Hydrological and Environmental Engineering

Dore Road Drainage Scheme (1606)

Swale Functional Design

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Contents

1 Introduction

In 2013, Stormy Water Solutions (SWS) produced a report entitled “Pakenham East Precinct Structure Plan, Proposed Drainage Strategy, Draft Report, 25 March 2013” (2013 PSP Report) for Cardinia Shire Council (Council).

This 2013 work detailed the overall requirements of the major drainage and the water sensitive urban design (WSUD) infrastructure required if the precinct structure plan (PSP) was developed for urban purposes. Figure 1 details the preliminary drainage proposals. It should be noted that the 50 metre offset to Deep Creek was ultimately increased to 100 metres by Council and Melbourne Water Corporation (MWC) to allow for:

- Placement of all (or most) required frog ponds in this reserve area,
- Containment of the 100 Year ARI flood in the flood plain without significant increasing existing flood levels (due to filling of developable land) as per Pakenham East Precinct Structure Plan, Deep Creek Corridor Proposals, “Stormy Water Solutions”, 5 October 2014 (2014 Floodplain Report).

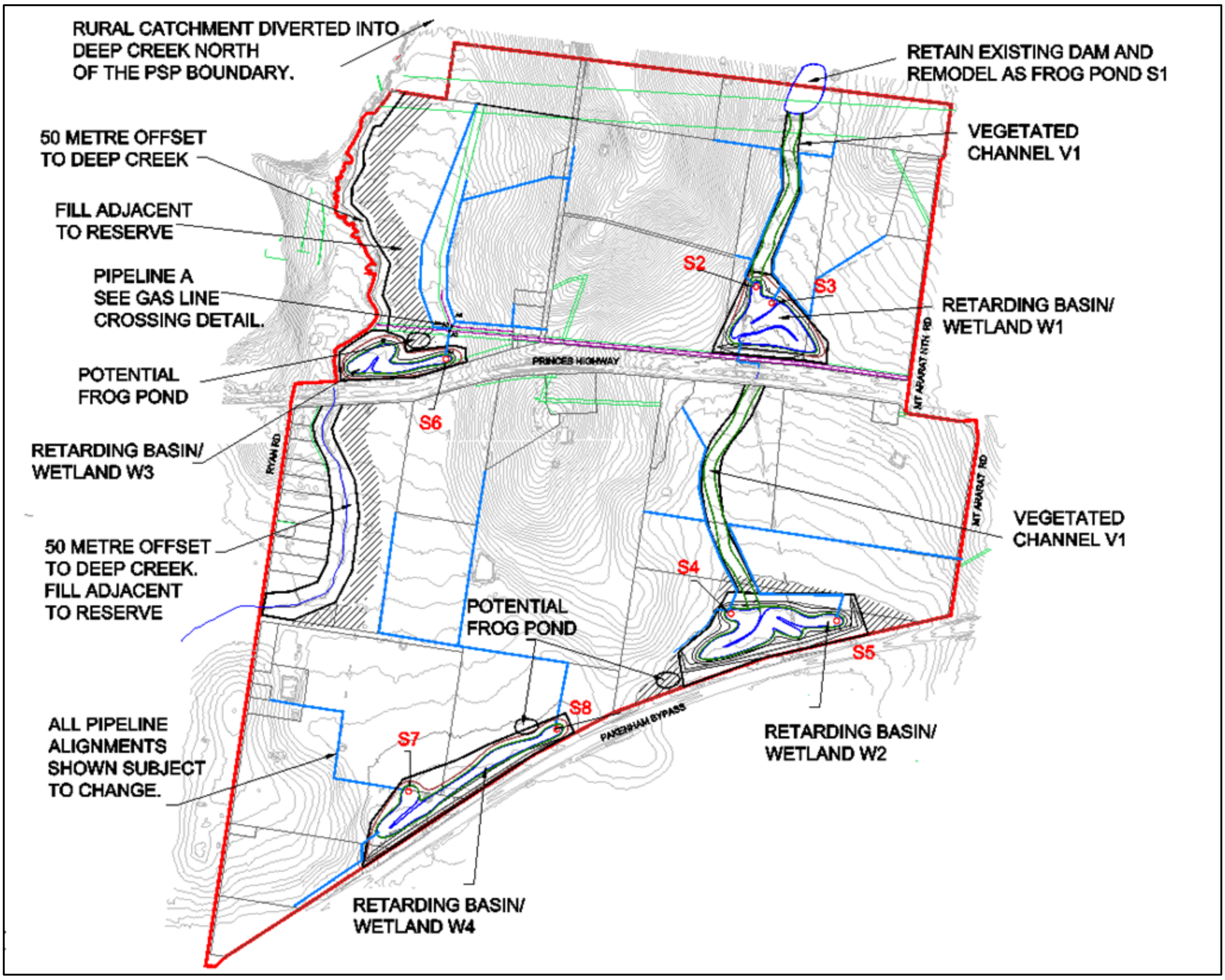


Figure 1 2013 Preliminary PSP Drainage Strategy

MWC has subsequently adopted the Dore Road Development Services Scheme (now the Dore Road Drainage Scheme (DS) 1606) which covers the north-west portion of the PSP area and the catchment contributing to W3. The adoption of the DS is to guide orderly provision of main drainage services through the PSP area.

In 2017, SWS produced a report entitled “Dore Road Development Services Scheme, Functional Design of the Dore Road DSS Wetland Retarding Basin, Revision A, 24 February 2017” (2017 Dore Road RB Report) for council and MWC which detailed the functional design of W3.

Critical to the functional design of the Dore Road wetland retarding basin (Dore Road RB) was the assumption that the only inflow into the Dore Road RB is from the development to the east. Section 3.2 of the 2017 Dore Road RB Report details this assumption and is summarised below.

In order to reduce wetland and retarding basin size of W3 all flows from the west of the north-south gas line are assumed to bypass the wetland system directly to Deep Creek. The 100m offset to the east of Deep Creek was proposed to enclose a swale which can safely conveys local flows around the Dore Road RB directly to Deep Creek North of the east-west gas line. As such a swale is to be designed to:

- Convey local flows (up to the 1% AEP event) directly to Deep Creek (to bypass W3),
- Minimize (and set on the boundary) the fill on the proposed land zoned residential and active open space in the PSP (as these regions are in the existing Deep Creek floodplain),
- Fit the swale within the 100 metre offset from Deep Creek,
- Supplement the stormwater treatment within the DS so that the total DS achieves the required pollutant reduction loads, and
- Convey the 1% AEP floodplain flow from Deep Creek when the creek overtops into its eastern flood plain in the 1% AEP event.

This report details the function design of a swale within the 100 metre offset from Deep Creek which meets the above design objectives.

2 Design Considerations

2.1 Deep Creek Floodplain

Attached as Addendum 1 is the report, “Pakenham East Precinct Structure Plan, Deep Creek Corridor Proposals, 5 October 2014”. This report details the behaviour of Deep Creek in the 1% AEP event and investigates it’s overtopping into the eastern and western floodplains both upstream and downstream of Princess Highway with and without works. Figure 2 below is a reproduction of Figure 6 of the 2014 floodplain report which conceptually shows a typical 1% AEP cross section upstream of Princess Highway.

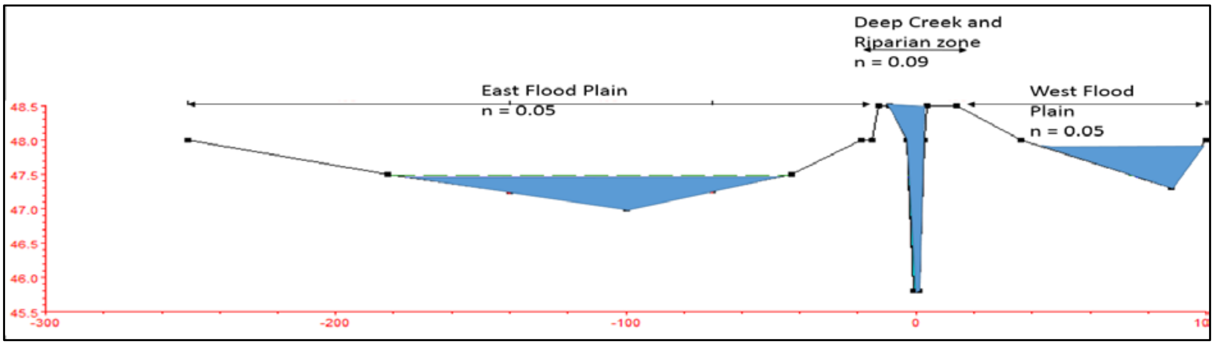


Figure 2 Reproduction of Figure 6, 2014 floodplain report – Typical Deep Creek Cross Section Upstream of Princess Highway

As found in the 2014 floodplain report, flood level and extent in the eastern floodplain (the Dore Road DS area) is much greater than the proposed 100 metres offset from Deep Creek. As such, the proposed swale must account for the 1% floodplain flows from Deep Creek as detailed below in Table 1 (reproduced Table 9, 2014 floodplain report). The levels (assuming corridor works) and flows at the locations shown in Table 1 have been used to design and assess the proposed swale.

Table 1 Reproduction of Table 9, 2014 floodplain report – Hec Ras Results with and without Deep Creek Corridor Works, Eastern Floodplain

Chainage (m)	100 year Flow in East Flood Plain	Existing 100 Year Level	100 Year Level incorporating Deep Creek Corridor works	100 Year ARI Flood Level Incorporating Deep Creek Corridor Works minus Existing 100 Yr Level (mm)
	(m3/s)	(m AHD)	(m AHD)	
3790	17.7	52.67	52.64	-0.03
3560	19.2	50.37	50.73	0.36
3320	21.1	48.72	49.31	0.59
3110	21.1	47.46	47.26	-0.2
2850	24.1	45.7	45.61	-0.09
2530	24.1	43.21	43.12	-0.09
2430	24.1	42.35	42.35	0

2.2 Bypass of Local Flows from W3

As detailed in Section 3.2 of the 2017 Dore Road RB report, critical to the functional design of W3 is that local flows from the Dore Road DS bypass W3 directly to Deep Creek upstream of the East-West Gas Line. This then allows the total 1% AEP post-development flow from the DS to be less than the total 1% AEP pre-development flow from the DS. In essence, the Dore Road RB over retards flows from the eastern catchments to account for the limited attenuation the swale can provide for the western catchment.

As such, the RORB model used in the Dore Road RB design has been used to produce local flows (i.e. assuming no interaction with Deep Creek) at important locations along the swale alignment as described below in Table 2.

Table 2 Local Flows along Swale Alignment

Location	1% AEP	18.13% AEP
External catchment inlet to swale at PSP boundary (Station 1106)	1 m^3/s (9-hour)	0.3 m^3/s (9-hour)
Inflow to swale From proposed residential development	4.5 m^3/s (15-min)	1.4 m^3/s (25-min)
Swale Flow at development merge (Station 773)	4.6 m^3/s (15-min)	1.4 m^3/s (25-min)
Swale flow at northern oval inlet (Station 450)	2.8 m^3/s (1-hour)	0.9 m^3/s (9-hour)
Swale flow into Deep Creek (Station 190)	2.8 m^3/s (9-hour)	0.9 m^3/s (9-hour)

The flows from the local catchment are well below those expected in the swale due to overtopping of Deep Creek. As such, the swale has been designed to convey Deep Creek floodplain flows as detailed in Table 1.

The downstream 1% AEP starting water level (at W3) has also been set to the level of 42.50 m AHD (W3 1% AEP level with Deep Creek high and outflow restricted) as this level is higher than the level of 42.35 m AHD detailed in Table 1 for the same location.

2.3 Gas Line Considerations

The Dore Road DS is bisected by two major gas lines, the Pakenham - Wollert line and the Langford – Dandendong line as shown in Figure 3. The current PSP zonings is also shown in Figure 3. As can be seen, there are two separate residential areas which are separated by the gas easement running North – South through the DS catchment.

As crossing the gas mains is costly, SWS and MWC have aimed to minimize the number of crossings within the DS catchment. As such, runoff from the residential area to the west (Deep Creek side) of the North-South gas line is proposed to be treated and mitigated by a swale located within the 100 metre offset from deep creek.

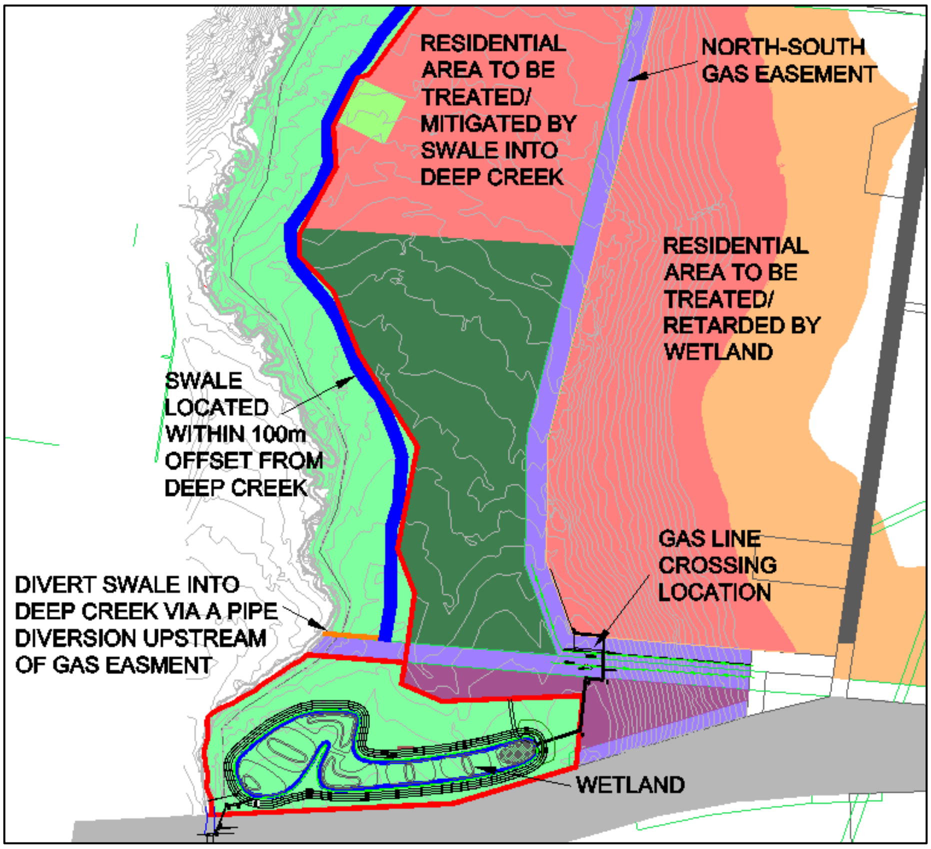


Figure 3 Dore Road DS Concept

All remaining areas are proposed to be treated and retarded within the wetland located in the south west portion of the DS. This results in only one crossing of the gas easement within the DS. Further details on APA requirements about the gas lines can be found in Section 2.2 of the 2017 Dore Road RB report.

2.4 Water Quality Requirements

The Dore DS must ensure all stormwater is treated to at least current best practice prior to discharge from the PSP area.

Therefore, the treatment systems must ensure 80% retention of Total Suspended Solids (TSS), 45% retention of Total Phosphorus (TP) and 45% retention of Total Nitrogen (TN) for the entire DS.

The wetland characteristics detailed in the 2017 Dore Road RB report, together with the swale characteristics have been used in the stormwater pollutant modelling within this report.

2.5 Development requirements of the land west of the North-South Gas Line

The proposed development bound by the 100 metre offset from Deep Creek to the west, the gas easement to the south and east and the power transmission lines to the north (as shown in Figure 3) is currently within the Deep Creek floodplain (Figure 2) and as such will require filling to allow development. The swale proposed has dual benefits to this land as:

- The swale is proposed to concentrate the entire 1% AEP flow within the 100 metre offset from Deep Creek, thus maximising developable land, and
- The swale proposal allows the opportunity to have a low swale invert level at the DS outlet from the residential zoned land (as the swale is to be cut into the existing floodplain). This is expected to greatly reduce the fill required over the entire land zoning, via allowing relatively deep DS pipes.

3 Proposed Functional Design

This section details the functional design of the swale system which has been designed to meet the objectives described in Section 2.

3.1 Swale

The swale system has been designed as shown in the functional design drawing set DORE/SWALE (Appendix A). An overview of the swale alignment is provided in Figure 4.

The swale generally consists of four main sections as detailed below. In all sections, the main channel alignment has been iterated so that there is enough space to batter down from the proposed fill levels at the zoning boundaries to the east of the swale.

Care has been taken to snake the swale (and cut line) around any existing trees. Survey of existing ecological attributes is to occur and compared with the swale cutline as the design progresses. A possible revision to the swale design may have to occur if a significant number of attributes are proposed to be removed by the cutting of the swale as per this functional design.

The main channel for the entire swale length is assumed to be heavily vegetated (n = 0.09) so MWC do not have to maintain the asset. Regions above the 1V:8H cutline are assumed to be grassed vegetated (n = 0.05).

In all sections, the flood and fill levels have been set using the 1% AEP Deep Creek floodplain flows (Table 1) not the local DS 1% AEP flows (Table 2). Generally, however, the main channel has enough capacity to contain the 1% AEP local flows over all sections. Appendix B details the HecRas modelling used in the design of the system.

3.1.1 Section 1 – Station 190 to 642

This section has a 20 metre base that is 0.45 metres deep (from the existing natural surface level) at 1V:8H batters.

The longitudinal slope of this section is the same as the existing natural surface level along the alignment.

3.1.2 Section 2 – Station 642 to 750

This section has a 20 metre base main channel. The depth along this section is generally greater than 0.45 metres. The longitudinal slope of the swale has been set at 1V:300H. The purpose of the longitudinal slope is to provide a lower swale invert for the MWC DS pipes to outfall too. At Station 750 (the assumed DS pipe outfall point) the swale invert level is proposed to be 1.25 metres lower than the existing natural surface level (48.75 m AHD – 47.50 m AHD). This represents great value to the developers of the proposed residential development as the fill required over the entire residential zoned land is expected to be reduced by at least 1 metre which equates to a saving of roughly $1,500,000 in fill costs (assuming fill rates as per MWC construction estimation rates).

Batters for the main channel edges in this section are at 1V:8H.

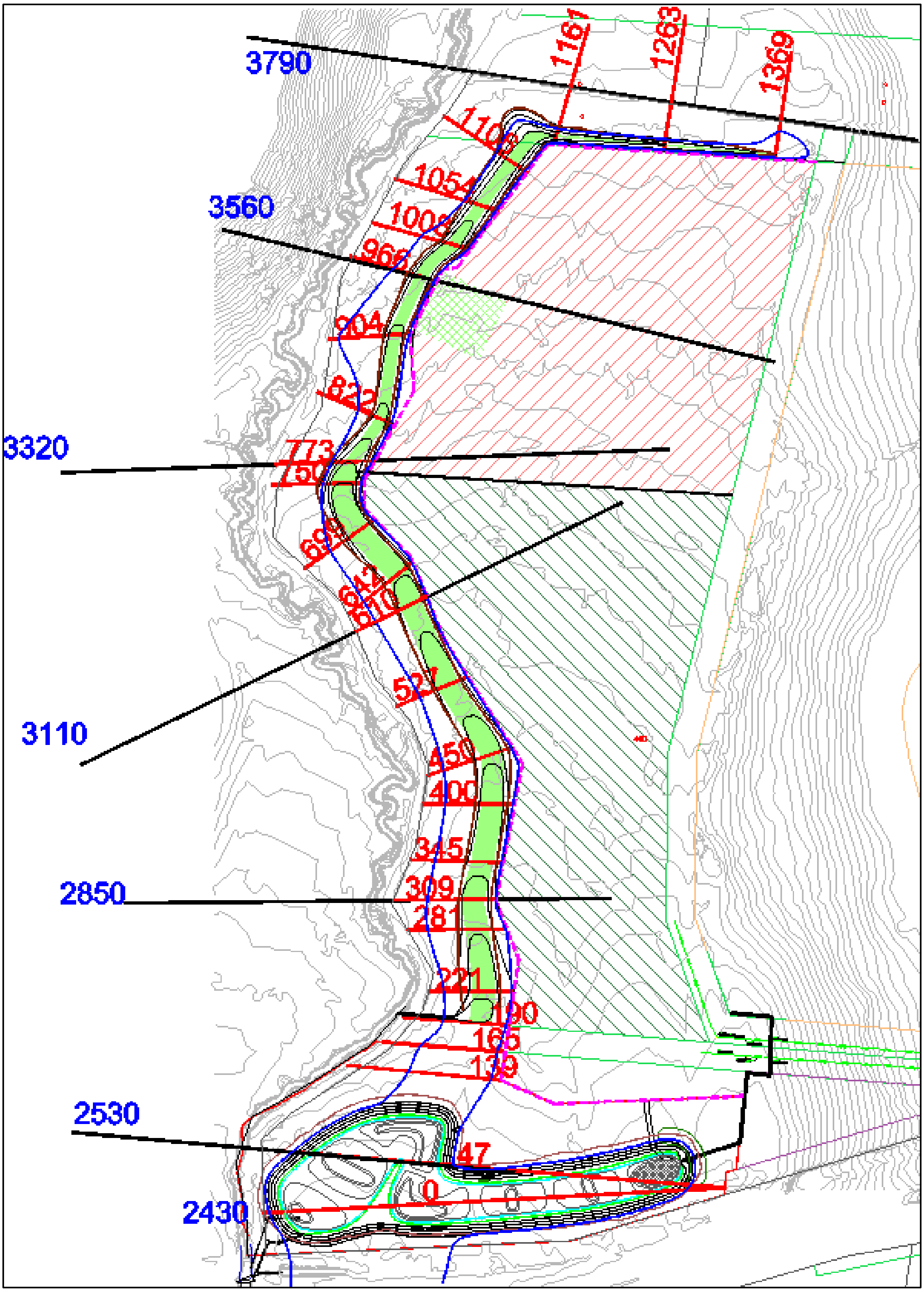


Figure 4 **Overview of Swale Alignment (See drawing set DORE/SWS for full detail)**

Note: Black sections (with blue text) correspond to sections from the 2014 Deep Creek Floodplain Report (Table 1).

3.1.3 Section 3 – Station 773 to 1106

This section has a 10 metre main channel. The depth initially is set at by sloping from station 750's invert level up to 1.0 metre minus natural surface level at Station 882. The invert is then set using a longitudinal slope of 1V:240H between Stations 904 and 1369 to minimize fill over the residential land zoning.

Batters for the main channel edges in this section are at 1V:8H.

3.1.4 Section 4 – Station 1106 to 1369

This small section of the swale has a 1 metre pilot channel. This section has been primarily designed to direct local flows from the north (1m^3/s, Table 3) towards the main swale channel. However, flood and fill levels in this section are set by floodplain tail water effects. As such, the depth of the channel has been set assuming a longitudinal slope of 1V:240H between Stations 904 and 1369.

3.2 Outlet to Deep Creek

As detailed above in Section 2, it is critical to the design of the Dore Road RB that the local 1% AEP flows are directed to Deep Creek upstream of the east-west gas line. To achieve this requirement, a 1% AEP culvert system has been sized to connect the swale to Deep Creek upstream of the gas line easement (Station 190).

The system has been designed assuming the culverts can outlet to a Deep Creek invert level of 43.00 m AHD. This level is to be confirmed at the detailed design phase of the project and the culvert system altered if the current design is no longer feasible.

The system consists of triple flood gated 825mmØ culverts with an upstream invert level of 43.85 m AHD.

Sizing calculations are detailed in Appendix C.

3.3 DS Inlet Concept Sizing

As discussed above in Section 3.1.2, the swale has been designed to minimize the fill requirements over the residential zoned land. Crucial to this the design of the DS pipes along the southern boundary of this land. The DS pipes have been sized as twin 825mmØ 18.13% AEP culverts to take a peak flow of 1.4 m^3/s.

Sizing calculations are detailed in Appendix D.

It is crucial that MWC restrict the final size of the DS pipe(s) to less than (or equal to) a maximum diameter of 825mm. Currently, rough estimates put the cover over the twin 825mmØ pipes at approximately 700mm at the connection to the swale (Station 750) with the fill level at the boundary set by the 1% AEP floodplain level within the swale (1% AEP level + 300mm). If the DS pipe size is increased, the fill level at the boundary will be then set by the cover requirements on the DS pipe, rather than the 1% AEP floodplain level. This will reduce the $1,500,000 saving on fill costs in the development discussed above.

4 Stormwater Pollutant Modelling

The performance in regard to stormwater pollutant retention of the Dore Road Swale (and DS) has been analysed using the MUSIC model, Version 6. Subareas and fraction imperviousness are as detailed in the RORB model (2017 Dore Road RB Report).

Sub Areas are subject to change given the final development layout, however, provided the criteria of directing as much catchment as possible to (or close to) the defined inlet locations is adhered to, the final MUSIC results are not expected to change significantly.

Bureau of Meteorology rainfall and evaporation data for Narre Warren North (1984 - 1993) at 6 minute intervals was utilised. This is the reference gauge defined by MWC for this area of Melbourne. Figure 5 details the model layout developed.

The modelled element characteristics are as detailed in Section 3.1 and the previous report. As required by MWC for similar systems (e.g. Deep Creek South Wetland, December 2015), all wetland as sediment ponds have been modelled separately.

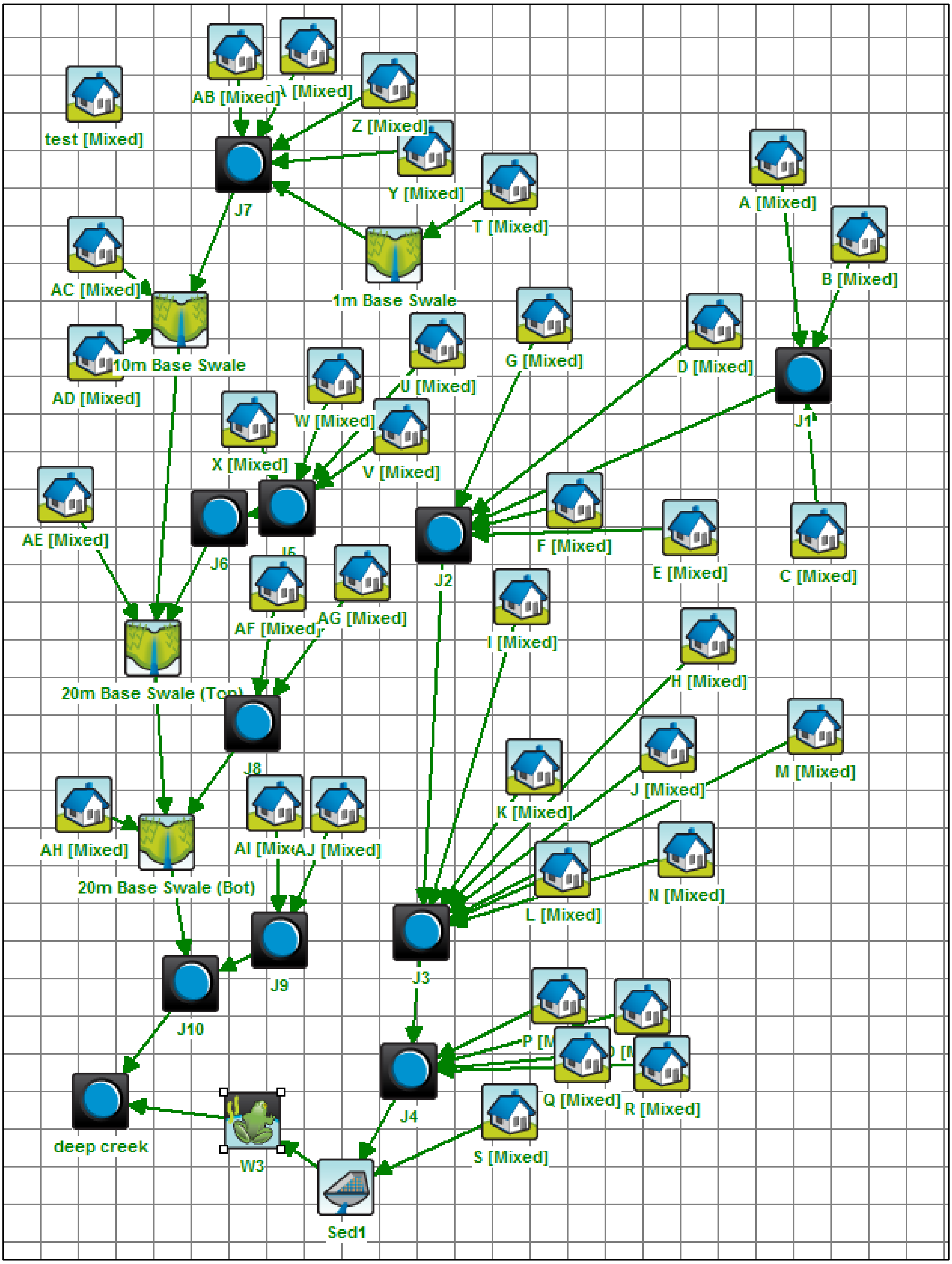


Figure 5 **MUSIC Model Schematic**

Note: Catchment delineation based on 2016 PSP proposals and is subject to change.

Table 3 MUSIC Results at Wetland and DS Outlet (External Catchments Included)

		Sources	Residual Load	% Reduction
Wetland Outlet	Flow (ML/yr)	306	284	7.4
	Total Suspended Solids (kg/yr)	46100	3470	92.5
	Total Phosphorus (kg/yr)	105	21.6	79.5
	Total Nitrogen (kg/yr)	821	353	56.9
	Gross Pollutants (kg/yr)	9640	0	100.0
Swale Outlet	Flow (ML/yr)	235	235	0.0
	Total Suspended Solids (kg/yr)	20300	4000	80.3
	Total Phosphorus (kg/yr)	61.3	32	47.8
	Total Nitrogen (kg/yr)	573	353	38.5
	Gross Pollutants (kg/yr)	3460	151	95.6
Total Flow to Deep Creek	Flow (ML/yr)	541	518	4.2
	Total Suspended Solids (kg/yr)	66300	7480	88.7
	Total Phosphorus (kg/yr)	167	53.6	67.8
	Total Nitrogen (kg/yr)	1390	707	49.3
	Gross Pollutants (kg/yr)	13100	151	98.8

The current best practice requirements of 80% TSS, 45% TP and 45% TN retention can be met by the combined wetland system and swale system. As such, the functional design of the elements meets the requirements of the current Dore Road DS. It should be noted that the results shown in Table 3 include the pollutants generated by the external catchments to the north. Once the external catchment is removed from the modelling, as shown in Table 4, it is clear that the total treatment train is adequately sized to treat stormwater to well in excess of best practice.

Table 4 MUSIC Results at Wetland and DS Outlet (External Catchments Excluded)

		Treatment Train Effectivness at Outlet			Pollutants Generated from External Catchments	Pollutants Generated from all Internal Catchments	% Reduction
		Sources	Residual Load	Pollutants Treated			
Wetland Outlet	Flow (ML/yr)	306	284	22.0	81.4	224.6	10%
	Total Suspended Solids (kg/yr)	46100	3470	42630.0	9710	36390	100%
	Total Phosphorus (kg/yr)	105	21.6	83.4	24.8	80.2	100%
	Total Nitrogen (kg/yr)	821	353	468.0	209	612	76%
	Gross Pollutants (kg/yr)	9640	0	9640.0	2190	7450	100%
Swale Outlet	Flow (ML/yr)	235	235	0.0	110	125	0%
	Total Suspended Solids (kg/yr)	20300	4000	16300.0	4900	15400	100%
	Total Phosphorus (kg/yr)	61.3	32	29.3	22.7	38.6	76%
	Total Nitrogen (kg/yr)	573	353	220.0	251	322	68%
	Gross Pollutants (kg/yr)	3460	151	3309.0	469	2991	100%
Total Flow to Deep Creek	Flow (ML/yr)	541	518	23.0	191.4	349.6	7%
	Total Suspended Solids (kg/yr)	66300	7480	58820.0	14610	51690	100%
	Total Phosphorus (kg/yr)	167	53.6	113.4	47.5	119.5	95%
	Total Nitrogen (kg/yr)	1390	707	683.0	460	930	73%
	Gross Pollutants (kg/yr)	13100	151	12949.0	2659	10441	100%

5 Further Work Required

The following further work is required as part of the design process going forward:

- Finalisation of the PSP land zonings (if there are any major changes, the wetland functional design may need to be reviewed),
- Ecological and archaeological studies are required to ensure no adverse impacts to existing site values,
- Confirmation of the Deep Creek flood level within the proposed swale given detailed design of the land to the east and subsequent setting of required adjacent development fill levels, and
- Detailed survey of Deep Creek at, and downstream of, the gas easement (to Princess Highway) to confirm outfall assumptions. This should include survey of the Princess Highway Culverts.

6 File Control

File Name	**File Type**	**Last Modified**	**Description**
Functional Design Drawings:			
1717_DORE_SWALE_1_9JUN17	.dwg	9/6/17	Functional Design Drawing of the swale showing plan and locality.
1717_DORE_SWALE_2_9JUN17	.dwg	9/6/17	Functional Design Drawing of the swale Longitudinal section
1717_DORE_SWALE_3_9JUN17	.dwg	9/6/17	Functional Design Drawing of the swale example cross sections
1717_DORE_SWALE_4_9JUN17	.dwg	9/6/17	Functional Design Drawing of the swale example cross sections
1717_DORE_SWALE_5_9JUN17	.dwg	9/6/17	Functional Design Drawing of the swale local outlet to Deep Creek
RORB Modelling:			
1987 IFD Loc 38_05S 145_525E	.map	27/2/17	1987 IFD File to be run in RORB
1603_Dore_Rd_DSS_PostDev_7Oct16	.dwg	7/10/16	AutoCAD File showing RORB catchment delineations and model schematic.
1603_Dore_Rd_DSS_RORB_POST_V6_7Oct16	.xlsx	16/11/16	A control Excel File tabulating all the information (Area's, Fimp, Reach Length & Slope) from the AutoCAD file
1603_Dore_Rd_DSS_Swale_PostDev_Outflow_V1_27Feb17	.cat	27/2/17	Catchment File containing all information for the development simulation including wetland characteristics

File Name	File Type	Last Modified	Description
Hydraulic Calculations			
1717_Dore_Rd_Swale_Details_V4_8Jun17	.xlsx	8/6/17	Control Excel File detailing all pipe sizing calculations, cross section determination, longitudinal sections etc for HecRas Modelling.
1717_DSwale_V4_8Jun17	.prj (and other associated file types)	8/6/17	Georeferenced HecRas File of the proposed Swale Design
1717_DSwale_V4_Centreline_8Jun17	.shp	8/6/17	Shapefile containing details on the river centreline information used in HecRas
1717_DSwale_V4_XSCutLines_8Jun17	.shp	8/6/17	Shapefile containing details on the Cross-Section information used in HecRas
MUSIC Modelling			
1603_Dore_Rd_Swale_V4_6Mar17	.sqz	8/6/17	The base MUSIC model used to assess the treatment effectiveness of the DS.
1717_Dore_Road_Swale_MUSIC_Results_8Jun17	.xlsx	8/6/17	Excel File to compile MUSIC results

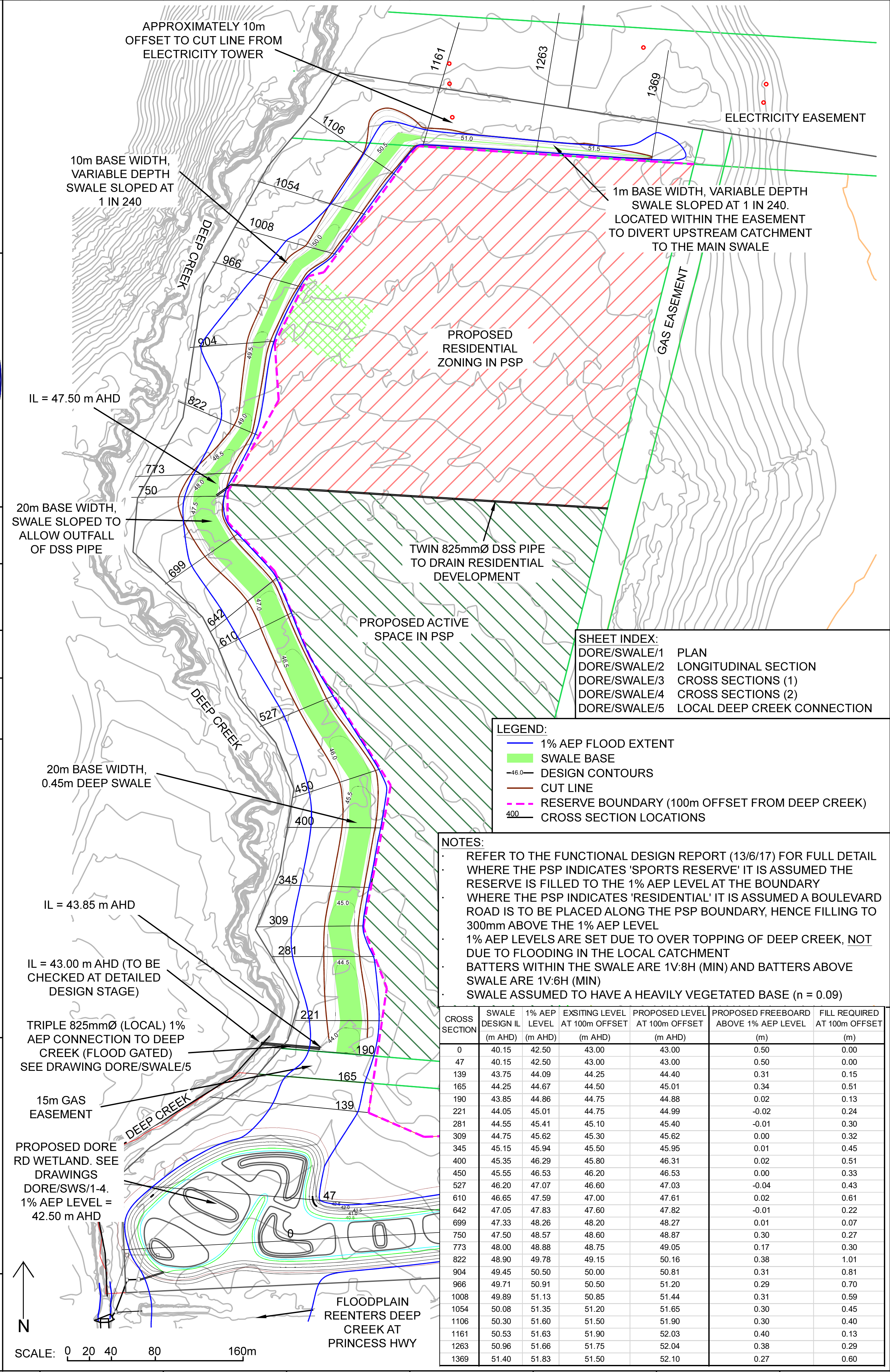
7 Abbreviations, Descriptions and Definitions

The following table lists some common abbreviations and drainage system descriptions and their definitions which are referred to in this report.

Abbreviation Descriptions	Definition
AHD - Australian Height Datum	Common base for all survey levels in Australia. Height in metres above mean sea level.
AEP – Annual Exceedance Probability	The probability of an event being exceeded per year. i.e. 1% AEP = 100 Year ARI event.
ARI - Average Recurrence Interval.	The average length of time in years between two floods of at least a given size. A 100 Year ARI event has a 1% chance of occurring in any one year.
DSS	Development Services Scheme – catchment drainage strategies developed, implemented and run by MWC.
EY – Exceedances per Year	Magnitude of event that is expected to be exceeded X times per year. i.e. 4 EY = 3-month ARI event.
Grassed Swale	A small shallow grassed drainage line designed to convey stormwater discharge. A complementary function to the flood conveyance task is its WSUD role (where the vegetation in the base acts as a treatment swale).
Hectare (ha)	10,000 square metres
Kilometre (km)	1000 metres
m^3/s -cubic metre/second	Unit of discharge usually referring to a design flood flow along a stormwater conveyance system
Megalitre (ML) (1000 cubic metres)	1,000,000 litres = 1000 cubic metres Often a unit of water body (e.g. pond) size
MUSIC	Hydrologic computer program used to calculate stormwater pollutant generation in a catchment and the amount of treatment which can be attributed to the WSUD elements placed in that catchment
MWC	Melbourne Water Corporation
Retarding basin	A flood storage dam which is normally empty. May contain a lake or wetland in its base
Normal Water Level (NWL)	Water level of a wetland or pond defined by the lowest invert level of the outlet structure
RORB	Hydrologic computer program used to calculate the design flood flow (in m^3/s) along a stormwater conveyance system (e.g. waterway)
Sedimentation basin (Sediment pond)	A pond that is used to remove coarse sediments from inflowing water mainly by Settlement processes.
Surface water	All water stored or flowing above the ground surface level
Total Catchment Management	A best practice catchment management convention which recognises that waterways and catchments do not stop at site boundaries and decisions relating to surface water management should consider the catchment as a whole
TSS	Total Suspended Solids – a term for a particular stormwater pollutant parameter
TP	Total Phosphorus – a term for a particular stormwater pollutant parameter
TN	Total Nitrogen – a term for a particular stormwater pollutant parameter
Extended Detention	Range of water level rise above normal water level where stormwater is temporarily stored for treatment for a certain detention period (usually 48 – 72 hours in a wetland system)
WSUD - Water Sensitive Urban Design	Term used to describe the design of drainage systems used to o Convey stormwater safely o Retain stormwater pollutants o Enhance local ecology o Enhance the local landscape and social amenity of built areas
Wetland	WSUD elements which are used to collect TSS, TP and TN. Usually incorporated at normal water level (NWL) below which the system is designed as shallow marsh, marsh, deep marsh and open water areas.

Appendix A – Functional Design Drawings

Note that the drawings detailed have been modified from the AutoCAD set. The AutoCAD drawings should be referred to for the full design detail.



SHEET INDEX:

DORE/SWALE/1	PLAN
DORE/SWALE/2	LONGITUDINAL SECTION
DORE/SWALE/3	CROSS SECTIONS (1)
DORE/SWALE/4	CROSS SECTIONS (2)
DORE/SWALE/5	LOCAL DEEP CREEK CONNECTION

LEGEND:

- 1% AEP FLOOD EXTENT
- SWALE BASE
- 46.0 DESIGN CONTOURS
- CUT LINE
- RESERVE BOUNDARY (100m OFFSET FROM DEEP CREEK)
- 400 CROSS SECTION LOCATIONS

NOTES:

- REFER TO THE FUNCTIONAL DESIGN REPORT (13/6/17) FOR FULL DETAIL
- WHERE THE PSP INDICATES 'SPORTS RESERVE' IT IS ASSUMED THE RESERVE IS FILLED TO THE 1% AEP LEVEL AT THE BOUNDARY
- WHERE THE PSP INDICATES 'RESIDENTIAL' IT IS ASSUMED A BOULEVARD ROAD IS TO BE PLACED ALONG THE PSP BOUNDARY, HENCE FILLING TO 300mm ABOVE THE 1% AEP LEVEL
- 1% AEP LEVELS ARE SET DUE TO OVER TOPPING OF DEEP CREEK, NOT DUE TO FLOODING IN THE LOCAL CATCHMENT
- BATTERS WITHIN THE SWALE ARE 1V:8H (MIN) AND BATTERS ABOVE SWALE ARE 1V:6H (MIN)
- SWALE ASSUMED TO HAVE A HEAVILY VEGETATED BASE (n = 0.09)

CROSS SECTION	SWALE DESIGN IL (m AHD)	1% AEP LEVEL (m AHD)	EXSITING LEVEL AT 100m OFFSET (m AHD)	PROPOSED LEVEL AT 100m OFFSET (m AHD)	PROPOSED FREEBOARD ABOVE 1% AEP LEVEL (m)	FILL REQUIRED AT 100m OFFSET (m)
0	40.15	42.50	43.00	43.00	0.50	0.00
47	40.15	42.50	43.00	43.00	0.50	0.00
139	43.75	44.09	44.25	44.40	0.31	0.15
165	44.25	44.67	44.50	45.01	0.34	0.51
190	43.85	44.86	44.75	44.88	0.02	0.13
221	44.05	45.01	44.75	44.99	-0.02	0.24
281	44.55	45.41	45.10	45.40	-0.01	0.30
309	44.75	45.62	45.30	45.62	0.00	0.32
345	45.15	45.94	45.50	45.95	0.01	0.45
400	45.35	46.29	45.80	46.31	0.02	0.51
450	45.55	46.53	46.20	46.53	0.00	0.33
527	46.20	47.07	46.60	47.03	-0.04	0.43
610	46.65	47.59	47.00	47.61	0.02	0.61
642	47.05	47.83	47.60	47.82	-0.01	0.22
699	47.33	48.26	48.20	48.27	0.01	0.07
750	47.50	48.57	48.60	48.87	0.30	0.27
773	48.00	48.88	48.75	49.05	0.17	0.30
822	48.90	49.78	49.15	50.16	0.38	1.01
904	49.45	50.50	50.00	50.81	0.31	0.81
966	49.71	50.91	50.50	51.20	0.29	0.70
1008	49.89	51.13	50.85	51.44	0.31	0.59
1054	50.08	51.35	51.20	51.65	0.30	0.45
1106	50.30	51.60	51.50	51.90	0.30	0.40
1161	50.53	51.63	51.90	52.03	0.40	0.13
1263	50.96	51.66	51.75	52.04	0.38	0.29
1369	51.40	51.83	51.50	52.10	0.27	0.60

REVISION | DATE

DRAFT FOR COMMENT 9 JUNE 2017

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AUTHORISED BY:

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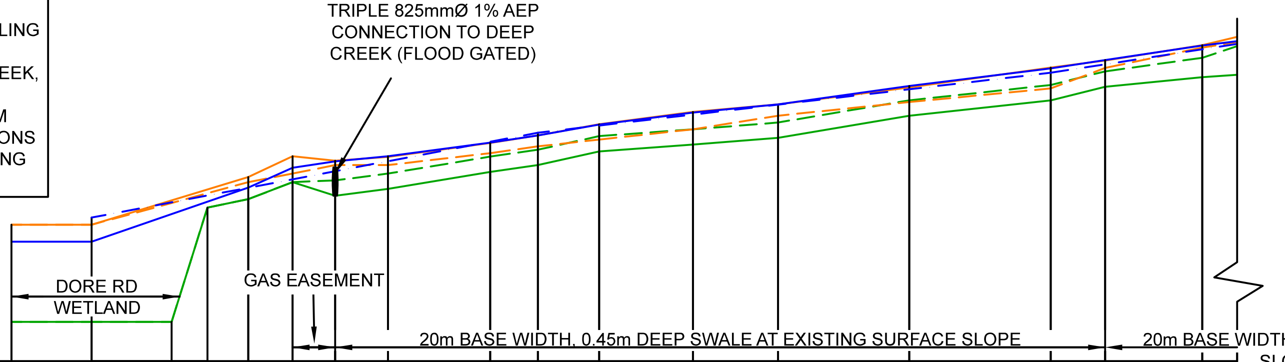
MELB WATER REF No. #

DORE ROAD DSS SWALE PLAN

SCALE: AS SHOWN
SHEET 1 OF 5
DRAWING No. DORE/SWALE/1

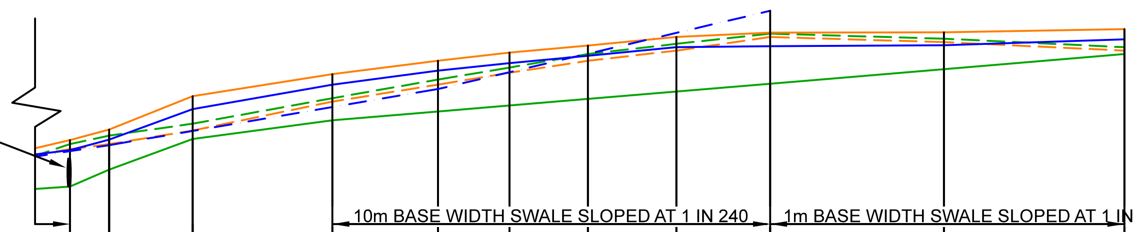
NOTES:

- WHERE THE PSP INDICATES 'SPORTS RESERVE' IT IS ASSUMED THE RESERVE IS FILLED TO THE 1% AEP LEVEL AT THE BOUNDARY
- WHERE THE PSP INDICATES 'RESIDENTIAL' IT IS ASSUMED A BOULEVARD ROAD IS ALONG THE PSP BOUNDARY, HENCE FILLING TO 300mm ABOVE THE 1% AEP LEVEL
- 1% AEP LEVELS ARE SET DUE TO OVER TOPPING OF DEEP CREEK, NOT DUE TO FLOODING FROM THE LOCAL CATCHMENT
- AS THE SWALE IL IS LOCATED WITHIN THE 100m OFFSET FROM DEEP CREEK, THE FLOOD LEVELS INCREASE IN SOME LOCATIONS AS THE PROPOSED SWALE HAS A IL HIGHER THAN THE EXISTING VALLEY (WHICH IS TO BE FILLED)



DATUM = 39.00 m AHD

STATION (m):	0	47	139	165	190	221	281	309	345	400	450	527	610	642	699
EXISTING CHANNEL IL	40.15	40.15	43.75	44.25	44.30	44.50	45.00	45.20	45.60	45.80	46.00	46.65	47.10	47.50	47.90
PROPOSED SWALE IL	40.15	40.15	43.75	44.25	43.85	44.05	44.55	44.75	45.15	45.35	45.55	46.20	46.65	47.05	47.33
EXISTING PSP BOUNDARY LEVEL	43.00	43.00	44.25	44.50	44.75	44.75	45.10	45.30	45.50	45.80	46.20	46.60	47.00	47.60	48.20
PROPOSED PSP BOUNDARY LEVEL	43.00	43.00	44.40	45.01	44.88	44.99	45.40	45.62	45.95	46.31	46.53	47.03	47.61	47.82	48.27
EXISTING 1% AEP FLOOD LEVEL		43.21						45.70					47.46		
REVISED 1% AEP FLOOD LEVEL	42.50	42.50	44.09	44.67	44.86	45.01	45.41	45.62	45.94	45.95	46.53	47.07	47.59	47.83	48.26



DATUM = 46.00 m AHD

STATION (m):	750	773	822	904	966	1008	1054	1106	1161	1263	1369
EXISTING CHANNEL IL	48.75	49.00	49.35	50.10	50.65	51.00	51.40	51.70	52.00	51.85	51.60
PROPOSED SWALE IL	47.50	48.00	48.90	49.45	49.71	49.89	50.08	50.30	50.53	50.96	51.40
EXISTING PSP BOUNDARY LEVEL	48.60	48.75	49.15	50.00	50.50	50.85	51.20	51.50	51.90	51.75	51.50
PROPOSED PSP BOUNDARY LEVEL	48.87	49.18	50.16	50.81	51.20	51.44	51.65	51.90	52.03	52.04	52.13
EXISTING 1% AEP FLOOD LEVEL		48.72			50.37				52.67		
REVISED 1% AEP FLOOD LEVEL	48.57	48.88	49.78	50.50	50.91	51.13	51.35	51.60	51.63	51.66	51.83

VERTICAL SCALE: 0 1 2 4 8m

HORIZONTAL SCALE: 0 20 40 80 160m

DRAFT FOR COMMENT	9 JUNE 2017
REVISION	DATE

Stormy Water Solutions

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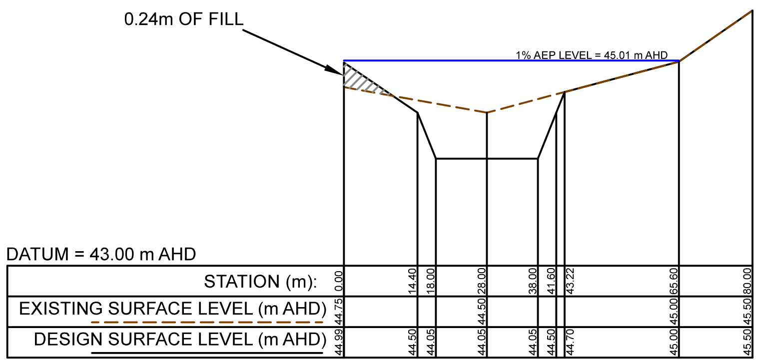
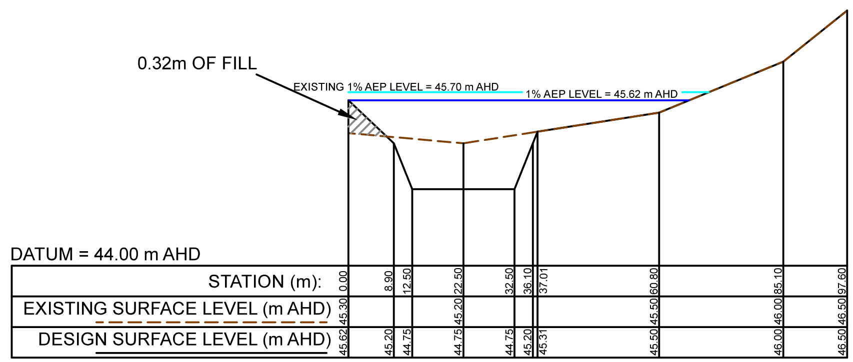
DORE ROAD DSS
SWALE
LONGITUDINAL SECTION

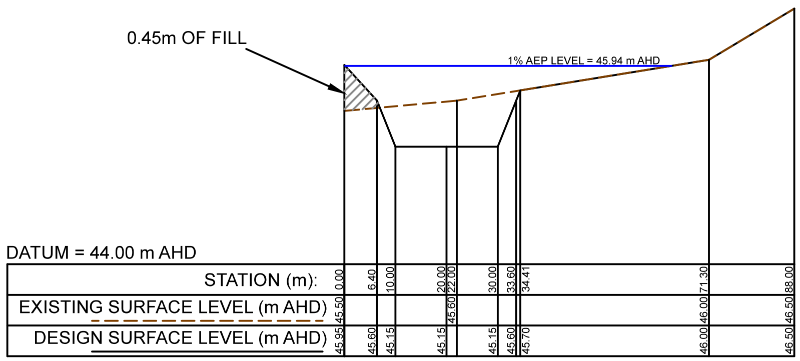
SCALE: AS SHOWN
SHEET 2 OF 5
DRAWING No. DORE/SWALE/2



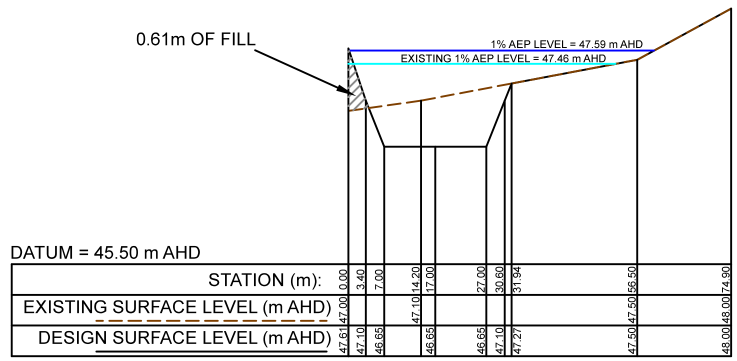
CROSS SECTION 221



CROSS SECTION 309



CROSS SECTION 345



CROSS SECTION 610

NOTE: 1% AEP FLOOD LEVEL INCREASES BY 0.13m AT THIS SECTION. FLOOD LEVEL INCREASE DUE TO CUTTING THE SWALE INTO THE EXISTING BATTER SLOPE AND FILLING THE DEPRESSION TO ALLOW FOR DEVELOPMENT TO THE EAST.

VERTICAL SCALE: 0 0.5 1.0 2.0m

HORIZONTAL SCALE: 0 10 20 40m

DRAFT FOR COMMENT	9 JUNE 2017
REVISION	DATE

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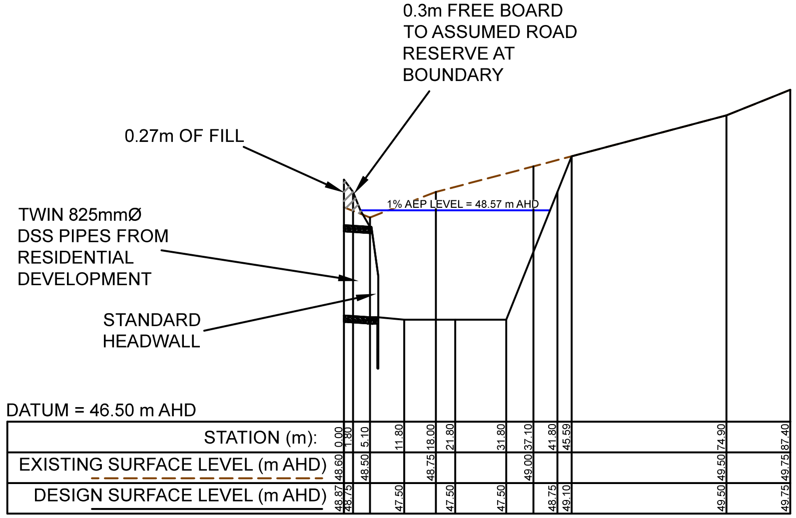
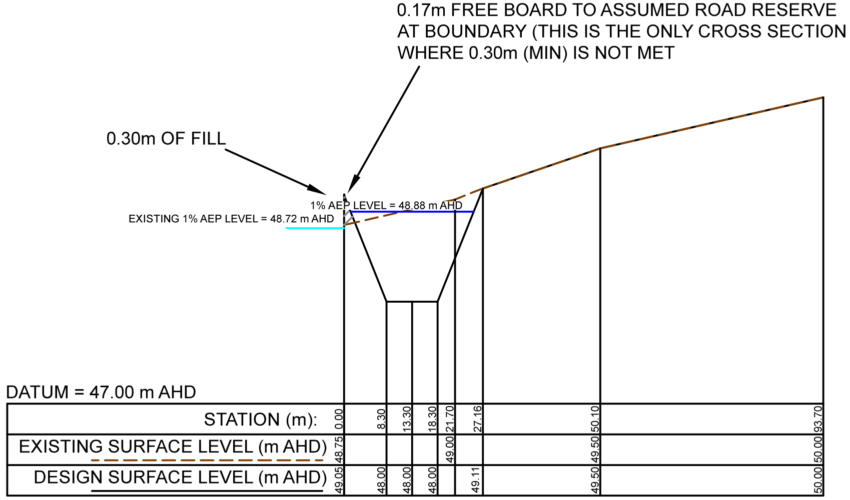
DORE ROAD DSS
SWALE
CROSS SECTIONS

SCALE: AS SHOWN
SHEET 3 OF 5
DRAWING No.
DORE/SWALE/3



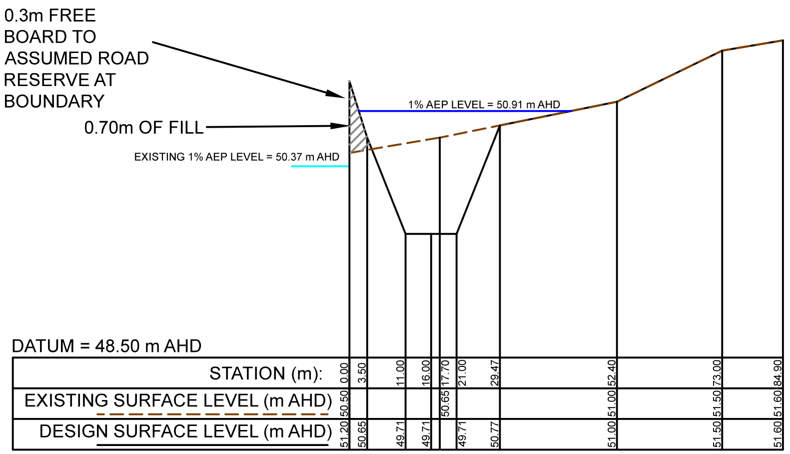
CROSS SECTION 750

NOTE: THIS SECTION HAS PURPOSEFULLY BEEN SLOPED AT 1 IN 300 FROM SECTION 699 (SEE LONGITUDINAL SECTION) TO ALLOW DSS OUTFALL WITH MINIMAL FILL OVER EXISTING SURFACE



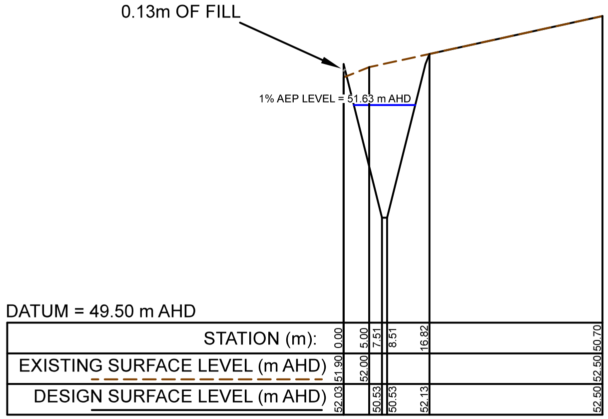
CROSS SECTION 773

NOTE: 1% AEP FLOOD LEVEL INCREASES BY 0.16m AT THIS SECTION. FLOOD LEVEL INCREASE DUE TO CUTTING THE SWALE INTO THE EXISTING BATTER SLOPE AND FILLING THE DEPRESSION TO ALLOW FOR DEVELOPMENT.



CROSS SECTION 966

NOTE: 1% AEP FLOOD LEVEL INCREASES BY 0.54m AT THIS SECTION. FLOOD LEVEL INCREASE DUE TO CUTTING THE SWALE INTO THE EXISTING BATTER SLOPE AND FILLING THE DEPRESSION TO ALLOW FOR DEVELOPMENT.



CROSS SECTION 1161

NOTE: SWALE INVERT LEVEL SET BY SLOPING AT 1 IN 240 FROM STA 904 TO STA 1369. SWALE SIZED TO ONLY CONVEY LOCAL UPSTREAM CATCHMENT AROUND RESIDENTIAL DEVELOPMENT TO MAIN SWALE.

VERTICAL SCALE: 0 0.5 1.0 2.0m

HORIZONTAL SCALE: 0 10 20 40m

DRAFT FOR COMMENT	9 JUNE 2017
REVISION	DATE

Stormy Water Solutions

DESIGNED	Michael Mag	PLAN REF.	#
CHECKED	Valerie Mag	MELWAY REF No.	#
AUTHORISED BY		MELB WATER REF No.	#

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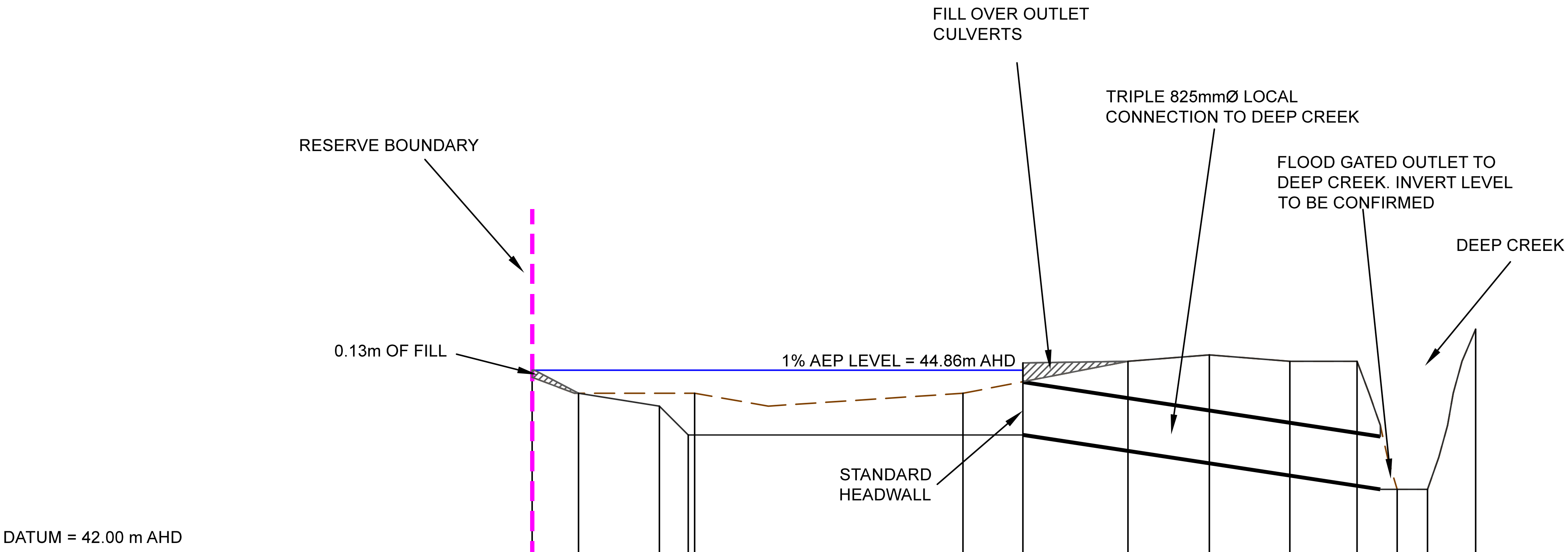
DORE ROAD DSS
SWALE
CROSS SECTIONS

SCALE: AS SHOWN
SHEET 4 OF 5
DRAWING No.
DORE/SWALE/4



STATION (m):	0.0	5.8	15.9	19.5	20.3	53.8	61.3	74.4	84.6	94.6	103.0	108.0	111.8	117.8
EXISTING SURFACE LEVEL (m AHD)	44.75	44.50			44.50	44.50	44.68	45.00	45.10	45.00	45.00	43.00	43.00	45.50
DESIGN SURFACE LEVEL (m AHD)	44.88	44.50	44.30	43.85			43.85 / 44.98							

CROSS SECTION 190

LOCAL CONNECTION TO DEEP CREEK

UPSTREAM OF GAS EASEMENT

VERTICAL SCALE: 0 1.0 2.0 2.5m

HORIZONTAL SCALE: 0 5 10 20m

DRAFT FOR COMMENT 9 JUNE 2017	Stormy Water Solutions	DESIGNED	Michael Mag	PLAN REF.	#	SCALE: AS SHOWN
		CHECKED	Valerie Mag	MELWAY REF No.	#	SHEET 5 OF 5
REVISION DATE		AUTHORISED BY		MELB WATER REF No.	#	DRAWING No. DORE/SWALE/5

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DORE ROAD DSS
SWALE
LOCAL DEEP CREEK CONNECTION

Appendix B – Hydraulic Modelling of the Swale Proposal

Hydraulic modelling of the proposed swale system has been completed using HecRas. Cross section locations have been taken as shown in Figure 4. Care has been taken to incorporate sections that align with the 2014 floodplain sections so that accurate comparisons could be made between the two models.

The HecRas cross sections have been georeferenced using the QGis plugin “RiverGIS”.

Four versions of the proposed swale (alignment and depth variable) have been iterated through in Hec Ras to develop the proposed design. Initial sizing’s were completed using Mannings calculations.

General cross sections are shown in the functional design drawings DORE/SWALE/3 & 4. Flows as detailed in Table 1 have been used along the swale. A downstream starting water level boundary condition has been used at 42.50 m AHD which represents the Dore Road RB at the 1% AEP level assuming Deep Creek is also in flood.

The model has been run assuming interpolated cross sections at 5m intervals. Table B.1 below summarises the results for all cross sections. As can be seen, all sections have a velocity less than 1.5 m/s thus meeting the MWC safety criteria. Table B.1 also details the calculations for the fill levels at the 100m offset interface with the PSP land zonings.

Table B.1 HecRas results for all cross sections

CROSS SECTION	SWALE DESIGN IL	1% AEP LEVEL	1% AEP CHANNEL VELOCITY	EXSITING LEVEL AT 100m OFFSET	PROPOSED LEVEL AT 100m OFFSET	PROPOSED FREEBOARD ABOVE 1% AEP LEVEL	FILL REQUIRED AT 100m OFFSET
	(m AHD)	(m AHD)	(m/s)	(m AHD)	(m AHD)	(m)	(m)
0	40.15	42.50	0.02	43.00	43.00	0.50	0.00
47	40.15	42.50	0.03	43.00	43.00	0.50	0.00
139	43.75	44.09	1.44	44.25	44.40	0.31	0.15
165	44.25	44.67	1.18	44.50	45.01	0.34	0.51
190	43.85	44.86	0.57	44.75	44.88	0.02	0.13
221	44.05	45.01	0.81	44.75	44.99	-0.02	0.24
281	44.55	45.41	0.79	45.10	45.40	-0.01	0.30
309	44.75	45.62	0.88	45.30	45.62	0.00	0.32
345	45.15	45.94	0.93	45.50	45.95	0.01	0.45
400	45.35	46.29	0.69	45.80	46.31	0.02	0.51
450	45.55	46.53	0.72	46.20	46.53	0.00	0.33
527	46.20	47.07	0.87	46.60	47.03	-0.04	0.43
610	46.65	47.59	0.74	47.00	47.61	0.02	0.61
642	47.05	47.83	0.86	47.60	47.82	-0.01	0.22
699	47.33	48.26	0.81	48.20	48.27	0.01	0.07
750	47.50	48.57	0.69	48.60	48.87	0.30	0.27
773	48.00	48.88	1.40	48.75	49.18	0.30	0.43
822	48.90	49.78	1.16	49.15	50.16	0.38	1.01
904	49.45	50.50	0.82	50.00	50.81	0.31	0.81
966	49.71	50.91	0.82	50.50	51.20	0.29	0.70
1008	49.89	51.13	0.71	50.85	51.44	0.31	0.59
1054	50.08	51.35	0.69	51.20	51.65	0.30	0.45
1106	50.30	51.60	0.67	51.50	51.90	0.30	0.40
1161	50.53	51.63	0.14	51.90	52.03	0.40	0.13
1263	50.96	51.66	0.26	51.75	52.04	0.38	0.29
1369	51.40	51.83	0.20	51.50	52.13	0.30	0.63

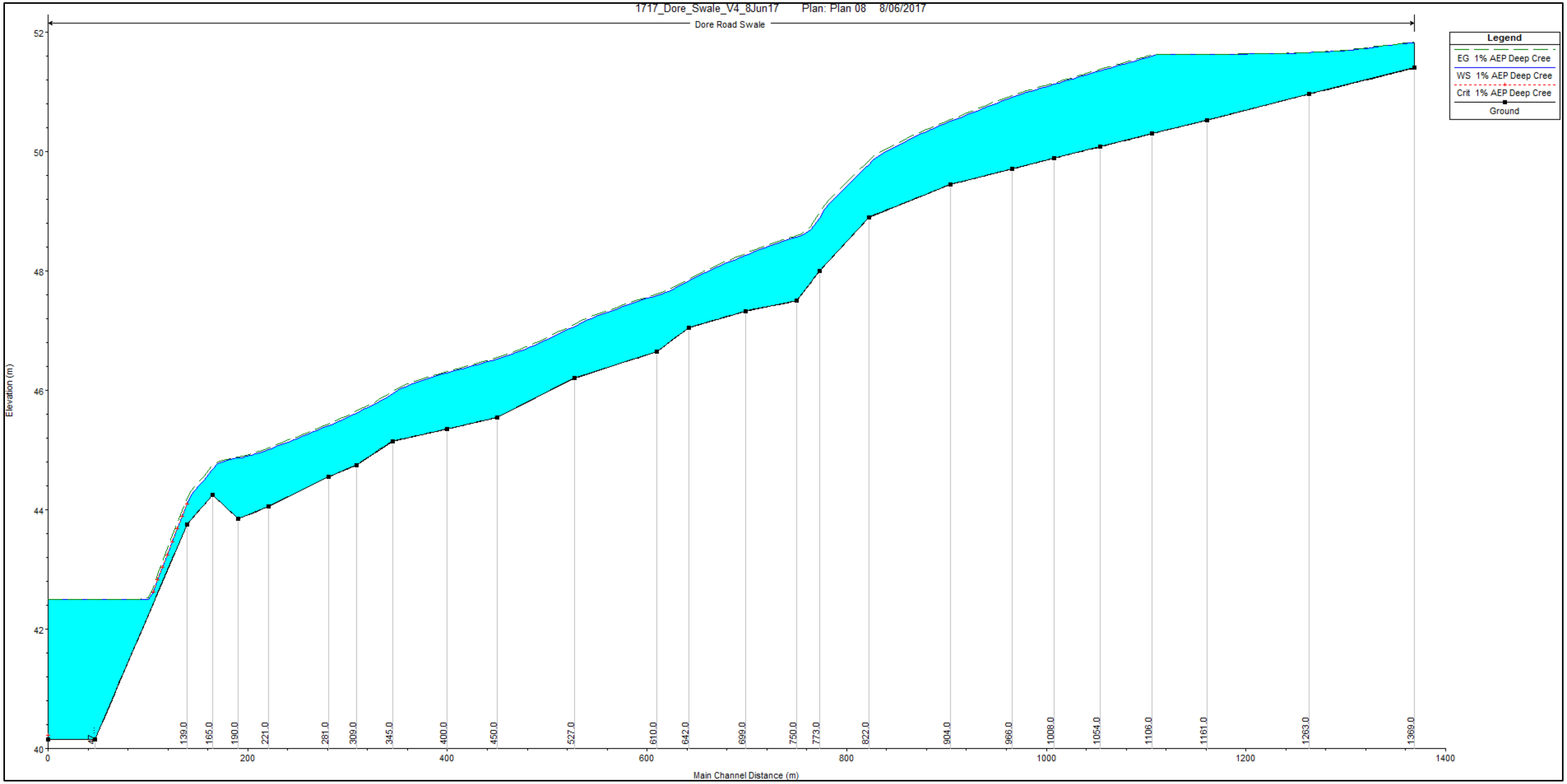

Figure B.1 **HecRas Longitudinal Section (Reproduced in drawing DORE/SWALE/2)**

Appendix C – Local connection to Deep Creek Sizing

The local connection to deep creek has to be sized to convey the 1% AEP local flow of 2.8 m^3/s to Deep Creek. The proposed cross section of Station 190 is shown in drawing DORE/SWALE/5.

The proposed fill level on the boundary (chainage 0) is 44.88 m AHD. As the invert of this section (and hence the pipe invert) is at 43.85 m AHD, this allows for 1.03 m of driving head from the culvert outlet obverts (assuming Deep Creek is low and there is no required freeboard to the 1% AEP event as the land adjacent is proposed to be zoned active space).

As such, a culvert system has been sized as shown below to convey the flow over the required head.

OUTLET CONTROL ABOVE US IL			
head loss = $(Ke+Kex)\times V^2/2g + S_f \times L$			
$S_f = Q^2n^2/A^2R^{4/3}$			
Number of Pipes =	3		
pipe dia =	0.825	m	
RCP pipe radius =	0.4125	m	
Design flow per pipe =	0.93	m^3/s	
Wetted perimeter =	2.59	m	
Area =	0.53	m^2	
Hyd radius =	0.20625	m	
V =	1.73	m/s	
Ke =	0.5		
Kex =	5	DUCK BILL FLOOD GATE	
n =	0.013		
L=	45		
S_f =	0.0042		
Head loss =	1.028	m	

Appendix D – MWC DS Pipeline Concept Design

The concept design sizing of the MWC DS pipe from the residential zoned land is shown below. The pipes have been sized as 18.13% AEP culverts that enter the swale at Station 750.

Capacity 18.13% AEP Pipes From Dev (RORB = 1.4 m^3/s)		
Pipe Mannings		
Diameter	0.825	m
Radius	0.4125	m
Area	0.53	m^2
WP	2.59	m
Hydraulic	0.20625	m
HGL slope	0.003	m/m
n	0.013	$s/m^{1/3}$
Capacity	0.83	m^3/s
Velocity	1.55	m/s

Note: Design Flow = 1.4 m^3/s, so twin 825mmØ required.

It is crucial that MWC restrict the final size of the DS pipe(s) to less than (or equal to) a maximum diameter of 825mm. Currently, rough estimates put the cover over 825mmØ pipes at approximately 700mm at the connection to the swale (Station 750) with the fill level at the boundary set by the 1% AEP floodplain level within the swale (1% AEP level + 300mm). If the DS pipe size is increased, the fill level at the boundary will be then set by the cover requirements on the DS pipe which will reduce the $1,500,000 saving on fill SWS has provided to the developers of the residential land as extra filling to cover the DS pipes will reduce the saving.

Hydrological and Environmental Engineering

Addendum 1:

Pakenham East Precinct Structure Plan

Deep Creek Corridor Proposals

5 October 2014

Report by: Valerie Mag BE Civil (Hons), M Eng Sci

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Contents

1. Introduction

In March 2013, Stormy Water Solutions produced a report entitled “Pakenham East Precinct Structure Plan, Proposed Drainage Strategy, Draft Report”. This 2013 report considered the major drainage, flooding and water quality management issues within the Pakenham East Precinct Structure Plan (PSP) area to define potential land take requirements required by major drainage assets.

As part of the 2013 work Stormy Water Solutions developed various strategy options for consideration. In this way, council could incorporate various scenarios in relation to drainage requirements and ultimately adopt a PSP formulation which optimises all PSP objectives, not just the drainage requirements.

Melbourne Water Corporation (MWC) subsequently commented on the draft report and options. Of particular concern was the corridor proposed for Deep Creek. The current PSP Proposals generally show:

- a 50 metre reserve on the west of Deep Creek and a 100 m reserve of the east of Deep Creek downstream of Princes Highway, and
- 100 m reserve of the east of Deep Creek upstream of Princes Highway
- An assumption that any future development west of Deep Creek upstream of Princes Highway would require a 50 m reserve to be consistent with the above. However, in the interim, the UFZ line (which is consistent with the declared flood plain line) could be assumed.

The two major issues identified by MWC in relation to the Deep Creek Corridor were:

- By setting the development line on either side of Deep Creek, as per Councils 2013 proposal, flows will be restricted and future development will be required to be filled to MWC standards to ensure adequate flood protection. This may result in a small increase in flood levels, and
- The PSP plan did not appear to address the breakaway flow from Deep Creek towards the south-east, where flows outfall at the Princes Freeway. Melbourne Water suggested that this could be addressed by either:
    a) Upgrading (/ increase the capacity of) Deep Creek downstream of Ryan Road, including upgrading the bridge; or
    b) Set aside land in the FUS plan to allow for breakaway flows to extend down to the proposed retarding basin at the Princes Freeway.

This report addresses the above two issues to clearly show that the Deep Creek Corridor proposals are sufficient to allow future works to address the above concerns. This report also proposals some downstream works (in line with (a) above) to ensure current flood protection provisions downstream of Ryan Road are not compromised.

2. Current PSP Proposals in Relation to Deep Creek

It is proposed to retain Deep Creek and its riparian zone in their current form. However, ongoing waterway management will occur in line with current and existing ecological and landscape requirements.

In line with current PSP proposals, the Deep Creek corridor is proposed to incorporate:

- a 50 metre reserve on the west of Deep Creek and a 100 m reserve of the east of Deep Creek downstream of Princes Highway, and
- 100 m reserve of the east of Deep Creek upstream of Princes Highway
- An assumption that any future development west of Deep Creek upstream of Princes Highway would require a 50 m reserve to be consistent with the above. However, in the interim, the UFZ line (which is consistent with the declared flood plain line) could be assumed.

The proposed reserve encompasses the entire Deep creek riparian vegetation and the existing Deep Creek Road (upstream of the Highway).

Any future development must incorporate filling to required MWC standards adjacent to the creek to ensure adequate flood protection. At this stage fill requirements are assumed to be 600 mm above the flood levels determined given ultimate reserve requirements. Fill requirements may vary in the order of between 600 to 1200 mm adjacent to Deep Creek. It is proposed to grade the fill down to natural surface level over (say) 100 metres, creating, in effect, a very wide, flat levee adjacent to the creek.

The Deep Creek Princess Highway Culvert has enough capacity to convey the future and existing 100 Year ARI flow (See Appendix B).

This report expands the above proposals and identifies additional corridor works required to address the issues highlighted in Section 1 above.

3. Hydrological Modelling - Deep Creek

Hydrological Modelling using the RORB model was developed for this study by SWS to estimate flood flows within Deep Creek. MWC have advised that the flood plain was declared assuming a 100 Year ARI flow of 43 m^3/s. The RORB model was developed to:

- Confirm this flow assumption,
- Account for flow reductions in upstream reaches, and
- Account for catchment development as per PSP proposals.

The analysis below only considers the 100 Year ARI storm events. Consideration of this event will provide realistic site delineation of the Deep Creek Corridor extent. Appendix A details the RORB model control vector. As detailed subareas H and I incorporate a fraction impervious of 0.6 to account for future development in these areas (accounting for future council reserves and the existing UFZ north of Princes highway and west of Deep Creek.

The regional parameter set developed by Melbourne Water for the South East region of Melbourne was utilised. This relationship is detailed below. Table 1 details the RORB results for Deep Creek

$K_c = 1.53A^{0.55} = 7.0$ (area = 15.9 km^2)
m = 0.8
Initial loss = 10 mm
Pervious area runoff coefficient, 100 year = C_{perv} = 0.6 mm
Pakenham Upper rainfall intensities were utilised.

Table 1 RORB Results

Location	100 Year ARI Design Flow (m3/s)	Critical Duration (hours)		
End Reach 10	24.3	9		
Upstream Reach 12	27.2	9		
Reach 13 input	8.1	1	6.6	(9hr)
Upstream Reach 14	33.8	9		
Reach 15 input	11.1	2	6.9	(9hr)
Deep Creek at Princes Highway	40.7	9		
Deep Creek at Ryan Road	40.4	9		
Deep Creek into Deep Creek RB	42.8	9		

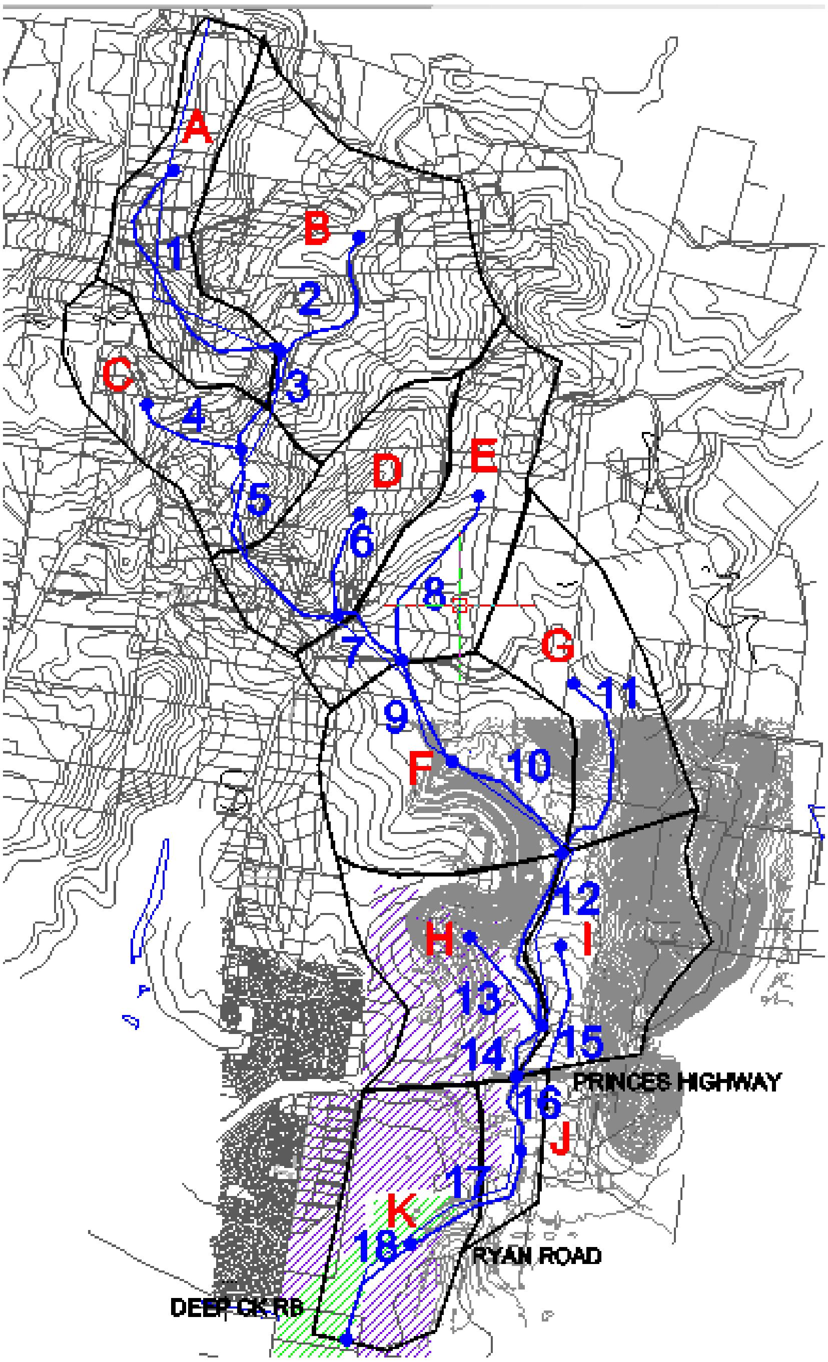

Figure 1 **Deep Creek RORB Model**

The rational method calculated a 100 Year ARI flow at the Deep Creek Retarding basin of 38.2 m^3/s (C=0.4, time of concentration = 3 hours. The DSE regional flow estimate graphs for rural catchment calculates a 100 Year ARI flow at the Deep Creek Retarding basin 38.5 m^3/s. The flow of 42.8 m^3/s is consistent with previous MWC assumptions (43 m^3/s as advised by Mark Warren in September 2014).

Given the above the flows above are considered reasonable to adopt in regard to assessing the flooding implications along the Depp Creek corridor upstream of the Deep Creek Retarding Basin.

4. Hec Ras Modelling - Existing Conditions

4.1 Deep Creek Retarding Basin to Ryan Road

The Hec Ras model described below was used to assess existing flood levels downstream of Ryan Road. This was done so that a “base” case could be determined to assess any potential PSP implications downstream of Ryan Road.

This model was constructed utilising:

- The design flow detailed above 43 m^3/s,
- A starting water level of 23.2 m AHD which is the declared flood level at Section 0),
- 0.5 metre Lidar information provided by Council,
- DVA drawing set 1606/1 which detailed flood mitigation works (1989) downstream of Ryan Road,
- Manning n of 0.05 for flood plain areas associated with paddocks or the golf course,
- Mannings n values of 0.05 to 0.06 for cleared drainage lines, and
- Mannings n values of 0.09 for drainage paths incorporating in stream vegetation.

Examination of the Lidar information suggested that the northern levee bank works directly downstream of Ryan Road were not included in the 1989 design plan set. The declared flood plain plans suggest the levee works were actually completed about 1992. As noted on one of the MWC declared flood plain plans, the aim of these works was to provide 100 year protection to the low density properties located north of Deep Creek, directly downstream of Ryan Road. However, other information suggests a capacity less than the 100 year flow (35 m^3/s as per the levee design plans).

Given the above, the cross section in this area of the creek were derived using a combination of the 1989 design plan information and the recent Lidar survey information.

The above is considered accurate enough to:

- Assess if existing flood levels are consistent with the declared flood levels, and
- To assess the impact of upstream PSP proposals along this section of creek.

However, actual flood levels should be determined at the functional design stage of the project given detailed site survey information.

In addition to the above a flow of 18 m^3/s was also run through the model. This was done to clearly show that the declared flood levels were based, conservatively, assumed that the total design flow of 43 m³/s and did not account for any breakaway flow to the south upstream of Ryan Road. This is considered a reasonable assumption as:

- The email advice from Keith Boniface of Melbourne Water dated 1/2/13 stating " the breakaway flow at the south end adjacent to Ryan Road, I think, has been eliminated or at least reduced in subsequent works",
- hand written notes on the MWC declared flood level plan indicate some filling upstream of Ryan Road and construction of a house on Canty Land may limit breakaway flow south, and
- A large proportion of any breakaway south may actually be directed west to Ryan Road due to the relatively hydraulic smoothness of Canty Lane as opposed to the surrounding land types.

Figure 2 shows the calculated flood levels assuming a design flow of 43 m³/s. Table 2 details the calculated flood levels (43 m³/s) compared with the MWC declared flood levels.

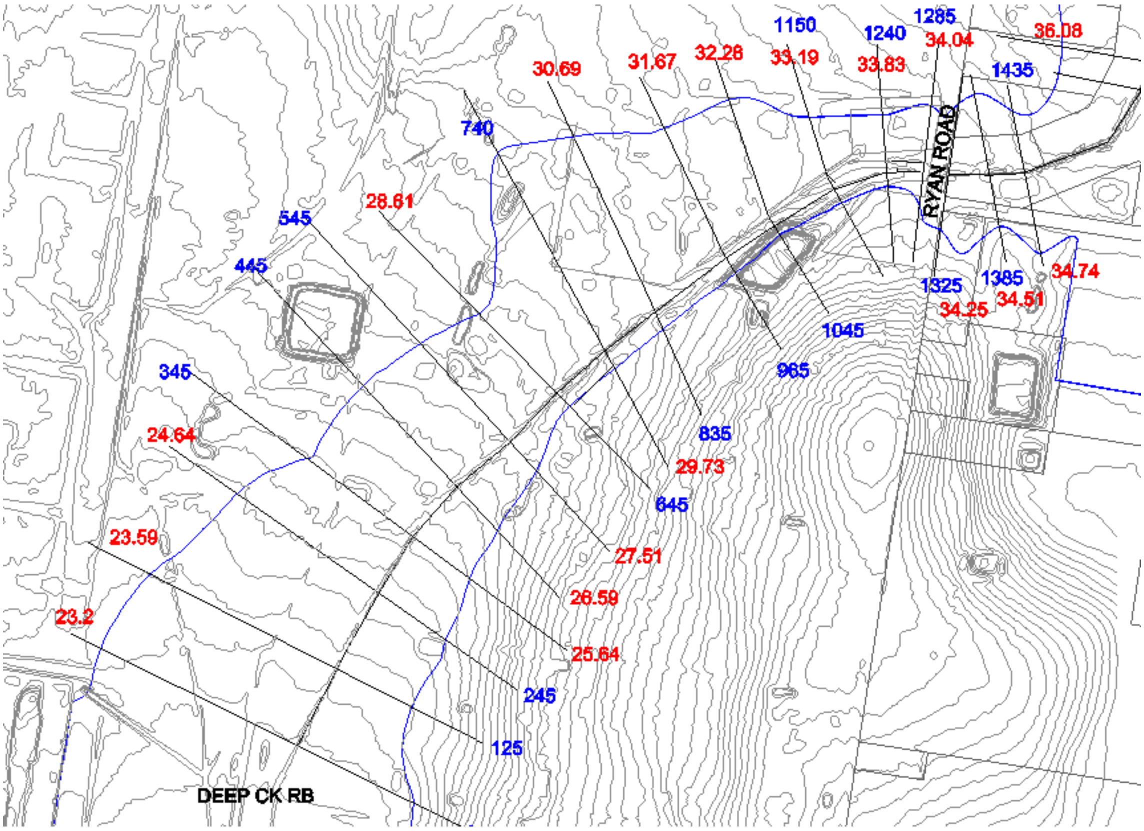

Figure 2 **Deep Creek - Existing Flood Levels Downstream of Ryan Road**

Blue text – Hec Ras Chainage

Red Text = 2014 Calculated flood level (existing situation)

Blue line – declared flood plain extent which gives an indication (only) of the extent of inundation in the 100 Year ARI event.

Table 2 **Hec Ras Results (43 m^3/s) compared with Declared Flood Plain Levels**

Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)*	(m3/s)	(m AHD)	
1285	33.7	43	34.04	340
1240	33.26	43	33.83	570
1150	33.19	43	33.19	0
1045	32.63	43	32.28	-350
965	31.68	43	31.67	-10
835	30.85	43	30.69	-160
740	29.75	43	29.73	-20
645	28.61	43	28.61	0
545	27.62	43	27.51	-110
445	26.71	43	26.59	-120
345	25.6	43	25.64	40
245	24.61	43	24.64	30
125	23.5	43	23.59	90
0	23.2	43	23.2	0

The results indicate that the expected 100 Year ARI flood levels are generally at or below the declared flood plain levels.

Flood levels are probably lower between chainages 835 and 1045 due to the declared flood levels possibly not accounting for the constructed on line pond in this area (the pond was constructed in 1989, and the survey used to define the flood plain for the flood plain declaration was completed in 1978).

In addition, flood levels are higher just downstream of Ryan Road, possibly due to the flood levels possibly not accounting for the constructed northern levee in the area (again this levee was only constricted in 1992). As shown in Figure 3 below, it is estimated that the levee just contains the 100 Year flow of 43 m^3/s (as was inferred in the declared flood plain plan set).

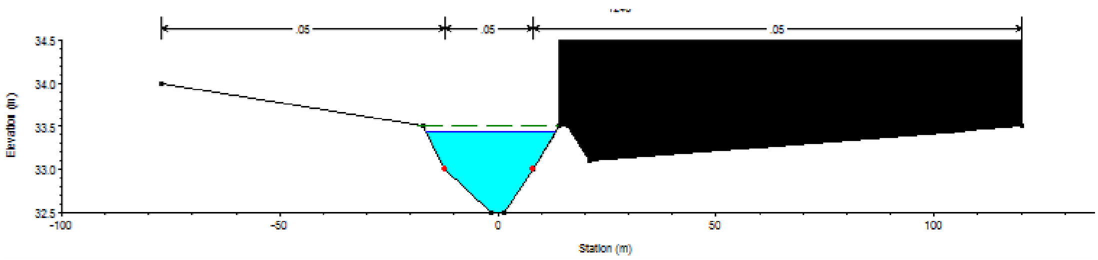

Figure 3 **Ch 1240 - Looking Downstream**

Table 3 details the calculated flood levels (18 m^3/s) compared with the MWC declared flood levels. This analysis was undertaken to investigate if the declared flood levels accounted for any breakaway flow to the south upstream of Ryan Road. As detailed, calculated flood levels are generally much lower than the declared flood levels, indicating that MWC, conservatively, assumed no breakaway flow when setting flood levels in this area in the past. This is considered a prudent assumption the issues highlighted above.

Table 3 Hec Ras Results (18 m^3/s) compared with Declared Flood Plain Levels

Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)*	(m3/s)	(m AHD)	
1285	33.7	18	33.63	-70
1240	33.26	18	33.45	190
1150	33.19	18	32.72	-470
1045	32.63	18	31.73	-900
965	31.68	18	31.5	-180
835	30.85	18	30.46	-390
740	29.75	18	29.63	-120
645	28.61	18	28.48	-130
545	27.62	18	27.38	-240
445	26.71	18	26.47	-240
345	25.6	18	25.55	-50
245	24.61	18	24.53	-80
125	23.5	18	23.51	10
0	23.2	18	23.2	0

The results do show that fill and flood levels downstream of Ryan Road do account for a design flow in this area of 43 m^3/s, not 18 m^3/s. As such, the PSP proposals in regard to assuming minimal breakaway flows to the south upstream of Ryan Road should not impact on flood protection provisions in this area.

It is considered that enough work has been completed for Council to move forward in confidence in regard to the PSP proposals in regard to reserve and overland flow path provisions upstream of Ryan Road. However, detailed design of the Deep Creek Reserve Corridor upstream of Ryan Road (see Section 5 below) should include detailed survey and updated modelling of the channel and levee downstream of Ryan Road to confirm the above results.

4.2 Existing Ryan Road Culvert System

The declared flood level directly upstream of Ryan Road is 34.2 m AHD.

A culvert and weir flow analysis (Appendix B) calculated a 100 Year flood level (assuming a design flow of 43 m^3/s) of 34.25 m AHD (15 m^3/s in the culvert system and 28 m^3/s over the road). If 18 m^3/s design flow is assumed a 100 Year ARI flood level of 34.1 m AHD (11 m^3/s in the culvert system and 7 m^3/s over the road).

Again, the results do show that fill and flood levels directly upstream of Ryan Road do account for a design flow in this area of 43 m^3/s, not 18 m^3/s.

However the results do indicate that there is an argument to upgrade the Ryan Road culvert system given the development which has occurred in the area over the last 25 years and the potential development in the PSP area. Flow over the road of 28m^3/s may be justified in a rural context, but possibly not when the population using the road drastically increases.

4.3 Ryan Road to Princes Highway

The Hec Ras model described below was used to assess existing flood levels between Ryan Road and Princes Highway. Again, this was done so that a "base" case could determine to assess any potential PSP implications between Ryan Road and Princes Highway.

This model was constructed utilising:

- The design flows detailed in Section 3,
- A starting water level of 34.25 m AHD which is the flood level calculate in Section 4.2 above at Section 1325),
- 0.5 metre Lidar information provided by Council, and
- Manning n of 0.05 for flood plain areas associated with paddocks,
- Mannings n values of 0.09 to 0.15 for to account for the vegetation in and adjacent to Deep Creek in this section of waterway.

The above is considered accurate enough to:

- Assess if existing flood levels are consistent with the declared flood levels, and
- To assess the impact of upstream PSP proposals along this section of creek.

Actual flood levels should be determined at the functional design stage of the project given detailed site survey information.

Figure 4 shows the calculated flood levels. Table 4 details the calculated flood levels compared with the MWC declared flood levels. Examination of the cross sections indicated that, although there are informal levees either side of Deep Creek, in this section of waterway, in the 100 Year event the system acts as one united cross section.

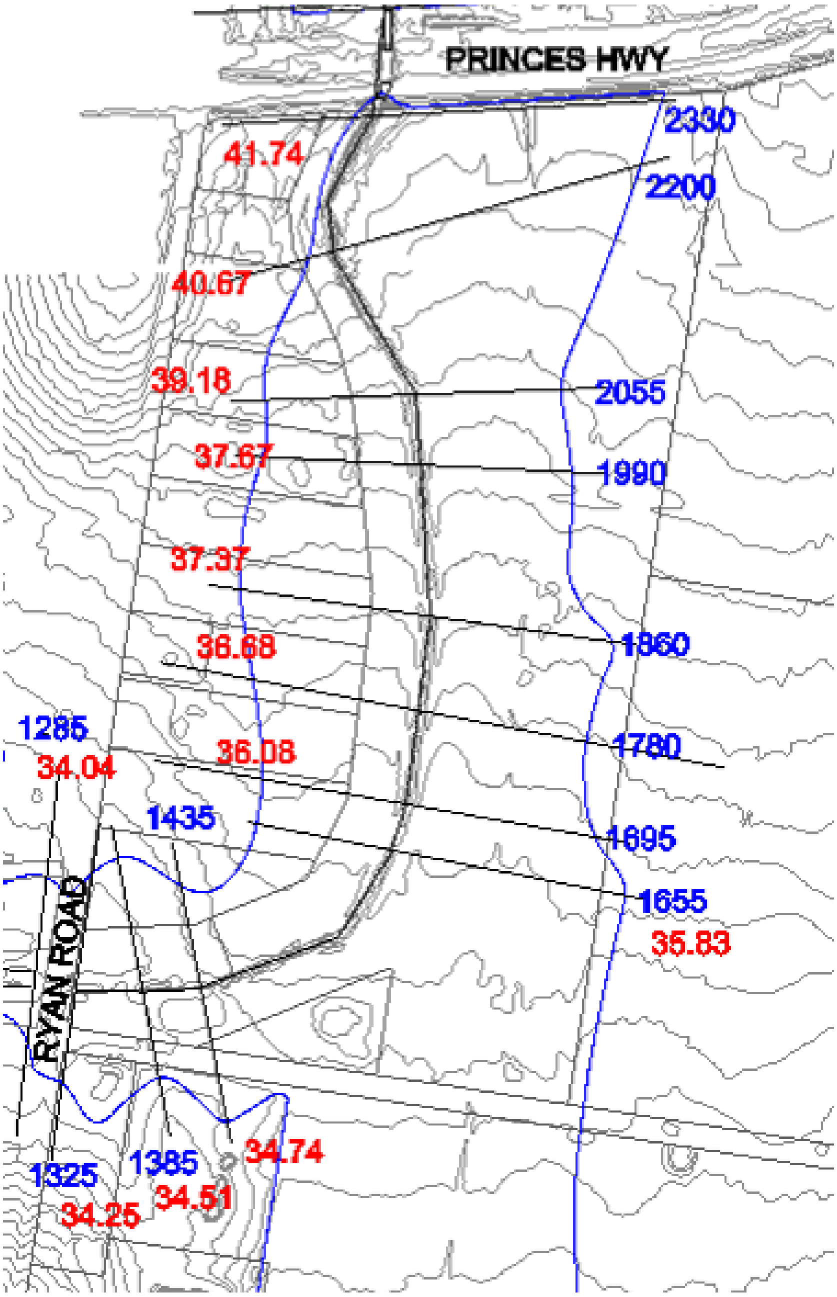

Figure 4 **Deep Creek - Ryan Road to Princes Highway**
Blue text – Hec Ras Chainage
Red Text = 2014 Calculated flood level (existing situation)
Blue line – declared flood plain extent which gives an indication (only) of the extent of inundation in the 100 Year ARI event

Table 4 Hec Ras Results compared with Declared Flood Plain Levels

Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)*	(m3/s)	(m AHD)	
2330	41.8	41	41.74	-60
2200	40.76	41	40.71	-50
2055	39.2	41	39.18	-20
1990	38.72	41	38.67	-50
1860	37.52	41	37.37	-150
1780	36.81	41	36.68	-130
1695	36.27	41	36.08	-190
1655	36.04	41	35.83	-210
1435	34.61	41	34.74	130
1385	34.4	41	34.51	110
1325	34.2	41	34.25	50

As detailed, flood levels are generally close to, or less than, the declared flood levels. This may be because the declared flood level plans (1978) may not have extended to include the full with of the flood plain. Flood levels may be slightly higher immediately upstream of Ryan Road, possibly due to a higher Manning n used than in the original flood plain declaration.

It is considered that the 2014 levels calculated above are reasonable to compare PSP impacts against (See Section 6 below)

4.4 Existing Princes Highway Culvert System

The declared flood level directly upstream of Ryan Road is 42.33 m AHD.

A culvert analysis (Appendix C) calculated a 100 Year flood level (assuming a design flow of 40.7 m^3/s) of 42.35 m AHD.

The culverts are not running under pressure in the 100 Year ARI event and do not need to be upgraded due to PSP implications.

4.5 Upstream of Princes Highway

The Hec Ras model described below was used to assess existing flood levels upstream of Princes Highway. Again, this was done so that a “base” case could determined to assess any potential PSP implications in this area of the Deep Creek corridor.

This model was constructed utilising:

- The design flows detailed in below,
- A starting water level of 42.35 m AHD which is the flood level calculate in Section 4.4 above at Section 2430),

- 0.5 metre Lidar information provided by Council, and
- Manning n values as detailed in Figure 6 below.

Again, the above is considered accurate enough to assess if existing flood levels are consistent with the declared flood levels and to assess the impact of upstream PSP proposals along this section of creek. Figure 5 shows the calculated flood levels. Table 6 details the calculated flood levels compared with the MWC declared flood levels.

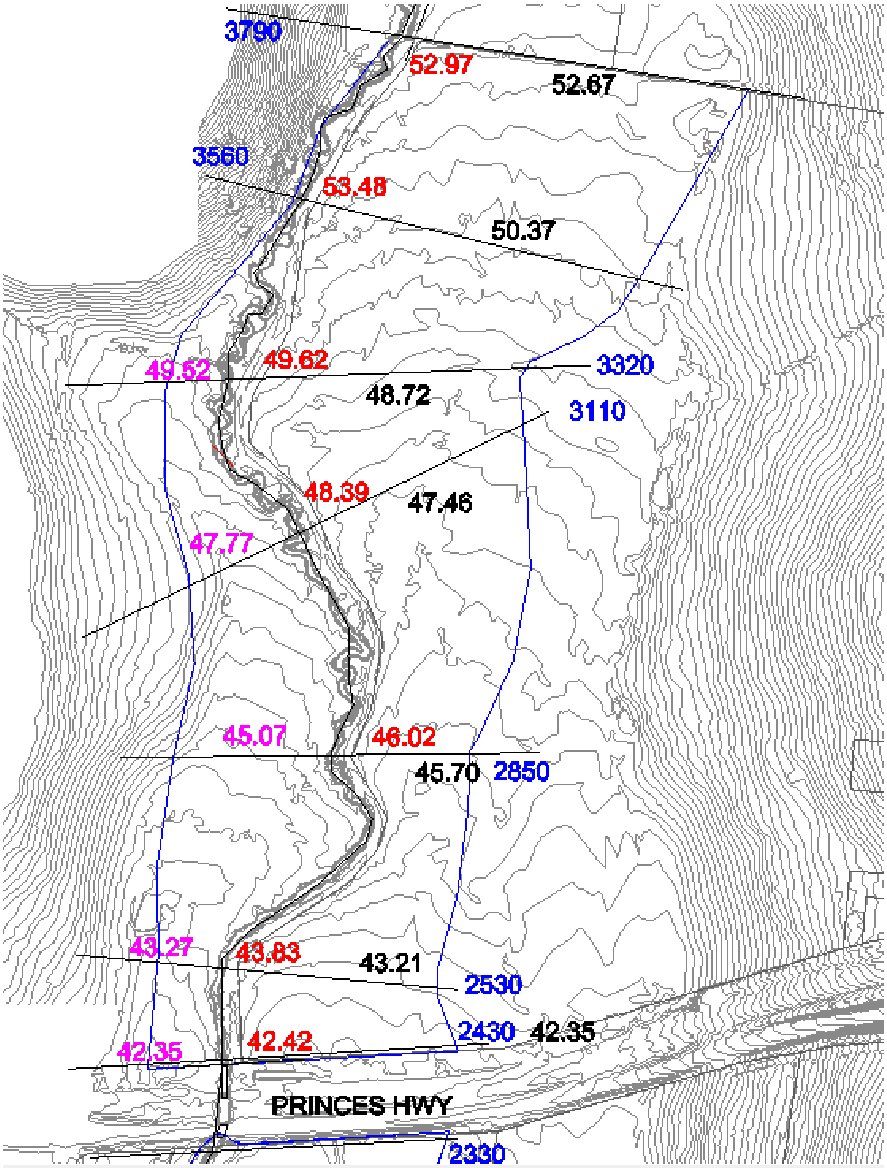

Figure 5 **Deep Creek - Upstream of Princes Highway**
Blue text – Hec Ras Chainage
Red Text = 2014 Calculated flood level in Deep Creek (existing situation)
Pink Text = 2014 Calculated flood level in Western Flood Plain (existing situation)
Black Text = 2014 Calculated flood level in Eastern Flood Plain (existing situation)
Blue line = declared flood plain extent (an indication only of the extent of inundation in the 100 Year ARI event)

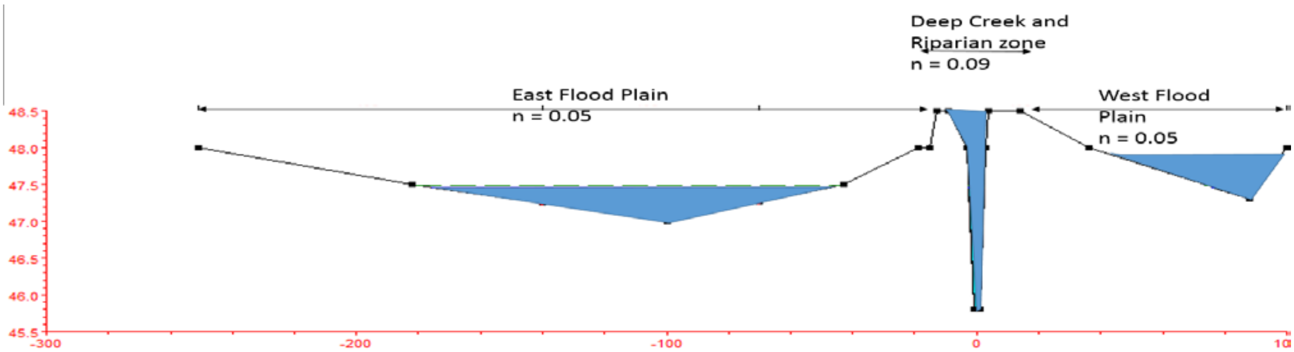

Figure 6 Deep Creek - Typical Cross Section Upstream of Princes Highway (3110)

As detailed below, it is clear that upstream of Princes Highway, the flows in Deep Creek, the eastern and Western floodplains act independently. That is, once flow enters the eastern or western flood plain, it cannot re-enter Deep Creek. Also, once flow leaves Deep Creek (by flowing over its adjacent levees or Deep Creek Road) it cannot re-enter the creek. The only Cross Section where flows combine is directly upstream of Princes Highway due to the table drain interaction.

Given this aspect of the flow process, three Hec Ras models were created as detailed for the channel, eastern and western floodplains. An iterative process determined how much flow could be contained within Deep Creek and where flow would be contained within the relevant flood plain. Flow splits are detailed below. Largely flows were for the 9 hour duration storm. However, higher flows than the 9 hour storm were used for the upper cross sections in the western flood plain due flows from the local catchment being higher than the 9 hour deep creek input at this location. This may explain the higher flood level produced at change 3320 in the western flood plain.

Table 5 Flow splits – Deep Creek upstream of Princes Highway

Cross Section	Total Deep Creek Contribution				Western Flood Plain		Eastern Flood Plain	
	Total Deep Creek Contribution	Western Flood Plain	***Channel***	Eastern Flood Plain	Assumed Flow from local catchment	***Total in flood plain including Deep Creek Breakaway***	Assumed Flow from local catchment	***Total in flood plain including Deep Creek Breakaway***
3790	27.2	0	***13***	14.2	0	***0***	3.5 (50% local catchment)	***17.7***
3560	27.2	0	***13***	14.2	0	***0***	5 (75% local catchment)	***19.2***
3320	27.2	0	***13***	14.2	8 (2hr)	***8 (2hr)***	6.9 (100 % local catchment)	***21.1***
3110	27.2	0	***13***	14.2	8 (2hr)	***8 (2hr)***	6.9 (100 % local catchment)	***21.1***
2580	27.3	3	***7.1***	17.2	6.9	***9.9***	6.9 (100 % local catchment)	***24.1***
2530	27.3	3	***7.1***	17.2	6.9	***9.9***	6.9 (100 % local catchment)	***24.1***
2430	27.3	3	***7.1***	17.2	6.9	***9.9***	6.9 (100 % local catchment)	***24.1***

All Critical Durations 9 hours unless specified)

Bold and italic - flows used in Hec Ras model

It should be noted, that in regard to flood protection under existing conditions, the relevant flood level is the flood level calculated in the flood plains, not the higher flood level in Deep Creek.

Table 6 Hec Ras Results compared with Declared Flood Plain Levels

Deep Creek Channel and Riparian Zone				
Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)	(m3/s)	(m AHD)	
3790	52.64	13	52.97	330
3560	50.28	13	51.48	1200
3320	48.73	13	49.62	890
3110	47.62	13	48.39	770
2850	45.39	7.1	46.02	630
2530	43.47	7.1	43.83	360
2430	42.33	7.1	42.42	90
Eastern Flood Plain				
Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)	(m3/s)	(m AHD)	
3790	52.64	17.7	52.67	30
3560	50.28	19.2	50.37	90
3320	48.73	21.1	48.72	-10
3110	47.62	21.1	47.46	-160
2850	45.39	24.1	45.7	310
2530	43.47	24.1	43.21	-260
2430	42.33	24.1	42.35	20
Western Flood Plain				
Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)	(m3/s)	(m AHD)	
3790	N/A	0		
3560	N/A	0		
3320	48.73	8	49.52	790
3110	47.62	8	47.77	150
2850	45.39	9.9	45.07	-320
2530	43.47	9.9	43.27	-200
2430	42.33	9.9	42.35	20

As detailed, flood levels in both the eastern and western flood plains are generally close to or less than the declared flood levels. Discrepancies would be due to the original analysis assuming all three systems act as one and possibly, variances in Mannings n assumptions

It is considered that the 2014 levels calculated above are reasonable to compare PSP impacts against (See Section 6 below)

5. Deep Creek Corridor PSP Implications

The March 2013 report highlighted the reserve requirements adjacent to Deep Creek. This previous work assumed that any flood mitigation or drainage augmentation works would be able to be contained within the 150 m reserve specified.

MWC identified two major issues identified by MWC in relation to the Deep Creek Corridor. These were:

- By setting the development line on either side of Deep Creek, as per Councils 2013 proposal, flows will be restricted and future development will be required to be filled to MWC standards to ensure adequate flood protection. This may result in a small increase in flood levels, and
- The PSP plan did not appear to address the breakaway flow from Deep Creek towards the south-east, where flows outfall at the Princes Freeway. Melbourne Water suggested that this could be addressed by either:
    c) Upgrading (/ increase the capacity of) Deep Creek downstream of Ryan Road, including upgrading the bridge; or
    d) Set aside land in the FUS plan to allow for breakaway flows to extend down to the proposed retarding basin at the Princes Freeway.

This report takes the PSP one step further than just setting a reserve requirement by specifying works within the proposed corridor which will address the above two issues. The aim is to show that works can be the proposed Deep Creek Reserve is wide enough to contain future works which can address the issues. Ultimate works may differ from those specified in this report.

Figures 7, 8 and 9 detail the concept design of the works proposed. Section 6 details the estimated effect on flood levels if these works are adopted.

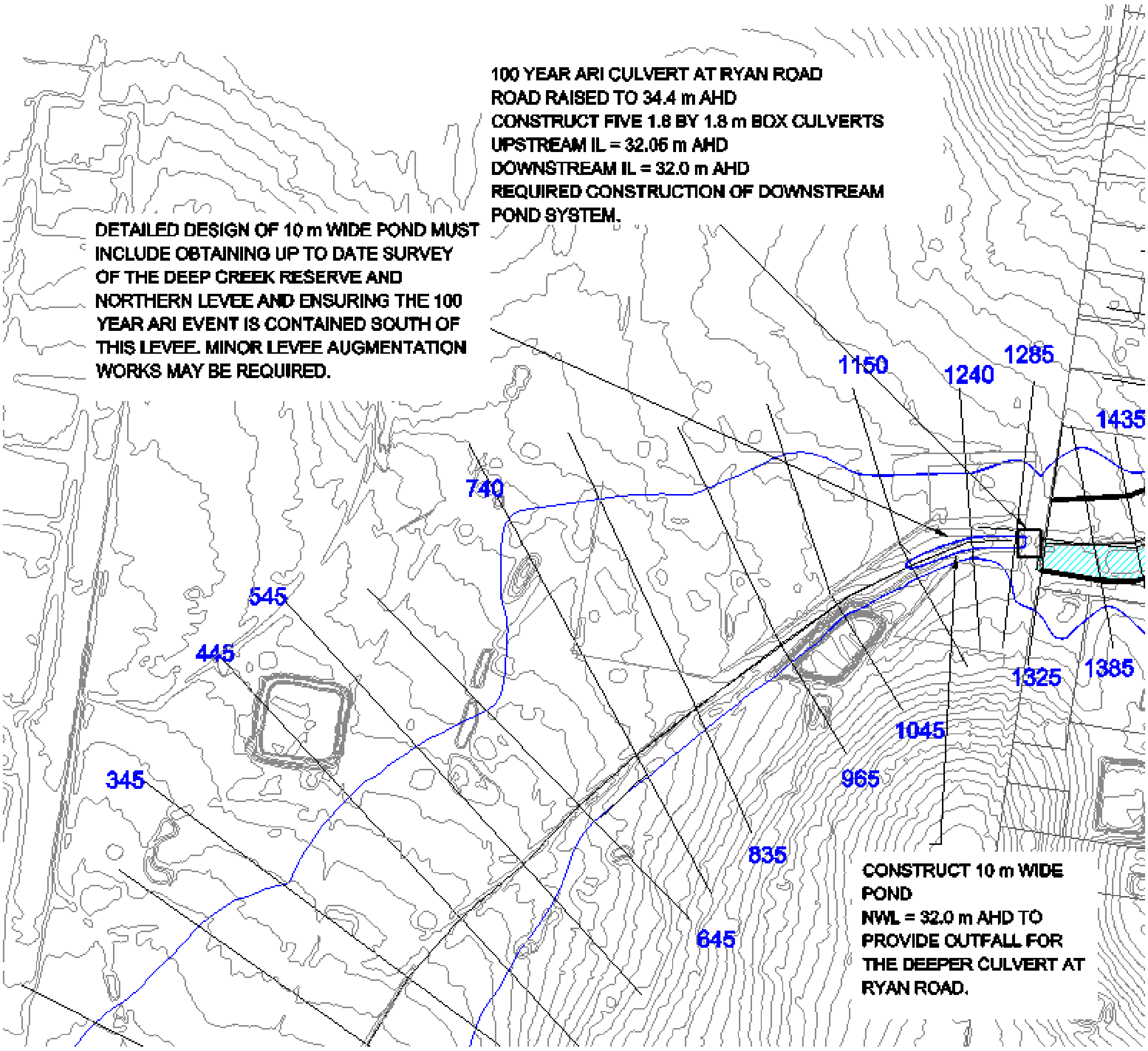

Figure 7 **Possible Deep Creek Corridor Works Downstream of Ryan Road**

Blue text – Hec Ras Chainage

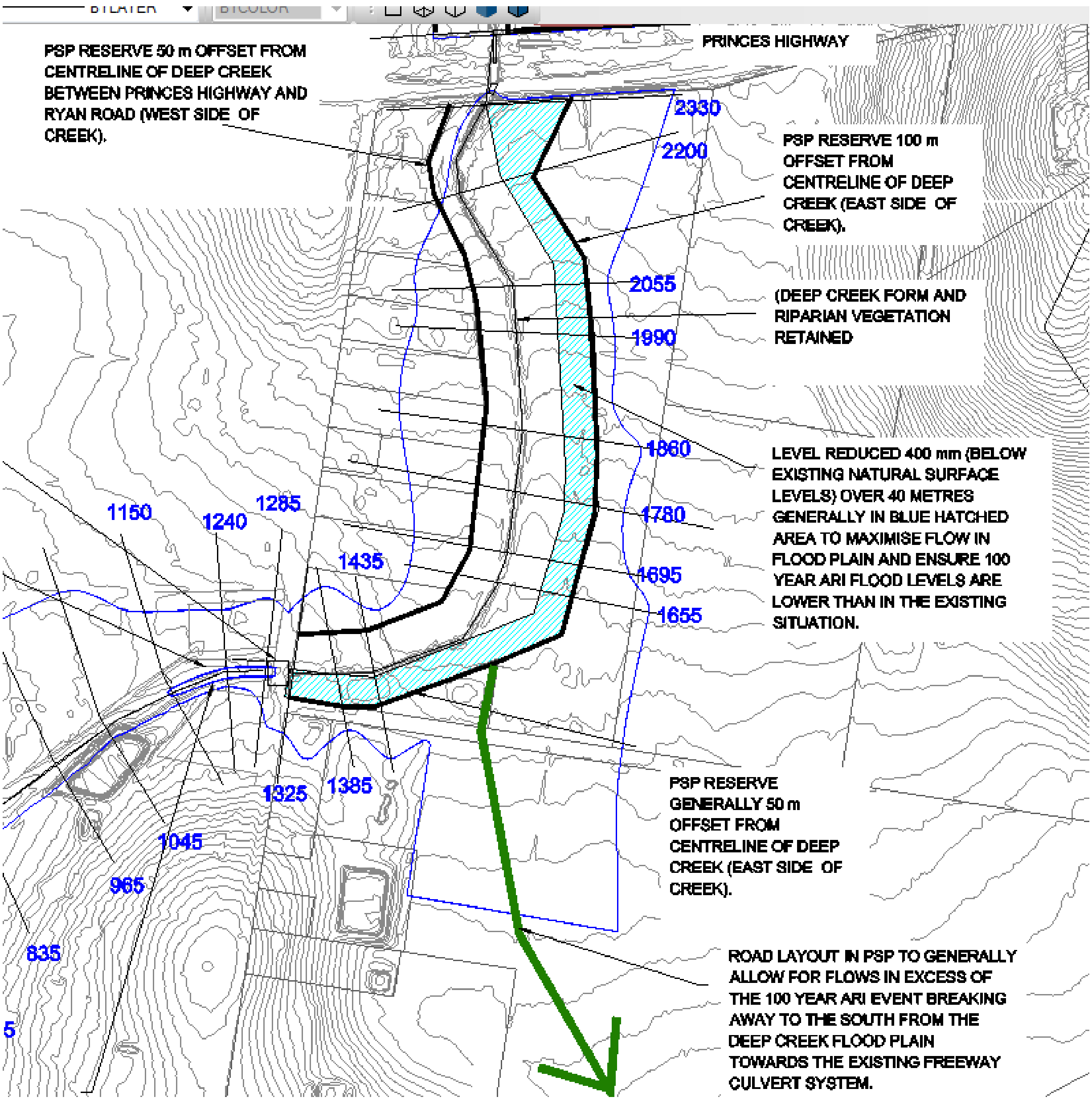

Figure 8 **Possible Deep Creek Corridor Works - Ryan Road to Princes Highway**

Blue text – Hec Ras Chainage

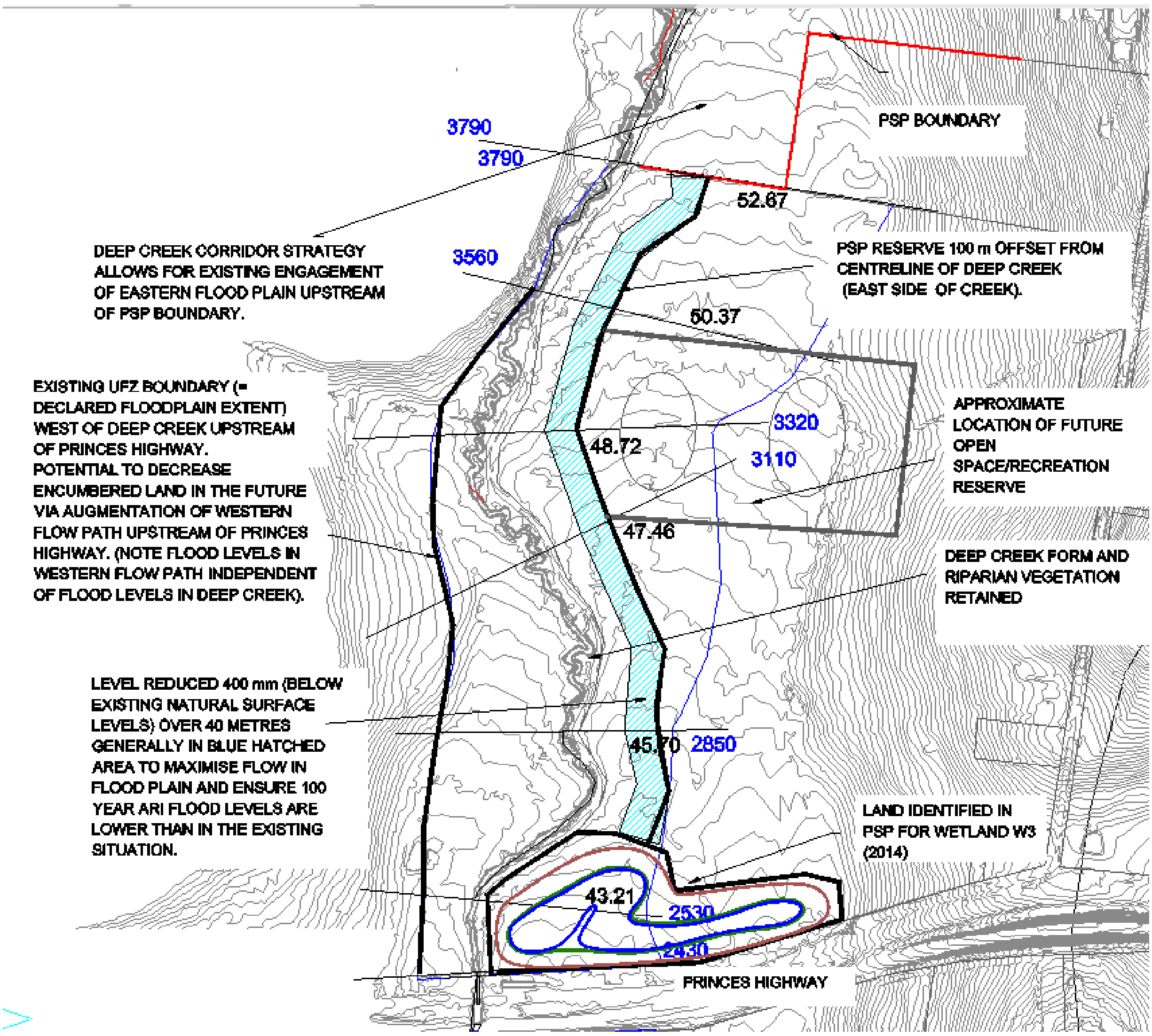

Figure 9 **Possible Deep Creek Corridor Works – Upstream of Princes Highway**

Blue text – Hec Ras Chainage

6. Hec Ras Modelling - Incorporating Deep Creek Corridor Works

6.1 Deep Creek Retarding Basin to Ryan Road

The Hec Ras model described in Section 4.1 was modified to include the on line pond as detailed in Figure 7 above. All other model aspects of the "existing" situation remained the same. Table 7 compares the "existing situation" against the situation incorporating possible future Deep Creek Corridor works.

Table 7 Hec Ras Results - With and without Deep Creek Corridor Works

Chainage (m)	Assumed 100 year Flow	Existing 100 Year Level	100 Year Level incorporating Deep Creek Corridor works	100 Year ARI Flood Level Incorporating Deep Creek Corridor Works minus Existing 100 Yr Level (mm)
	(m3/s)	(m AHD)	(m AHD)	
1285	43	34.04	33.82	-0.22
1240	43	33.83	33.69	-0.14
1150	43	33.19	33.18	-0.01
1045	43	32.28	32.28	0
965	43	31.67	31.67	0
835	43	30.69	30.69	0
740	43	29.73	29.73	0
645	43	28.61	28.61	0
545	43	27.51	27.51	0
445	43	26.59	26.59	0
345	43	25.64	25.64	0
245	43	24.64	24.64	0
125	43	23.59	23.59	0
0	43	23.2	23.2	0

As detailed, the proposed works should result in a slight decrease in design flood levels downstream of Deep Creek. However, the works are also required to ensure the culvert augmentation detailed in Section 6.2 can occur with the desired outfall invert levels.

The results indicate that the expected 100 Year ARI flood levels are generally at or below the declared flood plain levels.

6.2 Upgraded Ryan Road Culvert System

It is proposed to upgrade the Ryan Road culvert system to the size, amount, minimum road level and invert levels detailed in appendix D and Figure 7 above. This is considered a prudent proposal to ensure:

- No increase in upstream 100 year flood levels, and

- 100 Year ARI protection for the Ryan Road carriageway (to new minimum road levels) given the increased population in the area using the road in the future.

6.3 Ryan Road to Princes Highway

The Hec Ras model described in Section 4.3 was modified to include:

- An assumed constriction of all flows to the reserve boundaries as detailed in Figure 8 above, and
- The flood plain augmentation works as detailed in figure 8 above.

Note this is a conservative analysis as the assumed reserve line west of Deep Creek may not incorporate fill if the low density use of this land does not change in the future.

Table 8 compares the "existing situation" against the situation incorporating possible future Deep Creek Corridor works.

Table 8 Hec Ras Results - With and without Deep Creek Corridor Works

Chainage (m)	100 year Flow	Existing 100 Year Level	100 Year Level incorporating Deep Creek Corridor works	100 Year ARI Flood Level Incorporating Deep Creek Corridor Works minus Existing 100 Yr Level (mm)
	(m3/s)	(m AHD)	(m AHD)	
2330	41	41.74	41.73	-0.01
2200	41	40.71	40.78	0.07
2055	41	39.18	39.07	-0.11
1990	41	38.67	38.56	-0.11
1860	41	37.37	37.38	0.01
1780	41	36.68	36.64	-0.04
1695	41	36.08	36.04	-0.04
1655	41	35.83	35.76	-0.07
1435	41	34.74	34.68	-0.06
1385	41	34.51	34.54	0.03
1325	41	34.25	34.25	0

As detailed, the proposed works should result in a slight decrease in design flood levels in this section of waterway.

The 100 Year ARI flow will be contained to the reserve and directed west to the Deep Creek Retarding Basin. However, the updated PSP plan should allow for an overland flow path provision (e.g. road reserve or equivalent) to account for flows in excess of the 100 year flow possibly breaking away to the south upstream of Ryan Road.

6.4 Existing Princes Highway Culvert System

The flood levels directly downstream of Princes Highway do not change in the future situation. As such, the Princes Highway Culvert system is not required to be upgraded in the future.

6.5 Upstream of Princes Highway

The Hec Ras model described in Section 6.5 was modified to include:

- An assumed constriction of all flows to the reserve boundaries as detailed in Figure 9 above, and
- The eastern flood plain augmentation works as detailed in Figure 9 above.

It should be noted that this only required changing the Eastern Hec Ras model, as the PSP will have no impact in flood levels expected in Deep Creek itself or the western flood plain.

Table 9 compares the "existing situation" against the situation incorporating possible future Deep Creek Corridor works.

Table 9 Hec Ras Results - With and without Deep Creek Corridor Works Eastern flood Plain

Chainage (m)	100 year Flow in East Flood Plain	Existing 100 Year Level	100 Year Level incorporating Deep Creek Corridor works	100 Year ARI Flood Level Incorporating Deep Creek Corridor Works minus Existing 100 Yr Level (mm)
	(m3/s)	(m AHD)	(m AHD)	
3790	17.7	52.67	52.64	-0.03
3560	19.2	50.37	50.73	0.36
3320	21.1	48.72	49.31	0.59
3110	21.1	47.46	47.26	-0.2
2850	24.1	45.7	45.61	-0.09
2530	24.1	43.21	43.12	-0.09
2430	24.1	42.35	42.35	0

As detailed, the proposed works generally result in a slight decrease in design flood levels in this section of waterway. The modelling suggest that there may be a rise in flood levels at Chainage 3320 and 3560. However, as the three systems operate independently this does not affect flood levels to the west of the creek (i.e. any existing subdivisions). In addition, the proposed open space reserve (PSP plan) could be shaped to allow its western portion to be flood prone, thus reducing flood levels to closer to existing levels. Whatever the case, the only implication is on PSP land and, worse case, this results in more fill required in this area.

7. Conclusions and Further Work Required

The above work concludes that the PSP reserve areas adjacent to Deep Creek are adequate to address the MWC concerns highlighted in Section 1 above.

Further work required going forward in the design process includes, but is not limited to:

- Ensuring the design of any future subdivision relies on detailed flood plain survey information, and updated flood levels at this time to set adequate fill levels adjacent to the reserve and ensure the design of future reserve augmentation works meets the intent of the design as detailed in this report,
- Update the PSP plan to allow for an overland flow path provision (e.g. road reserve or equivalent) to account for flows in excess of the 100 year flow possibly breaking away to the south upstream of Ryan Road (although the Deep Creek corridor will have a 100 Year Capacity),
- Confirming that the ecological and cultural heritage constraints and opportunities have been fully captured by the proposals,
- Liaising with downstream affected landowners,

It is requested that MWC agree in principle to the PSP Deep Creek Reserve line given the result presented in this report.

APPENDIX A RORB Model Control Vector

```
C DEEP CREEK TO UPSTREAM OF PAKENHAM CREEK
C STORMY WATER SOLUTIONS
C SEPTEMBER 2014
C EXISTING CATCHMENT WITH ALLOWANCE
C FOR DEVELOPMENT DSOUTH OF ELEC EASEMENT
C CONSERVATIVLY NO RB'S
C
C  DEEP_2014_oct 2014.CAT
C
0
1,1,1.9,-99,          A
3
1,1,1.1,-99,          B
4
5,1,0.7,-99
3
1,1,0.7,-99,          C
4
5,1,1.5,-99,
3
1,1,0.7,-99,          D
4
5,1,0.5,-99,
3
1,1,1.3,-99,          E
4
5,1,0.7,-99,
2,1,1,-99, F
7
End 10
3
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4
7
upstream end 12
5,2,1.2,1.5,-99,
3
1,2,0.75,0.3,-99,     H
4
7
upstream end 14
5,2,0.4,1.3,-99,
3
1,2,1,0.3,-99,        I
4
7
DEEP CK AT PRINCES HWY
5,1,0.5,-99,
2,2,1,2,-99,          J
7
RYANS ROAD
2,2,0.8,2,-99,
7
DEEP CK UPSTREAM OF PAKENHAM CK
0
1.24,2.83,1.26,1.26,1.52,1.91,1.45,1.44,1.28,0.37,1.35,-99,
1,0.05,0.05,0.05,0.05,0.05,0.2,0.1,0.6,0.6,0.3,0.1,-99,
```

APPENDIX B - Ryan Road Culvert Analysis (Existing Conditions)

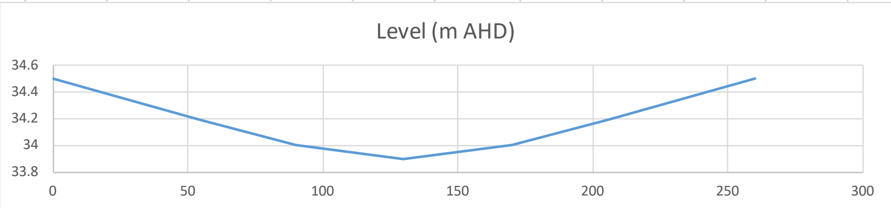
B.1 Design Flow = 43 m^3/s

Ryan Road culverts			
TWL =	33.85	m AHD	
Downstream IL =	32.5	m AHD	
Downstream obvert level =		33.425	m AHD
Must be outlet control - downstream end drowned			
head loss = $(Ke+Kex) \times V^2/2g + S_f \times L$			
$S_f = Q^2 n^2/A^2 R^{4/3}$			
culvert flowing full			
W =	1.825		
D =	0.925	m	
Design flow =	3.74	m^3/s	
Wetted perimeter =	5.50	m	
Area =	1.69	m^2	
Hyd radius =	0.306932	m	
V =	2.22	m/s	
Ke =	0.5		
Kex =	1		
n =	0.013		
L=	5		
S_f =	0.0040		
Head loss =	0.40	m	
HWL =	**34.25**	m AHD	
Total flow in four culverts =		14.96	m^3/s

Deep Creek - Ryan Road weir flow

Weir Cross Section

Chainage (m)	Level (m AHD)
0	34.5
54	34.2
90	34
130	33.9
170	34
206	34.2
260	34.5



Kw =	1.65	HWL =	**34.25** m AHD
Water Level =			

Chainage (m)	Level (m AHD)	Average Level (m)	Length (m)	H (m)	Weir flow in segment (m^3/s)
0	34.5				
54	34.2	34.35	54	-0.1	0.0
90	34	34.1	36	0.15	3.5
130	33.9	33.95	40	0.3	10.8
170	34	33.95	40	0.3	10.8
206	34.2	34.1	36	0.15	3.5
260	34.5	34.35	54	-0.1	0.0
				Total Weir Flow =	28.6 m^3/s
				total flow over road and in culverts =	43.6 m^3/s

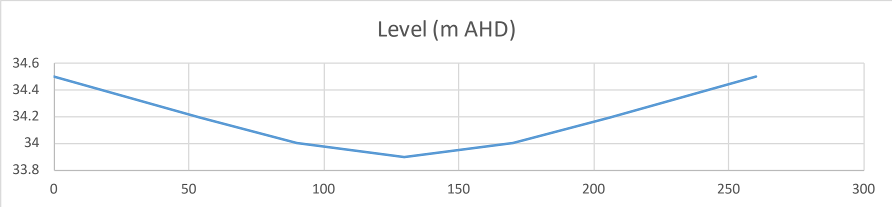
B.2 Design Flow = 18 m^3/s

Ryan Road culverts			
TWL =	33.85	m AHD	
Downstream IL =	32.5	m AHD	
Downstream obvert level =	33.425	m AHD	
Must be outlet control - downstream end drowned			
head loss = $(Ke+Kex) \times V^2/2g + S_f \times L$			
$S_f = Q^2n^2/A^2R^{4/3}$			
culvert flowing full			
W =	1.825		
D =	0.925	m	
Design flow =	2.9	m^3/s	
Wetted perimeter =	5.50	m	
Area =	1.69	m^2	
Hyd radius =	0.306932	m	
V =	1.72	m/s	
Ke =	0.5		
Kex =	1		
n =	0.013		
L=	5		
S_f =	0.0024		
Head loss =	0.24	m	
HWL =	**34.09**	m AHD	
Total flow in four culverts =	11.6	m^3/s	

Deep Creek - Ryan Road weir flow

Weir Cross Section

Chainage (m)	Level (m AHD)
0	34.5
54	34.2
90	34
130	33.9
170	34
206	34.2
260	34.5



Kw = 1.65 | HWL = **34.09** m AHD

Water Level =

Chainage (m)	Level (m AHD)	Average Level (m)	Length (m)	H (m)	Weir flow in segment (m^3/s)
0	34.5				
54	34.2	34.35	54	-0.26	0.0
90	34	34.1	36	-0.01	0.0
130	33.9	33.95	40	0.14	3.5
170	34	33.95	40	0.14	3.5
206	34.2	34.1	36	-0.01	0.0
260	34.5	34.35	54	-0.26	0.0
				Total Weir Flow =	6.9 m^3/s
				total flow over road and in culverts =	18.5 m^3/s

APPENDIX C – Princes Highway Culvert Analysis (Existing Conditions)

Deep Creek at Princes Highway							
Based on Vic Roads Drawings							
Assume all culverts flowing under outlet control							
Melbourne Bound carriageway culvert system							
Width =		3.7	m				
Depth =		3.7	m				
Number of culverts =		2					
Culvert Length =		18.3	m				
Upstream IL =		38.7	m AHD				
Upstream obvert level =		42.4	m AHD				
Downstream IL =		38.65	m AHD				
Downstream obvert level =		42.35	m AHD				
Upstream headwall =		43.3	m AHD				
100 Year Flood Level Downstream =			41.9	m AHD			
Note : conservative, assumes tailwater level dominated by water level in Deep Creek Channel							
Culverts not operating under pressure - as confirmed by Vic Roads design drawings							
Water Depth in culvert =		3.4	m				
Culvert Base width		3.7	m	Culvert slope = 0.001,			
Longitudinal Slope		0.00035		but backwater effects making HGL less			
side slope of batters		1 in	0.01				
Flow Area (A)		12.6956	m^2				
ss length		3.40	m				
Wetted Perimeter (P)		10.50	m				
Hydraulic Radius (R)		1.21	m				
mannings n		0.013					
Capacity (Q)		41.5	m^3/s - twin culverts - Ok approx 40.7 m3/s)				
Velocity (V)		1.63	m/s				
Exit Loss coefficient =		1					
Exist loss = $K_{ex}V^2/2g$ =		0.14	m				
Depth in culvert = TWL + existing gloss =			3.39		OK, matches above		
Inlet Loss coefficient =		0.5					
Inlet loss = $K_eV^2/2g$ =		0.07	m				
HWL =	42.15	.= tail water level of Warrigal bound culvert					

Warrigal Bound carriageway culvert system							
Width =		3.7	m				
Depth =		3.7	m				
Number of culverts =		2					
Culvert Length =		13.1	m				
Upstream IL =		38.8	m AHD				
Upstream obvert level =		42.5	m AHD				
Downstream IL =		38.8	m AHD				
Downstream obvert level =		42.5	m AHD				
Upstream headwall =		43.15	m AHD				
100 Year Flood Level Downstream =			42.15	m AHD			
Culverts not operating under pressure - as confirmed by Vic Roads design drawings							
Water Depth in culvert =		3.45	m				
Culvert Base width		3.7	m	Culvert slope = 0.001,			
Longitudinal Slope		0.00033		but backwater effects making HGL less			
side slope of batters		1 in	0.01				
Flow Area (A)		12.884025	m^2				
ss length		3.45	m				
Wetted Perimeter (P)		10.60	m				
Hydraulic Radius (R)		1.22	m				
mannings n		0.013					
Capacity (Q)		41.0	m^3/s - twin culverts - Ok approx 40.7 m3/s)				
Velocity (V)		1.59	m/s				
Exit Loss coefficient =		1					
Exist loss = $K_{ex}V^2/2g$ =		0.13	m				
Depth in culvert = TWL + existing gloss =			3.48		OK, matches above		
Inlet Loss coefficient =		0.5					
Inlet loss = $K_eV^2/2g$ =		0.06	m				
HWL =	42.35	.= tail water level of Warrigal bound culvert					
		Confirmed , culverts not running under pressure.					

APPENDIX D - Ryan Road Culvert Analysis (Future Conditions)

Width =		1.8	m			
Depth =		1.8	m			
Number of culverts =		5				
Culvert Length =		25	m			
Upstream IL =		32.05	m AHD			
Upstream obvert level =		33.85	m AHD			
Downstream IL =		32	m AHD			
Downstream obvert level =		33.8	m AHD			
Proposed minimum Road Level =		34.4	m AHD	Raising Road 500 mm		
Existing 100 Year ARI flood level upstream =			34.25	m AHD		
100 Year Flood Level Downstream =			33.8	m AHD		
		With Downstream wetland works				
		To be confirmed at detailed design stage				
Design Flow =		40.4	m^3/s (RORB)			
Maximum Head Loss =		0.45	m			
head loss = $(Ke+Kex)\times V^2/2g+S_f\times L$						
$S_f = Q^2n^2/A^2R^{4/3}$						
culvert flowing full						
W =		1.83	m (actual size)			
D =		1.85	m (actual size)			
Design flow =		8.08	m^3/s	5 culverts		
Wetted perimeter =		7.36	m			
Area =		3.38	m^2			
Hyd radius =		0.459860016	m			
V =		2.39	m/s			
Ke =		0.5				
Kex =		1				
n =		0.013				
L=		10				
S_f =		0.0027				
Head loss =		0.46	m	OK		