FLOOD RISK ASSESSMENT

Proposed development of land at Ballochyle, by Sandbank, Argyll

Prepared for:

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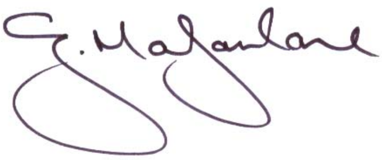
QUALITY ASSURANCE

The data used in this document and its input and reporting have undergone a quality assurance review which follows established TransTech procedures. The information and results presented herein constitute an accurate representation of the data collected.

Modelling undertaken by:

Mr Bruno Vercosa
Environmental Analyst
TransTech Ltd

Report written and modelling checked by:



Dr Garret Macfarlane
Managing Director
TransTech Ltd

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LIST OF ABBREVIATIONS

AOD	Above Ordnance Datum, Newlyn
FSSR	Flood Studies Supplementary Report
PAN69	Planning Advice Note 69
QMED	Median Annual Maximum Flow
SEPA	Scottish Environment Protection Agency
SPP7	Scottish Planning Policy 7: Planning and Flooding
XS	Cross-section

EXECUTIVE SUMMARY

This flood risk assessment has been prepared for proposed development of land at the north end of a grass field south of Ballochyle Farm, by Sandbank, Argyll.

The site is located at NS 1423 8211 (Planning Ref: 09/01308/PP). The River Little Eachaig flows in a north easterly direction approximately 70m from the site and is deemed to pose a potential flood risk.

In order to establish the risk of flooding from the River Little Eachaig seven cross-sections were taken through the watercourse to determine its flow carrying capacity. Two sections traverse the site, three are upstream of the site and two are downstream.

A 1 in 200 year flow for the river was calculated using data for the former gauging station adjacent to the site and the flood growth curve for Scotland. Manning's equations were then applied to the flow and topographic data to determine whether the channel has sufficient flow carrying capacity for the 1 in 200 year flow.

The study found that the channel does not have sufficient capacity for a 1 in 200 year flood event and HEC-RAS hydraulic modelling software was used to calculate the 1 in 200 year flood level within the floodplain adjacent to the site. For the 1 in 200 year flow the maximum predicted flood water level for the sections crossing the site was 12.43 mAOD at XS8 and 11.99 mAOD at XS9. The ground level at the proposed development site is ≥12.750 mAOD which gives a freeboard of ≥320 mm above the predicted 1 in 200 year flood level. The proposed finished floor level is 13.5 mAOD which provides a freeboard of 1070mm above the predicted 1 in 200 year flood level.

A multi-level approach to attenuating and treating surface water arising from the proposed development site will be investigated. Should ground conditions and site investigations confirm that full infiltration of the surface water is feasible then, given the nature of the development only one level of treatment would be necessary, i.e. infiltration to ground.

Foul water will be treated by means of a new BioDisc sewage treatment plant which will be located to the rear of the site and therefore outwith the predicted floodplain.

The conclusion of this FRA is that the proposed development site does not form part of the functional floodplain of the River Little Eachaig during a 1 in 200 year event. Development of the site will not result in the loss of floodwater storage or increase the flow of floodwater downstream. It is therefore considered to be compliant with the recommendations of Scottish Planning Policy 7 and Planning Advice Note 69.

1.0 INTRODUCTION

1.1 Any flood risk to the land proposed for development comes from high flows in the River Little Eachaig which flows in a north easterly direction approximately 70 m south of the site. (Figures 1 to 3). The planning process requires that it be demonstrated that the land can be developed with an acceptable risk of flooding, that any works needed to manage flood risk are sustainable over the likely life of the development, and that the development will not increase the risk of flooding elsewhere.

1.2 The assessment has been undertaken in accordance with the recommendations of SPP7 and PAN69.

1.3 The report is based on the following information:

(i) Topographical survey transects (to local grid) for the watercourse adjacent to the development site provided by Cowal Surveying.
(ii) Ordnance Survey Explorer Map.
(iii) Promap Digital Mapping (www.promap.co.uk).
(iv) Manning's Equation Calculator/Software (http://www.lmnoeng.com/manning.htm).

1.4 All comments and opinions contained in this report, including any conclusions are based on information available to TransTech during our investigations. The conclusions drawn by TransTech could therefore differ if the information is found to be inaccurate, incomplete or misleading. TransTech accepts no liability should this prove to be the case, or, if additional information exists or becomes available with respect to this site.

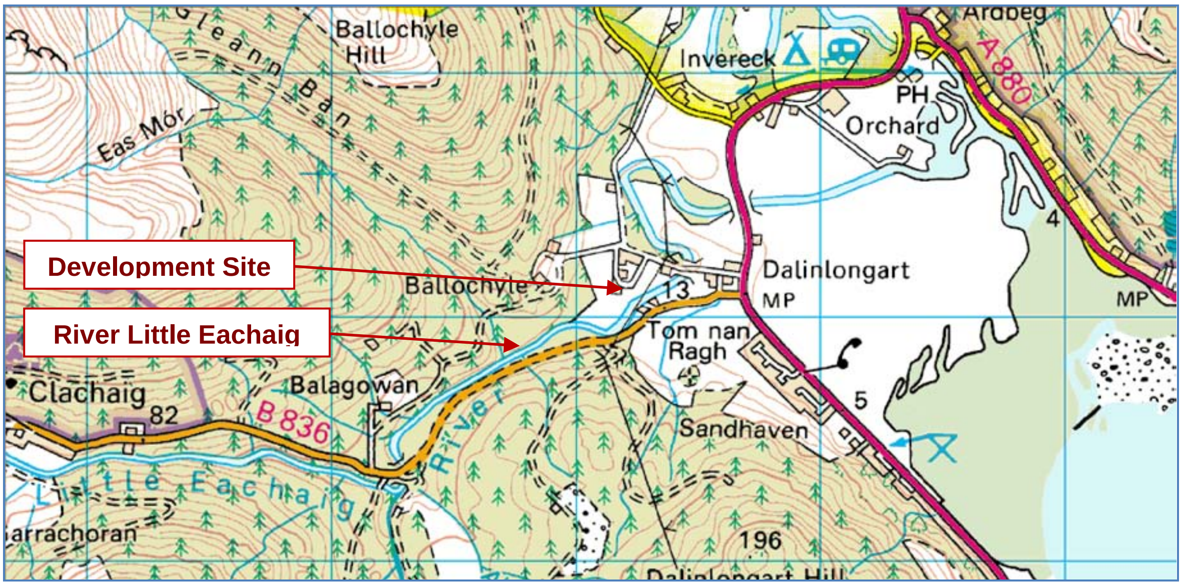


Figure 1. Location map

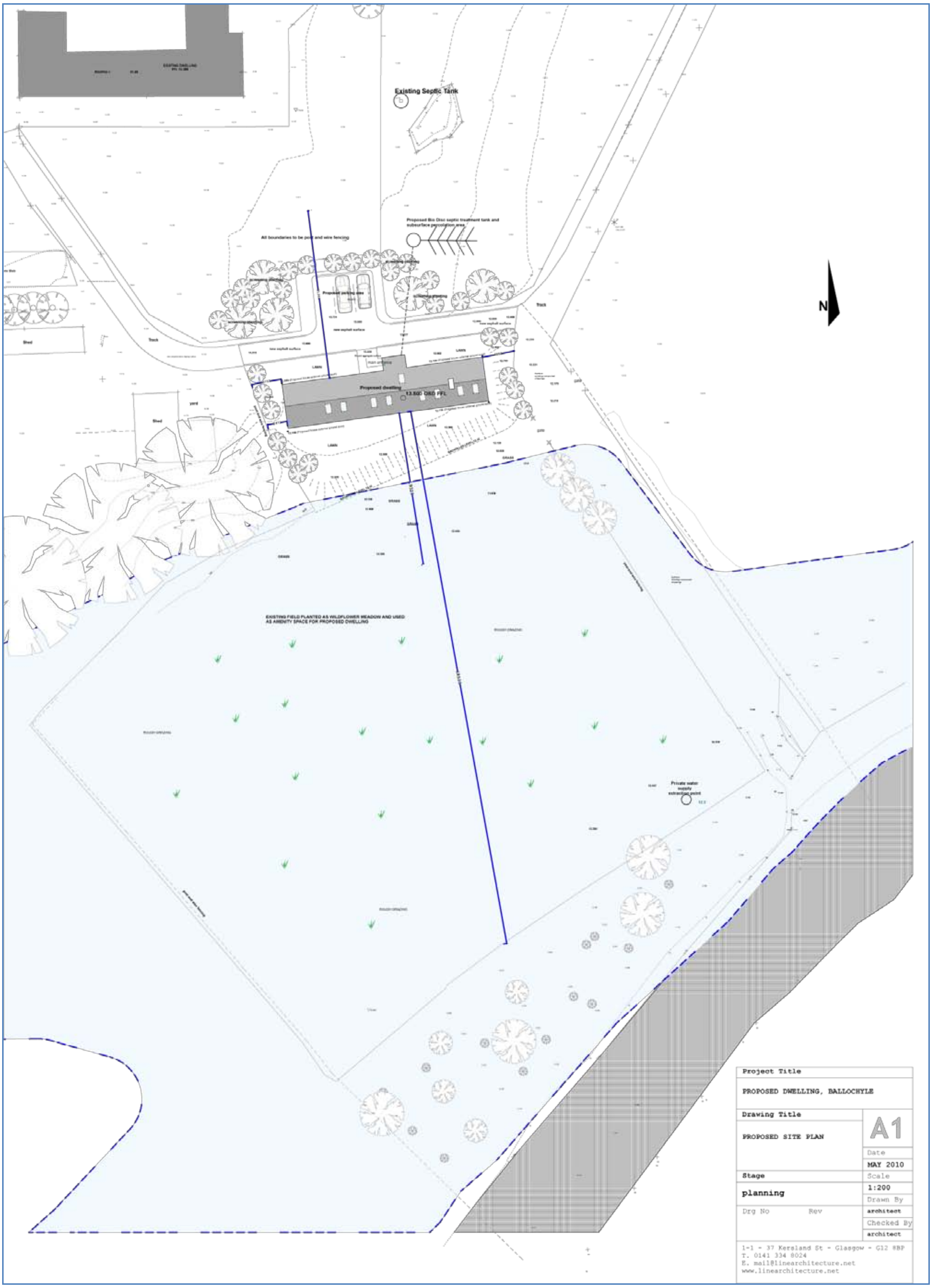


Figure 2. Proposed site plan

2.0 BACKGROUND INFORMATION

Site Details

2.1 The site currently consists of open grassed land. The watercourse runs in a north easterly direction approximately 70m south of the development site (Figure 3).

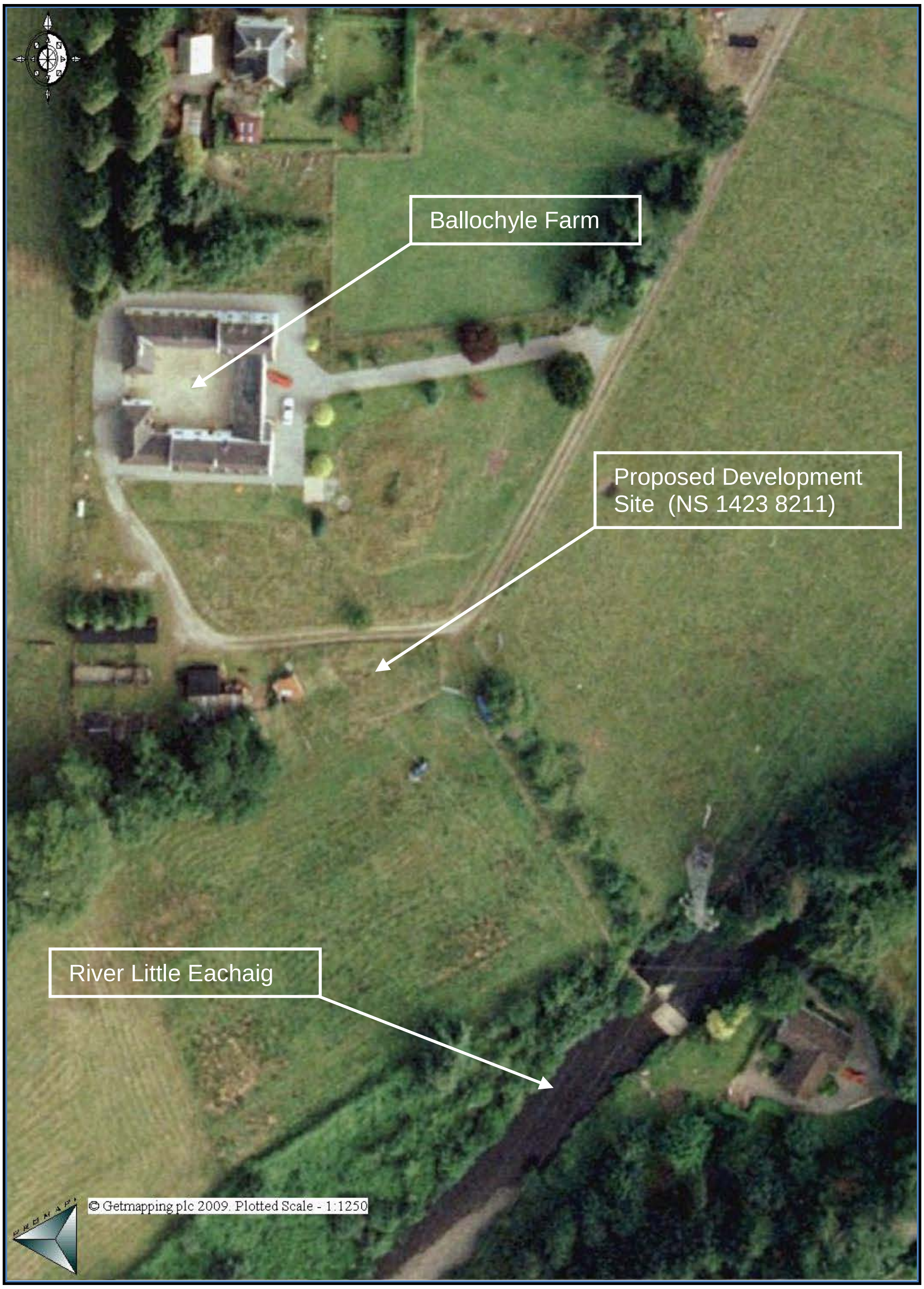


Figure 3. Aerial view of the proposed site

Proposed Development

2.2 It is understood that the development will consist of a dwellinghouse, formation of car parking, installation of a septic tank and creation of a private water supply. Please refer to planning application reference number 09/01308/PP for further information.

Identification of Need

2.3 An indicative floodplain map was obtained from the SEPA website. The map indicates that the site may lie close to the indicative fluvial floodplain of the River Little Eachaig.

2.4 In order to assess the potential flood risk to the site a hydrological assessment of the River Little Eachaig was carried out to meet the requirements of Scottish Planning Policy 7 and associated documents.

3.0 HYDROLOGICAL ASSESSMENT

Objective

3.1 The River Little Eachaig flows adjacent to the development site and therefore poses a potential source of flood risk. The objective of this Flood Risk Assessment is to determine the risk that the River Little Eachaig poses to the development of the site for a 1 in 200 year flow in the watercourse.

Hydrology

3.2 The River Little Eachaig travels from Loch Tarsan Reservoir south-eastwards into Glen Lean. It then turns north east and flows past the site to the Holy Loch.

3.3 There are no structures in the vicinity of the site such as bridges, pipes/ducts crossing the watercourse, culverts, screens, embankments, walls, outfalls or channels which may influence local surface water hydraulics.

3.4 There are no existing fluvial flood alleviation measures in place at the proposed development site.

Methodology for Derivation of Flow

3.5 The River Little Eachaig was gauged at the location of interest (Dalinlongart) until 2006.

3.6 According to HiFlows the QMED for the Little Eachaig adjacent to the site is 43.2 m^3/s (http://www.environment-agency.gov.uk/hiflows/apr.aspx?86001_amax).

3.7 A flood growth curve (Figure 4) using the FSSR 14[4] regional growth curve for NW Scotland was produced.

FSSR14 provides a growth factor for 1 in 2, 5, 10, 50, 100 and 500 year events. To derive the 1 in 200 year flow the best fit curve for the data provided was described by a fifth order logarithm with the model definition

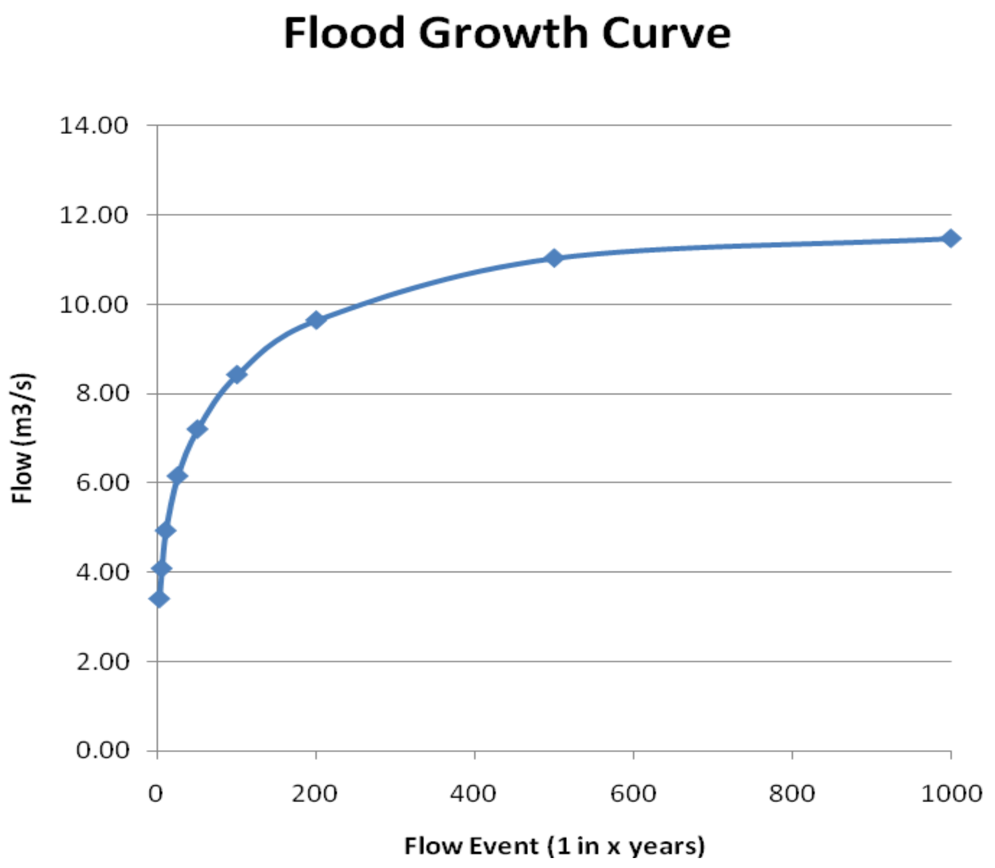
$$y = a+b*\text{logn}(x)+c*\text{logn}(x)^2+d*\text{logn}(x)^3+e*\text{logn}(x)^4+f*\text{logn}(x)^5$$

where,

y = flow rate in m^3/sec

The unexplained variance is 0.00091%, where:

a = 2.30416049929479
b = 0.923021537861735
c = 0.154770790072705
d = -0.0710985934180333
e = 0.0193556814875732
f = -0.00161825020696887



Return Period:	2	5	10	25	50	100	**200**	500
Growth Factor:		1.20	1.45	1.81	2.12	2.48	**2.84**	3.25
Flow (m^3/s):	43.2	51.8	62.6	78.2	91.6	107.1	**122.7**	140.4

Figure 4. Flood Growth Curve for the River Little Eachaig

The 1 in 200 year flow was calculated as 122.7 m^3/s.

Methodology for Estimation of the Hydraulic Capacity of the Watercourse

3.8 The geometry of the water course channel was recorded by using 7 surveyed cross-sections spaced out at 10 m intervals. The cross-sections used in the calculations are those labelled XS5 to XS11 on the supplied AutoCAD file. XS8 and XS9 traverse the site with XS5 to XS7 being upstream and XS10 and XS11 downstream. At these points the flow of water that can be conveyed by the channel at “bank-full” conditions can be estimated using the Manning’s Equation.

3.9 The Manning’s Equation provides a method of calculating the flow through a channel based on the size of the channel and an empirical Manning’s Number which represents the channel and river bed roughness and the resistance to flow presented by the river banks. This provides an indication of the volume of water that could be conveyed before the channel is overtopped.

3.10 The Manning’s Equation results for bank-full watercourse capacity are summarised in Table 1.

<u>Table 1. Bank-full watercourse capacity</u>

Cross-section	Area (m^2) *	Wetted Perimeter (m)	Manning’s Number [2,3]	Bed Slope **	Bank-full Capacity (m^3/s)
XS5	55.74	37.057	0.04	0.0054	134.4
XS6	43.57	33.465	0.04	0.0001	13.0
XS7	42.56	28.204	0.04	0.0203	199.4
XS8	42.47	35.899	0.04	0.0106	122.3
XS9	79.16	41.888	0.04	0.0381	590.5
XS10	63.66	34.622	0.04	0.0001	23.9
XS11	64.40	33.562	0.04	0.0444	523.9

* calculated using HEC-RAS v4.1.0 from survey data.
** bed slope from survey data.
XS1 to XS4 could not be used in the Manning’s Calculations/HEC-RAS modelling as they do not extend far enough south.

3.11 The results indicated that the river channel does not have enough flow carrying capacity for the predicted 1 in 200 year flow of 122.7 m^3/s.

Methodology for Estimation of the Flood Level within the Watercourse

3.12 The survey data and the predicted 1 in 200 year flow were used to calculate the flood level in the floodplain adjacent to the site using HEC-RAS v4.1.0.

3.13 The HEC-RAS results for maximum flood level are summarised in Table 2.

Table 2. Watercourse flood level derived from modelling cross-sections and the 1 in 200 year flow in HEC-RAS - steady flow with a subcritical flow regime - normal depth and critical depth boundaries

Cross-section	Normal Depth Maximum Predicted Flood Level (mAOD)	Critical Depth Maximum Predicted Flood Level (mAOD)	Below Site Level (m)
XS5	12.77	12.77	n/a
XS6	12.71	12.71	n/a
XS7	12.61	12.61	n/a
XS8	12.43	12.43	0.320
XS9	11.99	11.99	0.751
XS10	11.72	11.72	n/a
XS11	11.13	11.13	n/a

Flood levels are shown in Figures 6, 8, 10, 12, 14, 16 and 18.
XS1 to XS4 could not be used in the Manning's Calculations/HEC-RAS modelling as they do not extend far enough south.
Mannings values used in the modelling were 0.06 for banks and 0.04 for the river channel.

3.14 There was no difference in flood level for the two different downstream boundary conditions.

3.15 For the 1 in 200 year flow the maximum predicted flood water level for the sections crossing the site was 12.43 mAOD at XS8 and 11.99 mAOD at XS9. The ground level at the proposed development site is ≥12.750 mAOD which gives a freeboard of ≥320 mm above the predicted 1 in 200 year flood level. The proposed finished floor level is 13.5 mAOD which provides a freeboard of 1070mm above the predicted 1 in 200 year flood level.

4.0 INDICATIVE FLOOD INUNDATION & HISTORICAL FLOODING

4.1 The indicative flood inundation maps held by SEPA indicate that the site may lie within or adjacent to the 200 year flood envelope. The SEPA map shows an estimate of the areas of Scotland with a 1 in 200 or greater probability of being flooded in any given year. The maps are not based on hydraulic assessment, but as a guide they indicate that the site is potentially at risk of flooding and it is on this basis that a detailed flood risk assessment has been prepared.

4.2 Details of historical flooding have been sought from relevant authorities and sources. There is no measured information on the extent and depth of any flood events affecting the site or nearby properties.

4.3 The British Hydrological Society's "Chronology of British Hydrological Events"[1] was checked to provide any evidence of flood events in Ballochyle. No entries exist for the Ballochyle area.

4.4 There is therefore no measured information, direct, historical, photographic or other evidence on the extent or depth of flood events or flood water levels at the development site, or in the immediate area of the site.

5.0 EFFECT OF DEVELOPMENT ON GENERAL FLOOD RISK

5.1 SPP7 requires that the flood risk assessment includes consideration of impacts elsewhere in the river system arising as a result of the development. The development may increase flood risk upstream or downstream of the site by any of three mechanisms:

(i) Impedance of flood flows
(ii) Encroachment on river floodplain
(iii) Contribution to flood flows from development drainage

Impedance of Flood Flows

5.2 If the development causes a loss of transmission capacity for flood flows in the watercourse, this can cause a backwater effect. As a consequence, water levels upstream of the site can increase resulting in an increased flood risk.

5.3 The site is not subject to predicted flooding and as such there will be no loss of transmission capacity for flood flows.

Encroachment on River Floodplain

5.4 Where development encroaches on floodplain it can cause an increase in water levels through the loss of floodplain storage. This in turn can cause an increase in flood risk upstream by backwater effect. It can also increase flood risk downstream because the raised water level steepens the hydraulic gradient of downstream channels, thereby increasing their transmission capacity and the pass forward flow.

5.5 The development site is not predicted to form part of the functional floodplain.

Contribution to Flood Flows from Development Drainage

5.6 Surface water drainage from the proposed development is not available and does not form part of the scope of this report. It is thought likely that a multi-level approach to attenuating and treating surface water arising from the proposed development site will be investigated. Should ground conditions and site investigations confirm that full infiltration of the surface water is feasible then, given the residential nature of the development only one level of treatment would be necessary, i.e. infiltration to ground.

Other Potential Backwater Effects

5.7 A backwater effect can be created as a result of a bridge or other obstruction raising the surface of the water upstream of it.

5.8 There are no structures on the watercourse that will affect flood flows in the vicinity of the site.

Waste Water Treatment

5.9 Foul water will be treated by means of a new BioDisc sewage treatment plant located outwith the predicted floodplain.

6.0 CONCLUSIONS

6.1 The hydrological study presented here indicates that the proposed development site is not at significant risk of flooding from the River Little Eachaig.

6.2 SPP7 adopts the precautionary principle and states that new development should not take place if it would be at significant risk of flooding or would materially increase the probability of flooding elsewhere. The land proposed for development does not form part of a functional floodplain and as such there will be loss of floodwater storage as a result of the development.

6.3 The development will not cause an increase in flood risk in the wider catchment as it will not be sited on the functional floodplain.

6.4 Given the findings of this report it is considered that there will be no risk to the lives of occupants of the development as the result of flooding during a 1 in 200 year flood event.

6.5 Safe access to and egress from the development during extreme flow events, including access by emergency vehicles, needs to be considered. No difficulty is foreseen with this during the extreme event because the development including the access road is outwith the predicted functional floodplain.

6.6 In summary, the development may proceed without significant risk of flooding from the River Little Eachaig and will not increase the flow of floodwater downstream. It is therefore considered to be compliant with the recommendations of SPP7 and PAN69.

REFERENCES

1 Chronology of British Hydrological Events. Online database. The British Hydrological Society. 2007. (www.dundee.ac.uk/geography/cbhe/).

2 Chow, V. T. Open-channel Hydraulics. New York, McGraw-Hill Book Co. 1959.

3 Aldridge, B. N. & Garrett, J. M. Roughness coefficients for stream channels in Arizona. US Geological Survey Open-File Report, 87pp. 1973.

4 Flood Studies Supplementary Report 14. Regional Growth Curves Reviewed. Institute of Hydrology, Wallingford. 1983.

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Flood Estimation Handbook. Volume 3. Institute of Hydrology, Wallingford. 1999.

Planning Advice Note 69: Planning and Building Standards Advice on Flooding. Scottish Executive Development Department. August 2004.

Reporting Requirements for Flood Risk Assessments. Scottish Environment Protection Agency. 2007.

Scottish Planning Policy 7: Planning and Flooding. Scottish Executive Development Department. February 2004.

Technical Flood Risk Guidance for Stakeholders. Version 2. Scottish Environment Protection Agency. 30/01/08.

ACCOMPANYING FILES

The following files accompany this report:

HEC-Ballochyle.zip	–	HEC-RAS Modelling Files
J435 Dalinlongart Topo 3D Rev A.dwg	–	AutoCAD Cross-section Profiles
Ballochyle_Survey_Data.xlsx	–	Processed survey data for Manning's Calculations & for HEC-RAS Modelling

ADDITIONAL FIGURES

Manning's Equation Calculator / Software	The open channel flow software website

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More calculations: Design of Rectangular Channels Design of Trapezoidal Channels
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Q=VA simple flowrate calculator

$$Q = VA \qquad V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Select units:		Click to Calculate
○ Use feet and seconds units	k = 1.0, for unit conversion	
◉ Use meters and seconds units	Area, A (m²):	55.74
Select Calculation:	Wetted Perimeter, P (m):	37.057
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○ Channel Slope (S) from V etc.	Manning n:	0.04
○ Channel Slope (S) from Q etc.	Velocity, V (m/s):	2.41176336101126
○ Manning Coefficient (n) from V e	Discharge, Q (m³/s):	134.43168974276765
○ Manning Coefficient (n) from Q e		

The Manning Equation is the most commonly used equation to analyze open channel flows. It is a semi-empirical equation for simulating water flows in channels and culverts where the water is open to the atmosphere, i.e. not flowing under pressure, and was first presented in 1889 by Robert Manning. The channel can be any shape - circular, rectangular, triangular, etc. The units in the Manning equation appear to be inconsistent; however, the value k has hidden units in it to make the equation consistent. The Manning Equation was developed for uniform steady state flow (see Discussion and References for Open Channel Flow). S is the slope of the energy grade line and $S=h_f/L$ where h_f is energy (head) loss and L is the length of the channel or reach. For uniform steady flows, the energy grade line = the slope of the water surface = the slope of the bottom of the channel.

The product A/P is also known as the hydraulic radius, R_h.

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Figure 5. XS5 Manning's Calculation

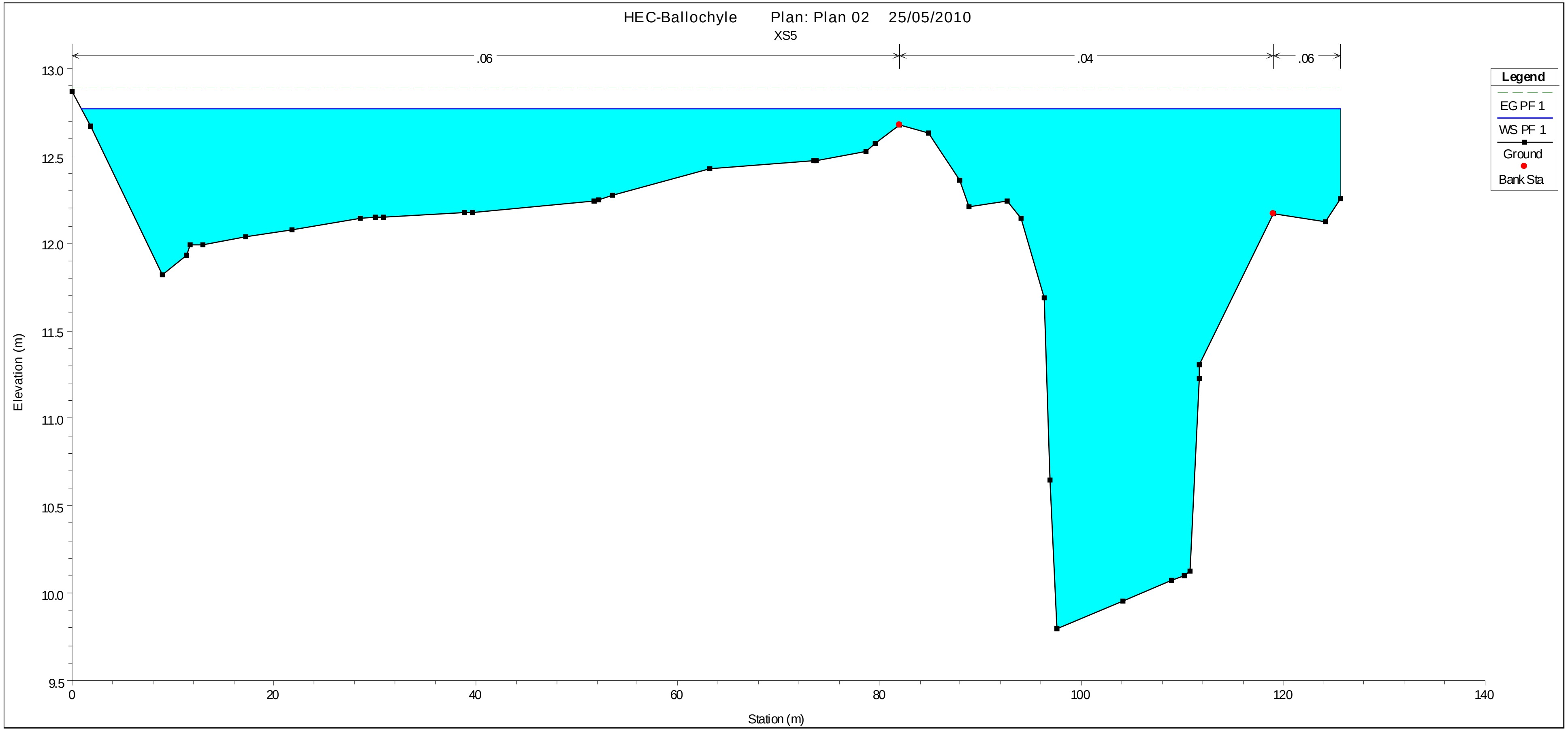
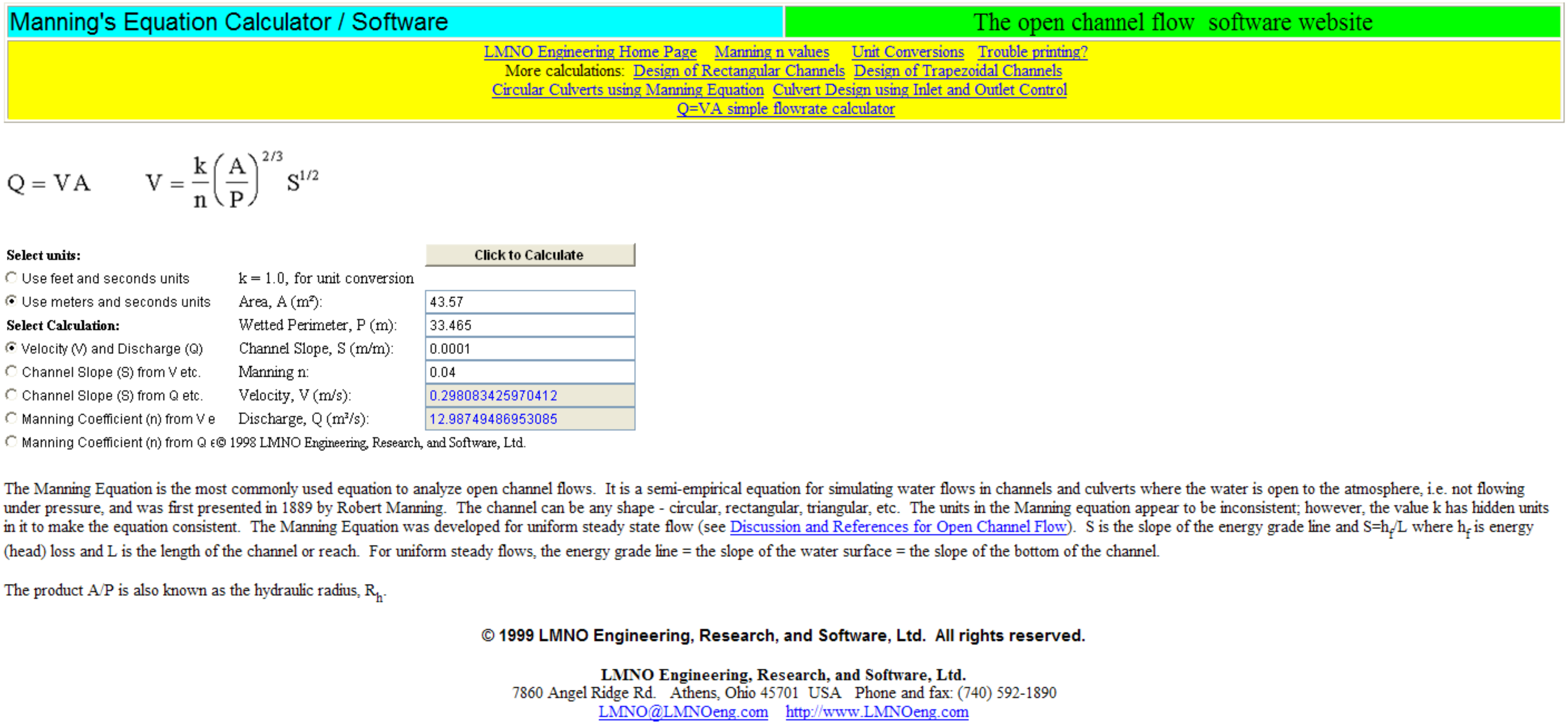


Figure 6. XS5 HEC-RAS - Water Surface Elevation is 12.77 mAOD



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○ Manning Coefficient (n) from V e	Discharge, Q (m³/s):	12.98749486953085

○ Manning Coefficient (n) from Q e© 1998 LMNO Engineering, Research, and Software, Ltd.

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Figure 7. XS6 Manning's Calculation

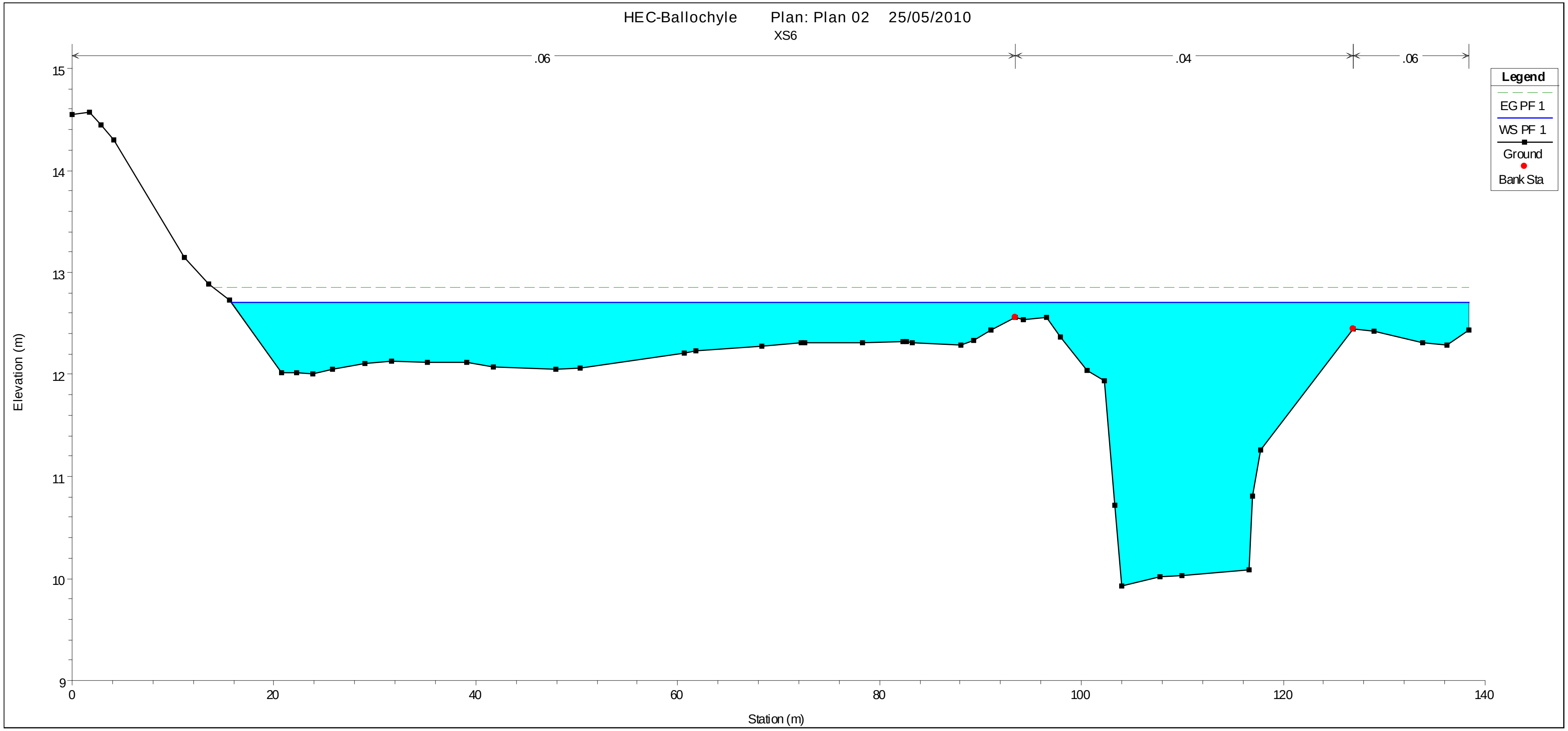
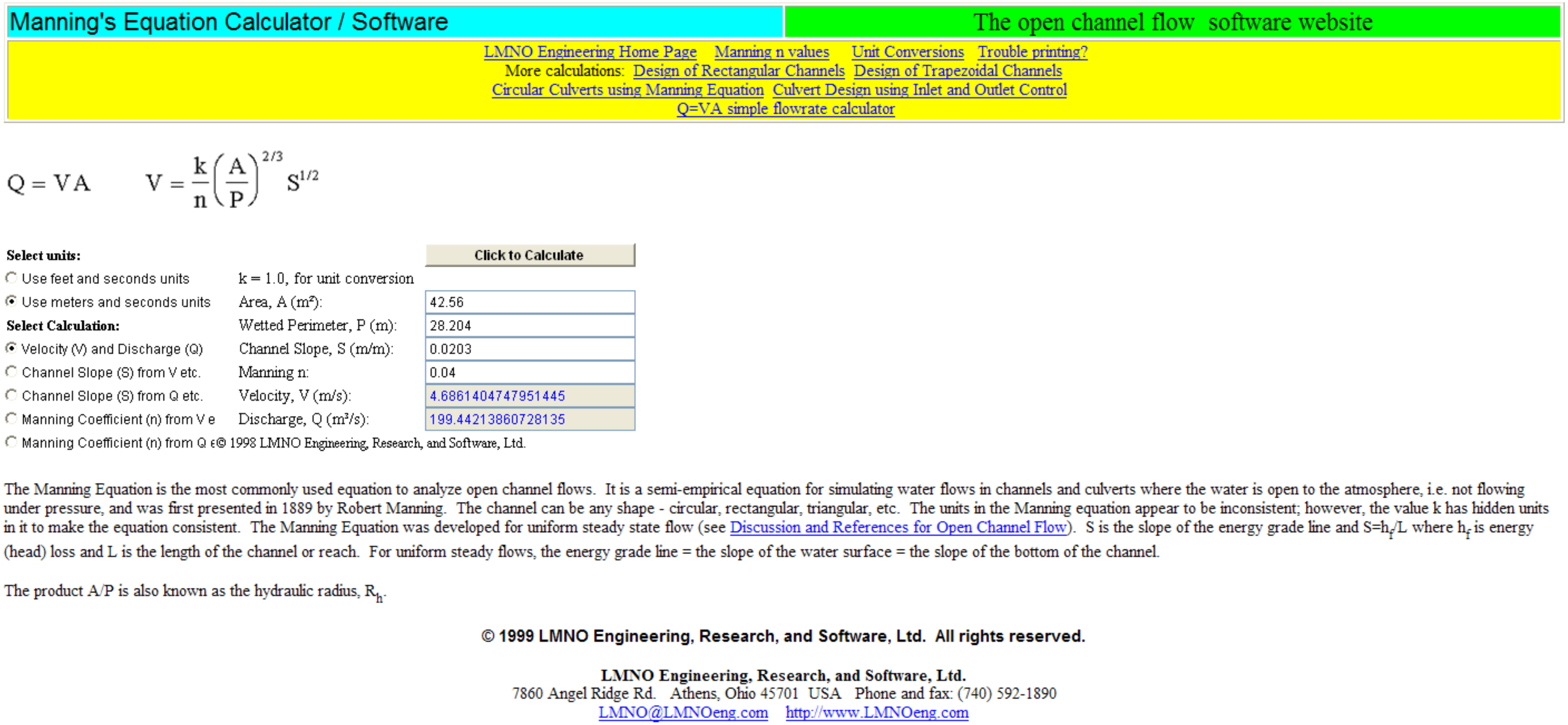


Figure 8. XS6 HEC-RAS - Water Surface Elevation is 12.71 mAOD



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○ Channel Slope (S) from Q etc.	Velocity, V (m/s):	4.6861404747951445
○ Manning Coefficient (n) from V e	Discharge, Q (m^3/s):	199.44213860728135
○ Manning Coefficient (n) from Q e	© 1998 LMNO Engineering, Research, and Software, Ltd.	

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Figure 9. XS7 Manning's Calculation

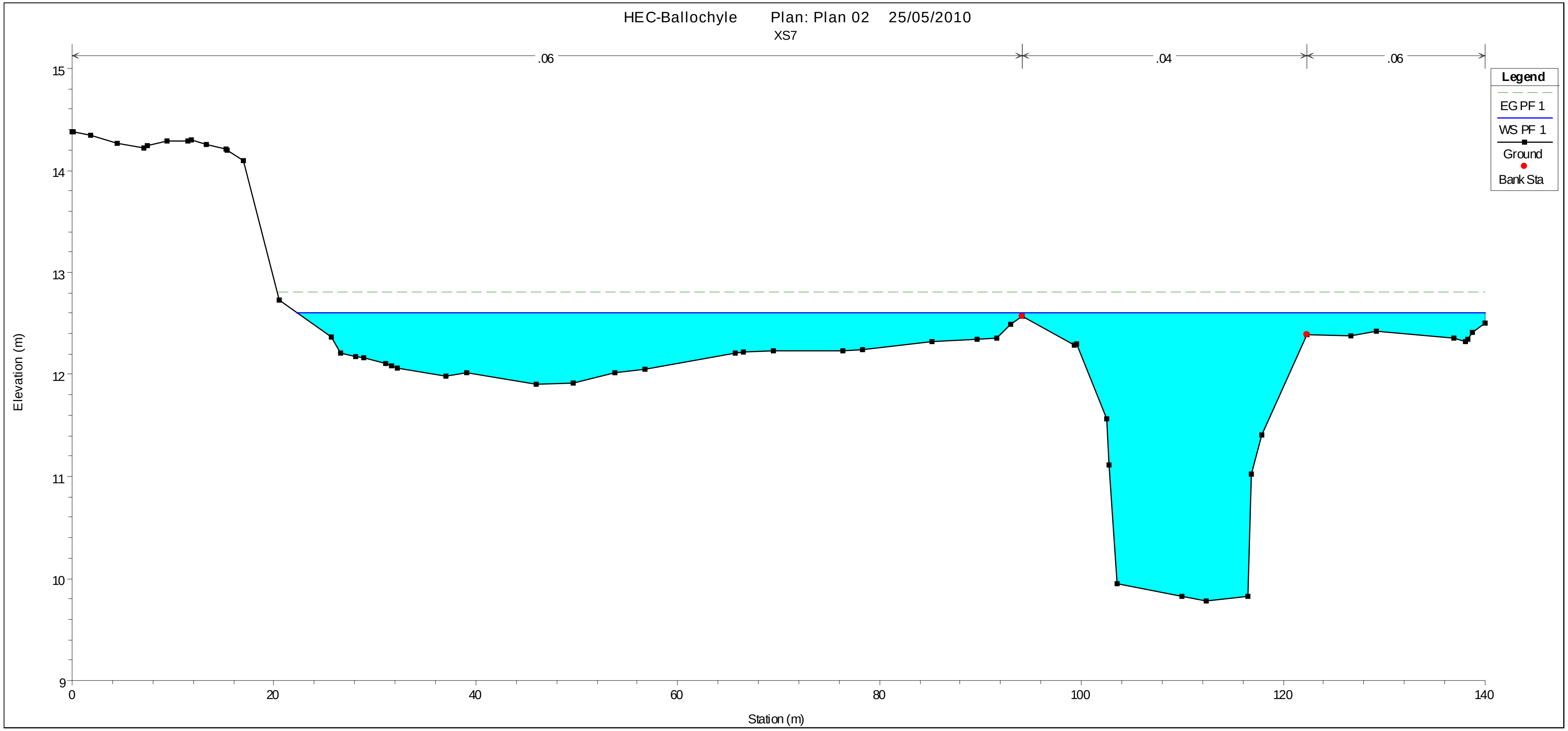
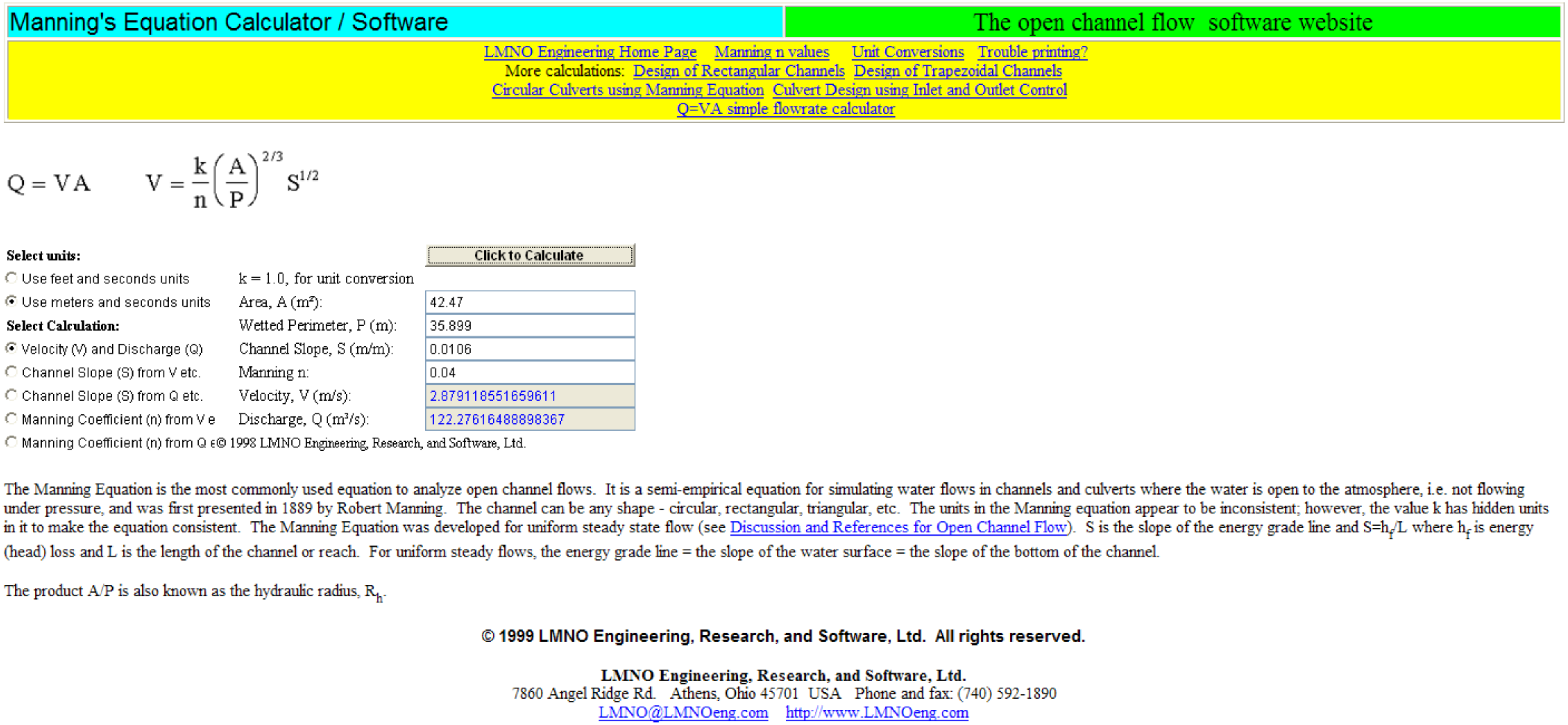


Figure 10. XS7 HEC-RAS - Water Surface Elevation is 12.61 mAOD



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Select units:		Click to Calculate
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○ Channel Slope (S) from V etc.	Manning n:	0.04
○ Channel Slope (S) from Q etc.	Velocity, V (m/s):	2.879118551659611
○ Manning Coefficient (n) from V e	Discharge, Q (m^3/s):	122.27616488898367

○ Manning Coefficient (n) from Q e© 1998 LMNO Engineering, Research, and Software, Ltd.

The Manning Equation is the most commonly used equation to analyze open channel flows. It is a semi-empirical equation for simulating water flows in channels and culverts where the water is open to the atmosphere, i.e. not flowing under pressure, and was first presented in 1889 by Robert Manning. The channel can be any shape - circular, rectangular, triangular, etc. The units in the Manning equation appear to be inconsistent; however, the value k has hidden units in it to make the equation consistent. The Manning Equation was developed for uniform steady state flow (see Discussion and References for Open Channel Flow). S is the slope of the energy grade line and $S=h_f/L$ where h_f is energy (head) loss and L is the length of the channel or reach. For uniform steady flows, the energy grade line = the slope of the water surface = the slope of the bottom of the channel.

The product A/P is also known as the hydraulic radius, R_h.

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Figure 11. XS8 Manning's Calculation

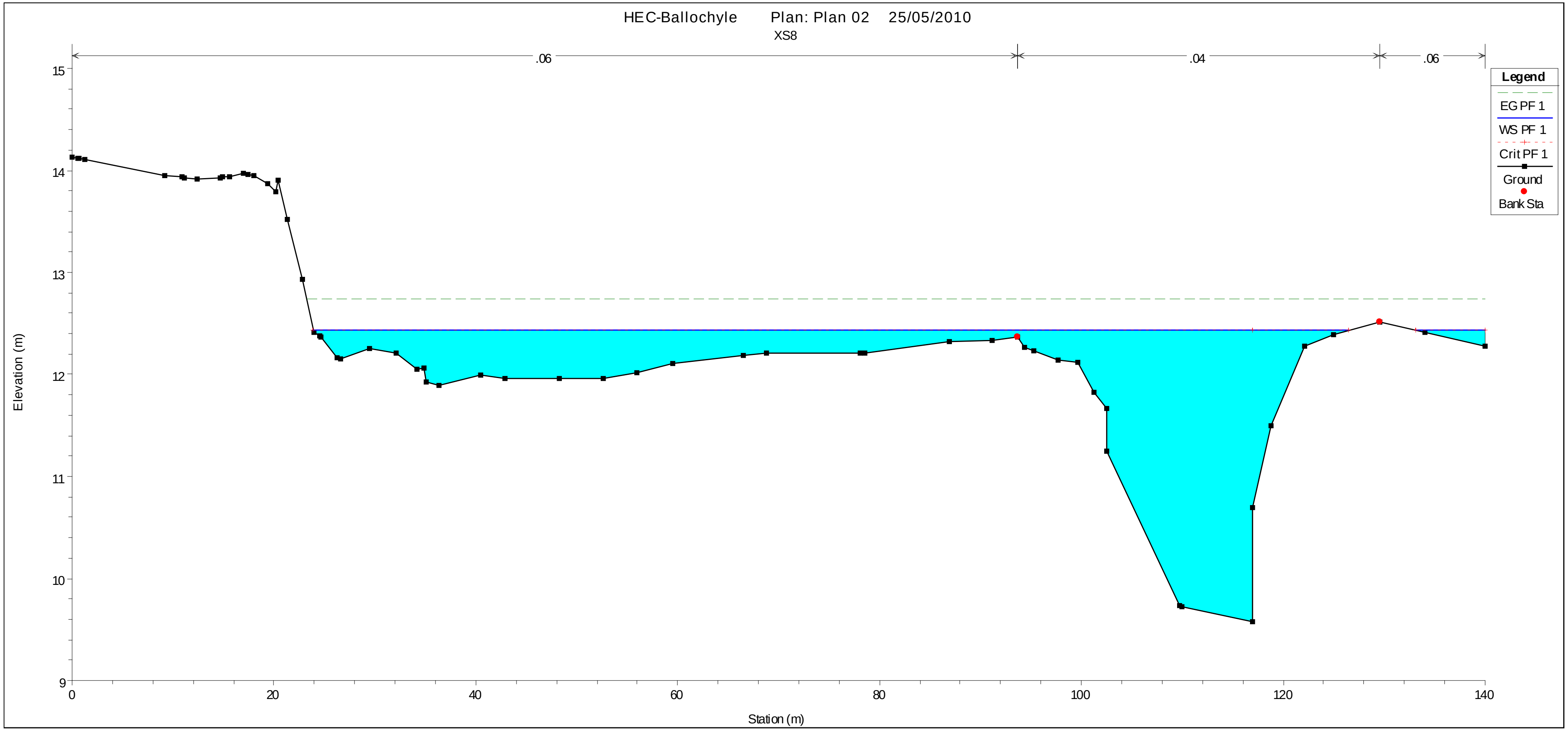

Figure 12. XS8 HEC-RAS - Water Surface Elevation is 12.43 mAOD

Manning's Equation Calculator / Software	The open channel flow software website

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More calculations: Design of Rectangular Channels Design of Trapezoidal Channels
Circular Culverts using Manning Equation Culvert Design using Inlet and Outlet Control
Q=VA simple flowrate calculator

$$Q = VA \qquad V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Select units:		Click to Calculate
◯ Use feet and seconds units	k = 1.0, for unit conversion	
◉ Use meters and seconds units	Area, A (m^2):	79.16
Select Calculation:	Wetted Perimeter, P (m):	41.888
◉ Velocity (V) and Discharge (Q)	Channel Slope, S (m/m):	0.0381
◯ Channel Slope (S) from V etc.	Manning n:	0.04
◯ Channel Slope (S) from Q etc.	Velocity, V (m/s):	7.458988489342369
◯ Manning Coefficient (n) from V e	Discharge, Q (m^3/s):	590.4535288163419
◯ Manning Coefficient (n) from Q e	© 1998 LMNO Engineering, Research, and Software, Ltd.	

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Figure 13. XS9 Manning's Calculation

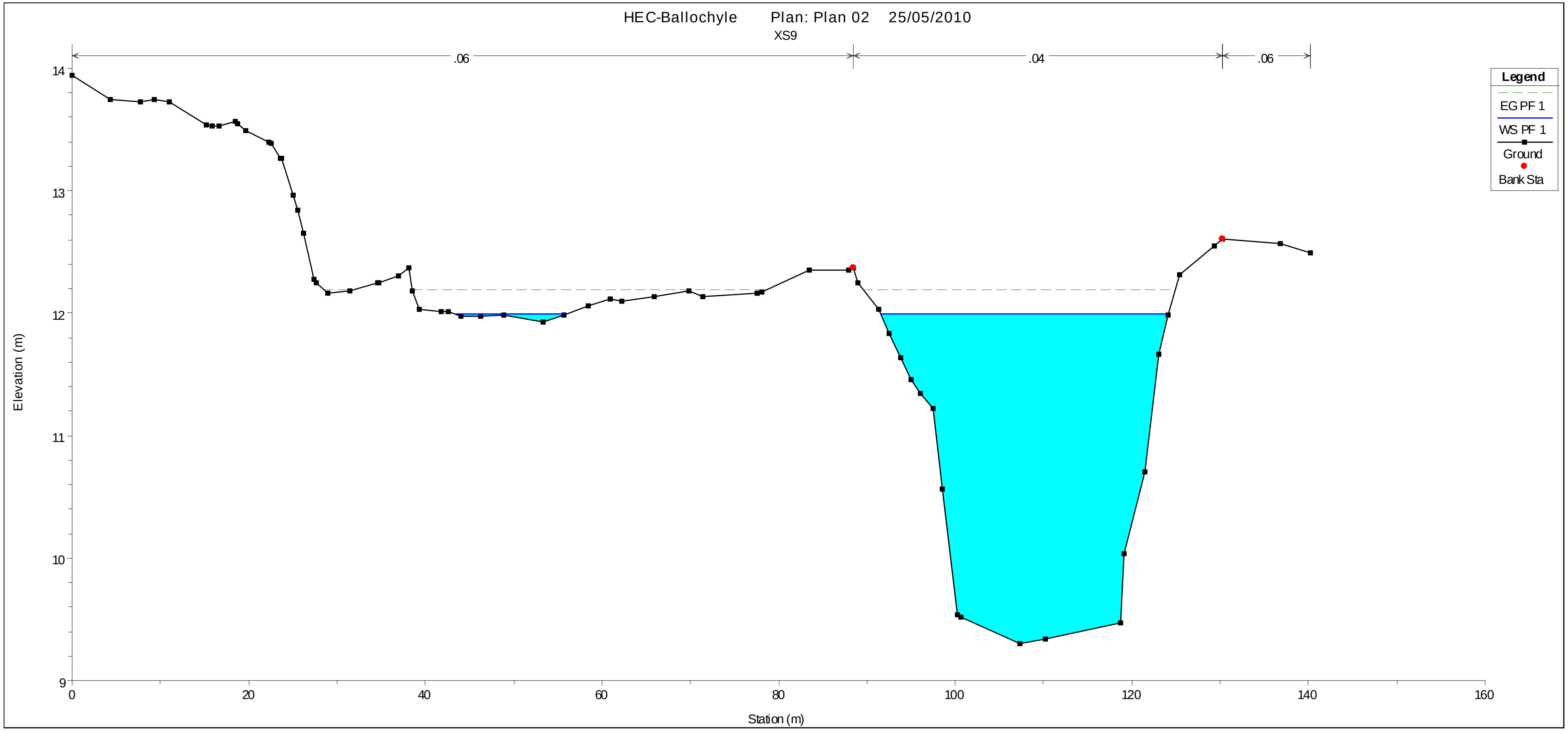

Figure 14. XS9 HEC-RAS - Water Surface Elevation is 11.99 mAOD

Manning's Equation Calculator / Software | The open channel flow software website

LMNO Engineering Home Page Manning n values Unit Conversions Trouble printing?
More calculations: Design of Rectangular Channels Design of Trapezoidal Channels
Circular Culverts using Manning Equation Culvert Design using Inlet and Outlet Control
Q=VA simple flowrate calculator

$$Q = VA \qquad V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Select units:		Click to Calculate
○ Use feet and seconds units	k = 1.0, for unit conversion	
◉ Use meters and seconds units	Area, A (m^2):	63.66
Select Calculation:	Wetted Perimeter, P (m):	34.622
◉ Velocity (V) and Discharge (Q)	Channel Slope, S (m/m):	0.0001
○ Channel Slope (S) from V etc.	Manning n:	0.04
○ Channel Slope (S) from Q etc.	Velocity, V (m/s):	0.37521742339051223
○ Manning Coefficient (n) from V e	Discharge, Q (m^3/s):	23.88634117304001
○ Manning Coefficient (n) from Q e	© 1998 LMNO Engineering, Research, and Software, Ltd.	

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Figure 15. XS10 Manning's Calculation

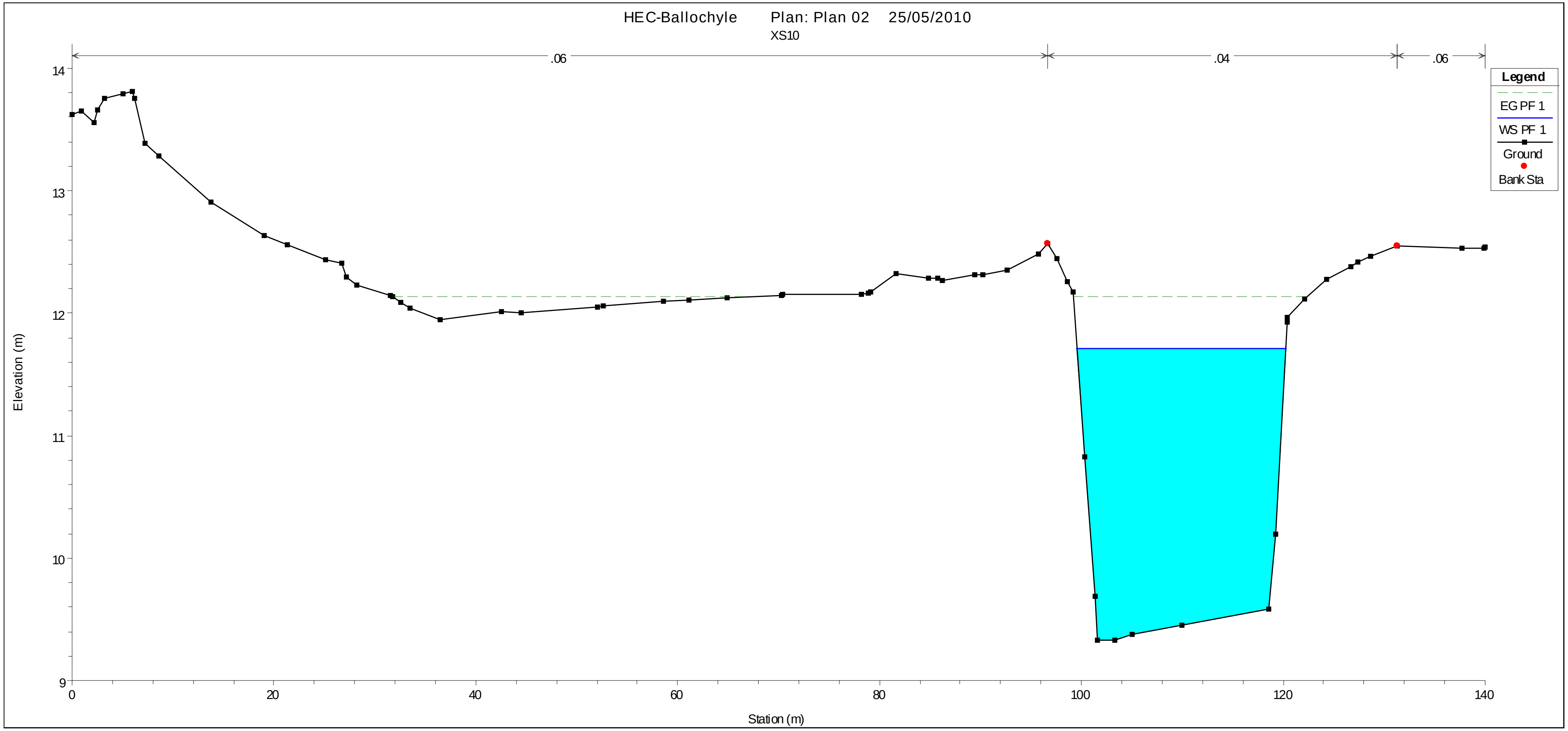

Figure 16. XS10 HEC-RAS - Water Surface Elevation is 11.72 mAOD

Manning's Equation Calculator / Software	The open channel flow software website

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More calculations: Design of Rectangular Channels   Design of Trapezoidal Channels
Circular Culverts using Manning Equation   Culvert Design using Inlet and Outlet Control
Q=VA simple flowrate calculator

$$Q = VA \qquad V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Select units:		Click to Calculate
○ Use feet and seconds units	k = 1.0, for unit conversion	
◉ Use meters and seconds units	Area, A (m^2):	64.4
Select Calculation:	Wetted Perimeter, P (m):	33.562
◉ Velocity (V) and Discharge (Q)	Channel Slope, S (m/m):	0.0444
○ Channel Slope (S) from V etc.	Manning n:	0.04
○ Channel Slope (S) from Q etc.	Velocity, V (m/s):	8.134362391047842
○ Manning Coefficient (n) from V e	Discharge, Q (m^3/s):	523.8529379834811
○ Manning Coefficient (n) from Q e		

The Manning Equation is the most commonly used equation to analyze open channel flows. It is a semi-empirical equation for simulating water flows in channels and culverts where the water is open to the atmosphere, i.e. not flowing under pressure, and was first presented in 1889 by Robert Manning. The channel can be any shape - circular, rectangular, triangular, etc. The units in the Manning equation appear to be inconsistent; however, the value k has hidden units in it to make the equation consistent. The Manning Equation was developed for uniform steady state flow (see Discussion and References for Open Channel Flow). S is the slope of the energy grade line and $S=h_f/L$ where h_f is energy (head) loss and L is the length of the channel or reach. For uniform steady flows, the energy grade line = the slope of the water surface = the slope of the bottom of the channel.

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Figure 17. XS11 Manning's Calculation

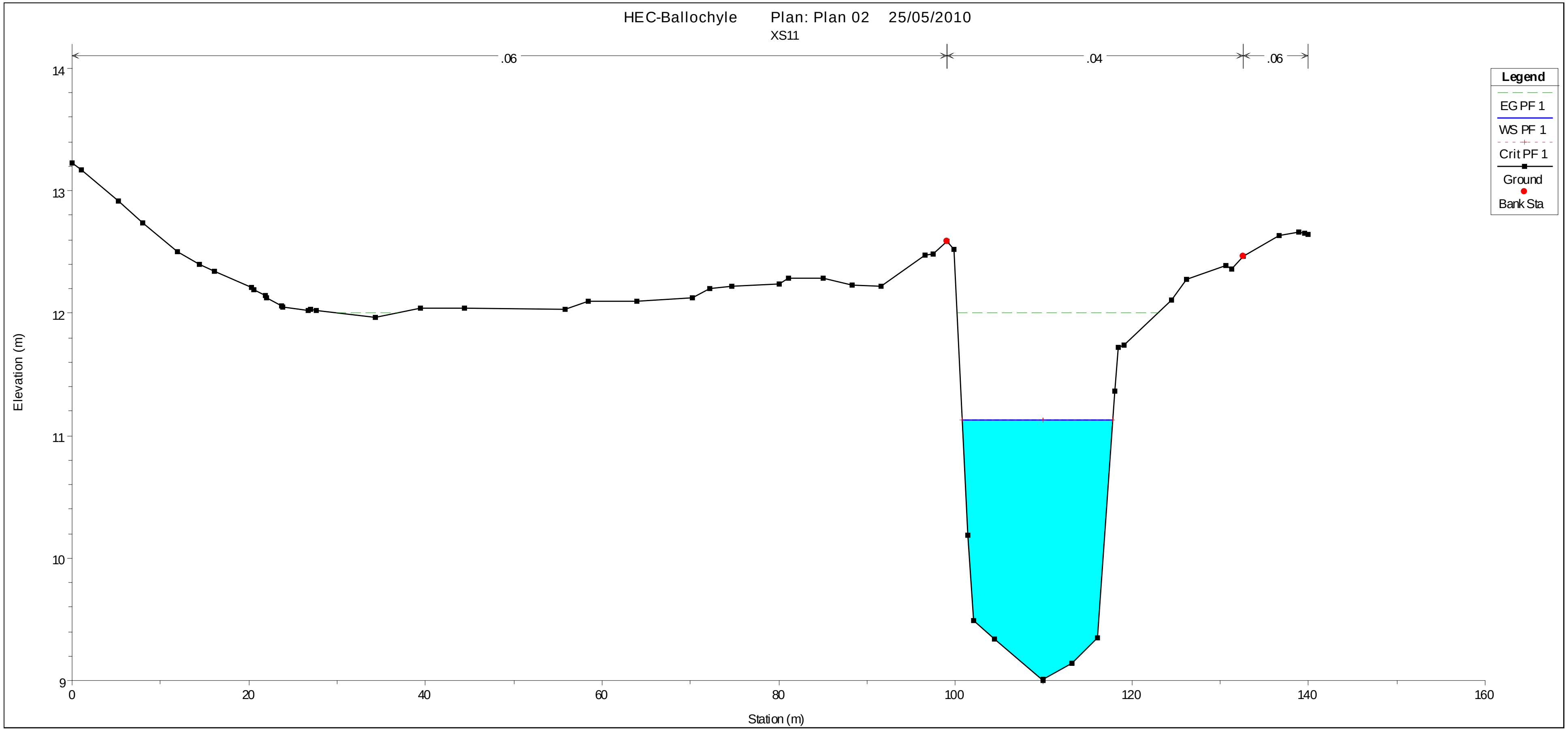

Figure 18. XS11 HEC-RAS - Water Surface Elevation is 11.13 mAOD