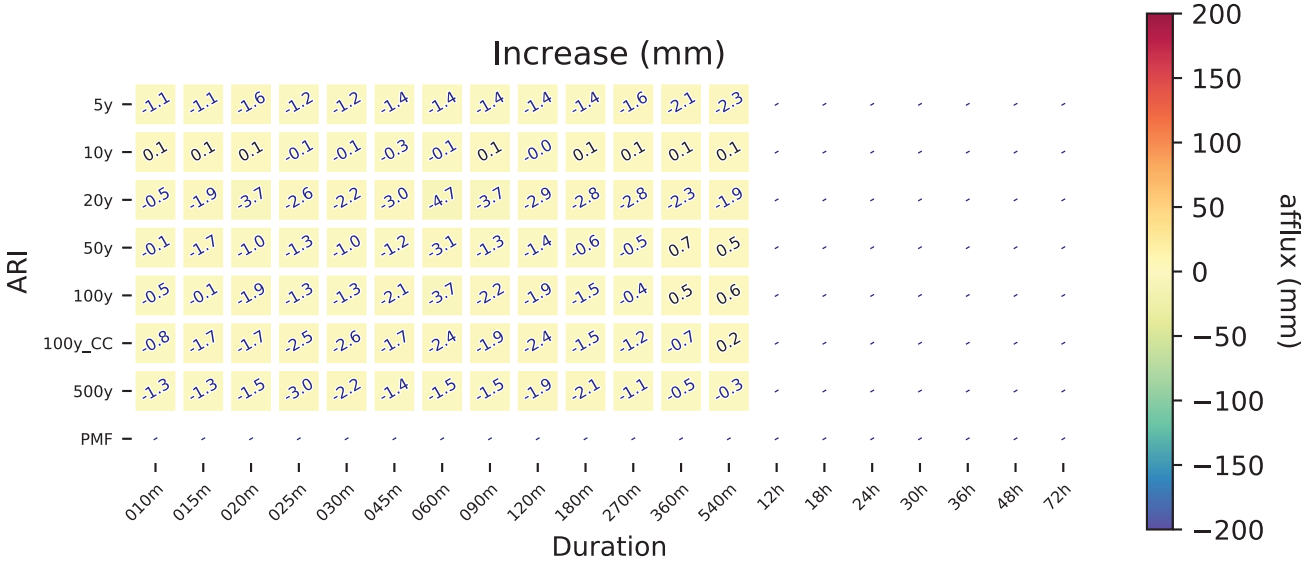
Banyule Creek - Coleen_St



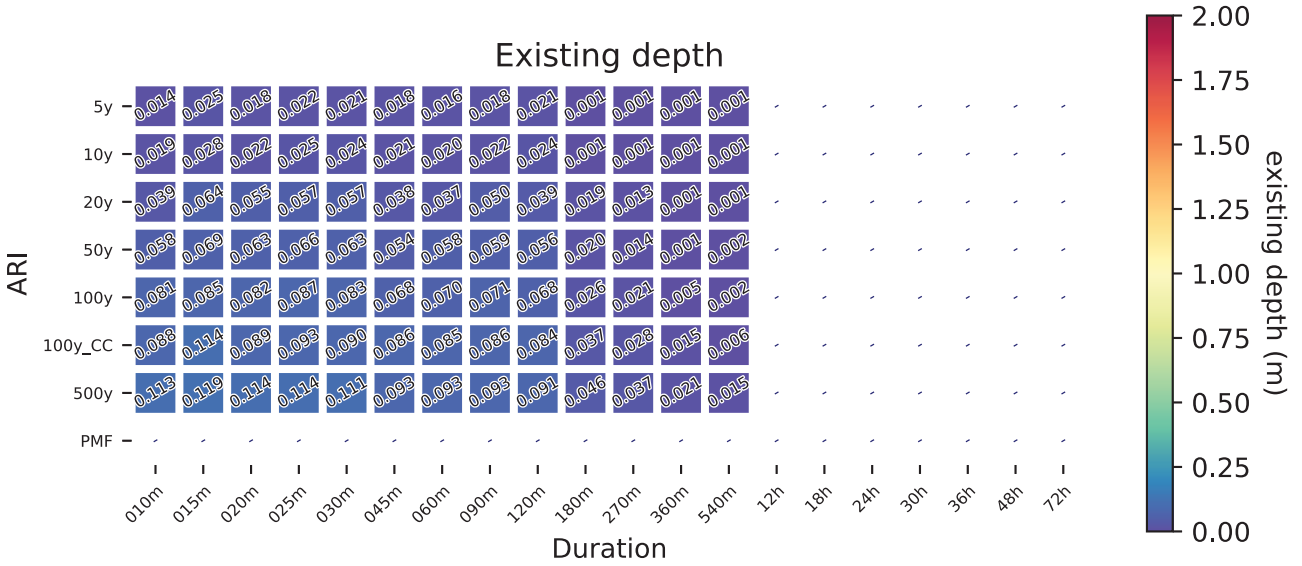
Banyule Creek - Erskine_Rd

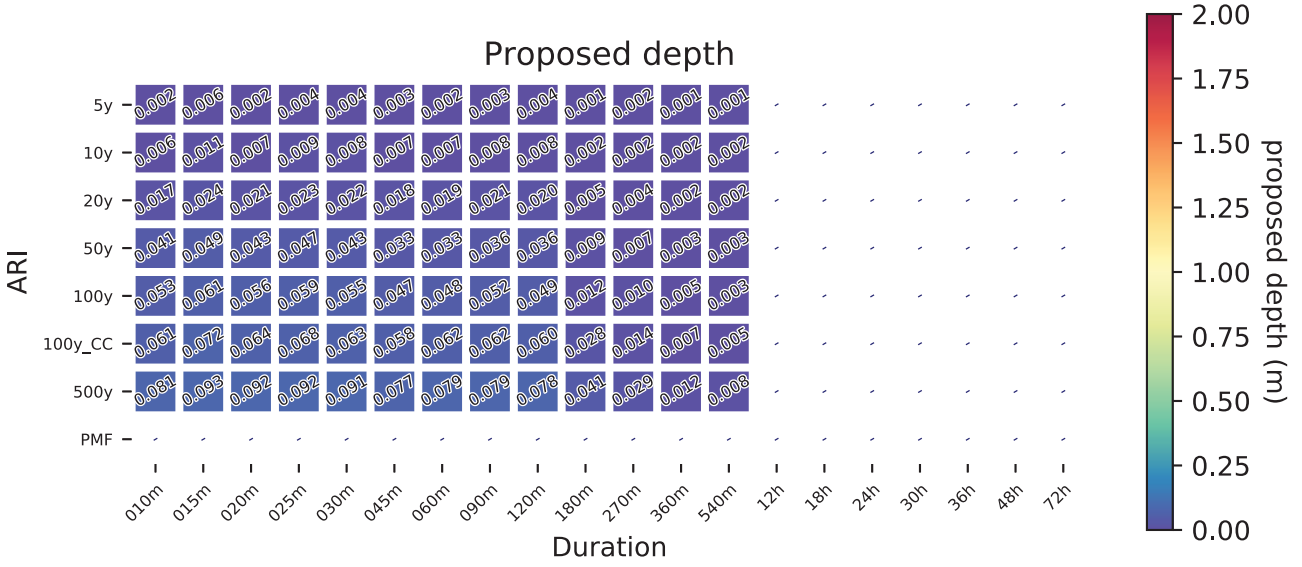


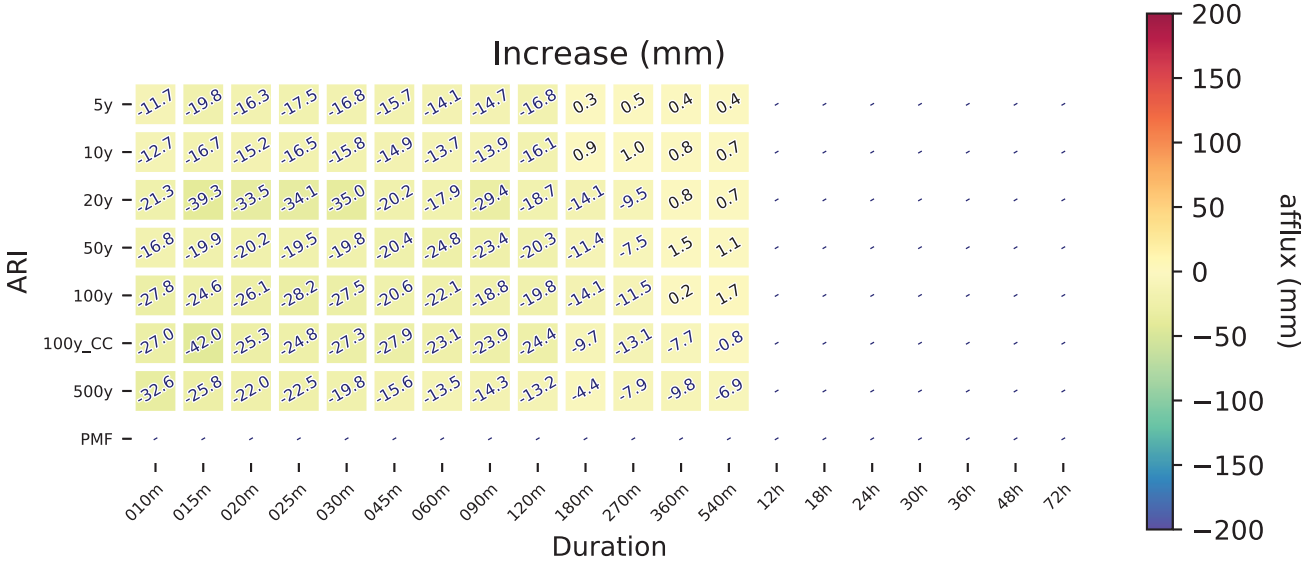




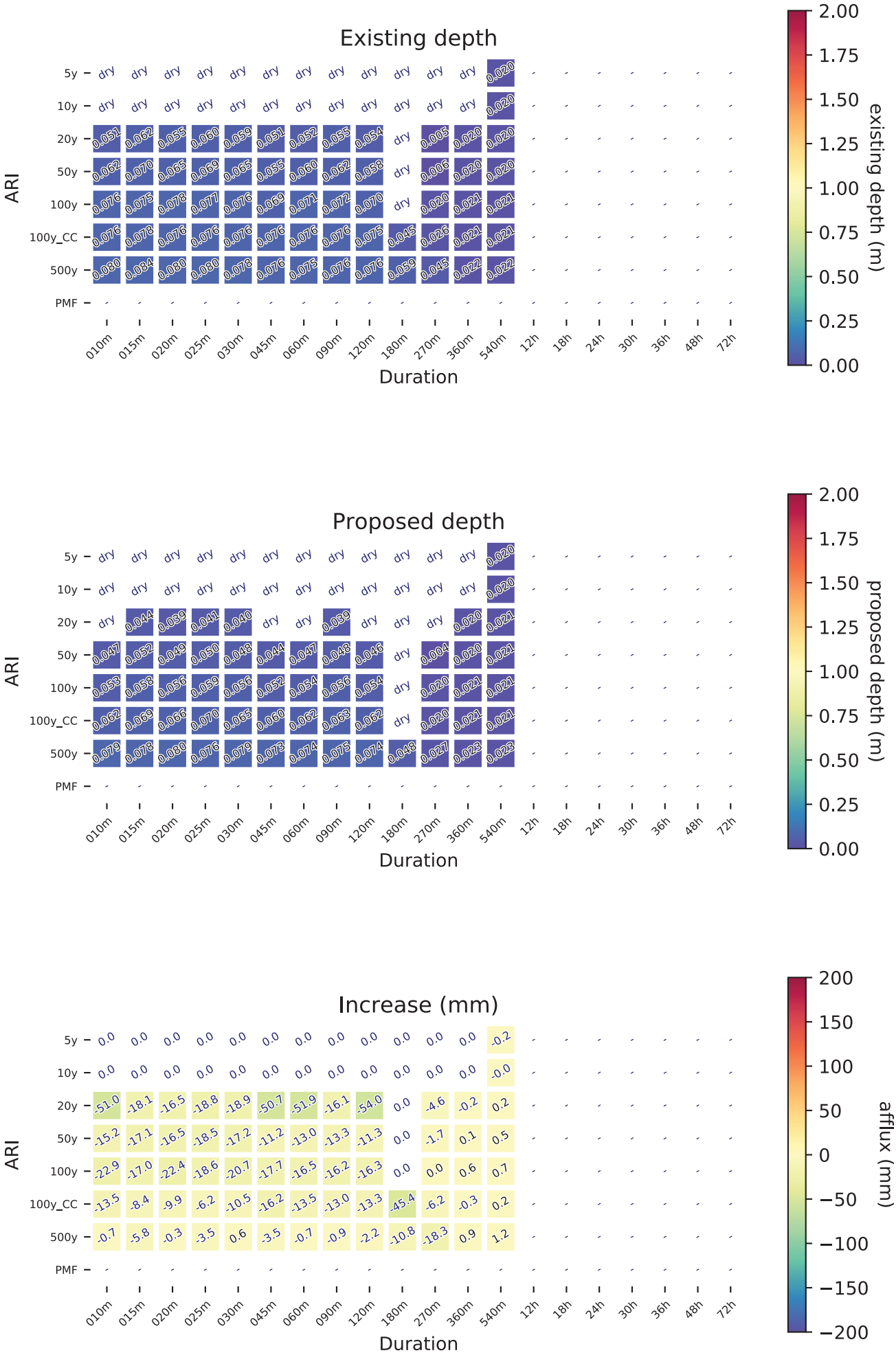
Banyule Creek - Oban_Way



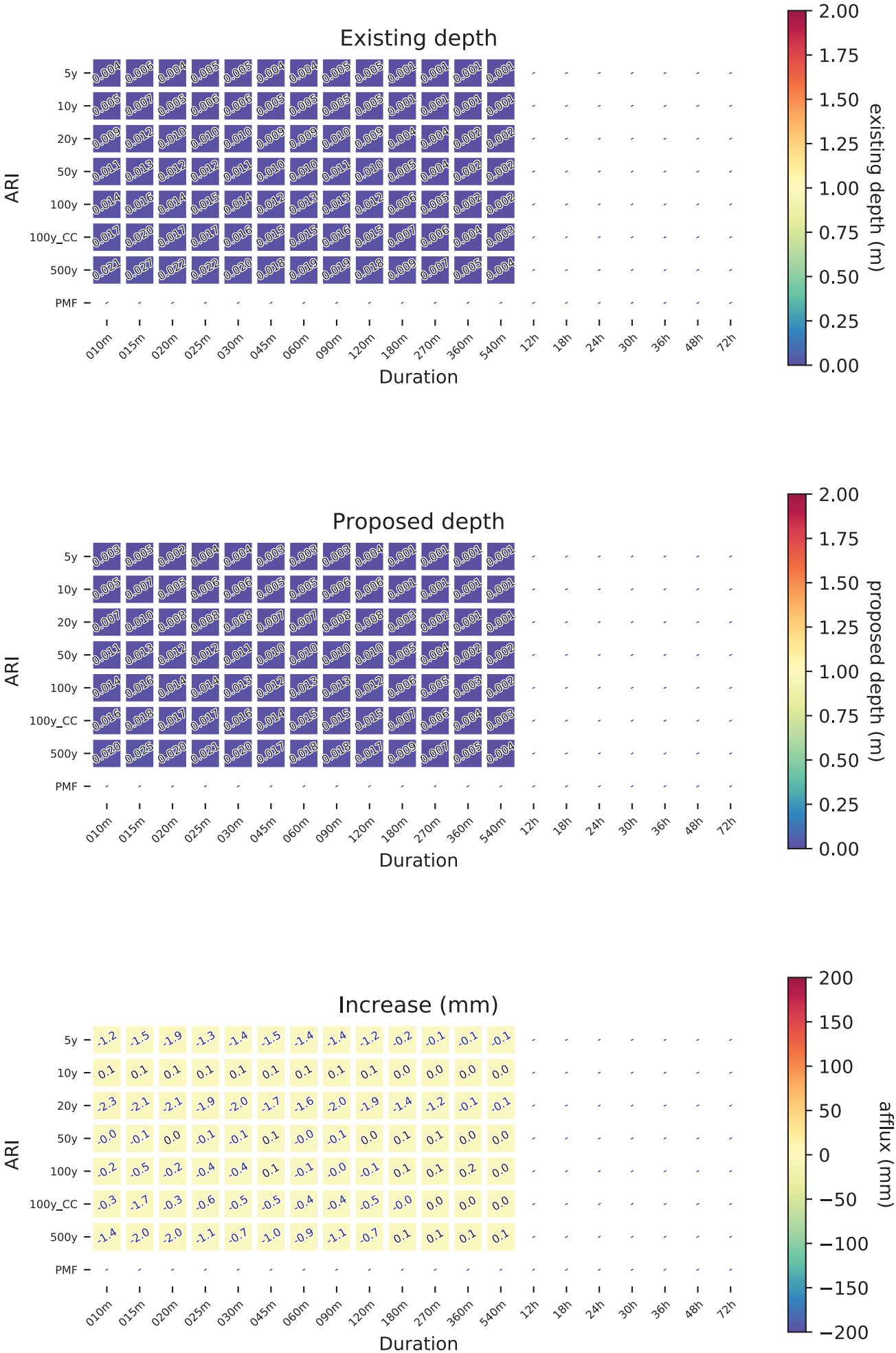




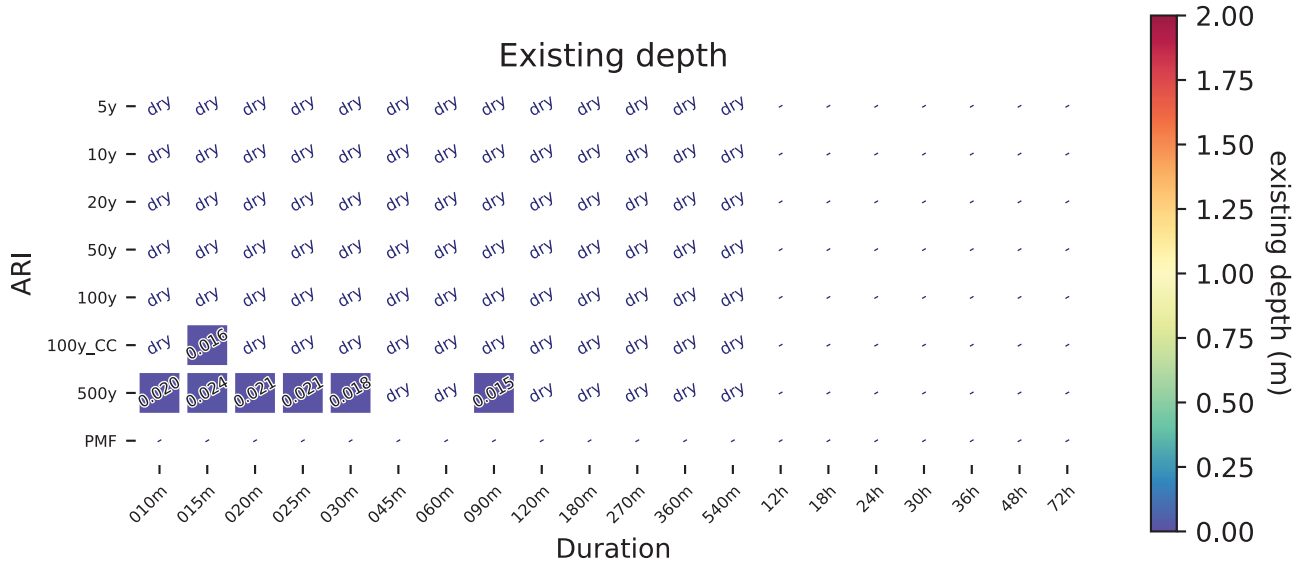
Banyule Creek - Edward_St

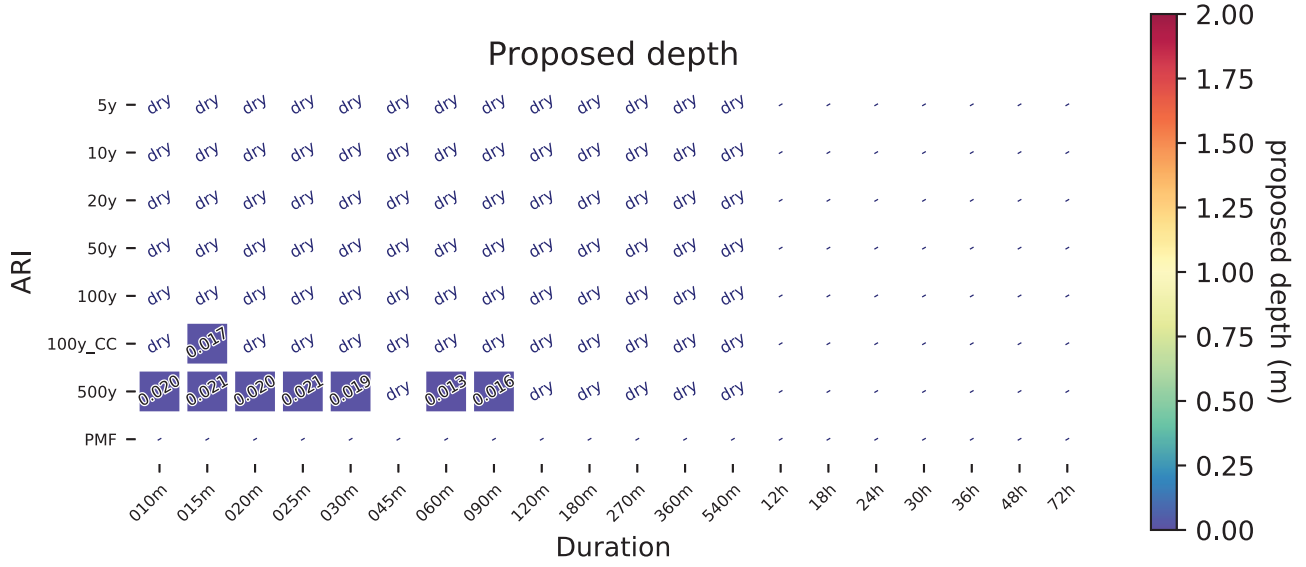


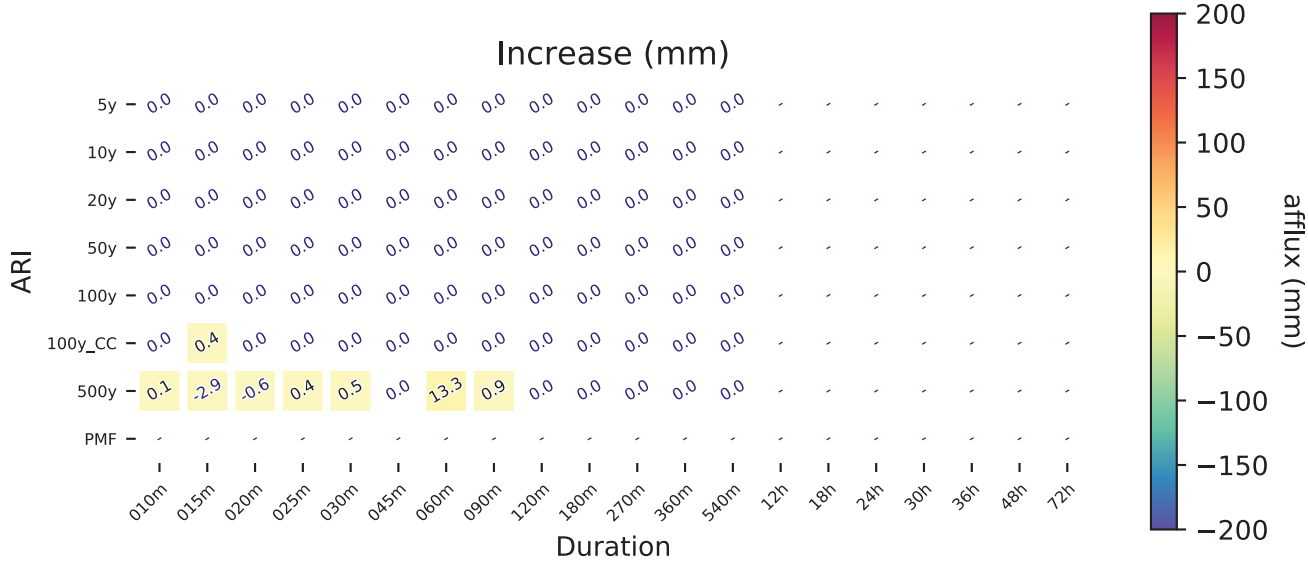
Banyule Creek - Strathallan_Rd



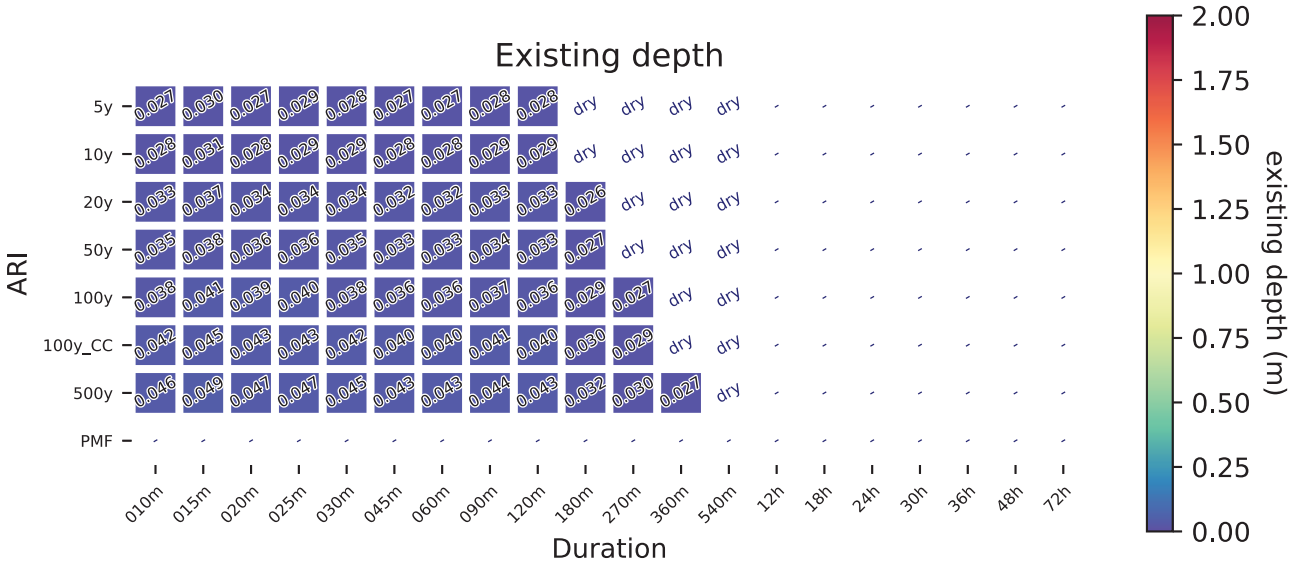
Banyule Creek - Sydney_St

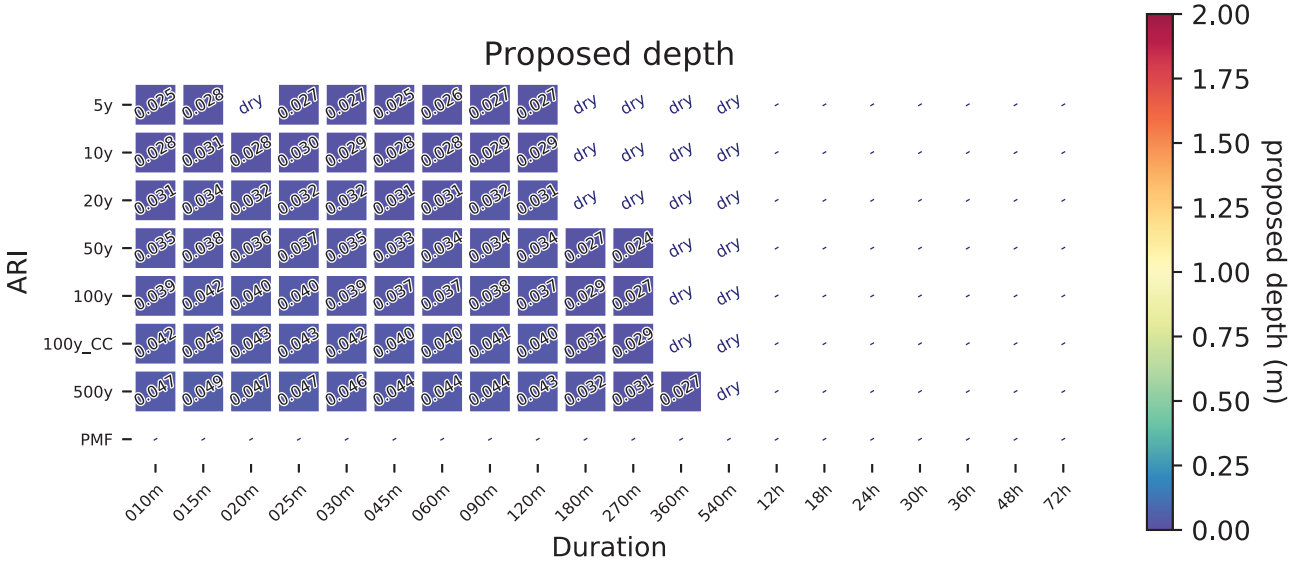


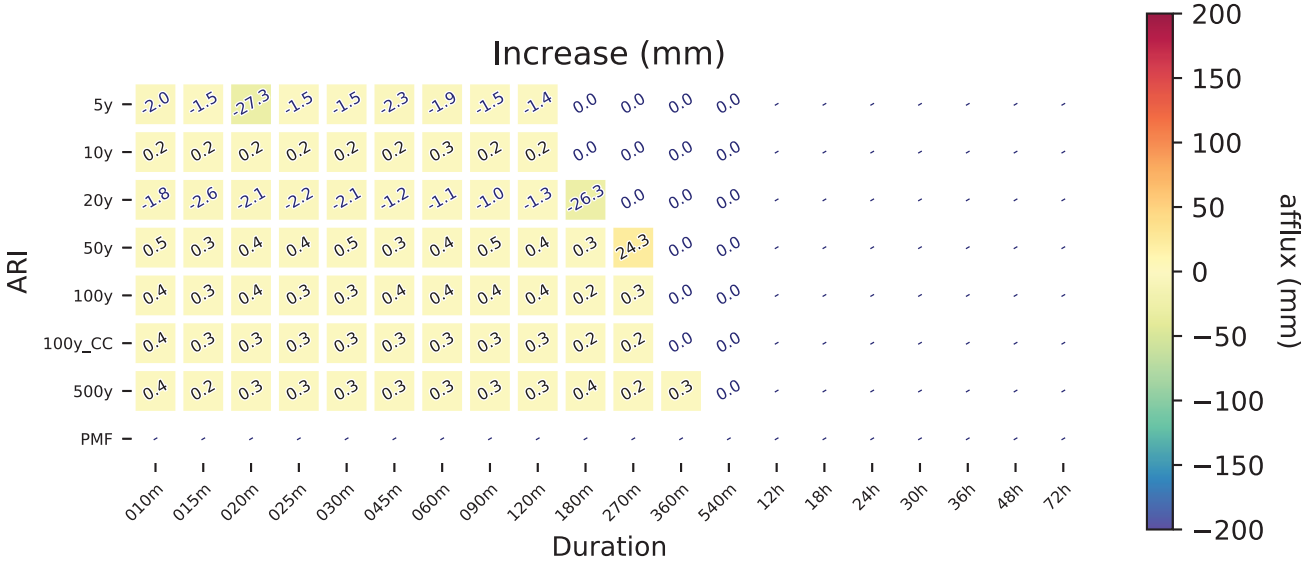




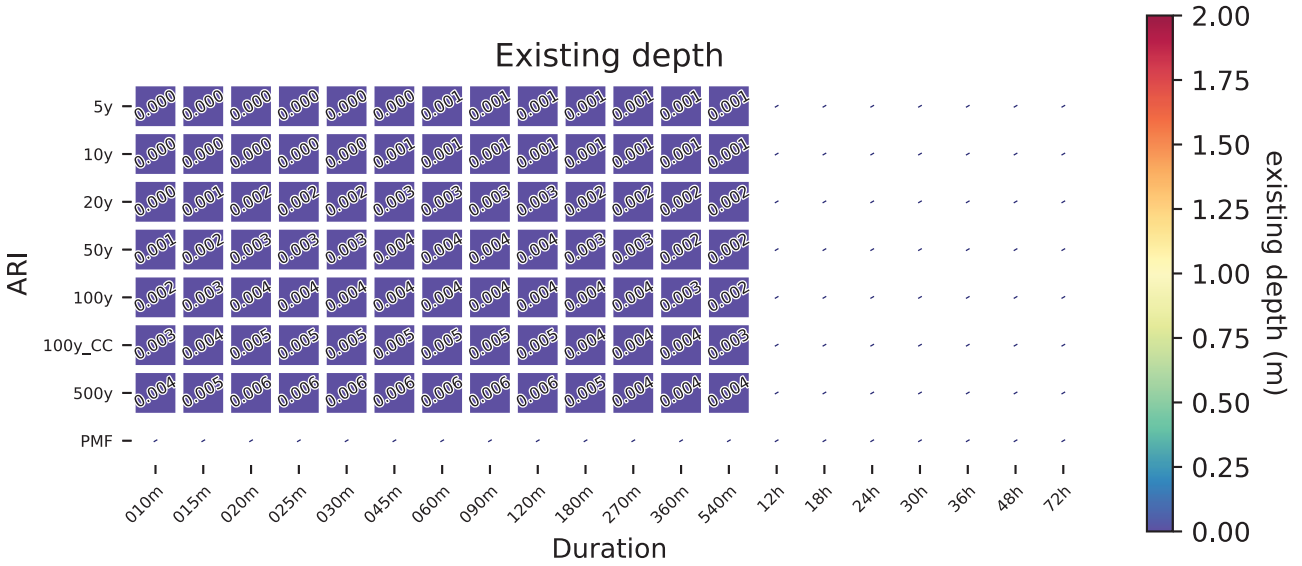
Banyule Creek - Fairlie_Ave

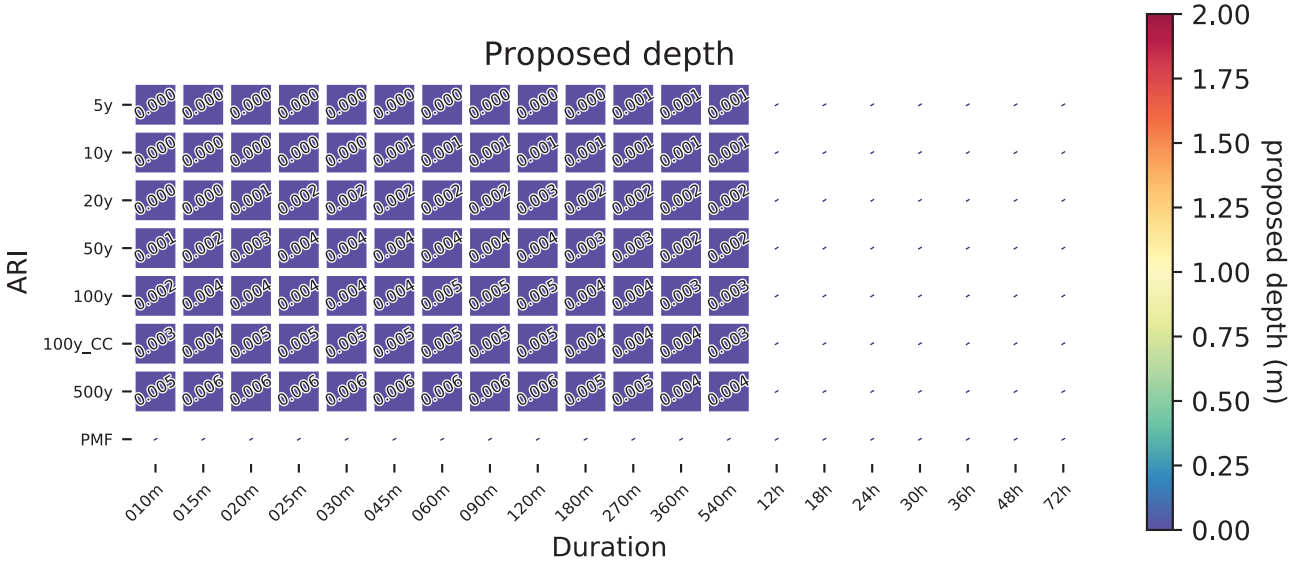


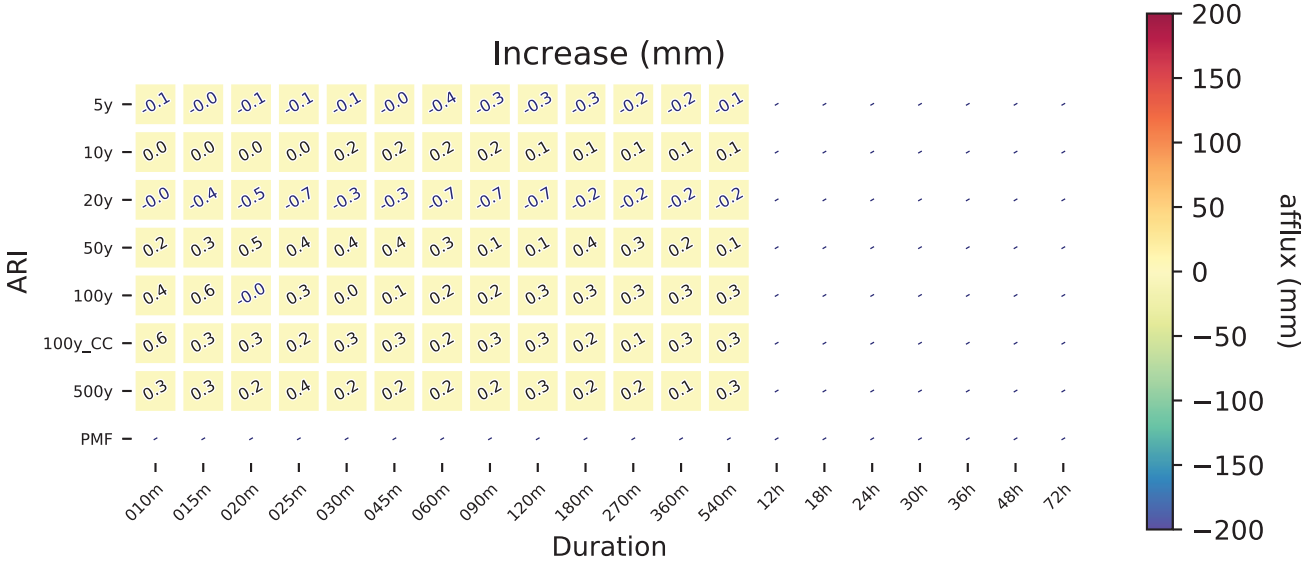




Banyule Creek - Blamey_Rd







LEGEND

★ Selected Locations

Paper Size A4

0 135 270 540

Metres

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

N

NORTH EAST LINK PROJECT

North East Link
North East Link Project

Job Number | 31-35006
Revision | D
Date | 13/11/2018

Yarra River 1 of 3
Comparison Locations

Appendix C-2-1

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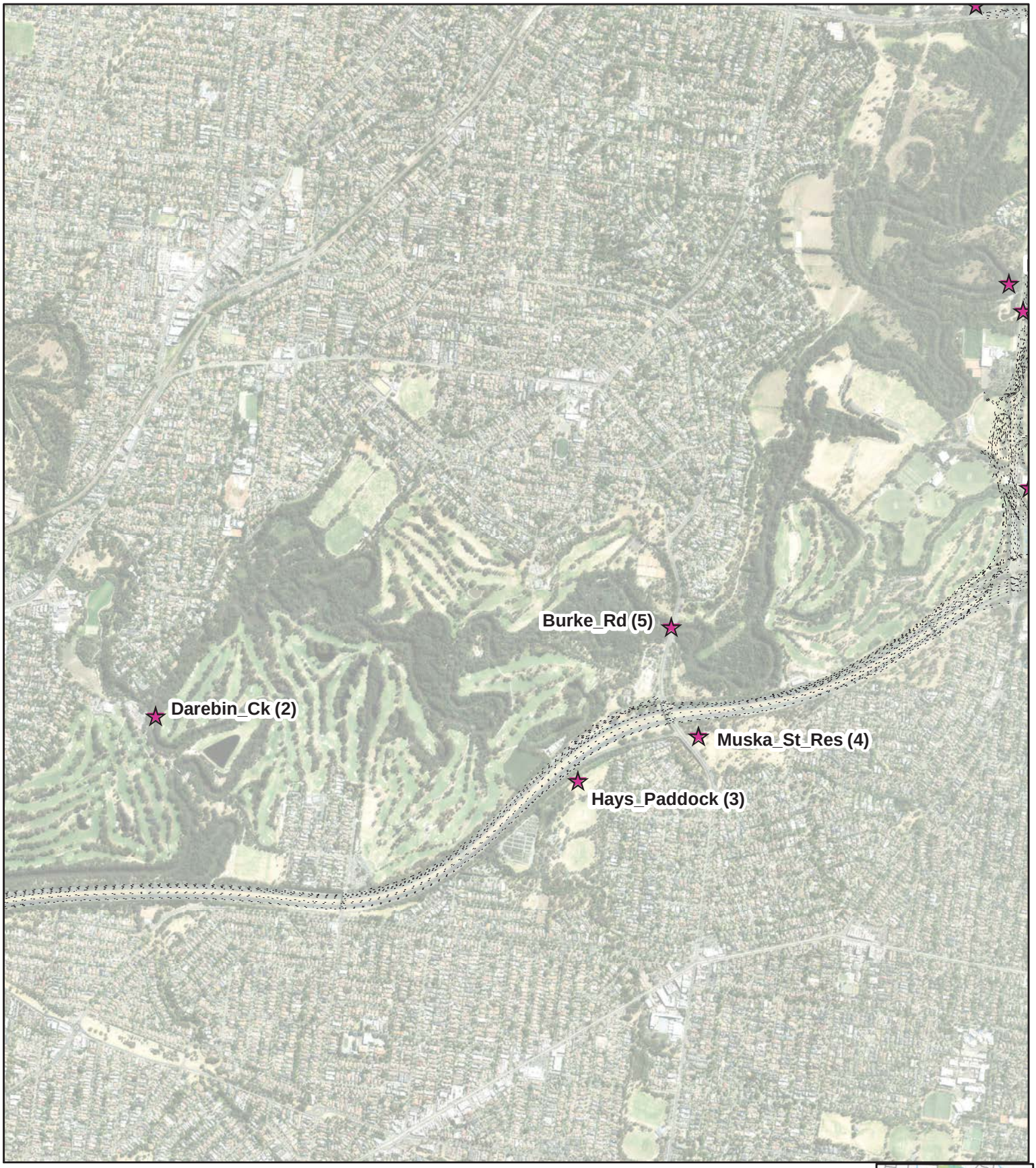
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



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★ Selected Locations

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N

NORTH EAST LINK PROJECT

North East Link
North East Link Project

Job Number | 31-35006
Revision | C
Date | 13/11/2018

Yarra River 2 of 3
Comparison Locations Appendix C-2-2

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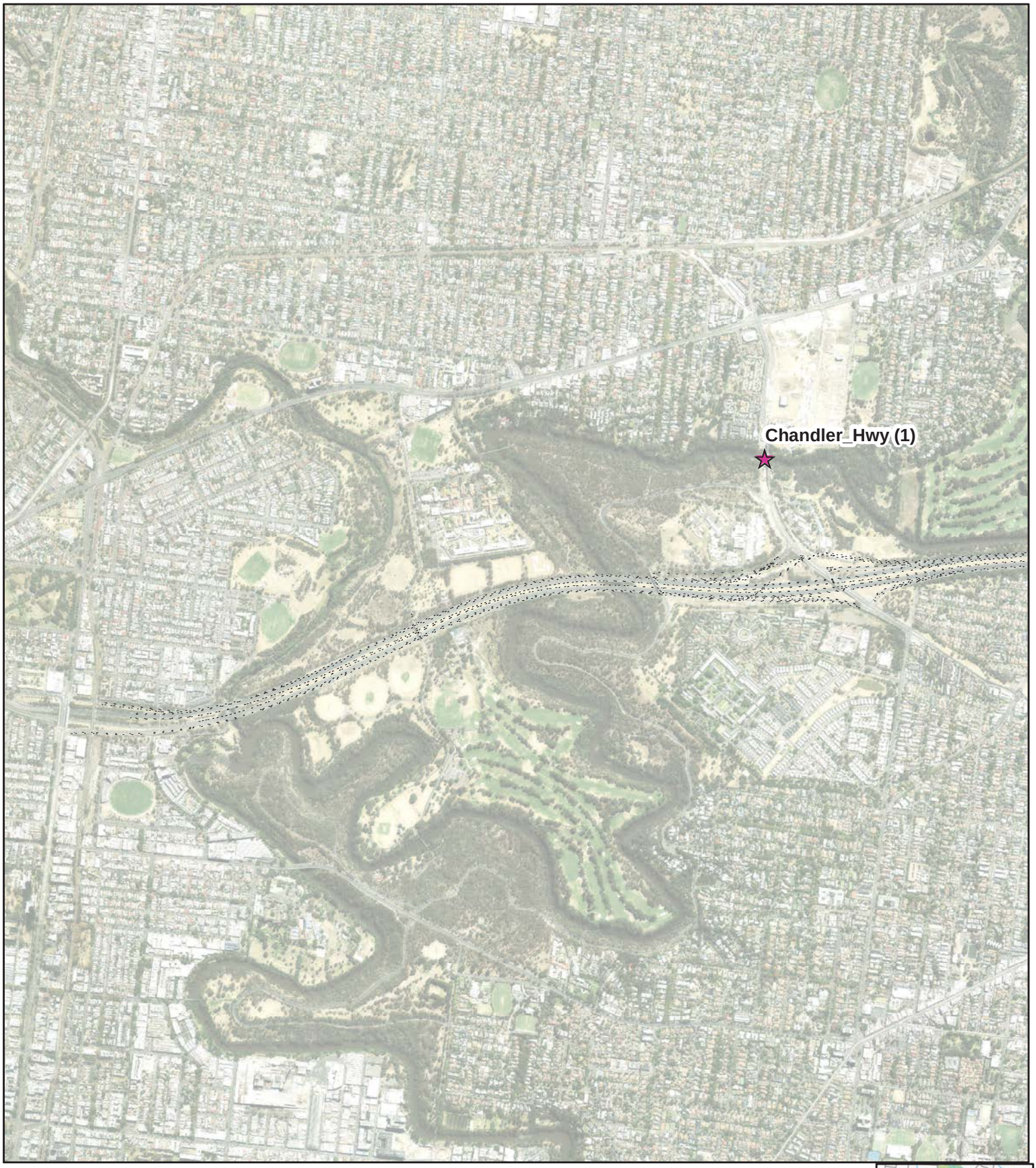
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



LEGEND

★ Selected Locations

Paper Size A4

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Metres

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

N

NORTH EAST LINK PROJECT

North East Link
North East Link Project

Job Number | 31-35006
Revision | C
Date | 13/11/2018

Yarra River 3 of 3
Comparison Locations Appendix C-2-3

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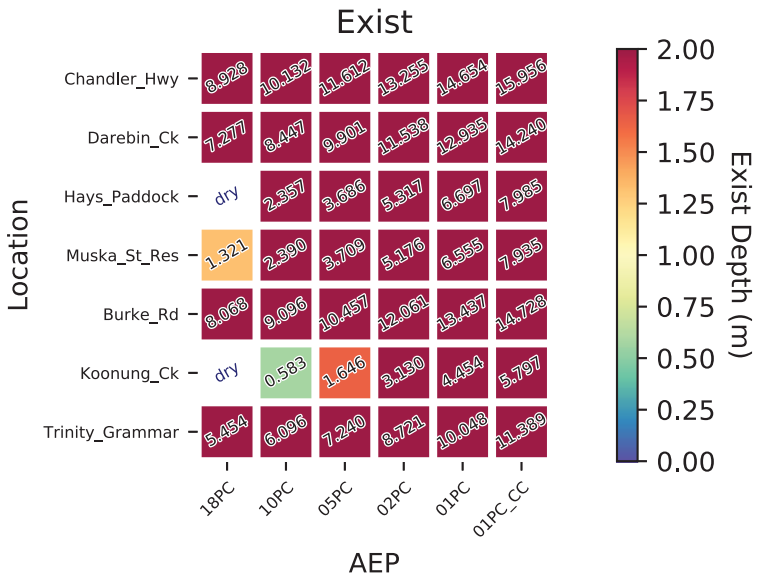
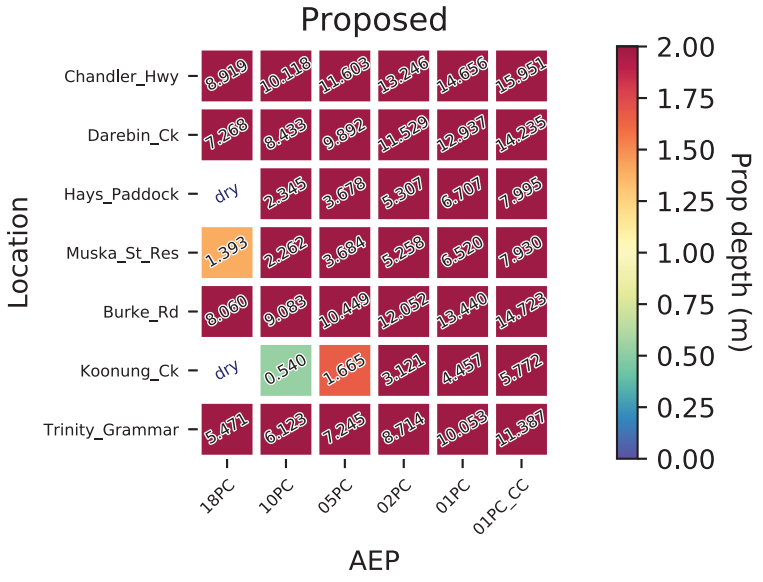
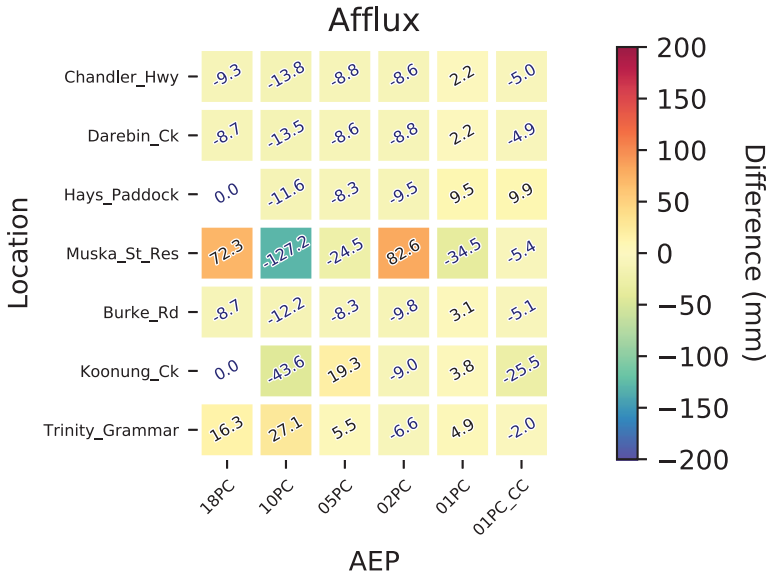
180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

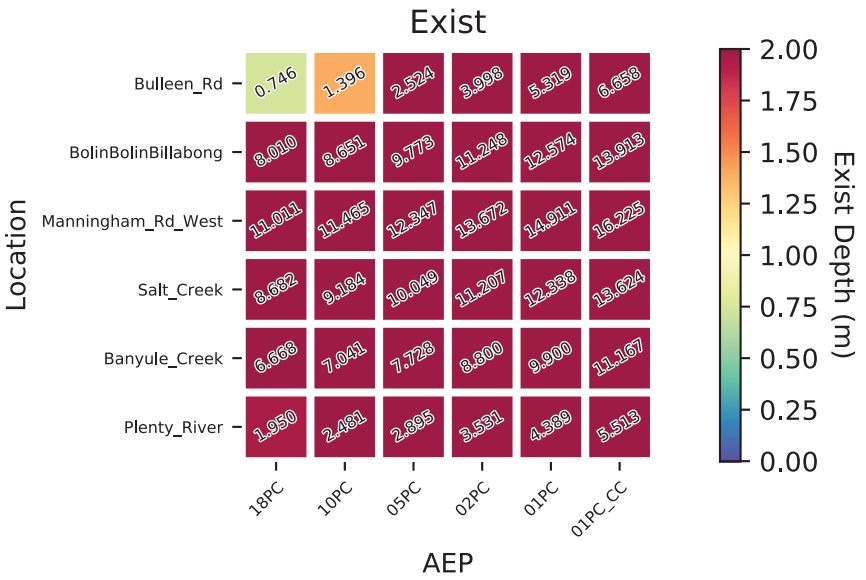
Yarra River - Overview

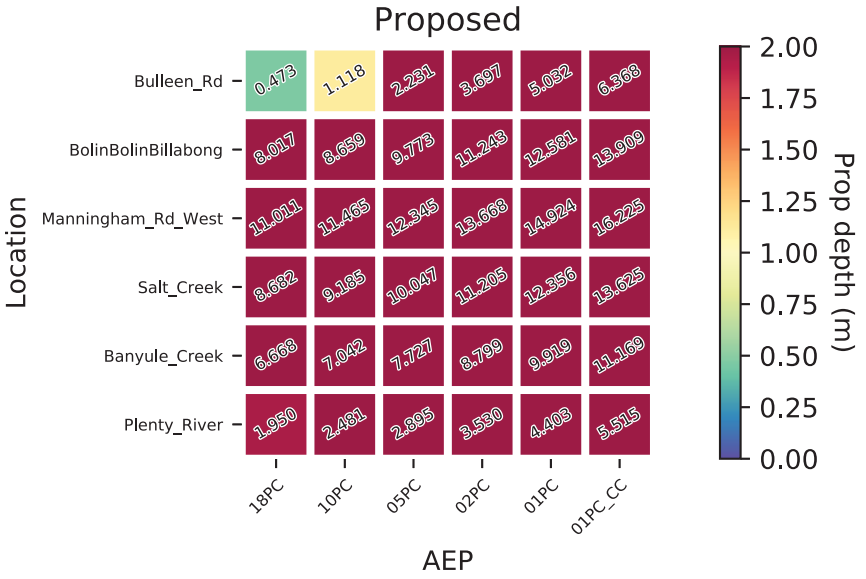


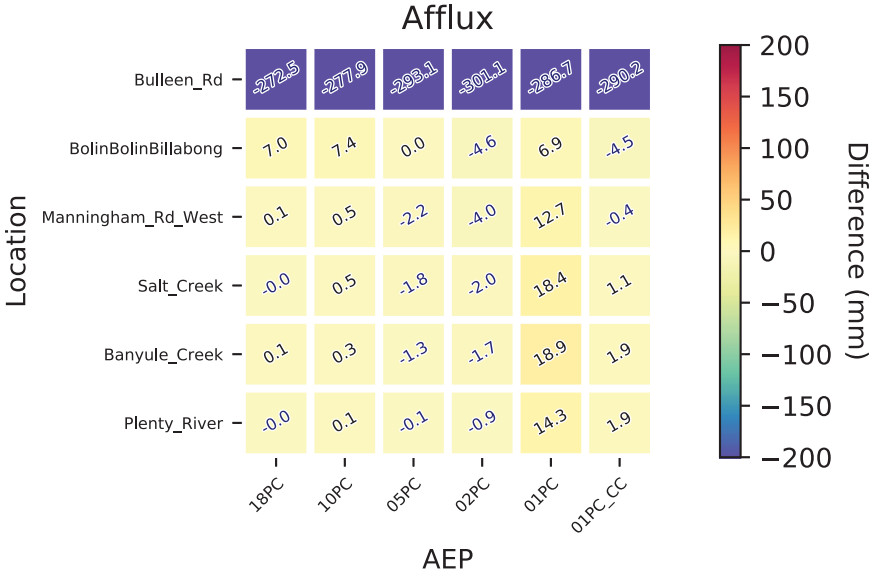




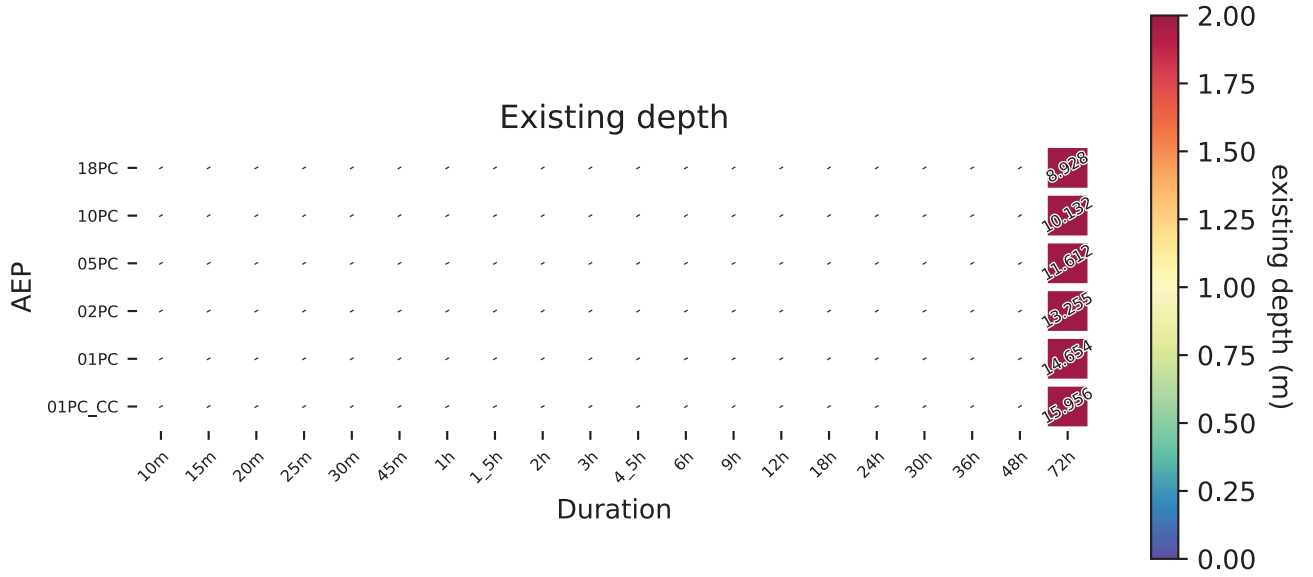
Yarra River - Overview

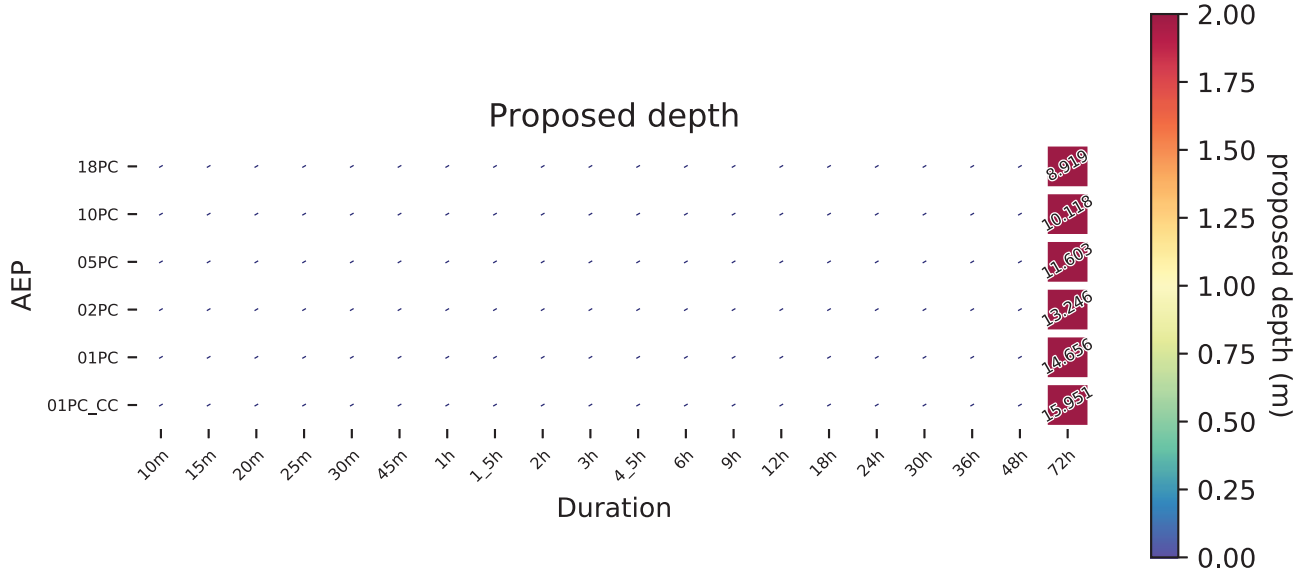


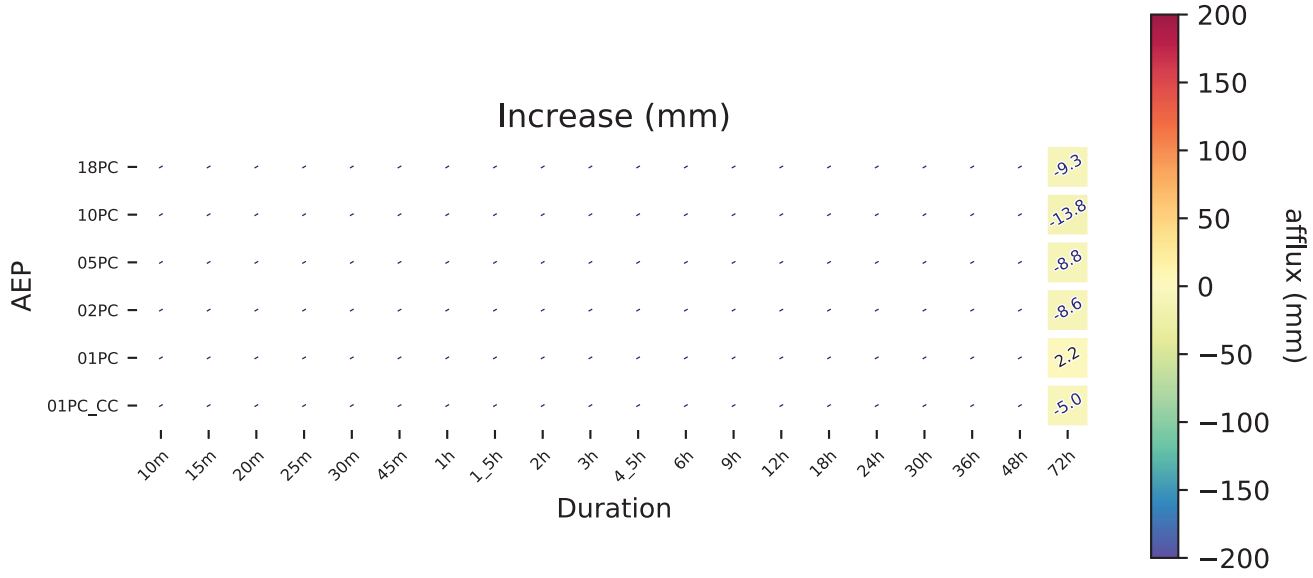




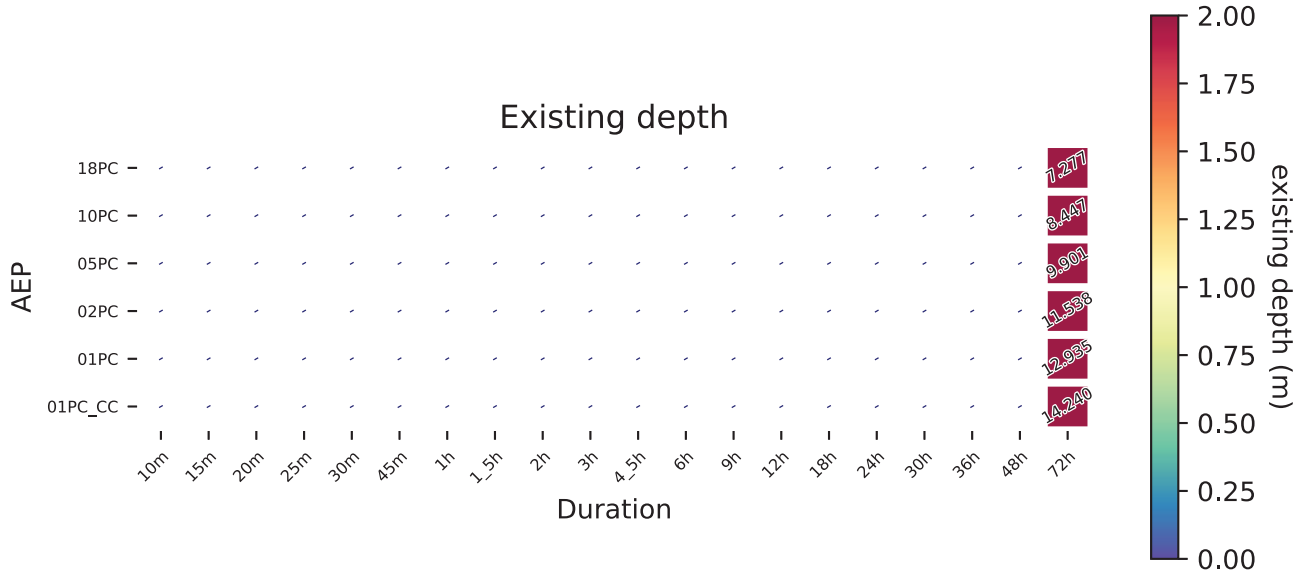
Yarra River - Chandler_Hwy

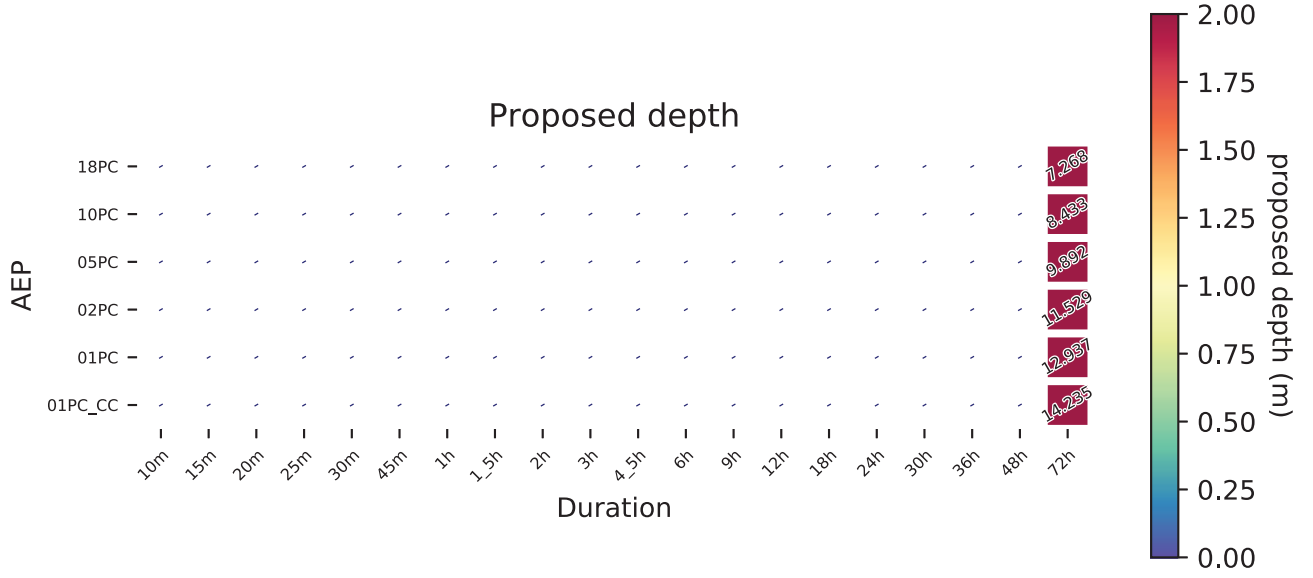


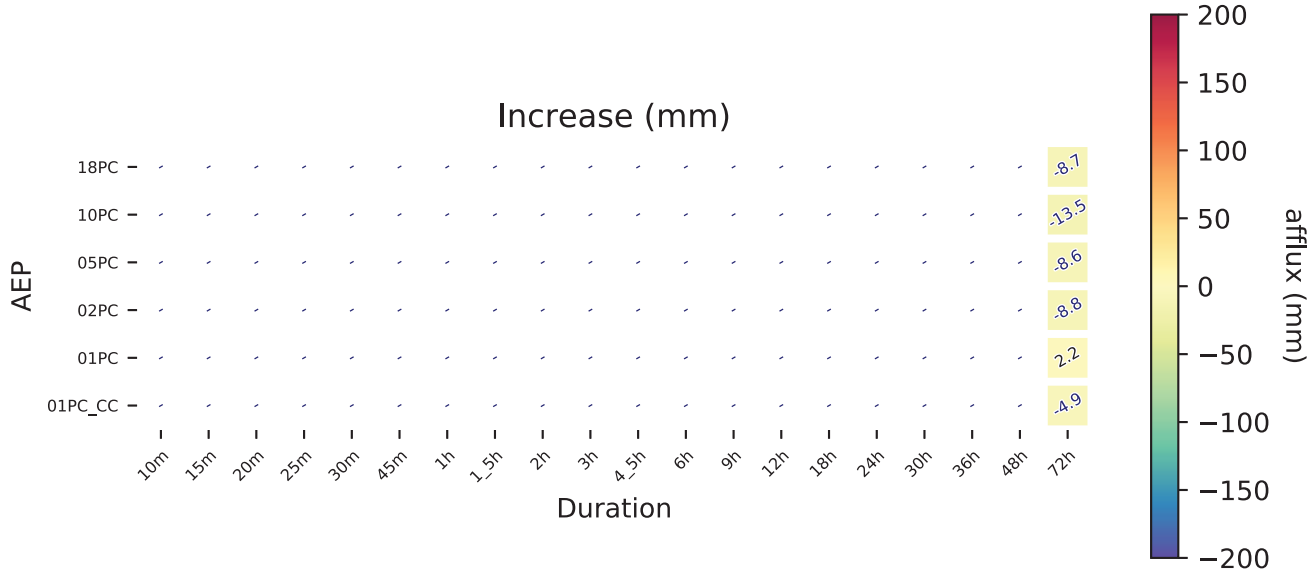




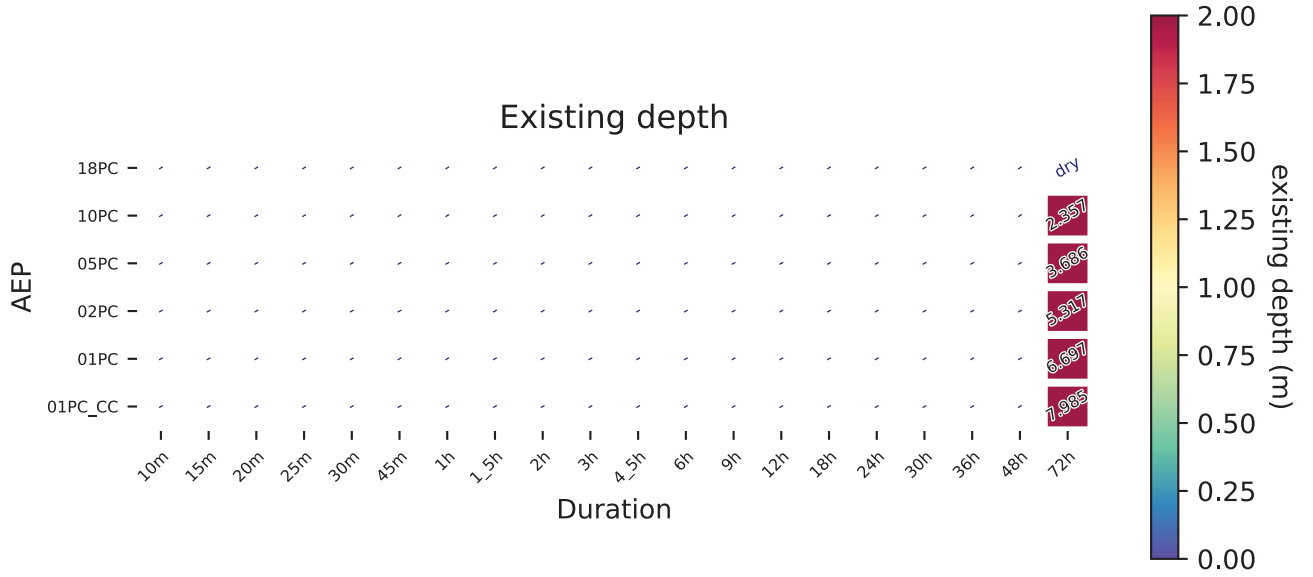
Yarra River - Darebin_Ck

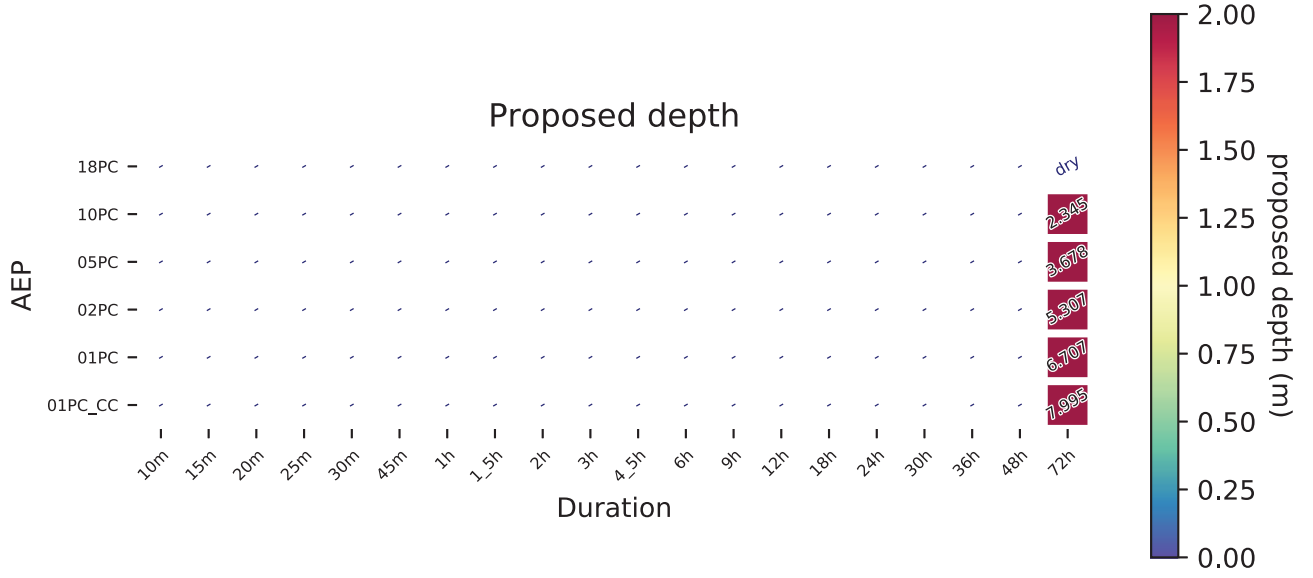


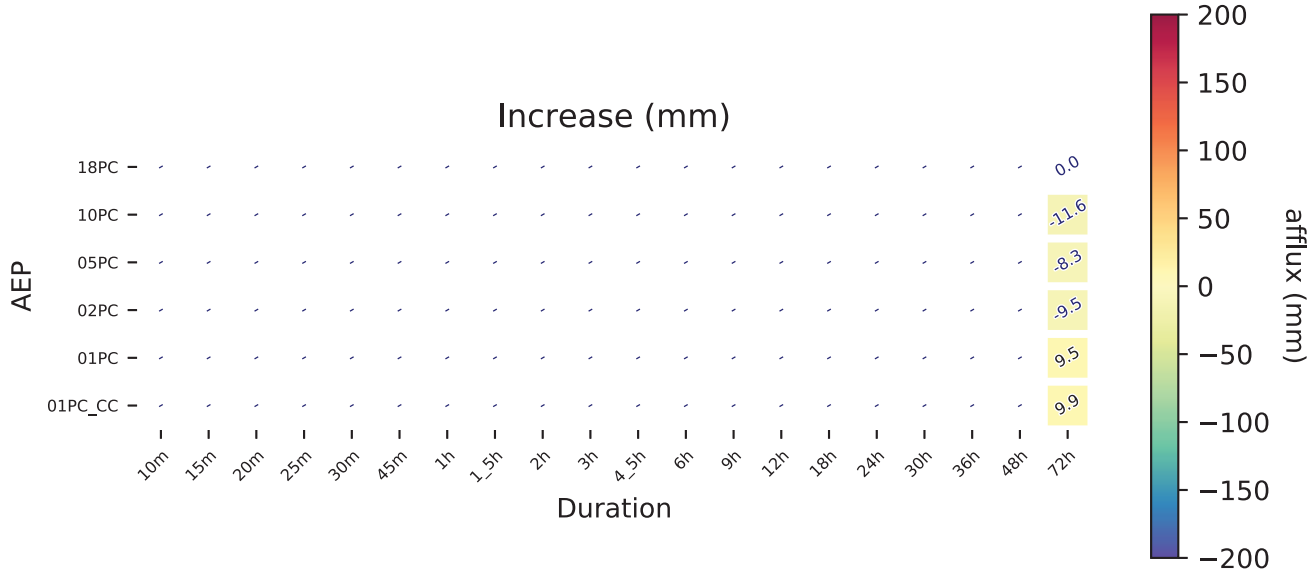




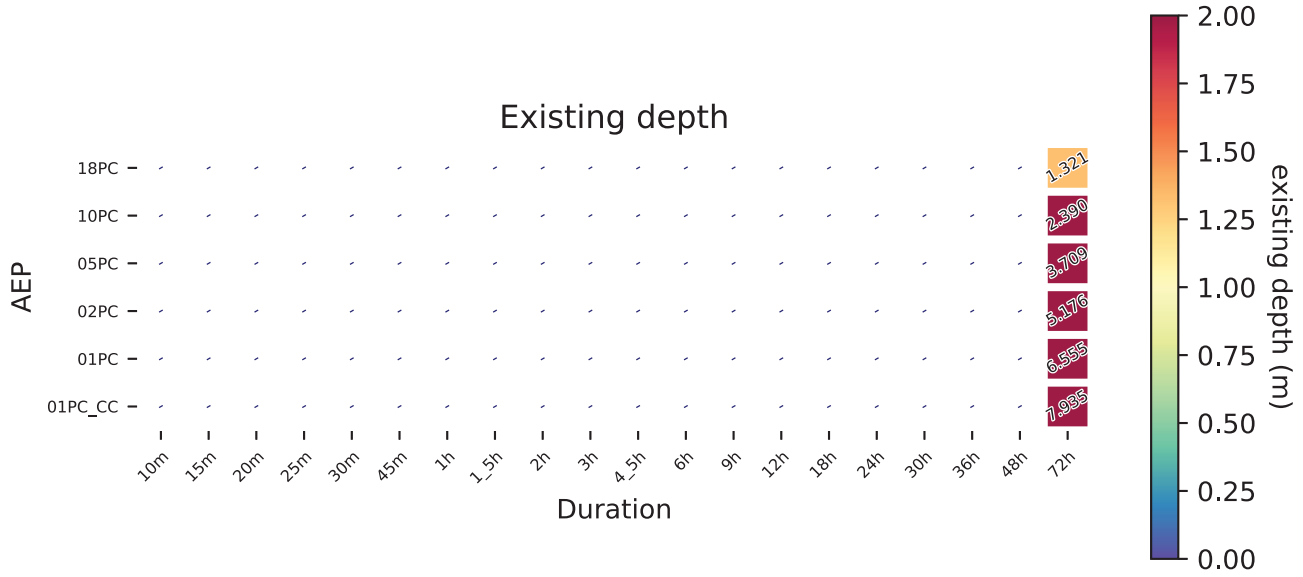
Yarra River - Hays_Paddock

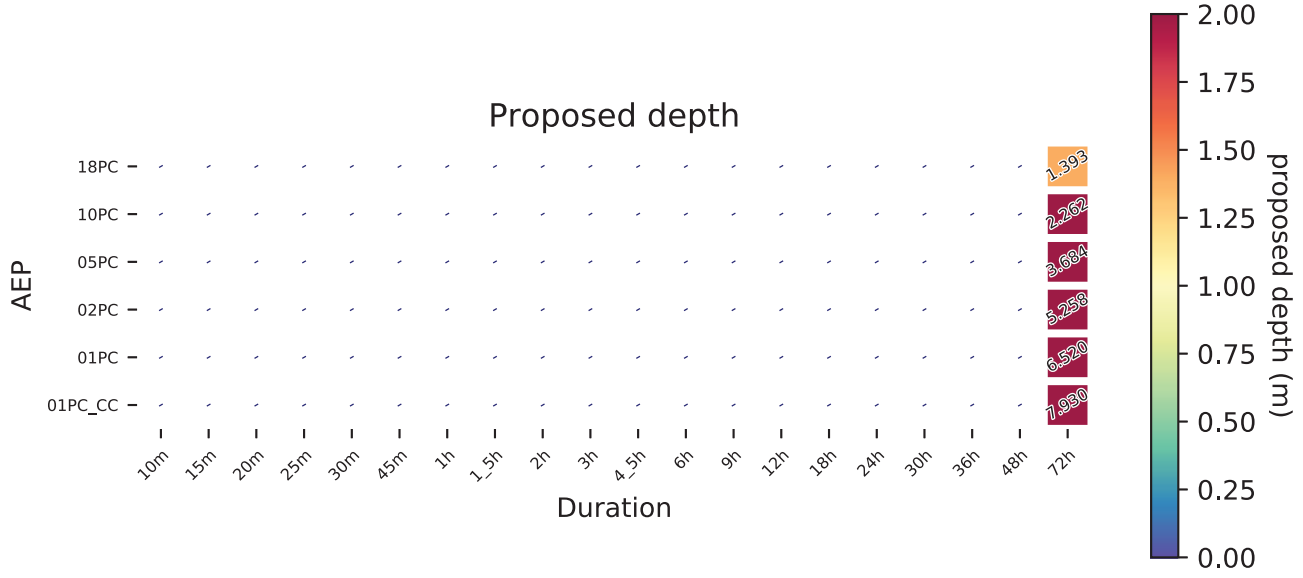


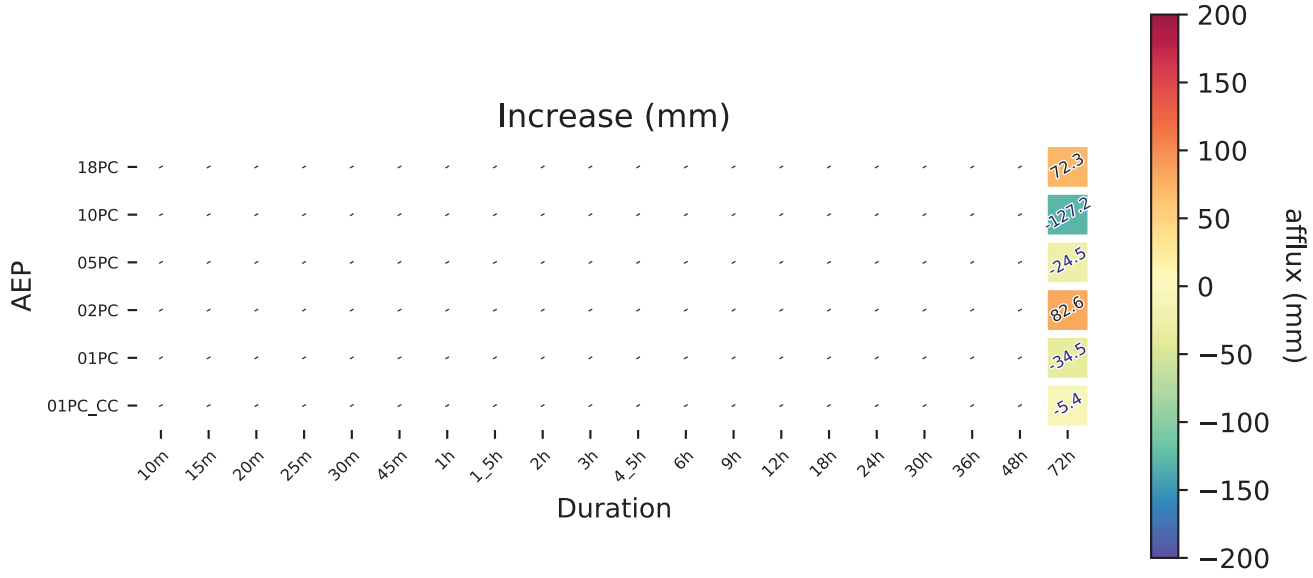




Yarra River - Muska_St_Res







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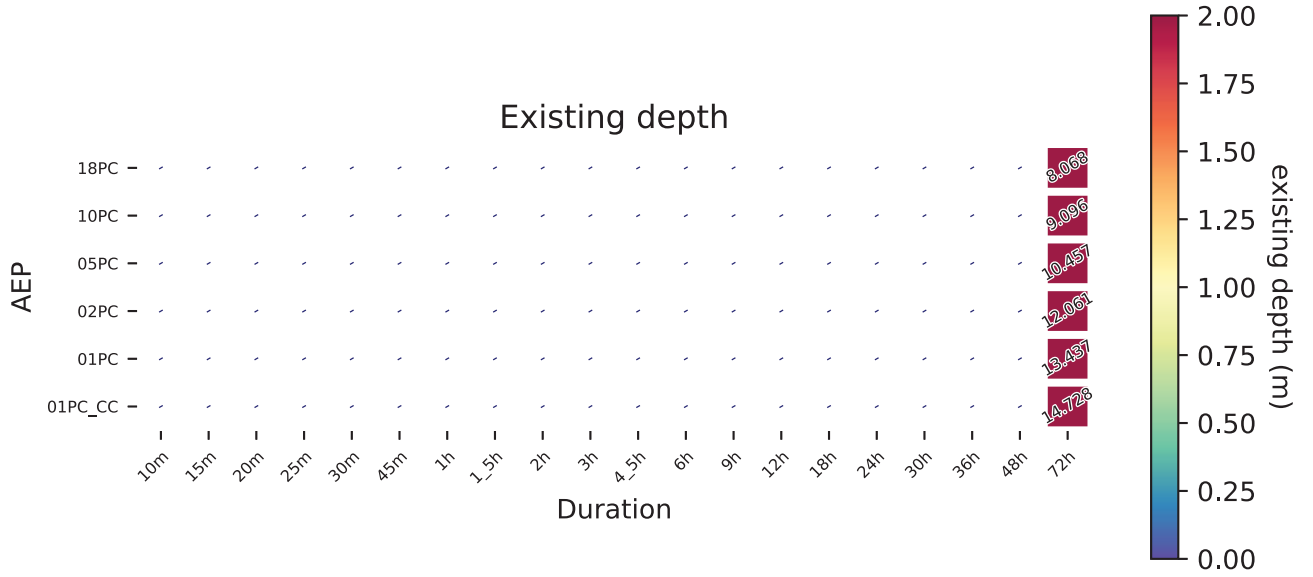
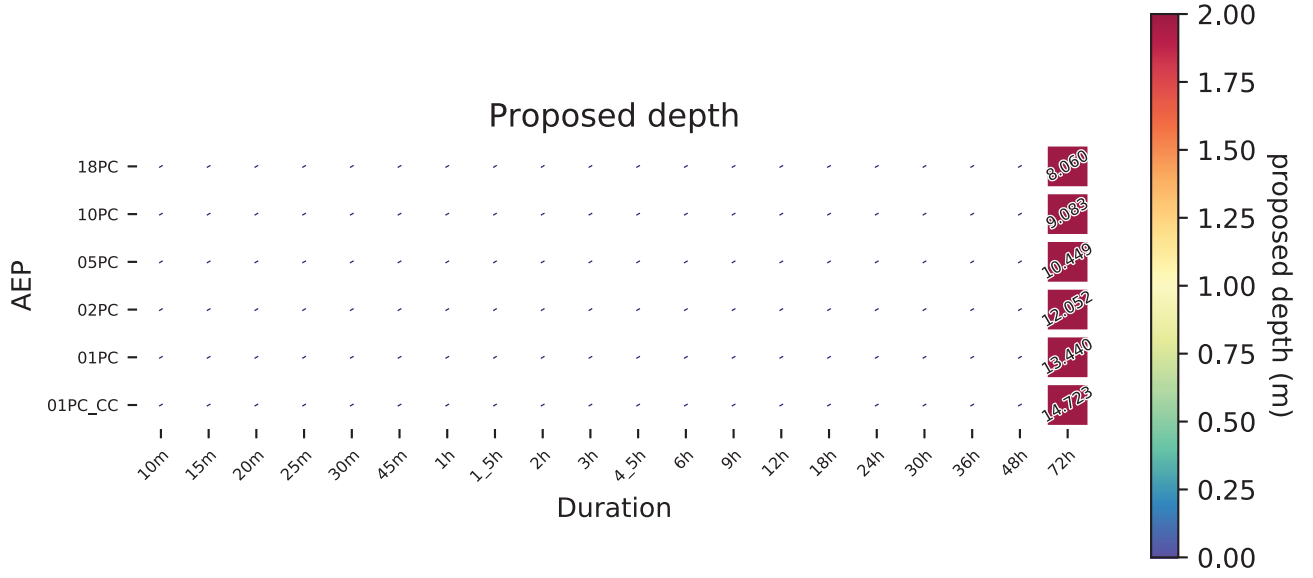
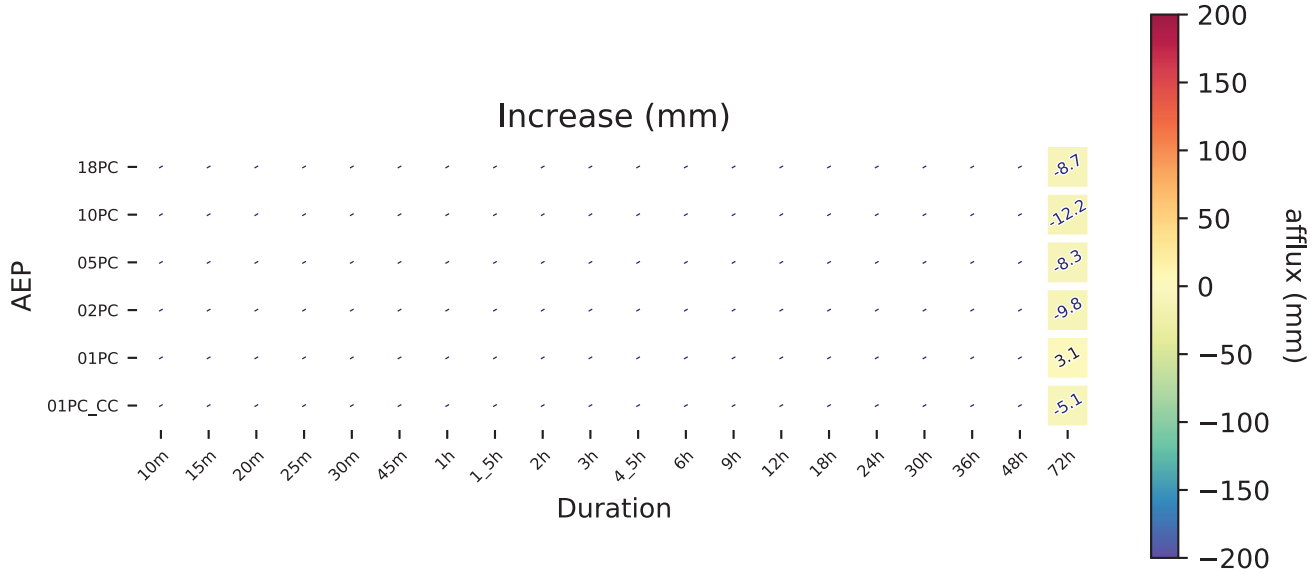
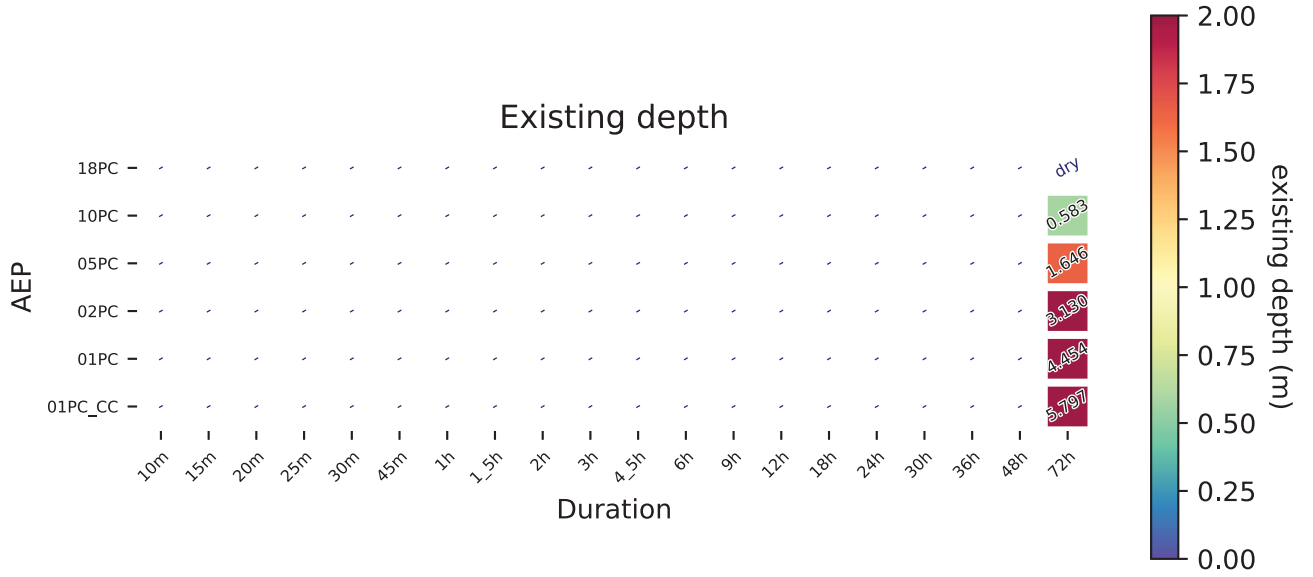
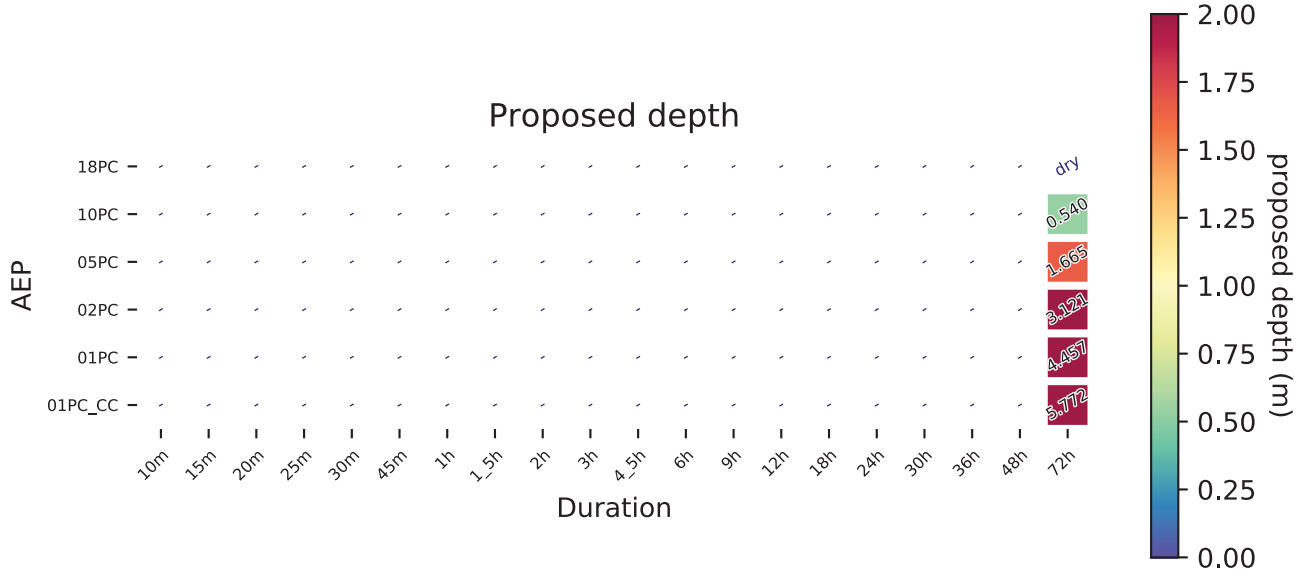


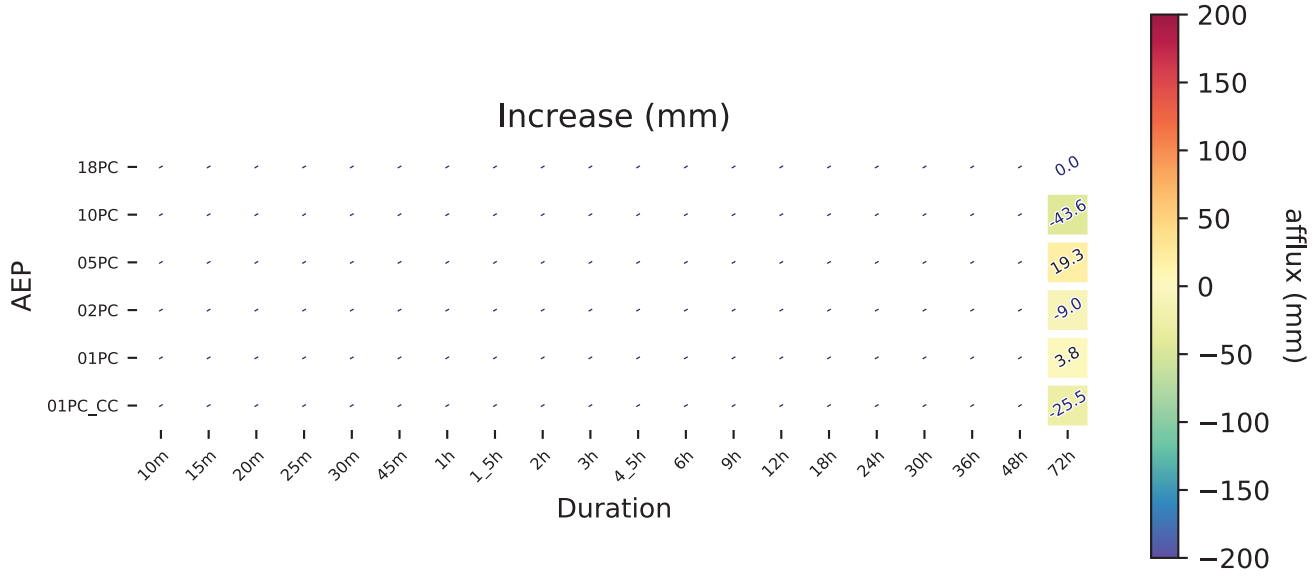




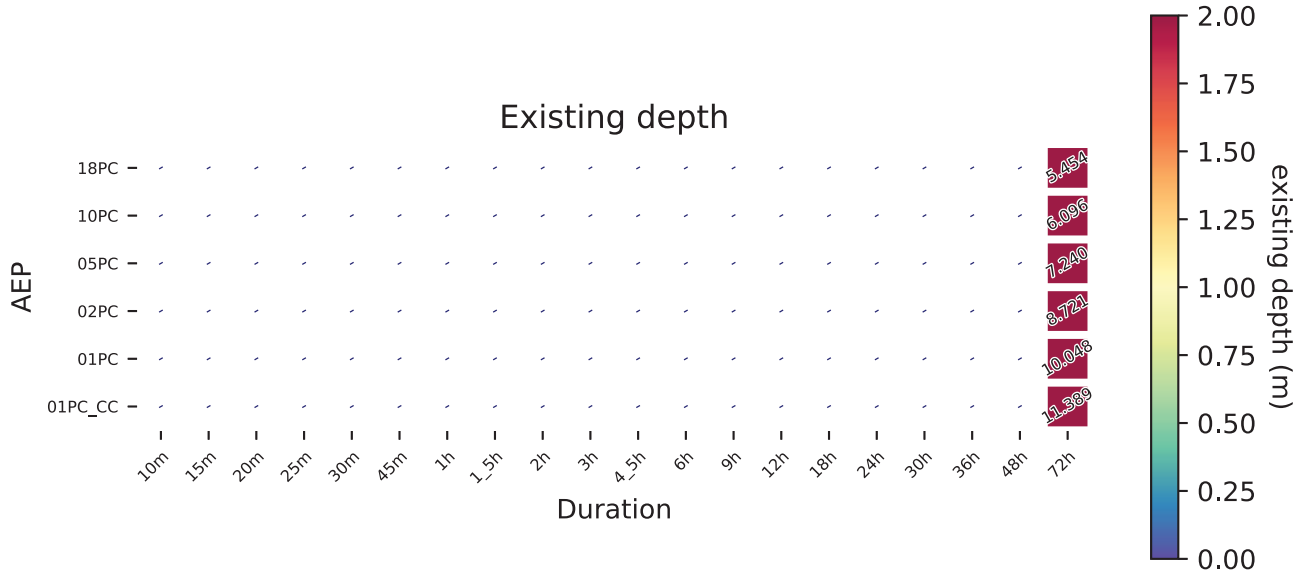
Yarra River - Koonung_Ck

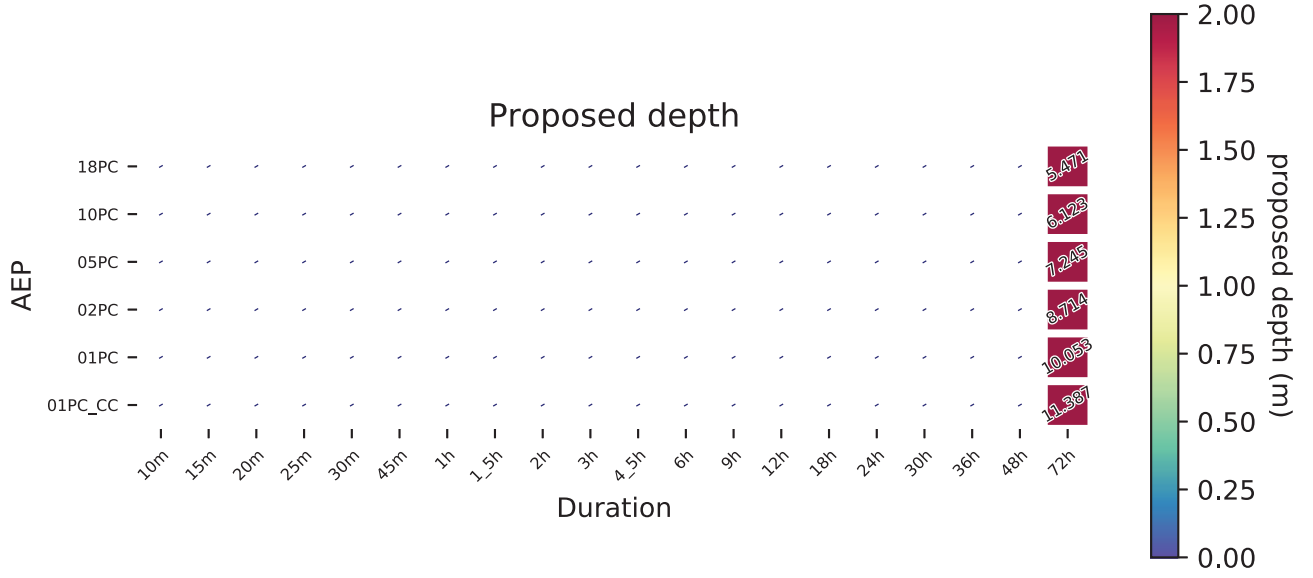


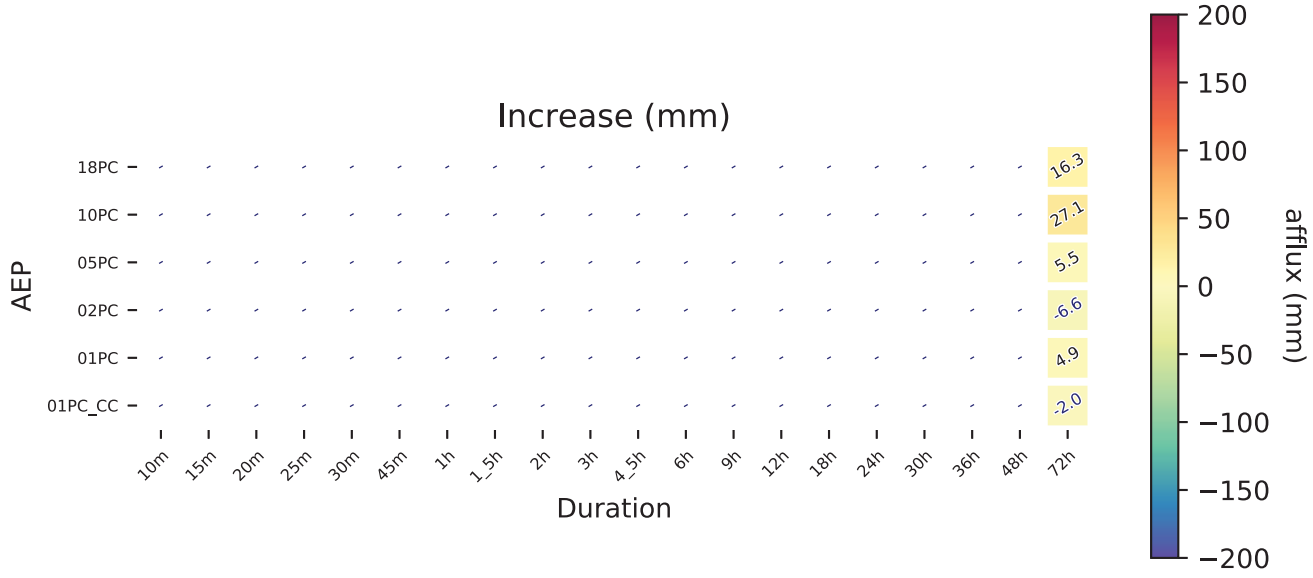




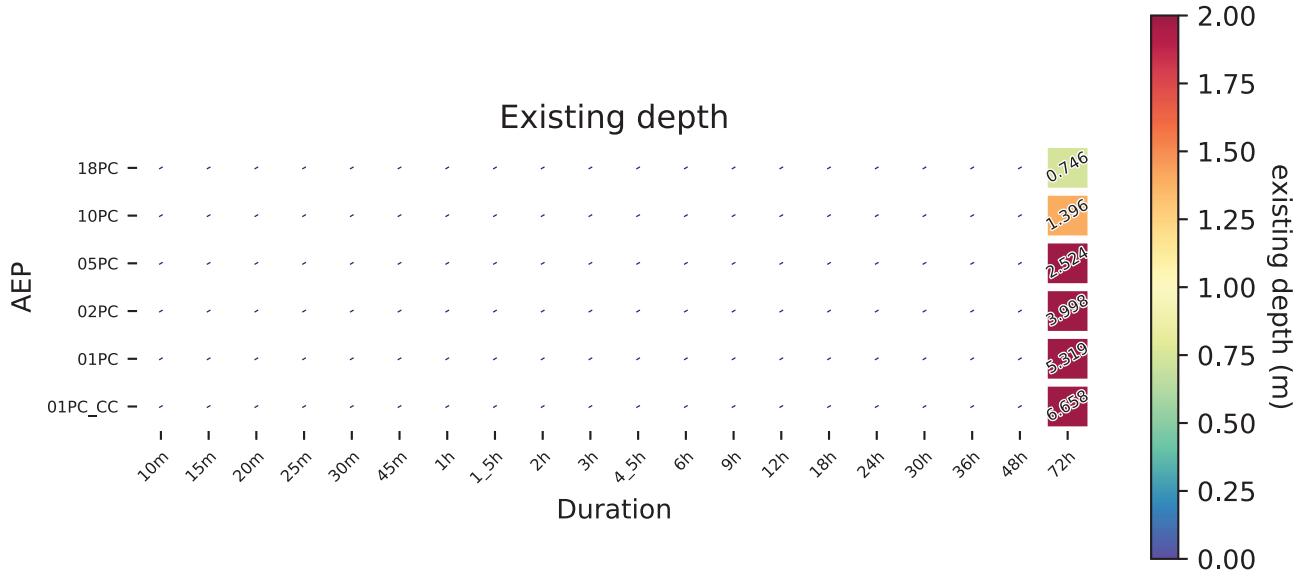
Yarra River - Trinity_Grammar

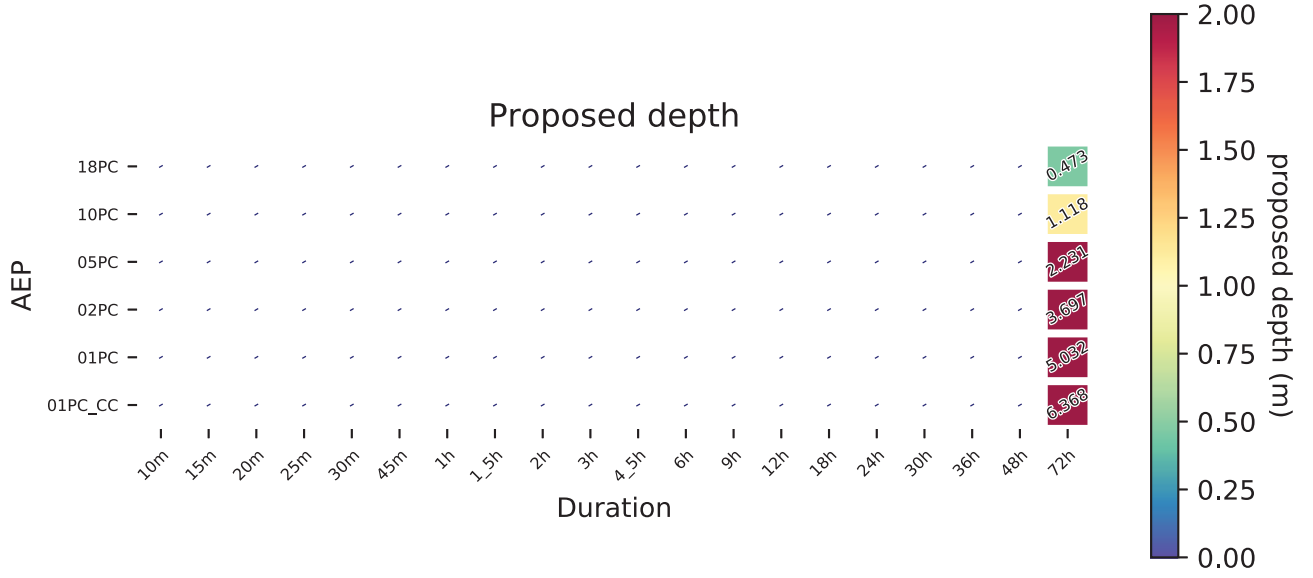


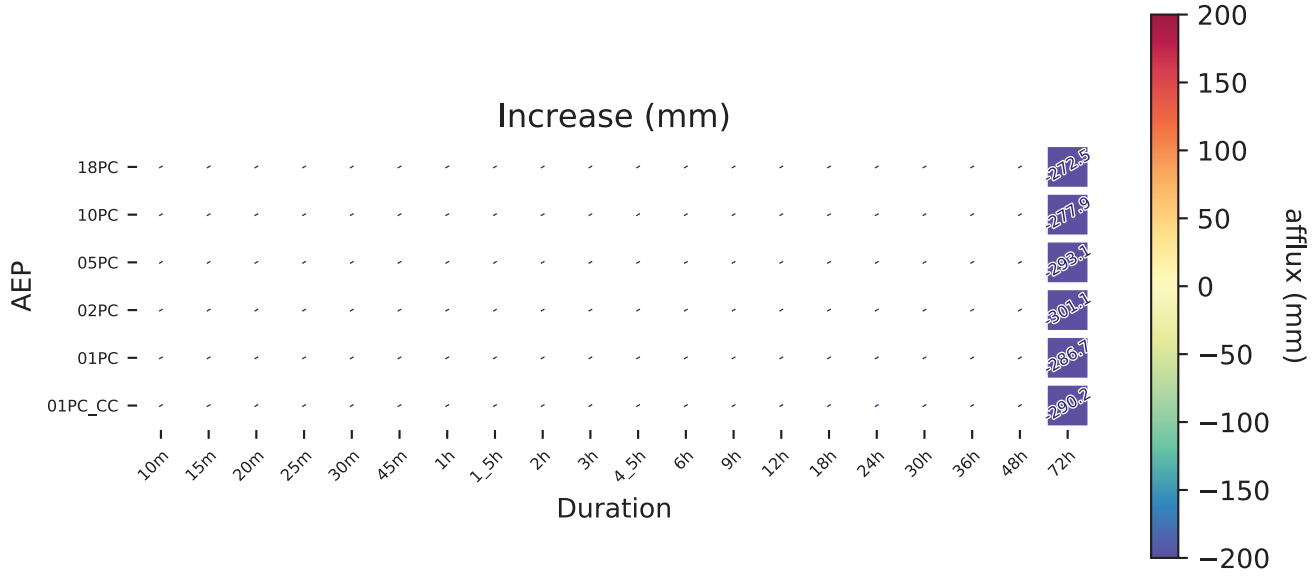




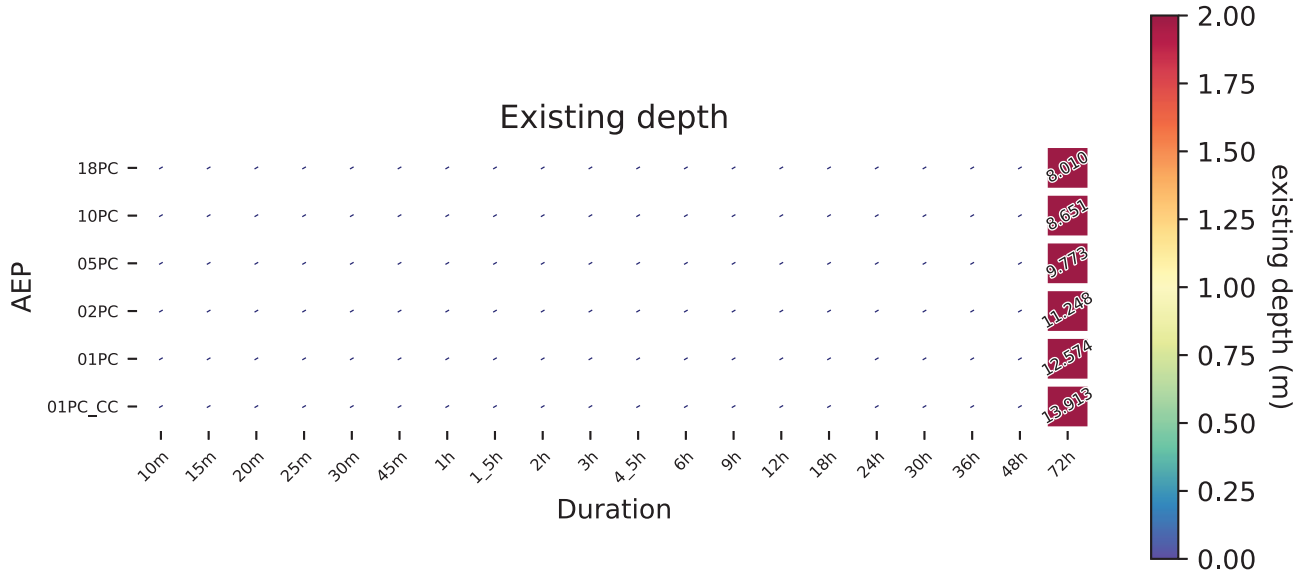
Yarra River - Bulleen_Rd

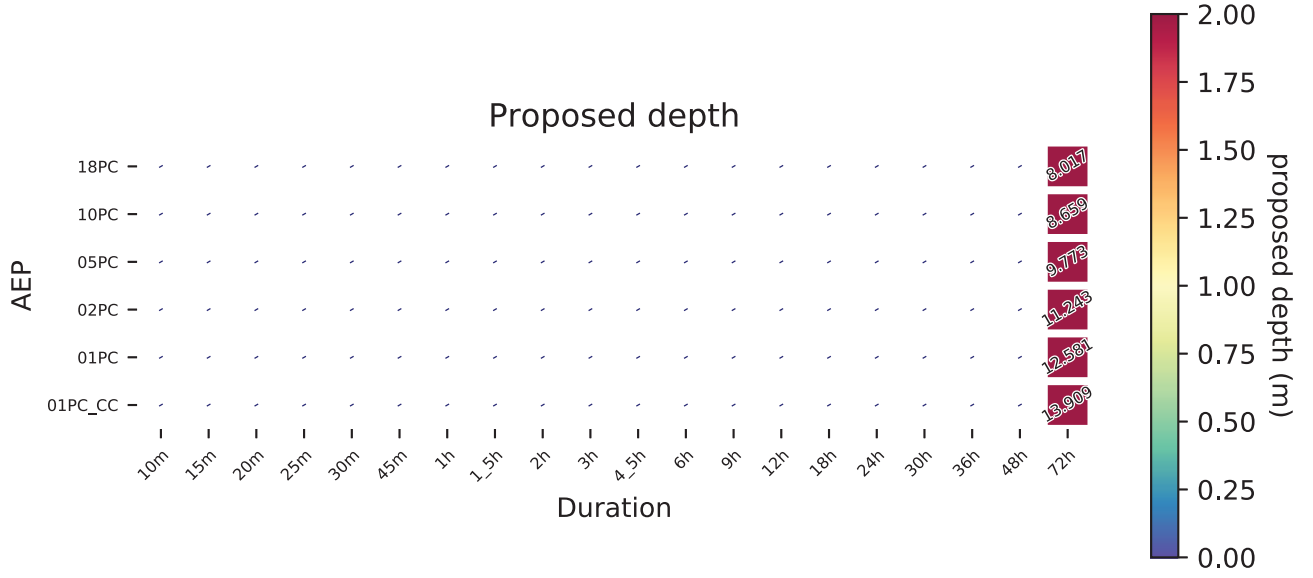


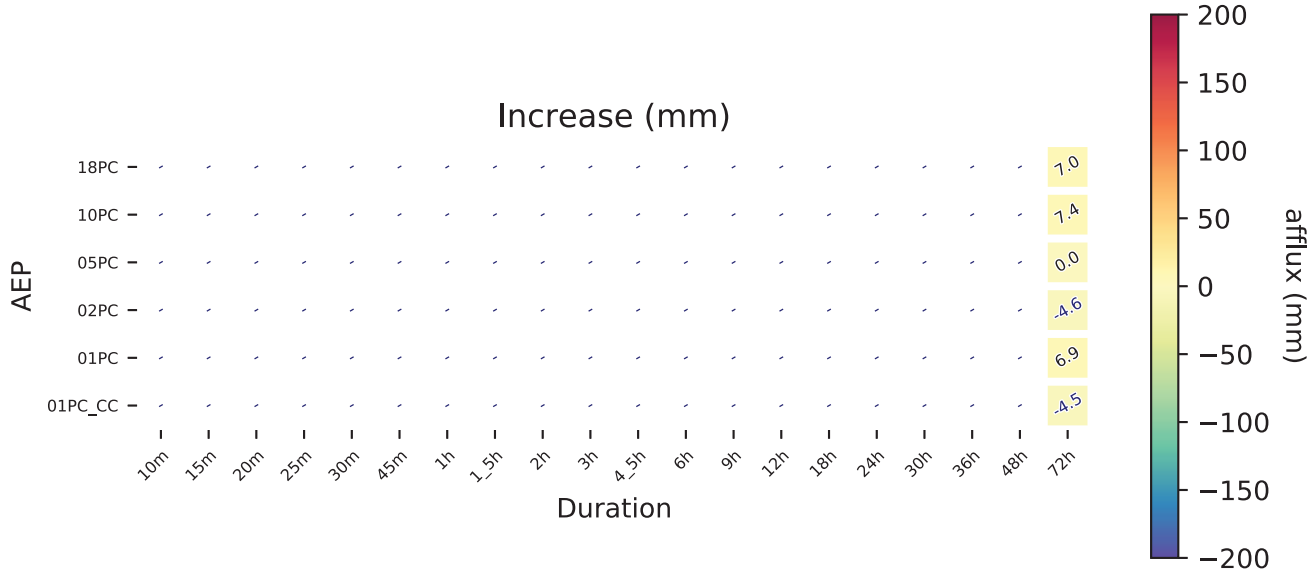




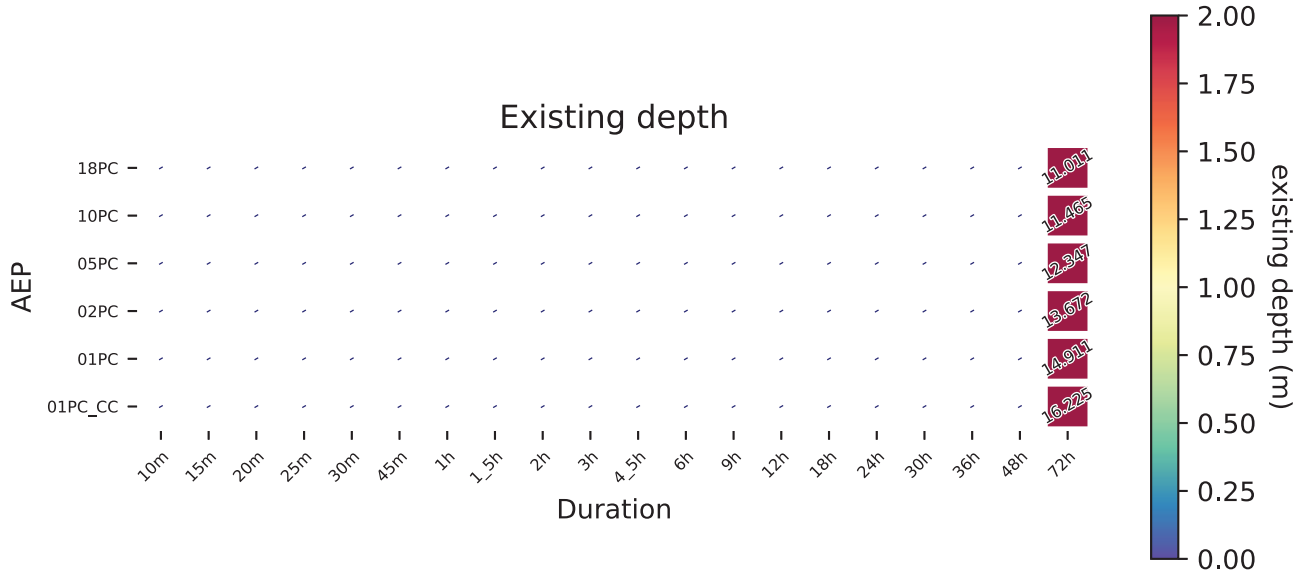
Yarra River - BolinBolinBillabong

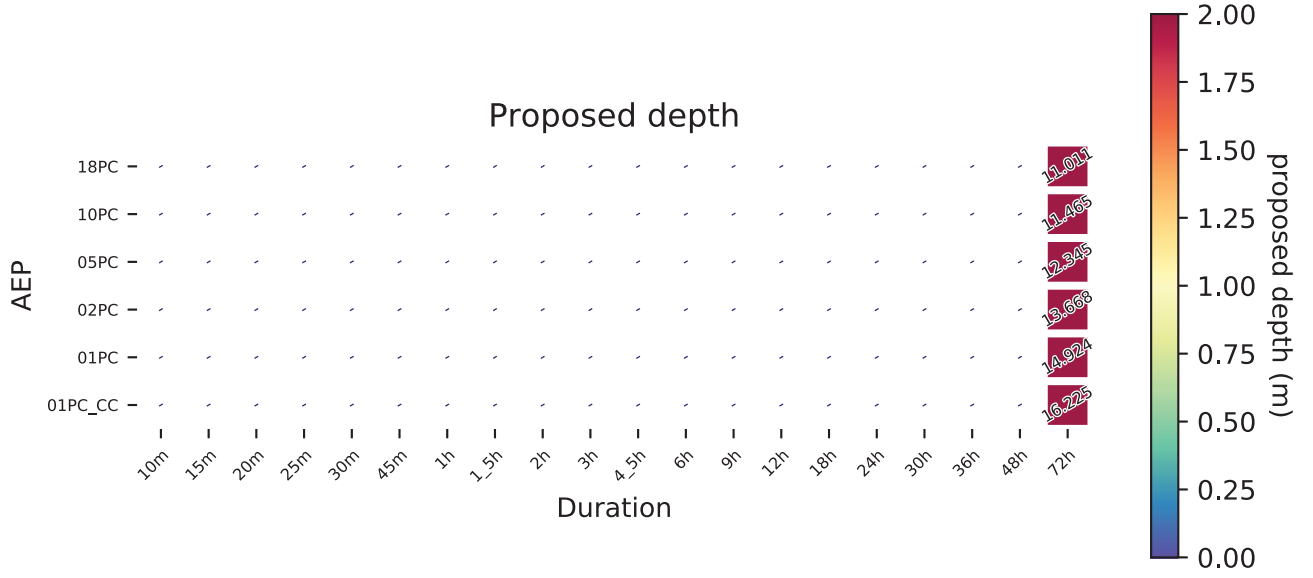


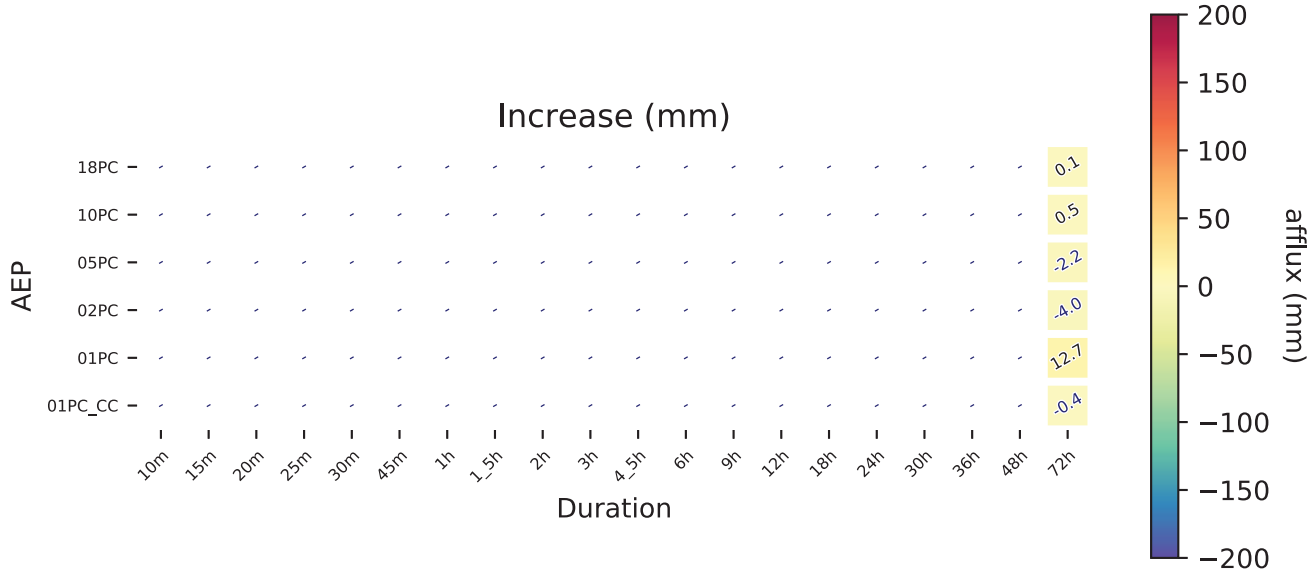




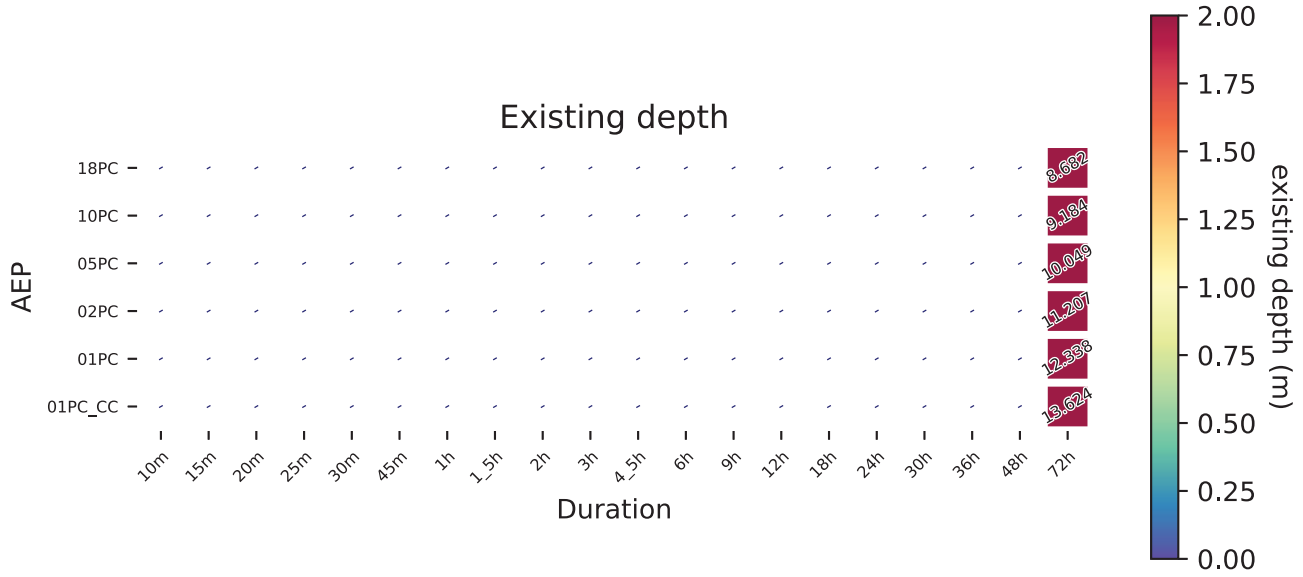
Yarra River - Manningham_Rd_West

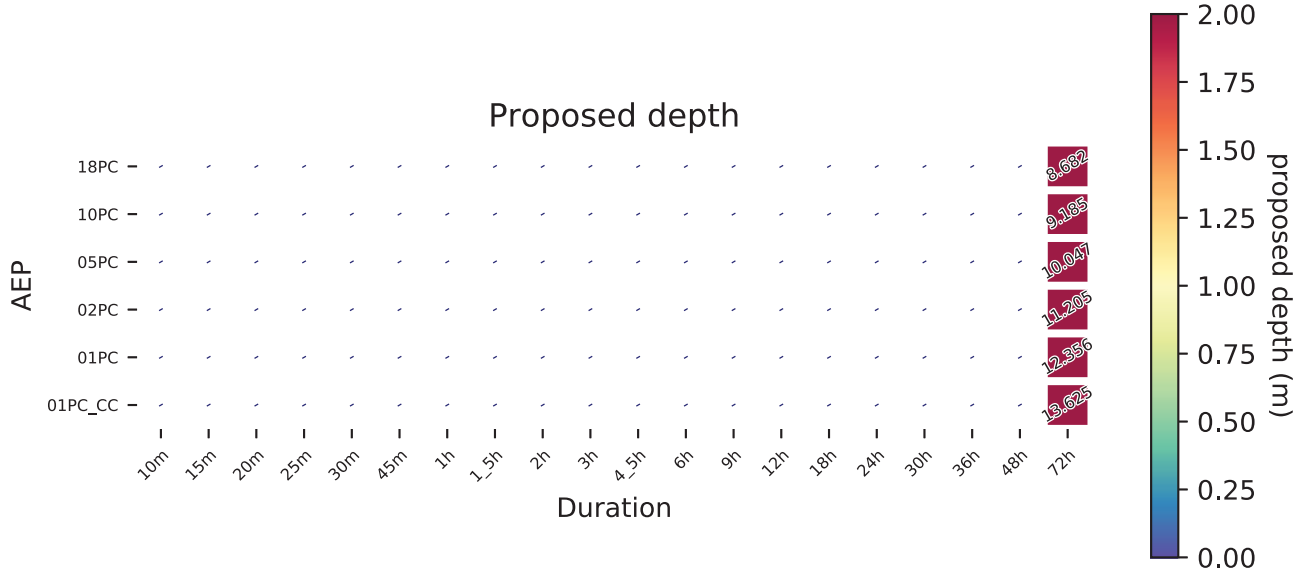


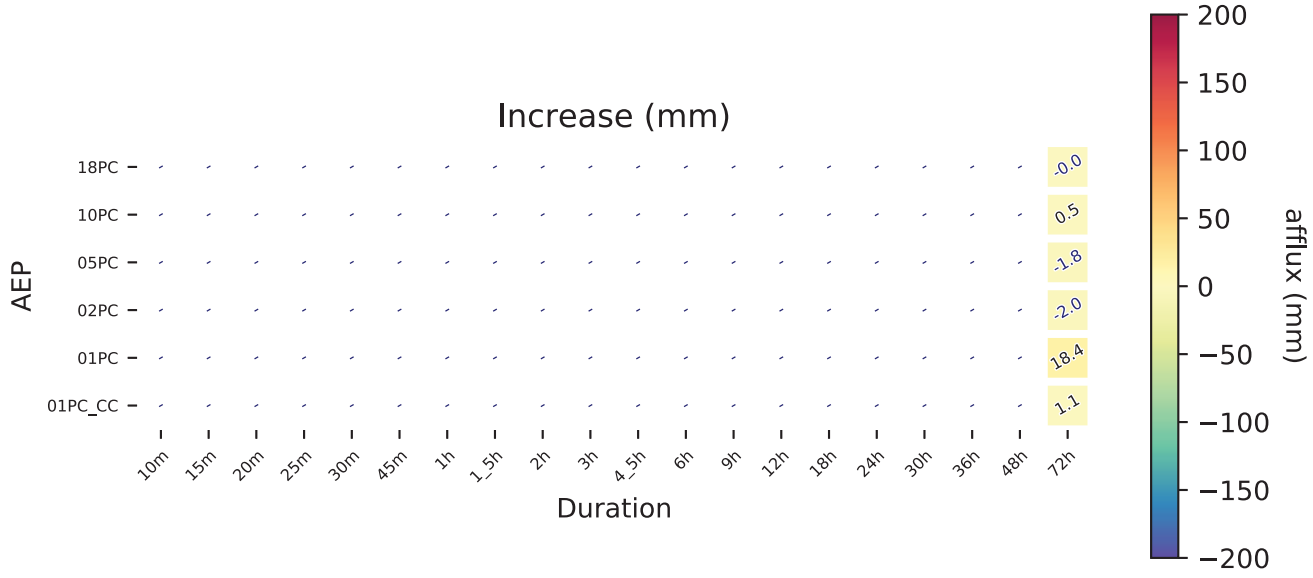




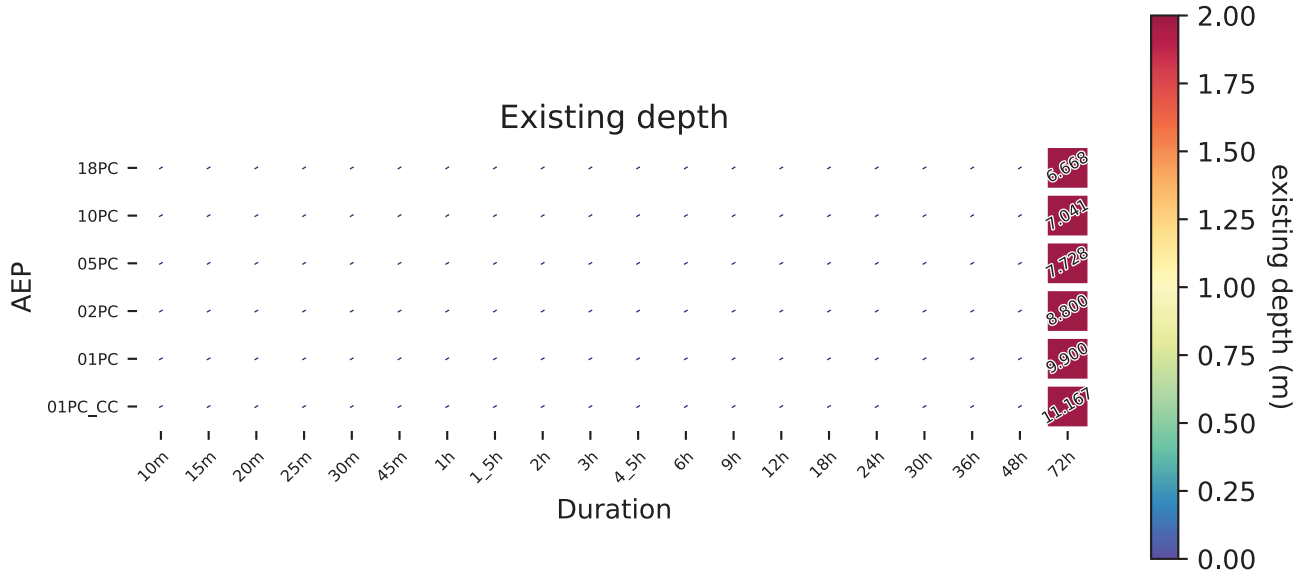
Yarra River - Salt_Creek

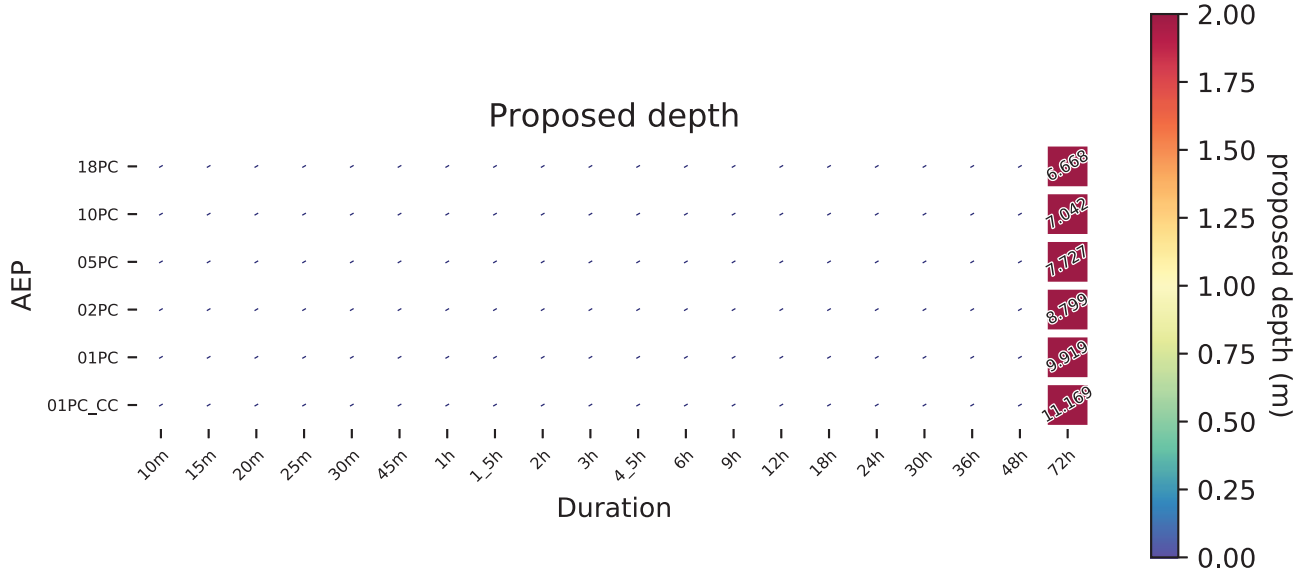


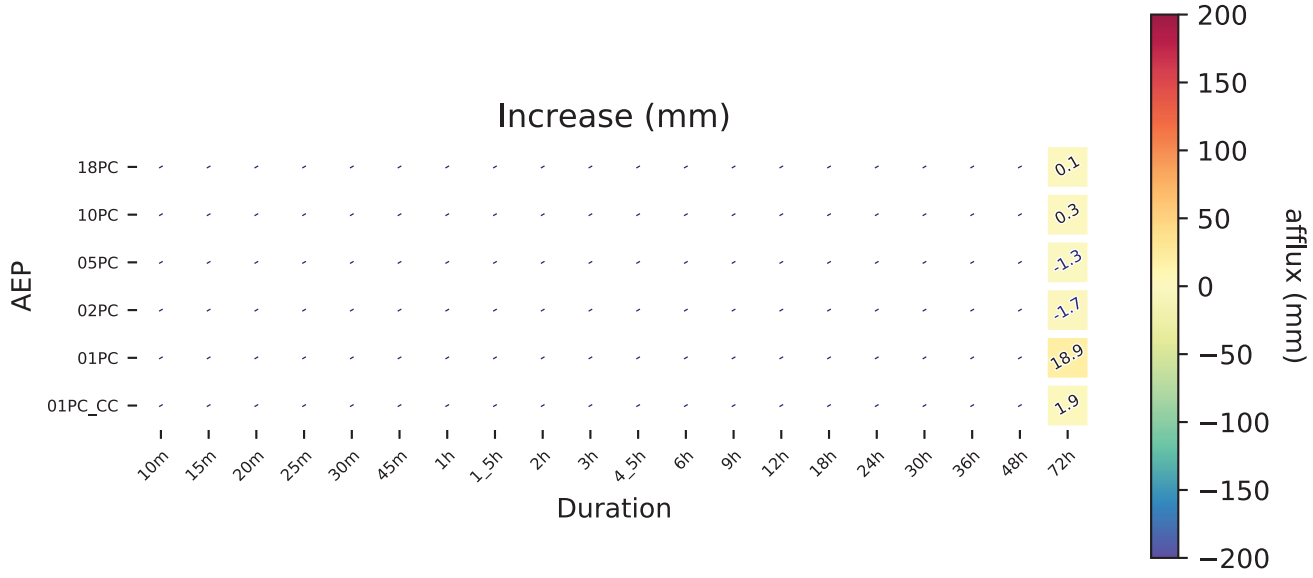




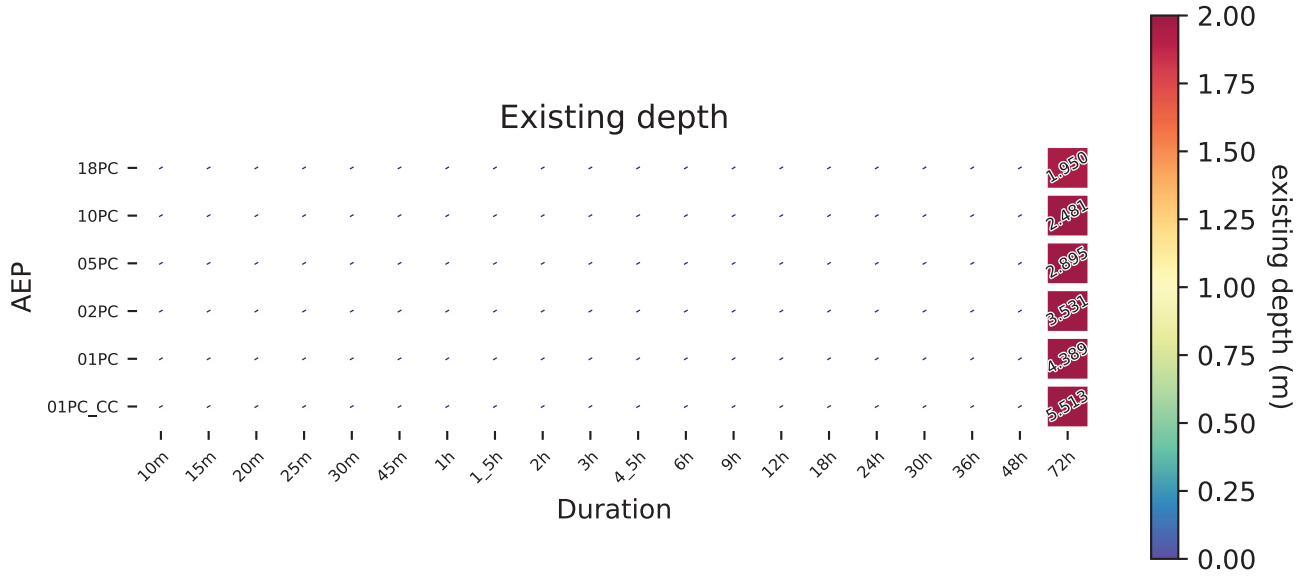
Yarra River - Banyule_Creek

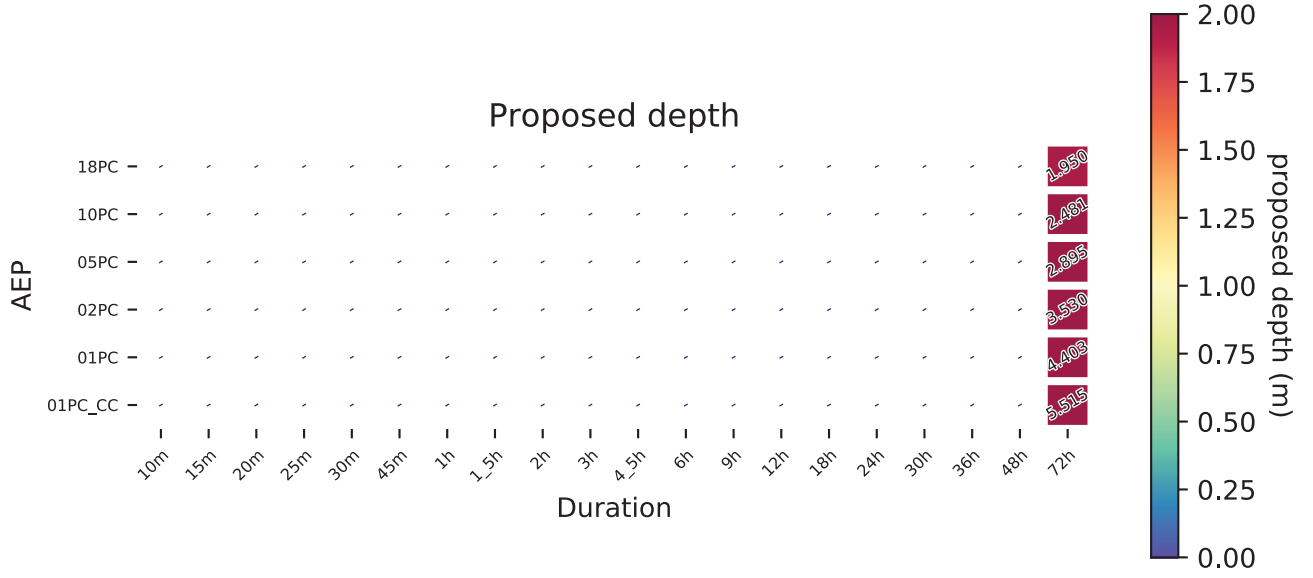


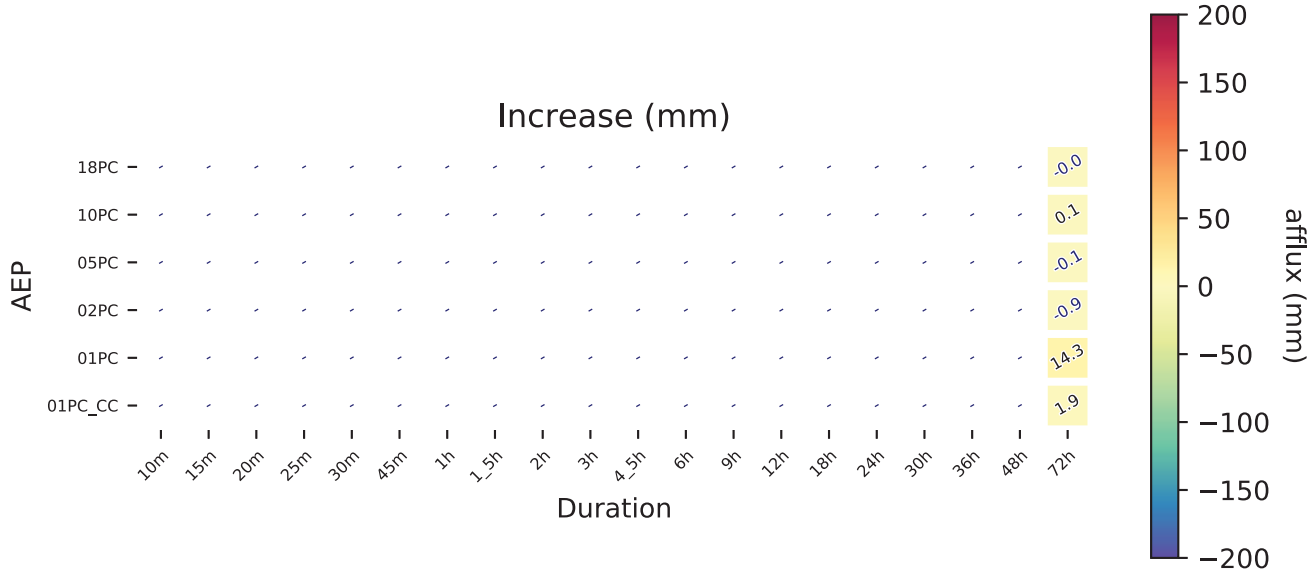




Yarra River - Plenty_River







LEGEND

★ Selected Locations

Paper Size A4

0 135 270 540

Metres

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

N

North East Link
North East Link Project

Job Number	31-35006
Revision	D
Date	13/11/2018

Koonung Creek 1 of 3
Comparison Locations Appendix C-3-1

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

LEGEND

★ Selected Locations

Paper Size A4

0 135 270 540

Metres

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

N

NORTH EAST LINK PROJECT

North East Link
North East Link Project

Job Number | 31-35006
Revision | D
Date | 13/11/2018

Koonung Creek 2 of 3
Comparison Locations Appendix C-3-2

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

LEGEND

★ Selected Locations

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Metres

Map Projection: Transverse Mercator
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N

North East Link
North East Link Project

Job Number | 31-35006
Revision | D
Date | 13/11/2018

Koonung Creek 3 of 3
Comparison Locations Appendix C-3-3

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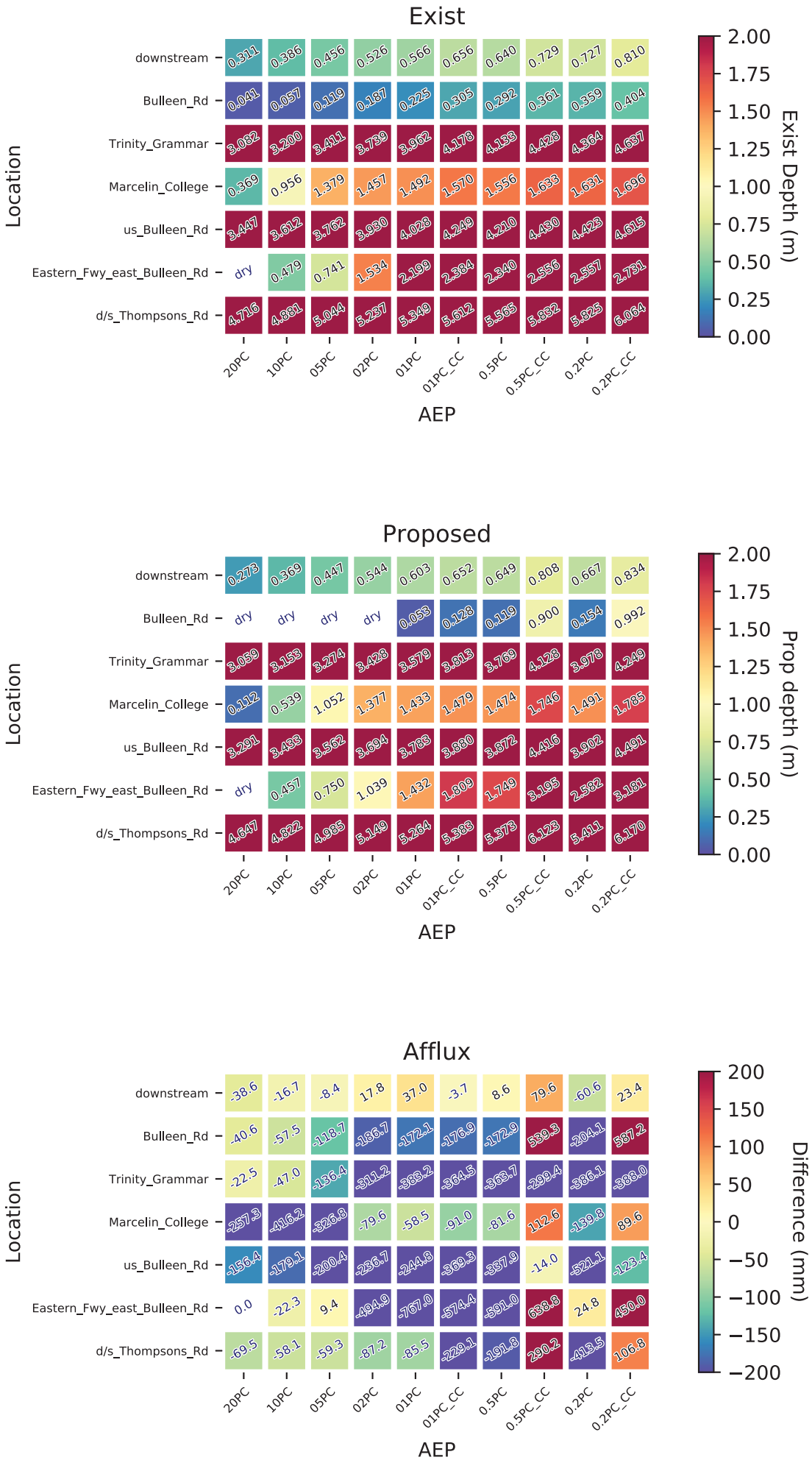
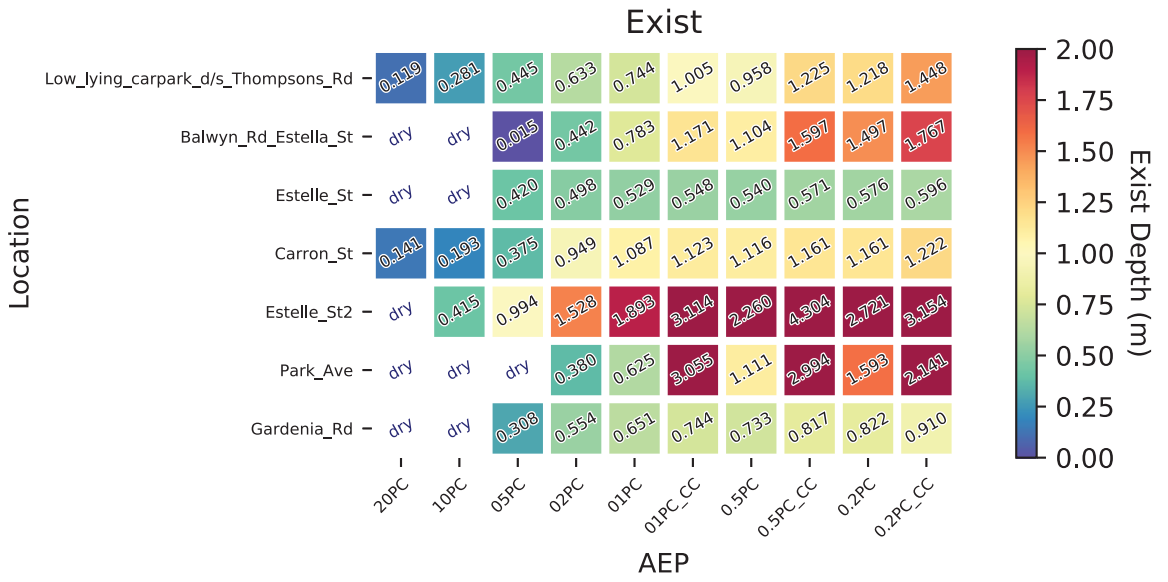
180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com

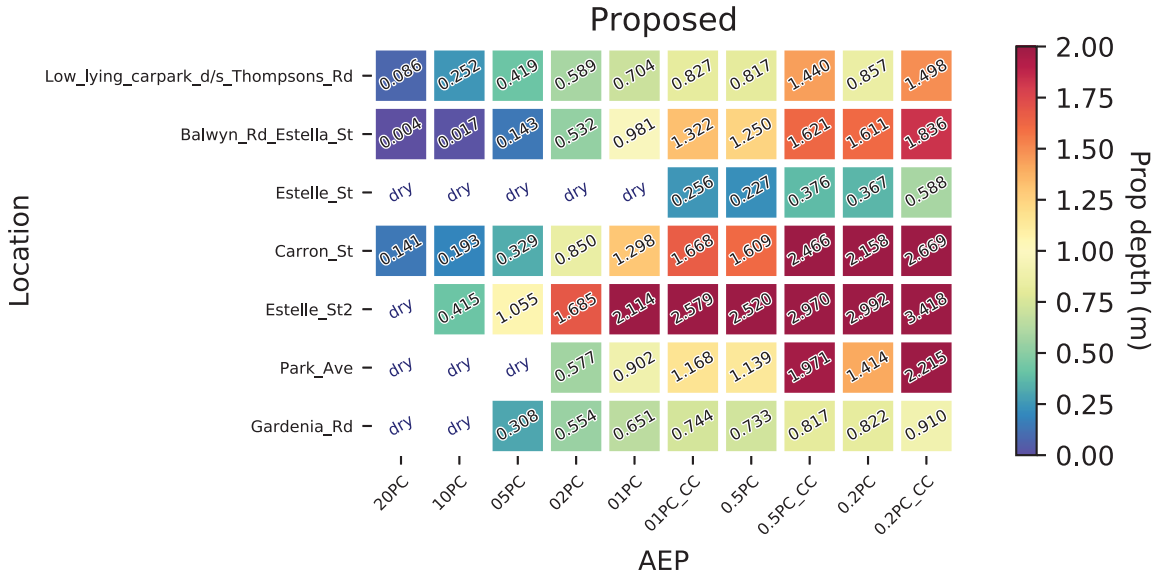
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

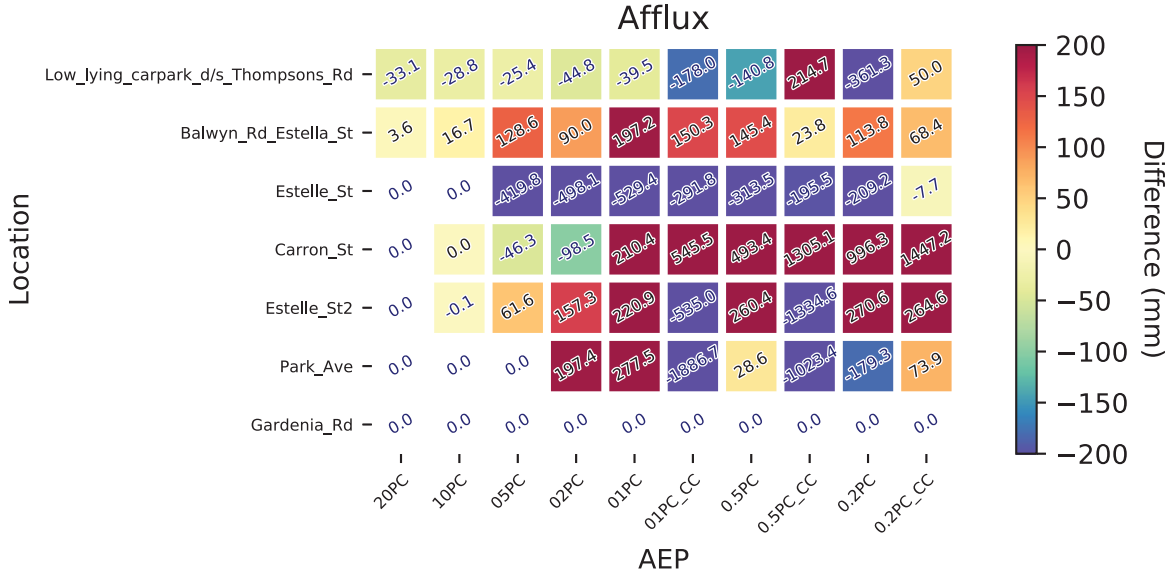
Koonung Creek - Overview



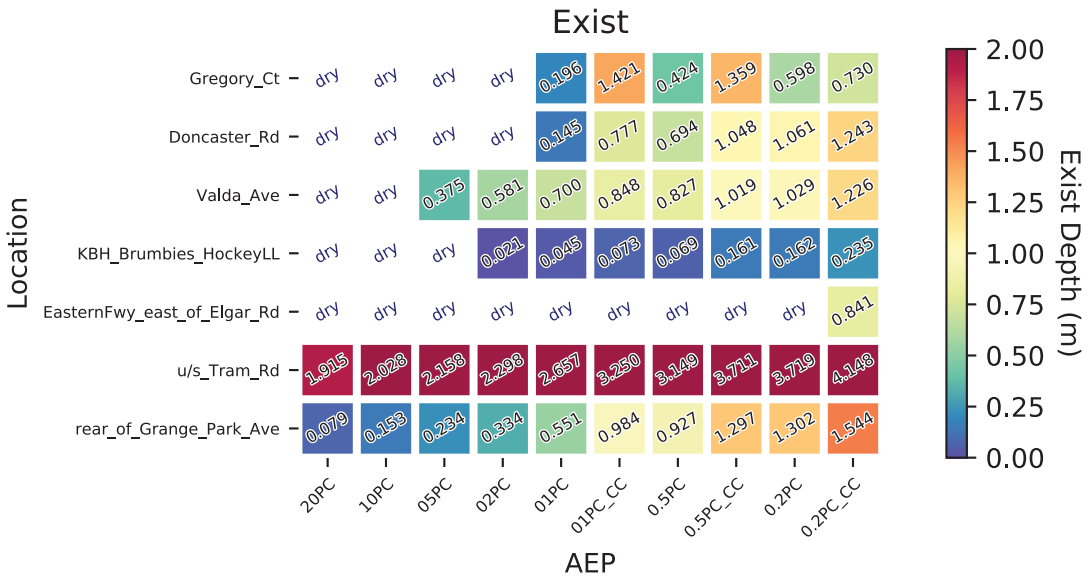
Koonung Creek - Overview

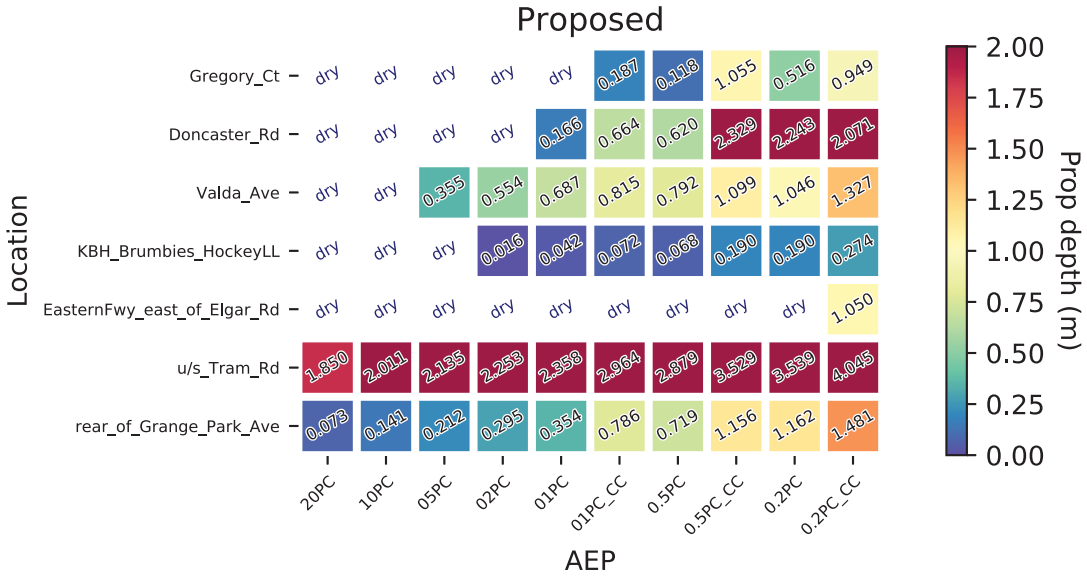


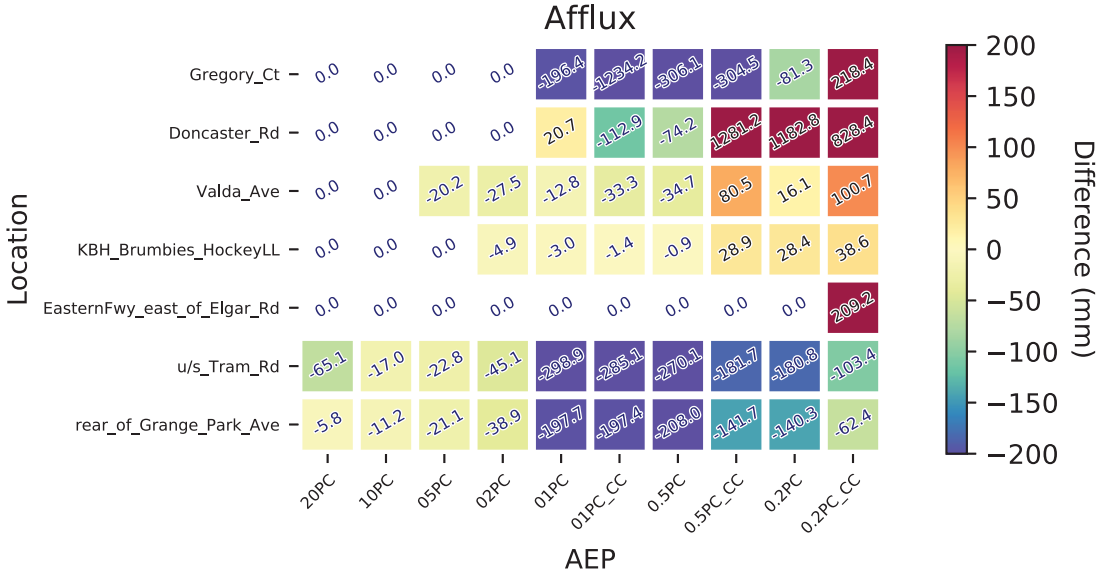




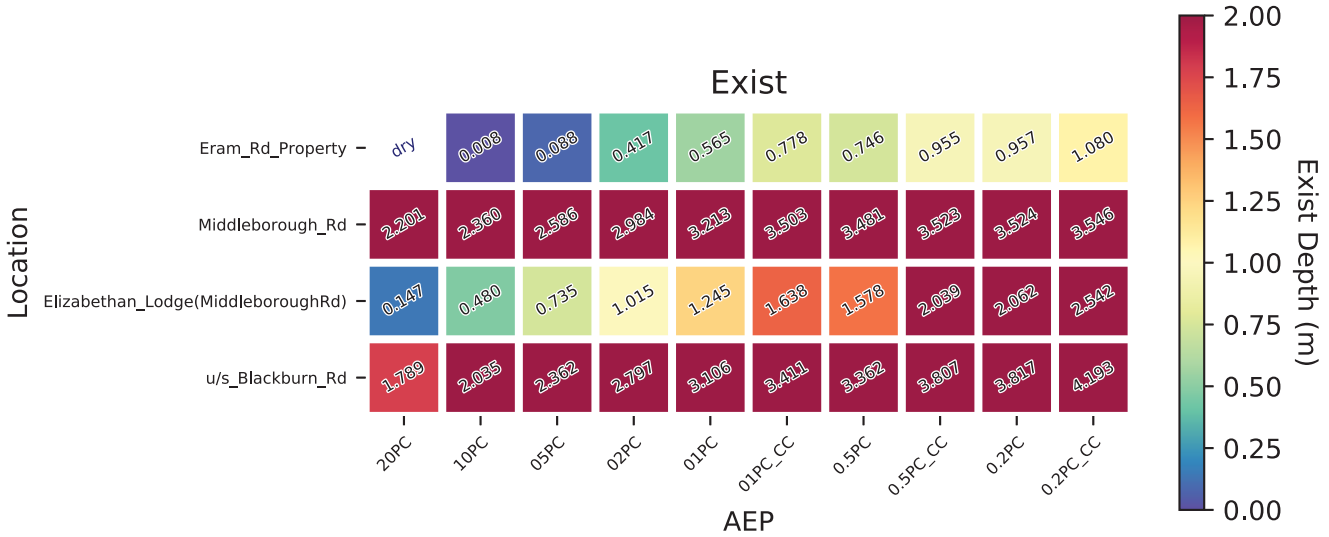
Koonung Creek - Overview

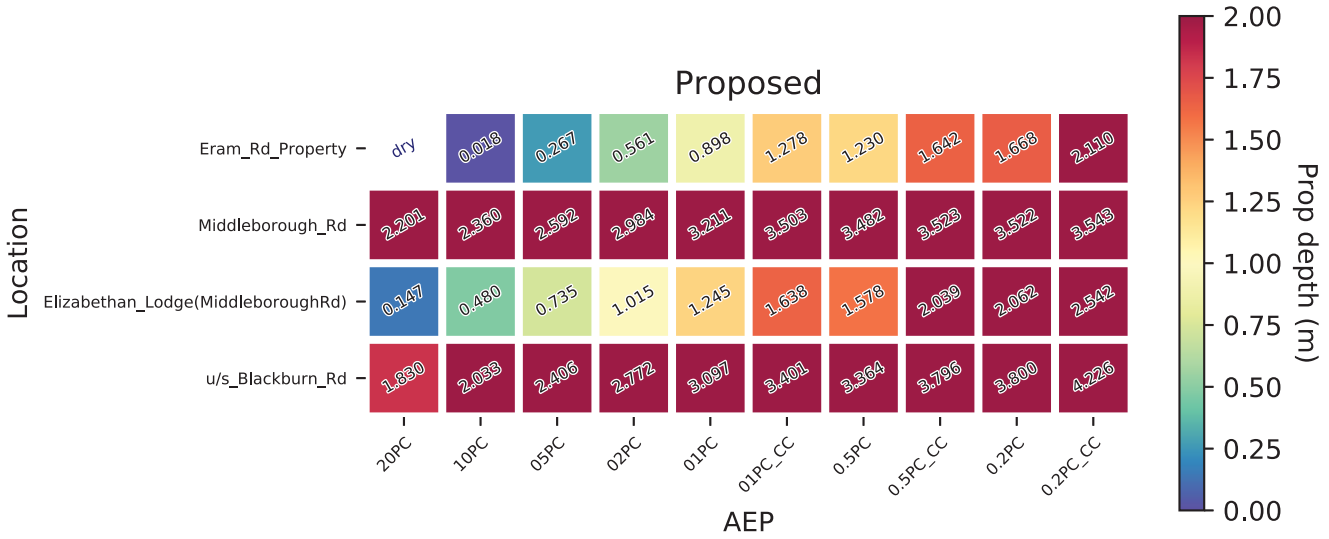


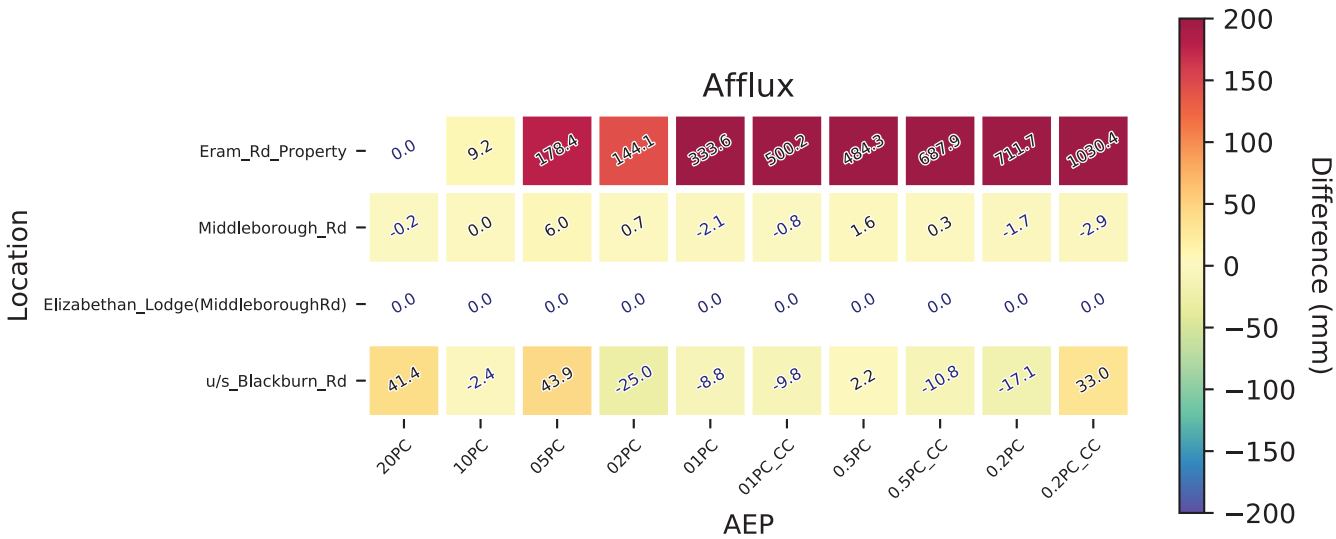




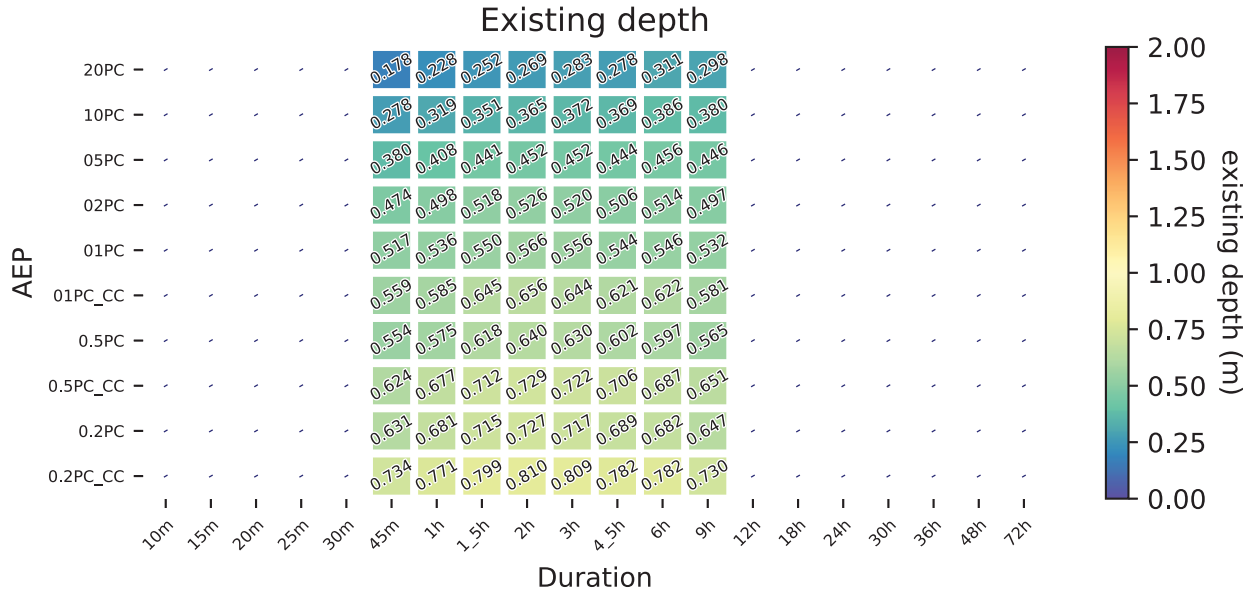
Koonung Creek - Overview

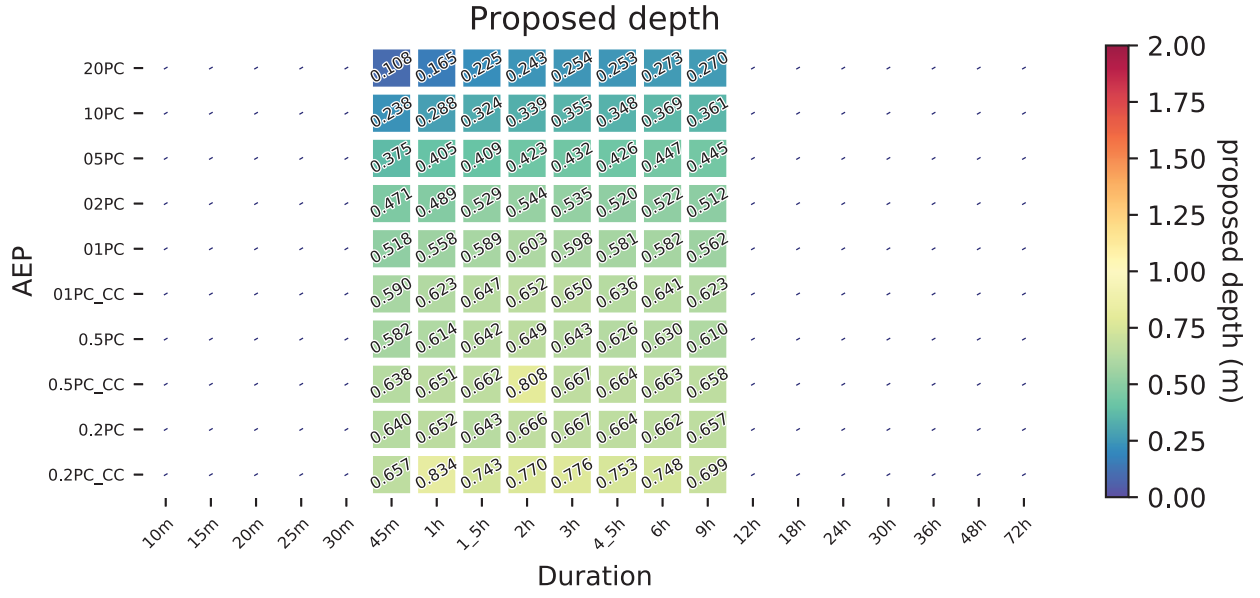


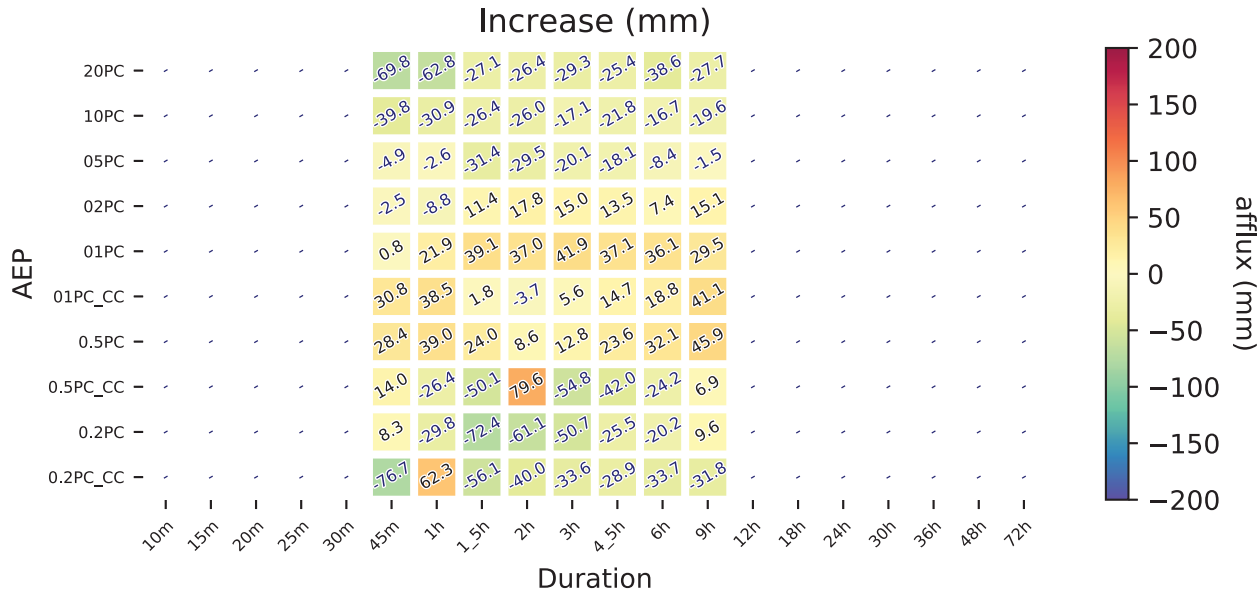




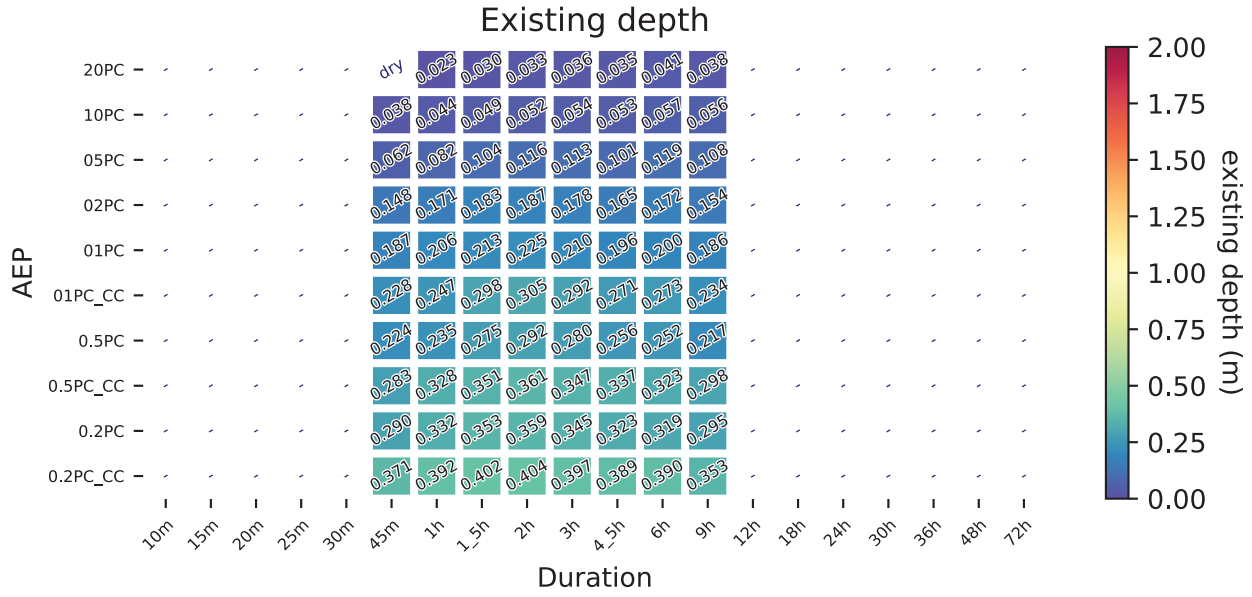
Koonung Creek - downstream

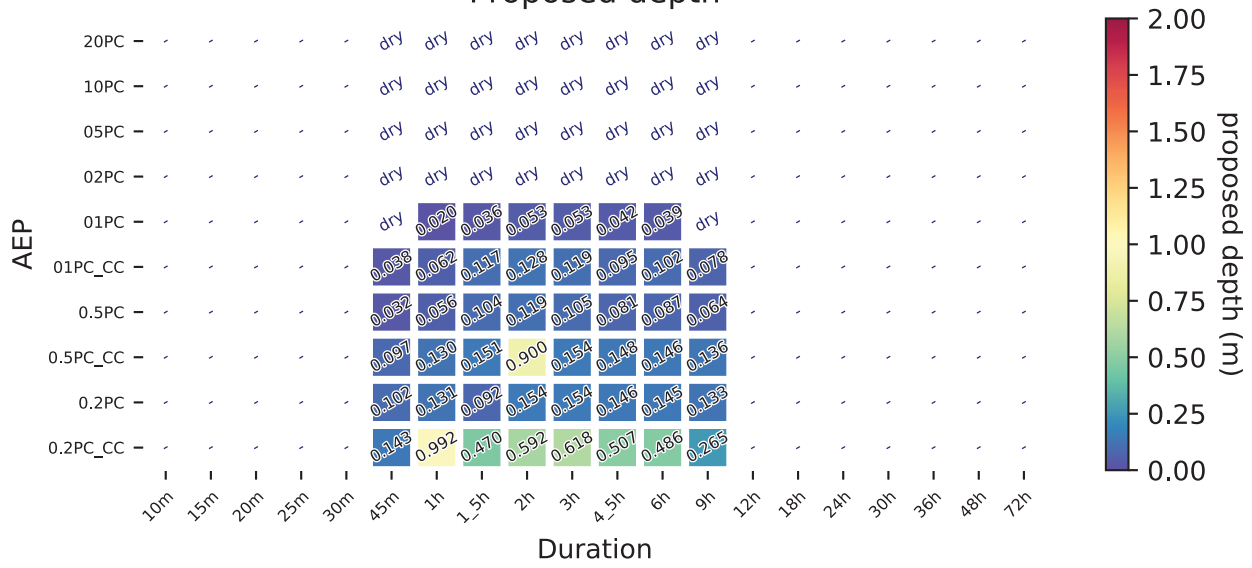


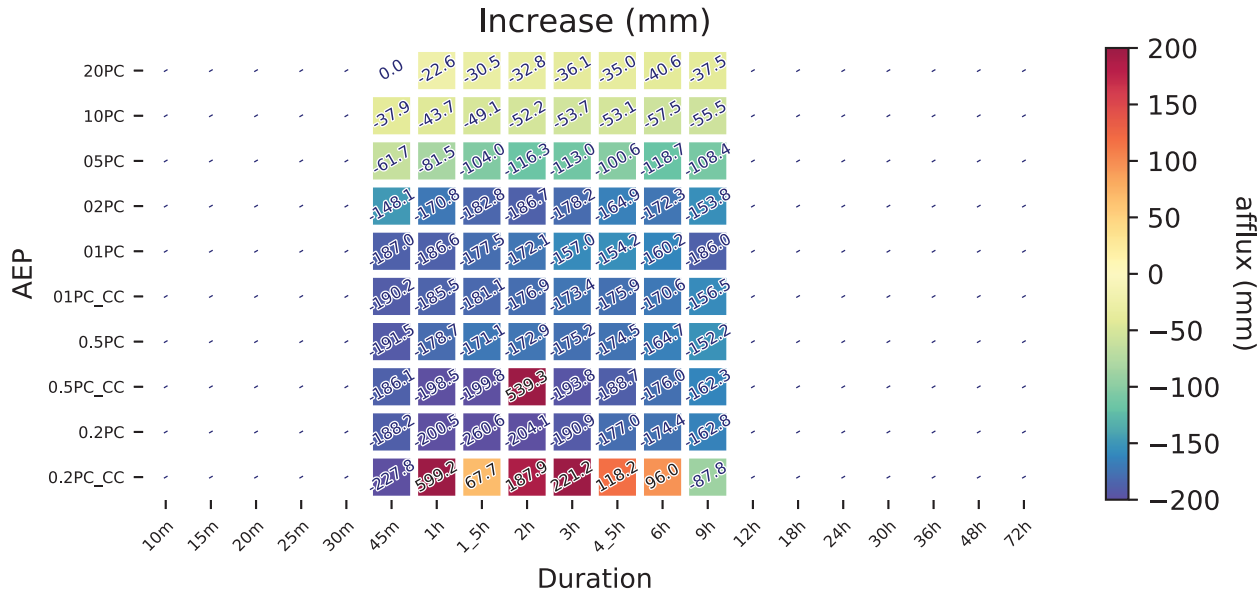




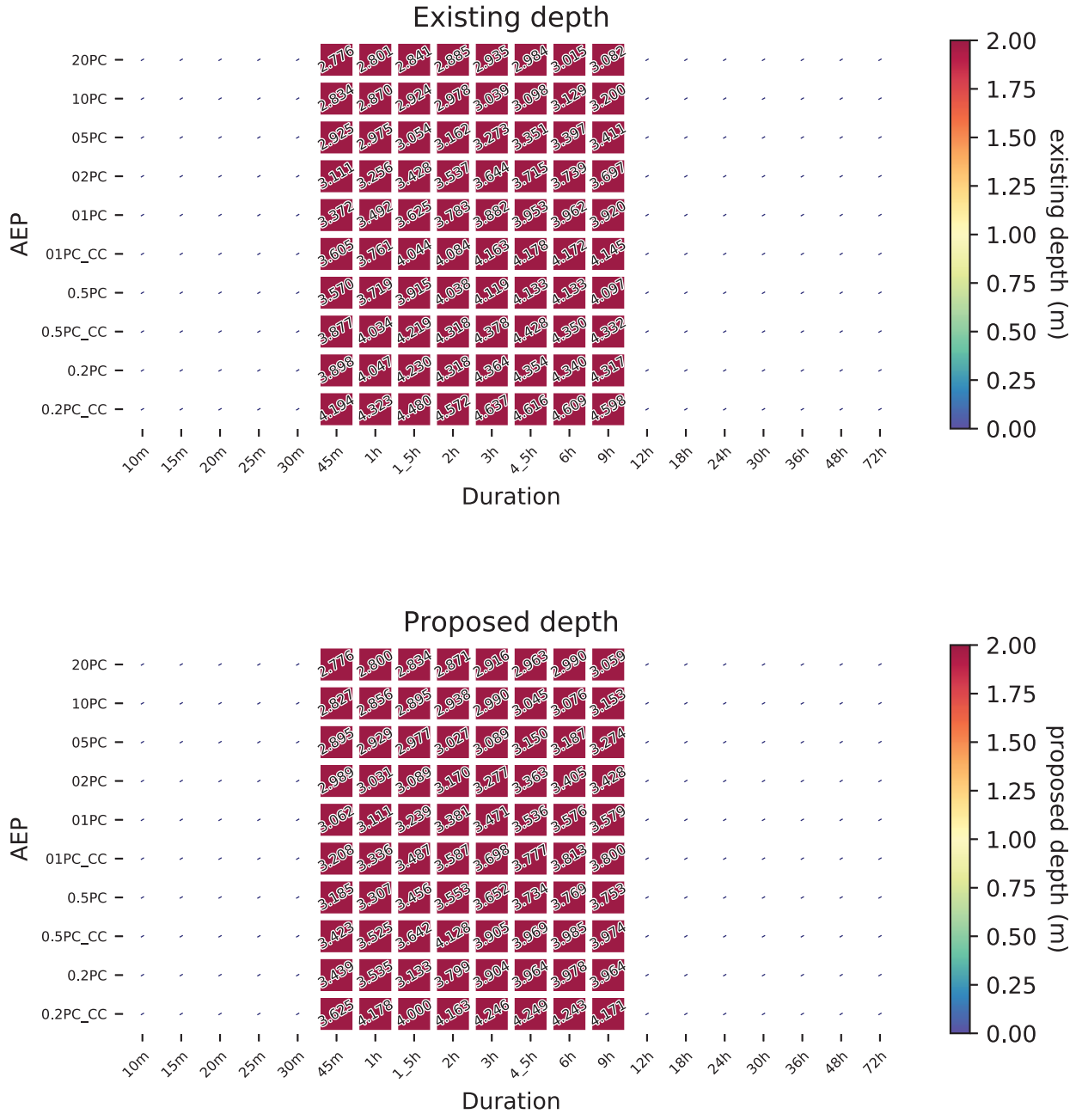
Koonung Creek - Bulleen_Rd

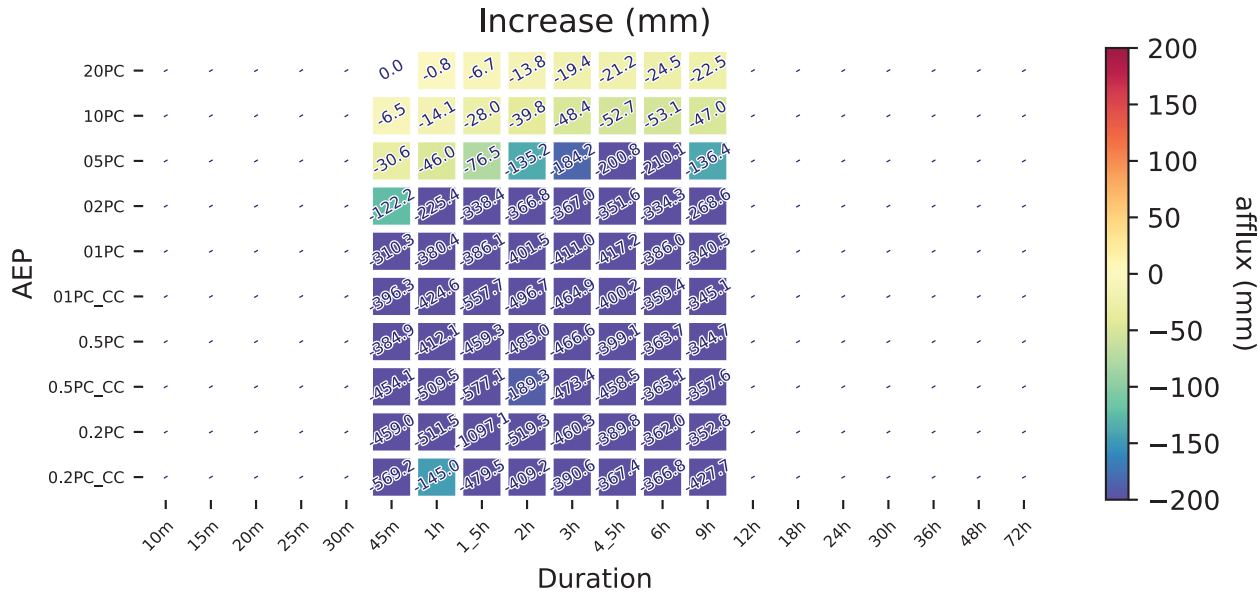




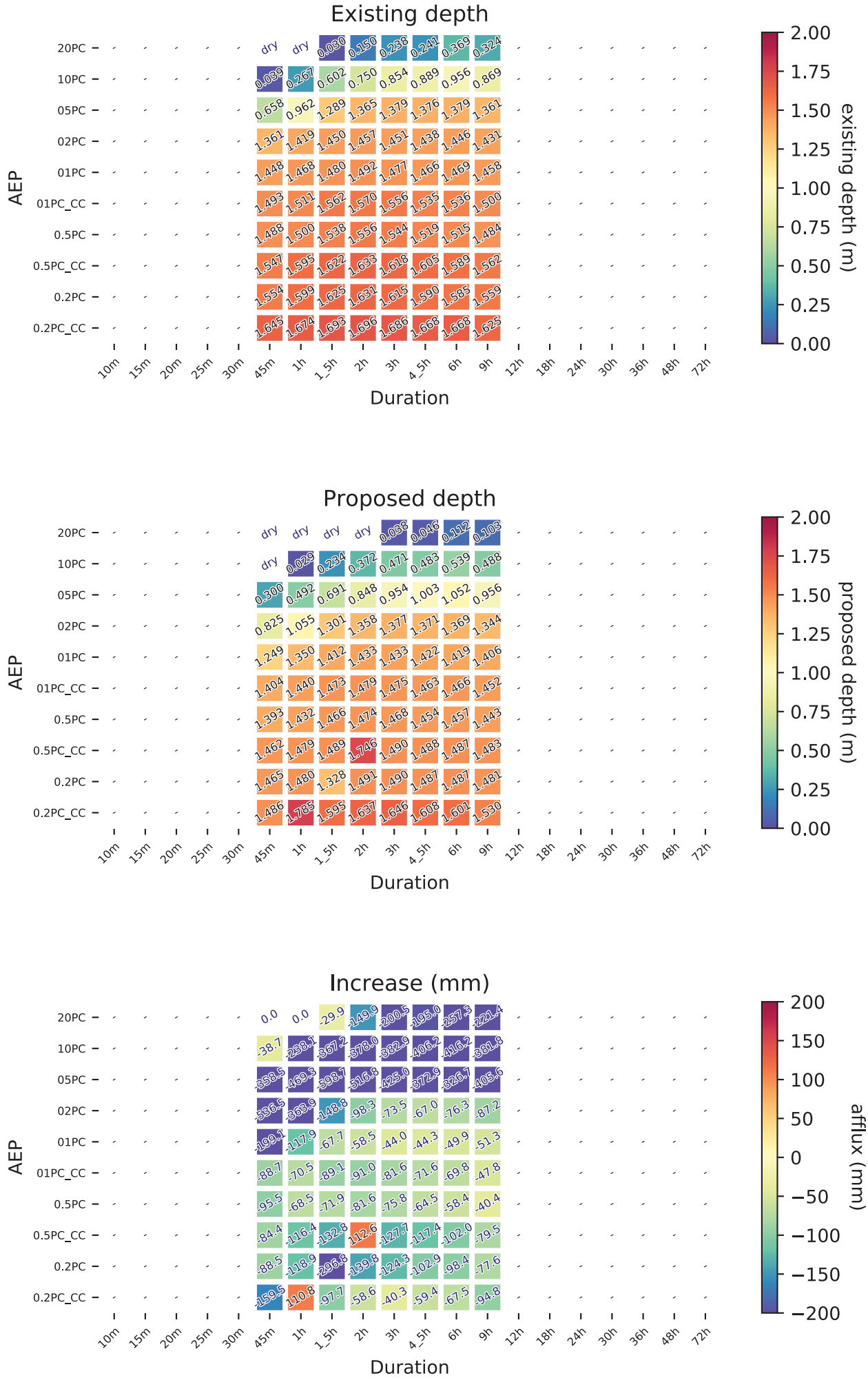


Koonung Creek - Trinity_Grammar

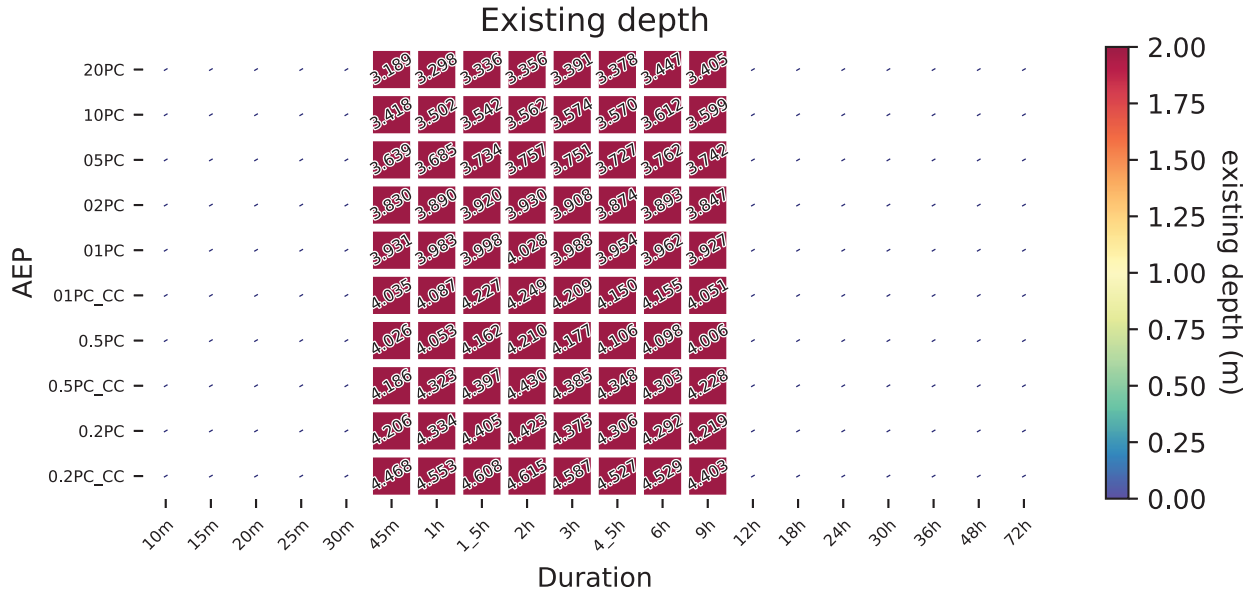


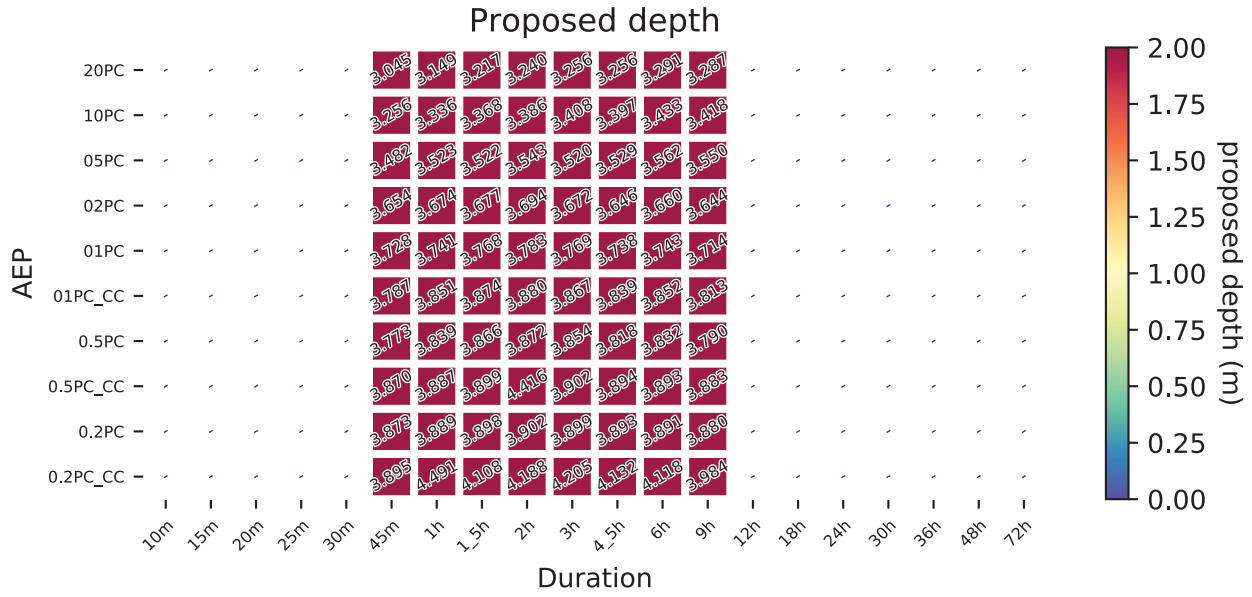


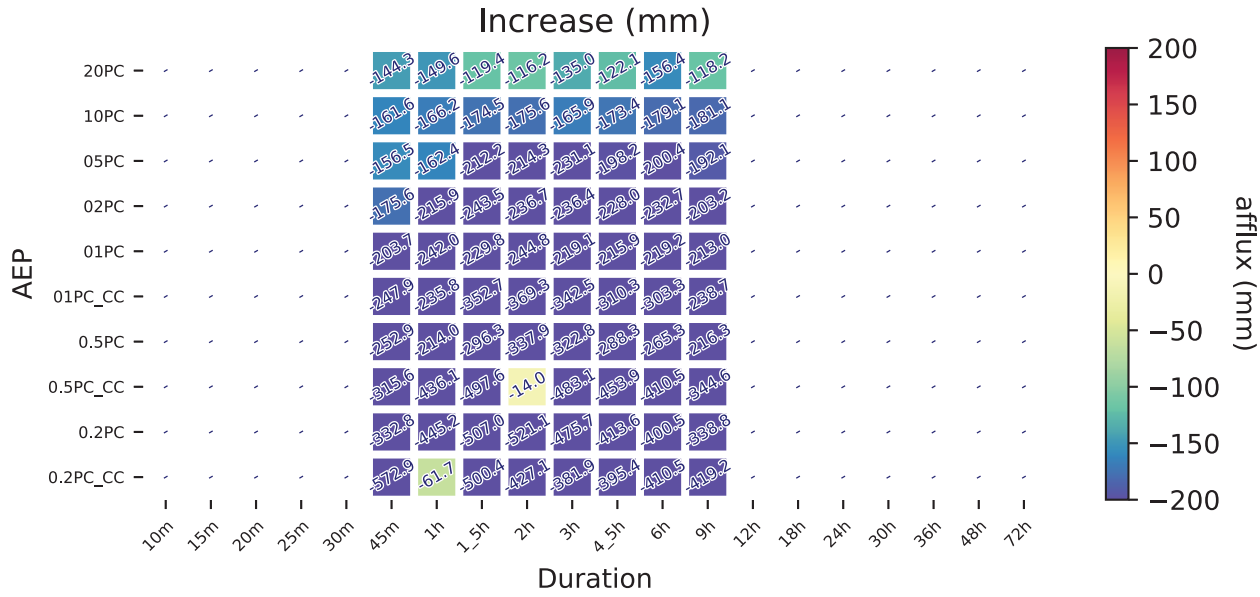
Koonung Creek - Marcelin_College



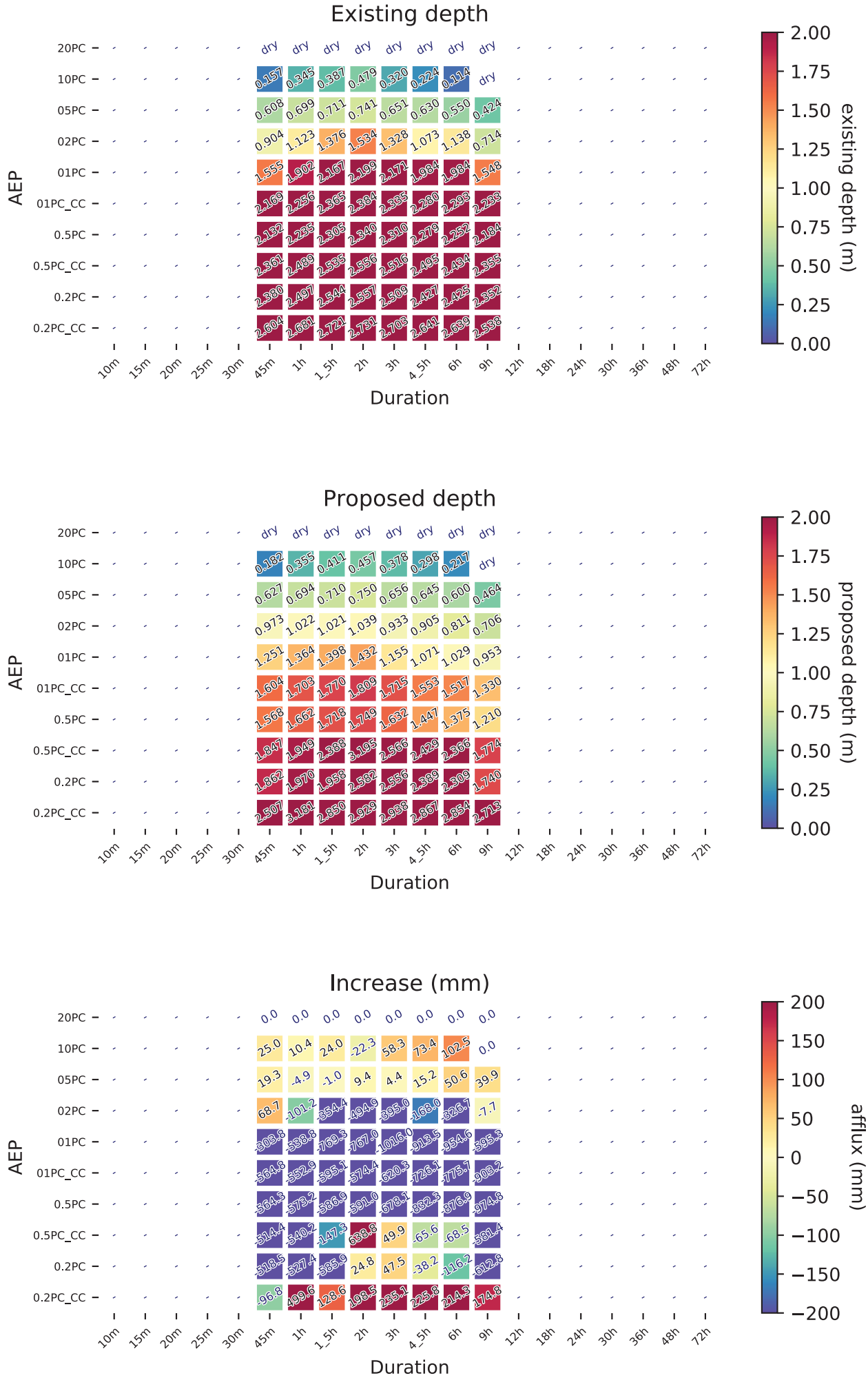
Koonung Creek - us_Bulleen_Rd



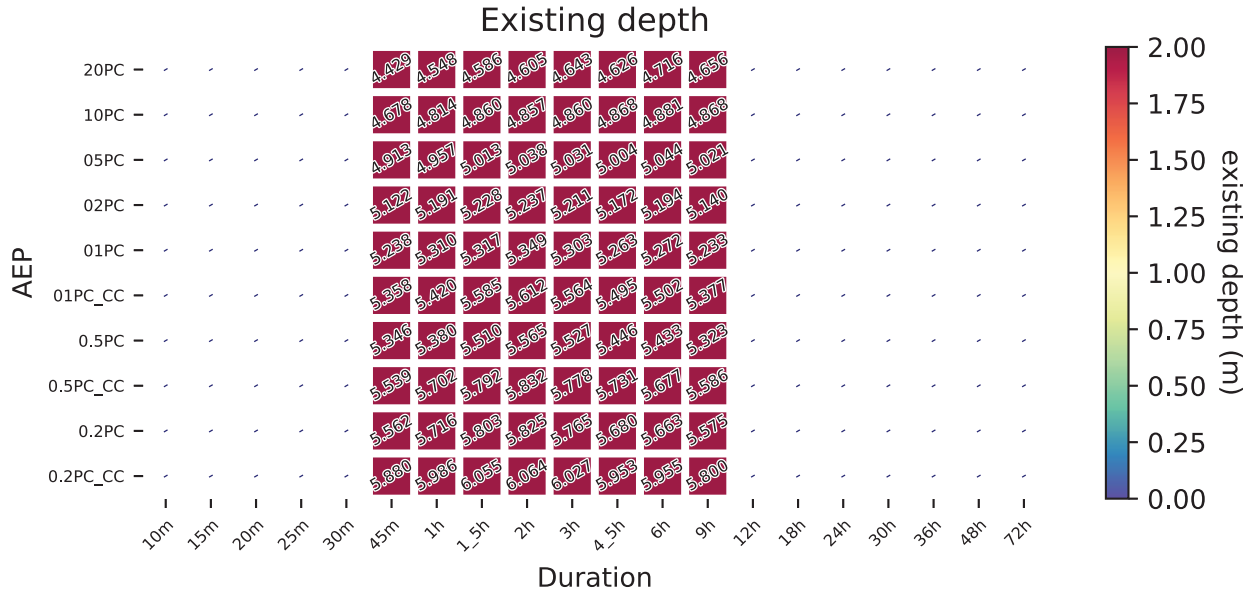


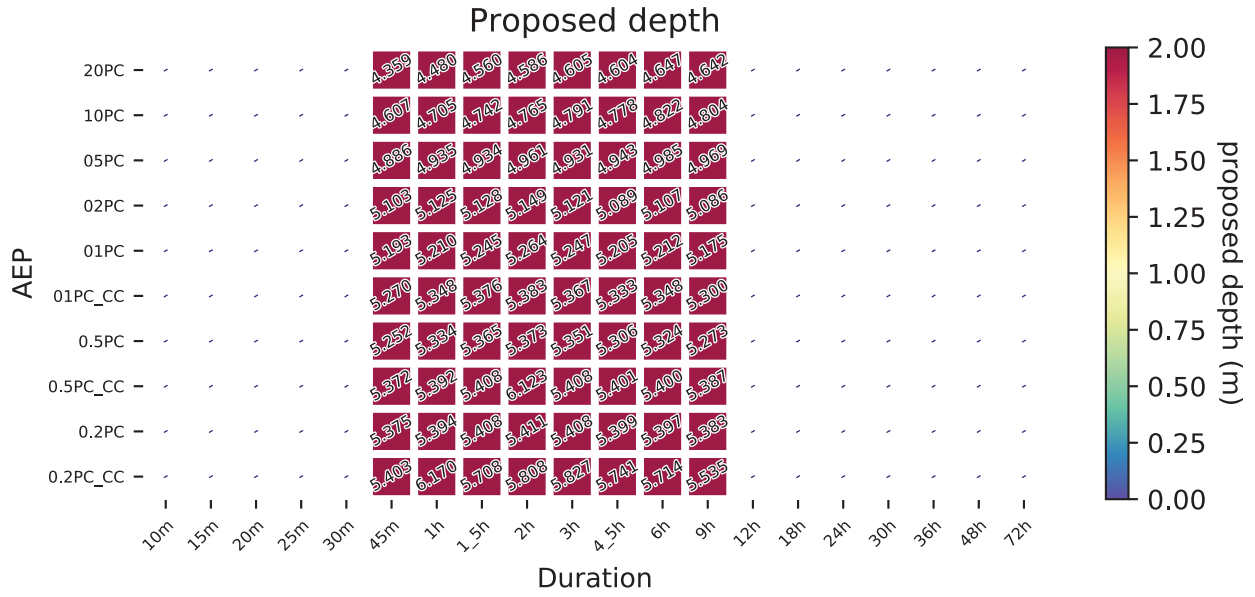


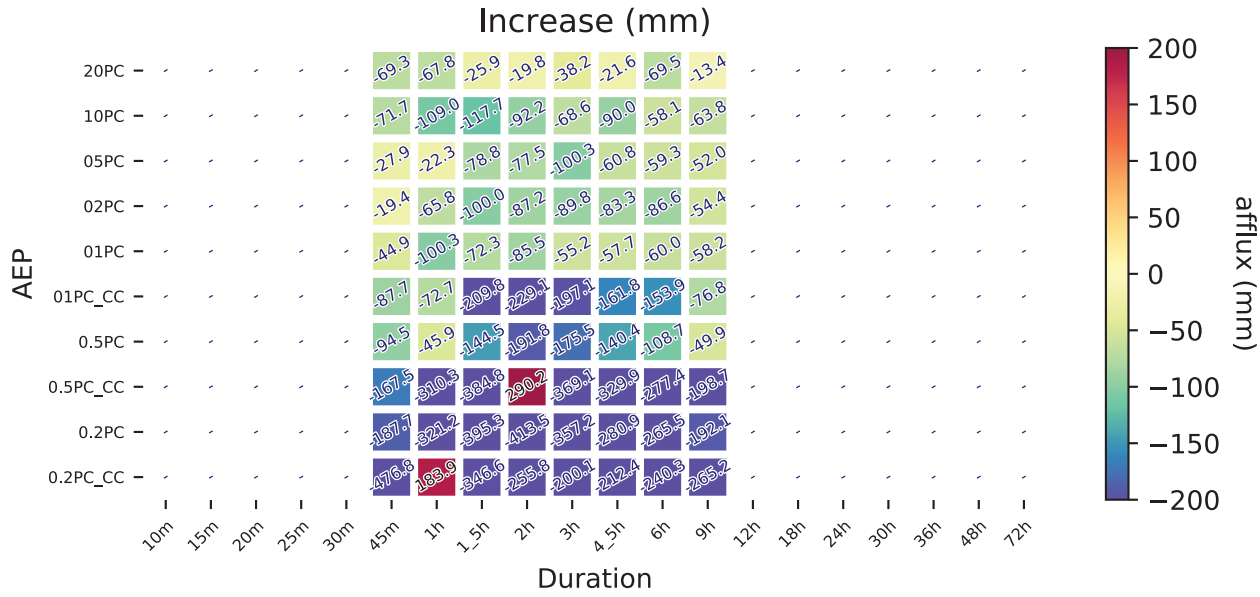
Koonung Creek - Eastern_Fwy_east_Bulleen_Rd



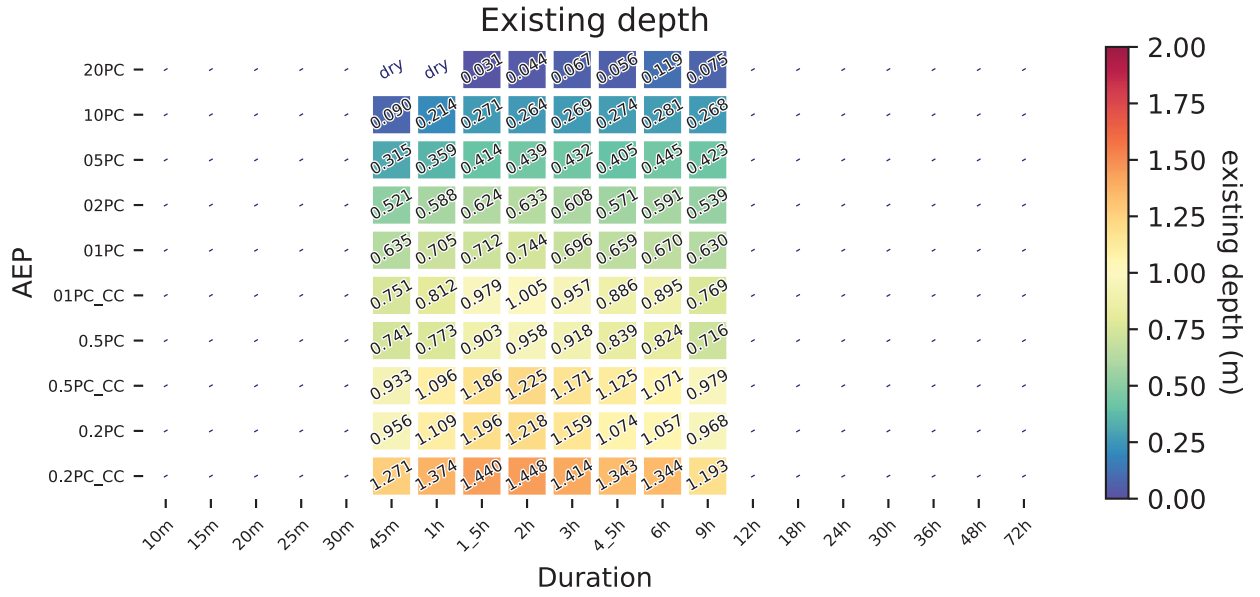
Koonung Creek - d/s_Thompsons_Rd

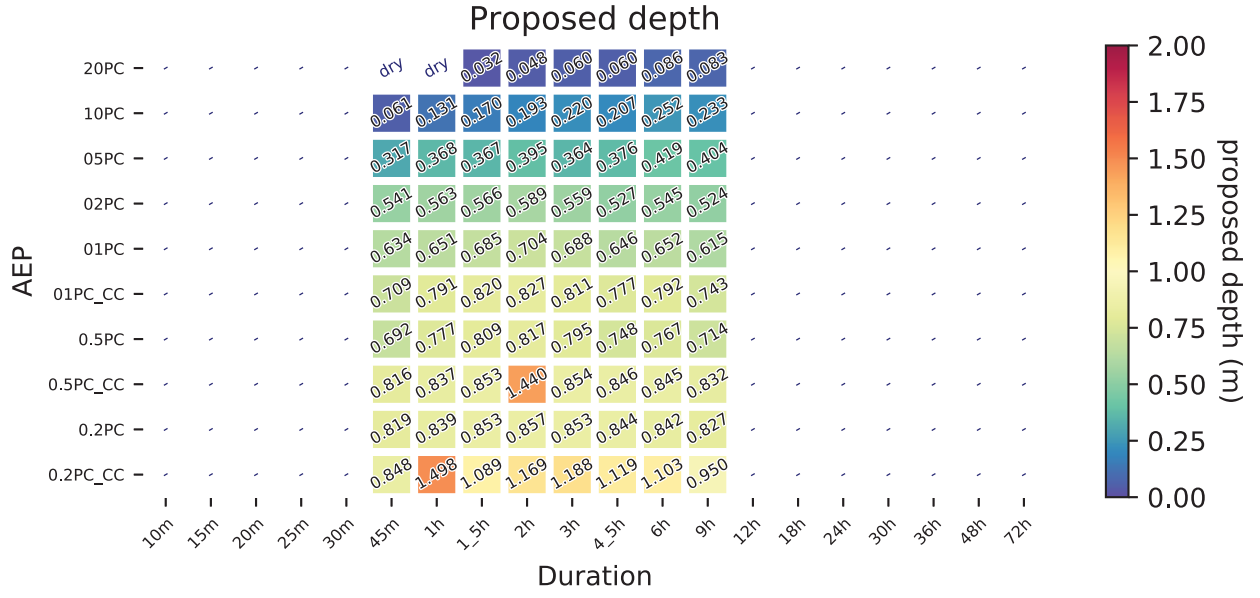


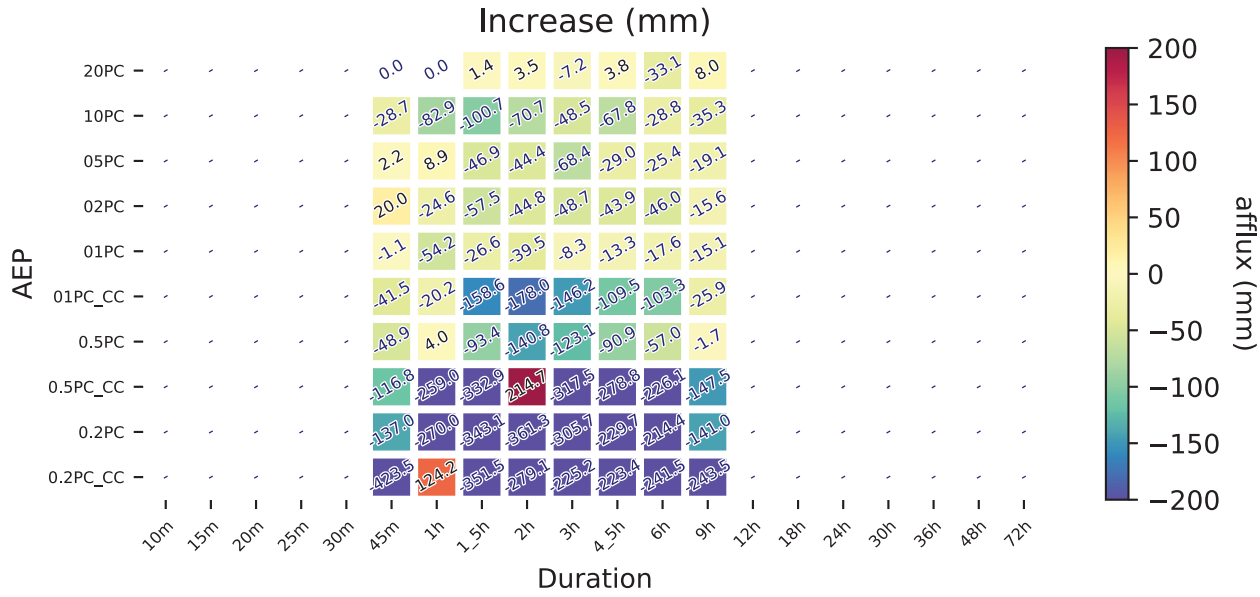




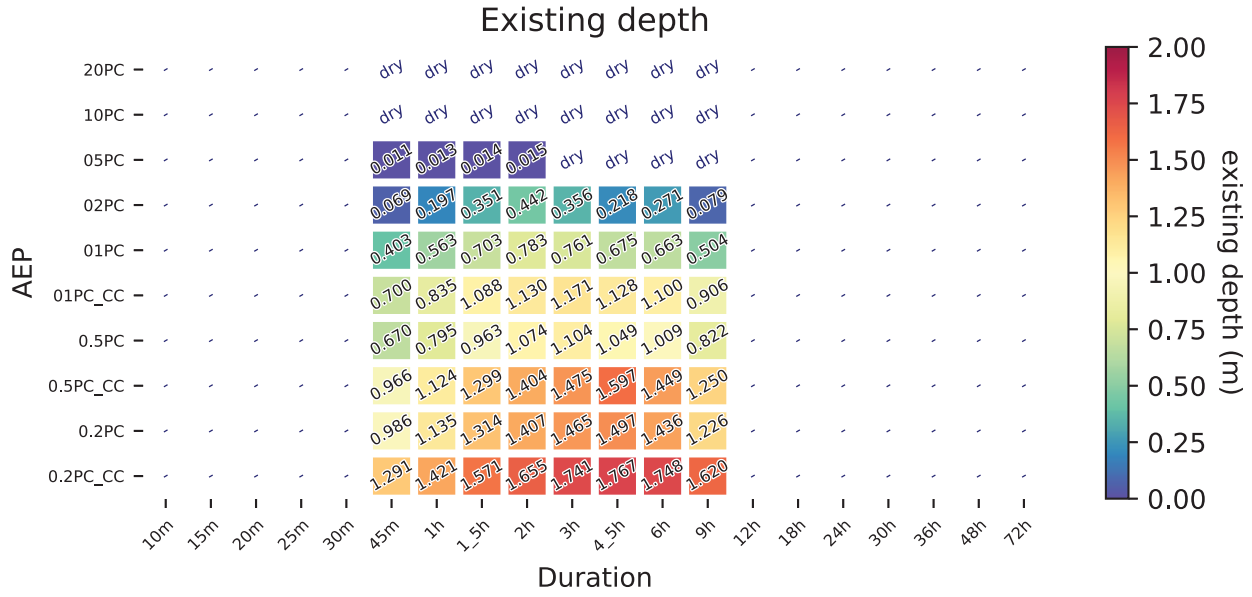
Koonung Creek - Low_lying_carpark_d/s_Thompsons_Rd

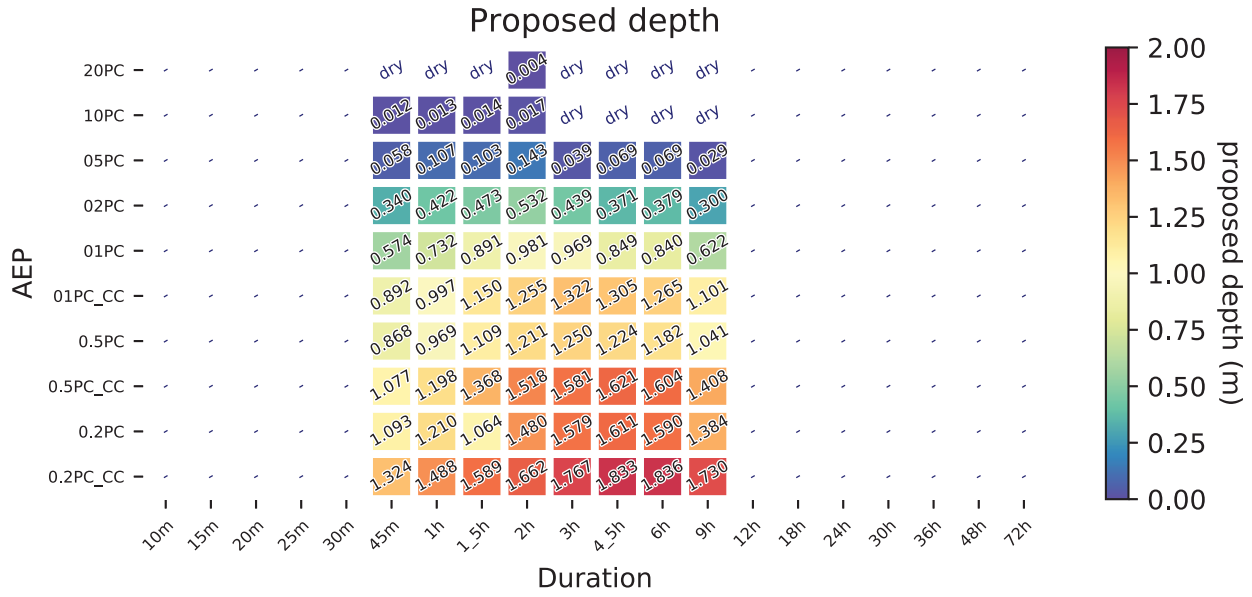


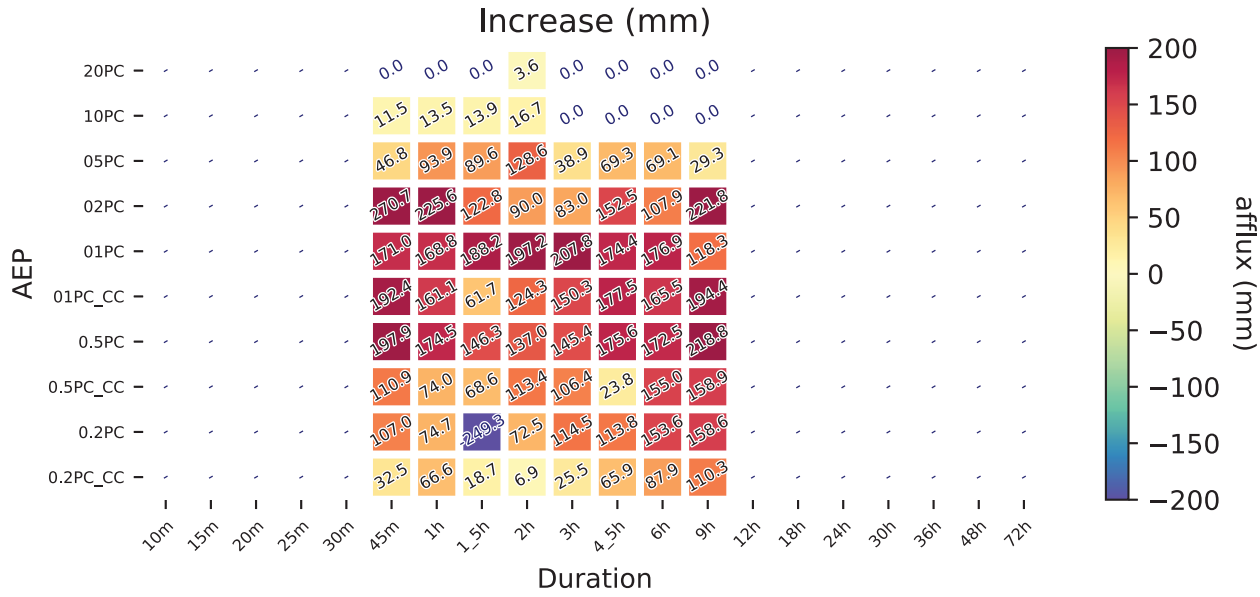




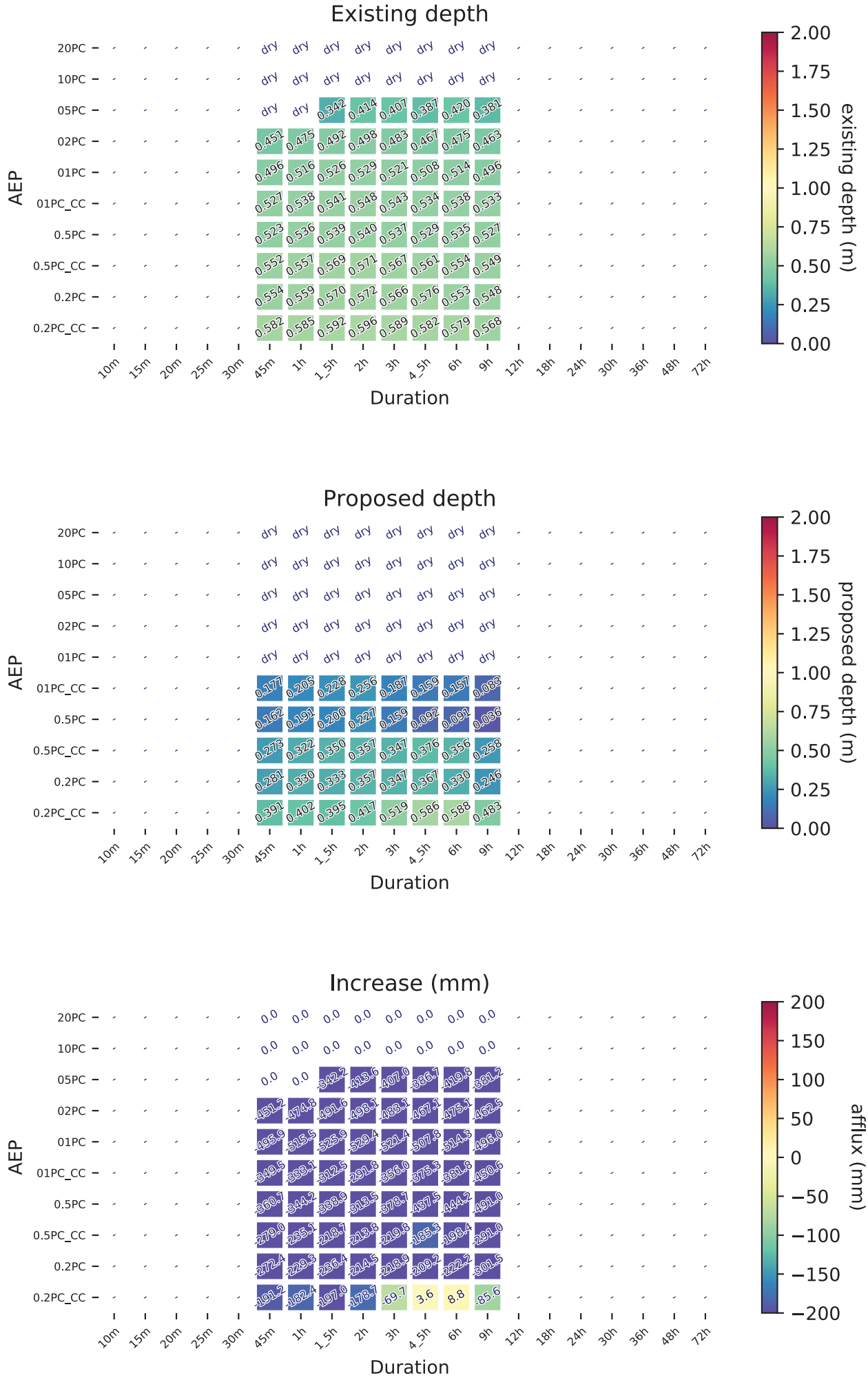
Koonung Creek - Balwyn_Rd_Estella_St



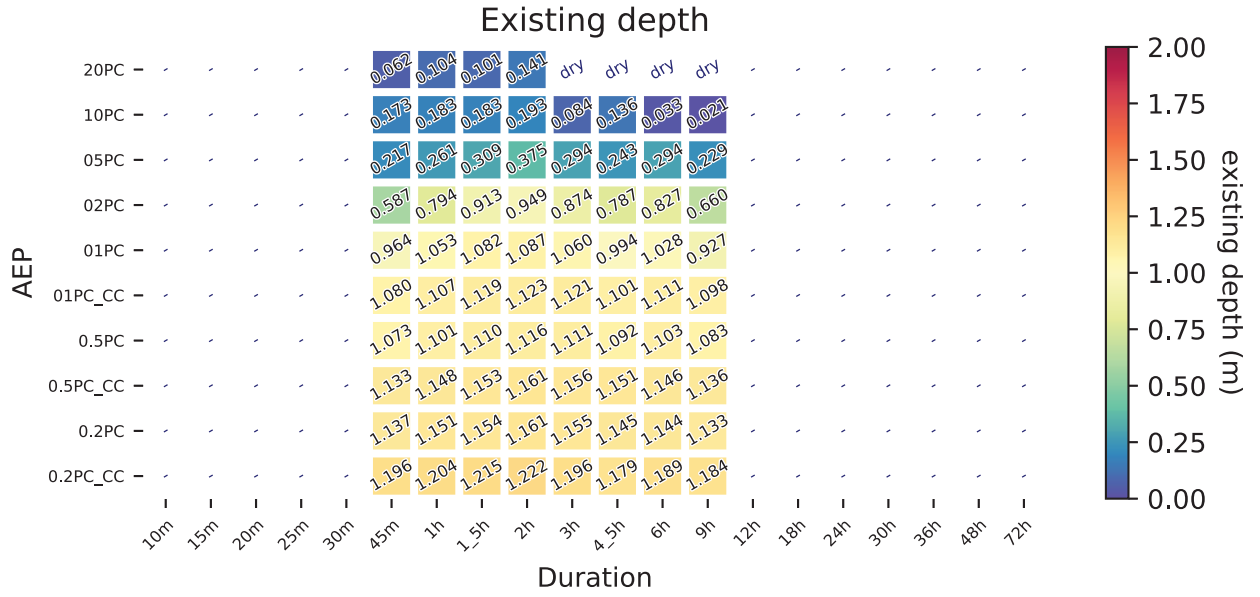


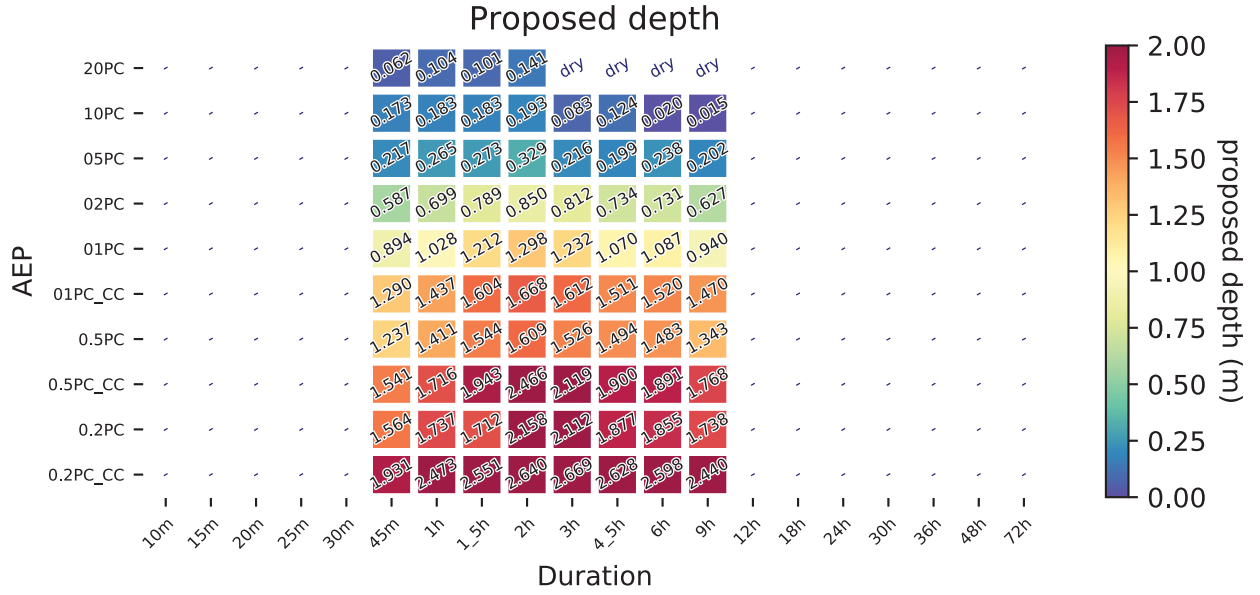


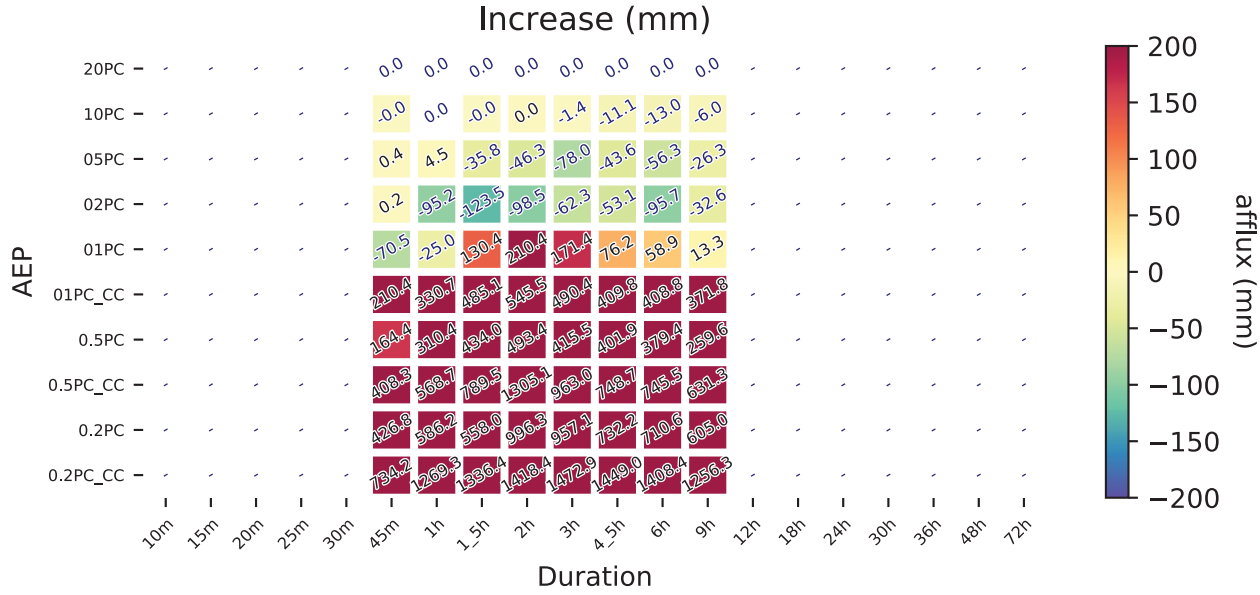
Koonung Creek - Estelle_St



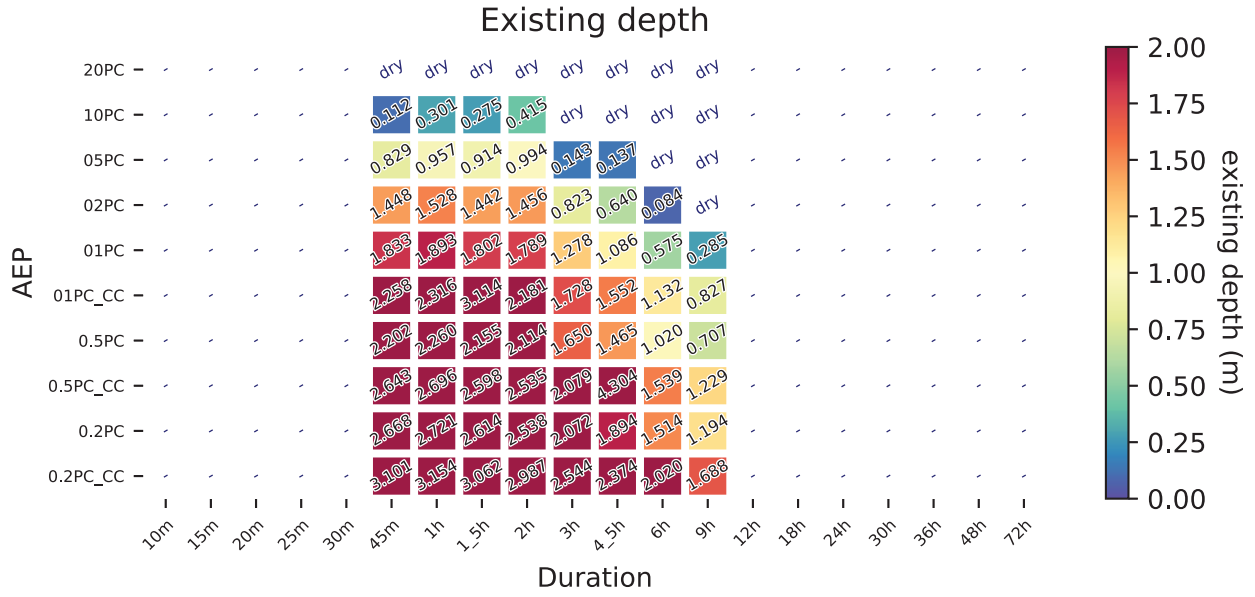
Koonung Creek - Carron_St

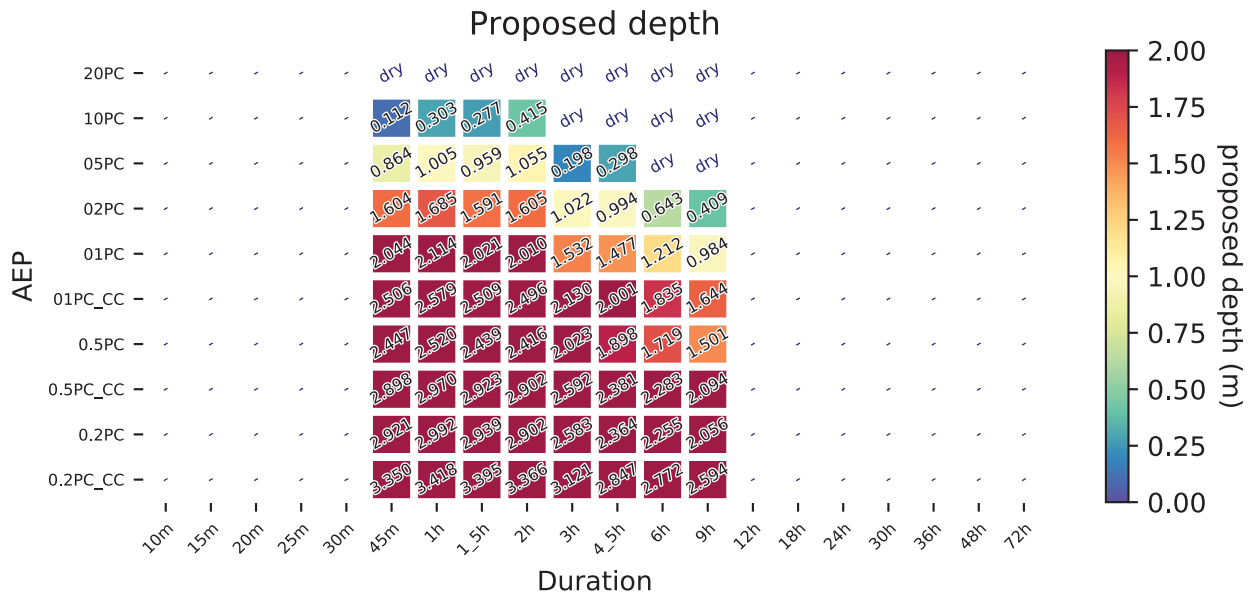


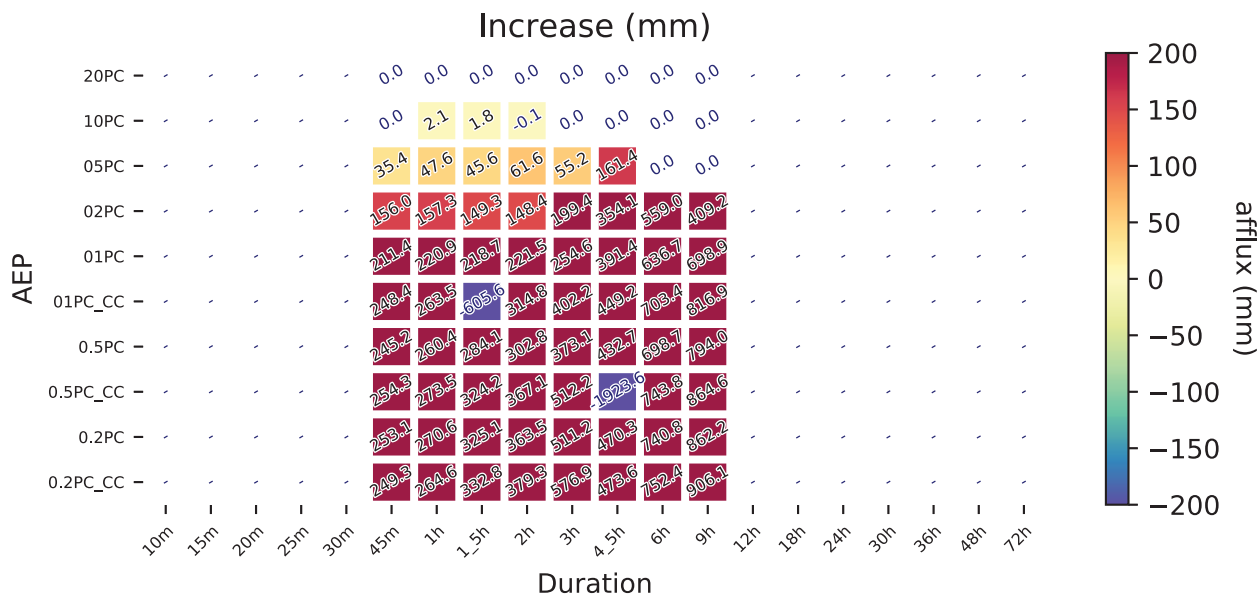




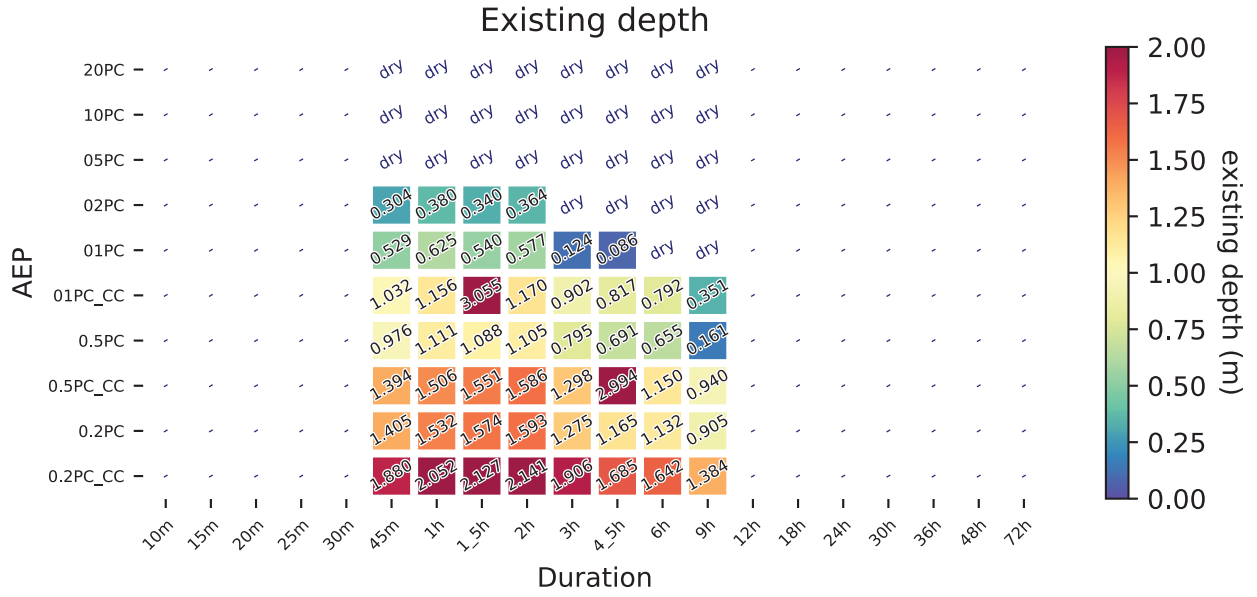
Koonung Creek - Estelle_St2

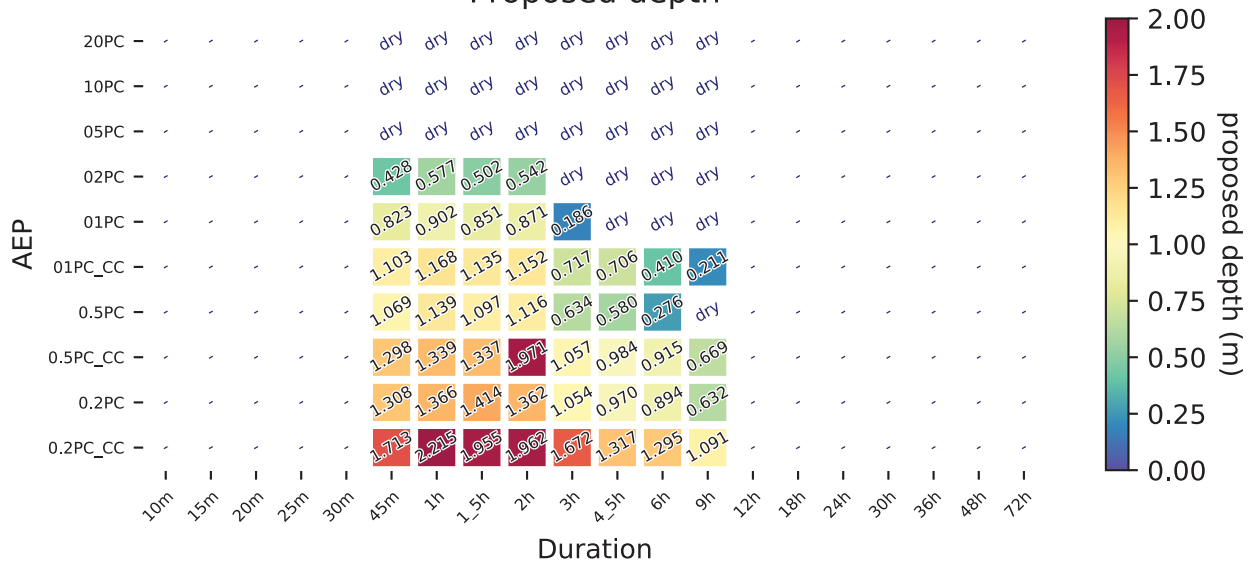


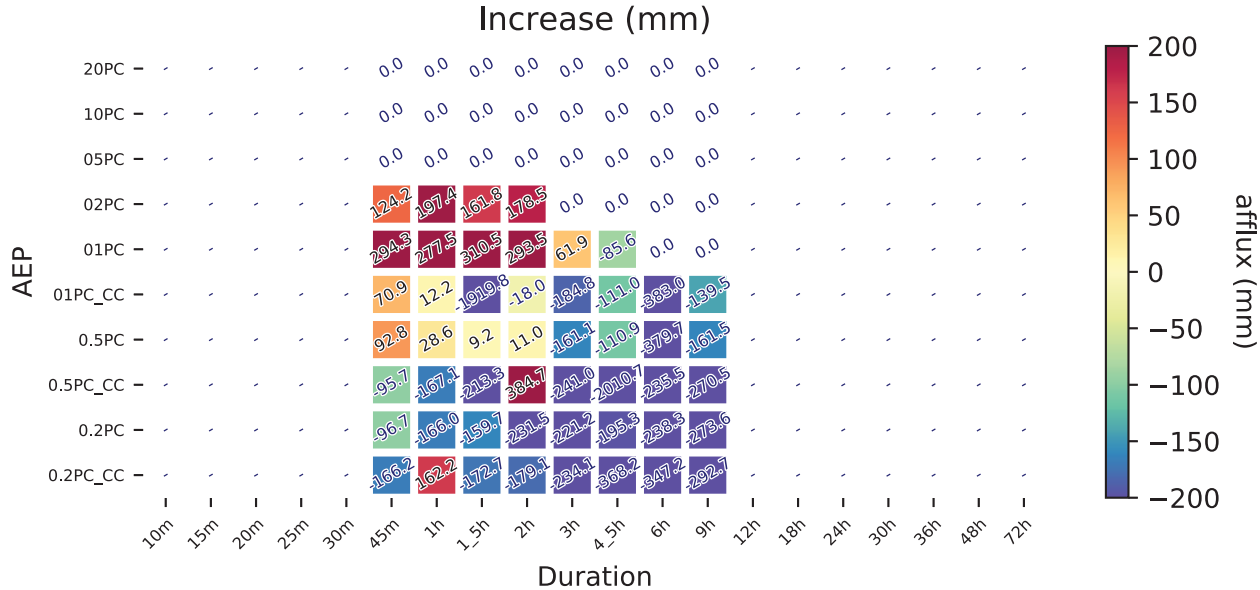




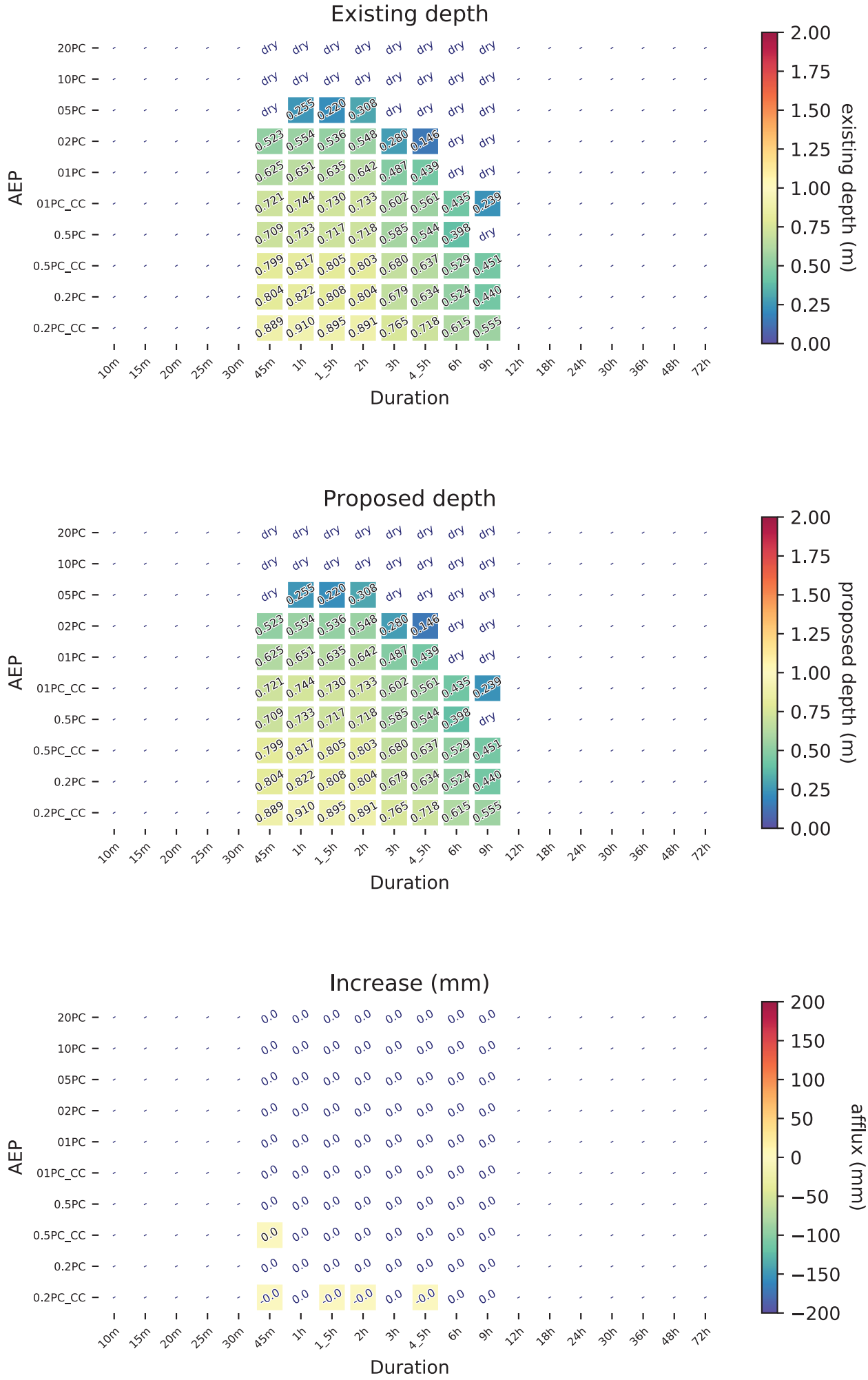
Koonung Creek - Park_Ave



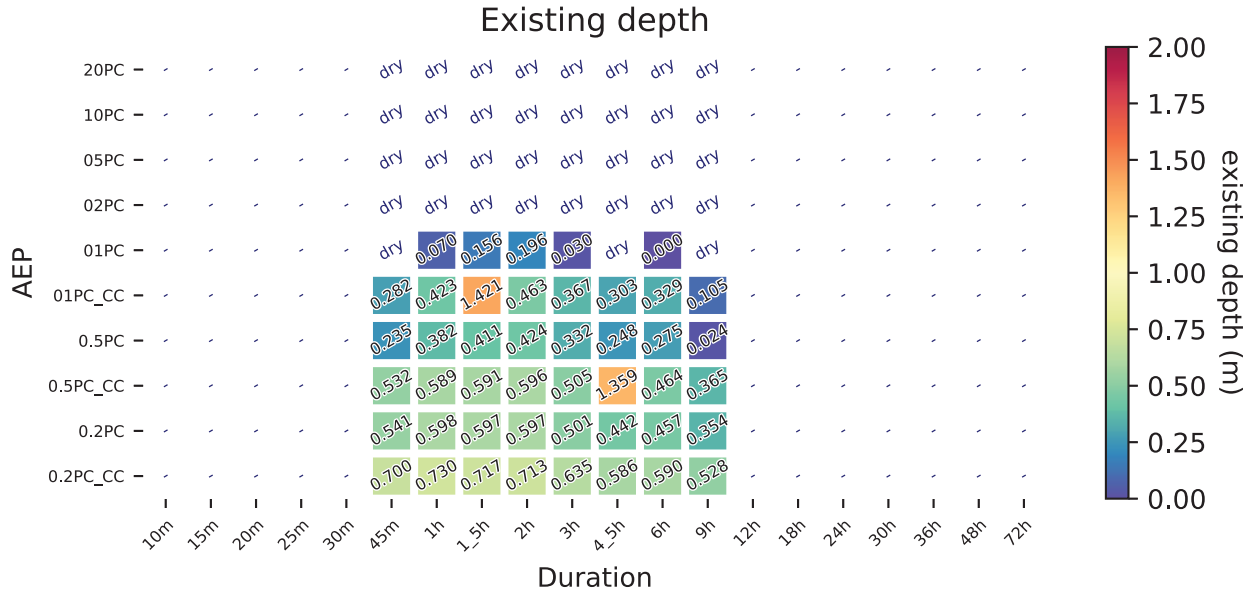


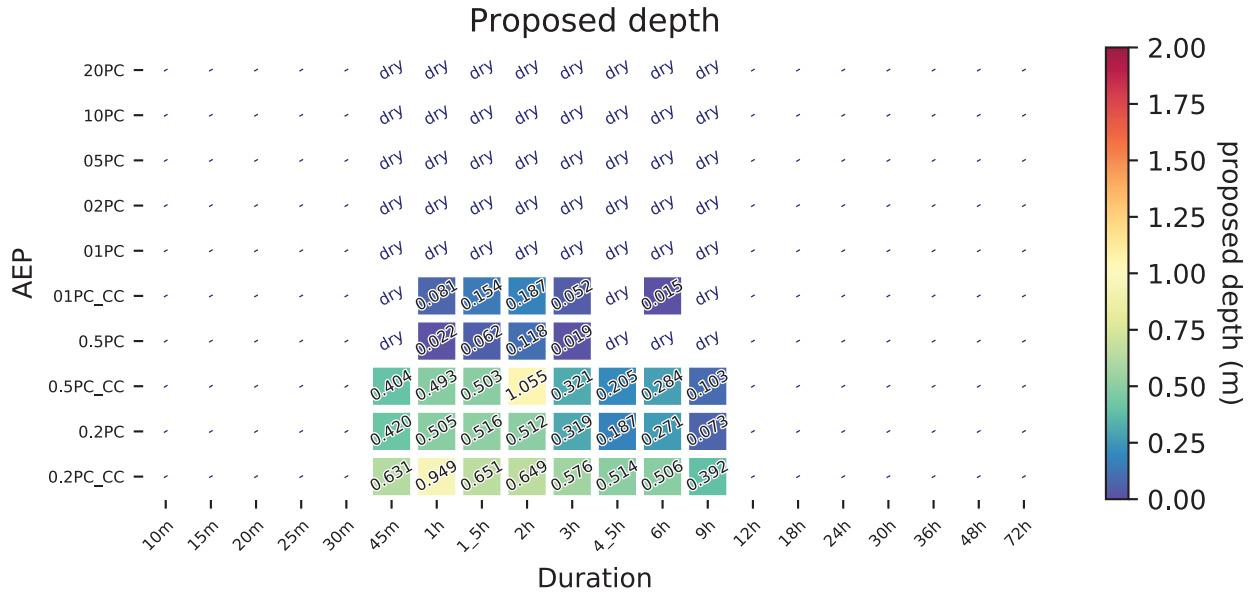


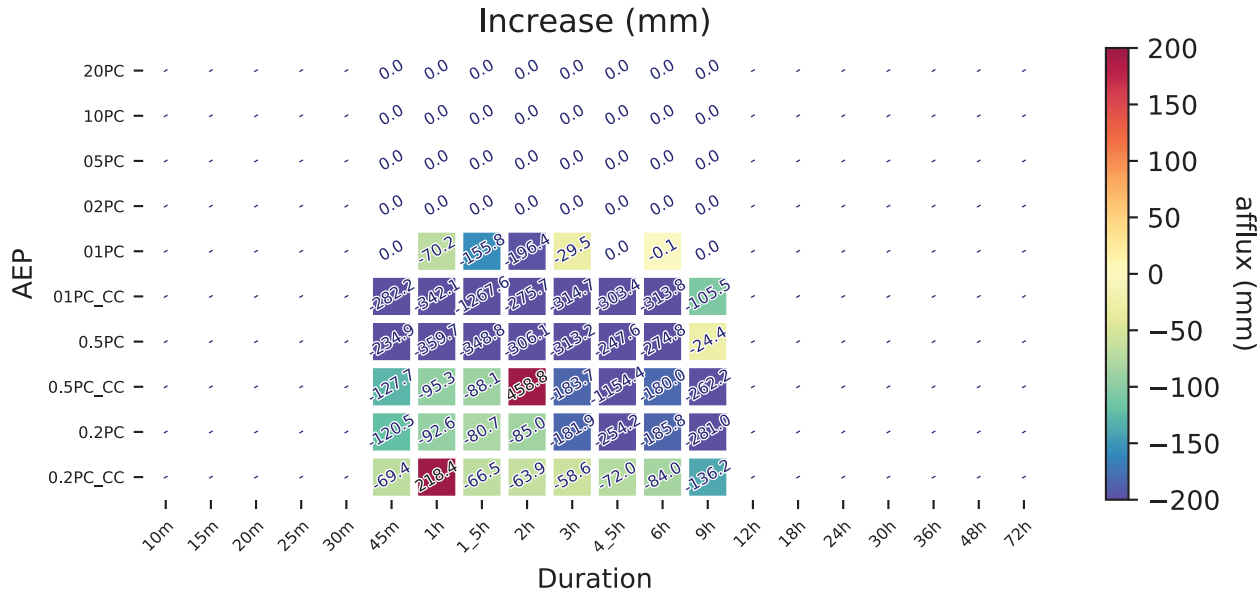
Koonung Creek - Gardenia_Rd



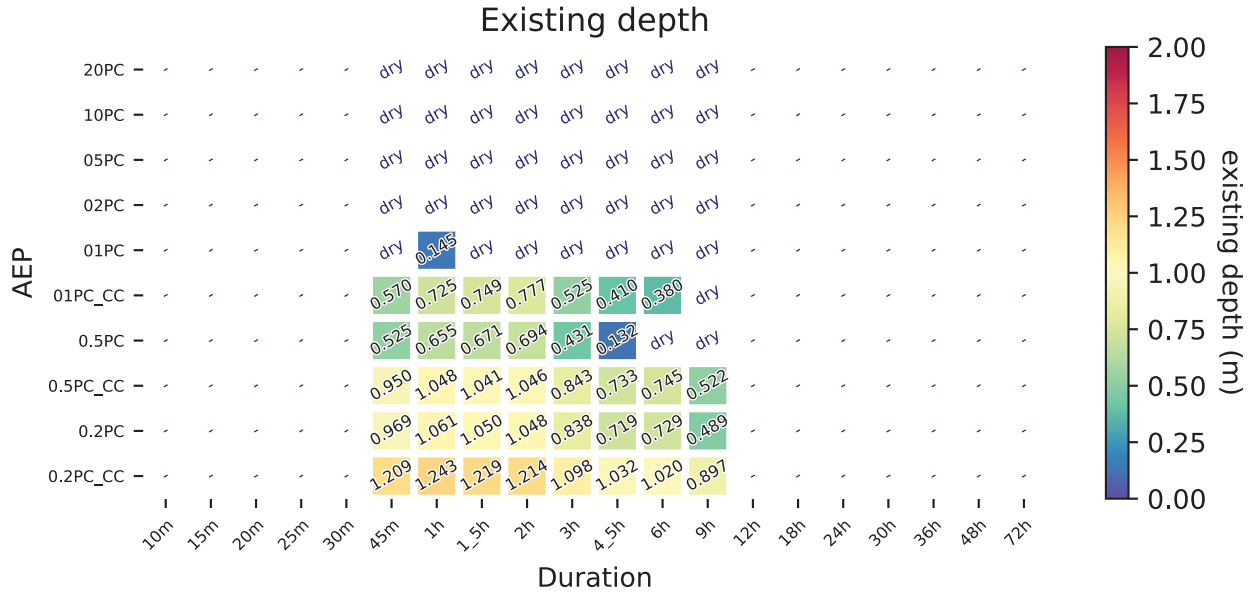
Koonung Creek - Gregory_Ct

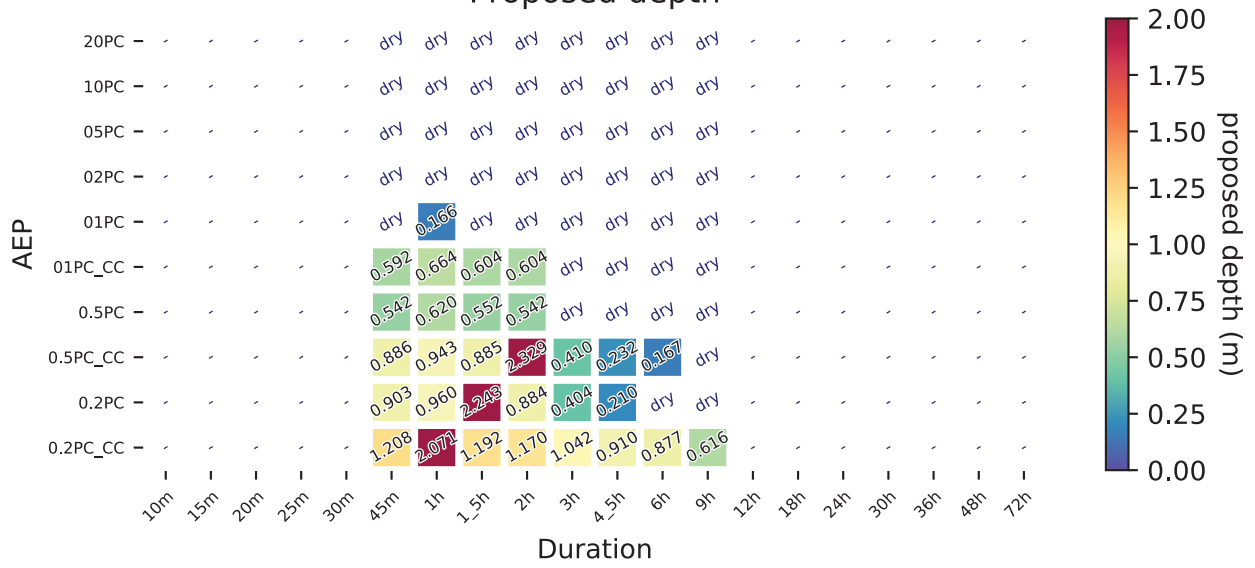


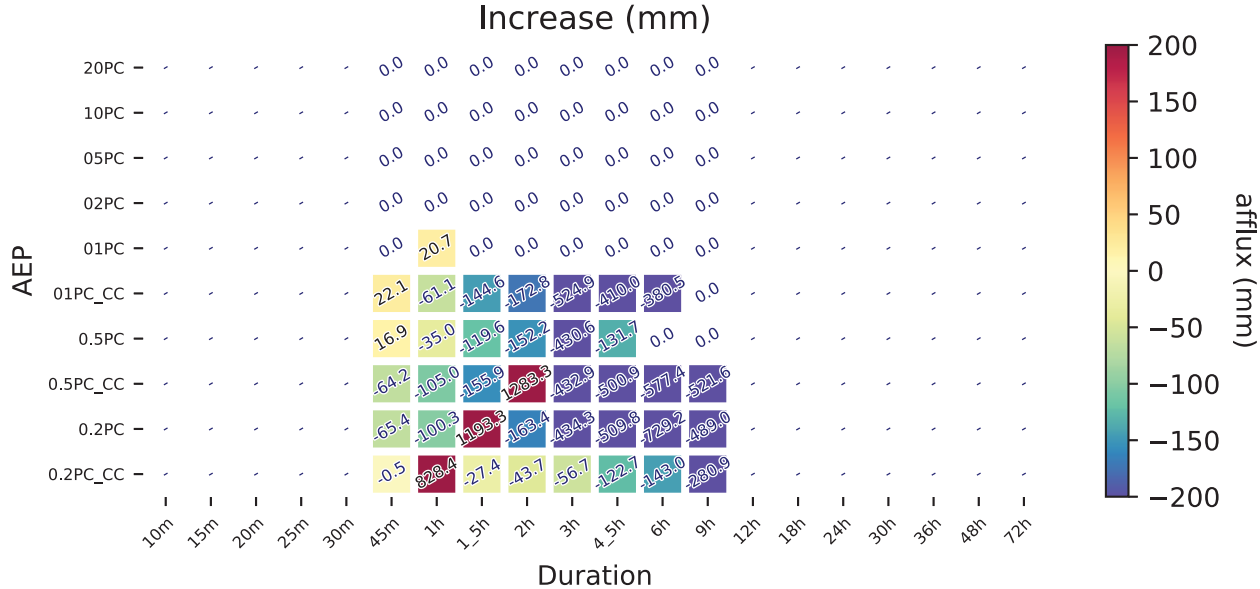




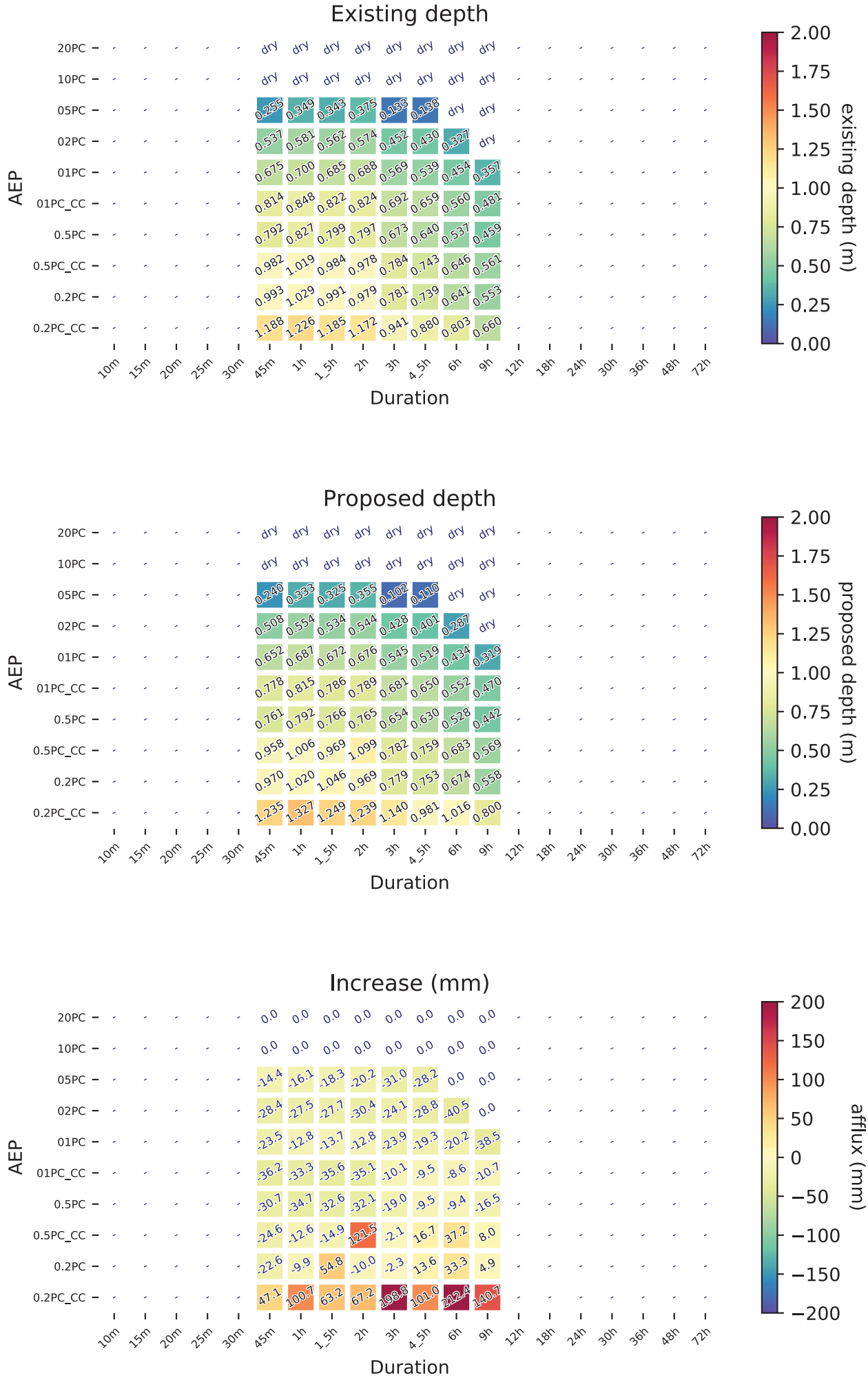
Koonung Creek - Doncaster_Rd



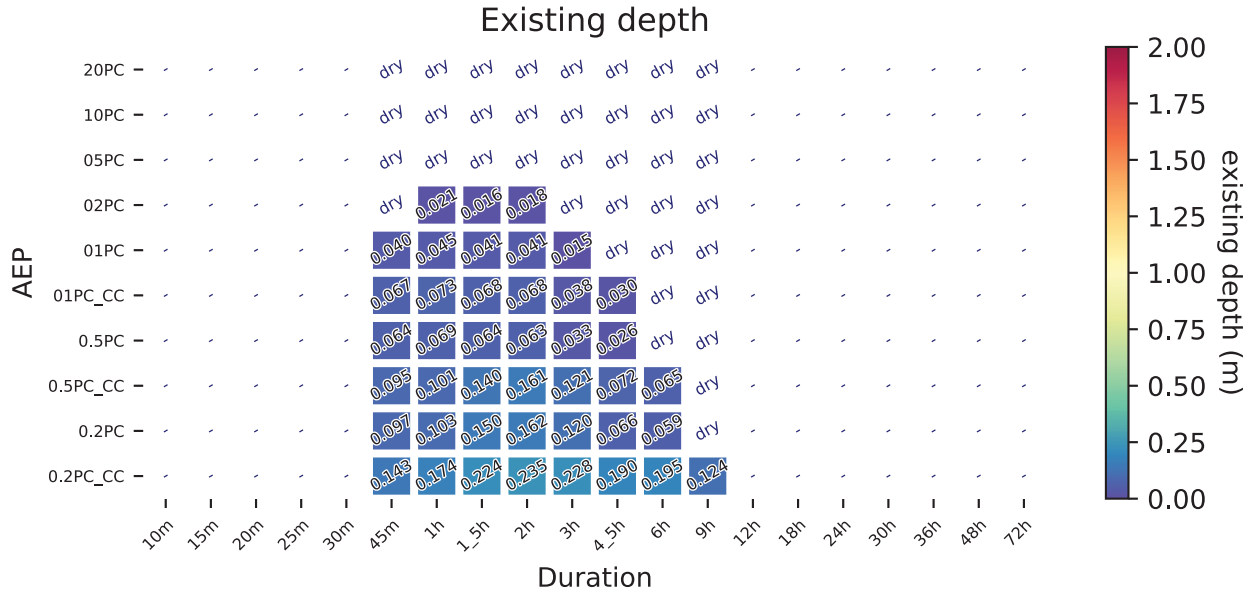


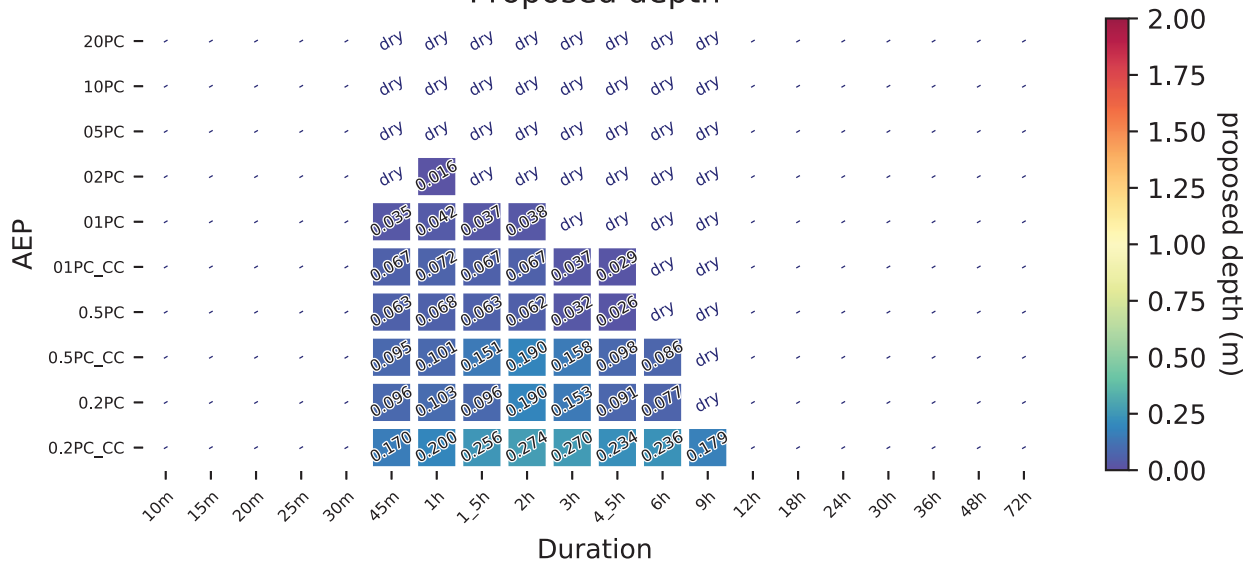


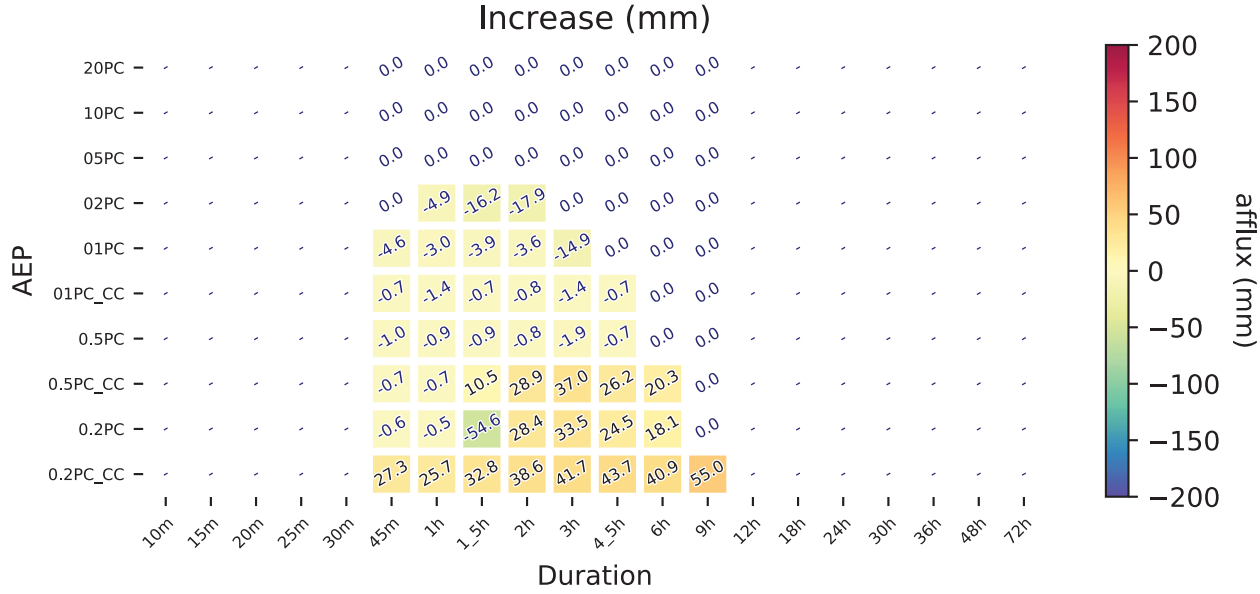
Koonung Creek - Valda_Ave



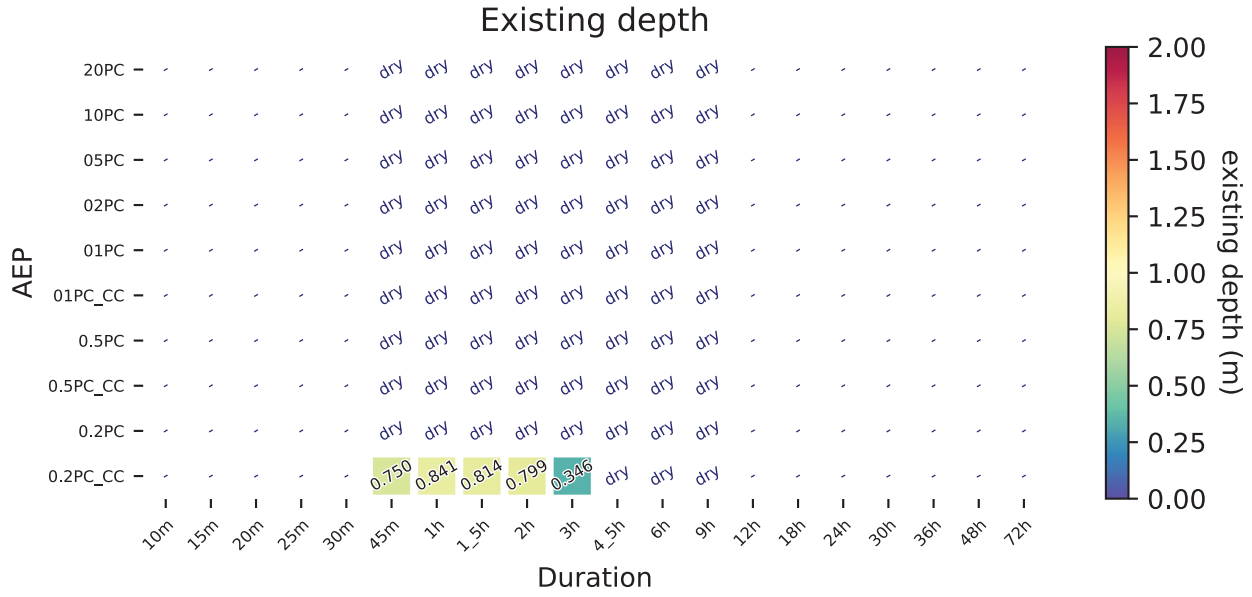
Koonung Creek - KBH_Brumbies_HockeyLL

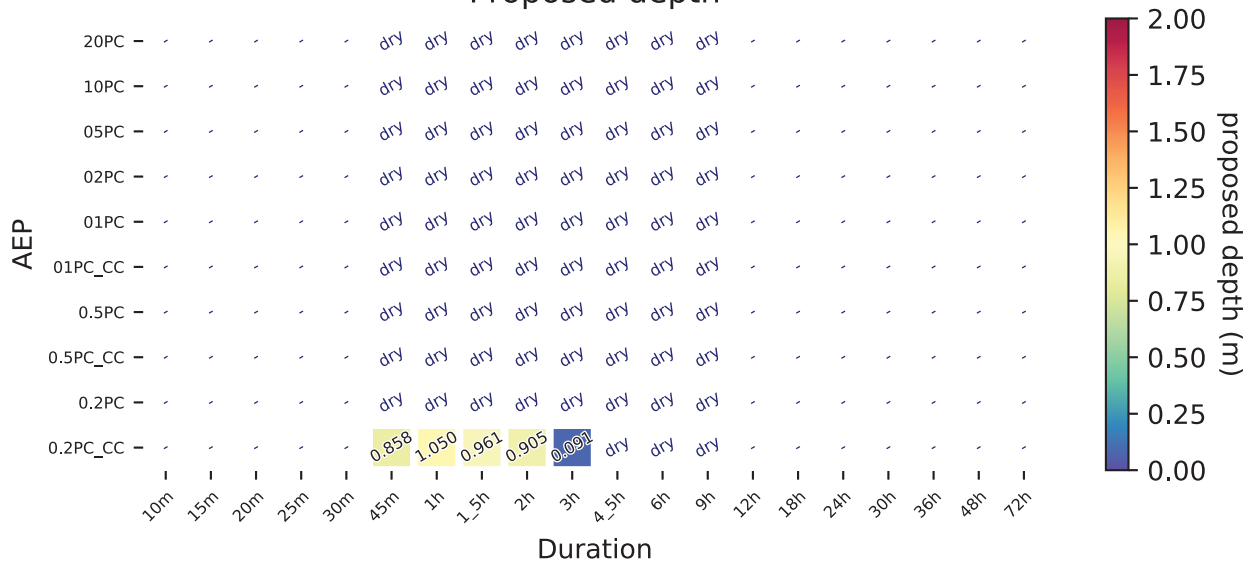


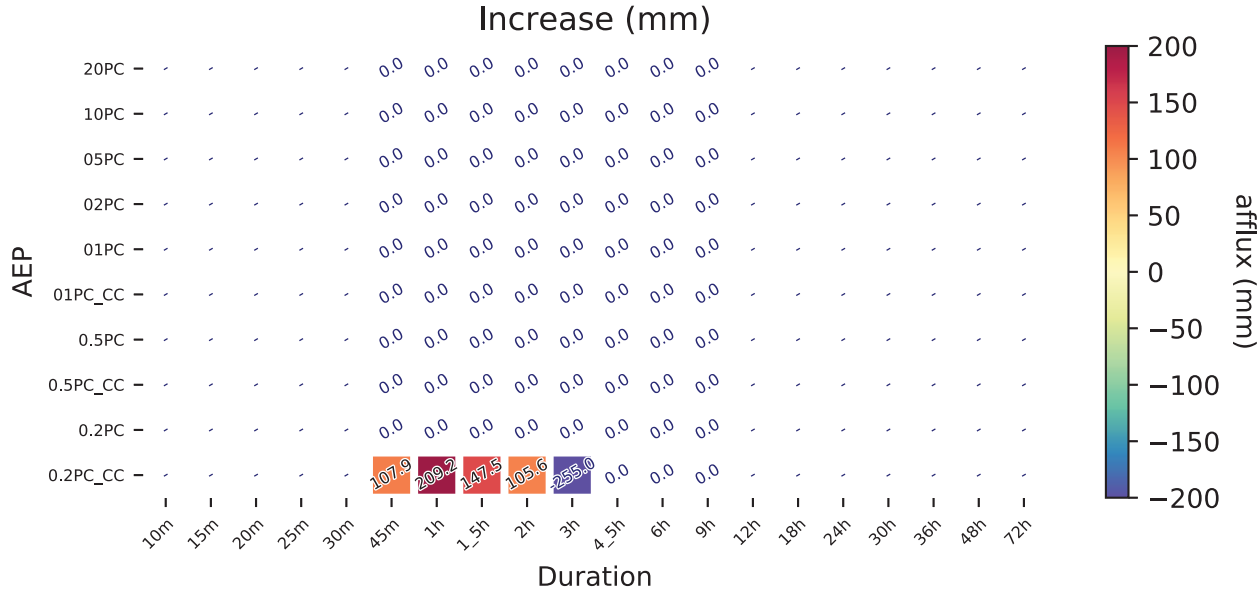




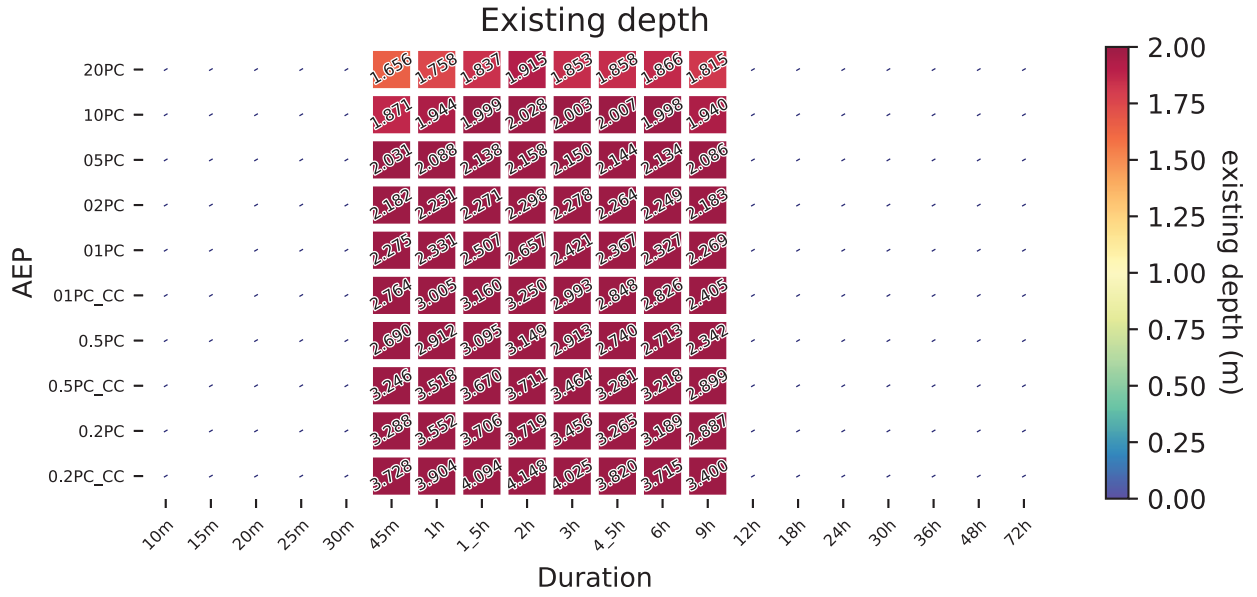
Koonung Creek - EasternFwy_east_of_Elgar_Rd

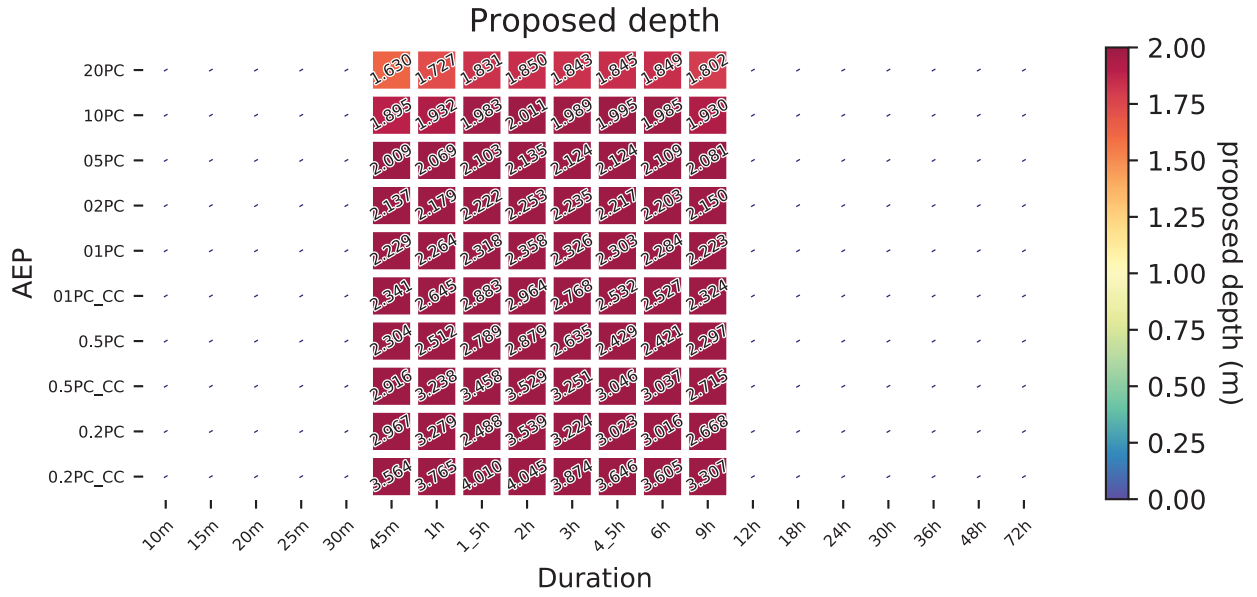


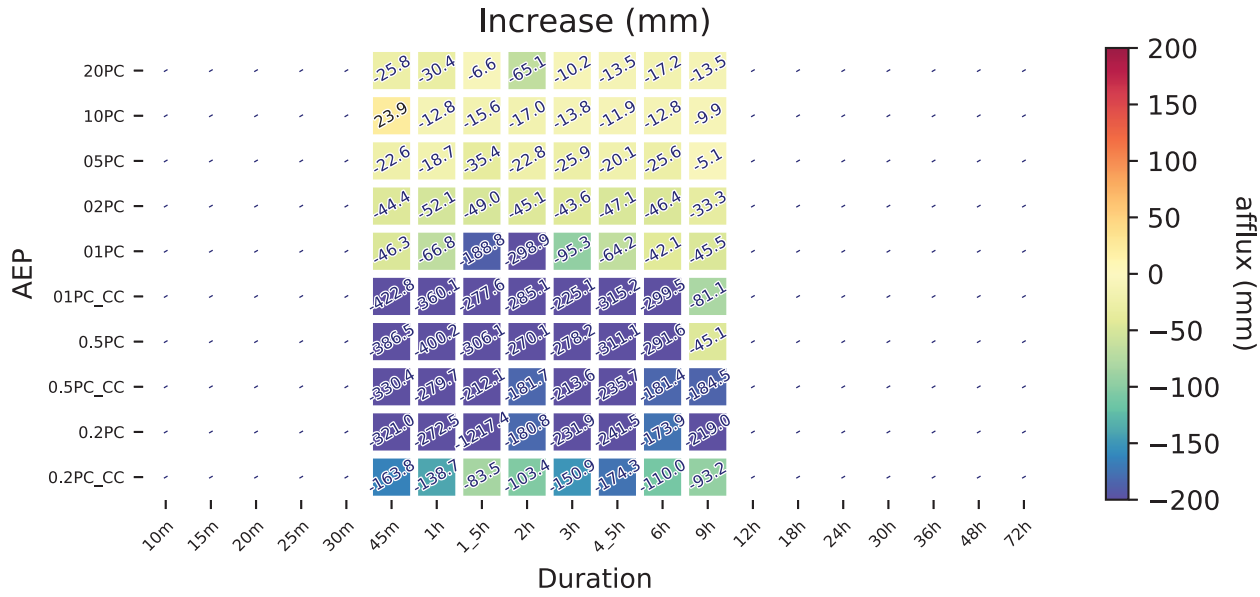




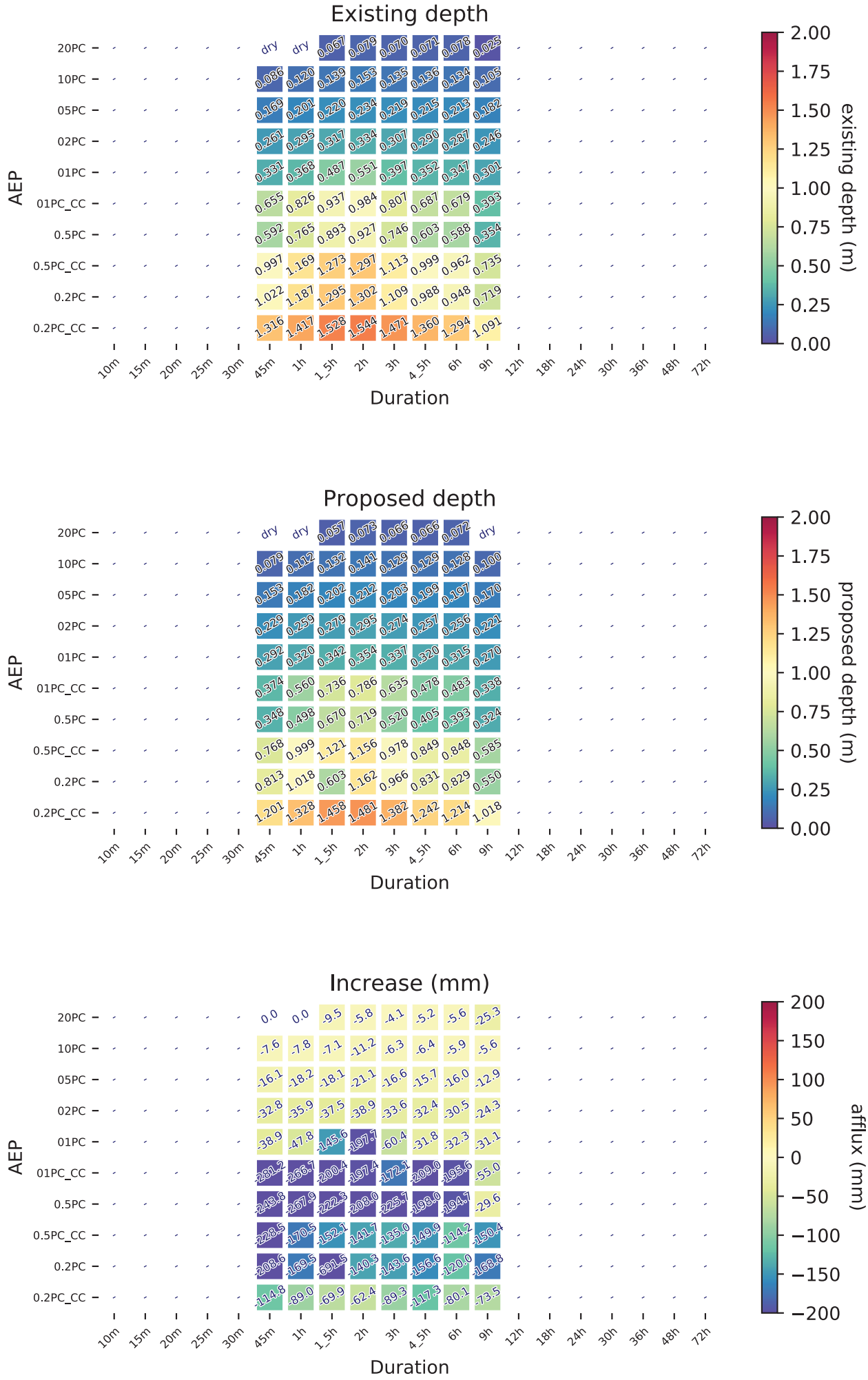
Koonung Creek - u/s_Tram_Rd



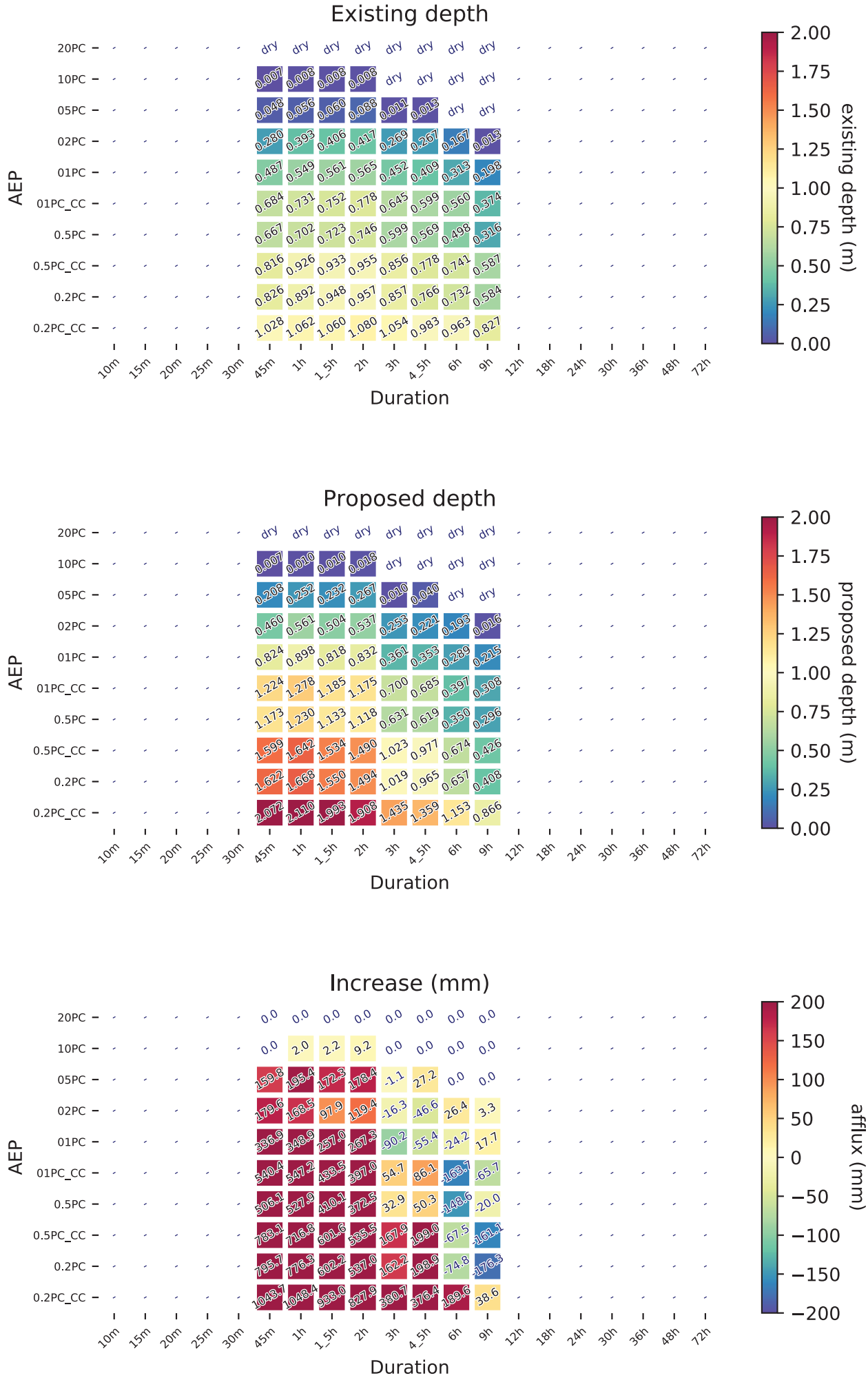




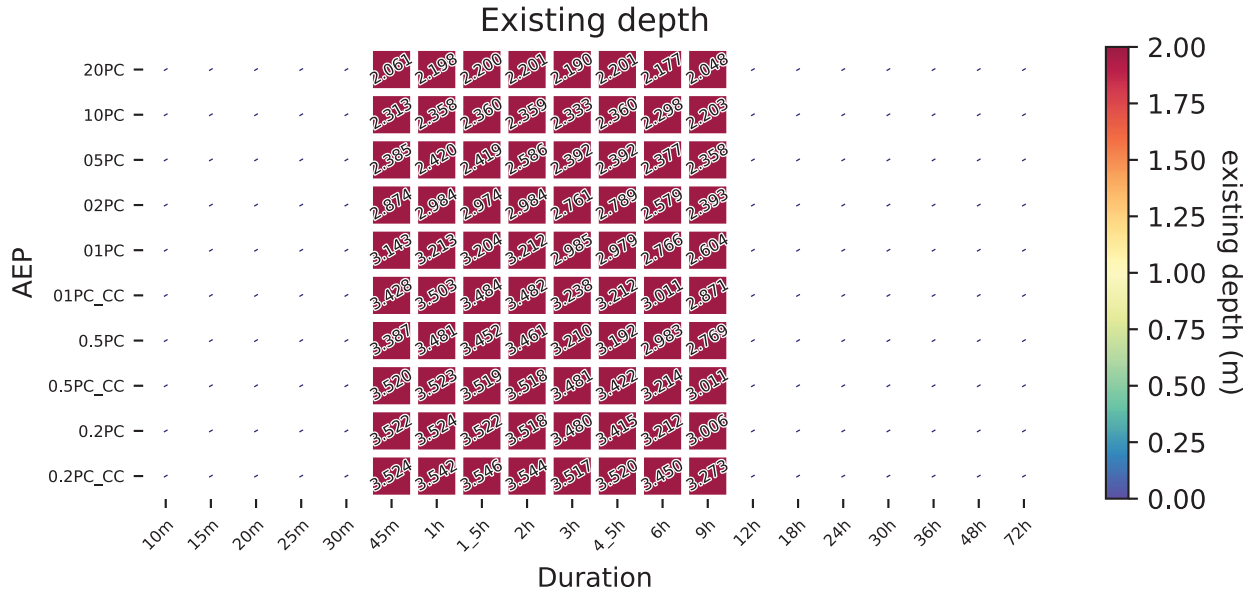
Koonung Creek - rear_of_Grange_Park_Ave

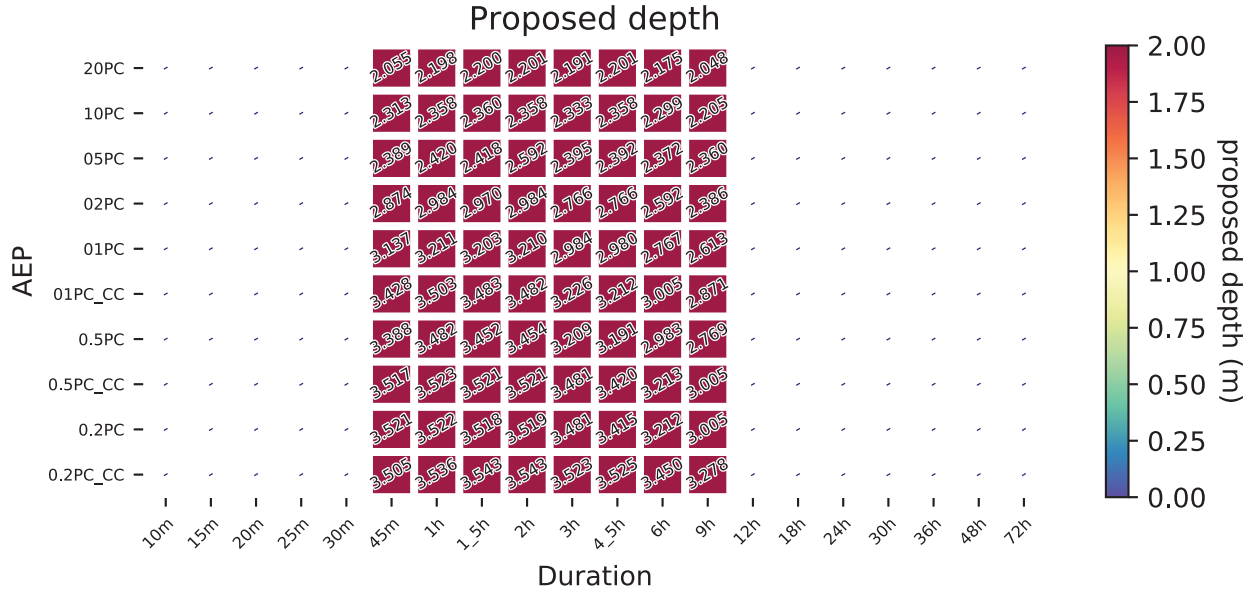


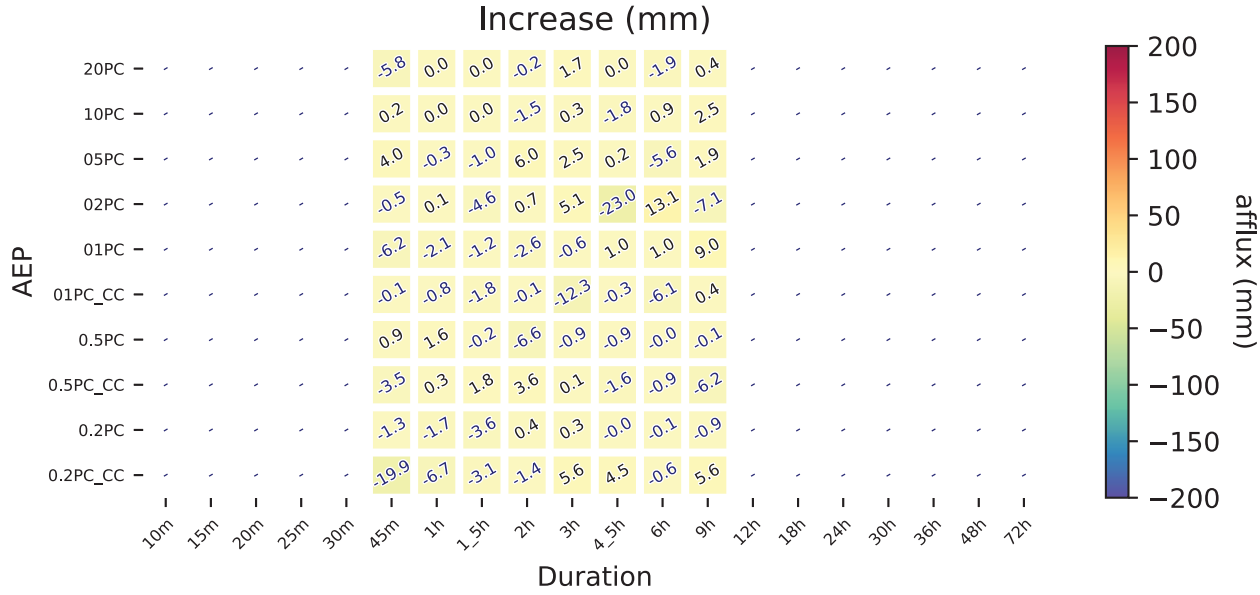
Koonung Creek - Eram_Rd_Property



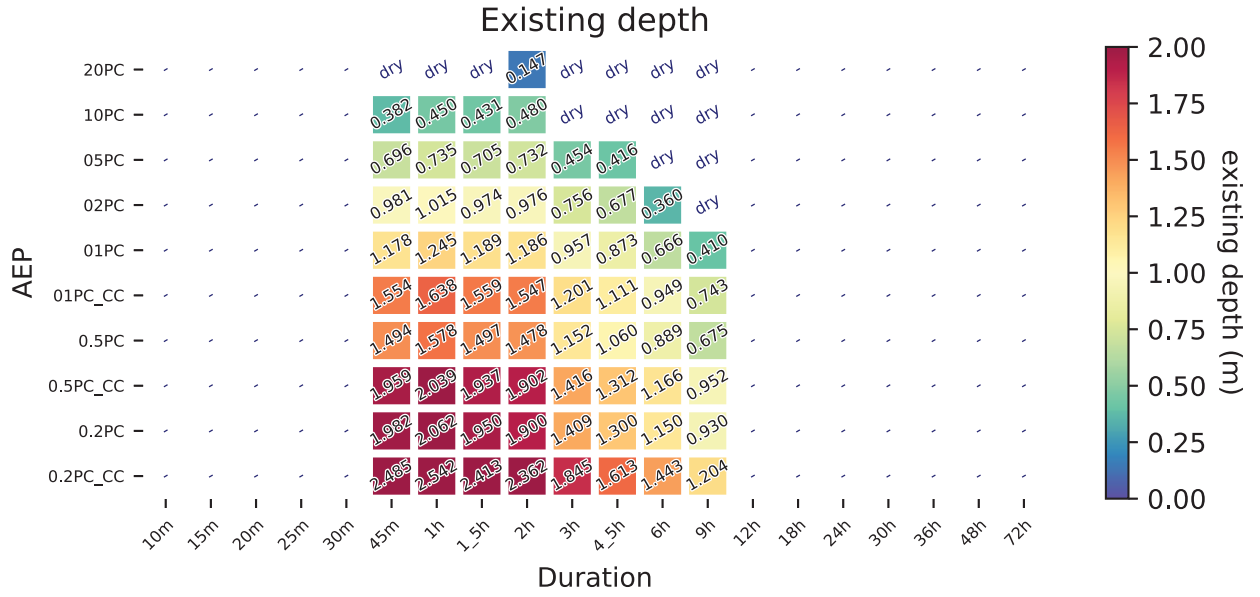
Koonung Creek - Middleborough_Rd

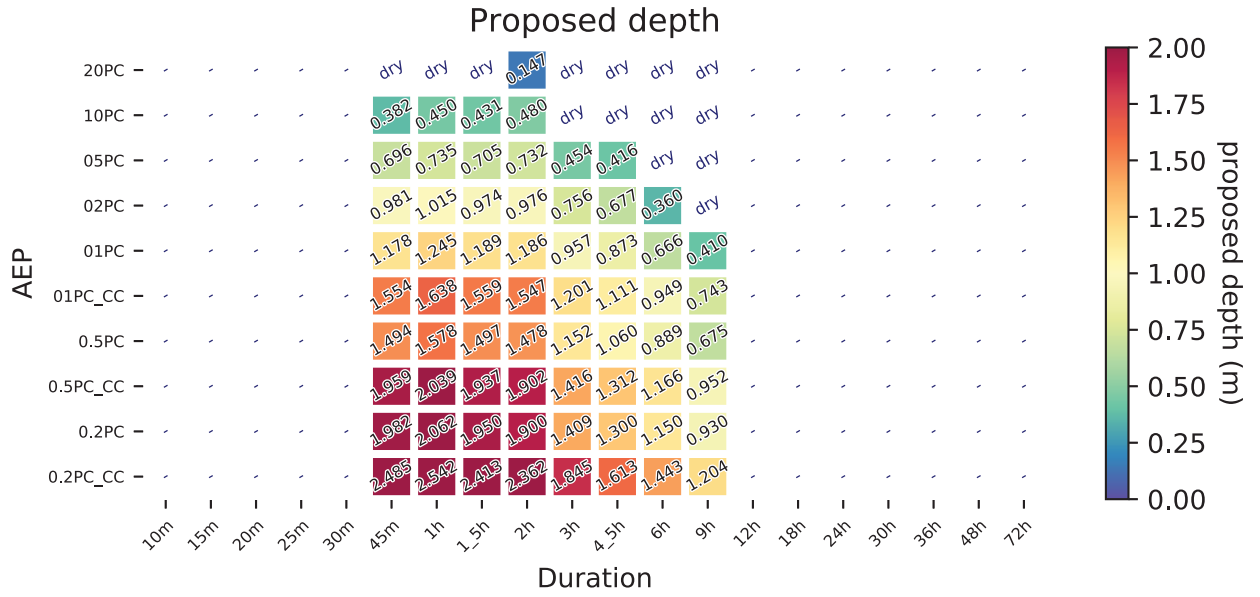


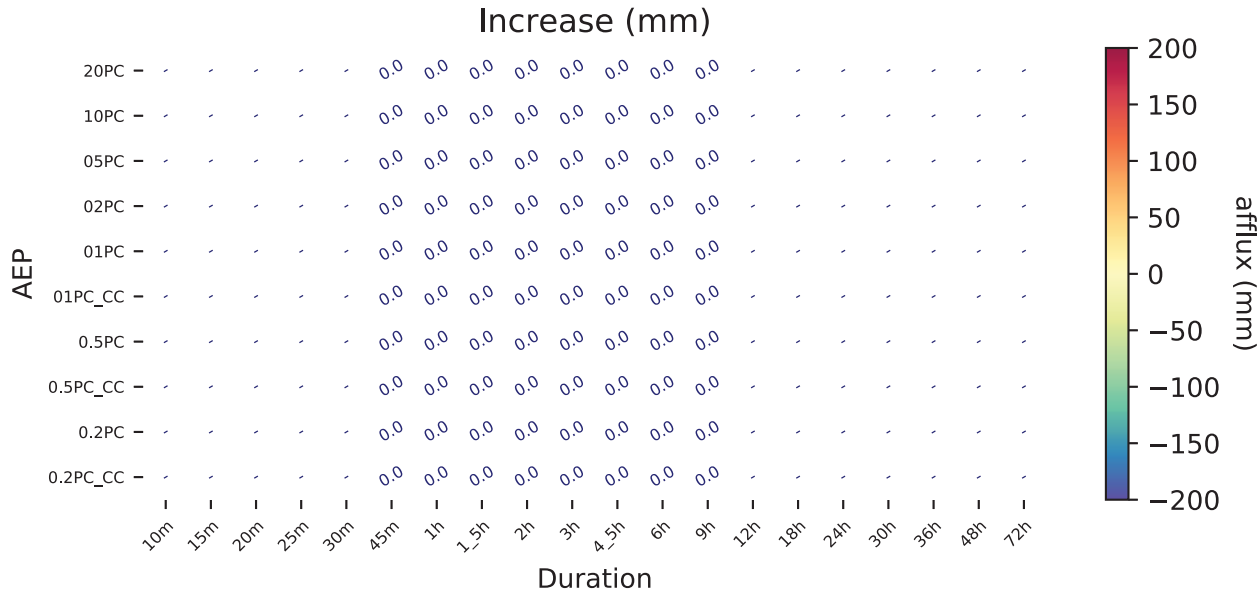




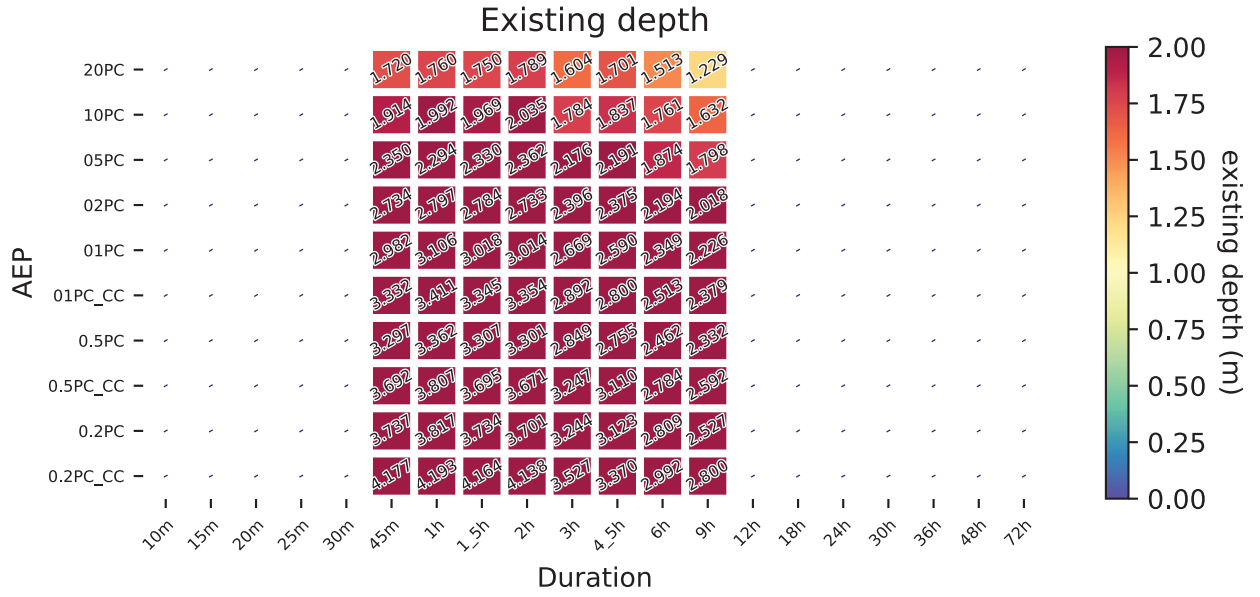
Koonung Creek - Elizabethan_Lodge(MiddleboroughRd)

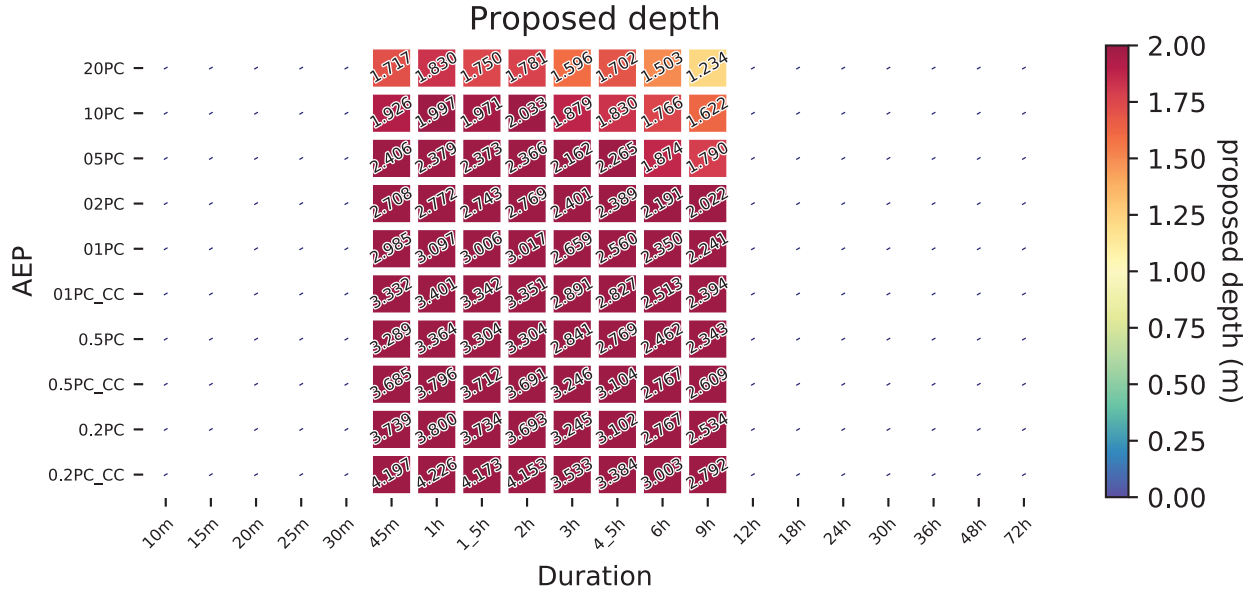


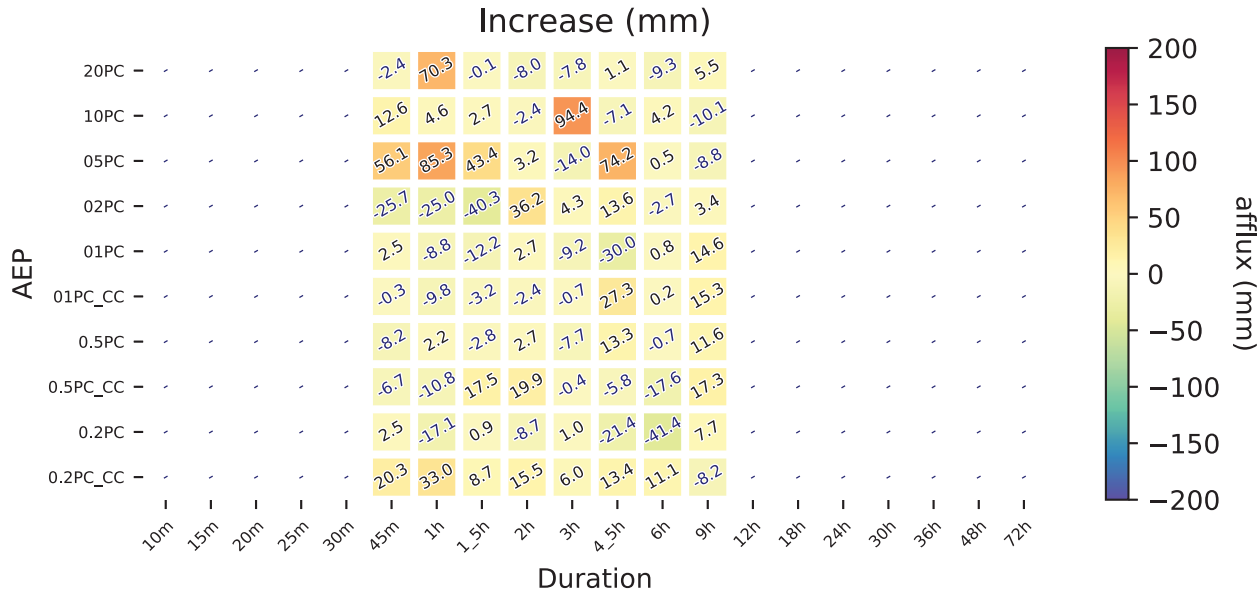




Koonung Creek - u/s_Blackburn_Rd

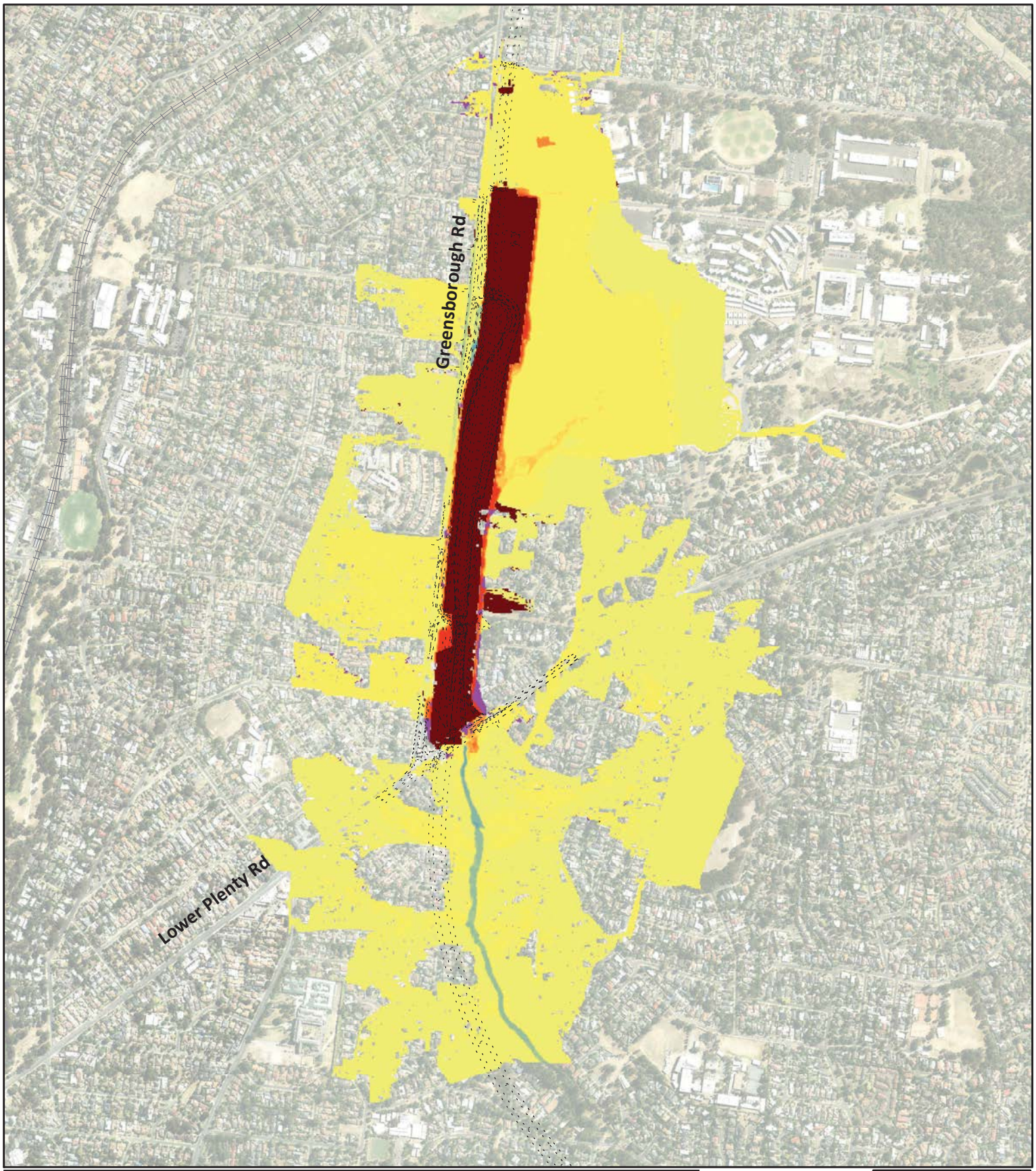






Appendix D – Alternative northern TBM launch site

D1 Banyule Creek



Flood Depth Afflux (m)

- Was Wet Now Dry
- <-0.500
- -0.499 - -0.300
- -0.299 - -0.200
- -0.199 - -0.150
- -0.149 - -0.100
- -0.099 - -0.050
- -0.049 - -0.030
- -0.029 - -0.020
- -0.019 - -0.010
- -0.009 - 0.000
- 0.001 - 0.010
- 0.011 - 0.020
- 0.021 - 0.030
- 0.031 - 0.050
- 0.051 - 0.100
- 0.101 - 0.150
- 0.151 - 0.200
- 0.201 - 0.300
- 0.301 - 0.500
- > 0.500
- Was Dry Now Wet

Paper Size A4

0 85 170 340

Metres

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

N

NORTH EAST LINK PROJECT

North East Link
North East Link Project

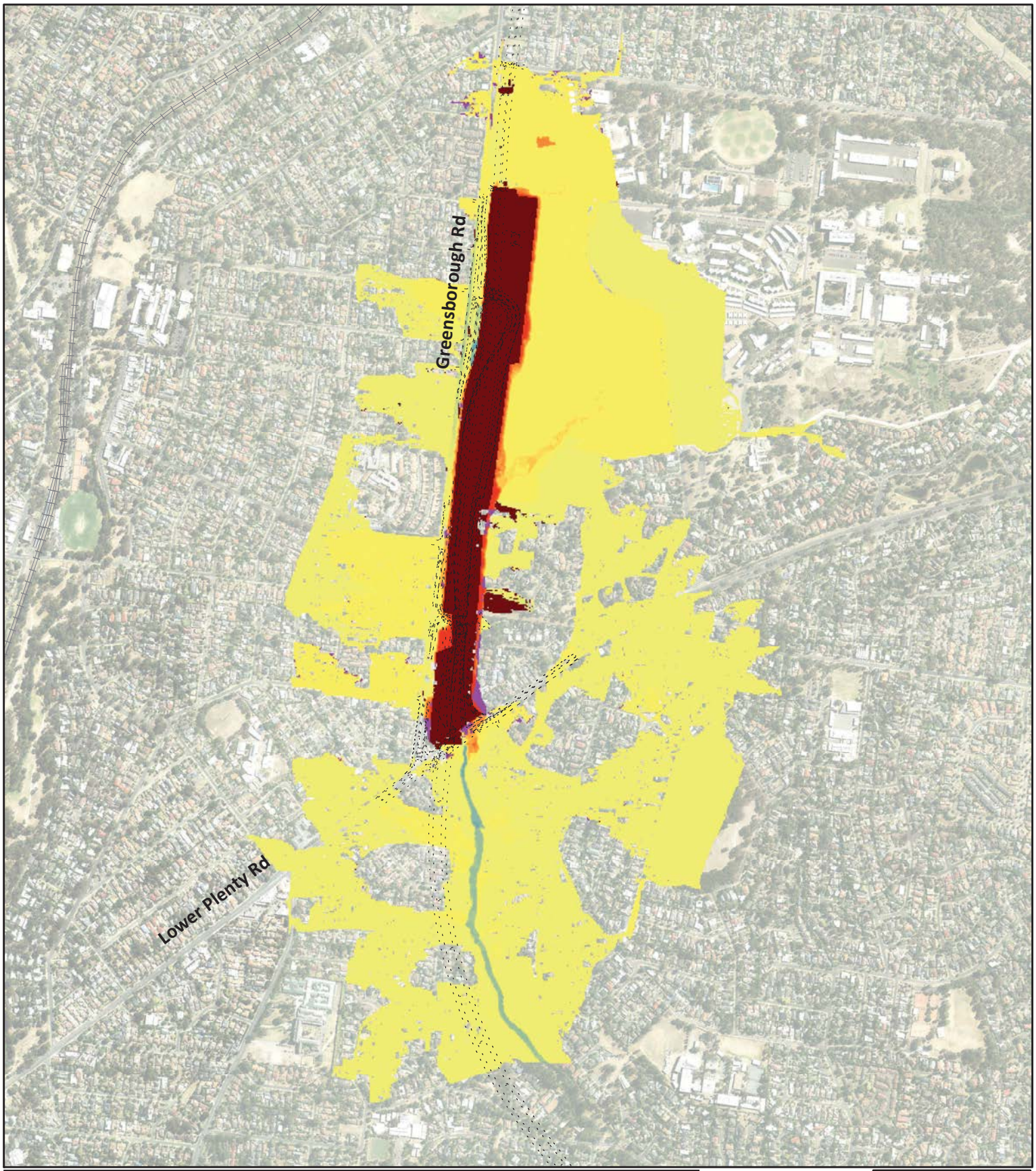
Job Number | 31-35006
Revision | B
Date | 08/10/2018

1% AEP peak flood depth afflux
Banyule Creek

Figure D-1

G:\31\35006\GIS\Maps\Working\Specialist Submission\EES\Groundwater and Hydrology\Surface_Water\35006_Hydraulics_KBM_A4P.mxd 180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



Flood Level Afflux (m)

Was Wet Now Dry	-0.199 - -0.150	-0.019 - -0.010	0.031 - 0.050	0.301 - 0.500
<-0.500	-0.149 - -0.100	-0.009 - 0.000	0.051 - 0.100	> 0.500
-0.499 - -0.300	-0.099 - -0.050	0.001 - 0.010	0.101 - 0.150	Was Dry Now Wet
-0.299 - -0.200	-0.049 - -0.030	0.011 - 0.020	0.151 - 0.200	
	-0.029 - -0.020	0.021 - 0.030	0.201 - 0.300	

Paper Size A4

0 85 170 340

Metres

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

N

North East Link
North East Link Project

Job Number | 31-35006
Revision | B
Date | 08/10/2018

1% AEP peak flood level afflux
Banyule Creek

Figure D-2

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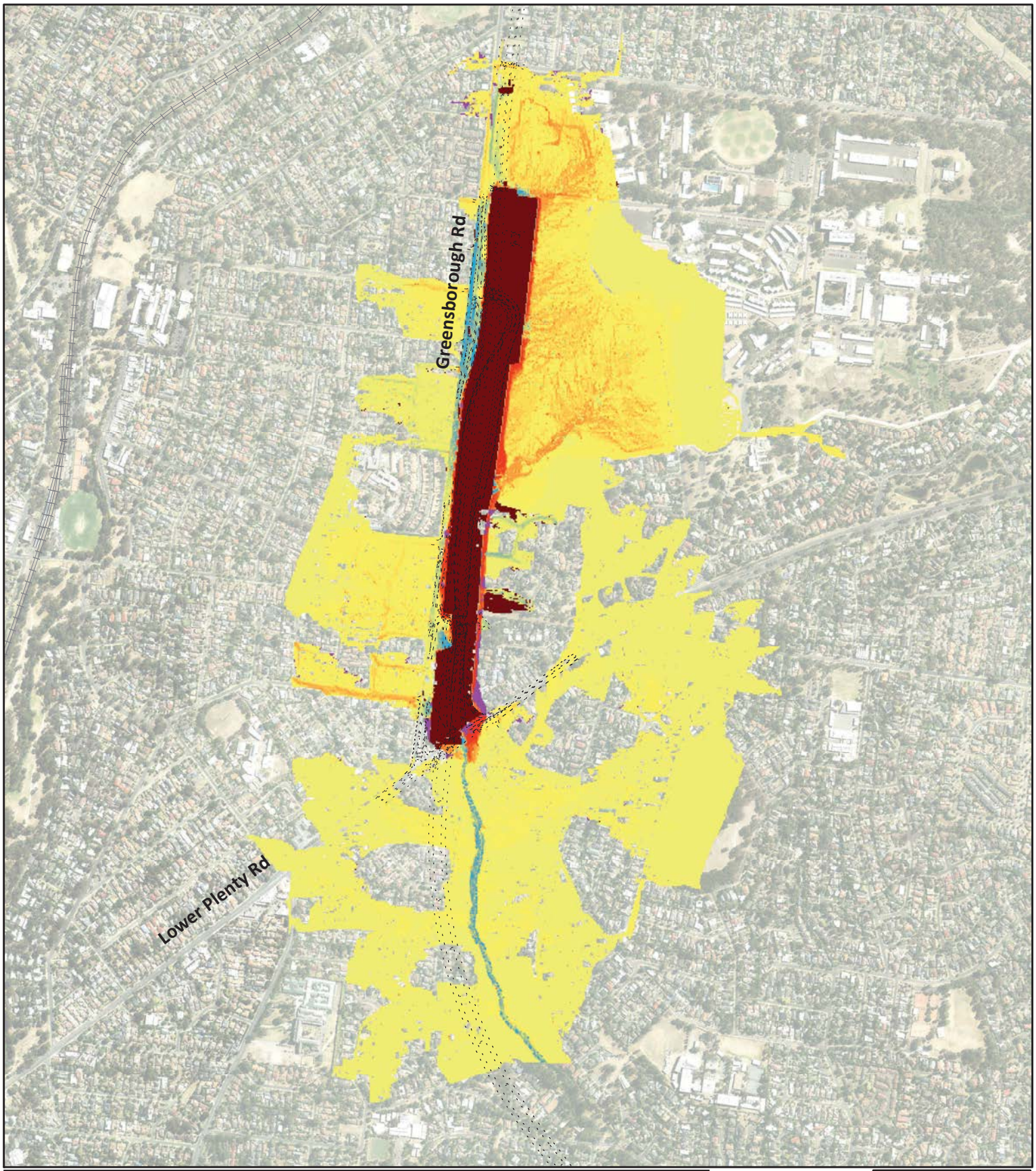
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



Flood Velocity Difference(m/s)				
Was Wet Now Dry	-0.199 - -0.150	-0.019 - -0.010	0.031 - 0.050	0.301 - 0.500
<-0.500	-0.149 - -0.100	-0.009 - 0.000	0.051 - 0.100	> 0.500
-0.499 - -0.300	-0.099 - -0.050	0.001 - 0.010	0.101 - 0.150	Was Dry Now Wet
-0.299 - -0.200	-0.049 - -0.030	0.011 - 0.020	0.151 - 0.200	
	-0.029 - -0.020	0.021 - 0.030	0.201 - 0.300	

Paper Size A4

0 85 170 340

Metres

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

N

North East Link
North East Link Project

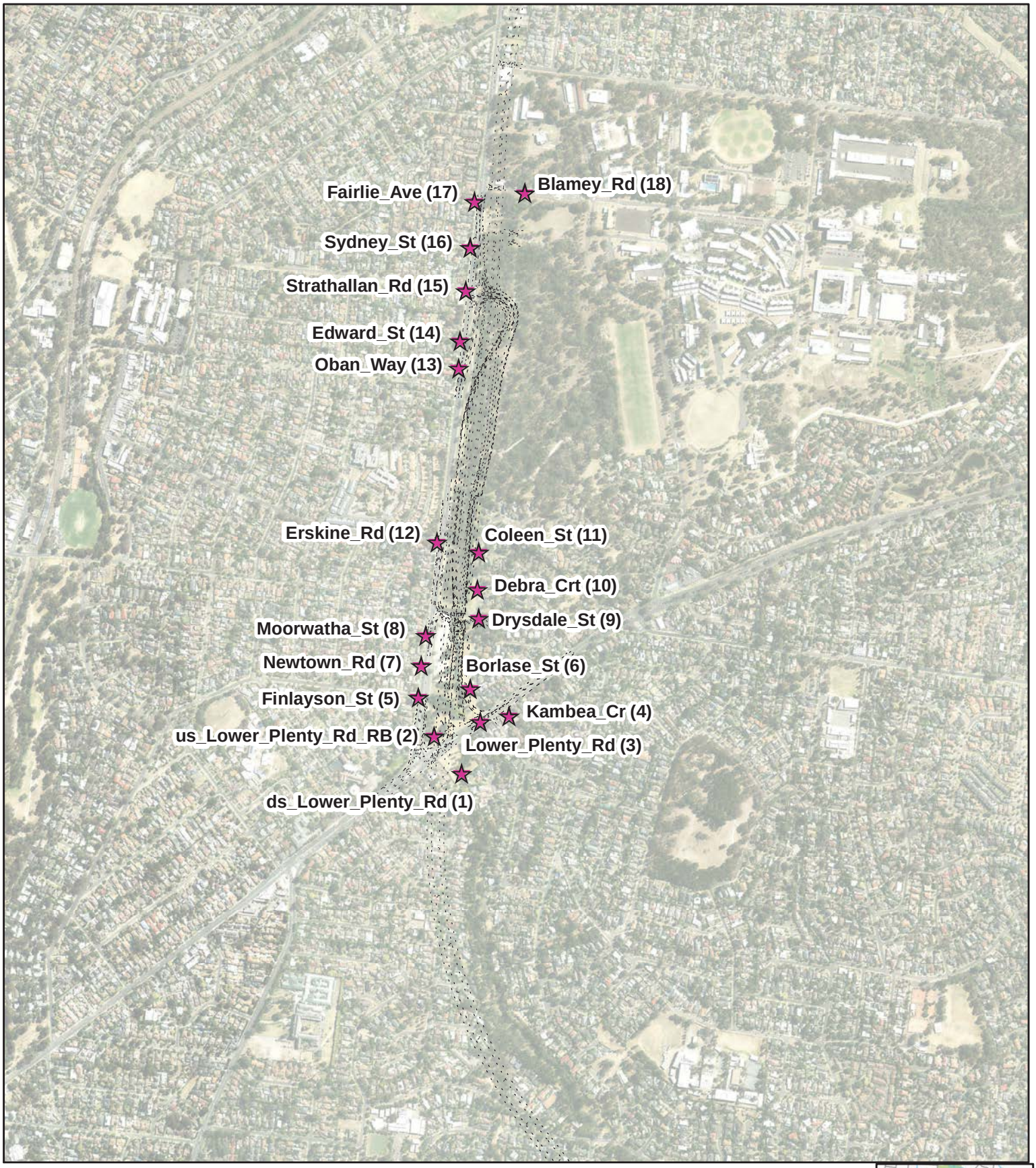
Job Number 31-35006
Revision B
Date 08/10/2018

1% AEP peak flood velocity difference Banyule Creek

Figure D-3

G:\31\35006\GIS\Maps\Working\Specialist Submission\EES\Groundwater and Hydrology\Surface_Water\35006_Hydraulics_KBM_A4P.mxd 180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari



LEGEND

★ Selected Locations

Paper Size A4

0 85 170 340

Metres

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

N

North East Link
North East Link Project

Job Number | 31-35006
Revision | C
Date | 13/11/2018

Banyule Creek
Comparison Locations Appendix D-4

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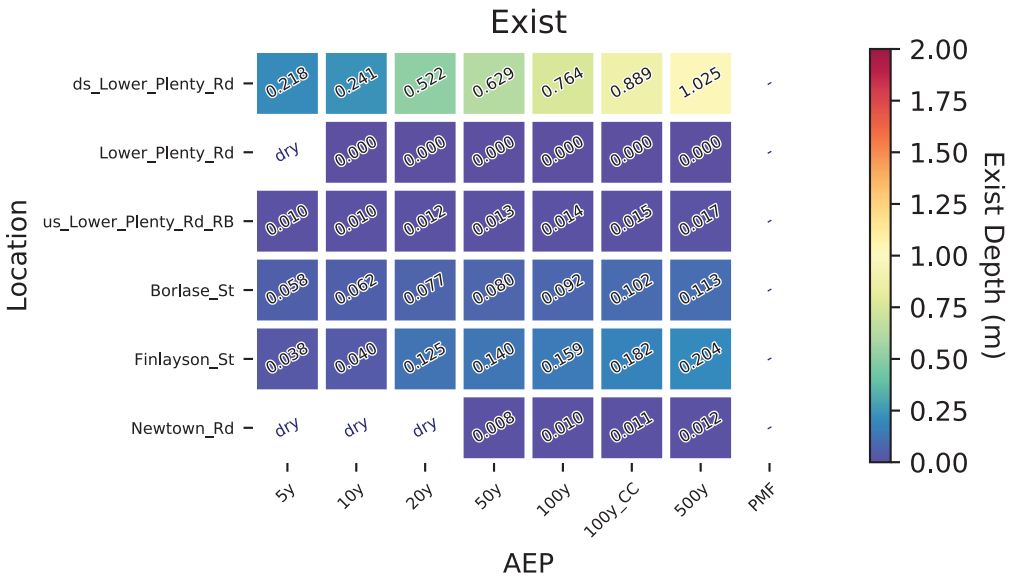
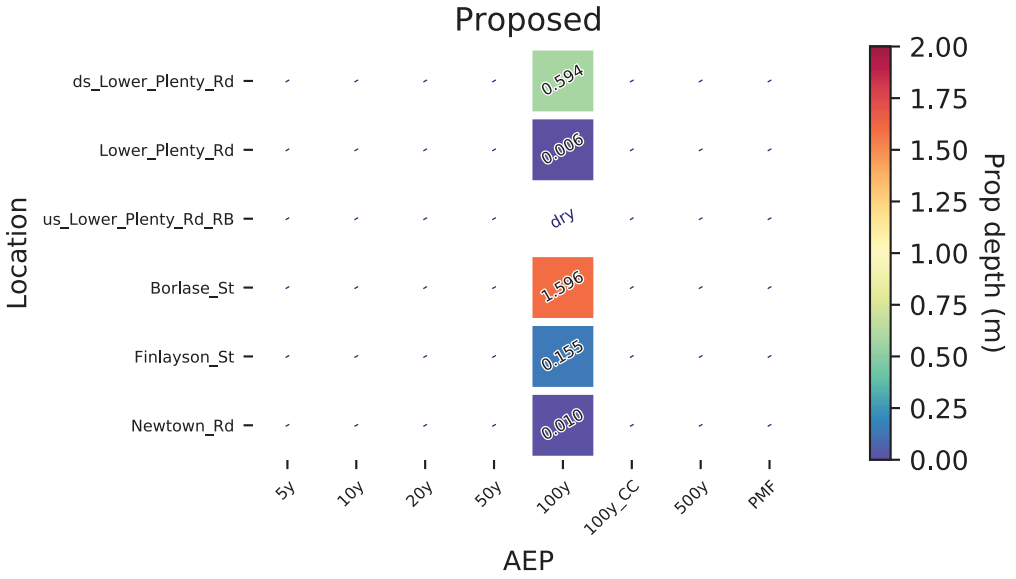
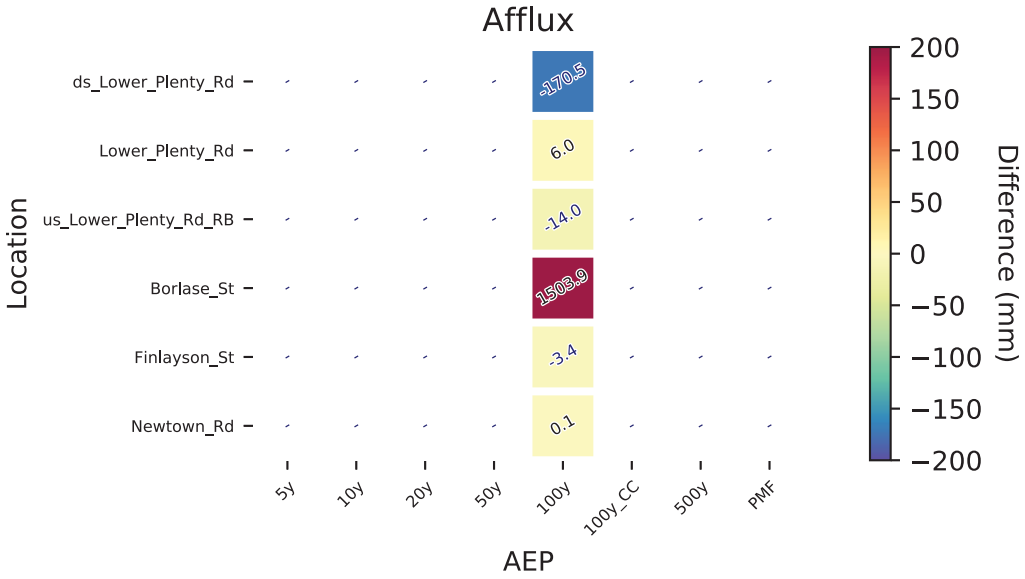
Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

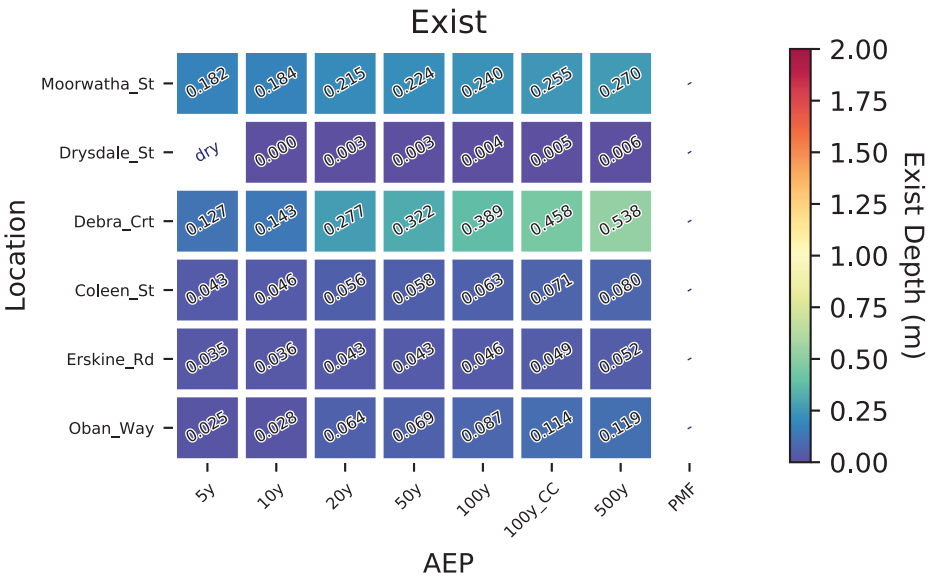
Banyule Creek - Construction Alternative Overview

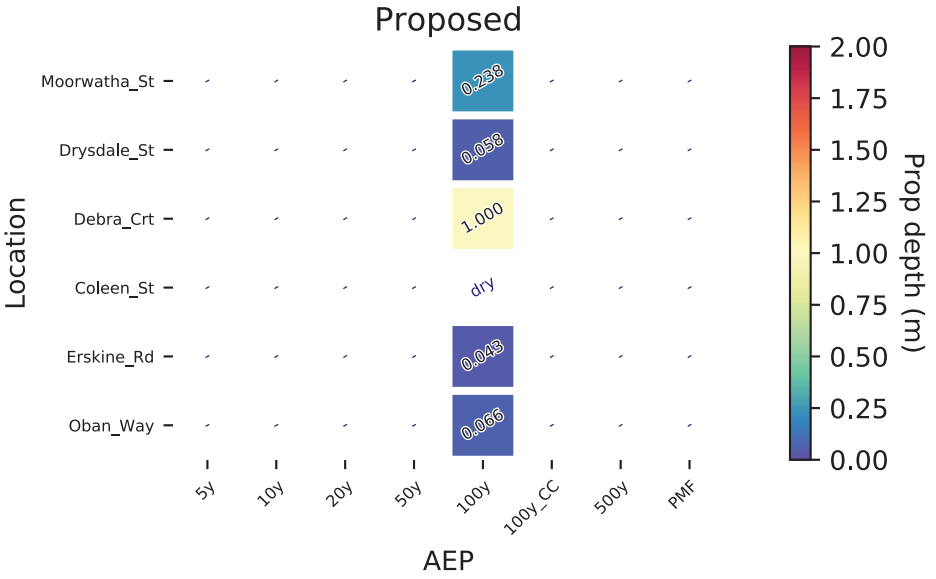


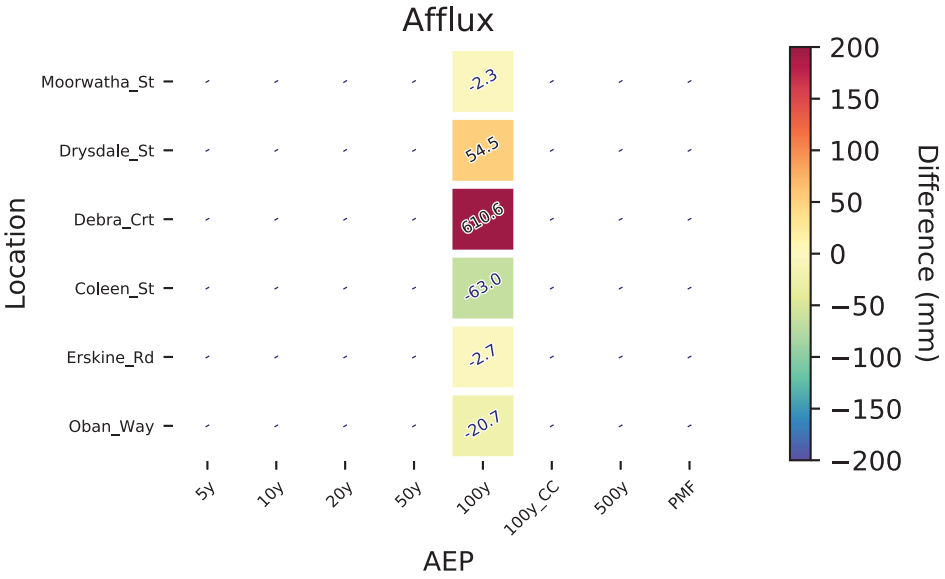




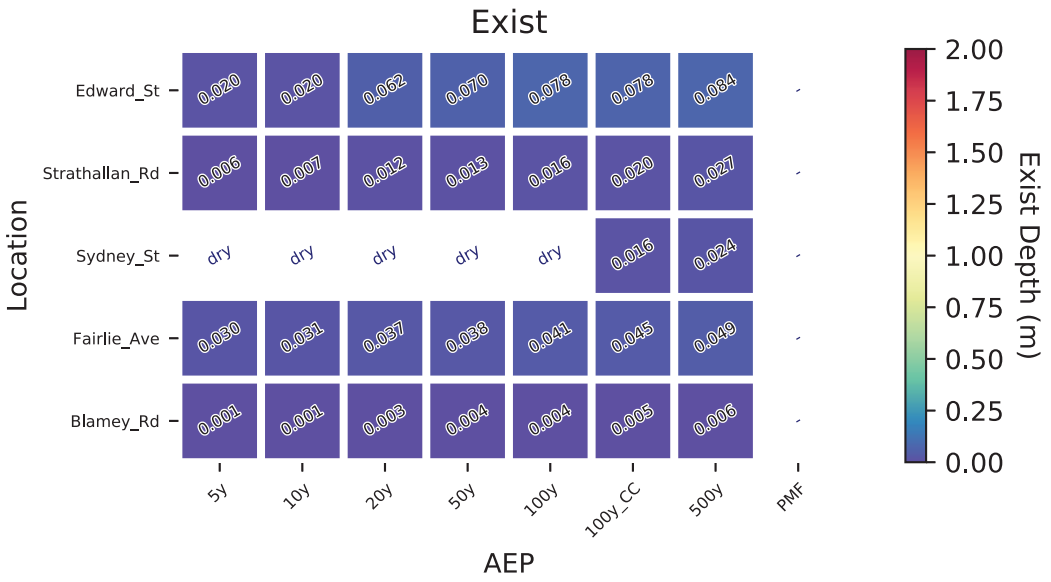
Banyule Creek - Construction Alternative Overview

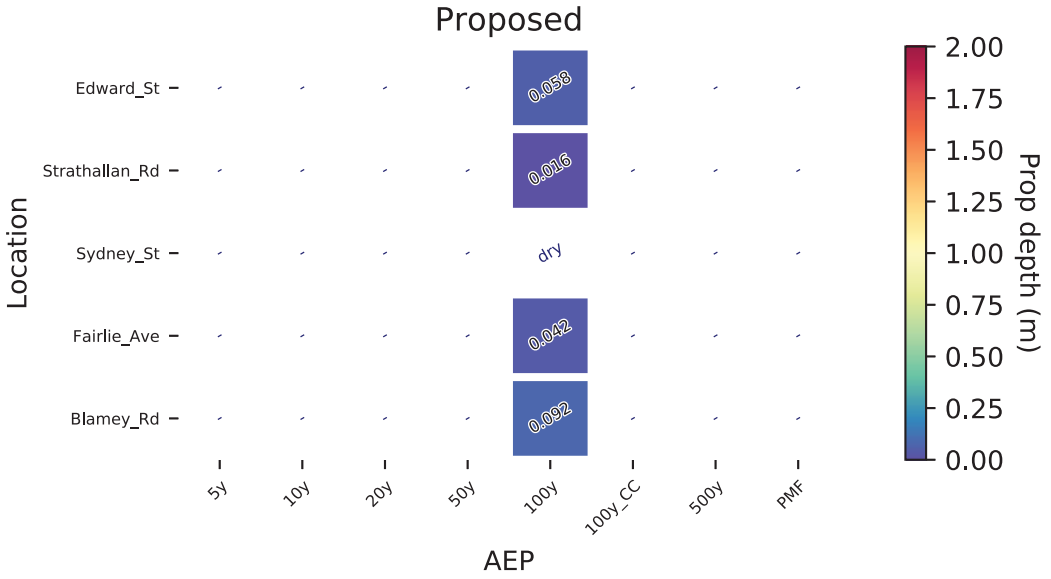


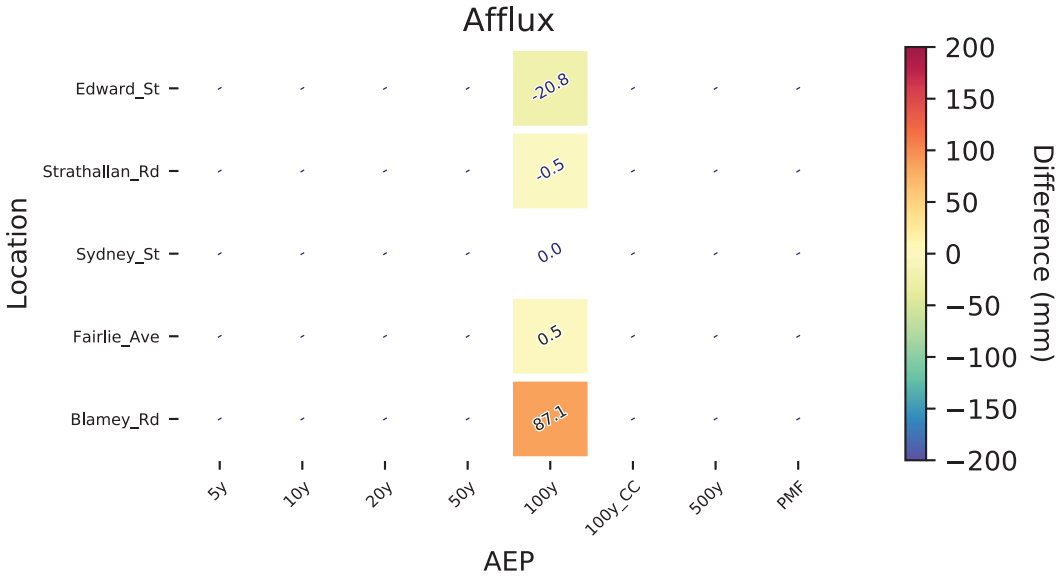




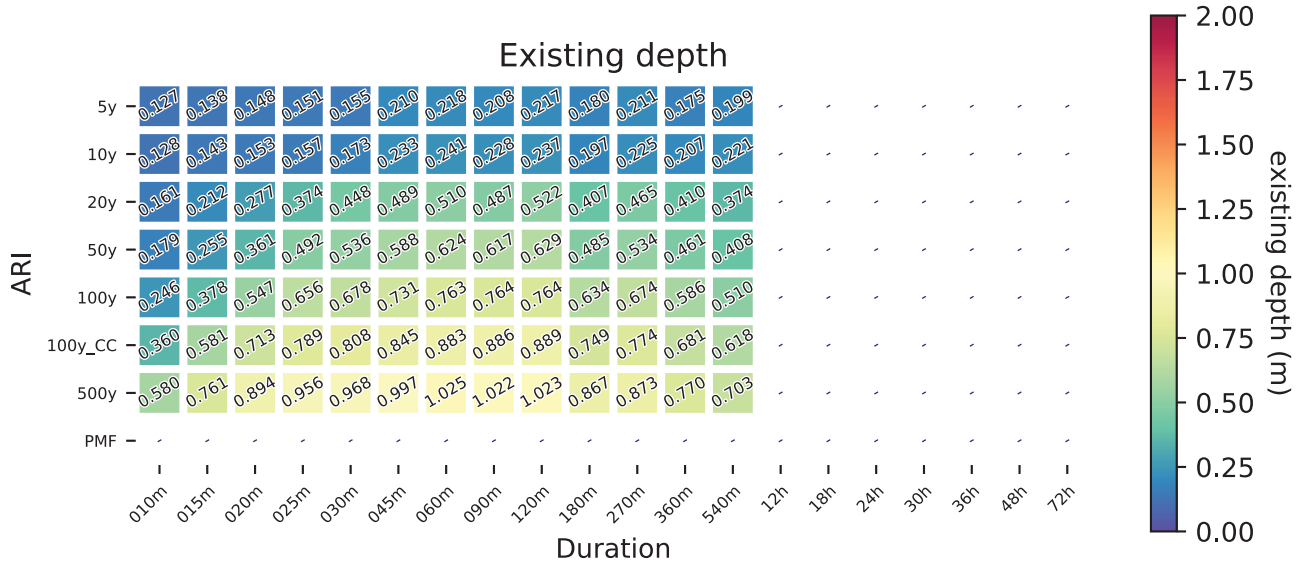
Banyule Creek - Construction Alternative Overview

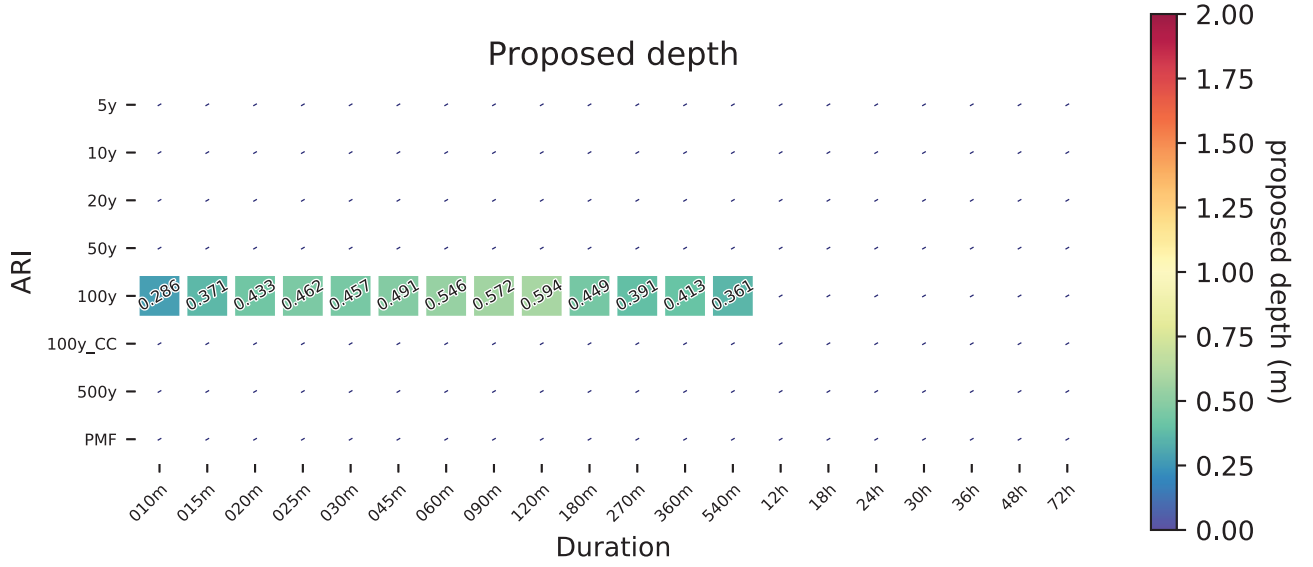


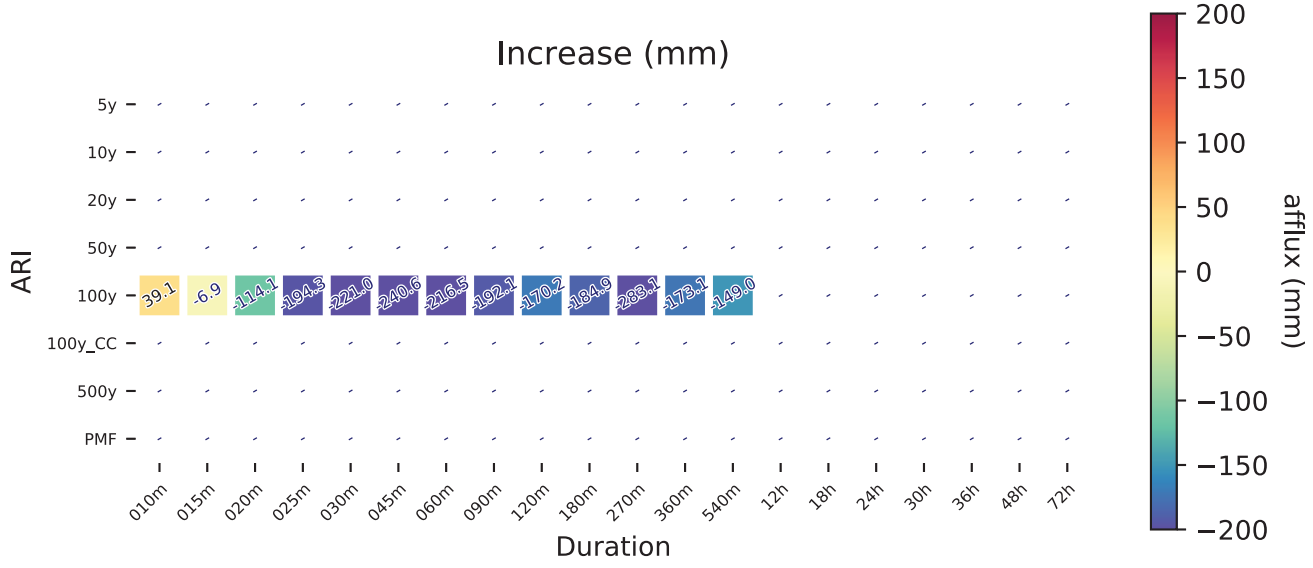




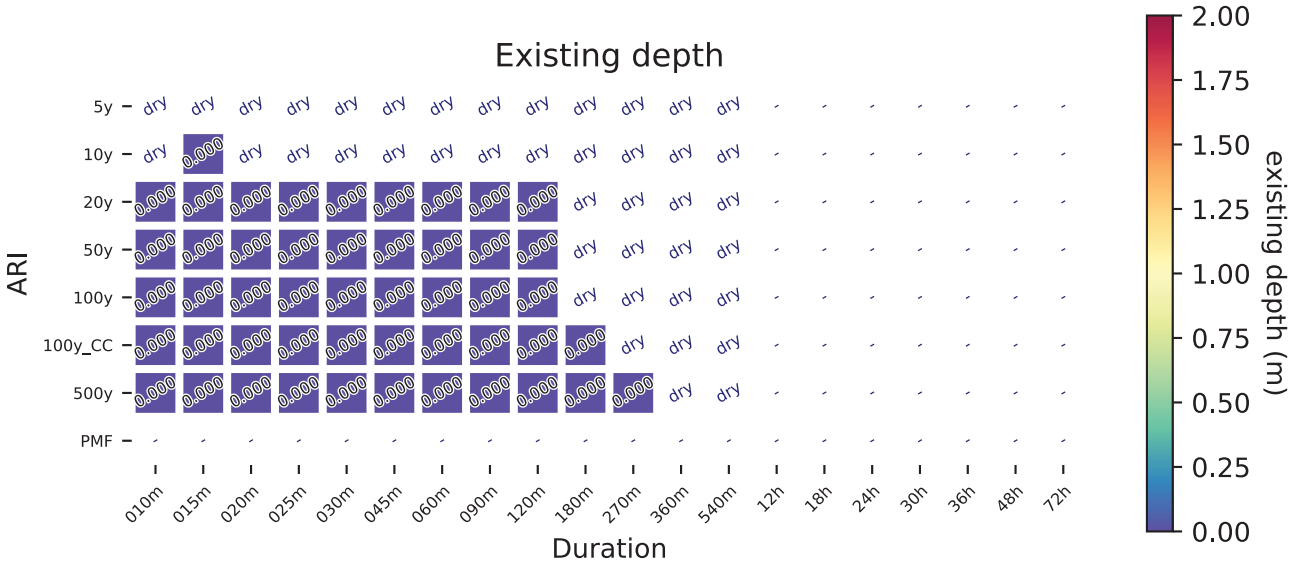
Banyule Creek Construction Alternate NthSth - ds_Lower_Plenty_Rd

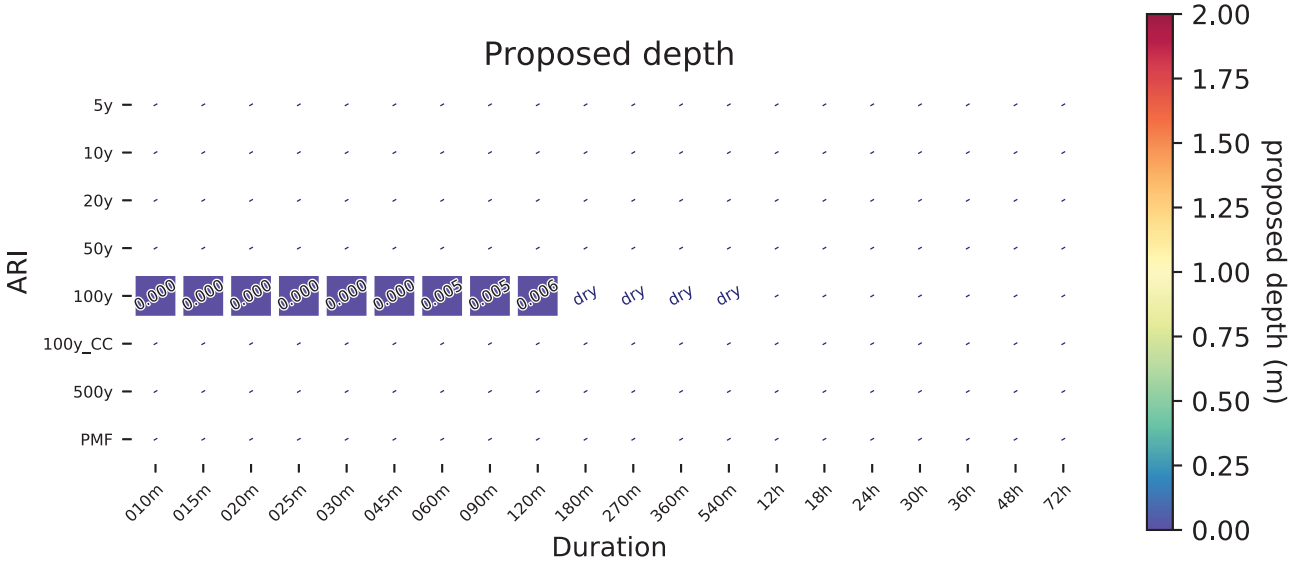


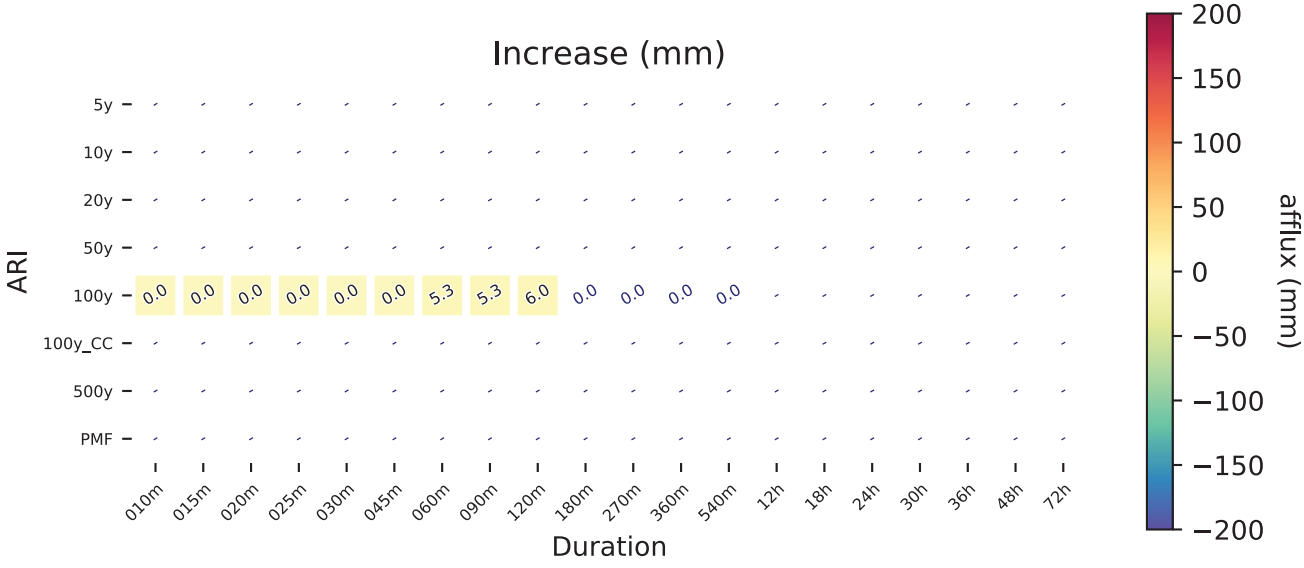




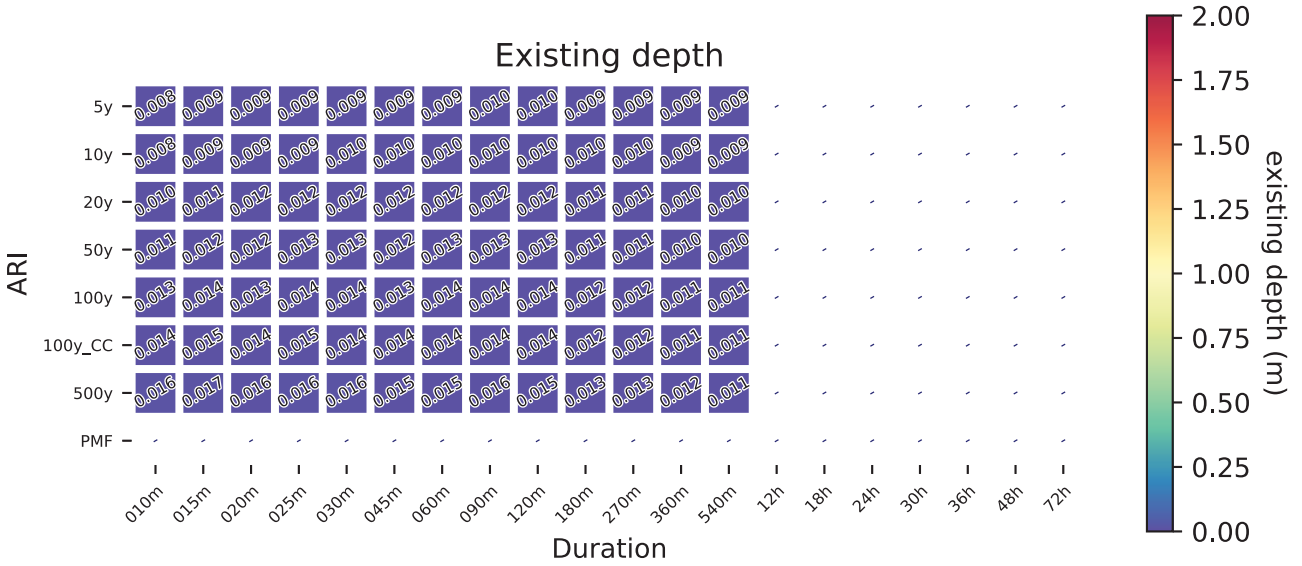
Banyule Creek Construction Alternate NthSth - Lower_Plenty_Rd

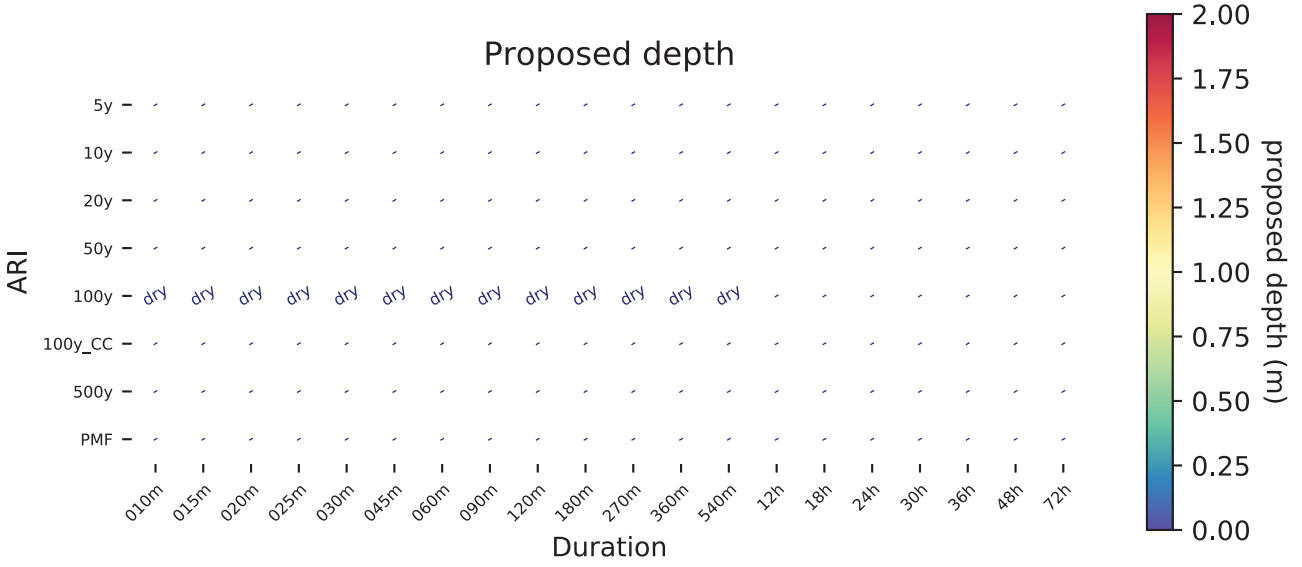


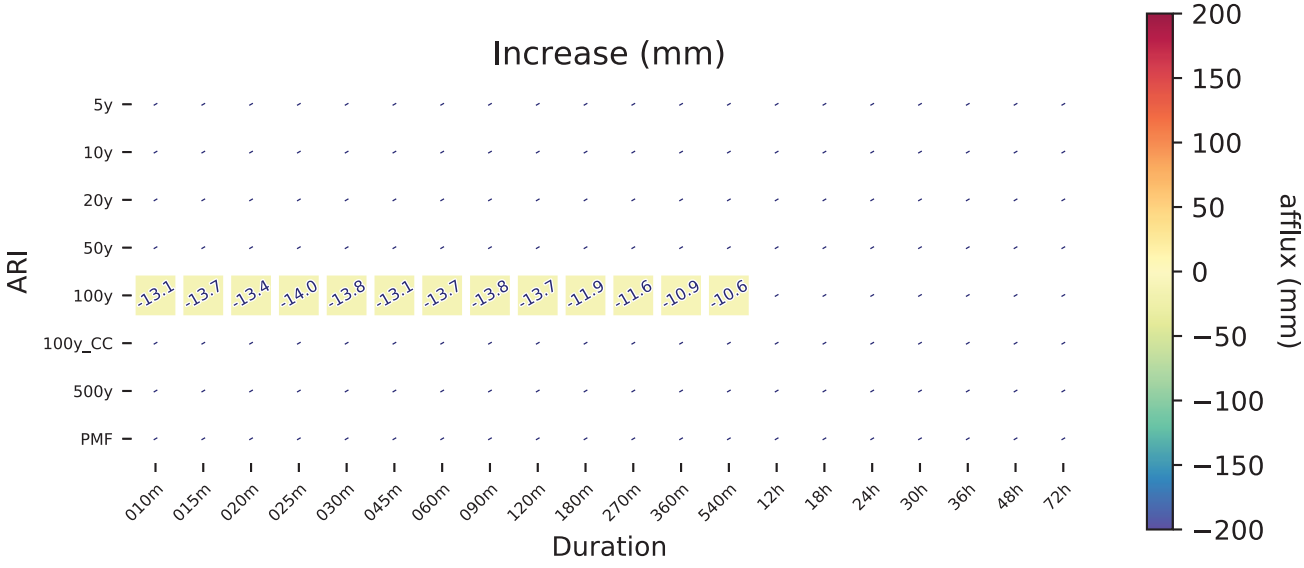




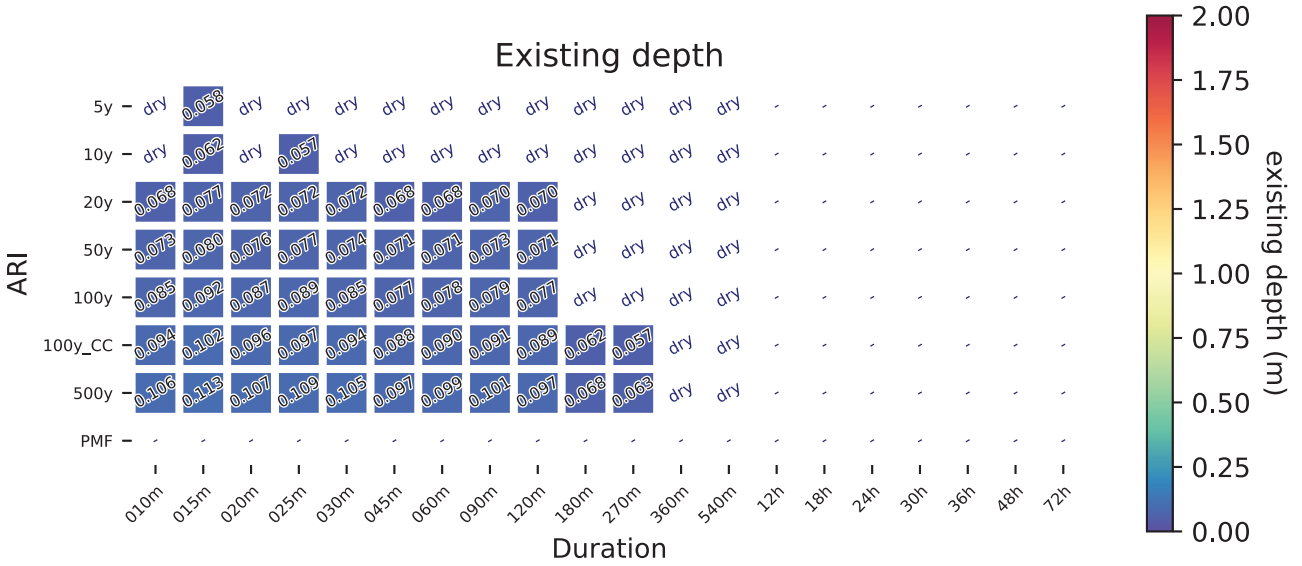
Banyule Creek Construction Alternate NthSth - us_Lower_Plenty_Rd_RB

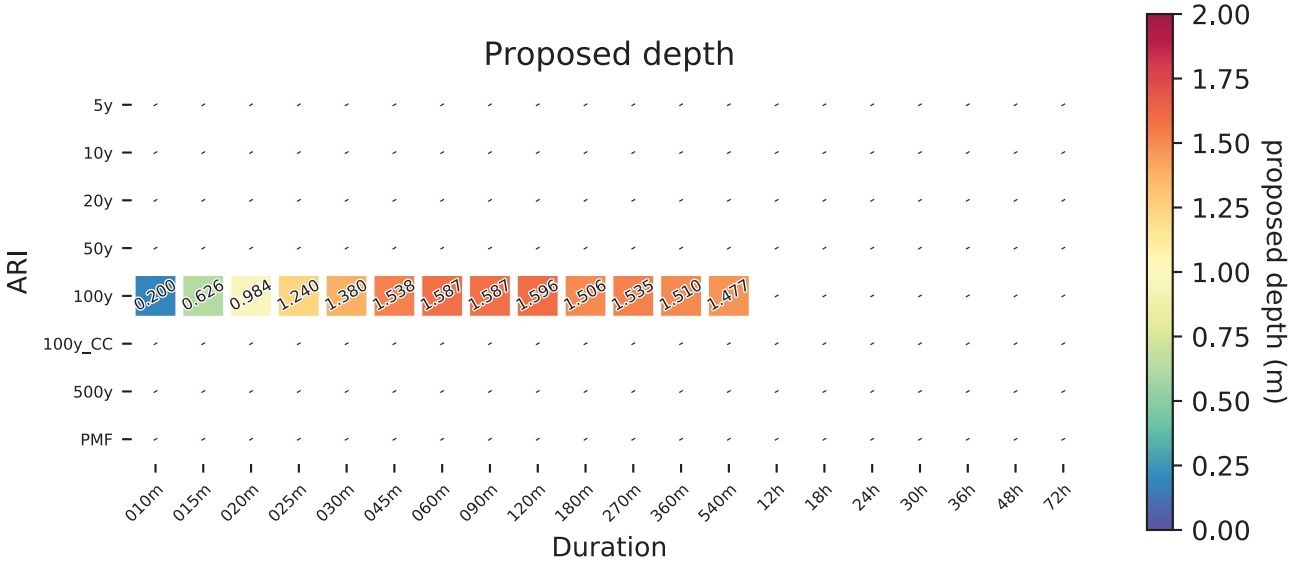


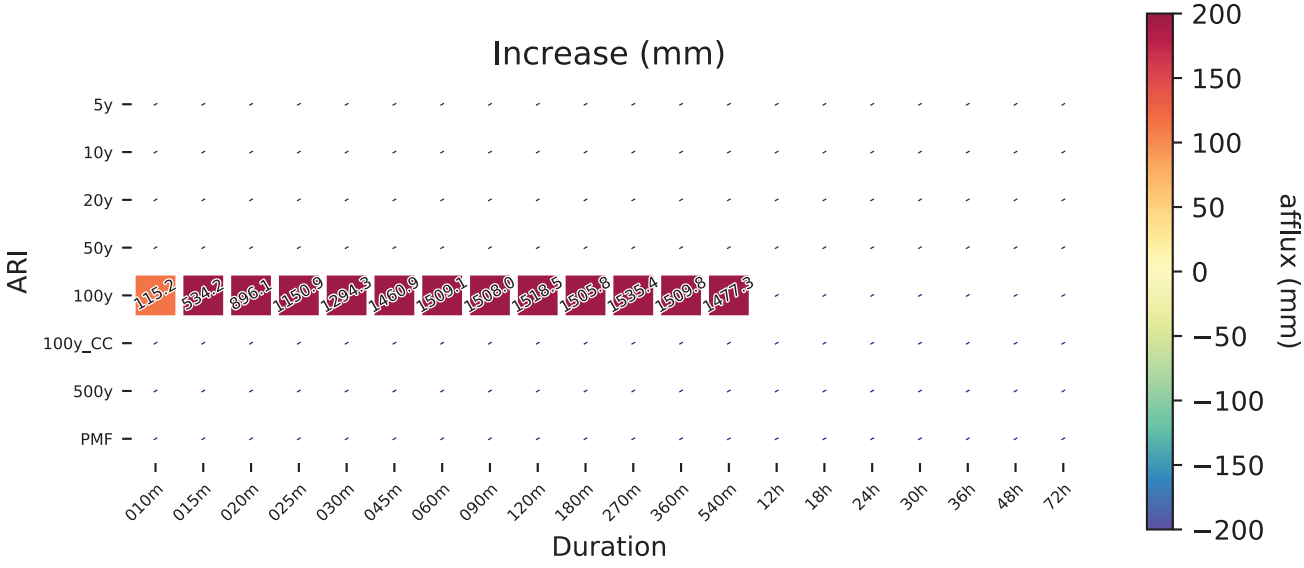




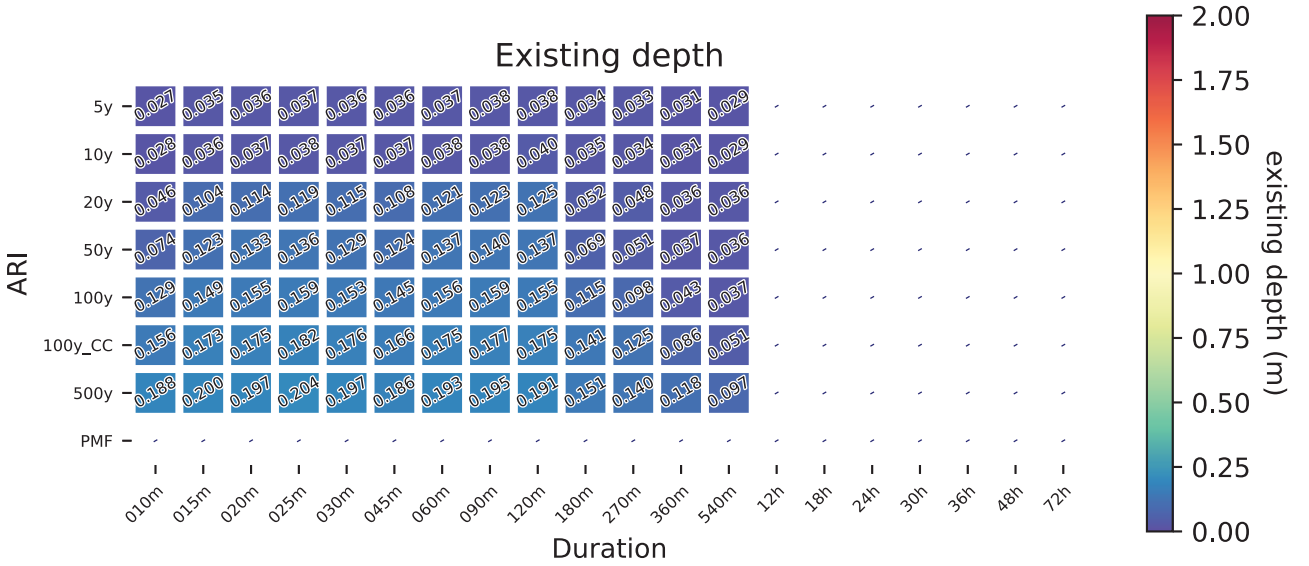
Banyule Creek Construction Alternate NthSth - Borlase_St

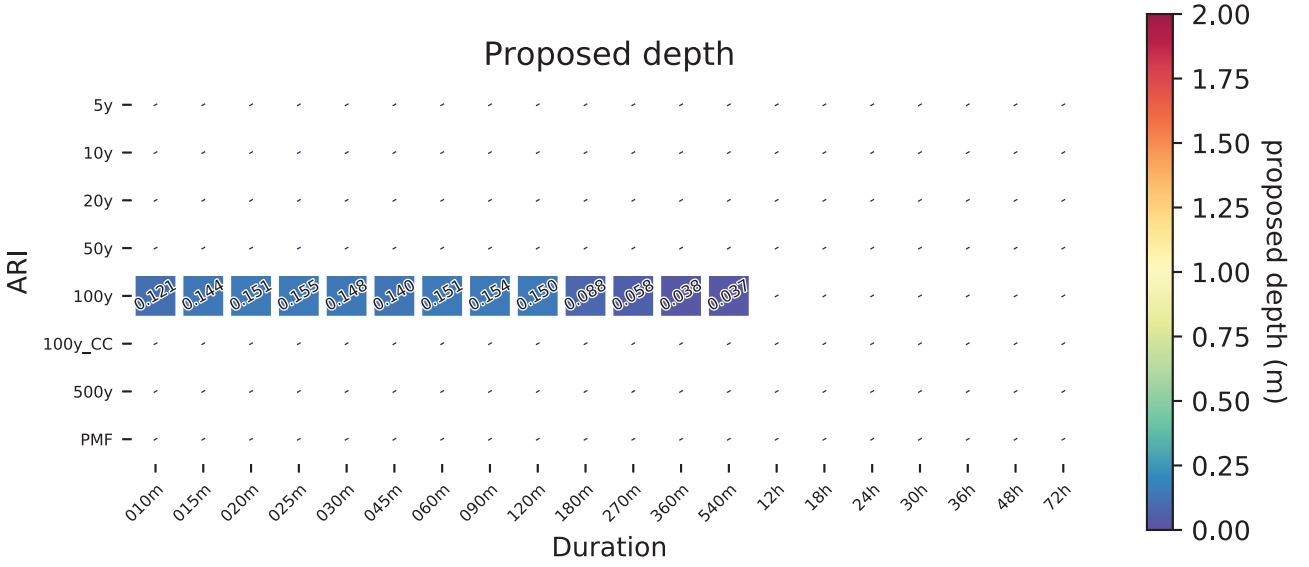


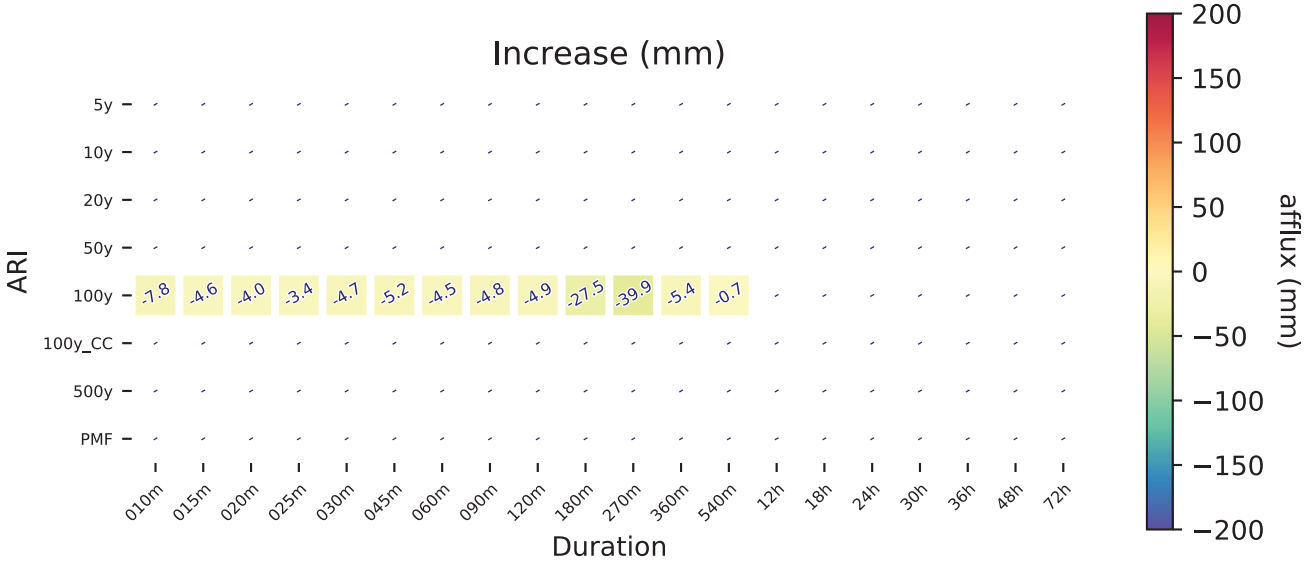




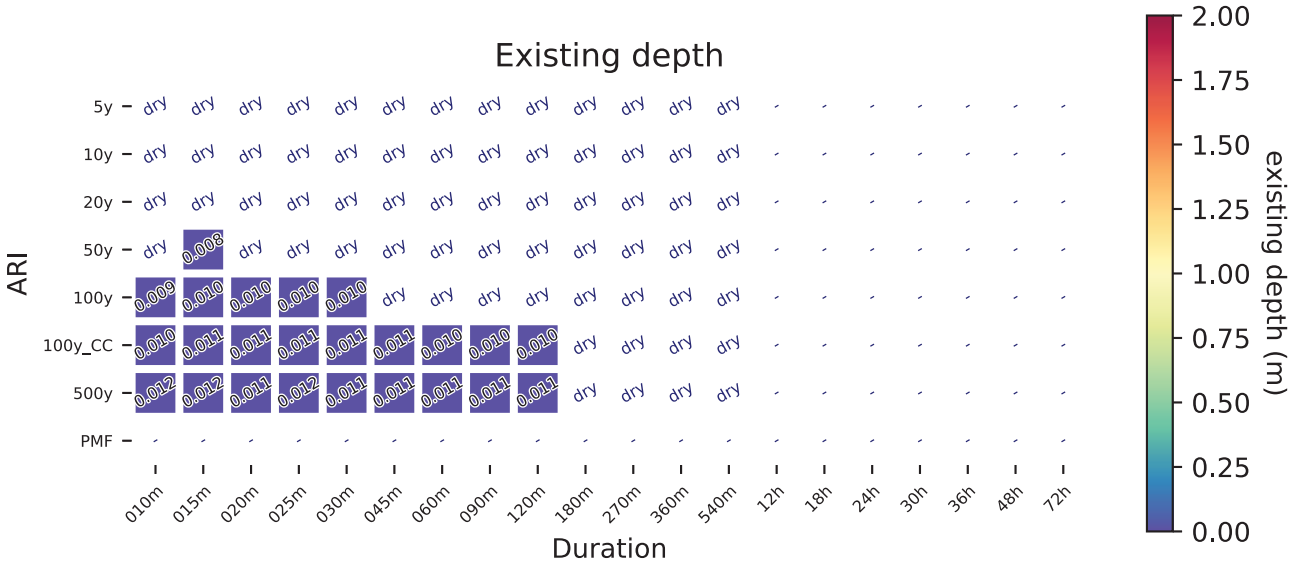
Banyule Creek Construction Alternate NthSth - Finlayson_St

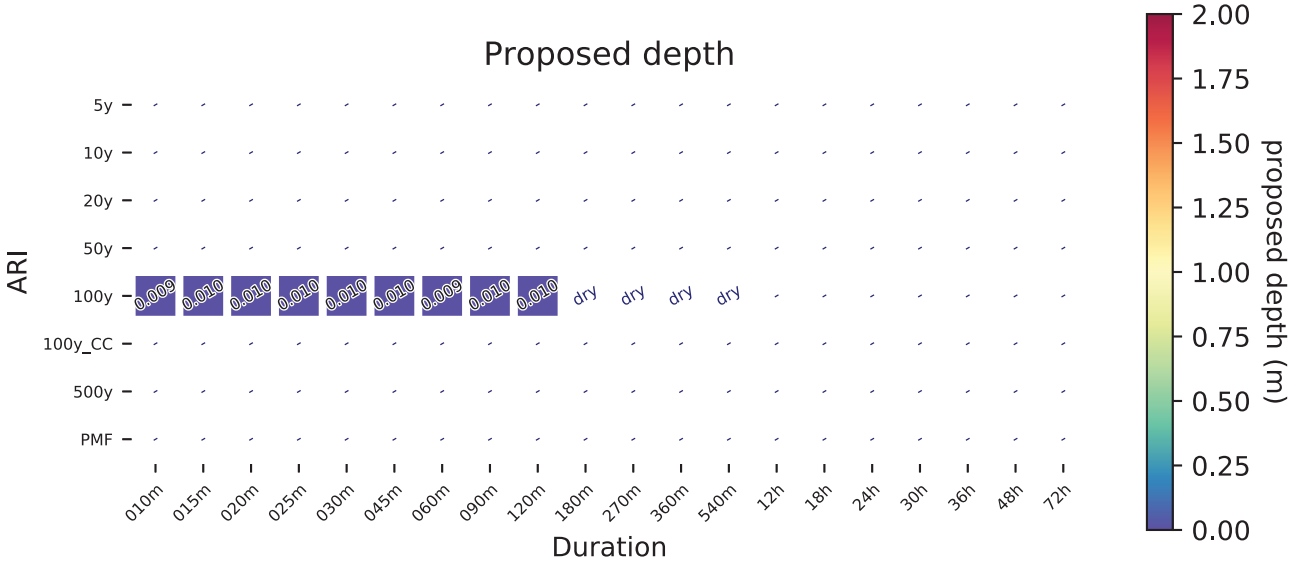


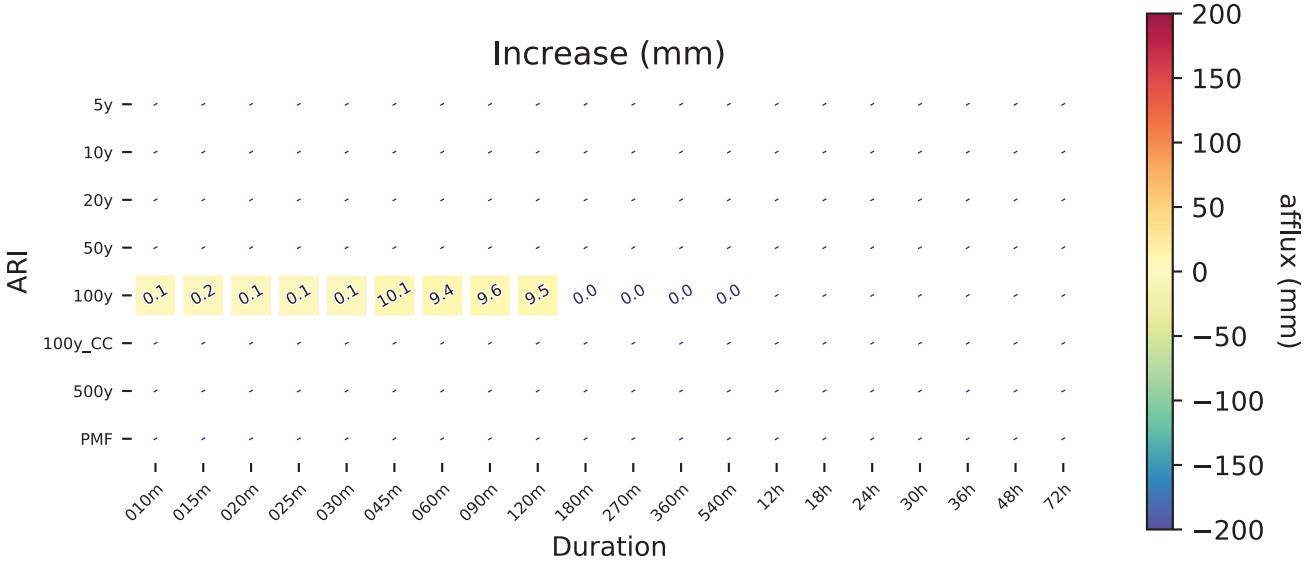




Banyule Creek Construction Alternate NthSth - Newtown_Rd







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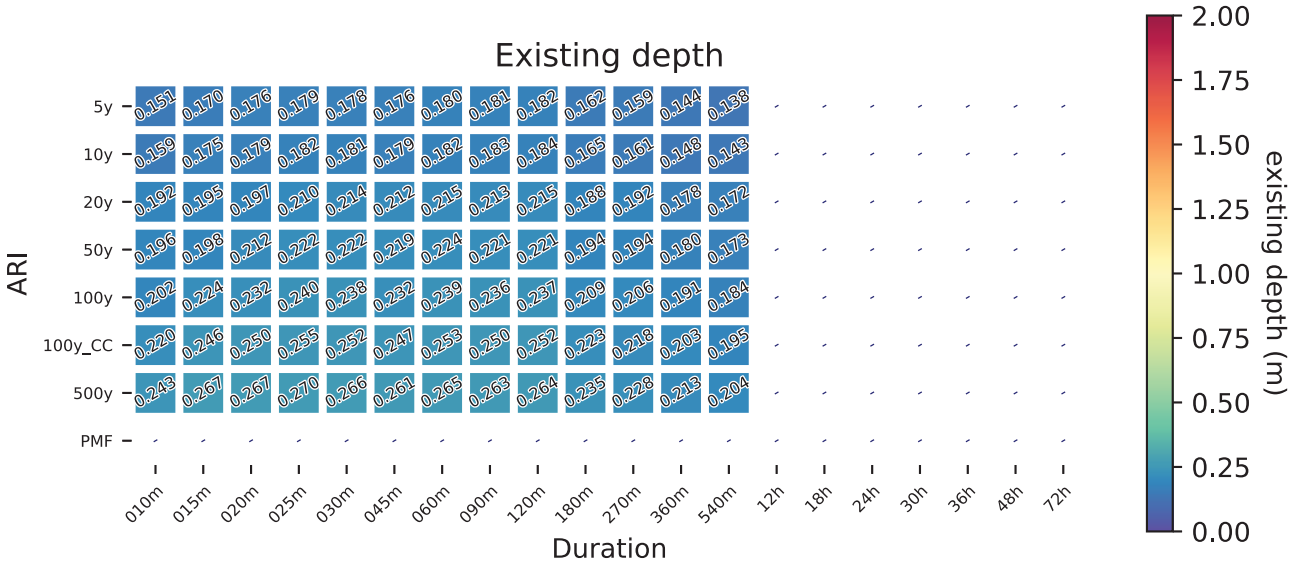

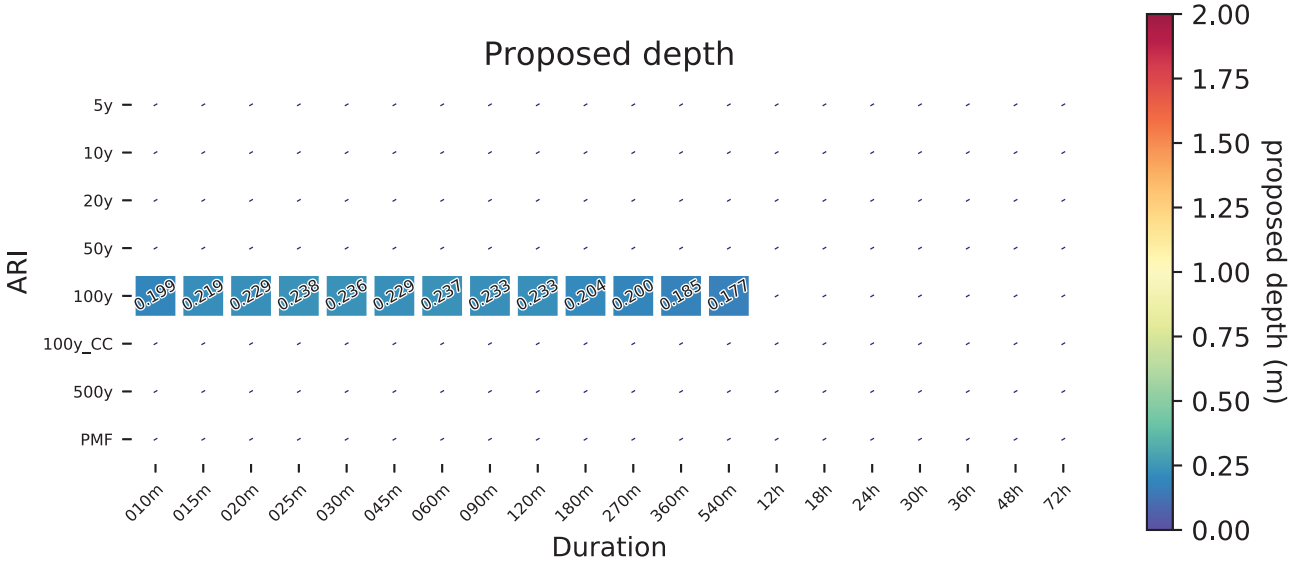

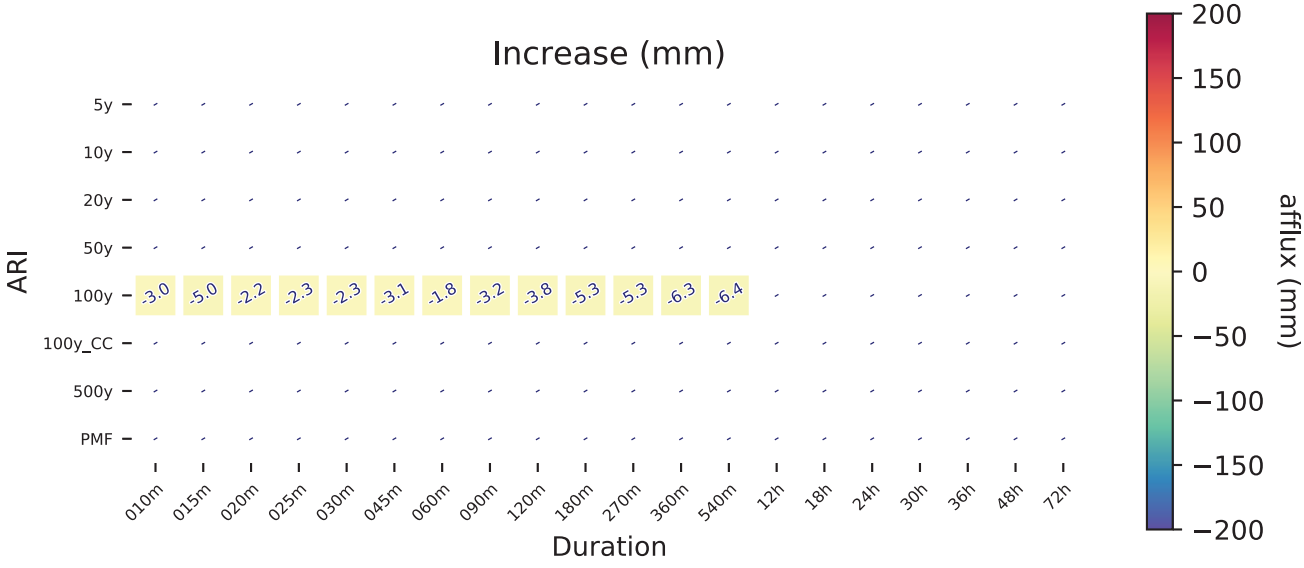

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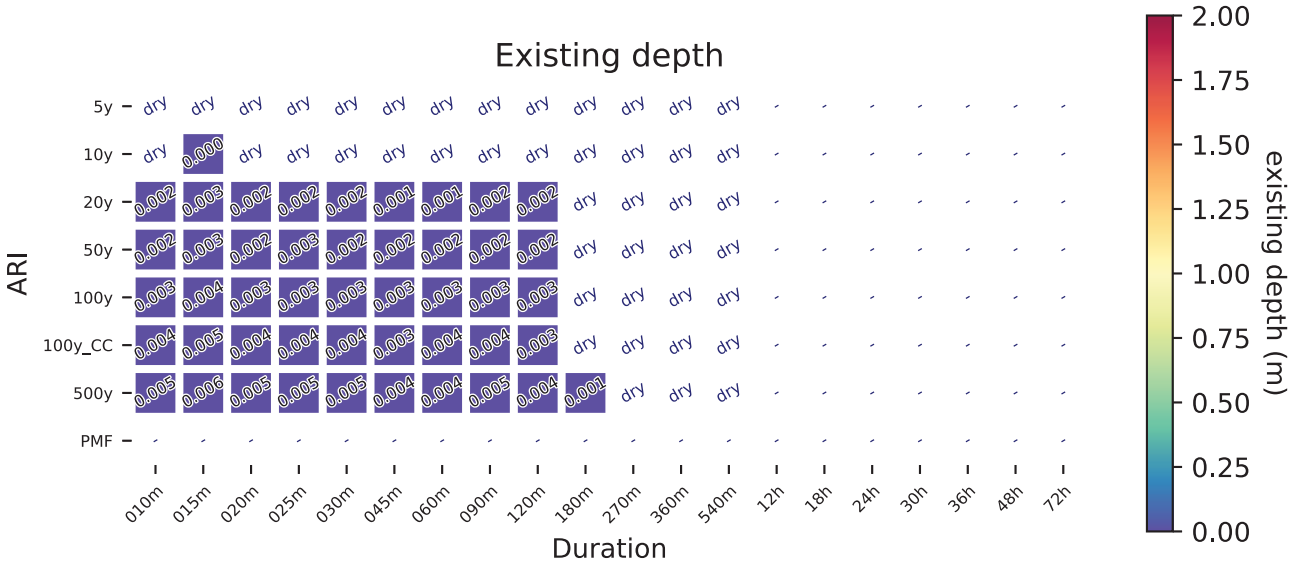

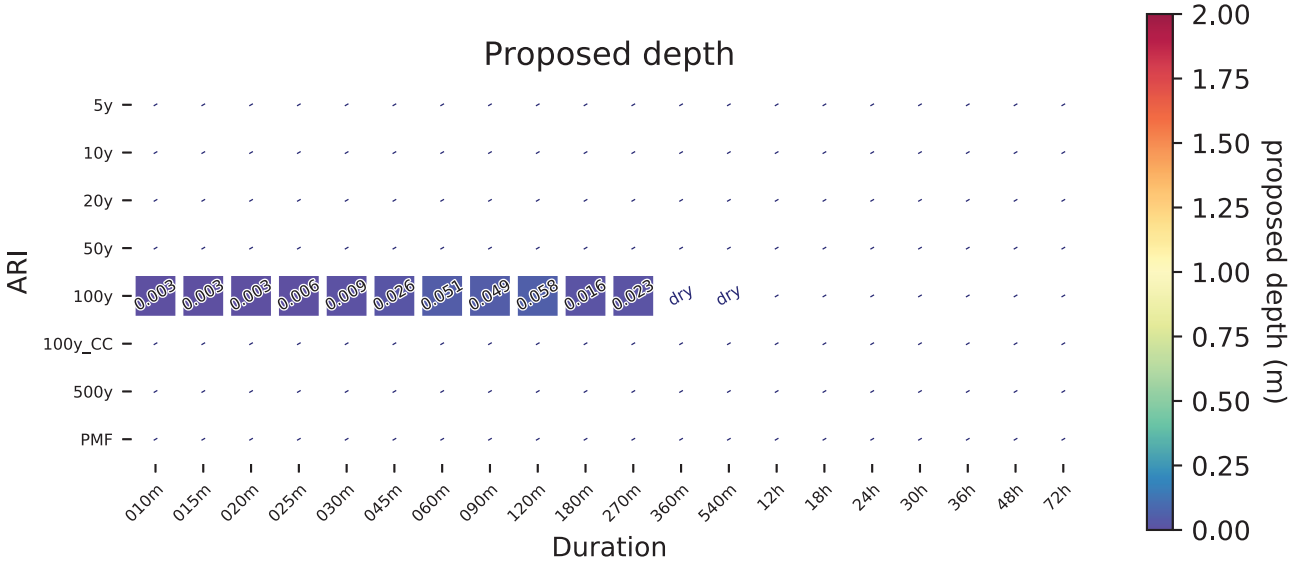

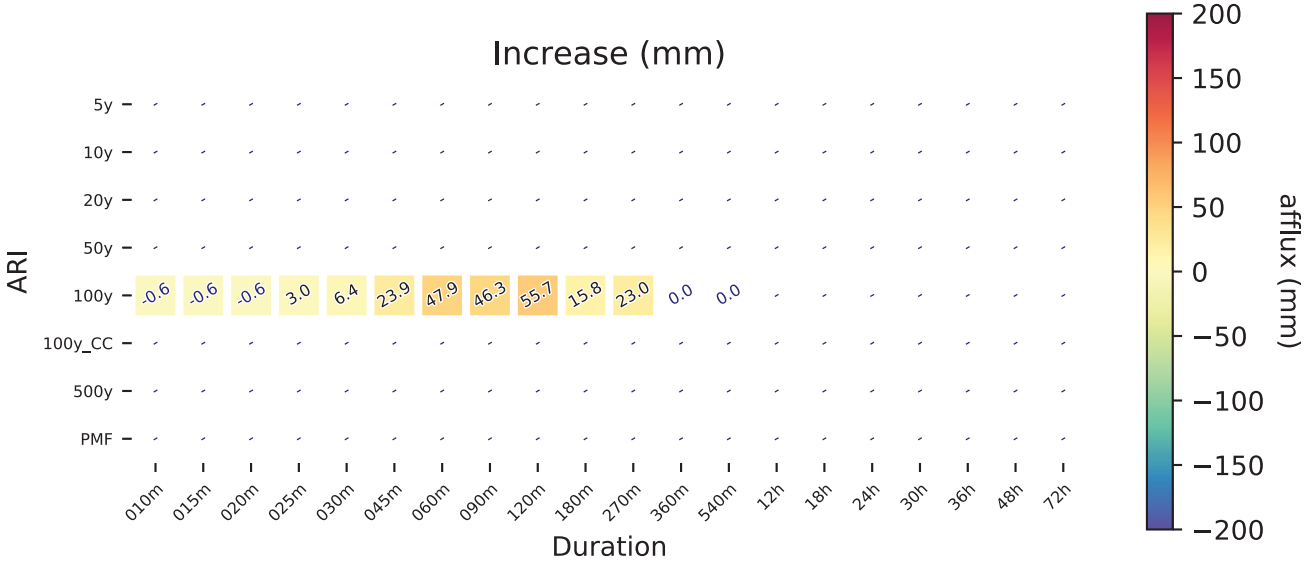

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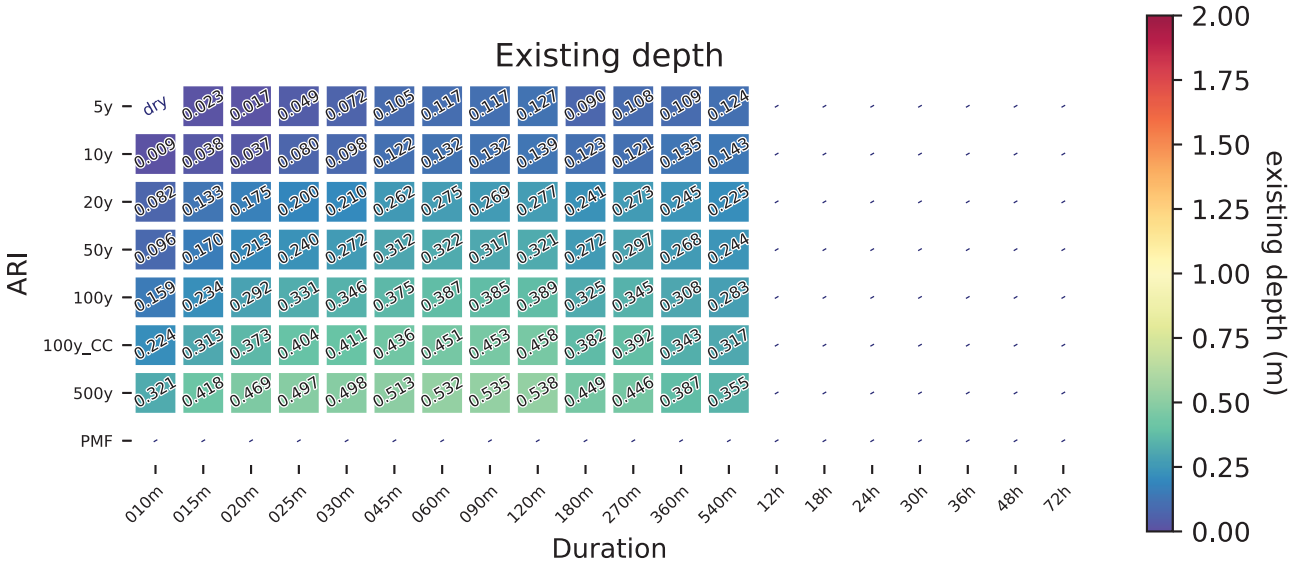

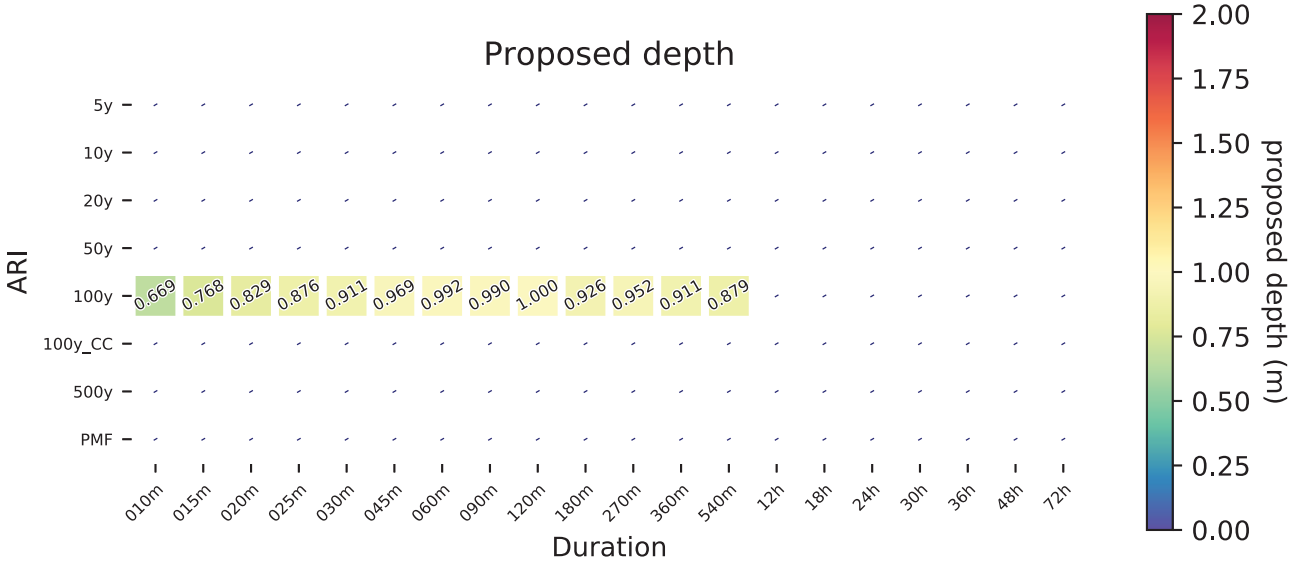

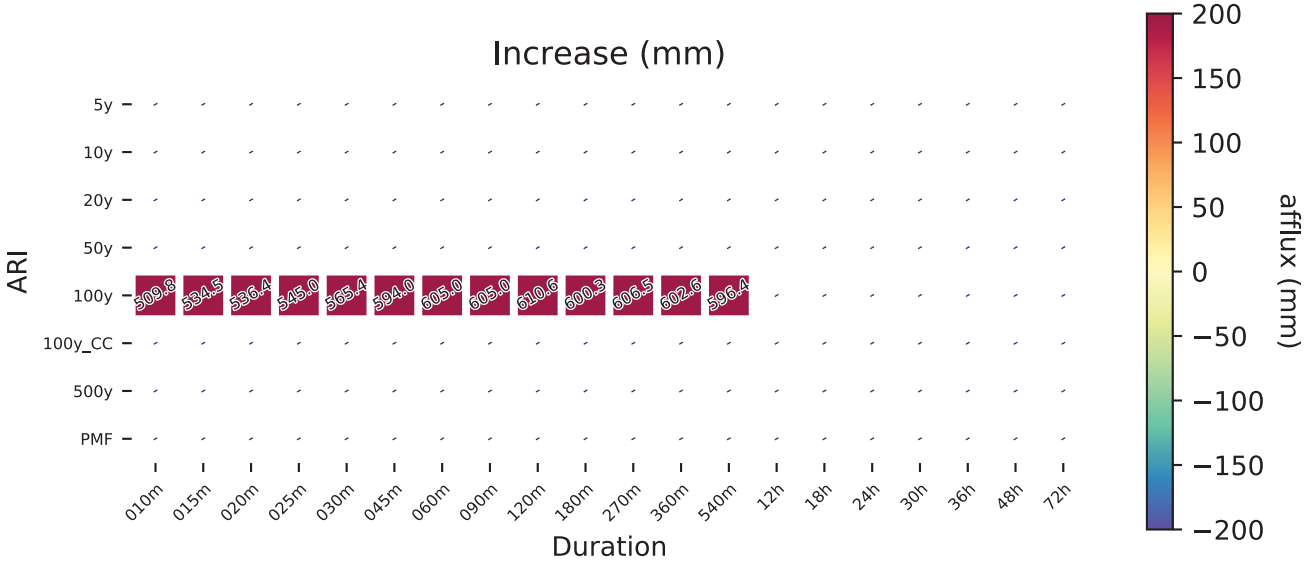

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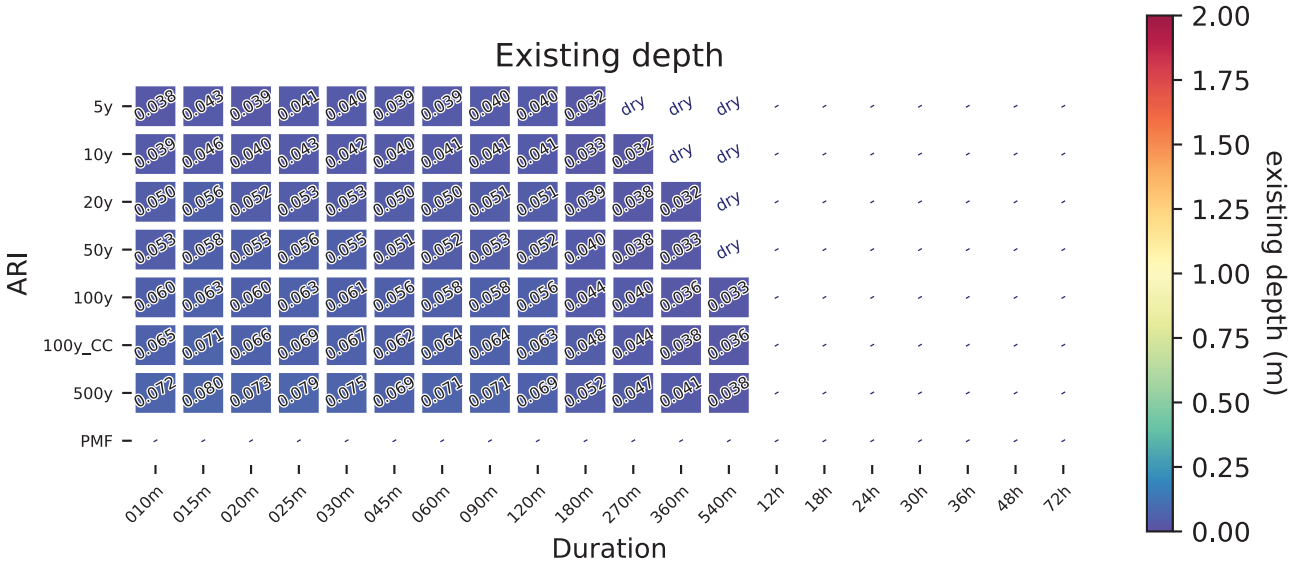
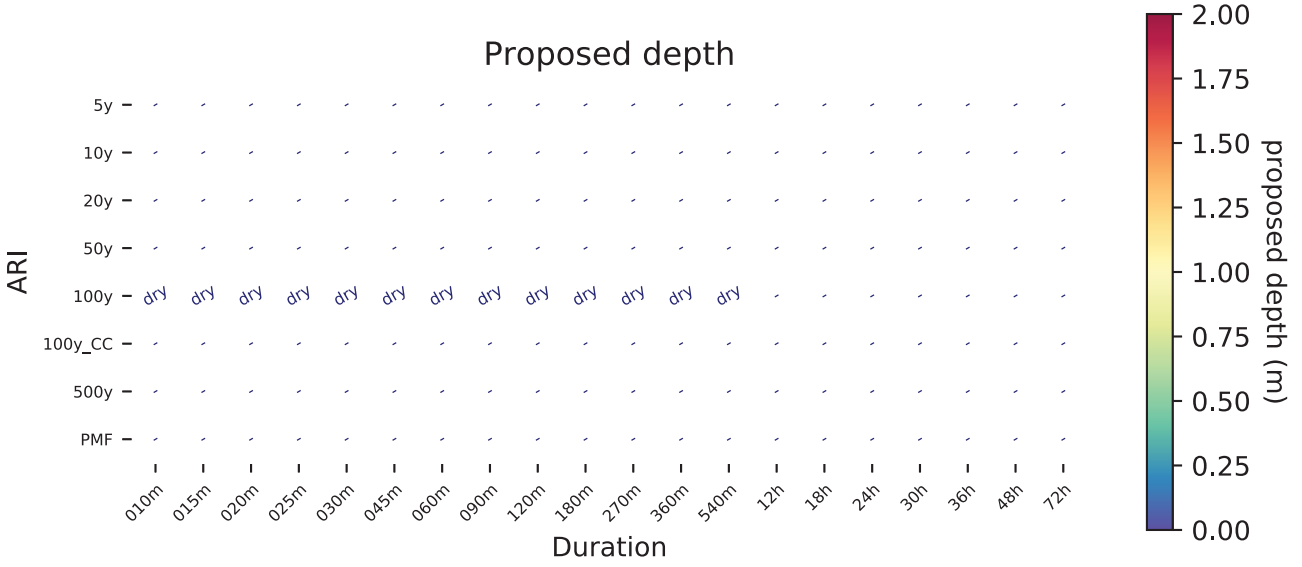
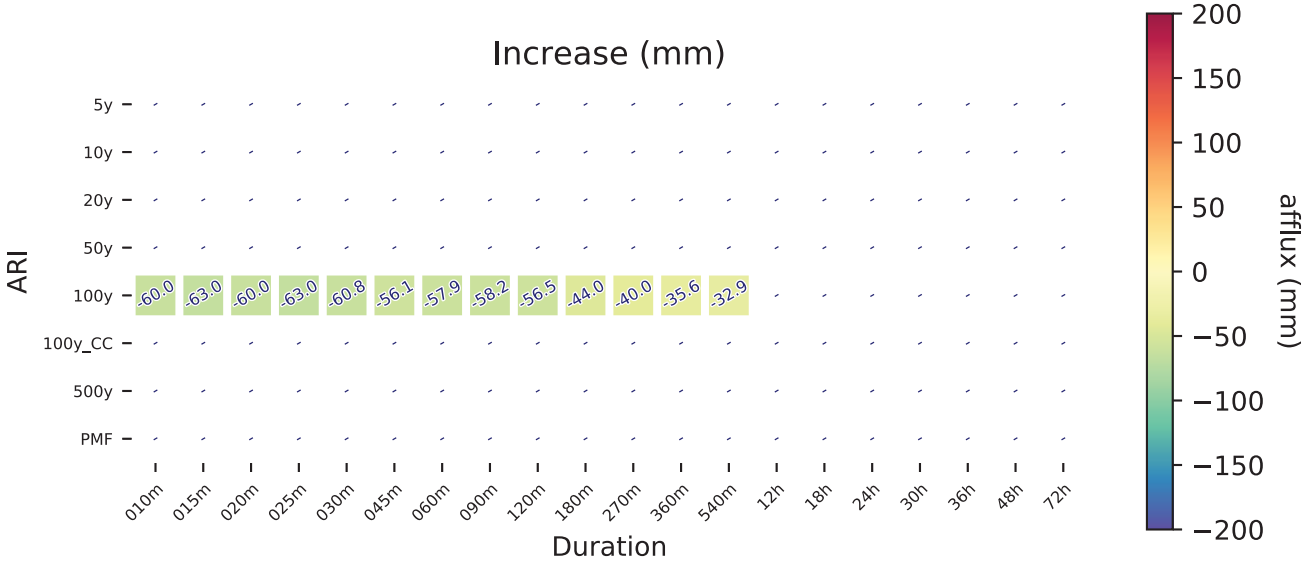
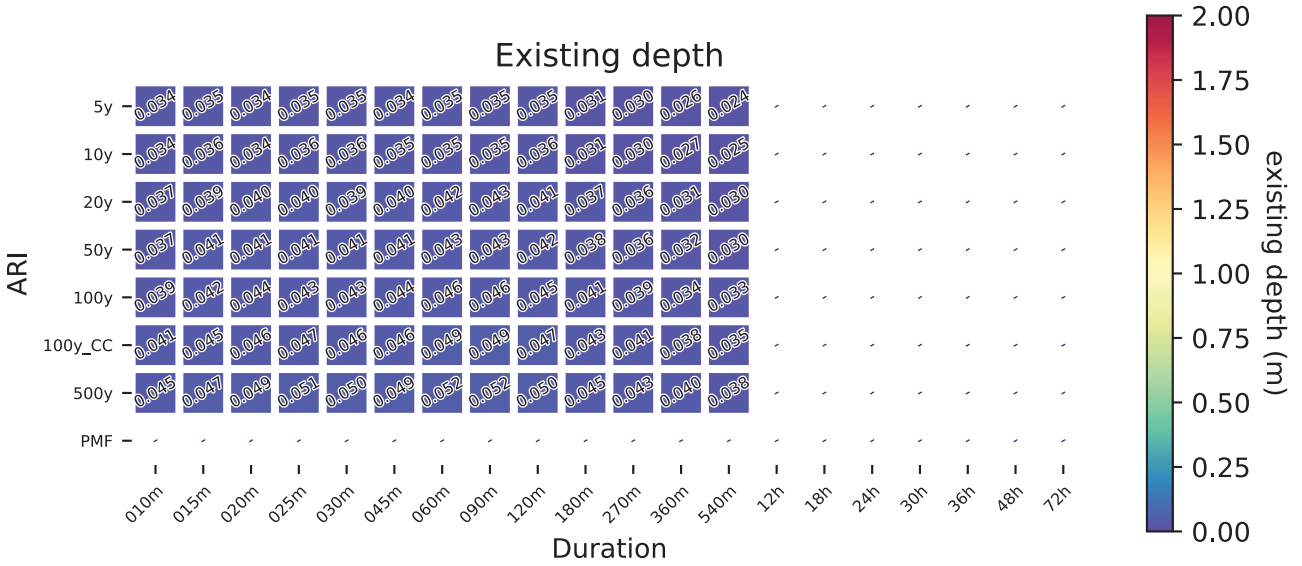
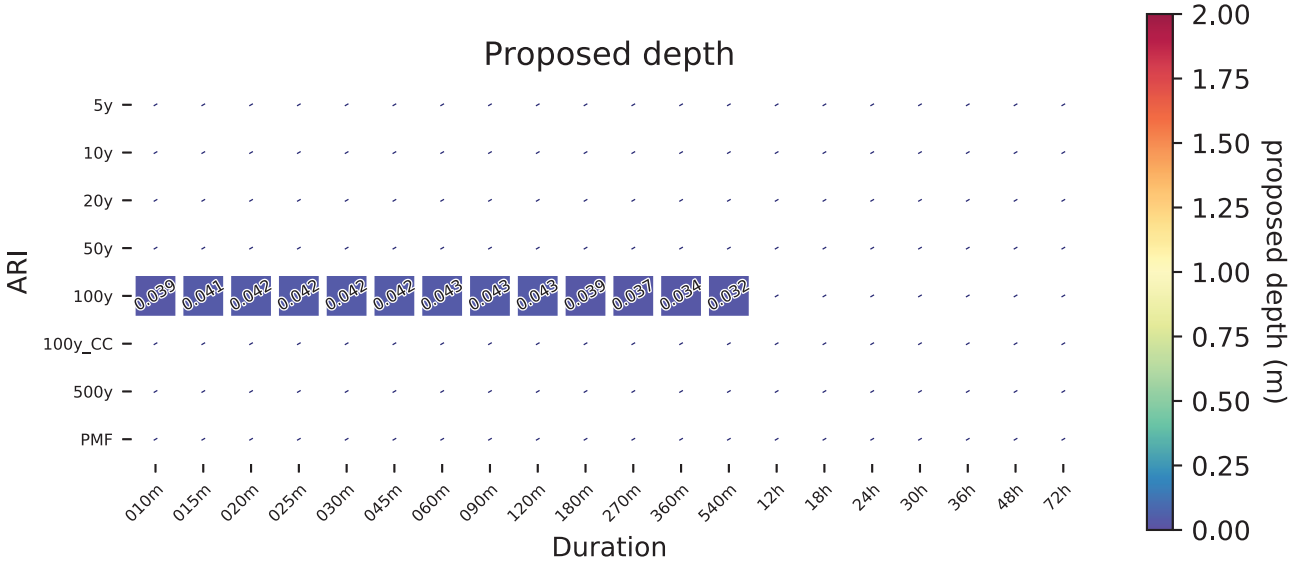


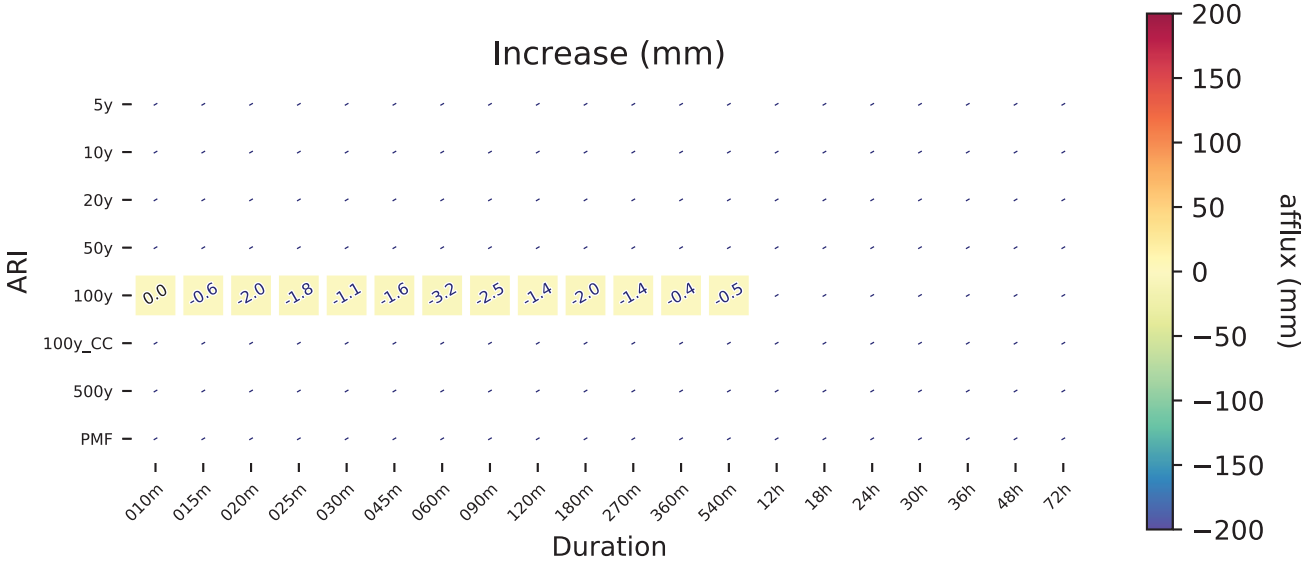




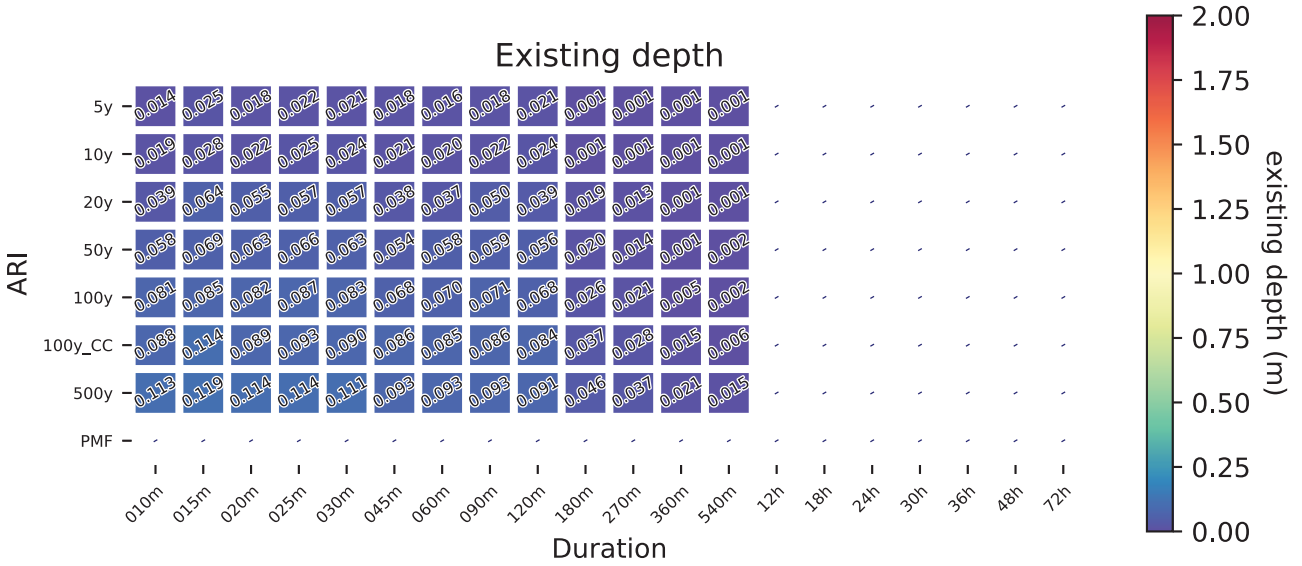
Banyule Creek Construction Alternate NthSth - Erskine_Rd

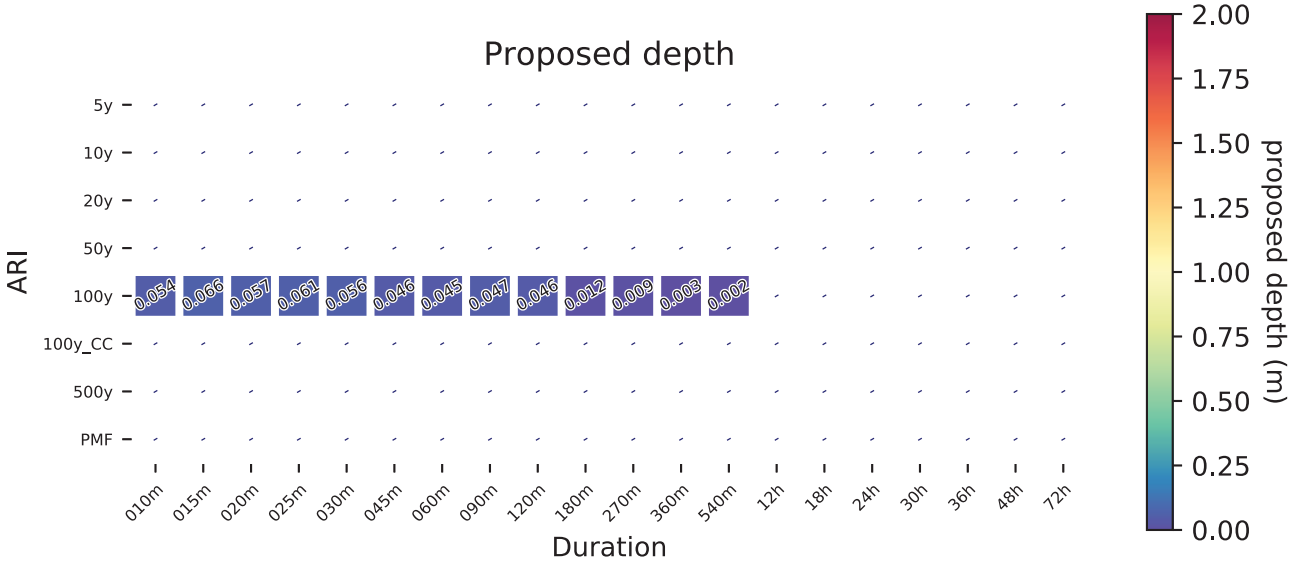


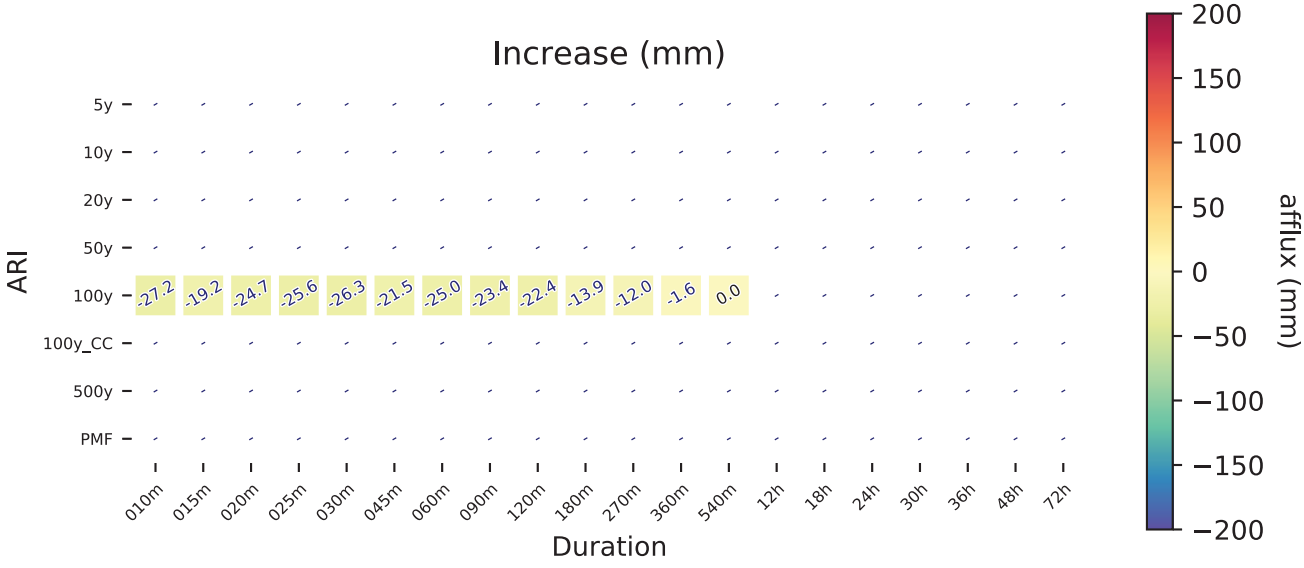




Banyule Creek Construction Alternate NthSth - Oban_Way







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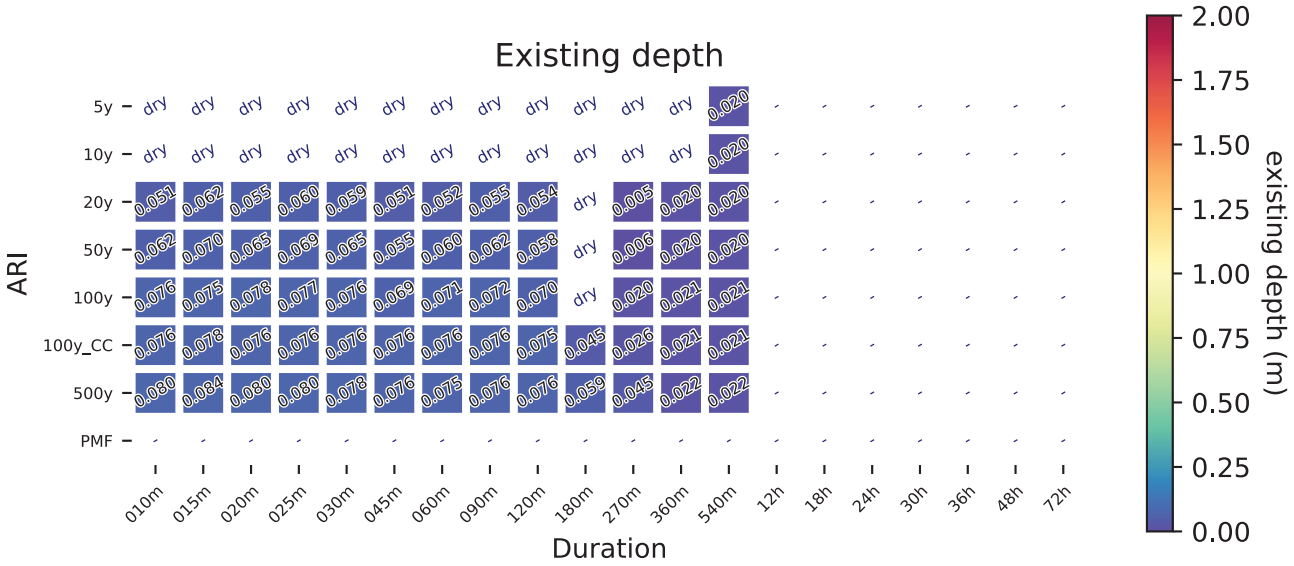
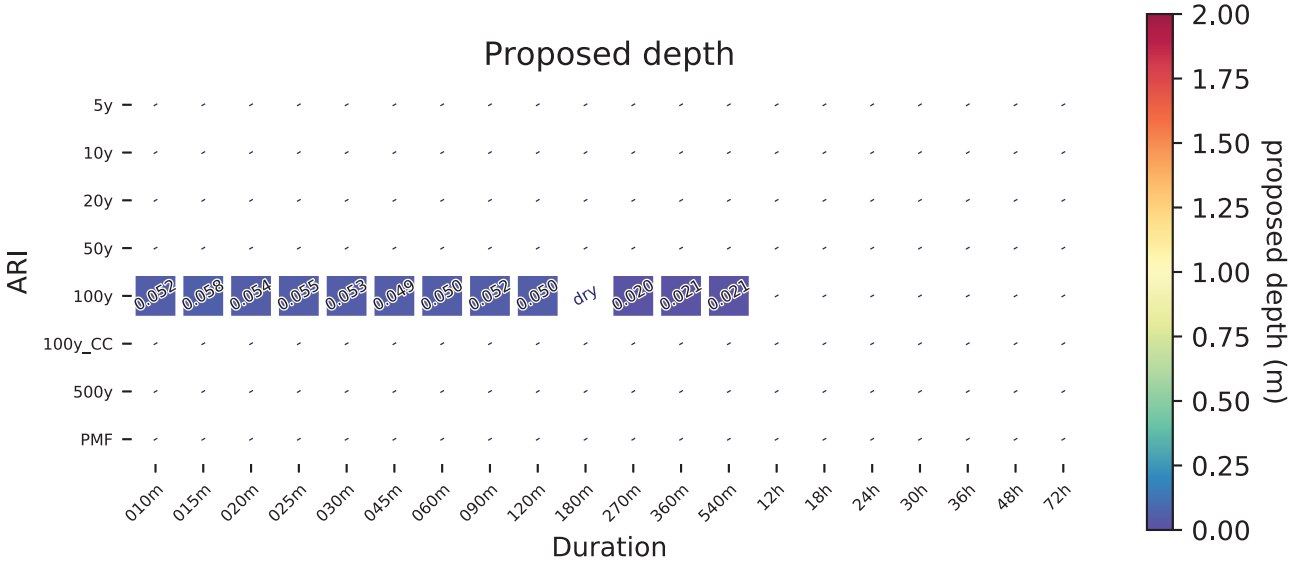
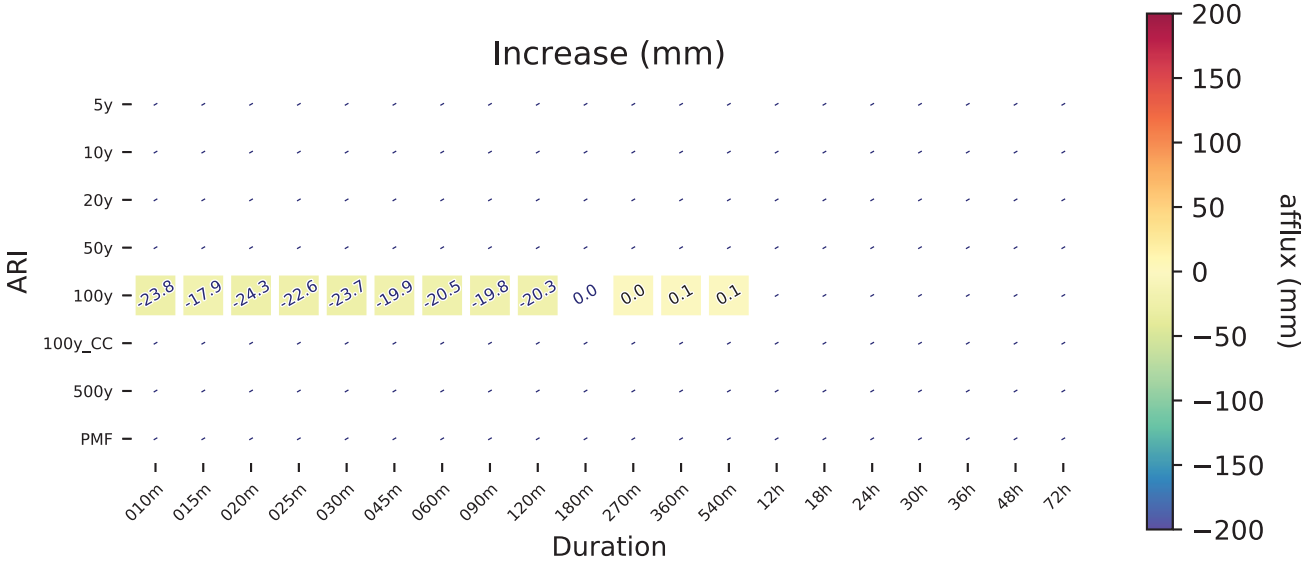
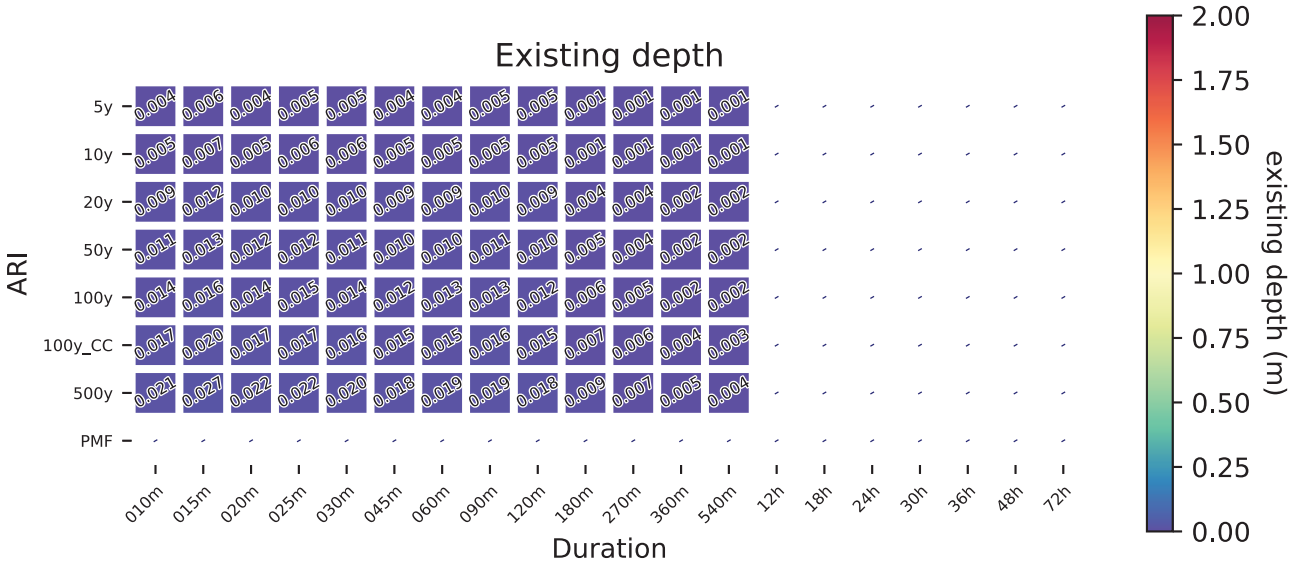
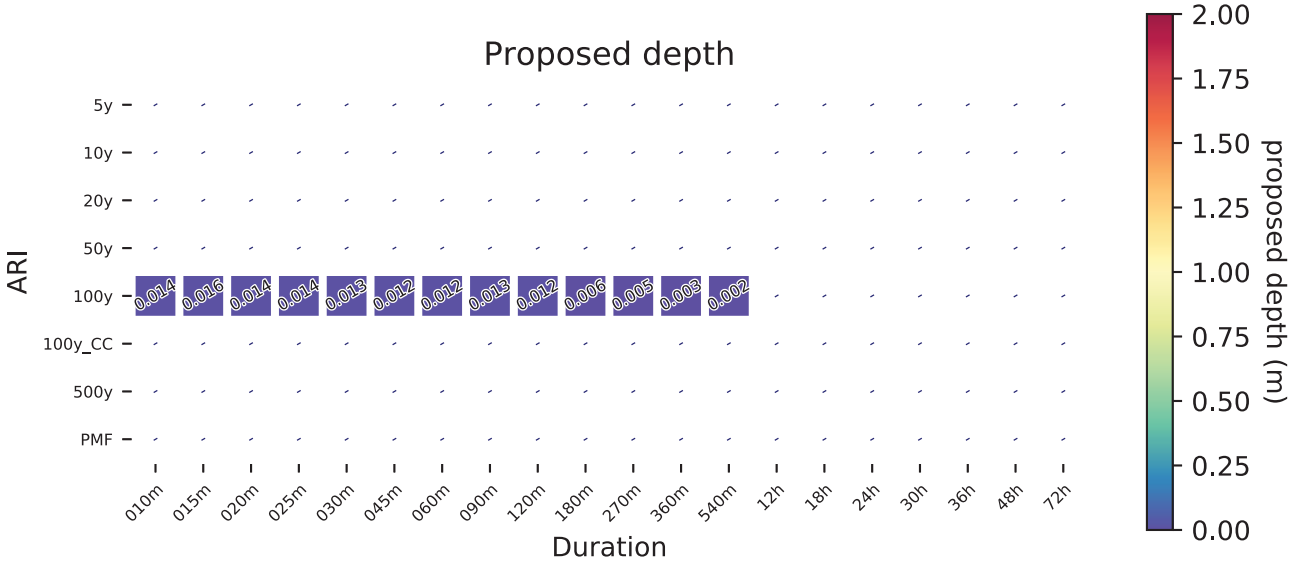


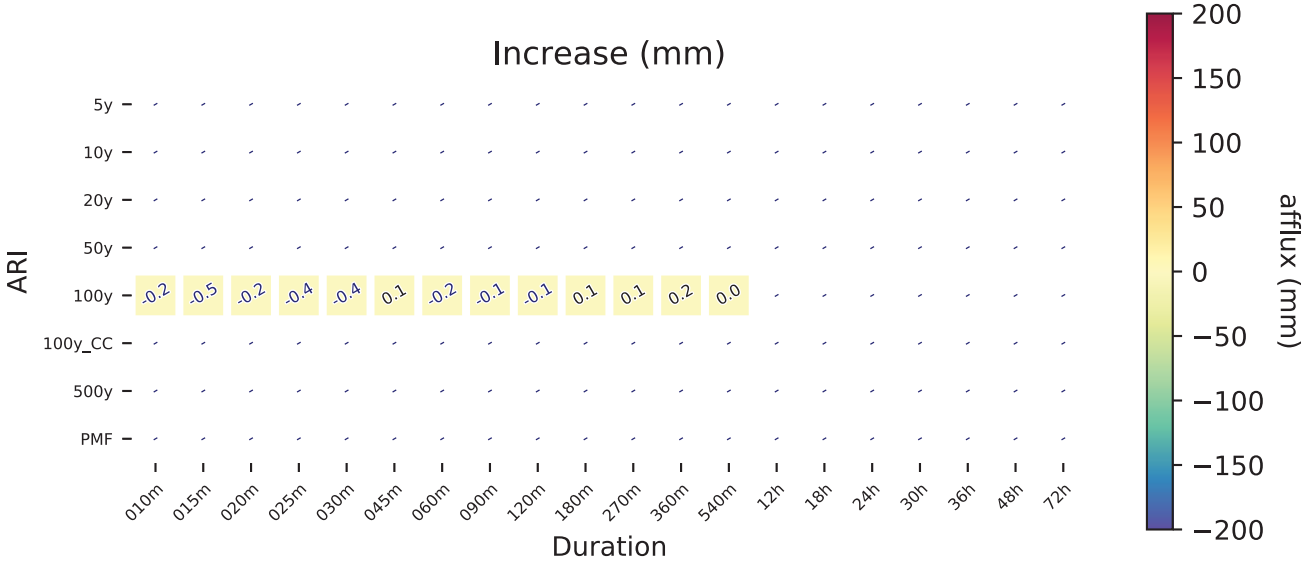




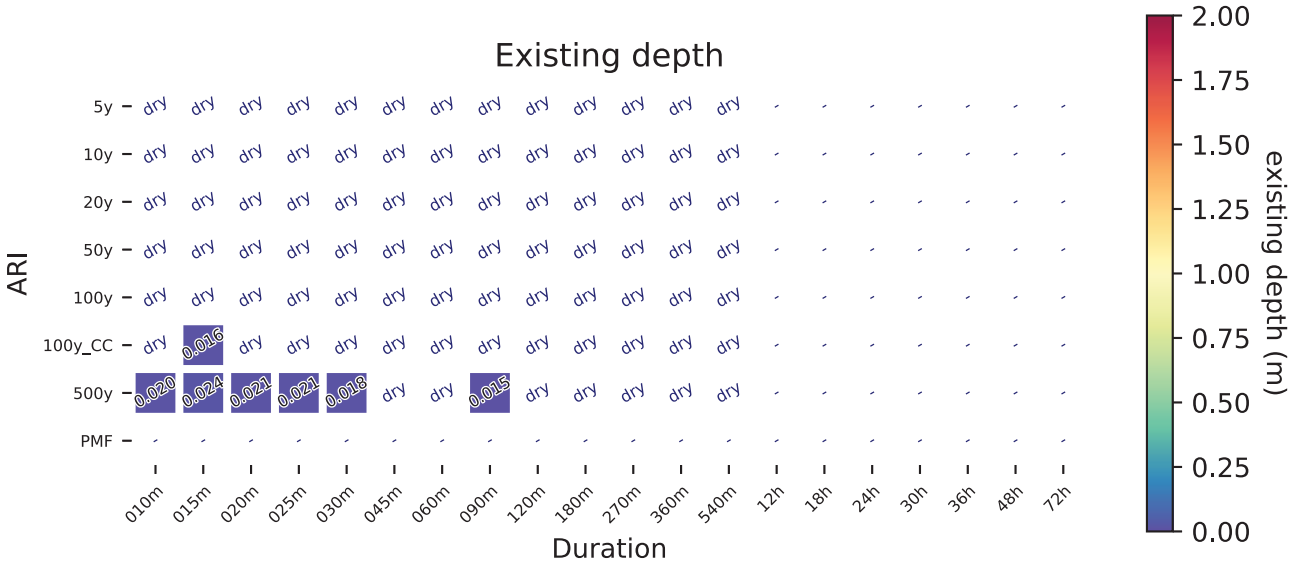
Banyule Creek Construction Alternate NthSth - Strathallan_Rd

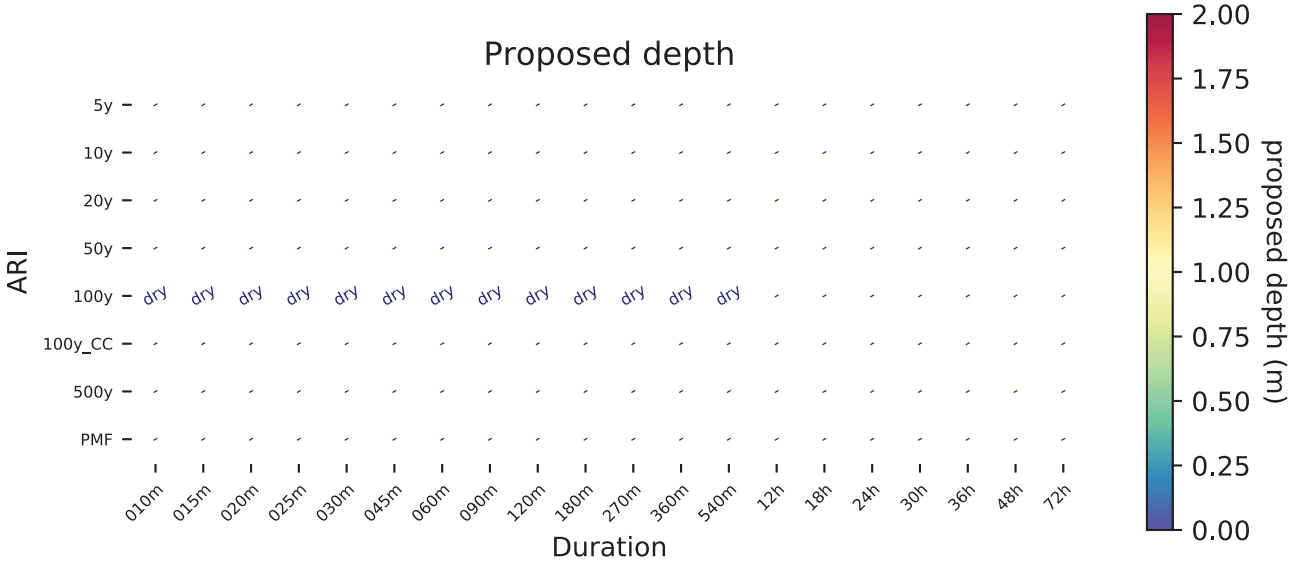


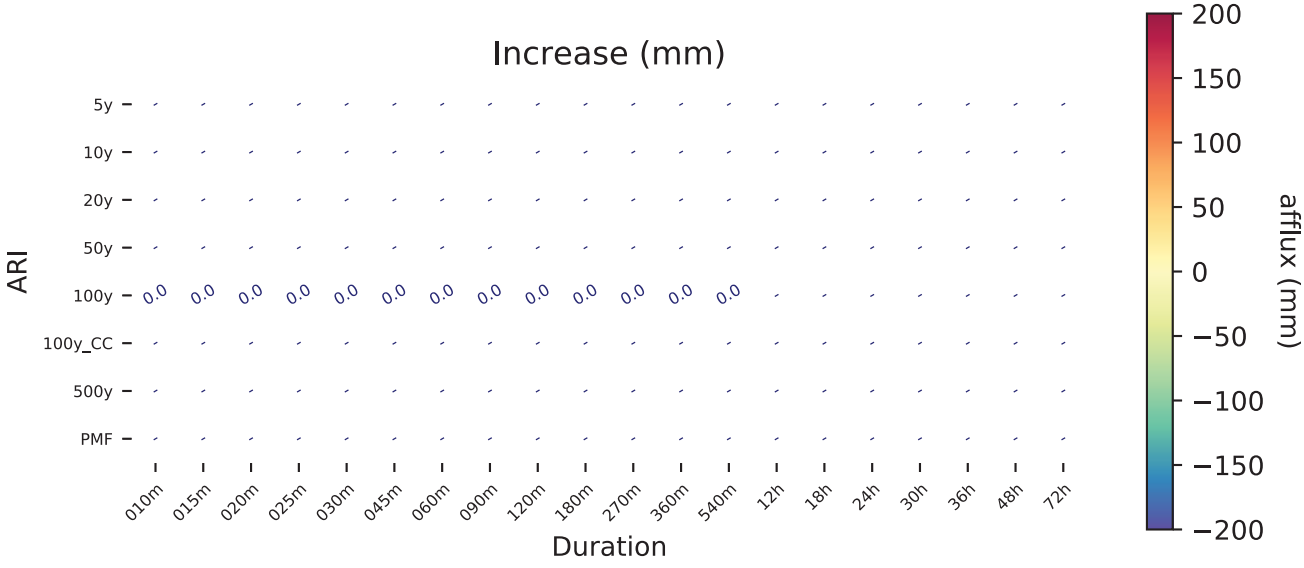




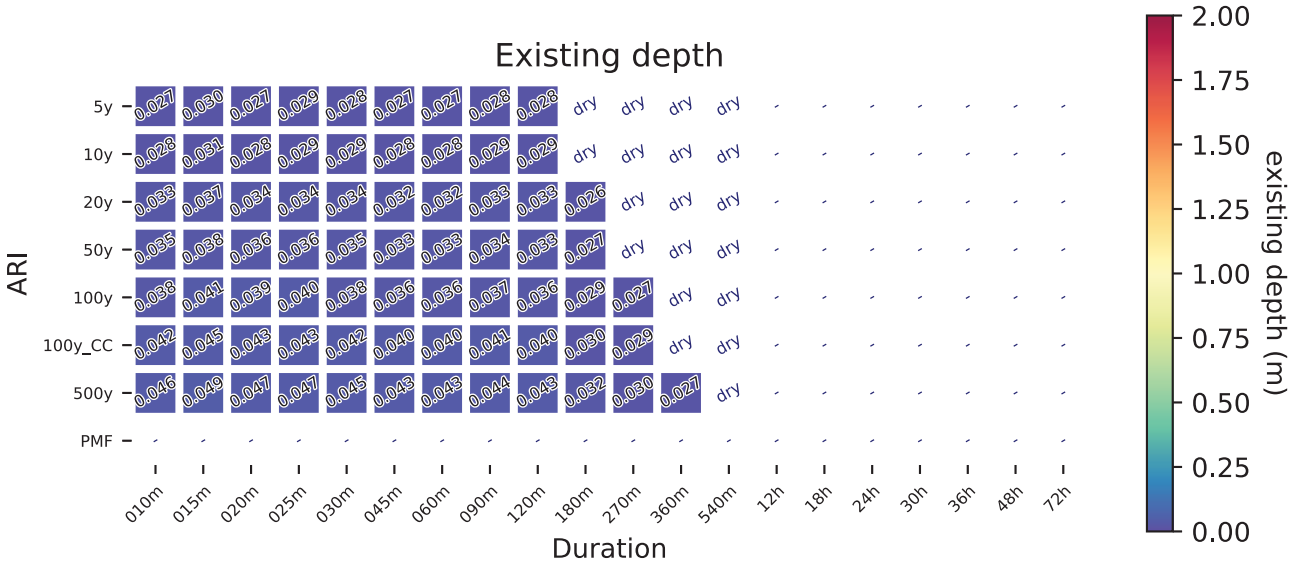
Banyule Creek Construction Alternate NthSth - Sydney_St

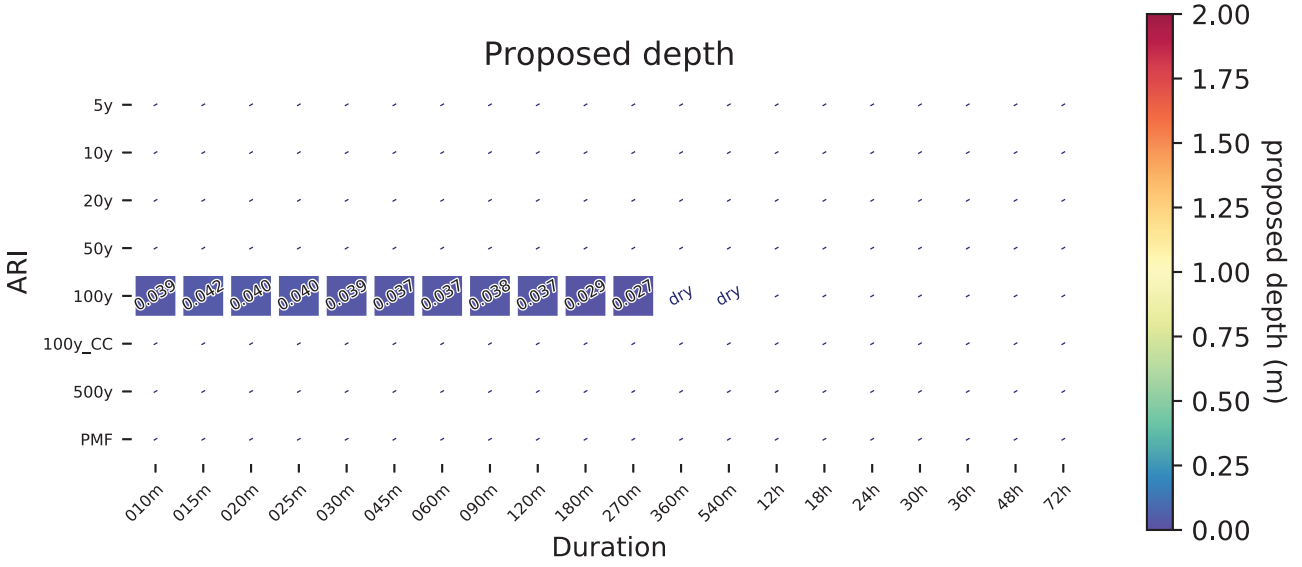


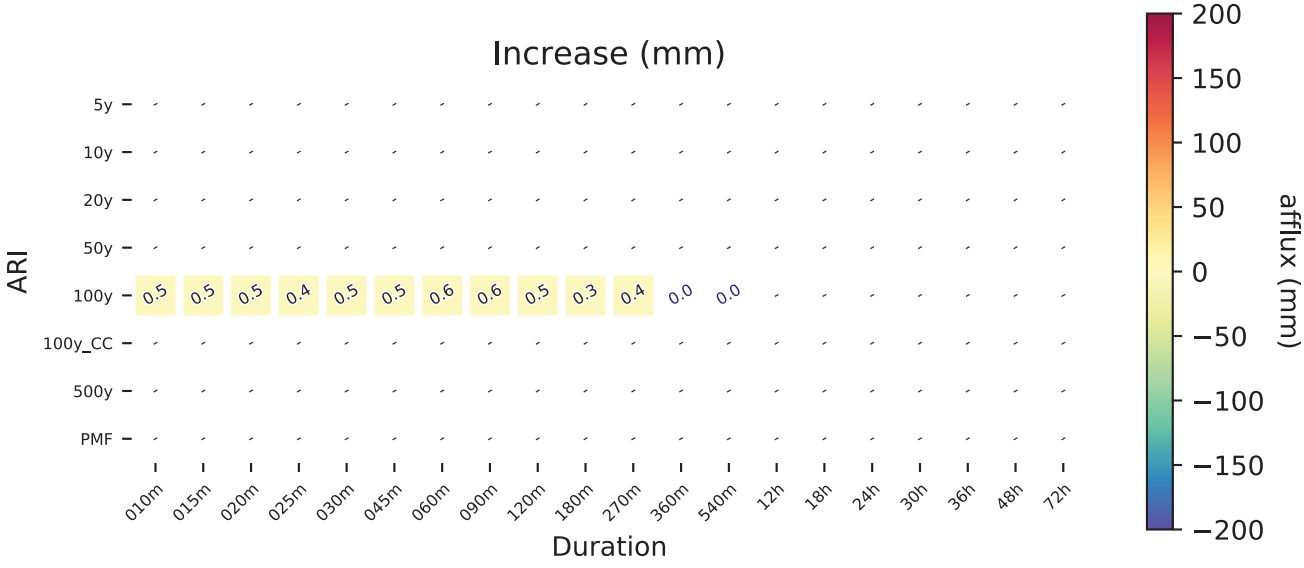




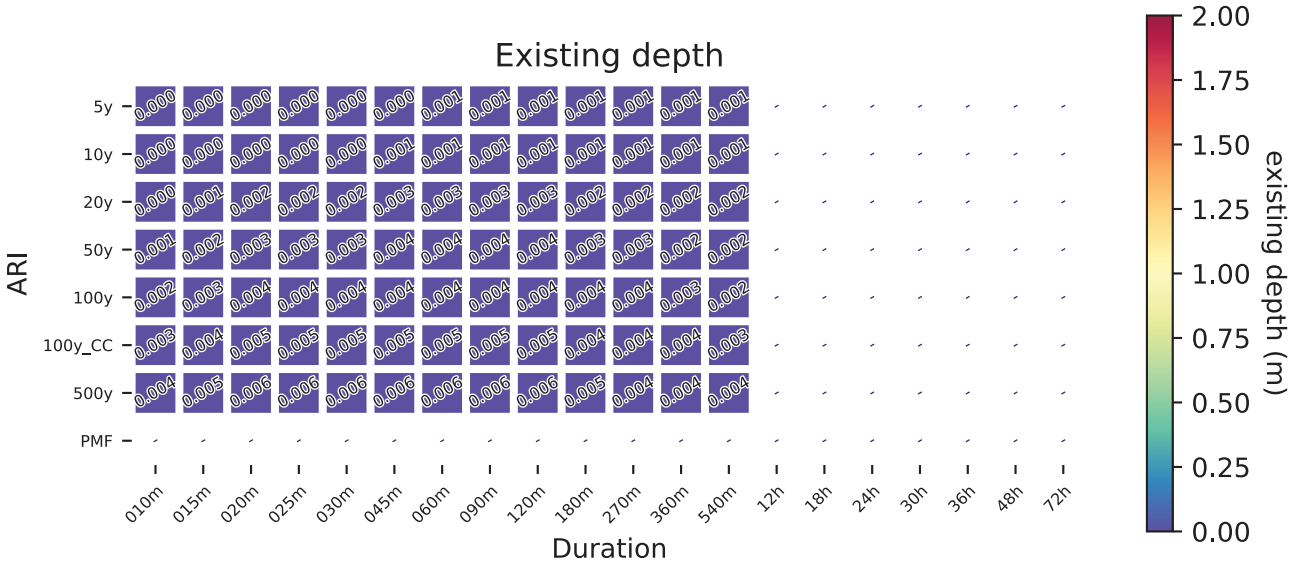
Banyule Creek Construction Alternate NthSth - Fairlie_Ave

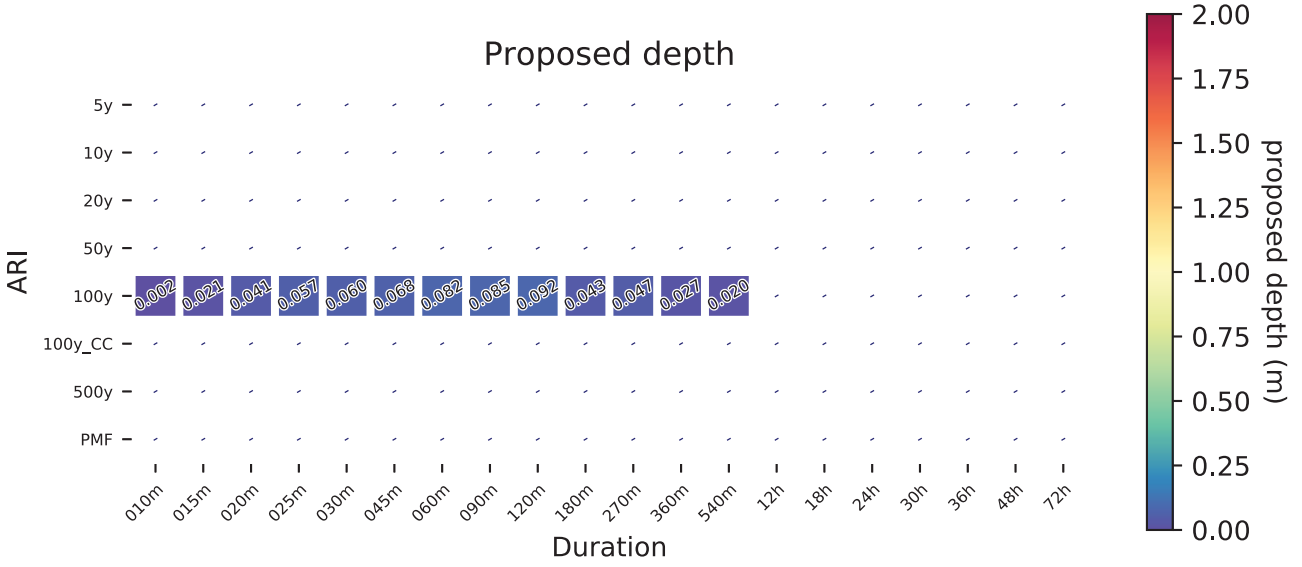


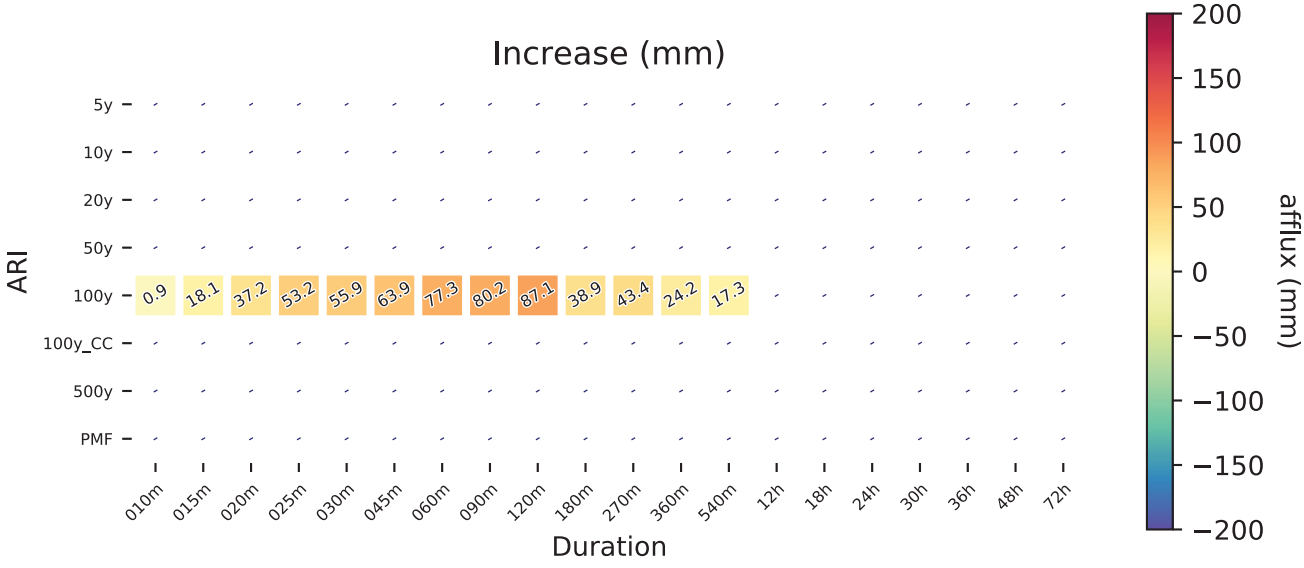




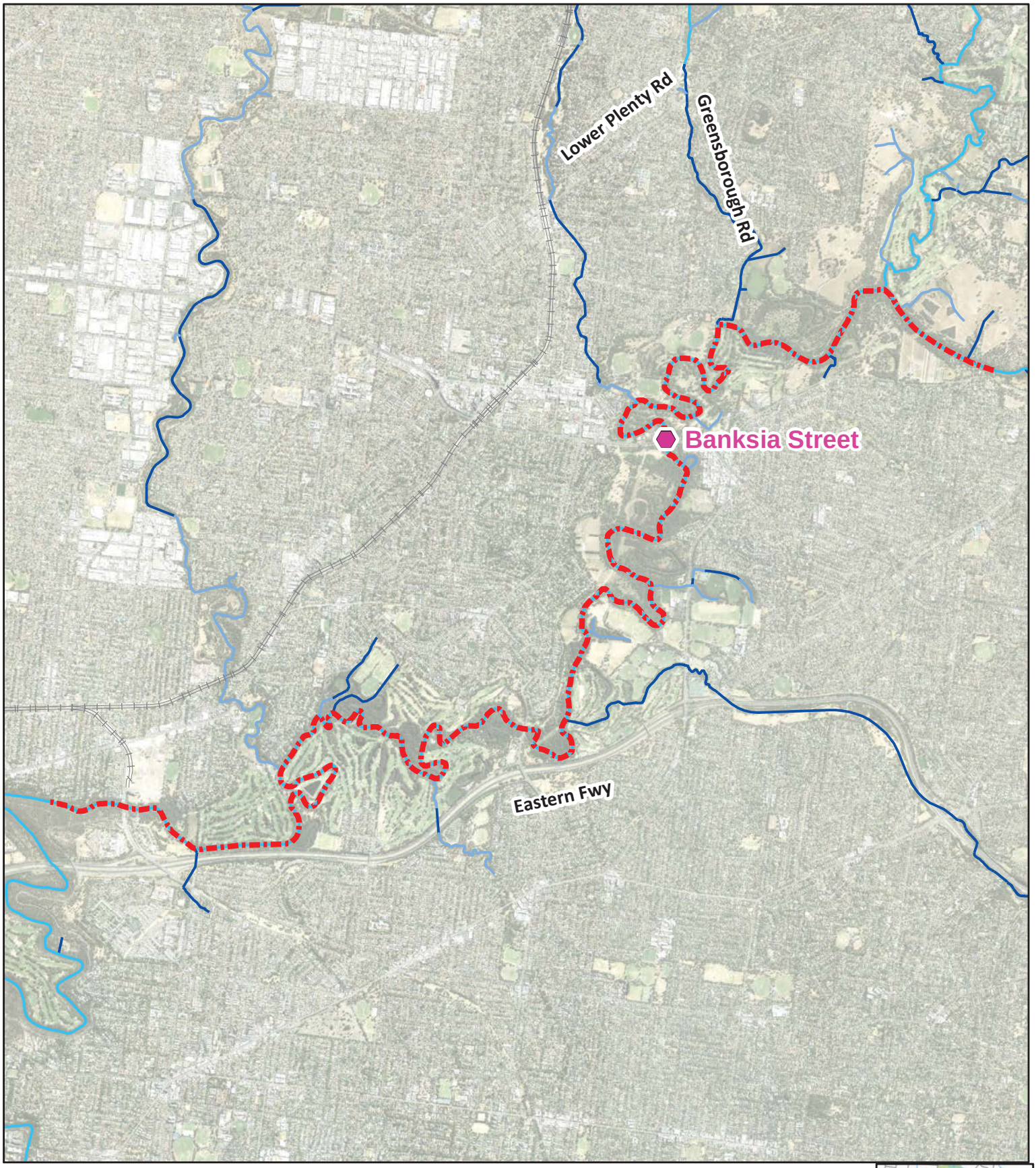
Banyule Creek Construction Alternate NthSth - Blamey_Rd







Appendix E – ARR 2016 sensitivity testing



LEGEND

- Banksia Street
- Yarra Long Section
- River
- Stream
- Channel
- Drain

Paper Size A4

0 280 560 1,120

Metres

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

N

NORTH EAST LINK PROJECT

North East Link
North East Link Project

Job Number 31-35006
Revision A
Date 23/10/2018

Comparison point and long section
Yarra River
Figure E-1

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Data source: Google Earth Pro Imagery, Vicmap, DELWP, 2018. Created by: rhasanzadehnafari

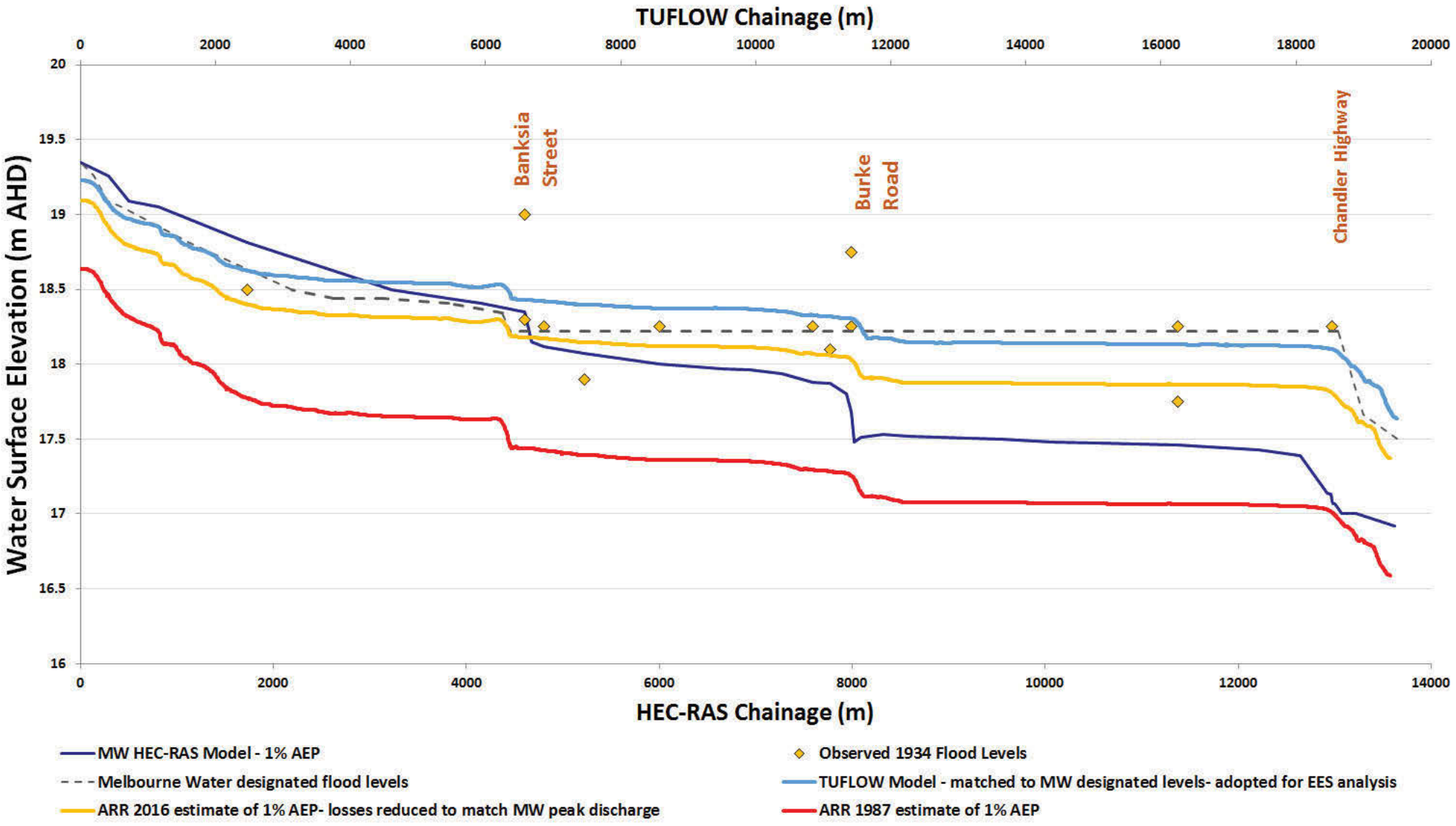

Figure E-2 Yarra River long sections and water surface elevation comparison

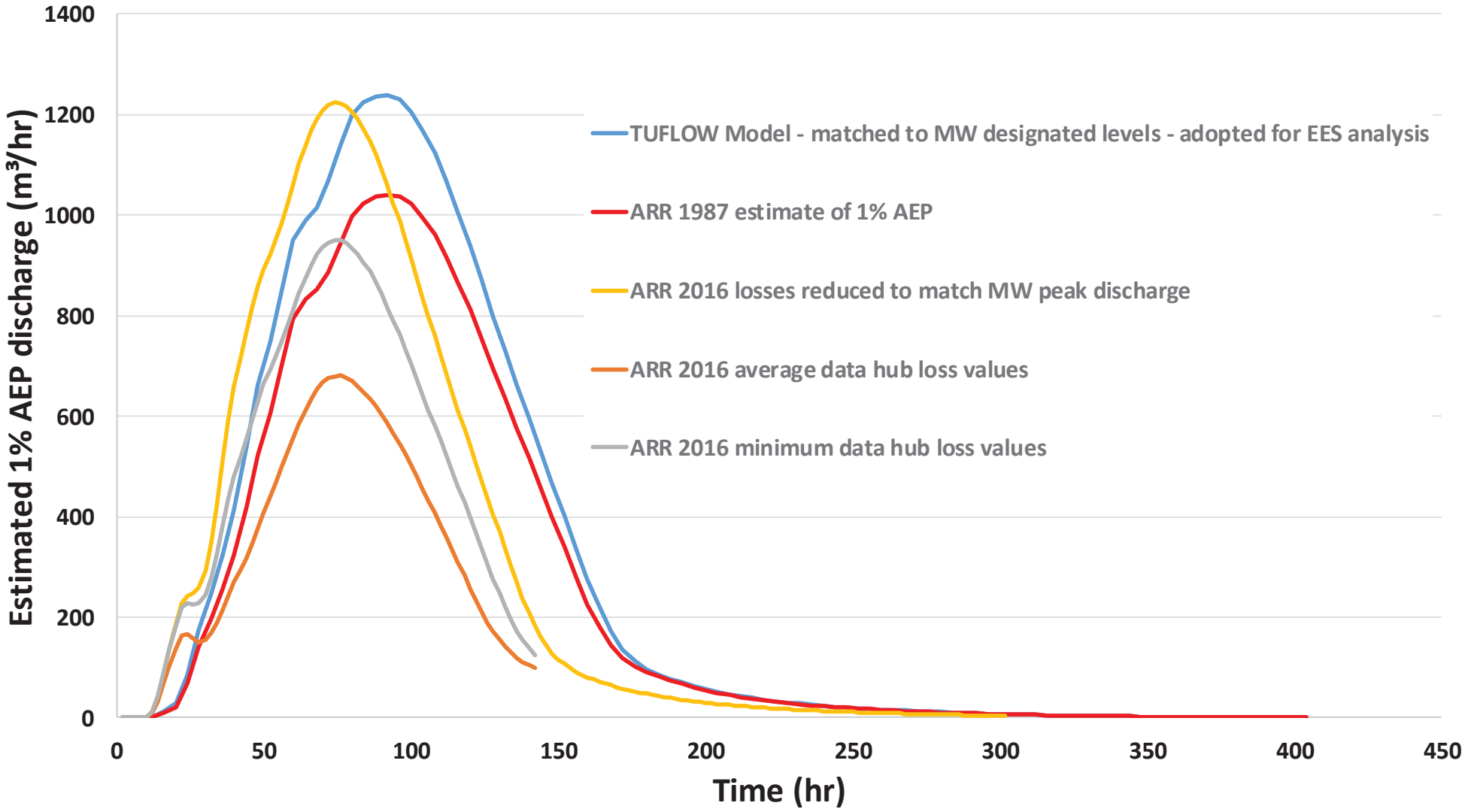

Figure E-3 Hydrograph comparison at Banksia street

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft Final	G Hay	K Aldous		M Roser		April 19
Final	G Hay	K Aldous		M Roser		September 19

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