Sylvanvale Foundation

Rezoning Application, Sylvanvale 147 Garnet Road, Kareela

(Lot 1142 DP 752064)

Location of proposed rezoning site at 147 Garnet Road, Kareela

Flood Assessment Report

April 2021

FloodMit

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1 INTRODUCTION

FloodMit Pty Ltd was commissioned by the Sylvanvale Foundation to prepare a flood assessment report for the potential subdivision and rezoning of their land at 147 Garnet Road, Kareela.

The Sylvanvale property comprises Lot 1 DP 225581 (for access) and Lot 1142 DP 752064. It is proposed to subdivide Lot 1142 and rezone that portion of the newly created northern lot to permit medium density residential development.

The total area of Lot 1142 is approximately 14,128m^2. The site is currently zoned SP2 *Educational Establishment* under Sutherland Shire LEP 2012. The existing property contains the Sylvanvale Foundation Administration building; a number of childcare classrooms; playgrounds; a hydrotherapy pool; a number of sheds; and various parking areas. The property also provides access to the Bates Drive Public School, which adjoins the eastern boundary of the property.

The site is within a stormwater catchment that drains to Oyster Bay, and eventually into the Georges River. A locality sketch is included on Figure 1.

The site has been identified as being partially affected by flooding, based on an *"Initial Subjective Assessment of Flooding"* throughout Sutherland Shire (Bewsher, 2004). Consequently, this flood assessment has been undertaken to provide more detailed information on flood behaviour in the vicinity of the site.

This flood assessment report provides:

i) a review of existing data that is available in relation to flooding;

ii) the establishment of hydrologic and hydraulic models to provide more detailed information on flood behaviour in the vicinity of the site;

iii) delineation of areas that would be inundated in a 100 year average recurrence interval (ARI) flood, and flood risk precinct mapping up to the probable maximum flood (PMF) event;

iv) a discussion on the constraints to future development as a result of flooding, including an assessment of the proposed development in terms of Council's flood risk management policies.

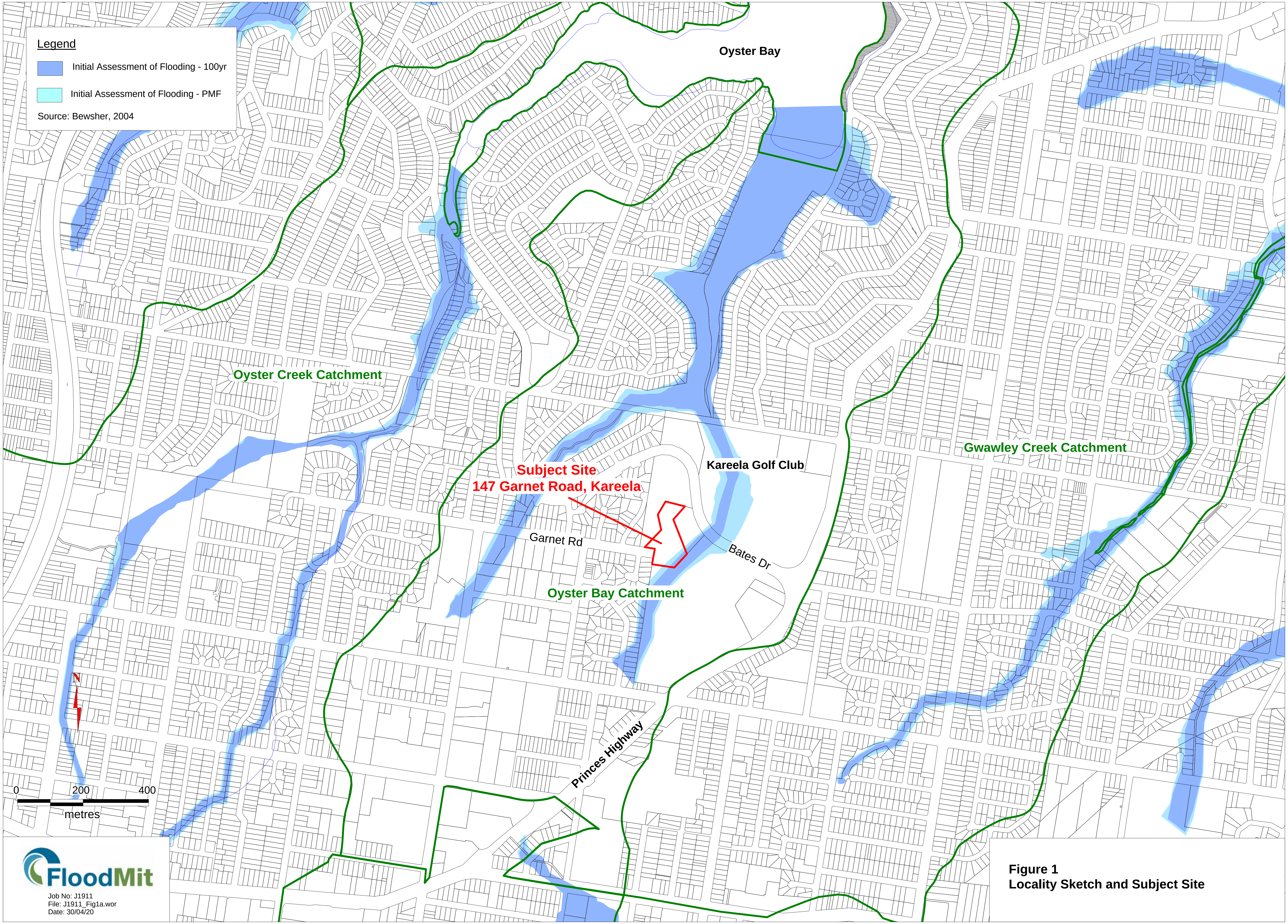

Figure 1
Locality Sketch and Subject Site

2 BACKGROUND INFORMATION

2.1 DESCRIPTION OF PROPOSAL

It is proposed to subdivide Lot 1142 DP 752064 into two lots, and to rezone the northern lot to permit future residential development.

Details of the proposed subdivision and future development are shown on drawings prepared by Couvaras Architects (27 March 2020, Issue L, Version R3). The most relevant drawing to this flood assessment is the site plan, which is reproduced at Figure 2. Key features of the proposed development have been digitised and overlaid on an aerial photo of the site, which is shown on Figure 3. These features are also included on subsequent flood mapping that has been prepared for the site for reference purposes.

Proposed Lot 104 is the northern portion of the property, and contains the existing Sylvanvale Administration Centre; a hydrotherapy pool; one classroom block; some minor sheds; and a driveway with parking areas. Proposed Lot 104 has an area of approximately 9,569m^2. It is intended to rezone part of this lot from SP2 *Educational Establishment* to R3 *Medium Density Residential* under Sutherland Shire LEP 2015. Proposed development is shown on Figures 2 and 3, and comprises:

i) 24 x 2BR villas;

ii) 19 x 3BR villas; and

iii) Basement parking

Proposed Lot 105 is the remaining portion of the original allotment. It largely contains the existing classrooms; play areas; driveway and parking areas. Proposed Lot 105 has an area of approximately 4,560m^2. It is intended that this part of the property would continue to operate as the Mikarie Childcare Centre.

2.2 AVAILABLE FLOOD DATA

The site has been identified by council as being potentially affected by stormwater flooding. This information is sourced from the *"Initial Subjective Assessment of Major Flooding"* (Bewsher 2004) that was prepared for Sutherland Shire Council. The subject site is shown to be partially inundated in both a 100 year ARI storm event and a more extreme Probable Maximum Flood (PMF) event along its southern boundary, as shown on Figures 1 and 3.

The initial assessment of major flooding is a broad scale assessment of flooding throughout the entire Sutherland Shire. It is based on relatively simple assessment criteria and limited topographic data available at the time. Its purpose is to alert Council of potential flood risk areas where more detailed investigations may be warranted. Inundation extents are very approximate and no information on flood levels or flood risk classification is available.

The purpose of the current flood assessment report is to better quantify the nature and risk of stormwater flooding in this part of the catchment.

2.3 AVAILABLE CATCHMENT DATA

The site is within the Oyster Bay Catchment, a stormwater catchment that drains to Oyster Bay, and eventually to the Georges River. It has a total catchment area of 265ha. The area that drains to the subject site has a contributing catchment area of 39ha.

An adjacent catchment, known as the Oyster Creek catchment, also drains to Oyster Bay and has been the subject of previous flood investigations (WMA Water, 2010). However, this study provides no information on flood behaviour at the subject site.

The catchment that drains to the subject site commences near the intersection of the Princes Highway and the Kingsway at Kirrawee. The flow in the upper catchment area is predominantly contained within the stormwater pipe drainage system. This directs flow in a northerly direction towards Kareela Oval. Surface flow continues to the north in an open drain adjacent to Kareela Oval, and as surface flow across these playing fields. Eventually the runoff enters an open drain along the southern boundary of the subject property, where it is directed towards a culvert under Bates Drive, and through the Kareela Golf Course to Oyster Bay.

Available catchment data that has been used in this flood assessment includes:

i) aerial photography;

ii) 1m resolution digital elevation model for the Port Hacking Area, derived from LiDAR survey captured in April 2013;

iii) ground contours at 0.25m intervals derived from the LiDAR model;

iv) site survey of the stormwater drain adjacent to the subject property, undertaken by Harrison, Friedmann & Associates in December 2019;

v) Council's stormwater pipe network;

vi) information from the "*Initial Assessment of Major Flooding"* (Bewsher, 2004); and

vii) field inspection undertaken on 8th November 2019.

The local catchment and drainage plan in the vicinity of the subject site is shown on Figure 4.

C	Issue for Community Consultation	04/05/20
D	Updated issue for Community Consultation	11/05/20
F	Updated Tree Plan	29/05/20
G	Issue for Planner Approval	23/07/20
J	Issue for Planner Version R3	30/3/21
L	Issue to Council Version R3	9/4/21

Figure 2

20020	147 Garnet Rd, Kareela	Site Plan	Sheet 06	Scale 1 : 500 @ A3	27 Mar 2020	Schematic plans only. NOT FOR CONSTRUCTION

Figure 3
Proposed Subdivision and Rezoning Application

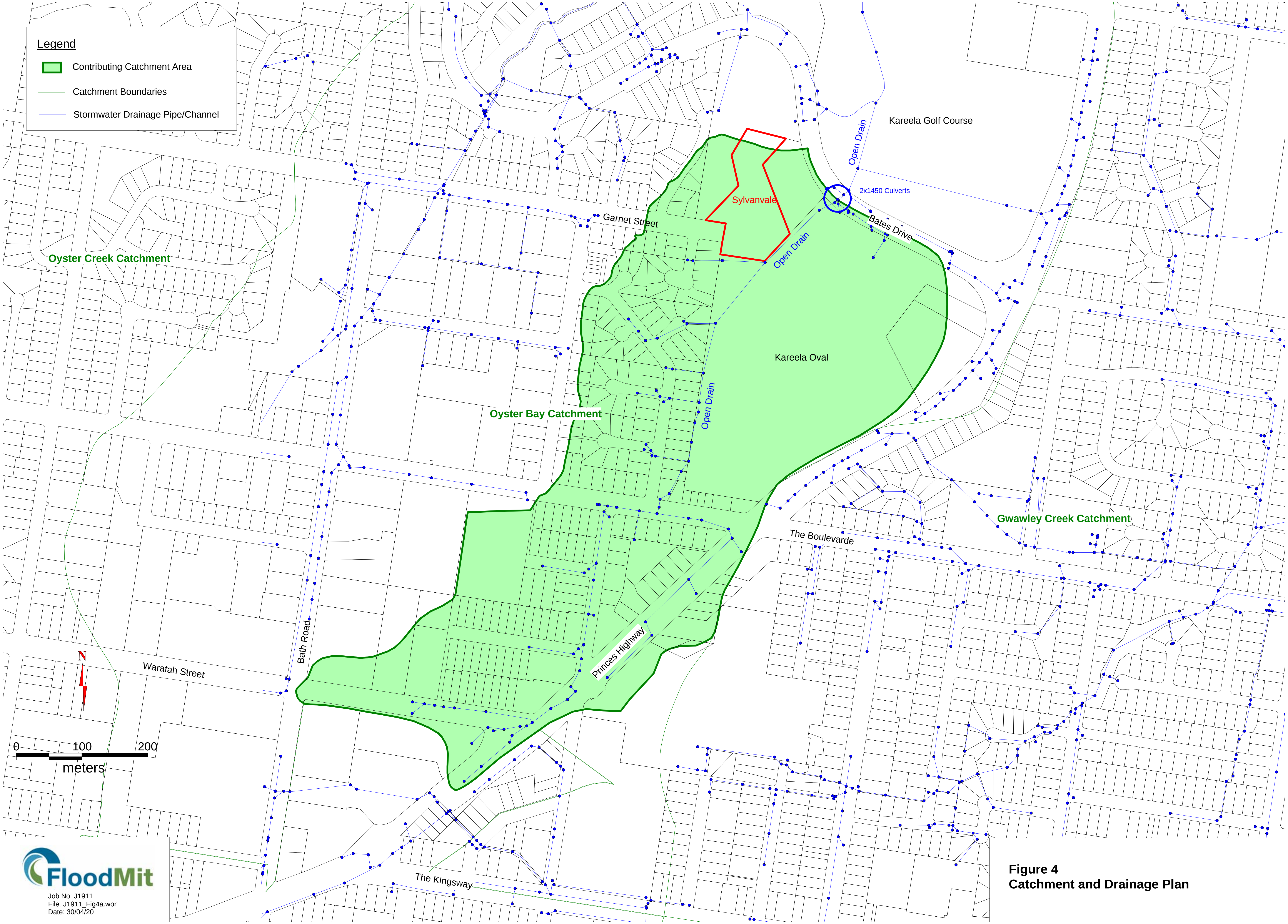

Figure 4
Catchment and Drainage Plan

3 DETAILED FLOOD ASSESSMENT

3.1 METHOD OF ASSESSMENT

The *"Initial Assessment of Major Flooding"* identified potential flooding along the southern boundary of the subject property. This coincides with a small open drain that is located in the adjacent reserve. The drain commences just downstream of Mikarie Place and runs along the southern boundary to culverts under Bates Drive.

A RAFTS hydrologic model of the catchment area was established to provide an assessment of stormwater runoff for the 20 year, 100 year and PMF storm events. Design rainfall intensities and patterns are based on Australian Rainfall & Runoff (ARR, 1987) for consistency with studies in adjacent catchments. An assessment of the sensitivity of results to more recent (ARR, 2019) rainfall data has also been undertaken.

These flows were then input to a HEC-RAS hydraulic model to simulate flood behaviour in the open drain and adjacent floodplain area. The hydraulic model extends from Mikarie Place to downstream of Bates Drive, and incorporates 16 model cross sections. Design flood levels were computed for the 20 year, 100 year and PMF storm events.

Computed flood levels were assigned to each model cross section included in the HEC-RAS model and a flood level grid derived. The extent of flooding was then delineated by computing the interception of the flood level grid with the surface DEM derived from the LiDAR survey.

Flood maps were then prepared to illustrate the extent of flooding and design flood level contours for the 100 year and PMF flood events. A flood risk management map that delineates the area of flooding into *High*, *Medium* and *Low Flood Risk* areas has also been prepared in accordance with procedures adopted by Sutherland Shire Council.

3.2 RAFTS HYDROLOGIC ANALYSIS

A RAFTS model of the local catchment area was developed to provide information on local catchment flows that contribute to flooding in the vicinity of the site.

The local catchment has a total area of 39Ha to Bates Drive. This area has been further subdivided into 14 smaller subcatchment areas, as shown on Figure 5. RAFTS model parameters adopted for the investigation are outlined in Table 1.

Design rainfall intensities were derived from Rainfall-Intensity-Duration tables provided by the Bureau of Meteorology for Sutherland (1987 AR&R intensities). Rainfall loss rates were based on 20mm and 2.5mm/hr for pervious areas within the catchment. These were reduced to 1.5mm and 0mm/hr for impervious areas. This is consistent with the approach adopted in studies undertaken in the adjacent Gwawley Bay catchment (FloodMit 2015), and Oyster Creek catchment (WMA Water, 2010).

All standard storm durations from 10 minutes to 6 hours were analysed to determine the maximum flow rate at various locations within the catchment. The critical duration across the study area was found to vary from 90 minutes to 2 hours for the 100 year flood. A PMF was also estimated, based on a 30 minute critical storm duration.

Peak flow rates through the catchment are summarised in Table 2.

Table 1
RAFTS Model Parameters

Subcatchment (Refer Fig 5)	**Location**	**Area (ha)**	**Av Slope (%)**	**Lag (mins)**	**Impervious**
1.00	Tea Gardens Ave	5.79	2.0%	4	80%
1.01	The Boulevarde	9.51	3.3%	3	65%
1.02	Kareela Oval	4.09	4.6%	2	60%
1.03	Kareela Oval	2.77	5.1%	2	60%
2.00	Garnet Rd	0.82	12.5%	1	60%
2.01	Open drain – U/S Site	1.63	10.0%	1	60%
1.04	Open drain – Mid Site	0.49	8.8%	2	0%
3.00	Oval runoff	5.21	6.0%	1	5%
1.05	Open Drain – D/S Site	0.31	6.7%	2	0%
4.00	Oval runoff	4.63	6.7%	2	5%
5.00	Inflow to Site	0.65	20.0%	1	5%
5.01	Outflow from Site	1.41	14.3%	1	60%
5.02	Outflow from D/S School	0.71	5.7%	1	65%
1.06	Open Drain - Bates Drive	0.66	5.0%	0	10%
TOTAL		38.68			

Table 2
Catchment Flow Estimates

Subcatchment (Refer Fig 5)	**Location**	**20 Year Flow (m^3/s)** (90/120 min storm)	**100 Year Flow (m^3/s)** (90/120 min storm)	**PMF (m^3/s)** (30minute storm)
1.00	Tea Gardens Ave	2.8	3.6	10.0
1.01	The Boulevarde	5.9	7.8	26.1
1.02	Kareela Oval	7.3	9.5	32.5
1.03	Kareela Oval	7.9	10.5	36.3
2.00	Garnet Rd	0.4	0.6	1.6
2.01	Open drain – U/S Site	1.3	1.6	4.7
1.04	Open drain – Mid Site	8.6	11.3	40.7
3.00	Oval runoff	1.9	2.5	9.1
1.05	Open Drain – D/S Site	10.2	13.3	49.4
4.00	Oval runoff	1.7	2.3	8.2
5.00	Inflow to Site	0.4	0.4	1.3
5.01	Outflow from Site	1.1	1.4	4.0
5.02	Outflow from D/S School	1.4	1.8	5.3
1.06	Open Drain - Bates Drive	12.5	16.3	61.3

3.3 SENSITIVITY TO CHANGES IN DESIGN RAINFALL INTENSITIES

Design rainfall intensities, patterns and loss rates have been under review since 2016, which is documented in Australian Rainfall & Runoff (ARR, 2019). A sensitivity assessment has been undertaken to determine the impact of revised rainfall data on design flows within the catchment.

A comparison of design rainfall intensities for the 100 year flood and storm durations ranging from 30 minutes to 6 hours is shown in Table 3. Results of the comparison indicate that the latest rainfall data is 22% to 29% lower than the adopted (1987) rainfall data.

Table 3
Comparison of Design Rainfall Intensities

Duration	Rainfall Total (mm)		Difference (%)
	ARR (1987)	ARR (2019)	
30 mins	63.5	49.5	22%
1.0 hr	88.2	64.4	27%
1.5 hrs	104.7	74.9	28%
2.0 hrs	117.4	83.9	29%
3.0 hrs	136.8	99.3	27%
6.0 hrs	176.4	137.0	22%

The impact of revised rainfall intensities and storm temporal patterns on design catchment flows was assessed in the RAFTS model. A comparison of peak flows at Bates Drive for a range in storm durations is provided in Table 4. Flows from the revised 2019 approach are considerably lower than flows from the adopted 1987 approach.

Table 4
Comparison of Design Flows at Bates Drive (100 Year Flood)

Duration	Peak Flow at Bates Drive Culvert (m^3/s)	
	ARR (1987)	ARR (2019) [1]
30 mins	14.0	9.6
45 mins	-	9.6
1.0 hr	15.7	9.0
1.5 hrs	15.4	7.5
2.0 hrs	16.3	8.4
3.0 hrs	12.3	-
6.0 hrs	8.6	-

1. Based on the median value from an ensemble of 10 different storm patterns

As the 1987 approach provides a conservative (higher) estimate of flood behaviour within the catchment, and this approach has been adopted in adjacent catchment studies, it has also been adopted for the current flood assessment.

3.4 HEC-RAS HYDRAULIC ANALYSIS OF FLOODING

A HEC-RAS model of the open drain and floodplain along the southern boundary of the subject property was established to model flood behaviour. The model, shown on Figure 6, includes a total of 17 cross sections from Mikarie Place to downstream of the Bates Drive culvert.

Cross sections were extracted from a DEM derived from LiDAR Survey acquired in April 2013. The DEM was sampled to provide 200 ground points along each cross section. The LiDAR survey provides an accurate representation of the ground terrain on clear ground (within 0.15m), but is less accurate in heavily vegetated areas. The existing open drain is heavily vegetated, and cross sections were consequently adjusted to match levels provided by the site survey in this area (Harrison, Friedmann & Associates, Dec 2019).

Model cross sections are included in Appendix A.

A lateral variation in roughness coefficients was assigned to each cross section based on the landuse type shown in Table 5.

Table 5
Adopted Manning's Roughness Coefficients

ID	Landuse Type	Adopted Manning's n
1	Road, bitumen	0.02
2	Maintained short grass	0.035
3	Moderate vegetation	0.07
4	Open Channel	0.07
5	Heavy vegetation	0.10
6	Property with building	0.10
7	Building	1.0

A besser block wall along the southern boundary of the subject property is an important feature that in places acts as a retaining wall, and in other places acts as a levee bank. The wall starts at the south-west corner of Lot 1142 and extends along the southern boundary for approximately 75m. The wall prevents flows from the open drain in the adjacent reserve from entering much of the subject property. The wall was included in the model as a vertical levee bank. The impact of the wall on flood behaviour was further assessed by undertaking a sensitivity assessment with the wall removed.

Culverts under Bates Drive were included in the model as twin 1450mm diameter pipes. These pipes are at a steep grade of approximately 8%, and supercritical flow through the structure occurs. It was assumed that these culverts were 50% blocked by debris, in accordance with council's normal policy.

Boundary conditions at the downstream end of the model are based on a normal depth calculation. The downstream channel is quite steep, and sensitivity testing indicated that model results upstream of Bates Drive were insensitive to assumed tailwater conditions.

Boundary inflows to the model are based on the results from the RAFTS analysis of catchment flows. Design inflows increase along the length of the open channel, as the contributing catchment area increases. Adopted flow rates are shown in Table 6.

Table 6
Surface Flows included in HEC-RAS Model

Section (Refer Fig 5)	**Location**	**20 Yr Flow** (m^3/s) (90/120 min storm)	**100 Yr Flow** (m^3/s) (90/120 min storm)	**PMF** (m^3/s) (30 min storm)
X17	Mikarie Place	1.3	1.6	4.7
X16		1.3	1.6	4.7
X15	Lot 1142 (SW corner)	1.3	1.6	4.7
X14		1.3	1.6	4.7
X13		3.7	4.8	16.7
X12		6.2	8.1	28.7
X11	Midpoint Lot 1142	8.6	11.3	40.7
X10		8.6	11.3	40.7
X9	Lot 1142 (SE corner)	10.2	13.3	49.4
X8		10.2	13.3	49.4
X7		10.2	13.3	49.4
X6		12.5	16.3	61.3
X5		12.5	16.3	61.3
X4	Bates Drive (Upstream)	12.5	16.3	61.3
X3	Bates Drive (Downstream)	12.5	16.3	61.3
X2		12.5	16.3	61.3
X1	Kareela Golf Club	12.5	16.3	61.3

Model results for the 20 year, 100 year and PMF Flood levels are shown in Table 7. Additional results for the 100 year flood are included in Appendix A. Further representation of the extent of flooding and design flood level contours is provided in Section 3.5.

The assessment indicates that the channel is hydraulically steep, with super critical or near super critical flood levels occurring at the majority of model cross sections. As a consequence, flood levels throughout the study area are relatively insensitive to downstream conditions, including the assumed tailwater levels in the Kareela Golf Course and blockage assumptions for the Bates Drive culvert.

Bates Drive is overtopped by approximately 0.31m in the 100 year flood, assuming 50% blockage. The depth of overtopping would reduce to 0.21m if there was no blockage of the culvert.

Table 7
Summary of HEC-RAS Results

Section (Refer Fig 6)	**Location**	**20 Year Level** (m AHD)	**100 Year Level** (m AHD)	**PMF Flood Level** (m AHD)
X17	Mikarie Place	48.74	48.76	48.86
X16		48.08	48.08	48.16
X15	Lot 1142 (SW corner)	45.34	45.36	45.53
X14		43.59	43.62	43.83
X13		42.55	42.58	42.81
X12		41.60	41.69	42.0
X11	Midpoint Lot 1142	40.34	40.45	40.72
X10		37.88	37.96	38.28
X9	Lot 1142 (SE corner)	36.45	36.56	37.19
X8		35.14	35.21	35.87
X7		34.14	34.30	34.96
X6		33.53	33.55	34.20
X5		33.57	33.62	34.04
X4	Bates Drive (Upstream)	33.56	33.61	34.07
X3	Bates Drive (Downstream)	30.98	31.13	32.11
X2		30.42	30.54	31.38
X1	Kareela Golf Club	26.43	26.60	27.81

3.5 IMPACT OF WALL ALONG SOUTHERN BOUNDARY

The Besser Block Wall along part of the southern property acts to prevent floodwater in the open channel and adjacent reserve from entering much of the site. Part of the wall also acts as a retaining wall, with ground levels in the adjacent reserve (and the open channel itself) considerably higher than levels within the subject property.

Lowering this wall to match the natural ground level within the adjacent reserve would permit additional flow within the open channel to spill from the reserve into the subject site, resulting in an increase in the extent of inundation experienced within the site. This has been assessed by removing the “levee” in the model that represents this wall. Results of the assessment indicate that whilst levels within the reserve are significantly lowered, this is at the expense of additional inundation within the subject site. This additional area of inundation is shown in subsequent flood maps that have been prepared.

It should also be noted that if the wall was completely removed, and the landform adjusted to more “natural” conditions, then it is likely that all flows within the channel and reserve would be directed onto the site, resulting in further inundation.

Table 8
Impact of Removing the Wall along the Southern Boundary

Section (Refer Fig 6)	**Location**	**Existing 100 Year Level** (m AHD)	**Wall Lowered to Level in Reserve**	
			100 Year Level	**Impact**
X17	Mikarie Place	48.76	48.76	0.00
X16		48.08	48.08	0.00
X15	Lot 1142 (SW corner)	45.36	45.36	0.00
X14		43.62	43.38	-0.24
X13		42.58	41.35	-1.23
X12		41.69	40.73	-0.96
X11	Midpoint Lot 1142	40.45	39.58	-0.87
X10		37.96	37.92	-0.04
X9	Lot 1142 (SE corner)	36.56	36.56	0.00
X8		35.21	35.21	0.00
X7		34.30	34.30	0.00
X6		33.55	33.55	0.00
X5		33.62	33.62	0.00
X4	Bates Drive (Upstream)	33.61	33.61	0.00
X3	Bates Drive (Downstream)	31.13	31.13	0.00
X2		30.54	30.54	0.00
X1	Kareela Golf Club	26.60	26.60	0.00

3.6 FLOOD LEVELS AND FLOOD EXTENTS

Flood levels were assigned to the HEC-RAS model Cross sections and a flood surface grid generated for the 100 year and PMF events. Flood extents were determined by calculating the point of intersection between the flood surface and the ground DEM. Flood Contours at 0.5m intervals were also determined from the relevant flood grids.

The extent of flooding and flood level contours for the 100 year flood event is depicted on Figure 7.

The results indicate that the majority of the site is protected by the besser block wall along the southern boundary of the site, with inundation from the adjacent reserve spilling onto the property where the wall terminates. Removal of this wall would result in more widespread inundation of the site, which would substantially impact on Proposed Lot 105 (the existing driveways and classroom buildings).

3.7 FLOOD RISK MANAGEMENT PRECINCTS

Sutherland Shire Council has adopted a flood risk classification that divides the floodplain into the following flood risk areas:

High Flood Risk – Land below the 100 year flood that is subject to a high hydraulic hazard or where there are significant evacuation issues;

Medium Flood Risk – Land that is below the 100 year flood that is not subject to a high hydraulic hazard and where there are no significant evacuation issues;

Low Flood Risk – All other land that could be potentially inundated up to the Probable Maximum Flood (PMF).

The flood risk classification is used by Council to determine the controls that apply to future development. All development is mostly restricted from the high flood risk area; development within the medium flood risk area is usually permissible subject to satisfying various flood related development controls; and most development is permitted within the low flood risk area with minimal flood related development controls.

A map showing the different flood risk precincts in the vicinity of the site is provided on Figure 8. The site would be classified as being partially within a *"Low Flood Risk"* area and partially within a *"Medium Flood Risk Area"*. The extent of the medium flood risk area would increase if the southern boundary wall were removed. This would impact mostly on proposed Lot 105, where it has been proposed to retain the majority of classroom buildings and driveways.

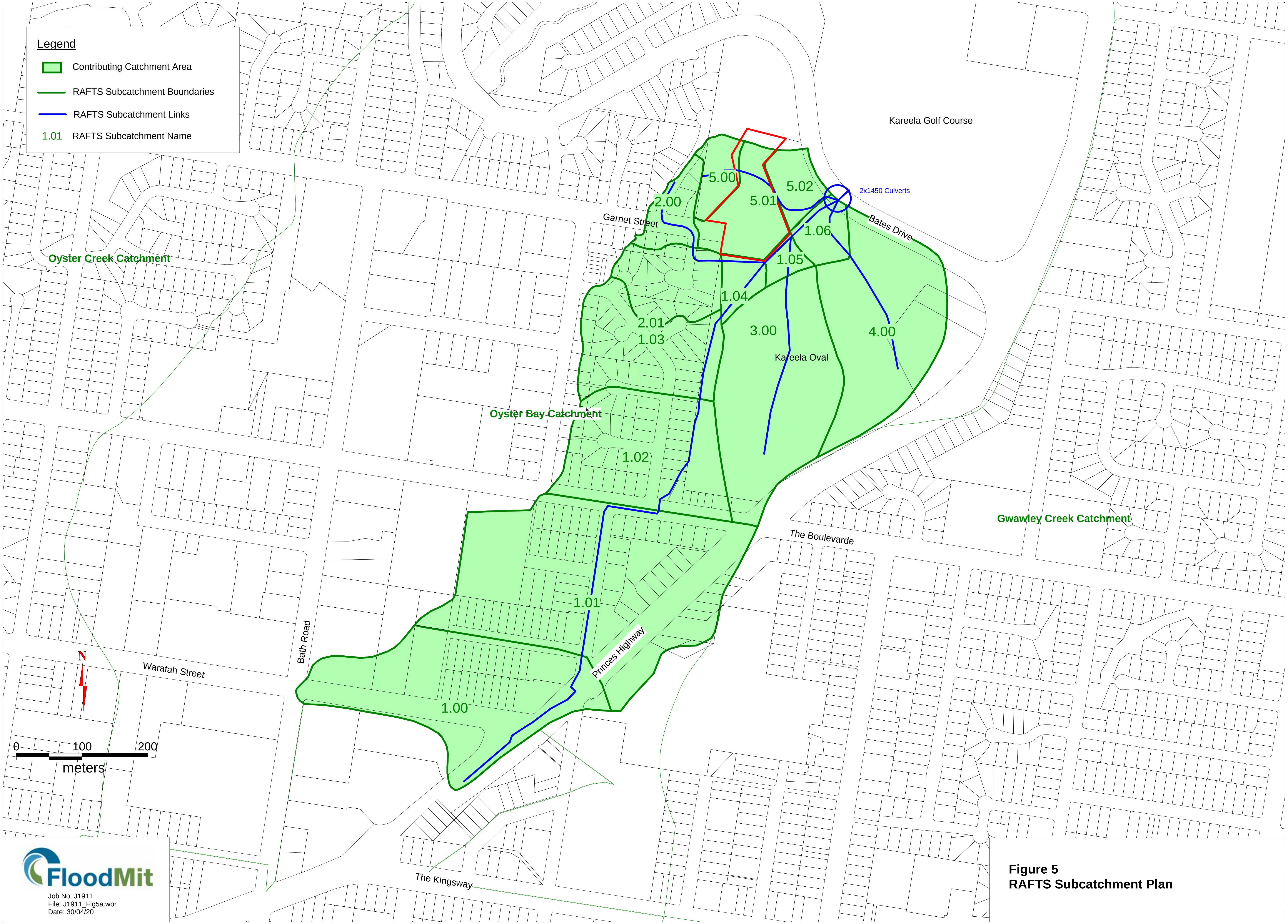

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Figure 5
RAFTS Subcatchment Plan

Figure 6
HEC-RAS Model Structure

Figure 7
100 Year Flood Extent and
Flood Level Contours (m AHD)

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Figure 8
Flood Risk Management Precincts

4 DISCUSSION

4.1 FLOOD AFFECTATION

The southern portion of the site is impacted by flooding from the open channel that is located in the adjacent reserve.

The extent of flooding in a 100 year flood, including design flood level contours, is shown on Figure 7. Floodwater spills out from the channel near the end of the besser block wall along the southern boundary and inundates approximately 470m^2 of proposed Lot 104. Additional inundation would occur if the besser block wall was removed, or it was to collapse. The additional inundation mainly impacts on proposed lot 105, where existing classrooms and driveway areas would be impacted.

The extent of flooding up to the probable maximum flood (PMF) is shown on Figure 8. This area has been delineated into high, medium and low flood risk areas, which is consistent with council's categorisation of flood liable land.

This flood assessment does not include consideration of stormwater drainage requirements within the site itself, or from the steep hill adjacent to the western boundary of the site. A separate site stormwater drainage assessment will be required.

4.2 COUNCIL FLOOD CONTROLS

Council's flood related development controls are specified in Sutherland Shire DCP 2015 – Chapter 40 (Environmental Risk). Development controls are based on the type of development proposed and the flood risk where the development is located.

Flood related development controls will apply to all land that has been identified as being within the medium and low flood risk areas, as shown on Figure 8. This mainly affects proposed lot 105 (where no new development is proposed) and a small portion of the south-east corner of proposed lot 104 (which partially impacts on proposed Block D which contains 2x 3 bed villas.

Council flood risk management requirements in relation to the proposed development is summarised below.

<u>Residential floor levels</u>

Habitable floor levels need to be 0.5m above the 100 year flood level (shown on Figure 7). The 100 year flood level is approximately RL 37.0m AHD, requiring a minimum floor level of RL 37.5m AHD.

The proposed ground floor level of Block D was shown on previous architectural drawings (Issue C) at RL 37.46m AHD. This is close to Council's minimum requirement, and can comply with minor variation to the design floor level.

The latest architectural drawings (Issue J) do not show the ground floor level of Block D, but it would appear that the building has been elevated by approximately 0.2m. It is assumed that the minimum floor level requirement has been complied with.

All other proposed buildings are outside the low flood risk area and not subject to flood related development controls.

Building components and methods

All structures are required to have flood compatible building materials below a level that is 0.5m above the 100 year flood level. Flood compatible materials include brick, concrete, steel, etc.

This condition would apply to the two villas in Block D.

It is considered that this condition can be satisfied.

Structural soundness

A flood certificate may be required to certify that the structure is capable of withstanding the forces of floodwater up to a level 0.5m above the 100 year flood level.

This condition would apply to the two villas in Block D.

Given the shallow depth of inundation within this area, it is considered that normal building practices will satisfy this requirement.

Flood Affects

A flood impact assessment may be required to demonstrate that the proposed development will not adversely affect neighbouring properties, or the development itself. This will particularly be important if there are proposals to fill the south-east corner of Lot 104 to reduce its flood liability.

All newly proposed buildings are located above the 100 year flood level, and there is no proposed filling below this level. Consequently, there will be no impact on floods up to the 100 year event.

Only a small portion of Block D is located within the PMF event, and it is considered that there will be very minor impacts in extreme flood events.

It is considered that this requirement can be satisfied.

Car parking and driveway access

Basement parking needs to be protected from inundation to a level that is 0.2m (and ideally 0.5m) above the 100 year flood level, and include other precautionary measures. Garages need to be 0.2m above the 100 year flood level. Open parking spaces need to be above the 100 year flood level. There are also requirements for driveways, including that the depth of inundation along the driveway does not increase between the parking space and the street.

Basement parking is proposed at two locations, as shown on Sheet 3 of the Architectural drawings. Both locations are outside the low flood risk area, and will satisfy this requirement.

Evacuation

Reliable access for pedestrians or vehicles is required to a point of refuge that is above the PMF flood level.

All proposed buildings, other than the two in Block D, have ground floor levels that are above the PMF, and evacuation during flood periods will not be required. The two buildings in Block D provide first floor levels above the PMF flood level, and shelter-in-place will be available.

It is considered that this requirement can be satisfied.

4.3 WALL ON SOUTHERN BOUNDARY

The besser block wall along the southern boundary of the site provides a degree of flood protection to the site, and it has been assumed that this wall will remain in place.

The wall also acts as a retaining wall, with higher ground levels within the reserve compared with levels within the southern part of the site. This is illustrated at Section 13 in the flood model (Appendix A) where the bottom of the channel (in the reserve) is about 1.0m higher than the levels along the driveway (within the site). If the wall was removed, and the landform adjusted to more natural conditions, the driveway in the site would effectively become the new “channel”. This would significantly impact on the existing access to the site and to Bates Drive Public School, as well as impacting on existing classrooms.

4.4 ENTRANCE FROM GARNET ROAD & MIKARIE PLACE

The two entrances to the site, at the end of Garnet Road and from Mikarie Place, could potentially be impacted by stormwater flow from Manooka Place and the lower end of Garnet Road. The stormwater flow from this area is estimated at $0.6m^3/s$ in a 100 year storm. Normally, this could be expected to be contained within the road reserve. However, the sharp bend from Garnet Road into Mikarie Place provides some propensity for at least part of this flow to continue across the road into one or both entrances to the site.

This could be rectified by local drainage provisions within the subject site, or preferably by preventing this flow from entering the site in the first place. For example, the two driveway entrances could be regraded to slope up to a crest height that is at least 0.3m above the kerb level on the main road prior to sloping back down into the site. This may need to be accompanied by minor landscaping changes between the two entrances.

5 REFERENCES

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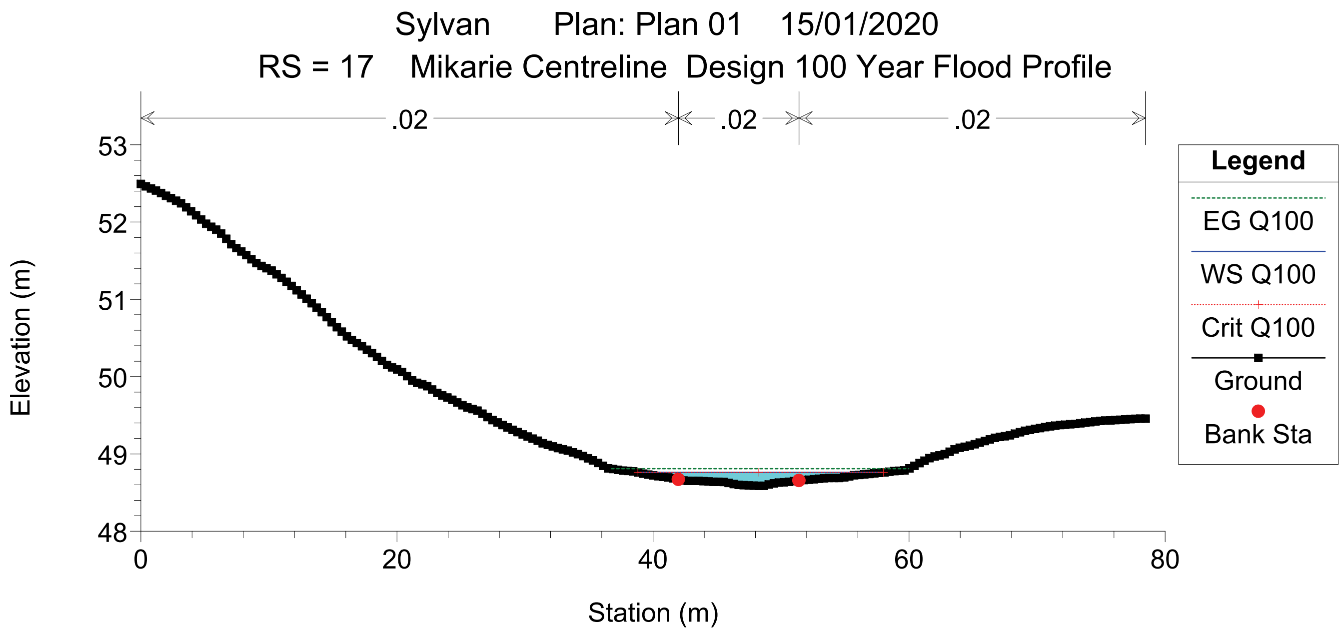
APPENDIX A

HEC-RAS Model Results and Cross Sections

HEC-RAS Plan: Existing River: Kareela Ck Reach: Main

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Main	17	Q20	1.30	48.59	48.745	48.75	48.79	0.006670	0.99	1.50	17.91	0.91
Main	17	Q100	1.60	48.59	48.761	48.76	48.81	0.006257	1.04	1.78	19.20	0.90
Main	17	PMF	4.70	48.59	48.858	48.86	48.94	0.005458	1.39	4.01	24.59	0.92
Main	16	Q20	1.30	47.99	48.076	48.08	48.20	0.179931	1.92	1.12	18.33	2.44
Main	16	Q100	1.60	47.99	48.076	48.08	48.27	0.272559	2.37	1.12	18.33	3.00
Main	16	PMF	4.70	47.99	48.158	48.16	48.25	0.055948	1.88	4.93	31.03	1.57
Main	15	Q20	1.30	45.10	45.337	45.34	45.41	0.030920	1.19	1.09	7.69	1.01
Main	15	Q100	1.60	45.10	45.361	45.36	45.44	0.029907	1.25	1.28	8.20	1.01
Main	15	PMF	4.70	45.10	45.529	45.53	45.66	0.025156	1.61	2.92	11.25	1.01
Main	14	Q20	1.30	43.00	43.587	43.49	43.62	0.025409	0.78	1.67	8.21	0.55
Main	14	Q100	1.60	43.00	43.624	43.52	43.66	0.024431	0.80	1.99	9.10	0.55
Main	14	PMF	4.70	43.00	43.832	43.72	43.89	0.025457	1.07	4.40	13.77	0.60
Main	13	Q20	3.70	42.00	42.552	42.55	42.63	0.088079	1.21	3.06	20.12	0.98
Main	13	Q100	4.80	42.00	42.578	42.58	42.67	0.087371	1.34	3.60	20.21	1.01
Main	13	PMF	16.70	42.00	42.813	42.81	43.02	0.065740	2.01	8.44	21.02	1.00
Main	12	Q20	6.20	40.61	41.601	41.49	41.71	0.030607	1.46	4.27	9.93	0.68
Main	12	Q100	8.10	40.61	41.685	41.57	41.82	0.030327	1.61	5.14	11.01	0.69
Main	12	PMF	28.70	40.61	42.000	42.00	42.00	0.000351	0.23	100.73	87.17	0.08
Main	11	Q20	8.60	39.22	40.341	40.34	40.59	0.056443	2.25	4.14	9.23	0.93
Main	11	Q100	11.30	39.22	40.453	40.45	40.74	0.053008	2.42	5.24	10.42	0.92
Main	11	PMF	40.70	39.22	40.720	40.72	40.73	0.000161	0.16	86.42	90.17	0.05
Main	10	Q20	8.60	37.31	37.881	37.88	38.04	0.067450	1.79	4.82	15.38	0.98
Main	10	Q100	11.30	37.31	37.955	37.96	38.14	0.058851	1.91	6.04	17.55	0.95
Main	10	PMF	40.70	37.31	38.276	38.28	38.51	0.008929	1.09	24.42	56.87	0.41
Main	9	Q20	10.20	35.29	36.449	36.45	36.68	0.038920	2.17	4.92	11.24	0.78
Main	9	Q100	13.30	35.29	36.559	36.56	36.81	0.032660	2.17	6.33	14.14	0.73
Main	9	PMF	49.40	35.29	37.190	37.19	37.55	0.011519	1.84	22.01	35.32	0.48
Main	8	Q20	10.20	33.81	35.140	35.00	35.30	0.031575	1.78	5.74	9.23	0.72
Main	8	Q100	13.30	33.81	35.213	35.11	35.43	0.038673	2.07	6.42	9.53	0.81
Main	8	PMF	49.40	33.81	35.865	35.86	36.19	0.023049	2.41	19.82	34.40	0.69
Main	7	Q20	10.20	33.30	34.139	34.09	34.34	0.048702	1.97	5.19	10.33	0.89
Main	7	Q100	13.30	33.30	34.300	34.20	34.49	0.036911	1.91	6.97	11.76	0.79
Main	7	PMF	49.40	33.30	34.959	34.96	35.36	0.037061	2.92	19.97	26.33	0.88
Main	6	Q20	12.50	32.64	33.530	33.38	33.64	0.022927	1.45	8.66	19.81	0.62
Main	6	Q100	16.30	32.64	33.547	33.50	33.72	0.034311	1.82	9.01	20.12	0.77
Main	6	PMF	61.30	32.64	34.201	34.20	34.50	0.017967	2.18	29.08	43.19	0.63
Main	5	Q20	12.50	31.88	33.568	32.72	33.58	0.000978	0.51	22.56	41.35	0.15
Main	5	Q100	16.30	31.88	33.616	32.85	33.64	0.001243	0.59	24.56	42.32	0.16
Main	5	PMF	61.30	31.88	34.038	33.61	34.18	0.002302	0.96	44.28	49.40	0.23
Main	4	Q20	12.50	31.51	33.565	32.25	33.58	0.001238	0.56	24.94	47.07	0.15
Main	4	Q100	16.30	31.51	33.613	32.40	33.63	0.001655	0.66	27.22	48.24	0.18
Main	4	PMF	61.30	31.51	34.070	33.62	34.15	0.003429	1.15	53.12	62.85	0.27
Main	3.5		Culvert									
Main	3	Q20	12.50	29.86	30.975	30.97	31.30	0.059211	2.53	4.93	7.55	1.00
Main	3	Q100	16.30	29.86	31.125	31.12	31.48	0.057126	2.66	6.14	8.52	1.00
Main	3	PMF	61.30	29.86	32.112	32.11	32.65	0.049478	3.26	18.82	17.41	1.00
Main	2	Q20	12.50	29.52	30.416	30.42	30.69	0.060596	2.32	5.38	9.77	1.00
Main	2	Q100	16.30	29.52	30.537	30.54	30.85	0.059767	2.46	6.63	10.95	1.01
Main	2	PMF	61.30	29.52	31.382	31.38	31.92	0.046486	3.25	18.97	18.95	0.98
Main	1	Q20	12.50	25.01	26.425	25.97	26.51	0.010009	1.27	9.86	11.25	0.43
Main	1	Q100	16.30	25.01	26.596	26.10	26.69	0.010001	1.38	11.84	11.84	0.44
Main	1	PMF	61.30	25.01	27.805	27.02	28.01	0.010000	2.06	31.80	24.02	0.48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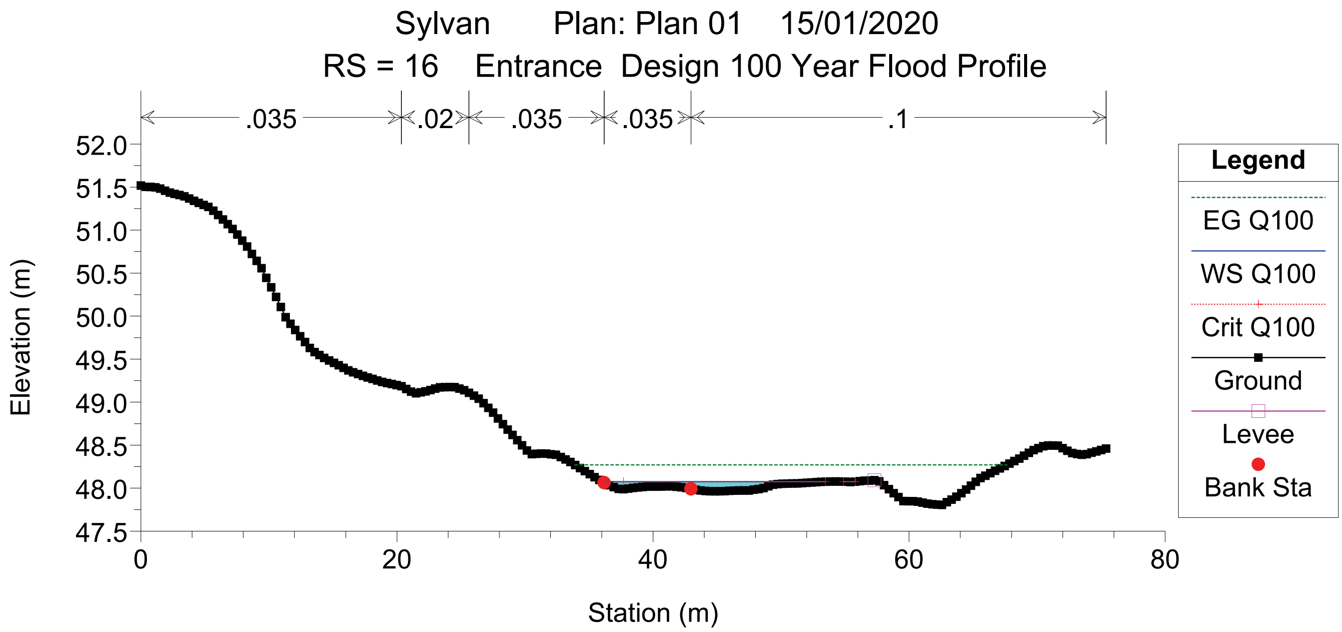
Crit Q100
Ground
Bank Sta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Station (m)
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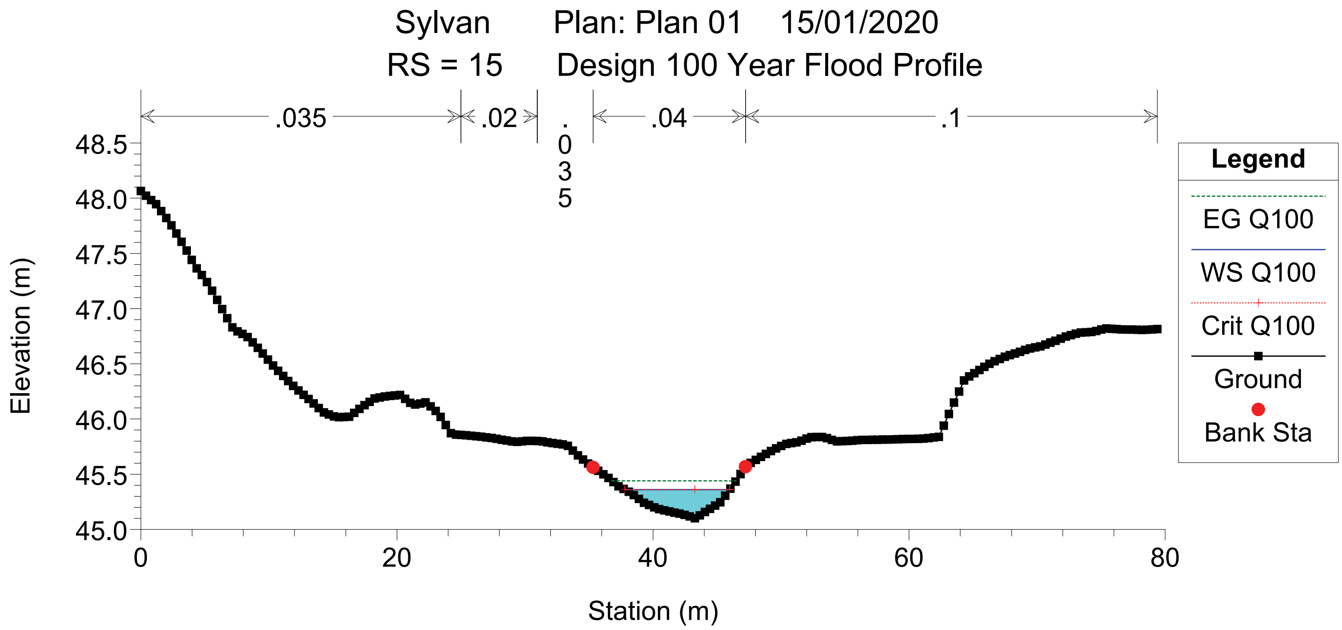
Crit Q100
Ground
Levee
Bank Sta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.04
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Station (m)
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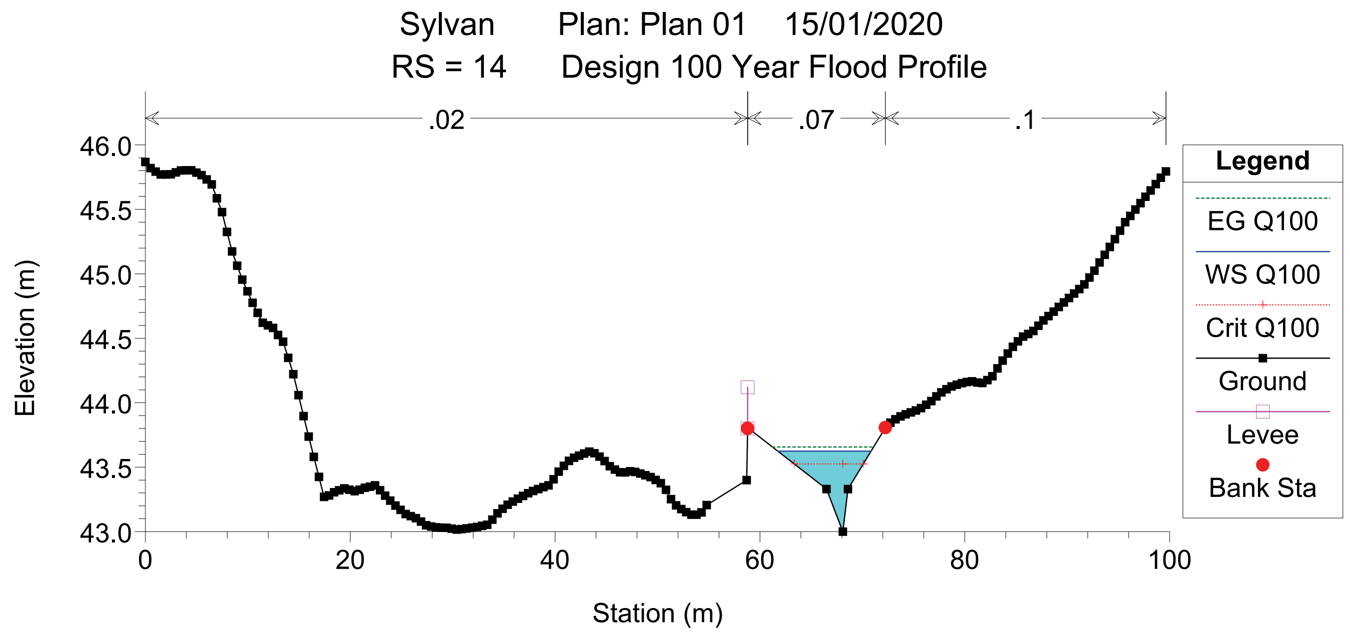
WS Q100
Crit Q100
Ground
Bank Sta



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WS Q100
Crit Q100
Ground
Levee
Bank Sta
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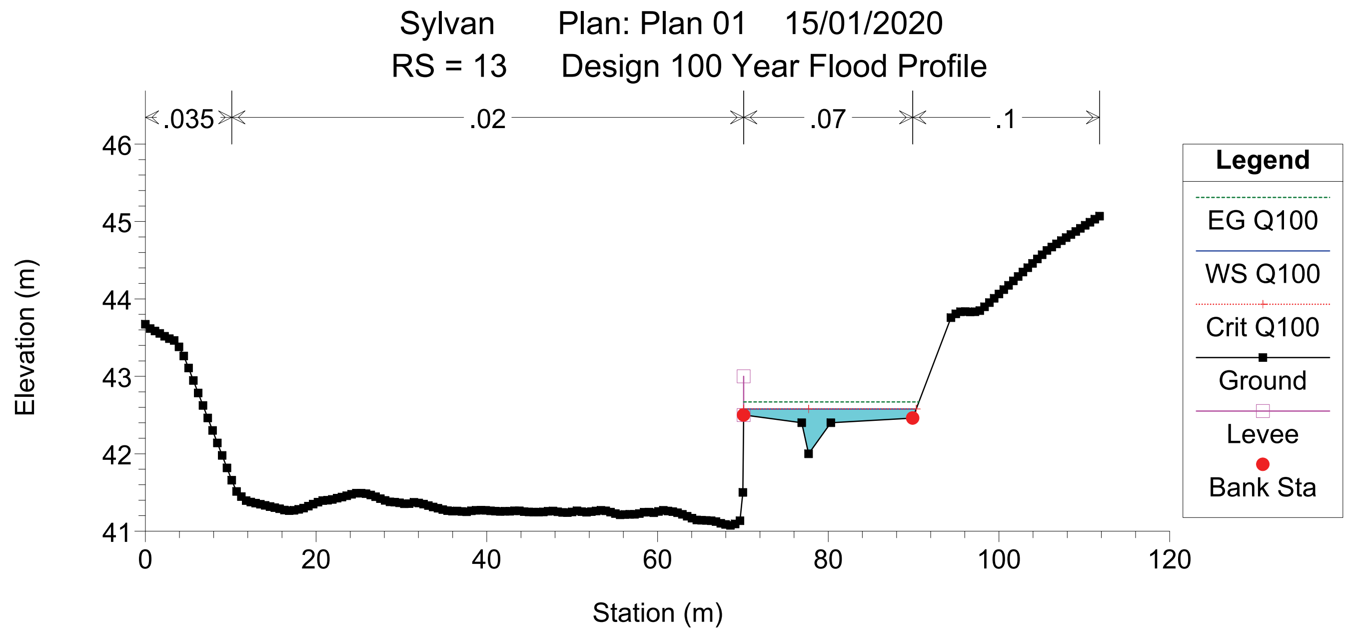
45.0
44.5
44.0
43.5
43.0
0
20
40
60
80
100
Station (m)



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.02
.07
.1
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Bank Sta
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45
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43
42
41
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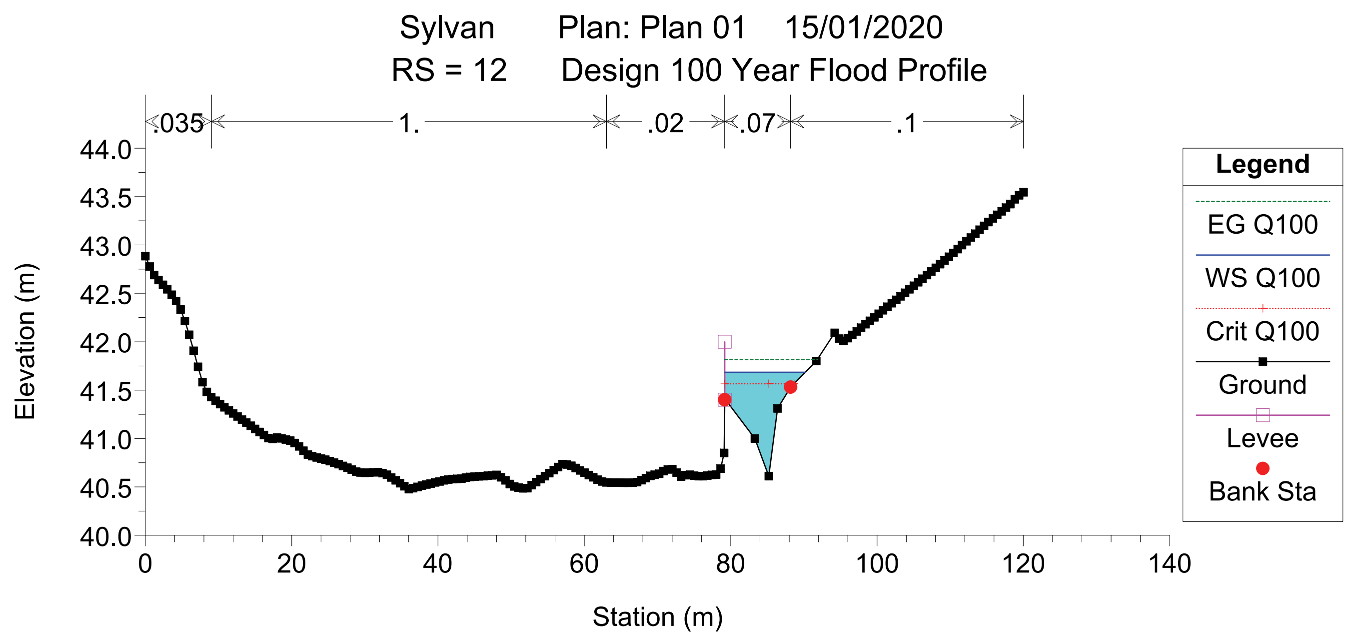
20
40
60
80
100
120
Station (m)



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RS = 12 Design 100 Year Flood Profile
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1.
.02
.07
.1
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Bank Sta
Elevation (m)
44.0
43.5
43.0
42.5
42.0
41.5
41.0
40.5
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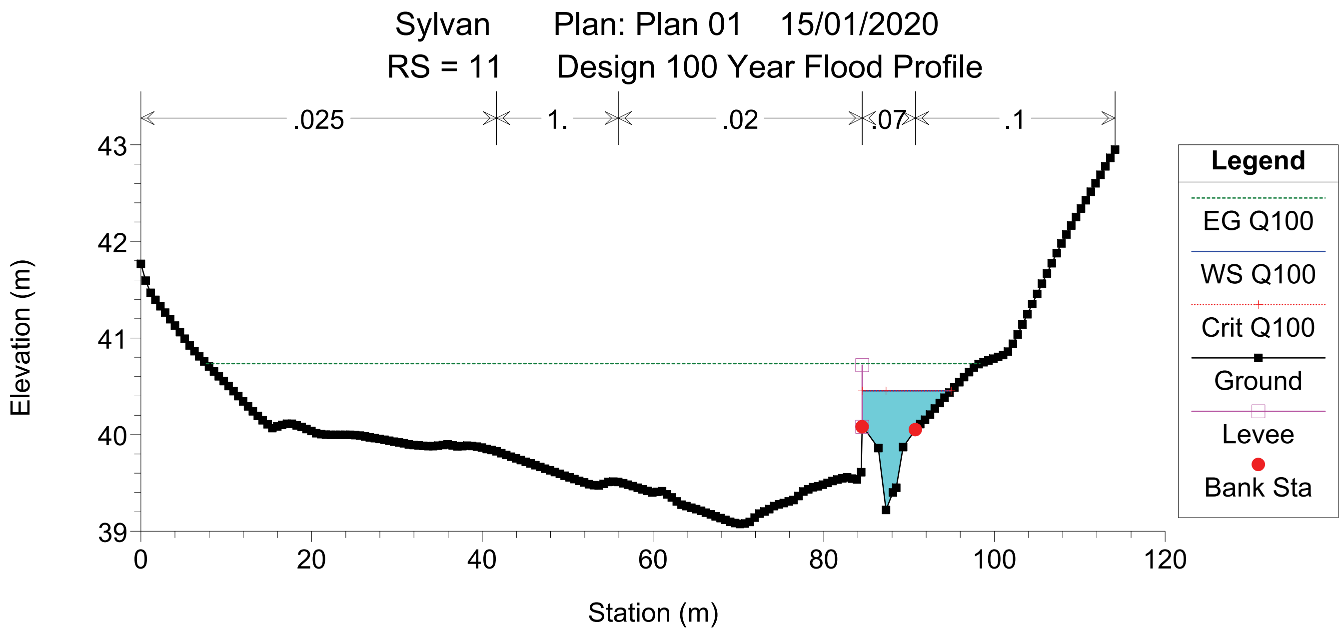
0
20
40
60
80
100
120
140
Station (m)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1.
.02
.07
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Station (m)
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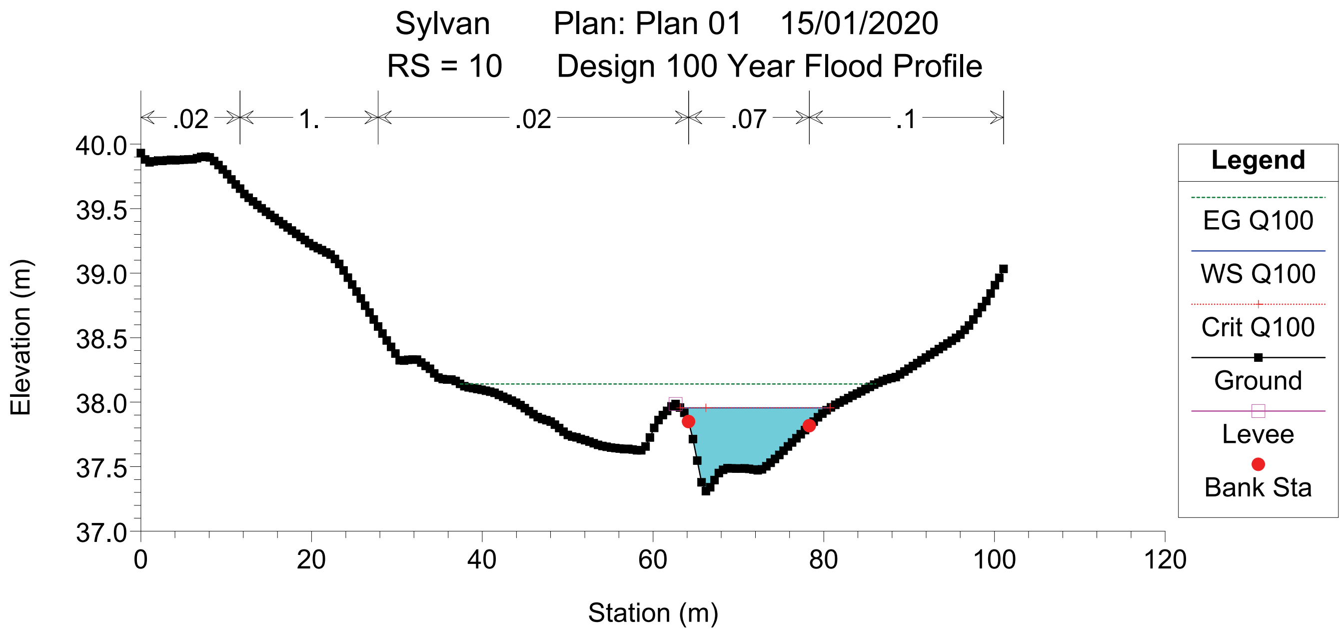
Crit Q100
Ground
Levee
Bank Sta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1.
.02
.07
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Station (m)
Legend
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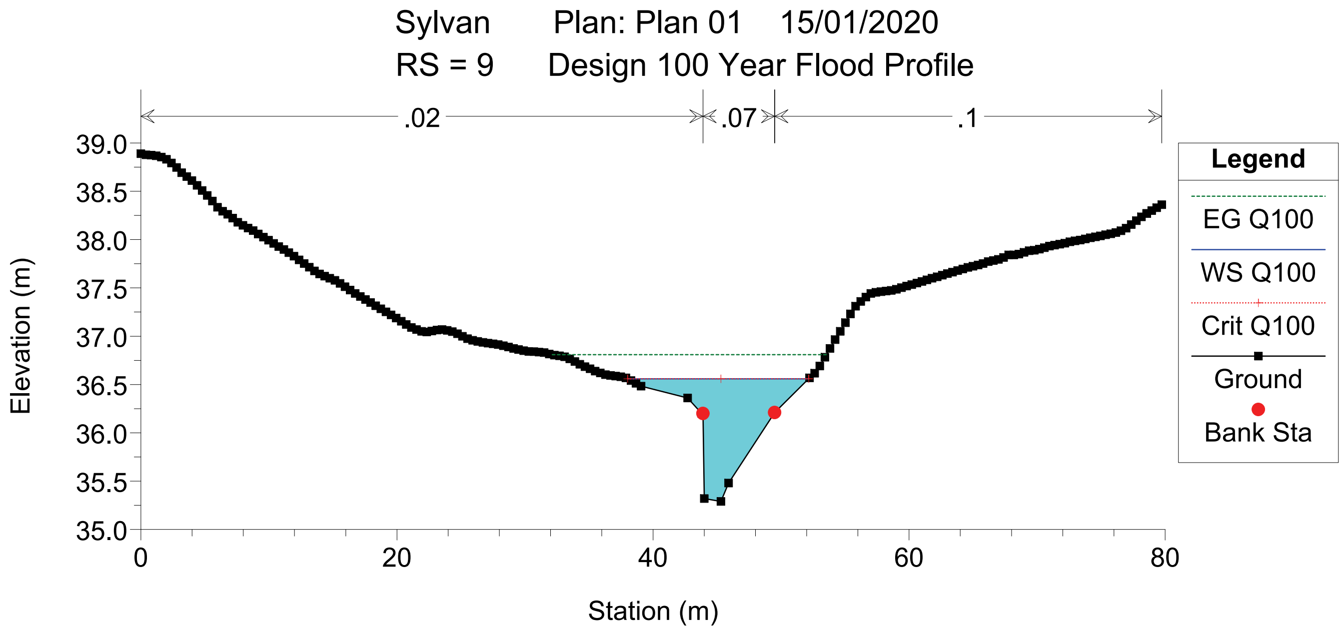
WS Q100
Crit Q100
Ground
Levee
Bank Sta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Station (m)
Legend
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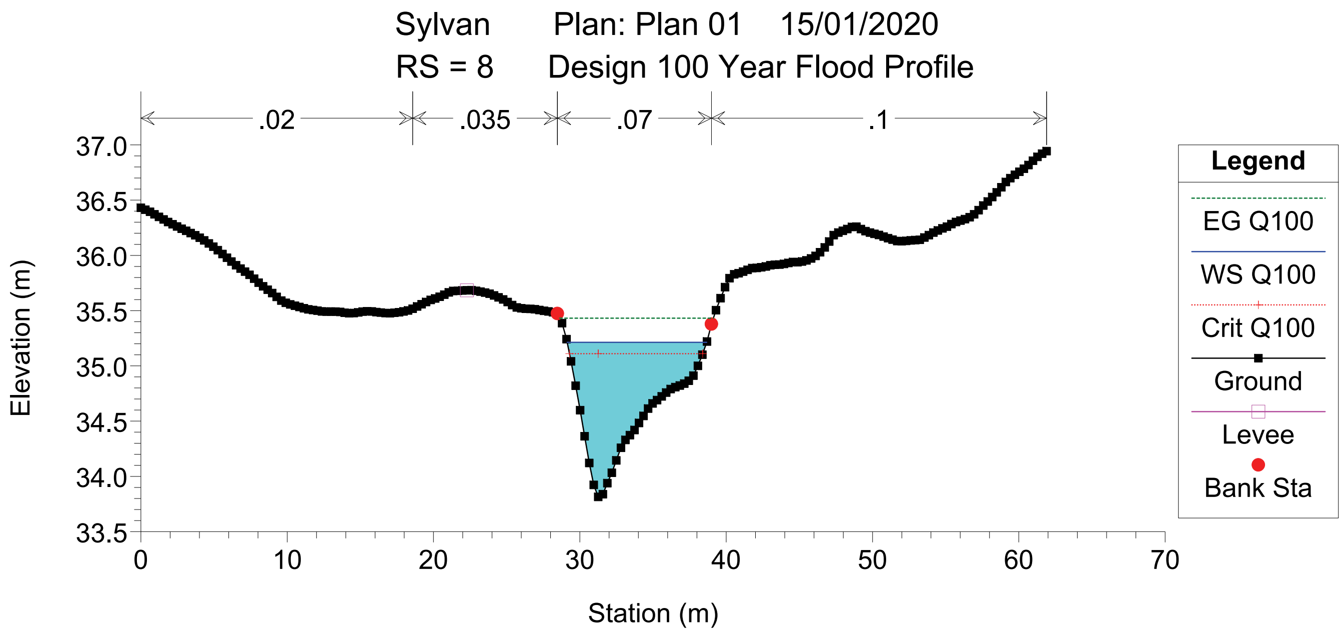
WS Q100
Crit Q100
Ground
Bank Sta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.035
.07
.1
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36.5
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35.0
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34.0
33.5
0
10
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60
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Station (m)
Legend
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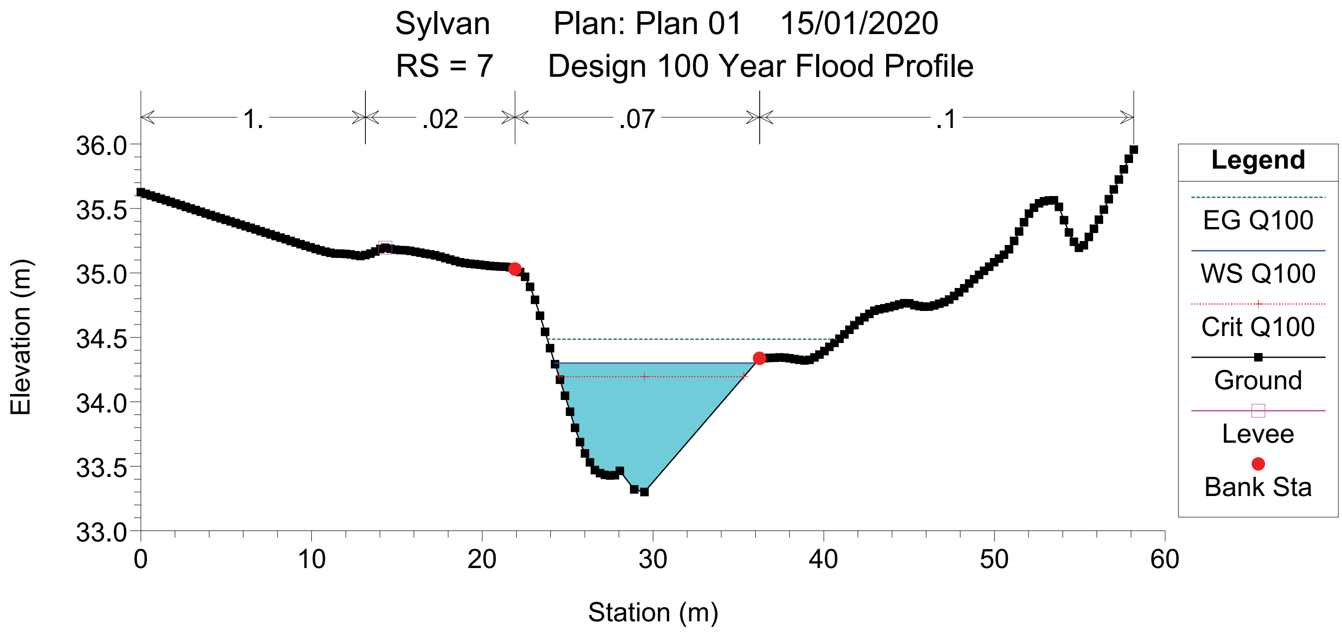
WS Q100
Crit Q100
Ground
Levee
Bank Sta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.02
.07
.1
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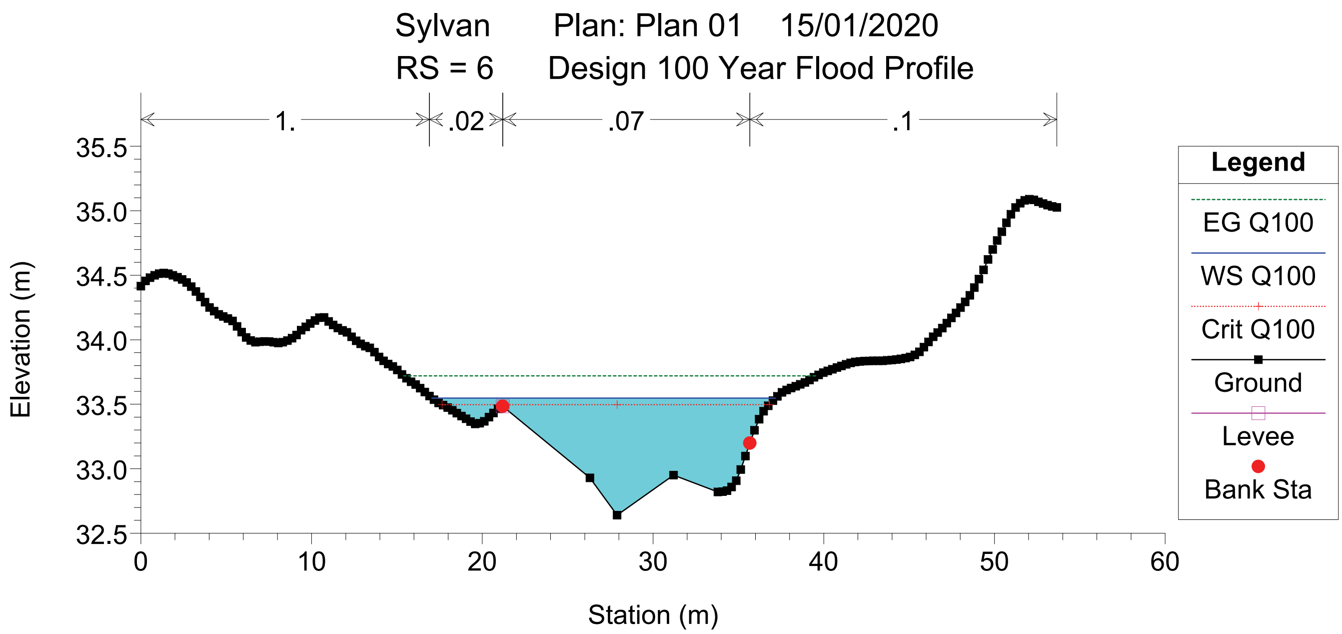
34.0
33.5
33.0
0
10
20
30
40
50
60
Station (m)
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Bank Sta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.02
.07
.1
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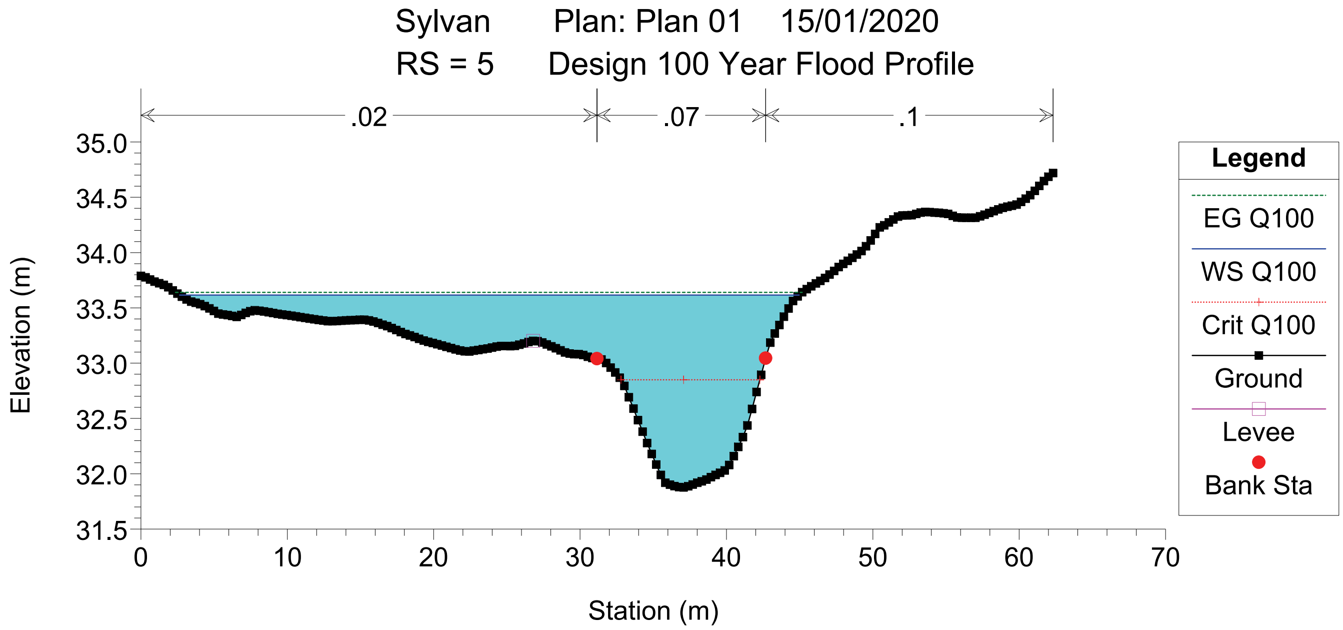
33.5
33.0
32.5
0
10
20
30
40
50
60
Station (m)
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Bank Sta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Station (m)
Legend
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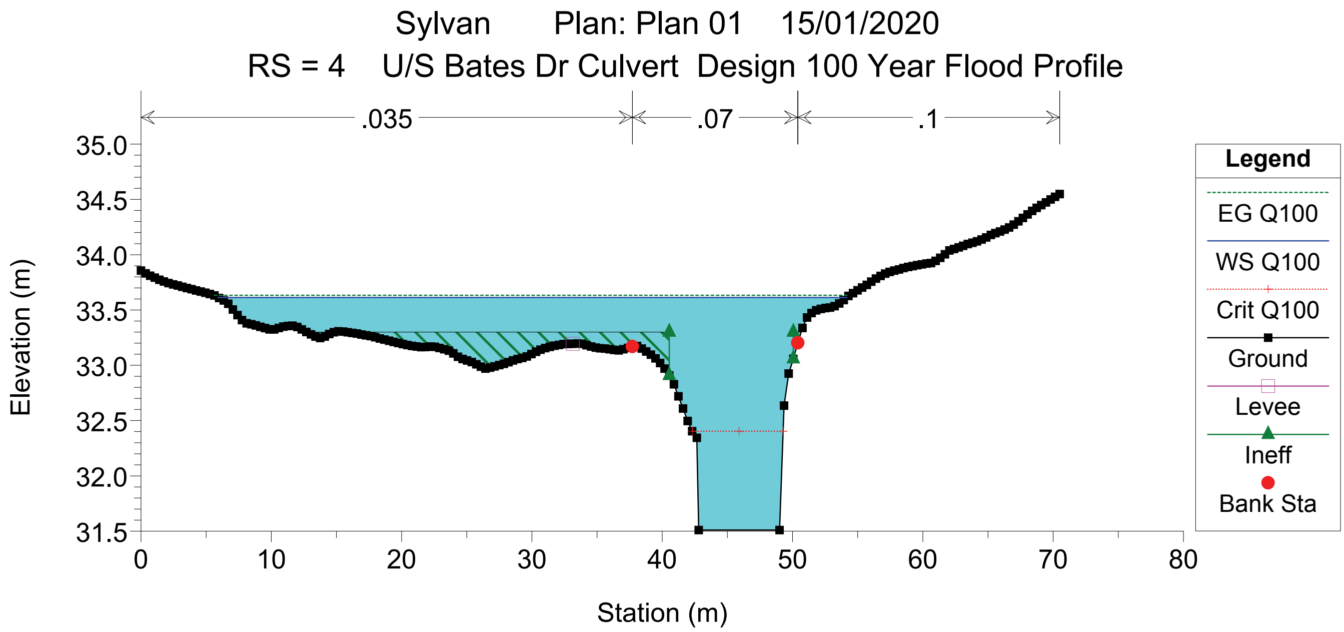
Ground
Levee
Bank Sta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.035
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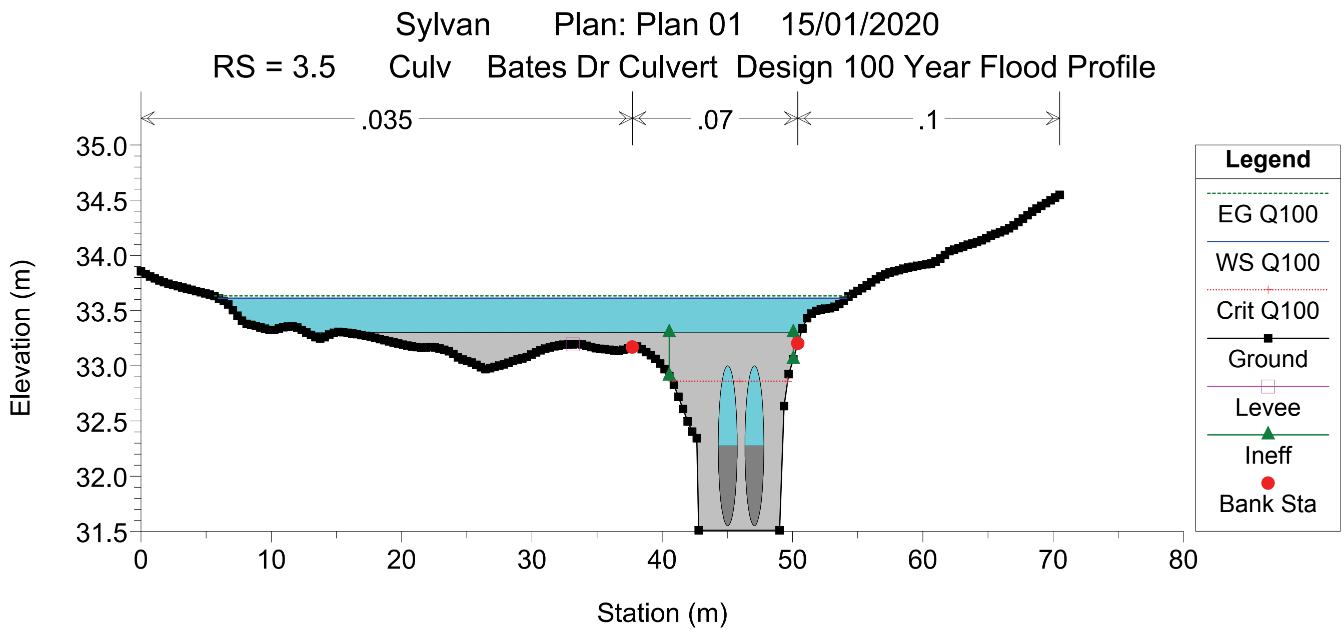
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Ineff
Bank Sta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.035
.07
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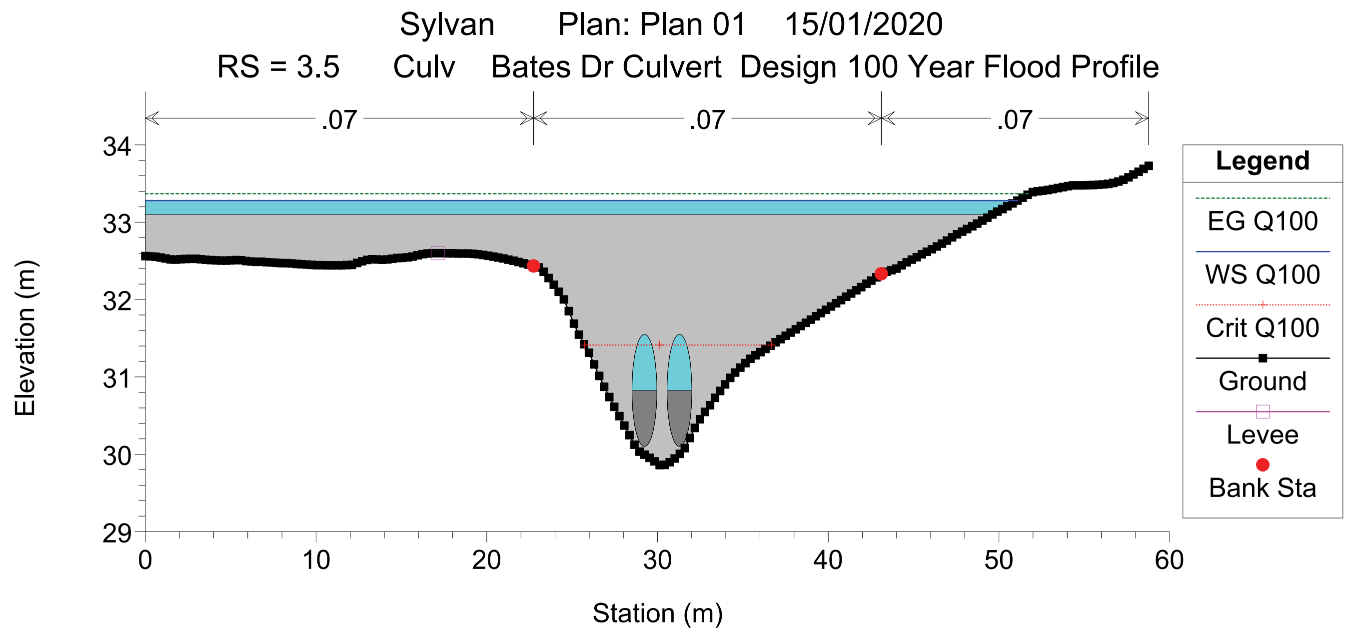
Station (m)
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Ineff
Bank Sta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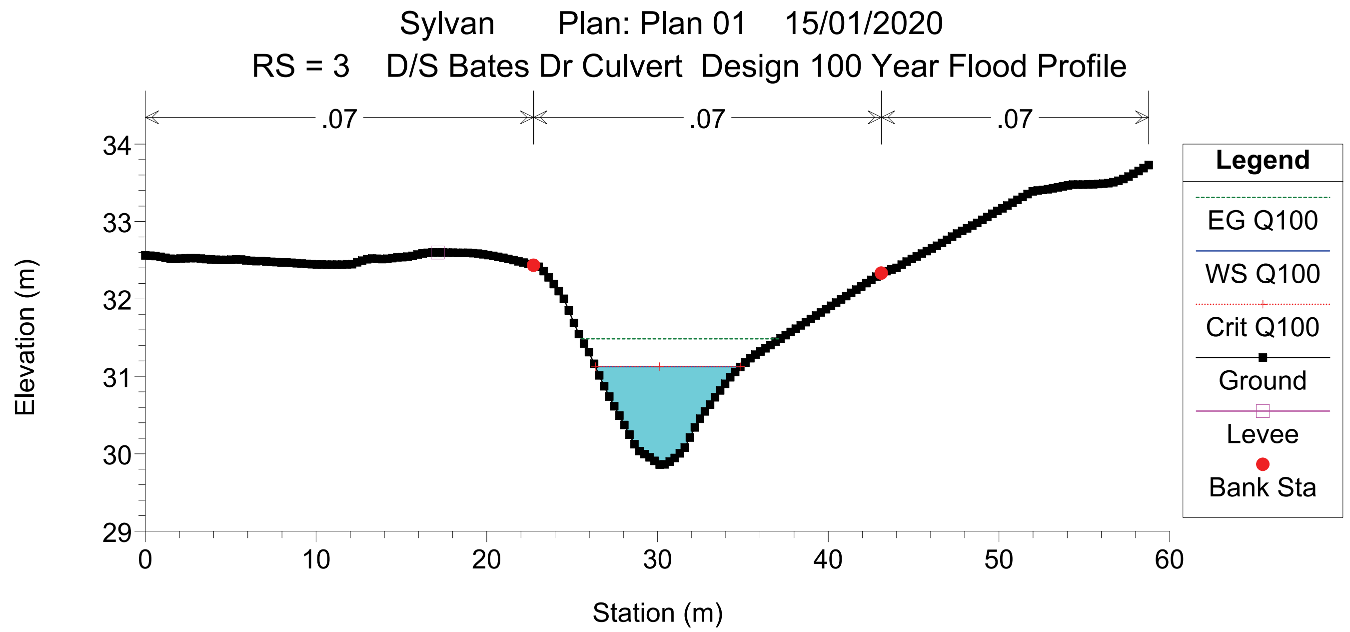
RS = 3.5 Culv Bates Dr Culvert Design 100 Year Flood Profile
.07
.07
.07
Elevation (m)
Station (m)
34
33
32
31
30
29
0
10
20
30
40
50
60
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Bank Sta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RS = 3 D/S Bates Dr Culvert Design 100 Year Flood Profile
.07
.07
.07
Elevation (m)
Station (m)
34
33
32
31
30
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50
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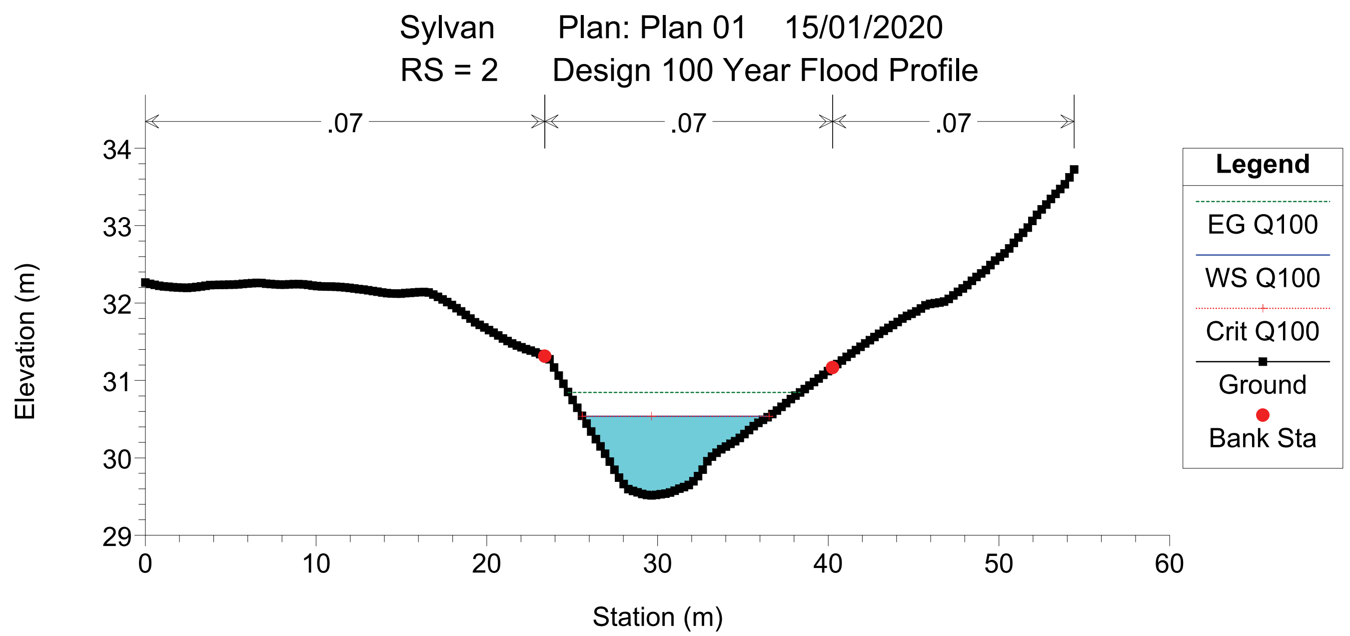
Legend
EG Q100
WS Q100
Crit Q100
Ground
Levee
Bank Sta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.07
.07
Elevation (m)
Station (m)
34
33
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31
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10
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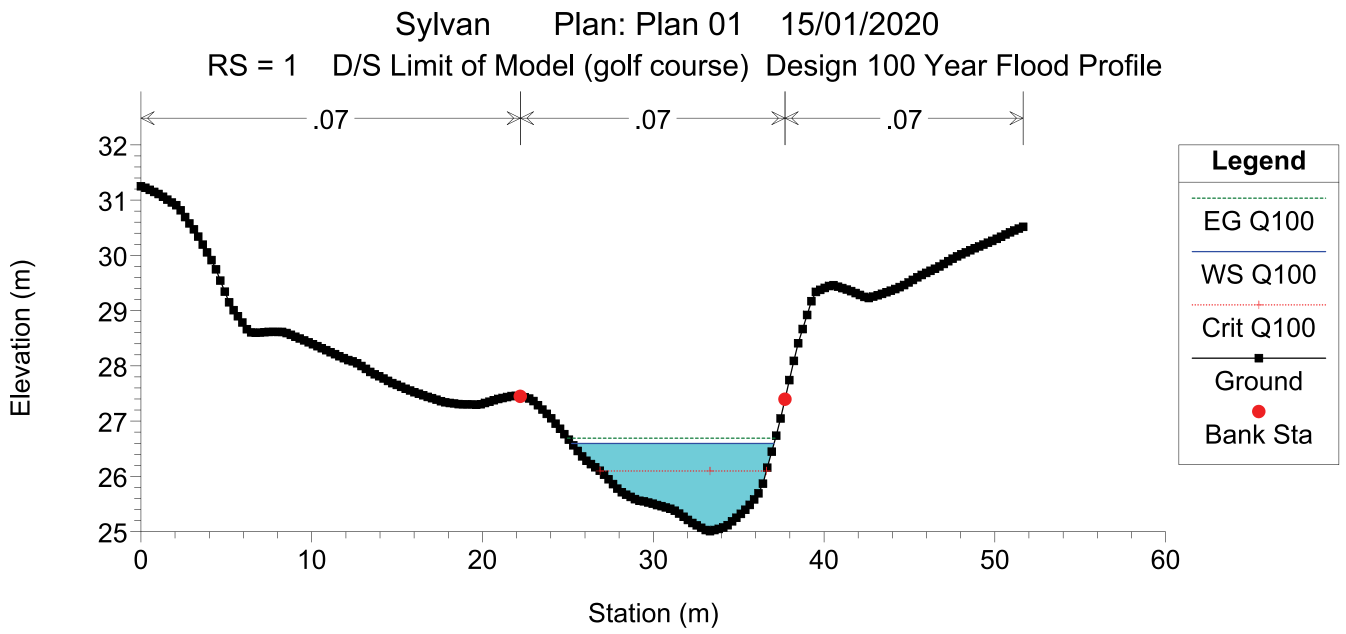
50
60
Legend
EG Q100
WS Q100
Crit Q100
Ground
Bank Sta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.07
.07
.07
Elevation (m)
32
31
30
29
28
27
26
25
0
10
20
30
40
50
60
Station (m)
Legend
EG Q100
WS Q100
Crit Q100
Ground
Bank Sta