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GOSFORD CITY COUNCIL

MIDDLE CREEK, PEARL BEACH FLOOD STUDY

Final Report
DECEMBER 2003

GOSFORD CITY COUNCIL

Middle Creek, Pearl Beach Flood Study

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Document Amendment and Approval Record

Issue	Description of Amendment	Prepared by [date]	Verified by [date]	Approved by [date]
1	Draft	BGP (11/11/98)	MST (11/11/98)	MST (11/11/98)
2	Final Draft	BGP (18/11/99)	MST (18/01/99)	MST (18/01/99)
3	Final	BGP (15/04/99)	MST (15/04/99)	MST (15/04/99)
4	Revisions to Final	BGP (12/08/99)	MST (12/08/99)	MST (12/08/99)
5	Public Exhibition Draft	BGP (26/11/99)	MST (26/11/99)	MST (26/11/99)
6	Final Report	RHB (03/12/03)	4/12/03	4.12.03

Note: This document is preliminary unless it is approved by a principal of Patterson Britton & Partners.

Document Reference: rp3144.01rhb-jl031202-middle creek final

Time and Date Printed: 5:21 PM 2 December, 2003

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consulting engineers

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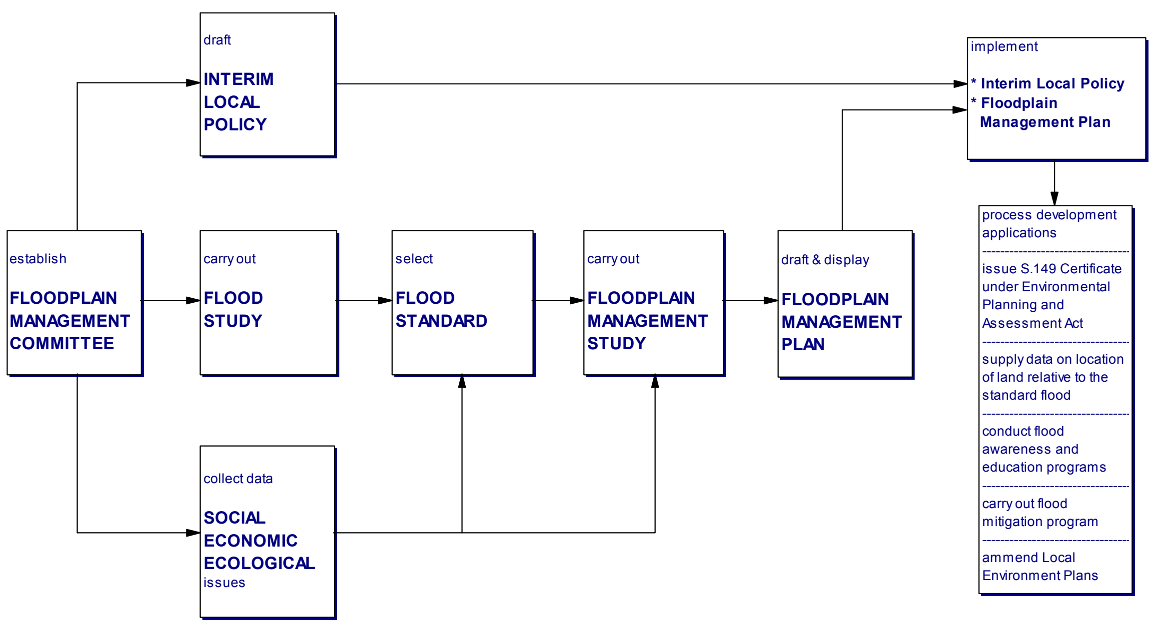
1 SUMMARY

Gosford City Council commissioned Patterson Britton & Partners to undertake an investigation into the flooding of the Middle Creek catchment at Pearl Beach.

The *'Floodplain Development Manual' (Ref.)* outlines the steps involved in the floodplain management process (*refer below*). No detailed flood study has been undertaken for the Middle Creek catchment. Therefore, the first step that needs to be carried out in this process is the Flood Study, which will include detailed flood modelling for the purposes of carrying out the Floodplain Management Study and Plan.



The floodplain management plan for the study area will then address the existing, future, and residual flood and environmental problems, in accordance with the NSW Government's Flood Policy as detailed in NSW Government's *Floodplain Development Manual*.

Specifically, the objectives of this flood study were to:

- define flood behaviour along Middle Creek for the 20%, 5%, 1% AEP and an extreme event using hydrologic and hydraulic models; and
- present the flood behaviour for Middle Creek in a clear and concise manner, including flood flows, velocities and levels for the above events.

The approach adopted for this flood study was:

- collect and collate background information;
- assemble and calibrate hydrological model of catchment;
- review and modify existing hydraulic model, refine and calibrate as necessary; and
- define design flood flows, levels, velocities and extents for three scenarios, these being:

1. Existing conditions;
2. Flood Mitigation Works – Proposed culvert extension upstream of Diamond Road; and
3. Ultimate Flood Mitigation Works – Proposed culvert extension upstream of Diamond Road, and channel widening works between chainage 270.0 and 405.0.

The findings of the flood study were that the proposed culverts works currently under construction upstream of Diamond Road would effectively alleviate inundation of existing properties along Middle Creek between Chainage 0.0 and 270.0 up to and including a 1% AEP flood event.

Also it was found that the proposed channel works, combined with the culvert works will effectively ensure flood free conditions for all existing properties along Middle Creek at Pearl Beach.

As no detailed coastal analysis has been undertaken, Council has advised that a flood level of RL 4.0 m AHD be adopted for locations between the beach, up to a point where the flood level is 4.0 m AHD from catchment flows. Council's advice regarding coastal effects has been based on the recent analysis of the nearby Green Point Creek outlet. These investigations indicated that a flood level of RL 4.05 m was appropriate for the hindrance to flood flows caused by the beach berm and dune at this and other similar creek outlets to Pearl Beach.

During an extreme event (*twice the 1% AEP flow*), it is estimated that for the ultimate flood mitigation works scenario, up to 9 sheds and garages and 1 residence would be inundated.

Estimated flood flows, levels, velocities and extents for the various events are presented in this report.

2 INTRODUCTION

2.1 STUDY AREA

The study area for this investigation is the Middle Creek channel between the western end of Emerald Street, and the outlet into Broken Bay near Pearl Parade, Pearl Beach. Middle Creek flows between the properties fronting Pearl Beach Drive and Emerald Avenue. The study area is shown in **Figure 1**.

2.2 BACKGROUND

Recent investigations of Middle Creek have been undertaken for Council by various consultants. These include a flood investigation dated April 1989 by Giammarco Civil & Structural Engineering Pty Ltd, and hydrological and hydraulic modelling prepared by Boyden & Partners as part of their recent design works for the creek. These more recent investigations provided the base hydraulic model for the study, although it has been modified to suit existing conditions.

2.3 DATA

The following background data was used to undertake this study:

<u>*Topographic Maps*</u>

- **Broken Bay 2782-4-A** (1:2000) Orthophotomap - *Central Mapping Authority*, Dept of Lands, 1974;

- **Broken Bay 2782-1-C** (1:2000) Orthophotomap - *Central Mapping Authority*, Dept of Lands, 1974

<u>*Design Drawings*</u>

- Drainage Improvement Works, Middle Creek Catchment, Pearl Beach – File No. 920.14.18, **Dwg No.s 14/38/00 to 14/38/15** inclusive – *Boyden & Partners Pty Ltd* for Gosford City Council, May 1998

<u>*Hydraulic Models*</u>

- HEC-RAS model: **98047.prj**, *Boyden & Partners Pty Ltd* for Gosford City Council, May 1998

<u>*Local Zoning Plan*</u>

- **Zoning Plan for Pearl Beach**, *Gosford City Council*, 1998.

2.4 ELEMENTS OF STUDY

The elements of this study include:

- *review of existing data*, including the previous investigations listed above in terms of the suitability of the survey data for hydraulic modelling, and a comprehensive review of the hydrological and hydraulic modelling;
- *Hydrologic Modelling*, establishment of RAFTS rainfall/runoff model of the Middle Creek catchment including the study area to estimate flows under existing catchment conditions for the 1%, 5% and 20% AEP events as well as an extreme flood event;
- *Hydraulic Modelling*, utilisation of the HEC-RAS hydraulic model from the previous investigations undertaken by Boyden & Partners, with modifications to identify flood behaviour for existing and post flood mitigation works scenarios (*3 Scenarios in total*) and flood levels for the design events listed above; and
- Produce a bound report describing the methodology and results of the flood study, in accordance with the NSW Government Floodplain Development Manual and the headings outlined in the brief.

3 HYDROLOGIC MODELLING

3.1 RAFTS HYDROLOGIC MODEL

RAFTS is a non-linear rainfall/runoff program developed by WP software, in Canberra. RAFTS can be used to estimate peak flows for catchments, using actual storm events, or design rainfall data derived from AR&R, 1987 (*Ref.*).

To undertake the hydrologic modelling, a RAFTS rainfall/runoff model was established for the Middle Creek catchment. This model was used to estimate flows under existing catchment condition for the 1%, 5% and 20% AEP events as well as an extreme flood event. All hydrologic analyses were undertaken in accordance with "*Australian Rainfall and Runoff – A Guide to Flood Estimation*", (*Volumes I and II, IEAust, 1987*).

RAFTS was chosen for this investigation because it has the following attributes:

- it can account for spatial and temporal variation in storm rainfall across a catchment;
- it can accommodate variations in catchment characteristics;
- it can be used to estimate discharge hydrographs at any location within the catchment; and
- it has been widely used across NSW.

3.2 MODEL SET-UP

The catchment was divided into a number of subcatchments based on the topography, land use, road and the existing drainage system layout. Estimates of existing peak design flows were derived for input into the hydraulic model.

Each subcatchment has parameters defined including area, weighted average catchment slope, the percentage of impervious area, and lag time to the next downstream sub-catchment. A summary of adopted subcatchment parameters is enclosed in **Appendix A**.

A total of 13 subcatchments were identified for the RAFTS model, with a total catchment area of approximately 60 ha. The catchment breakdown is shown on **Figure 1**, including the RAFTS model network layout.

3.3 CALIBRATION

As no stream gauge exists in the catchment, there was no possibility of a true storm calibration, however comparison was made with the rational formula calculations for "small to medium sized rural catchments", as outlined in ARR 1987 (*Ref.*). The results of this comparison are shown below in **Table 3.1**.

Table 3.1 : Comparison of Peak Flow Results between RAFTS and Rational Method

Average Recurrence Interval (AEP)	Peak discharge estimated using Rational Method (m^3/s)	Peak discharge estimated using RAFTS model (m^3/s)
20%	9.0	12.2
5%	14.7	16.1
1%	24.0	20.2
extreme (2 x 1% AEP)	N/A *	41.2

Note: * : The rational method is only intended to be used up to and including the 100 year ARI event.

As can be seen from the results tabulated above, the RAFTS results are slightly higher than those derived using the rational formula for events more frequent than the 1% AEP event, however, the rational method overestimates the peak 1% AEP peak flow, compared to the RAFTS model. This effect could be caused by storage effects in the RAFTS model, which tend to reduce the differences in peak flow estimates for different recurrence interval storm events.

The rational method calculations gave results that were comparable to the RAFTS model results. The RAFTS model results were adopted because the methodology is more comprehensive than the rational method, taking into account subcatchment slope, roughness, impervious percentage and lag times.

3.4 DESIGN STORM SIMULATION RESULTS

The RAFTS model, once "calibrated" was used to simulate runoff generated using design storm rainfall intensities and temporal patterns for the study area. Storm rainfall data was generated by applying the principals of rainfall intensity estimation and design temporal distributions outlined in AR&R (*Ref.).*

A range of storm durations were considered and modelled to establish the critical storm duration for the catchment. The critical storm duration corresponds to the maximum peak discharge generated by the hydrologic model for the most downstream node within the catchment.

A critical duration of 2 hours was determined for the catchment.

Using a critical duration of 2 hours and the corresponding rainfall intensities and design temporal patterns, peak discharges and discharge hydrographs were generated for the range of flood frequencies.

Peak catchment discharges at the outlet to the catchment as determined using the hydrologic model are listed in **Tables 3.1** above. Discharge hydrographs for the downstream end of the catchment are shown in **Appendix B**.

4 HYDRAULIC MODELLING

4.1 REVIEW OF EXISTING HEC-RAS MODEL

HEC-RAS is a steady-state backwater program developed by US Army Corp of Engineers Hydrological Engineering Centre (*HEC*). HEC-RAS can be used to estimate peak flood levels in open channels, taking into account the effects of bridges, culverts and other hydraulic controls. (*Ref. - HEC-RAS User Manual*)

The existing HEC-RAS model set up by Boyden and Partners Pty Ltd for their drainage improvement works was reviewed for technical correctness, and application for the purposes of a flood study. The modelling was found to be comprehensive, including the inclusion of culvert works associated with the proposed improvements just upstream of the existing Diamond Road culverts.

A plan of the model cross sections is shown in **Figure 2**.

Some minor modifications were made to the extent of a number of the model cross sections, to allow the modelling of the extreme (*2x 1% AEP*) event. This involved examining the design plan contours, or simply extrapolating cross section grades up to the extreme flood level, where additional contour information was not available on the plans.

4.2 MODEL CALIBRATION

The hydraulic model was tested by comparing predicted flood levels with the flood levels determined in the previous investigation. The changes to the cross sections for the purposes of modelling the extreme event, outlined above, had a very minor effect on the design 1% AEP flood levels derived by Boyden & Partners.

4.3 MODEL SCENARIOS

The hydraulic model was run for a number of scenarios, based on the proposed flood mitigation works proposed by Gosford City Council. Three scenarios were identified, as follows:

1. Existing conditions;
2. Flood Mitigation Works – Proposed culvert extension upstream of Diamond Road; and
3. Ultimate Flood Mitigation Works – Proposed culvert extension upstream of Diamond Road, and channel widening works between chainage 270.0 and 405.0.

Case 2 above was examined at Council's request because the culvert works upstream of Diamond Road were in the process of being constructed, when the modelling for this study was finalised.

4.4 COASTAL EFFECTS

The beach berm and dune at creek outlets hinder flood flows until the crest is overtopped and a channel is eroded across the beach by flood flows. No detailed coastal analysis has been undertaken of the dune and berm levels at the outlet of Middle Creek, but recent experience at Green Point Creek, which discharges across the southern end of Pearl Beach, has been taken into account in determining these coastal effects.

Council has drawn on a recent flooding investigation for Green Point Creek, where a flood level of RL 4.05 m was adopted, due to coastal effects. Also, Council recently recorded a flood level of approximately RL 4.0 m AHD near the culvert under Coral Crescent for Pearl Beach Lagoon.

In light of this information Council has requested that a flood level of RL 4.0 m AHD be adopted in the creek for areas from the outlet up to a point where the predicted flood level in the creek is RL 4.0 m AHD from the catchment flows alone.

This coastal backwater effect is incorporated into the reported design storm results in **Section 4.5**, and the flood profiles and extents shown in the **Figures**.

4.5 DESIGN STORM RESULTS

The estimated peak flood level results for the above three scenarios are presented in **Tables 4.1** to **4.3**. It should be noted that these results include an allowance for a downstream level water surface profile at RL 4.0 m AHD, as nominated by Council *(Refer* **Section 4.4***)*.

Longitudinal section profiles of these flood levels are provided for Scenarios 2 and 3 in **Figures 4** and **6** respectively. Flood extents, contours and velocity vectors are shown for the 1% AEP event in **Figures 3** and **5**.

Peak flood levels and velocities for all scenarios and storm events are shown in the hydraulic model results listing in **Appendix C**.

The results of the modelling indicate that the proposed culvert works upstream of Diamond Road will reduce the estimated flood levels between chainage 220.0 and 370.0. The most significant reduction in estimated flood level occurs just upstream of the proposed culverts, where flood levels for the 1% AEP event are reduced by up to one metre.

The modelling also shows that a further reduction in estimated flood levels is achieved by the proposed channel improvement works. Estimated flood levels for the 1% AEP event are reduced between chainage 280.0 and 420.0, again by as much as one metre from the flood levels predicted for the existing conditions scenario.

4.6 POTENTIALLY FLOOD AFFECTED PROPERTIES

Table 4.4 lists various locations along Middle Creek where the estimated 1% AEP water surface level, plus 500 mm freeboard for Scenario 2 comes close to or exceeds surveyed building floor levels.

The results indicate that the proposed culvert works will effectively ensure flood free conditions for existing properties along Middle Creek between chainages 0.0 and 270.0 at Pearl Beach. However, immediately upstream of the proposed culvert works, the flood profile will rise quite steeply to around chainage 315.0, where the profile settles back into a typical normal flow.

This steeper profile is believed to be caused by a gradually varied profile transitioning from the slower, deeper flow of the existing channel, down through the more hydraulically efficient culvert extension at Diamond Road.

Table 4.5 compares the same floor levels to the estimated 1% AEP water surface levels (*plus 500 mm freeboard*) for Scenario 3.

These results indicate that the proposed channel and culvert works will effectively ensure flood free conditions for all existing properties along Middle Creek at Pearl Beach.

The flood profile upstream of the extended Diamond Road culverts continues upstream at a lower level, as a result of the channel improvement works proposed under this scenario. However, once the channel transitions back to the existing cross section at chainage 405.0, the profile rises quit steeply, back to the level in the original channel.

Adequate development controls by Council should ensure that future development along the creek is also flood free up to and including the 1% AEP event.

Table 4.1: **Estimated peak water surface levels for 20%, 5%, 1% AEP and extreme events for Scenario 1 (*Existing conditions*)**

Middle Creek Chainage (m)	Estimated Peak Water Surface Levels			
	20% AEP	5% AEP	1% AEP	Extreme Event (*2 x 1% AEP*)
0	4.00	4.00	4.00	4.00
15	4.00	4.00	4.00	4.00
30	4.00	4.00	4.00	4.00
45	4.00	4.00	4.00	4.00
60	4.00	4.00	4.00	4.00
75	4.00	4.00	4.00	4.00
90	4.00	4.00	4.00	4.00
105	4.00	4.00	4.00	4.00
120	4.00	4.00	4.00	4.04
135	4.00	4.00	4.00	4.77
150	4.00	4.00	4.07	4.85
207	4.15	4.39	4.61	5.38
221	4.27	4.56	4.96	6.26
222	4.25	4.54	4.96	6.15
240	4.73	4.97	5.36	6.36
255	5.58	5.83	6.10	6.52
270	5.87	6.11	6.36	6.79
284	6.01	6.25	6.50	6.95
285	6.02	6.25	6.51	6.96
300	6.09	6.31	6.57	7.04
315	6.19	6.41	6.67	7.17
330	6.24	6.47	6.72	7.24
345	6.44	6.67	6.93	7.46
359	6.53	6.71	6.95	7.49
360	6.54	6.73	6.97	7.50
375	6.67	6.83	7.10	7.59
390	7.08	7.34	7.49	7.79
399	7.20	7.45	7.60	7.92
400	7.17	7.42	7.54	7.74
405	7.25	7.48	7.63	8.01
420	7.37	7.55	7.71	8.25
435	7.78	7.97	8.21	8.59
450	7.87	8.06	8.29	8.72
465	7.89	8.07	8.30	8.71
480	7.92	8.10	8.33	8.78
495	8.04	8.22	8.43	8.85
510	8.10	8.27	8.46	8.92
525	8.29	8.46	8.68	9.13
540	8.51	8.69	8.87	9.28
555	8.55	8.72	8.91	9.31
570	8.60	8.75	8.91	9.29
585	8.74	8.90	9.10	9.56
600	8.85	9.02	9.21	9.62
615	9.05	9.19	9.37	9.80

Table 4.2: **Estimated peak water surface levels for 20%, 5%, 1% AEP and extreme events for Scenario 2 (*Culvert works without channel works*)**

Middle Creek Chainage (m)	Estimated Peak Water Surface Levels			
	20% AEP	5% AEP	1% AEP	Extreme Event (*2 x 1% AEP*)
0	4.00	4.00	4.00	4.00
15	4.00	4.00	4.00	4.00
30	4.00	4.00	4.00	4.00
45	4.00	4.00	4.00	4.00
60	4.00	4.00	4.00	4.00
75	4.00	4.00	4.00	4.00
90	4.00	4.00	4.00	4.00
105	4.00	4.00	4.00	4.00
120	4.00	4.00	4.00	4.04
135	4.00	4.00	4.00	4.77
150	4.00	4.00	4.07	4.85
207	4.15	4.39	4.61	5.38
221	4.27	4.56	4.96	6.28
222	4.25	4.54	4.96	6.26
270	4.39	4.71	5.36	6.44
284	5.27	5.45	5.68	6.30
285	5.46	5.66	5.90	6.49
300	5.80	5.99	6.23	6.82
315	6.01	6.21	6.47	7.05
330	6.11	6.31	6.56	7.14
345	6.37	6.60	6.86	7.41
359	6.49	6.68	6.89	7.45
360	6.51	6.71	6.91	7.46
375	6.65	6.82	7.09	7.56
390	7.07	7.34	7.49	7.79
399	7.20	7.45	7.60	7.92
400	7.17	7.41	7.54	7.75
405	7.25	7.48	7.63	8.01
420	7.37	7.55	7.71	8.25
435	7.78	7.97	8.21	8.59
450	7.87	8.06	8.29	8.72
465	7.89	8.07	8.30	8.71
480	7.92	8.10	8.33	8.78
495	8.04	8.22	8.43	8.85
510	8.10	8.27	8.46	8.92
525	8.29	8.46	8.68	9.13
540	8.51	8.69	8.87	9.28
555	8.55	8.72	8.91	9.31
570	8.60	8.75	8.91	9.29
585	8.74	8.90	9.10	9.56
600	8.85	9.02	9.21	9.62
615	9.05	9.19	9.37	9.80

<u>Table 4.3</u>: Estimated peak water surface levels for 20%, 5%, 1% AEP and extreme events for Scenario 3 (*Ultimate case: Culvert and channel works*)

Middle Creek Chainage (m)	Estimated Peak Water Surface Levels			
	20% AEP	5% AEP	1% AEP	Extreme Event (*2 x 1% AEP*)
0	4.00	4.00	4.00	4.00
15	4.00	4.00	4.00	4.00
30	4.00	4.00	4.00	4.00
45	4.00	4.00	4.00	4.00
60	4.00	4.00	4.00	4.00
75	4.00	4.00	4.00	4.00
90	4.00	4.00	4.00	4.00
105	4.00	4.00	4.00	4.01
120	3.31	3.49	3.67	4.04
135	3.52	3.74	3.96	4.77
150	3.62	3.85	4.08	4.85
207	4.15	4.39	4.61	5.38
221	4.27	4.56	4.98	6.18
222	4.25	4.54	4.96	6.15
270	4.39	4.71	5.36	6.31
284	4.49	4.81	5.43	6.36
285	4.49	4.66	5.27	6.18
300	4.95	5.16	5.49	6.34
315	5.12	5.33	5.65	6.48
330	5.25	5.47	5.78	6.59
345	5.38	5.62	5.94	6.77
359	5.50	5.75	6.08	6.96
360	5.43	5.60	5.87	6.82
375	5.89	6.10	6.36	7.12
390	6.05	6.27	6.55	7.32
399	5.27	5.39	5.55	7.42
400	5.86	6.00	6.17	6.69
405	6.87	7.07	7.58	8.32
420	7.40	7.60	7.74	8.42
435	7.81	7.99	8.21	8.64
450	7.90	8.08	8.29	8.76
465	7.92	8.10	8.31	8.76
480	7.96	8.14	8.36	8.84
495	8.07	8.25	8.45	8.91
510	8.15	8.32	8.54	9.02
525	8.31	8.48	8.72	9.19
540	8.59	8.73	8.90	9.32
555	8.61	8.75	8.93	9.35
570	8.64	8.77	8.94	9.34
585	8.78	8.95	9.15	9.61
600	8.90	9.11	9.32	9.71
615	9.07	9.24	9.44	9.83

Table 4.4: Comparison of Estimated 1% AEP Peak Flood with building floor levels for Scenario 2

Approximate Middle Creek Chainage (m)	Estimated Peak Water Surface Level for 1% AEP + 500 mm freeboard for Scenario 2 (m, AHD)	Surveyed Building Floor Level adjacent to creek (m, AHD)
230	5.66	No. 36 Diamond Rd - Carport FL* RL **5.63**
265	5.90	No. 36 Diamond Rd - Shed FL RL **5.74**
375 "	7.60 "	No. 14 Emerald Rd - Shed FL RL **6.87** and No. 14 Emerald Rd - Cottage FL RL **6.75**
490	8.90	No. 28 Emerald Rd – Shed FL RL **9.02**

Note: * : FL refers to surveyed Floor Level

Table 4.5: Comparison of Estimated 1% AEP Peak Flood with building floor levels for Scenario 3

Approximate Middle Creek Chainage (m)	Estimated Peak Water Surface Level for 1% AEP + 500 mm freeboard for Scenario 3 (m, AHD)	Surveyed Building Floor Level adjacent to creek (m, AHD)
230	5.50	No. 36 Diamond Rd - Carport FL* RL **5.63**
265	5.80	No. 36 Diamond Rd - Shed FL RL **5.74**
375 "	6.86 "	No. 14 Emerald Rd - Shed FL RL **6.87** and No. 14 Emerald Rd - Cottage FL RL **6.75**
490	8.90	No. 28 Emerald Rd – Shed FL RL **9.02**

Note: * : FL refers to surveyed Floor Level

4.7 SENSITIVITY TESTING

Parameters having a significant influence on the model predictions for flood levels were varied in order to test the sensitivity of the results to the likelihood of inundation of habitable floor levels. The parameter values tested were:-

- flow – 1.2 times the adopted 1% AEP discharge estimates; and
- Manning's "n" channel and overbank roughness – raised by 0.02, ie. 0.055 increased to 0.075.

The sensitivity testing runs were undertaken using the Scenario 3, model (*Ultimate Flood Mitigation Works*), the result sof which are are presented in **Appendix D**.

The increase in flow by 20% resulted in an increase in predicted 1% AEP flood level by up to 500mm. The increase in Manning's "n" roughness by 0.02 (*with original peak flow rates*) had a similar effect, with predicted 1% AEP flood levels being raised by up to 500mm higher than the adopted 1% AEP flood levels.

The sensitivity testing suggests that there is adequate freeboard to habitable floor levels to account for reasonable inaccuracies in the modelling.

4.8 EFFECT OF EXTREME FLOOD

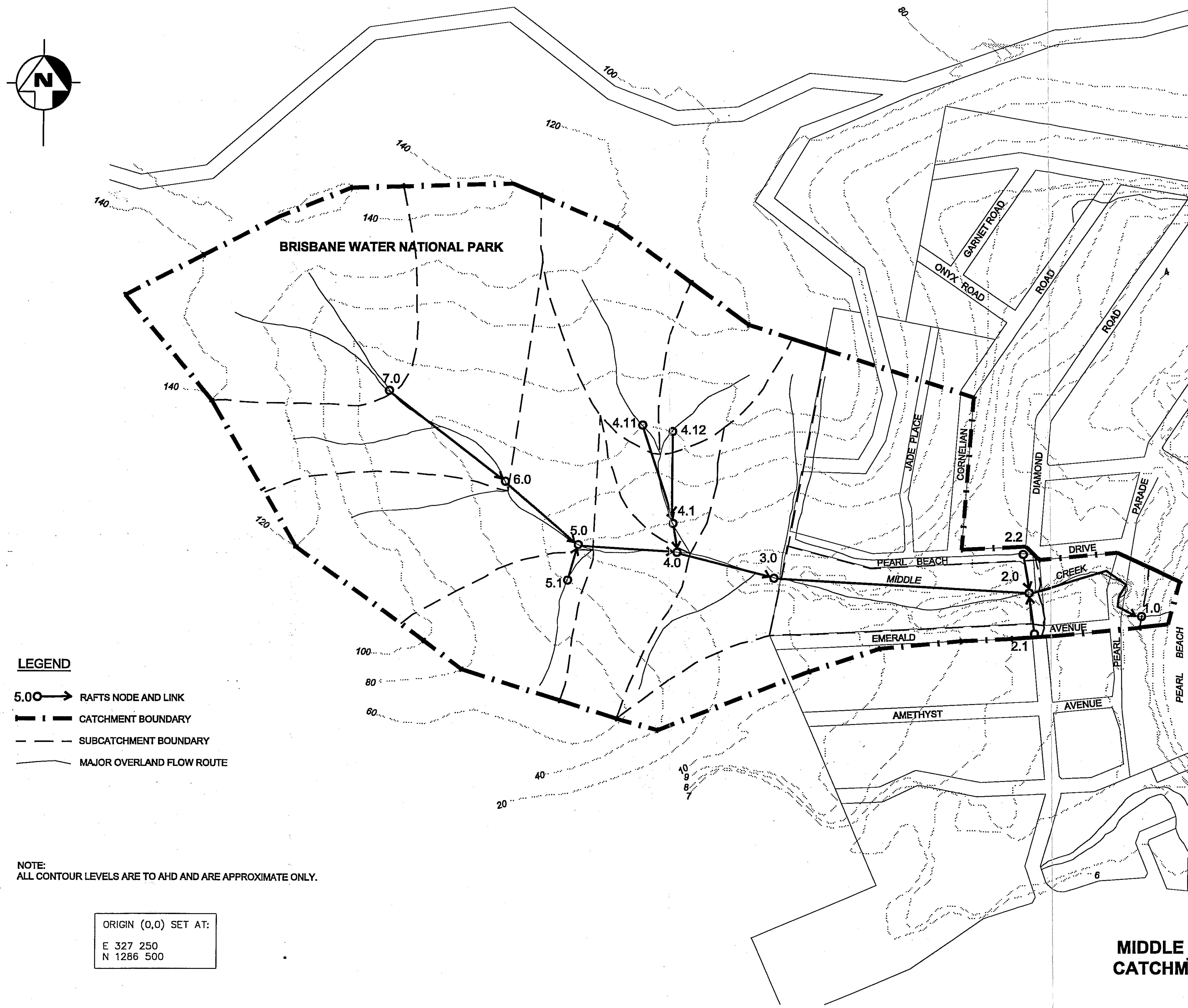
An extreme flood (*flow twice the estimated 1% AEP peak flow rate*) for the ultimate flood mitigation works scenario would cause inundation of up to 9 sheds and garages and 1 residence along the creek.

5 REFERENCES

- **Australian Rainfall & Runoff (AR&R)**, *Institute of Engineers Australia*, 1987
- **Runoff and Flow Simulation (RAFTS)**, User Manual V2.8, *WP Software*, June 1992
- **HEC-RAS River Analysis System**, User Manual V2.0, *US Army Corp of Engineers*, April 1997
- **Drainage Improvement Works – Middle Creek Catchment, Pearl Beach**, *Boyden & Partners Pty Ltd* for Gosford City Council, May 1998.
- **Floodplain Development Manual,** *NSW Public Works Department*, December 1986

FIGURES

FIGURE 1



LEGEND

5.0 RAFTS NODE AND LINK
CATCHMENT BOUNDARY
SUBCATCHMENT BOUNDARY
MAJOR OVERLAND FLOW ROUTE

NOTE:
ALL CONTOUR LEVELS ARE TO AHD AND ARE APPROXIMATE ONLY.

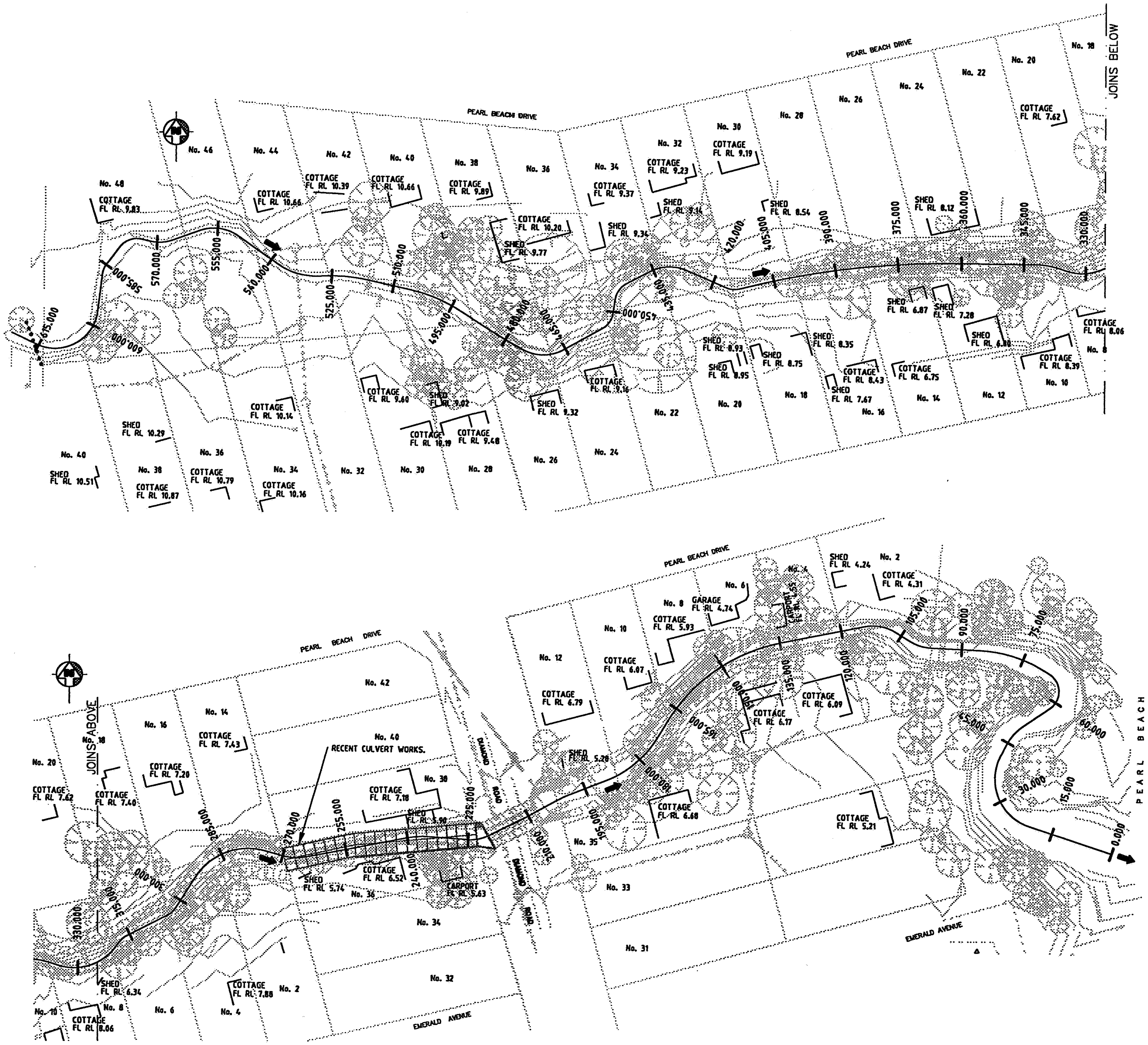
ORIGIN (0,0) SET AT:
E 327 250
N 1286 500

0 200m
1:5000 (A3)

J3144

MIDDLE CREEK FLOOD STUDY
CATCHMENT PLAN AND RAFTS MODEL NETWORK

FIGURE 2



LEGEND

375.000 HEC-RAS MODEL CHANNEL CROSS SECTION AND CHAINAGE.

APPROXIMATE CREEK THALWEG.

EXISTING GROUND CONTOUR LEVEL.

No. 23 LOT No.

COTTAGE FL RL 7.62 BUILDING FLOOR LEVEL.

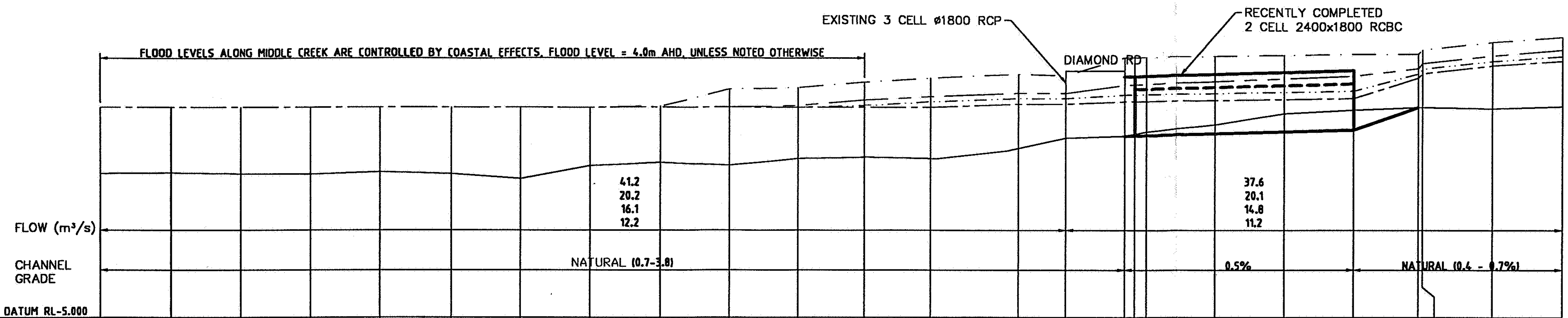
FLOW DIRECTION.

0 20 m
1:1000 (A3)

J3144/R1958

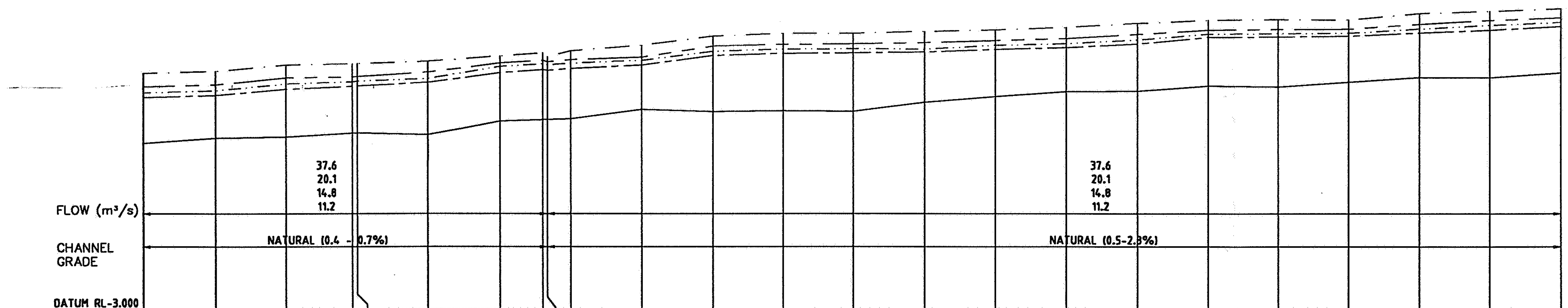
MIDDLE CREEK FLOOD STUDY
PLAN OF HEC-RAS HYDRAULIC MODEL CROSS SECTIONS.

MIDDLE CREEK FLOOD STUDY 1% AEP EVENT, PEAK WATER LEVELS AND VELOCITIES FOR SCENARIO 2: PROPOSED CULVERT WORKS ONLY, WITHOUT CHANNEL WORKS.



CHAINAGE	EXTREME EVENT 2x1% AEP TWL	ESTIMATED 1% AEP TWL	EXISTING 5% AEP TWL	EXISTING 20% AEP TWL	EXISTING CHANNEL INVERT
0.00	4.00	4.00	4.00	4.00	1.161
15.00	4.00	4.00	4.00	4.00	1.187
30.00	4.00	4.00	4.00	4.00	1.146
45.00	4.00	4.00	4.00	4.00	1.130
60.00	4.00	4.00	4.00	4.00	1.237
75.00	4.00	4.00	4.00	4.00	1.153
90.00	4.00	4.00	4.00	4.00	0.941
105.00	4.01	4.00	4.00	4.00	1.504
120.00	4.04	4.00	4.00	4.00	1.634
135.00	4.77	4.00	4.00	4.00	1.512
150.00	4.85	4.08	4.00	4.00	1.808
164.25	5.08	4.31	4.08	4.00	1.866
178.50	5.26	4.46	4.24	4.00	1.800
197.50	5.44	4.61	4.38	4.14	2.139
207.69	5.38	4.61	4.39	4.15	2.690
220.29	6.15	4.96	4.54	4.25	2.780
222.23	5.130	5.130	5.130	4.610	2.792
225.00	5.150	5.150	5.150	4.650	2.820
240.00	5.150	5.150	5.150	4.720	2.890
255.00	5.360	5.360	5.360	4.800	2.970
270.00	6.31	5.36	4.71	4.39	3.040
284.00	6.30	5.68	5.45	5.27	4.000
285.00	6.49	5.90	5.66	5.46	4.000
300.00	6.82	6.23	5.99	5.80	3.950
315.00	7.05	6.47	6.21	6.01	4.050

SCALES: HORIZ - 1:500 VERT - 1:100



CHAINAGE	EXTREME EVENT 2x1% AEP TWL	ESTIMATED 1% AEP TWL	EXISTING 5% AEP TWL	EXISTING 20% AEP TWL	EXISTING CHANNEL INVERT
315.00	7.05	6.47	6.21	6.01	4.050
330.00	7.14	6.56	6.31	6.11	4.280
345.00	7.41	6.86	6.60	6.37	4.320
359.00	7.45	6.89	6.68	6.49	4.500
360.00	7.46	6.91	6.71	6.51	4.500
375.00	7.56	7.09	6.82	6.65	4.420
390.00	7.79	7.49	7.34	7.07	5.070
399.00	7.92	7.60	7.45	7.20	5.070
400.00	7.75	7.54	7.41	7.17	5.260
405.00	8.01	7.63	7.48	7.25	5.749
420.00	8.25	7.74	7.60	7.40	5.756
435.00	8.64	8.21	7.99	7.81	5.662
450.00	8.76	8.29	8.08	7.90	5.700
465.00	8.76	8.31	8.10	7.92	5.674
480.00	8.84	8.36	8.14	7.96	6.050
495.00	8.91	8.45	8.25	8.07	6.306
510.00	9.02	8.54	8.32	8.15	6.517
525.00	9.19	8.72	8.48	8.31	6.534
540.00	9.32	8.90	8.73	8.59	6.757
555.00	9.35	8.93	8.75	8.61	6.715
570.00	9.34	8.94	8.77	8.64	6.921
585.00	9.61	9.15	8.95	8.78	7.123
600.00	9.71	9.32	9.11	8.90	7.109
615.00	9.83	9.44	9.24	9.07	7.321

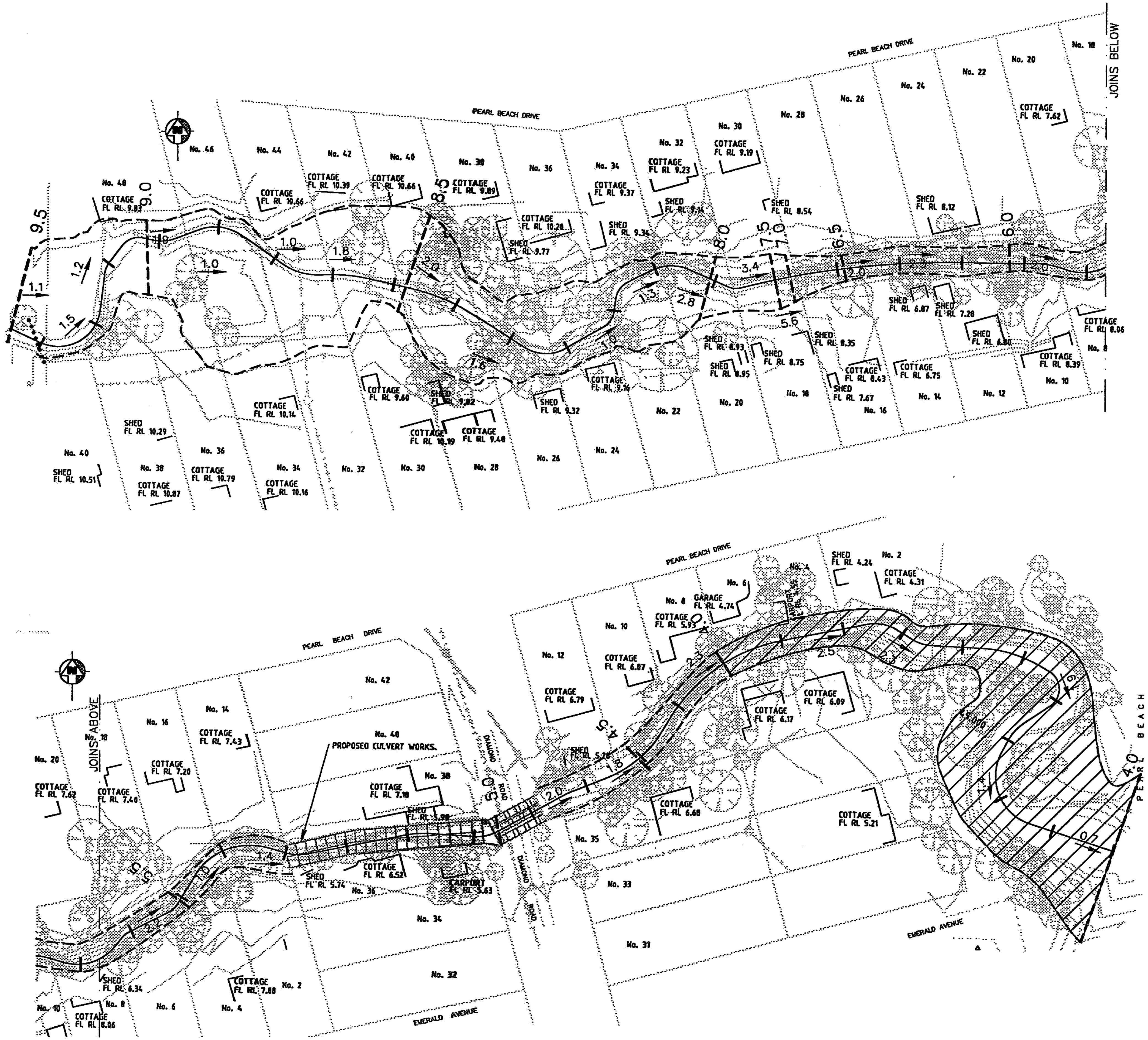
SCALES: HORIZ - 1:500 VERT - 1:100

HORIZONTAL A3 1:1000 0 10 20 30 40 50 m

VERTICAL A3 1:200 0 2 4 6 8 10 m

MIDDLE CREEK FLOOD STUDY LONGITUDINAL SECTION SHOWING 20%, 5%, 1% AEP AND EXTREME FLOOD PROFILES FOR SCENARIO 2 : PROPOSED CULVERT WORKS ONLY, WITHOUT CHANNEL WORKS

FIGURE 5



LEGEND

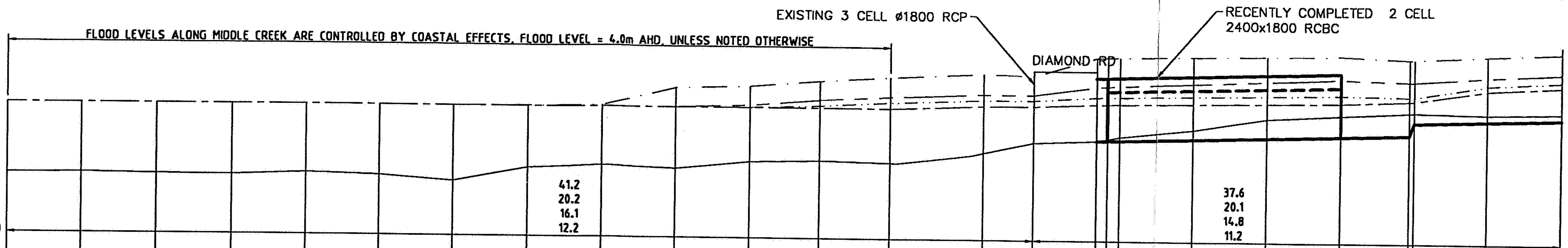
- HEC-RAS MODEL CHANNEL CROSS SECTION
- 6.5 — ESTIMATED PEAK FLOOD CONTOUR FOR 1% AEP DESIGN EVENT (m AHD).
- 1.0 — ESTIMATED MAXIMUM CHANNEL VELOCITY (m/s)
- APPROXIMATE CREEK THALWEG
- EXISTING GROUND CONTOUR LEVEL
- No. 23 — LOT No.
- COTTAGE FL RL 7.62 — BUILDING FLOOR LEVEL.
- AREA ASSUMED TO BE INUNDATED DUE TO COASTAL DUNE EFFECTS – RL 4.0m AHD.

0 20 m
1:1000 (A3)

MIDDLE CREEK FLOOD STUDY 1% AEP EVENT, PEAK WATER LEVELS AND VELOCITIES FOR SCENARIO 3 ULTIMATE FLOOD MITIGATION WORKS, INCLUDING CULVERT AND CHANNEL UPGRADING

J3144/R1958

FIGURE 6



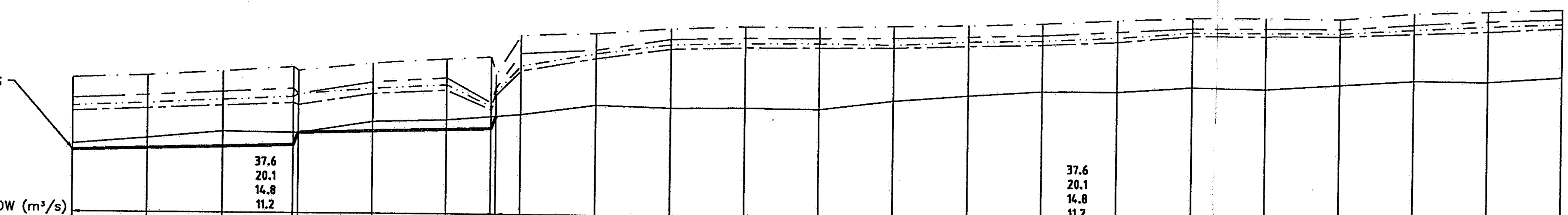
FLOW (m³/s): 41.2 / 20.2 / 16.1 / 12.2 — 37.6 / 20.1 / 14.8 / 11.2

CHANNEL GRADE: NATURAL (0.7-3.8%) — 0.5% — 0.6%

DATUM RL-5.000

	EXTREME EVENT 2x1% AEP TWL	ESTIMATED 1% AEP TWL	EXISTING 5% AEP TWL	EXISTING 20% AEP TWL	EXISTING CHANNEL INVERT
CHAINAGE 0.00	4.00	4.00	4.00	4.00	1.161
15.00	4.00	4.00	4.00	4.00	1.187
30.00	4.00	4.00	4.00	4.00	1.146
45.00	4.00	4.00	4.00	4.00	1.130
60.00	4.00	4.00	4.00	4.00	1.237
75.00	4.00	4.00	4.00	4.00	1.153
90.00	4.00	4.00	4.00	4.00	0.941
105.00	4.01	4.00	4.00	4.00	1.504
120.00	4.04	4.00	4.00	4.00	1.634
135.00	4.77	4.00	4.00	4.00	1.512
150.00	4.85	4.08	4.00	4.00	1.808
164.25	5.08	4.31	4.08	4.00	1.866
178.50	5.26	4.46	4.24	4.00	1.800
197.50	5.44	4.61	4.38	4.14	2.139
207.69	5.38	4.61	4.39	4.15	2.690
220.29	6.15	4.96	4.54	4.25	2.780
222.23	5.130	5.130	5.130	4.610	2.792
225.00	5.150	5.150	5.150	4.650	2.820
240.00	5.150	5.150	5.150	4.720	2.890
255.00	5.360	5.360	5.360	4.800	2.970
270.00	6.31	5.36	4.71	4.39	3.040
284.00	6.18	5.27	4.66	4.49	3.100
285.00	6.18	5.27	4.66	4.49	3.610
300.00	6.34	5.49	5.16	4.95	3.710
315.00	6.48	5.65	5.33	5.12	3.800

SCALES: HORIZ - 1:500 VERT - 1:100



FLOW (m³/s): 37.6 / 20.1 / 14.8 / 11.2 — 37.6 / 20.1 / 14.8 / 11.2

CHANNEL GRADE: 0.6% — NATURAL (0.5-2.8%)

DATUM RL-3.000

	EXTREME EVENT 2x1% AEP TWL	ESTIMATED 1% AEP TWL	EXISTING 5% AEP TWL	EXISTING 20% AEP TWL	EXISTING CHANNEL INVERT
CHAINAGE 315.00	6.48	5.65	5.33	5.12	3.800
330.00	6.59	5.78	5.47	5.25	3.890
345.00	6.77	5.94	5.62	5.38	3.970
359.00	6.96	6.08	5.75	5.50	4.050
360.00	6.82	5.87	5.60	5.43	4.550
375.00	7.12	6.36	6.10	5.89	4.630
390.00	7.32	6.55	6.27	6.05	4.710
399.00	7.42	5.55	5.39	5.27	4.760
400.00	6.69	6.17	6.00	5.86	5.260
405.00	8.32	7.58	7.07	6.87	5.749
420.00	8.42	7.74	7.60	7.40	5.756
435.00	8.64	8.21	7.99	7.81	5.662
450.00	8.76	8.29	8.08	7.90	5.700
465.00	8.76	8.31	8.10	7.92	5.674
480.00	8.84	8.36	8.14	7.96	6.050
495.00	8.91	8.45	8.25	8.07	6.306
510.00	9.02	8.54	8.32	8.15	6.517
525.00	9.19	8.72	8.48	8.31	6.534
540.00	9.32	8.90	8.73	8.59	6.757
555.00	9.35	8.93	8.75	8.61	6.715
570.00	9.34	8.94	8.77	8.64	6.921
585.00	9.61	9.15	8.95	8.78	7.123
600.00	9.71	9.32	9.11	8.90	7.109
615.00	9.83	9.44	9.24	9.07	7.321

SCALES: HORIZ - 1:500 VERT - 1:100

HORIZONTAL A3 1:1000 0 10 20 30 40 50 m

VERTICAL A3 1:200 0 2 4 6 8 10 m

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MIDDLE CREEK FLOOD STUDY LONGITUDINAL SECTION SHOWING 20%, 5%, 1% AEP AND EXTREME FLOOD PROFILES FOR SCENARIO 3 : ULTIMATE FLOOD MITIGATION WORKS, INCLUDING CULVERT AND CHANNEL UPGRADING

APPENDIX A – RAFTS MODEL INPUT PARAMETERS

Run started at: 26th August 1998 17:27:07

##
3144 Middle Creek Flood Study-GCC-Existing Conditions Model

Results for period from 0: .0 1/ 1/1990
to 6: .0 1/ 1/1990
##

ROUTING INCREMENT (MINS)	=	.60
STORM DURATION (MINS)	=	120.
RETURN PERIOD (YRS)	=	100.
BX	=	.5000
TOTAL OF FIRST SUB-AREAS (HA)	=	56.04
TOTAL OF SECOND SUB-AREAS (HA)	=	3.51
TOTAL OF ALL SUB-AREAS (HA)	=	59.55

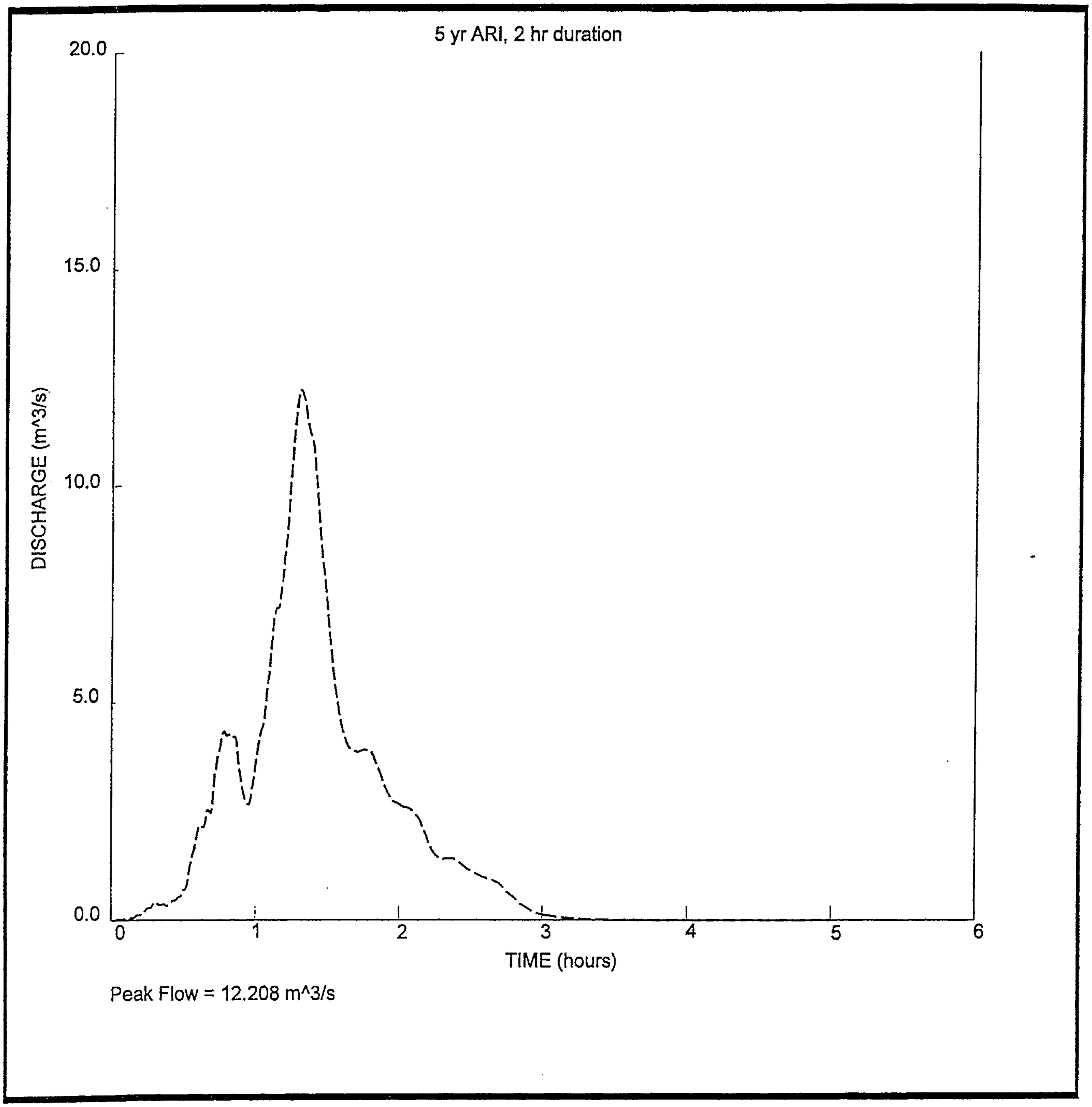
SUMMARY OF CATCHMENT AND RAINFALL DATA

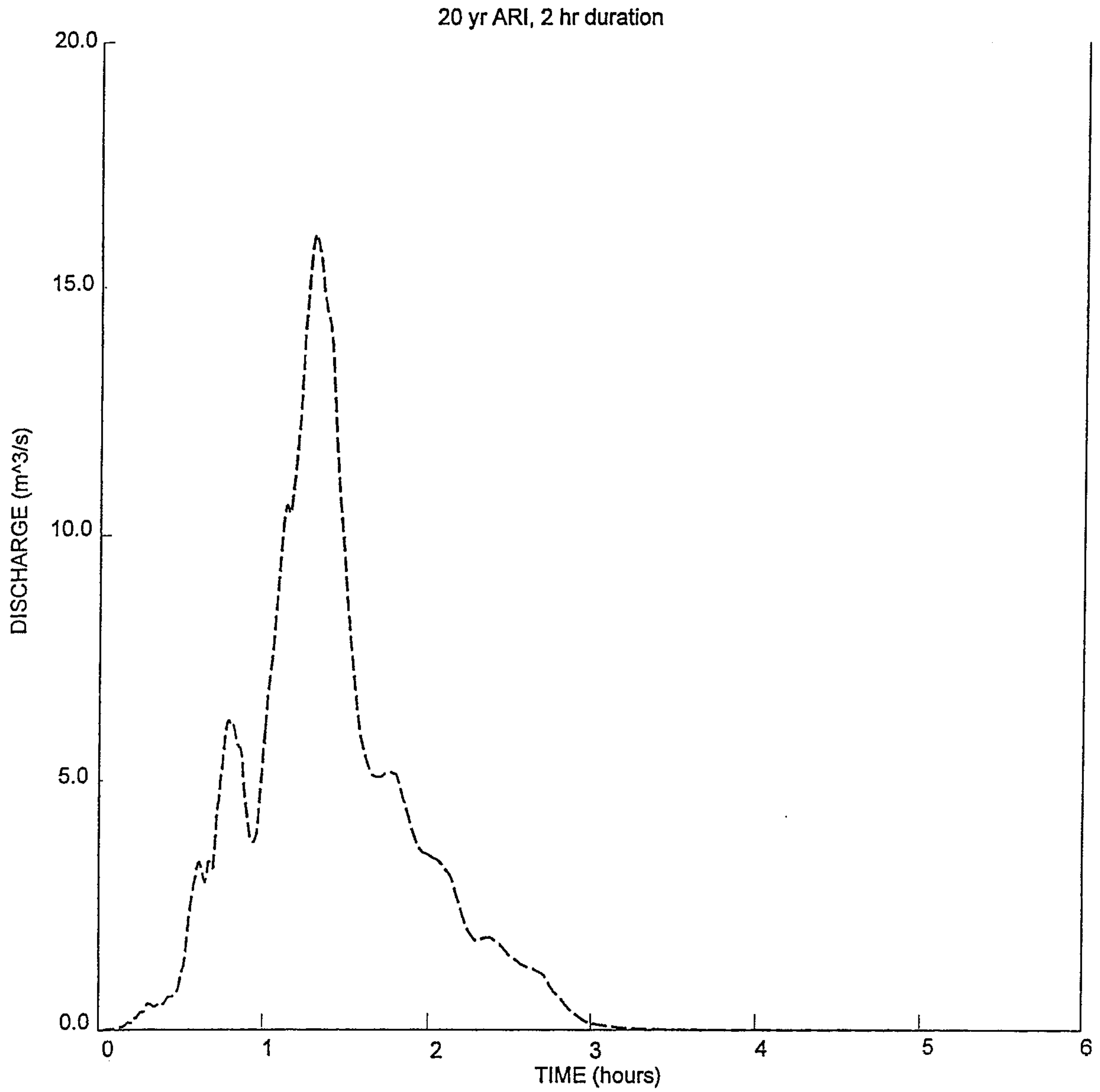
Link Label	Catch. Area #1 (hectares)	#2	Slope #1 (%)	#2	% Impervious #1 (%)	#2	Pern #1	#2	B #1	#2	Link No.
7.0	9.540	.000	18.00	.0000	5.000	.0000	.060	.00	.0154	.0000	1.000
6.0	8.930	.000	18.00	.0000	5.000	.0000	.060	.00	.0149	.0000	1.001
5.1	2.900	.000	29.00	.0000	5.000	.0000	.060	.00	.0066	.0000	2.000
5.0	8.300	.000	23.00	.0000	5.000	.0000	.060	.00	.0127	.0000	1.002
4.11	3.680	.000	20.00	.0000	5.000	.0000	.060	.00	.0089	.0000	3.000
4.12	2.500	.000	30.00	.0000	5.000	.0000	.060	.00	.0060	.0000	4.000
4.1	1.760	.000	23.00	.0000	5.000	.0000	.060	.00	.0057	.0000	3.001
4.0	3.040	.000	15.30	.0000	5.000	.0000	.060	.00	.0092	.0000	1.003
3.0	5.330	.00100	20.00	20.00	5.000	100.0	.035	.015	.0071	0.000	1.004
2.1	2.060	.00100	6.000	6.000	5.000	100.0	.035	.015	.0079	0.000	5.000
2.2	4.800	1.720	10.00	10.00	5.000	100.0	.035	.015	.0095	.0003	6.000
2.0	2.060	1.370	1.200	1.200	5.000	100.0	.025	.015	.0139	.0008	1.005
1.0	1.140	.4200	1.500	1.500	5.000	100.0	.025	.015	.0091	.0004	1.006
Outlet	.00100	.000	1.000	.0000	5.000	.0000	.025	.00	.0003	.0000	1.007

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	#2	Cont. Loss #1 (mm/h)	#2	Excess Rain #1 (mm)	#2	Peak Inflow (m^3/s)	Time to Peak	Link Lag (mins)
7.0	56.075	10.00	.0000	1.500	.0000	99.272	.000	5.253	36.00	5.500
6.0	56.075	10.00	.0000	1.500	.0000	99.272	.000	9.185	40.20	4.000
5.1	56.075	10.00	.0000	1.500	.0000	99.272	.000	1.781	34.80	5.500
5.0	56.075	10.00	.0000	1.500	.0000	99.272	.000	12.745	40.20	6.000
4.11	56.075	10.00	.0000	1.500	.0000	99.272	.000	2.186	35.40	3.500
4.12	56.075	10.00	.0000	1.500	.0000	99.272	.000	1.541	34.80	3.500
4.1	56.075	10.00	.0000	1.500	.0000	99.272	.000	4.520	38.40	6.000
4.0	56.075	10.00	.0000	1.500	.0000	99.272	.000	17.840	45.00	6.000
3.0	56.075	10.00	.0000	1.500	.0000	99.272	111.96	18.488	51.00	18.00
2.1	56.075	10.00	.0000	1.500	.0000	99.272	111.96	1.215	35.40	3.000
2.2	56.075	10.00	.0000	1.500	.0000	99.272	111.96	3.882	34.80	3.000
2.0	56.075	10.00	.0000	1.500	.0000	99.272	111.96	20.040	69.00	8.000
1.0	56.075	10.00	.0000	1.500	.0000	99.272	111.96	20.206	76.80	1.000
Outlet	56.075	10.00	.0000	1.500	.0000	99.272	.000	20.206	78.00	.0000

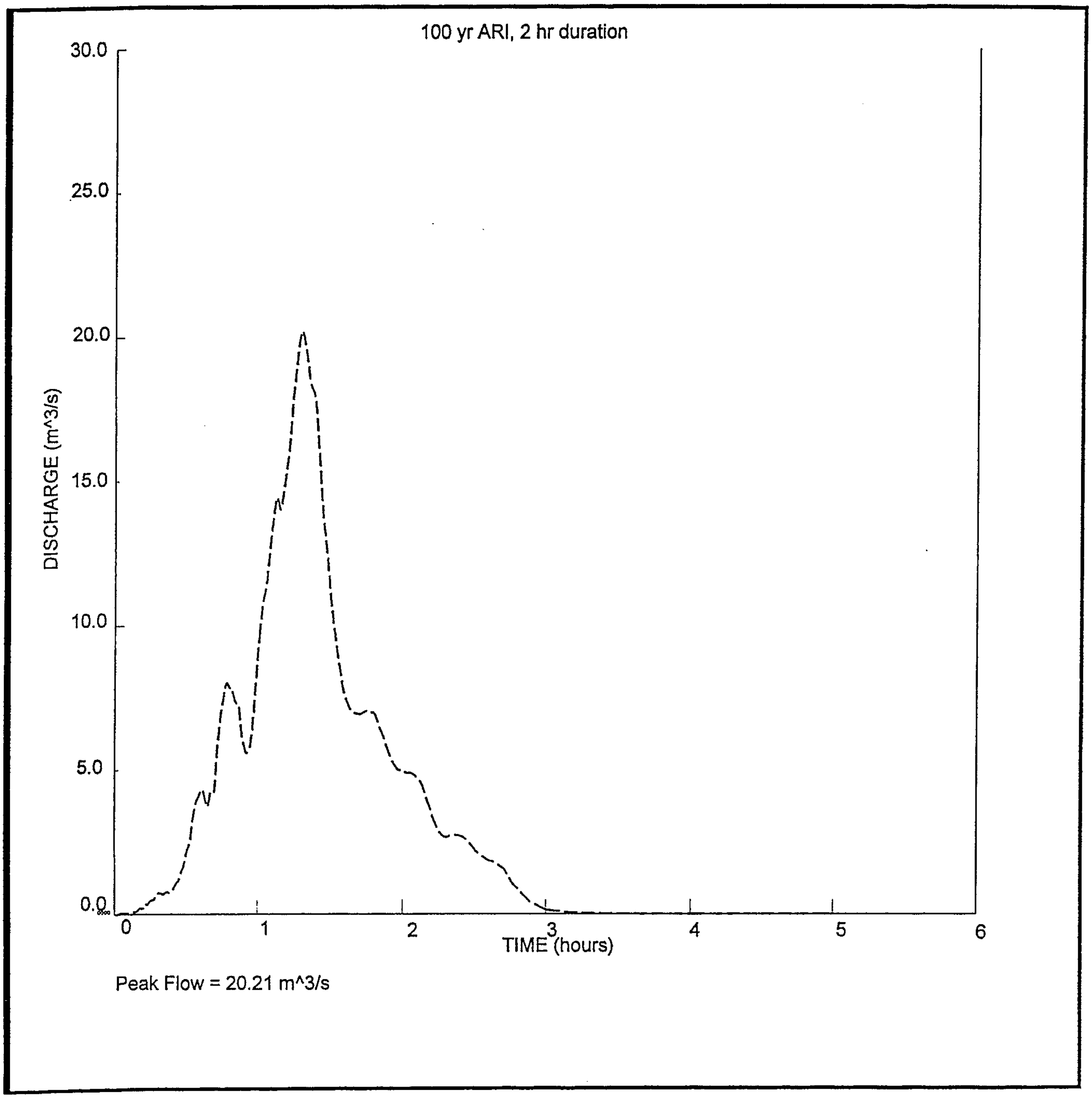
Run completed at: 26th August 1998 17:27:40

APPENDIX B – RAFTS DISCHARGE HYDROGRAPHS

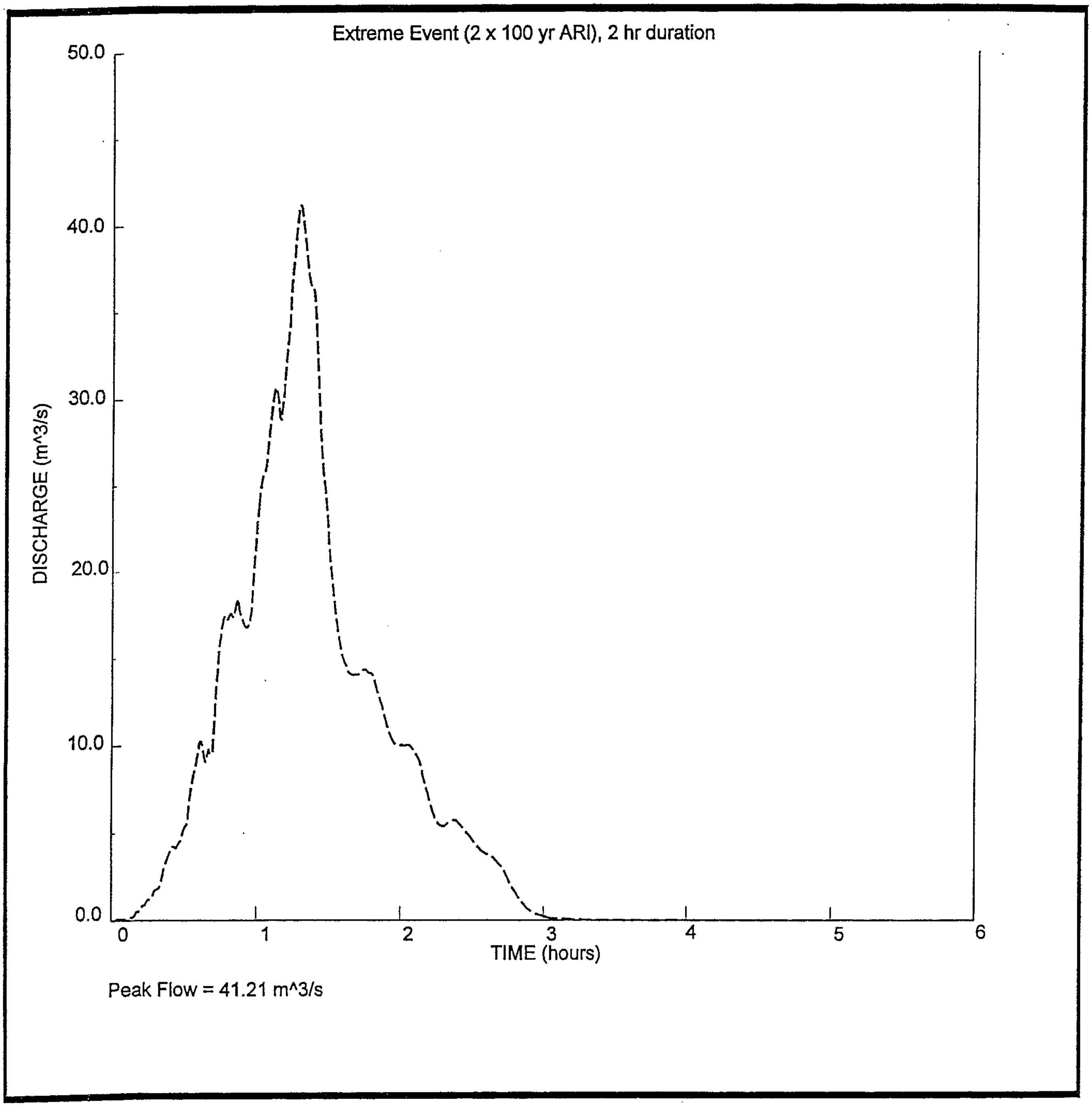

5 yr ARI, 2 hr duration
20.0
15.0
10.0
5.0
0.0
DISCHARGE (m^3/s)
0
1
2
3
4
5
6
TIME (hours)
Peak Flow = 12.208 m^3/s



Peak Flow = 16.06 m^3/s



100 yr ARI, 2 hr duration
DISCHARGE (m^3/s)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
1
2
3
4
5
6
TIME (hours)
Peak Flow = 20.21 m^3/s


Extreme Event (2 x 100 yr ARI), 2 hr duration
50.0
40.0
30.0
20.0
10.0
0.0
DISCHARGE (m^3/s)
0
1
2
3
4
5
6
TIME (hours)
Peak Flow = 41.21 m^3/s

APPENDIX C – HEC-RAS HYDRAULIC MODEL RESULTS LISTING

HEC-RAS Plan: Existing River: WATERCOURSE Reach: WATERCOURSE

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	615	11.20	7.25	9.05		9.09	0.004467	1.11	15.77	27.80	0.32
WATERCOURSE	615	14.80	7.25	9.19		9.24	0.004269	1.14	20.02	29.78	0.32
WATERCOURSE	615	20.10	7.25	9.37		9.41	0.004213	1.20	25.45	32.13	0.32
WATERCOURSE	615	37.60	7.25	9.80		9.85	0.004035	1.32	40.06	36.91	0.32
WATERCOURSE	600	11.20	7.03	8.85		8.98	0.011569	1.73	8.81	18.76	0.50
WATERCOURSE	600	14.80	7.03	9.02		9.14	0.010307	1.73	12.27	20.69	0.48
WATERCOURSE	600	20.10	7.03	9.21		9.32	0.009595	1.77	16.17	20.91	0.47
WATERCOURSE	600	37.60	7.03	9.62		9.76	0.010272	2.04	25.04	24.68	0.49
WATERCOURSE	585	11.20	7.04	8.74		8.84	0.007030	1.48	10.34	20.58	0.40
WATERCOURSE	585	14.80	7.04	8.90		9.00	0.006922	1.58	14.41	28.95	0.41
WATERCOURSE	585	20.10	7.04	9.10		9.20	0.006330	1.64	21.11	39.02	0.40
WATERCOURSE	585	37.60	7.04	9.56		9.63	0.004368	1.59	41.12	43.85	0.34
WATERCOURSE	570	11.20	6.91	8.60		8.71	0.010450	1.60	8.67	13.37	0.50
WATERCOURSE	570	14.80	6.91	8.75		8.87	0.011033	1.74	10.82	15.19	0.52
WATERCOURSE	570	20.10	6.91	8.91		9.06	0.012099	1.93	13.53	17.22	0.55
WATERCOURSE	570	37.60	6.91	9.29		9.51	0.014885	2.39	20.95	21.83	0.63
WATERCOURSE	555	11.20	6.70	8.55		8.59	0.004029	0.94	14.32	29.69	0.32
WATERCOURSE	555	14.80	6.70	8.72		8.76	0.003430	0.96	19.62	33.21	0.30
WATERCOURSE	555	20.10	6.70	8.91		8.95	0.003123	1.00	25.81	33.63	0.29
WATERCOURSE	555	37.60	6.70	9.31		9.37	0.003258	1.21	39.61	34.25	0.31
WATERCOURSE	540	11.20	6.74	8.51		8.54	0.003265	0.97	18.98	30.24	0.28
WATERCOURSE	540	14.80	6.74	8.69		8.71	0.002825	0.99	24.62	34.01	0.26
WATERCOURSE	540	20.10	6.74	8.87		8.90	0.002739	1.05	31.33	38.01	0.26
WATERCOURSE	540	37.60	6.74	9.28		9.32	0.002890	1.26	48.38	44.14	0.28
WATERCOURSE	525	11.20	6.53	8.29		8.44	0.010373	1.82	8.00	15.19	0.51
WATERCOURSE	525	14.80	6.53	8.46		8.62	0.010072	1.95	11.00	19.97	0.51
WATERCOURSE	525	20.10	6.53	8.68		8.82	0.008312	1.94	17.21	33.08	0.48
WATERCOURSE	525	37.60	6.53	9.13		9.25	0.006310	1.99	33.75	40.06	0.43
WATERCOURSE	510	11.20	6.48	8.10		8.27	0.012241	1.89	7.39	12.73	0.55
WATERCOURSE	510	14.80	6.48	8.27		8.45	0.012310	2.06	9.71	16.23	0.56
WATERCOURSE	510	20.10	6.48	8.46		8.66	0.011955	2.22	13.41	21.25	0.57
WATERCOURSE	510	37.60	6.48	8.92		9.12	0.010334	2.45	25.74	32.57	0.55
WATERCOURSE	495	11.20	6.28	8.04		8.13	0.005662	1.33	10.60	18.29	0.39
WATERCOURSE	495	14.80	6.28	8.22		8.31	0.005257	1.41	14.07	20.28	0.38
WATERCOURSE	495	20.10	6.28	8.43		8.52	0.005106	1.52	18.47	22.56	0.39
WATERCOURSE	495	37.60	6.28	8.85		8.99	0.005974	1.93	29.40	29.72	0.43
WATERCOURSE	480	11.20	6.04	7.92		8.03	0.007399	1.54	9.15	15.90	0.42
WATERCOURSE	480	14.80	6.04	8.10		8.21	0.007114	1.64	12.91	23.56	0.42
WATERCOURSE	480	20.10	6.04	8.33		8.44	0.006072	1.66	18.89	27.79	0.40
WATERCOURSE	480	37.60	6.04	8.78		8.89	0.005940	1.91	32.70	34.62	0.41
WATERCOURSE	465	11.20	5.66	7.89		7.94	0.003081	1.03	13.15	17.91	0.28
WATERCOURSE	465	14.80	5.66	8.07		8.13	0.003244	1.12	16.51	19.14	0.30
WATERCOURSE	465	20.10	5.66	8.30		8.36	0.003382	1.22	20.98	20.66	0.31
WATERCOURSE	465	37.60	5.66	8.71		8.81	0.004703	1.62	30.02	23.79	0.37
WATERCOURSE	450	11.20	5.69	7.87		7.89	0.002228	0.92	20.93	35.48	0.24
WATERCOURSE	450	14.80	5.69	8.06		8.08	0.001945	0.93	28.17	41.01	0.23
WATERCOURSE	450	20.10	5.69	8.29		8.31	0.001749	0.96	39.07	51.66	0.22
WATERCOURSE	450	37.60	5.69	8.72		8.75	0.001693	1.08	63.02	59.11	0.22
WATERCOURSE	435	11.20	5.66	7.78		7.84	0.005735	1.29	12.47	17.33	0.35
WATERCOURSE	435	14.80	5.66	7.97		8.03	0.005339	1.31	15.93	18.61	0.34
WATERCOURSE	435	20.10	5.66	8.21		8.27	0.005109	1.35	20.41	20.14	0.34
WATERCOURSE	435	37.60	5.66	8.59		8.69	0.007113	1.74	28.74	22.71	0.41
WATERCOURSE	420	11.20	5.65	7.37		7.65	0.033464	2.51	5.36	7.96	0.73
WATERCOURSE	420	14.80	5.65	7.55		7.85	0.031988	2.64	6.98	9.34	0.71
WATERCOURSE	420	20.10	5.65	7.71		8.07	0.037382	3.00	8.51	10.48	0.77
WATERCOURSE	420	37.60	5.65	8.25		8.49	0.029714	2.40	18.55	25.75	0.78
WATERCOURSE	405	11.20	5.35	7.25		7.37	0.008387	1.71	9.15	13.86	0.45
WATERCOURSE	405	14.80	5.35	7.48		7.59	0.007229	1.75	12.65	16.95	0.43
WATERCOURSE	405	20.10	5.35	7.63		7.77	0.008724	2.03	15.28	18.95	0.48

HEC-RAS Plan: Existing River: WATERCOURSE Reach: WATERCOURSE (Continued)

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	400	14.80	5.35	7.42		7.55	0.008708	1.87	11.63	16.11	0.47
WATERCOURSE	400	20.10	5.35	7.54		7.72	0.011336	2.24	13.60	17.70	0.54
WATERCOURSE	400	37.60	5.35	7.74		8.13	0.022090	3.37	17.61	20.57	0.77
WATERCOURSE	399	11.20	5.07	7.20		7.30	0.007256	1.51	9.76	14.31	0.39
WATERCOURSE	399	14.80	5.07	7.45		7.53	0.005458	1.46	16.44	31.17	0.35
WATERCOURSE	399	20.10	5.07	7.60		7.68	0.005831	1.59	21.13	32.69	0.37
WATERCOURSE	399	37.60	5.07	7.92		8.03	0.007188	1.96	32.30	36.05	0.42
WATERCOURSE	390	11.20	5.07	7.08		7.21	0.010725	1.74	8.14	12.75	0.47
WATERCOURSE	390	14.80	5.07	7.34		7.46	0.008242	1.72	13.23	30.09	0.43
WATERCOURSE	390	20.10	5.07	7.49		7.61	0.008741	1.87	17.60	31.55	0.45
WATERCOURSE	390	37.60	5.07	7.79		7.95	0.010752	2.30	27.57	34.67	0.51
WATERCOURSE	375	11.20	4.42	6.67		6.94	0.022312	2.34	5.02	4.80	0.62
WATERCOURSE	375	14.80	4.42	6.83	6.56	7.17	0.024639	2.64	7.04	20.99	0.67
WATERCOURSE	375	20.10	4.42	7.10		7.30	0.015740	2.34	14.59	32.01	0.55
WATERCOURSE	375	37.60	4.42	7.59		7.71	0.008757	2.04	30.44	32.49	0.42
WATERCOURSE	360	11.20	4.49	6.54		6.67	0.011919	1.62	6.91	6.42	0.50
WATERCOURSE	360	14.80	4.49	6.73		6.88	0.012293	1.75	9.72	20.61	0.51
WATERCOURSE	360	20.10	4.49	6.97		7.10	0.010144	1.74	15.61	30.67	0.48
WATERCOURSE	360	37.60	4.49	7.50		7.59	0.005854	1.65	33.14	33.71	0.38
WATERCOURSE	359	11.20	4.49	6.53		6.66	0.012369	1.64	6.82	6.38	0.51
WATERCOURSE	359	14.80	4.49	6.71		6.87	0.012962	1.79	9.37	20.02	0.53
WATERCOURSE	359	20.10	4.49	6.95		7.09	0.010688	1.77	15.19	29.86	0.49
WATERCOURSE	359	37.60	4.49	7.49		7.59	0.005953	1.66	32.94	33.70	0.39
WATERCOURSE	345	11.20	4.32	6.44		6.49	0.004637	1.21	13.74	23.29	0.33
WATERCOURSE	345	14.80	4.32	6.67		6.71	0.003437	1.16	19.34	25.06	0.29
WATERCOURSE	345	20.10	4.32	6.93		6.97	0.002869	1.17	26.12	27.15	0.27
WATERCOURSE	345	37.60	4.32	7.46		7.51	0.002852	1.38	41.70	31.63	0.29
WATERCOURSE	330	11.20	4.28	6.24		6.37	0.008552	1.57	7.44	8.84	0.43
WATERCOURSE	330	14.80	4.28	6.47		6.61	0.008307	1.72	9.86	12.90	0.44
WATERCOURSE	330	20.10	4.28	6.72		6.88	0.007933	1.86	13.80	17.74	0.44
WATERCOURSE	330	37.60	4.28	7.24		7.43	0.008048	2.21	25.53	27.73	0.46
WATERCOURSE	315	11.20	4.05	6.19		6.26	0.004911	1.26	9.37	10.40	0.35
WATERCOURSE	315	14.80	4.05	6.41		6.51	0.004768	1.38	12.14	13.84	0.35
WATERCOURSE	315	20.10	4.05	6.67		6.78	0.004738	1.52	16.24	17.83	0.36
WATERCOURSE	315	37.60	4.05	7.17		7.32	0.005723	1.95	26.88	25.75	0.41
WATERCOURSE	300	11.20	3.95	6.09		6.18	0.005578	1.38	8.78	9.73	0.37
WATERCOURSE	300	14.80	3.95	6.31		6.43	0.005572	1.52	11.36	13.41	0.38
WATERCOURSE	300	20.10	3.95	6.57		6.70	0.005566	1.68	15.44	18.18	0.39
WATERCOURSE	300	37.60	3.95	7.04		7.23	0.007079	2.19	26.60	33.09	0.45
WATERCOURSE	285	11.20	4.00	6.02		6.10	0.004958	1.27	9.44	11.36	0.35
WATERCOURSE	285	14.80	4.00	6.25		6.34	0.004669	1.38	12.46	14.70	0.35
WATERCOURSE	285	20.10	4.00	6.51		6.61	0.004561	1.51	16.81	18.85	0.36
WATERCOURSE	285	37.60	4.00	6.96		7.11	0.005711	1.96	27.49	28.13	0.41
WATERCOURSE	284	11.20	4.00	6.01		6.10	0.005028	1.28	9.38	11.28	0.36
WATERCOURSE	284	14.80	4.00	6.25		6.34	0.004725	1.38	12.39	14.63	0.35
WATERCOURSE	284	20.10	4.00	6.50		6.61	0.004611	1.51	16.72	18.78	0.36
WATERCOURSE	284	37.60	4.00	6.95		7.11	0.005786	1.96	27.32	28.03	0.42
WATERCOURSE	270	11.20	3.88	5.87		6.01	0.008826	1.65	7.78	9.93	0.42
WATERCOURSE	270	14.80	3.88	6.11		6.25	0.008447	1.77	10.63	14.28	0.42
WATERCOURSE	270	20.10	3.88	6.36		6.51	0.008153	1.90	14.86	18.98	0.42
WATERCOURSE	270	37.60	3.88	6.79		7.01	0.010893	2.48	26.34	38.97	0.50
WATERCOURSE	255	11.20	3.73	5.58		5.80	0.015883	2.13	5.86	7.73	0.57
WATERCOURSE	255	14.80	3.73	5.83		6.07	0.014075	2.24	8.29	11.77	0.55
WATERCOURSE	255	20.10	3.73	6.10		6.33	0.012838	2.36	12.03	16.60	0.54
WATERCOURSE	255	37.60	3.73	6.52		6.83	0.015469	2.95	22.29	35.92	0.62
WATERCOURSE	240	11.20	3.10	4.73	4.73	5.29	0.064224	3.32	3.37	3.01	1.00
WATERCOURSE	240	14.80	3.10	4.97	4.97	5.62	0.065376	3.58	4.14	3.22	1.01
WATERCOURSE	240	20.10	3.10	5.36	5.36	6.01	0.057099	3.58	5.66	4.75	0.98

HEC-RAS Plan: Existing River: WATERCOURSE Reach: WATERCOURSE (Continued)

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	225	20.10	2.94	5.03		5.18	0.007579	1.70	11.83	6.77	0.41
WATERCOURSE	225	37.60	2.94	6.36		6.44	0.002785	1.45	38.81	51.95	0.27
WATERCOURSE	222	11.20	2.80	4.25	3.62	4.38	0.006945	1.58	7.10	6.08	0.42
WATERCOURSE	222	14.80	2.80	4.54	3.78	4.69	0.007198	1.73	8.55	6.12	0.42
WATERCOURSE	222	20.10	2.80	4.96	4.00	5.14	0.007254	1.89	10.65	6.17	0.42
WATERCOURSE	222	37.60	2.80	6.26	4.62	6.42	0.004047	1.78	21.17	6.30	0.31
WATERCOURSE	221	11.20	2.79	4.27	3.55	4.37	0.002928	1.40	7.98	6.78	0.37
WATERCOURSE	221	14.80	2.79	4.56	3.70	4.68	0.002793	1.55	9.57	6.82	0.37
WATERCOURSE	221	20.10	2.79	4.98	3.91	5.13	0.002537	1.70	11.83	6.87	0.37
WATERCOURSE	221	37.60	2.79	6.28	4.49	6.41	0.002951	1.58	23.82	7.00	0.27
WATERCOURSE	214	Culvert									
WATERCOURSE	207	12.20	2.70	4.15	3.51	4.28	0.003724	1.56	7.82	7.06	0.41
WATERCOURSE	207	16.10	2.70	4.39	3.67	4.55	0.003902	1.77	9.10	7.13	0.43
WATERCOURSE	207	20.20	2.70	4.61	3.83	4.81	0.004084	1.96	10.29	7.20	0.45
WATERCOURSE	207	41.20	2.70	5.38	4.51	5.79	0.005479	2.85	14.45	7.43	0.56
WATERCOURSE	150	12.20	1.77	3.62		3.84	0.013059	2.08	5.87	5.46	0.64
WATERCOURSE	150	16.10	1.77	3.85		4.10	0.013079	2.23	7.23	6.04	0.65
WATERCOURSE	150	20.20	1.77	4.07		4.35	0.012809	2.34	8.64	6.59	0.65
WATERCOURSE	150	41.20	1.77	4.85		5.26	0.012286	2.84	14.98	13.05	0.67
WATERCOURSE	135	12.20	1.41	3.52		3.66	0.007535	1.69	7.24	5.47	0.47
WATERCOURSE	135	16.10	1.41	3.74		3.92	0.008556	1.89	8.52	5.99	0.51
WATERCOURSE	135	20.20	1.41	3.96		4.17	0.009131	2.04	9.88	6.50	0.53
WATERCOURSE	135	41.20	1.41	4.77		5.06	0.008927	2.48	19.13	23.34	0.55
WATERCOURSE	120	12.20	1.56	3.31		3.51	0.010618	1.97	6.21	5.06	0.57
WATERCOURSE	120	16.10	1.56	3.49		3.75	0.012791	2.26	7.12	5.36	0.63
WATERCOURSE	120	20.20	1.56	3.67		3.98	0.014164	2.49	8.12	5.67	0.66
WATERCOURSE	120	41.20	1.56	4.04	4.04	4.84	0.029171	3.98	10.48	6.84	0.97
WATERCOURSE	105	12.20	1.49	3.13		3.28	0.007503	1.68	7.27	6.15	0.49
WATERCOURSE	105	16.10	1.49	3.22		3.44	0.010657	2.05	7.84	6.34	0.59
WATERCOURSE	105	20.20	1.49	3.33		3.62	0.013289	2.36	8.55	6.57	0.66
WATERCOURSE	105	41.20	1.49	3.98		4.47	0.016191	3.10	13.54	11.77	0.75
WATERCOURSE	90	12.20	0.94	3.10		3.18	0.003383	1.27	9.61	5.90	0.32
WATERCOURSE	90	16.10	0.94	3.17		3.30	0.005263	1.61	10.02	5.98	0.40
WATERCOURSE	90	20.20	0.94	3.25		3.44	0.007251	1.92	10.53	6.09	0.47
WATERCOURSE	90	41.20	0.94	3.72		4.19	0.015120	3.04	13.61	7.87	0.68
WATERCOURSE	75	12.20	1.05	3.10		3.14	0.001513	0.91	13.43	8.72	0.23
WATERCOURSE	75	16.10	1.05	3.16		3.23	0.002331	1.15	14.04	8.85	0.29
WATERCOURSE	75	20.20	1.05	3.25		3.35	0.003162	1.36	14.81	9.02	0.34
WATERCOURSE	75	41.20	1.05	3.78		3.99	0.005538	2.04	21.59	21.57	0.46
WATERCOURSE	60	12.20	1.44	3.02		3.09	0.003669	1.20	10.25	10.06	0.37
WATERCOURSE	60	16.10	1.44	3.04		3.16	0.006080	1.56	10.41	10.08	0.48
WATERCOURSE	60	20.20	1.44	3.06		3.24	0.008993	1.92	10.63	10.26	0.59
WATERCOURSE	60	41.20	1.44	3.28	3.22	3.80	0.020410	3.22	13.12	12.17	0.91
WATERCOURSE	45	12.20	1.11	3.03		3.05	0.000613	0.68	21.21	19.96	0.16
WATERCOURSE	45	16.10	1.11	3.06		3.09	0.001003	0.88	21.74	20.24	0.21
WATERCOURSE	45	20.20	1.11	3.09		3.14	0.001454	1.07	22.45	20.62	0.25
WATERCOURSE	45	41.20	1.11	3.43		3.55	0.002870	1.69	30.26	27.31	0.37
WATERCOURSE	30	12.20	1.12	3.00		3.04	0.001449	0.84	14.60	11.27	0.23
WATERCOURSE	30	16.10	1.12	3.00		3.06	0.002522	1.10	14.60	11.27	0.31
WATERCOURSE	30	20.20	1.12	3.00		3.10	0.003968	1.38	14.61	11.27	0.39
WATERCOURSE	30	41.20	1.12	3.00		3.41	0.016568	2.82	14.58	11.27	0.79
WATERCOURSE	15	12.20	1.15	3.00		3.02	0.000555	0.58	20.94	13.93	0.15
WATERCOURSE	15	16.10	1.15	3.00		3.03	0.000966	0.77	20.94	13.93	0.20
WATERCOURSE	15	20.20	1.15	3.00		3.05	0.001521	0.96	20.94	13.93	0.25
WATERCOURSE	15	41.20	1.15	3.00		3.20	0.006324	1.97	20.94	13.93	0.51
WATERCOURSE	0	12.20	1.14	3.00	1.73	3.01	0.000413	0.41	29.75	28.88	0.13
WATERCOURSE	0	16.10	1.14	3.00	1.83	3.01	0.000719	0.54	29.75	28.88	0.17

HEC-RAS Plan: Culv, No US River: WATERCOURSE Reach: WATERCOURSE

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	615	11.20	7.25	9.05		9.09	0.004467	1.11	15.77	27.80	0.32
WATERCOURSE	615	14.80	7.25	9.19		9.24	0.004269	1.14	20.02	29.78	0.32
WATERCOURSE	615	20.10	7.25	9.37		9.41	0.004213	1.20	25.45	32.13	0.32
WATERCOURSE	615	37.60	7.25	9.80		9.85	0.004035	1.32	40.06	36.91	0.32
WATERCOURSE	600	11.20	7.03	8.85		8.98	0.011569	1.73	8.81	18.76	0.50
WATERCOURSE	600	14.80	7.03	9.02		9.14	0.010307	1.73	12.27	20.69	0.48
WATERCOURSE	600	20.10	7.03	9.21		9.32	0.009595	1.77	16.17	20.91	0.47
WATERCOURSE	600	37.60	7.03	9.62		9.76	0.010272	2.04	25.04	24.68	0.49
WATERCOURSE	585	11.20	7.04	8.74		8.84	0.007030	1.48	10.34	20.58	0.40
WATERCOURSE	585	14.80	7.04	8.90		9.00	0.006922	1.58	14.41	28.95	0.41
WATERCOURSE	585	20.10	7.04	9.10		9.20	0.006330	1.64	21.11	39.02	0.40
WATERCOURSE	585	37.60	7.04	9.56		9.63	0.004368	1.59	41.12	43.85	0.34
WATERCOURSE	570	11.20	6.91	8.60		8.71	0.010450	1.60	8.67	13.37	0.50
WATERCOURSE	570	14.80	6.91	8.75		8.87	0.011033	1.74	10.82	15.19	0.52
WATERCOURSE	570	20.10	6.91	8.91		9.06	0.012099	1.93	13.53	17.22	0.55
WATERCOURSE	570	37.60	6.91	9.29		9.51	0.014885	2.39	20.95	21.83	0.63
WATERCOURSE	555	11.20	6.70	8.55		8.59	0.004028	0.94	14.32	29.69	0.32
WATERCOURSE	555	14.80	6.70	8.72		8.76	0.003430	0.96	19.62	33.21	0.30
WATERCOURSE	555	20.10	6.70	8.91		8.95	0.003123	1.00	25.81	33.63	0.29
WATERCOURSE	555	37.60	6.70	9.31		9.37	0.003258	1.21	39.61	34.25	0.31
WATERCOURSE	540	11.20	6.74	8.51		8.54	0.003265	0.97	18.98	30.24	0.28
WATERCOURSE	540	14.80	6.74	8.69		8.71	0.002825	0.99	24.62	34.01	0.26
WATERCOURSE	540	20.10	6.74	8.87		8.90	0.002739	1.05	31.33	38.01	0.26
WATERCOURSE	540	37.60	6.74	9.28		9.32	0.002890	1.26	48.38	44.14	0.28
WATERCOURSE	525	11.20	6.53	8.29		8.44	0.010373	1.82	8.00	15.19	0.51
WATERCOURSE	525	14.80	6.53	8.46		8.62	0.010072	1.95	11.00	19.97	0.51
WATERCOURSE	525	20.10	6.53	8.68		8.82	0.008312	1.94	17.21	33.08	0.48
WATERCOURSE	525	37.60	6.53	9.13		9.25	0.006310	1.99	33.75	40.06	0.43
WATERCOURSE	510	11.20	6.48	8.10		8.27	0.012241	1.89	7.39	12.73	0.55
WATERCOURSE	510	14.80	6.48	8.27		8.45	0.012310	2.06	9.71	16.23	0.56
WATERCOURSE	510	20.10	6.48	8.46		8.66	0.011955	2.22	13.41	21.25	0.57
WATERCOURSE	510	37.60	6.48	8.92		9.12	0.010334	2.45	25.74	32.57	0.55
WATERCOURSE	495	11.20	6.28	8.04		8.13	0.005662	1.33	10.60	18.29	0.39
WATERCOURSE	495	14.80	6.28	8.22		8.31	0.005257	1.41	14.07	20.28	0.38
WATERCOURSE	495	20.10	6.28	8.43		8.52	0.005106	1.52	18.47	22.56	0.39
WATERCOURSE	495	37.60	6.28	8.85		8.99	0.005974	1.93	29.40	29.72	0.43
WATERCOURSE	480	11.20	6.04	7.92		8.03	0.007398	1.54	9.15	15.90	0.42
WATERCOURSE	480	14.80	6.04	8.10		8.21	0.007114	1.64	12.91	23.56	0.42
WATERCOURSE	480	20.10	6.04	8.33		8.44	0.006072	1.66	18.89	27.79	0.40
WATERCOURSE	480	37.60	6.04	8.78		8.89	0.005940	1.91	32.70	34.62	0.41
WATERCOURSE	465	11.20	5.66	7.89		7.94	0.003081	1.03	13.15	17.91	0.28
WATERCOURSE	465	14.80	5.66	8.07		8.13	0.003244	1.12	16.51	19.14	0.30
WATERCOURSE	465	20.10	5.66	8.30		8.36	0.003382	1.22	20.98	20.66	0.31
WATERCOURSE	465	37.60	5.66	8.71		8.81	0.004703	1.62	30.02	23.79	0.37
WATERCOURSE	450	11.20	5.69	7.87		7.89	0.002228	0.92	20.93	35.48	0.24
WATERCOURSE	450	14.80	5.69	8.06		8.08	0.001945	0.93	28.17	41.01	0.23
WATERCOURSE	450	20.10	5.69	8.29		8.31	0.001749	0.96	39.07	51.66	0.22
WATERCOURSE	450	37.60	5.69	8.72		8.75	0.001693	1.08	63.02	59.11	0.22
WATERCOURSE	435	11.20	5.66	7.78		7.84	0.005734	1.29	12.47	17.33	0.35
WATERCOURSE	435	14.80	5.66	7.97		8.03	0.005339	1.31	15.93	18.61	0.34
WATERCOURSE	435	20.10	5.66	8.21		8.27	0.005109	1.35	20.41	20.14	0.34
WATERCOURSE	435	37.60	5.66	8.59		8.69	0.007113	1.74	28.74	22.71	0.41
WATERCOURSE	420	11.20	5.65	7.37		7.65	0.033529	2.52	5.35	7.96	0.73
WATERCOURSE	420	14.80	5.65	7.55		7.85	0.032137	2.65	6.97	9.33	0.72
WATERCOURSE	420	20.10	5.65	7.71		8.07	0.037382	3.00	8.51	10.48	0.77
WATERCOURSE	420	37.60	5.65	8.25		8.49	0.029715	2.40	18.55	25.75	0.78
WATERCOURSE	405	11.20	5.35	7.25		7.37	0.008425	1.72	9.14	13.84	0.45
WATERCOURSE	405	14.80	5.35	7.48		7.59	0.007283	1.75	12.60	16.92	0.43

HEC-RAS Plan: Culv, No US River: WATERCOURSE Reach: WATERCOURSE (Continued)

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	400	14.80	5.35	7.41		7.55	0.008798	1.88	11.57	16.06	0.47
WATERCOURSE	400	20.10	5.35	7.54		7.72	0.011336	2.24	13.60	17.70	0.54
WATERCOURSE	400	37.60	5.35	7.75		8.13	0.022059	3.37	17.62	20.57	0.77
WATERCOURSE	399	11.20	5.07	7.20		7.30	0.007302	1.52	9.74	14.29	0.40
WATERCOURSE	399	14.80	5.07	7.45		7.53	0.005529	1.46	16.34	31.14	0.35
WATERCOURSE	399	20.10	5.07	7.60		7.68	0.005831	1.59	21.13	32.69	0.37
WATERCOURSE	399	37.60	5.07	7.92		8.03	0.007182	1.96	32.31	36.05	0.42
WATERCOURSE	390	11.20	5.07	7.07		7.21	0.010853	1.75	8.09	12.70	0.48
WATERCOURSE	390	14.80	5.07	7.34		7.46	0.008492	1.74	13.01	30.01	0.43
WATERCOURSE	390	20.10	5.07	7.49		7.61	0.008741	1.87	17.60	31.55	0.45
WATERCOURSE	390	37.60	5.07	7.79		7.95	0.010730	2.30	27.60	34.67	0.51
WATERCOURSE	375	11.20	4.42	6.65		6.93	0.023326	2.37	4.94	4.75	0.64
WATERCOURSE	375	14.80	4.42	6.82	6.56	7.17	0.025643	2.68	6.79	19.91	0.68
WATERCOURSE	375	20.10	4.42	7.09		7.30	0.016586	2.39	14.22	32.00	0.56
WATERCOURSE	375	37.60	4.42	7.56		7.69	0.009546	2.11	29.53	32.46	0.44
WATERCOURSE	360	11.20	4.49	6.51		6.65	0.012937	1.67	6.71	6.33	0.52
WATERCOURSE	360	14.80	4.49	6.71		6.87	0.013257	1.80	9.22	19.77	0.53
WATERCOURSE	360	20.10	4.49	6.91		7.07	0.012367	1.87	14.05	27.62	0.52
WATERCOURSE	360	37.60	4.49	7.46		7.56	0.006564	1.72	31.79	33.62	0.41
WATERCOURSE	359	11.20	4.49	6.49		6.64	0.013487	1.70	6.60	6.28	0.53
WATERCOURSE	359	14.80	4.49	6.68		6.85	0.014411	1.86	8.69	18.81	0.55
WATERCOURSE	359	20.10	4.49	6.89		7.06	0.013239	1.91	13.55	26.58	0.54
WATERCOURSE	359	37.60	4.49	7.45		7.56	0.006693	1.73	31.57	33.60	0.41
WATERCOURSE	345	11.20	4.32	6.37		6.44	0.006137	1.35	12.19	22.78	0.38
WATERCOURSE	345	14.80	4.32	6.60		6.65	0.004381	1.27	17.60	24.53	0.33
WATERCOURSE	345	20.10	4.32	6.86		6.91	0.003513	1.26	24.20	26.55	0.30
WATERCOURSE	345	37.60	4.32	7.41		7.47	0.003124	1.43	40.32	31.26	0.30
WATERCOURSE	330	11.20	4.28	6.11		6.27	0.012335	1.76	6.41	6.67	0.51
WATERCOURSE	330	14.80	4.28	6.31		6.50	0.012521	1.97	8.07	9.99	0.53
WATERCOURSE	330	20.10	4.28	6.56		6.78	0.012057	2.15	11.14	14.62	0.53
WATERCOURSE	330	37.60	4.28	7.14		7.37	0.010082	2.41	22.91	25.83	0.51
WATERCOURSE	315	11.20	4.05	6.01		6.12	0.008045	1.46	7.74	7.94	0.43
WATERCOURSE	315	14.80	4.05	6.21		6.35	0.007932	1.62	9.69	10.81	0.44
WATERCOURSE	315	20.10	4.05	6.47		6.63	0.007637	1.78	12.96	14.72	0.45
WATERCOURSE	315	37.60	4.05	7.05		7.24	0.007242	2.12	24.02	23.59	0.46
WATERCOURSE	300	11.20	3.95	5.80		5.96	0.012323	1.77	6.41	6.80	0.53
WATERCOURSE	300	14.80	3.95	5.99		6.19	0.012557	1.98	7.89	8.71	0.55
WATERCOURSE	300	20.10	3.95	6.23		6.47	0.012640	2.22	10.28	11.83	0.56
WATERCOURSE	300	37.60	3.95	6.82		7.10	0.011217	2.58	20.47	23.42	0.56
WATERCOURSE	285	11.20	4.00	5.46		5.71	0.025510	2.20	5.09	5.81	0.75
WATERCOURSE	285	14.80	4.00	5.66		5.94	0.025123	2.35	6.31	6.44	0.76
WATERCOURSE	285	20.10	4.00	5.90		6.23	0.022473	2.54	8.18	9.63	0.74
WATERCOURSE	285	37.60	4.00	6.49		6.87	0.016685	2.86	16.46	18.55	0.68
WATERCOURSE	284	11.20	4.00	5.27	5.27	5.66	0.047815	2.78	4.02	5.19	1.01
WATERCOURSE	284	14.80	4.00	5.45	5.45	5.89	0.046247	2.95	5.02	5.77	1.01
WATERCOURSE	284	20.10	4.00	5.68	5.68	6.18	0.043982	3.13	6.43	6.50	1.00
WATERCOURSE	284	37.60	4.00	6.30	6.30	6.84	0.026439	3.35	13.25	15.53	0.84
WATERCOURSE	270	11.20	3.05	4.39	3.84	4.50	0.005729	1.47	7.64	7.79	0.43
WATERCOURSE	270	14.80	3.05	4.71	3.99	4.83	0.004888	1.51	9.83	8.22	0.41
WATERCOURSE	270	20.10	3.05	5.36	4.19	5.45	0.002976	1.37	14.63	9.08	0.32
WATERCOURSE	270	37.60	3.05	6.44	4.74	6.53	0.001808	1.35	27.91	10.00	0.26
WATERCOURSE	245	Culvert									
WATERCOURSE	222	11.20	2.80	4.25	3.62	4.38	0.006945	1.58	7.10	6.08	0.42
WATERCOURSE	222	14.80	2.80	4.54	3.78	4.69	0.007198	1.73	8.55	6.12	0.42
WATERCOURSE	222	20.10	2.80	4.96	4.00	5.14	0.007254	1.89	10.65	6.17	0.42
WATERCOURSE	222	37.60	2.80	6.26	4.62	6.42	0.004047	1.78	21.17	6.30	0.31
WATERCOURSE	221	11.20	2.79	4.27	3.55	4.37	0.002928	1.40	7.98	6.78	0.37
WATERCOURSE	221	14.80	2.79	4.56	3.70	4.68	0.002793	1.55	9.57	6.82	0.37

HEC-RAS Plan: Culv, No US River: WATERCOURSE Reach: WATERCOURSE (Continued)

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	214	Culvert									
WATERCOURSE	207	12.20	2.70	4.15	3.51	4.28	0.003724	1.56	7.82	7.06	0.41
WATERCOURSE	207	16.10	2.70	4.39	3.67	4.55	0.003902	1.77	9.10	7.13	0.43
WATERCOURSE	207	20.20	2.70	4.61	3.83	4.81	0.004084	1.96	10.29	7.20	0.45
WATERCOURSE	207	41.20	2.70	5.38	4.51	5.79	0.005479	2.85	14.45	7.43	0.56
WATERCOURSE	150	12.20	1.77	3.62		3.84	0.013059	2.08	5.87	5.46	0.64
WATERCOURSE	150	16.10	1.77	3.85		4.10	0.013079	2.23	7.23	6.04	0.65
WATERCOURSE	150	20.20	1.77	4.07		4.35	0.012809	2.34	8.64	6.59	0.65
WATERCOURSE	150	41.20	1.77	4.85		5.26	0.012286	2.84	14.98	13.05	0.67
WATERCOURSE	135	12.20	1.41	3.52		3.66	0.007535	1.69	7.24	5.47	0.47
WATERCOURSE	135	16.10	1.41	3.74		3.92	0.008556	1.89	8.52	5.99	0.51
WATERCOURSE	135	20.20	1.41	3.96		4.17	0.009131	2.04	9.88	6.50	0.53
WATERCOURSE	135	41.20	1.41	4.77		5.06	0.008927	2.48	19.13	23.34	0.55
WATERCOURSE	120	12.20	1.56	3.31		3.51	0.010618	1.97	6.21	5.06	0.57
WATERCOURSE	120	16.10	1.56	3.49		3.75	0.012791	2.26	7.12	5.36	0.63
WATERCOURSE	120	20.20	1.56	3.67		3.98	0.014164	2.49	8.12	5.67	0.66
WATERCOURSE	120	41.20	1.56	4.04	4.04	4.84	0.029171	3.98	10.48	6.84	0.97
WATERCOURSE	105	12.20	1.49	3.13		3.28	0.007503	1.68	7.27	6.15	0.49
WATERCOURSE	105	16.10	1.49	3.22		3.44	0.010657	2.05	7.84	6.34	0.59
WATERCOURSE	105	20.20	1.49	3.33		3.62	0.013289	2.36	8.55	6.57	0.66
WATERCOURSE	105	41.20	1.49	3.98		4.47	0.016191	3.10	13.54	11.77	0.75
WATERCOURSE	90	12.20	0.94	3.10		3.18	0.003383	1.27	9.61	5.90	0.32
WATERCOURSE	90	16.10	0.94	3.17		3.30	0.005263	1.61	10.02	5.98	0.40
WATERCOURSE	90	20.20	0.94	3.25		3.44	0.007251	1.92	10.53	6.09	0.47
WATERCOURSE	90	41.20	0.94	3.72		4.19	0.015120	3.04	13.61	7.87	0.68
WATERCOURSE	75	12.20	1.05	3.10		3.14	0.001513	0.91	13.43	8.72	0.23
WATERCOURSE	75	16.10	1.05	3.16		3.23	0.002331	1.15	14.04	8.85	0.29
WATERCOURSE	75	20.20	1.05	3.25		3.35	0.003162	1.36	14.81	9.02	0.34
WATERCOURSE	75	41.20	1.05	3.78		3.99	0.005538	2.04	21.59	21.57	0.46
WATERCOURSE	60	12.20	1.44	3.02		3.09	0.003669	1.20	10.25	10.06	0.37
WATERCOURSE	60	16.10	1.44	3.04		3.16	0.006080	1.56	10.41	10.08	0.48
WATERCOURSE	60	20.20	1.44	3.06		3.24	0.008993	1.92	10.63	10.26	0.59
WATERCOURSE	60	41.20	1.44	3.28	3.22	3.80	0.020410	3.22	13.12	12.17	0.91
WATERCOURSE	45	12.20	1.11	3.03		3.05	0.000613	0.68	21.21	19.96	0.16
WATERCOURSE	45	16.10	1.11	3.06		3.09	0.001003	0.88	21.74	20.24	0.21
WATERCOURSE	45	20.20	1.11	3.09		3.14	0.001454	1.07	22.45	20.62	0.25
WATERCOURSE	45	41.20	1.11	3.43		3.55	0.002870	1.69	30.26	27.31	0.37
WATERCOURSE	30	12.20	1.12	3.00		3.04	0.001449	0.84	14.60	11.27	0.23
WATERCOURSE	30	16.10	1.12	3.00		3.06	0.002522	1.10	14.60	11.27	0.31
WATERCOURSE	30	20.20	1.12	3.00		3.10	0.003968	1.38	14.61	11.27	0.39
WATERCOURSE	30	41.20	1.12	3.00		3.41	0.016568	2.82	14.58	11.27	0.79
WATERCOURSE	15	12.20	1.15	3.00		3.02	0.000555	0.58	20.94	13.93	0.15
WATERCOURSE	15	16.10	1.15	3.00		3.03	0.000966	0.77	20.94	13.93	0.20
WATERCOURSE	15	20.20	1.15	3.00		3.05	0.001521	0.96	20.94	13.93	0.25
WATERCOURSE	15	41.20	1.15	3.00		3.20	0.006324	1.97	20.94	13.93	0.51
WATERCOURSE	0	12.20	1.14	3.00	1.73	3.01	0.000413	0.41	29.75	28.88	0.13
WATERCOURSE	0	16.10	1.14	3.00	1.83	3.01	0.000719	0.54	29.75	28.88	0.17
WATERCOURSE	0	20.20	1.14	3.00	1.92	3.02	0.001132	0.68	29.75	28.88	0.21
WATERCOURSE	0	41.20	1.14	3.00	2.33	3.10	0.004709	1.38	29.75	28.88	0.44

HEC-RAS Plan: Ult Culv US River: WATERCOURSE Reach: WATERCOURSE

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	615	11.20	7.25	9.05		9.09	0.004467	1.11	15.77	27.80	0.32
WATERCOURSE	615	14.80	7.25	9.19		9.24	0.004269	1.14	20.02	29.78	0.32
WATERCOURSE	615	20.10	7.25	9.37		9.41	0.004213	1.20	25.45	32.13	0.32
WATERCOURSE	615	37.60	7.25	9.80		9.85	0.004034	1.32	40.06	36.92	0.32
WATERCOURSE	600	11.20	7.03	8.85		8.98	0.011569	1.73	8.81	18.76	0.50
WATERCOURSE	600	14.80	7.03	9.02		9.14	0.010307	1.73	12.27	20.69	0.48
WATERCOURSE	600	20.10	7.03	9.21		9.32	0.009595	1.77	16.17	20.91	0.47
WATERCOURSE	600	37.60	7.03	9.62		9.76	0.010267	2.04	25.05	24.68	0.49
WATERCOURSE	585	11.20	7.04	8.74		8.84	0.007029	1.48	10.35	20.58	0.40
WATERCOURSE	585	14.80	7.04	8.90		9.00	0.006922	1.58	14.41	28.95	0.41
WATERCOURSE	585	20.10	7.04	9.10		9.20	0.006331	1.64	21.11	39.02	0.40
WATERCOURSE	585	37.60	7.04	9.56		9.63	0.004364	1.59	41.14	43.85	0.34
WATERCOURSE	570	11.20	6.91	8.60		8.71	0.010448	1.60	8.67	13.37	0.50
WATERCOURSE	570	14.80	6.91	8.75		8.87	0.011032	1.74	10.82	15.19	0.52
WATERCOURSE	570	20.10	6.91	8.91		9.06	0.012101	1.93	13.52	17.22	0.55
WATERCOURSE	570	37.60	6.91	9.29		9.51	0.014859	2.39	20.97	21.84	0.63
WATERCOURSE	555	11.20	6.70	8.55		8.59	0.004027	0.94	14.32	29.70	0.32
WATERCOURSE	555	14.80	6.70	8.72		8.76	0.003430	0.96	19.62	33.21	0.30
WATERCOURSE	555	20.10	6.70	8.91		8.95	0.003123	1.00	25.81	33.63	0.29
WATERCOURSE	555	37.60	6.70	9.31		9.37	0.003253	1.21	39.63	34.25	0.31
WATERCOURSE	540	11.20	6.74	8.51		8.54	0.003264	0.97	18.98	30.24	0.28
WATERCOURSE	540	14.80	6.74	8.69		8.71	0.002825	0.99	24.62	34.01	0.26
WATERCOURSE	540	20.10	6.74	8.87		8.90	0.002740	1.05	31.33	38.01	0.26
WATERCOURSE	540	37.60	6.74	9.28		9.32	0.002884	1.25	48.42	44.14	0.28
WATERCOURSE	525	11.20	6.53	8.29		8.44	0.010365	1.82	8.01	15.20	0.51
WATERCOURSE	525	14.80	6.53	8.46		8.62	0.010070	1.95	11.00	19.98	0.51
WATERCOURSE	525	20.10	6.53	8.68		8.82	0.008319	1.94	17.20	33.08	0.48
WATERCOURSE	525	37.60	6.53	9.14		9.25	0.006286	1.98	33.80	40.08	0.43
WATERCOURSE	510	11.20	6.48	8.11		8.27	0.012203	1.89	7.40	12.75	0.55
WATERCOURSE	510	14.80	6.48	8.27		8.45	0.012299	2.06	9.71	16.23	0.56
WATERCOURSE	510	20.10	6.48	8.46		8.66	0.011991	2.22	13.39	21.23	0.57
WATERCOURSE	510	37.60	6.48	8.92		9.12	0.010206	2.44	25.87	32.67	0.55
WATERCOURSE	495	11.20	6.28	8.04		8.13	0.005634	1.33	10.63	18.30	0.39
WATERCOURSE	495	14.80	6.28	8.22		8.31	0.005251	1.41	14.08	20.29	0.38
WATERCOURSE	495	20.10	6.28	8.43		8.52	0.005123	1.52	18.45	22.55	0.39
WATERCOURSE	495	37.60	6.28	8.86		8.99	0.005904	1.92	29.54	29.80	0.43
WATERCOURSE	480	11.20	6.04	7.92		8.03	0.007347	1.53	9.18	16.02	0.42
WATERCOURSE	480	14.80	6.04	8.10		8.22	0.007097	1.64	12.92	23.58	0.42
WATERCOURSE	480	20.10	6.04	8.33		8.44	0.006106	1.67	18.84	27.76	0.40
WATERCOURSE	480	37.60	6.04	8.78		8.90	0.005844	1.90	32.92	34.72	0.41
WATERCOURSE	465	11.20	5.66	7.89		7.94	0.003059	1.03	13.19	17.93	0.28
WATERCOURSE	465	14.80	5.66	8.07		8.13	0.003237	1.12	16.52	19.14	0.30
WATERCOURSE	465	20.10	5.66	8.29		8.36	0.003398	1.22	20.94	20.65	0.31
WATERCOURSE	465	37.60	5.66	8.71		8.82	0.004630	1.61	30.20	23.86	0.37
WATERCOURSE	450	11.20	5.69	7.87		7.90	0.002204	0.92	21.03	35.56	0.24
WATERCOURSE	450	14.80	5.69	8.06		8.08	0.001939	0.93	28.20	41.03	0.23
WATERCOURSE	450	20.10	5.69	8.29		8.31	0.001762	0.96	38.96	51.63	0.22
WATERCOURSE	450	37.60	5.69	8.73		8.75	0.001661	1.07	63.46	59.24	0.22
WATERCOURSE	435	11.20	5.66	7.79		7.84	0.005657	1.28	12.54	17.36	0.35
WATERCOURSE	435	14.80	5.66	7.98		8.03	0.005322	1.31	15.95	18.62	0.34
WATERCOURSE	435	20.10	5.66	8.20		8.26	0.005145	1.36	20.36	20.12	0.34
WATERCOURSE	435	37.60	5.66	8.60		8.70	0.006967	1.72	28.96	22.78	0.40
WATERCOURSE	420	11.20	5.65	7.44		7.67	0.026086	2.29	5.98	8.52	0.65
WATERCOURSE	420	14.80	5.65	7.58		7.86	0.029202	2.55	7.27	9.56	0.68
WATERCOURSE	420	20.10	5.65	7.75		8.08	0.033424	2.88	8.93	10.77	0.73
WATERCOURSE	420	37.60	5.65	8.31		8.51	0.024229	2.25	20.06	26.98	0.71
WATERCOURSE	405	11.20	5.35	6.87	6.87	7.23	0.031685	2.73	4.88	8.68	0.83
WATERCOURSE	405	14.80	5.35	7.07	7.07	7.42	0.027564	2.84	6.80	11.30	0.80
		20.10	5.35	7.27	7.27	7.64	0.025414	3.01	9.42	14.11	0.79

HEC-RAS Plan: Ult Culv US River: WATERCOURSE Reach: WATERCOURSE (Continued)

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	400	14.80	5.26	5.96	6.31	7.11	0.126663	4.76	3.11	4.93	1.92
WATERCOURSE	400	20.10	5.26	6.17	6.53	7.34	0.096496	4.79	4.19	5.22	1.71
WATERCOURSE	400	37.60	5.26	6.94	7.12	7.91	0.043725	4.37	8.60	6.24	1.19
WATERCOURSE	399	11.20	4.76	5.26	5.64	6.61	0.212374	5.15	2.17	4.67	2.41
WATERCOURSE	399	14.80	4.76	5.38	5.81	6.89	0.189554	5.45	2.72	4.82	2.32
WATERCOURSE	399	20.10	4.76	5.55	6.03	7.16	0.154393	5.63	3.57	5.05	2.14
WATERCOURSE	399	37.60	4.76	7.43		7.73	0.008799	2.44	15.43	7.56	0.54
WATERCOURSE	390	11.20	4.71	6.05		6.20	0.008241	1.70	6.57	5.79	0.51
WATERCOURSE	390	14.80	4.71	6.27		6.45	0.008644	1.88	7.88	6.08	0.53
WATERCOURSE	390	20.10	4.71	6.55		6.77	0.009139	2.09	9.62	6.45	0.55
WATERCOURSE	390	37.60	4.71	7.33		7.65	0.009324	2.49	15.10	7.50	0.56
WATERCOURSE	375	11.20	4.63	5.89		6.06	0.010130	1.83	6.11	5.68	0.56
WATERCOURSE	375	14.80	4.63	6.10		6.31	0.010605	2.02	7.32	5.96	0.58
WATERCOURSE	375	20.10	4.63	6.36		6.62	0.011215	2.25	8.94	6.31	0.60
WATERCOURSE	375	37.60	4.63	7.14		7.50	0.010882	2.64	14.26	7.35	0.60
WATERCOURSE	360	11.20	4.55	5.43	5.43	5.82	0.033634	2.78	4.03	5.17	1.00
WATERCOURSE	360	14.80	4.55	5.60	5.60	6.06	0.032853	3.01	4.92	5.40	1.00
WATERCOURSE	360	20.10	4.55	5.85	5.82	6.36	0.029398	3.17	6.34	5.74	0.96
WATERCOURSE	360	37.60	4.55	6.86		7.30	0.014572	2.94	12.81	7.08	0.70
WATERCOURSE	359	11.20	4.05	5.50		5.62	0.006341	1.55	7.21	5.94	0.45
WATERCOURSE	359	14.80	4.05	5.75		5.89	0.006529	1.70	8.71	6.26	0.46
WATERCOURSE	359	20.10	4.05	6.07		6.25	0.006594	1.86	10.83	6.70	0.47
WATERCOURSE	359	37.60	4.05	7.00		7.23	0.006192	2.14	17.57	7.93	0.46
WATERCOURSE	345	11.20	3.97	5.38		5.53	0.007774	1.68	6.67	5.42	0.48
WATERCOURSE	345	14.80	3.97	5.62		5.79	0.008253	1.86	7.96	5.65	0.50
WATERCOURSE	345	20.10	3.97	5.93		6.14	0.008679	2.06	9.75	5.96	0.51
WATERCOURSE	345	37.60	3.97	6.82		7.12	0.008658	2.43	15.48	6.85	0.52
WATERCOURSE	330	11.20	3.89	5.25		5.40	0.008924	1.76	6.35	5.36	0.52
WATERCOURSE	330	14.80	3.89	5.47		5.66	0.009516	1.96	7.56	5.58	0.54
WATERCOURSE	330	20.10	3.89	5.76		6.00	0.010034	2.17	9.25	5.87	0.55
WATERCOURSE	330	37.60	3.89	6.67		6.99	0.009473	2.51	14.97	6.78	0.54
WATERCOURSE	315	11.20	3.80	5.12		5.27	0.008805	1.74	6.42	5.76	0.53
WATERCOURSE	315	14.80	3.80	5.33		5.52	0.009189	1.92	7.71	6.05	0.54
WATERCOURSE	315	20.10	3.80	5.63		5.86	0.009334	2.10	9.55	6.44	0.55
WATERCOURSE	315	37.60	3.80	6.57		6.85	0.007703	2.32	16.20	7.70	0.51
WATERCOURSE	300	11.20	3.71	4.95		5.13	0.010770	1.87	5.98	5.65	0.58
WATERCOURSE	300	14.80	3.71	5.16		5.37	0.011219	2.06	7.18	5.93	0.60
WATERCOURSE	300	20.10	3.71	5.44		5.70	0.011227	2.25	8.93	6.31	0.60
WATERCOURSE	300	37.60	3.71	6.45		6.73	0.007992	2.35	15.98	7.66	0.52
WATERCOURSE	285	11.20	3.61	4.49	4.49	4.88	0.033552	2.78	4.03	5.17	1.00
WATERCOURSE	285	14.80	3.61	4.66	4.66	5.12	0.032785	3.00	4.93	5.40	1.00
WATERCOURSE	285	20.10	3.61	5.14		5.49	0.016976	2.61	7.70	6.04	0.74
WATERCOURSE	285	37.60	3.61	6.32		6.61	0.008278	2.38	15.78	7.62	0.53
WATERCOURSE	284	11.20	3.11	4.45		4.51	0.003235	1.14	9.82	8.68	0.34
WATERCOURSE	284	14.80	3.11	4.76		4.83	0.002722	1.17	12.66	9.31	0.32
WATERCOURSE	284	20.10	3.11	5.34		5.40	0.001767	1.10	18.33	10.45	0.26
WATERCOURSE	284	37.60	3.11	6.47		6.55	0.001370	1.20	31.36	12.00	0.24
WATERCOURSE	270	11.20	3.05	4.33	3.84	4.45	0.006664	1.54	7.25	7.71	0.47
WATERCOURSE	270	14.80	3.05	4.66	3.99	4.78	0.005505	1.57	9.43	8.14	0.43
WATERCOURSE	270	20.10	3.05	5.26	4.19	5.36	0.003476	1.45	13.83	8.94	0.35
WATERCOURSE	270	37.60	3.05	6.43	4.74	6.52	0.001833	1.35	27.77	10.00	0.26
WATERCOURSE	245	Culvert									
WATERCOURSE	222	11.20	2.80	4.17	3.62	4.31	0.008276	1.68	6.68	6.07	0.46
WATERCOURSE	222	14.80	2.80	4.46	3.78	4.63	0.008223	1.82	8.15	6.11	0.45
WATERCOURSE	222	20.10	2.80	4.87	4.00	5.07	0.008184	1.97	10.18	6.16	0.44
WATERCOURSE	222	37.60	2.80	6.24	4.62	6.40	0.004121	1.79	21.02	6.30	0.31
WATERCOURSE	221	11.20	2.79	4.18	3.55	4.30	0.003541	1.49	7.54	6.77	0.40
[illegible]	[illegible]	14.80	2.79	4.48	3.70	4.62	0.003241	1.62	9.15	6.81	0.40

HEC-RAS Plan: Ult Culv US River: WATERCOURSE Reach: WATERCOURSE (Continued)

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	214	Culvert									
WATERCOURSE	207	12.20	2.70	4.05	3.51	4.19	0.004802	1.68	7.24	7.02	0.46
WATERCOURSE	207	16.10	2.70	4.30	3.67	4.48	0.004668	1.87	8.63	7.10	0.47
WATERCOURSE	207	20.20	2.70	4.53	3.83	4.75	0.004678	2.05	9.88	7.18	0.48
WATERCOURSE	207	41.20	2.70	5.32	4.51	5.76	0.005870	2.91	14.15	7.42	0.57
WATERCOURSE	150	12.20	1.77	3.59		3.82	0.013850	2.13	5.74	5.40	0.66
WATERCOURSE	150	16.10	1.77	3.82		4.09	0.013974	2.28	7.05	5.97	0.67
WATERCOURSE	150	20.20	1.77	4.04		4.33	0.013741	2.40	8.41	6.50	0.67
WATERCOURSE	150	41.20	1.77	4.84		5.25	0.012440	2.85	14.90	12.90	0.68
WATERCOURSE	135	12.20	1.41	3.48		3.63	0.008185	1.74	7.01	5.37	0.49
WATERCOURSE	135	16.10	1.41	3.69		3.89	0.009361	1.96	8.23	5.88	0.53
WATERCOURSE	135	20.20	1.41	3.91		4.14	0.010014	2.12	9.54	6.38	0.55
WATERCOURSE	135	41.20	1.41	4.76		5.06	0.008943	2.48	19.04	22.02	0.56
WATERCOURSE	120	12.20	1.56	3.22		3.45	0.012947	2.12	5.77	4.92	0.62
WATERCOURSE	120	16.10	1.56	3.35		3.67	0.016914	2.51	6.42	5.13	0.72
WATERCOURSE	120	20.20	1.56	3.49		3.90	0.019787	2.82	7.17	5.37	0.78
WATERCOURSE	120	41.20	1.56	4.11	4.04	4.85	0.025520	3.81	11.04	9.97	0.91
WATERCOURSE	105	12.20	1.49	3.13		3.28	0.007496	1.68	7.28	6.15	0.49
WATERCOURSE	105	16.10	1.49	3.23		3.44	0.010643	2.05	7.85	6.34	0.59
WATERCOURSE	105	20.20	1.49	3.33		3.62	0.013267	2.36	8.55	6.57	0.66
WATERCOURSE	105	41.20	1.49	3.98		4.47	0.016194	3.10	13.54	11.77	0.75
WATERCOURSE	90	12.20	0.94	3.10		3.18	0.003380	1.27	9.62	5.90	0.32
WATERCOURSE	90	16.10	0.94	3.17		3.30	0.005258	1.61	10.03	5.98	0.40
WATERCOURSE	90	20.20	0.94	3.25		3.44	0.007240	1.92	10.54	6.09	0.47
WATERCOURSE	90	41.20	0.94	3.72		4.19	0.015124	3.04	13.61	7.87	0.68
WATERCOURSE	75	12.20	1.05	3.10		3.14	0.001512	0.91	13.44	8.72	0.23
WATERCOURSE	75	16.10	1.05	3.17		3.23	0.002329	1.15	14.05	8.85	0.29
WATERCOURSE	75	20.20	1.05	3.25		3.35	0.003157	1.36	14.82	9.02	0.34
WATERCOURSE	75	41.20	1.05	3.78		3.99	0.005540	2.04	21.59	21.57	0.46
WATERCOURSE	60	12.20	1.44	3.02		3.09	0.003662	1.20	10.25	10.06	0.37
WATERCOURSE	60	16.10	1.44	3.04		3.16	0.006062	1.56	10.42	10.09	0.48
WATERCOURSE	60	20.20	1.44	3.06		3.24	0.008942	1.91	10.65	10.28	0.59
WATERCOURSE	60	41.20	1.44	3.28	3.22	3.80	0.020223	3.21	13.16	12.20	0.90
WATERCOURSE	45	12.20	1.11	3.03		3.05	0.000612	0.68	21.22	19.97	0.16
WATERCOURSE	45	16.10	1.11	3.06		3.09	0.001001	0.88	21.76	20.26	0.21
WATERCOURSE	45	20.20	1.11	3.10		3.14	0.001448	1.07	22.49	20.64	0.25
WATERCOURSE	45	41.20	1.11	3.44		3.55	0.002853	1.68	30.34	27.35	0.37
WATERCOURSE	30	12.20	1.12	3.00		3.04	0.001447	0.84	14.60	11.27	0.23
WATERCOURSE	30	16.10	1.12	3.00		3.06	0.002516	1.10	14.62	11.28	0.31
WATERCOURSE	30	20.20	1.12	3.00		3.10	0.003950	1.38	14.63	11.29	0.39
WATERCOURSE	30	41.20	1.12	3.01		3.41	0.016188	2.80	14.71	11.32	0.78
WATERCOURSE	15	12.20	1.15	3.00		3.02	0.000554	0.58	20.94	13.93	0.15
WATERCOURSE	15	16.10	1.15	3.00		3.03	0.000964	0.77	20.96	13.93	0.20
WATERCOURSE	15	20.20	1.15	3.00		3.05	0.001514	0.96	20.97	13.93	0.25
WATERCOURSE	15	41.20	1.15	3.01		3.21	0.006174	1.95	21.11	13.95	0.51
WATERCOURSE	0	12.20	1.14	3.00	1.73	3.01	0.000413	0.41	29.75	28.88	0.13
WATERCOURSE	0	16.10	1.14	3.00	1.83	3.01	0.000719	0.54	29.75	28.88	0.17
WATERCOURSE	0	20.20	1.14	3.00	1.93	3.02	0.001132	0.68	29.75	28.88	0.21
WATERCOURSE	0	41.20	1.14	3.00	2.33	3.10	0.004709	1.38	29.75	28.88	0.44

APPENDIX D – RESULTS OF SENSITIVITY TESTING

HEC-RAS Plan: Sens, 1.2x Q River: WATERCOURSE Reach: WATERCOURSE

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
WATERCOURSE	615	24.12	7.25	9.55		9.59	0.003334	1.13	31.44	33.59	0.29
WATERCOURSE	600	24.12	7.03	9.44		9.52	0.006696	1.57	23.53	30.67	0.39
WATERCOURSE	585	24.12	7.04	9.27		9.31	0.002931	1.19	41.54	73.33	0.27
WATERCOURSE	570	24.12	6.91	9.05		9.20	0.011832	1.99	15.93	18.84	0.55
WATERCOURSE	555	24.12	6.70	9.04		9.09	0.002959	1.04	31.63	41.94	0.29
WATERCOURSE	540	24.12	6.74	9.02		9.05	0.002531	1.07	37.05	41.11	0.26
WATERCOURSE	525	24.12	6.53	8.86		8.97	0.006175	1.79	23.43	35.87	0.42
WATERCOURSE	510	24.12	6.48	8.68		8.84	0.008858	2.09	18.67	27.39	0.50
WATERCOURSE	495	24.12	6.28	8.57		8.67	0.004935	1.59	21.79	24.13	0.38
WATERCOURSE	480	24.12	6.04	8.48		8.58	0.005500	1.67	23.22	30.11	0.39
WATERCOURSE	465	24.12	5.66	8.42		8.49	0.003669	1.31	23.54	21.49	0.32
WATERCOURSE	450	24.12	5.69	8.40		8.43	0.001882	1.03	48.58	74.83	0.23
WATERCOURSE	435	24.12	5.66	8.31		8.38	0.005672	1.46	22.50	20.81	0.36
WATERCOURSE	420	24.12	5.65	8.00		8.19	0.033842	2.09	12.74	20.31	0.79
WATERCOURSE	405	24.12	5.35	7.83	7.40	7.96	0.007326	1.99	19.34	21.69	0.44
WATERCOURSE	400	24.12	5.26	6.28	6.68	7.58	0.095881	5.06	4.77	5.36	1.71
WATERCOURSE	399	24.12	4.76	5.66	6.18	7.41	0.146782	5.86	4.12	5.20	2.10
WATERCOURSE	390	24.12	4.71	6.75		7.00	0.009201	2.20	10.96	6.72	0.55
WATERCOURSE	375	24.12	4.63	6.56		6.84	0.011193	2.36	10.20	6.57	0.61
WATERCOURSE	360	24.12	4.55	6.20		6.62	0.019142	2.87	8.41	6.20	0.79
WATERCOURSE	359	24.12	4.05	6.35		6.54	0.006080	1.89	12.75	7.07	0.45
WATERCOURSE	345	24.12	3.97	6.21		6.44	0.007942	2.10	11.51	6.25	0.49
WATERCOURSE	330	24.12	3.89	6.08		6.32	0.008619	2.16	11.17	6.19	0.51
WATERCOURSE	315	24.12	3.80	5.98		6.19	0.007342	2.03	11.90	6.91	0.49
WATERCOURSE	300	24.12	3.71	5.87		6.08	0.007594	2.05	11.75	6.88	0.50
WATERCOURSE	285	24.12	3.61	5.75		5.97	0.007789	2.07	11.64	6.86	0.51
WATERCOURSE	284	24.12	3.11	5.87		5.92	0.001181	1.00	24.16	11.51	0.22
WATERCOURSE	270	24.12	3.05	5.81	4.33	5.89	0.002320	1.32	18.29	9.67	0.29
WATERCOURSE	245	Culvert									
WATERCOURSE	222	24.12	2.80	5.38	4.16	5.56	0.006395	1.89	12.78	6.22	0.38
WATERCOURSE	221	24.12	2.79	5.40	4.06	5.54	0.002044	1.71	14.09	6.93	0.34
WATERCOURSE	214	Culvert									
WATERCOURSE	207	24.24	2.70	4.80	3.97	5.03	0.004268	2.14	11.33	7.26	0.47
WATERCOURSE	150	24.24	1.77	4.27		4.57	0.012571	2.43	9.98	7.07	0.65
WATERCOURSE	135	24.24	1.41	4.15		4.39	0.009299	2.17	11.22	7.74	0.54
WATERCOURSE	120	24.24	1.56	3.83		4.19	0.014953	2.67	9.11	6.42	0.69
WATERCOURSE	105	24.24	1.49	3.48		3.81	0.014192	2.54	9.55	6.88	0.69
WATERCOURSE	90	24.24	0.94	3.38		3.61	0.008588	2.14	11.32	6.25	0.51
WATERCOURSE	75	24.24	1.05	3.36		3.48	0.003819	1.54	15.79	9.22	0.37
WATERCOURSE	60	24.24	1.44	3.09		3.34	0.011831	2.23	10.95	10.53	0.68
WATERCOURSE	45	24.24	1.11	3.14		3.21	0.001872	1.24	23.46	21.15	0.29
WATERCOURSE	30	24.24	1.12	3.00		3.14	0.005671	1.65	14.65	11.29	0.46
WATERCOURSE	15	24.24	1.15	3.00		3.07	0.002173	1.15	20.99	13.93	0.30
WATERCOURSE	0	24.24	1.14	3.00	2.01	3.03	0.001630	0.81	29.75	28.88	0.26

HEC-RAS Plan: Sens, n+0.02 River: WATERCOURSE Reach: WATERCOURSE

Reach	River Sta	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)	
WATERCOURSE	615	20.10	7.25	9.54		9.56	0.004001	0.92	30.90	33.37	0.24
WATERCOURSE	600	20.10	7.03	9.42		9.48	0.008132	1.30	23.11	30.41	0.33
WATERCOURSE	585	20.10	7.04	9.27		9.30	0.003358	0.95	41.57	73.36	0.22
WATERCOURSE	570	20.10	6.91	9.09		9.18	0.012434	1.55	16.76	19.36	0.42
WATERCOURSE	555	20.10	6.70	9.04		9.07	0.003539	0.85	31.61	41.93	0.24
WATERCOURSE	540	20.10	6.74	9.01		9.03	0.002915	0.86	36.58	40.87	0.21
WATERCOURSE	525	20.10	6.53	8.88		8.94	0.006866	1.43	23.95	36.09	0.33
WATERCOURSE	510	20.10	6.48	8.71		8.81	0.009617	1.65	19.49	28.36	0.39
WATERCOURSE	495	20.10	6.28	8.59		8.66	0.005493	1.27	22.37	24.40	0.30
WATERCOURSE	480	20.10	6.04	8.50		8.56	0.006126	1.33	23.77	30.39	0.31
WATERCOURSE	465	20.10	5.66	8.42		8.47	0.004375	1.07	23.56	21.49	0.26
WATERCOURSE	450	20.10	5.69	8.39		8.40	0.002281	0.85	47.24	73.34	0.19
WATERCOURSE	435	20.10	5.66	8.29		8.34	0.006723	1.19	22.23	20.73	0.29
WATERCOURSE	420	20.10	5.65	7.98		8.12	0.042684	1.74	12.39	19.93	0.66
WATERCOURSE	405	20.10	5.35	7.62	7.27	7.76	0.014902	1.99	15.23	18.92	0.47
WATERCOURSE	400	20.10	5.26	6.25	6.53	7.22	0.144782	4.37	4.60	5.32	1.50
WATERCOURSE	399	20.10	4.76	6.96		7.10	0.009684	1.67	12.03	6.94	0.40
WATERCOURSE	390	20.10	4.71	6.86		7.01	0.010426	1.72	11.71	6.87	0.42
WATERCOURSE	375	20.10	4.63	6.67		6.84	0.012627	1.84	10.92	6.72	0.46
WATERCOURSE	360	20.10	4.55	6.39		6.61	0.017928	2.09	9.62	6.45	0.55
WATERCOURSE	359	20.10	4.05	6.46		6.57	0.007101	1.49	13.48	7.21	0.35
WATERCOURSE	345	20.10	3.97	6.31		6.45	0.009345	1.66	12.14	6.35	0.38
WATERCOURSE	330	20.10	3.89	6.15		6.31	0.010521	1.73	11.62	6.26	0.41
WATERCOURSE	315	20.10	3.80	6.01		6.15	0.009523	1.66	12.11	6.95	0.40
WATERCOURSE	300	20.10	3.71	5.85		6.00	0.010645	1.73	11.62	6.86	0.42
WATERCOURSE	285	20.10	3.61	5.66		5.83	0.012301	1.82	11.03	6.74	0.45
WATERCOURSE	284	20.10	3.11	5.75		5.79	0.001887	0.88	22.80	11.27	0.20
WATERCOURSE	270	20.10	3.05	5.68	4.19	5.75	0.003698	1.16	17.27	9.51	0.26
WATERCOURSE	245	Culvert									
WATERCOURSE	222	20.10	2.80	5.32	4.00	5.45	0.009251	1.61	12.49	6.22	0.33
WATERCOURSE	221	20.10	2.79	5.33	3.91	5.44	0.003026	1.46	13.73	6.92	0.29
WATERCOURSE	214	Culvert									
WATERCOURSE	207	20.20	2.70	4.93	3.83	5.07	0.004793	1.68	12.00	7.30	0.36
WATERCOURSE	150	20.20	1.77	4.39		4.56	0.013820	1.87	10.81	7.35	0.49
WATERCOURSE	135	20.20	1.41	4.21		4.37	0.011306	1.74	11.72	8.33	0.43
WATERCOURSE	120	20.20	1.56	3.91		4.14	0.017335	2.11	9.64	6.59	0.53
WATERCOURSE	105	20.20	1.49	3.64		3.82	0.014416	1.90	10.65	7.20	0.50
WATERCOURSE	90	20.20	0.94	3.48		3.62	0.010167	1.69	11.93	6.36	0.39
WATERCOURSE	75	20.20	1.05	3.40		3.48	0.004860	1.25	16.18	9.30	0.30
WATERCOURSE	60	20.20	1.44	3.19		3.34	0.012079	1.70	12.09	11.42	0.49
WATERCOURSE	45	20.20	1.11	3.18		3.22	0.002357	1.00	24.20	21.52	0.23
WATERCOURSE	30	20.20	1.12	3.06		3.15	0.006958	1.33	15.24	11.54	0.37
WATERCOURSE	15	20.20	1.15	3.02		3.07	0.002859	0.95	21.23	13.96	0.25
WATERCOURSE	0	20.20	1.14	3.00	1.92	3.02	0.002219	0.68	29.75	28.88	0.21

THE END