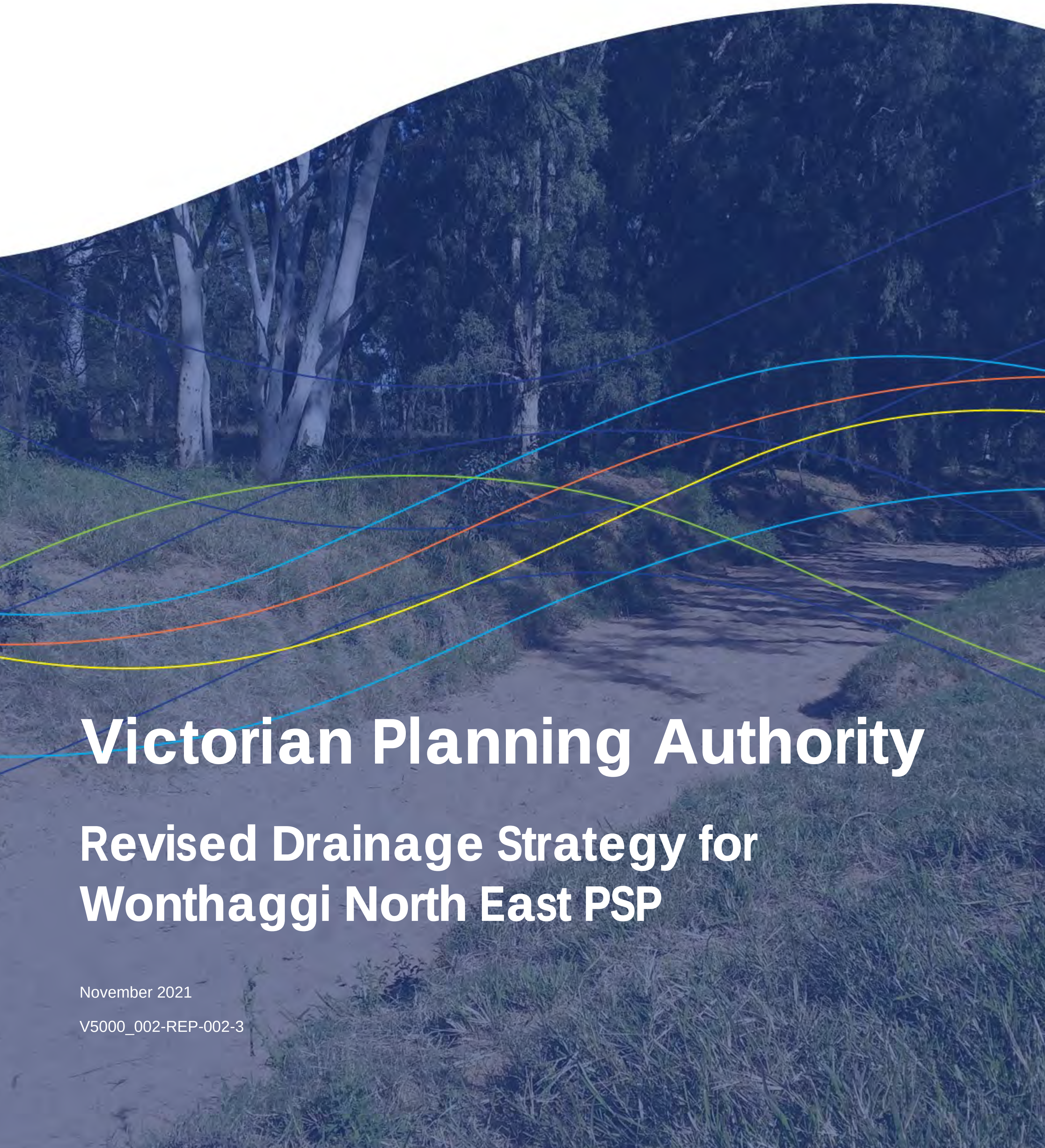

# Victorian Planning Authority

## Revised Drainage Strategy for Wonthaggi North East PSP

November 2021

V5000_002-REP-002-3

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| Rev | Date | Description | Author | Reviewer | Project Mgr. | Approver |
|---|---|---|---|---|---|---|
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**DISCLAIMER**

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# 1 INTRODUCTION

A drainage strategy for the Wonthaggi North East Precinct Structure Plan (Wonthaggi NE PSP) growth area was developed in 2016. The 2016 strategy utilised methodology from Australian Rainfall and Runoff 1987, the current standard when the project was initiated, and considered the design of drainage assets to a concept level.

Following the standing advisory committee hearing in early 2021 and an associated conclave of drainage experts, a recommendation was made to update the drainage strategy to utilise Australian Rainfall and Runoff 2019 (ARR 2019) methodologies. The VPA has also undertaken separate functional designs of all assets to reduce the uncertainties associated with the concept designs. A gas transmission main and two significant water mains were also identified in early 2021. The updated design work also responds to the constraints of these existing services, including providing suitable setback distances from the gas transmission main to proposed residential housing in the PSP. Further work has also been undertaken by Engeny to develop a design for an outfall channel from Wetlands 1 and 2 to the receiving tributary of the Powlett River.

Additional information was sought to inform the functional design work, which included localised survey and service proving.

The same general drainage design layout as in the 2016 strategy has been adopted for the updated strategy, with adjustments in assets sizes as necessary to satisfy the updated design standards being applied and to respond to the constraints of the existing services.

## 1.1 STRATEGY DESIGN ASSUMPTIONS

The following key assumptions have been made to inform the drainage strategy:

- Development density of 11 houses per hectare in new residential areas in the PSP.
- Fraction impervious of the new residential areas of the PSP of 0.65 (in line with the housing density above).
- Fraction impervious in new industrial and commercial areas of the PSP of 0.9.
- Existing conditions flood mapping reveals that a large area of land within the PSP adjacent to Korumburra Wonthaggi Road is subject to flooding in the 1 % annual exceedance probability (AEP) event. It has been assumed that this flood prone area can be used for stormwater treatment.
- The development area will need to meet best practice treatment of stormwater prior to discharging into the Powlett River.
- All drains discharging into an existing or proposed waterway will first receive primary sediment removal treatment (mainly through sedimentation basins).
- The Infrastructure Design Manual (IDM) has been adopted by Bass Coast Shire Council. The standards within the IDM for drainage have generally been adopted.
- The IDM does not contain detailed design information relating to the design of water sensitive urban design (WSUD) assets or waterways. While it does reference other design guidelines, it is Engeny’s view that Melbourne Water has the most up to date guidelines in this field and that it would be appropriate to apply the Melbourne Water guidelines to the design of WSUD assets and waterways within Bass Coast Shire Council. As such the designs of the wetlands and waterways have been undertaken generally in accordance with the following Melbourne Water design guidelines:
  - Waterway Corridors: Guidelines for greenfield development areas within the Port Phillip and Westernport Region (Melbourne Water, 2013)
  - Wetland Design Manual (Melbourne Water, December 2020)
  - Constructed Waterway Design Manual (Melbourne Water, December 2019)
  - MUSIC Guidelines (Melbourne Water, 2018)

## 1.2 DESIGN AND MODELLING APPROACH TO DRAINAGE STRATEGY ELEMENTS

Engeny has utilised a range of appropriate modelling software to size the difference elements of the stormwater management strategy. Below is a summary of the different modelling software and calculation methods utilised to size the different drainage infrastructure proposed within the PSP area.

RORB has been used to undertake all hydrological calculations to determine the flows for the following uses:

- Pipes
  - Pipes from external catchments passing through residential areas of the PSP have generally been sized using the 20 % AEP flows from the external catchment only.
  - Pipes from external catchment passing through industrial areas of the PSP have been sized to convey the 10 % AEP flows from the external catchments only.
- Waterways
  - Sized to convey 1 % AEP flows with 300 mm freeboard within the waterway.
  - Pilot channels size to convey approximately the 1 exceedance per year (EY) flows.
  - Waterways have been designed to be excavated below the existing surface levels (in cut) where possible, i.e. no additional fill in adjacent developable areas required to achieve 300 mm freeboard within the waterway.
- Retarding basins
  - Flows from the RORB model have been used as inputs into the TUFLOW model to size the retarding basins.

HECRAS has been used for the hydraulic modelling of the two waterways and associated culverts.

TUFLOW has been used to size the WL1, WL2, WL3 and WL4 retarding basins and associated outfall pipes and culverts.

The pipes from external catchments have been sized using spreadsheet calculations utilising the Manning's Equation, to provide the required capacity based on the RORB flows, as listed above.

Sedimentation basins have been sized using the Fair and Geyer equation.

All water sensitive urban design assets have been modelled in MUSIC. The sedimentation basin sizes from the Fair and Geyer Calculations have been used as inputs for the MUSIC modelling.

## 1.3 FUNCTIONAL DESIGNS

Functional designs for the key infrastructure in the PSP are being completed by engineering consultants Alluvium. The functional design drawings have been informed by the work completed as part of this drainage strategy. Many of the details of the proposed assets discussed in this report will be contained on the functional design drawings.

# 2 HYDROLOGY

## 2.1 OVERVIEW

The drainage strategy for the Wonthaggi NE PSP has been updated from the work previously presented to the standing advisory committee in the 2016 drainage strategy. Some of the key updates to the hydrology include:

- Modelling updated to ARR2019 methodologies and input data rather than the ARR1987 methodology that was used at the time of the 2016 strategy.
- Improved representation of catchments to the east/north-east of the PSP area to help accurately quantify downstream tailwater conditions and impacts of development.
- Combining the original 3 separate RORB models of the local catchments utilised as part of the 2016 strategy into a single RORB model.
- Producing a rural conditions RORB model for validation purposes.
- Producing an existing conditions RORB model and a developed conditions RORB model.

The key objective of the hydrological modelling in this study was to provide flows to size the required PSP infrastructure. The flows from this modelling has been used to size:

- Retarding basins and culverts in TUFLOW.
- Waterways and associated culverts in HECRAS.
- Pipes using Manning's Equation calculations.
- Sedimentation basins using the Fair and Geyer equation.

MiRORB (Mapinfo RORB) was utilised to develop the RORB models. MiRORB was developed by SKM with the support of Melbourne Water to:

- Draw RORB catchments using MapInfo, allowing automatic generation of physical catchment data such as reach lengths and impervious fractions.
- Collate this data and create a catchment file, which can be used directly by RORB.

The following sections describe the key tasks and assumptions in the development of the RORB hydrological model. **Appendix A** provides technical details relating to the hydrology of the catchment and the development of the RORB model.

## 2.2 RORB MODEL DEVELOPMENT

### 2.2.1 Existing Conditions Sub Catchment Delineation

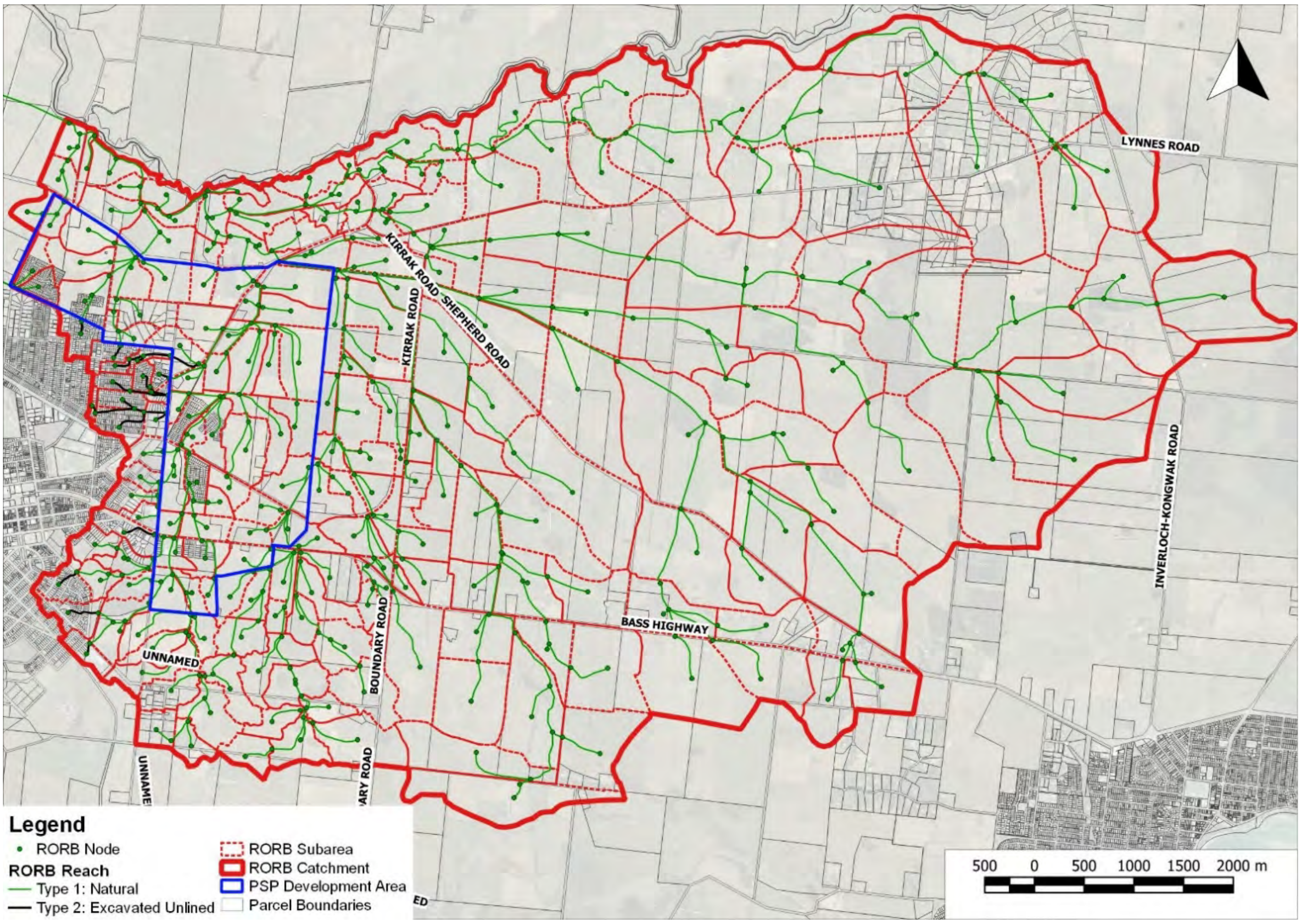
The sub-catchments for the RORB hydrology model were delineated considering the following information:

- LiDAR from Wonthaggi dataset.
- LiDAR from Powlett River dataset.
- 10 m contour data from VicMap.
- 10 m Digital elevation model data from ELVIS.
- Pipe GIS drainage data showing pipe alignments.
- VicMap hydrology watercourse mapping layer.
- Land use identified in the Victorian Planning Scheme.
- Property boundaries.
- Aerial photography.

For some catchments outside of the PSP area, the only available elevation data was the 10 metre contours data. Given the flat nature of some of the upstream catchment areas the 10 metre contour data does not provide a detailed representation of topography and there is a degree of uncertainty in the exact sub-catchment boundaries and exact watercourse locations. The "hydro watercourse" layer obtained from the Department of Environment Land Water and Planning (DELWP) and aerial imagery has been used to inform waterway locations in some of the external catchment areas. While there may be some uncertainty in sub-catchment boundaries the overall catchment boundary is considered to be accurate as the ground topography becomes steeper at the upstream ends of the catchment, so the 10 metre contours provide better definition of the top of the catchment. The entire catchment also drains to the same location so any minor discrepancies of sub-catchment boundaries or reach alignments should not have a major impact on the overall volumes of flow reaching the catchment outfall.

Figure 2-1 shows the RORB model delineation for the Wonthaggi NE PSP study area.

**Figure 2-1: Existing Conditions RORB Model Delineation**




## 2.3 VALIDATION APPROACH

ARR 2019 sets out a number of ways to calibrate or validate a model. A report titled “Benchmarking ARR 2019 for Victoria” (HARC et al 2020) was recently released and provides guidance specifically for hydrologic modelling in Victorian catchments. The report proposes the following hierarchy of validation methods be adopted with the higher ranked methods being preferable.

1. Reconciliation with at-site flood frequency quantiles: initial and continuing losses are varied within their expected range to achieve a reasonable level of agreement between estimates derived from rainfall-based modelling and flood frequency analysis.
2. Reconciliation using within-catchment transposed flood quantiles: streamflow observations are commonly available at gauging stations upstream or downstream of the site of interest, and flood quantiles derived from these sites can be transposed to the site of interest and used for reconciliation as described in approach 1.
3. Event-based calibration: continuing losses obtained from calibration of historical events provide some indication of typical design values, noting that past historical events are biased towards wet catchment conditions; initial losses from historical

events are highly variable and information from a small sample of events are of low utility (and therefore some form of reconciliation with other sources of information is recommended).

4. Reconciliation using nearby catchment transposed flood quantiles: regional flood quantiles derived using RFFE and other procedures (Section 3, Book 3, ARR2019) can be used for reconciliation as described in approach 1.
5. Transposition of losses: initial and continuing loss estimates validated on nearby catchments which are considered to be hydrologically similar.
6. Regional losses (ARR Data Hub): unmodified initial and continuing loss estimates obtained from the Data Hub losses can be adopted in data poor areas, noting that in loss region 3 these should be combined with 75th percentile pre-burst values.

### 2.3.1 Catchment Delineation and Validation

There are no gauges within the development area local catchment to be able to complete a flood frequency analysis. There is also no calibration data available from past flood events that could be used to calibrate the RORB.

The approach that was adopted for the validation was to utilise the RFFE tool to calculate flows for a rural or natural catchment (approach 4 in the list above). The RFFE tool uses the catchment area and catchment centroid and outlet location as an input, to produce the resultant mean peak flows as well as the lower and upper confidence limit flows and is based on nearby gauged catchments. When estimating flows, this tool assumes that the catchment is rural or natural in nature and that there are no significant hydraulic controls impacting on the ability of water to flow through the catchment. These hydraulic constraints could be things like dams, retarding basins, or road or rail embankments across floodplains which interfere with the natural flow of water.

Given that some development has occurred within the catchment, a RORB model was created which assumed no development and also removed any significant hydraulic controls on flows, such as Korumburra Wonthaggi Road. All reaches were assumed to be natural type and all subareas set to a fraction impervious (FI) of 0. The model was then run with a range of hydrological loss and routing parameters to get the best match to RFFE flow estimations at the outlet of the RORB model for the 1 % and 50 % AEP events. The flows were also compared to the DRNE flood regression analysis, which provides a secondary check on the magnitude of flows.

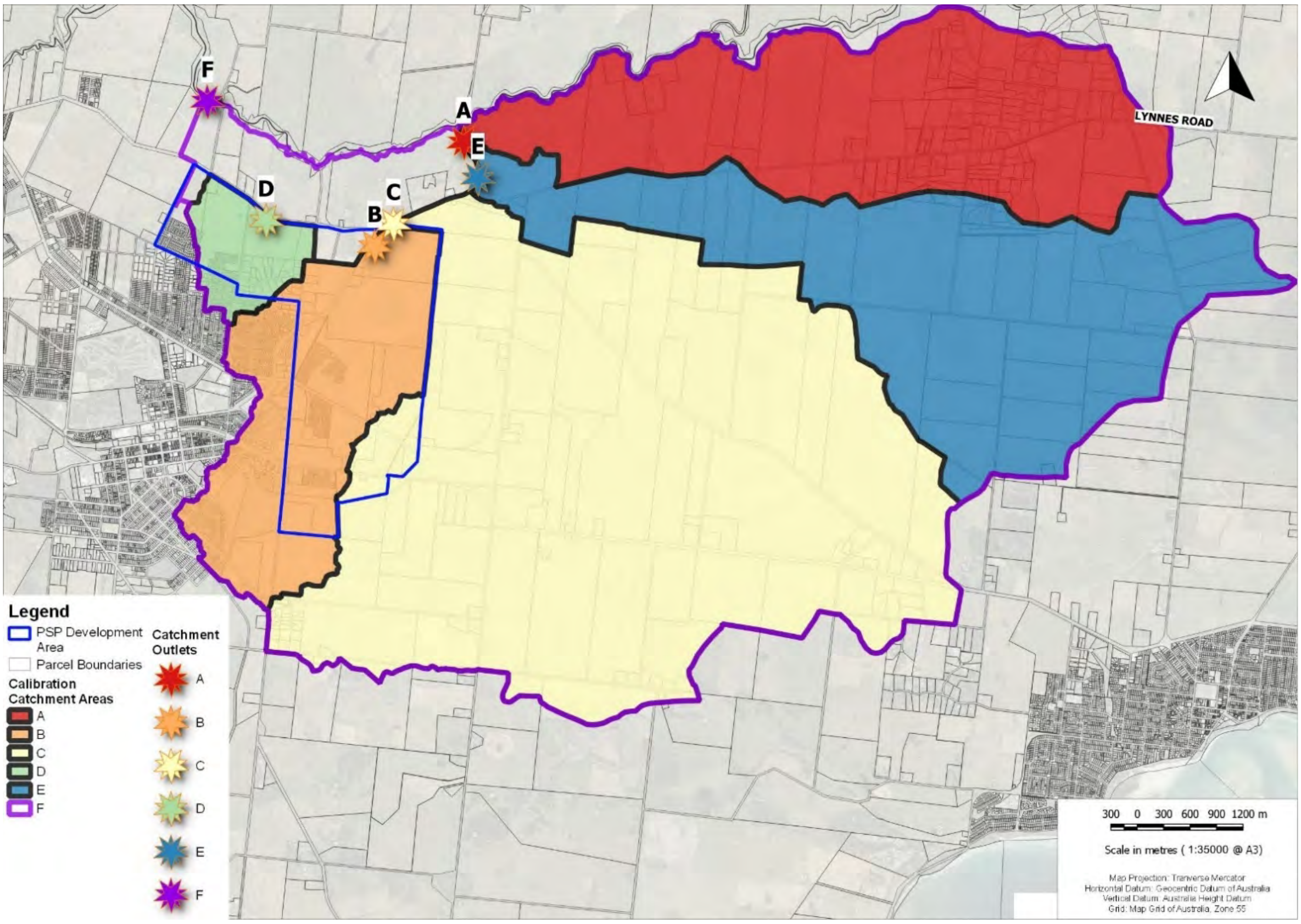
The flood modelling (TUFLOW) which has been undertaken to determine the size of the retarding basins and quantify any downstream impacts flows. Input flows will be required at locations further upstream than the outfall of the model RORB, which was a focus of the RORB validation. Five validation points within the main catchment have been considered and the flows form the RORB model compared to the flows from the RFFE calculations and also the DRNE flood regression analysis at these validation points. Figure 2-2 shows the sub catchments relating to the validation points, which are listed below.

- Sub catchment A: External catchment that drains to a culvert crossing at Korumburra-Wonthaggi Road north of Lynnes Road.
- Sub catchment B: PSP area that drains to the proposed wetland area (focus of our study).
- Sub catchment C: External catchment that drains to a culvert crossing at Korumburra-Wonthaggi Road south of Lynnes Road.
- Sub catchment D: Other catchment area within the PSP that drains into the Powlett River north of Wonthaggi.
- Sub catchment E: External catchment that drains to a culvert crossing at Korumburra-Wonthaggi Road south of Lynnes Road.

The objective of the flows comparison on the sub catchments was to match flows as closely as possible for the 1 % and 50 % AEP events at the outfall while also maintaining flows with the 5-95 % confidence accuracy for the smaller sub-catchments when compared to the RFFE estimates. Table 2-1 shows the estimated flows. The kc (RORB routing parameter), initial loss (IL) and continuing loss (CL) were all adjusted as part of the validation process.

It is noted that the RFFE tool is predicting significantly higher flows for the smaller sub-catchment catchments, D and B, than the DRNE flood regression analysis. In the larger sub-catchments, there is much better agreement between the two estimation methods. The RFFE method is believed to be overestimating the flows in the smaller catchments as there is very limited data for small catchments which is utilised by the RFFE tool and so the fact that the adopted flows for the smaller catchments is lower than what is predicted by the RFFE tool is not considered to be a concern.

**Figure 2-2: Validation Sub catchments**




The initial RORB runs trialled using initial and continuing losses from the data hub and a kc based on the Pearse (a Victorian specific kc estimation) equation. All models were run with an areal reduction factor (ARF) matching the total catchment size of 67.3 km². The adopted initial loss is at the low end of the expected range, but was required to meet the 50 % AEP flow targets based on the RFFE estimates. The 75 % preburst depths were adopted in line with the updated Victorian specific guidance for prebursts and are shown in Appendix A.

The following scenarios were modelled:

1. Pearse et al kc (kc 10.48) and losses adopted from the ARR2019 Datahub (initial loss of 21 and continuing loss of 4.6).
2. Pearse et al kc (kc 10.48) and reduction in losses (initial loss of 20 and continuing loss of 3.8).
3. Lower kc (kc 10), initial loss of 20 and continuing loss of 3.8.
4. Higher kc (kc 15), initial loss of 20 and continuing loss of 3.8.
5. kc 13, initial loss of 20 and continuing loss of 3.8.
6. **Chosen Validation Parameters: kc 13, initial loss of 10 and continuing loss of 3.8.**

A summary of the RORB validation analysis is presented in Table 2-1 and Table 2-2.

### Table 2-1: RORB Validation – 1 % AEP Modelled Flows vs RFFE Expected Flows

| Calibration Catchment Outlet | Catchment A | Catchment B | Catchment C | Catchment D | Catchment E | Catchment F (total catchment) |
|---|---|---|---|---|---|---|
| Catchment Area (km$^2$) | 12.17 | 6.80 | 29.78 | 1.45 | 14.07 | 67.34 |
| RFFE | 35.2 | 31.2 | 74.9 | 20.0 | 35.9 | 108.0 |
| RFFE 5 % limit | 15.3 | 13.6 | 32.6 | 8.7 | 15.6 | 47.0 |
| RFFE 95 % limit | 80.2 | 71.1 | 171.0 | 45.7 | 81.7 | 248.0 |
| DNRE | 31.4 | 20.2 | 62.2 | 6.2 | 35.1 | 116.0 |
| kc 10.48 (Pearse), IL 21, CL 4.6 | 18.4 | 14.9 | 55.4 | 7.1 | 23.9 | 104.6 |
| kc 10.48, IL 20, CL 3.8 | 21.2 | 16.6 | 62.0 | 7.5 | 26.6 | 115.9 |
| kc 10, IL 20, CL 3.8 | 21.9 | 17.1 | 64.3 | 7.8 | 27.4 | 119.9 |
| kc 15, IL 20, CL 3.8 | 15.9 | 12.4 | 46.9 | 5.4 | 20.2 | 90.1 |
| kc 13, IL 20, CL 3.8 | 18.1 | 14.0 | 51.7 | 6.2 | 23.1 | 100.7 |
| kc 13, IL 10, CL 3.8 | 20.6 | 15.7 | 59.6 | 7.9 | 25.9 | 116.1 |
| Difference between Chosen Parameters and RFFE | -14.6 | -15.5 | -15.3 | -12.1 | -10.0 | 8.1 |

### Table 2-2: RORB Validation – 50 % AEP Modelled Flows vs RFFE Expected Flows

| Calibration Catchment Outlet | Catchment A | Catchment B | Catchment C | Catchment D | Catchment E | Catchment F |
|---|---|---|---|---|---|---|
| Catchment Area (km$^2$) | 12.17 | 6.80 | 29.78 | 1.45 | 14.07 | 67.34 |
| RFFE | 6.9 | 6.1 | 14.6 | 3.9 | 7.0 | 21.3 |
| RFFE 5 % limit | 3.4 | 3.1 | 7.4 | 2.0 | 3.5 | 10.8 |
| RFFE 95 % limit | 13.7 | 12.1 | 29.1 | 7.8 | 13.9 | 42.1 |
| kc 10.48 (Pearse), IL 20, CL 3.8 | 2.2 | 2.1 | 7.6 | 1.2 | 2.8 | 13.1 |
| kc 10.48, IL 21, CL 4.6 | 1.2 | 1.3 | 4.5 | 0.9 | 1.6 | 7.7 |
| kc 10, IL 20, CL 3.8 | 2.3 | 2.3 | 8.0 | 1.3 | 3.0 | 13.8 |
| kc 15, IL 20, CL 3.8 | 1.4 | 1.4 | 5.0 | 0.8 | 1.8 | 8.6 |
| kc 13, IL 20, CL 3.8 | 1.7 | 1.6 | 5.9 | 1.0 | 2.2 | 10.2 |
| kc 13, IL 10, CL 3.8 | 3.6 | 3.3 | 12.1 | 2.1 | 4.7 | 21.0 |
| Difference between Chosen Parameters and RFFE | -3.2 | -2.8 | -2.5 | -1.9 | -2.3 | -0.3 |

## 2.4 BASELINE MODEL

A baseline RORB model was then developed to represent the existing levels of development in the catchment outside of the PSP area. The baseline model was run with the same losses and kc as the validation model (kc 13, IL 10, CL 3.8) with the following model changes:

- Reaches were set to excavated unlined for areas of the catchment that have already been developed.
- Impervious fractions were updated based on planning scheme zones and aerial photography. Note all recent residential development including Parklea, Powlett Ridge and Summerfields estates were assumed as not developed.
- Model was run with ARF for a catchment area of 6.8 km² (which is the main catchment B within the development area). A sensitivity analysis was carried out on utilising different total catchment area ARF values and there was not found to be a significant difference in the flows.
- Having the ARF set to the entire model area (67.34 km²) results in lower peak flows than the runs adopting an ARF for an area of 6.8 km². Table 2-3 provides a comparison of the ARF sensitivity.

**Table 2-3: RORB Calibration- 1 % AEP and 50 % AEP Modelled Flows for Baseline Model**

| Calibration Catchment Outlet | Catchment A | Catchment B | Catchment C | Catchment D | Catchment E | Catchment F |
|---|---|---|---|---|---|---|
| Catchment Area ($km^2$) | 12.17 | 6.80 | 29.78 | 1.45 | 14.07 | 67.34 |
| 1 % AEP kc 13, IL 10, CL 3.8, ARF Area 67.34 $km^2$ | 20.6 | 15.7 | 59.6 | 7.9 | 25.9 | 116.1 |
| 1 % AEP kc 13, IL 10, CL 3.8, ARF Area 6.8 $km^2$ | 23.4 | 18.3 | 68.6 | 9.6 | 29.5 | 131.8 |
| 50 % AEP kc 13, IL 10, CL 3.8, ARF Area 67.34 $km^2$ | 3.6 | 3.3 | 12.1 | 2.1 | 4.7 | 21.0 |
| 50 % AEP kc 13, IL 10, CL 3.8 ARF Area 6.8 $km^2$ | 4.4 | 4,1 | 14.7 | 2.5 | 5.7 | 25.5 |

Flows from the baseline RORB model were then used as input into the TUFLOW model for baseline hydraulic modelling.

## 2.5 DEVELOPED CONDITIONS MODEL

To model the full development of the PSP area the baseline conditions model was updated to include to the following changes and model runs:

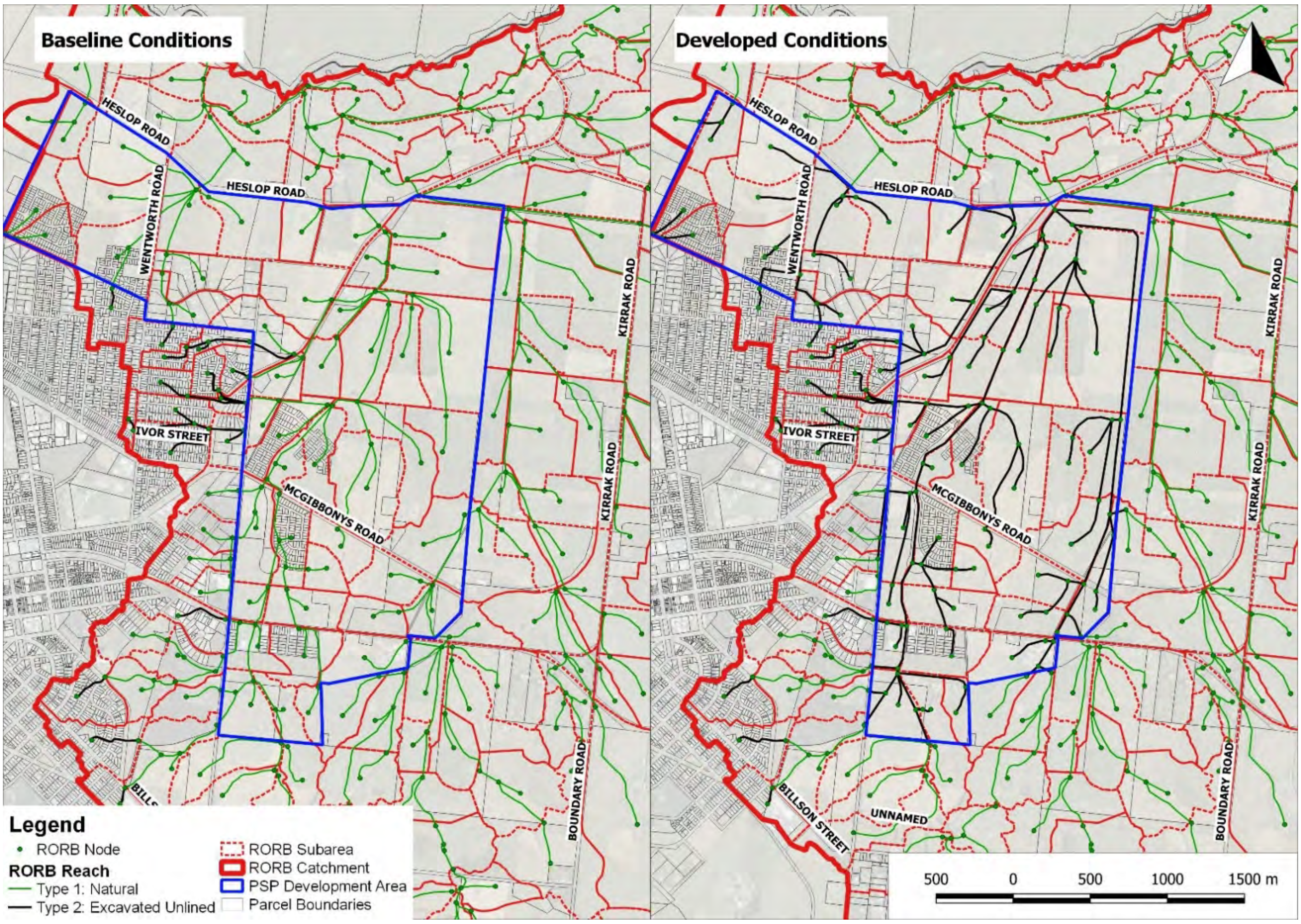
- Reaches in the development area were all changed from a natural reach type to an excavated unlined reach type in RORB. This is to reflect the change from narrow channels on a floodplain to wider constructed waterways or overland flow paths along roads which convey water more efficiently than flows across a floodplain.
- Fraction impervious (FI) was updated based on the PSP landuse breakdown (proposed residential areas increased to FI of 0.65 and proposed industrial/commercial areas increased to FI of 0.9 in line with the anticipated density of future housing in the development area).
- Adjusted the reach alignments to match the alignment of the proposed constructed waterways which convey flows to the proposed wetland/retarding basins.
- Run the RORB model with an ARF based on a catchment area of 6.8 km² (for RB sizing and the flows used in the TUFLOW development only area modelling). This catchment area matches the area of the catchment upstream of RBWL1.
- Run the RORB model with an ARF based on a catchment area of 362 km². This is the catchment area of the Powlett River catchment up to where the development area discharges to the Powlett River. These flows were used for the TUFLOW modelling to assess the impact of the Powlett River on flooding downstream of the development area.
- Run the RORB model with an ARF set to 1 for sizing sediment basins, pipes and waterways. The basis for this decision is that most of the pipes and sedimentation basins would have a total catchment area of less than 100 ha (the point at which the ARF starts to be reduced below 1). Some of the lower reaches of the waterway would have catchment areas in excess

of 100 ha, however the reduction in flows by the ARF from utilising a slightly larger catchment area would not result in a significant change in flows. This approach was considered to be slightly conservative and simplifies the hydrologic modelling approach as a single set of modelling parameters can be used to obtain the flows for the waterways, pipes, sedimentation basins and culverts. It avoids running the RORB model multiple times with slightly varying ARF values for each individual reach. This makes setting and reviewing the target flows simpler without a significant loss of accuracy.

- Run the RORB model for the 1 % AEP with an increase in rainfall intensity to account for climate change. The details of the climate change parameters used are discussed further in section 2.6.

A comparison of the baseline and developed conditions RORB model reach alignments is shown in Figure 2-3. The main change shown in the figure below is that the reach types and alignments within the PSP development area have changed to reflect the proposed future stormwater management infrastructure. In the RORB model the fraction impervious values were also increased to account for the proposed development.

**Figure 2-3: RORB Model Baseline Conditions and Developed Conditions Comparison**




## 2.6 CLIMATE CHANGE SENSITIVITY

The influence of climate change was modelled as an increase in rainfall intensity, with the climate change scenario modelled for the 1 % AEP event. The IFD values were increased by a factor that scales rainfall intensity to be appropriate for the 2100 RCP 8.5 scenario. As the ARR Data Hub does not currently provide temperature increase and rainfall increase values for the 2100 RCP 8.5 scenario, the factor was calculated by extrapolation of both temperature and percentage increase in rainfall intensity to 2100 based on values provided for the years 2080 and 2090. An 18.4 % increase in rainfall intensity was adopted for flood modelling under the climate change scenario based on extrapolation calculations. Refer to Appendix B for details.

## 2.7 POWLETT RIVER RORB MODEL

Flows were needed for the Powlett River to assess the impact of the Powlett River flooding on the development area and also of the development area on the Powlett River flood plain. A RORB model of the Powlett River was developed as part of the Victorian Desalination Project Environmental Effects Statement (EES). The details of this RORB model are contained in Technical Appendix 43 of the Victorian Desalination Project EES. Engeny obtained a copy of this technical report and recreated the RORB model using information contained within the report – a copy of the original model could not be obtained.

Some key data for the model is presented below:

The peak flows documented within the requested '*Technical Appendix 43*' document prepared by GHD focused on two locations, downstream of the Foster Creek and Powlett River confluence and at the Powlett River Outlet marked on Figure 2-4 shown below and presented in Table 2-4.

**Figure 2-4: Location of documented flows within requested Technical Appendix 43**

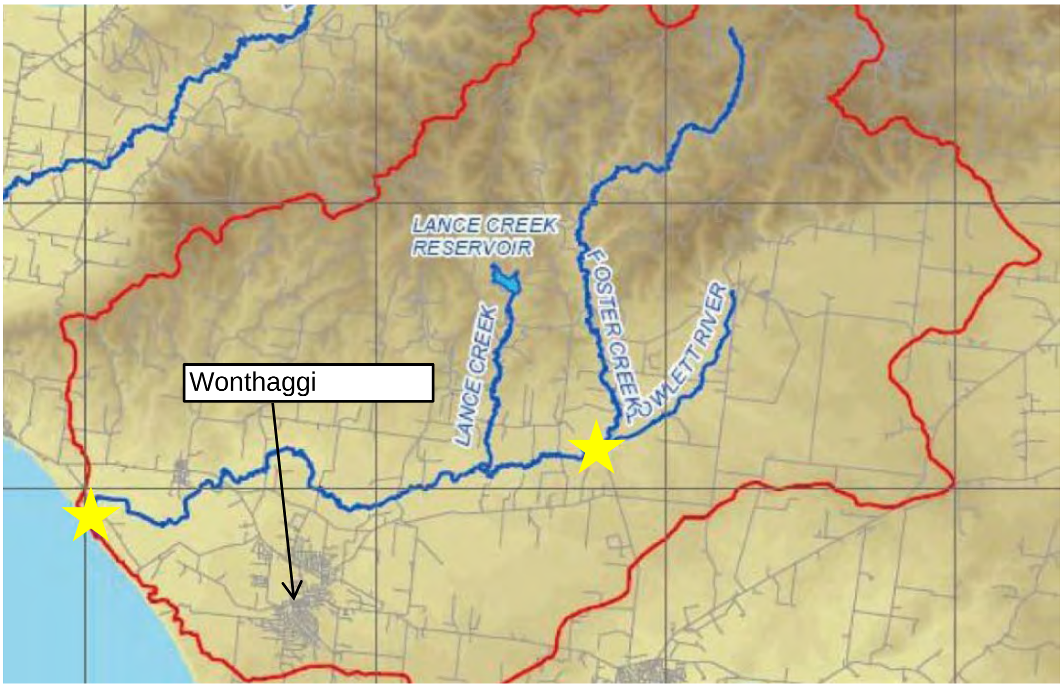



**Table 2-4: Peak flows extracted from GHD Technical Appendix 43 document**

**Table 3-11 Summary of Sensitivity Results at Gauging Station 227236**

| AEP | Peak Flow ($m^3/s$) | Upper Estimate ($m^3/s$) | Lower Estimate ($m^3/s$) |
|---|---|---|---|
| 1 in 50 | 82 | 108 | 64 |
| 1 in 100 | 104 | 133 | 80 |

**Table 3-12 Summary of Sensitivity Results At Outlet of Powlett River**

| AEP | Peak Flow ($m^3/s$) | Upper Estimate ($m^3/s$) | Lower Estimate ($m^3/s$) |
|---|---|---|---|
| 1 in 50 | 97 | 124 | 74 |
| 1 in 100 | 127 | 158 | 92 |

Table 2-5 presents the peak flows estimated using the RFFE online tool for the Powlett River Catchment.

### Table 2-5: RFFE online tool results

| AEP (%) | Discharge ($m^3/s$) | Lower Confidence Limit (5 %) ($m^3/s$) | Upper Confidence Limit (95 %) ($m^3/s$) |
|---|---|---|---|
| 50 | 60.8 | 30.9 | 119 |
| 20 | 108 | 56.9 | 206 |
| 10 | 147 | 75.1 | 288 |
| 5 | 190 | 92.7 | 387 |
| 2 | 254 | 116 | 553 |
| 1 | 309 | 133 | 710 |

As shown, the peak flows derived from the GHD Technical Appendix and those estimated using the RFFE online tool differ significantly with the estimated 1 % AEP peak flows from the GHD Technical Appendix being below the lower confidence limit of the RFFE tool. The DNRE flood regression analysis for a catchment of 507 $km^2$ (the size of the Powlett River catchment to the mouth and roughly where the downstream gauge is located) predicts a flow of 540 $m^3/s$, also significantly higher than was determined by the RORB model.

The use of this model for validation purposes of flows within the development area was considered but ultimately rejected due to a lack of confidence for the following reasons:

- The flows reported in the study are significantly different to the flows estimated by the RFFE tool.
- The flows reported in the study were significantly less than the predicted flows from the DNRE flood regression analysis.
- The model does not consider spatial variation despite the large size of the catchment.
- The model was built and run using ARR 1987 and updating it to ARR 2019 would require significant work which was not possible within the timeframe of this project.
- The accuracy of the gauges used in the study is unknown and it was not possible to further investigate this within the timeframe of this project.

Despite these concerns the model was deemed suitable to use only for a sensitivity test of the impact of flooding on properties downstream of the development area when the Powlett River flows are considered. Given the concern is that the model may be underestimating flows on the Powlett River utilising these flows represents a conservative position as higher flows would reduce the relative impact of the flows from the development area compared to the Powlett River.

The key parameters used to run the Powlett River RORB model are contained in Table 2-6 below.

### Table 2-6: Powlett River RORB model parameters

| Parameter | Value |
|---|---|
| Initial Loss | 20 mm |
| Continuing Loss | 3.8 mm / hr |
| $D_{av}$ (Average Distance of RORB reaches from the catchment centroid to the outlet) | 32.49 |
| $K_c$ | 69.2 |
| Rainfall (taken at catchment centroid) | Bureau of Meteorology (BoM) + 10 % increase to rainfall depths (as per GHD Technical Report) |

Some minor adjustments to the parameters were made compared to the values used in the GHD Technical Appendix as the average distance parameter in the Engeny recreation of the GHD RORB model was slightly different to the original value from the GHD model and so the kc was adjusted to ensure the same kc/dav ratio. The flows from the Engeny model were a close match to those reported on from the original GHD model. The areal reduction factor applied to the model was adjusted to reflect a catchment size of 362 $km^2$, approximately the Powlett River catchment to the Wonthaggi NE PSP development area.

The Powlett River RORB model was run for the 100 year ARI (1 % AEP) and the 2 year ARI (38 % AEP). The flows from the 100 year ARI were matched with flows from the 1 % AEP from the local catchment model developed and the flows from the 2 year ARI were matched with flows from the 50 % AEP event from the local catchment model.

# 3 HYDRAULICS

## 3.1 OVERVIEW

A combined 1D/2D dynamic hydraulic model of the northern part of the PSP area and surrounding catchment was developed using TUFLOW version 2020-10-AA. This was done to estimate flood water levels, extents, flows and other hydraulic variables for a range of scenarios and design events. The model was run using the TUFLOW HPC (Heavily Parallelised Compute) scheme with sub-grid sampling enabled.

Separate TUFLOW models were constructed for the baseline and developed conditions scenarios. Both hydraulic models were constructed using a 3-metre cell size to sufficiently represent the PSP development area as well as the existing and proposed open channel drainage networks.

## 3.2 METHODOLOGY

The following steps outline the tasks undertaken to develop the TUFLOW models for the study area and to obtain the relevant flood mapping outputs:

- Generate a Digital Elevation Model (DEM).
- Create inflow boundary conditions in order to reference the relevant inflow hydrographs generated in the validated RORB model including both rainfall excess hydrographs and routed inflow hydrographs.
- Input surface roughness (materials layer) based on existing conditions defined by the obtained aerial photographs utilising standard industry values.
- Input and verify data for the 1-D networks (pits, pipes and culverts).
- Improved the representation of waterways / open channels / drains where required (utilising z-shapes, design drawings, design DEMs from 12d and the obtained survey data).
- Improved the representation of roads and levees where required (utilising z-shape breaklines and the latest 1 - metre LiDAR data and survey data where available).
- Set 1-D and 2-D boundary conditions to pipes / pits and overland flows where required.
- Run the TUFLOW HPC baseline model for the 1 % and 50 % AEP events for all storm durations and temporal patterns discussed in Section 3.3.
- Estimate the required storage volume upstream of Korumburra – Wonthaggi Road to maintain predeveloped flows downstream (informed by the 1 % AEP event).
- Iteratively run the TUFLOW HPC developed conditions model with the designed retarding basin to validate the required storage volume.
- Prepare relevant outputs including flood depth, extents and velocities layout plans.
- Prepare flood difference (afflux) plots comparing the baseline and developed conditions flood depths.

**Section 3.4** provides technical details relating to the development of the TUFLOW hydraulic model.

## 3.3 SCENARIOS AND DURATIONS MODELLED

For each AEP, Engeny has run a single, middle loaded temporal pattern design storm through the hydraulic model for a range of storm durations. This was completed to determine the critical durations throughout the catchment. These were not able to be determined from the RORB modelling alone as previous modelling had demonstrated that there was significant storage upstream of Korumburra Wonthaggi Road between Korumburra Wonthaggi Road and the Powlett River. The outflows from these storage areas were also impacted by the downstream conditions which dynamically varied during each individual flood event, making obtaining a stage-discharge relationship to input into RORB very challenging. As the same volumetric runoff (less any impact from the temporal distribution of continuing losses) is applied for each duration, using a middle loaded temporal pattern allows for a reasonable estimation of critical durations within the catchment whilst reducing the overall runs required to develop the envelope of flood results.

The critical storm durations were selected based on the above approach, for which then all ten temporal patterns were run through the hydraulic model for each AEP event. At each grid cell, the flood height derived from the median temporal pattern was taken for each duration. The maximum for the critical durations was then taken to provide the design flood height for each AEP. This was repeated for the other flood modelling outputs.

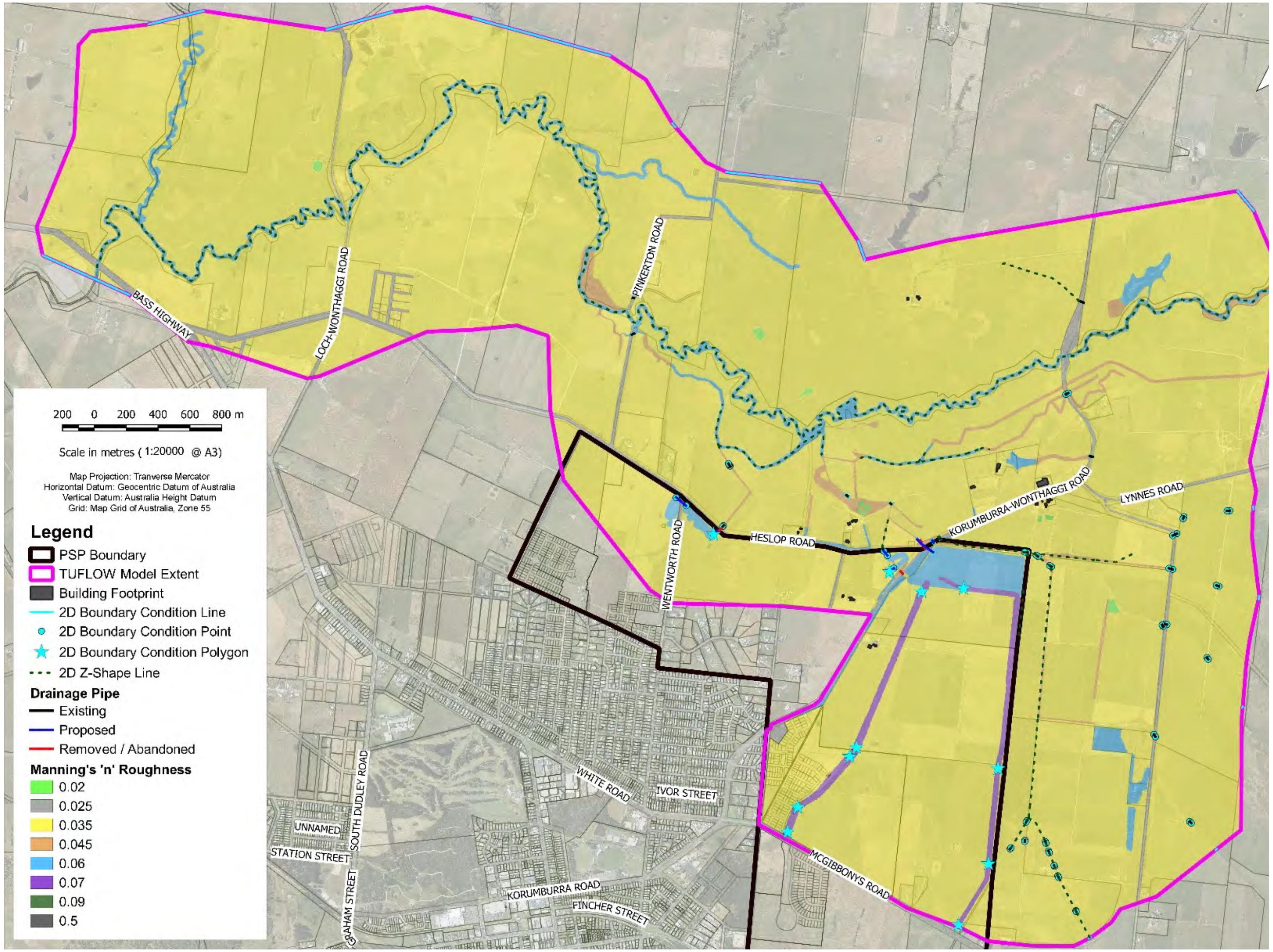
## 3.4 MODEL DEVELOPMENT AND ASSUMPTIONS

### 3.4.1 Model Extent

The extent of the hydraulic model is based on enabling the key topographical features of the study area (such as waterways and open drains) to be modelled focussing on the PSP boundary and the downstream properties at 435 and 465 Heslop Road. As the RORB model provides inflows to the area where the key hydraulic constraints were it was not necessary to model the entire catchment in the TUFLOW model. There were also limitations on available LiDAR data which limited the model extent.

Figure 3-1 shows the extent of the hydraulic model and depicts some of the key inputs to the model which are described further in the following sections of this report.

## Figure 3-1: Wonthaggi Northeast PSP TUFLOW Model Layout



### 3.4.2 Topography

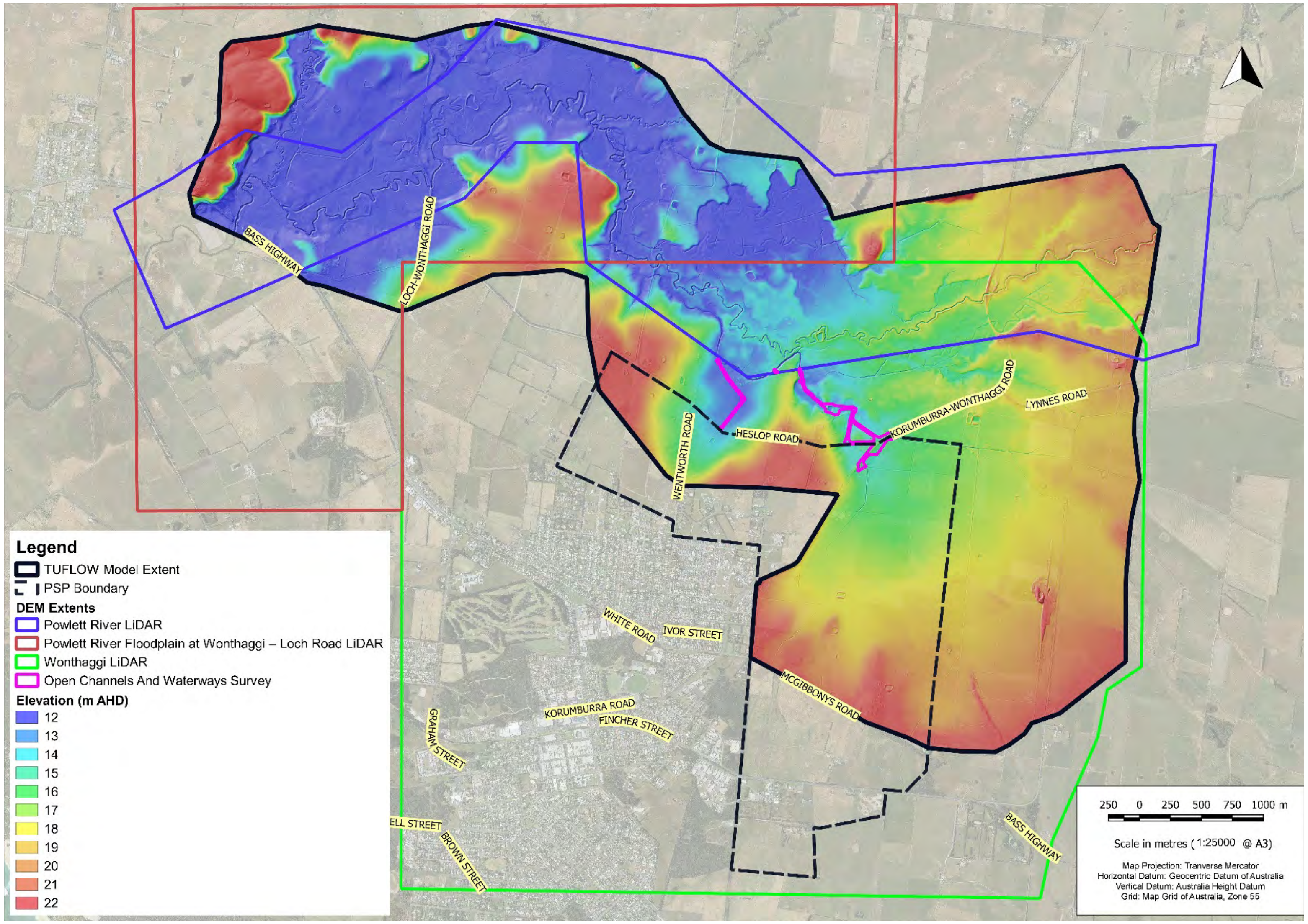
A model resolution (grid size) of three metres has been used, resulting in the definition of elevation every 1.5 horizontal metres in the model. This grid size is in accordance with recommendations in industry guidelines and allows for key catchment features such as waterways, open channels, and roads to be defined in the model. Sub-grid sampling using a sample size of 1 m has also been enabled in the modelling to improve the conveyance through narrow channels, particularly relevant in the more frequent events. Additional break lines have been added to the model to reinforce key hydraulic embankment such as roads and levees within the key areas of interest.

Table 3-1 provides a summary of the LiDAR data used to assign elevations throughout the flood model including details on the resolution, accuracy, and source. Figure 3-2 depicts the extent of the topographical data sets utilised in this study. These data sets have been used to generate a DEM with 1-metre resolution for the study area.

**Table 3-1: Summary of LiDAR data sets**

| Data Set | Resolution | Source | Year Captured | Purpose |
|---|---|---|---|---|
| Powlett River LiDAR | 1 metre | Victorian Department of Sustainability and Environment (DSE) | 2009-2010 | Used to develop DEM for Powlett River and floodplain |
| Powlett River Floodplain at Wonthaggi – Loch Road LiDAR | 1 metre | DSE + Bass Coast Shire Council | 2012 | Used to better defined elevations along the Powlett River further downstream (near Wonthaggi Loch Road) |
| Wonthaggi LiDAR | 1 metre | Bass Coast Shire Council | 2012 | Used to develop DEM for PSP area and surrounds |
| Open Channels and Waterways Survey from 435 and 465 Heslop Road | 1 metre | Raso Consulting Surveyors (RCS) | 2021 | Used to better define invert levels and ground elevations along open channels and waterways within property downstream of Heslop and Korumburra-Wonthaggi Road |

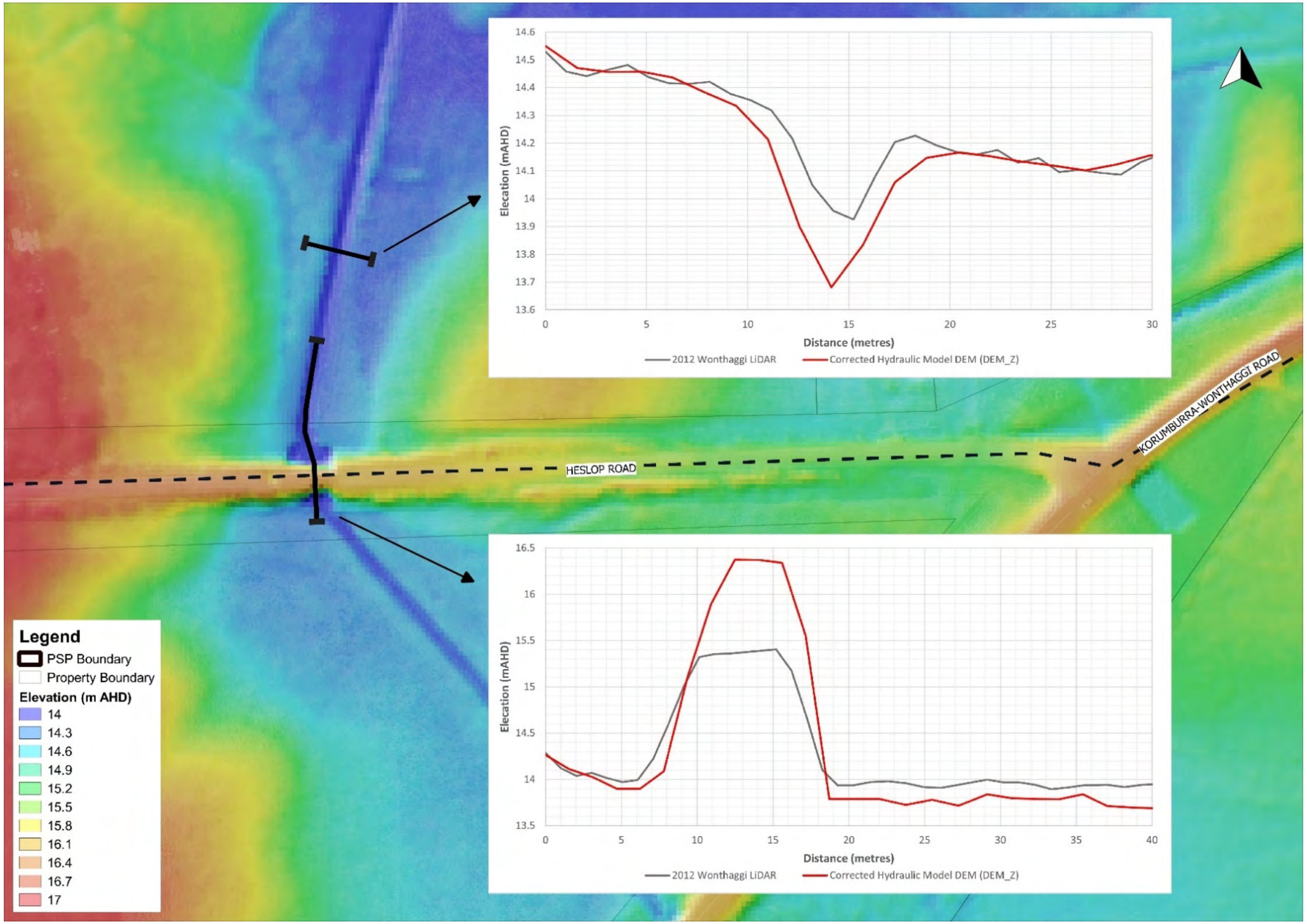
**Figure 3-2: DEM and Extent of Topography Data Sets**



### 3.4.3 Waterways and Open Channel Drains

The study area includes several open channel drains. The available terrain data consisting of both LiDAR and survey data was found to be unsatisfactory in representing channel invert levels at several locations. This was due to the elevation data picking up existing water surface levels, or in most instances, thick vegetation and / or trees rather than the actual bed levels. In these instances, z-shapes were used to lower waterways to allow open channels and downstream culverts to drain freely, improving the hydraulic model stability and conveyance of the channels. Care was taken to not artificially deepen channel beyond what was considered likely to exist on site. These judgements were informed by the observations during the site visit, survey data, known culvert inverts and variation within the LiDAR DEM (i.e. the LiDAR may pickup a lower level where there is less vegetation which can then be extrapolated to a nearby area covered in dense vegetation. An example is provided in Figure 3-3 at 465 Heslop Road, just west of the intersection of Heslop and Korumburra-Wonthaggi Road.

**Figure 3-3: Long and cross section comparisons of corrected hydraulic model DEM (DEM Z) and LiDAR data at Heslop Road**



### 3.4.4 Culverts and Bridge Structures

There are several drainage pipes, culverts and bridge structures which have been included in the model. The culverts have been modelled as pipes in the 1-D domain and the bridges and pedestrian crossings modelled as layered flow constrictions in the 2-D domain. The culverts included major crossings under Heslop and Korumburra-Wonthaggi Road as well as minor open channel foot and farm equipment crossings within the existing PSP area and adjacent properties. The bridge structures included mostly road crossings along the Powlett River (downstream from the study area).

Figure 3-4 shows the location of key drainage assets, culverts, and waterway crossings within the hydraulic model extent and Table 3-2 provides a summary of the 1-D drainage assets and 2-D road and pedestrian bridge crossings respectively. Where possible culvert size data was informed by Council GIS, site measurement, or survey data. There were some culvert crossings on waterways, mainly upstream of the development area, within private property which could not be accessed to obtain measurement. At these locations an assumption was made on a possible culvert dimension informed by the size of nearby known crossings.

**Figure 3-4: Location of Key Drainage Assets or Waterway Crossings**

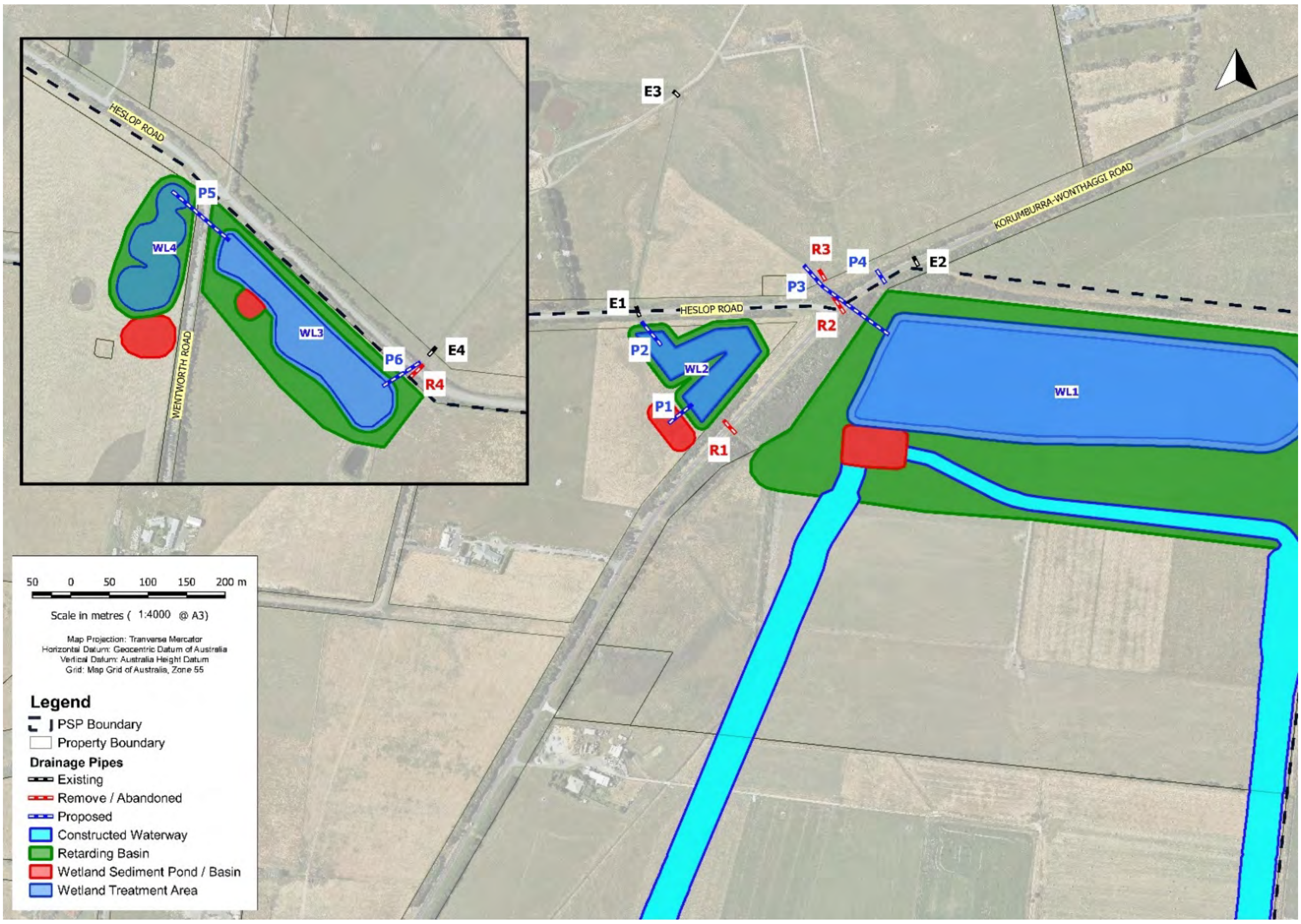


**Table 3-2: Summary of key culverts associated with wetlands**

| Location (Figure 3-4) | Description | Number | Width or Diameter (mm) | Height (mm) |
|---|---|---|---|---|
| E1 | Circular culverts under Heslop Road | 3 | 1650 | - |
| E2 | Box Culverts under Korumburra – Wonthaggi Road | 3 | 1220 | 1220 |
| E3 | Circular culvert in existing channel in 465 Heslop Property under farm access track | 1 | 1500 | - |
| E4 | Circular pipe in existing channel downstream of Heslop Road at proposed WL3 culverts | 1 | 600 | 00 |
| R1 | Existing box culverts under Korumburra-Wonthaggi Road south of intersection with Heslop Road – to be removed / abandoned | 4 | 1260 | 1250 |
| R2 | Circular culvert under Korumburra-Wonthaggi Road just east of intersection with Heslop Road – to be removed / abandoned | 1 | 600 | - |
| R3 | Circular pipe in existing channel in 465 Heslop Property just downstream of Korumburra – Wonthaggi Road– to be removed / abandoned | 1 | 600 | - |
| R4 | Box culverts under Heslop Road north of proposed WL3 to be retained with additional culverts added (see P6) | 2 | 1200 | 450 |
| P1 | Proposed WL2 sediment pond to wetland circular transfer pipe | 1 | 1200 | - |
| P2 | Proposed WL2 circular low level outlet pipe | 1 | 1200 | |
| P3 | Proposed WL1 low level polypropylene circular pipes (running under Korumburra-Wonthaggi Road) | 10 | 338 | - |
| P4 | Proposed WL2 high outlet box culverts conveying spillway flows through Korumburra-Wonthaggi Road | 3 | 1200 | 900 |
| P5 | Proposed WL4 to WL3 circular transfer pipe | 1 | 1050 | - |
| P6 | Proposed WL3 low level outlet pipe (running under Heslop Road), 1 new culvert and extension to 2 existing culverts | 3 | 1200 | 450 |

The location, as well as size, number, and orientation of some of the existing culverts has changed under the proposed developed conditions. This was done to achieve the required retardation storages and effectively capture and convey additional runoff from the modelled PSP development. The changes to specific waterway culvert crossings and the management of flows under the developed conditions is discussed further in Section 4.2.7

### 3.4.5 Surface Roughness

The hydraulic model includes a land use (materials) layer that reflects the surface roughness (Manning's 'n') throughout the catchment. The surface roughness defines how much resistance there is to runoff / overland flow passing over different land use types. For instance, high surface roughness values are found in densely vegetated swales as well as properties (due to the presence of buildings, fences and other structures that impede the flow of water), while flow through an open paddock will have a lower surface roughness value.

Table 3-3 summarises the roughness values applied to the hydraulic model. These values are based on Melbourne Water and industry standard guidelines and were verified during site visits and from aerial photographs.

**Table 3-3: Manning's 'n' Roughness Values**

| Land Use Type | Manning's 'n' Roughness |
|---|---|
| Open paddock with minimal vegetation | 0.03 |
| Open paddock with moderate vegetation | 0.06 |
| Open paddock with thick vegetation | 0.09 |
| Commercial and residential building footprints | 0.50 |
| Paved road / carparks / driveways | 0.025 |
| Remainder of parcel (residential high density) | 0.01 |
| Waterway – main channel, with some vegetation, weeds / stone | 0.045 |
| Waterway – vegetated, sluggish reaches / wetlands / deep pools | 0.06 |
| Waterway – proposed open channel(s) with moderate to thick vegetation | 0.07 |
| Waterbody – Open waterbodies with submerged vegetation (ponds / dams) | 0.02 |

### 3.4.6 2D Boundary Conditions

A series of QT (flow versus time) boundaries were placed along the perimeter of the model boundary to represent the inflows from the major overland flow paths. These relationships were set up to reference the plot outputs of flow versus time results from the RORB hydrological model discussed in Section 2 and enabled the TUFLOW model extent to be reduced to focus on the study area.

Rainfall excess hydrographs were applied as 2-D source areas (2d_sa) onto the ground surface covering the sub-catchments within the TUFLOW model extent, containing part of the PSP area and Powlett River floodplain. In the developed conditions model 2d_sa regions within the PSP area were placed within the proposed constructed waterways to ensure inflows generated were distributed directly into the main waterways within their respective subarea. This was considered appropriate as the final development form is not known but the design will require that all developed areas provide safe drainage flow paths for events up to the 1 % AEP to the waterways.

2D boundary conditions of SX type (source of flow from 1D model) were used to link 1D network and 2D domain, for example, at inlet pits, culverts and headwalls. This allows water to inflow from the surface to the pits and surcharge from the pits / pipes to the surface.

**Downstream Boundary**

2D HQ (head versus flow) model boundary conditions have been adopted where the overland flow exits the model (along the Powlett River). This approach prevents water ponding against the 2D code boundary, which would produce incorrect flood level estimates. The downstream boundary was placed downstream of where ethe Powlett River crosses the Bass Highway. This crossing is a significant hydraulic constraint on the river system and is approximately 7 km downstream of the development area. By placing the boundary condition on the downstream side of this constraint the impacts of the boundary condition on the modelling in the area of interest are minimised. The same downstream boundary condition was used for the baseline and developed condition modelling.

### 3.4.7 Initial Water Levels

Initial water levels were specified where ponds and other permanent waterbodies, such as constructed wetlands, were located throughout the study area to fill these storages and to avoid double counting hydrological losses. For the proposed wetlands in the developed conditions model, the 2D initial water levels were set to the extended detention depth (EDD). Where plans for these bodies were not available, site observations and LiDAR data was used to set 2D initial water levels.

## 3.5 BASELINE CONDITIONS MODEL RESULTS

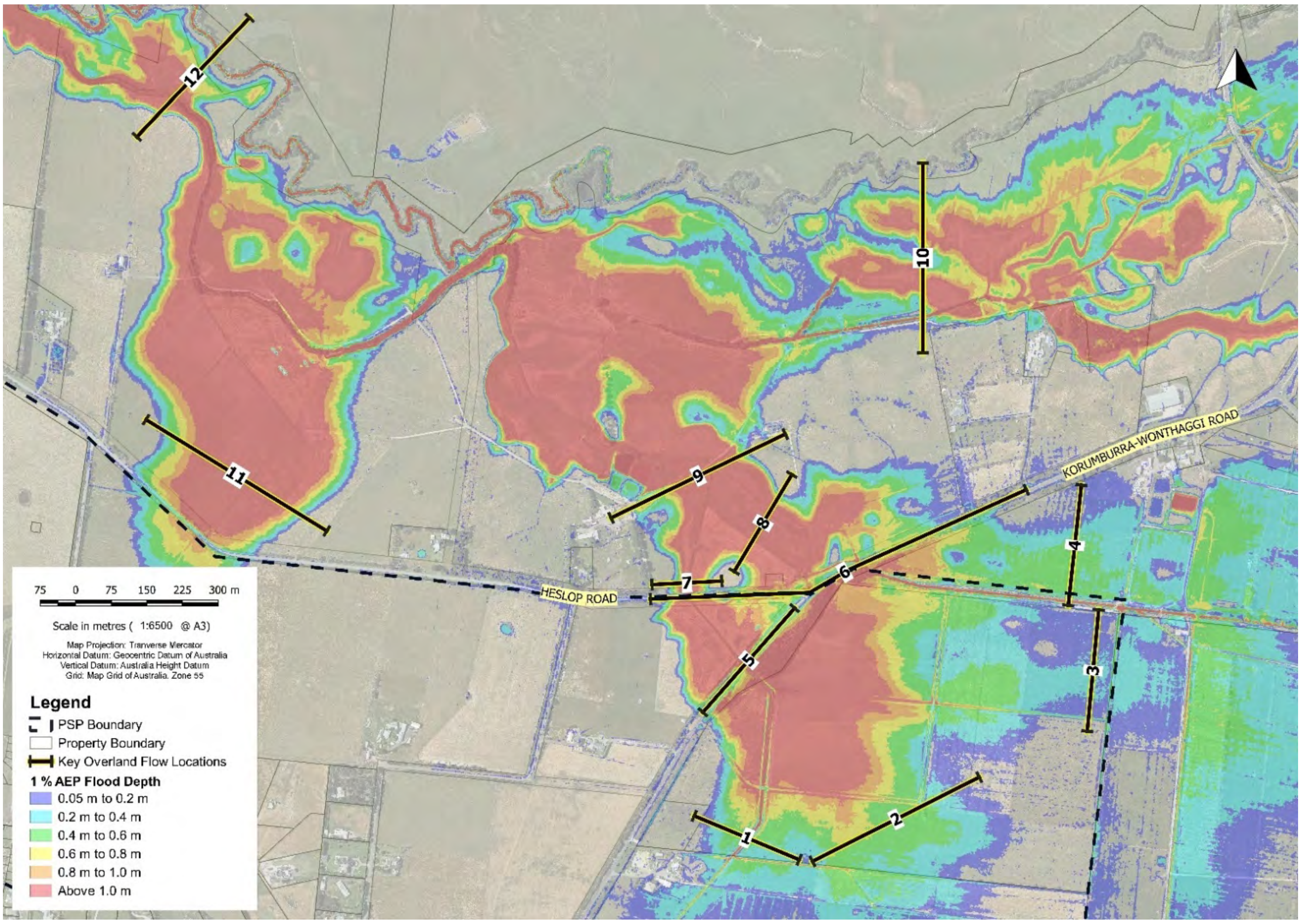
**Appendix B** provides the resultant flood depth layout plans for all modelled design storm events for existing / baseline conditions. Table 3-4 provides a summary of the peak 50 % and 1 % AEP flows at key flow locations with the hydraulic model extent. These selected locations, which are annotated onto Figure 3-5, represent critical areas and road crossings subject to overland flooding / ponding of flood waters.

The baseline conditions modelling results show a significant volume of water ponding along the southern (upstream) side of Korumburra – Wonthaggi Road, with depths up to 1.0 m and 1.9 m in the 50 % and 1 % AEP respectively. In the 1 % AEP event flood levels reach 16.45 m AHD, exceeding the Korumburra – Wonthaggi Road crest. The crest level of the ranges between 16.20 and 16.64 m AHD in the area adjacent WLRB 1. Overland flow overtopping Korumburra-Wonthaggi Road in 1 % AEP ponds behind Heslop Road with depths up to 2.0 m in the farmland directly south of Heslop Road. The water level in this area is up to 15.9 m AHD under existing conditions and 15.85 m AHD under developed conditions and exceeds the Heslop Road crest level in this area which ranges from 15.30 to 16.20 m AHD. This results in a combined overland flow of 44 $m^3/s$ and flood depths between 0 and 450 millimetres across Korumburra-Wonthaggi and Heslop Road. An additional 27 $m^3/s$ is conveyed through the existing culverts under Korumburra- Wonthaggi and Heslop Road resulting in a total peak flow 71 $m^3/s$ to the downstream property in the 1 % AEP.

**Table 3-4: Peak Overland Flows ($m^3/s$)**

| Location | 50 % AEP | 1 % AEP |
|---|---|---|
| 1 | 2.9 | 11.7 |
| 2 | 2.5 | 17.4 |
| 3 | 3.0 | 16.1 |
| 4 | 7.5 | 35.4 |
| 5 | 0 | 33.0 |
| 6 | 0 | 44.3 |
| 7 | 6.4 | 15.6 |
| 8 | 5.1 | 52.6 |
| 9 | 11.3 | 64.7 |
| 10 | 7.4 | 41.5 |
| 11 | 2.4 | 4.9 |
| 12 | 14.9 | 82.4 |

**Figure 3-5: Key Locations Subject to Overland Flooding (1 % AEP Flood Depth, Baseline Conditions)**



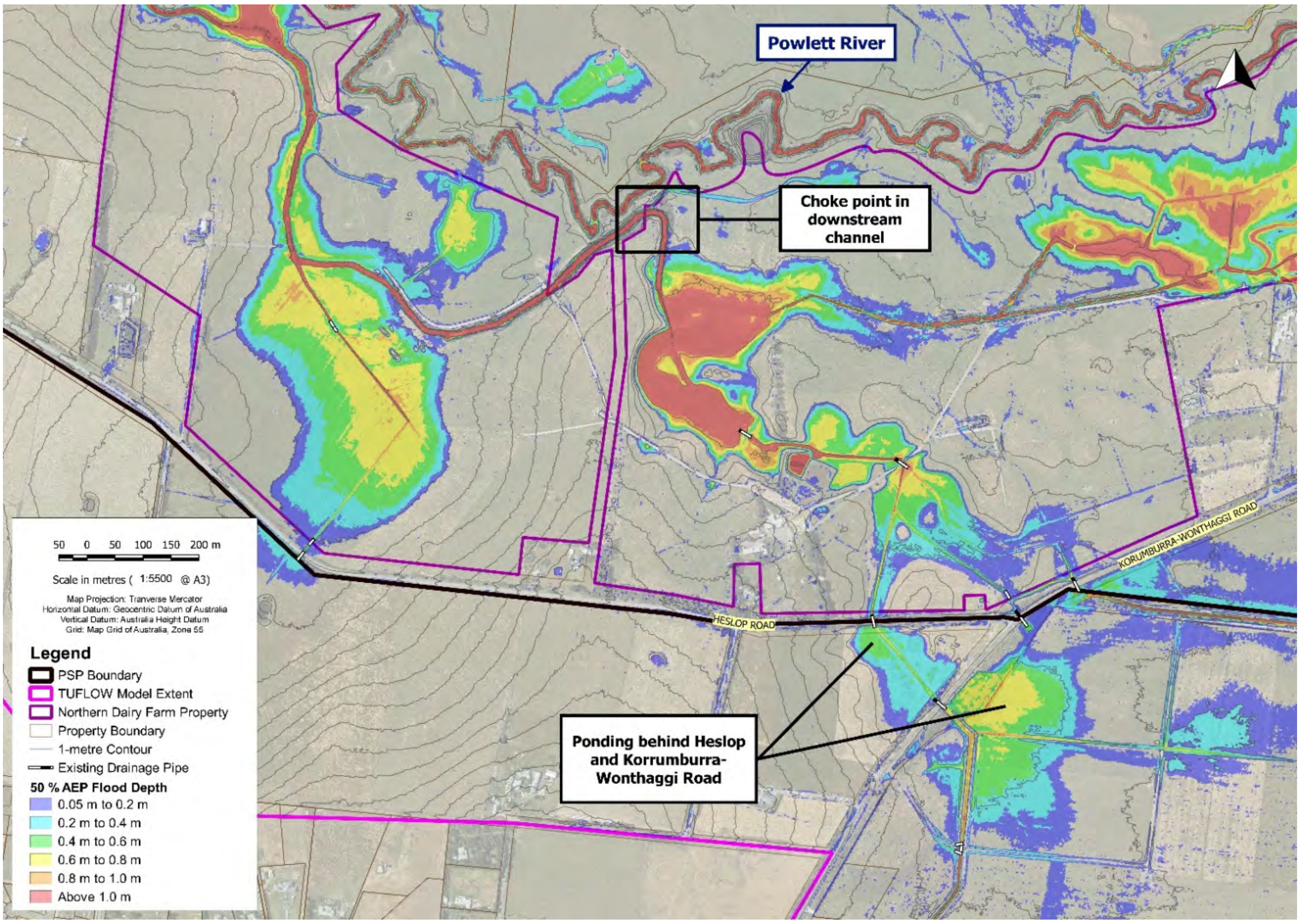

### 3.5.1 Flooding Characteristics

Figure 3-6 displays the 50 % AEP baseline conditions flood depths across the study area focussing on 435 and 465 Heslop Road, the downstream farmland properties from the several discharge points of the Wonthaggi NE PSP area (across Heslop Road and Korumburra-Wonthaggi Road). These results show two significant hydraulic constraints in the catchment including:

1. Korumburra-Wonthaggi and Heslop Road which act as embankments, causing water to pond behind the roads like large retarding basins.
2. Natural hydraulic constraints in the downstream channel within 465 Heslop Road, the northern dairy farm property.

The flows within the Powlett River do not to break out to the south of the main channel in the 50 % AEP event. This is due to the presence of a levee adjacent to the southern bank. In the 1 % AEP event flows break out of the main channel of the Powlett River and the flood plain is fully engaged. This differing flood behaviour in frequent events compared to rare events limits options to make connections to the Powlett River main channel without impacting on flood behaviour in the frequent events and potentially increasing flooding from the Powlett River onto 435 and 465 Heslop Road.

**Figure 3-6: Baseline Conditions 50 % AEP Flood Depth**




## 3.6 DEVELOPED CONDITIONS MODEL RESULTS

**Appendix B** provides the resultant flood depth and difference (afflux) plans for all modelled design storm events for the developed conditions.

### 3.6.1 Required Retardation Storages

The retardation storages required to ensure development peak flows are retarded back to existing pre-development flows for the 50 % AEP and 1 % events were estimated using the TUFLOW hydraulic model. The developed conditions hydraulic model was run iteratively where the storage volumes and outlet configurations were modified until the peak flows across the PSP area and downstream flood levels were equivalent to or lower than the baseline conditions.

Table 3-5 provides a comparison of the baseline and post retarding developed conditions peak flows for the 50 % and 1 % event. Table 3-6 provides a comparison of the baseline and developed conditions maximum water levels upstream and downstream of the PSP area.

**Table 3-5: Comparison of Baseline and Developed Condition Peak Flows**

| | 50 % AEP Peak Flow ($m^3/s$) | | 1 % AEP Peak Flow ($m^3/s$) | |
|---|---|---|---|---|
| **Location** | **Baseline** | **Developed** | **Baseline** | **Developed** |
| 1 | 2.9 | 8.3 | 11.7 | 13.1 |
| 2 | 2.5 | 0 | 17.4 | 0 |
| 3 | 3.0 | 3.3 | 16.1 | 28.3 |
| 4 | 7.5 | 3.7 | 35.4 | 28.7 |
| 5 | 0 | 0 | 33.0 | 41.8 |
| 6 | 0 | 0 | 44.3 | 40.8 |
| 7 | 6.4 | 1.4 | 15.6 | 14.7 |
| 8 | 5.1 | 8.5 | 52.6 | 61.9 |
| 9 | 11.3 | 8.3 | 64.7 | 70.71 |
| 10 | 7.4 | 7.4 | 41.5 | 41.4 |
| 11 | 2.4 | 1.3 | 4.9 | 4.2 |
| 12 | 14.9 | 12.74 | 82.4 | 87.6 |

**Table 3-6: Comparison of Baseline and Developed Maximum Water Levels**

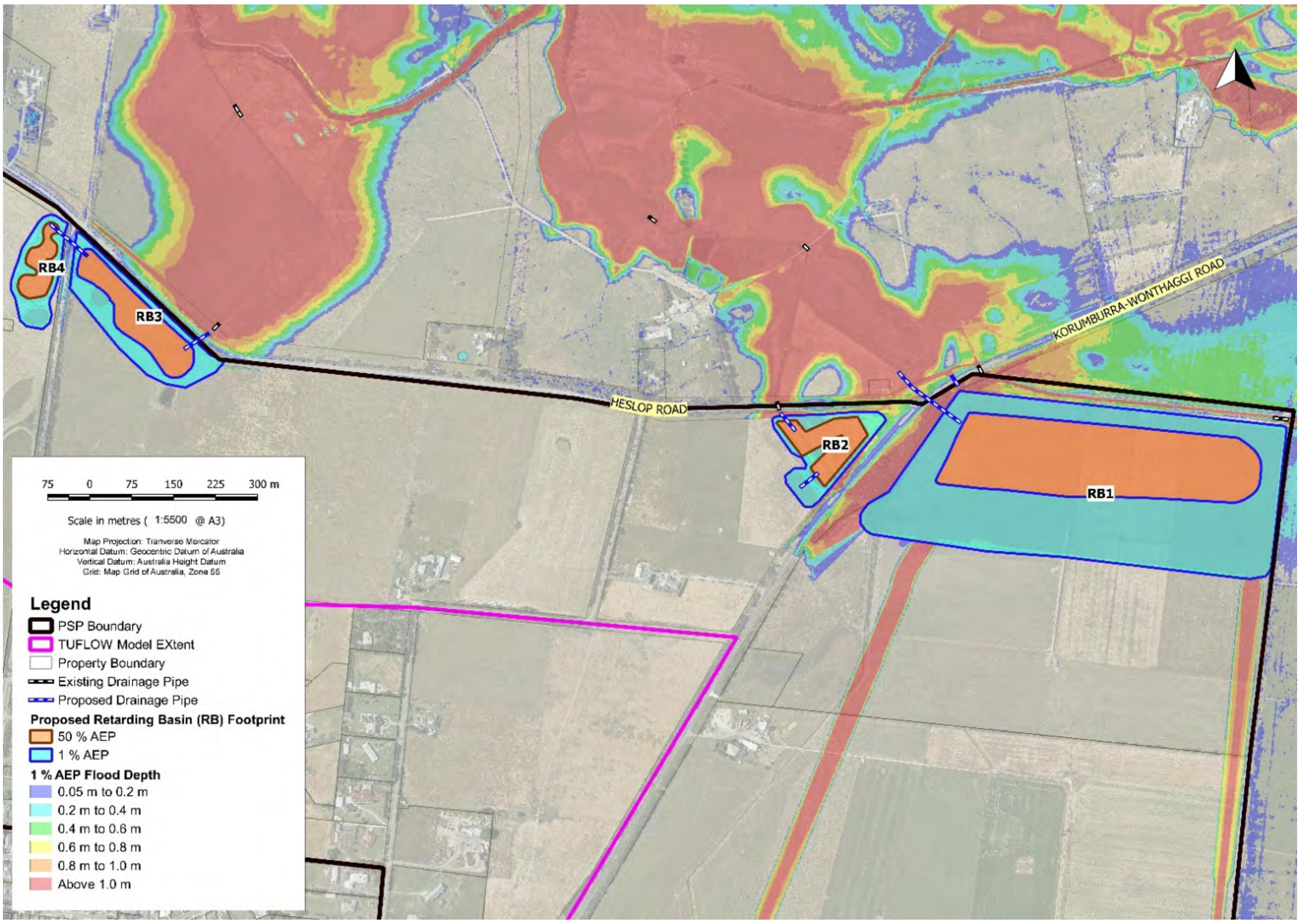
| | 50 % AEP Max Water Level (m AHD) | | 1 % AEP Max Water Level (m AHD) | |
|---|---|---|---|---|
| **Statistic** | **Baseline** | **Developed** | **Baseline** | **Developed** |
| Upstream of Korumburra-Wonthaggi Road at WL1 location | 15.55 | 15.40 | 16.45 | 16.48 |
| Upstream of Heslop Road at WL2 location | 15.01 | 14.66 | 15.9 | 15.85 |
| Downstream of Heslop and Korumburra-Wonthaggi Road | 14.31 | 14.11 | 15.83 | 15.85 |

The resultant peak flood storages for the 50 % and 1 % AEP event at each of the proposed wetland / retarding basin locations are summarised in Table 3-7. Figure 3-7 shows the proposed footprint that the retarding basins would require, with the existing 50 % AEP represented in orange and the 1 % AEP footprint overlain in blue in the background. The exact location and shape of each of the retarding basins and wetland could be refined in the functional / detailed design to accommodate an alternative development layout provided that the total volume of storage is maintained.

### Table 3-7: Required 50 % and 1 % AEP Retardation Storage Volumes

| Asset | 50 % AEP Required Volume (ML) | 1 % AEP Required Volume (ML) |
|---|---|---|
| WLRB1 | 229.6 | 444.5 |
| WLRB2 | 7.3 | 30.0 |
| WLRB3 | 3.9 | 9.3 |
| WLRB4 | 14.3 | 21.4 |

### Figure 3-7: Developed conditions 1 % AEP flood depths and proposed retarding basin locations



# 4 MANAGEMENT OF FLOWS

The Wonthaggi NE PSP is in a location which is prone to widespread flooding in the 1 % AEP event. **Appendix B** shows the 1 % AEP flood extent under current existing conditions. The flooding is influenced by inflows from the proposed development areas and also areas upstream of the development. Areas in the north of the PSP and to the north of the PSP are also flooded from the Powlett River in a 1 % AEP flood event. To enable the development of this land, the inflows from external catchments will need to be managed as will the runoff from the developing areas.

## 4.1 PIPES AND ROADWAYS

The drainage design within the development areas should follow the major / minor principle set out in the Infrastructure Design Manual. Where 1 % AEP flows are less than 10 m³/s a combination of piping the 20 % AEP flows and having the “gap” flow to safely be conveyed along a future road has been adopted as a suitable drainage solution. Where flows are above 10 m³/s it is generally difficult to convey them safely along a road with a pipe underneath. In these areas open waterways have been proposed.

It is important that the development plans for these areas allow for a road network to convey runoff in major storms through to the waterways. This scenario applies for the existing urban catchments and for some of the smaller rural catchments which flow into the development area. **Appendix C** shows the proposed stormwater management strategy including the preliminary pipe flow locations entering the development area from the external urban and rural catchments. **Appendix D** includes the recommended points of discharge and pipe alignments connecting into primary treatment infrastructures for each internal catchment.

## 4.2 CONSTRUCTED WATERWAYS

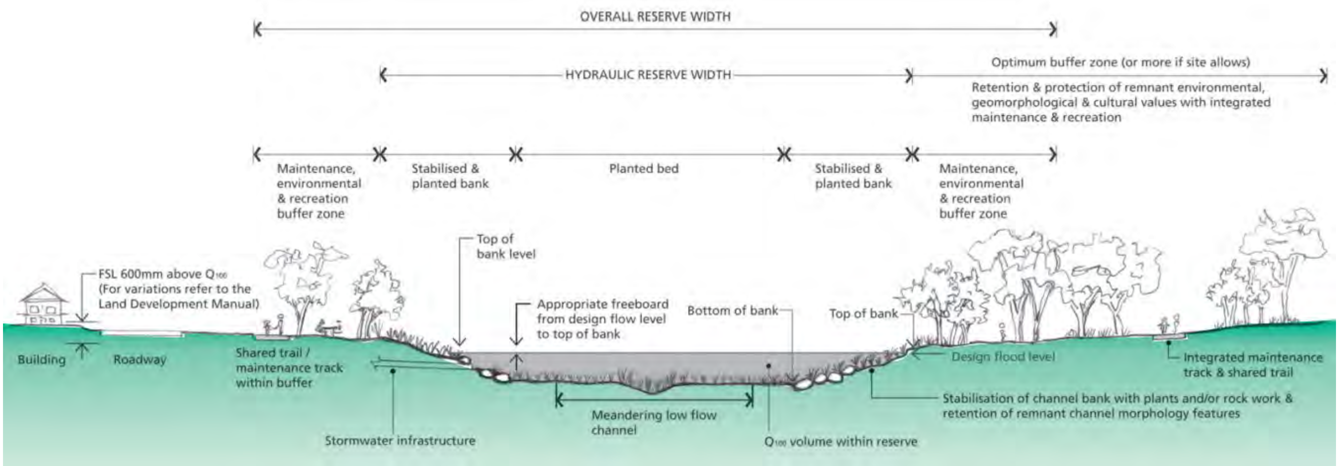
Engeny understands that the existing waterways within the development area have been significantly modified from their natural form and most are what would be classified as rural drains. These drains are suitable for management of flows in a rural environment but do not provide an adequate level of service in an urban setting.

Where the flow in the 1 % AEP event is greater than 10 m³/s a constructed waterway is proposed. Constructed waterways should be sized to convey the full 1 % AEP flow with 600 mm freeboard to the habitable floor level of any adjacent dwellings. They should be designed with a pilot channel capable of conveying regular flows. Constructed waterways offer improved environmental and aesthetical outcomes over an open drain as they can provide habitat for native fauna and flora while still providing the drainage utility. Other benefits include public amenity and the opportunity for shared paths to link communities. Engeny recommend that Council adopt Melbourne Water’s Constructed Waterway Guidelines and Waterway Corridor Guideline documents as a basis for the design of waterways in the precinct given that Bass Coast Shire Council does not have its own relevant guideline.

The Infrastructure Design Manual (IDM) does not include guidance for constructed waterways however it does provide guidance for design of floodways. The key difference between a floodway as defined in the IDM and a constructed waterways is that a floodway conveys gap flows and low flows are conveyed in pipes (as opposed to low flows conveyed in a low flow channel for a constructed waterway). The IDM indicates a minimum 1 in 300 grade for a floodway to avoid the impacts of sedimentation. Natural grades in the development area are flatter than 1 in 300. The IDM also allows rural channels at 1 in 500 in Bass Coast Shire and up to 1 in 2000 in other municipal areas. Melbourne Water’s constructed waterway design guidelines allows for channel grade to be down to 1 in 800. The channel grades adopted in the PSP area are all steeper than 1 in 800, however some reaches near wetland 1 are approaching this slope.

Council should require roads be built on either side of the waterway corridor where possible to promote passive surveillance of the waterways to reduce the risk of rubbish dumping and also to allow for maintenance access along the waterway. With the current location of the eastern waterway roads will only be able to be built along the western side of the waterway within the development area as the eastern boundary of the proposed waterway is on the edge of the development area.

**Figure 4-1: Schematic example of a constructed waterway (source MW constructed waterway guidelines)**

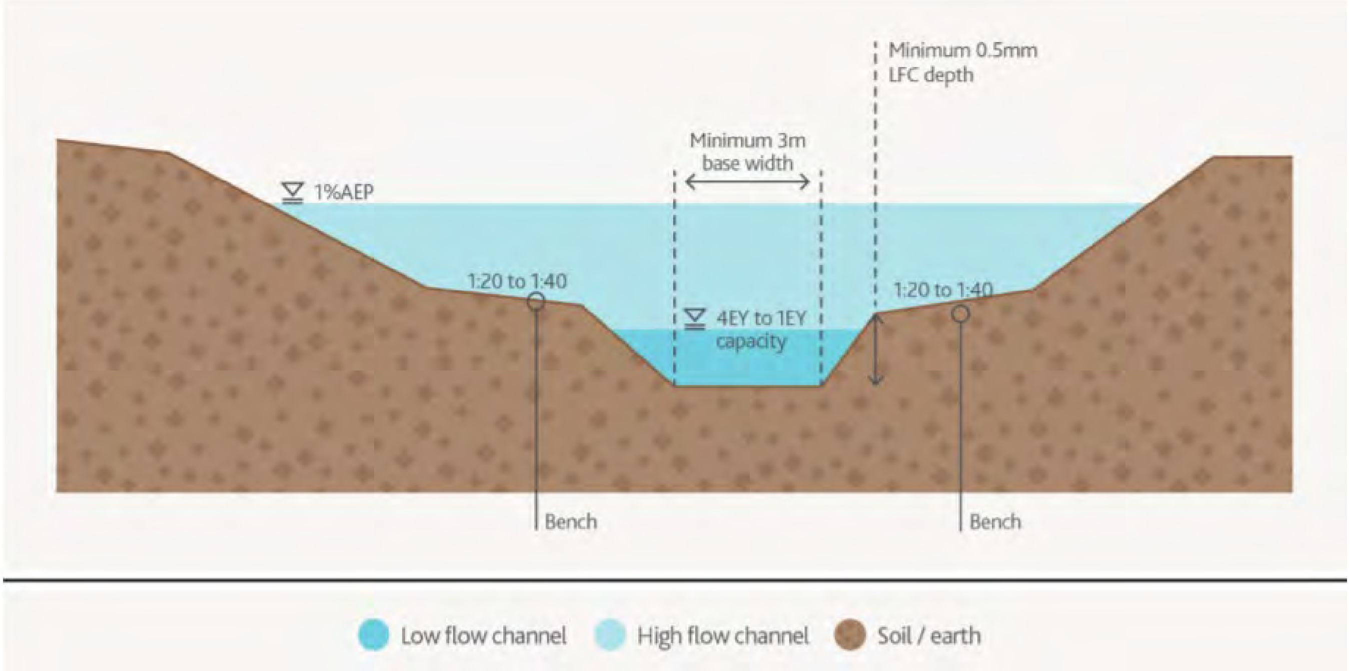



**Appendix C** shows the proposed constructed waterway alignments. The development area will require two constructed waterways, referred to in this document as the east and west waterways. The west waterway generally follows the existing waterway drainage lines through the area. The WGCMA has requested a 60 m waterway corridor downstream of McGibbonys Road through to the proposed wetlands adjacent to the Korumburra Wonthaggi Road. Upstream of McGibbonys Road the proposed waterway corridor width varies between 55 and 30 m. Approved development plans for Parklea Estate and Powlett Ridge Estate have been provided by council indicating the land designated for the proposed west waterway. Although the overall waterway corridor width varies from Powlett Ridge Estate down to Parklea Estate, the land takes set out in the approved development plans have been adopted in this document.

Both constructed waterways have been designed generally in accordance with Melbourne Water's Constructed Waterway Design Manual (December, 2019). The constructed waterways have been designed with a defined low flow or pilot channel and high flow channel as shown in the section in Figure 4-2.

The location of the east waterway is somewhat flexible in some areas given the very flat topography closer to the proposed wetlands. There is a defined low point in the Bass Highway where the upstream end of the waterway is proposed to begin. Downstream of this it is recommended that the waterway runs along the edge of the development area where council has expressed a preference for locating the waterway within the development boundary. Locating the waterway along the boundary of the development will effectively ensure the shallow but widespread flow paths from the rural catchments are safely intercepted and conveyed, without sheet flow into urban properties. Alternatively, locating the waterway elsewhere would mean that the safe conveyance of these external flows would be significantly dependent on the capacity and location of the road networks within the development area.

**Figure 4-2: Typical compound waterway section example (MW Constructed Waterway Design Manual)**




### 4.2.1 Design Methodology

The pilot channel has been designed to convey up to and including the 1EY flow with flows up to and including the 1 % AEP conveyed in the larger high flow channel with an allowance for 300 mm freeboard within the channel. It is proposed that the remaining 300 mm freeboard (to achieve a total of 600 mm freeboard to habitable floor levels) should be achieved within the development areas through either filling the lots or through a raised slab for the dwelling. The pilot channels for both constructed waterways were indicatively sized using a channel manning's calculation with 1EY flows from the developed conditions RORB model at specific locations along both waterways. These indicative sizes were then entered into the HECRAS model of each of the waterways to confirm that the pilot channel has sufficient capacity to convey the 1EY flows.

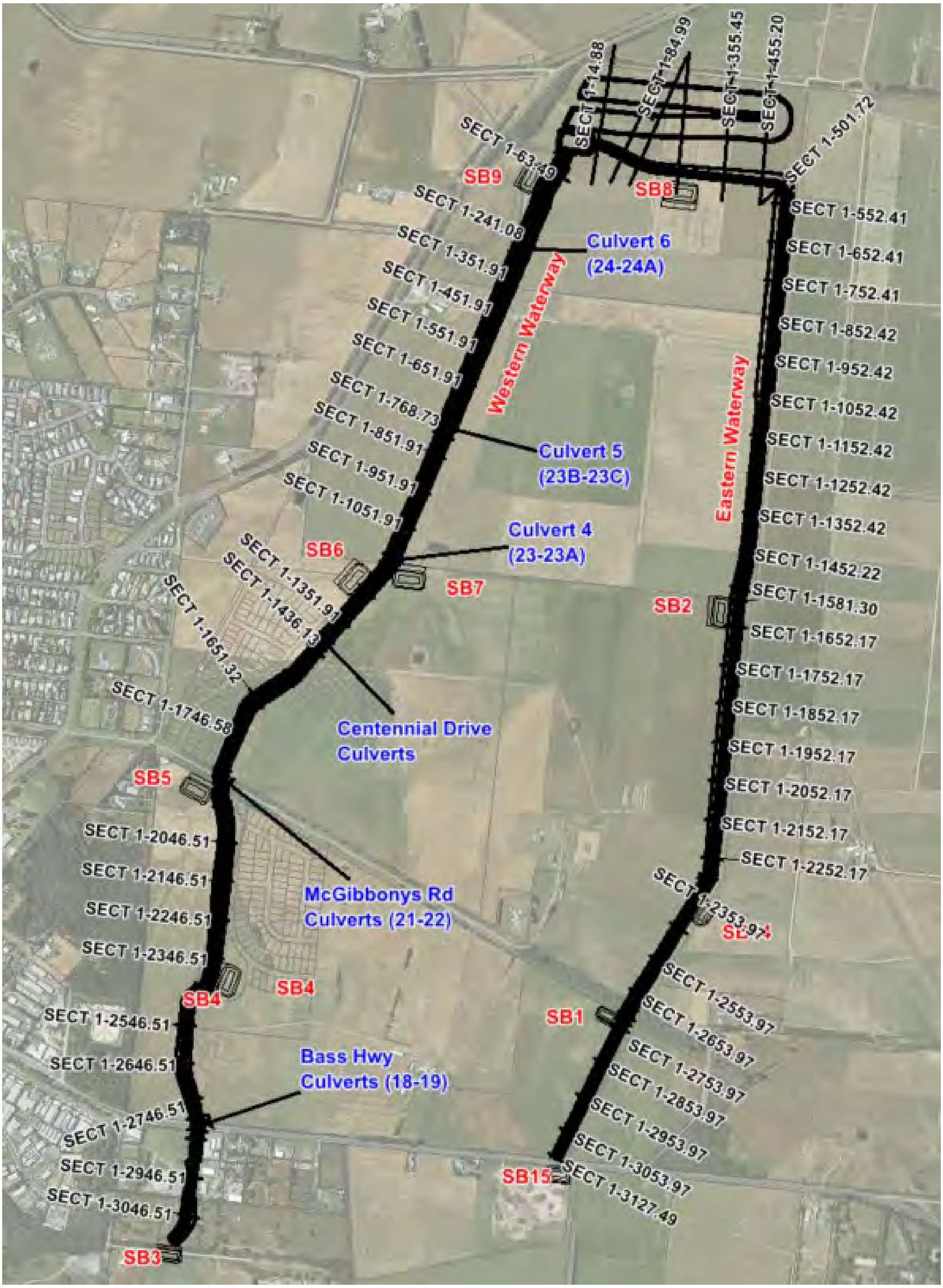
The inverts of the constructed waterways, and more specifically the pilot channels, have been set based on downstream wetland levels and incoming sedimentation basin levels. The inverts of the waterways have been set below the sedimentation basin normal water levels (NWL). The pilot channel has been sized such that the 1EY flow can be conveyed in the pilot channel with the peak water level being below the adjacent sedimentation basin NWL. This will ensure that frequent backflow into the sedimentation basins from the channel does not occur. Further detail on how the sedimentation basin NWLs have been set is contained in section 5.3.

### 4.2.2 HECRAS Modelling

Engeny developed a HECRAS model for both the east and west waterway to confirm 1EY flows are contained within the pilot channel and 1 % AEP flows are contained within the larger flow channel with an allowance for freeboard. The peak flood levels from the TUFLOW modelling were used to inform the downstream tailwater conditions on each of the channels in the HECRAS model. Figure 4-3 below provides an overview of the developed HECRAS models for the east and west waterways.

The modelling of the channels assumed a Manning's roughness value of 0.055. This is within the recommended range within the Melbourne Water Constructed Waterway Guidelines of between 0.045 and 0.06 for a compound waterway. The value has been applied uniformly across the whole channel.

**Figure 4-3: HECRAS models for east and west waterways**



### 4.2.3 Eastern Waterway HECRAS Modelling

The flows modelled in HECRAS at various locations for each flood event are tabulated in Table 4-1.

**Table 4-1: Eastern Waterway HECRAS Model Inflow Locations**

| HECRAS Chainage | Location | 1 EY flow ($m^3/s$) | 1 % AEP flow ($m^3/s$) | 1 % AEP Climate Change flow ($m^3/s$) |
|---|---|---|---|---|
| 3127.49 | SB 15 | 1.23 | 6.06 | 7.74 |
| 2718.85 | SB 1 | 3.43 | 18.11 | 22.52 |
| 2300.42 | SB 14 | 3.76 | 19.88 | 23.26 |
| 1552.02 | SB 2 | 4.11 | 20.80 | 26.42 |
| 235.87 | SB 8 | 4.52 | 20.87 | 27.19 |

The downstream retarding basin Top Water Level (TWL) was used to set the downstream tailwater condition in the HECRAS model in both the 1 EY and 1 % AEP and 1 % AEP climate change flows. The upstream boundary condition modelled was based on the upstream slope. Table 4-2 shows the boundary conditions that were used for HECRAS modelling.

**Table 4-2: Eastern Waterway HECRAS Model Boundary Conditions**

| Boundary Condition | 1 EY | 1 % AEP | 1 % AEP Climate Change |
|---|---|---|---|
| Downstream fixed water level (m AHD) | 15.4 | 16.45 | 16.45 |
| Upstream (normal slope) | 0.00384 | 0.00384 | 0.00384 |

Table 4-3 shows dimensions of the pilot channel and high-flow channel at each section of the waterway.

**Table 4-3: Eastern Waterway Dimensions**

| Section | Pilot Channel Base Width (m) | Pilot Channel Depth (m) | High Flow Channel Base Width (m) | Approximate Top Width of Channel (m) |
|---|---|---|---|---|
| SB 15 – SB 1 | 3 | 0.50 | 10 | 25 |
| SB 1 – SB 14 | 7 | 0.50 | 14 | 30 |
| SB 14 – SB 2 | 8 | 0.75 | 16.5 | 38 |
| SB 2 – Ch 1052 | 9 | 0.75 | 17.5 | 35 |
| Ch 1052 – Ch 552 | 9 | 0.75 | 33.5 | 50 |
| Ch 501 – SB 8 | 9 | 0.75 | High-flow channel not present | Not Applicable (channel is adjacent to retarding basin in this section) |
| SB 8 – WL 1 | 9 | 0.75 | High-flow channel not present | Not Applicable (channel is adjacent to retarding basin in this section) |

Table 4-4 indicates the invert levels and longitudinal grade at each section of the waterway.

**Table 4-4: Eastern Waterway Invert Levels and Longitudinal Grades**

| Section | Upstream Invert Level (m AHD) | Downstream Invert Level (m AHD) | Longitudinal Grade |
|---|---|---|---|
| SB 15 – SB 1 | 22.0 | 20.50 | 1 in 271 |
| SB 1 – SB 14 | 20.50 | 17.35 | 1 in 133 |
| SB 14 – SB 2 | 17.35 | 16.21 | 1 in 613 |
| SB 2 – SB 8 | 16.21 | 14.0 | 1 in 613 |
| SB 8 – WL 1 | 14.0 | 13.60 | 1 in 613 |

### 4.2.4 Eastern Waterway HECRAS Results

HECRAS modelling for the eastern waterway has indicated the following:

- A minimum of 300 mm freeboard is being achieved in all sections.
- The pilot channel generally conveys the 1 EY flows, with the exception being the section of channel in between chainage 750 and the downstream end of the channel, as the 1 EY flood level is influenced by the downstream tail water level of the retarding basin in this section.
- The 1 % AEP climate change flows are contained within the channel.

The results of the HECRAS modelling at shown in Appendix E.

### 4.2.5 Western Waterway HECRAS Modelling

The flows modelled in HECRAS at various locations for each flood event are tabulated in Table 4-5.

**Table 4-5: Western Waterway HECRAS Model Inflow Locations**

| HECRAS Chainage | Location | 1 EY flow ($m^3/s$) | 1 % AEP flow ($m^3/s$) | 1 % AEP Climate Change flow ($m^3/s$) |
|---|---|---|---|---|
| 3046.51 | SB 3 | 3.44 | 15.57 | 19.53 |
| 2824.61 | CDS (Bass Highway) | 3.83 | 16.71 | 21.10 |
| 2346.51 | SB 4 | 4.86 | 20.59 | 26.10 |
| 1913.10 | SB 5 (McGibbonys Road) | 5.81 | 24.23 | 30.52 |
| 1165.58 | SB 7 (Culvert 4) | 8.70 | 34.44 | 42.92 |

As was modelled for the Eastern Waterway, the retarding basin Top Water Level (TWL) was used to set the downstream tailwater condition in the HECRAS model in both the 1 EY and 1 % AEP and 1 % AEP climate change flows. The upstream boundary condition was based on the upstream slope. Table 4-6 shows the boundary conditions used for the HECRAS modelling.

**Table 4-6: Western Waterway HECRAS Model Boundary Conditions**

| Boundary Condition | 1 EY | 1 % AEP | 1 % AEP Climate Change |
|---|---|---|---|
| Downstream fixed water level (m AHD) | 15.4 | 16.45 | 16.45 |
| Upstream (normal slope) | 0.00592 | 0.00592 | 0.00592 |

Table 4-7 shows dimensions of the pilot channel and high-flow channel at each section of the waterway.

### Table 4-7: Western Waterway Dimensions

| Section | Pilot Channel Base Width (m) | Pilot Channel Depth (m) | High Flow Channel Base Width (m) | Approximate Top Width of Channel (m) |
|---|---|---|---|---|
| SB 3 to Bass Highway | 5.5 | 0.60 | 13.1 | 30 |
| Bass Highway to south of Powlett Ridge Estate | 5.5 | 0.70 | 13.7 | 35 |
| South of Powlett Ridge Estate South to SB 4 (assumed to be constructed) | 4 | 1 | 18.0 | 35 |
| SB 4 to SB 5 / McGibbonys Road (constructed) | 4 | 1 | 18.0 | 40 |
| McGibbonys Road to Centennial Drive Culvert | 10 | 0.60 | 17.6 | 40 |
| Centennial Drive Culvert to SB 7 / Culvert 4 | 12 | 0.55 | 19.4 | 35 |
| Culvert 4 to Culvert 5 | 12 | 0.75 | 20.5 | 40 |
| Culvert 5 to Culvert 6 | 12 | 0.80 | 30.8 | 45 |
| Culvert 6 to SB 9 | 12 | 1.0 | 28 | 45 |
| SB 9 to WL 1 | 12 | 1.1 | 28.6 | 45 |

Table 4-8 shows dimensions of the pilot channel and high-flow channel at each section of the waterway.

### Table 4-8: Western Waterway Invert Levels and Longitudinal Grades

| Section | Upstream Invert Level (m AHD) | Downstream Invert Level (m AHD) | Longitudinal Grade |
|---|---|---|---|
| SB 3 to Bass Highway | 24.80 | 23.0 | 1 in 168 |
| Bass Highway to south of Powlett Ridge Estate | 22.80 | 21.40 | 1 in 173 |
| South of Powlett Ridge Estate South to SB 4 (assumed to be constructed) | 21.39 | 20.98 | 1 in 332 |
| SB 4 to SB 5 / McGibbonys Road (constructed) | 20.98 | 19.48 | 1 in 332 |
| McGibbonys Road to Centennial Drive Culvert | 19.28 | 17.02 | 1 in 186 |
| Centennial Drive Culvert to SB 7 / Culvert 4 | 16.82 | 15.65 | 1 in 209 |
| Culvert 4 to Culvert 5 | 15.55 | 14.98 | 1 in 607 |
| Culvert 5 to Culvert 6 | 14.88 | 14.15 | 1 in 657 |
| Culvert 6 to SB 9 | 14.05 | 13.72 | 1 in 653 |
| SB 9 to Wetland | 13.72 | 13.60 | 1 in 344 |

### 4.2.6 Western Waterway HECRAS Results

HECRAS modelling has indicated the following:

- Generally, a minimum of 300 mm of freeboard is achieved from the 1 % AEP Flood Level to the top of the channel. However, there are sections within the waterway which modelling shows that 300 mm of freeboard is not achieved to the top of the channel. This is evident from approximately Chainage 751 to Chainage 241. In these sections, the ground level on the eastern and western sides are required to be filled to a minimum of 300 mm above the applicable adjacent flood level.
- The pilot channel generally conveys the 1 EY flows, with the exception being the section of channel in between Chainage 1332 and the downstream end of the channel, as the 1 EY flood level is influenced by the downstream tail water level of the retarding basin.
- There is no overtopping of any of the culvert crossings in the 1 % AEP flood event.

The results of the HECRAS modelling at shown in **Appendix E**.

### 4.2.7 Western waterway culvert sizing

Culvert crossings for the proposed road crossings of the waterways have been sized mainly in HECRAS. The culverts have been sized to convey the 1 % AEP event. No blockage factor or increase in flows from climate change has been used when sizing the culverts. The culverts have also been sized with the objective of providing at least 700 mm cover from the obvert of the culvert to the proposed road surface level. Table 4-9 shows the proposed culvert sizes.

**Table 4-9: Western Waterway Culvert Details**

| Culvert ID | Chainage | Size | Length (m) | Upstream Invert Levels (m AHD) | Downstream Invert Level (m AHD) | Top Road level (m AHD) |
|---|---|---|---|---|---|---|
| Bass Highway Culverts (18-19) | 2871 | 4 x 1500 mm | 32 | 23.0 | 22.8 | 25.10 (upstream side)<br>24.89 (downstream side) |
| Existing McGibbonys Road Culverts (21-22) | 1960 | 4 x 1650 mm | 48.03 | 19.48 | 19.28 | 22.04 |
| Centennial Drive Culverts | 1480 | 2 x [3.6 m (W) x 1.2 m (H)] Box Culverts | 20 | 17.02 | 16.83 | 18.97 (upstream side)<br>18.78 (downstream side) |
| Culvert 4 (23-23A) | 1212 | 4 x [3.6 m (W) x 1.5 m (H)] Box Culverts | 22 | 15.65 | 15.55 | 17.90 (upstream side)<br>17.80 (downstream side) |
| Culvert 5 (23B-23C) | 846 | 4 x [3.6 m (W) x 1.5 m (H)] Box Culverts | 27 | 14.98 | 14.88 | 17.23 (upstream side)<br>17.13 (downstream side) |
| Culvert 6 (24-24A) | 339 | 4 x [3.6 m (W) x 1.5 m (H)] Box Culverts | 32 | 14.16 | 14.05 | 16.76 |

Note that while the Centennial Drive culverts have been included in the modelling to determine their impact on the hydraulic function of the waterway the culverts are not a PSP item as Centennial Drive is not a crossing outlined in the PSP layout.

Sensitivity runs of the HECRAS model have been completed to determine what the impact of blockage or climate change would be on the culverts. **Appendix F** contains the culvert blockage calculations. Table 4-10 shows the assumed blockage level on each of the culverts as a result of the assessment completed. The results of the modelling showed that the roads would overtop in the event of blockage occurring on the culverts. Table 4-10 also shows the depth of overtopping at each of the culverts. The depth and velocity of overtopping results in a hazard category of H1 as defined by book 6 chapter 7 (Safety Design Criteria) of Australian Rainfall and Runoff. This category is classed as being generally safe for people, vehicles and buildings.

**Table 4-10: Assumed culvert blockages and overtopping**

| Culvert Name (PSP Identifier) | % Blocked | Overtopping depth (m) | Overtopping velocity (m/s) | Overtopping D*V ($m^2/s$) |
|---|---|---|---|---|
| Bass Highway Culverts (18-19) | 25 | 0.06 | 0.33 | 0.02 |
| Existing McGibbonys Road Culverts (21-22) | 25 | 0.13 | 0.39 | 0.06 |
| Centennial Drive Culverts | 25 | 0.16 | 0.55 | 0.09 |
| Culvert 4 (23-23A) | 25 | 0.07 | 0.38 | 0.03 |
| Culvert 5 (23B-23C) | 25 | 0.15 | 0.54 | 0.08 |
| Culvert 6 (24-24A) | 25 | 0.11 | 0.47 | 0.05 |

Table 4-11 shows the overtopping depths and velocities which occur under the 1 % AEP climate change conditions flows. The depth and velocity of overtopping results in a hazard category of H1 as defined by book 6 chapter 7 (Safety Design Criteria) of Australian Rainfall and Runoff. This category is classed as being generally safe for people, vehicles and buildings.

**Table 4-11: Climate change sensitivity overtopping**

| Culvert Name (PSP Identifier) | Overtopping depth (m) | Overtopping velocity (m/s) | Overtopping D*V ($m^2/s$) |
|---|---|---|---|
| Bass Highway Culverts (18-19) | 0.04 | 0.26 | 0.01 |
| Existing McGibbonys Road Culverts (21-22) | 0.15 | 0.44 | 0.07 |
| Centennial Drive Culverts | 0.17 | 0.56 | 0.10 |
| Culvert 4 (23-23A) | 0.11 | 0.46 | 0.05 |
| Culvert 5 (23B-23C) | 0.17 | 0.57 | 0.10 |
| Culvert 6 (24-24A) | 0.11 | 0.45 | 0.05 |

### 4.2.8 Waterway corridor widths

Table 4-12 below summarises the required hydraulic widths and total corridor widths of the waterways within the development area. All proposed corridor widths tabulated below (excluding waterway reaches 17-18, 22-23, 23-24) include an allowance for vehicle access on both sides of the waterway, alternatively if future road alignments already provide this access, waterway widths can be reduced in accordance with Melbourne Water's Constructed Waterways Guidelines. **Appendix C** contains a plan showing the locations of each of the waterways.

**Table 4-12: Waterway corridor widths**

| Waterway Reach | Required Hydraulic Width | Proposed Corridor Width |
|---|---|---|
| Eastern Waterway | | |
| SB 15 – SB 1 | 30 | 55 |
| SB 1 – SB 14 | 30 | 60 |
| SB 14 – SB 2 | 50 | 60 |
| SB 2 – Ch 1052 | 50 | 60 |

| Waterway Reach | Required Hydraulic Width | Proposed Corridor Width |
|---|---|---|
| Ch 1052 – Ch 552 | 50 | 60 |
| Ch 501 – WL1 | N/A – Within WLRB1 | N/A – Within WLRB1 |
| **Western Waterway** | | |
| SB 3 to Bass Highway | 30 | 40 |
| Bass Highway to south of Powlett Ridge Estate | 35 | 55 |
| South of Powlett Ridge Estate South to SB 4 (assumed to be constructed) | 35 | 55 |
| SB 4 to SB 5 / McGibbonys Road (constructed) | 40 | 60 |
| McGibbonys Road to Centennial Drive Culvert | 40 | 60 |
| Centennial Drive Culvert to SB 7 / Culvert 4 | 35 | 60 |
| Culvert 4 to Culvert 5 | 40 | 60 |
| Culvert 5 to Culvert 6 | 45 | 60 |
| Culvert 6 to SB 9 | 45 | 60 |
| SB 9 to WL 1 | 45 | 60 |

The widths upstream of McGibbonys Road and through Powlett Ridge Estate on the western waterway have been documented in this report to match the widths and locations from previous work, approved development plans and from consultation with landowners as they hydraulically can still convey the 1 % AEP flows. Adjustments to the total corridor width in approved development areas may be required however to provide access to both sides of the waterway in accordance with Melbourne Water's Guidelines.

The Eastern Waterway has been assumed to have a shared path/road on one side of the waterway across the entire length where the other side could require the addition of a shared trail or maintenance track as outlined in Melbourne Water's Waterway Corridors Guideline (2013).

## 4.3 EXTERNAL CATCHMENTS

There are a number of external catchments which will drain into the development area. To the west of the development area there are some existing urban catchments, while to the south and east there are large rural catchments. The external catchments which drain into the development area are shown in **Appendix A**. To manage the external catchments passing through the PSP, a series of pipes have been sized to convey the 20 % AEP flows through the PSP's residential area and 10 % AEP flows for pipes located within the PSP's southern industrial area. Future development within the PSP will also need to appropriately consider the road / easement alignments in order to safely convey major flows and ensure dwellings are not affected by flooding during these storm events.

The following approach and assumptions have been adopted in the sizing of external catchment conveyance pipes:

- The critical median 20 % AEP (for residential areas) or 10 % AEP (for industrial areas) flows have been extracted from the developed RORB model.
- A manning's calculation has been undertaken to size each pipe for the RORB flow and a pipe grade informed by the natural ground levels.

Table 4-13 summarises the external catchment conveyance pipe diameters with the Pipe IDs referenced and displayed on a plan in Figure 4-4.

## Figure 4-4: Proposed Stormwater Treatment Infrastructure

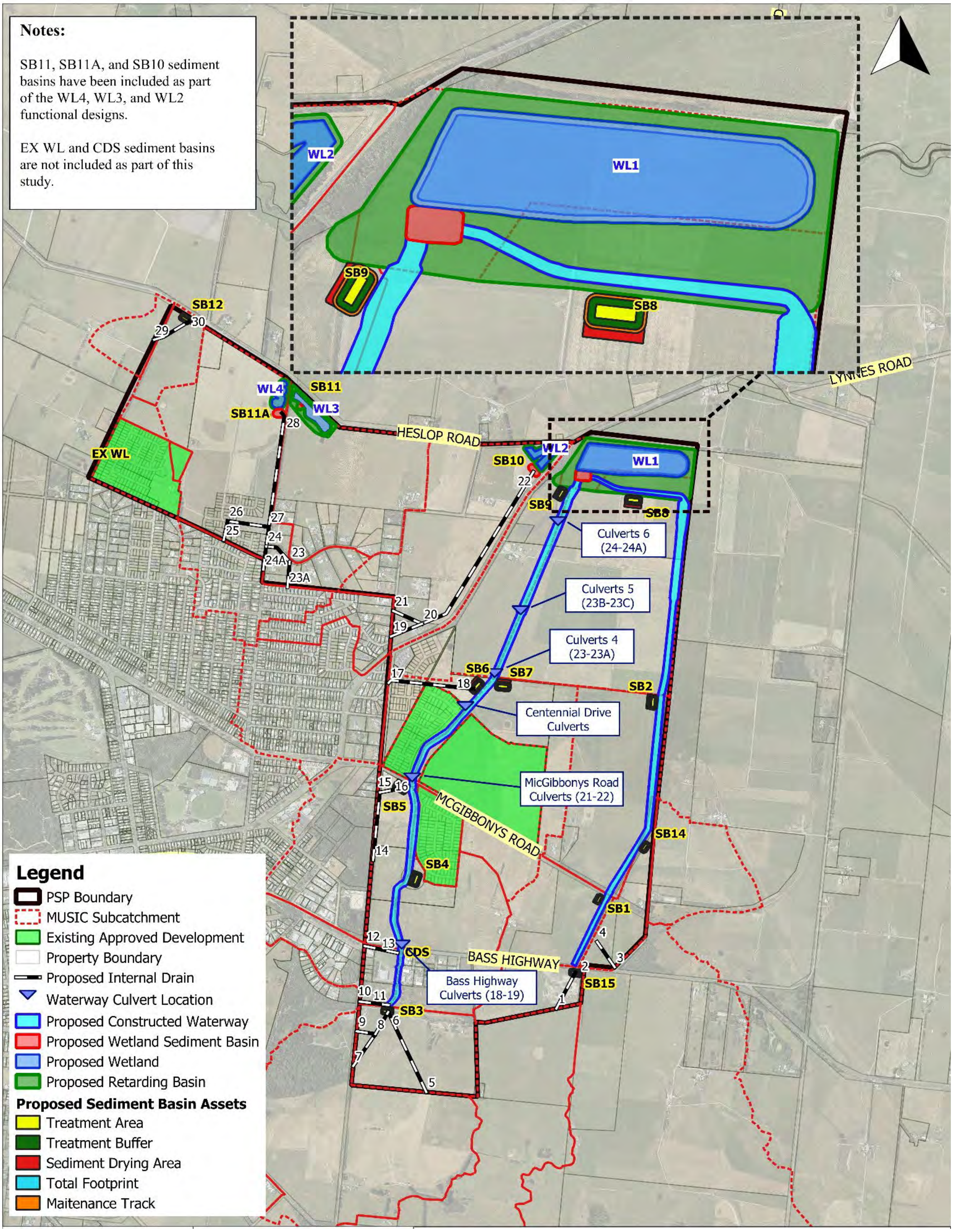


**Table 4-13: External Catchment Conveyance Pipes**

| Pipe ID | PSP Land use | Flow ($m^3/s$) | Pipe Slope (1 in x) | Pipe Diameter (m) | Pipe Length (m) |
|---|---|---|---|---|---|
| P1-2 | Industrial | 3.36 | 290 | 1.50 | 230 |
| P3-4 | Residential | 5.17 | 300 | 1.65 | 165 |
| P5-6 | Industrial | 2.56 | 348 | 1.35 | 475 |
| P7-8 | Industrial | 2.54 | 63 | 1.05 | 210 |
| P8-6 | Industrial | 2.97 | 193 | 1.35 | 150 |
| P9-8 | Industrial | 0.72 | 317 | 0.825 | 100 |
| P10-11 | Industrial | 2.58 | 131 | 1.20 | 155 |
| P12-13 | Industrial | 2.43 | 79 | 1.05 | 180 |
| P14-15 | Residential | 2.38 | 330 | 1.35 | 365 |
| P15-16 | Residential | 2.33 | 300 | 1.35 | 165 |
| P17-18 | Residential | 4.67 | 133 | 1.50 | 480 |
| P19-20 | Residential | 0.89 | 77 | 0.675 | 180 |
| P20-22 | Residential | 1.77 | 158 | 1.05 | 1035 |
| P21-20 | Residential | 0.88 | 51 | 0.675 | 170 |
| P23A-23 | Residential | 5.05 | 31 | 1.20 | 135 |
| P23-24 | Residential | 5.05 | 105 | 1.35 | 160 |
| P24A-24 | Residential | 5.05 | 38 | 1.20 | 125 |
| P24-27 | Residential | 5.05 | 38 | 1.20 | 105 |
| P25-26 | Residential | 3.05 | 45 | 1.35 | 105 |
| P26-27 | Residential | 3.05 | 221 | 1.35 | 225 |
| P27-28 | Residential | 8.10 | 103 | 1.65 | 620 |
| P29-30 | Residential | 1.24 | 94 | 0.825 | 210 |

# 5 STORMWATER TREATMENT

## 5.1 PURPOSE

The stormwater runoff generated from the development will need to be treated in accordance with Clause 56 of the planning scheme and the State Environment Protection Policy Waters of Victoria. These documents require stormwater to be treated in accordance with the Best Practice Environmental Management Guidelines (BPEMG). Table 5-1 displays the stormwater pollutant percentage reductions before it is discharged into the "receiving waters" or in the case of this development, the Powlett River.

**Table 5-1: Required pollutant removal**

| Pollutant | Required percentage reduction |
|---|---|
| Total Suspended Solids (TSS) | 80 % |
| Total Phosphorus (TP) | 45 % |
| Total Nitrogen (TN) | 45 % |
| Gross Pollutants | 70 % |

## 5.2 APPROACH

Water Sensitive Urban Design (WSUD) assets are to be constructed to achieve the BPEMG pollutant removal targets. Council has expressed a preference for centralised stormwater treatment infrastructure to help minimise the maintenance associated with the assets. Providing centralised assets also helps to reduce the total overall cost and can allow for assets to be located in logical areas, such as within flood affected land which could otherwise not be developed.

Engeny has utilised the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software version 6.3 to assess the treatment effectiveness and footprint area requirements of the proposed stormwater quality assets.

The following provides a summary of the key inputs and assumptions adopted:

- 10 Year Rainfall data (1984-1993) obtained for the Narre Warren North Station (ID 086085) and corresponding to Melbourne Water's MUSIC rainfall template. Given no pluviographic data is available for Wonthaggi, this data was considered to be suitably representative. Data was available for other stations but the nearest was 45 km away and was the Koo Wee Rup station which has a lower annual rainfall of 769 mm when compared to Wonthaggi recorded mean annual rainfall of approximately 940 mm. The Narre Warren weather station is approximately 65 km from Wonthaggi and has a mean annual rainfall of 932 mm.
- Mean monthly potential evapotranspiration data consistent with Melbourne Water's Narre Warren North rainfall template (equating to a mean annual value of 985 mm).
- Soil input parameters in line with Melbourne Water's guidelines including:
  - Soil Storage Capacity = 120 mm
  - Field Capacity = 50 mm
- Source nodes informed by combined RORB subarea boundaries and the corresponding weighted fraction impervious values. The following source node types have been utilised:
  - Urban source node for existing residential areas and the proposed PSP development areas.
  - Agricultural source node for external farmland catchment areas.
- WSUD assets represented by the relevant stormwater treatment nodes including:
  - Rainwater tanks connected to roof areas.

- Wetlands treating runoff from the development PSP area and external catchments.
- Sediment Ponds treating runoff from the development PSP area and external catchments to provide a primary form of treatment and protect the receiving proposed eastern and western constructed waterways where relevant.

**Appendix G** shows a layout plan of the location and size of the proposed treatment assets. As discussed in the following sections of the report, these assets have been sized to treat the runoff generated from the Wonthaggi North East PSP area and meet the BPEMG pollutant removal targets. The plan also highlights that the only developable area not treated by an asset or included within the MUSIC model is the north-western portion of the PSP. This area of approximately 17.7 hectares is directed into an existing wetland asset which is understood to have been sized to cater for this PSP catchment area.

## 5.3 SEDIMENT BASINS

In order to protect the proposed constructed waterways and / or wetland assets from high sediment loads all stormwater generated within the PSP will be discharged into a sedimentation basin for primary treatment. This may result in the need to construct drainage pipes running in parallel to the constructed waterways for short lengths to convey the stormwater to the sedimentation ponds and limit the number of discharge points into the waterway.

The following provides a summary of the approach adopted in the sizing of each sediment pond proposed:

- The developed conditions RORB model was utilised to extract the 1EY inflow to each sediment basin. This flow was multiplied by 40 % to estimate the 4EY or 3-month flow in line with Melbourne Water's Constructed Wetlands Guidelines. Sizing the sediment ponds based on a 3-month flow is not consistent with the recommendations within the IDM which suggest assets should be sized to treat the 1EY flows. This would however result in substantially larger assets and footprint requirements. As the Melbourne Water Constructed Wetland Guideline is being referred to for the design of wetlands this was considered a more consistent approach.
- The sediment pond inflow includes the runoff generated from the PSP area in addition to the external catchments where relevant particularly if the external areas consist of existing residential land use areas. A portion of the agricultural land to the south and east of the PSP has been assumed to enter the waterway directly without any pretreatment as it is assumed that sediment loads from farmland should be low. A sediment pond has also been proposed at the inlet to Wetland 1 to help protect the significant wetland asset from high sediment loads, especially during the long period in which development construction is occurring within the catchment.
- The Fair and Geyer equation has been adopted with the following key inputs:
  - Sediment removal fraction > 95 %.
  - Hydraulic efficiency = 0.3 (which corresponds to a length to width ratio of 1:3).
  - Sufficient storage for a 5-year cleanout frequency.
  - Permanent pool volume depth of 1.5 metres.
  - Extended detention depth of 0.35 metres.
  - 2.8 metre safety bench immediately below the normal water level at 1 in 8 for a depth of 0.35 metres.
  - 1 in 3 slope below the 2.8 metre wide safety bench.
- The sediment dry out area has been informed by the contributing catchment area, typical sediment loading rate (1.6 $m^3$ / ha), cleanout frequency and assumption that sediment dry out would occur at a 0.5 metre thickness.

Table 5-2 summarises the proposed size of each of the sediment basins. The treatment areas at NWL and the estimated permanent pool volume were the key MUSIC model inputs utilised in addition to ensuring the notional detention time was approximately 12 hours and an overflow weir of 6 metres.

### Table 5-2: Sedimentation Basins Summary

| Asset ID | Area at Normal Water Level ($m^2$) | Area Required for Sediment Drying ($m^2$) | Permanent Pool Volume ($m^3$) | Estimated Total Asset footprint (allowing for sediment drying area, battering and maintenance track) ($m^2$) |
|---|---|---|---|---|
| SB1 | 520 | 359 | 283 | 2875 |
| SB2 | 810 | 750 | 569 | 4290 |
| SB3 | 700 | 432 | 457 | 2670 |
| SB4 | 850 | 808 | 611 | 4440 |
| SB5 | 880 | 854 | 642 | 4380 |
| SB6 | 1030 | 1058 | 803 | 5070 |
| SB7 | 980 | 988 | 749 | 4900 |
| SB8 | 1230 | 1357 | 1025 | 5990 |
| SB9 | 700 | 595 | 457 | 3823 |
| SB10 | 1080 | 1131 | 858 | 4100 |
| SB11 | 920 | 795 | 685 | 2800 |
| SB11A | 900 | 1364 | 726 | 4320 |
| SB12 | 500 | 173 | 264 | 2620 |
| SB14 | 500 | 215 | 264 | 2500 |
| SB15 | 500 | 204 | 264 | 2500 |

As shown within the table above, as part of the sizing and concept design of each asset, the total footprint area for each sediment pond was also estimated. The following provides a summary of the approach adopted and considerations made to obtain these areas:

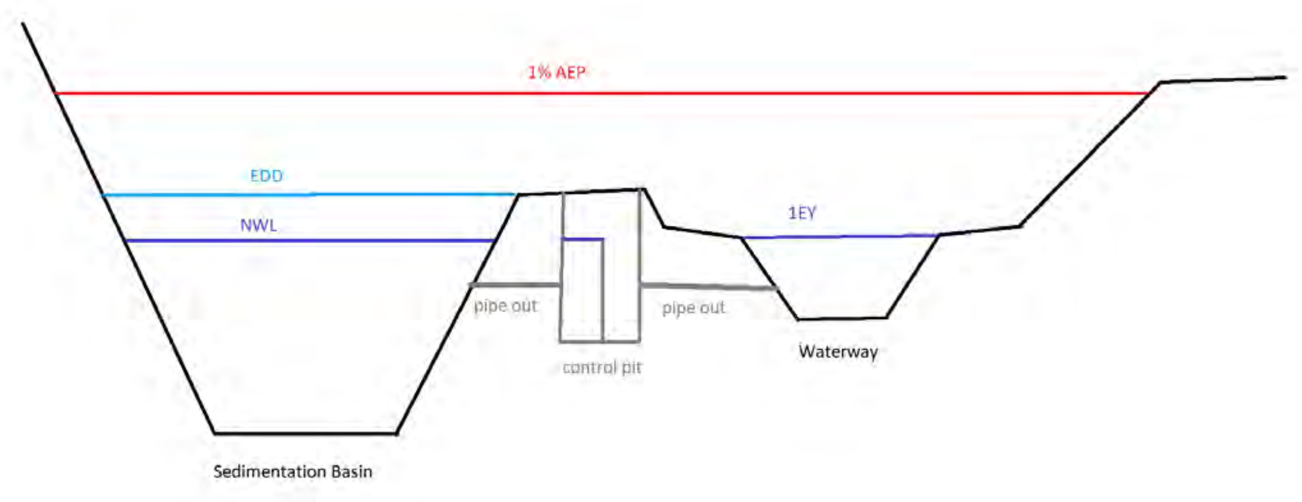
- The NWL of each sediment pond which was determined by:
  - Estimating the incoming pipe diameter based on a manning's calculation and sized for the peak 1EY upstream flow and a minimum 1 in 300 grade (the minimum pipe grade recommended in the IDM).
  - Making an allowance for 700 mm cover on top of the estimated incoming pipe diameter.
  - Assuming the incoming pipe would discharge into the sediment pond at the NWL.
  - Estimating the average natural ground level (based on LiDAR data or the proposed fill levels within the areas affected by flooding).
  - Subtracting the above total depth (pipe diameter + cover) from the ground / fill level to obtain the sediment pond's NWL.
- A 1 in 5 slope from the given NWL to the average natural ground or designated fill level was assumed.
- An allowance for a 4-metre-wide maintenance access track around the entire perimeter of the sediment pond top of bank was made.
- An allowance for the given sediment dry-out area beside a section of the maintenance access track was made.

**Appendix C** displays the resultant sediment pond locations and corresponding concept footprint areas. As part of future design stages (to be undertaken by others), detailed terrain modelling will be undertaken to define the exact footprint areas required particularly considering how battering would differ in areas which are not flat.

Based on the concept design approach described above the outfall arrangement was also considered. Figure 5-1 displays a typical section of how the sediment pond's outfall would function. As shown this would consist of:

- A low flow pipe. When discharging into a proposed constructed waterway it would outlet just below the main channel invert within the pilot channel as shown below.
- A spillway set at EDD.

**Figure 5-1: Sediment Pond Outfall Arrangement Typical Section**




## 5.4 CDS UNIT

An appropriately sized proprietary product such as a Continuous Deflection Separation (CDS) unit (or similar) is recommended to treat stormwater from Catchment G, upstream of Bass Highway as the catchment is relatively small creating an additional crossing of Bass Highway to pipe flows into the downstream sediment basin would add significant cost. These units are propriety sediment removal devices which are installed underground requiring significantly less land take whilst achieving comparable sediment load reductions to small sedimentation basins for small catchments.

## 5.5 RAINWATER TANKS

Implementing rainwater tanks as part of this strategy is proposed to:

- Reduce the total size and cost of treatment infrastructure by reducing the total annual volume of runoff entering the drainage system and requiring treatment.
- Provide a valuable alternative water source and opportunity to offset future potable water demands.

Each rainwater tank is proposed to be plumbed for toilet flushing to ensure a regular reuse demand. Harvested rainwater could also be used for garden irrigation, however given irrigation demands are variable depending on weather conditions and the habits of dwelling occupiers, no reuse for gardening has been assumed in the modelling. Rainwater tanks can also reduce peak runoff flow rates and provide attenuation during a storm event. Relying on this storage availability would require low flow outlets / smart tanks to be mandated to ensure that there is capacity in the tanks when a rainfall event occurs. Neither of these outfall arrangements have been assumed / modelled in the PSP area and so no benefit for storage is being claimed from the rainwater tanks.

Given possible maintenance and long term compliance issues associated with the ongoing effective operation and maintenance of the rainwater tanks, and their reliance on providing some stormwater treatment, the strategy has assumed that only 50 % of the lots would have rainwater tanks installed and connected to the dwellings roof area.

Rainwater tanks were also not modelled in areas where existing development or approved development plans exist and have already been approved without the requirement of rainwater tank installations. These make up portions of the Parklea and

Powlett Ridge Estates and other approved developments within the PSP which are represented with a green shade on the layout plan attached as **Appendix G**. Rainwater tanks have been assumed for the Summerfields Estate as it is understood they were required as part of that development.

The following provides a summary of the assumptions and inputs adopted for the MUSIC modelling of rainwater tanks:

- 11 dwellings per hectare of which 50 % of dwellings outside of approved / existing residential development areas would be connected to a rainwater tank (for new PSP development areas only).
- Rainwater tank size per lot = 2 KL.
- Roof Area per lot connected to tank = 200 $m^2$.
- Reuse rate = 16.5 L/person/day from toilet flushing.
- Average Number of people per house = 2.2 people / house (based on the 2016 Census data for the Wonthaggi urban centre and locality, this includes the suburbs of Wonthaggi, Wonthaggi North and South Dudley and represents the whole Wonthaggi township).
- Total reuse rate = 36.3 L / dwelling / day.

## 5.6 WETLANDS

### 5.6.1 Concept Design

Four wetland assets are proposed along the northern boundary of the PSP located within the retarding basin assets and providing the final form of treatment prior to discharging into 435 and 465 Heslop Road and then into the Powlett River. The MUSIC model was run iteratively to determine the treatment areas required to achieve the overall PSP's BPEMG pollutant removal targets. To appropriately consider the footprint requirements of these joint wetland and retarding basin assets, terrain modelling was undertaken.

The following approach and key design parameters were adopted in the MUSIC modelling of each wetland:

- Extended detention depth: 0.35 m.
- Inlet Pond Volume of zero for Wetland 3 given the sedimentation basin was modelled as an individual treatment node.
- Inlet Pond Volume set to the estimated volumes presented above for Wetlands 4, 2 and 1 given the concept wetland design has assumed the same NWL for both the sediment pond and wetland.
- Permanent Pool Depth equivalent to the bathymetry design below normal water level.
- Custom relationships for each wetland which included:
  - A stage storage relationship beginning at the NWL but also considering the permanent pool volume beneath the NWL. This was based on the concept terrain modelling undertaken for each wetland / retarding basin asset.
  - A pipe custom stage discharge relationship representing the penstock low flow outlet controlling the outflows between the wetland's NWL and EDD.
  - A weir custom stage discharge relationship representing the high flows from the wetland informed by the constraint of either a grated pit or spillway opening or relevant culvert crossing at Heslop Road or Korumburra-Wonthaggi Road. Flows for the culverts under Heslop Road and Korumburra-Wonthaggi Road came from the TUFLOW modelling, which also considers the impact of tailwater restrictions on outflows.

Table 5-3 summarises the resultant design parameters for each wetland. In contrast, Wetlands 1 and 2 are based on the terrain modelling undertaken as part of this scope of work. These concept designs have considered:

- The sediment inlet ponds sized and presented within Section 5.3 above and the corresponding sediment dry out area.
- A 4-metre-wide maintenance access track around the perimeter of the wetland.
- 1 in 5 batters from the wetland's NWL to the existing / proposed fill levels.
- The downstream culvert and farm channel invert levels and tailwater level constraints.
- The wetland outlet configuration influencing the inundation frequency, resultant effective NWL, residence time and planting requirements discussed further within Section 5.6.2 and Section 5.6.3.

**Table 5-3: Wetland stormwater treatment assets**

| Asset ID | Total Contributing Catchment Area (ha) | PSP Catchment Area excluding external catchment area (ha) | Wetland Treatment Area at Normal Water Level ($m^2$) | NWL (m AHD) |
|---|---|---|---|---|
| WL1 | 1138 | 423.5 | 58,000 | 13.6 |
| WL2 | 73.0 | 58.8 | 8,000 | 14.05 |
| WL3 | 143.4 (includes the full 91.1 ha catchment to WL 4) | 120.2 (includes WL4 Catchment) | 13,220 | 13 |
| WL4 | 91.1 | 67.9 | 5,850 | 13.3 |

### 5.6.2 Inundation Frequency Analysis

An inundation frequency analysis was undertaken for each wetland utilising the online *MUSIC Auditor Wetland Analysis Tool*. The inundation frequency is influenced by the wetland's permanent pool volume, penstock outlet configuration and high flow outlet configuration.

This assessment provides guidance on the appropriate vegetation which should be selected to ensure the water level does not exceed half the vegetation height for more than 20 per cent of the time. Considering these plant heights relative to the water levels ultimately reduces the risks of vegetation drowning out. Figure 5-2, Figure 5-3, Figure 5-4 and Figure 5-5 displays the resultant inundation frequency curves. Table 5-4 summarises the minimum plant heights which should be adopted for each zone based on the water level exceeded more than 20 per cent of the time value and the assumption that the constructed wetland will have a shallow marsh area of 0.15 metres depth and a deep marsh area of 0.35 metres. These heights still allow for a variety of macrophyte species to be suitable for planting in the wetland. The final selection of wetland vegetation should consider input from a biodiversity specialist and potentially include locally native species where possible.

**Table 5-4: Minimum average plant height species for shallow and deep marsh areas**

| Wetland ID | Shallow marsh area minimum average plant height (m) | Deep marsh area minimum average plant height (m) |
|---|---|---|
| WL1 | 0.94 | 1.14 |
| WL2 | 0.70 | 0.90 |
| WL3 | 0.70 | 0.90 |
| WL4 | 0.75 | 0.95 |

**Figure 5-2: Wetland 1 Inundation Frequency Curve**

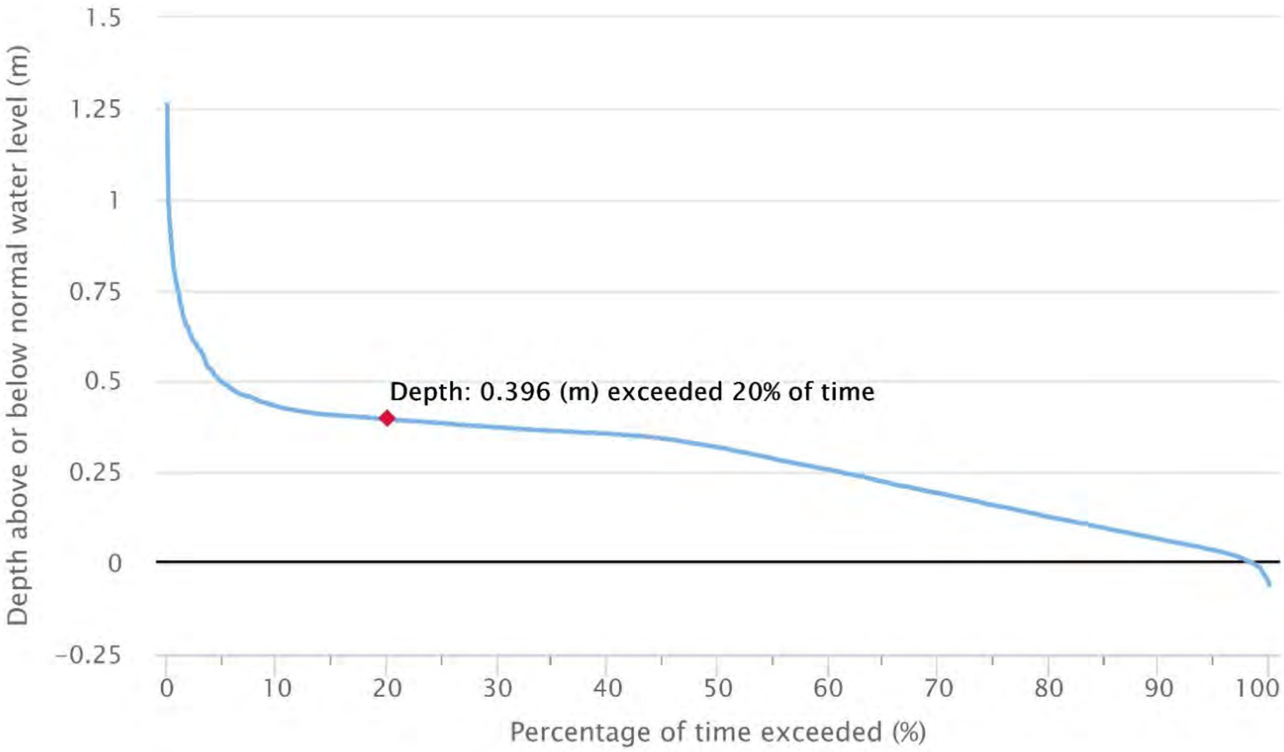



**Figure 5-3: Wetland 2 Inundation Frequency Curve**

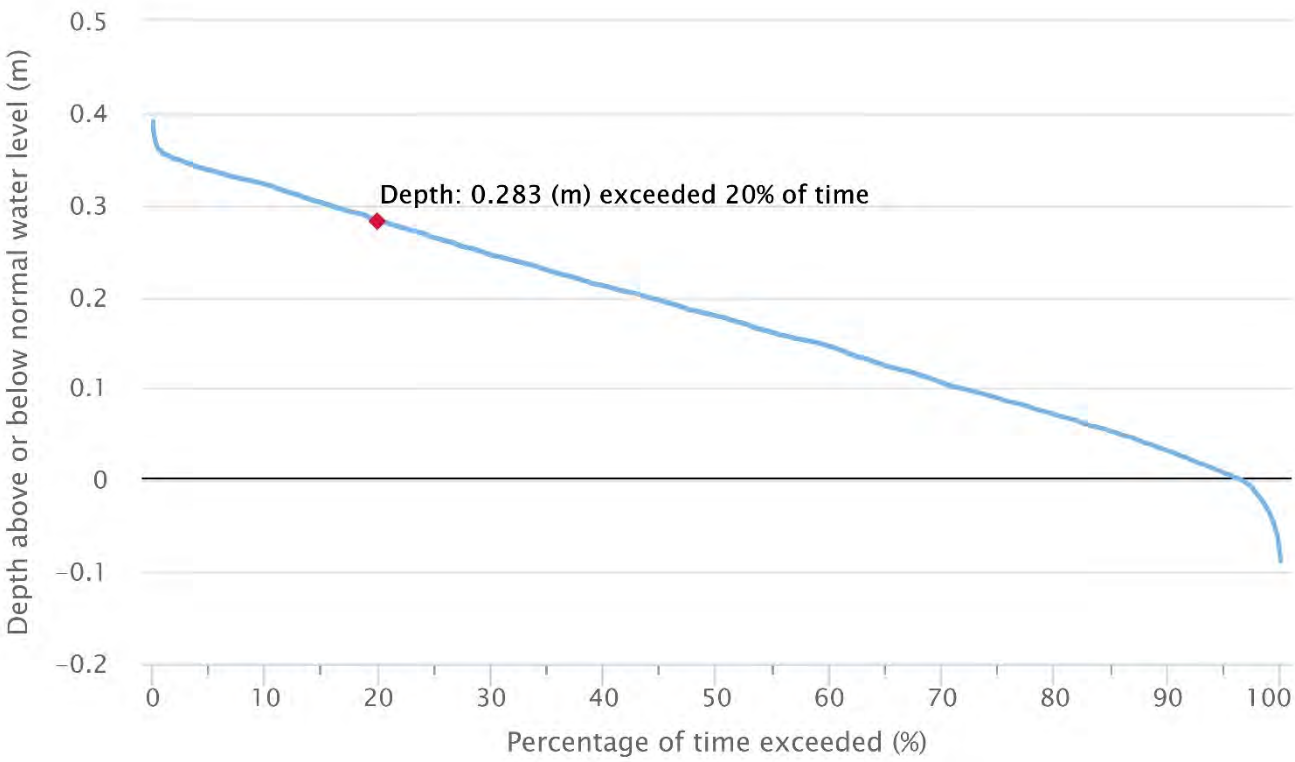


**Figure 5-4: Wetland 3 Inundation Frequency Curve**

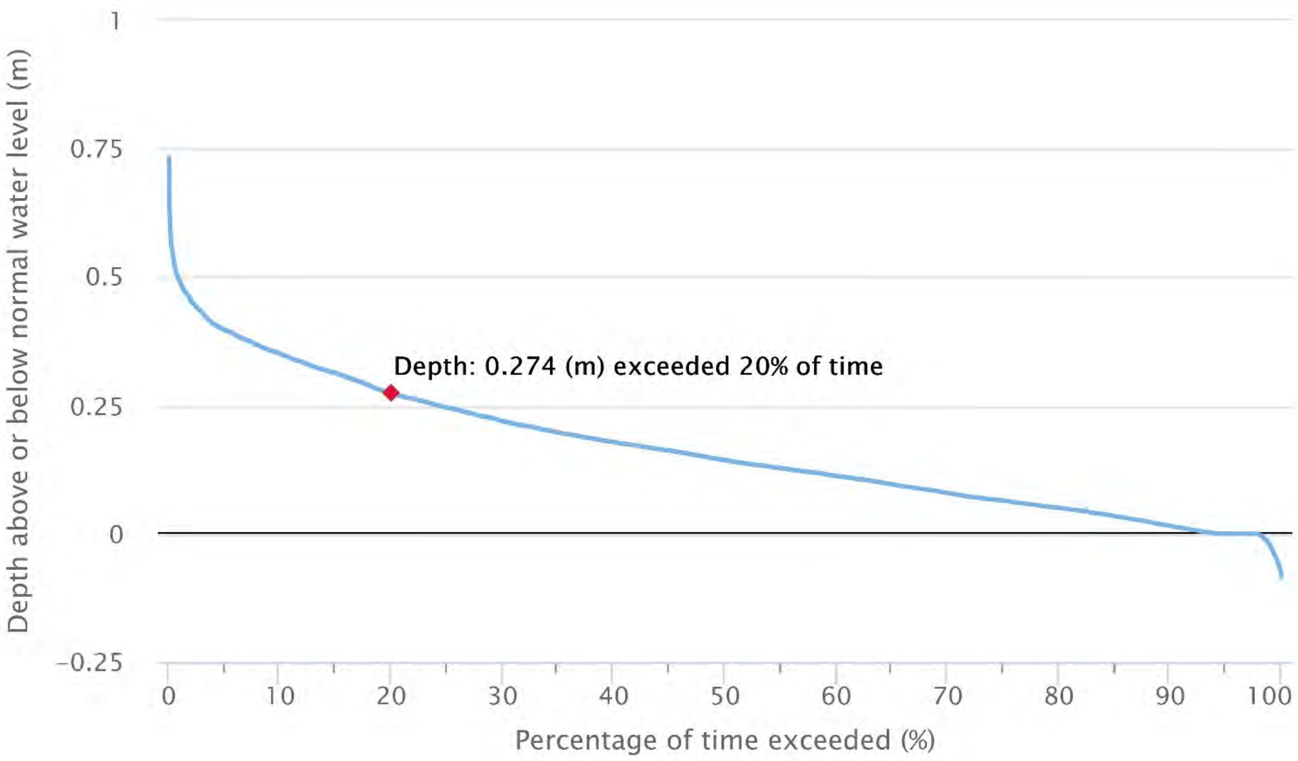
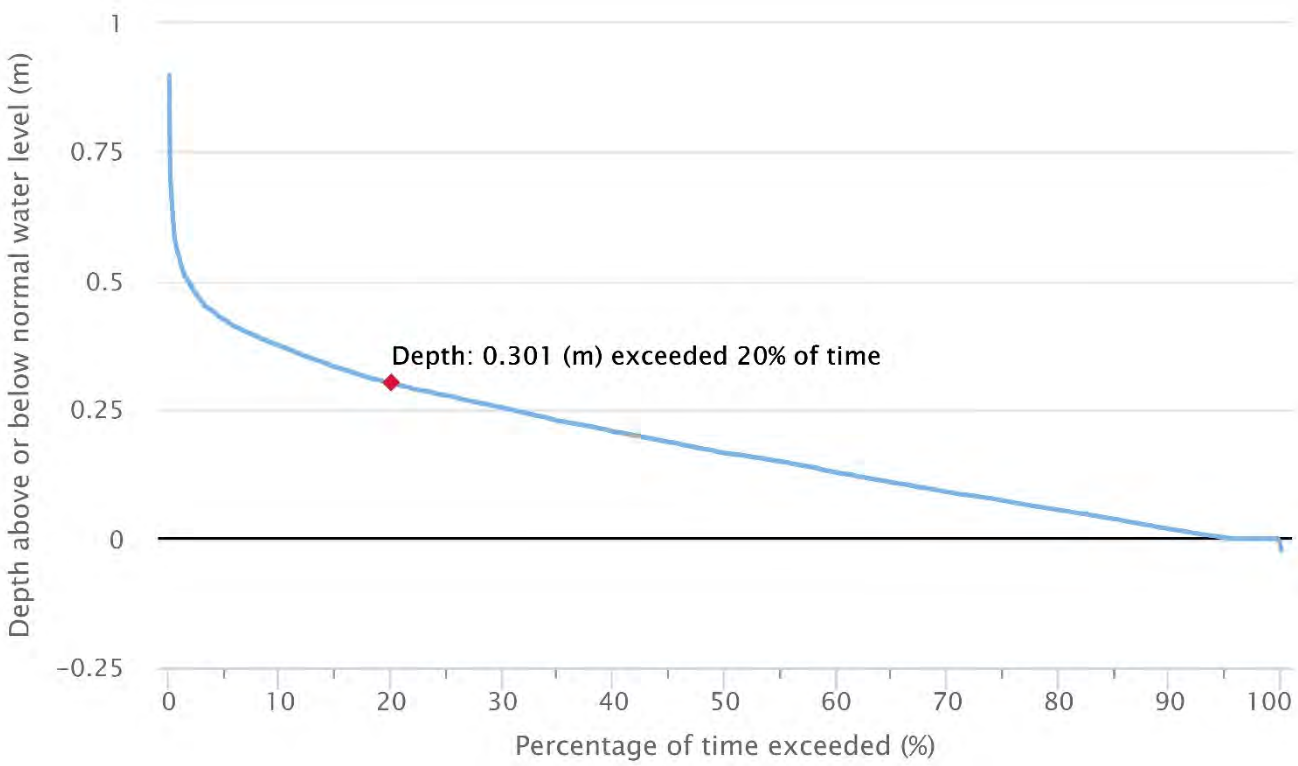



**Figure 5-5: Wetland 4 Inundation Frequency Curve**



The wetlands all have higher effective normal water levels (eNWL) than the design NWL. This is largely due to the external urban catchments also being treated and in the case of wetland 1, the rural catchment too, which behaves in a hydrologically different way to developed catchments. Rural catchments tend to generate a greater base flow of runoff for many days or weeks following a rainfall event, whereas urban catchments will typically have a short sharp flow response and then stop flowing. The external residential catchments entering Wetlands 2, 3 and 4 also contribute to higher water levels.

These higher water levels are also evident when assessing each wetland's water level exceeded for more than 50 per cent of the time inundation outputs. This value is also typically referred to as the wetland's effective normal water level (eNWL). To prevent vegetation drowning out, guidelines also recommend that this value should be within 50 mm of the normal water level. Based on the outlet configuration proposed for each wetland which achieves the required residence of 3 days, the water level exceeded for more than 50 per cent of the time is greater than the recommended 50 mm in all wetlands.

As recommended within the guidelines, in these situations' modifications to the planting zones should be made where the zones are raised to match the eNWL as shown on the online MUSIC auditor's example included as Figure 5-6. The key objective of these modifications being to also accommodate the ephemeral and shallow marsh vegetation along the fringes / safety batters of the wetland to maintain the required 80 % macrophyte coverage consisting of equal portions of shallow and deep marsh vegetation.

**Figure 5-6: Modification of planting zones for an eNWL of 0.2 m (extracted from online MUSIC auditor tool)**

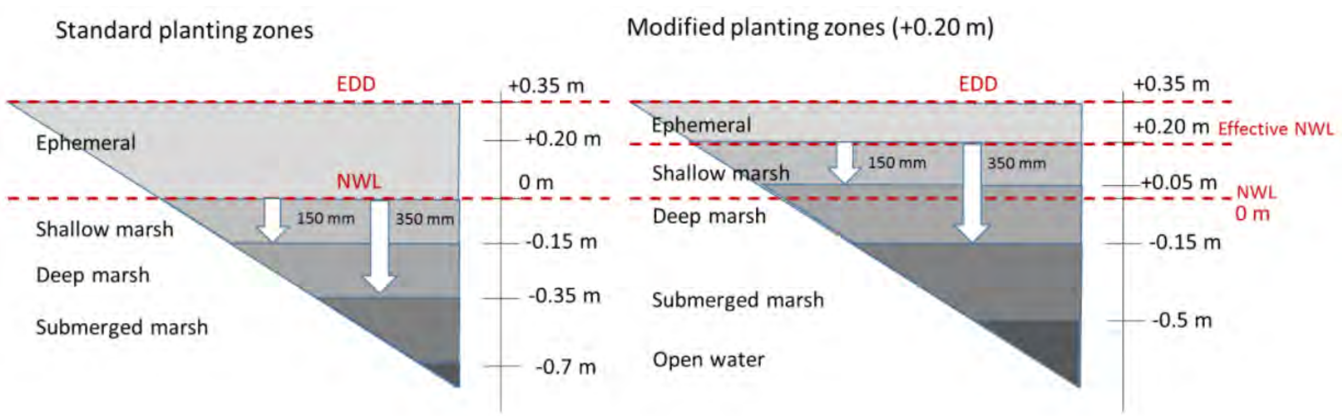



Table 5-5 summarises the wetland outlet design parameters including the penstock opening which achieves the 3-day residence time and contributes to the resultant higher eNWL. During further design stages, consideration should also be made to alternatively accept a lower residence time of 2 days or 48 hours in contrast to the higher water levels within the wetland. The MUSIC modelling suggests that a shorter residence time of 2 days would results in improved treatment performance, however the design guidelines also recognise that 3 days (72 hours) is a preferred residence time to achieve effective treatment of stormwater within a wetland. Once the wetland is constructed the residence time can be altered by adjusting the penstock opening width in the wetland control pit.

**Table 5-5: Wetland Outlet Design Parameters**

| Wetland ID | Penstock Opening (mm) | Residence Time | Water Level Exceeded 50 % of the time (m) | Design NWL (m AHD) | Resultant eNWL (m AHD) |
|---|---|---|---|---|---|
| WL1 | 250.0 | 3 days | 0.319 | 13.6 | 13.869 |
| WL2 | 47.0 | 3 days | 0.17 | 14.05 | 14.17 |
| WL3 | 130.4 | 3 days | 0.144 | 13 | 13.094 |
| WL4 | 52.4 | 3 days | 0.166 | 13.3 | 13.416 |

### 5.6.3 Spells Analysis

A spells analysis utilising the online MUSIC auditor tool was also undertaken. This analysis estimates the frequency of exceedances of depths greater than 300 mm above the NWL. Based on the online resource, shallow marsh plants are unlikely to persist with water levels 300 mm above the NWL for greater than 10 days occurring repeatedly. As such the spells analysis was undertaken to ensure that the exceedances greater than 10 days is no more than once in 10 years.

The assessment was undertaken considering the modified planting ranges presented above in Section 5.6.2 (i.e. the allowable 300 mm plus the raised depth due to the eNWL).

Figure 5-7, Figure 5-8, Figure 5-9 and Figure 5-10 displays the resultant spells graphs highlighting that the criteria is met with the modification of planting zones. These figures show that each wetland is compliant with the spells analysis criteria.

**Figure 5-7: Wetland 1 SPELLS Analysis**

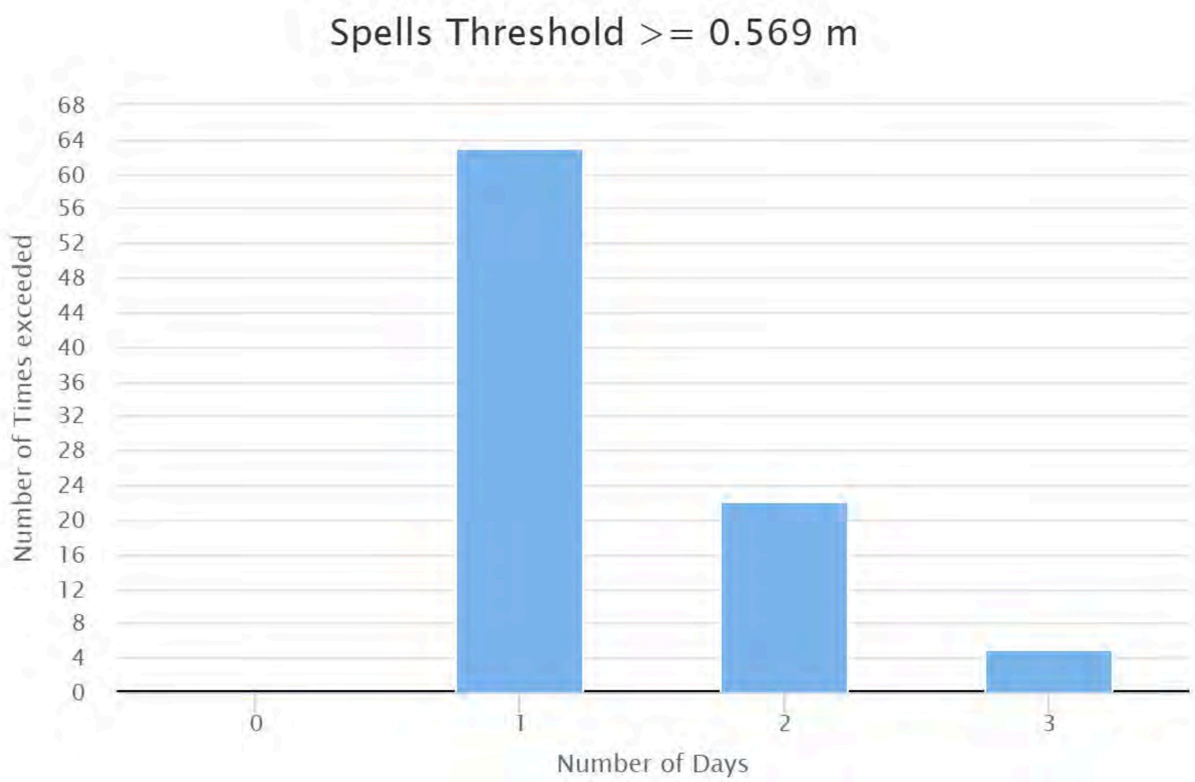


**Figure 5-8: Wetland 2 SPELLS Analysis**

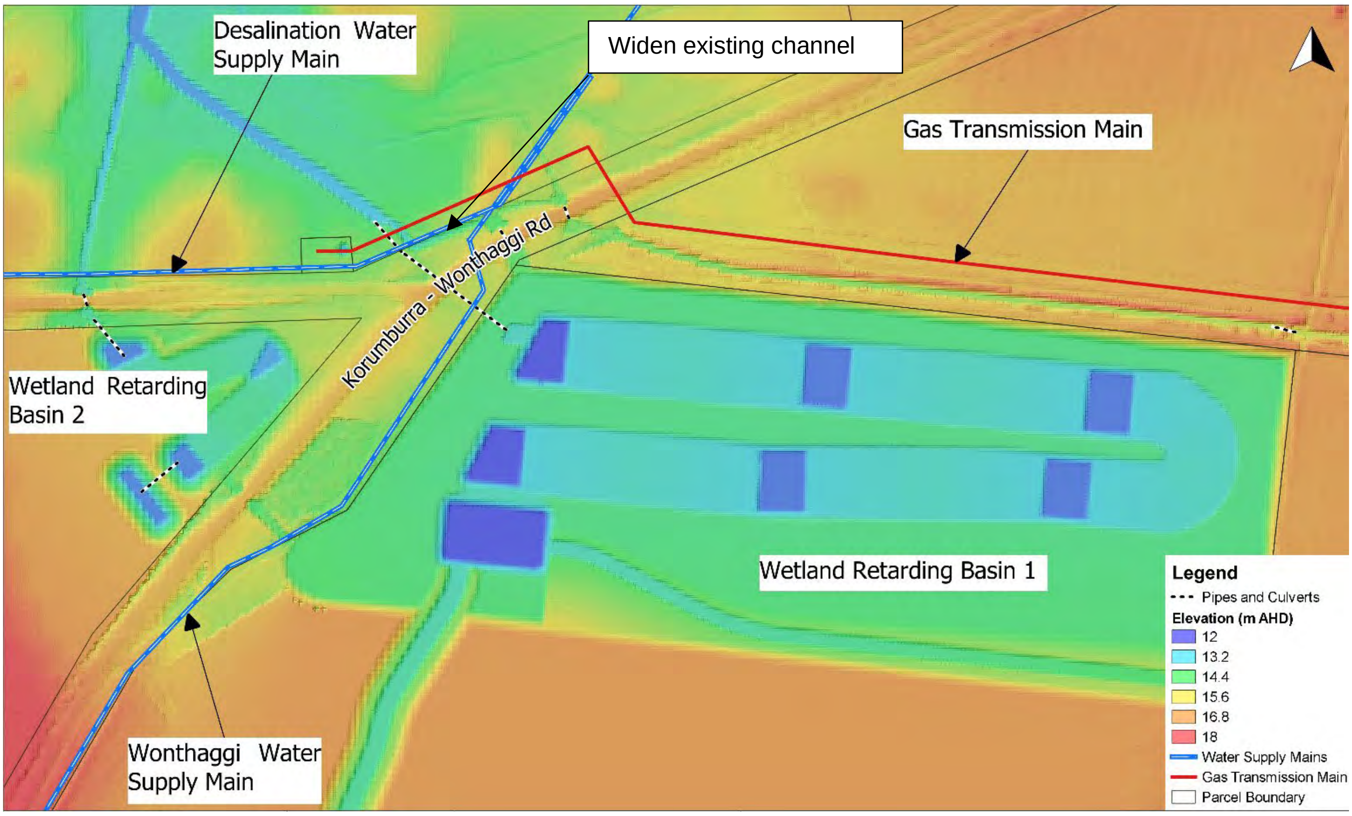

**Figure 5-9: Wetland 3 SPELLS Analysis**

**Figure 5-10: Wetland 4 SPELLS Analysis**


## 5.7 WETLAND RB1 AND EXISTING SERVICES

There is an existing gas transmission main managed by Multinet located adjacent to the northern boundary of the PSP. There are also two significant water mains, one running from the Victorian desalination plant to a storage reservoir and located adjacent to Heslop Road and the other providing the main water supply for the township of Wonthaggi and located in the Korumburra Wonthaggi Road easement. The water mains are both managed by South Gippsland Water. The outfall from retarding basin wetland 1 needs to cross each of these assets.

**Figure 5-11: Existing gas and water services**

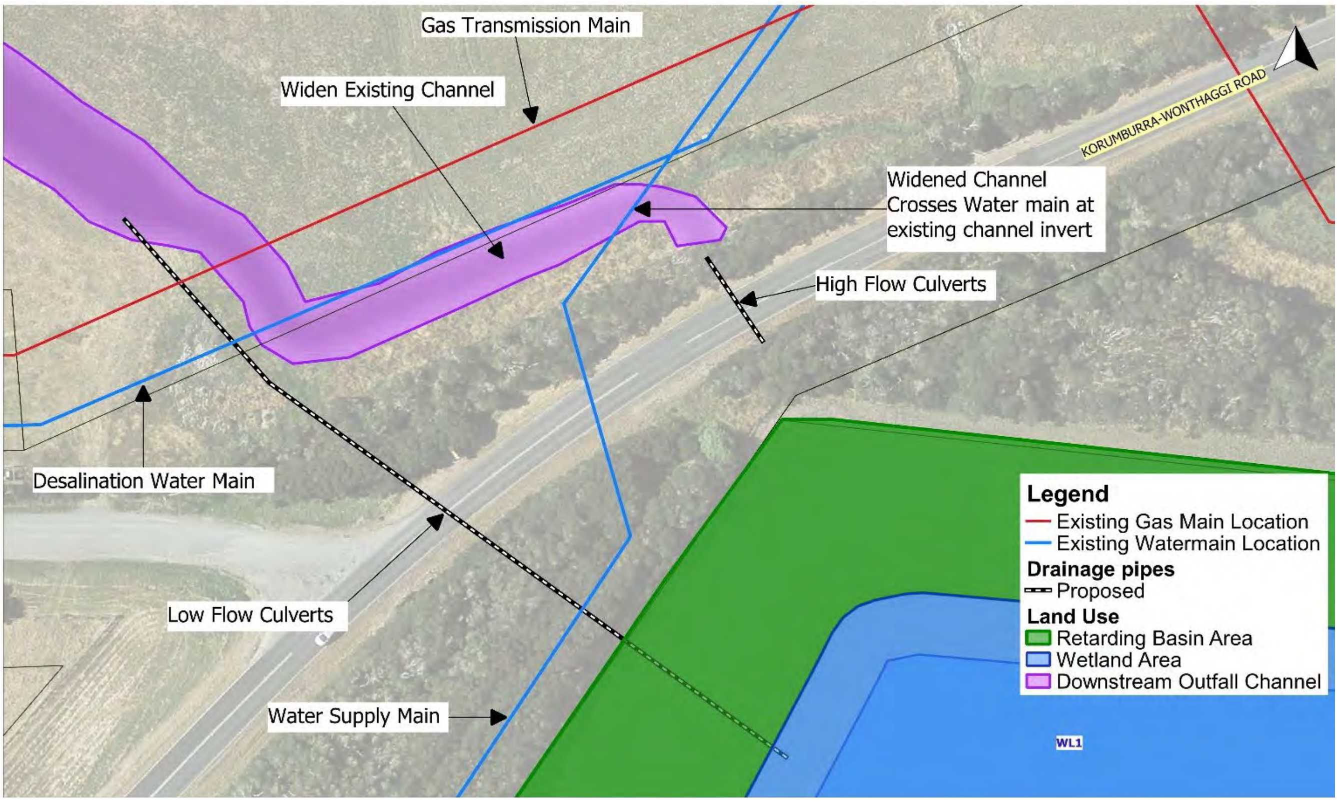



Engeny has contacted Multinet and South Gippsland Water to obtain their requirements in relation to clearances and offsets for crossing their assets. Service proving of the three pipelines has also been undertaken to confirm the as constructed level of the pipes in the ground.

Multinet require a minimum vertical clearance of 500 mm to services and drains crossing the gas transmission main. The option of lowering the gas main was also discussed with Multinet, however as the pipe is relatively new Multinet are opposed to any relocation of the pipe. Gas transmission pipelines also have special legislative controls designed to protect the pipeline and areas around the pipeline. As a result of discussions with Multinet lowering the gas main was considered a last resort to be avoided if possible.

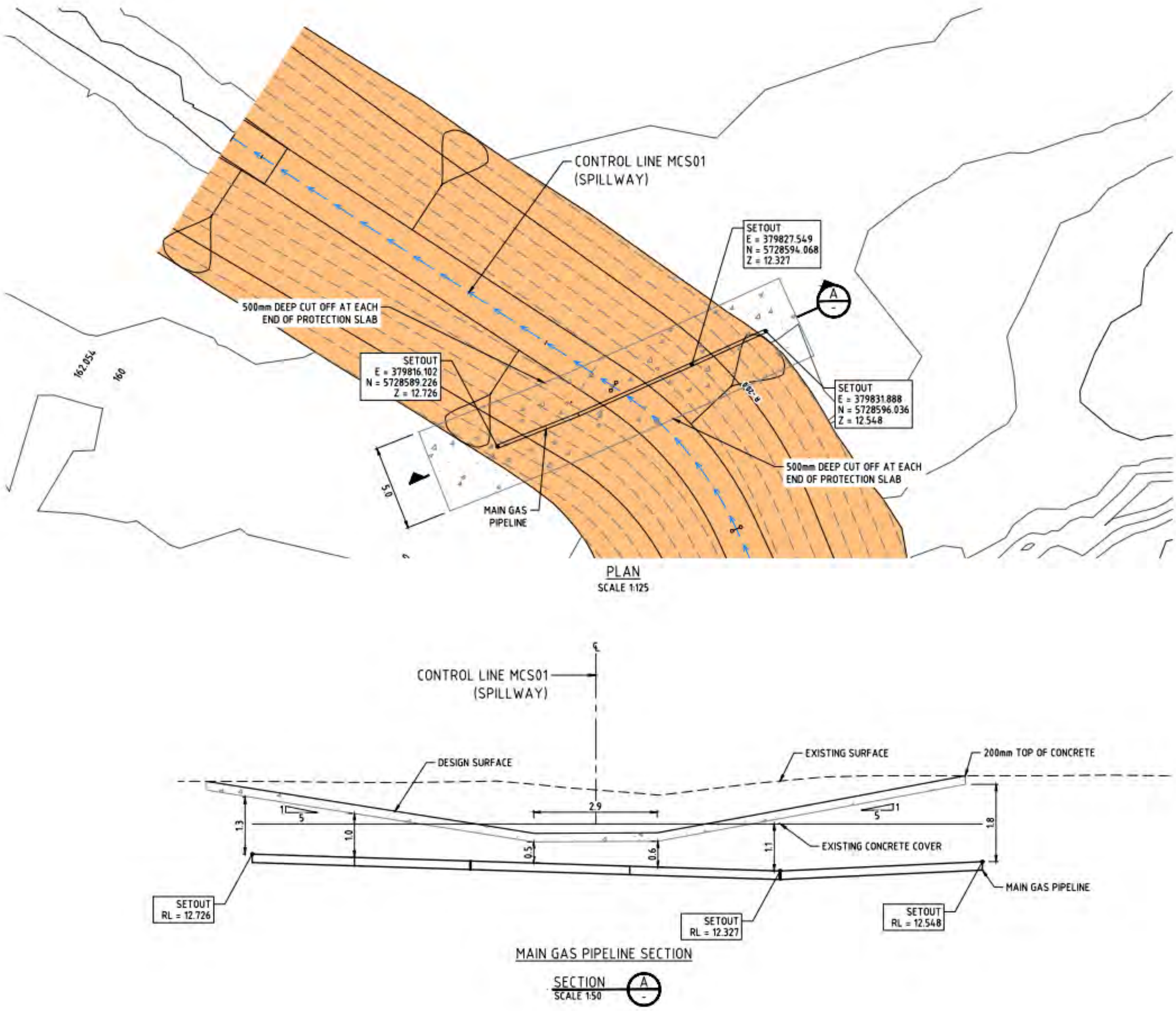
Figure 5-12 shows the proposed crossing locations for the low flow culverts and the widened existing channel of the existing gas and water main services.

**Figure 5-12: Existing gas and water services proposed crossing locations**




The current design proposes low flow pipes to cross the gas main with a clearance of at least 500 mm. A high flow channel would also cross the gas transmission main with vertical separation of 700 mm between the top of the gas main and the invert of the channel. A 200 mm thick concrete slab would be constructed over the top of the gas main to protect from erosion. A 500 mm deep cut-off wall is proposed on the upstream and downstream ends of the slab to protect from undermining of the concrete slab. Figure 5-13 shows the proposed gas main crossing of the channel. The low flow pipe sits adjacent to the high flow channel and so there is still sufficient clearance above the proposed low flow pipes to the existing surface levels.

**Figure 5-13: Proposed channel crossing of gas main**




South Gippsland Water confirmed that the water main requires a 300 mm clearance for drainage pipes crossing over the water mains and a 150 mm clearance for drainage pipes passing under the water mains. The lower clearance for pipes passing under the water mains is due to the lower risk of contamination of the water main from a stormwater drain if the drain is below the water supply pipe. South Gippsland Water confirmed that while it would be possible to lower either the desalination pipeline or the water supply main both exercises would carry significant risk. The desalination pipeline could only be altered during winter as it is required to be in use during summer months. It also has limited flushing points, meaning a very large volume of water would be required to clean the pipeline and make it safe for transporting potable water once any works were completed. The water supply main feeding Wonthaggi could also be lowered, however as it is the main supply for Wonthaggi and the storages within the town hold only a small reserve of water, there would be significant risk mitigation planning needed in the event that a cutover between the existing pipe and a proposed pipe did not proceed as planned.

The proposed low flow outfall would pass under the Wonthaggi supply main on the south side of Korumburra Wonthaggi Road with 150 mm clearance. The water supply main is at its highest point where this crossing occurs. The low flow pipes would then pass over the desalination pipeline with at least 300 mm clearance. The high flow outfall channel and culverts would not need to pass the watermains on the south side of Korumburra Wonthaggi Road. The culverts would pass under Korumburra Wonthaggi Road and then tie into an existing channel on the north side of the road. Figure 5-14 shows a longitudinal section of the proposed low flow outfall from the wetland. The figure also shows the vertical clearance to the existing gas and water services.

The existing channel would be widened but not deepened, where it crosses the Wonthaggi water supply main ensuring that the existing cover over the channel is maintained. If necessary, a concrete protection slab could be placed over the water main at this location. The channel would be deepened where it crosses the desalination pipeline and a concrete protection slab is proposed at this location. The minimum clearance between the invert of the channel and the top of the pipeline would be 500 mm, 200 mm of which would be the concrete protection slab. The top of the desalination water main is approximately 200 mm deeper than the gas transmission pipeline as shown in Figure 5-14. The water main can also be crossed with 200 mm less cover than the gas transmission main. This makes achieving the vertical offsets for this crossing much easier than for the gas transmission main.

**Figure 5-14: Longitudinal section of wetland low flow outfall and clearances to services**

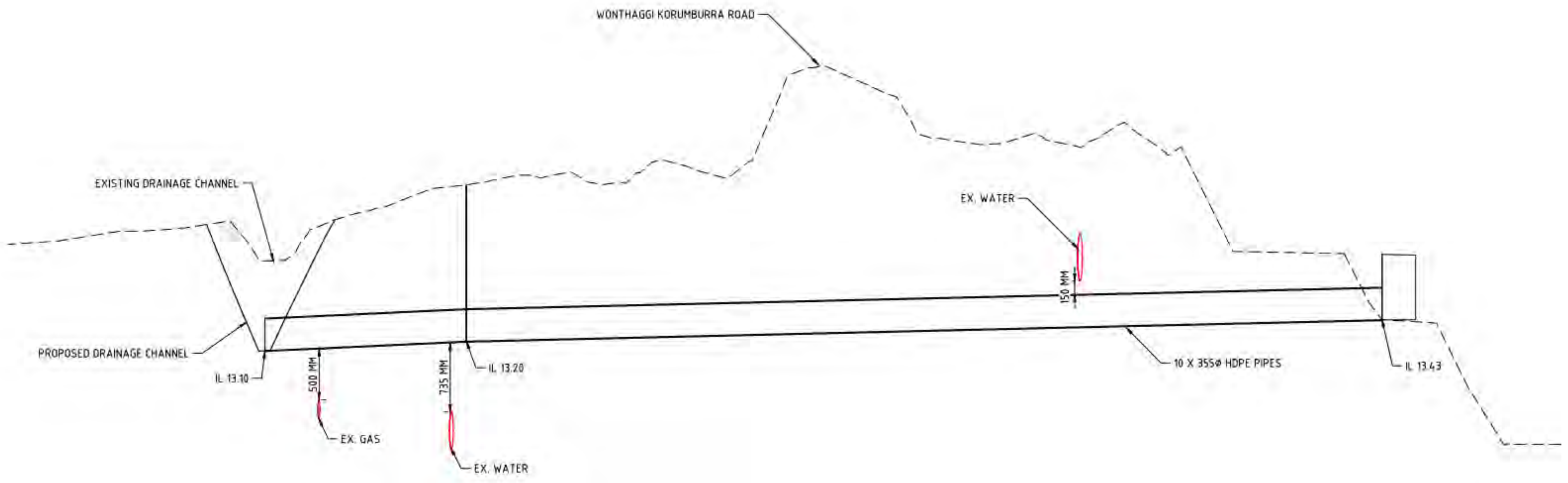


Figure 5-15 shows the alignment of the proposed outfall channel from Wetlands 1 and 2. The outfall channel is required to deepen the invert of the existing channel (from Wetland 1) and to increase the capacity of the channel to be able to convey the increased flows which are expected to occur in frequent flow events. The channels have been sized to convey the flows from the development area in the 50 % AEP event. There is still some residual flooding outside of the channels in the 50 % AEP event as there are flows contributing to the channels from outside of the development area. Table 5-6 shows the key dimension of the proposed outfall channel. The proposed outfall channel will connect into an existing deep channel on 465 Heslop Road. The inverts of the proposed channel have been designed to match into the invert of the existing deep channel. A tapered contraction in the proposed channel will be required at the connection point. This existing channel wraps around the base of a small hill on the floodplain. There is established vegetation along the edge of the existing channel and so it is not proposed to enlarge this channel as doing so would require the removal of the vegetation. It also passes quite close to the main channel of the Powlett River which may limit the scope of any potential increases in the size of the existing channel. The modelling has also demonstrated that the channel does not need to be increased in size to achieve satisfactory flooding outcomes.

**Figure 5-15: Outfall Channel Alignment**

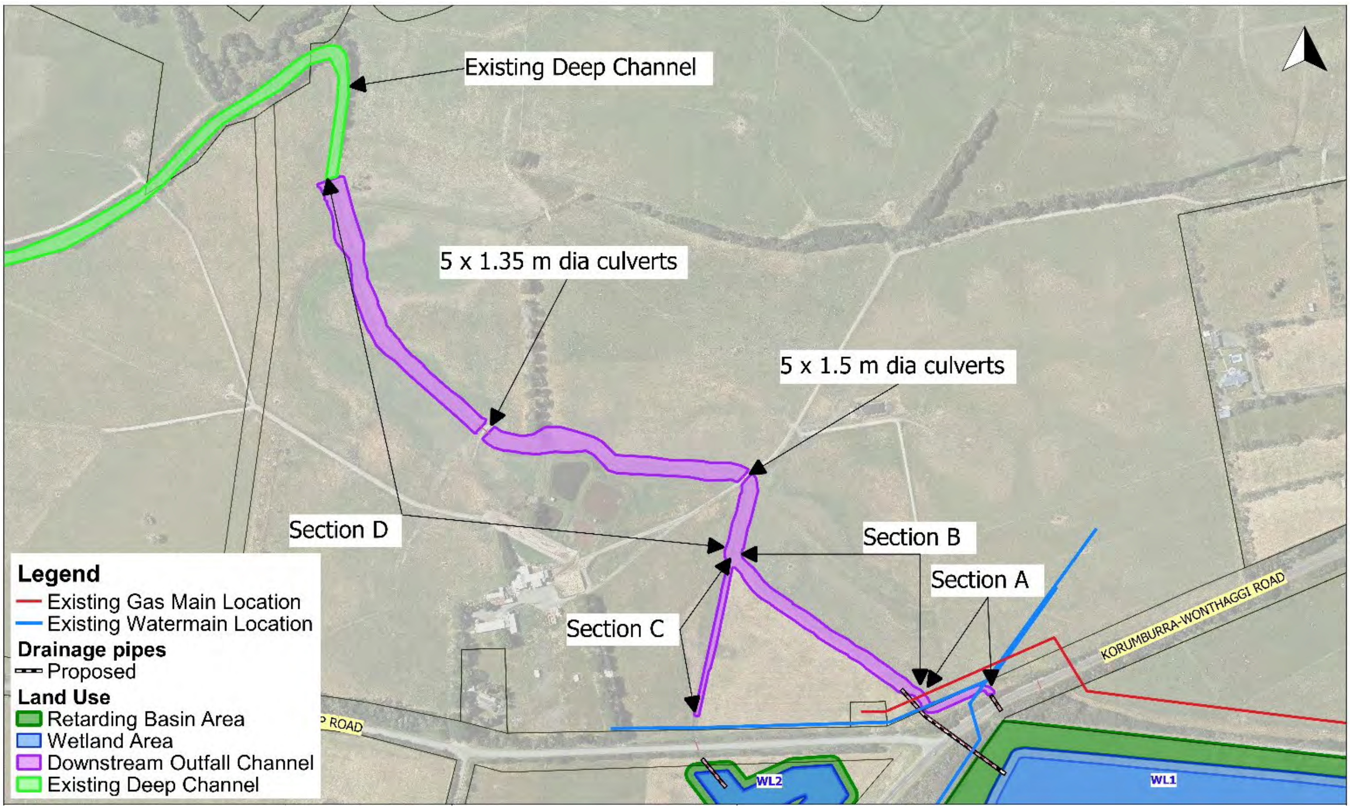



**Table 5-6: Outfall Channel Dimensions and flows**

| | Design Flow (m³/s) | Top width (m) | Bottom width (m) | Depth (m) | Slope (m/m) |
|---|---|---|---|---|---|
| Section A | 5.0 | 9 | 4 | 0.85 | 0.005 |
| Section B | 7.8 | 16 | 11 | 0.85 | 0.002 |
| Section C | 1.4 | 8 | 5 | 0.5 | 0.002 |
| Section D | 10.5 | 19 | 14 | 0.85 | 0.002 |

## 5.8 POTENTIAL STORMWATER HARVESTING OPPORTUNITY

The large wetlands proposed for stormwater treatment provide an opportunity for stormwater harvesting. Wetland 1 in particular provides a significant opportunity given the current proposal for open space to be located in the vicinity of the wetland, which could be a possible reuse demand centre. The PSP catchment flowing into wetland 1 is approximately 424 ha, in addition to the external catchments which will also flow into this wetland. It would be reasonable and beneficial to harvest the additional flows that the urbanisation of the development area will create. It will still be necessary to maintain outflows from the wetland system which are equal to the predevelopment outflows to ensure that the downstream waterway and water licence holders are not adversely impacted.

If stormwater harvesting is implemented, then additional water storage could be constructed adjacent to the wetland where harvesting is proposed. The most cost-effective storage would be an open water body which would be integrated into the wetland system. Given the wetland is operating with a higher than designed effective normal water level it may also be possible to harvest water from the wetland directly without impacting on the survivability of plants, however limits on wetland drawdown would need to be considered.

## 5.9 MUSIC RESULTS

The results from the MUSIC modelling including pollutant removal rates from the developing areas are shown below in Table 5-7. The table shows that more than 100 % of total suspended solids and gross pollutants from the new development area are being removed. This is due to the additional pollutant loads being treated by the wetlands from the external rural and urban catchments in additional to the developing catchment. Wetlands are highly effective at removing gross pollutants as they become trapped within the wetland. Note that gross pollutants do not just include litter from urban areas, but also includes leaf litter and vegetation from both urban and rural areas.

**Table 5-7: Stormwater treatment results for development area only**

| | Pollutant Load from Developable Area (kg/yr) | Pollutant Load Removed (kg/yr) | % of Development Pollutant Load Removed |
|---|---|---|---|
| Total Suspended Solids (kg/yr) | 693,250 | 709,000 | > 100 % |
| Total Phosphorus (kg/yr) | 1,473 | 1,269 | 86.2 % |
| Total Nitrogen (kg/yr) | 10,780 | 4,900 | 45.5 % |
| Gross Pollutants (kg/yr) | 141,521 | 176,000 | > 100 % |

Table 5-8 shows the treatment results for the entire catchment including the large external rural catchments draining into the development area. There is no requirement to treat the existing upstream rural catchments to best practice as part of the development.

**Table 5-8: Stormwater treatment results for entire catchment including external rural catchment areas**

| | Pollutant Load from Entire Catchment (including External Rural Catchments) (kg/yr) | Pollutant Load Removed (kg/yr) | % of Entire Catchment Pollutant Load Removed |
|---|---|---|---|
| Total Suspended Solids (kg/yr) | 900,000 | 709,000 | 78.8 % |
| Total Phosphorus (kg/yr) | 2,070 | 1,269 | 61.2 % |
| Total Nitrogen (kg/yr) | 15,600 | 4,900 | 31.3 % |
| Gross Pollutants (kg/yr) | 176,000 | 176,000 | 100.0 % |

# 6 CONCLUSIONS

Engeny has updated the drainage strategy for the Wonthaggi NE PSP development area in response to the issued raised in at the standing advisory committee in early 2021. The key updates have been to:

- Update the hydrology to be compliant with Australian Rainfall and Runoff 2019.
- Update the strategy to take into account the presence of existing gas transmission and water supply pipelines.
- Update the strategy to include an outfall channel from Wetlands 1 and 2 towards the Powlett River.

The key change to the layout of the proposed stormwater management strategy as a result of this update has been the reshaping of the footprint of wetland retarding basin 1. It has been reshaped to provide a buffer between the gas transmission main and the future residential development. Multinet Gas have confirmed that a retarding basin can be located within this buffer distance. The total footprint of the retarding basin asset remains the same as in the previous strategy, at approximately 18.4 ha.

Some of the channels, culverts and wetlands have also increased or decreased in response to the updated design work undertaken. The treatment area of wetland 1 has increased from 3.9 ha to 5.8 ha. This is in response to progressing the design to the functional stage and responding to the design constraints posed by the gas and water mains.

All of the other wetlands, both total footprint and treatment area are unchanged. The widths of the proposed waterway corridors are also unchanged, although the widths of the channels within the corridors have been adjusted to accommodate the updated flow data. The alignments of the waterway corridors are also very similar to the previous strategy with slight adjustments occurring near WLRB 1 to connect the waterway to the wetland.

This report should be read in conjunction with the functional design plans prepared by Alluvium for the VPA which detail the key wetland, culvert and waterway designs.

# 7 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

    i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

    ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.

f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g) This Report does not provide legal advice.

# 8 REFERENCES

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# 9 ABBREVIATIONS

- AEP – Annual Exceedance Probability. The probability that a given rainfall total accumulated over a given duration or peak flow rate at a point in a catchment will be exceeded in any one year.
- AHD – Australian Height Datum. The datum that sets mean sea level as zero elevation. Mean sea level was determined from observations recorded by 30 tide gauges around the coast of the Australian continent for the period 1966–1968.
- ARI – Annual Recurrence Interval. The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration, or of a peak flow rate at a point in a catchment. It is implicit in this definition that the periods between exceedances are generally random.
- BCSC – Bass Coast Shire Council
- LSIO – Land Subject to Inundation Overlay
- MUSIC – Model for Urban Stormwater Improvement Conceptualisation, used to model the effectiveness of proposed stormwater treatment assets.
- PSP – Precinct Structure Plan
- RB – Retarding Basin
- RORB – RunOff Routing Burroughs. An industry standard package used in hydrologic modelling (the “Burroughs” refers to the fact that the original software package was developed and maintained on a Burroughs B6700 computer).
- SB – Sedimentation Basin
- TUFLOW – Two-dimension Unsteady FLOW. The name of an industry standard flood modelling package.
- VPA – Victorian Planning Authority
- WGCMA – West Gippsland Catchment Management Authority
- WL – Wetland

# Appendix A:
## RORB Model Technical Details

## A.1 SPATIAL VARIATION

**Appendix Table A- 1: Existing Conditions Percent (%) Weighting for each Subarea relative to Adopted IFD (Subarea FL) (1 % AEP)**

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| A | 0.14 | 100.18 | 100.47 | 100.10 | 100.02 | 100.16 | 99.85 | 99.51 | 99.43 | 99.21 | 99.33 | 99.54 | 99.72 | 100.07 | 100.49 | 100.78 | 101.66 | 101.79 | 101.95 | 101.83 | 102.03 | 102.01 | 101.75 |
| B | 0.12 | 100.18 | 100.47 | 100.10 | 100.02 | 100.16 | 99.85 | 99.51 | 99.43 | 99.21 | 99.33 | 99.54 | 99.72 | 100.07 | 100.49 | 100.78 | 101.66 | 101.79 | 101.95 | 101.83 | 102.03 | 102.01 | 101.75 |
| C | 0.25 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| D | 0.19 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| E | 0.21 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| F | 0.18 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| G | 0.13 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| H | 0.13 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| I | 0.15 | 100.18 | 100.47 | 100.10 | 100.02 | 100.16 | 99.85 | 99.51 | 99.43 | 99.21 | 99.33 | 99.54 | 99.72 | 100.07 | 100.49 | 100.78 | 101.66 | 101.79 | 101.95 | 101.83 | 102.03 | 102.01 | 101.75 |
| J | 0.38 | 99.67 | 99.64 | 99.74 | 99.36 | 99.54 | 99.32 | 99.27 | 99.22 | 99.40 | 99.51 | 99.69 | 99.99 | 100.42 | 100.70 | 100.78 | 101.66 | 101.79 | 101.95 | 101.83 | 102.03 | 102.01 | 101.75 |
| K | 0.20 | 100.18 | 100.47 | 100.10 | 100.02 | 100.16 | 99.85 | 99.51 | 99.43 | 99.21 | 99.33 | 99.54 | 99.72 | 100.07 | 100.49 | 100.78 | 101.66 | 101.79 | 101.95 | 101.83 | 102.03 | 102.01 | 101.75 |
| L | 0.12 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| M | 0.11 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| N | 0.23 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| O | 0.26 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| P | 0.07 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| Q | 0.32 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| R | 0.25 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| S | 0.12 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| T | 0.19 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| U | 0.21 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| V | 0.13 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| W | 0.14 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| X | 0.09 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| Y | 0.12 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| Z | 0.09 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| AA | 0.10 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| AB | 0.22 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |

ENGENY WATER MANAGEMENT

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| AC | 0.09 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AD | 0.18 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AE | 0.09 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AF | 0.06 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AH | 0.08 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AG | 0.59 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AI | 0.05 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AJ | 0.05 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AK | 0.20 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AL | 0.20 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AM | 0.17 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AN | 0.13 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AO | 0.12 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AP | 0.14 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AQ | 0.10 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AR | 0.28 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| AS | 0.11 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BL | 0.03 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| BM | 0.22 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BN | 0.04 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BO | 0.19 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BQ | 0.39 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| AT | 0.64 | 99.67 | 99.64 | 99.74 | 99.36 | 99.54 | 99.32 | 99.27 | 99.22 | 99.40 | 99.51 | 99.69 | 99.99 | 100.42 | 100.70 | 100.78 | 101.66 | 101.79 | 101.95 | 101.83 | 102.03 | 102.01 | 101.75 |
| AU | 0.49 | 99.67 | 99.64 | 99.74 | 99.36 | 99.54 | 99.32 | 99.27 | 99.22 | 99.40 | 99.51 | 99.69 | 99.99 | 100.42 | 100.70 | 100.78 | 101.66 | 101.79 | 101.95 | 101.83 | 102.03 | 102.01 | 101.75 |
| AV | 0.53 | 99.16 | 98.80 | 99.01 | 98.69 | 98.93 | 98.79 | 99.02 | 99.01 | 99.21 | 99.51 | 99.84 | 99.99 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 101.39 | 101.31 | 101.52 | 101.51 | 101.26 |
| AW | 0.61 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| AZ | 0.56 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| BA | 0.35 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| BD | 0.22 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| AX | 0.61 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| AY | 0.26 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| BC | 0.38 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| BB | 0.38 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| BF | 0.63 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| BE | 0.40 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| BG | 0.25 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| BK | 0.15 | 100.70 | 100.47 | 100.47 | 100.35 | 100.47 | 100.12 | 99.99 | 99.86 | 99.79 | 99.85 | 99.84 | 99.99 | 100.19 | 100.28 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 100.76 |
| BJ | 0.11 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BI | 0.35 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BH | 1.01 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| CW | 0.38 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BP | 0.52 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BS | 0.32 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| BT | 0.36 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| BU | 0.27 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| BV | 0.91 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| BX | 0.29 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| BY | 0.60 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| BW | 0.66 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| CE | 0.62 | 99.16 | 99.22 | 99.37 | 99.36 | 99.23 | 99.59 | 99.75 | 99.86 | 99.98 | 100.02 | 100.14 | 100.12 | 100.07 | 99.96 | 99.87 | 100.04 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.76 |
| BZ | 0.82 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| CA | 0.45 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| CB | 0.36 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| CC | 0.40 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| CD | 0.82 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| CF | 1.35 | 99.67 | 99.64 | 99.37 | 99.36 | 99.54 | 99.59 | 99.51 | 99.64 | 99.79 | 99.85 | 100.14 | 100.26 | 100.42 | 100.60 | 100.78 | 100.85 | 101.15 | 100.83 | 101.31 | 101.02 | 101.01 | 101.26 |
| CV | 0.90 | 100.18 | 100.05 | 100.10 | 100.35 | 100.16 | 100.39 | 100.23 | 100.28 | 100.17 | 100.19 | 99.99 | 99.99 | 99.83 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| CR | 0.48 | 99.16 | 99.22 | 99.37 | 99.36 | 99.23 | 99.59 | 99.75 | 99.86 | 99.98 | 100.02 | 100.14 | 100.12 | 100.07 | 99.96 | 99.87 | 100.04 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.76 |
| CS | 0.74 | 100.18 | 100.05 | 100.10 | 100.35 | 100.16 | 100.39 | 100.23 | 100.28 | 100.17 | 100.19 | 99.99 | 99.99 | 99.83 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| CT | 0.51 | 100.18 | 100.05 | 100.10 | 100.35 | 100.16 | 100.39 | 100.23 | 100.28 | 100.17 | 100.19 | 99.99 | 99.99 | 99.83 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| CU | 0.39 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| CX | 0.64 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| DD | 0.17 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| BR | 0.16 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| DC | 0.21 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| DE | 0.07 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| DF | 0.16 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| DG | 0.16 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| DH | 0.19 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| DI | 0.16 | 101.72 | 101.72 | 101.56 | 101.68 | 101.40 | 100.92 | 100.72 | 100.28 | 99.98 | 99.85 | 99.84 | 99.99 | 100.30 | 100.70 | 101.69 | 101.66 | 102.42 | 102.51 | 102.36 | 102.54 | 102.51 | 102.25 |
| DJ | 0.11 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DK | 0.13 | 101.72 | 101.72 | 101.56 | 101.68 | 101.40 | 100.92 | 100.72 | 100.28 | 99.98 | 99.85 | 99.84 | 99.99 | 100.30 | 100.70 | 101.69 | 101.66 | 102.42 | 102.51 | 102.36 | 102.54 | 102.51 | 102.25 |
| DL | 0.12 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DM | 0.16 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DN | 0.16 | 101.72 | 101.72 | 101.56 | 101.68 | 101.40 | 100.92 | 100.72 | 100.28 | 99.98 | 99.85 | 99.84 | 99.99 | 100.30 | 100.70 | 101.69 | 101.66 | 102.42 | 102.51 | 102.36 | 102.54 | 102.51 | 102.25 |
| DO | 0.11 | 101.72 | 101.72 | 101.56 | 101.68 | 101.40 | 100.92 | 100.72 | 100.28 | 99.98 | 99.85 | 99.84 | 99.99 | 100.30 | 100.70 | 101.69 | 101.66 | 102.42 | 102.51 | 102.36 | 102.54 | 102.51 | 102.25 |
| DP | 0.20 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DQ | 0.09 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DR | 0.21 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DS | 0.14 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DT | 0.10 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DU | 0.18 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DV | 0.08 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DW | 0.13 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DX | 0.10 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DY | 0.06 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| DZ | 0.05 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EA | 0.14 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EB | 0.13 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EC | 0.07 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| ED | 0.13 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EE | 0.07 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EF | 0.12 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| EG | 0.08 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EH | 0.16 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EI | 0.11 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EJ | 0.06 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EQ | 0.03 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| ER | 0.09 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| ES | 0.15 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| ET | 0.08 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FA | 0.06 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EU | 0.07 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EV | 0.04 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EW | 0.05 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EK | 0.12 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EL | 0.15 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EM | 0.10 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EN | 0.28 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.65 | 100.47 | 100.07 | 99.98 | 99.85 | 99.84 | 99.99 | 100.19 | 100.49 | 100.78 | 100.85 | 101.79 | 101.95 | 101.83 | 101.52 | 101.51 | 101.75 |
| EO | 0.22 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EP | 0.19 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EX | 0.04 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EY | 0.05 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| EZ | 0.16 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FB | 0.06 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FC | 0.08 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FD | 0.19 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FE | 0.13 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FF | 0.18 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FG | 0.32 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FH | 0.09 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FI | 0.09 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FJ | 0.18 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FK | 0.07 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| FL | 0.24 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FM | 0.15 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FN | 0.09 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FO | 0.08 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| FP | 0.70 | 98.13 | 97.97 | 98.28 | 98.36 | 98.31 | 98.79 | 99.02 | 99.43 | 99.59 | 99.85 | 99.99 | 99.99 | 99.95 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 98.68 | 98.48 | 98.51 | 98.26 |
| FQ | 0.60 | 98.13 | 97.97 | 98.28 | 98.36 | 98.31 | 98.79 | 99.02 | 99.43 | 99.59 | 99.85 | 99.99 | 99.99 | 99.95 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 98.68 | 98.48 | 98.51 | 98.26 |
| FR | 0.86 | 98.64 | 98.80 | 98.64 | 98.69 | 98.93 | 99.32 | 99.51 | 99.86 | 99.98 | 100.19 | 100.14 | 99.99 | 99.72 | 99.43 | 98.96 | 98.41 | 97.99 | 98.03 | 97.63 | 97.46 | 97.51 | 97.27 |
| FS | 1.64 | 98.13 | 97.97 | 98.28 | 98.36 | 98.31 | 98.79 | 99.02 | 99.43 | 99.59 | 99.85 | 99.99 | 99.99 | 99.95 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 98.68 | 98.48 | 98.51 | 98.26 |
| FT | 0.89 | 99.67 | 99.64 | 99.74 | 100.02 | 99.85 | 100.12 | 100.23 | 100.49 | 100.56 | 100.53 | 100.44 | 100.26 | 99.95 | 99.64 | 98.96 | 99.22 | 98.63 | 98.59 | 98.68 | 98.48 | 98.51 | 98.76 |
| FU | 1.27 | 99.16 | 99.22 | 99.37 | 99.36 | 99.23 | 99.59 | 99.75 | 99.86 | 99.98 | 100.02 | 100.14 | 100.12 | 100.07 | 99.96 | 99.87 | 100.04 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.76 |
| FV | 1.03 | 99.67 | 99.64 | 99.74 | 100.02 | 99.85 | 100.12 | 100.23 | 100.49 | 100.56 | 100.53 | 100.44 | 100.26 | 99.95 | 99.64 | 98.96 | 99.22 | 98.63 | 98.59 | 98.68 | 98.48 | 98.51 | 98.76 |
| FW | 0.63 | 99.16 | 99.22 | 99.37 | 99.36 | 99.23 | 99.59 | 99.75 | 99.86 | 99.98 | 100.02 | 100.14 | 100.12 | 100.07 | 99.96 | 99.87 | 100.04 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.76 |
| FX | 0.70 | 99.67 | 99.64 | 99.74 | 100.02 | 99.85 | 100.12 | 100.23 | 100.49 | 100.56 | 100.53 | 100.44 | 100.26 | 99.95 | 99.64 | 98.96 | 99.22 | 98.63 | 98.59 | 98.68 | 98.48 | 98.51 | 98.76 |
| FY | 0.98 | 100.70 | 100.89 | 100.83 | 101.02 | 101.09 | 100.92 | 100.96 | 100.92 | 100.95 | 100.70 | 100.59 | 100.39 | 100.07 | 99.86 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| FZ | 0.37 | 100.70 | 100.89 | 100.83 | 101.02 | 101.09 | 100.92 | 100.96 | 100.92 | 100.95 | 100.70 | 100.59 | 100.39 | 100.07 | 99.86 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| GA | 0.59 | 100.70 | 100.89 | 100.83 | 101.02 | 101.09 | 100.92 | 100.96 | 100.92 | 100.95 | 100.70 | 100.59 | 100.39 | 100.07 | 99.86 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| GB | 0.53 | 100.70 | 100.89 | 100.83 | 101.02 | 101.09 | 100.92 | 100.96 | 100.92 | 100.95 | 100.70 | 100.59 | 100.39 | 100.07 | 99.86 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| GC | 0.37 | 101.72 | 101.72 | 101.93 | 101.68 | 101.71 | 101.72 | 101.68 | 101.34 | 101.34 | 101.04 | 100.74 | 100.53 | 100.30 | 100.17 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| GD | 0.38 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GE | 0.12 | 101.72 | 101.72 | 101.93 | 101.68 | 101.71 | 101.72 | 101.68 | 101.34 | 101.34 | 101.04 | 100.74 | 100.53 | 100.30 | 100.17 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| GF | 0.10 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GG | 0.05 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GH | 0.26 | 101.72 | 101.72 | 101.93 | 101.68 | 101.71 | 101.72 | 101.68 | 101.34 | 101.34 | 101.04 | 100.74 | 100.53 | 100.30 | 100.17 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| GI | 0.11 | 101.72 | 101.72 | 101.93 | 101.68 | 101.71 | 101.72 | 101.68 | 101.34 | 101.34 | 101.04 | 100.74 | 100.53 | 100.30 | 100.17 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| GJ | 0.03 | 101.72 | 101.72 | 101.93 | 101.68 | 101.71 | 101.72 | 101.68 | 101.34 | 101.34 | 101.04 | 100.74 | 100.53 | 100.30 | 100.17 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| GK | 0.11 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| CG | 0.86 | 97.10 | 97.13 | 97.18 | 97.03 | 97.38 | 97.72 | 98.30 | 98.80 | 99.21 | 99.68 | 99.84 | 99.99 | 99.95 | 99.86 | 99.87 | 99.22 | 98.63 | 98.59 | 98.16 | 98.48 | 98.01 | 97.76 |
| CH | 1.02 | 98.13 | 97.97 | 98.28 | 98.36 | 98.31 | 98.79 | 99.02 | 99.43 | 99.59 | 99.85 | 99.99 | 99.99 | 99.95 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 98.68 | 98.48 | 98.51 | 98.26 |
| CI | 1.27 | 98.13 | 97.97 | 98.28 | 98.36 | 98.31 | 98.79 | 99.02 | 99.43 | 99.59 | 99.85 | 99.99 | 99.99 | 99.95 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 98.68 | 98.48 | 98.51 | 98.26 |
| CK | 0.97 | 97.61 | 97.55 | 97.54 | 97.69 | 98.00 | 98.26 | 98.30 | 98.80 | 99.01 | 99.33 | 99.54 | 99.58 | 99.60 | 99.54 | 98.96 | 99.22 | 98.63 | 98.59 | 98.68 | 98.98 | 99.01 | 98.76 |
| CL | 1.37 | 97.61 | 97.55 | 97.54 | 97.69 | 98.00 | 98.26 | 98.30 | 98.80 | 99.01 | 99.33 | 99.54 | 99.58 | 99.60 | 99.54 | 98.96 | 99.22 | 98.63 | 98.59 | 98.68 | 98.98 | 99.01 | 98.76 |

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| CJ | 0.80 | 98.13 | 97.97 | 98.28 | 98.36 | 98.31 | 98.79 | 99.02 | 99.43 | 99.59 | 99.85 | 99.99 | 99.99 | 99.95 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 98.68 | 98.48 | 98.51 | 98.26 |
| CM | 1.22 | 99.16 | 99.22 | 99.37 | 99.36 | 99.23 | 99.59 | 99.75 | 99.86 | 99.98 | 100.02 | 100.14 | 100.12 | 100.07 | 99.96 | 99.87 | 100.04 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.76 |
| CN | 0.85 | 99.16 | 99.22 | 99.37 | 99.36 | 99.23 | 99.59 | 99.75 | 99.86 | 99.98 | 100.02 | 100.14 | 100.12 | 100.07 | 99.96 | 99.87 | 100.04 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.76 |
| CO | 1.42 | 98.64 | 98.38 | 98.64 | 98.69 | 98.62 | 98.79 | 99.02 | 99.22 | 99.59 | 99.85 | 100.14 | 100.39 | 100.66 | 100.81 | 100.78 | 100.85 | 101.15 | 100.83 | 100.78 | 101.02 | 101.01 | 101.26 |
| CP | 1.00 | 99.16 | 99.22 | 99.37 | 99.36 | 99.23 | 99.59 | 99.75 | 99.86 | 99.98 | 100.02 | 100.14 | 100.12 | 100.07 | 99.96 | 99.87 | 100.04 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.76 |
| CQ | 1.21 | 100.18 | 100.05 | 100.10 | 100.35 | 100.16 | 100.39 | 100.23 | 100.28 | 100.17 | 100.19 | 99.99 | 99.99 | 99.83 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| DA | 1.17 | 100.18 | 100.05 | 100.10 | 100.35 | 100.16 | 100.39 | 100.23 | 100.28 | 100.17 | 100.19 | 99.99 | 99.99 | 99.83 | 99.75 | 99.87 | 99.22 | 99.26 | 99.15 | 99.21 | 99.49 | 99.51 | 99.26 |
| CZ | 0.18 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| CY | 0.08 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| DB | 0.19 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GN | 0.06 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GL | 0.27 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GM | 0.10 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GO | 0.10 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GP | 0.09 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GQ | 0.16 | 101.21 | 101.30 | 101.20 | 101.02 | 101.09 | 100.92 | 100.96 | 100.70 | 100.37 | 100.19 | 99.84 | 99.58 | 99.36 | 99.22 | 98.96 | 99.22 | 98.63 | 99.15 | 99.21 | 98.98 | 99.01 | 99.26 |
| GR | 0.11 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GS | 0.14 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GT | 0.13 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GU | 0.07 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GV | 0.09 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GW | 0.12 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GX | 0.10 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GY | 0.11 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| GZ | 0.17 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| HA | 0.14 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HB | 0.21 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HD | 0.20 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HE | 0.17 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| HF | 0.18 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HG | 0.18 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |

| Subarea | Area (km2) | Duration | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 min | 15 min | 20 min | 25 min | 30 min | 45 min | 1 hour | 1.5 hour | 2 hour | 3 hour | 4.5 hour | 6 hour | 9 hour | 12 hour | 18 hour | 24 hour | 48 hour | 72 hour | 96 hour | 120 hour | 144 hour | 168 hour |
| HH | 0.26 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| HI | 0.19 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| HJ | 0.07 | 101.72 | 102.14 | 101.93 | 102.01 | 101.71 | 101.45 | 101.20 | 100.92 | 100.56 | 100.19 | 99.84 | 99.58 | 99.36 | 99.33 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 99.49 | 99.51 | 99.26 |
| HK | 0.16 | 102.75 | 102.55 | 102.66 | 102.68 | 102.64 | 102.25 | 102.16 | 101.76 | 101.34 | 100.87 | 100.44 | 100.12 | 99.72 | 99.54 | 98.96 | 99.22 | 99.26 | 99.71 | 99.73 | 100.00 | 99.51 | 99.76 |
| HL | 0.07 | 103.27 | 102.97 | 103.02 | 103.01 | 102.94 | 102.78 | 102.41 | 101.76 | 101.34 | 100.87 | 100.29 | 99.85 | 99.36 | 99.22 | 98.96 | 99.22 | 99.26 | 99.15 | 99.73 | 99.49 | 99.51 | 99.26 |
| HC | 0.04 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HM | 0.05 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HN | 0.12 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HO | 0.11 | 103.27 | 102.97 | 103.02 | 103.01 | 102.94 | 102.78 | 102.41 | 101.76 | 101.34 | 100.87 | 100.29 | 99.85 | 99.36 | 99.22 | 98.96 | 99.22 | 99.26 | 99.15 | 99.73 | 99.49 | 99.51 | 99.26 |
| HQ | 0.09 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |
| HP | 0.10 | 102.24 | 102.55 | 102.29 | 102.35 | 102.33 | 101.72 | 101.44 | 100.92 | 100.56 | 100.19 | 99.84 | 99.72 | 99.60 | 99.54 | 99.87 | 100.04 | 99.89 | 100.27 | 100.26 | 100.51 | 100.51 | 100.26 |

## A.2 CATCHMENT SUBAREA FRACTIONS

The Total Impervious Area (TIA) was determined for each subarea, the following EIA to TIA ratios were adopted

- 60 % Residential / Road Zones
- 77 % Industrial Zones

The following

$$Sum\ Area\ EIA_x = \sum_{1}^{i}(FI_i * \frac{EIA}{TIA}) * \ Area_i$$

$$Sum\ Area\ Pervious\ Area\ (PA) = \ PA_x = \sum_{1}^{i}(1 - FI_i) * \ Area_i$$

$$Sum\ Area\ ICA_x = \ Sum\ Area\ EIA_x - \ Sum\ Area\ PA_x$$

Where,

$i$ = parcel zone within subarea $x$

**Appendix Table A- 2: Subarea Fraction EIA, ICA and Rural for Existing Conditions**

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| A | 0.14 | 0.123 | 0.082 | 0.795 |
| B | 0.122 | 0.000 | 0.000 | 1.000 |
| C | 0.25 | 0.000 | 0.000 | 1.000 |
| D | 0.185 | 0.067 | 0.044 | 0.889 |
| E | 0.214 | 0.000 | 0.000 | 1.000 |
| F | 0.176 | 0.000 | 0.000 | 1.000 |
| G | 0.127 | 0.000 | 0.000 | 1.000 |
| H | 0.128 | 0.000 | 0.000 | 1.000 |
| I | 0.149 | 0.000 | 0.000 | 1.000 |
| J | 0.378 | 0.000 | 0.000 | 1.000 |
| K | 0.202 | 0.000 | 0.000 | 1.000 |
| L | 0.117 | 0.000 | 0.000 | 1.000 |
| M | 0.111 | 0.000 | 0.000 | 1.000 |
| N | 0.225 | 0.000 | 0.000 | 1.000 |
| O | 0.256 | 0.000 | 0.000 | 1.000 |
| P | 0.066 | 0.000 | 0.000 | 1.000 |
| Q | 0.318 | 0.000 | 0.000 | 1.000 |
| R | 0.248 | 0.000 | 0.000 | 1.000 |

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| S | 0.123 | 0.000 | 0.000 | 1.000 |
| T | 0.185 | 0.000 | 0.000 | 1.000 |
| U | 0.21 | 0.013 | 0.009 | 0.978 |
| V | 0.132 | 0.013 | 0.008 | 0.979 |
| W | 0.14 | 0.006 | 0.004 | 0.990 |
| X | 0.086 | 0.023 | 0.016 | 0.961 |
| Y | 0.117 | 0.000 | 0.000 | 1.000 |
| Z | 0.094 | 0.015 | 0.010 | 0.975 |
| AA | 0.101 | 0.006 | 0.004 | 0.990 |
| AB | 0.215 | 0.000 | 0.000 | 1.000 |
| AC | 0.086 | 0.000 | 0.000 | 1.000 |
| AD | 0.176 | 0.000 | 0.000 | 1.000 |
| AE | 0.085 | 0.000 | 0.000 | 1.000 |
| AF | 0.056 | 0.000 | 0.000 | 1.000 |
| AH | 0.081 | 0.041 | 0.028 | 0.931 |
| AG | 0.592 | 0.008 | 0.006 | 0.986 |
| AI | 0.049 | 0.054 | 0.036 | 0.910 |
| AJ | 0.051 | 0.038 | 0.025 | 0.937 |
| AK | 0.196 | 0.003 | 0.002 | 0.995 |
| AL | 0.199 | 0.009 | 0.006 | 0.985 |
| AM | 0.171 | 0.000 | 0.000 | 1.000 |
| AN | 0.126 | 0.000 | 0.000 | 1.000 |
| AO | 0.115 | 0.000 | 0.000 | 1.000 |
| AP | 0.141 | 0.000 | 0.000 | 1.000 |
| AQ | 0.095 | 0.000 | 0.000 | 1.000 |
| AR | 0.276 | 0.000 | 0.000 | 1.000 |
| AS | 0.106 | 0.000 | 0.000 | 1.000 |
| BL | 0.033 | 0.000 | 0.000 | 1.000 |
| BM | 0.223 | 0.000 | 0.000 | 1.000 |
| BN | 0.044 | 0.000 | 0.000 | 1.000 |

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| BO | 0.194 | 0.000 | 0.000 | 1.000 |
| BQ | 0.39 | 0.000 | 0.000 | 1.000 |
| AT | 0.641 | 0.000 | 0.000 | 1.000 |
| AU | 0.493 | 0.000 | 0.000 | 1.000 |
| AV | 0.533 | 0.000 | 0.000 | 1.000 |
| AW | 0.605 | 0.000 | 0.000 | 1.000 |
| AZ | 0.561 | 0.000 | 0.000 | 1.000 |
| BA | 0.354 | 0.014 | 0.010 | 0.976 |
| BD | 0.223 | 0.010 | 0.007 | 0.983 |
| AX | 0.606 | 0.007 | 0.005 | 0.988 |
| AY | 0.256 | 0.015 | 0.010 | 0.975 |
| BC | 0.377 | 0.011 | 0.007 | 0.982 |
| BB | 0.379 | 0.011 | 0.007 | 0.982 |
| BF | 0.625 | 0.000 | 0.000 | 1.000 |
| BE | 0.395 | 0.000 | 0.000 | 1.000 |
| BG | 0.251 | 0.000 | 0.000 | 1.000 |
| BK | 0.154 | 0.000 | 0.000 | 1.000 |
| BJ | 0.113 | 0.000 | 0.000 | 1.000 |
| BI | 0.353 | 0.000 | 0.000 | 1.000 |
| BH | 1.011 | 0.000 | 0.000 | 1.000 |
| CW | 0.376 | 0.000 | 0.000 | 1.000 |
| BP | 0.517 | 0.000 | 0.000 | 1.000 |
| BS | 0.315 | 0.014 | 0.010 | 0.976 |
| BT | 0.363 | 0.005 | 0.003 | 0.992 |
| BU | 0.273 | 0.031 | 0.021 | 0.948 |
| BV | 0.911 | 0.000 | 0.000 | 1.000 |
| BX | 0.287 | 0.000 | 0.000 | 1.000 |
| BY | 0.601 | 0.000 | 0.000 | 1.000 |
| BW | 0.657 | 0.000 | 0.000 | 1.000 |
| CE | 0.623 | 0.000 | 0.000 | 1.000 |

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| BZ | 0.821 | 0.006 | 0.004 | 0.990 |
| CA | 0.452 | 0.013 | 0.009 | 0.978 |
| CB | 0.364 | 0.019 | 0.012 | 0.969 |
| CC | 0.401 | 0.016 | 0.010 | 0.974 |
| CD | 0.815 | 0.000 | 0.000 | 1.000 |
| CF | 1.352 | 0.000 | 0.000 | 1.000 |
| CV | 0.895 | 0.000 | 0.000 | 1.000 |
| CR | 0.483 | 0.000 | 0.000 | 1.000 |
| CS | 0.738 | 0.000 | 0.000 | 1.000 |
| CT | 0.508 | 0.000 | 0.000 | 1.000 |
| CU | 0.387 | 0.000 | 0.000 | 1.000 |
| CX | 0.639 | 0.000 | 0.000 | 1.000 |
| DD | 0.17 | 0.000 | 0.000 | 1.000 |
| BR | 0.159 | 0.000 | 0.000 | 1.000 |
| DC | 0.209 | 0.000 | 0.000 | 1.000 |
| DE | 0.074 | 0.013 | 0.008 | 0.979 |
| DF | 0.158 | 0.017 | 0.011 | 0.972 |
| DG | 0.159 | 0.007 | 0.005 | 0.988 |
| DH | 0.191 | 0.009 | 0.006 | 0.985 |
| DI | 0.162 | 0.326 | 0.217 | 0.457 |
| DJ | 0.105 | 0.014 | 0.010 | 0.976 |
| DK | 0.13 | 0.089 | 0.060 | 0.851 |
| DL | 0.119 | 0.114 | 0.076 | 0.810 |
| DN | 0.162 | 0.298 | 0.198 | 0.504 |
| DO | 0.105 | 0.270 | 0.180 | 0.550 |
| DP | 0.199 | 0.011 | 0.007 | 0.982 |
| DQ | 0.093 | 0.000 | 0.000 | 1.000 |
| DR | 0.207 | 0.022 | 0.014 | 0.964 |
| DS | 0.143 | 0.000 | 0.000 | 1.000 |
| DT | 0.099 | 0.000 | 0.000 | 1.000 |

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| DU | 0.181 | 0.000 | 0.000 | 1.000 |
| DV | 0.079 | 0.000 | 0.000 | 1.000 |
| DW | 0.133 | 0.000 | 0.000 | 1.000 |
| DX | 0.1 | 0.098 | 0.066 | 0.836 |
| DY | 0.057 | 0.012 | 0.008 | 0.980 |
| DZ | 0.052 | 0.000 | 0.000 | 1.000 |
| EA | 0.141 | 0.067 | 0.045 | 0.888 |
| EB | 0.125 | 0.013 | 0.009 | 0.978 |
| EC | 0.068 | 0.000 | 0.000 | 1.000 |
| ED | 0.127 | 0.000 | 0.000 | 1.000 |
| EF | 0.116 | 0.134 | 0.089 | 0.777 |
| EG | 0.082 | 0.022 | 0.015 | 0.963 |
| EH | 0.163 | 0.000 | 0.000 | 1.000 |
| EI | 0.105 | 0.046 | 0.031 | 0.923 |
| EJ | 0.057 | 0.000 | 0.000 | 1.000 |
| EQ | 0.026 | 0.360 | 0.240 | 0.400 |
| ER | 0.086 | 0.355 | 0.237 | 0.408 |
| ES | 0.146 | 0.351 | 0.234 | 0.415 |
| ET | 0.077 | 0.124 | 0.083 | 0.793 |
| FA | 0.055 | 0.360 | 0.240 | 0.400 |
| EU | 0.066 | 0.360 | 0.240 | 0.400 |
| EV | 0.039 | 0.184 | 0.123 | 0.693 |
| EW | 0.05 | 0.000 | 0.000 | 1.000 |
| EK | 0.118 | 0.000 | 0.000 | 1.000 |
| EL | 0.151 | 0.000 | 0.000 | 1.000 |
| EM | 0.095 | 0.000 | 0.000 | 1.000 |
| EN | 0.28 | 0.000 | 0.000 | 1.000 |
| EO | 0.217 | 0.000 | 0.000 | 1.000 |
| EP | 0.192 | 0.000 | 0.000 | 1.000 |
| EX | 0.035 | 0.364 | 0.242 | 0.394 |

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| EY | 0.052 | 0.338 | 0.225 | 0.437 |
| EZ | 0.156 | 0.052 | 0.034 | 0.914 |
| FB | 0.055 | 0.343 | 0.229 | 0.428 |
| FC | 0.075 | 0.066 | 0.044 | 0.890 |
| FD | 0.19 | 0.008 | 0.005 | 0.987 |
| FE | 0.13 | 0.000 | 0.000 | 1.000 |
| FF | 0.181 | 0.000 | 0.000 | 1.000 |
| FG | 0.32 | 0.000 | 0.000 | 1.000 |
| FH | 0.092 | 0.005 | 0.003 | 0.992 |
| FI | 0.085 | 0.014 | 0.009 | 0.977 |
| FJ | 0.177 | 0.000 | 0.000 | 1.000 |
| FK | 0.074 | 0.023 | 0.015 | 0.962 |
| FL | 0.237 | 0.007 | 0.005 | 0.988 |
| FM | 0.149 | 0.012 | 0.008 | 0.980 |
| FN | 0.094 | 0.000 | 0.000 | 1.000 |
| FO | 0.078 | 0.000 | 0.000 | 1.000 |
| FP | 0.695 | 0.010 | 0.006 | 0.984 |
| FQ | 0.603 | 0.000 | 0.000 | 1.000 |
| FR | 0.864 | 0.012 | 0.008 | 0.980 |
| FS | 1.635 | 0.015 | 0.010 | 0.975 |
| FT | 0.888 | 0.011 | 0.007 | 0.982 |
| FU | 1.272 | 0.019 | 0.012 | 0.969 |
| FV | 1.032 | 0.004 | 0.003 | 0.993 |
| FW | 0.633 | 0.000 | 0.000 | 1.000 |
| FX | 0.699 | 0.000 | 0.000 | 1.000 |
| FY | 0.984 | 0.000 | 0.000 | 1.000 |
| FZ | 0.374 | 0.000 | 0.000 | 1.000 |
| GA | 0.593 | 0.000 | 0.000 | 1.000 |
| GB | 0.526 | 0.000 | 0.000 | 1.000 |
| GC | 0.374 | 0.000 | 0.000 | 1.000 |

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| GD | 0.382 | 0.000 | 0.000 | 1.000 |
| GE | 0.124 | 0.000 | 0.000 | 1.000 |
| GF | 0.102 | 0.000 | 0.000 | 1.000 |
| GG | 0.053 | 0.000 | 0.000 | 1.000 |
| GH | 0.256 | 0.003 | 0.002 | 0.995 |
| GI | 0.109 | 0.005 | 0.003 | 0.992 |
| GJ | 0.033 | 0.010 | 0.006 | 0.984 |
| GK | 0.105 | 0.001 | 0.001 | 0.998 |
| CG | 0.86 | 0.001 | 0.000 | 0.999 |
| CH | 1.021 | 0.004 | 0.003 | 0.993 |
| CI | 1.269 | 0.000 | 0.000 | 1.000 |
| CK | 0.972 | 0.000 | 0.000 | 1.000 |
| CL | 1.374 | 0.001 | 0.000 | 0.999 |
| CJ | 0.795 | 0.000 | 0.000 | 1.000 |
| CM | 1.221 | 0.000 | 0.000 | 1.000 |
| CN | 0.846 | 0.008 | 0.005 | 0.987 |
| CO | 1.422 | 0.000 | 0.000 | 1.000 |
| CP | 0.998 | 0.000 | 0.000 | 1.000 |
| CQ | 1.214 | 0.000 | 0.000 | 1.000 |
| DA | 1.173 | 0.000 | 0.000 | 1.000 |
| CZ | 0.181 | 0.000 | 0.000 | 1.000 |
| CY | 0.078 | 0.000 | 0.000 | 1.000 |
| DB | 0.188 | 0.000 | 0.000 | 1.000 |
| GN | 0.061 | 0.008 | 0.006 | 0.986 |
| GL | 0.272 | 0.000 | 0.000 | 1.000 |
| GM | 0.103 | 0.008 | 0.006 | 0.986 |
| GO | 0.098 | 0.016 | 0.011 | 0.973 |
| GP | 0.086 | 0.002 | 0.001 | 0.997 |
| GQ | 0.161 | 0.000 | 0.000 | 1.000 |
| GR | 0.112 | 0.000 | 0.000 | 1.000 |

| Subarea | Area (km²) | FI Directly Connected | FI Indirectly Connected | FI Rural |
|---|---|---|---|---|
| GS | 0.143 | 0.000 | 0.000 | 1.000 |
| GT | 0.133 | 0.000 | 0.000 | 1.000 |
| GU | 0.068 | 0.000 | 0.000 | 1.000 |
| GV | 0.093 | 0.000 | 0.000 | 1.000 |
| GW | 0.122 | 0.000 | 0.000 | 1.000 |
| GX | 0.097 | 0.385 | 0.257 | 0.358 |
| GY | 0.112 | 0.124 | 0.082 | 0.794 |
| GZ | 0.169 | 0.117 | 0.078 | 0.805 |
| HA | 0.135 | 0.154 | 0.102 | 0.744 |
| HB | 0.206 | 0.001 | 0.000 | 0.999 |
| HD | 0.197 | 0.000 | 0.000 | 1.000 |
| HE | 0.174 | 0.000 | 0.000 | 1.000 |
| HF | 0.179 | 0.000 | 0.000 | 1.000 |
| HG | 0.18 | 0.000 | 0.000 | 1.000 |
| HH | 0.256 | 0.000 | 0.000 | 1.000 |
| HI | 0.19 | 0.017 | 0.012 | 0.971 |
| HJ | 0.07 | 0.000 | 0.000 | 1.000 |
| HK | 0.16 | 0.000 | 0.000 | 1.000 |
| HL | 0.07 | 0.007 | 0.005 | 0.988 |
| HC | 0.086 | 0.000 | 0.000 | 1.000 |
| HM | 0.091 | 0.000 | 0.000 | 1.000 |
| HN | 0.12 | 0.000 | 0.000 | 1.000 |
| HO | 0.108 | 0.000 | 0.000 | 1.000 |
| HQ | 0.09 | 0.001 | 0.000 | 0.999 |
| HP | 0.099 | 0.000 | 0.000 | 1.000 |
| EE | 0.07 | 0.383 | 0.114 | 0.503 |
| DM | 0.16 | 0.444 | 0.132 | 0.424 |

## A.3 IFD

The Intensity Frequency Duration

**Appendix Table A- 3: Intensity Frequency Duration of Subarea FL (38.5875 S 145.6125 E)**

| Duration | 63.2 % | 50 % | 20 % | 10 % | 5 % | 2 % | 1 % |
|---|---|---|---|---|---|---|---|
| 10 min | 6.73 | 7.62 | 10.5 | 12.5 | 14.6 | 17.5 | 19.8 |
| 15 min | 8.19 | 9.28 | 12.8 | 15.3 | 17.9 | 21.5 | 24.5 |
| 20 min | 9.33 | 10.6 | 14.6 | 17.5 | 20.4 | 24.6 | 27.9 |
| 25 min | 10.3 | 11.7 | 16.1 | 19.3 | 22.5 | 27 | 30.7 |
| 30 min | 11.1 | 12.6 | 17.4 | 20.8 | 24.3 | 29.1 | 32.9 |
| 45 min | 13.1 | 14.9 | 20.5 | 24.5 | 28.5 | 33.9 | 38.1 |
| 1 hour | 14.7 | 16.6 | 22.8 | 27.2 | 31.7 | 37.4 | 41.9 |
| 1.5 hour | 17.2 | 19.4 | 26.4 | 31.4 | 36.4 | 42.7 | 47.6 |
| 2 hour | 19.2 | 21.5 | 29.2 | 34.5 | 39.8 | 46.6 | 51.9 |
| 3 hour | 22.2 | 24.9 | 33.3 | 39.2 | 45.1 | 52.7 | 58.7 |
| 4.5 hour | 25.7 | 28.6 | 37.9 | 44.4 | 50.8 | 59.7 | 66.7 |
| 6 hour | 28.4 | 31.5 | 41.5 | 48.4 | 55.3 | 65.3 | 73.3 |
| 9 hour | 32.6 | 36 | 47 | 54.8 | 62.6 | 74.6 | 84.4 |
| 12 hour | 35.8 | 39.4 | 51.4 | 59.9 | 68.5 | 82.4 | 93.8 |
| 18 hour | 40.6 | 44.7 | 58.1 | 68 | 78.2 | 95.1 | 109 |
| 24 hour | 44.2 | 48.6 | 63.5 | 74.6 | 86.2 | 106 | 122 |
| 48 hour | 53.8 | 59.2 | 78.1 | 93 | 109 | 135 | 157 |
| 72 hour | 60.2 | 66.2 | 87.8 | 105 | 124 | 152 | 178 |
| 96 hour | 65.2 | 71.8 | 94.8 | 113 | 133 | 163 | 190 |
| 120 hour | 69.6 | 76.5 | 100 | 118 | 138 | 169 | 196 |
| 144 hour | 73.7 | 80.7 | 104 | 122 | 140 | 172 | 199 |
| 168 hour | 77.5 | 84.7 | 108 | 124 | 141 | 172 | 199 |

## A.4 CLIMATE CHANGE

The adopted multiplication factor for rainfall intensity increase by the year 2100 is to be the maximum expected increase as based on either the projected temperature increase or projected rainfall intensity increase.

The results of the extrapolation calculations are presented in Appendix Table A- 4.

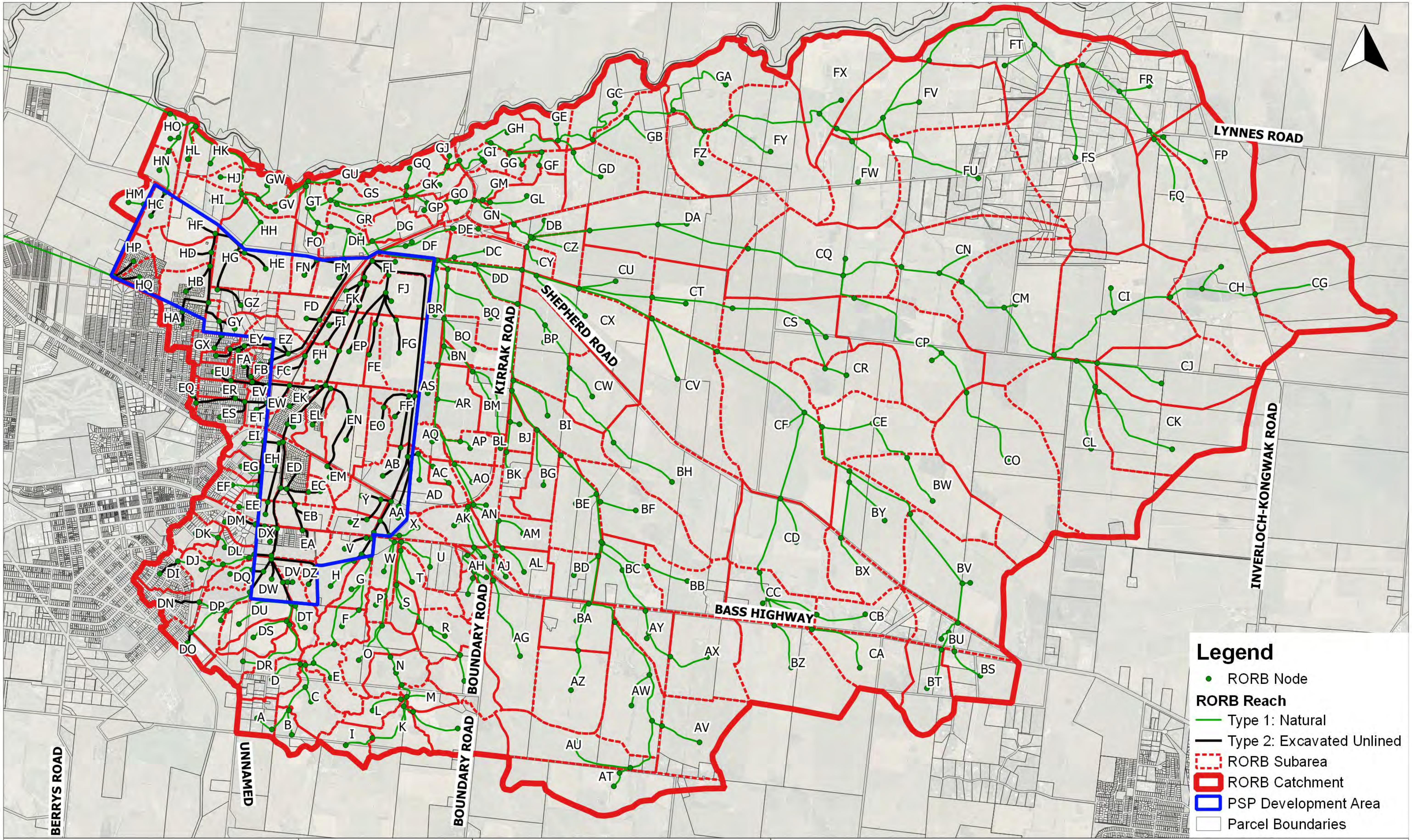
**Appendix Table A- 4: Extrapolation of Climate Change Factors (RCP 8.5 Scenario)**

| Year | Temperature Increase (°C) | Rainfall Intensity Increase |
|---|---|---|
| 2030 | 0.81 | 4.0 % |
| 2040 | 1.08 | 5.4 % |
| 2050 | 1.45 | 7.3 % |
| 2060 | 1.19 | 10.0 % |
| 2070 | 2.30 | 11.9 % |
| 2080 | 2.72 | 14.2 % |
| 2090 | 3.09 | 16.3 % |
| 2100 | 3.46 | 18.4 % |

The percentage increase of rainfall intensity, as based on the temperature increase, was calculated using the following formula:

$$p = 100\left(1.05^{\Delta T} - 1\right) = 18.4\,\%$$

Therefore, an 18.4 % increase in rainfall intensity was adopted for flood modelling under the climate change scenario.

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ENGENY WATER MANAGEMENT

BASS COAST

300 0 300 600 900 1200 m

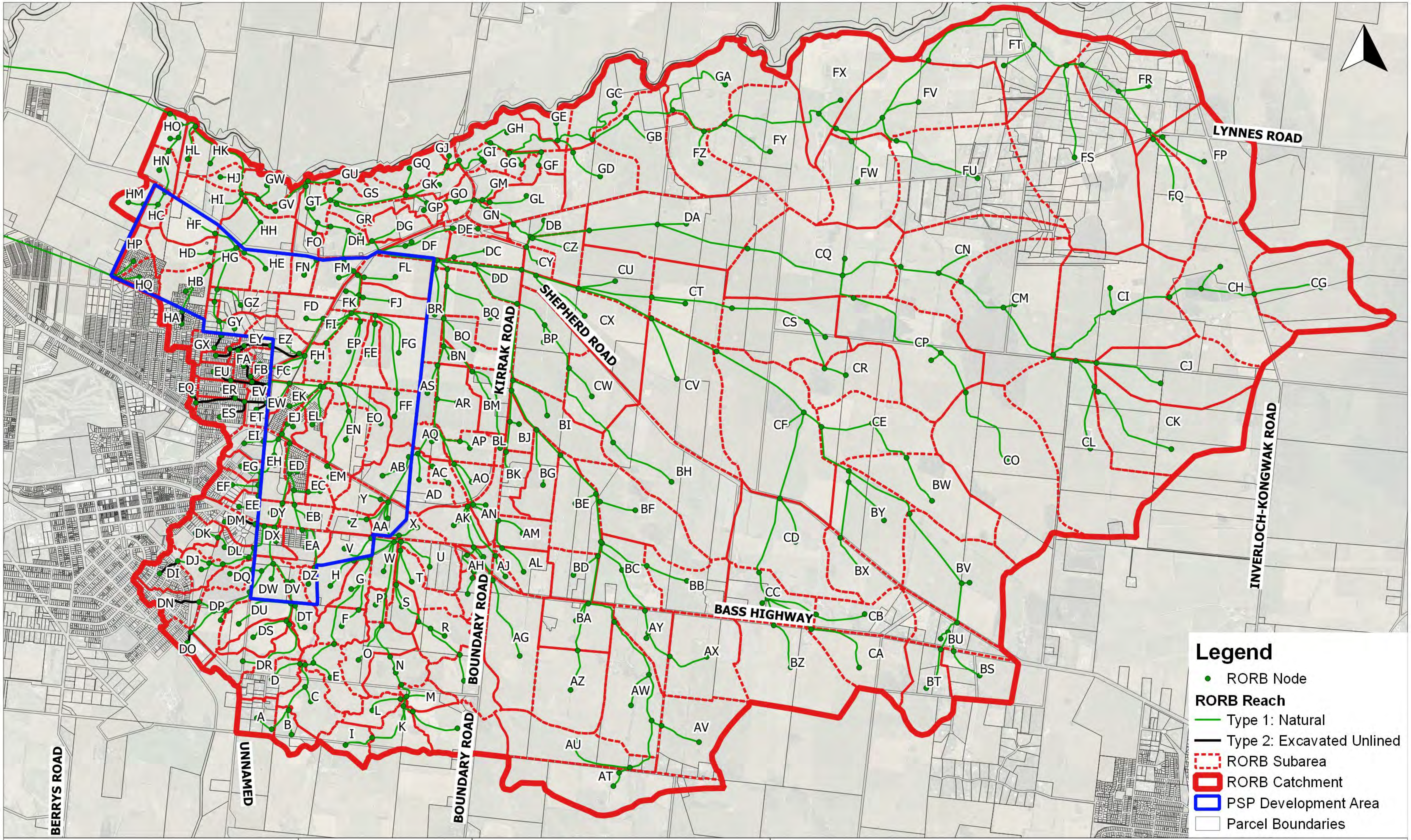
Scale in metres ( 1:35000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

# Wonthaggi NE PSP

## Developed Conditions RORB Model Layout

Job Number: V5000_002
Revision: 0
Drawn: KP
Checked: GO
Date: 20/8/2021

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ENGENY WATER MANAGEMENT

BASS COAST

300 0 300 600 900 1200 m

Scale in metres ( 1:35000 @ A3)

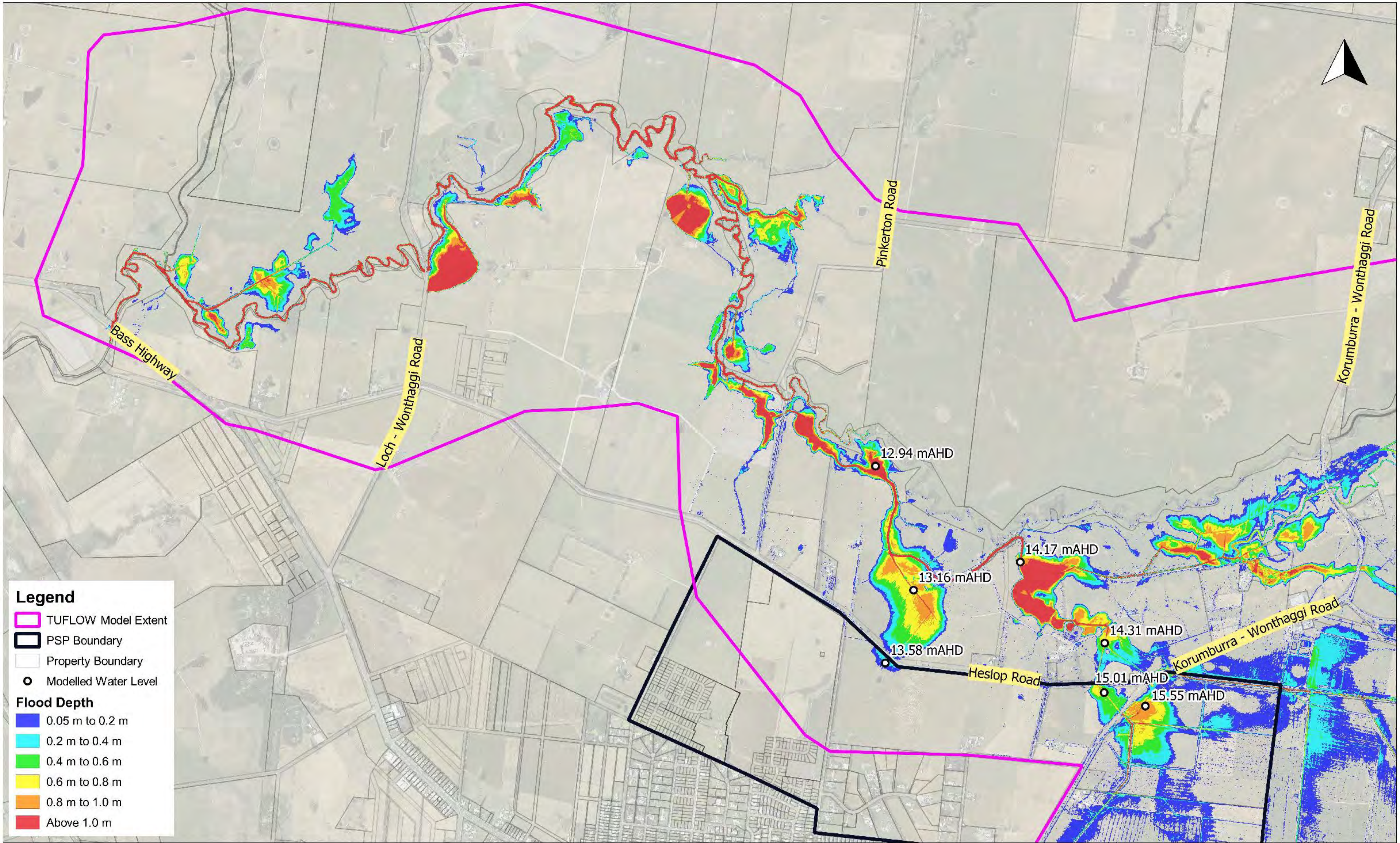
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

# Wonthaggi NE PSP

Job Number: V5000_002
Revision: 0
Drawn: KP
Checked: GO
Date: 20/8/2021

## Existing Conditions RORB Model Layout

# Appendix B:
## Flood Maps





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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

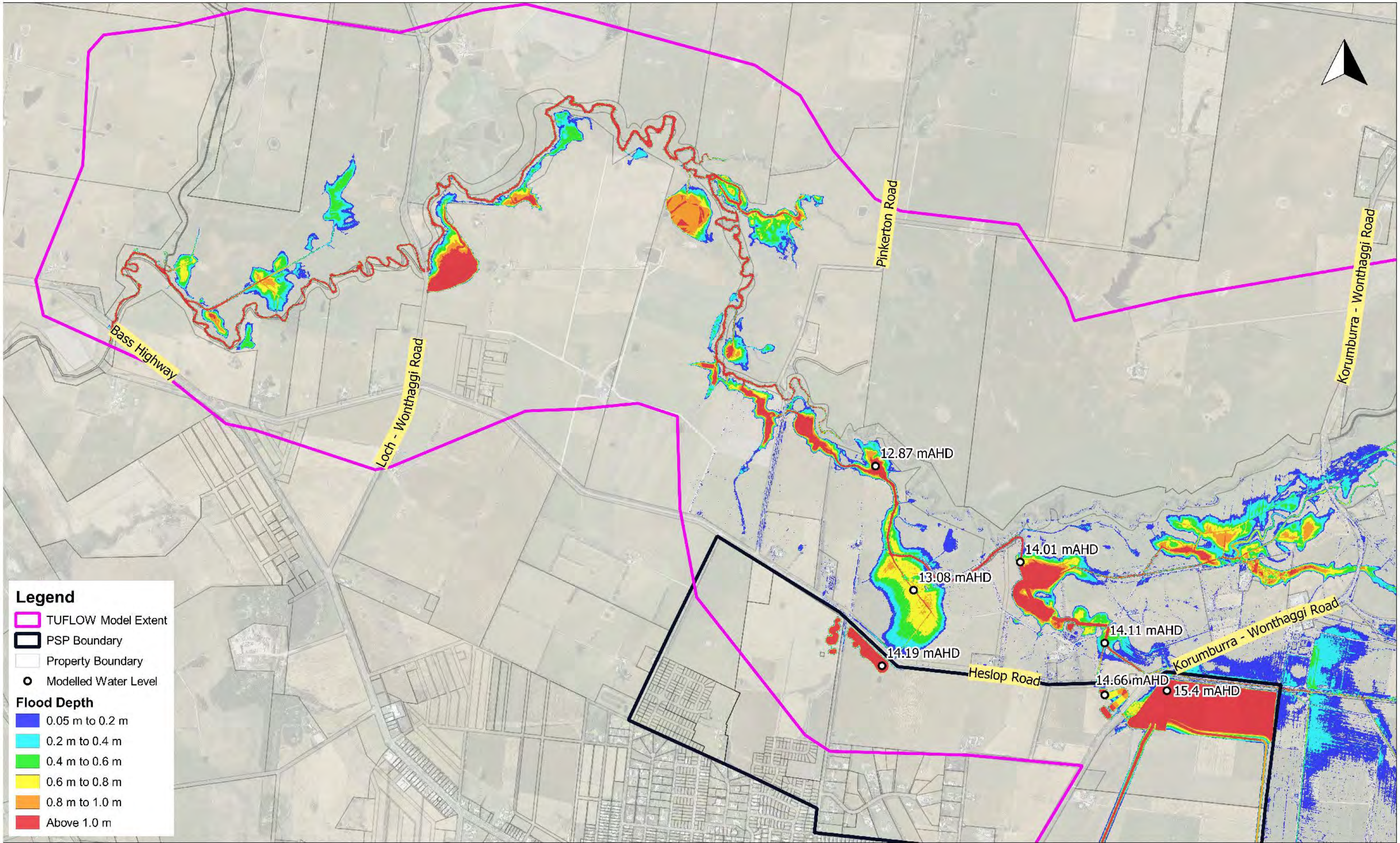
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

50 % AEP Flood Depth
Predeveloped Conditions
No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021

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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

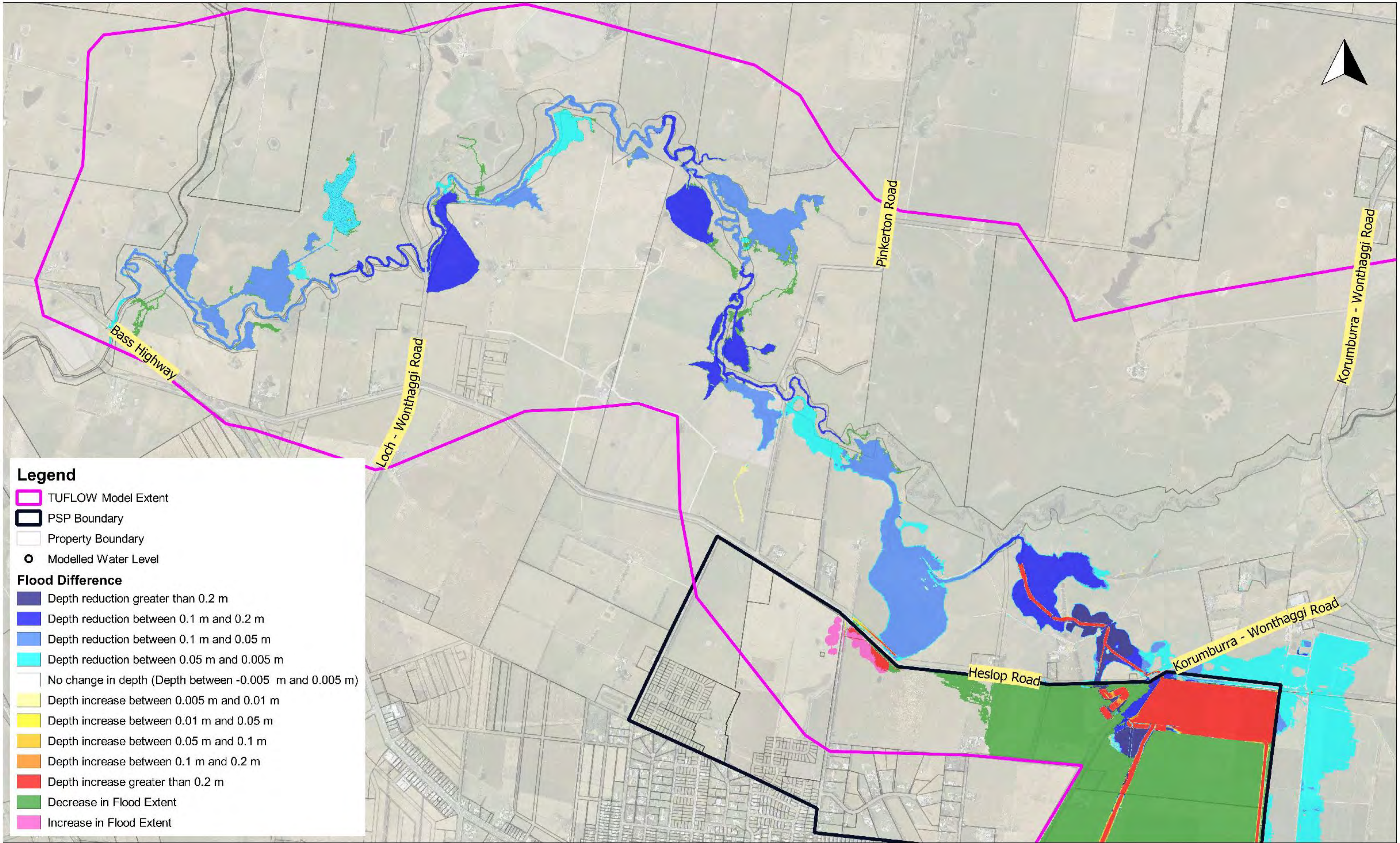
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

50 % AEP Flood Depth
Developed Conditions
No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021

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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

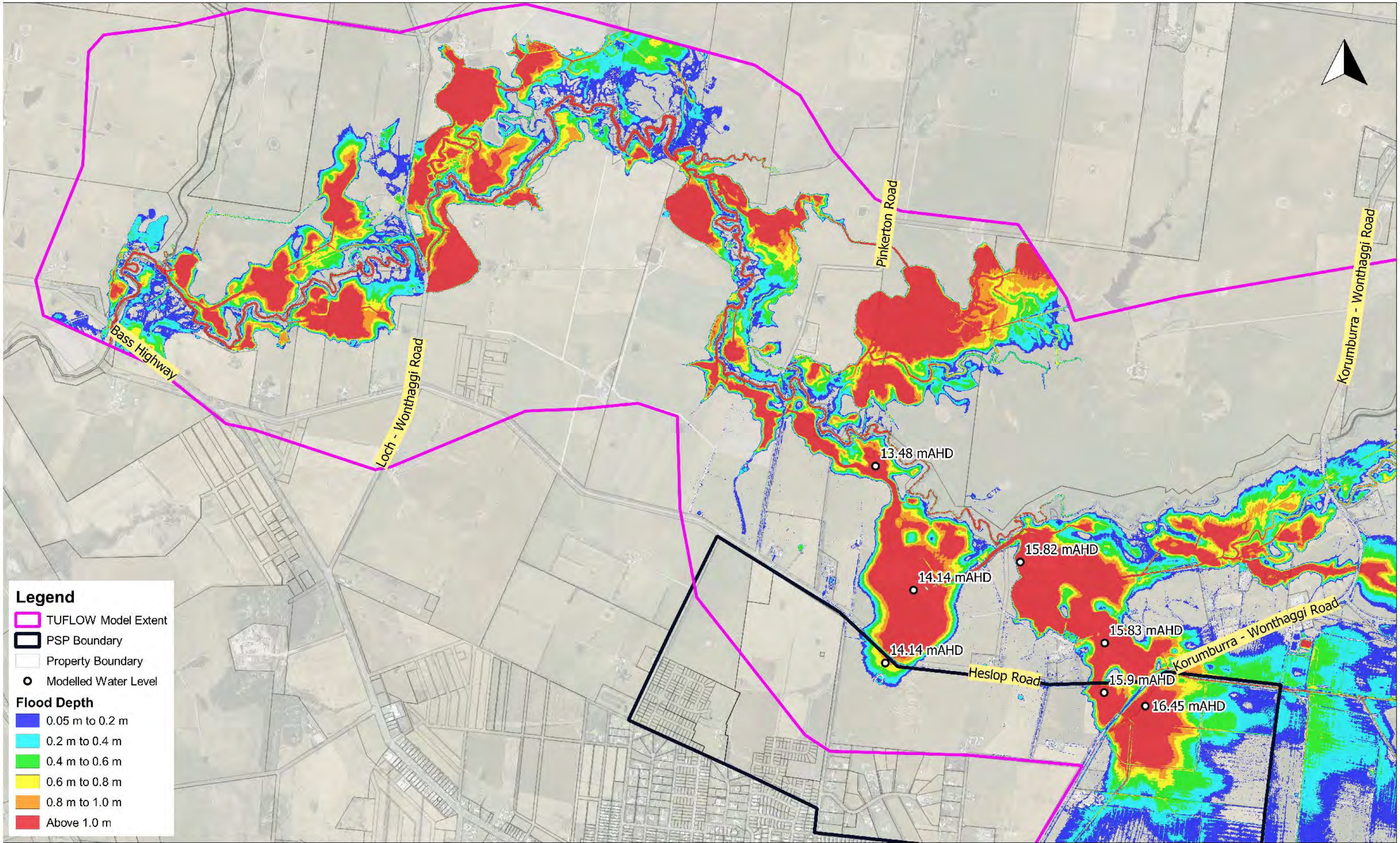
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

### 50 % AEP Flood Difference Plot (Afflux) Developed Conditions Minus Predeveloped Conditions No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021

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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

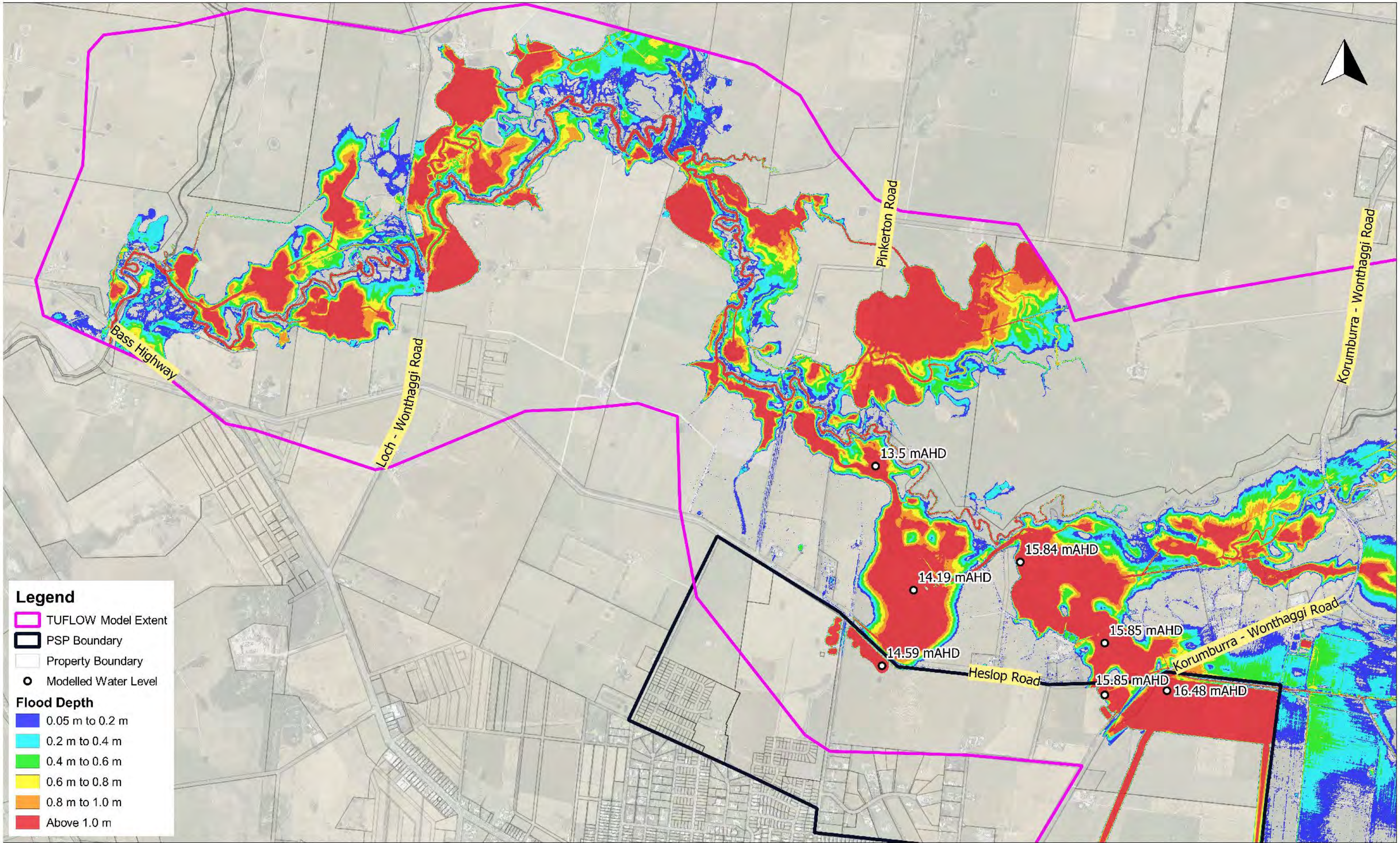
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

## 1 % AEP Flood Depth
## Predeveloped Conditions
## No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021





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ENGENY WATER MANAGEMENT

BASS COAST


200 0 200 400 600 800 m

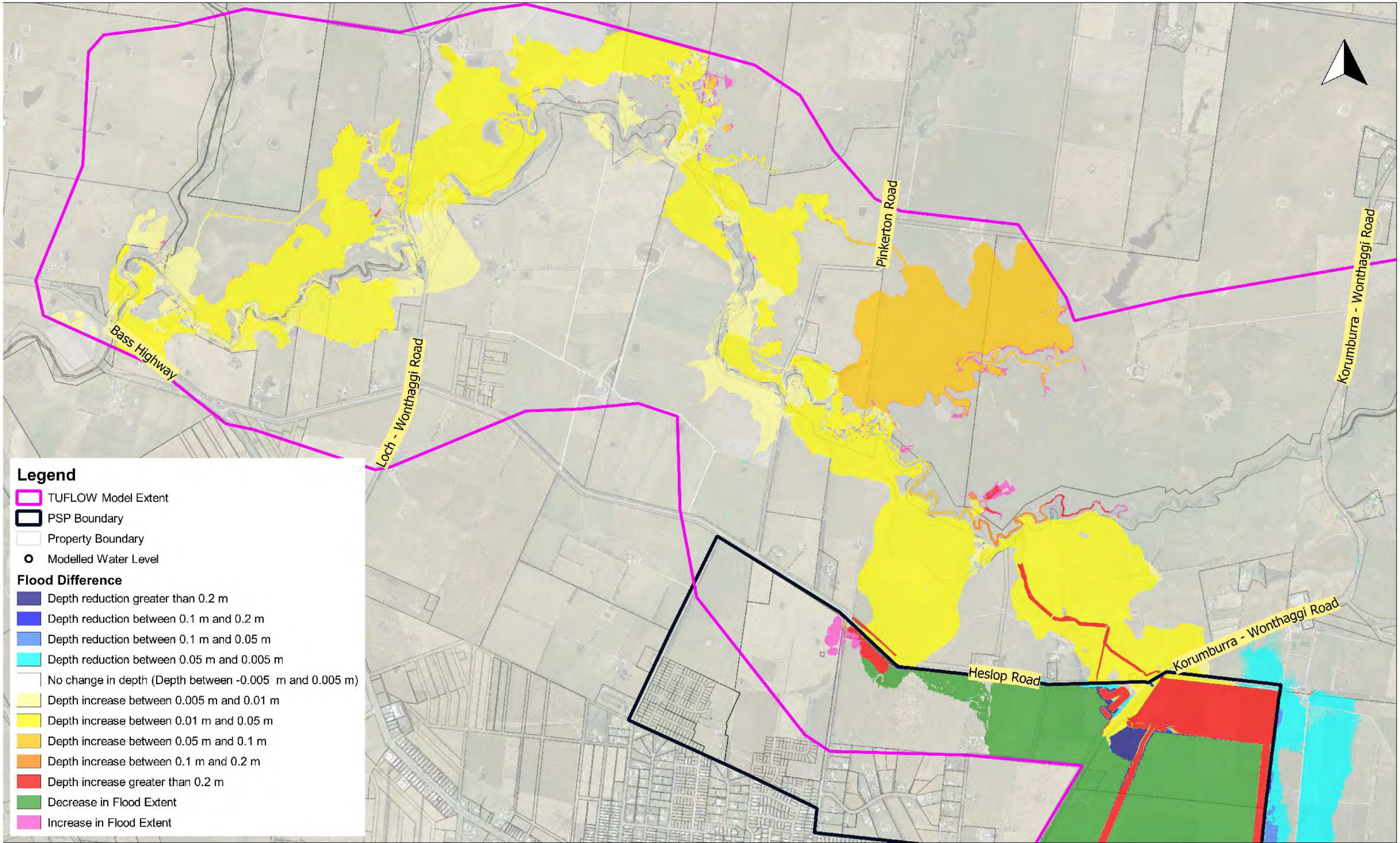
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

## 1 % AEP Flood Depth
## Developed Conditions
## No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021





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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

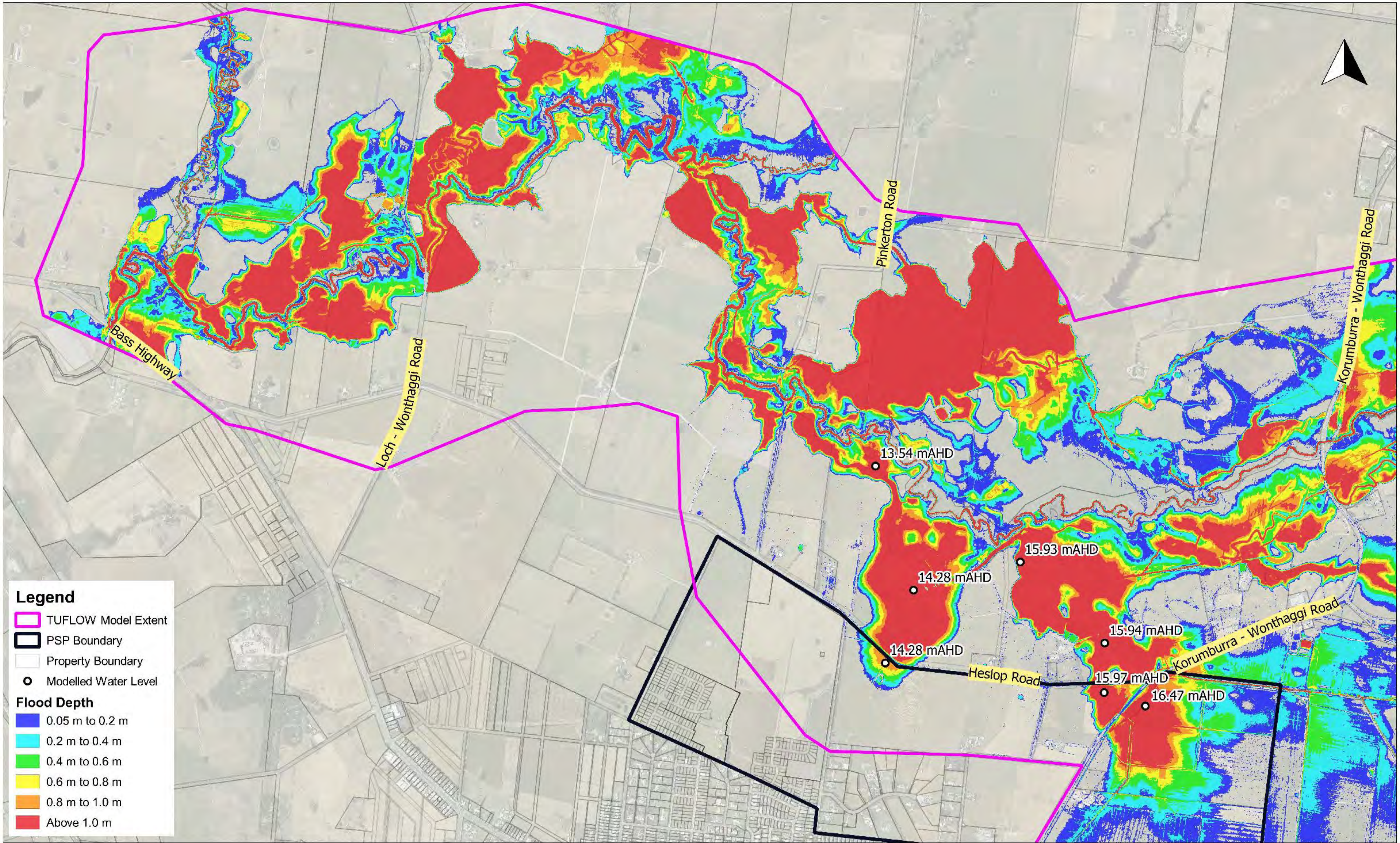
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

1 % AEP Flood Difference Plot (Afflux)
Developed Conditions Minus Predeveloped Conditions
No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021




Level 34, Tenancy 5, 360 Elizabeth St,
Melbourne VIC 3000
PO Box 12192, A'Beckett St
VIC 8006
www.engeny.com.au
P: 03 9888 6978
F: 03 9830 2601
E: melb@engeny.com.au

ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

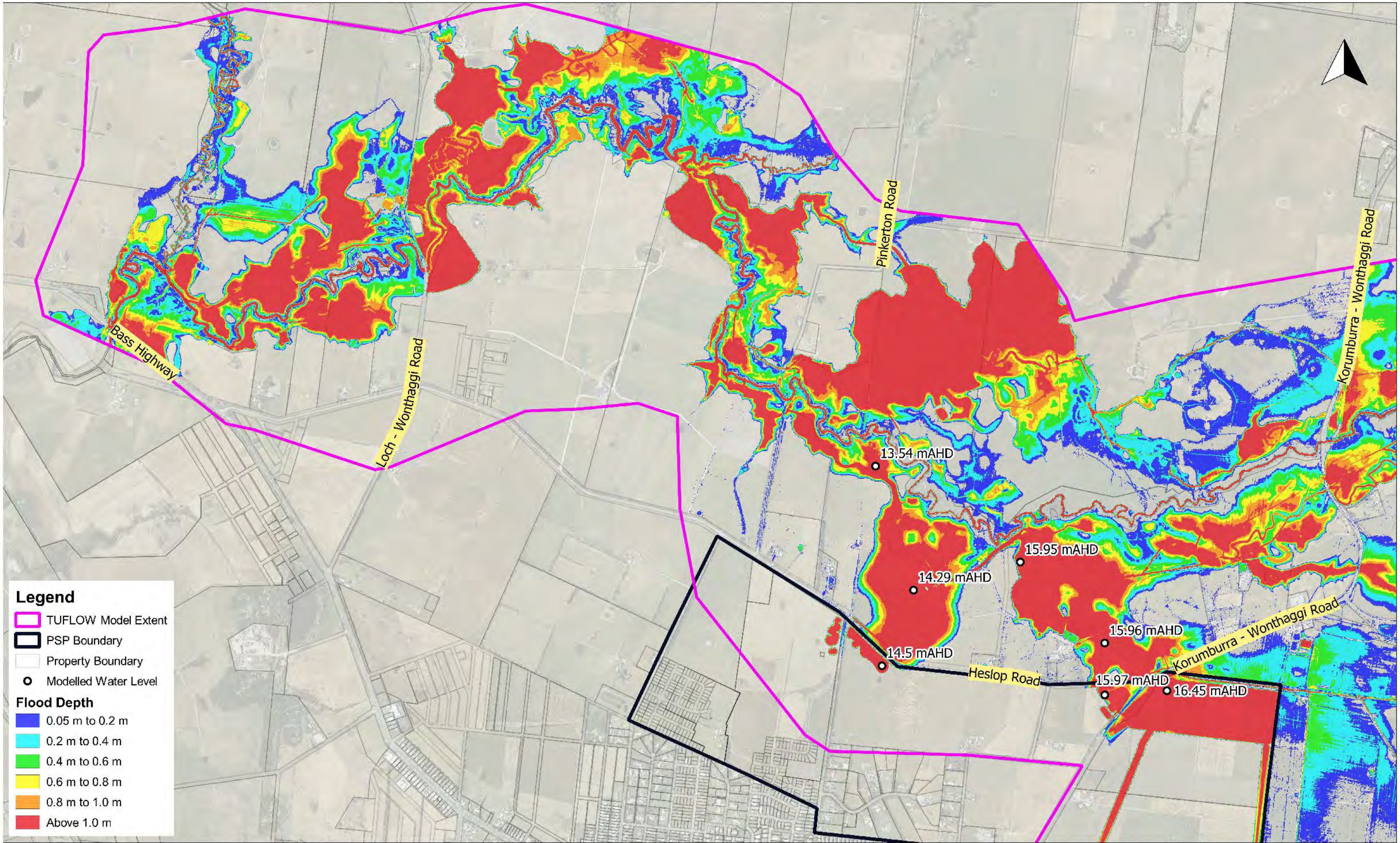
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

## 1 % AEP Flood Depth Predeveloped Conditions With Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021





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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

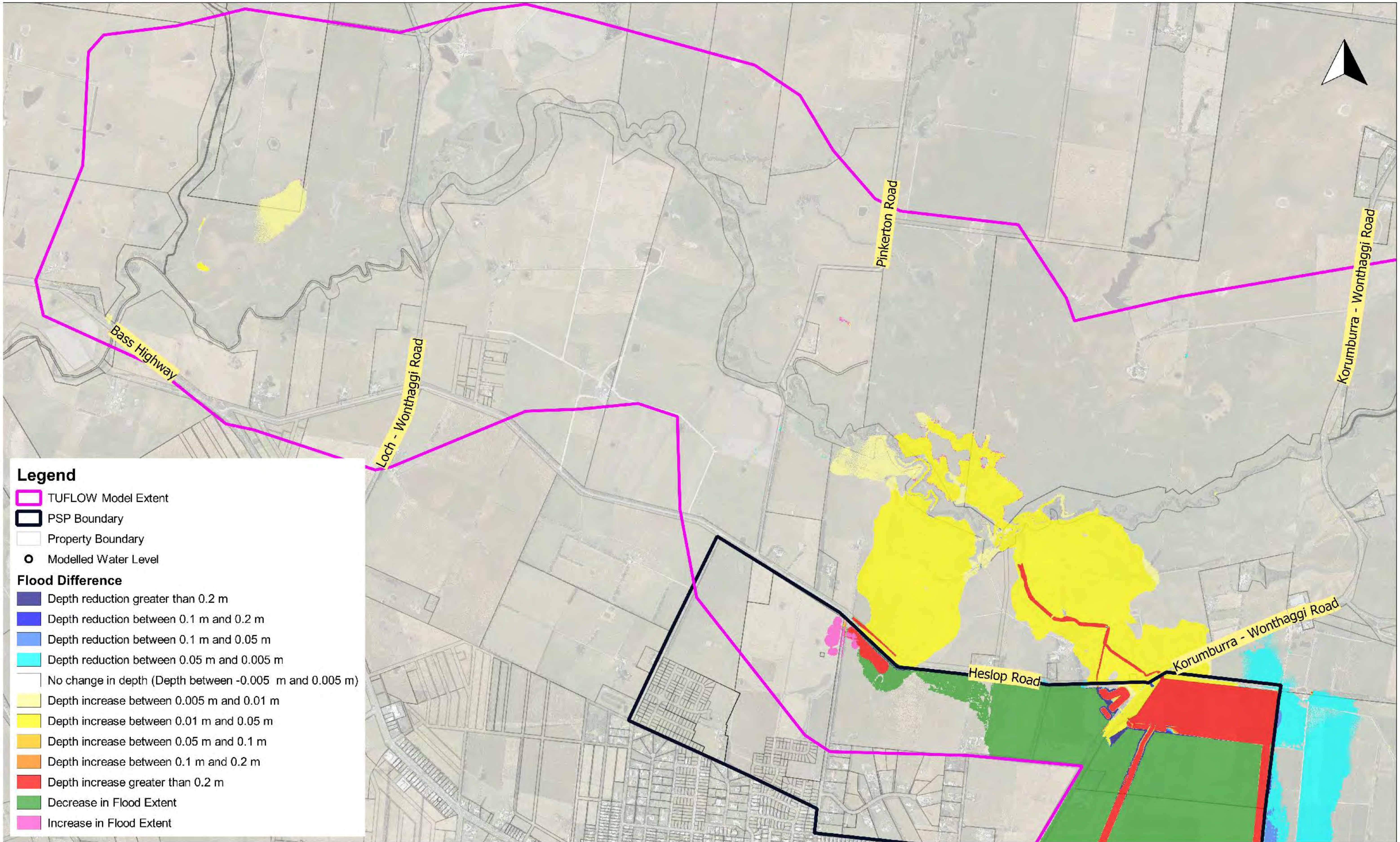
Scale in metres ( 1:17000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

### 1 % AEP Flood Depth Developed Conditions With Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021

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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

Scale in metres ( 1:17000 @ A3)

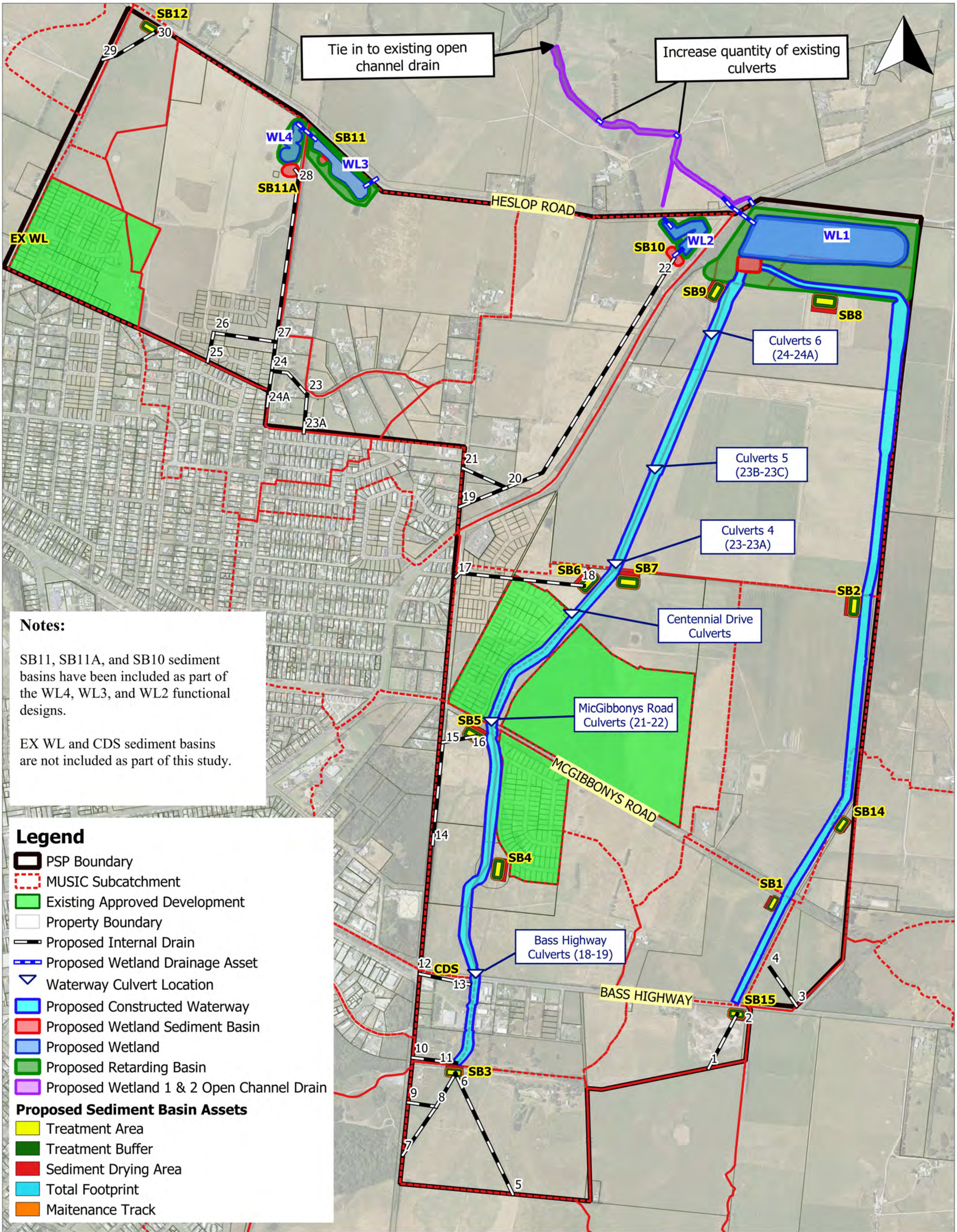
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

1 % AEP Flood Difference Plot (Afflux)
Developed Conditions RB1 Minus Predeveloped Conditions
With Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 24/8/2021

# Appendix C:
## Proposed Stormwater Infrastructure Layout

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ENGENY WATER MANAGEMENT

BASS COAST

0 150 300 450 600 m

Scale in metres (1:12000 @ A3)

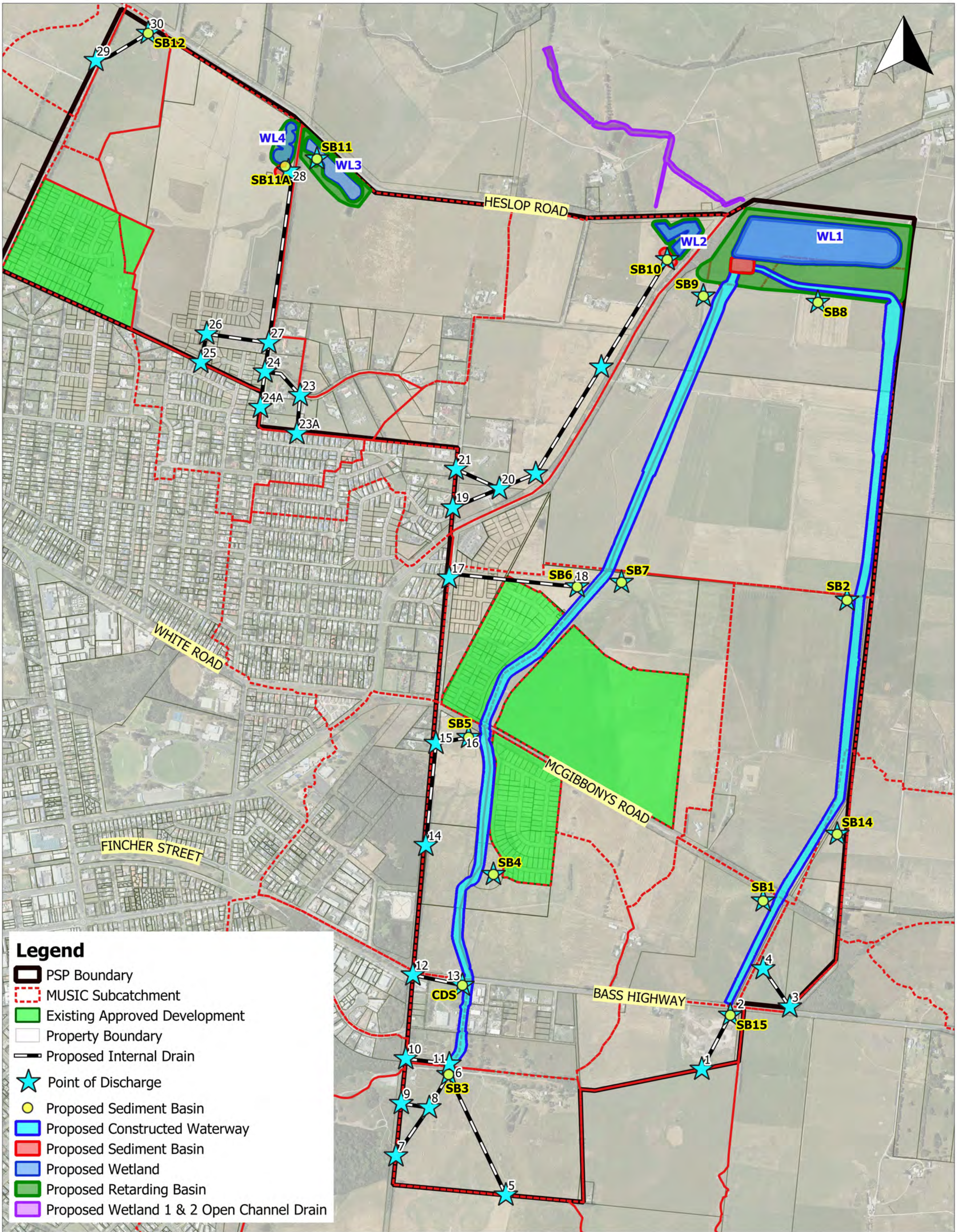
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

## Wonthaggi NE PSP

Proposed Stormwater Infrastructure Layout Plan

Job Number: V5000_002
Revision: 0
Drawn: AM
Checked: GTO
Date: 3/9/2021

# Appendix D:
## Layout of Proposed Points of Discharge for Development

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ENGENY WATER MANAGEMENT

BASS COAST

0 150 300 450 600 m

Scale in metres (1:12000 @ A3)

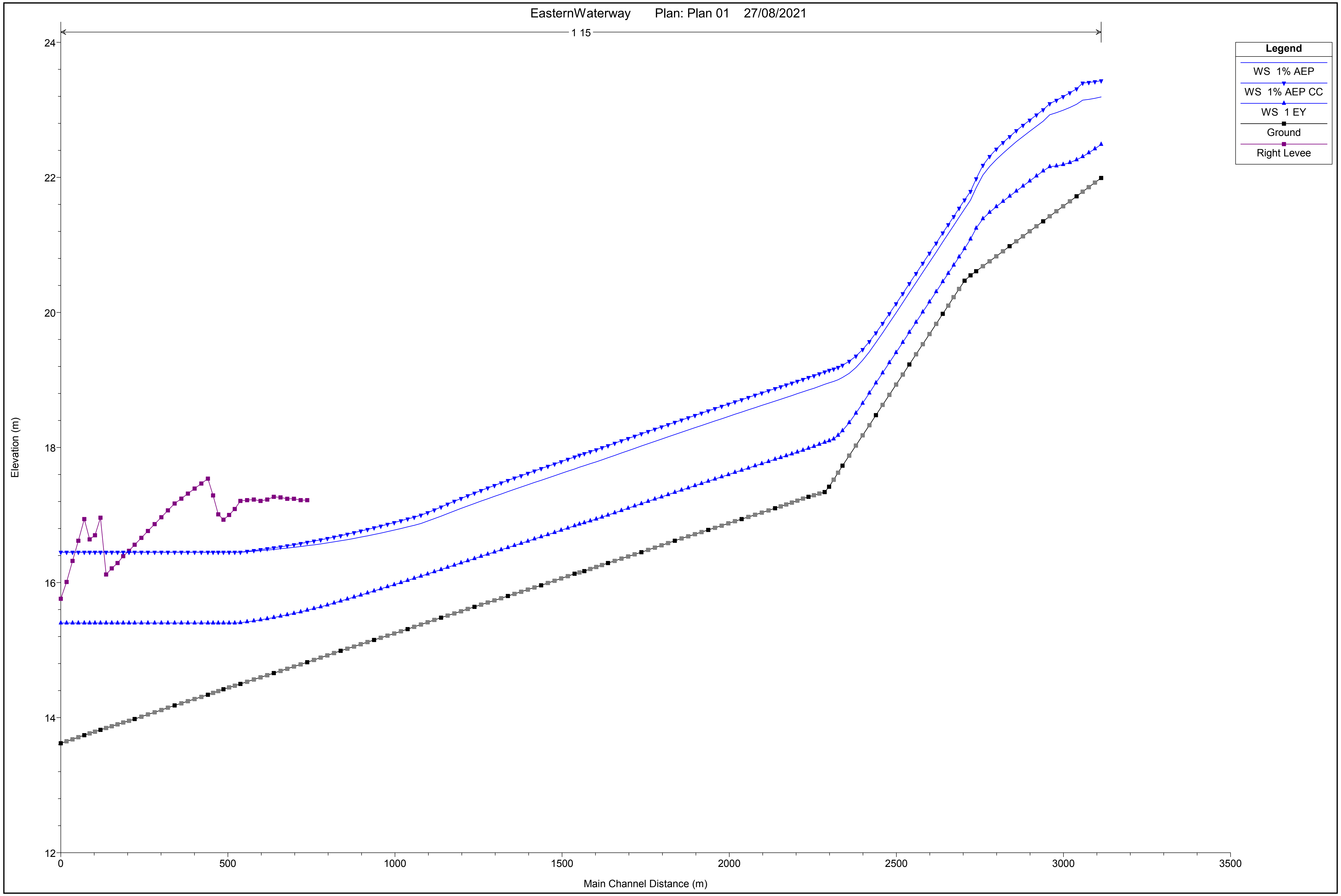
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

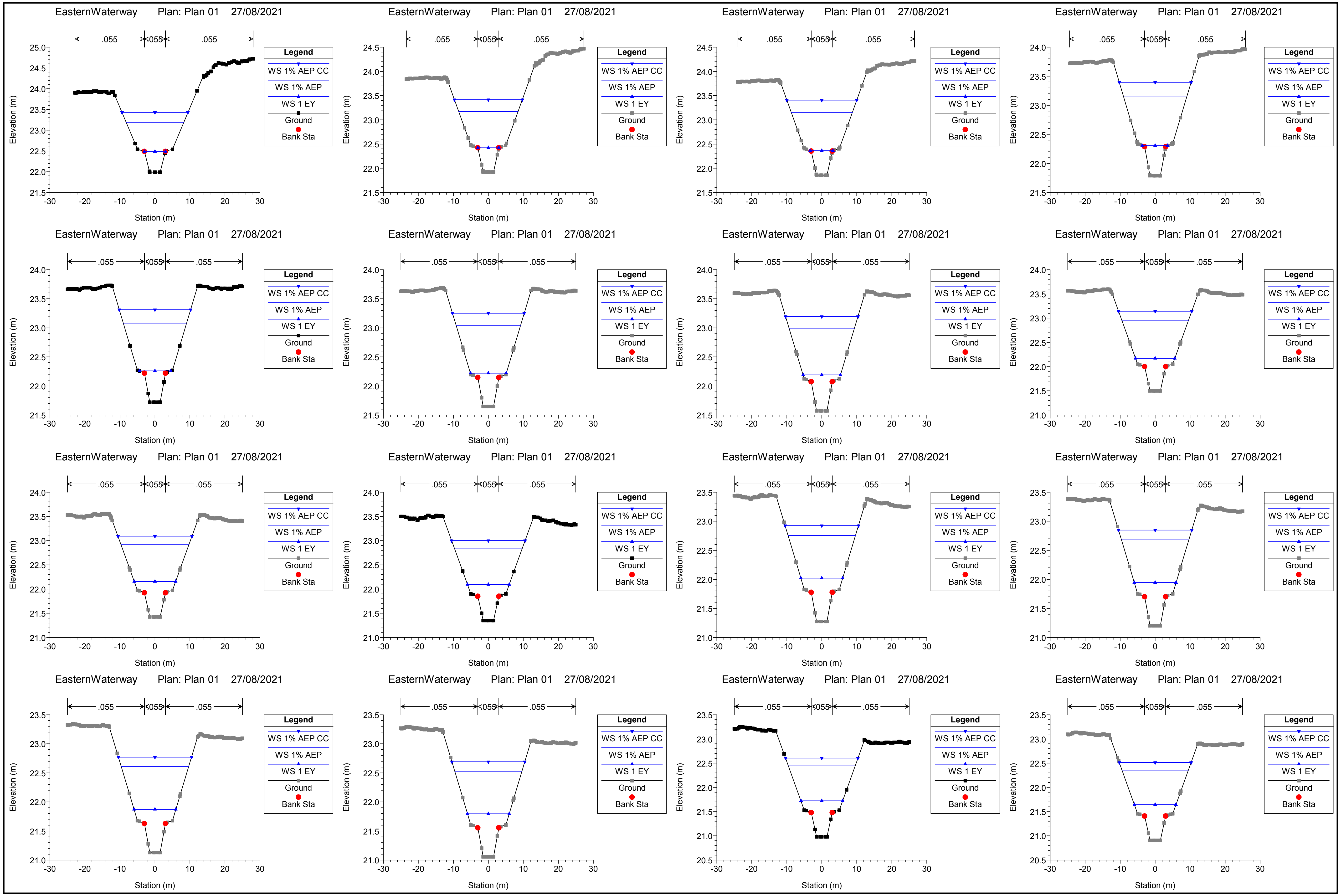
# Wonthaggi NE PSP

Proposed Points of Discharge Layout Plan

Job Number: V5000_002
Revision: 0
Drawn: AM
Checked: GTO
Date: 3/9/2021

# Appendix E:
## HECRAS Modelling Results


EasternWaterway Plan: Plan 01 27/08/2021
1 15
Legend
WS 1% AEP
WS 1% AEP CC
WS 1 EY
Ground
Right Levee
Elevation (m)
24
22
20
18
16
14
12
0
500
1000
1500
2000
2500
3000
3500
Main Channel Distance (m)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Legend
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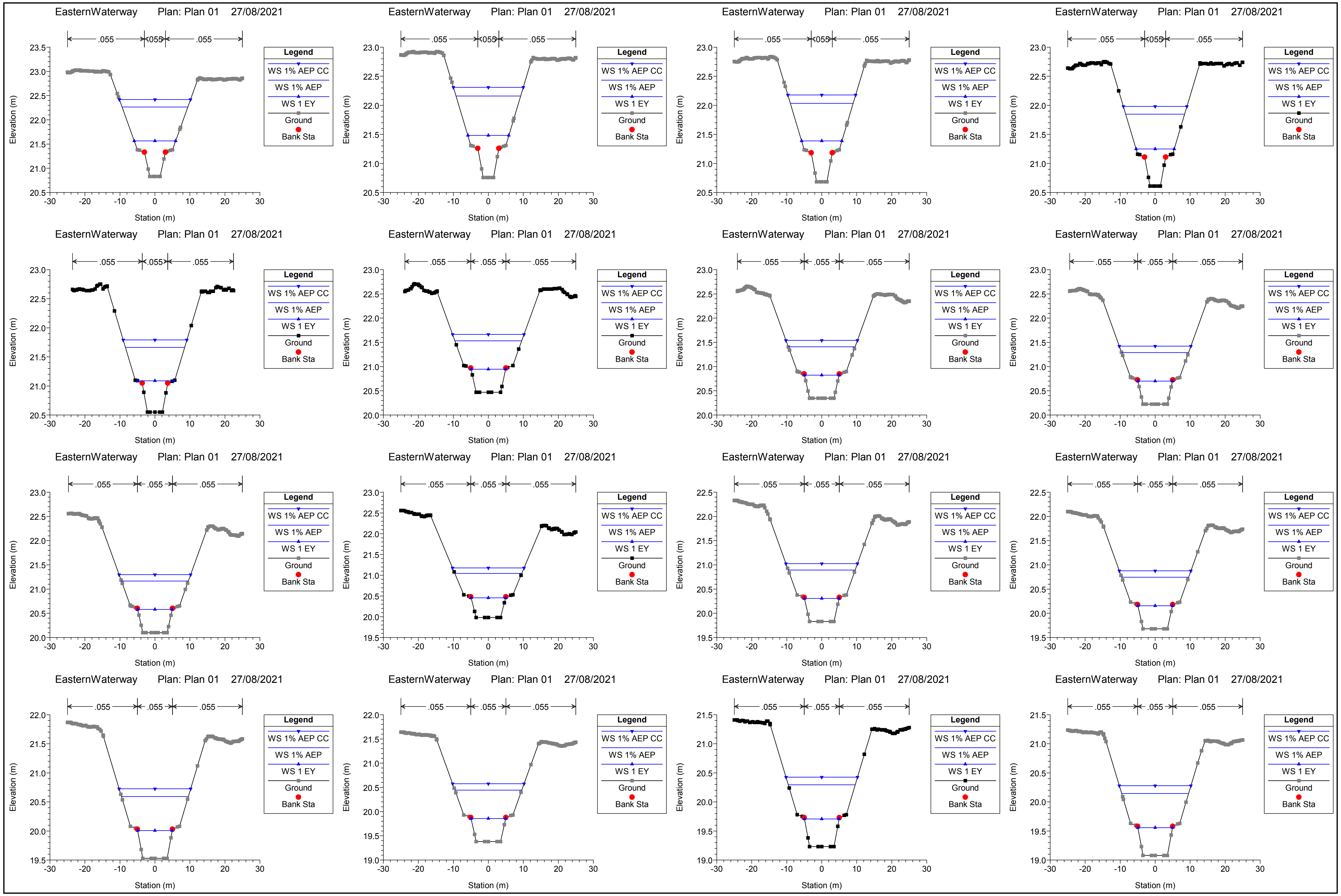
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)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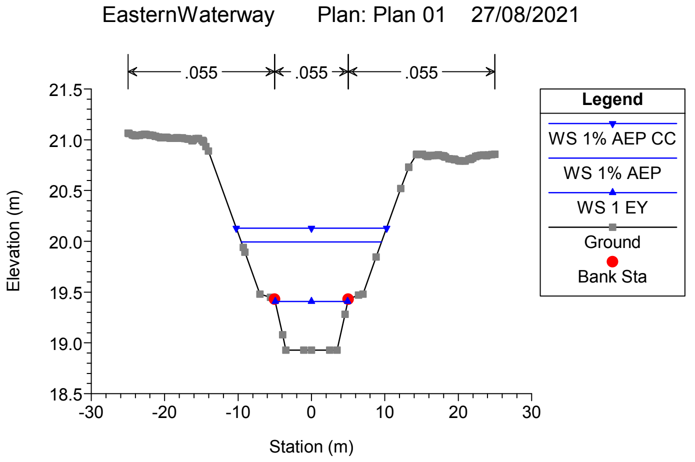
Ground
Bank Sta
Elevation (m)
Station (m)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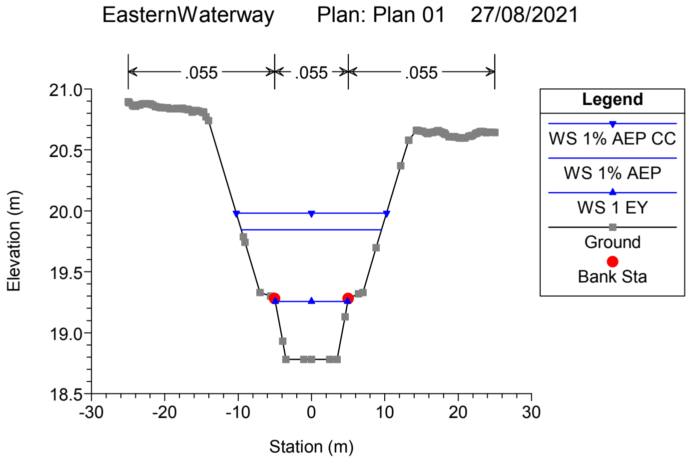
Ground
Bank Sta
Elevation (m)
Station (m)


EasternWaterway Plan: Plan 01 27/08/2021
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Legend
WS 1% AEP CC
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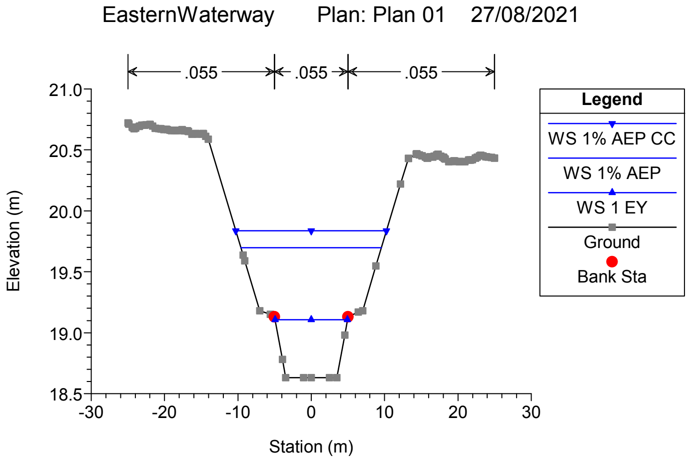
Ground
Bank Sta
Elevation (m)
Station (m)


EasternWaterway Plan: Plan 01 27/08/2021
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Legend
WS 1% AEP CC
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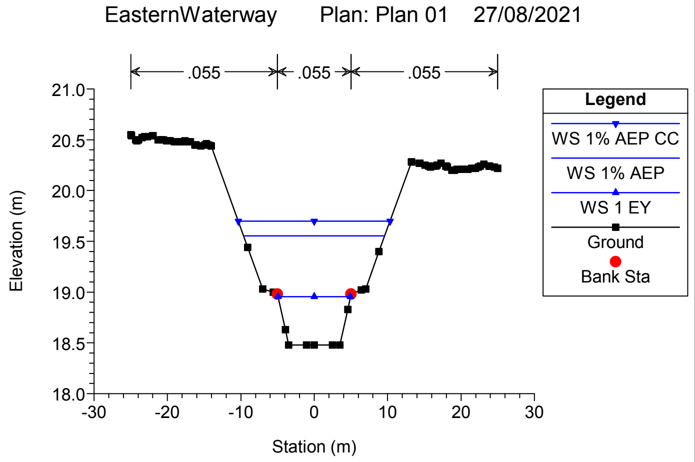
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)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Legend
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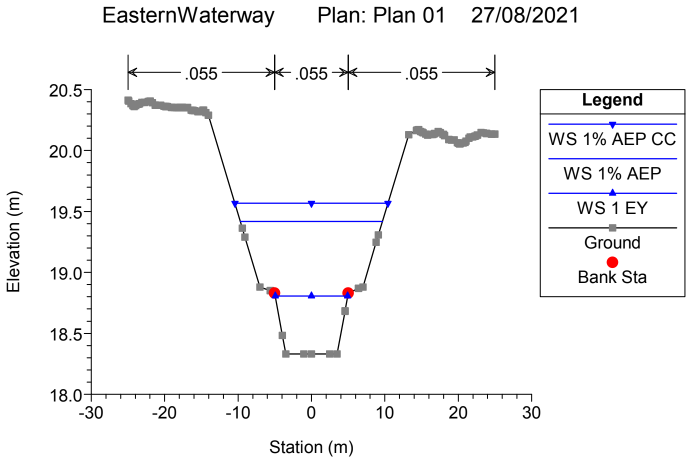
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


EasternWaterway Plan: Plan 01 27/08/2021
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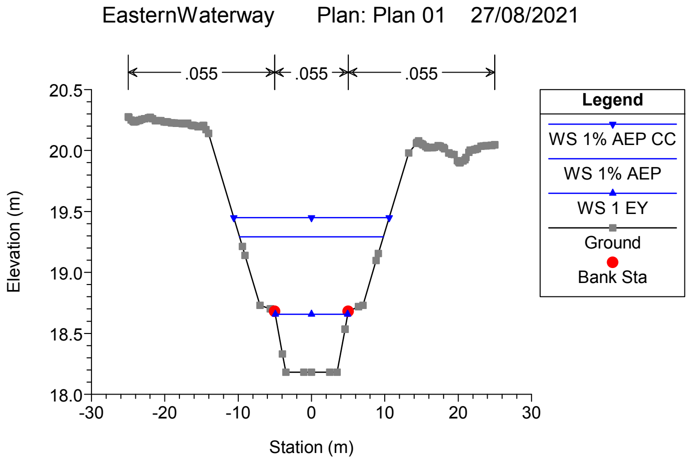
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


EasternWaterway Plan: Plan 01 27/08/2021
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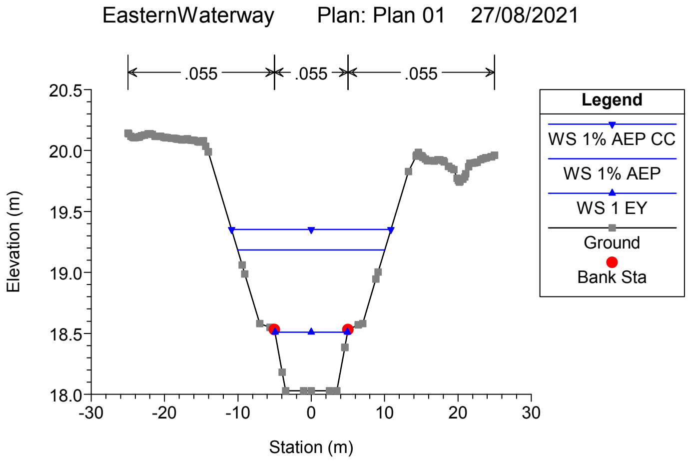
Ground
Bank Sta
Elevation (m)
Station (m)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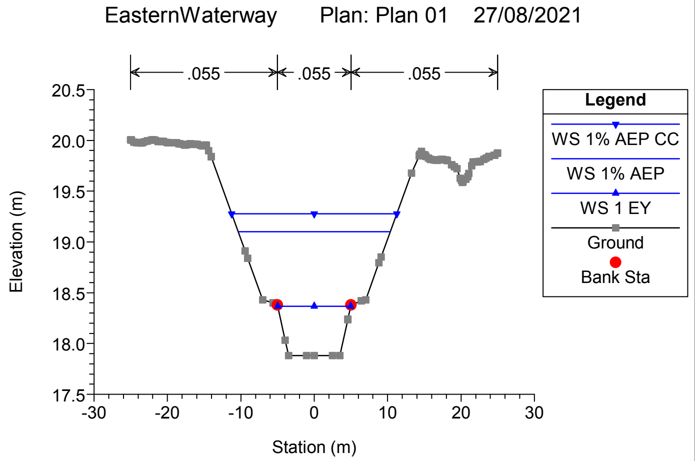
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)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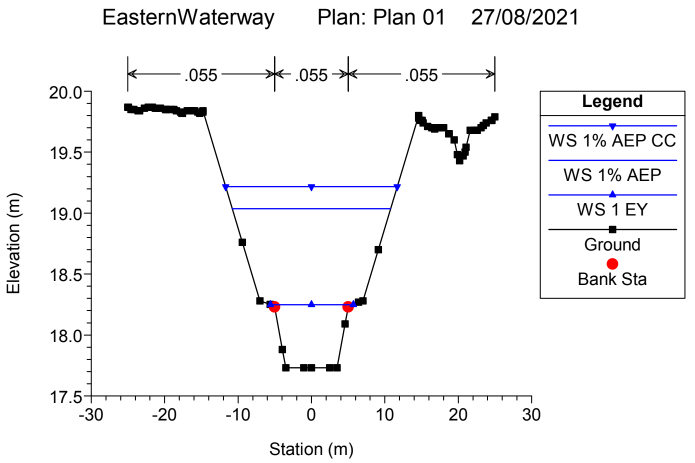
Ground
Bank Sta
Elevation (m)
Station (m)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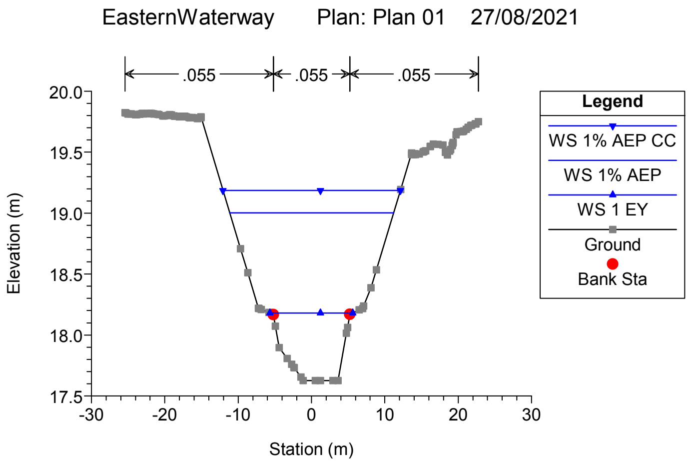
Ground
Bank Sta
Elevation (m)
Station (m)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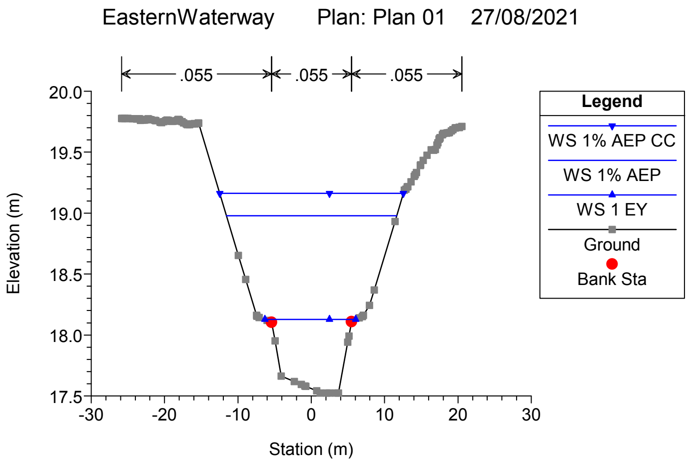
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)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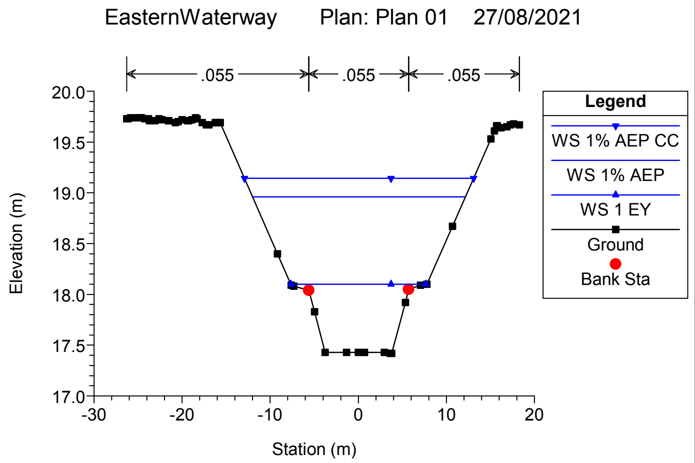
Ground
Bank Sta
Elevation (m)
Station (m)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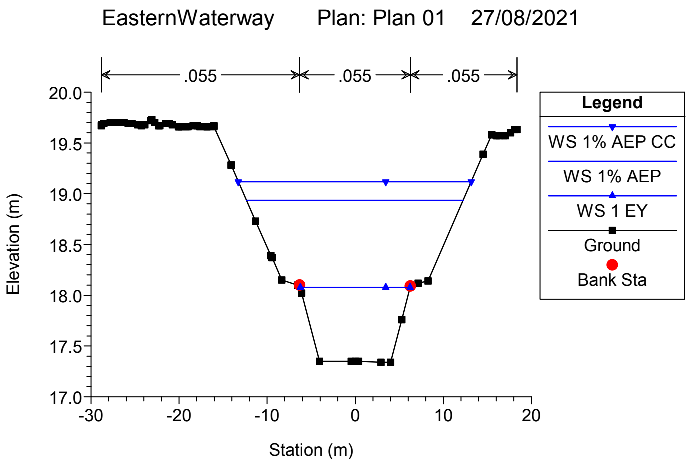
Ground
Bank Sta
Elevation (m)
Station (m)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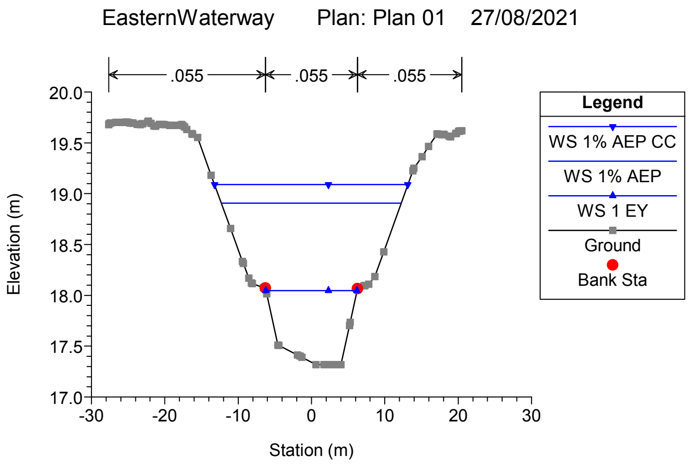
Elevation (m)
Station (m)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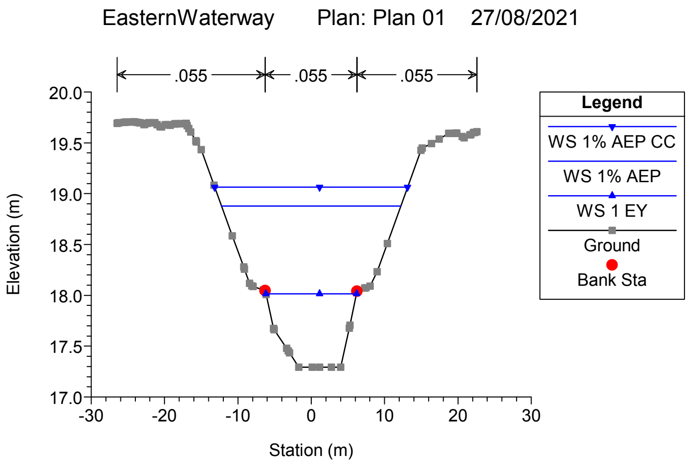
Elevation (m)
Station (m)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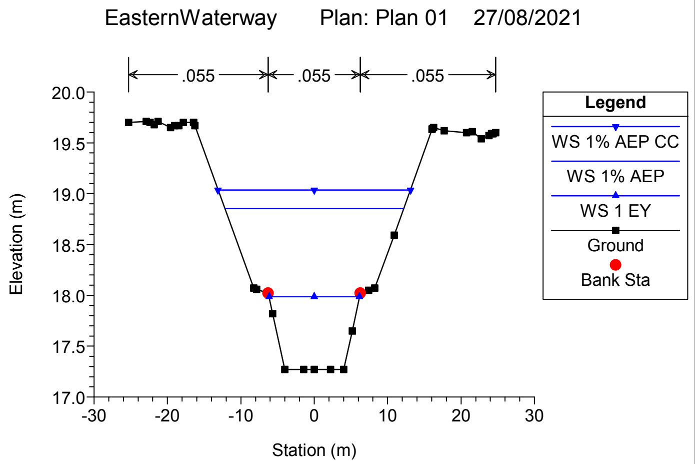
Bank Sta
Elevation (m)
Station (m)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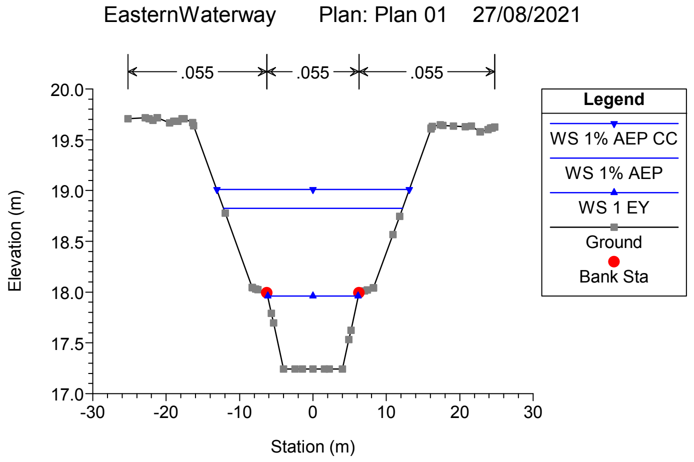
Elevation (m)
Station (m)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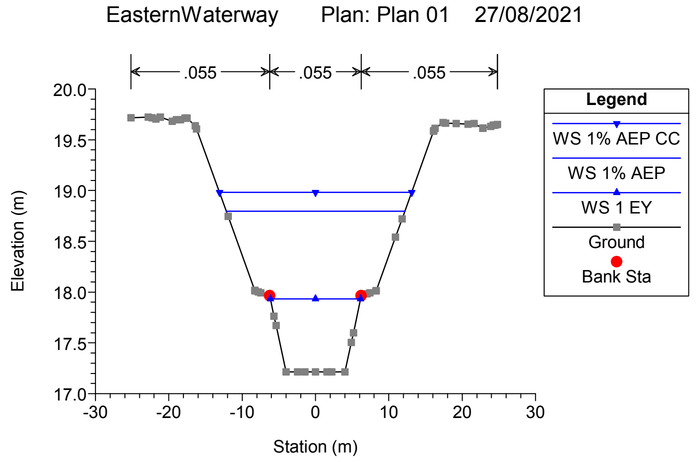
Elevation (m)
Station (m)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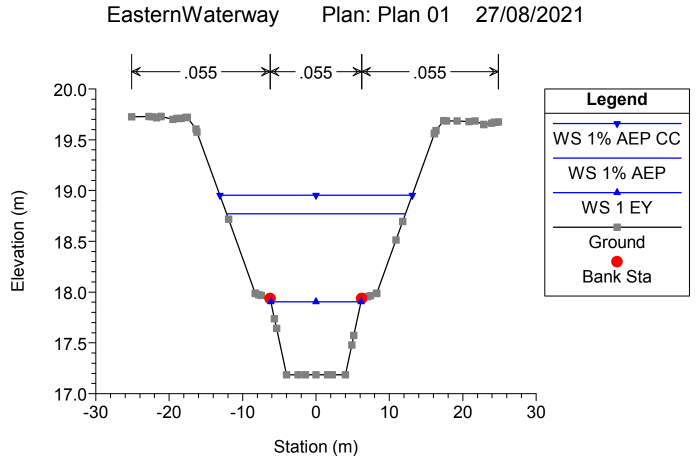
Bank Sta
Elevation (m)
Station (m)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Elevation (m)
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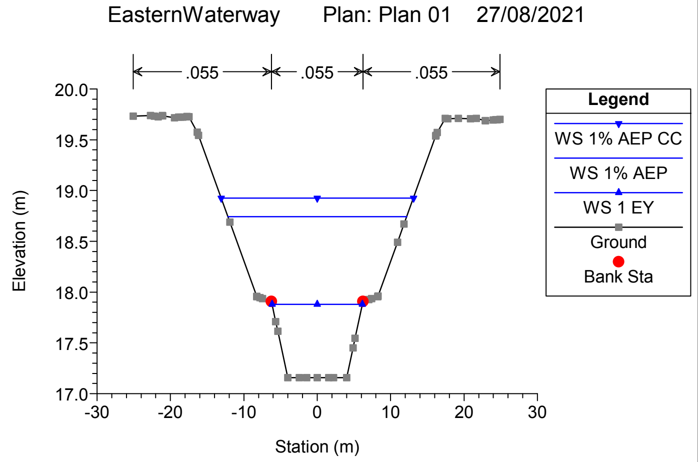
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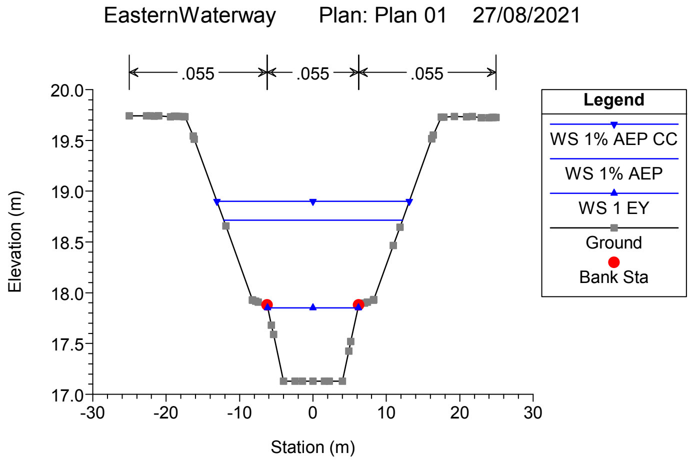
Bank Sta
Elevation (m)
Station (m)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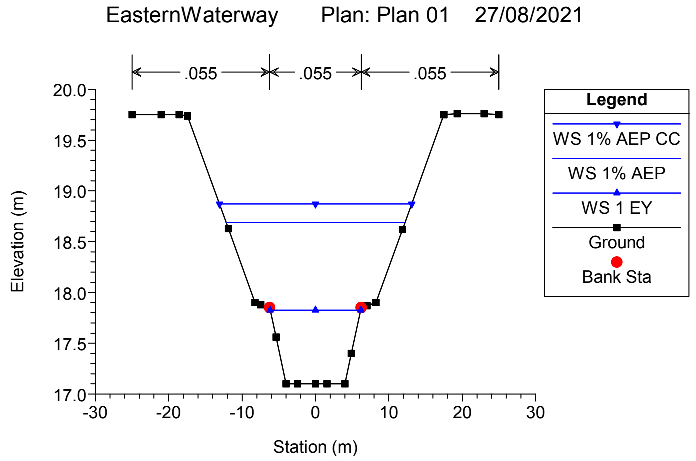
Bank Sta
Elevation (m)
Station (m)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WS 1 EY
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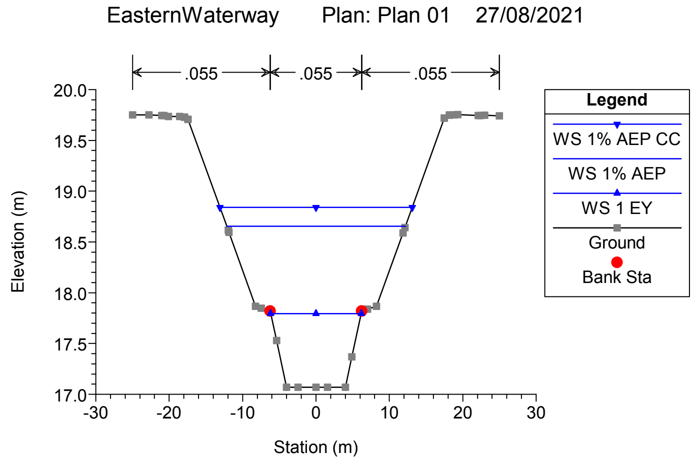
Elevation (m)
Station (m)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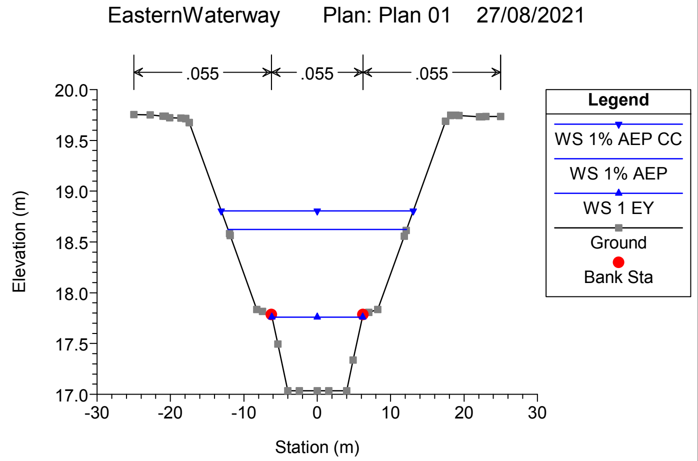
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)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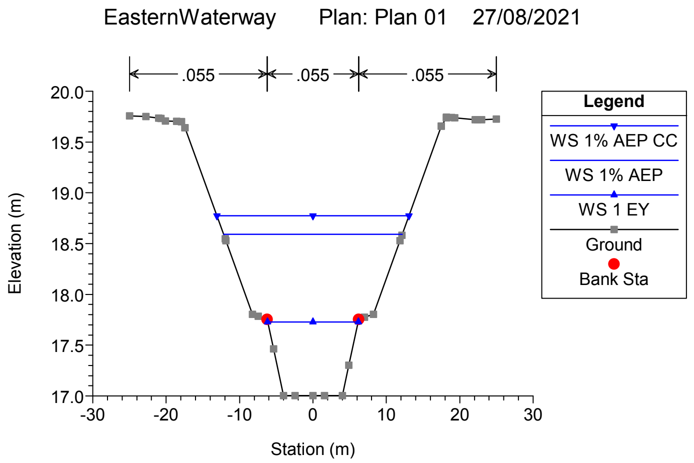
Bank Sta
Elevation (m)
Station (m)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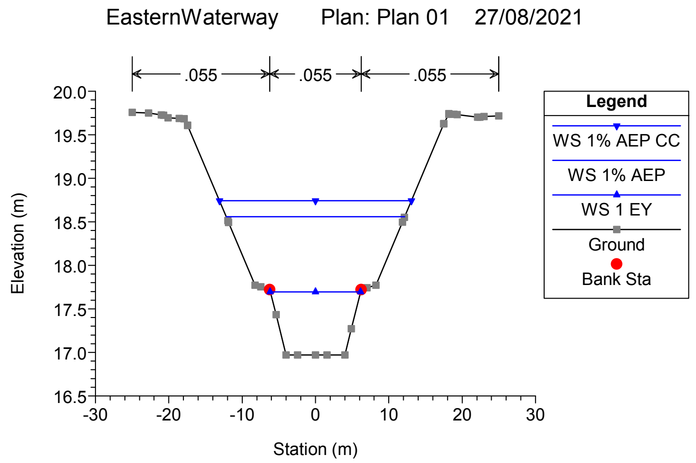
Bank Sta
Elevation (m)
Station (m)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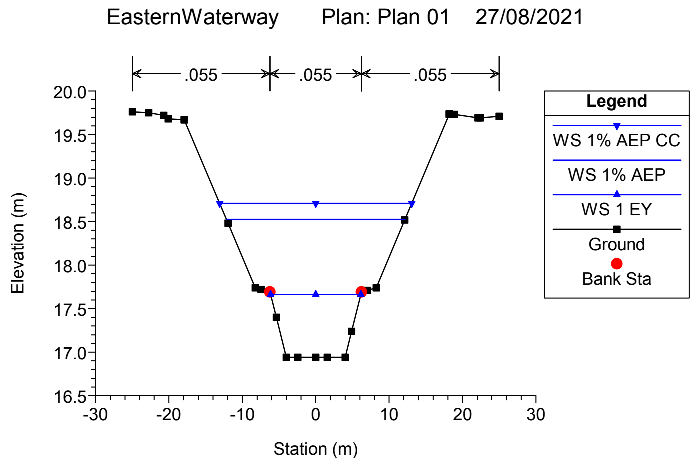
Ground
Bank Sta
Elevation (m)
Station (m)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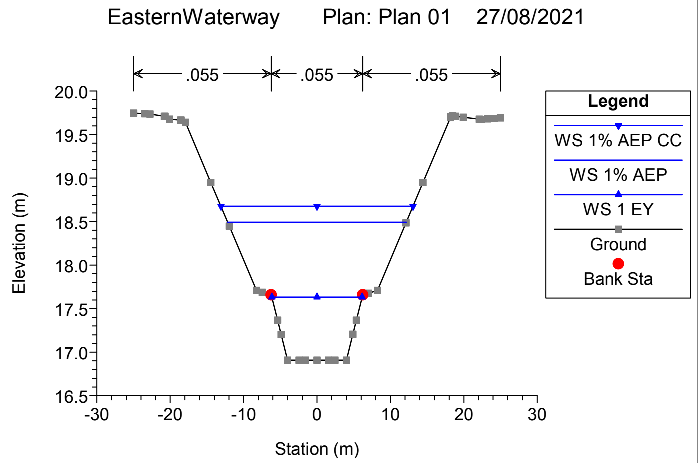
Ground
Bank Sta
Elevation (m)
Station (m)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Elevation (m)
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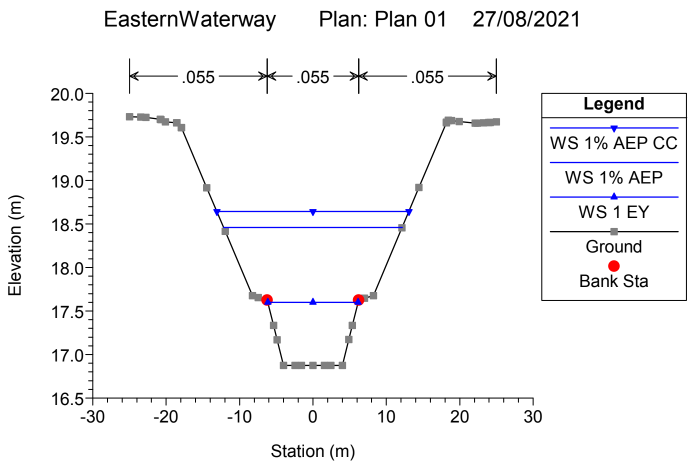
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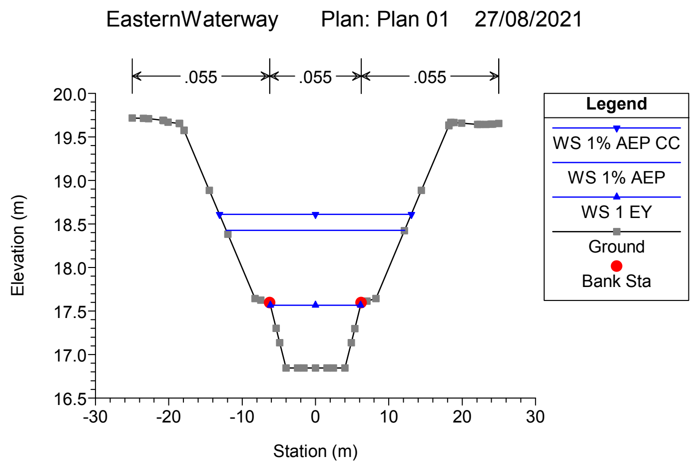
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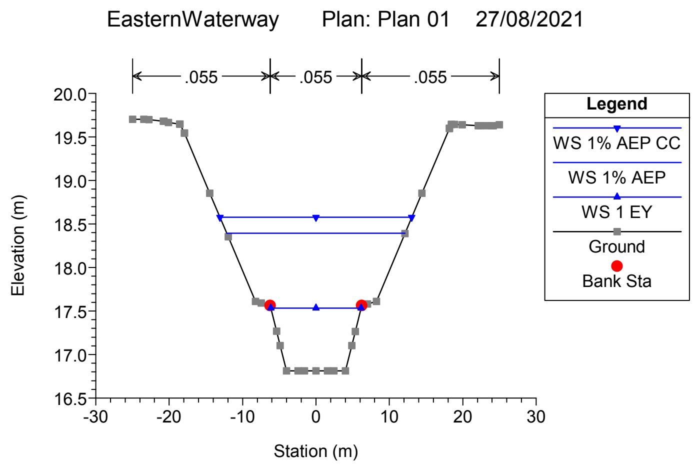
Ground
Bank Sta
Elevation (m)
Station (m)


EasternWaterway Plan: Plan 01 27/08/2021
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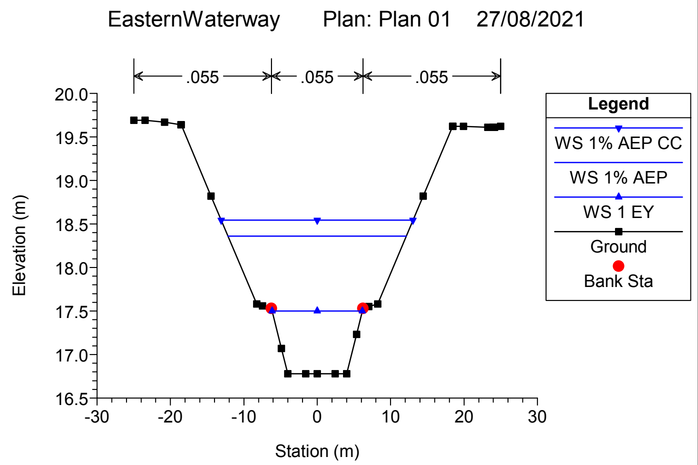
Ground
Bank Sta
Elevation (m)
Station (m)


EasternWaterway Plan: Plan 01 27/08/2021
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Ground
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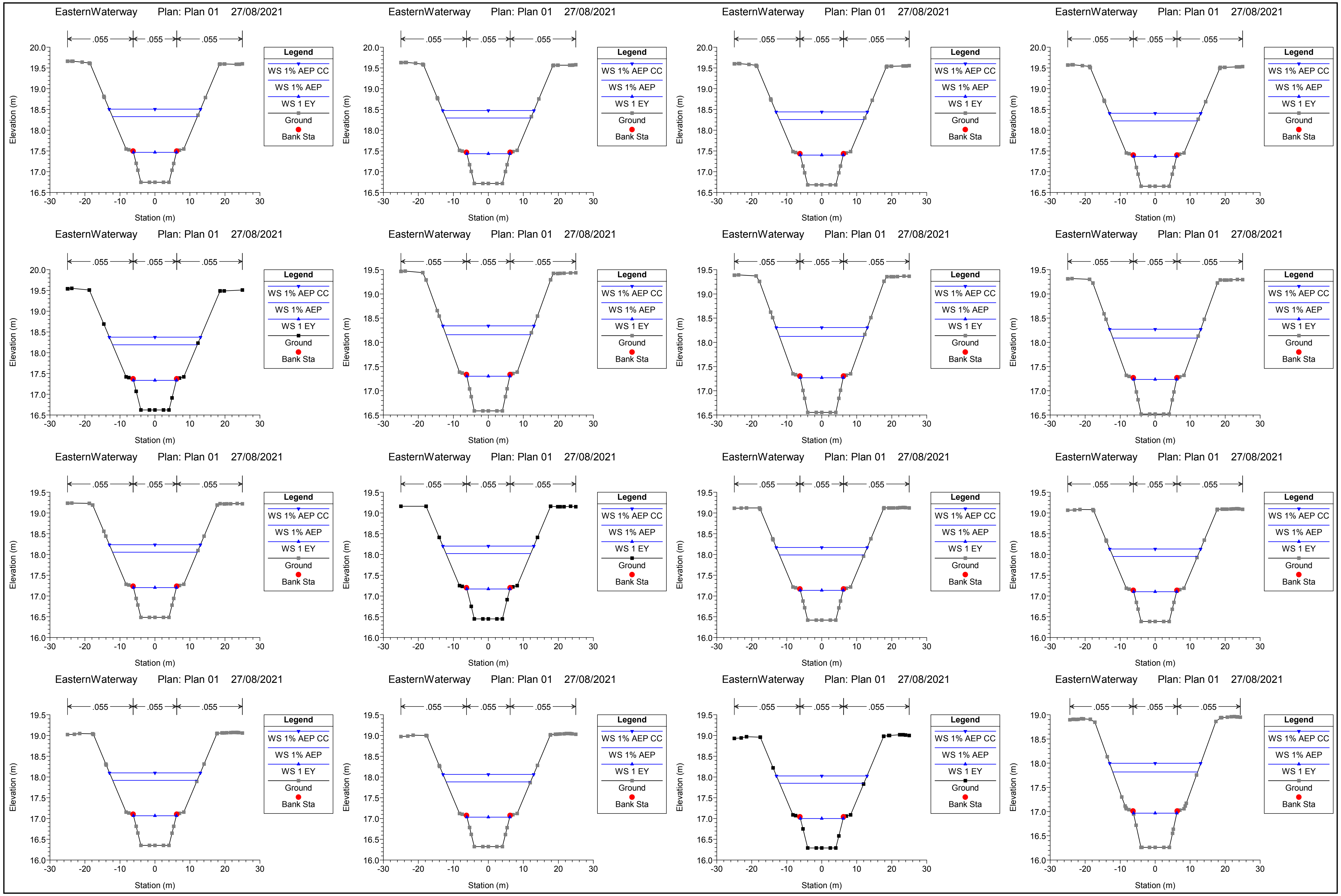
Elevation (m)
Station (m)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Legend
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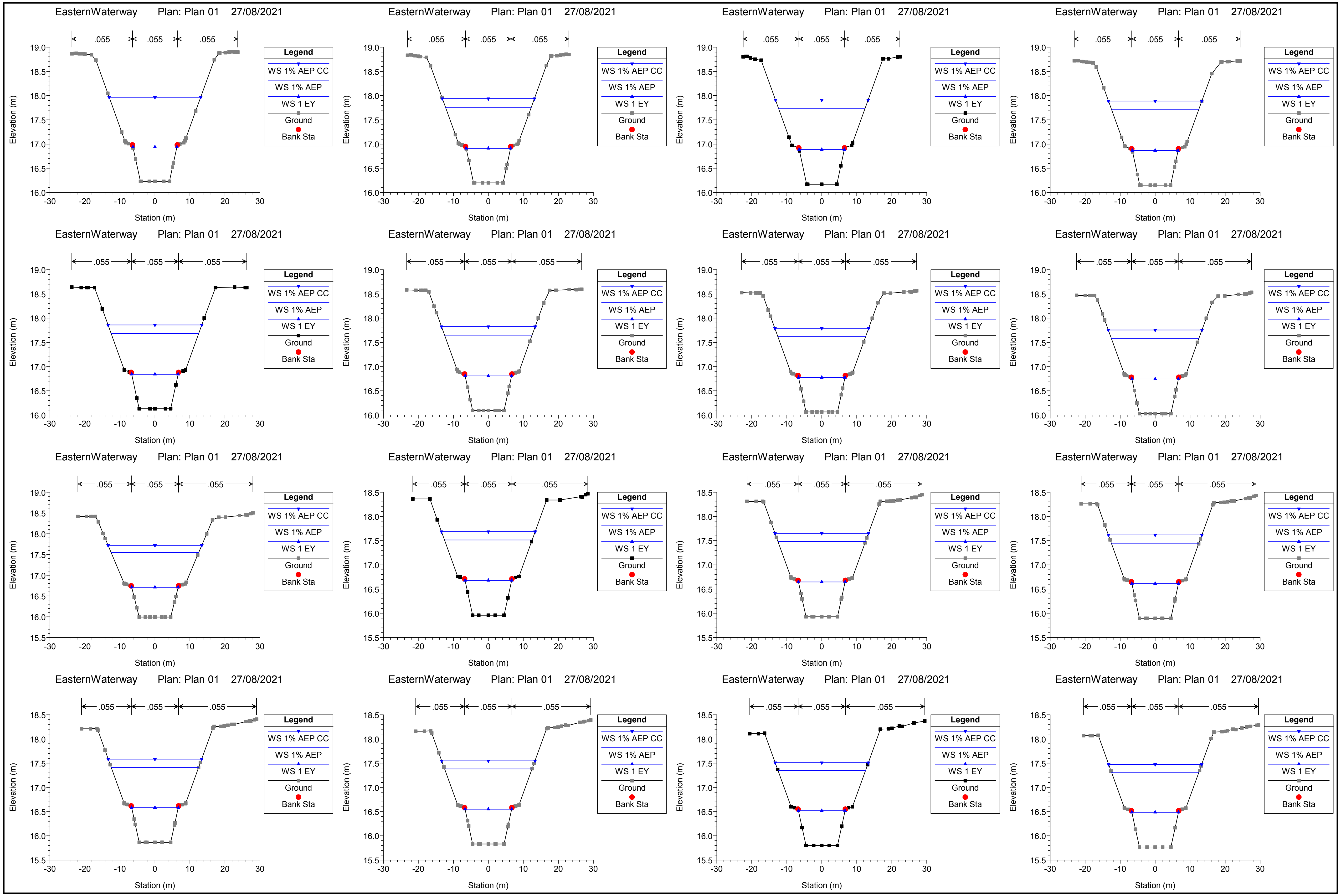
Ground
Bank Sta
Elevation (m)
Station (m)


EasternWaterway Plan: Plan 01 27/08/2021
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Legend
WS 1% AEP CC
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Ground
Bank Sta
Elevation (m)
Station (m)
EasternWaterway Plan: Plan 01 27/08/2021
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Legend
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Ground
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Elevation (m)
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EasternWaterway Plan: Plan 01 27/08/2021
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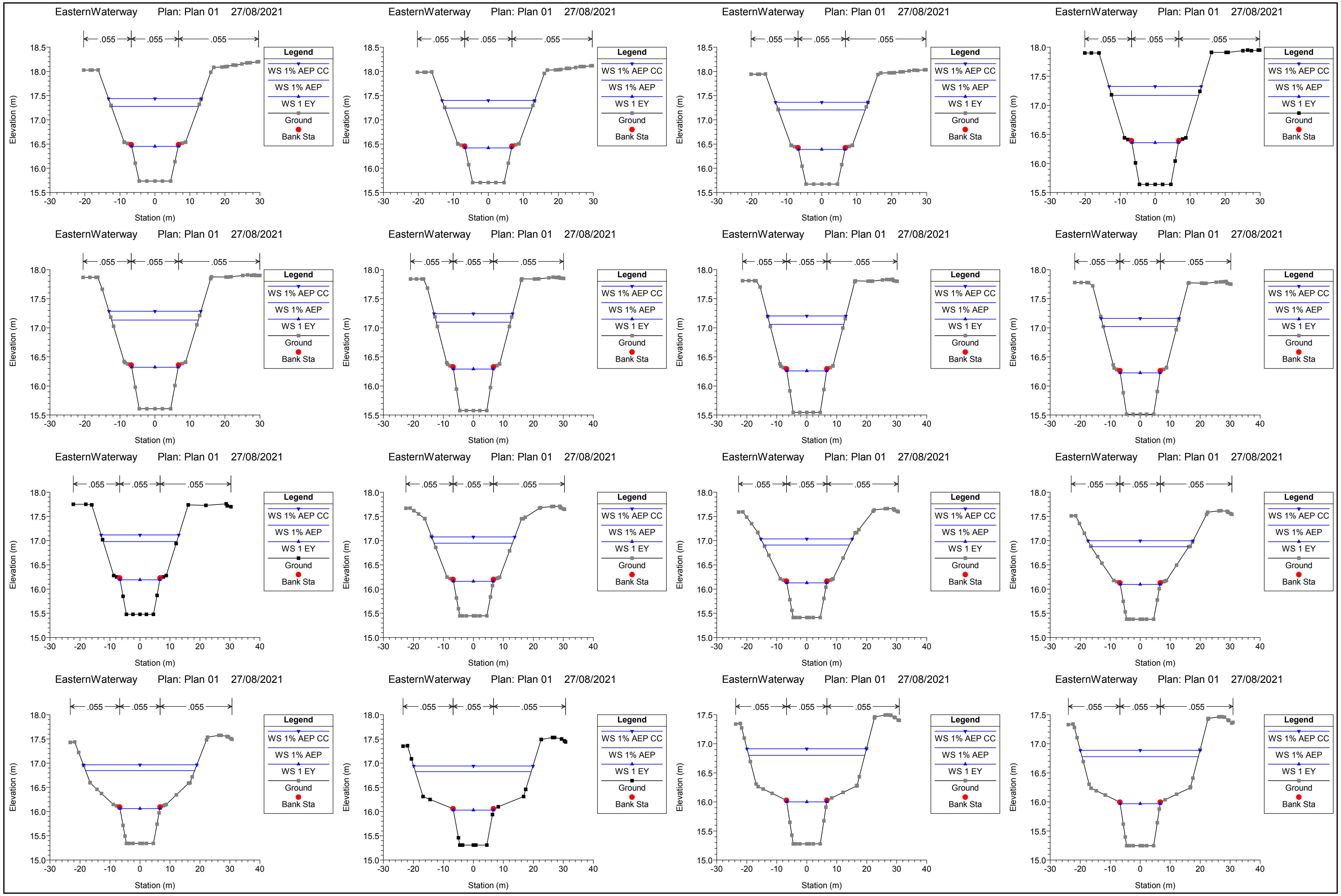
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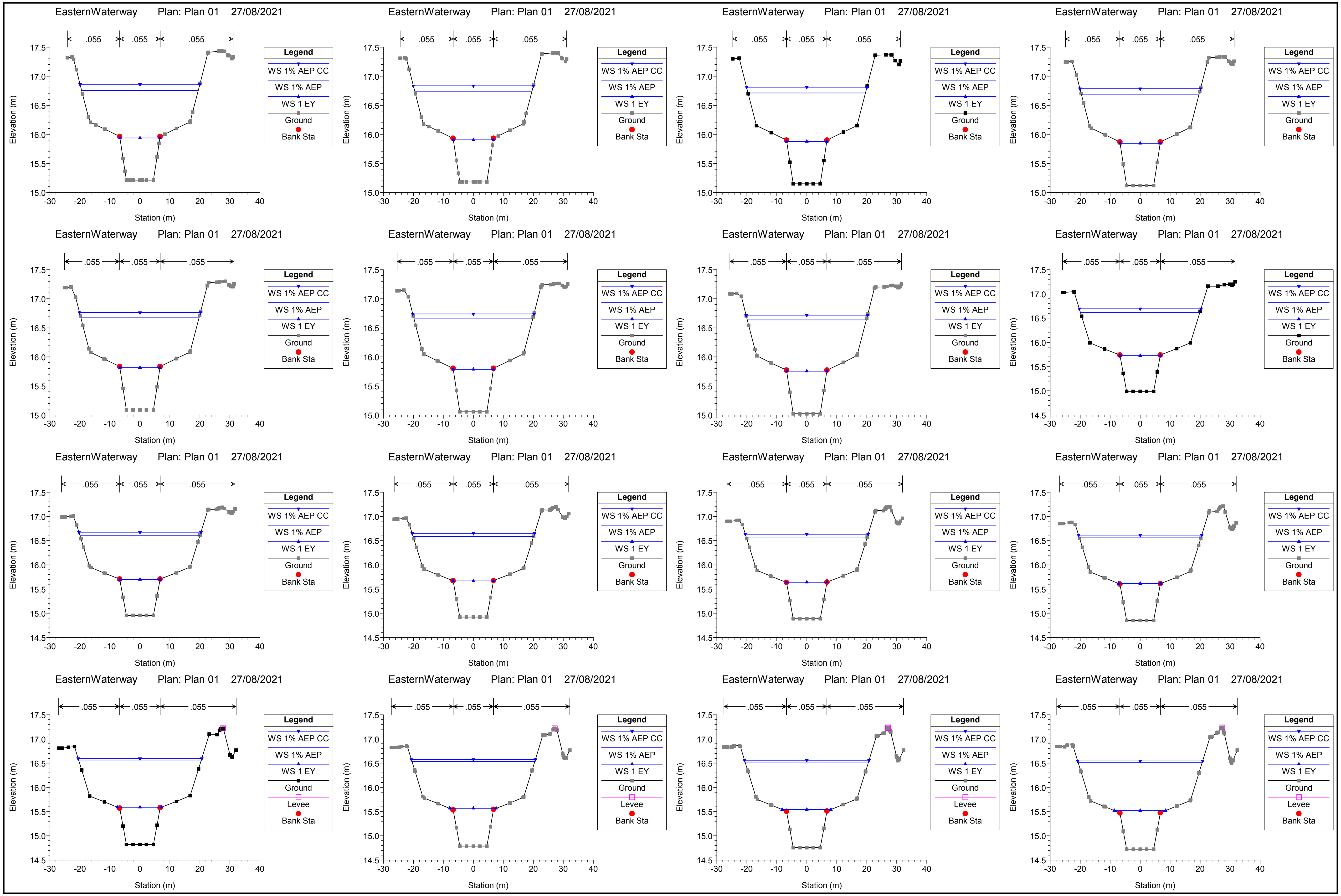

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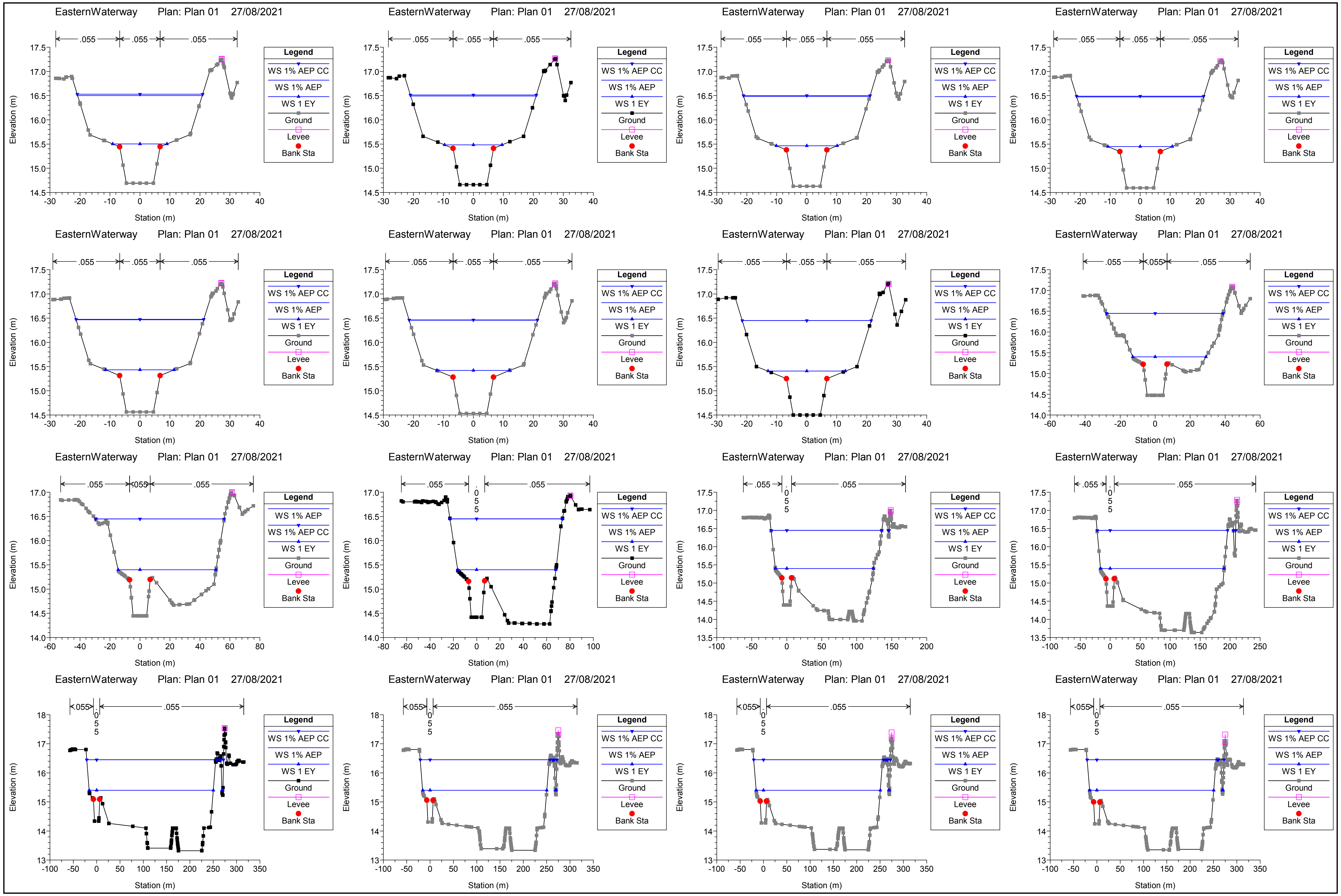
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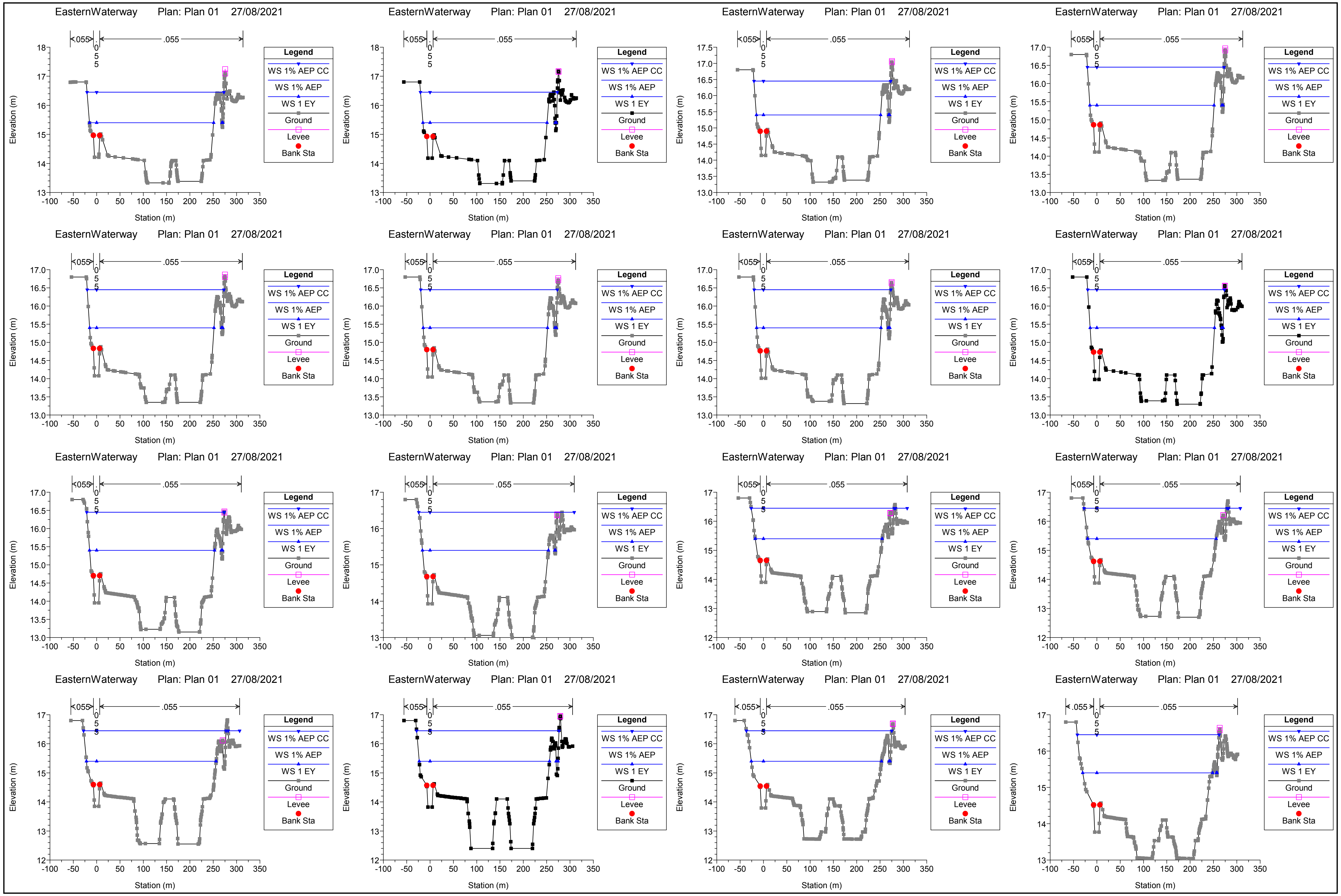
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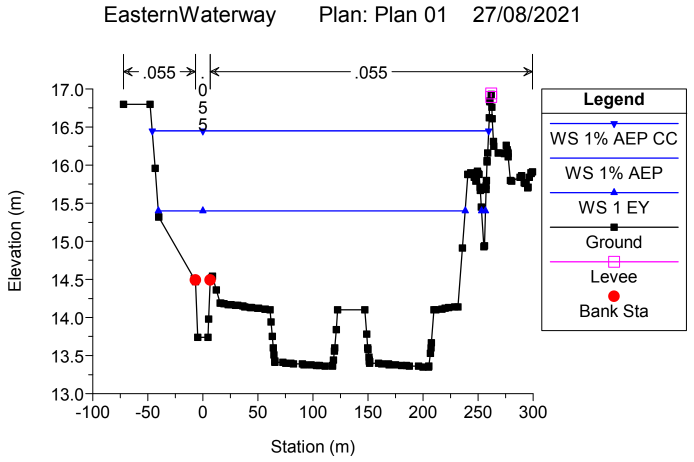
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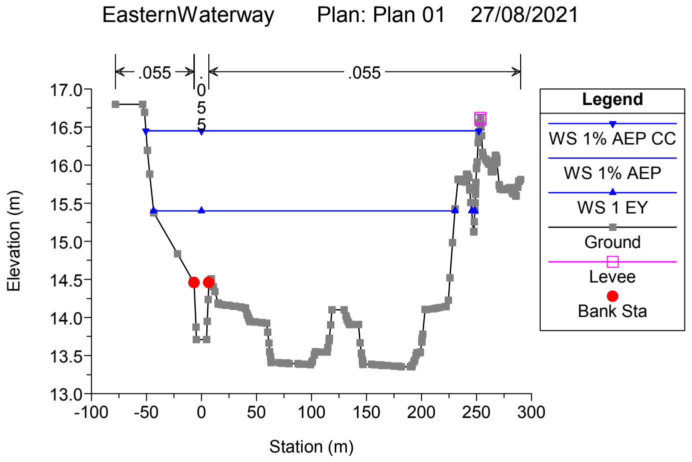
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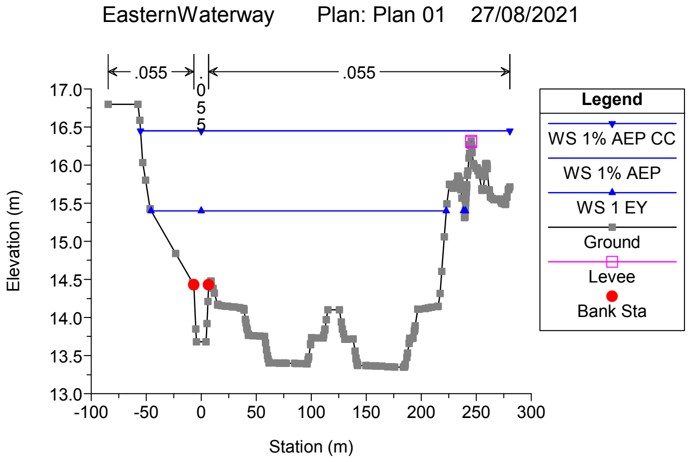
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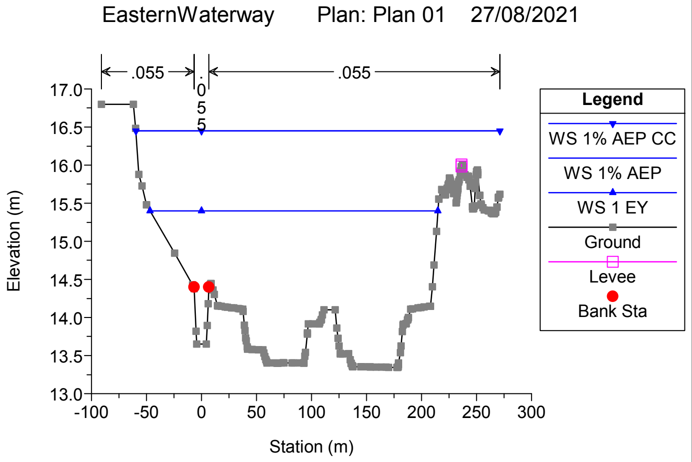
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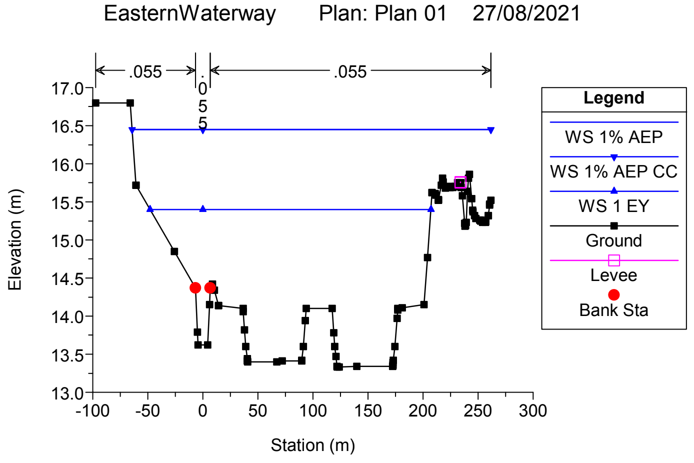
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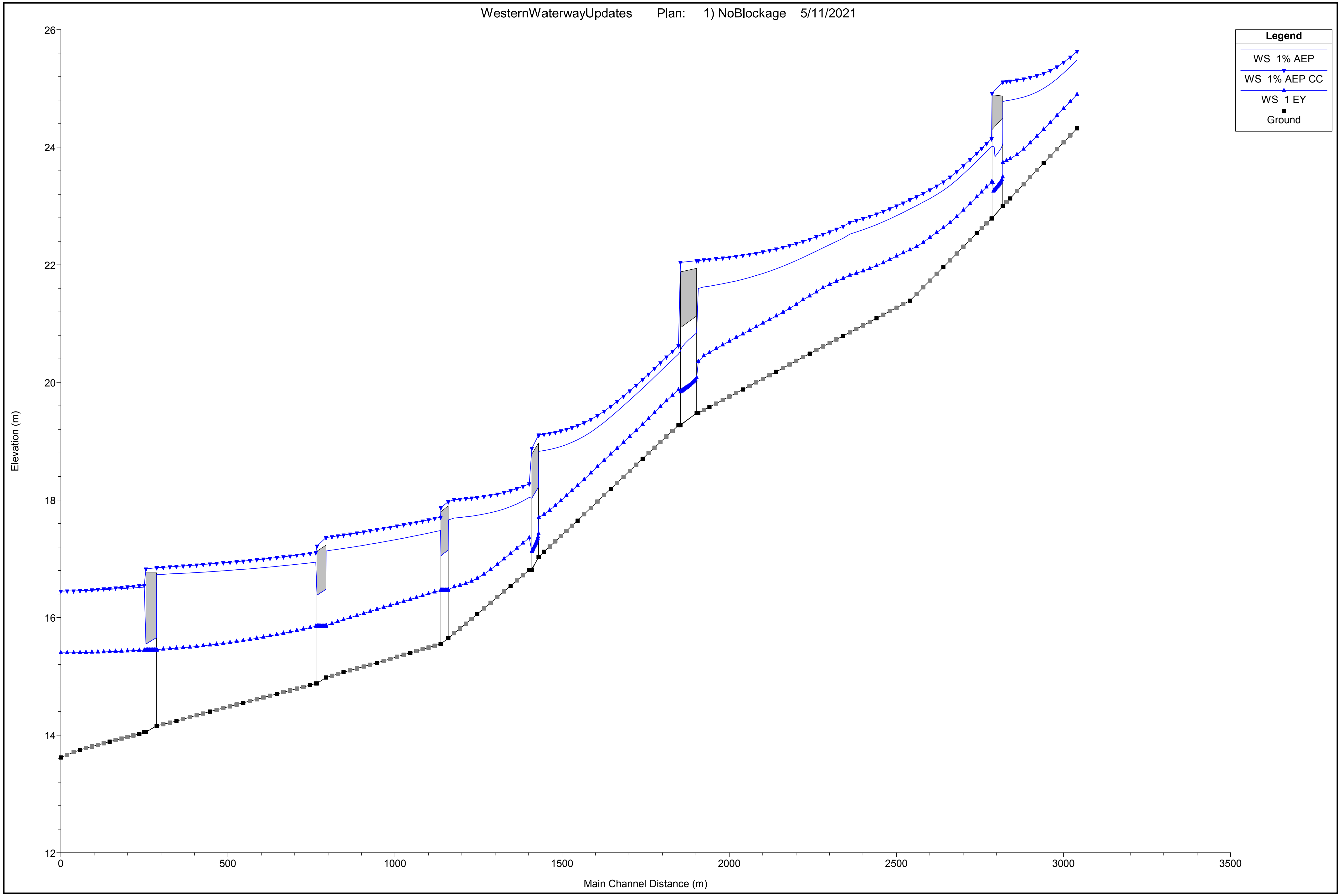

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Ground
Elevation (m)
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24
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16
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3000
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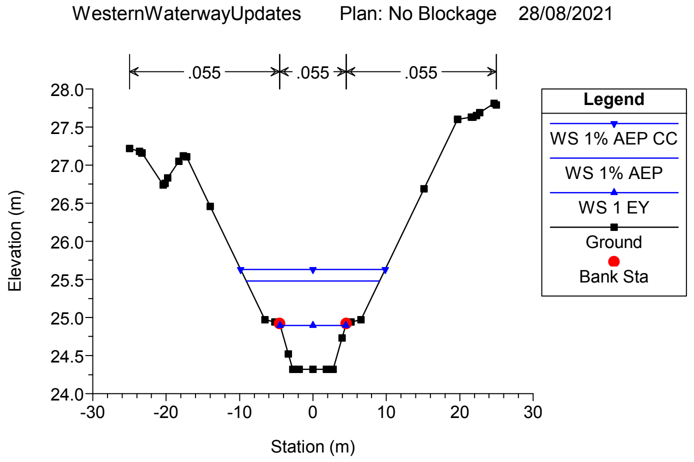
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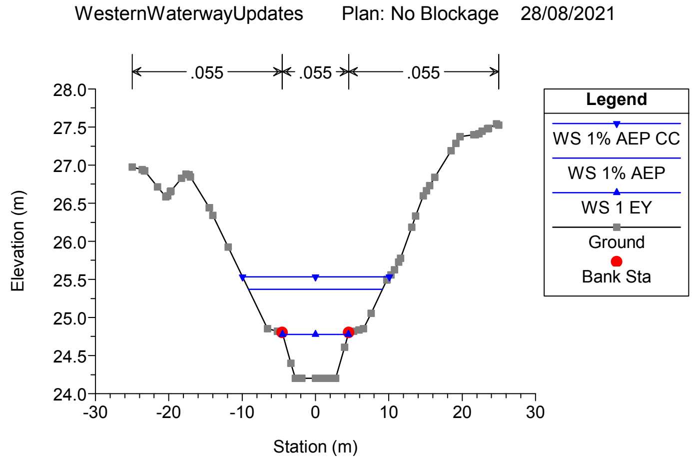
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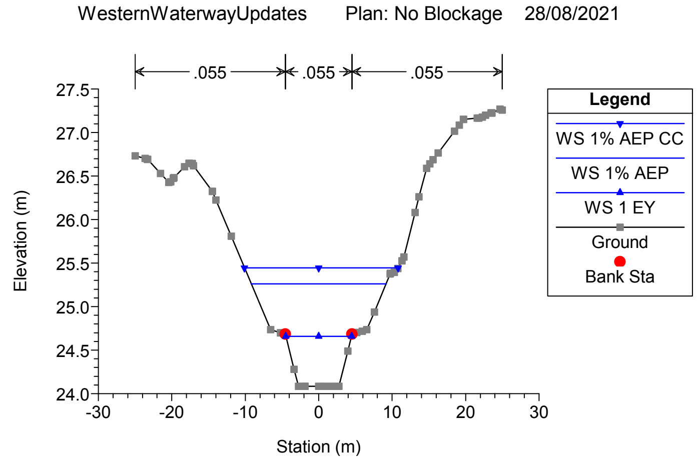
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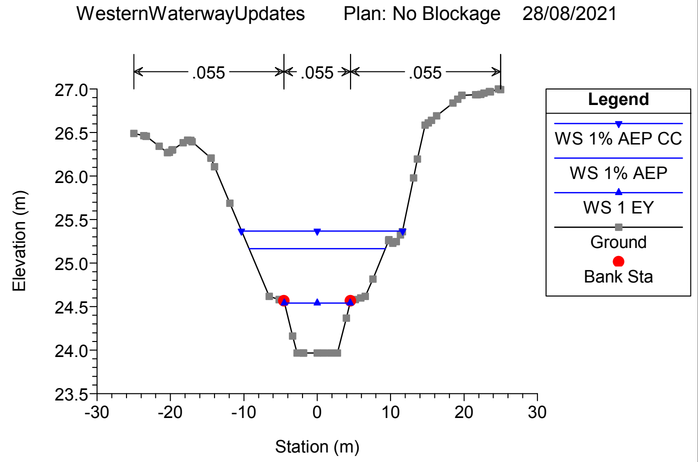
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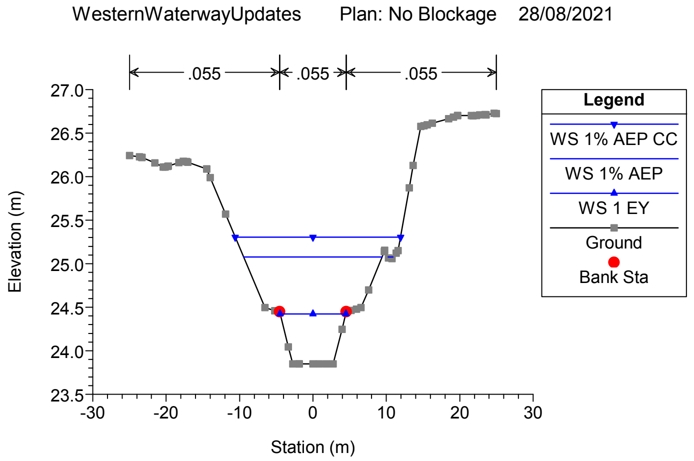
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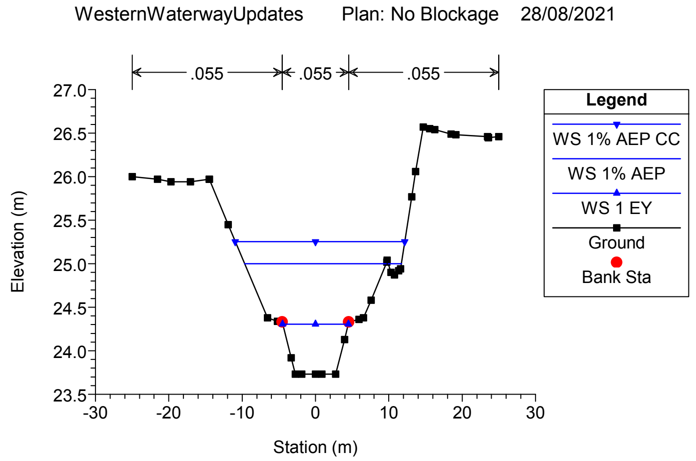
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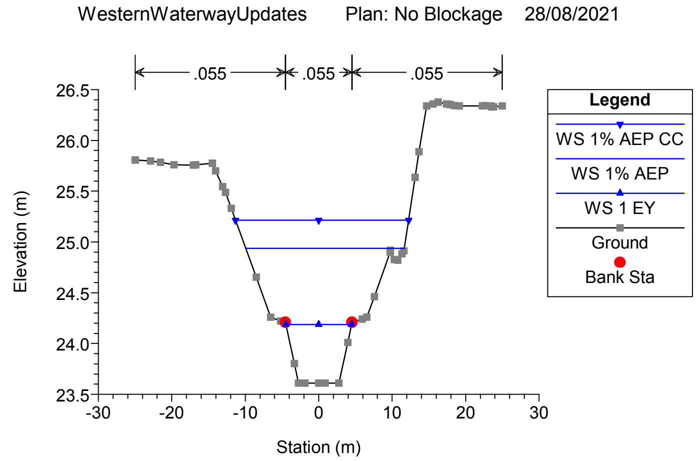
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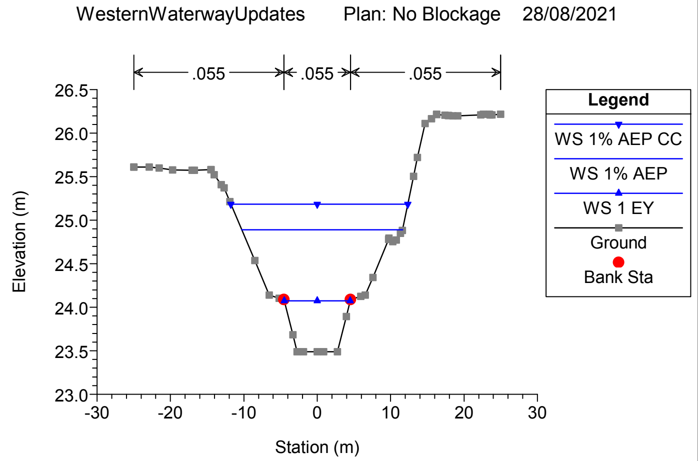
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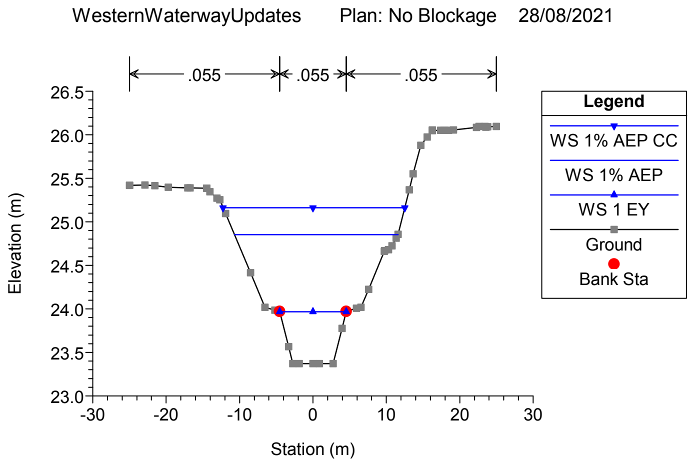
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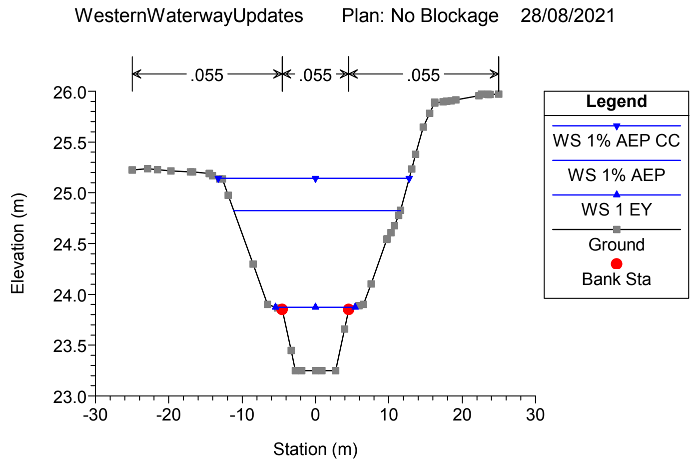
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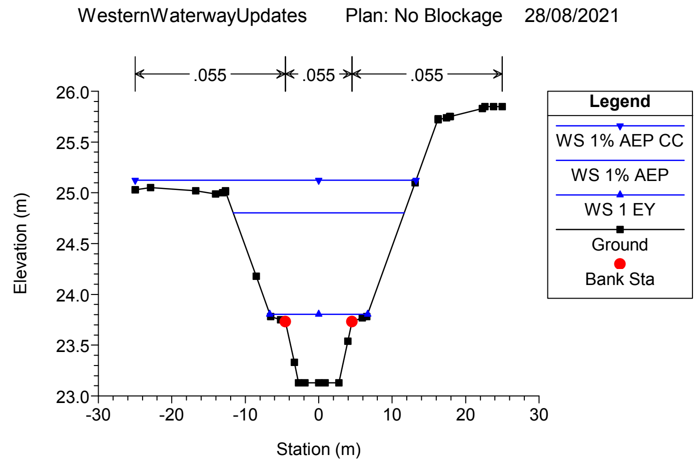
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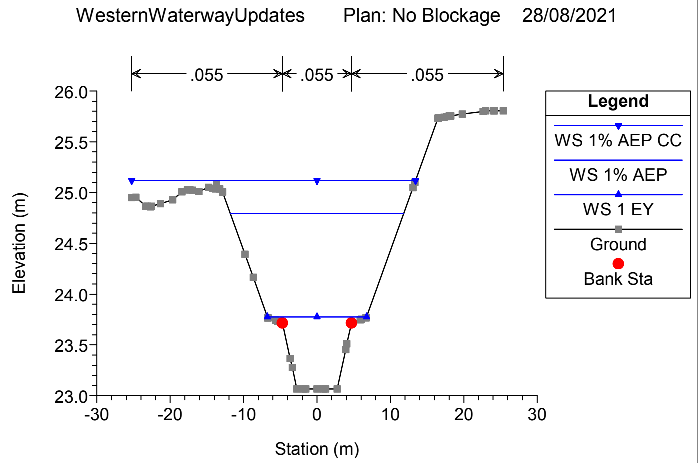
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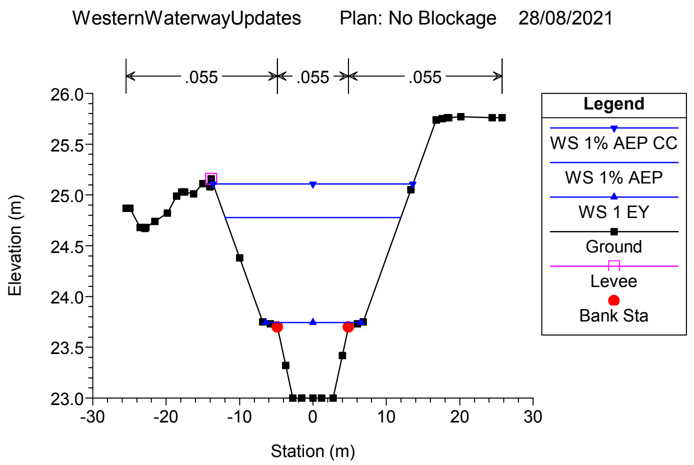
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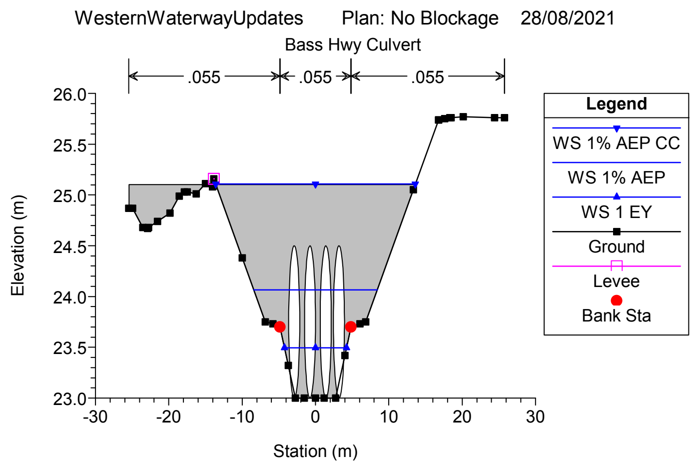
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Bass Hwy Culvert
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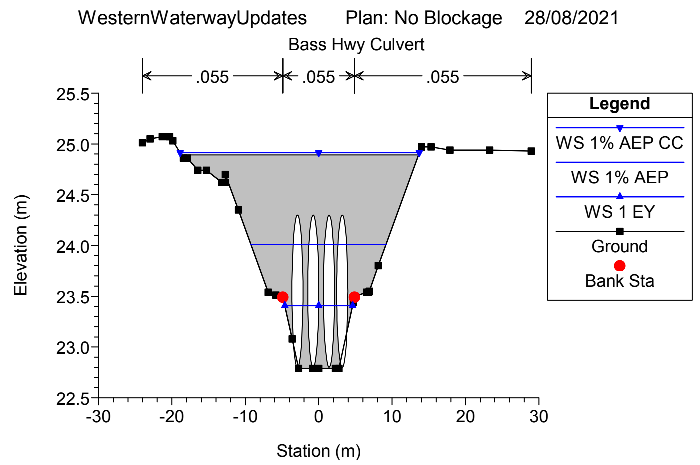
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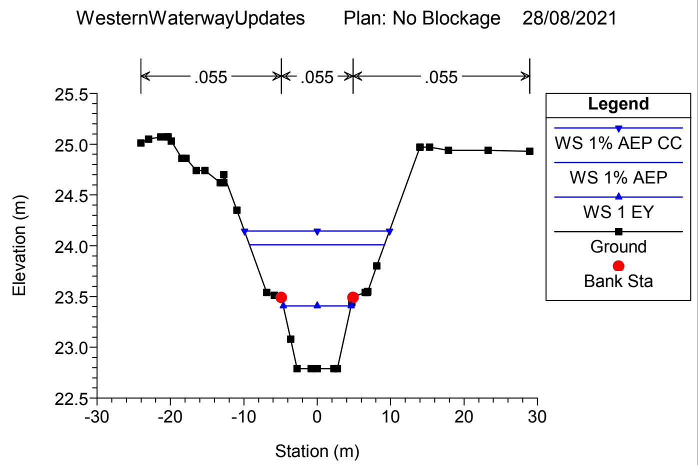
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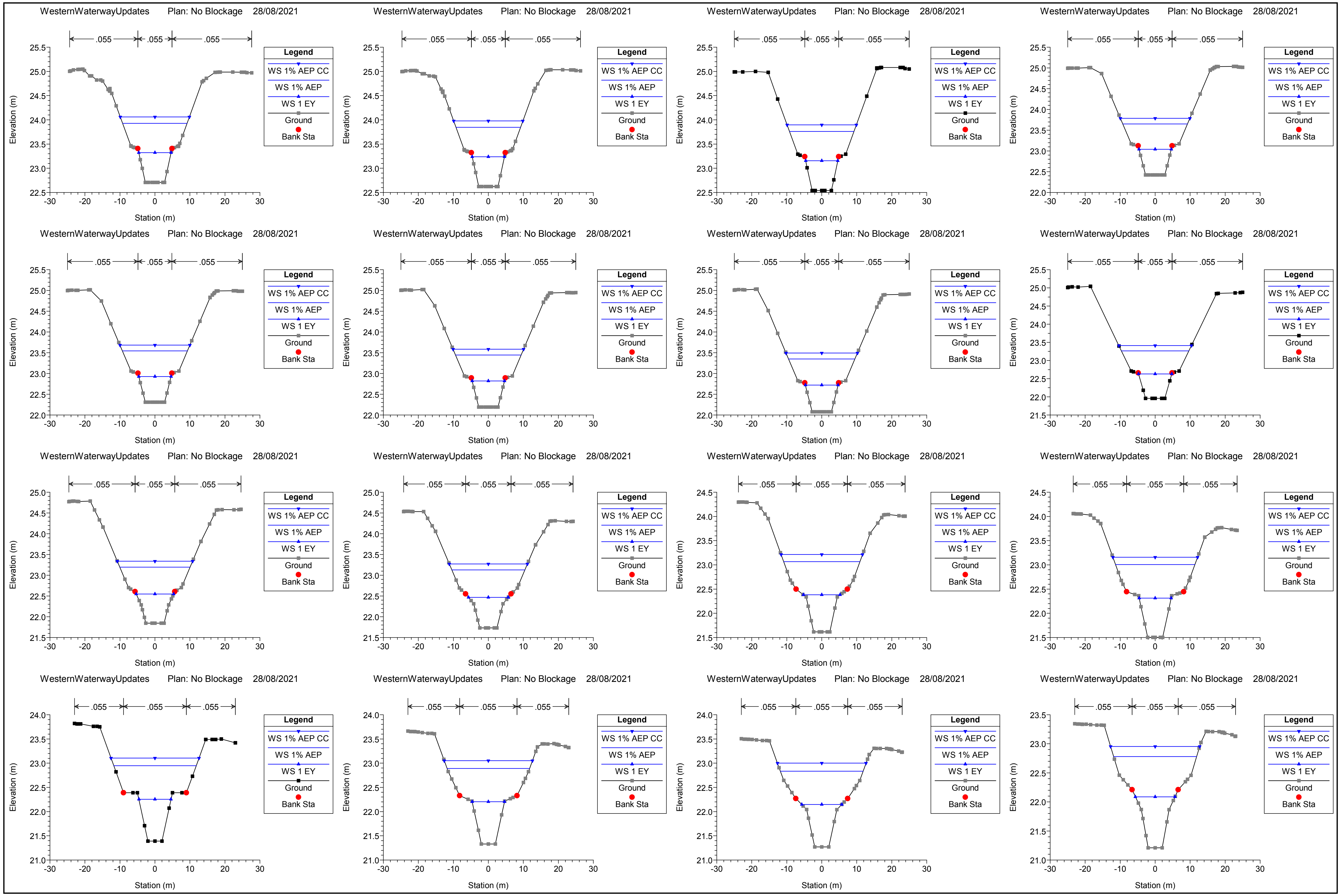
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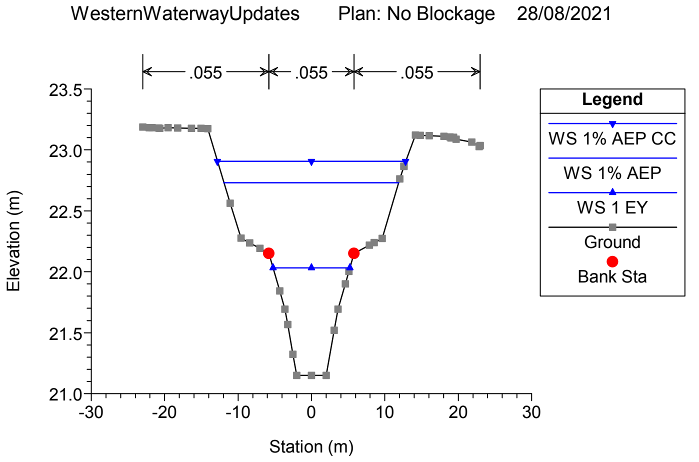
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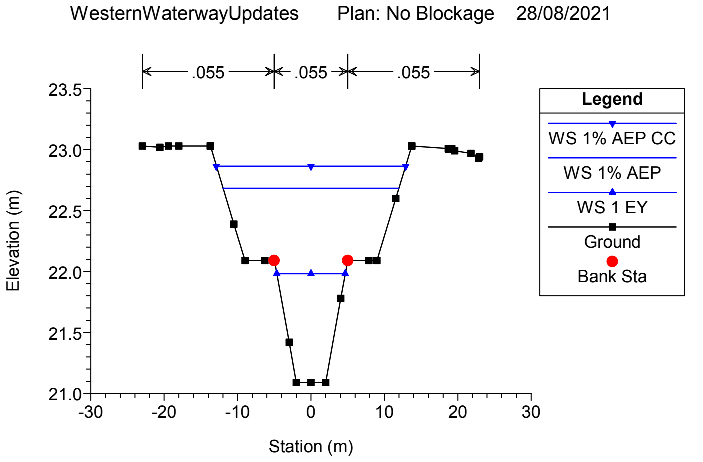
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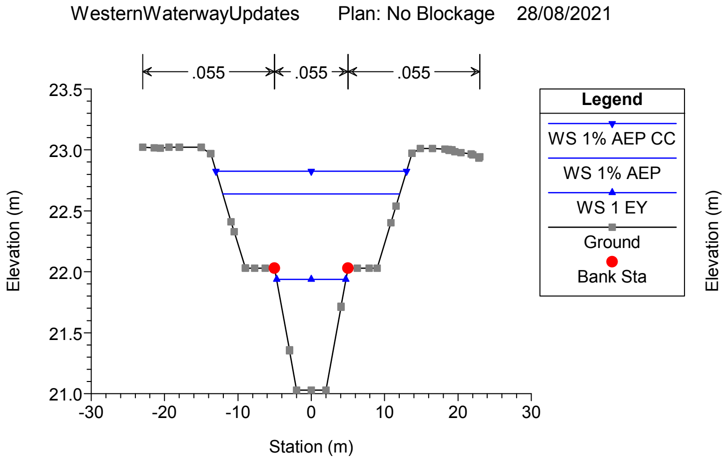
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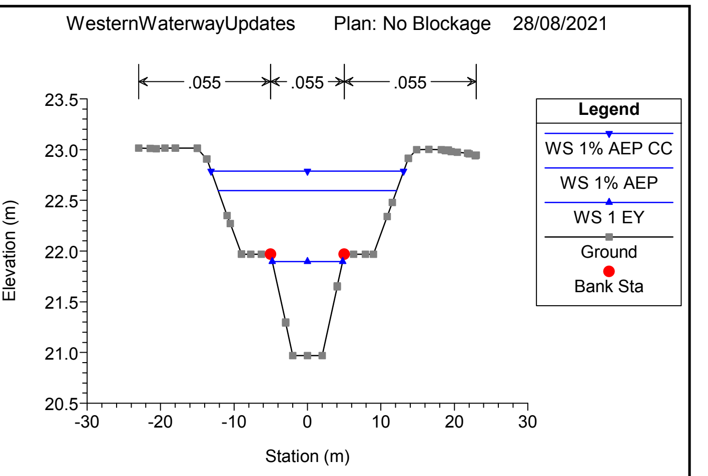
Ground
Bank Sta
Elevation (m)
Station (m)

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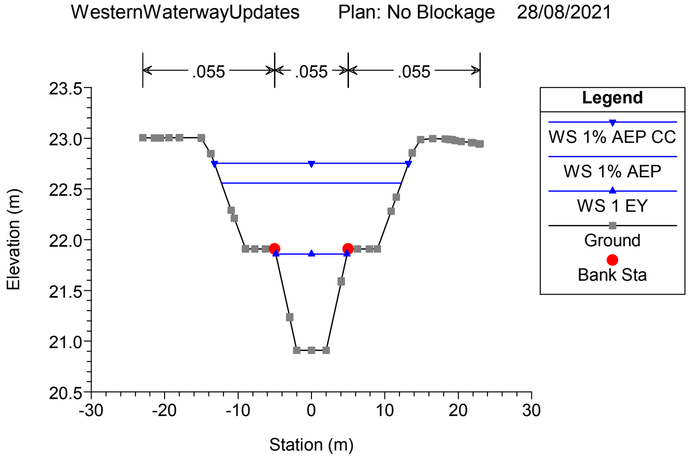
Station (m)

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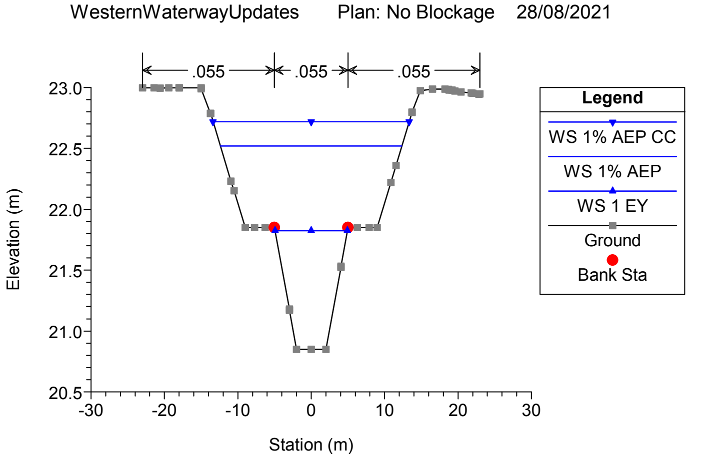
Station (m)

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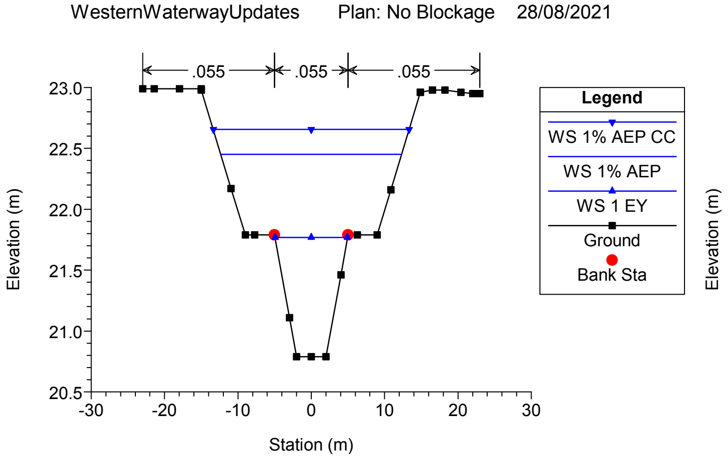
Station (m)

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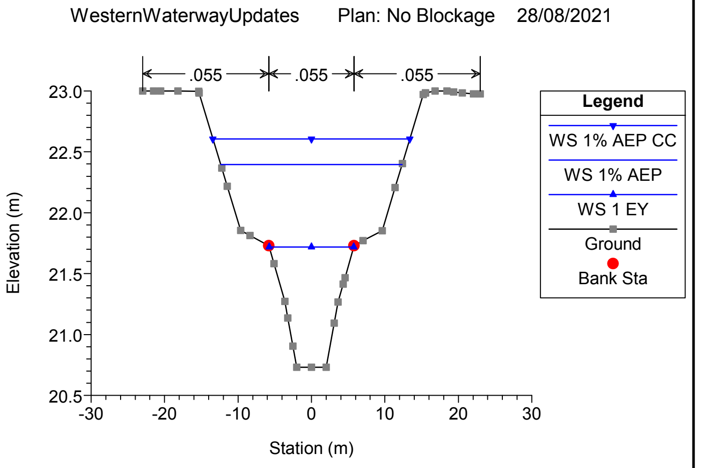
Station (m)

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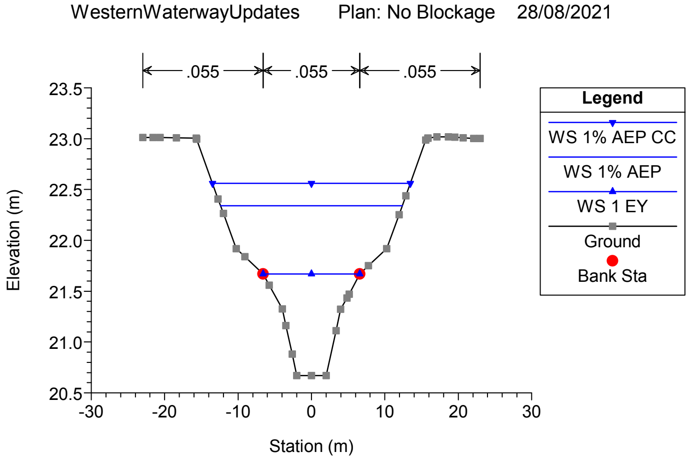
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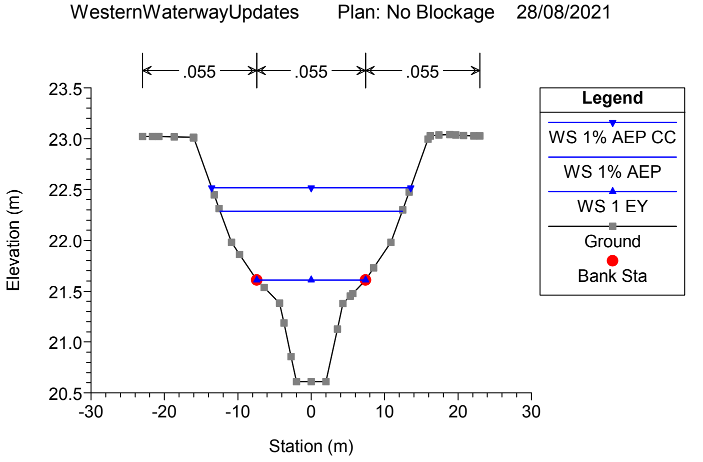
Station (m)

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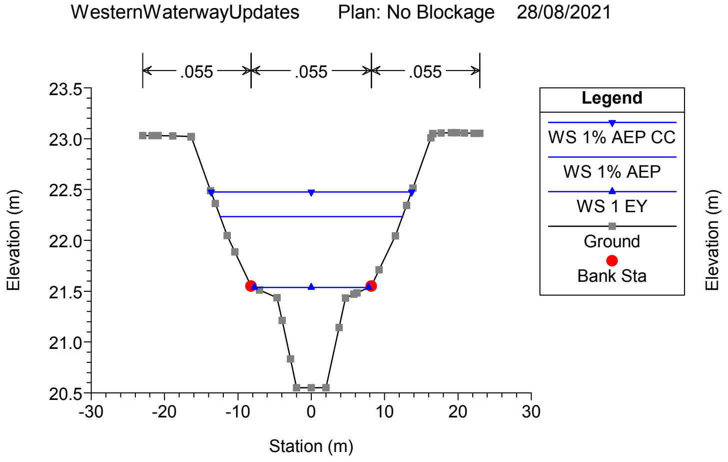
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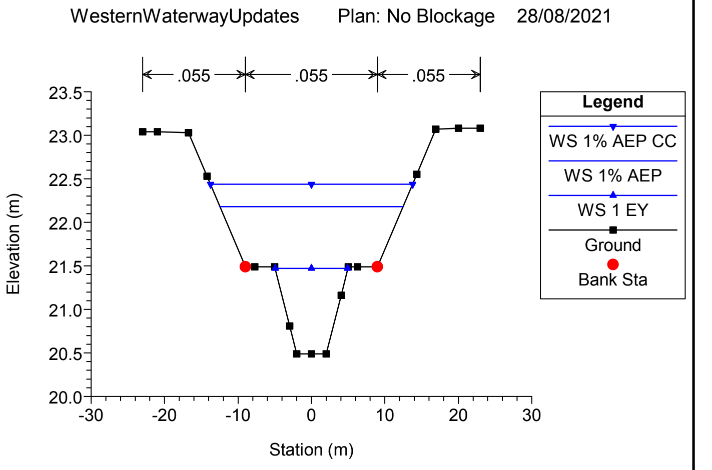
Station (m)

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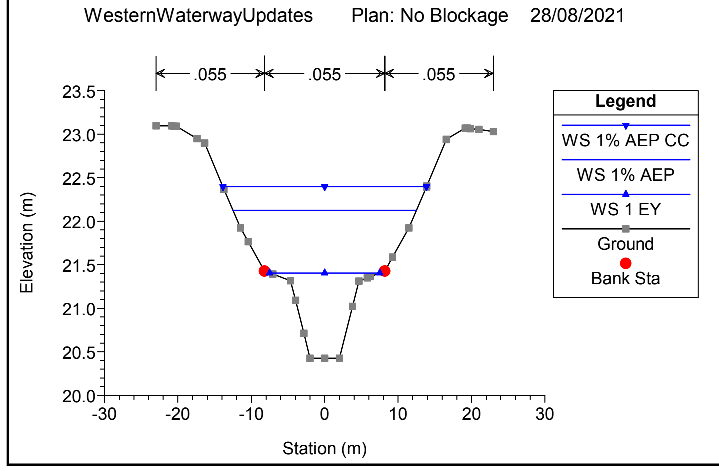
Elevation (m)
Station (m)

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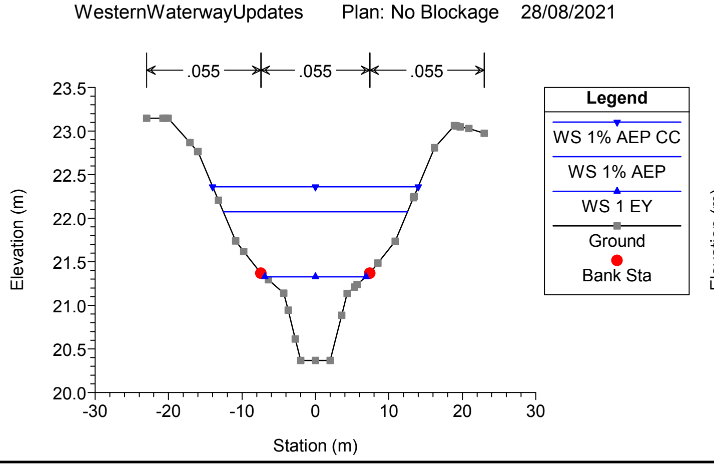
Station (m)

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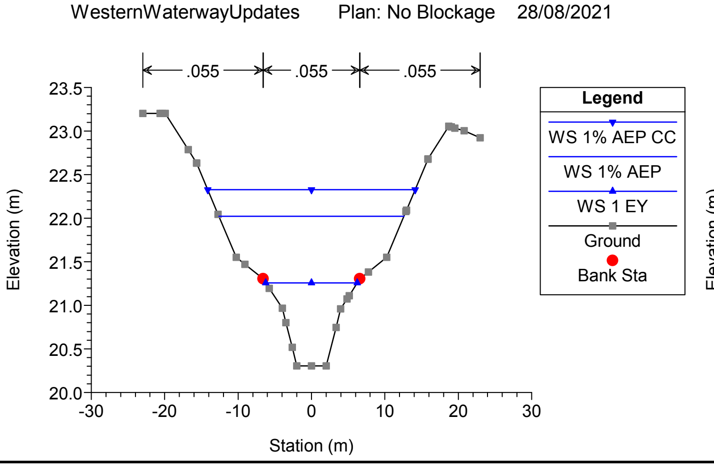
Station (m)

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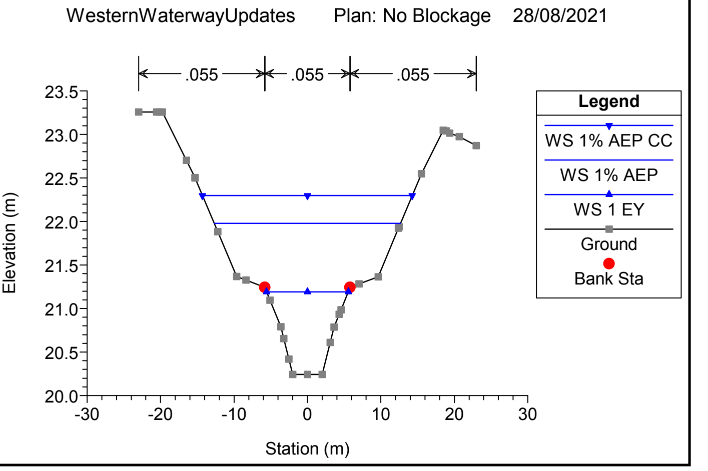
Ground
Bank Sta
Elevation (m)
Station (m)

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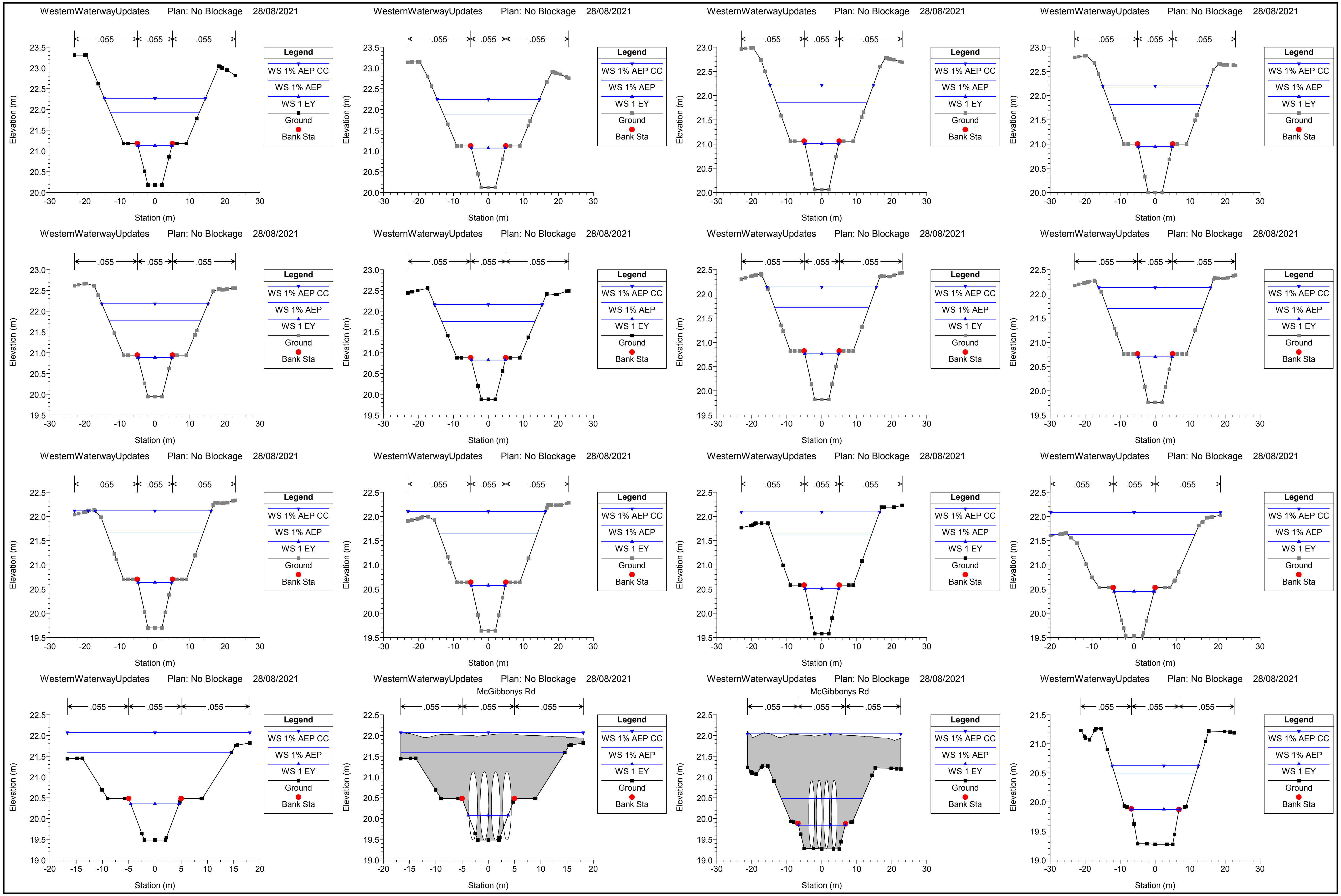
Ground
Bank Sta
Elevation (m)
Station (m)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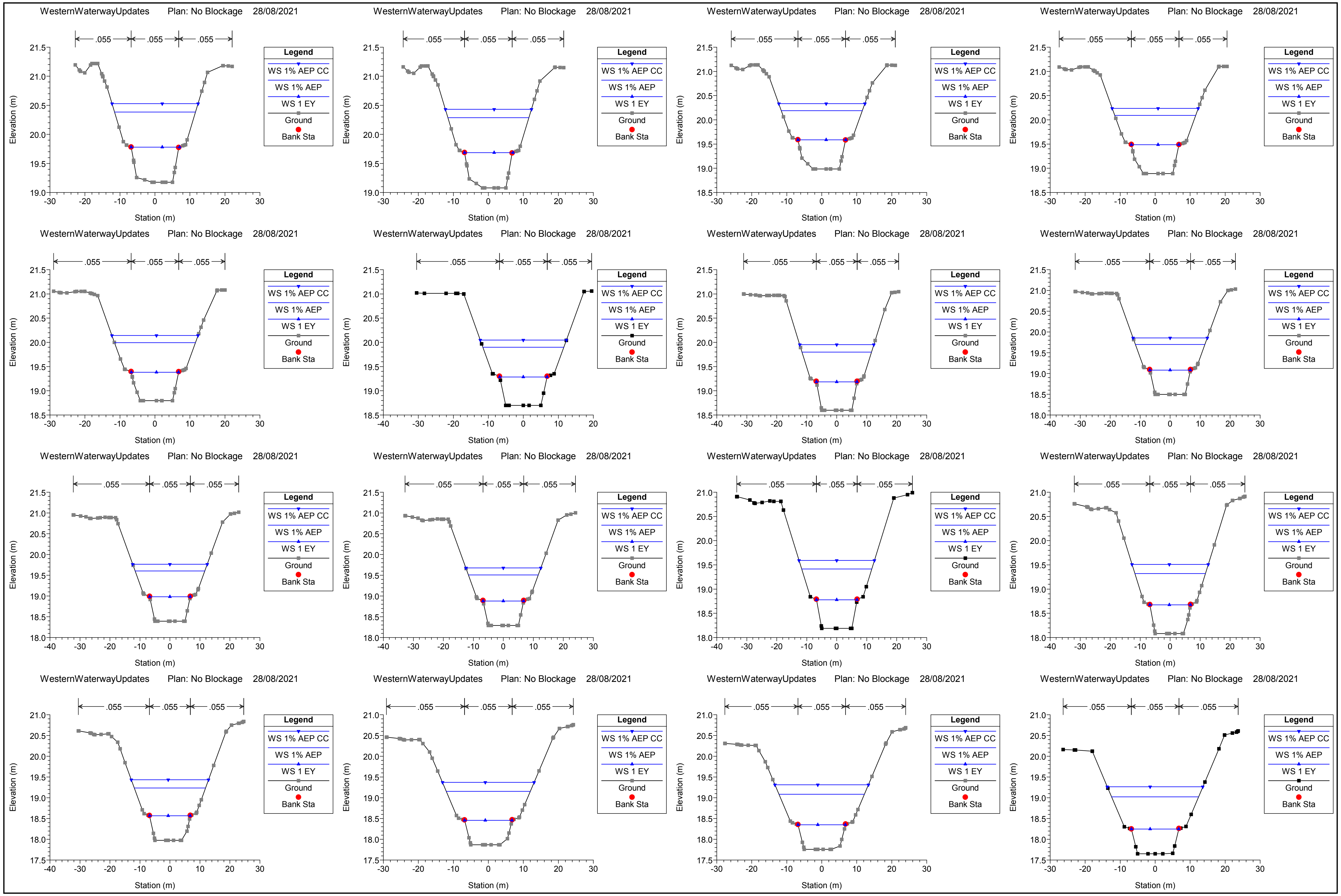
Ground
Bank Sta
Elevation (m)
Station (m)
McGibbonys Rd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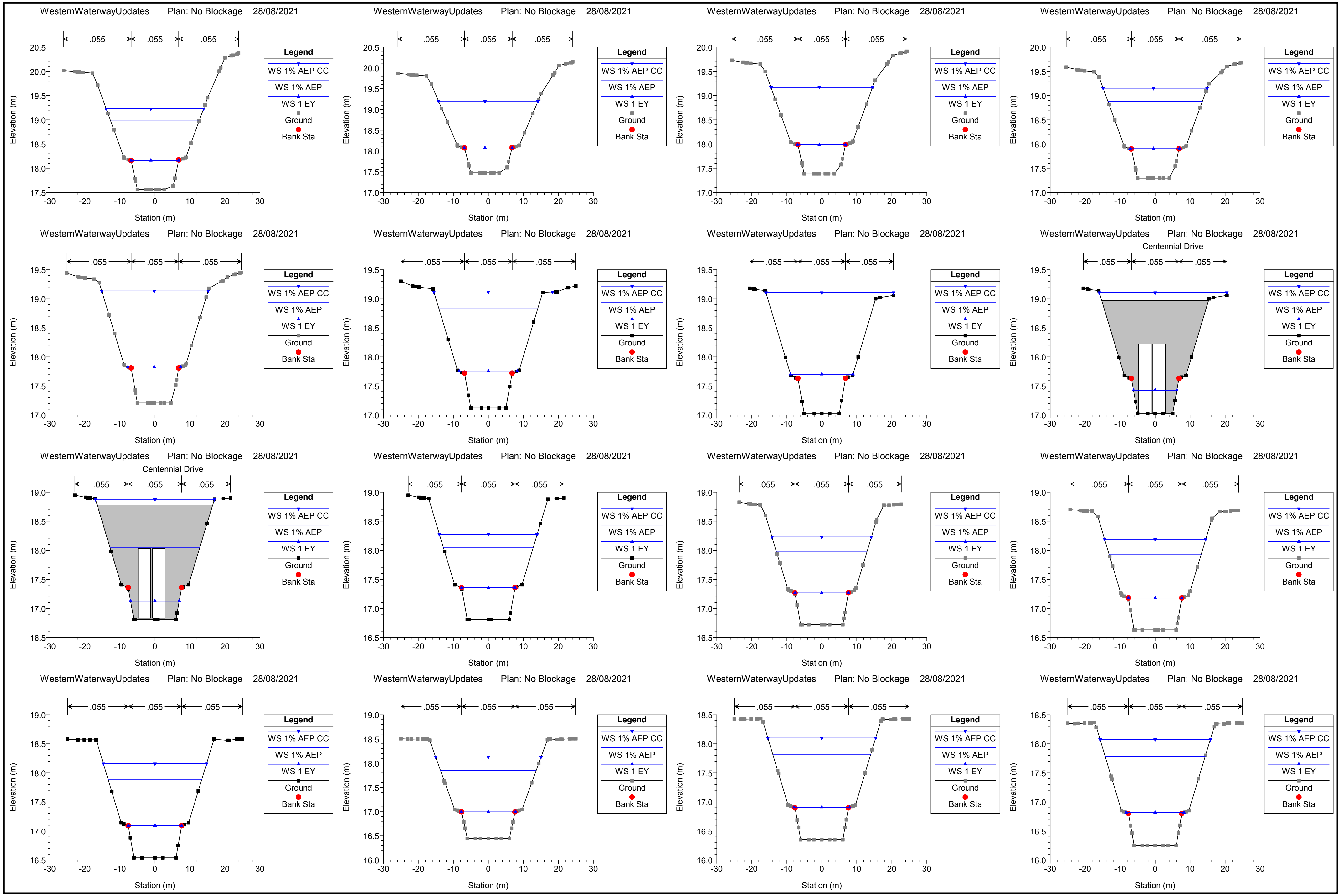
Ground
Bank Sta
Elevation (m)
Station (m)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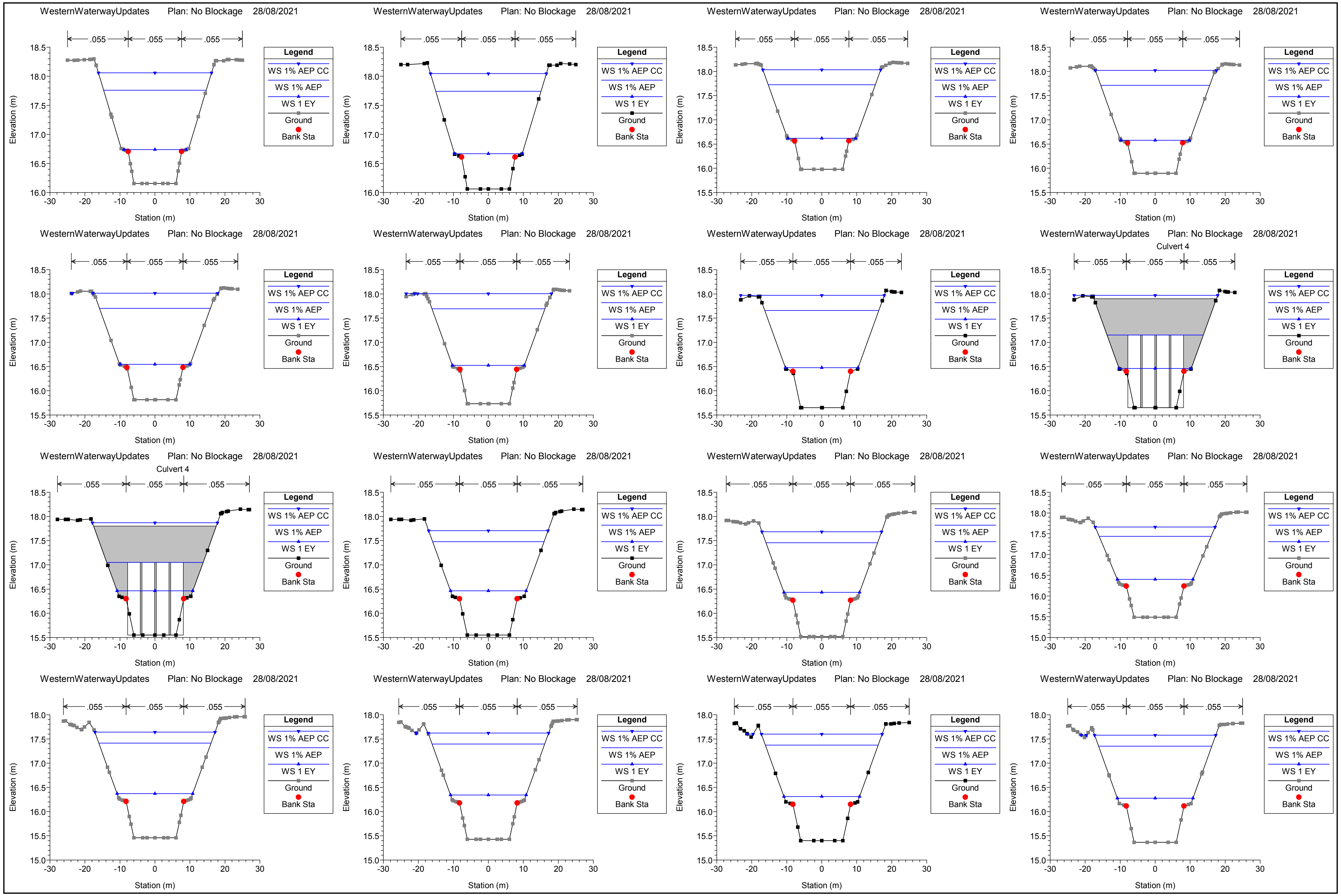
Ground
Bank Sta
Elevation (m)
Station (m)
Centennial Drive
WesternWaterwayUpdates Plan: No Blockage 28/08/2021
Centennial Drive


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
Culvert 4
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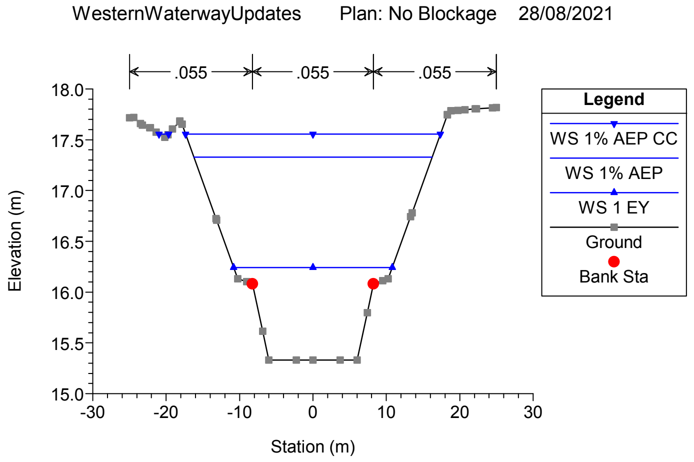
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)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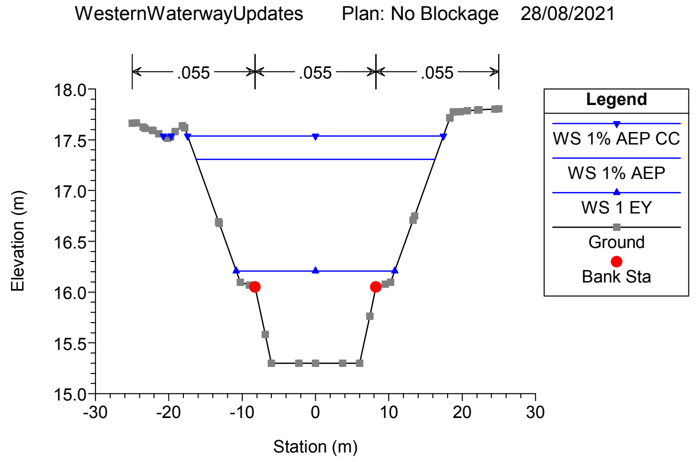
Ground
Bank Sta
Elevation (m)
Station (m)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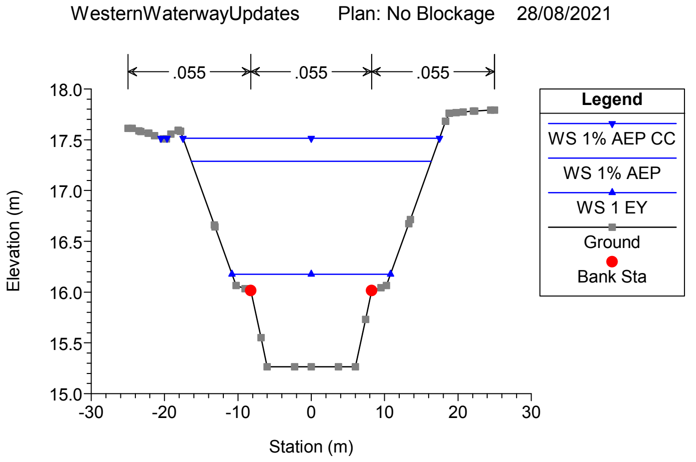
Ground
Bank Sta
Elevation (m)
Station (m)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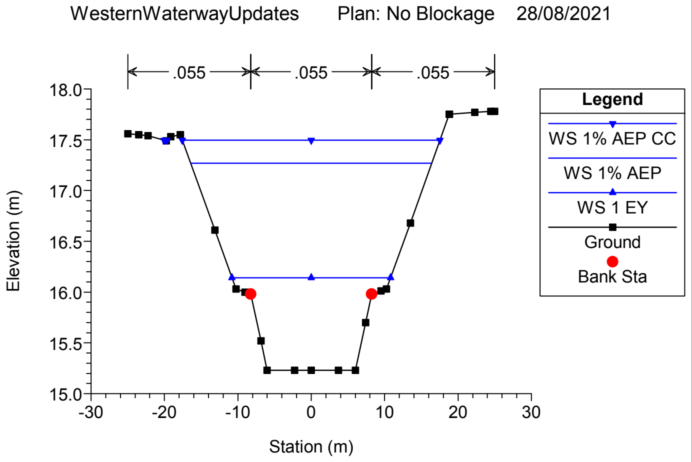
Bank Sta
Elevation (m)
Station (m)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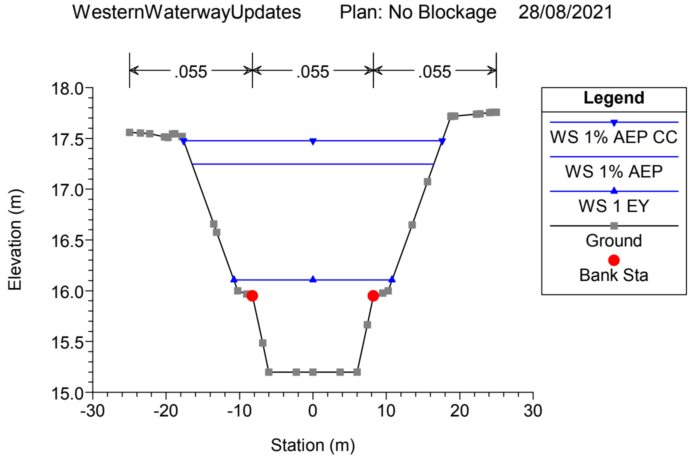
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)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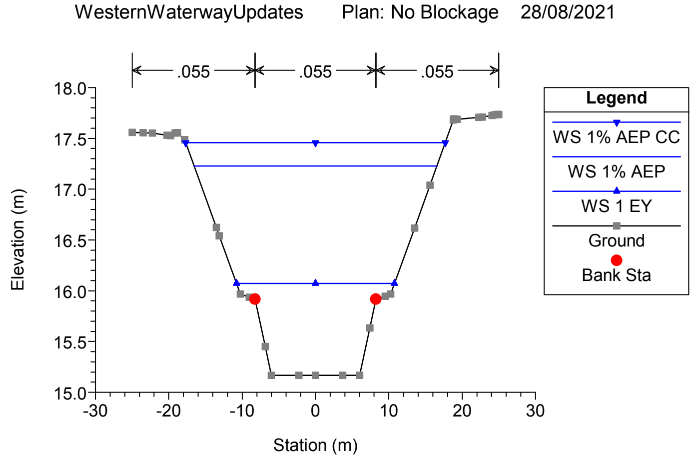
Bank Sta
Elevation (m)
Station (m)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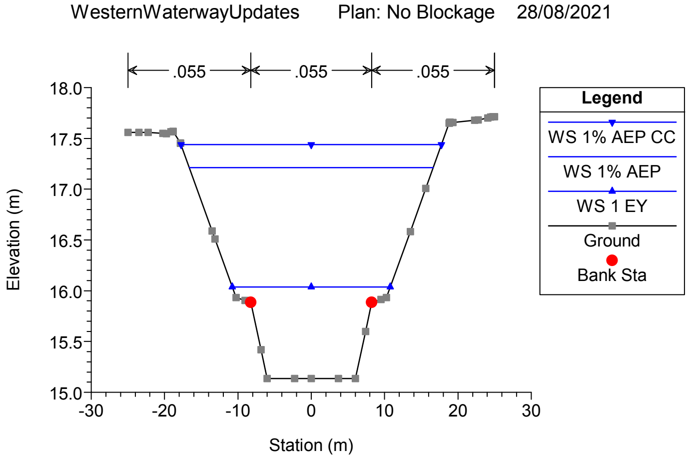
Bank Sta
Elevation (m)
Station (m)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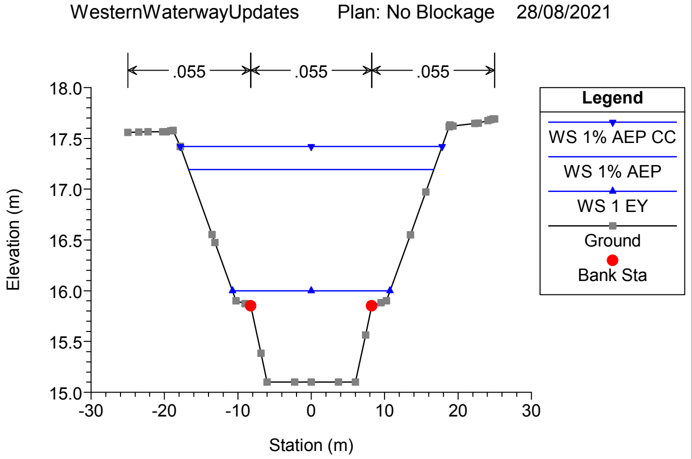
Bank Sta
Elevation (m)
Station (m)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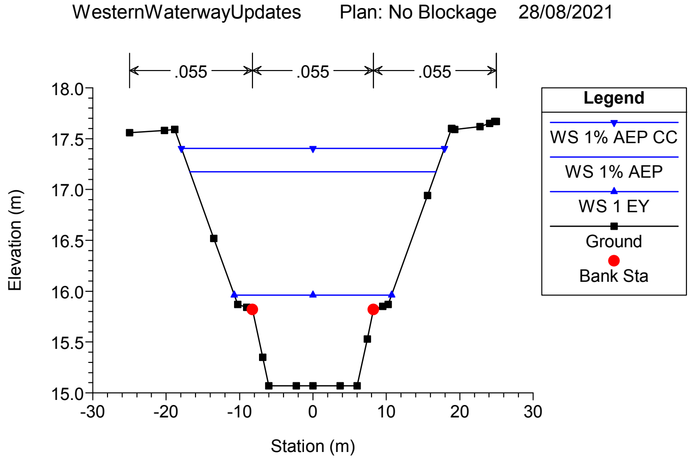
Bank Sta
Elevation (m)
Station (m)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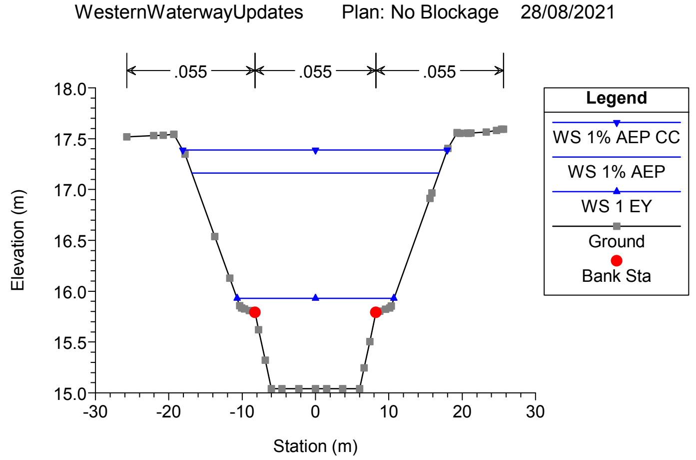
Ground
Bank Sta
Elevation (m)
Station (m)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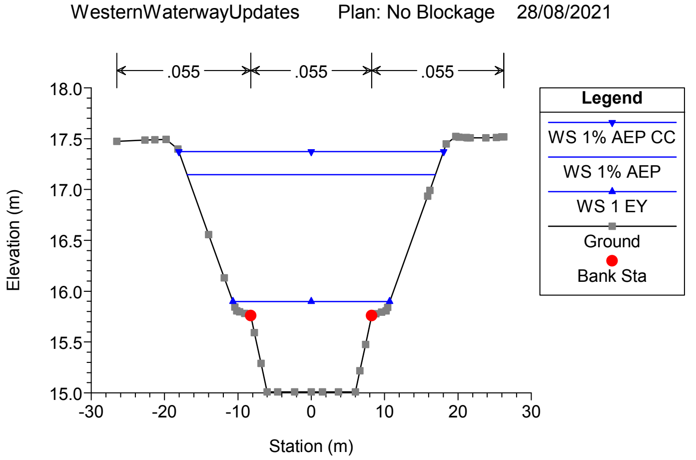
Ground
Bank Sta
Elevation (m)
Station (m)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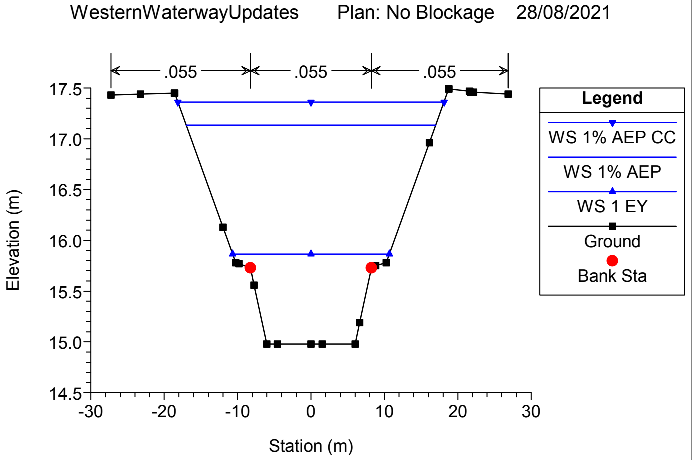
Ground
Bank Sta
Elevation (m)
Station (m)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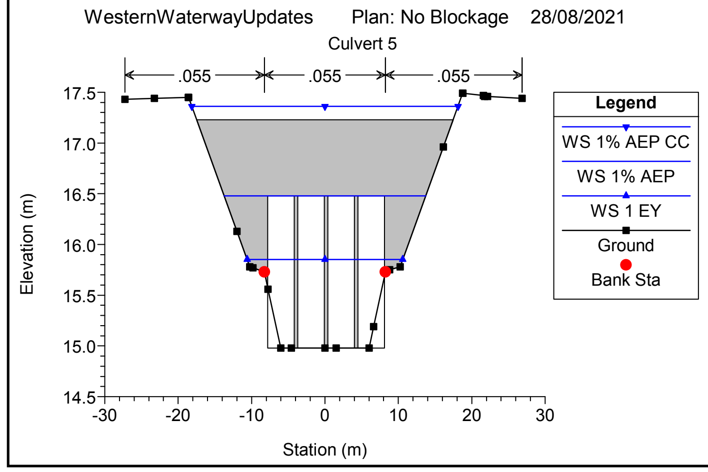
Ground
Bank Sta
Elevation (m)
Station (m)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Culvert 5
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Legend
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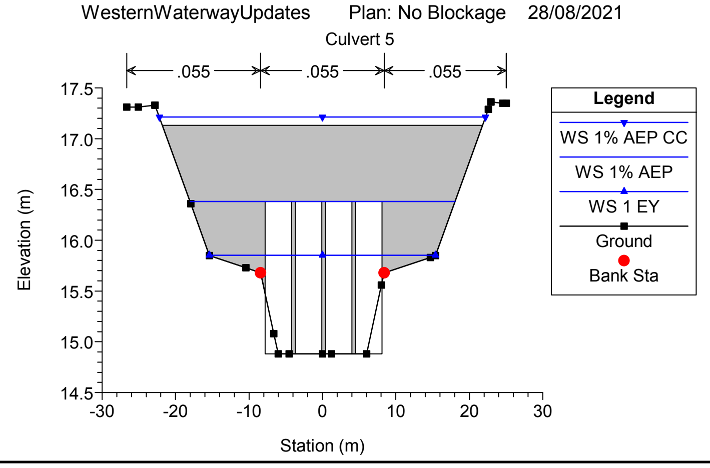
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
Culvert 5
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Legend
WS 1% AEP CC
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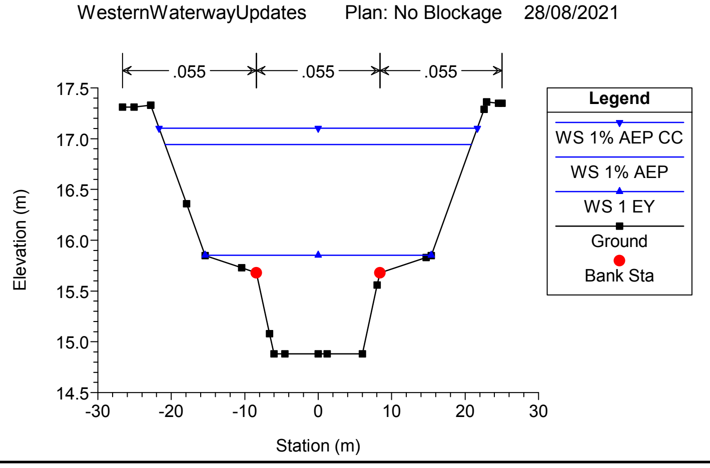
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
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Legend
WS 1% AEP CC
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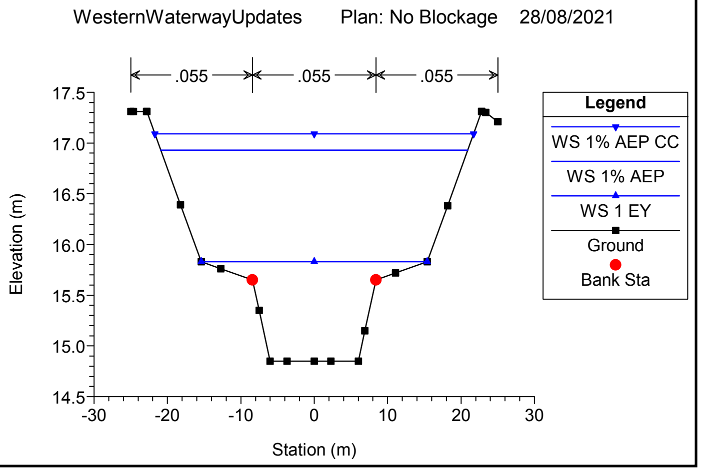
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
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Legend
WS 1% AEP CC
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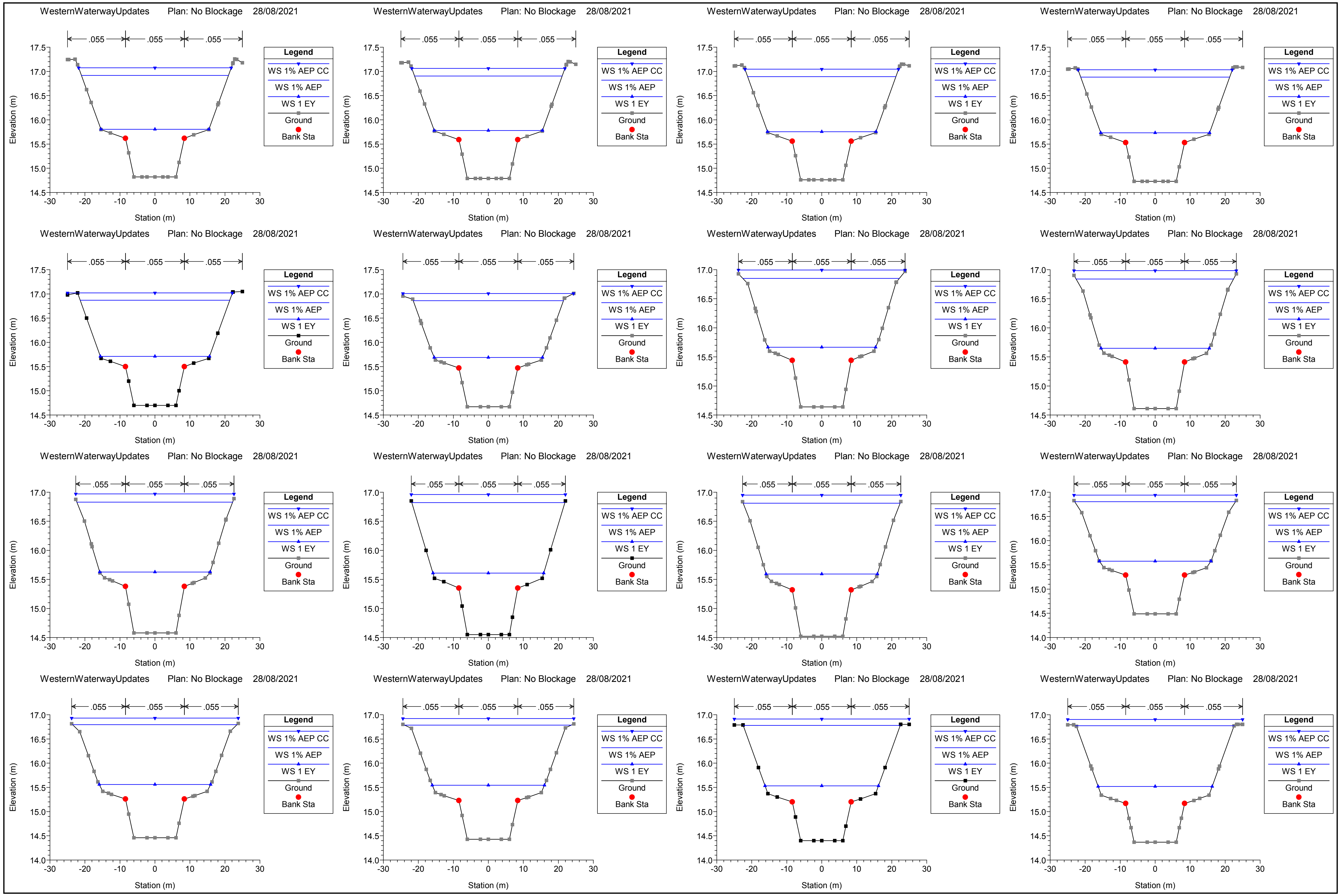
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
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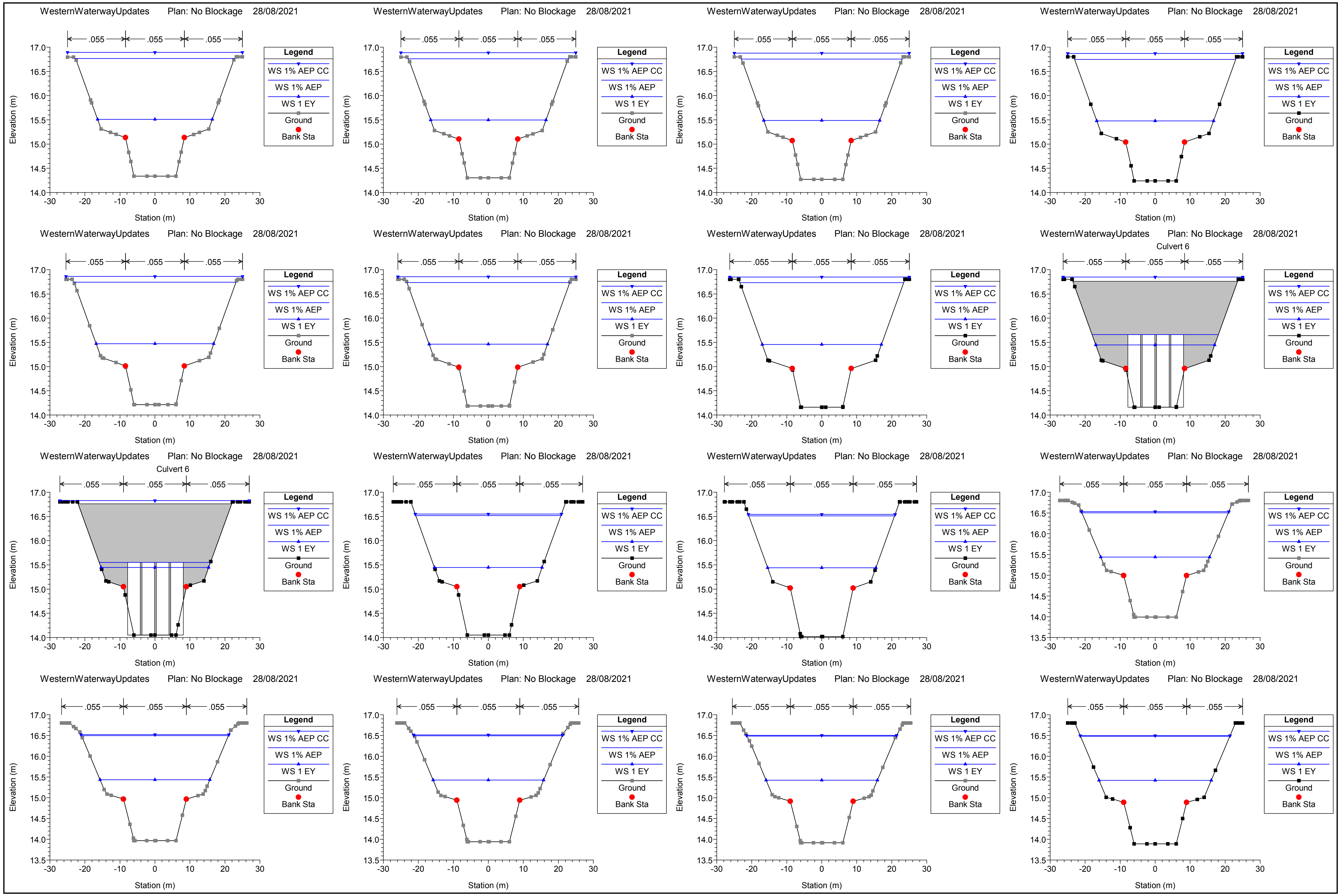
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)



WesternWaterwayUpdates Plan: No Blockage 28/08/2021
Culvert 6
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Legend
WS 1% AEP CC
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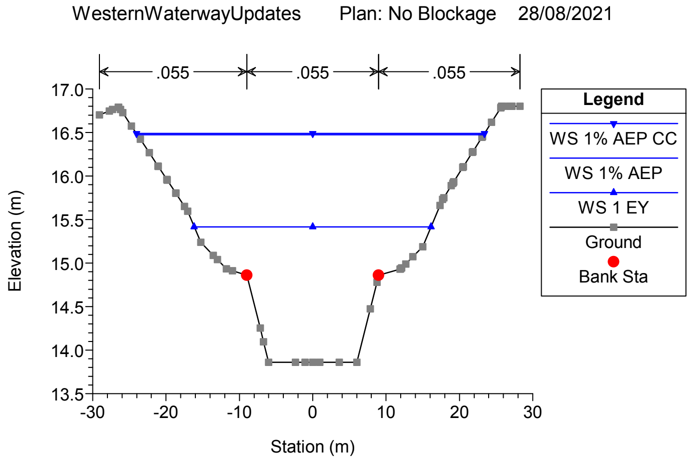
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
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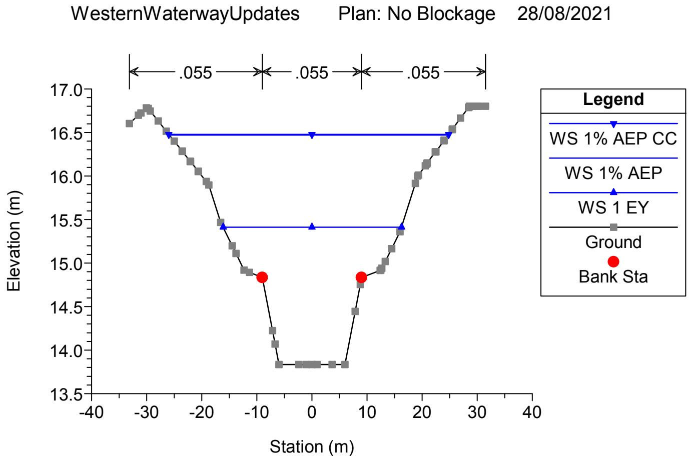
Elevation (m)
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
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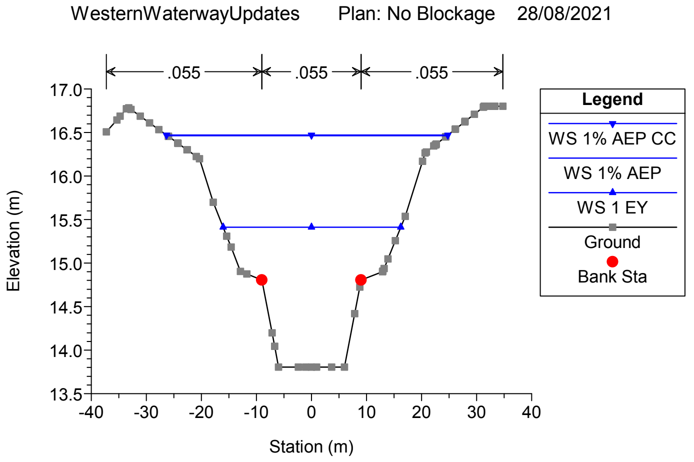
Elevation (m)
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
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Elevation (m)
Station (m)
Legend
WS 1% AEP CC
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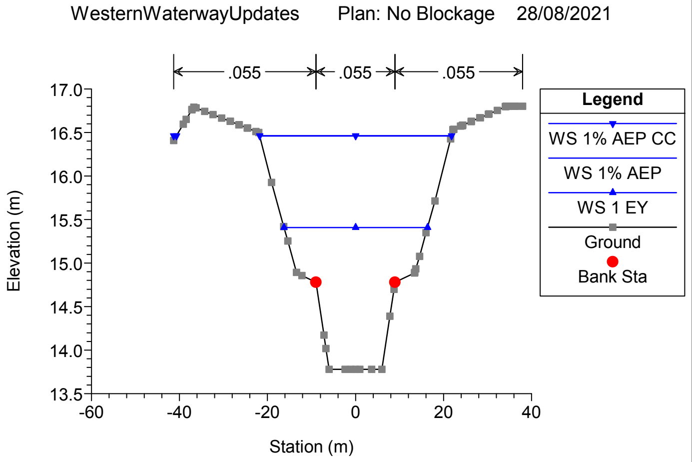
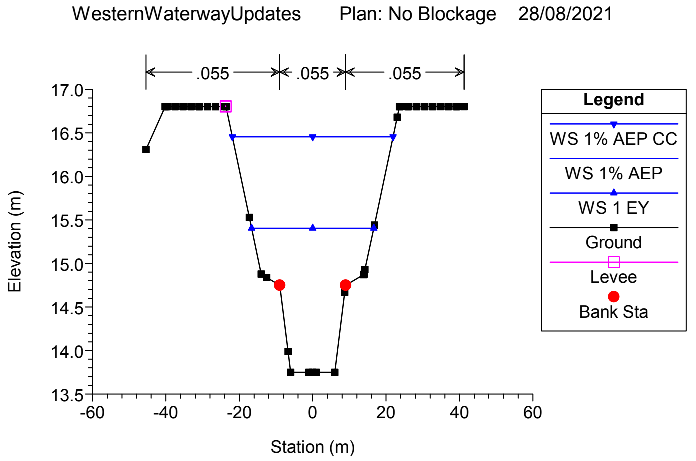
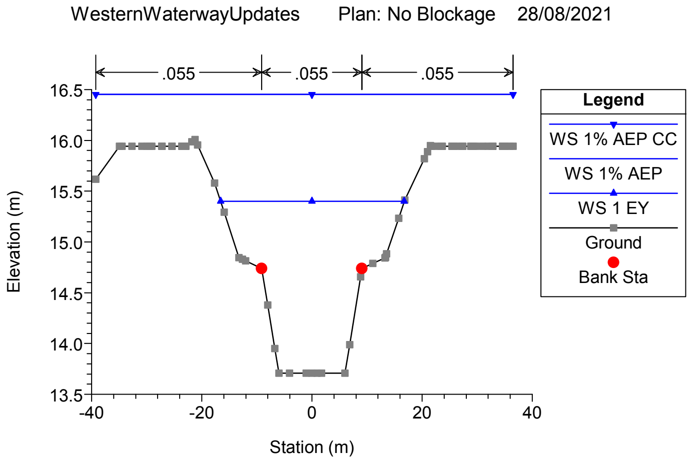
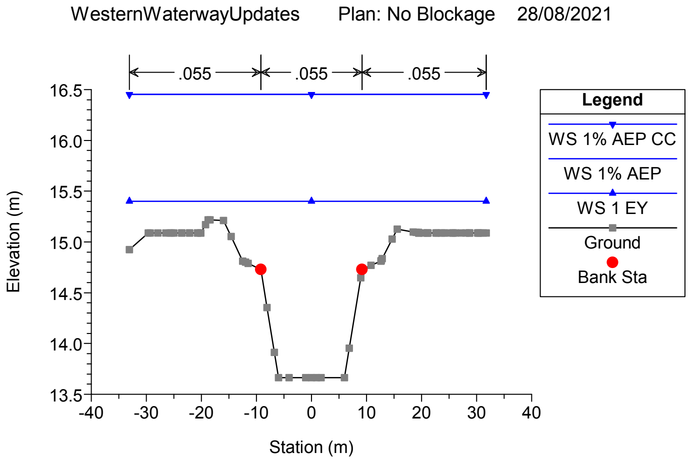
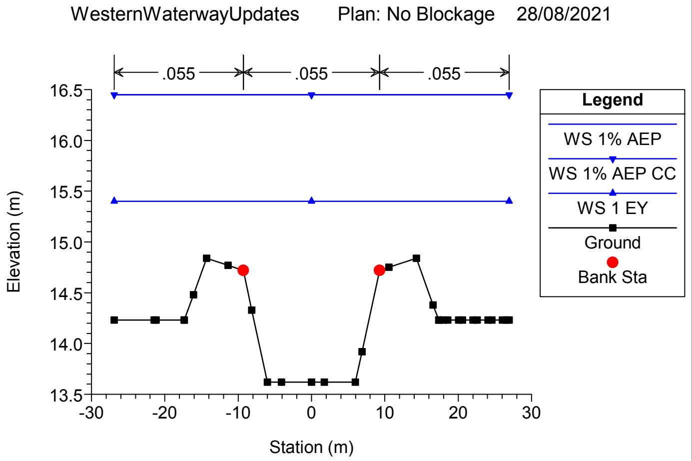
WS 1 EY
Ground
Bank Sta

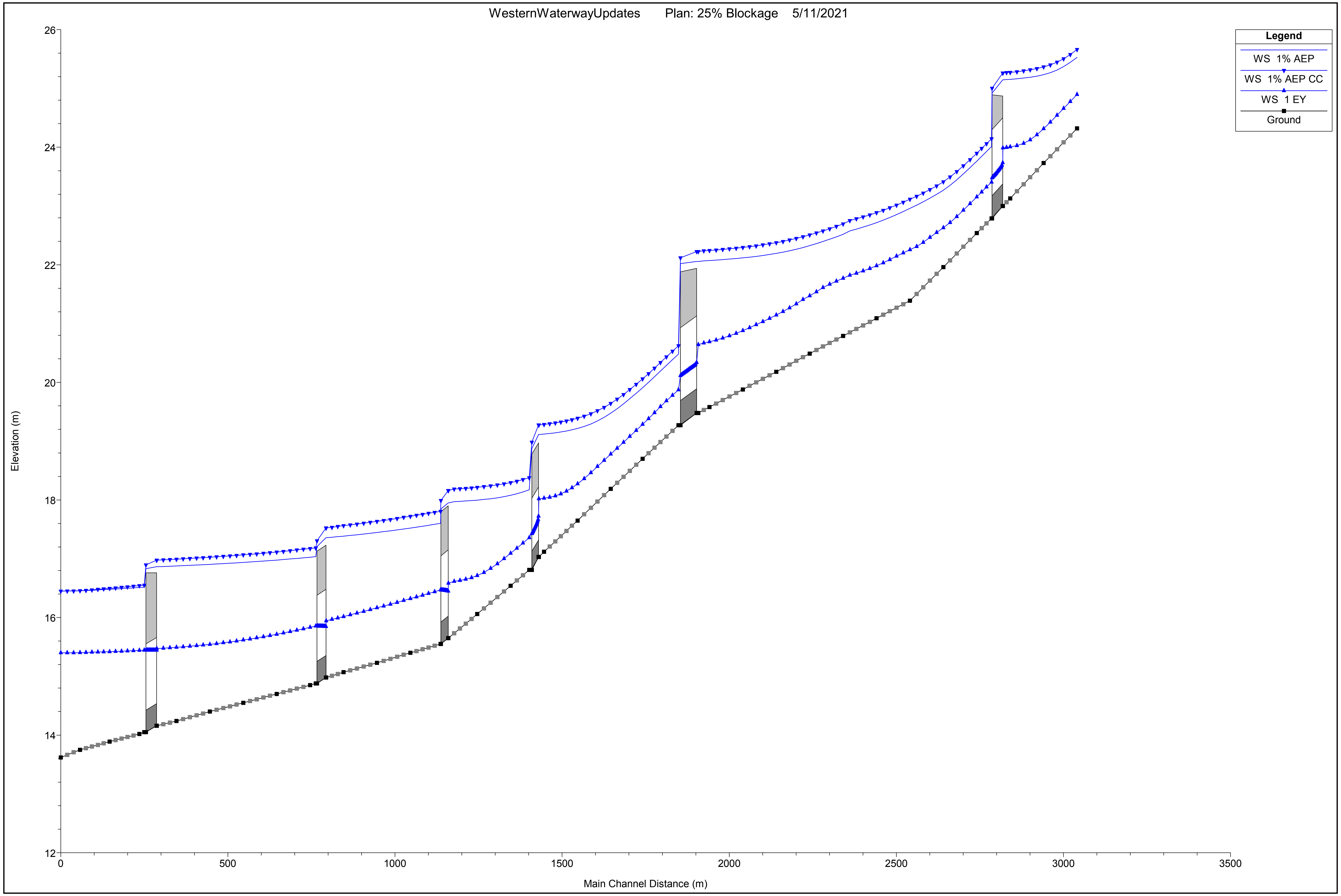

WesternWaterwayUpdates Plan: No Blockage 28/08/2021
.055 .055 .055
Elevation (m)
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta

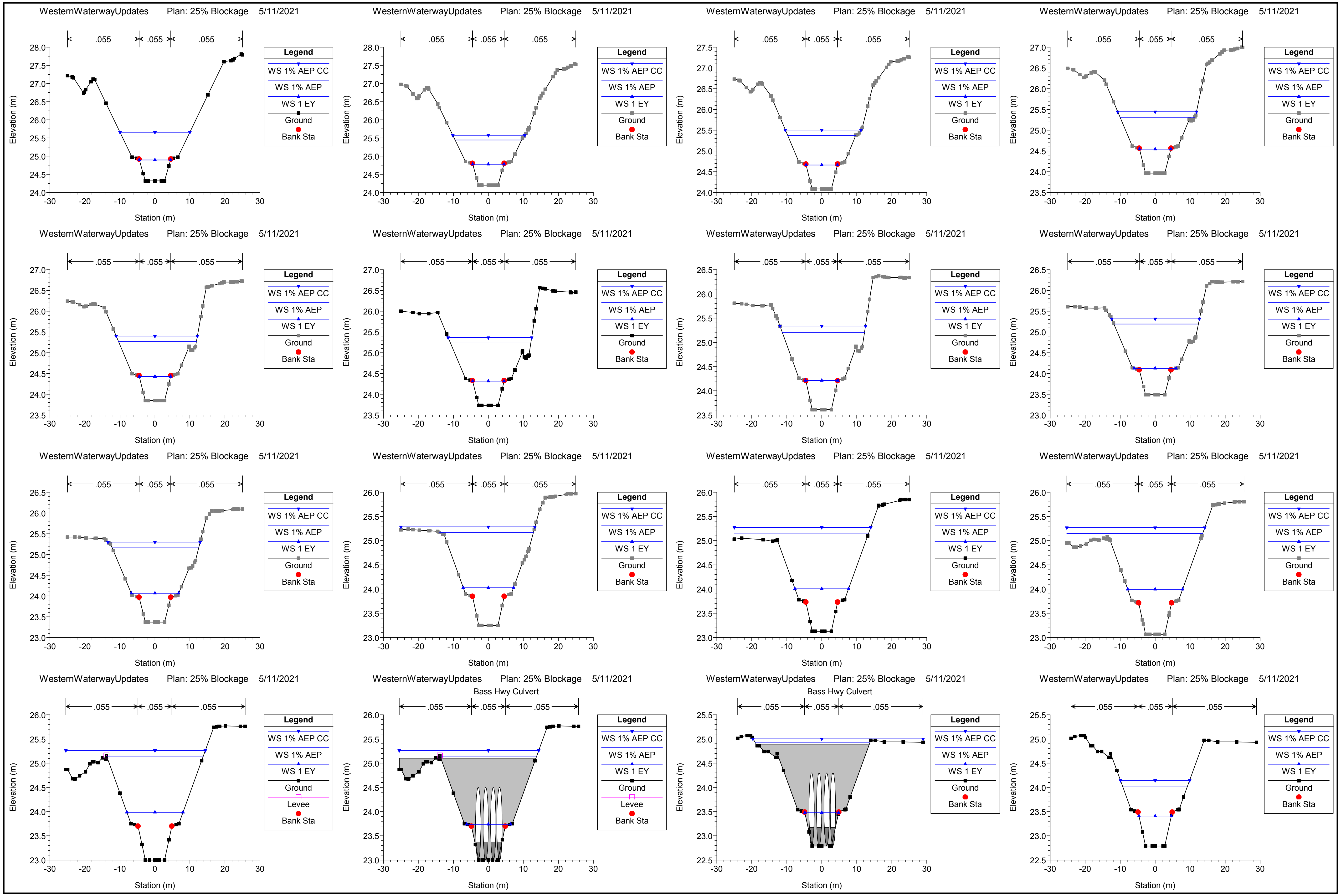

WesternWaterwayUpdates Plan: No Blockage 28/08/2021
.055 .055 .055
Elevation (m)
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Levee
Bank Sta


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
.055 .055 .055
Elevation (m)
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
.055 .055 .055
Elevation (m)
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta


WesternWaterwayUpdates Plan: No Blockage 28/08/2021
.055 .055 .055
Elevation (m)
Station (m)
Legend
WS 1% AEP
WS 1% AEP CC
WS 1 EY
Ground
Bank Sta


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
Legend
WS 1% AEP
WS 1% AEP CC
WS 1 EY
Ground
Elevation (m)
Main Channel Distance (m)
26
24
22
20
18
16
14
12
0
500
1000
1500
2000
2500
3000
3500


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
Bass Hwy Culvert
.055 .055 .055
Legend
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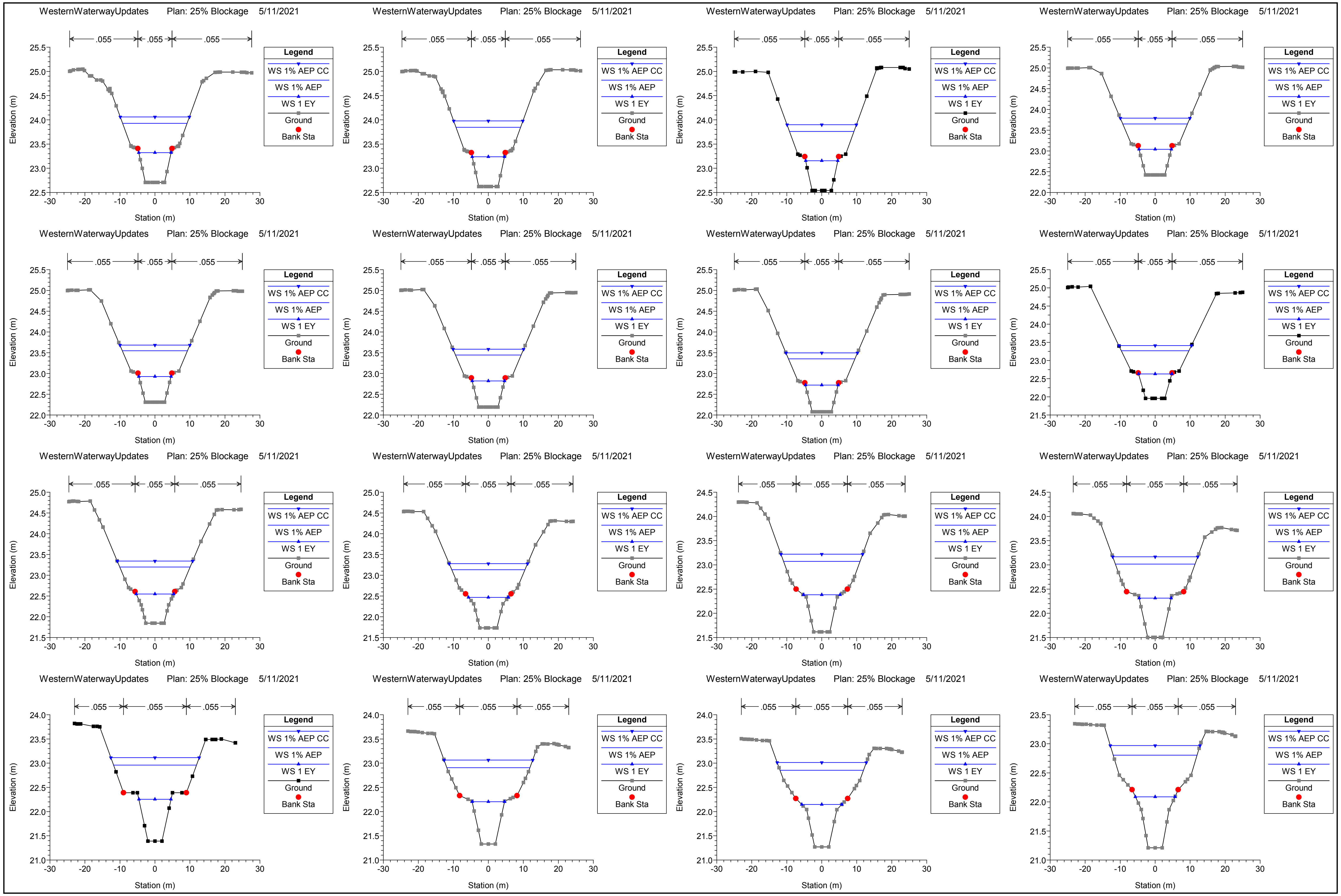
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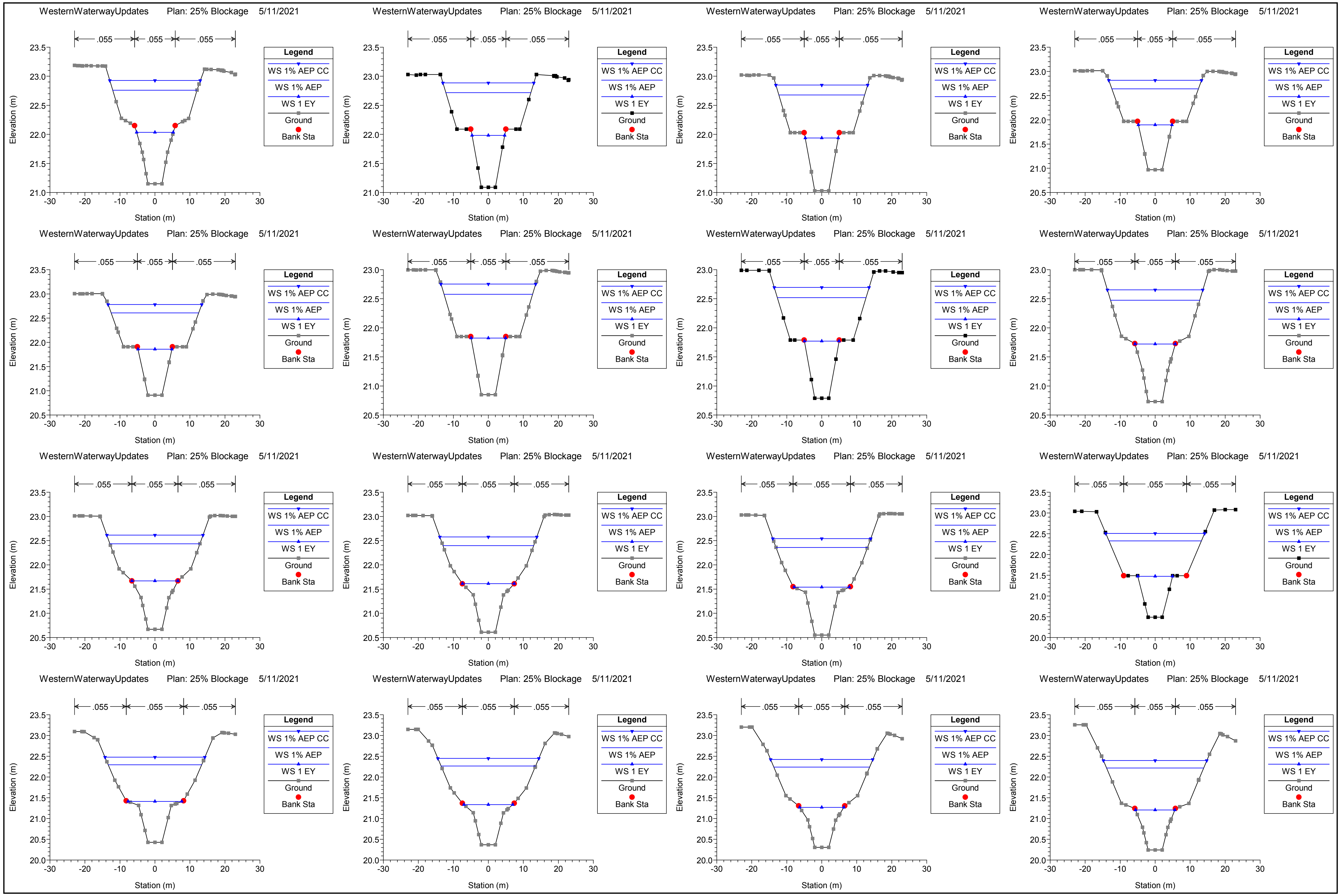
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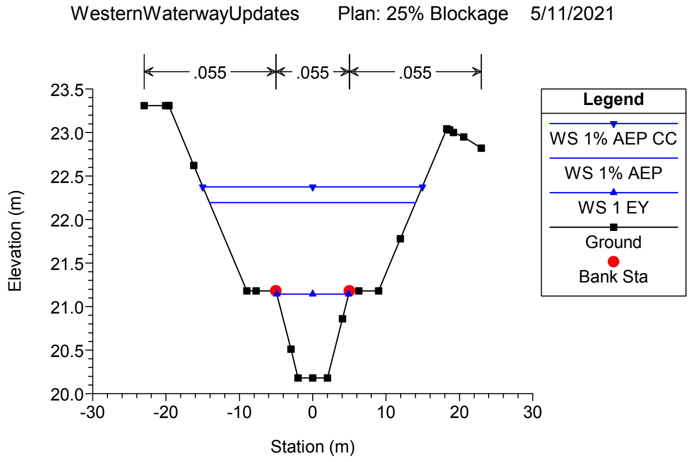
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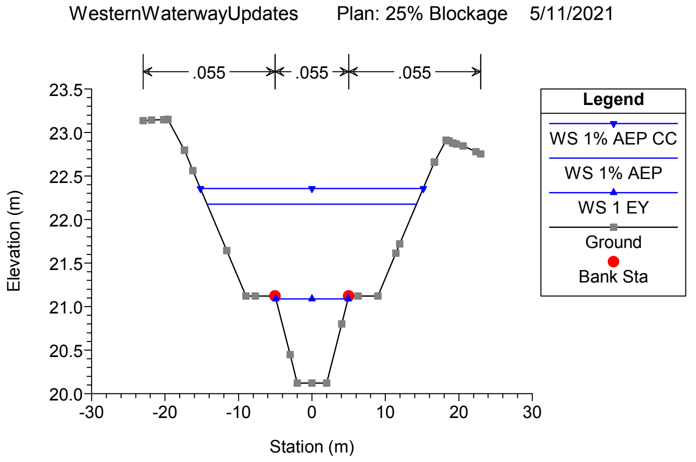
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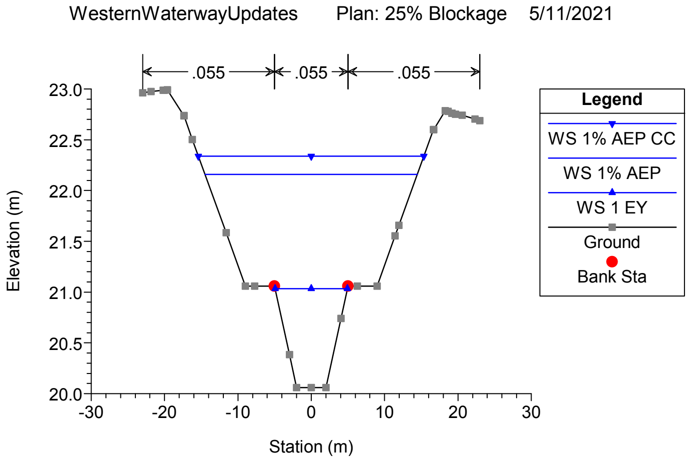
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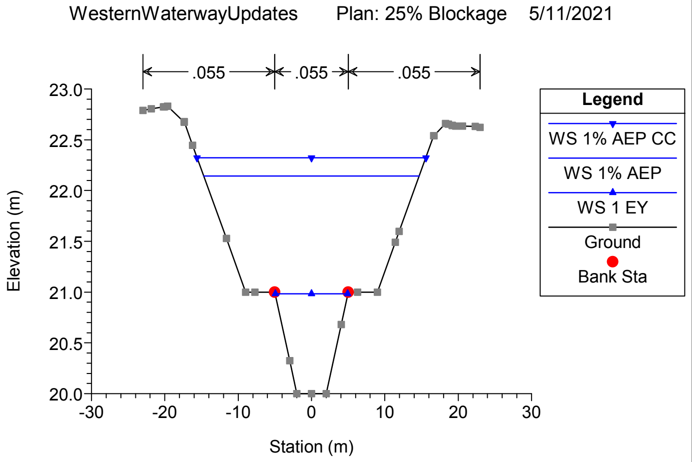
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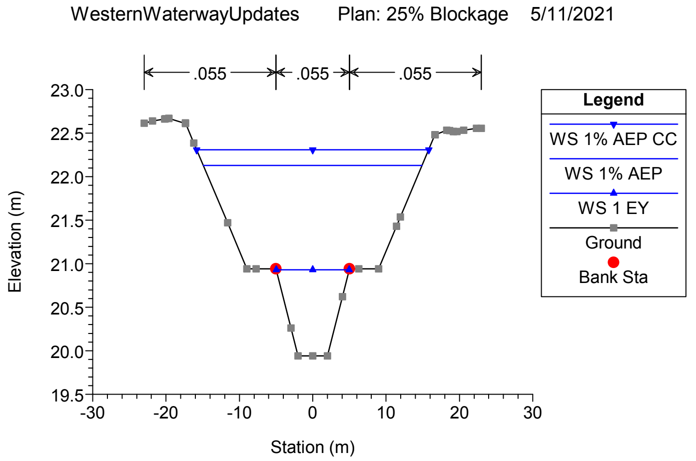
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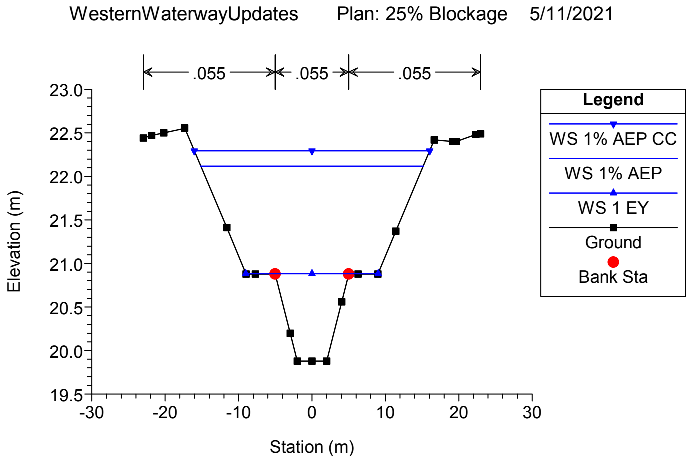
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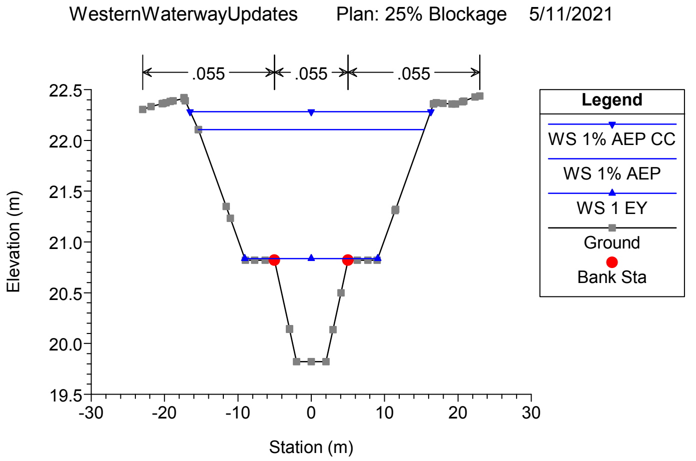
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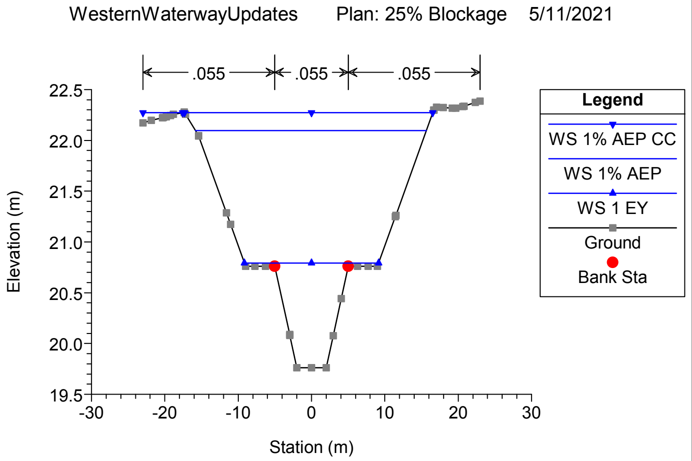
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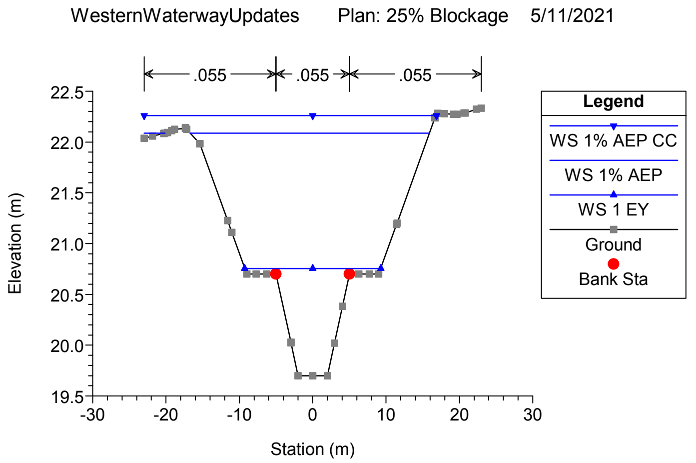
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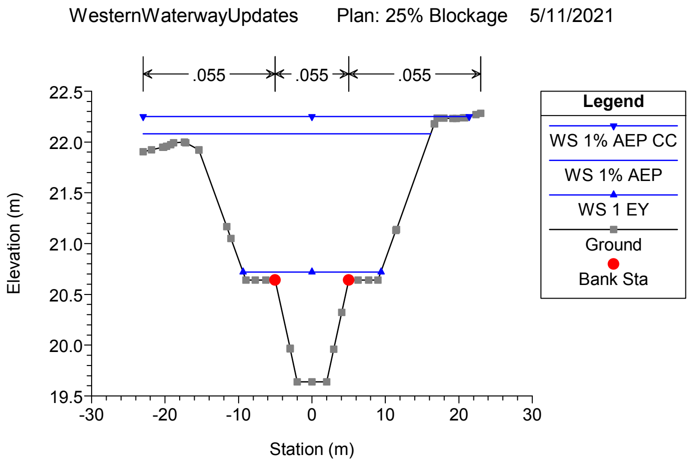
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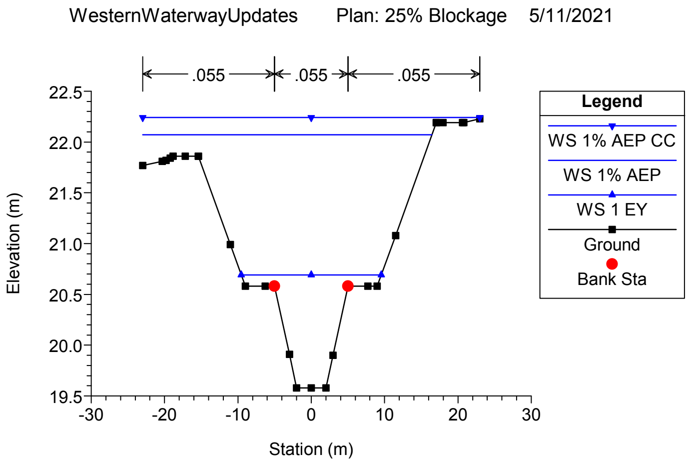
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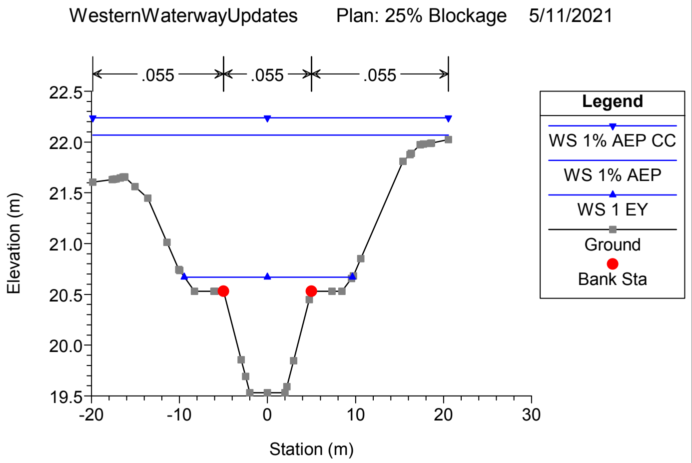
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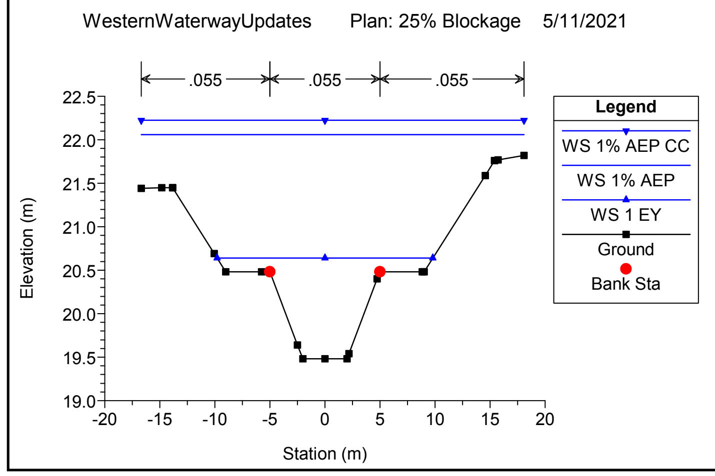
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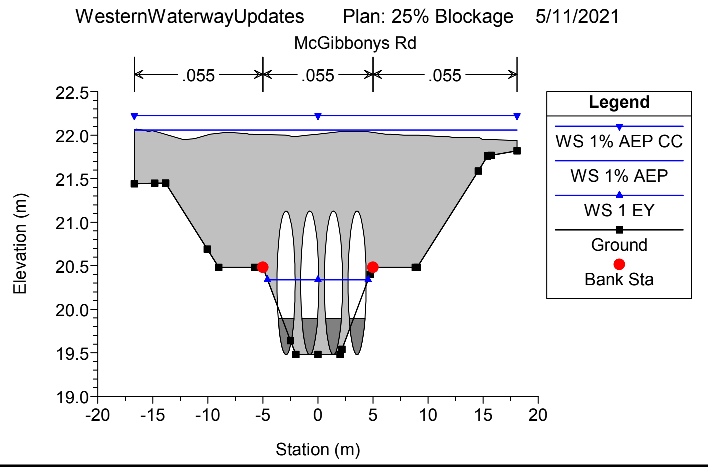
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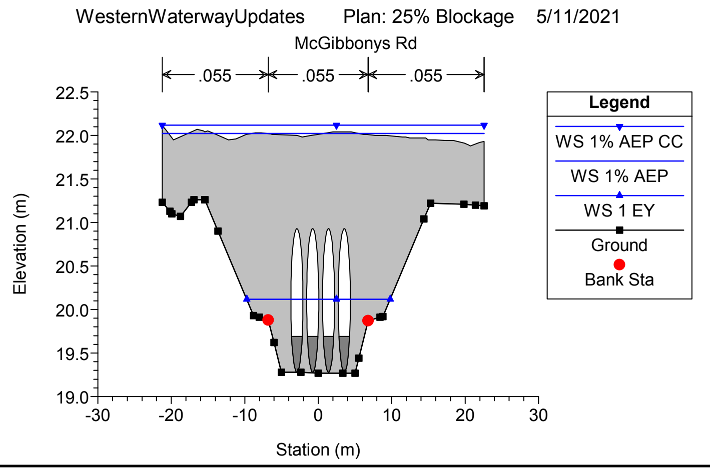
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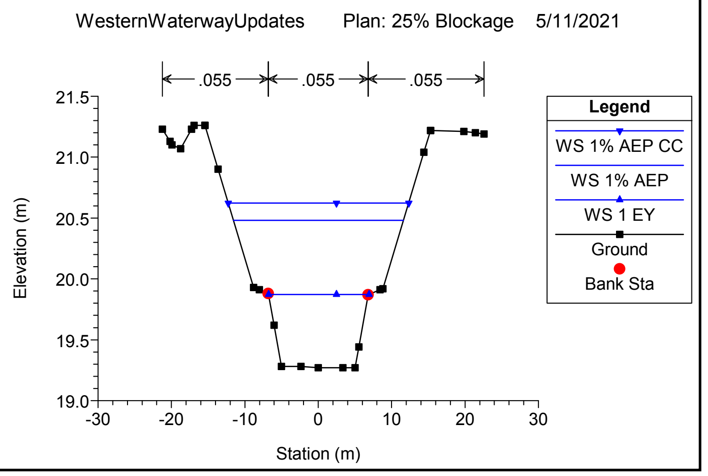
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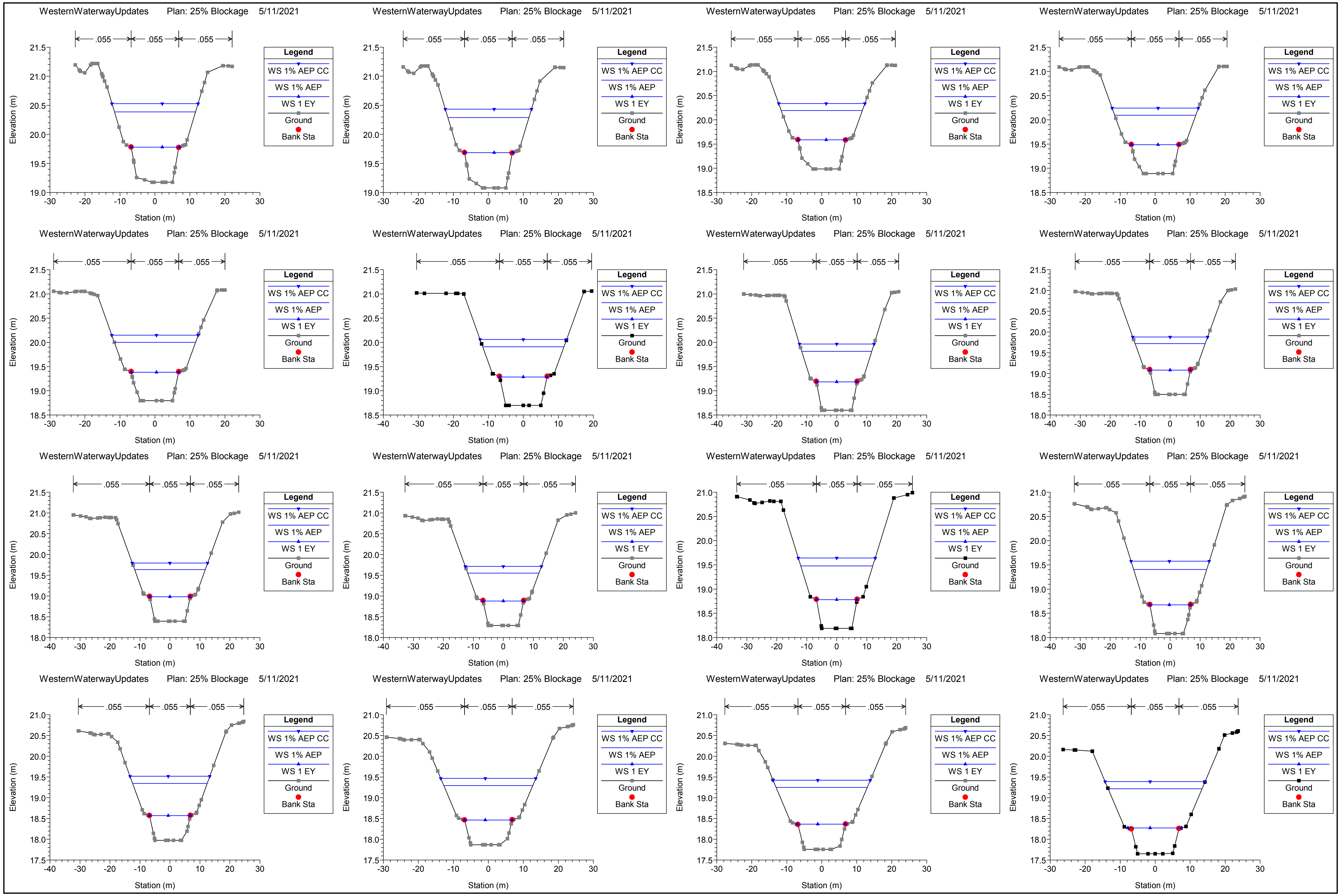
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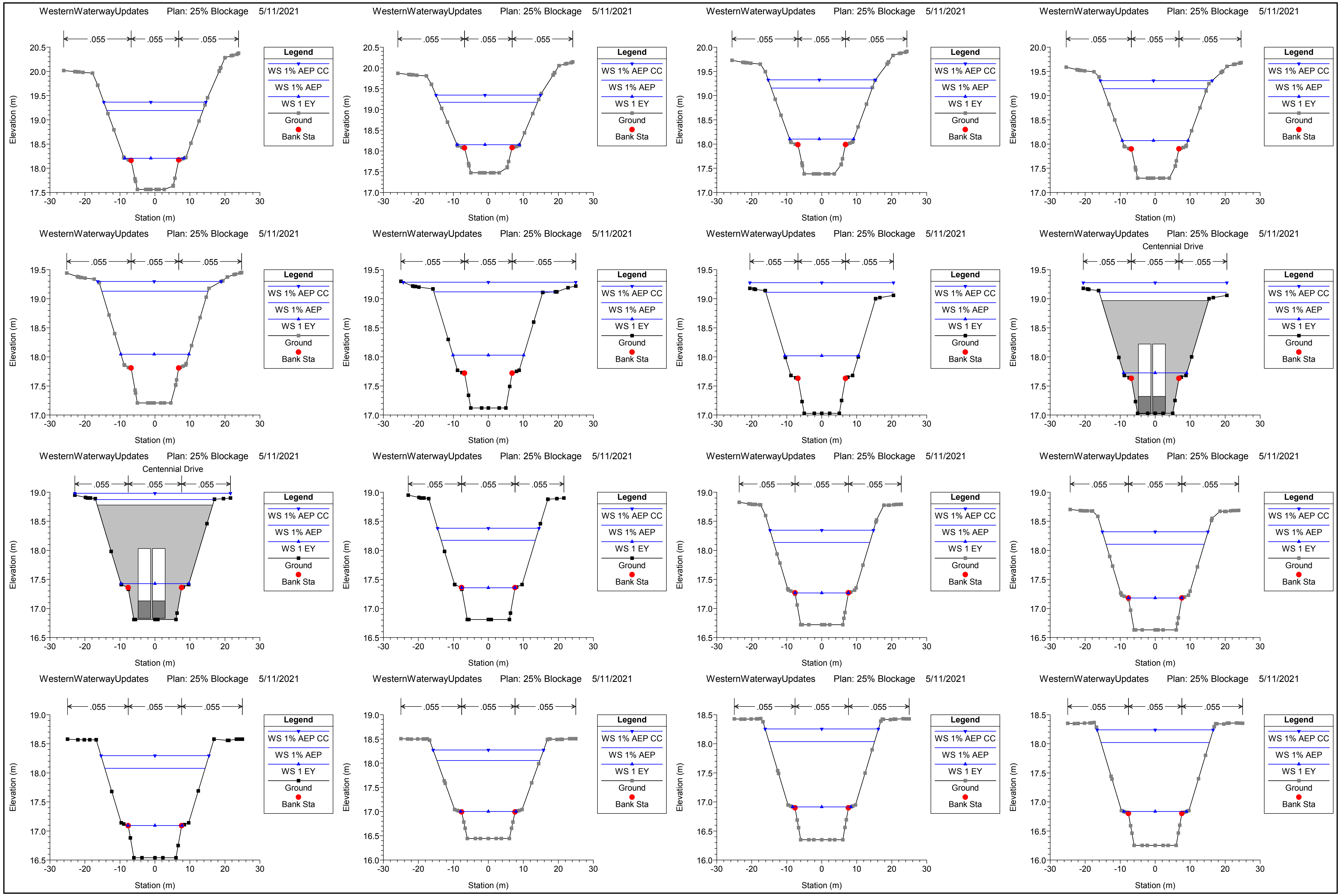

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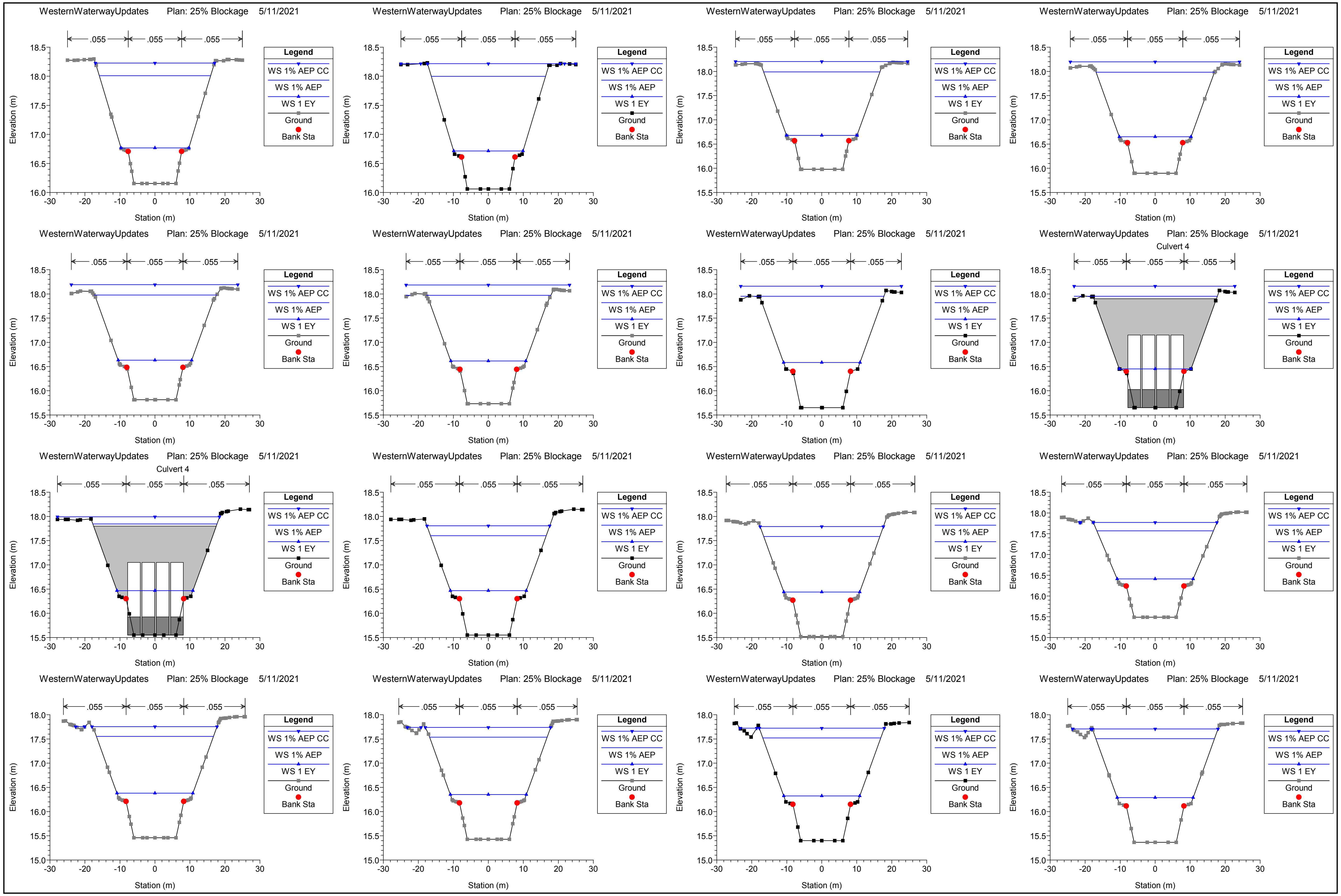
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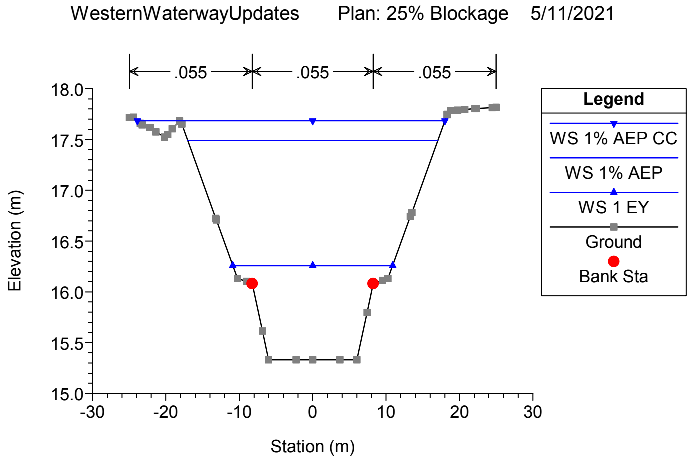
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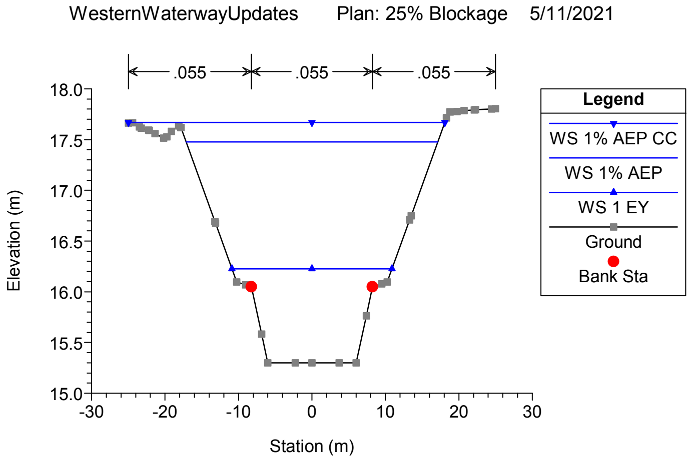
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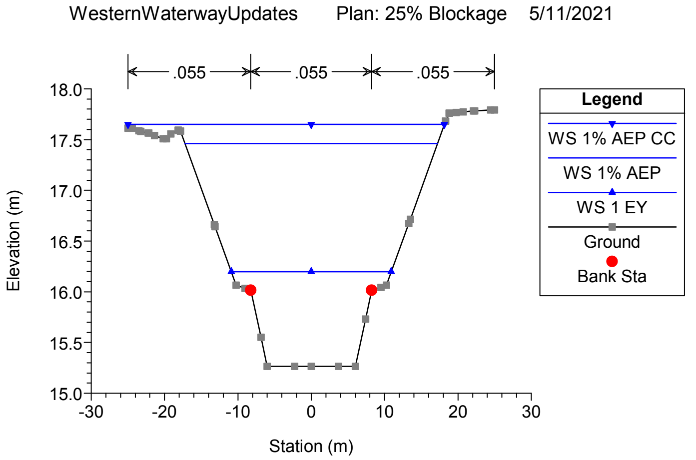
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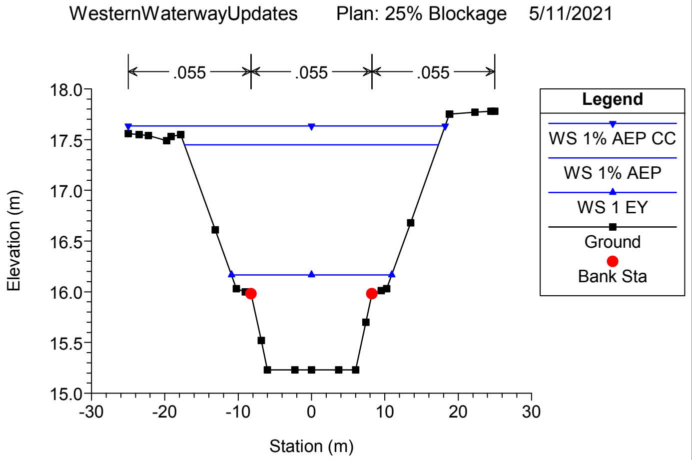
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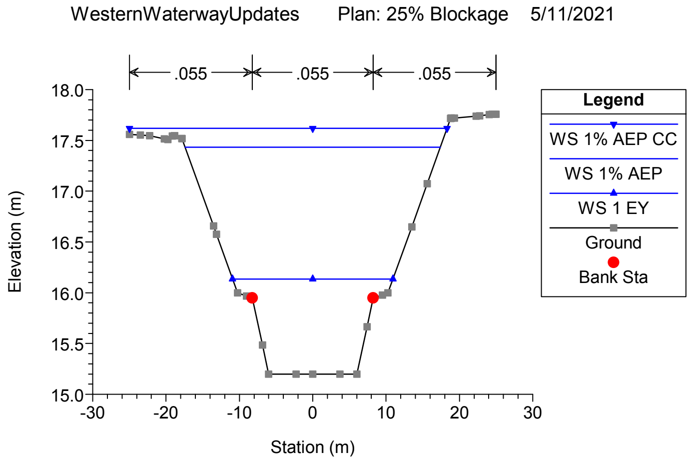
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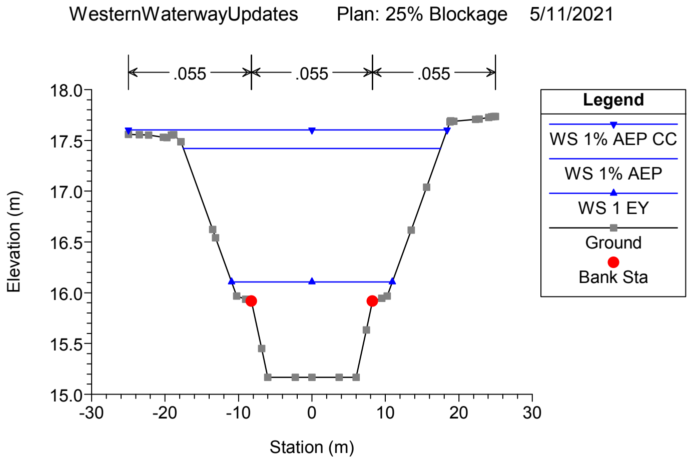
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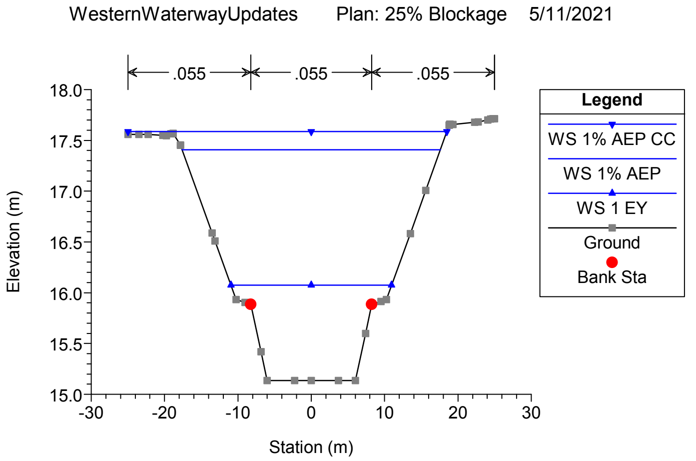
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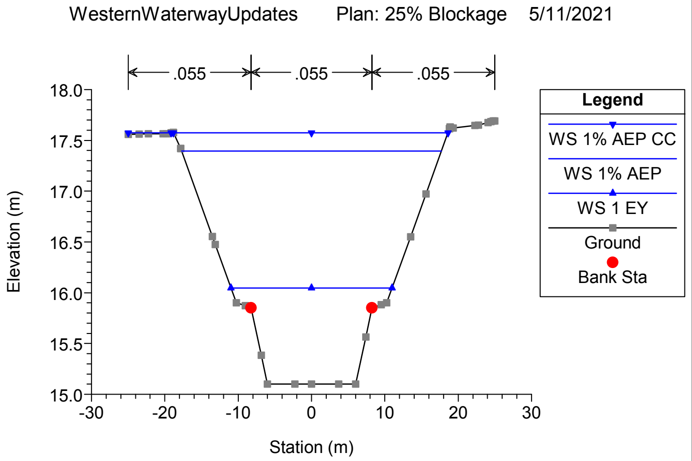
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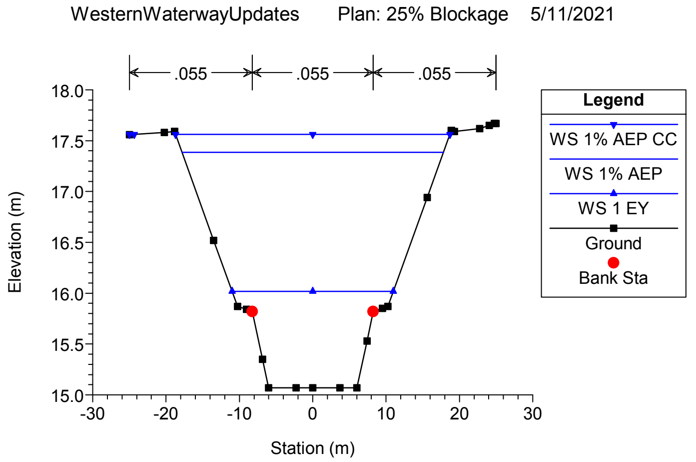
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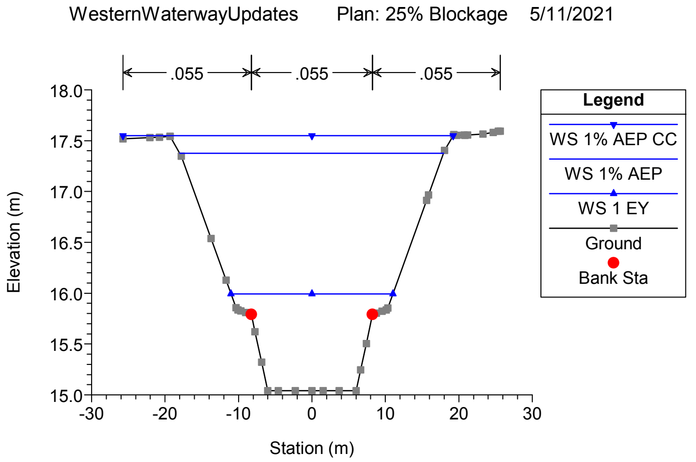
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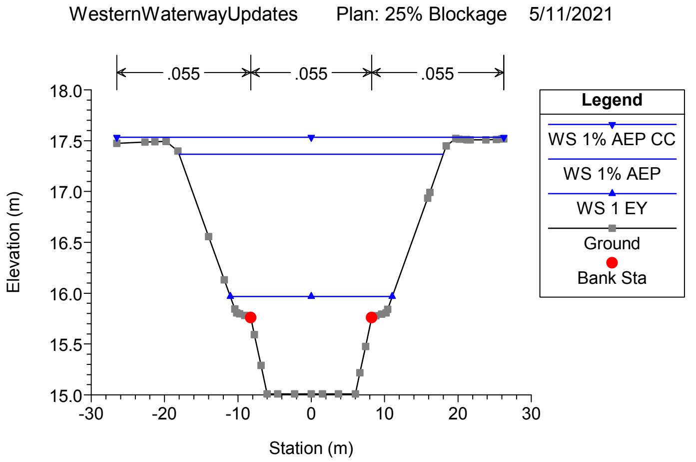
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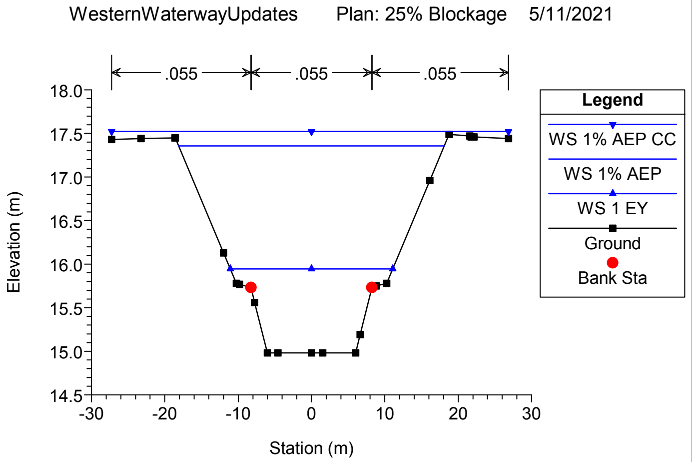
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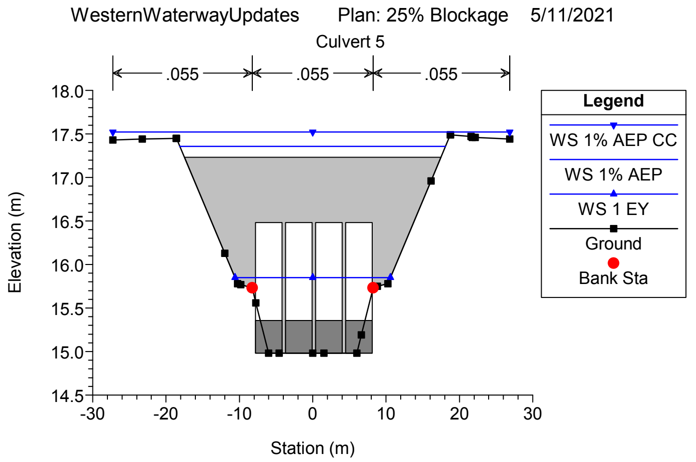
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Culvert 5
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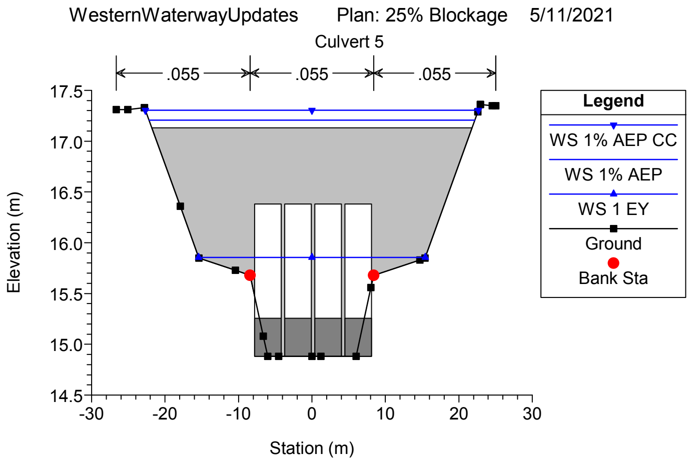
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Culvert 5
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Station (m)
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Ground
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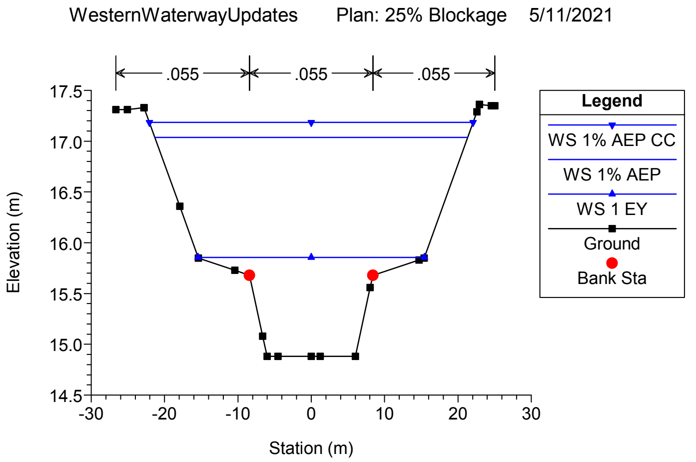
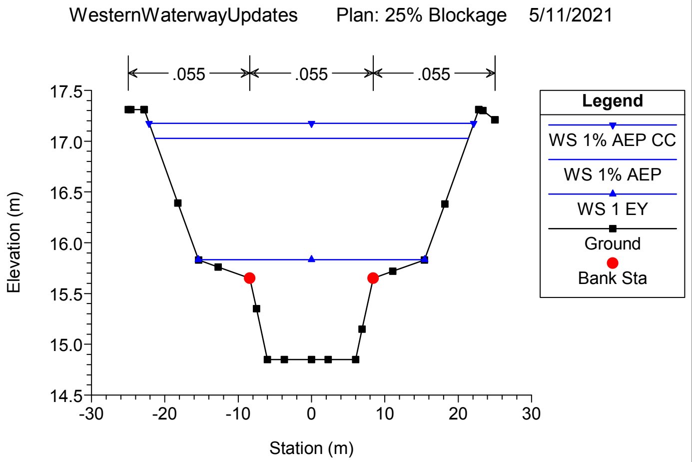
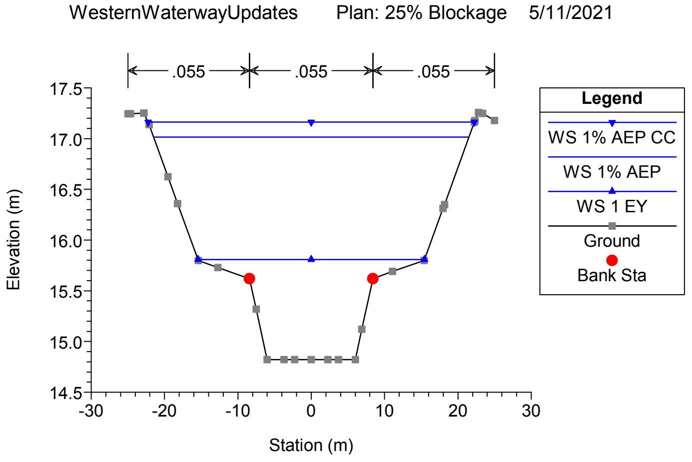

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Elevation (m)
17.5 17.0 16.5 16.0 15.5 15.0 14.5
-30 -20 -10 0 10 20 30
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Elevation (m)
17.5 17.0 16.5 16.0 15.5 15.0 14.5
-30 -20 -10 0 10 20 30
Station (m)
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
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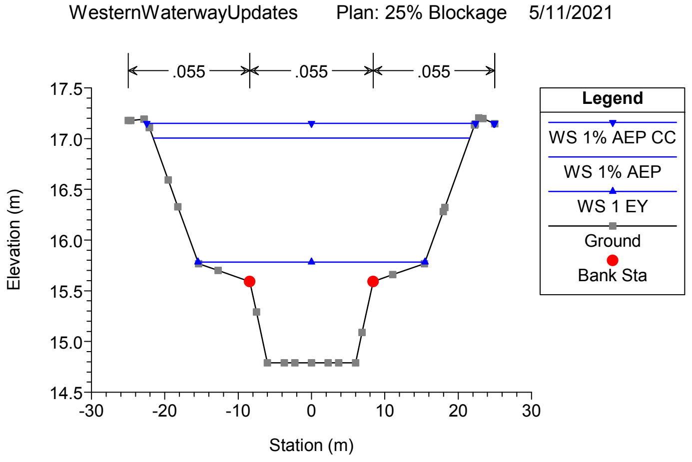
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

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Legend
WS 1% AEP CC
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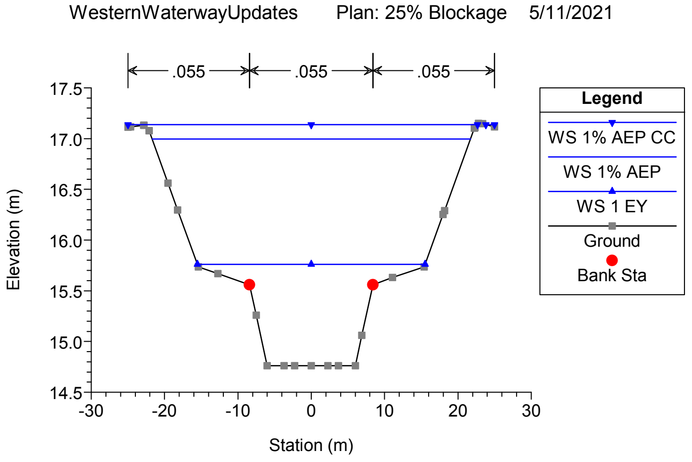
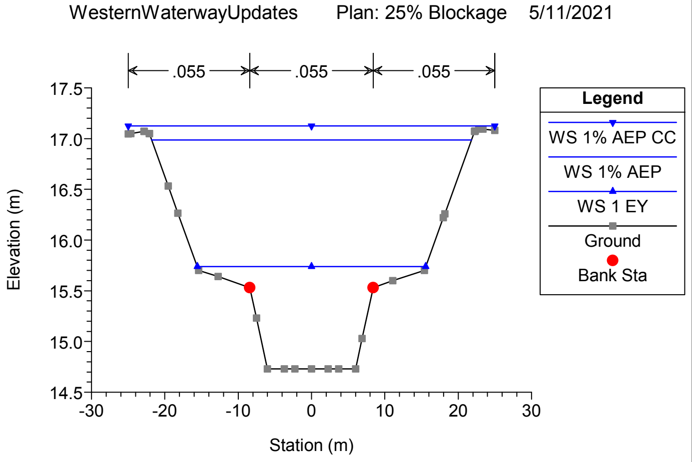
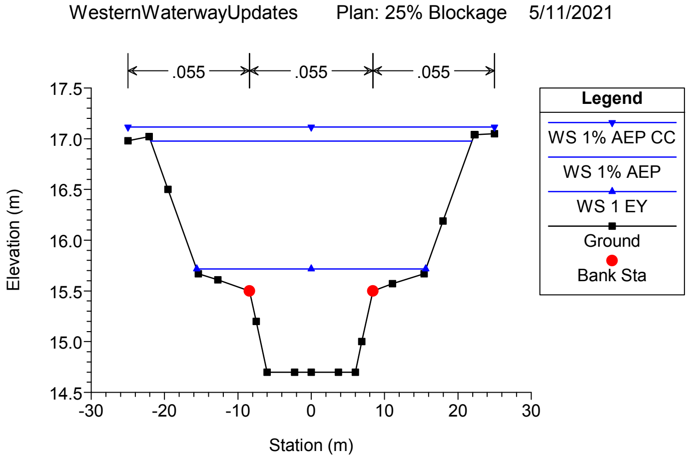
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
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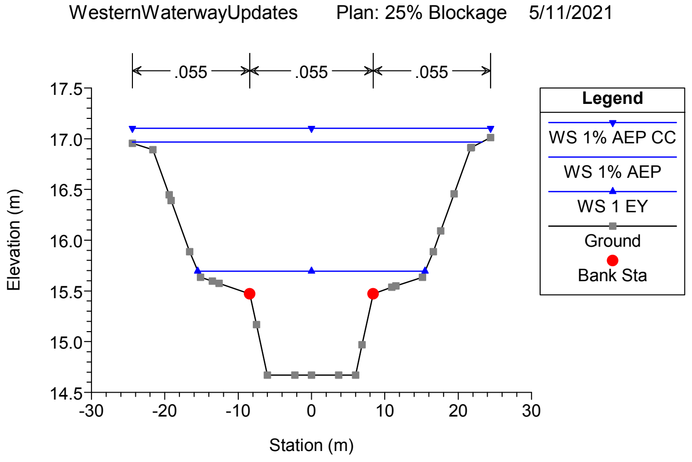
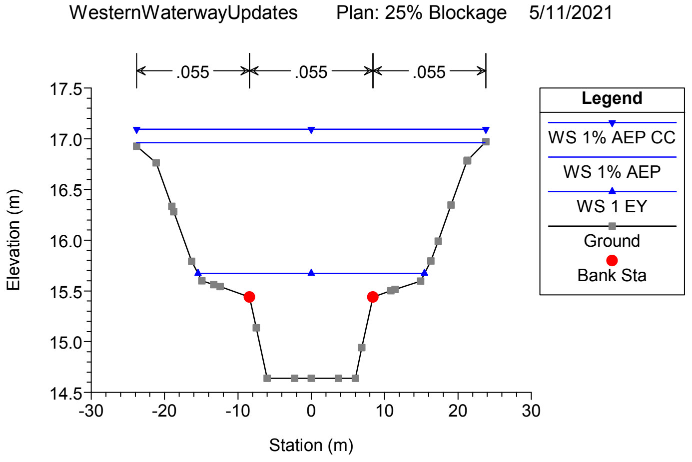
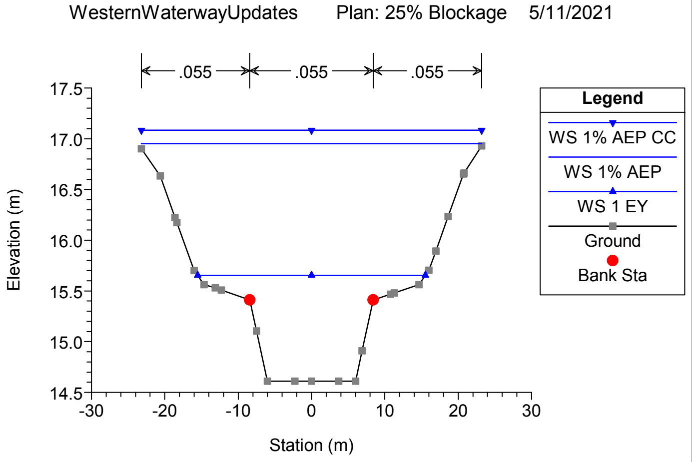
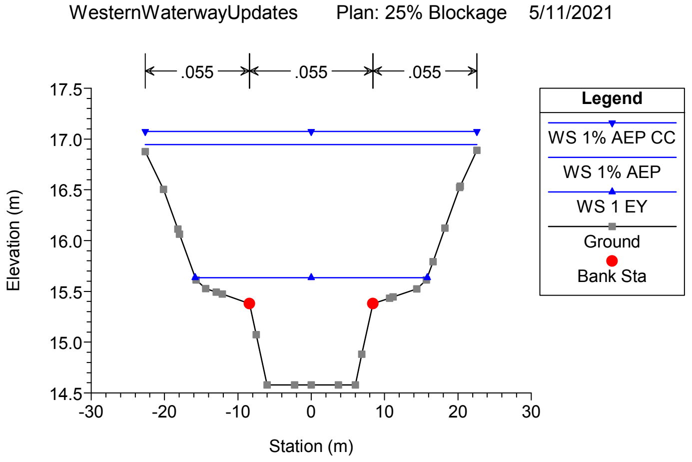
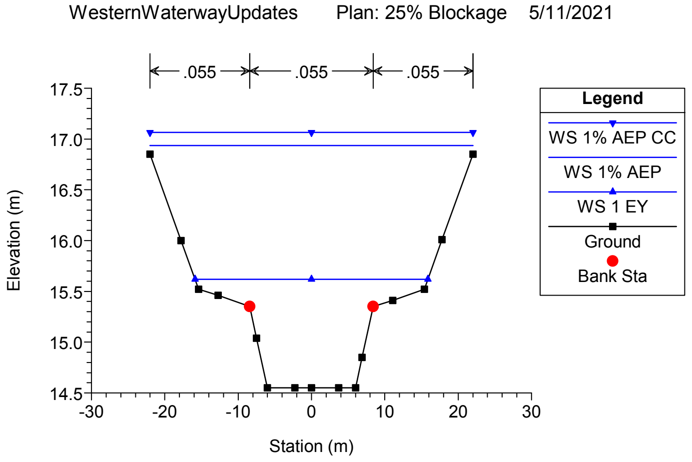
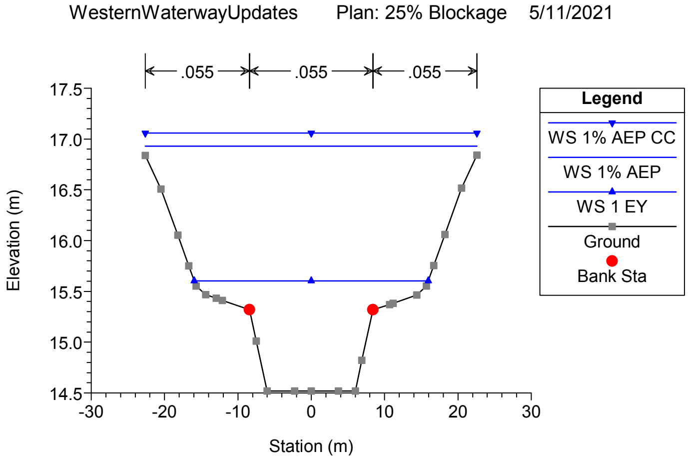
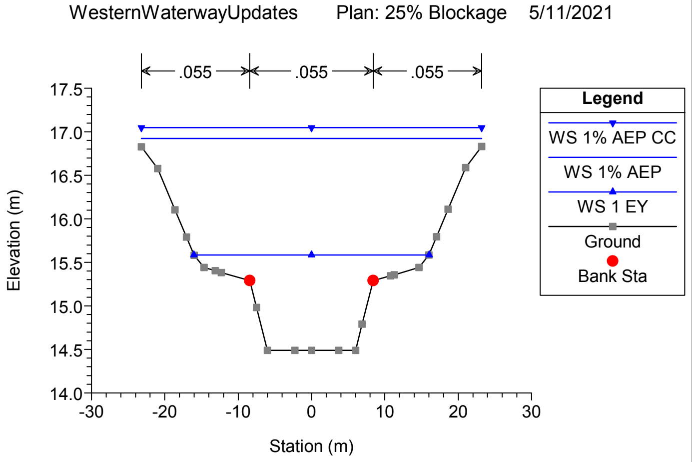
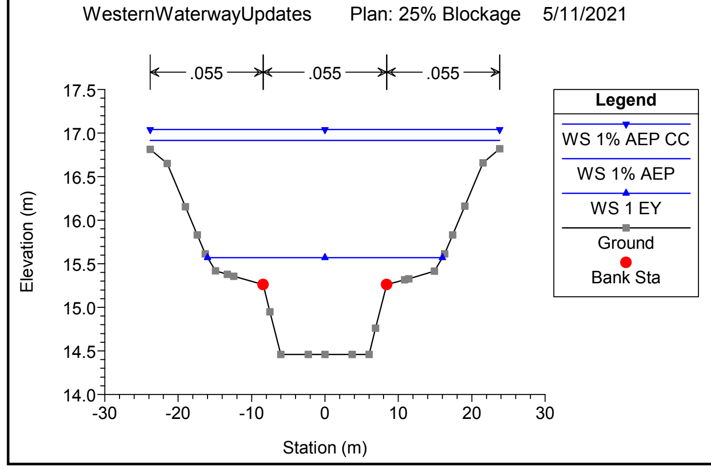
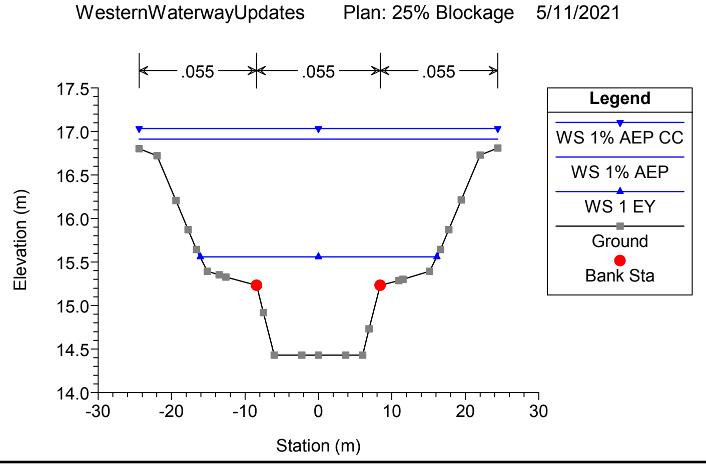
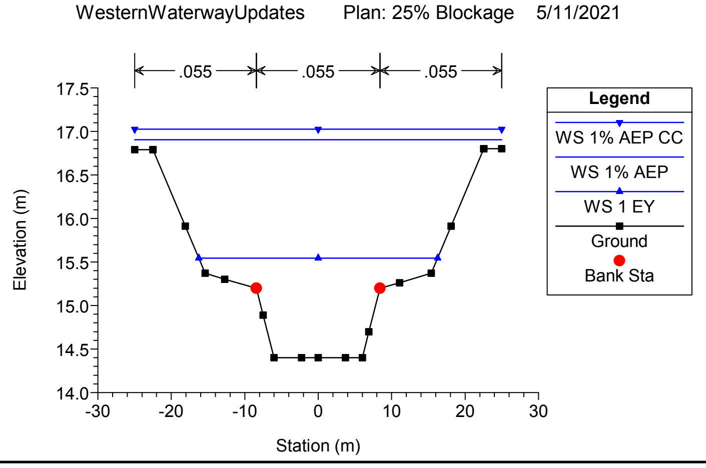
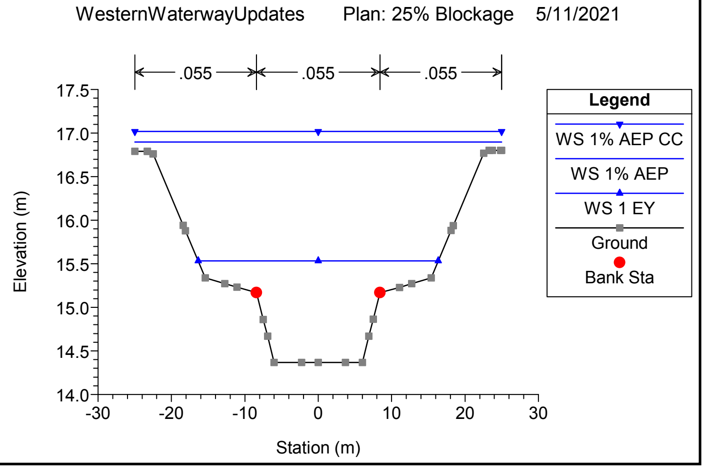
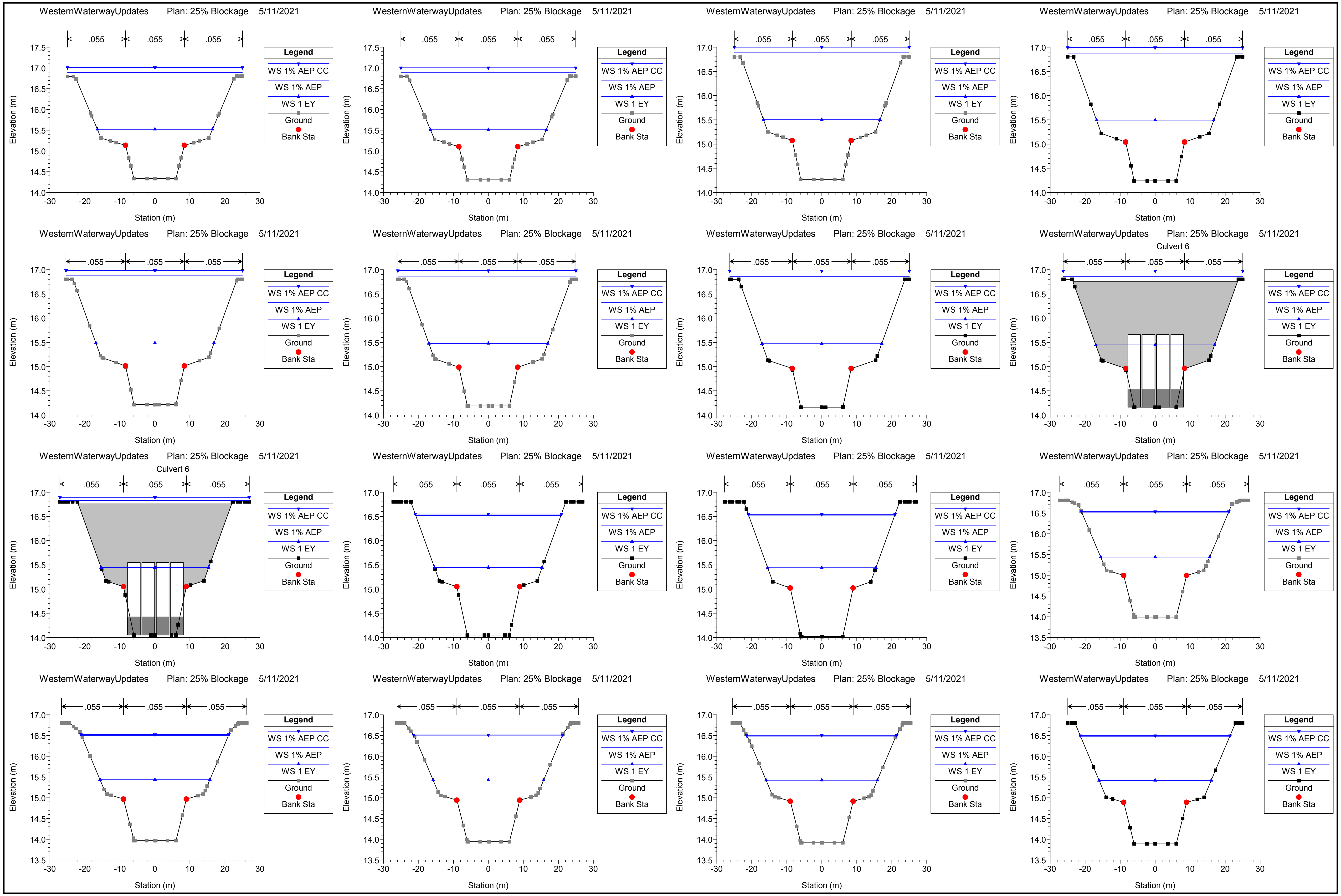
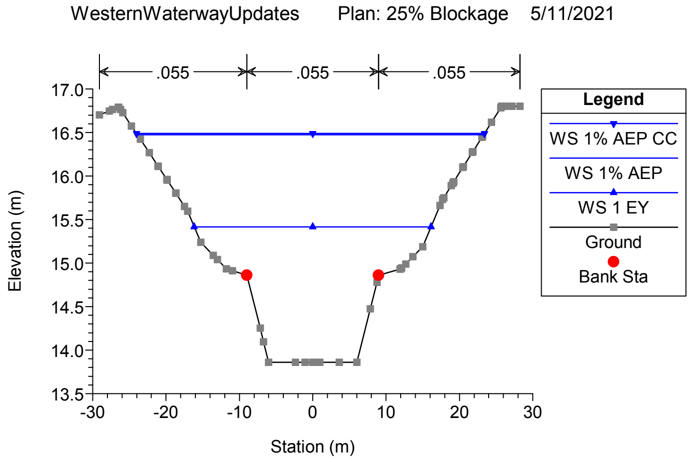
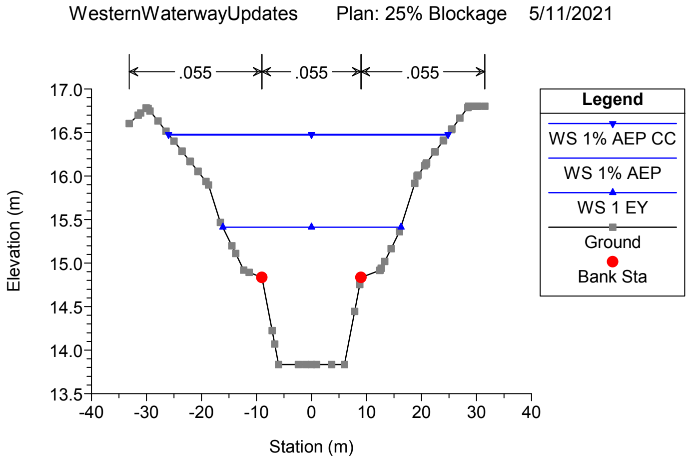
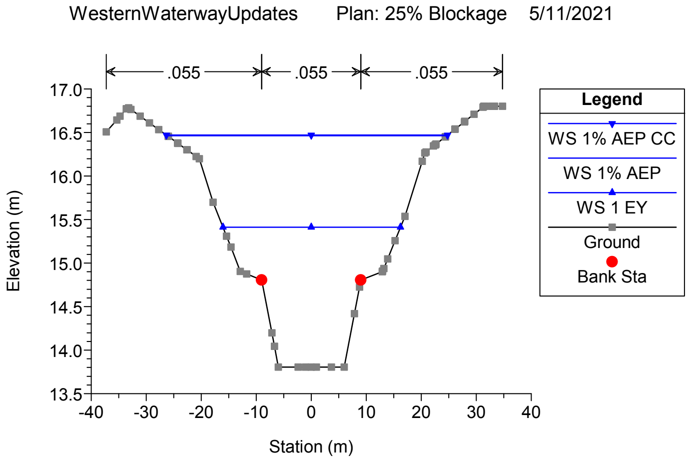
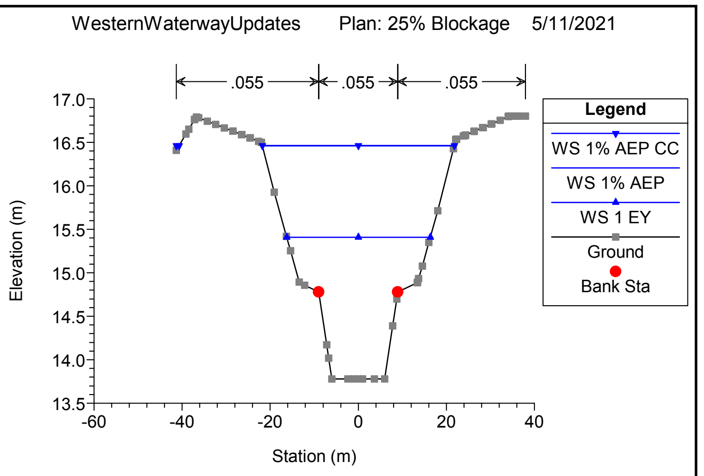
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

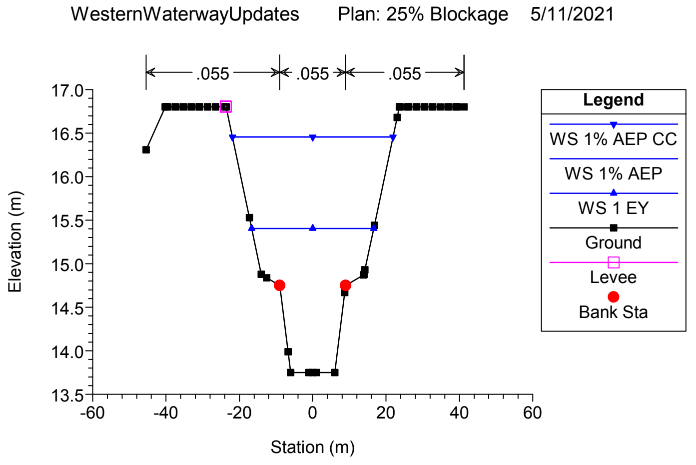

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)
Culvert 6

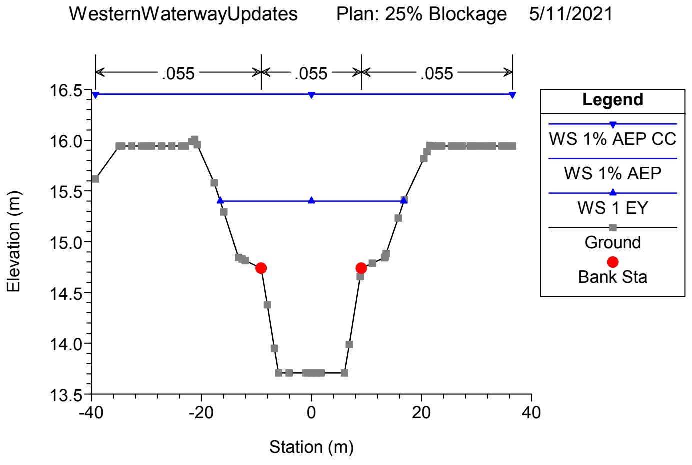

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

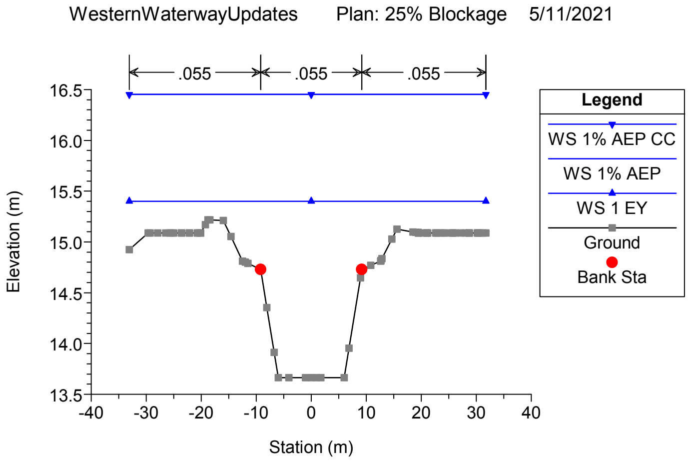

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

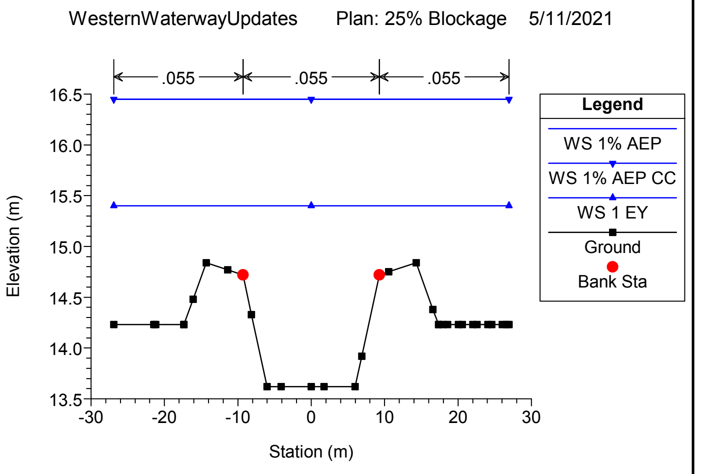

WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP CC
WS 1% AEP
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)


WesternWaterwayUpdates Plan: 25% Blockage 5/11/2021
.055 .055 .055
Legend
WS 1% AEP
WS 1% AEP CC
WS 1 EY
Ground
Bank Sta
Elevation (m)
Station (m)

# Appendix F:
## Culvert Blockage Calculations

# BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

| | |
|---|---|
| **Project:** | Wonthaggi NE PSP |
| **Structure/Drawing:** | Culvert Bass Hwy (18-19) |
| **Location & LGA:** | |
| **Designer/Engineer:** | MW |
| **Checked by:** | GO |
| **Date:** | 6/08/2021 |

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

| **STEP 1: Setup Details** | | |
|---|---|---|
| Catchment Area: | 2.21 | ha or km2 |
| Source Area (&Landuse): | Rural land and future urban | S6.3.3 |
| **Inlet Blockage Data** (floating /non-floating debris) | | |
| Description: | Sticks, grass, falling branchs limbs from current and futur | |
| How assessed: | Estimated | |
| Inlet Clear Width **(W)** | 1.5 | (m) |
| Inlet Clear Height **(D)** | 1.5 | (m) |
| Check W/D<=3 | 1.0 | (m/m) S6.4.4.8 |
| $L_{10}$ | 4.0 | (m) S6.4.4.1 |
| **Barrel Blockage Data** (sediment & bedload) | | |
| Description: | Soils are clayey based on site observation, future develop | |
| How assessed: | visual assessment at site and esitmate of future condition | |
| $D_{50}$ | 5 | (mm) |
| Barrel velocity **(V)** | 3.7 | (m/s) |

| **STEP 2: Debris Potential at Structure for 1% AEP** | | | |
|---|---|---|---|
| Blockage Location | Inlet (debris) | Barrel (sediment) | |
| Availability (H,M,L) | L | L | S6.4.4.2 & T6.6.1 |
| Mobility (H,M,L) | M | M | S6.4.4.3 & T6.6.2 |
| Transportability (H,M,L) | M | M | S6.4.4.4 & T6.6.3 |
| Combined Result | LMM | LMM | |
| 1% Debris Potential | LOW | LOW | S6.4.4.5 & T6.6.4 |

| **STEP 3: AEP Adjusted Debris Potential** (S6.4.4.6 & T6.6.5) | | | |
|---|---|---|---|
| Event AEP(%) [1:yr] | HIGH | MED | LOW |
| >5% [<1:20] | Med | Low | Low |
| 5%-0.5% [1:20 - 1:200] | High | Med | Low |
| <0.5% [>1:200] | High | High | Med |

| **STEP 4: Inlet Blockage Level** (S6.4.4.7 & T6.6.6) | | | |
|---|---|---|---|
| AEP Adjusted Debris Potential At Structure (Inlet) | | | |
| **Control Dimension** | High | Med | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $L_{10} <= W <= 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| **STEP 5: Likelihood of Sediment Deposition in Barrel** (T6.6.7) | | | | | |
|---|---|---|---|---|---|
| Sediment (Type & $D_{50}$) | Clay/Silt | Sand | Gravel | Cobbles | Boulders |
| Structure Velocity (m/s) | <=0.04mm | >0.04-2mm | >2-63mm | >63-200mm | >200mm |
| >=3.0 | *low* | *low* | *low* | *low* | *med* |
| 1.0 to < 3.0 | *low* | *low* | *low* | *med* | *med* |
| 0.5 to < 1.0 | *low* | *low* | *low* | *med* | *high* |
| 0.1 to < 0.5 | *low* | *low* | *med* | *high* | *high* |
| < 0.1 | *low* | *med* | *high* | *high* | *high* |

| **STEP 6: Depositional Blockage Levels** (T6.6.8) | | | |
|---|---|---|---|
| AEP Adjusted Sediment Potential At Structure (barrel) | | | |
| Likelihood of Deposition | High | Med | Low |
| *high* | 100% | 60% | 25% |
| *med* | 60% | 40% | 15% |
| *low* | 25% | 15% | 0% |

| **STEP 7: BLK-DES%** | **Inlet (Debris)** | | **Barrel (Sediment)** | |
|---|---|---|---|---|
| Event AEP(%) [1:yr] | LOW | STEP 4 | LOW | STEP 6 |
| >5% [<1:20] | Low | 25% | Low | 0% |
| 5%-0.5% [1:20 - 1:200] | Low | 25% | Low | 0% |
| <0.5% [>1:200] | Med | 50% | Med | 15% |

**STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS**

**ASSESS:**

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

**If CONSEQUENCES HIGH:**

**Flood Study:** Review blockage parameters. Notify asset owner.

**Design:** Review blockage parameters. Mitigate Risk. **(see S6.6)**

# BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

| | |
|---|---|
| **Project:** | Wonthaggi NE PSP |
| **Structure/Drawing:** | Culvert McGibbonys Rd (21-22) |
| **Location & LGA:** | |
| **Designer/Engineer:** | MW |
| **Checked by:** | GO |
| **Date:** | 6/08/2021 |

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

| STEP 1: Setup Details | | |
|---|---|---|
| Catchment Area: | 3.28 | ha or km2 |
| Source Area (&Landuse): | Rural land and future urban | S6.3.3 |
| **Inlet Blockage Data** (floating /non-floating debris) | | |
| Description: | Sticks, grass, falling branchs limbs from current and futur | |
| How assessed: | Estimated | |
| Inlet Clear Width **(W)** | 1.65 | (m) |
| Inlet Clear Height **(D)** | 1.65 | (m) |
| Check W/D<=3 | 1.0 | (m/m) S6.4.4.8 |
| $L_{10}$ | 4.0 | (m) S6.4.4.1 |
| **Barrel Blockage Data** (sediment & bedload) | | |
| Description: | Soils are clayey based on site observation, future develop | |
| How assessed: | visual assessment at site and esitmate of future condition | |
| $D_{50}$ | 5 | (mm) |
| Barrel velocity **(V)** | 3.5 | (m/s) |

| STEP 2: Debris Potential at Structure for 1% AEP | | | |
|---|---|---|---|
| Blockage Location | Inlet (debris) | Barrel (sediment) | |
| Availability (H,M,L) | L | L | S6.4.4.2 & T6.6.1 |
| Mobility (H,M,L) | M | M | S6.4.4.3 & T6.6.2 |
| Transportability (H,M,L) | M | M | S6.4.4.4 & T6.6.3 |
| Combined Result | LMM | LMM | |
| 1% Debris Potential | LOW | LOW | S6.4.4.5 & T6.6.4 |

| STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5) | | | |
|---|---|---|---|
| Event AEP(%) [1:yr] | HIGH | MED | LOW |
| >5% [<1:20] | Med | Low | Low |
| 5%-0.5% [1:20 - 1:200] | High | Med | Low |
| <0.5% [>1:200] | High | High | Med |

| STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6) | | | |
|---|---|---|---|
| AEP Adjusted Debris Potential At Structure (Inlet) | | | |
| **Control Dimension** | High | Med | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $L_{10} <= W <= 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7) | | | | | |
|---|---|---|---|---|---|
| Sediment (Type & $D_{50}$) | Clay/Silt | Sand | Gravel | Cobbles | Boulders |
| Structure Velocity (m/s) | <=0.04mm | >0.04-2mm | >2-63mm | >63-200mm | >200mm |
| >=3.0 | *low* | *low* | *low* | *low* | *med* |
| 1.0 to < 3.0 | *low* | *low* | *low* | *med* | *med* |
| 0.5 to < 1.0 | *low* | *low* | *low* | *med* | *high* |
| 0.1 to < 0.5 | *low* | *low* | *med* | *high* | *high* |
| < 0.1 | *low* | *med* | *high* | *high* | *high* |

| STEP 6: Depositional Blockage Levels (T6.6.8) | | | |
|---|---|---|---|
| AEP Adjusted Sediment Potential At Structure (barrel) | | | |
| Likelihood of Deposition | High | Med | Low |
| *high* | 100% | 60% | 25% |
| *med* | 60% | 40% | 15% |
| *low* | 25% | 15% | 0% |

| STEP 7: BLK-DES% | Inlet (Debris) | | Barrel (Sediment) | |
|---|---|---|---|---|
| Event AEP(%) [1:yr] | LOW | STEP 4 | LOW | STEP 6 |
| >5% [<1:20] | Low | 25% | Low | 0% |
| 5%-0.5% [1:20 - 1:200] | Low | 25% | Low | 0% |
| <0.5% [>1:200] | Med | 50% | Med | 15% |

**STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS**

**ASSESS:**

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

**If CONSEQUENCES HIGH:**

**Flood Study:** Review blockage parameters. Notify asset owner.

**Design:** Review blockage parameters. Mitigate Risk. **(see S6.6)**

# BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

**Project:** Wonthaggi NE PSP
**Structure/Drawing:** Centennial Drive Culvert
**Location & LGA:**
**Designer/Engineer:** MW
**Checked by:** GO
**Date:** 6/08/2021

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

| STEP 1: Setup Details | | |
|---|---|---|
| Catchment Area: | 3.32 | ha or km2 |
| Source Area (&Landuse): | Rural land and future urban | S6.3.3 |
| **Inlet Blockage Data** (floating /non-floating debris) | | |
| Description: | Sticks, grass, falling branchs limbs from current and futur | |
| How assessed: | Estimated | |
| Inlet Clear Width **(W)** | 3.6 | (m) |
| Inlet Clear Height **(D)** | 1.2 | (m) |
| Check W/D<=3 | 3.0 | (m/m) S6.4.4.8 |
| $L_{10}$ | 4.0 | (m) S6.4.4.1 |
| **Barrel Blockage Data** (sediment & bedload) | | |
| Description: | Soils are clayey based on site observation, future develop | |
| How assessed: | visual assessment at site and esitmate of future condition | |
| $D_{50}$ | 5 | (mm) |
| Barrel velocity **(V)** | 1.7 | (m/s) |

| STEP 2: Debris Potential at Structure for 1% AEP | | | |
|---|---|---|---|
| Blockage Location | Inlet (debris) | Barrel (sediment) | |
| Availability (H,M,L) | L | L | S6.4.4.2 & T6.6.1 |
| Mobility (H,M,L) | M | M | S6.4.4.3 & T6.6.2 |
| Transportability (H,M,L) | M | M | S6.4.4.4 & T6.6.3 |
| Combined Result | LMM | LMM | |
| 1% Debris Potential | LOW | LOW | S6.4.4.5 & T6.6.4 |

| STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5) | | | |
|---|---|---|---|
| Event AEP(%) [1:yr] | HIGH | MED | LOW |
| >5% [<1:20] | Med | Low | Low |
| 5%-0.5% [1:20 - 1:200] | High | Med | Low |
| <0.5% [>1:200] | High | High | Med |

| STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6) | | | |
|---|---|---|---|
| AEP Adjusted Debris Potential At Structure (Inlet) | | | |
| **Control Dimension** | High | Med | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $L_{10} <= W <= 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7) | | | | | |
|---|---|---|---|---|---|
| Sediment (Type & $D_{50}$) | Clay/Silt | Sand | Gravel | Cobbles | Boulders |
| Structure Velocity (m/s) | <=0.04mm | >0.04-2mm | >2-63mm | >63-200mm | >200mm |
| >=3.0 | *low* | *low* | *low* | *low* | *med* |
| 1.0 to < 3.0 | *low* | *low* | *low* | *med* | *med* |
| 0.5 to < 1.0 | *low* | *low* | *low* | *med* | *high* |
| 0.1 to < 0.5 | *low* | *low* | *med* | *high* | *high* |
| < 0.1 | *low* | *med* | *high* | *high* | *high* |

| STEP 6: Depositional Blockage Levels (T6.6.8) | | | |
|---|---|---|---|
| AEP Adjusted Sediment Potential At Structure (barrel) | | | |
| Likelihood of Deposition | High | Med | Low |
| *high* | 100% | 60% | 25% |
| *med* | 60% | 40% | 15% |
| *low* | 25% | 15% | 0% |

| STEP 7: BLK-DES% | Inlet (Debris) | | Barrel (Sediment) | |
|---|---|---|---|---|
| Event AEP(%) [1:yr] | LOW | STEP 4 | LOW | STEP 6 |
| >5% [<1:20] | Low | 25% | Low | 0% |
| 5%-0.5% [1:20 - 1:200] | Low | 25% | Low | 0% |
| <0.5% [>1:200] | Med | 50% | Med | 15% |

**STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS**

**ASSESS:**

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

**If CONSEQUENCES HIGH:**

**Flood Study:** Review blockage parameters. Notify asset owner.

**Design:** Review blockage parameters. Mitigate Risk. **(see S6.6)**

# BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

**Project:** Wonthaggi NE PSP
**Structure/Drawing:** Culvert 4 (23 - 23A)
**Location & LGA:**
**Designer/Engineer:** MW
**Checked by:** GO
**Date:** 6/08/2021

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

| STEP 1: Setup Details | | |
|---|---|---|
| Catchment Area: | 4.6 | ha or km2 |
| Source Area (&Landuse): | Rural land and future urban | S6.3.3 |
| **Inlet Blockage Data** (floating /non-floating debris) | | |
| Description: | Sticks, grass, falling branchs limbs from current and futur | |
| How assessed: | Estimated | |
| Inlet Clear Width **(W)** | 3.6 | (m) |
| Inlet Clear Height **(D)** | 1.5 | (m) |
| Check W/D<=3 | 2.4 | (m/m) S6.4.4.8 |
| $L_{10}$ | 4.0 | (m) S6.4.4.1 |
| **Barrel Blockage Data** (sediment & bedload) | | |
| Description: | Soils are clayey based on site observation, future develop | |
| How assessed: | visual assessment at site and esitmate of future condition | |
| $D_{50}$ | 5 | (mm) |
| Barrel velocity **(V)** | 1.6 | (m/s) |

| STEP 2: Debris Potential at Structure for 1% AEP | | | |
|---|---|---|---|
| Blockage Location | Inlet (debris) | Barrel (sediment) | |
| Availability (H,M,L) | L | L | S6.4.4.2 & T6.6.1 |
| Mobility (H,M,L) | M | M | S6.4.4.3 & T6.6.2 |
| Transportability (H,M,L) | M | M | S6.4.4.4 & T6.6.3 |
| Combined Result | LMM | LMM | |
| 1% Debris Potential | LOW | LOW | S6.4.4.5 & T6.6.4 |

| STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5) | | | |
|---|---|---|---|
| Event AEP(%) [1:yr] | HIGH | MED | LOW |
| >5% [<1:20] | Med | Low | Low |
| 5%-0.5% [1:20 - 1:200] | High | Med | Low |
| <0.5% [>1:200] | High | High | Med |

| STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6) | | | |
|---|---|---|---|
| AEP Adjusted Debris Potential At Structure (Inlet) | | | |
| **Control Dimension** | High | Med | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $L_{10} <= W <= 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7) | | | | | |
|---|---|---|---|---|---|
| Sediment (Type & $D_{50}$) | Clay/Silt | Sand | Gravel | Cobbles | Boulders |
| Structure Velocity (m/s) | <=0.04mm | >0.04-2mm | >2-63mm | >63-200mm | >200mm |
| >=3.0 | *low* | *low* | *low* | *low* | *med* |
| 1.0 to < 3.0 | *low* | *low* | *low* | *med* | *med* |
| 0.5 to < 1.0 | *low* | *low* | *low* | *med* | *high* |
| 0.1 to < 0.5 | *low* | *low* | *med* | *high* | *high* |
| < 0.1 | *low* | *med* | *high* | *high* | *high* |

| STEP 6: Depositional Blockage Levels (T6.6.8) | | | |
|---|---|---|---|
| AEP Adjusted Sediment Potential At Structure (barrel) | | | |
| Likelihood of Deposition | High | Med | Low |
| *high* | 100% | 60% | 25% |
| *med* | 60% | 40% | 15% |
| *low* | 25% | 15% | 0% |

| STEP 7: BLK-DES% | Inlet (Debris) | | Barrel (Sediment) | |
|---|---|---|---|---|
| Event AEP(%) [1:yr] | LOW | STEP 4 | LOW | STEP 6 |
| >5% [<1:20] | Low | 25% | Low | 0% |
| 5%-0.5% [1:20 - 1:200] | Low | 25% | Low | 0% |
| <0.5% [>1:200] | Med | 50% | Med | 15% |

**STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS**

**ASSESS:**

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

**If CONSEQUENCES HIGH:**

**Flood Study:** Review blockage parameters. Notify asset owner.

**Design:** Review blockage parameters. Mitigate Risk. **(see S6.6)**

# BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

**Project:** Wonthaggi NE PSP
**Structure/Drawing:** Culvert 5 (23B-23C)
**Location & LGA:**
**Designer/Engineer:** MW
**Checked by:** GO
**Date:** 6/08/2021

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

| **STEP 1: Setup Details** | | |
|---|---|---|
| Catchment Area: | 4.6 | ha or km2 |
| Source Area (&Landuse): | Rural land and future urban | S6.3.3 |
| **Inlet Blockage Data** (floating /non-floating debris) | | |
| Description: | Sticks, grass, falling branchs limbs from current and futur | |
| How assessed: | Estimated | |
| Inlet Clear Width **(W)** | 3.6 | (m) |
| Inlet Clear Height **(D)** | 1.5 | (m) |
| Check W/D<=3 | 2.4 | (m/m) S6.4.4.8 |
| $L_{10}$ | 4.0 | (m) S6.4.4.1 |
| **Barrel Blockage Data** (sediment & bedload) | | |
| Description: | Soils are clayey based on site observation, future develop | |
| How assessed: | visual assessment at site and esitmate of future condition | |
| $D_{50}$ | 5 | (mm) |
| Barrel velocity **(V)** | 1.6 | (m/s) |

| **STEP 2: Debris Potential at Structure for 1% AEP** | | | |
|---|---|---|---|
| Blockage Location | Inlet (debris) | Barrel (sediment) | |
| Availability (H,M,L) | L | L | S6.4.4.2 & T6.6.1 |
| Mobility (H,M,L) | M | M | S6.4.4.3 & T6.6.2 |
| Transportability (H,M,L) | M | M | S6.4.4.4 & T6.6.3 |
| Combined Result | LMM | LMM | |
| 1% Debris Potential | LOW | LOW | S6.4.4.5 & T6.6.4 |

| **STEP 3: AEP Adjusted Debris Potential** (S6.4.4.6 & T6.6.5) | | | |
|---|---|---|---|
| Event AEP(%) [1:yr] | HIGH | MED | LOW |
| >5% [<1:20] | Med | Low | Low |
| 5%-0.5% [1:20 - 1:200] | High | Med | Low |
| <0.5% [>1:200] | High | High | Med |

| **STEP 4: Inlet Blockage Level** (S6.4.4.7 & T6.6.6) | | | |
|---|---|---|---|
| AEP Adjusted Debris Potential At Structure (Inlet) | | | |
| **Control Dimension** | High | Med | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $L_{10} <= W <= 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| **STEP 5: Likelihood of Sediment Deposition in Barrel** (T6.6.7) | | | | | |
|---|---|---|---|---|---|
| Sediment (Type & $D_{50}$) | Clay/Silt | Sand | Gravel | Cobbles | Boulders |
| Structure Velocity (m/s) | <=0.04mm | >0.04-2mm | >2-63mm | >63-200mm | >200mm |
| >=3.0 | *low* | *low* | *low* | *low* | *med* |
| 1.0 to < 3.0 | *low* | *low* | *low* | *med* | *med* |
| 0.5 to < 1.0 | *low* | *low* | *low* | *med* | *high* |
| 0.1 to < 0.5 | *low* | *low* | *med* | *high* | *high* |
| < 0.1 | *low* | *med* | *high* | *high* | *high* |

| **STEP 6: Depositional Blockage Levels** (T6.6.8) | | | |
|---|---|---|---|
| AEP Adjusted Sediment Potential At Structure (barrel) | | | |
| Likelihood of Deposition | High | Med | Low |
| *high* | 100% | 60% | 25% |
| *med* | 60% | 40% | 15% |
| *low* | 25% | 15% | 0% |

| **STEP 7: BLK-DES%** | **Inlet (Debris)** | | **Barrel (Sediment)** | |
|---|---|---|---|---|
| Event AEP(%) [1:yr] | LOW | STEP 4 | LOW | STEP 6 |
| >5% [<1:20] | Low | 25% | Low | 0% |
| 5%-0.5% [1:20 - 1:200] | Low | 25% | Low | 0% |
| <0.5% [>1:200] | Med | 50% | Med | 15% |

**STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS**

**ASSESS:**

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

**If CONSEQUENCES HIGH:**

**Flood Study:** Review blockage parameters. Notify asset owner.

**Design:** Review blockage parameters. Mitigate Risk. **(see S6.6)**

# BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

| | |
|---|---|
| **Project:** | Wonthaggi NE PSP |
| **Structure/Drawing:** | Culvert 6 (24-24A) |
| **Location & LGA:** | |
| **Designer/Engineer:** | MW |
| **Checked by:** | GO |
| **Date:** | 6/08/2021 |

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

| STEP 1: Setup Details | | |
|---|---|---|
| Catchment Area: | 4.6 | ha or km2 |
| Source Area (&Landuse): | Rural land and future urban | S6.3.3 |
| **Inlet Blockage Data** (floating /non-floating debris) | | |
| Description: | Sticks, grass, falling branchs limbs from current and futur | |
| How assessed: | Estimated | |
| Inlet Clear Width **(W)** | 3.6 | (m) |
| Inlet Clear Height **(D)** | 1.5 | (m) |
| Check W/D<=3 | 2.4 | (m/m) S6.4.4.8 |
| $L_{10}$ | 4.0 | (m) S6.4.4.1 |
| **Barrel Blockage Data** (sediment & bedload) | | |
| Description: | Soils are clayey based on site observation, future develop | |
| How assessed: | visual assessment at site and esitmate of future conditior | |
| $D_{50}$ | 5 | (mm) |
| Barrel velocity **(V)** | 1.6 | (m/s) |

| STEP 2: Debris Potential at Structure for 1% AEP | | | |
|---|---|---|---|
| Blockage Location | Inlet (debris) | Barrel (sediment) | |
| Availability (H,M,L) | L | L | S6.4.4.2 & T6.6.1 |
| Mobility (H,M,L) | M | M | S6.4.4.3 & T6.6.2 |
| Transportability (H,M,L) | M | M | S6.4.4.4 & T6.6.3 |
| Combined Result | LMM | LMM | |
| 1% Debris Potential | LOW | LOW | S6.4.4.5 & T6.6.4 |

| STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5) | | | |
|---|---|---|---|
| Event AEP(%) [1:yr] | HIGH | MED | LOW |
| >5% [<1:20] | Med | Low | Low |
| 5%-0.5% [1:20 - 1:200] | High | Med | Low |
| <0.5% [>1:200] | High | High | Med |

| STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6) | | | |
|---|---|---|---|
| AEP Adjusted Debris Potential At Structure (Inlet) | | | |
| **Control Dimension** | High | Med | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $L_{10} <= W <= 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7) | | | | | |
|---|---|---|---|---|---|
| Sediment (Type & $D_{50}$) | Clay/Silt | Sand | Gravel | Cobbles | Boulders |
| Structure Velocity (m/s) | <=0.04mm | >0.04-2mm | >2-63mm | >63-200mm | >200mm |
| >=3.0 | *low* | *low* | *low* | *low* | *med* |
| 1.0 to < 3.0 | *low* | *low* | *low* | *med* | *med* |
| 0.5 to < 1.0 | *low* | *low* | *low* | *med* | *high* |
| 0.1 to < 0.5 | *low* | *low* | *med* | *high* | *high* |
| < 0.1 | *low* | *med* | *high* | *high* | *high* |

| STEP 6: Depositional Blockage Levels (T6.6.8) | | | |
|---|---|---|---|
| AEP Adjusted Sediment Potential At Structure (barrel) | | | |
| Likelihood of Deposition | High | Med | Low |
| *high* | 100% | 60% | 25% |
| *med* | 60% | 40% | 15% |
| *low* | 25% | 15% | 0% |

| STEP 7: BLK-DES% | Inlet (Debris) | | Barrel (Sediment) | |
|---|---|---|---|---|
| Event AEP(%) [1:yr] | LOW | STEP 4 | LOW | STEP 6 |
| >5% [<1:20] | Low | 25% | Low | 0% |
| 5%-0.5% [1:20 - 1:200] | Low | 25% | Low | 0% |
| <0.5% [>1:200] | Med | 50% | Med | 15% |

**STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS**

**ASSESS:**

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

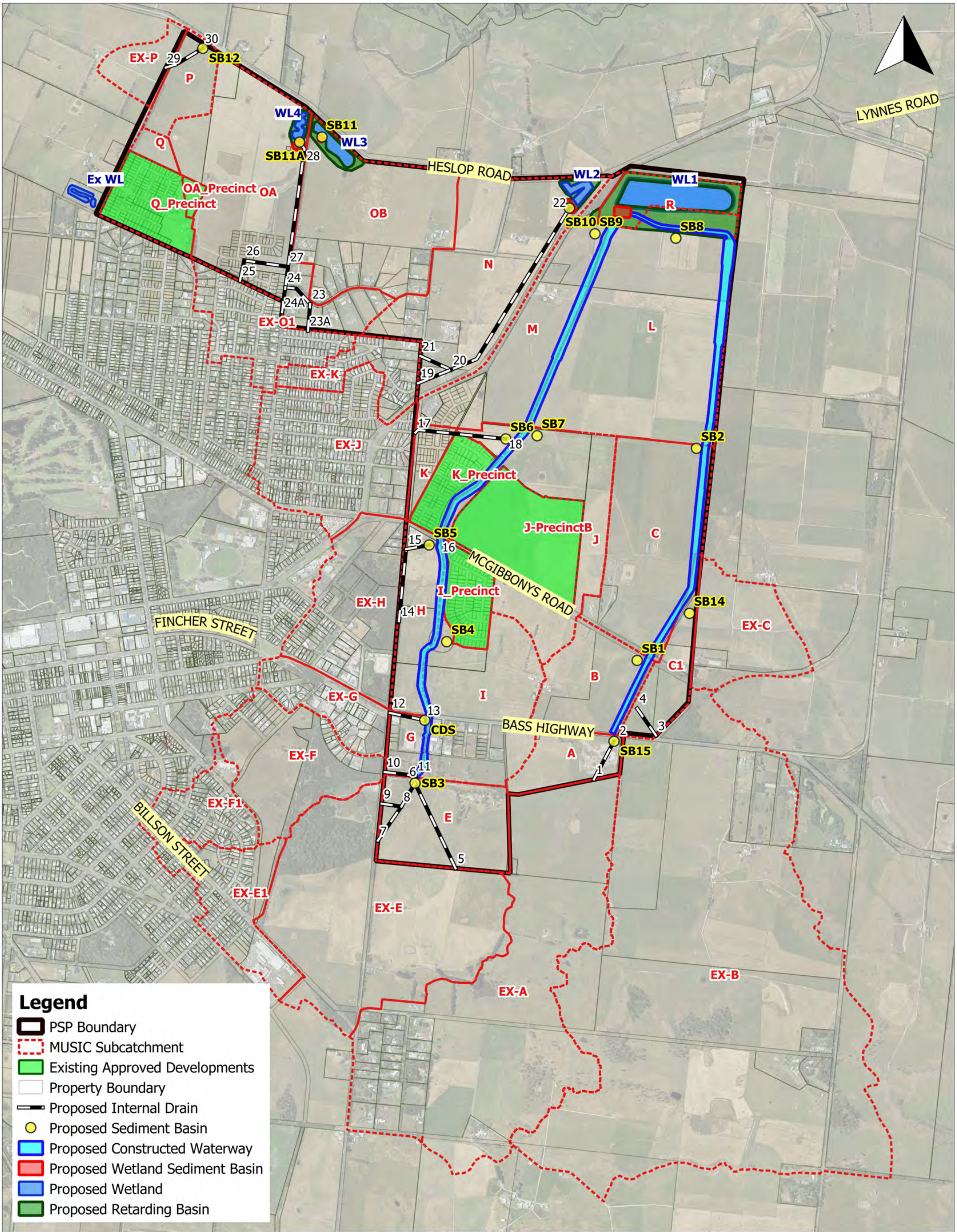
2). Worse case downstream flooding using "All Clear" case (S6.4.5)

**If CONSEQUENCES HIGH:**

**Flood Study:** Review blockage parameters. Notify asset owner.

**Design:** Review blockage parameters. Mitigate Risk. **(see S6.6)**

# Appendix G:
## MUSIC Layout Plan

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ENGENY WATER MANAGEMENT

BASS COAST

0 200 400 600 800 m

Scale in metres ( 1:17000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

# Wonthaggi NE PSP

MUSIC Layout plan

Job Number: V5000_002
Revision: 0
Drawn: AM
Checked: GTO
Date: 24/8/2021

ENGENY
WATER MANAGEMENT

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