Appendix L
Surface Water Assessment

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Glossary

Alluvial	Sediments/soils derived from the deposition of material by waterways.
Annual Exceedance Probability	That is the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. Eg, if a peak flood discharge of 500 m3/s has an AEP of 5%, it means that there is a 5% chance of a 500 m3/s or larger events occurring in any one year.
Afflux	The rise in upstream water level caused by a hydraulic structure.
Alluvial	Consisting of sediment deposited by flowing water, in a riverbed, floodplain or delta.
Avulsion	The rapid abandonment of a river channel and the formation of a new river channel.
Biological diversity	The maintenance of a full and diverse range of plant and animal species.
Bund	An impervious embankment of earth or a brick wall, which may form part or all of the perimeter of a compound that is provided to retain liquid.
Catchment	The land area contributing to the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Cess drain	A surface drain that is located at the formation level at the side of tracks to remove water.
Chain of ponds	A waterway characterised by a series of ponds with no defined channel separating the ponds.
Chainage	The chainage at a location along a rail line is the distance of the point in relation to Sydney (NSW only) based on 0.000 kilometres being located at the end of Central No. 1 Platform.
Coal path	A train path that is dedicated to the movement of coal haulage.
Concept design	Initial functional layout of a concept, such as for the proposed duplication, to provide a level of understanding to later establish detailed design parameters.
Confluence	Location where two creeks connect.
Consent	Approval to undertake a development received from the consent authority.
Construction Environmental Management Plan	A document setting out the management, control and monitoring measures to be implemented during construction of a development, to avoid or minimise the potential environmental impacts identified during an environmental impact assessment process.
Corridor	Refers to the rail corridor.

Crossover	Railway infrastructure that provides a train the ability to cross between two adjacent tracks.
Culvert	A totally enclosed drain under a road or railway.
Cut	An excavation for constructing below the natural ground level.
Cut batters	The side slopes of cuttings.
Discharge	The rate of water flow measured in terms of volume per unit time (cubic metres per second – m^3/s).
Detailed design stage	The stage at which the project design is detailed on the basis of an approved concept design.
Director-General's Requirements	Requirements for an environmental assessment issued by the Director-General of the NSW Department of Planning in accordance with the Environment Planning and Assessment Act 1979.
Dispersivity	Potential for soil to break down into fine particles in water.
Down Main	Primary (main) rail line that trains traverse when they are heading away from Sydney (usually positioned on the left when your back is to Sydney).
Duplication	Construction of an additional track adjacent to an existing single track.
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
Fauna	The animals of a given region or period, taken collectively.
Flora	Plants of a particular region that make up the vegetation of a site.
Floodplain	The area of land subject to inundation by floods up to and including the probable maximum flood event.
Floodway	The area of the floodplain where a significant portion of flow is conveyed during floods. Usually aligned with naturally defined channels.
Fill	Earth used to construct an embankment.
Fugro Survey	Digital terrain model developed from aerial photography.
Geotechnical	A discipline of engineering associated with studying the ground and its geology.
Geomorphology	The study of landforms and the processes that shape them.
Gradient	The degree of ascent or descent with a uniform slope.
Groundwater	Subsurface water stored in pores of soil or rocks.
Headways	The time difference between scheduled train services.
HEC-RAS	1-dimensional waterway software used for determination of flood extents for both steady (time variant) and unsteady (time varying) flow conditions.

Hydrology	The study of rainfall and surface water run-off processes.
Hydraulics	The study of water flow in waterways, in particular the water level and velocity.
Hydrograph	A graph which shows how the discharge at any particular location varies with time during a flood.
Hunter 8 Alliance	Hunter 8 Alliance, which has been formed to deliver a new third track and ancillary infrastructure between Maitland and Minimbah.
Incised valley fill	A waterway exhibiting a single channel that is interpreted to have incised into valley floor fill sediments.
Investigation area	The investigation area for this project is defined as a linear corridor, which follows the route of the Main Northern Railway between chainages 194.500 kilometres and 224.220 kilometres, as shown in Figure 1.1.
Lag	The time taken for runoff to flow from the outlet of one catchment to the outlet of the next catchment.
Low sinuosity	Refers to a waterway channel that is relatively straight in plan view.
Mitigation	Reduction in severity.
Option	A concept design alternative developed for consideration.
Overbank	The portion of the flow that extends over the top of waterway banks.
Overbridge	Where a road or pedestrian footway is situated over the railway line.
Particulates	Dust and other fine particles.
Partly confined low sinuosity	Refers to a waterway where 10 – 90% of the channel abuts the margins of the valley.
Peak discharge	The maximum discharge occurring during a flood event.
Proponent	Australian Rail Track Corporation (ARTC).
Rail corridor	The area of land dedicated to the ARTC between Maitland and Minimbah.
Reach	A segment of a waterway.
Riparian	Of, on, or relating to the banks of a natural watercourse.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Sediment	Material of varying sizes that has been or is being moved from its site of origin by the action of wind, water or gravity.
Slew	Horizontal realignment of track to connect new track to existing track without using a turnout.
Spoil	Excess of rock and/or earth material resulting from construction activities.

Substrates	The materials/sediments that line the bed of a waterway.
Toe of fill batters	The base or bottom of a fill batter or embankment.
Train paths	A train path is a dedicated route between two locations, which is often scheduled.
Turnout	The intersection and mechanisms for the meeting of two tracks.
tc	Time of concentration – time for stormwater to travel from the top of a catchment to the catchment outlet.
Topographic survey	Graphic delineation of natural and main-made features of a property showing their relative positions and elevation.
Underbridge	Where a creek, road or pedestrian underpass is situated under the railway line.
Up Main	Primary (main) rail line that trains traverse when they are heading toward Sydney (usually positioned on the right when your back is to Sydney).
Up Relief Main	Secondary rail line that runs parallel with the main line(s) that trains traverse when they are heading toward Sydney and is usually positioned on the right of the main line when your back is to Sydney. Usually provides a passing facility, enabling trains to pass those traversing or stationary on the main line thus giving relief to the main line operations.
Valley floor fill	A waterway with no defined channel set within a valley that has a flat and featureless floor composed of alluvial sediments.
XP-RAFTS	Runoff and streamflow routing software used to calculate flood hydrographs from rainfall and other channel inputs.

Abbreviations

AEP	Annual Exceedance Probability.
ANZECC	Australian and New Zealand Environment Conservation Council
AR&R	Australian Rainfall and Runoff
ARTC	Australian Rail Track Corporation
CEMP	Construction Environmental Management Plan
DECCW	Department of Environment, Climate Change and Water
DGRs	Director-General's Requirements
DWE	Department of Water and Energy
HCRCMA	Hunter Central Rivers Catchment Management Authority
LGA	Local Government Area
NHMRC	National Health and Medical Research Council
OW	Office of Water
SFMP	Spoil and Fill Management Plan

Executive Summary

The proposed upgrade to approximately 30 kilometres of the Main Northern Railway between Maitland and Minimbah by the Hunter 8 Alliance includes the construction / modification of infrastructure. The key components of the Third Track Project that would potentially impact surface water include:

- Major cut and fill earthworks along the route and other minor earthworks.
- Re-alignment of Sawyers Creek.
- Amendments to 53 culverts for cross drainage.
- Central and cess track drainage.
- Other drainage works around new structures.
- A new rail underbridge at Stony Creek and Wollombi Road, Farley.
- A new rail underbridge at Allandale Road, Allandale.
- A new rail underbridge for an unnamed tributary of Anvil Creek (approximate chainage 207.776 kilometres).
- Demolition and replacement of the existing rail underbridge at an unnamed tributary of Anvil Creek (approximate change 209.989 kilometres).
- A new rail underbridge at Sawyers Creek, Greta.
- A new rail underbridge at Black Creek, Belford.
- A new rail underbridge at Jump Up Creek, Belford.

The objectives of this surface water assessment were to assess the existing conditions with respect to flooding / hydrology, surface drainage, water quality, waterway geomorphic conditions, wetlands and drainage areas that may be potentially affected by the Project and to define the design principles that would be adopted for the Project. While other aspects of the natural water environment, such as aquatic ecology, fauna, flora, fauna and groundwater, are potentially impacted by the Project these are addressed in separate specialist reports.

The assessment considered waterways, including drainage lines, minor and major waterways, that are either intersected by the Project or are located within the investigation area. The aspects that were investigated for each waterway included:

- Existing geomorphology.
- Existing hydrologic and hydraulic characteristics.
- Existing water quality.

The risk assessment undertaken for surface water identified a number of potential impacts on flooding/hydrology, surface drainage, water quality, waterway conditions, wetlands and drainage areas that may result from the Project. The key risk impacts identified for construction and operation included:

- Potential decline in water quality.

- Potential increase in existing flood levels at Major waterways.
- Potential increase in scour at culvert outlets, along existing waterways and adjacent to embankments.
- Potential blockages to low flows at locations such as culverts and causeways.

To minimise the effect of these potential impacts, a number of standard mitigation measures were proposed. These mitigation measures would be adopted during the detail design phase and be incorporated into the Project as both permanent and construction controls and included:

- Undertake flood modelling to determine the existing conditions and develop a design that minimises the potential increase in flood level.
- Design protection measures to minimise the potential for scour and maximise stability of waterways and earthworks.
- Design causeways and culvert extensions to maintain base flows to the downstream environment.
- Nomination of erosion and sedimentation control, including a response plan and monitoring, within a Soil and Water Management Plan in the Environmental Management Plan.

The adoption of the proposed standard and additional mitigation measures would result in the Project having a minimal impact on surface drainage, water quality, flooding/hydrology and the condition of existing waterways.

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1. Introduction

This Surface Water Assessment report has been undertaken by the Hunter 8 Alliance on behalf of the Australian Rail Track Corporation (ARTC) for the Maitland to Minimbah Project (referred to as 'the Project'). This report has been prepared to assess surface water for the existing conditions and to determine the potential impacts that may arise as a result of the Project.

1.1 Background

ARTC was created by the Commonwealth and State Governments in 1998 to provide a single body responsible for the National Interstate Rail Network. ARTC is a Commonwealth Government corporation and currently has responsibility for the management of over 10,000 route kilometres of standard gauge interstate rail track in South Australia, Victoria, Western Australia and New South Wales (NSW), as well as the Hunter Valley Rail Network and other regional rail links in NSW.

The Hunter Valley Rail Network extends from the Port of Newcastle to Ulan and Narrabri in the west. It is used by passenger services, freight, wheat and coal services. The majority of trains carry coal from mines located across the Hunter Valley to either Carrington (Port Waratah) or Kooragang Island ports at Newcastle for loading onto ships for export.

Due to the forecast increase in coal throughput at the Port of Newcastle to 190 million tonnes per annum (mtpa) by 2012, a number of rail infrastructure improvements to the Hunter Valley Rail Network have been proposed by ARTC. One of the key improvement projects included in the ARTC ten-year strategic plan is a proposed third track adjacent to the existing Main Northern Railway between Maitland and Whittingham, known as the Maitland to Whittingham Third Track Project.

The Maitland to Whittingham Third Track Project is divided into two stages. Stage 1 consists of the construction of the third track between Minimbah and Whittingham. Project Approval for this project was granted by the Minister of Planning on 26 May 2009 and construction commenced in July 2009.

Stage 2 consists of the construction of the third track between Maitland and Minimbah, known as the Maitland to Minimbah Third Track Project. Stage 2 is the subject of this Surface Water Assessment and is referred to as 'the Project'.

The purpose of the Project is to increase rail reliability and future capacity between the Hunter Valley and the Port of Newcastle. In addition to providing increased track capacity, the Project aims to improve operational performance along the route. These improved efficiencies would be created through:

- Reduced impacts on coal traffic due to track maintenance activities.
- Reduced loss of freight train paths due to shadow effects from passenger services.
- Reduced loss of available train paths due to train breakdowns.

The Project would also bring benefits to the local and broader community by generating up to 650 full time jobs during construction, creating opportunities for local and regional goods and service providers, and providing greater security for existing coal industry jobs.

1.2 Description of Project

The Hunter 8 Alliance, on behalf of the ARTC, is proposing to construct a third track adjacent to the existing Main Northern Railway between Maitland and Minimbah. The proposed third track would commence in Farley approximately 2 kilometres west of Maitland Station at approximate chainage 194.500 kilometres and would run adjacent to the Main Northern Railway for approximately 30 kilometres concluding at Minimbah at approximate chainage 224.200 kilometres.

The proposed third track would be predominantly located on the Up side of the Main Northern Railway. Approximately 3 kilometres of track, from chainages 210.170 kilometres to 211.180 kilometres and 214.060 kilometres to 216.000 kilometres, would be located on the Down side.

The Project would involve the construction of approximately 30 kilometres of new rail track as well as construction and/ or modification of major infrastructure along the Main Northern Railway. A summary of the major elements of the Project is provided in Table 1-1.

Table 1-1 Major Project Elements

Project Elements	
Earthworks	Major cut and fill earthworks along the route. Other minor earthworks.
Track	Approximately 30 kilometres of new track including turnouts and junctions. Relocation of turnouts from Minimbah and Branxton to Belford. Upgrade of maintenance siding turnouts at Branxton. Track reconditioning of existing Up Main at Greta and Branxton Stations and of the Branxton crossovers.
Drainage	Central and cess track drainage. Amendments to 53 culverts for cross drainage. Re-alignment of Sawyers Creek. Other drainage works around new structures.
Bridges	A new rail underbridge at Stony Creek and Wollombi Road, Farley. Closure of the stock crossing at Farley. Demolition of the existing rail overbridge at Old North Road, Allandale. A new rail underbridge at Allandale Road, Allandale. A new rail underbridge for an unnamed tributary of Anvil Creek (chainage 207.776 kilometres).

Project Elements	
	Demolition and replacement of the existing rail underbridge at an unnamed tributary of Anvil Creek, Greta (chainage 209.989 kilometres). A new rail underbridge at Sawyers Creek, Greta. Modification of the existing rail overbridge at Bridge Street, Branxton. A new rail underbridge at Black Creek, Belford. A new rail underbridge at Jump Up Creek, Belford.
Station Modifications	Modifications to Lochinvar Railway Station. Modifications to Greta Railway Station. Modifications to Branxton Railway Station.

1.3 Investigation Area

The investigation area for this surface water assessment is a linear corridor 100 metres either side of the rail alignment, which follows the route of the Main Northern Railway between chainages 194.500 kilometres and 224.200 kilometres, as shown in Figure 1.1.

1.4 Objectives of this Report

The objectives of this surface water assessment are to:

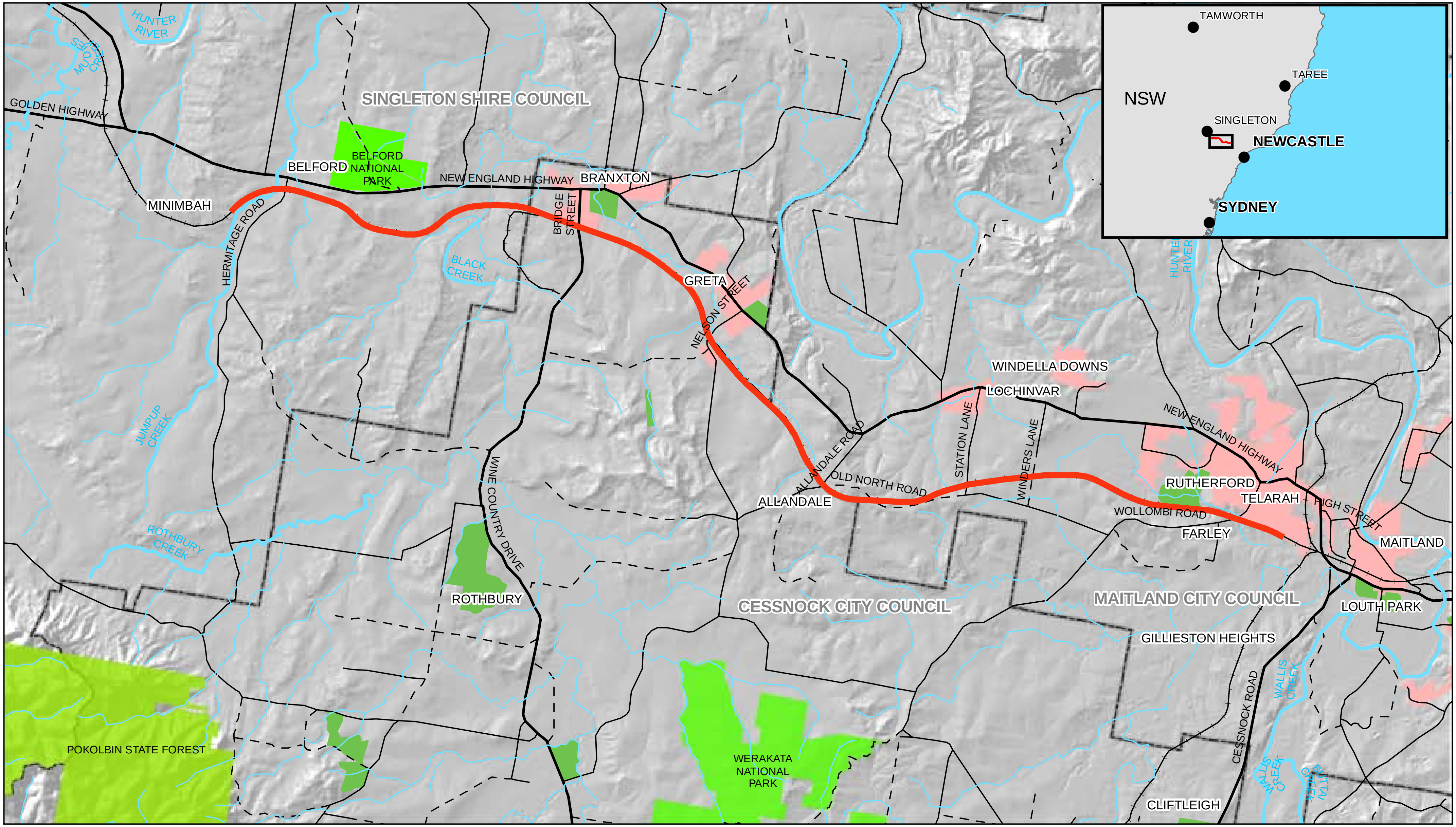
- Assess the potential impact of construction and operation of the Project on surface water.
- Address the Director General's Requirements (DGRs) for the Environmental Assessment of the Project.

The DGRs identify hydrology as a key issue for the Environmental Assessment. Table 1-2 outlines the DGRs relating to hydrology and where they have been addressed in this report.

Table 1-2 Director General's Requirements

Director-General's Requirements	Where Addressed in this Report
Hydrology	
Project effects on flood characteristics (on surrounding land, property and infrastructure) and effects of flooding on the project with specific reference to the Hunter River Floodplain. A range of flood events (including the PMF) shall be assessed in all flood prone areas within and adjoining the corridor.	Section 4, Section 5, Appendix B, Appendix C, Appendix D, Appendix E

Director-General's Requirements	Where Addressed in this Report
General construction impacts	
Assess and present a management framework for earthworks, including a considered approach to minimising impacts associated with the excavation, movement, stockpiling, rehabilitation and disposal of spoil and fill. Consideration should be given to:	
◗ Erosion and sedimentation control measures at excavation, storage and placement locations to protect adjoining watercourses, including during flood events and from the blockage or alteration of flow paths.	Section 6
◗ A strategy for managing earthworks with a particular focus on those works that have the greatest potential to disturb soils that are contaminated, have a high erosion and run off hazards and adverse impacts on watercourses, and a broader, more generic approach for ongoing construction management.	Section 6



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0 600 1,200 2,400 3,600 4,800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Railway
- Watercourse
- Highway
- Main Road
- Minor Road
- Unsealed
- Recreation Areas
- State Forest
- National Park
- Built Up Area
- LGA

Maitland To Minimbah Third Track
Surface Water Assessment

Job Number	22-14471
Revision	A
Date	May 2010

Regional Location

Figure 1.1

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Data Source: GeoScience Australia: 250k Topo Data - Series 3. Created by: msmiljkovski, tmorton, fmackay

2. Legislation

The *Environmental Planning and Assessment Act* 1979 (EP&A Act) contains the core legislation relating to planning and development activities in NSW and provides the statutory frameworks under which development proposals are assessed. Under this legislation, Part 3A provides for the control of major projects that require approval from the Minister for Planning.

Part 3A is therefore applicable to the Project and Hunter 8 is seeking project approval from the Minister for Planning under Part 3A of the EP&A Act.

The following section provides a brief overview of the legislation and policy documents relevant to surface water investigations for the Project.

2.1 Legislation

2.1.1 *Environmental Planning and Assessment* Act 1979, Section 75F

Section 75F of the *Environmental Planning and Assessment Act* 1979 (EP&A Act) outlines the Director General's Requirements (DGR's) for the environmental assessment approval of the Project.

This Specialist Report provides the results of a surface water impact assessment for the Project which was undertaken to satisfy the specific DGR's outlined in the Key Issues relevant to waterways, water quality, flooding and geomorphologic impact of the Project.

2.1.2 *Water Management Act* 2000

The Water *Management Act* 2000 (WMAct) is intended to ensure that water resources are conserved and properly managed for sustainable use for the benefit of present and future generations. It is also intended to provide formal means for the protection and enhancement of the environment qualities of waterways and their in-stream uses and to provide for the protection of catchment conditions.

Part 10 of the Act outlines the Waterway Management responsibilities and requirements for regional drainage and floodplain management, as relevant to the Authorities responsible for waterway management districts.

Guidelines for Controlled Activities

Section 39A of the *Water Management (General) Regulation* 2004 provides that public authorities are exempt from a Section 91 controlled activity approval in relation to all controlled activities that they carry out in, on or under waterfront land. The ARTC, as a declared public authority, would not be required to obtain a controlled activity approval for the Project. Furthermore, pursuant to Section 75U of the EP&A Act, a controlled activity approval is not required for an approved Part 3A project however the intent of these guidelines is to be applied.

The Department of Water and Energy (DWE), now Office of Water (OW), has provided guidelines for controlled activities regulated by the WMAct. These guidelines provide design and construction principles and information required for assessment of the works. DWE Guidelines for Controlled Activities relevant to the Project include In-stream, watercourse crossings, outlet structures and riparian corridors.

2.2 Policy

2.2.1 National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)

The National Water Quality Management Strategy (NWQMS) provides a national approach to improving water quality in Australia's waterways. The main policy objective of the NWQMS is to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development. The NWQMS process involves community and government development, and implementation, of a management plan for each catchment, aquifer, estuary, coastal water or other water body. This includes use of high-status national guidelines with local implementation. National guidelines relevant to the Project are provided for water quality benchmarks and groundwater management.

2.2.2 National Water Quality Management Strategy Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC 2000)

As part of the NWQMS, there are a number of policies, procedures and guidelines that are nationally accepted for the undertaking of monitoring and reporting of water quality. This applies to fresh, groundwater and marine waters. For the Project these would be applied to surface and groundwater sampling.

2.2.3 Managing Urban Stormwater: Source Control (EPA 1998)

The intent of this document is to provide guidance to local and state government agencies and developers as well as community and business groups, on a range of source control (water quality and quantity) techniques that can be adopted to minimise impacts of works on the surface water environment. It highlights the need for pollutant control using sustainable cost-effective structural and non-structural methods such as street sweeping, swales, basins and gross pollutant traps.

This document provides guidance to the Project for the selection of suitable source control measures where appropriate.

2.2.4 Managing Urban Stormwater: Soils and Construction (Vol. 1)

Managing Urban Stormwater: Soils and Construction (Vol 1) outlines the basic principles for the design and construction of sediment and erosion control measures. This document relates particularly to urban development sites however it is relevant to the Project as it provides guidance on the configuration of erosion and sedimentation controls required during construction of the Project.

Managing Urban Stormwater: Soils and Construction (Vol. 2D)

Managing Urban Stormwater: Soils and Construction (Vol 2D) provides guidelines, principles and recommended minimum design standards for good management practice in erosion and sediment control during the construction of main roads and large scale earthworks projects. Volume 1 principles broadly apply to main roads, however Volume 2D provides unique characteristics of main roads projects that warrant special consideration including bridges and culverts, batch plant sites and side access tracks. Although the Project is not classified as a main road project, is does involve large scale earthworks and bridges, culverts and access tracks.

Due to the similar large scale linear nature of the Project, this document is has been applied in the specific management of sediment and erosion control during construction.

2.2.5 Managing Urban Stormwater: Treatment Techniques (EPA 1998)

This document includes a detailed discussion of treatment techniques including primary, secondary and tertiary levels of treatment for trapping pollutants as well as guidelines for treatment selection and design of treatment measures.

This document provides guidance to the Project for the design and location of treatment solutions.

2.2.6 City Wide Development Control Plan: Hunter River Floodplain Management (Maitland City Council, January 2006)

This plan is to be read in conjunction with the complete City Wide Development Control Plan. It provides guidance for development within the Hunter River floodplain area and outlines Council’s objectives and polices for development within the area.

3. Methodology

This section identifies and describes the catchments and waterways that intersect the Project. The identification of waterways potentially impacted by the Project was based on a review of the Department of Lands digital database, Fugro aerial survey, topographic survey, site plans and aerial photography. Waterway crossings were numbered sequentially east to west along the rail alignment. Subsequent site inspections enabled the findings of the desktop study to be ground-truthed.

To establish the potential impact of any proposed development on the identified waterways, the existing geomorphic, hydrologic, hydraulic and water quality conditions need to be established. The existing condition assessment was based on a desktop study and field investigations.

3.1 Desktop Study

For the desktop component of the assessment a number of tasks were undertaken including:

- Identification of waterways and drainage lines within the investigation area, based on Department of Lands topographic information, in accordance with the *Water Management Act* 2000.
- General assessment and description of waterways and the contributing catchments.
- Condition assessment of each waterway.
- Hydrologic assessment to determine existing conditions peak flow rates for each of the assessed waterways using XP-RAFTS.
- Hydraulic assessment of named creeks to determine the existing conditions flood levels for these waterways using HEC-RAS.
- Review of flood information for Wentworth Swamp to determine the potential impact.
- Water quality assessment using existing catchment information from the Hunter Central Rivers Catchment Management Authority (HRCMA) and Council documents.

3.1.1 Waterway Assessment

Waterway Identification

The method for waterway identification at each crossing location used for the Project was based on:

- Area of the contributing catchment at the crossing location.
- The Strahler stream order at the crossing location. This system starts at the top of the catchment and defines any watercourse that has no other watercourses flowing into it as a 1st order watercourse. Where two perennial 1st order watercourses join, the watercourse becomes a 2nd order watercourse and where two 2nd order stream join, the river becomes a 3rd order watercourse.
- The definition of the channel and valley.

Based on the desktop study, waterways were classified at each crossing location in general accordance with the parameters set out in Table 3-1.

Table 3-1 Waterway Crossing Classification Descriptions

Waterway Classification	Catchment Area (ha)	Stream Order*	Valley / Channel Definition
Drainage Line	< 20	Unmapped to first order	No defined channel and valley floor fill < 10 metres wide.
Minor Waterway	20 to 100	First to second order	Defined channel and / or valley floor fill > 10 metres wide.
Major Waterway	> 100	Second order and higher	Defined channel and / or valley floor fill > 10 metres wide.

* Based on Department of Lands 1:25,000 drainage layer

Waterway Types

The site inspections of the waterway crossings located along the Project route form the basis of an existing waterway geomorphic condition assessment and details of the site inspections are provided in Appendix A.

The preliminary and site-specific nature of the site assessments should be noted. References to site conditions are based on observations made on a single day and as such do not reflect changes in response to seasonal variation. Similarly, the site assessment sought to document the general environmental condition of the crossing location (within the investigation area) and wider surveys of the catchment and downstream receiving waters were not undertaken. However, where information has been available, references to broader environmental values in a catchment context have been included.

It is further noted that documentation of flora and fauna values is considered outside the scope of this surface water assessment and are addressed in the Flora and Aquatic Ecology Assessment.

3.1.2 Hydrologic Assessment

In order to determine the existing conditions at each waterway crossing, with respect to peak flow rates, a hydrologic assessment of each waterway was undertaken. These hydrologic assessments included both Rational Method calculations and the development of XP-RAFTS models with the resultant flows to be used in the detail design of each crossing structure.

The Probabilistic Rational Method (PRM) is provided in Australian Rainfall and Runoff (Institute of Engineers Australia, 1998) as a standard method for peak flow estimation for small to medium sized catchments. It is widely used in the design of stormwater drainage systems, farm dam spillways and small culverts in road and railway embankments.

For larger or more complex catchments, an XP-RAFTS model (Version 7.0) was developed. XP-RAFTS is a rainfall-runoff model designed for Australian catchments that uses non-linear runoff routing to develop hydrographs from either actual or design storm events utilising Intensity-Frequency-Duration data together with storm temporal patterns. Rainfall-runoff is simulated for each catchment with the hydrographs then routed through the stream network.

Hydrologic Models

The following provides a summary of the inputs and methodology used in developing each of the XP-RAFTS models while Section 4.4 provides the results of this modelling.

Catchment Areas

The catchment area for each contributing waterway crossing was determined from a combination of topographic survey, Fugro aerial survey and the Department of Lands digital database.

Rainfall Data

A range of design storm events, up to and including the probable maximum flood (PMF), have been considered in this assessment.

Design storm events of magnitude up to the 1% Annual Exceedance Probability (AEP) were generated from Australian Rainfall and Runoff (AR&R) intensity-frequency-duration (IFD) design rainfall curves and correspond to the design rainfall data included in the council design standard corresponding to the LGA in which the catchment is located.

In determination of the PMF, a regression equation for calculating a triangular PMF hydrograph was used. This equation was derived from analysis of PMF estimates from 56 catchments in South Eastern Australia ranging in size from 1 square kilometre to 10,000 square kilometres and can be applied to catchments that do not have large lakes or artificial storages.

Lags

Lags were calculated using the Stream Velocity Method (based on the Manning's equation) for assumed average stream velocities for catchment areas less than 500 ha. The assumed average stream velocities are summarised in Table 3-2 and these were applied to the catchment connectors to determine an appropriate lag time.

Table 3-2 Assumed Average Stream Velocities

	Average Slope of Catchment Surface (%)	Assumed Stream Velocity (m/s)
Flat	0 to 1.5	0.3
Rolling	1.5 to 4	0.7
Hilly	4 to 8	0.9
Steep	8 to 15	1.5
Very Steep Rocky Mountains	> 15	3.0

Loss Model

The catchment loss model for the Project was based on AR&R design loss rates for New South Wales for east of the western slopes. Table 3-3 summaries the loss model parameters.

Table 3-3 Loss Model

Location	Loss Model	Median Value of Parameters
East of the western slopes	Initial loss – Continuing loss	Initial loss 10 to 35 mm, varying with catchment size and mean annual rainfall. 10 mm was adopted. Continuing loss 2.5 mm/h

Manning's n Roughness

Two sources were considered in nominating Manning n roughness values for the hydrologic assessment. These were Chow (1959) and AR&R with the value ranges for both pervious and impervious areas provided in Table 3-4.

Table 3-4 Manning n Roughness

Surface Type	Chow	AR&R
Pervious	◗ Scattered brush: 0.035 – 0.07 ◗ Light brush and trees: 0.04 – 0.08 (Summer)	◗ Long Pasture grass, no brush: 0.03 – 0.05 ◗ Light brush and trees: 0.04 – 0.08
Impervious	◗ Concrete: 0.013 – 0.015 ◗ Asphalt: 0.016 – 0.018	◗ Concrete (formed, without finishing): 0.013 – 0.018 ◗ Bricks: 0.014 – 0.016

For this assessment, Manning's n values of 0.05 and 0.015 were adopted for the pervious and impervious portions of each catchment.

Percentage Impervious

In determining the percentage impervious for sub-catchments, a review of the relevant council design guidelines was undertaken. Examination of available aerial photographs and Google Earth Pro was then undertaken to determine the appropriate percentage impervious for each sub-catchment.

Peak Flow Estimates

Probabilistic Rational Method

A preliminary estimation of the peak flow rate for each of the catchments was undertaken using the Probabilistic Rational Method (PRM). This calculation was used for comparative purposes against the peak flow rates determined through the XP-RAFTS modelling.

XP-RAFTS Modelling

Several XP-RAFTS models were established for the catchments associated with the Project. For the major waterways of Stony Creek, Anvil Creek and Jump Up Creek, the total contributing catchment was further divided into sub-catchments to enable a more reasonable representation of flow contributing to each of the crossings. Catchment plans for each of these major waterways are provided in Appendix B, Appendix C and Appendix E respectively.

With respect to Black Creek, no XP-RAFTS model was developed as WMA Water made an existing model available to Hunter 8 Alliance. WMA Water is currently engaged to develop both hydrologic and hydraulic models for the Hunter River through the Cessnock and Maitland LGAs. The extent of their hydrologic model includes the full extent of the Black Creek catchment and the Hunter 8 Alliance was provided with the peak flow rate at the location where the rail corridor crosses Black Creek, for a range for storm events. This data is provided in Appendix D and was used in the Black Creek hydraulic modelling.

For the remaining major waterways, minor waterways and drainage lines, these were also modelled as single catchment areas within XP-RAFTS. The peak flow rates determined by the XP-RAFTS models for each of the waterway crossings are provided in Section 4.4, Table 4-2.

3.1.3 Hydraulic Assessment

A hydraulic assessment of Stony Creek, Anvil Creek, Black Creek and Jump Up Creek was undertaken using HEC-RAS (Version 4), a 1-dimensional depth averaged model developed by the US Army Corp of Engineers. This model can consider both steady (time variant) and unsteady (time varying) flow conditions. These waterways were assessed as they are major waterways with total catchment areas of greater than 1,500 hectares.

The HEC-RAS models were established from existing topographic survey data and the peak flow rates as determined within the XP-RAFTS models were then incorporated into the respective HEC-RAS models.

Channel Roughness

Further to the review of Manning’s n values discussed in Section 3.1.2, an additional literature review for Manning’s values appropriate for various channel conditions was undertaken. Through this it was determined that Brisbane City Council*, Natural Channel Design Guideline* provided comprehensive documentation of the roughness associated within channels and the overbank portion of the natural flow path.

This guideline provides a series of photographs of varying conditions and the associated Manning’s n roughness. For each of the hydraulic models developed, this document was used to establish the most appropriate value.

Downstream Control

Each of the major waterways assessed within HEC-RAS contributes to a regionally significant waterway system however the distance to that system varies considerably. In determining if the receiving water system acted as a downstream boundary condition a review of the distance to each of these systems was determined and the outcomes provided in Table 3-5.

Table 3-5 Downstream Boundary Controlled

Waterway	Downstream Receiving System	Distance to Downstream Receiving System	Downstream Boundary Controlled
Stony Creek	Wentworth Swamp	At boundary of hydraulic model.	Yes. Wentworth Swamp flood level 10.2 m AHD (1% AEP)
Anvil Creek	Black Creek	7.5 km (approx.)	No
Black Creek	Hunter River	7.5 km (approx.)	No
Jump Up Creek	Hunter River	10.8 km (approx.)	No

For waterways where the effects of the downstream control levels did not extend to the site boundary, a normal depth boundary condition was adopted.

3.1.4 Water Quality

Water quality within the waterways can be attributed to, and is affected by, the land use within each of the contributing catchments. A broad overview of the land uses within each of the catchments assessed is provided in Table 4-5 along with the potential pollutants generated as a result of these land uses.

There are a number of organisations, such as local government authorities, Hunter Water Corporation, Stream Watch and Waterwatch NSW, that make available surface water data. A review of the publicly available data was undertaken and the outcome of this review is provided in Section 4.6.

3.2 Field Investigations

Site inspections of a number of waterways, within the investigation area, identified through the desktop study were undertaken on 2 and 7 October 2009. The waterways inspected are nominated in Table 4-1 and details of the inspection are provided in Appendix A. During the inspection, consideration was given to:

- Valley confinement.
- Channel planform.
- Bank and channel condition.
- Instream features.
- Floodplain condition and features.

4. Existing Environment

4.1 Major Waterway Catchment Descriptions

Four major catchments are impacted by the Project, these include Stony Creek, Anvil Creek, Black Creek and Jump Up Creek. Figure 4.1 indicates the location of each of the major contributing catchments in relation to the Project alignment. In addition to this, there are a number of minor catchments that are discussed in detail in Section 4.1.1.

Stony Creek Catchment

Stony Creek is a tributary of Wentworth Swamp, which in turn drains into Swamp Creek, Wallis Creek and subsequently the Hunter River. Both Wentworth Swamp and Stony Creek are affected by flooding caused by backwater from the Hunter River.

The total catchment area contributing the Stony Creek brick arch culverts is located within the Maitland Local Government Area (LGA). It is in the order of 1,520 hectares with approximately 88% of the catchment located north of the corridor and extending from Rutherford through to the vicinity of Windella Downs. The remaining 12% located in the Farley area south of the corridor is adjacent to the rail corridor, extending a maximum 600 metres.

Development within the catchment includes residential, rural residential, industrial and commercial land uses.

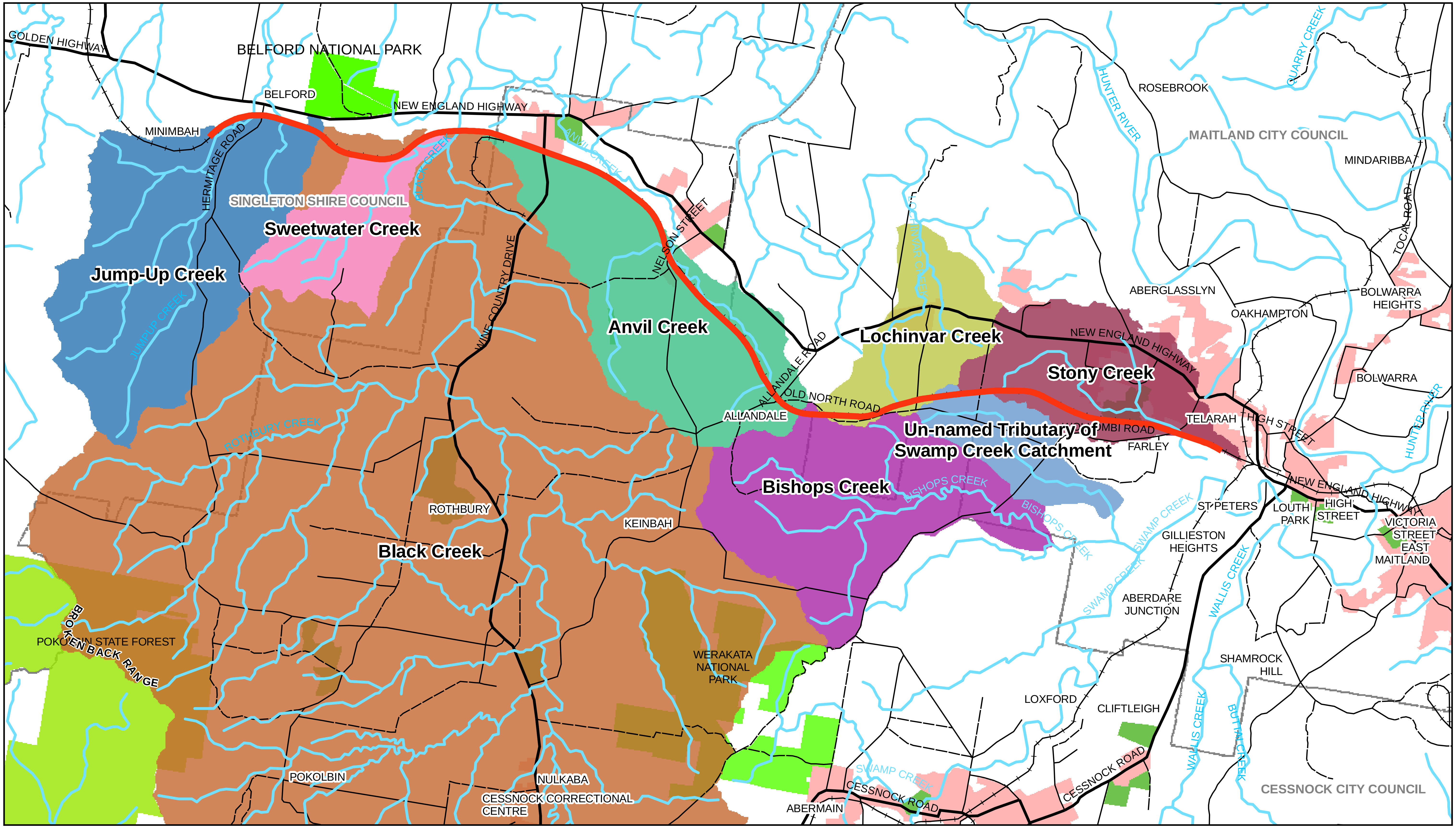
The existing Stony Creek brick arch culverts currently support both the existing Up and Down Mains and it is proposed that they would be retained. A new four span bridge would be constructed parallel to the existing structures to support the new Up Relief track. The new bridge would be located approximately 15 metres on the Up side of the existing structures and would span over both Stony Creek (upstream/north of the existing brick arch culverts) and Wollombi Road.

Anvil Creek Catchment

Anvil Creek is a tributary of Black Creek and has an overall catchment area, to the confluence of Anvil and Black Creek, in excess of 4,600 hectares. The upstream end of Anvil Creek is located south of Allandale Road within the Cessnock LGA, it then extends through a small portion of the Maitland LGA and continues within the Cessnock LGA through the townships of Greta and Branxton. The confluence of Black and Anvil Creeks is located approximately 2.5 kilometres downstream of where the rail corridor crosses Black Creek.

The waterways that contribute to Anvil Creek include Red House Creek, Sawyers Creek and several un-named tributaries. Development within the catchment is predominantly rural and bushland with the remaining portion of the catchment consisting of urban areas and a small component of industrial land.

The existing alignment of the rail corridor divides this catchment such that approximately 50% is located south of the corridor with the remaining 50% located to the north. Of the runoff generated from the total Anvil Creek catchment, in the order of 58% is affected by the rail corridor either by conveyance through waterways structures such as bridges or culverts, or conveyance within waterways adjacent to the corridor.



1:130,000(at A4)

0 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Railway
- Watercourse
- Built Up Area
- Recreation Areas
- State Forest
- National Park

Catchments

- Anvil Creek
- Bishops Creek
- Black Creek
- Jump-Up Creek
- Lochinvar Creek
- Stony Creek
- Sweetwater Creek
- Un-named

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Catchments

Figure 4.1

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Catchment_Plan_20091016_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: GeoScience Australia: 250k Topo Data - Series 3. Created by: msmiljkovski, fmackay

As outlined in Table 1-1, a number of new structures are proposed including new underbridges at 209.174 kilometres, 209.989 kilometres and Sawyers Creek (211.010 kilometres). All of the existing structures support both the existing Up and Down mains and new structures would be constructed to cater for the new Up Relief Main. These structures would be:

- 209.174 kilometres: A new precast concrete arch under the proposed Up Relief.
- 209.989 kilometres: Demolish and replace existing underbridge with a new single span precast concrete underbridge under the proposed Up Relief.
- 211.010 kilometres: New single span precast concrete underbridge under the proposed Up Relief Main, adjacent to the existing underbridge.

Black Creek Catchment

Black Creek is a tributary of the Hunter River and its catchment is bound to the west by the Broken Back Range, to the east by the Wallis Creek / Swamp Creek catchment and to the north by the Hunter River. It flows in a northerly direction through the township of Cessnock and a large area of rural land within the Cessnock LGA before crossing into the Singleton LGA and across the rail corridor.

There are numerous named and un-named waterways that contribute to Black Creek, including Anvil Creek and Sweetwater Creek, with the predominant land use being bushland and rural development with a small component of urban development.

Of the total 38,000 hectares catchment associated with Black Creek, 80% is located south of the existing rail corridor and is conveyed through the heritage listed underbridge that supports the existing Up and Down mains. This underbridge would remain and a new three span precast concrete underbridge would be constructed adjacent to this to cater for proposed third track.

Jump Up Creek Catchment

Jump Up Creek is a tributary of the Hunter River and has a total catchment area in the order of 6,000 hectares. Its catchment extends from the Broken Back Range in the west to the shared boundary with the Black Creek catchment in the east and the Hunter River to the north. Approximately 55% of the total catchment area is located south of the existing rail corridor with flows being conveyed by the existing two-span concrete bridge.

The catchment is located within the Singleton LGA and Jump Up Creek flows from the south through the township of Belford towards the Hunter River. There are numerous un-named waterways contributing to Jump Up Creek, conveying runoff from the largely bushland and rural land uses with negligible components of either urban or industrial areas.

The existing Jump Up Creek underbridge, which supports the Up and Down mains, would remain and a new single span bridge would be constructed adjacent to support the new Up Relief Main.

4.1.1 Other Catchment Descriptions

In addition to the four major catchments there are also three minor contributing catchments. These are the un-named tributary of Swamp Creek, Lochinvar Creek and Bishops Creek.

Un-named Tributary of Swamp Creek

The un-named tributary of Swamp Creek flows from north to south across the rail corridor with the catchment predominantly located to the south of the existing rail corridor. Only a small portion of the total catchment area (less than 1%) is located to the north and is conveyed through the corridor through a culvert at chainage 201.480 kilometres.

Lochinvar Creek

Lochinvar Creek is a tributary of the Hunter River and flows from south of the existing rail corridor to its confluence with the Hunter River. The catchment associated with Lochinvar Creek is primarily located north of the rail corridor with less than 1% located to the south. There a several small waterway structures within the existing rail embankment that convey flows associated with this catchment and it is anticipated that each of the existing structures would be extended to cater for the proposed third track.

Bishops Creek

Bishops Creek is a tributary of Swamp Creek that flows south towards it's confluence with Swamp Creek. The catchment associated with Bishops Creek is predominantly located south of the rail corridor is a negligible component located to the north. This small portion of the catchment is conveyed through the corridor by a culvert under the existing embankment. This existing culvert would be extended to cater for the proposed third track.

4.2 Waterway Identification

A series of maps showing the alignment of the Project and location of identified waterway crossings has been included in Figure 4.2. Details of each individual waterway crossing are provided in Appendix A and include the chainage location of the waterway crossing in relation to the Project.

Table 4-1 provides a summary of the identified waterway crossings according to their classification. Of the 59 identified waterway crossings, 12 were classified as Major Waterways, 11 as Minor Creeks and 36 as Drainage Lines. The crossings have been listed according to the overall catchment to which they contribute and are divided into major waterways, minor waterways and drainage lines.

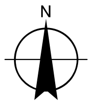
Table 4-1 Summary of Waterway Crossings

Contributing Catchment	Major Waterway Crossings	Minor Waterway Crossings	Drainage Line Crossings
Stony Creek	**W3***	**W2, W12, W13**	W1, W4, W5, W6, W7, W8, W9, W10, W11, W14, W15, W16
Un-named Tributary of Swamp Creek			W17
Lochinvar Creek		**W23**	W18, W19, W20, W21, W22, W24

Contributing Catchment	Major Waterway Crossings	Minor Waterway Crossings	Drainage Line Crossings
Bishops Creek			W25, W26
Anvil Creek	**W27*, W30, W31, W37*, W41, W44**	**W28, W34, W35, W38, W40, W48**	W29, W32, W33, W36, W39, W42, W43, W45, W46, W47
Black Creek	**W49*, W53, W54**	**W52**	W50, W51, W55
Jump Up Creek	**W57, W58***		W56, W59

BOLD text indicates crossings at which a site inspection was undertaken.

* Indicates permanent water.



1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

Maitland To Minimbah Third Track
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Date MAY 2010

Waterway Crossings
Chainage 221.5 to 224.4

Figure 4.2a

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Maitland To Minimbah Third Track
Surface Water Assessment

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Date	MAY 2010

Waterway Crossings
Chainage 218.5 to 221.5

Figure 4.2b

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Date MAY 2010

Waterway Crossings
Chainage 216.0 to 218.5

Figure 4.2c

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Surface Water Assessment

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Waterway Crossings
Chainage 213.3 to 216.0

Figure 4.2d

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Waterway Crossings
Chainage 211.0 to 213.3

Figure 4.2e

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gcmdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Waterway Crossings
Chainage 209.5 to 211.0

Figure 4.2f

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Waterway Crossings
Chainage 207.3 to 209.5

Figure 4.2g

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Maitland To Minimbah Third Track
Surface Water Assessment

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Date	MAY 2010

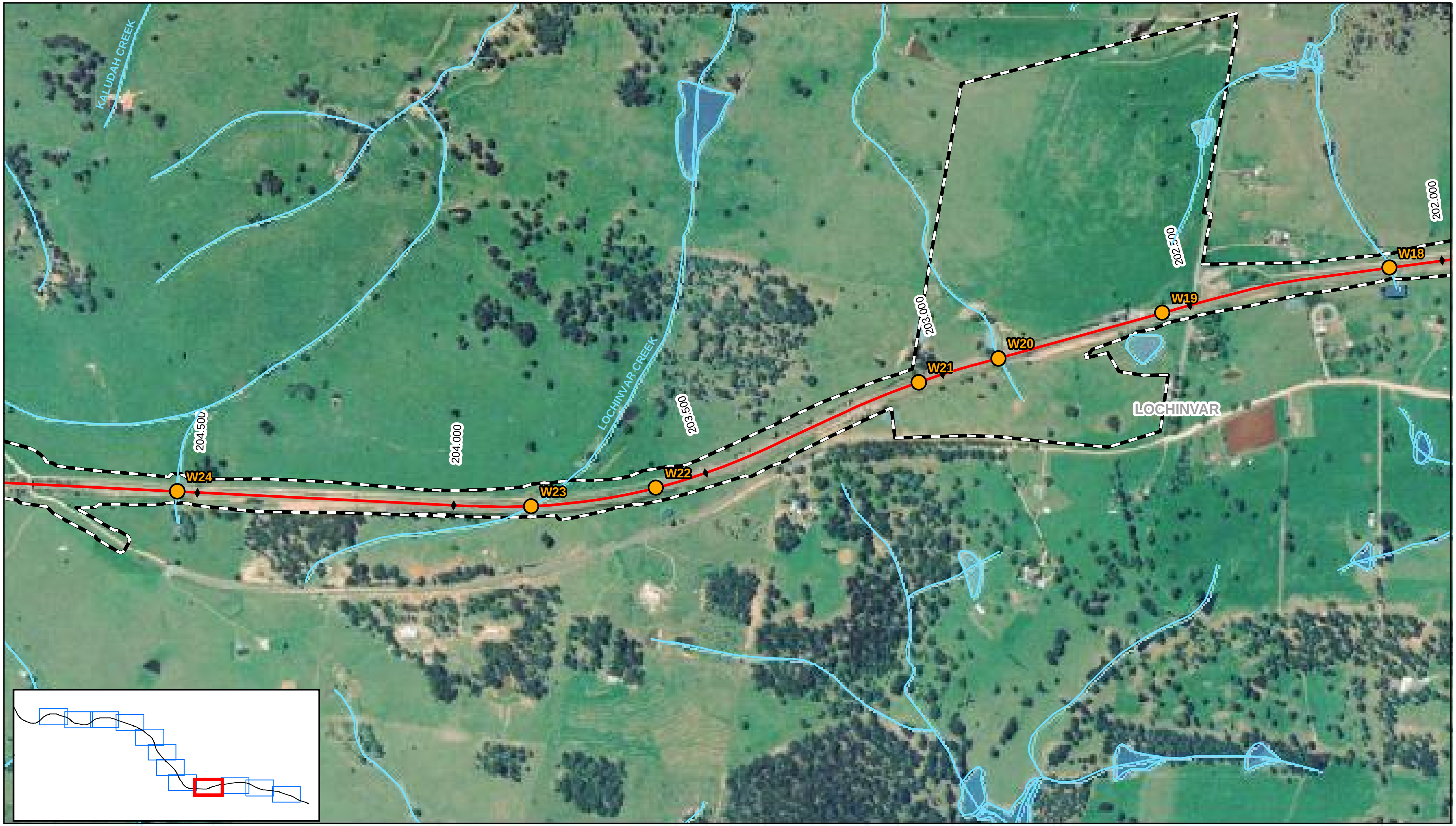
Waterway Crossings
Chainage 204.5 to 207.3

Figure 4.2h

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay



1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Surface Water Assessment

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Date	MAY 2010

Waterway Crossings
Chainage 202.0 to 204.5

Figure 4.2i

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

Maitland To Minimbah Third Track
Surface Water Assessment

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Date	MAY 2010

Waterway Crossings
Chainage 199.5 to 202.0

Figure 4.2j

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

Hunt8r ALLIANCE

Maitland To Minimbah Third Track
Surface Water Assessment

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Revision A
Date MAY 2010

Waterway Crossings
Chainage 196.8 to 199.5

Figure 4.2k

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

1:10,000 (at A4)

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

Legend

- Existing Culverts
- Watercourse
- Watercourse Area
- Project Location
- Construction Impact Zone

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Waterway Crossings
Chainage 194.0 to 196.8

Figure 4.2I

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Waterways_20091203_A.pdf.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: DPT of Lands: DCDB - 2007, Aerial Photography - 2006. Created by: msmiljkovski, gmcdiarmid, fmackay

4.3 Waterway Types

The waterways inspected for the purposes of this assessment were predominately set within a rural or semi-rural landuse context and have been modified over time by land clearance, the existing rail and other agricultural practices. Most waterways are ephemeral in nature and no flows were observed at the time of the site inspections. Additionally, the existing rail line has influenced stream type, with many waterways exhibiting differing geomorphology upstream and downstream of the rail.

The following sections provide a summary description of the waterway types observed during the field inspection.

Undefined Systems

Many of the Drainage Lines had relatively undefined flow paths such that flows at the crossing point are largely derived from hillslope sheet flow rather than concentrated within a defined channel or valley.

Valley Fill Systems

Many of the Minor Waterways were generally typical of valley fill system. These systems are characterised by a relatively flat, unincised valley floor surface with substrates comprised of alluvial fine silts and muds. Such features are typically formed by flows that lose their velocity and competence as they spread over an intact valley floor and deposit their sediment load. Material eroded from the catchment is not transported through the reach, which is often on a relatively flat longitudinal grade.

Incised Valley Fill Systems

Some waterways displayed slightly different characteristics and have been described as ‘incised valley fill systems’. While these are similar to the valley fill systems described above, they have a more defined watercourse and channel bank. In some cases, the waterways have been channelised or formed as a constructed drainage line. Generally it is likely that these were also once valley fill systems however have been modified to convey flows from urbanised or industrialised catchments, or to drain land for agricultural use.

Chain of Ponds Systems

This waterway type was exhibited along some of the Minor and Major Waterways. These waterways display a series of symmetrical (occasionally irregular) ponds that occur at irregular intervals along a drainage line. The bank of the ponds and the bed in which they exist is composed of fine sand, mud and organic material. Ponds tend to retain water throughout the year and during high flows, sands and finer material are transported downstream. This waterway type is often associated with lower gradients and lower flow velocity. Chain of Ponds systems are regarded to be a relatively rare and fragile waterway type, such that they are prone to channelisation between the ponds forming a continuous channel. This reduces the water retention capacity of the ponds with associated loss of aquatic habitat.

Partly Confined Low Sinuosity Systems

This waterway type was exhibited along most Major Waterways. The channel of these waterways is single, trench-like and symmetrical and has low sinuosity with moderate stability. Valley shape controls channel sinuosity and floodplain extents, creating discontinuous floodplains as the river migrates between valley margins. Cohesive fine-grained sediments dominate the bed and alluvial banks.

Low Sinuosity Systems

This waterway type was exhibited along some of the Major Waterways. This waterway type exhibits a low sinuosity channel with wide, continuous floodplains and relatively stable, cohesive bank due to the fine-grained material. The bed consists of fine-grained sediments with some sand and gravel sections creating moderate hydraulic diversity within the channel. The channel itself is of low gradient and usually low energy allowing a build up of fine-grained sediment.

4.3.1 Major Waterway Crossing Descriptions

Further details of the crossings of the 12 Major Creeks are discussed in the following sections with details of all waterways provided in Appendix A.

Stony Creek Catchment

Crossing W3 (Figure 4.2a) is located on Stony Creek, with a catchment area of 1,520 hectares at the crossing site. Upstream of the existing rail, Stony Creek is also crossed by Wollombi Road. At this location and further upstream, the creek exhibits a valley fill geomorphology that is well vegetated with macrophytes and typha. At the existing rail crossing a large scour hole up to 2 metres deep and approximately 50 metres long has developed. The banks of the scour hole are vertical and it is considered the hole is undergoing continued enlargement through headward retreat of its upstream extents.

Downstream, the channel exhibits a Low sinuosity, fine-grained geomorphology, with a narrow (3 metre wide) channel inset within a broad floodplain. The channel is stable and vegetated with juncus. The floodplain is flat, featureless and dominated by pasture grasses.

Anvil Creek Catchment

Crossing W27 (Figure 4.2e) is located on Anvil Creek with a catchment area of 163 hectares at the crossing site. Upstream of the rail, the waterway is a valley fill system that is disturbed by dams and the Allandale Road crossing. Downstream, the waterway has a partly confined, low sinuosity geomorphology. The channel is approximately 8 metres wide and 1.5 metres deep and appears to have been excavated in the past. Channel banks consist of cohesive fine-grained sediments and are grassed and stable. Instream features consist of small pools with fringing macrophtyes.

Crossings W30 and W31 (Figure 4.2f) are both left bank tributaries of Anvil Creek, with catchment areas of 292 hectares and 285 hectares at their respective crossing sites. The waterways both have a partly confined, low sinuosity geomorphology upstream and downstream of the existing rail. The channel both upstream and downstream is relatively narrow (2 to 3 metres wide) and approximately 1 metre deep. Banks are near vertical and undercut in sections. Scour pools are present although no standing water was observed at the time of inspection. The waterway at crossing W31 flows into Anvil Creek approximately 15 metres downstream of the existing rail.

Crossing W37 (Figure 4.2g) is located on Sawyers Creek, with a catchment area of 578 hectares at the crossing site. Sawyers Creek has a partly confined, low sinuosity geomorphology and exhibits a defined channel with permanent pools. Downstream of the existing rail, the channel is approximately 5 metres wide and 1 metres deep and is affected by a private road causeway. Banks consist of cohesive, fine grained sediments and are stable although riparian vegetation is dominated by weed species.

Upstream, the channel runs east along the existing rail embankment for approximately 70 metres prior to diverting to the south. The channel abutting the embankment is trapezoidal in cross-section suggesting the creek may have been diverted for construction of the existing rail. Blackberry and native shrubs dominate riparian vegetation. The floodplain is moderately well vegetated with native grasses and scattered eucalypts. A flood channel/backswamp complex is located on the western extent of the floodplain.

This upstream section of Sawyers Creek requires realignment to accommodate the proposed third track (as outlined in Section 6.3.4). At the proposed diversion point a bedrock outcrop controls the channel bed and the creek exhibits an improvement in condition upstream both in geomorphic form and riparian vegetation associations.

Crossing W41 (Figure 4.2h) is on a left bank tributary of Anvil Creek, with a catchment area of 208 hectares at the crossing site. The channel has a partly confined, low sinuosity geomorphology. The channel upstream is relatively narrow (2 to 3 metres wide) and approximately 1 metre deep. Banks are near vertical and undercut in sections. Scour pools are present although no standing water was observed at the time of inspection.

Downstream of the existing rail the channel enlarges, being approximately 15 metres wide and 2 to 3 metres deep. Here, the channel is crossed by the rail access track via a bridge structure with embankments protected by shotcrete. A further 10 metres downstream, the channel is crossed again by a private track via a low level concrete causeway, forming a shallow pool upstream. Downstream of the causeway the channel exhibits a bedrock base and limited diversity in instream features. The grassed, graded banks are stable and floodplains are well-vegetated.

Crossing W44 (Figure 4.2i) is on a left bank tributary of Anvil Creek, with a catchment area of 312 hectares at the crossing site. The channel has a partly confined, low sinuosity geomorphology and exhibits a well vegetated and stable channel. Flows within this waterway are carried through two culverts, 20 metres apart, under the existing rail. Upstream of the main culvert, the channel is up to 10 metres wide and displays an inset low flow channel with dimensions of approximately 1 metre wide and 1 metre deep. The downstream side was inaccessible due to fencing/ noise barrier and was not assessed during the inspection. However, aerial imagery indicates a similar geomorphology downstream.

Black Creek Catchment

Crossing W49 (Figure 4.2j) is located on Black Creek, with a catchment area of 30,400 hectares at the crossing site. The waterway has a Low sinuosity geomorphology, exhibiting extensive continuous floodplains. The channel at the crossing location is approximately 50 metres wide and 8 to 10 metres deep. A long pool is present extending both and downstream of the crossing location. Banks are graded, stepped and consist of fine-grained sediments. Banks are stable being well-vegetated with pasture grasses and casuarinas (river oak).

Crossings W53 and W54 (Figure 4.2k) are both located on an unnamed left bank tributary of Sweetwater Creek (a tributary of Black Creek), with catchment areas of 197 and 148 hectares respectively. Upstream of Crossing W54 and between the two crossings, this tributary exhibits Chain of Ponds geomorphology. The ponds are typically around 20 to 30 metres long and 5 to 10 metres wide and are relatively well vegetated with native riparian species. As a result the ponds are largely stable, although channel incision between the ponds was noted at one location upstream of W53. Downstream of W53 the waterway flows into a farm dam prior to discharging into Sweetwater Creek and the chain of ponds geomorphology is no longer present.

Jump Up Creek Catchment

Crossing W57 (Figure 4.2l) is located on a right bank tributary of Jump Up Creek, with a catchment area of 309 hectares at the crossing site. The waterway has a valley fill geomorphology. Upstream of the rail the valley fill is intact, although salt scalds (bare ground due to die off of vegetation from high salinity levels) are present. Immediately downstream of the rail, a large pond is present extending for approximately 30 metres downstream. Beyond the pond and intact valley, a gully is retreating upstream forming a continuous, 1 to 2 metre deep channel within the valley fill.

Crossing W58 (Figure 4.2l) is located on Jump Up Creek with a catchment area of 2,970 hectares at the crossing site. The waterway has a Low sinuosity geomorphology, exhibiting extensive continuous floodplains. The channel at the crossing location is approximately 20 to 30 metres wide and 4 to 5 metres deep. The crossing site is relatively disturbed as a result of the construction of a new rail bridge over Jump Up Creek. Upstream of the rail, a construction access track consisting of loose rock is present. Further upstream the creek exhibits a long pool and is well-vegetated.

Downstream, the creek banks are protected with large loose rock for a distance of approximately 15 metres. The waterway is then crossed by the existing rail access track. Downstream from this point, a natural channel is present with well-vegetated banks.

4.4 Existing Hydrology

Table 4-2 provides the results from both the XP-RAFTS and PRM calculations as well as the percentage difference between the XP-RAFTS and PRM peak flow rates.

Table 4-2 Flow Estimates for Peak Storm Events

Waterway	1% AEP (m^3/s)	PRM (m^3/s)	% Difference
W1	4.2	3.8	11%
W2	12.3	9.7	27%
W3 - Stony Creek	97.3	156	-38%
W4	1.2	1.1	9%
W5	1.8	1.7	6%
W6	0.6	0.6	0%
W7	0.4	0.5	-20%
W8	7.1	6.8	4%
W9	5.8	5.3	9%
W10	4.1	4.5	-9%
W11	5.8	5.2	12%
W12	7.4	7.1	4%
W13	6.4	7.3	-12%
W14	3.3	3.4	-3%
W15	2.3	2.8	-18%
W16	2.6	3.1	-16%
W17	2.8	4	-30%
W18	1.1	1.4	-21%
W19	2.8	3.2	-13%
W20	1.5	1.6	-6%
W21	1.1	1.1	-5%
W22	1.1	1.2	-7%
W23	4.7	4.3	8%
W24	1.4	1.4	2%

Waterway	1% AEP (m^3/s)	PRM (m^3/s)	% Difference
W25	3.0	2.6	15%
W26	0.5	0.5	0%
W27	15.0	24.5	-39%
W28	10.8	13.1	-17%
W29	N/A	N/A	N/A
W30	28.6	38.5	-26%
W31	38.3	36.2	6%
W32	6.2	7.6	-19%
W33	0.5	0.8	-36%
W34	22.2	18.9	17%
W35	6.7	7	-4%
W36	1.2	1.6	-25%
W37	44.1	62.5	-29%
W38	7.0	6.5	8%
W39	2	2	0%
W40	9.9	9.7	3%
W41	31.3	28.3	10%
W42	1.2	1.4	-12%
W43	3.2	3	7%
W44	35.3	38.8	-9%
W45	1.7	1.9	-9%
W46	0.4	0.4	1%
W47	4.2	4.1	3%
W48	7.5	6.6	13%
W49 - Black Creek	925	1210	-24%
W50	3	2.5	20%
W51	3	2.5	20%
W52	8.2	7.8	5%

Waterway	1% AEP (m^3/s)	PRM (m^3/s)	% Difference
W53	18.2	25.4	-28%
W54	15.8	20.5	-23%
W55	3	2.8	7%
W56	3.8	3.4	12%
W57	31.7	36.3	-13%
W58 - Jump Up Creek	142.6	209.2	-32%
W59	4.9	4.1	20%

Table 4-2 indicates that the flows estimated by XP-RAFTS are generally within 25% of the peak flow rate estimated by the PRM and are therefore in the correct order of magnitude. It should be noted that the PRM does not take into consideration the slope or density of vegetation within a catchment in the determination of the peak flow rate.

The results of the hydrologic models developed for Stony Creek, Anvil and Sawyers Creek, Black Creek and Jump Up Creek are provided in Appendix B, Appendix C, Appendix D and Appendix E respectively and the structures to which each of the waterways assessed contributes are detailed in Appendix F.

4.5 Existing Hydraulics

Modelling Results

With the establishment of the downstream controls and the peak flow rates within the waterways, the resulting existing peak flood levels were determined. The extent of inundation resulting from the 1% AEP design storm event is provided for Stony Creek, Anvil Creek, Black Creek and Jump Up Creek in Figure 4.3, Figure 4.4, Figure 4.5 and Figure 4.6 respectively with a summary of the flood levels provided in Table 4-3.

Table 4-3 Existing 100 Year Flood Level

Major Waterway	Existing 1% AEP Flood Level RL (m AHD)
W3 – Stony Creek	11.5
W34 – Anvil Creek (un-named tributary)	55.2
W37 – Sawyers Creek	49.3
W49 – Black Creek	29.3
W58 – Jump Up Creek	46.7

The flood level nominated in Table 4-3 for Stony Creek is on the basis of a 1% AEP flood level within Wentworth Swamp. Consideration was also given to a 1% AEP occurring within the Stony Creek catchment without a 1% AEP flood level in Wentworth Swamp and the resulting flood level at W3 was determined to be 10.5 metres AHD.

The HEC-RAS results associated with each of these models is provided in Appendix B, Appendix C, Appendix D and Appendix E respectively.

Design Flood Levels

The Project has the potential to increase flood levels through the investigation area if earthworks encroach into waterways or the extension of structures reduces the open waterway area. The design guidelines for the three local government authorities (Maitland City Council, Cessnock City Council and Singleton Shire Council) requires developments to maintain the existing 1% AEP flood level. This design philosophy would be adopted by the Project and therefore there would be negligible impact on the existing flood level and extent.

PMF

The estimated PMF flow was incorporated into the HEC-RAS models developed for each of the waterways and assessed as outlined in Table 4-4. From this it was determined that for the existing conditions, the rail embankment is overtopped in the PMF event.

It can therefore be determined that provided the Project does not increase the height of the rail embankment, there will be no adverse impacts on the PMF.

Table 4-4 Probable Maximum Flood

Waterway	PMF (m^3/s)	Overtops Existing Rail Embankment
Stony Creek	690	Yes
Anvil Creek	830	Yes
Black Creek	5,015	Yes
Jump Up Creek	1,045	Yes

1:2,000 (at A4)

0 5 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Water Course
- Watercourse Areas
- Stoney Creek 100yr Flood Extent

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Maitland To Minimbah Third Track
Surface Water Assessment

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Date	May 2010

Stony Creek Flood Extents
Existing Conditions

Figure 4.3

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_StoneyCrk_100yrFlood_20091007_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski, gmcdiarmid

1:2,000 (at A4)

0 5 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Water Course
- Watercourse Areas
- Proposed Nelson St Overpass
- Anvil Creek 100yr Flood Extent

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Anvil Creek Flood Extents Existing Conditions

Figure 4.4

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_AnvilCk_100yrFlood_20091007_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski, gmcdiarmid

1:2,000 (at A4)

0 5 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Water Course
- Watercourse Areas
- Black Creek 100yr Flood Extent

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Surface Water Assessment

Job Number	22-14471
Revision	A
Date	May 2010

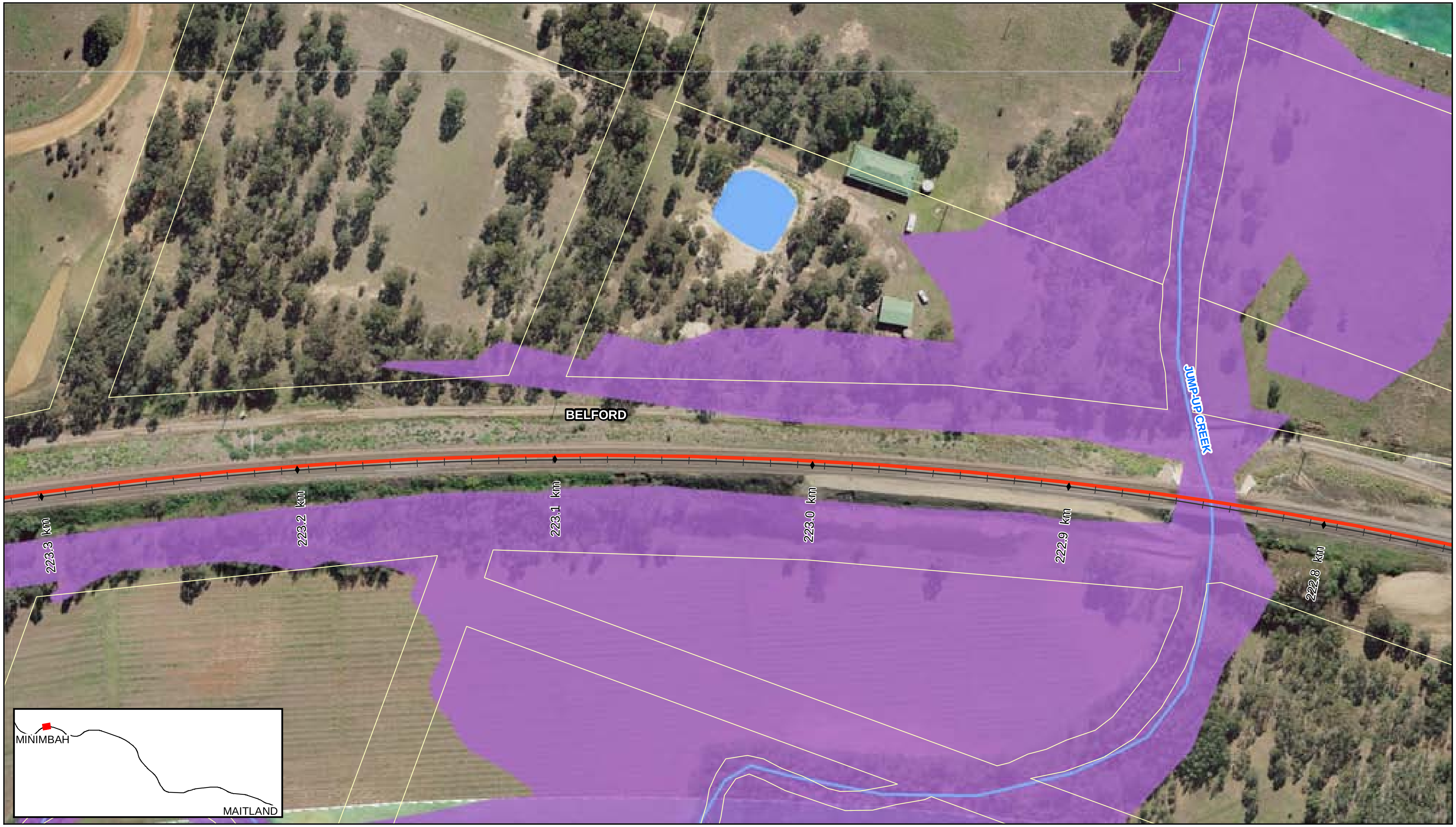
Black Creek Flood Extents
Existing Conditions

Figure 4.5

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_BlackCrk_100yrFlood_20091012_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski



1:2,000 (at A4)

0 5 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Water Course
- Watercourse Areas
- Jump Up Creek 100yr Flood Extent

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Surface Water Assessment

Job Number	22-14471
Revision	A
Date	May 2010

Jump Up Creek Flood Extents Existing Conditions

Figure 4.6

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_JumpUpCrk_100yrFlood_20091007_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski

4.6 Water Quality

A review of the land use within the contributing catchments and the anticipated pollutants that would be expected from these land uses is provided in Table 4-5.

Table 4-5 Contributing Catchment Land Uses

Contributing Catchment	Land Use	Potential Pollutants
Stony Creek	Rural, residential, industrial, existing rail line.	Nutrients, sediment, oils, greases, metals.
Un-named tributary of Swamp Creek	Pasture, vineyards, existing rail line.	Nutrients, sediment.
Bishops Creek	Pasture, grazing, crop, existing rail line.	Nutrients, sediment.
Lochinvar Creek	Pasture, grazing, crop, existing rail line.	Nutrients, sediment.
Anvil Creek	Pasture, grazing, crops, urban, existing rail line.	Nutrients, sediment.
Black Creek	Pasture, grazing, vineyards, urban, existing rail line.	Nutrients, sediment, oils, greases, metals.
Jump Up Creek	Pasture, existing rail line.	Nutrients, sediment, oils, greases, metals.

While various organisations such as Stream Watch and Waterwatch NSW make available surface water quality data, there was insufficient information available for the waterways potentially impacted by the Project to enable an assessment of the water quality. There was however, limited water quality data for Black Creek, Anvil Creek and Swamp Creek within the vicinity of existing Cessnock, Branxton and Loxford sewage treatment plants.

From information available from the Hunter Water Corporation monitoring program, the data associated with Black Creek and Swamp Creek was considered to be unsuitable for this assessment. The sampling location within Black Creek is approximately 25 kilometres upstream of where Black Creek crosses the Project and therefore there would be a potential for considerable variation in the water quality between these locations. With respect to Swamp Creek, only a negligible portion of the Project contributes to this catchment and the sampling location is not located in the vicinity of either of the contributing tributaries.

The data available for Anvil Creek, upstream of the Branxton sewage treatment plan, is considered to be an appropriate reference for water quality as the sampling site is located approximately 700 metres downstream of the Project. However, Table 3 within the *Supplementary State of the Environment Report 2007–2008:* Cessnock City Council, indicates that only Nitrate/Nitrogen data is available. Additionally, this table does not include any actual data but rather indicates that the nitrate/nitrogen levels comply with the Australian and New Zealand Environment Conservation Council (ANZECC) and National Health and Medical Research Council (NHMRC) guideline levels of maintenance of aquatic ecosystems.

As there is limited data currently available, a monitoring program would be established prior to commencement of construction. The results from this water quality sampling would then form the background data against which the impact of construction would be measured.

In addition, monitoring will continue at locations upstream of the Project area of disturbance and the background data will be reviewed bi-annually.

The water quality parameters that will be monitored for the establishment of the baseline include water temperature, pH, dissolved oxygen, turbidity, pathogens, nutrients, pesticides, chemicals and heavy metals.

5. Impact Assessment

5.1 Environmental Risk Assessment

A detailed Environmental Risk and Impact Assessment (Risk Assessment) has been conducted as part of the Environmental Assessment process to evaluate the potential impacts that the Project could have on a wide range of environmental, social and economic assets and beneficial uses, which has contributed to help form the conclusions of this study.

In summary:

- The Risk Assessment was conducted to identify the potential environmental, social and economic impacts on the wider environment and community of implementing the Project.
- The Risk Assessment was based on the Description of the Project included in the Environmental Assessment and the outputs of the risk assessment represent the risk and impacts of implementing the Project as described in the Description of the Project.
- Heighten awareness and provide rigour for decision making and planning.
- The Risk Assessment was conducted in close consultation with all of the technical specialists and is based on input provided by those technical specialists. All of the Risk Assessment inputs including consequence and likelihood ratings were provided by the technical specialists.
- Incorporates the outputs of the Community Consultation which occurred as part of the Environmental Assessment, although separate to the risk assessment process. The values and outcomes of the community consultation were incorporated to inform the risk assessment process.
- The Risk Assessment approach used a multi-disciplinary group of technical specialists to assess the consequence and likelihood of the identified risks. To assess risks consistently, consequence tables were developed that clearly define levels of consequence, from insignificant to catastrophic, in terms of magnitude, space and time. Consequence, having regard to ‘reasonable worst- case scenarios’ (considering activity controls), and the likelihood of that consequence occurring are defined for all identified risks and impacts, allowing risks to be ranked.

  The consequence table relevant to this study and the likelihood descriptions are provided in Appendix G. The consequence tables used for estimating diverse consequence types on an even basis were developed specifically for the Project based on consultation and advice from the technical specialists. The likelihood table was developed to incorporate the scoping requirements concept of predicted and potential risks and impacts. The scale ranges from rare to almost certain.
- The risk ranking was calculated via the risk matrix, considering both consequence and likelihood allocations.

  The risk matrix and the risk outputs relevant to this report are both presented in Appendix G.

The potential impacts identified as posing a medium risk in the Risk Assessment are:

- Construction of the Project results in discharge of polluted runoff to stormwater / rivers / Waterways resulting in decline in water quality.
- Extent of works associated with the Project results in increasing existing flood levels at Major waterways.
- Construction of the Project results in scour at culvert outlets, along existing waterways and embankments.
- Construction of the Project results in blockages in low flow zones such as in creeks at causeway crossings.

5.2 Potential Impacts

During the construction and operation of the Project, there is a potential for existing waterways to be impacted and the following section provides an overview of these potential impacts.

5.2.1 Water Quality Decline

Water quality decline is an adverse change in water parameters such as water temperature, pH, dissolved oxygen, turbidity, pathogens, nutrients, pesticides, chemicals and heavy metals. Changes to water quality outside the bounds of natural variability for the waterway can reduce river health values by adversely impacting aquatic life and vegetation. This also has the potential to impact downstream water users.

While both construction and operation of the Project has the potential to detrimentally affect water quality, the impacts on water quality are most likely to be directly attributed to construction. The potential impacts could include:

- Increased sediment export.
- Increased sediment loads into waterways.
- Creation of long-term barriers to fish movement.
- Bed and bank erosion that causes changes to the geomorphology of waterways over time.
- Continuing pollution from erosion and sedimentation as sediment moves downstream.

In the longer term, operation of the Project may increase the risk of contaminants from the rail corridor being discharged to receiving waterways. The potential pollutants could include particulate matter, nutrients, heavy metals and petroleum based products.

As there is currently no baseline data, the magnitude or significance of this impact cannot be determined at this stage. Once the baseline data is established, the potential significance of an increase in pollutants discharged to waterways would be established.

5.2.2 Increase Existing Flood Levels

The aspects likely to have an impact on flood levels in waterways associated with the Project include:

- Hydrologic change such as an increase in the peak flow rate and/or volume of runoff.

- Afflux as a result of constriction at waterway crossings.
- Placement of spoil within existing flood extents.

Hydrologic Change

Changes in the flow regime refers to modifications to the timing, duration, frequency and volume of flow in a waterway system. This can cause a decline in waterway health by adversely impacting flora and fauna communities including fish migration, spawning and habitat. There is also a potential that changes in flow regimes could affect the frequency of floodplain inundation, the rate of sediment production and the rate of erosion or bed aggradation.

In order to assess the potential hydrologic change, consideration was given to the catchment area of the nominated waterways and the relative catchment area associated with the Project. The potential changes were then compared and the results are provided in Table 5-1.

Table 5-1 Potential Hydrologic Change

Waterway	Area (ha)	Project Area (ha)	% Increase	Waterway 1% AEP (m^3/s)	Project Area 1% AEP (m^3/s)	% Increase
Stony Creek	1,520	11.8	<1%	104	1.5	1%
Anvil Creek/Sawyers Creek confluence	2,050	11.0	<1%	167	1.6	1%
Black Creek	30,400	7.7	<1%	925	2.1	<1%
Jump Up Creek	3,030	6.2	<1%	142.6	1.7	1%

From this it can be seen that there will be minimal impact on the hydrology of the surrounding catchments as a result of the Project.

Afflux

Afflux refers to a rise in water level as a direct result of decreasing the available flow area. This can be as a result of a decrease in opening at a culvert or bridge or it can result from an encroachment of earthworks into open channels such as waterways.

The Project has the potential to result in afflux in areas upstream of new or extended waterway crossings during peak flow events thereby increasing flood levels. The impact of this would vary and be dependant on the works associated with the Project however, as all culvert extensions and underbridges would maintain the existing waterway area the impact would be minimal.

The Project also has the potential to cause afflux in locations where the proposed embankment encroaches into existing waterway areas. The extent of impact would be directly related to the extent of encroachment into the waterway area. The design philosophy in these locations should be to minimise the encroachment into the waterway and maintain existing waterway areas. Within the investigation area, the locations where the encroachment of earthworks could potentially increase flood levels include Stony Creek, Allandale Road, waterway W30 at approximate chainages 209.250 kilometres and 209.650 kilometres and Jump Up Creek.

At each of these locations, the impact of earthworks would be assessed by amending the existing conditions hydraulic models to incorporate the proposed earthworks. In locations where an afflux occurs, options such as increasing batter slopes or the inclusion of retaining walls would be considered such that there was no impact on flood levels that could lead to adverse impacts on the affected properties.

Detailed modelling has already been undertaken for Stony Creek and the outcomes of this modelling indicate that for a local catchment 1%AEP rainfall event in conjunction with a 1%AEP downstream flood event, there is no increase in flood level. This is primarily due to the very low flow velocities that occur for this scenario. Consideration was also given to a local catchment 1%AEP rainfall event in conjunction with a 5%AEP downstream flood event and it was found that there was minimal impact with a maximum increase in flood level of 40 millimetres.

Through a review of the aerial photography and re-mapping of the flood extent, it was confirmed that there would be no impact on existing structures as a result of the Project.

Placement of Spoil

There are a number of locations along the Project route that have been identified as potential locations for the placement of spoil. The identified areas include:

- 196.060 kilometres to 196.720 kilometres (the quarry).
- 202.760 kilometres to 203.100 kilometres (Station Lane, Lochinvar).
- 210.620 kilometres to 210.720 kilometres (Nelson Street, Greta).
- 217.250 kilometres to 218.050 kilometres (Black Creek, Branxton).
- 221.300 kilometres to 221.620 kilometres (Belford).

The placement of spoil within the quarry, Station Lane and Belford areas would be undertaken such that surface flow paths would not be altered and catchment boundaries would be maintained. Within the quarry, a number of shaped channels would be incorporated into the spoil placement to enable conveyance of catchment runoff to the existing culvert structures.

For the spoil placement in the vicinity of Station Lane, shaping of the spoil would be also undertaken so that existing flow paths would be maintained. With respect to the spoil placement at Belford, this would be required as a function of the removal of the existing dams. The filling of these dams would be undertaken in a manner such that the flow paths continued to direct runoff to the existing culverts and therefore no impact on catchment runoff would occur.

The placement of spoil adjacent to Black Creek would be within the existing flood extents therefore amendments to the hydraulic modelling have been undertaken. This modelling incorporated the proposed configuration of the spoil placement and generated flood levels associated with those works. The hydraulic model was also amended to incorporate both the 50% and 20% AEP rainfall events so that the impact of more regular flows could be determined.

Figure 5.1 indicates the flood extent associated with each of the design events assessed and from this it can be seen that the placement of spoil would have no impact on the 50% AEP event. For the 20%AEP and greater, there is an increase in flood extent. The maximum increase in flood extent would be approximately 200 millimetres upstream of the Black Creek bridge structure in the 1% AEP. A review of the aerial photography confirmed that while there is a minor increase in the flood extent, there are no adverse impacts on existing buildings.

5.2.3 Increase in Scour

The ongoing loss of native riparian vegetation and decline in vegetation condition presents a significant threat to the health of surface water systems. A decline in vegetation condition may include increased fragmentation, weed invasion and the loss of vegetation diversity. Loss of riparian vegetation can also lead to an increase in bank erosion and bed degradation.

Construction of the Project may result in local removal of riparian and instream vegetation at waterway crossing locations. Removal of vegetation may impact bed and bank stability and increase the potential for channel erosion.

Stream Bed Degradation and Aggradation

Stream bed degradation refers to the lowering of the stream bed elevation through ongoing erosion processes. Most often the erosion is headward progressing (moving in an upstream direction) associated with the movement of nick points or head cuts. This can impact waterway health through the loss of existing instream features and can result in destabilisation and the production of sediment that may have adverse downstream impacts.

Stream bed aggradation is a process of net sediment deposition within the stream channel that results in ongoing rise in bed elevation. This can lead to the decline in waterway health by smothering of bed forms and associated loss of bed diversity including pools, riffles and instream structure. Ongoing aggradation can accelerate channel avulsion development.

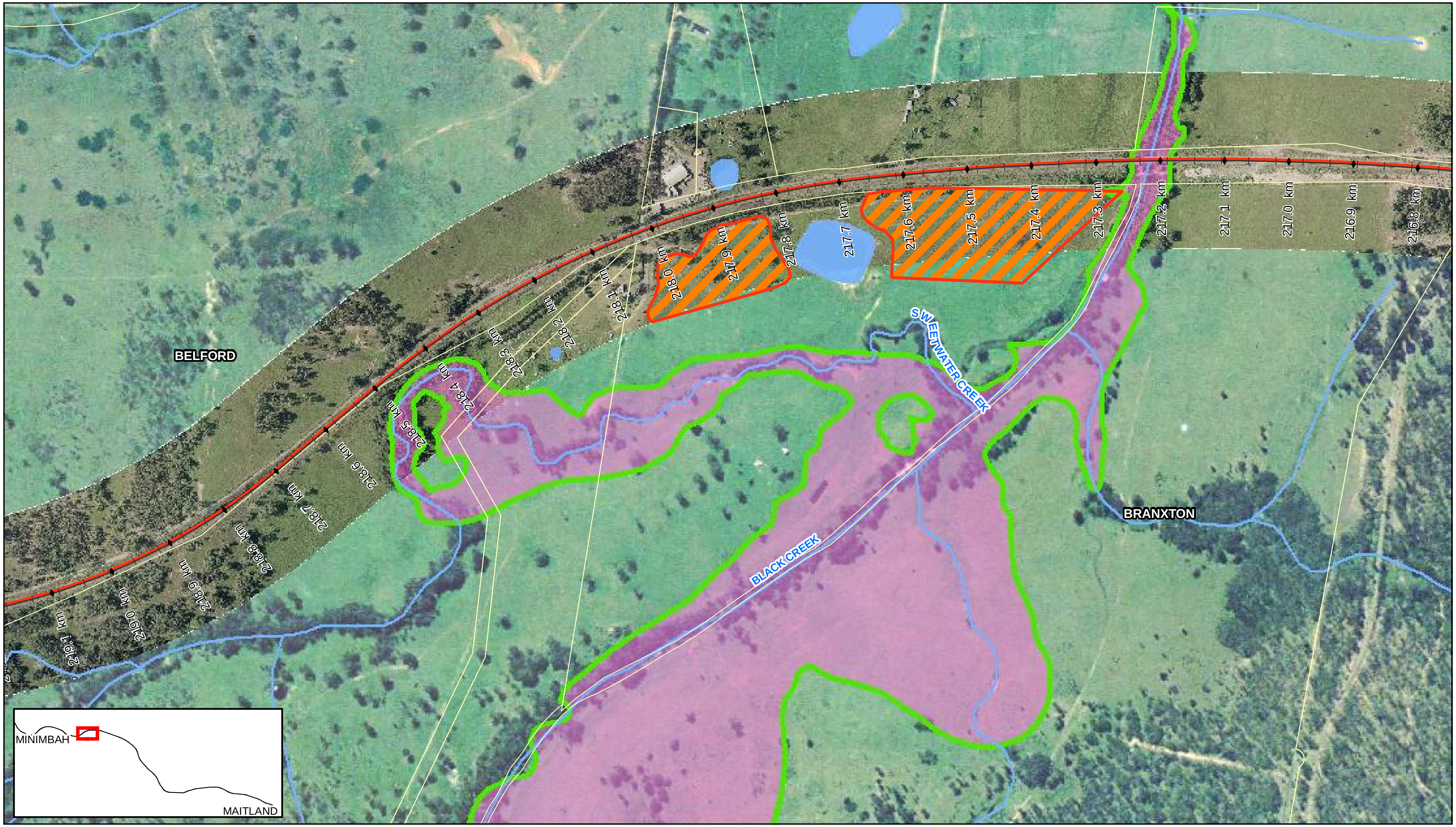
Works on waterways during construction have the potential to increase sediment loading to the downstream waterway in the short term as a result of channel disturbance and removal of stabilising bed and bank vegetation. The construction of culvert extensions also has the potential to accelerate stream bed degradation and aggradation processes due to the change in hydraulic conditions and discontinuity of sediment transport processes.

Bed and Bank Instabilities

Bed and Bank instabilities refer to accelerated rates of erosion associated with either channel enlargement or meander development. These can be the results of direct impacts or more indirect processes such as channel incision.

Bank instabilities threaten remnant riparian vegetation and provide a source of sediment that can have an adverse impact on the waterway. Bank instabilities may also threaten adjoining infrastructure assets.

Works on Waterways during construction of the Project have the potential to increase bed and bank instabilities due to removal of existing instream and riparian vegetation and disturbance of the channel profile.



1:8,000 (at A4)

0 35 70 140 210 280

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Spoil Area
- Water Course
- Watercourse Areas
- Black Creek Flood Extent 2yr Design
- Black Creek Flood Extent 2yr Existing

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Maitland To Minimbah Third Track
Surface Water Assessment

Job Number 22-14471
Revision A
Date MAY 2010

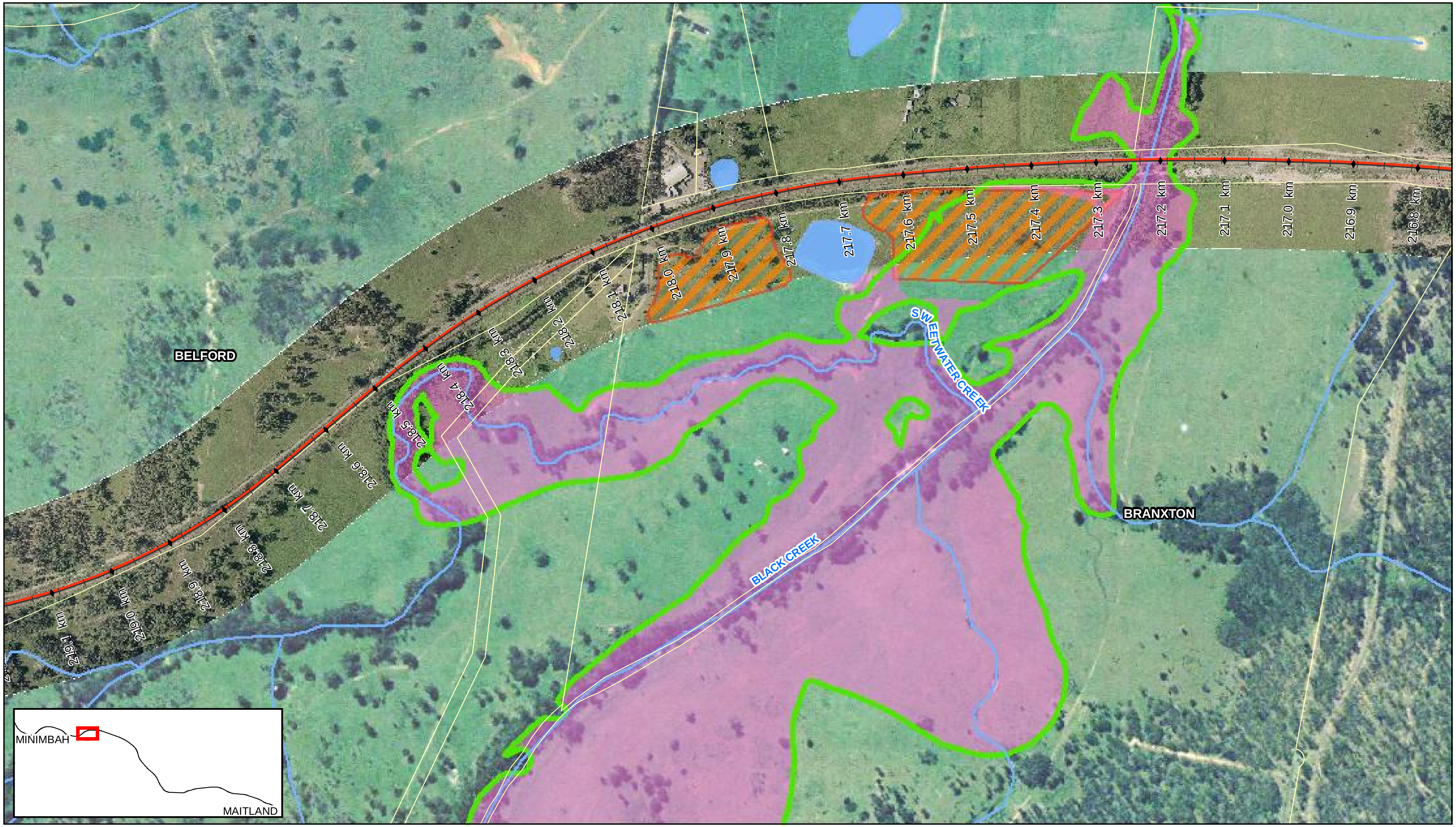
Black Creek Flood Extents
50% AEP

Figure 5.1a

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_BlackCrk_100yrFlood_20091012_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski



1:8,000 (at A4)

0 35 70 140 210 280

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Spoil Area
- Water Course
- Watercourse Areas
- Black Creek Flood Extent 5yr Design
- Black Creek Flood Extent 5yr Existing

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Maitland To Minimbah Third Track
Surface Water Assessment

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Date	MAY 2010

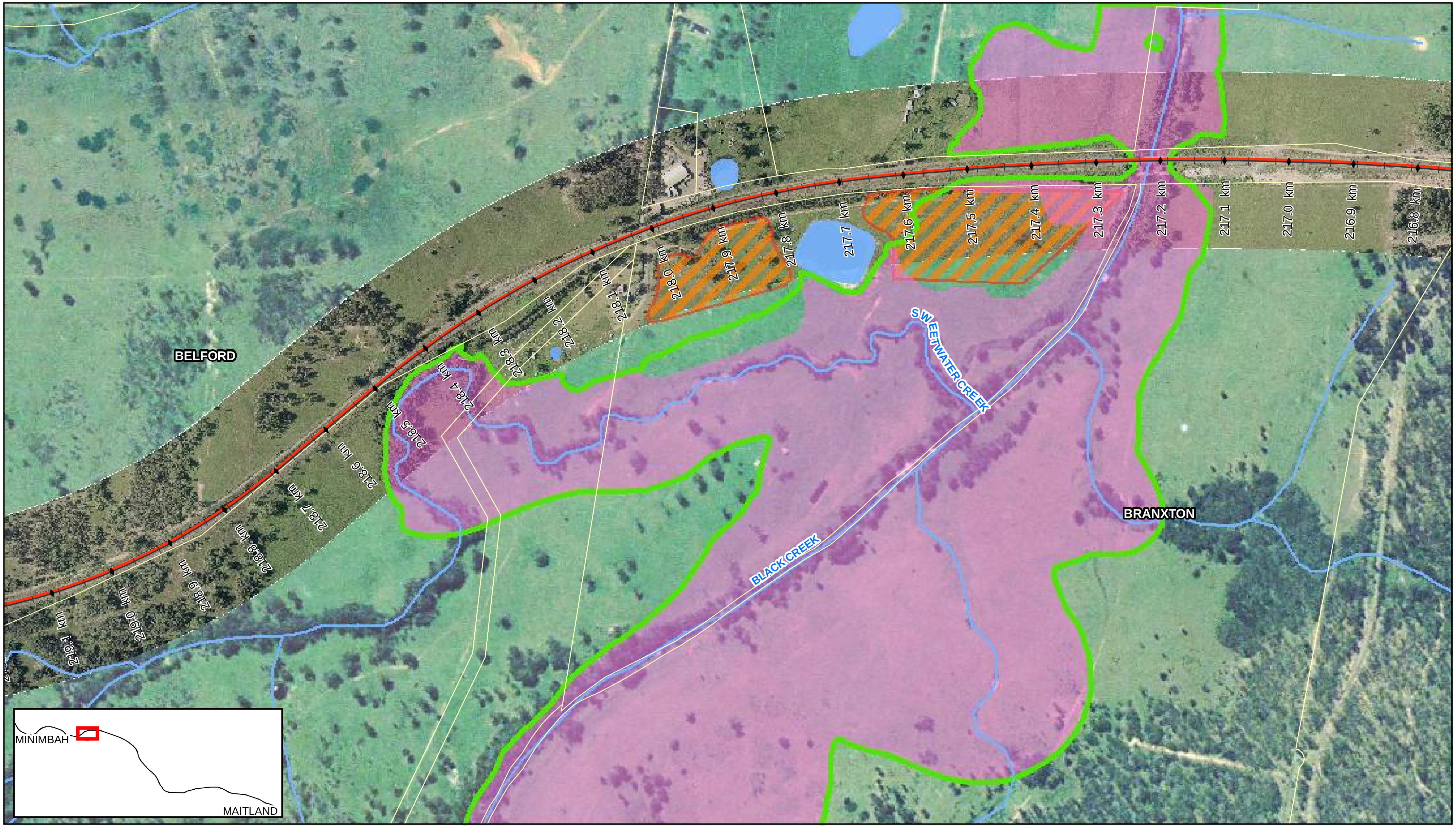
Black Creek Flood Extents 20% AEP

Figure 5.1b

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_BlackCrk_100yrFlood_20091012_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski



1:8,000 (at A4)

0 70 140 210 280

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Spoil Area
- Water Course
- Watercourse Areas
- Black Creek Flood Extent 100yr Design
- Black Creek Flood Extent 100yr Existing

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Maitland To Minimbah Third Track
Surface Water Assessment

Job Number 22-14471
Revision A
Date MAY 2010

Black Creek Flood Extents
1% AEP

Figure 5.1c

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_BlackCrk_100yrFlood_20091012_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski

5.2.4 Blockage of Low Flows

Instream barriers prevent the movement of instream sediments and can prevent the passage of fish through the catchment as well as reducing environmental flows to the downstream environment. The impact of these structures on aquatic habitat is discussed in the Flora and Aquatic Ecology Assessment while the impact on fauna in general is discussed in the Fauna Assessment.

The ephemeral nature of many of the waterways implies there are natural stream flow barriers to fish movement throughout the catchments however for all perennial waterways or where there is evidence of regular flows, the culvert crossings and causeways should consider both fish passage and the maintenance of low flows.

5.2.5 Realignment of Sawyers Creek

The alignment of the Project has the potential to impact approximately 120 metres of Sawyers Creek and would require either realignment of the creek or construction of a 100 metre viaduct over the creek.

During the site inspection and through a review of the aerial photography, it was determined that Sawyers Creek has migrated to its current position over time and there is evidence of an historical flow path to the west of its current alignment. To minimise the impact of the Project on Sawyers Creek, realignment of approximately 120 metres of the creek has been proposed. The concept for the proposed realignment is provided in Figure 5.2.

Potential impacts that may result from the realignment of Sawyers Creek include:

- Loss of native riparian vegetation, which may increase the potential for bank erosion and bed degradation. The assessment of the existing vegetation is addressed in the Flora and Aquatic Ecology Assessment.
- Short term decline in water quality due to the increased sediment loading resulting from bed and bank disturbance. This could lead to a decline in waterway health by smothering of bed forms and associated loss of bed diversity including pools, riffles and instream structures.
- Acceleration of existing erosion issues such as headward erosion from a nick point or head cut. This can impact waterway health through the loss of existing instream features, destabilisation of the channel and the production of sediment.
- Modification to the hydrologic regime in Sawyers Creek.

It is noted that the majority of the length of Sawyers Creek affected by the Project is relatively degraded with limited over storey vegetation. This is further detailed within the Flora and Aquatic Ecology Assessment report. Downstream of this location the creek remains in relatively good condition.

5.2.6 Cumulative Impacts of the Hunter Expressway

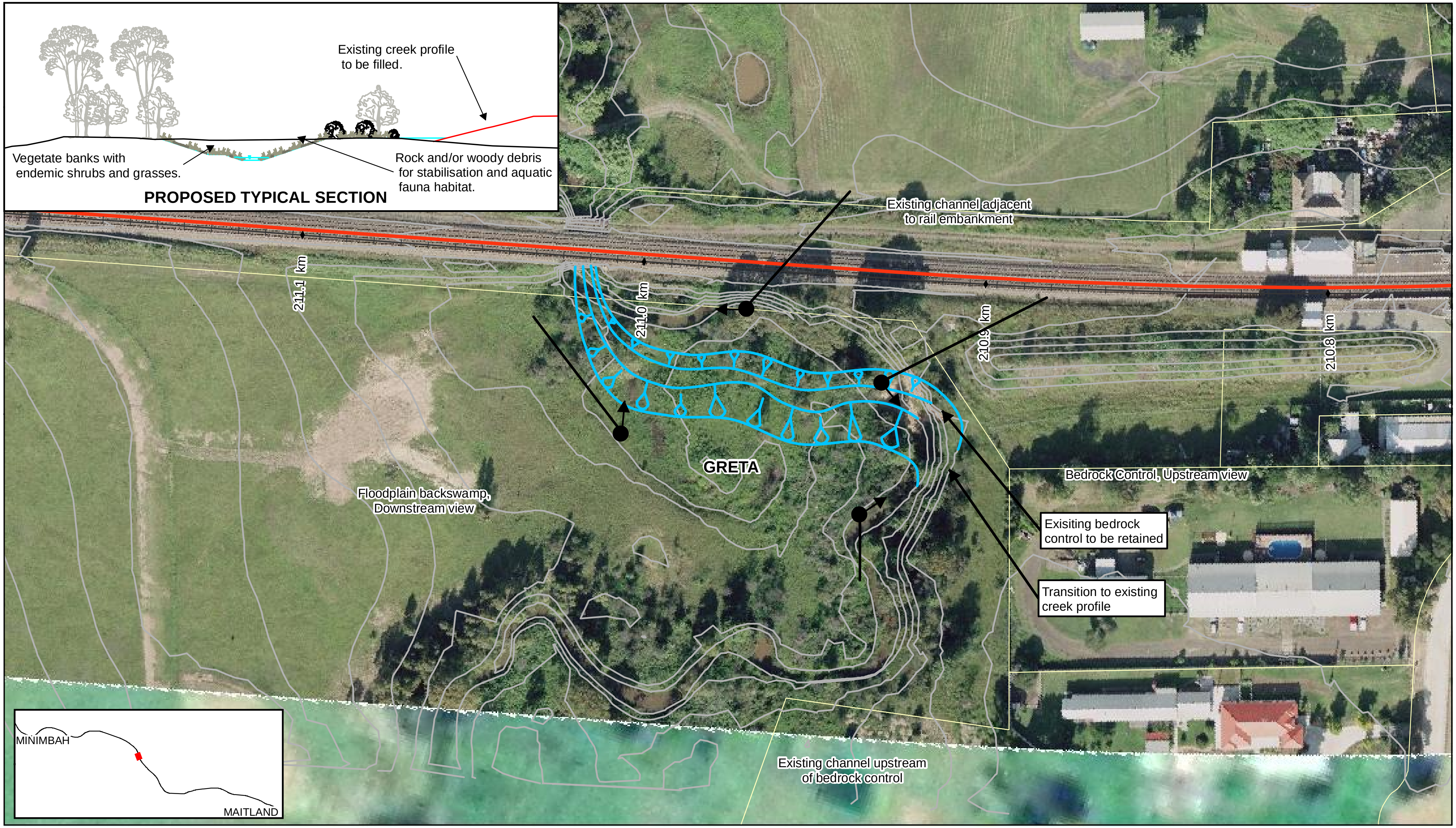
There are a number of waterways that are potentially impacted by both the Project and the Hunter Expressway including W38 through to W48. All of these waterways are ephemeral and the potential impacts include an increase in peak flow rates resulting in an increase in scour.

For the purposes of this assessment, it has been assumed that the assessment of surface water for the Hunter Expressway would have considered similar aspects as considered in this surface water assessment. Therefore, it has been assumed that the concept design of the Hunter Expressway includes measures to minimise the increase in runoff as a direct result of that project and that scour protection and energy dissipation have also been incorporated.

Consideration was also given to the location of the Hunter Expressway in relation to the Project. The Hunter Expressway is located primarily upstream of, and in close proximity to, the Project. Therefore the flows generated from the Hunter Expressway would be controlled by the waterway structures within the Project. In the event that the Hunter Expressway flows were not within a reasonable range of the existing flows at that location, it is anticipated that the peak flow rate directed to the environment downstream of the Project would not be significantly increased due to this constriction. Additionally, the scour protection and energy dissipation provided as part of this Project should minimise any cumulative impacts on the downstream environment.

5.2.7 Climate Change

It is outside the scope of this surface water assessment report to specifically consider potential climate change impacts on the Project. Climate change impacts that could affect the sites may include (without limitation) changed rainfall intensities.



1:1,500 (at A4)

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Existing Railway
- Cadastre
- Proposed alignment for Sawyers creek

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Sawyers Creek
Realignment

Figure 5.2

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Sawyers_Creek_Alignment_withPhotos_20091203_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski

6. Mitigation Measures

This section outlines the potential mitigation measures that should be applied during the detail design phase and also provides guidance with respect to the likely mitigation measures required during construction. These mitigation measures should form the basis of the design principles that would be adopted for the Project.

For each of the nominated risks, there are a number of standard mitigation measures that would be applied to the Project to minimise discharge of pollutants to the surface and groundwater systems.

6.1 Water Quality Decline

To offset the potential impacts of the Project on water quality during construction and operation, both temporary and permanent sediment and erosion control measures would be incorporated. The permanent control measures would be incorporated into the works as part of the detail design while the temporary measures would be incorporated within the Spoil and Fill Management Plan (SFMP) as part of the Construction Environmental Management Plan (CEMP).

Both the SFMP and the CEMP would include details of the proposed control measures, where and how the measures are to be applied, as well as a response plan and monitoring. A broad outline of these is provided below.

6.1.1 Standard Measures

A range of standard mitigation measures to minimise the impact of excavation, storage and placement of material on the surface and groundwater systems during construction includes, but is not limited to:

- Minimise area of disturbance.
- Land adjacent to waterways to remain undisturbed for as long as possible.
- Temporary catch and diversion drains to divert runoff from upslope land and reduce erosion hazard.
- Temporary diversions should outlet to stable discharge areas with additional protection as necessary.
- Progressively revegetate disturbed areas to encourage infiltration.
- Direct sediment laden runoff through a sediment trap or basin to minimise discharge of pollutants to downstream environment.
- Direct smaller volumes of sediment laden runoff to sediment filters such as straw bale filters and sediment fences.
- Locate stockpiles clear of flood prone areas, stream banks, channels and stormwater drainage areas.
- Stabilise stockpiles that are to be in place for longer than 10 days.

- Divert flows around stockpiles by bunds/diversion drains.
- Place sediment fences downstream to capture sediment and minimise sediment discharge to downstream environment.
- Provide treatment facilities to the Truck Washdown facility.

The range of standard mitigation measures that would be adopted as permanent sediment and erosion control measures includes, but is not limited to:

- Permanent catch and diversion drains to divert runoff from upslope land and reduce erosion hazard.
- Permanent diversions to outlet to stable discharge areas with protection as necessary.
- Revegetation of disturbed areas to encourage infiltration.
- Locate permanent areas of spoil clear of flood prone areas, stream banks, channels and stormwater drainage areas.
- Scour protection to structures and embankments as necessary.
- Permanent diversion of flows around spoil areas and quarries by bunds / diversion drains.
- Permanent areas of spoil to have maximum batter slopes of 1 vertical to 2 horizontal and stabilised by vegetation.

6.1.2 Emergency Response Plan

The development of an emergency response plan would address the steps required in the event that the capacity of sediment and erosion control measures were exceeded. This emergency response plan would also be required to address other potential pollution incidents such as a spill.

Spill Containment

Currently, there is a potential for a spill to impact water quality and waterway health if discharged to a waterway through the open channel system or conveyed by a cross drainage culvert. Changes to water quality outside the bounds of the background data and natural variability for the waterway can reduce waterway health by adversely impacting aquatic life and vegetation.

Further investigations need to be undertaken to develop suitable spill containment procedures and response plan for the operation of the Project.

It is however, already recommended that refuelling of plant and machinery be undertaken either by fuel trucks with spill trays or within bunded areas or off-site in appropriate locations wherever possible and, where topography and track elevations allow, consideration be given to the provision of a secondary containment measure to limit the discharge of spills to waterways. Consideration should also be given to the likelihood of the spill event in determining the appropriate mitigation measure.

6.1.3 Monitoring

In determining the effectiveness of the standard mitigation measures, collection of water quality data would be required. As there is limited information available for the existing condition of the waterways, a surface water-monitoring program would be established prior to commencement of construction.

During construction, a surface water-monitoring program would be maintained at each of the previously monitored waterways as part of the CEMP. A comparison between the pre-construction and ongoing monitoring data would then enable an assessment of the effectiveness of the sediment and erosion control measures.

6.1.4 Additional Measures

Other aspects of the construction that would be addressed within the SFMP include:

- Project team members involved in the construction of the Project would be made aware of their environmental responsibilities and the measures to minimise impacts.
- Stabilisation of disturbed soils through such measures as revegetation.
- Establishment of the works compound, including the machinery, fuel and chemical storage areas with bunded areas away from drainage lines.
- Appropriate storage of construction materials on site so as to prevent leaching, leaking or other transfer of material into waterways or onto land.
- Development of an Emergency Response Plan. This would include, but not be limited to, the requirement that an appropriate spill kit is to be kept on site at all times and any spillage is to be immediately cleaned up. In the event of a large or hazardous spill, the fire brigade, police, ambulance and DECCW would be contacted as appropriate.

6.2 Increase Existing Flood Levels

As discussed in Section 5.2.2, an increase in flood levels can arise due to a variation in flow regimes or constriction of waterway areas. Table 5-1 indicated that the Project would not have an adverse impact on the flow regimes within the existing waterways and the proposed extension of waterway crossings would not significantly decrease waterway area.

During the detail design process, review of the extent of encroachment into existing waterway areas would need to occur. The flood models developed for the existing conditions would be updated to incorporate the configuration of the Project. In the event that afflux occurred outside the rail corridor, the configuration of the Project would be revised to minimise the extent of impact such that no significant increase occurred outside the rail corridor.

6.3 Increase in Scour

To minimise the potential for scour and maximise stability, a number of protection measures would be incorporated. These measures would be aimed at the protection and rehabilitation of waterways.

6.3.1 Waterway Protection and Rehabilitation

Through the impact of increased flows and removal of riparian vegetation, the bed and banks of waterways can become highly susceptible to erosion. This in turn may result in increased turbidity, smothering instream vegetation and ultimately increasing sediment load to the Hunter River and Wentworth Swamp. Increased erosion also has the potential to undermine remnant indigenous vegetation in adjoining areas and threatens assets such as bridges.

Disturbance of waterways as a result of construction activities associated with the Project will require suitable protection and rehabilitation works to minimise these impacts. These could include:

- Silt Fences and Sediment Traps (Construction):

  Silt fences and sediment traps are structures designed to physically capture sediment or slow down flow to cause sediment deposition. The structures are simple to construct and generally not used as a permanent solution or to control large erosion issue, rather are best suited to small streams or used to control sediment inputs to the channel. The structures are built using materials that are prone to decay or movement such as hay bales, silt fences and stakes. More permanent variations involve driving wooden posts with wire mesh attached to cables.

  Silt fences and / or sandbags (dependant upon flow rates) may be used to stabilise small erosion heads (less than 0.6 metre drop) or minor bed deepening, to trap sediment and reverse minor bed deepening processes and/or be placed on features such as the floodplain or benches to capture sediment and accelerate the recovery of these features. They may also be used to prevent sediment entering the stream from works sites or other potential sources.

- Rock Beaching (Operation):

  Rock beaching involves the placement of quarried rock (rip rap) on stream banks. The rock is founded on the bed of the stream and generally extends up the portion of the bank threatened by erosion. This technique provides localised protection only and does not address system wide processes.

  The purpose of rockwork is to provide protection and stabilisation of the bed and banks of waterways from erosion and to minimise velocity of stormwater flows. There are a number of types of rockwork: toe and edge rocks, lining rock, filter/embedment layers and outfall pipe rockwork.

  Rockworks should generally:

  – Be made up of angular rock (either quarried or broken up field rock).
  – Be made up of well sized, well graded, well embedded, well interlocked rock.
  – Have all voids sealed to provide stability and resistance to flow velocities and infiltration / undermining.

– Form an interlocking mass of rock in which the larger rocks in the mix are not free to move.

Rockwork information needs to be provided on the design drawings, such as rock sizes and grading, thickness of rock layers (including filter/embedment layer) and extent of rock structures.

6.3.2 Culvert Extensions

The design philosophy recommended for the culvert extensions is to maintain the existing open waterway area. If this is not possible, the maximum practical waterway area is to be provided. Assessment of the provided waterway area would be undertaken for each waterway crossing.

6.3.3 Culvert Inlet and Outlet Works

The assessment of waterway crossings would include the determination of the velocity upstream and downstream of the crossing structure. The protection required and the extent of works would be determined based on the calculated velocities.

The alignment of the inlet and outlet earthworks would consider the existing waterway alignment and be designed to minimise the risk of constrictions or the potential for scour through the inclusion of natural form inlets and outlets that utilise rock and/or vegetation as protection.

Additional Mitigation Works

In some locations such as crossing W57 within the Jump Up Creek catchment, construction of the Project may decrease the distance to some migratory geomorphic features. Protection of the proposed embankment and/or culvert extensions may therefore be required.

6.3.4 Realignment of Sawyers Creek

In determining the proposed realignment of Sawyers Creek consultation with the Department of Primary Industry (Fisheries), the Office of Water (previously DWE) and the Department of Environment, Climate Change and Water was sought. The proposed alignment has considered the criterion nominated by these agencies and included maintaining (where possible) of the existing:

- Stream length.
- Stream grade.
- Stream power.

Additionally, consideration would also be given to the reinstatement of riparian vegetation and the provision of geomorphic features such as pools and riffles.

It is proposed that construction and reinstatement of riparian vegetation within the realignment would occur while maintaining the existing waterway flow. Once the realignment was determined to be stable, and reinstatement of vegetation completed, connection to the existing creek would then occur.

6.3.5 Other Waterway Re-alignments

A review of the extent of work potentially associated with the Project indicated that in addition to Sawyers Creek, there may be some other minor waterway re-alignments required. The extent of these re-alignments would be defined during the detail design and the design principles nominated for Sawyers Creek would be adopted to any additional re-alignments.

The locations that have been identified as possible re-alignment locations at this time include Sweetwater Creek and Anvil Creek (at approximate chainages 209.300 kilometres and 210.600 kilometres).

6.4 Blockage of Low Flows

The constriction of waterway areas has the potential to block low flows to the downstream environment and alter flow regimes thereby potentially impacting downstream water users as well as aquatic habitat. Where practicable, diversion of flows around the work area (up to the 50% AEP) should occur.

6.4.1 Waterway Structures

To minimise the potential impact on flood levels and to maintain low flows, the existing open waterway area at each waterway crossing is to be maintained throughout construction activities where possible. In locations where it is feasible, it is also recommended that the open waterway area be increased. This includes the use of oversized culverts with placed rock in the invert to provide fish resting areas as well as placed rock upstream and downstream for energy dissipation and to reduce concentrated flow velocities.

6.4.2 Causeways

In locations where the access track (or haul road) alignment crosses through a waterway, a causeway may be required. It is anticipated that this will occur primarily at locations where existing causeways are already in place.

The configuration of the proposed causeways was developed in consultation with the OW and includes either a bed level crossing through the invert of the waterway or a low level crossing with low flow culverts beneath to allow base flows to be conveyed.

Temporary crossings should also include a lower section for higher flows to pass with culverts extending beyond the toe of fill embankments. These crossings would be removed and the waterway rehabilitated.

6.4.3 Fish Passage through Culverts

Many native fish migrate as part of their life cycle. Standard culvert design and construction can represent a barrier to fish, preventing fish migration, isolating habitat and interfering with or preventing fish spawning. Culverts can be modified and/or designed to provide suitable conditions for fish passage as follows:

- Culverts should be constructed to provide light, encourage fish to enter and pass through the culvert.

- Culverts should not reduce stream cross-section to the extent that flow velocities are in excess of fish burst speed.
- Culverts should contain flow velocity diversity and depth suited to target species.
- Culverts should have a natural substrate (bed material).

The benefit of providing fish passage as part of the design for major waterway crossings on the Project include improved breeding opportunities and allowances for fish to complete their lifecycle and increased geographic distribution of desired fish species.

Design guidelines to consider when establishing fish passage and other sources of related information include:

- Fairfull, S. and Witheridge, G. 2003, Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla (available on line at www.fisheries.nsw.gov.au).
- Cotterell, E. 1998, Fish Passage in Streams – Fisheries Guidelines for Design of Stream Crossings, Fish Habitat Guideline FHG001, Fisheries Group, Queensland Department of Primary Industries (available on line at www.dpi.qld.gove.au).

7. Conclusions

The objective of the surface water assessment was to determine the potential impacts related to surface drainage, water quality, flooding / hydrology and the condition of existing waterways.

7.1 Impact and Risk Assessment

The potential waterway impacts of the construction and operation of the Project were used as a basis for determining the risk pathways in the risk assessment. The outcomes of the impact and risk assessment identified that:

- With the application of standard mitigation measures, three of the seven identified risk items were considered to be Low risk.
- With application of the standard mitigation measures, four of the seven identified risk items were considered to be Medium risk. These were:
  - Decline in water quality.
  - Increasing existing flood levels at Major waterways.
  - Increase in scour at culvert outlets, along existing waterways and embankments.
  - Blockages in low flow zones such as in creeks at causeway crossings.
  - With the application of additional control measures, one of the Medium risk items was reduced to a Low risk. That was:
  - Increasing existing flood levels at Major waterways. The additional measure was increase property acquisition.
  - For the remaining risk items, the risk rating could not be definitively reduced.

This risk rating acknowledges that while the local environmental condition of the waterway crossing locations along the Project route is often degraded, these impacts relate to the potential impact to waterway health in a broader catchment context (beyond the Project footprint).

7.2 Mitigation Measures

The standard and additional mitigation measures nominated in Section 6 of this report would result in minimal impact of the Project on surface drainage, water quality, flooding / hydrology and the condition of existing waterways.

It is therefore recommended that the Project proceed with the inclusion of the nominated mitigation measures and design philosophies.

8. References

Brisbane City Council*, Natural Channel Design Guideline, November 2003.*

Cessnock City Council, *Supplementary State of the Environment Report 2007-2008 Annexure 1 – Cessnock City Council Annual Report.*

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Department of Environment and Climate Change, *Managing Urban Stormwater Volume 2D Main road construction.*

Department of Environment and Heritage, Canberra, *ANECC / ARMCANZ 2000, Australian and New Zealand guidelines for fresh and marine water quality.*

Department of Natural Resources 2004, *Riparian Corridor Management Study*, NSW Government, Wollongong.

Department of Water and Energy 2000, *Water Management Act 2000.*

Institute of Engineers (1998) *Australian Rainfall and Runoff, A Guide to Flood Estimation Volumes 1 and 2.*

Landcom 2004, *Managing Urban Stormwater: Soils and Construction Volume 1*, 4th Edition March 2004, NSW.

Maitland City Council, *Manual of Engineering Standards 2004.*

Maitland City Council, *City Wide Development Control Plan Hunter River Floodplain Management, 2006.*

Natural Resources and Water, *Queensland Urban Drainage Manual Volume 1, Second Edition 2007.*

Webb, McKeown & Associates Pty Ltd, *Lower Hunter Valley (Oakhampton to Green Rocks) Supplementary Flood Study, 1998.*

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Appendix A

Waterway Crossing Field Investigation

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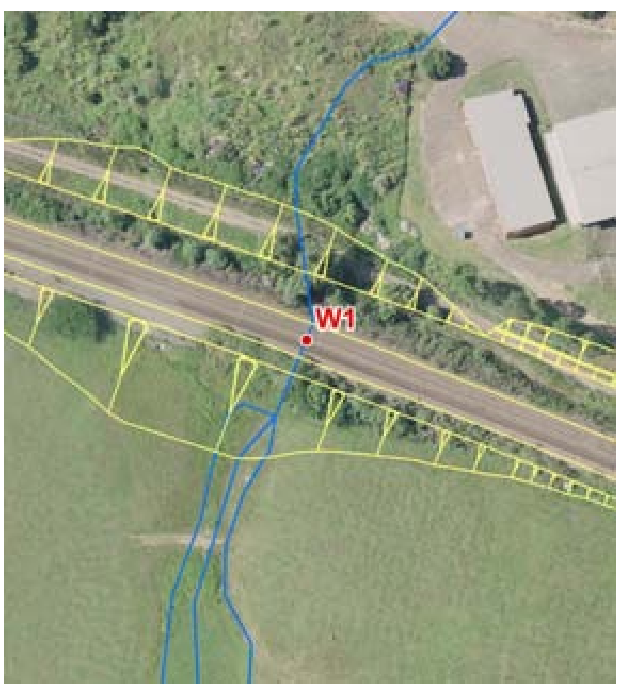
Waterway Crossing – W1				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Channelised Fill	Downstream	Valley Fill
Land Use	Upstream – Industrial, Downstream - Grazing			
Catchment Area	13.3 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Partly confined			
Channel dimensions	Upstream: < 4 m wide, < 1m deep			
Channel sinuosity	Low			
Average slope				
Adjustment potential	Low potential for scour downstream due to cohesive soils and flow dissipation.			
Banks	Upstream banks well vegetated and stable.			
Instream Features	N/A			
Floodplain	Upstream highly developed due to industrial landuses Downstream valley fill dominated by pasture grasses			
Contextual Notes	Upstream - Drains industrial area, access track crosses channel on upstream side, channel has been constructed as a swale for draining purposes.			




Downstream view


Upstream view

Waterway Crossing – W2				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Channelised Fill	Downstream	Valley Fill
Land Use	Upstream – Industrial, Downstream - Grazing			
Catchment Area	43 ha			
Stream Order	Second			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Partly confined			
Channel dimensions	Upstream:			
Channel sinuosity	Low			
Average slope				
Adjustment potential	Low potential for scour downstream due to cohesive soils and flow dissipation.			
Banks	Upstream banks well vegetated (grasses and exotics) and stable.			
Instream Features	N/A			
Floodplain	Upstream highly developed due to industrial landuses. Downstream valley fill dominated by pasture grasses.			
Contextual Notes	Upstream drains industrial area, access track crosses channel on upstream side. A quite defined channel.			


Downstream view


View across rail access crossing on upstream side

Waterway Crossing – W3				
Waterway	Stony Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Valley fill/Scour hole	Downstream	Low Sinuosity Fine Grained
Land Use	Upstream – marsh/swamp, Downstream - Grazing			
Catchment Area	1520 ha			
Stream Order	Third			
Flow Frequency	Permanent			
Site Inspection				
Date	02/10/09			
Valley Confinement	Unconfined			
Channel dimensions	Downstream beyond scour pool < 3 m wide, < 1 m deep			
Channel sinuosity	Low			
Average slope	9.6 %			
Adjustment potential	Limited potential to adjust laterally due to cohesive banks, ongoing headward erosion of scour pool upstream			
Banks	Grassed, stable downstream of scour pool.			
Instream Features	Downstream beyond scour pool, channel exhibits an inset low flow channel with small pools.			
Floodplain	Modified pasture land			
Contextual Notes	Large scour pool through existing rail culverts. Wollombi Road and existing rail cross the creek in close succession.			


Upstream view

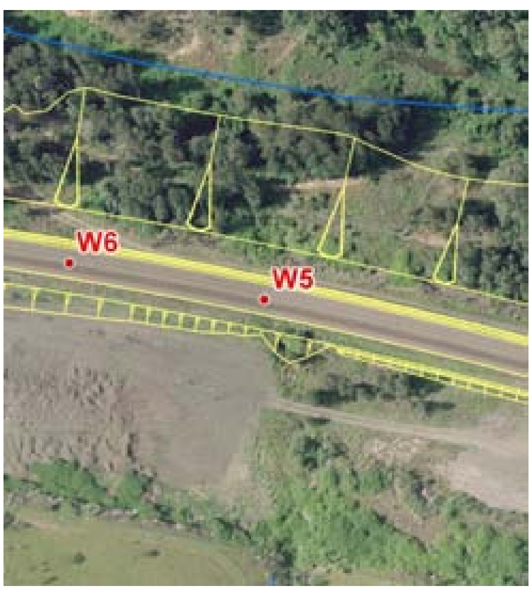

Downstream view

Waterway Crossing – W4				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Confined
Land Use	Upstream – quarry. Downstream - rail embankment and Stony Creek floodplain.			
Catchment Area	3 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	19.5 %			
Adjustment potential	There is a moderate adjustment potential on downstream side due to the steepness of the bank however, due to the small catchment area, presence of vegetation and rubble in the drainage line, stability is increased.			
Banks	N/A			
Instream Features	N/A			
Floodplain	N/A - downstream is Stony Creek floodplain			
Contextual Notes	Upstream - undefined quarry runoff, rail access track is on upstream side. Downstream – steep grassed embankment containing some rubble that abuts the Stony Creek floodplain.			


Upstream view


Downstream view

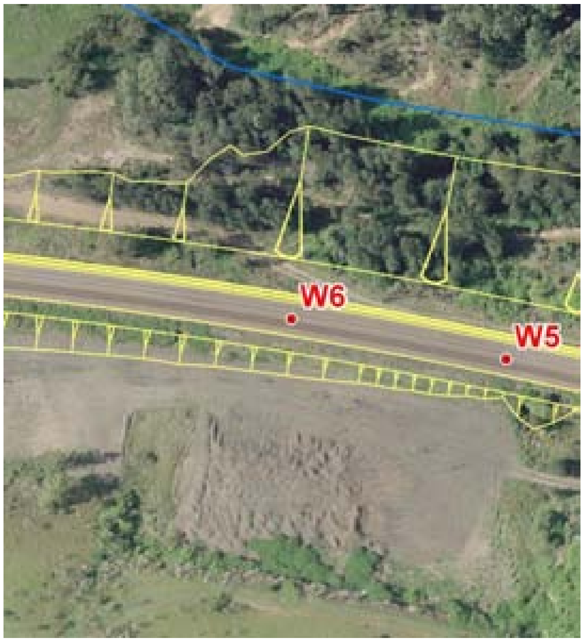
Waterway Crossing – W5				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Channelised	Downstream	Confined
Land Use	Upstream – quarry. Downstream - rail embankment and Stony Creek floodplain.			
Catchment Area	4.9 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	Upstream : < 3 m wide, < 2m deep			
Channel sinuosity	Low			
Average slope	21.5 %			
Adjustment potential	Minimal on upstream side due to bedrock base adjacent to the culvert. Moderate adjustment potential on downstream side due to the steepness of the bank. As in W4 due to the small catchment area, presence of vegetation and rubble in the drainage line, stability is increased.			
Banks	Stable, clay banks with bedrock bed (upstream side)			
Instream Features	Rock base			
Floodplain	Downstream is Stony Creek floodplain, upstream modified by quarry			
Contextual Notes	Upstream - undefined quarry runoff into excavated bedrock channel adjacent to the rail. Downstream – contains rubble from embankment and flows onto Stony Creek floodplain.			




Upstream view


Downstream view

Waterway Crossing – W6				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Valley Fill
Land Use	Upstream – quarry. Downstream - rail embankment and Stony Creek floodplain.			
Catchment Area	1.5 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Partly Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	-			
Adjustment potential	Low			
Banks	N/A			
Instream Features	N/A			
Floodplain	Modified grazing land.			
Contextual Notes	Upstream - undefined quarry runoff. Downstream – Valley Fill and flows onto Stony Creek floodplain.			




Upstream view


Downstream view

Waterway Crossing – W7				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Valley Fill
Land Use	Upstream – Grassed ex-quarry. Downstream - rural			
Catchment Area				
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Partly confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	12 %			
Adjustment potential	Low			
Banks	N/A			
Instream Features	N/A			
Floodplain	Grazed with patches of remnant native vegetation downstream			
Contextual Notes				


Downstream view

Waterway Crossing – W8				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Channelised	Downstream	Channelised
Land Use	Upstream – Grassed ex-quarry. Downstream - rural			
Catchment Area				
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Partly confined			
Channel dimensions	Downstream: 1 - 2 m wide , < 1 m deep			
Channel sinuosity	Moderate potential for bed scour and bank erosion due to sandy soils.			
Average slope	11.1 %			
Adjustment potential	Moderate potential for bed scour and bank erosion downstream			
Banks	Grassed, stable banks composed of sandy silt.			
Instream Features	Small pools separated by gravel riffles in downstream channel.			
Floodplain	Cleared in vicinity of existing rail, native remnant vegetation 40 metres downstream.			
Contextual Notes	Downstream of culvert is Channelised Fill that then becomes further confined.			


Upstream view


Downstream view

Waterway Crossing – W9				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Dam	Downstream	Valley Fill
Land Use	Downstream – old golf course (commercial)			
Catchment Area	19.8 ha			
Stream Order	Second			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Partly confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	2.2 %			
Adjustment potential	Low potential for downstream scour due to flow dissipation over wide area.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Modified grazing land, affected by dam upstream.			
Contextual Notes	Some slumping on wall of dam.			


Upstream view of dam wall


Downstream view

Waterway Crossing – W10				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Valley Fill
Land Use	Downstream - Rural/ old golf course (commercial)			
Catchment Area	16.4 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Downstream – Confined/partly confined			
Channel dimensions	N/A			
Channel sinuosity	Low			
Average slope	3.4 %			
Adjustment potential	Moderate potential for scour downstream.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Modified grazing land, some exotics (willows) downstream			
Contextual Notes	Downstream – several scour pools as a result of culvert scour, prior to intact Valley Fill. Upstream – undefined then runs adjacent to track from both directions and into culvert.			


Upstream view


Downstream view

Waterway Crossing – W11				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Channelised Fill
Land Use	Forest			
Catchment Area	19.6 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Downstream – partly confined			
Channel dimensions	Downstream: < 1.0 m wide, < 0.5 m deep			
Channel sinuosity	Low			
Average slope	3 %			
Adjustment potential	Moderate potential for bed scour and bank erosion downstream			
Banks	Although well vegetated, downstream banks have moderate erosion potential due to sandy clay			
Instream Features	Nil			
Floodplain	Downstream regenerating with native vegetation. Modified grazing land upstream.			
Contextual Notes	Undefined upstream catchment flooding is being channelled into culvert and creating Channelised Fill on the downstream side.			

Upstream view

Downstream view

Waterway Crossing – W12				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Valley fill
Land Use	Upstream – grazing/rural. Downstream - forest			
Catchment Area	28.7 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Downstream - Partly Confined			
Channel dimensions	< 1.5 m wide, 0.5 m deep			
Channel sinuosity	Low			
Average slope	3.3 %			
Adjustment potential	Moderate potential for bed erosion upstream due to existing headcuts. Low Potential for scour downstream due to densely vegetated channel.			
Banks	Banks downstream are moderately stable and consist of a sandy clay.			
Instream Features	Minor scour pools downstream.			
Floodplain	Disturbed native vegetation upstream. Well-vegetated downstream.			
Contextual Notes	Upstream – undefined, some channelising immediately before culvert			


Upstream view


Downstream view

Waterway Crossing – W13				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Minor Creek (Downstream)			
Stream Type	Upstream	Undefined	Downstream	Channelised Fill
Land Use	Forest			
Catchment Area	29.6 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Partly Confined			
Channel dimensions	Downstream: 1 - 2 m wide, 2 m deep.			
Channel sinuosity	Low			
Average slope	1.9 %			
Adjustment potential	Moderate to high potential for bed scour due to presence of existing scour below rail access road.			
Banks	Active erosion of concave banks downstream.			
Instream Features	Downstream consists of featureless bed of ballast material.			
Floodplain	Well-vegetated with native woodland species.			
Contextual Notes	Large scour hole downstream of rail access road. Ballast is actively being transported downstream.			


Upstream view


Downstream view

Waterway Crossing – W14				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined/dam	Downstream	Undefined/Valley Fill
Land Use	Grazing			
Catchment Area	13 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Partly confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	1.7 %			
Adjustment potential	Minor potential for scour downstream			
Banks	N/A			
Instream Features	N/A			
Floodplain	Modified grazing land.			
Contextual Notes	Adjacent to the culvert is a dam and upstream of this is undefined. An erosive area exists further upstream of the undefined section (approximately 100 metres upstream of rail) which has the potential to contribute further quantities of sediment if it expands.			


Upstream view


Downstream view

Waterway Crossing – W15				
Waterway	Unnamed tributary of Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined/Dam	Downstream	Undefined
Land Use	Grazing			
Catchment Area	10.2 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	2 %			
Adjustment potential	Low potential for scour downstream due to flow dissipation over wide area.			
Banks	N/A			
Instream Features	N/A			
Floodplain	No floodplain, modified grazing land.			
Contextual Notes	Upstream - undefined drainage line containing a dam. Downstream – undefined.			

Upstream view

Downstream view

Waterway Crossing – W16				
Waterway	Stony Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Channelised Fill
Land Use	Grazing/Rural			
Catchment Area	11.4 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Unconfined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	1.8 %			
Adjustment potential	Moderate potential for scour due to existing gully 30 metres downstream of rail.			
Banks	N/A			
Instream Features	Nil			
Floodplain	Modified grazing land with remnant woodland and pasture understorey.			
Contextual Notes	Gully head 30 metres downstream creating channel < 2 metres wide and 0.5 metres deep.			


Upstream view


Downstream view

Waterway Crossing – W17				
Waterway	Unnamed tributary of Bishops Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined/Valley Fill	Downstream	Valley Fill/Dams
Land Use	Grazing			
Catchment Area	15.9 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope				
Adjustment potential	Low due to dams.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Highly modified grazing land.			
Contextual Notes	Upstream – Undefined drainage line forms Valley Fill adjacent to and as a result of the rail embankment, some scour adjacent to culvert. Downstream - dams separated by Valley Fills beginning to form minor creek.			

Upstream view

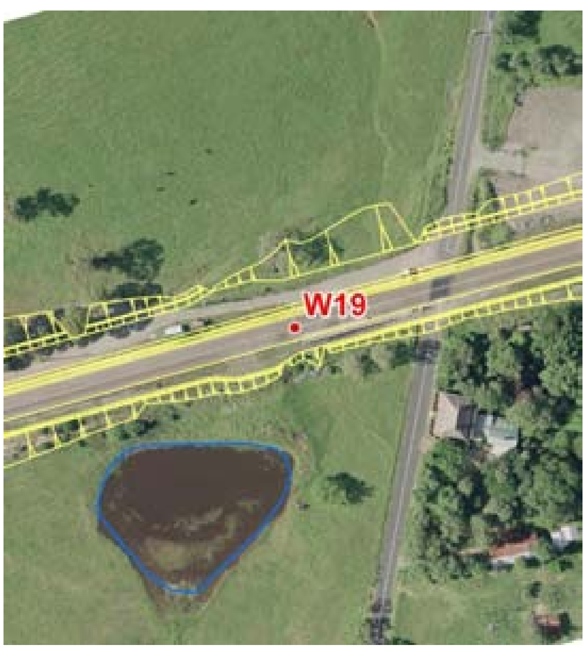
Downstream view

Waterway Crossing – W18				
Waterway	Unnamed tributary of Lochinvar Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Dam/Undefined	Downstream	Valley Fill
Land Use	Rural/Grazing			
Catchment Area	4.4 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	N/A			
Adjustment potential	Low potential for scour downstream due to densely vegetated flow path.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Downstream valley floor dominated by juncus surrounded by highly modified grazing land.			
Contextual Notes				


Upstream view


Downstream view

Waterway Crossing – W19				
Waterway	Unnamed tributary of Lochinvar Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Dam	Downstream	Channelised Fill
Land Use	Grazing			
Catchment Area	11.8 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	Downstream: 1 - 2 m wide, < 1 m deep			
Channel sinuosity	Low			
Average slope	N/A			
Adjustment potential	Low Potential for scour downstream due to cohesive, grassed bed and bank sediments.			
Banks	Stable, grassed banks downstream consisting of cohesive alluvial silts.			
Instream Features	Nil			
Floodplain	Highly modified grazing land.			
Contextual Notes	Downstream of culvert is Channelised Fill for 20 m, then Valley Fill until dam. Some localised pools. Upstream is undefined and dam.			




Upstream view


Downstream view

Waterway Crossing – W20				
Waterway	Unnamed tributary of Lochinvar Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Dam
Land Use	Grazing			
Catchment Area	5.2 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	N/A			
Adjustment potential				
Banks	N/A			
Instream Features	N/A			
Floodplain	Highly modified grazing land.			
Contextual Notes	Downstream of culvert contains rubble material. Upstream undefined/no channel.			


Upstream view


Downstream view

Waterway Crossing – W21				
Waterway	Unnamed tributary of Lochinvar Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Channelised Fill
Land Use	Grazing			
Catchment Area	3.1 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	N/A			
Adjustment potential	Moderate potential for scour due to existing gully 20 metres downstream of rail.			
Banks	N/A			
Instream Features	Nil			
Floodplain	Highly modified grazing land.			
Contextual Notes	Gully head 20 metres downstream creating channel < 2 metres wide and 0.5 metres deep.			


Upstream view


Downstream view

Waterway Crossing – W22				
Waterway	Unnamed tributary of Lochinvar Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Dam/Undefined	Downstream	Undefined/Valley Fill
Land Use	Grazing			
Catchment Area	3.5 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	N/A			
Adjustment potential	Low potential for downstream scour due to dissipation of flow over wide area.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Highly modified grazing land.			
Contextual Notes				


Upstream view


Downstream view

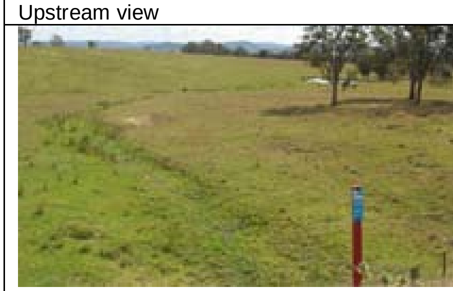
Waterway Crossing – W23				
Waterway	Lochinvar Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Undefined	Downstream	Confined/artificial
Land Use	Grazing			
Catchment Area	17.5 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined			
Channel dimensions	Downstream: < 4 m wide, < 1 m deep			
Channel sinuosity	Low			
Average slope				
Adjustment potential	Moderate potential for bank erosion downstream until banks revegetate.			
Banks	Unvegetated banks downstream composed of clay.			
Instream Features	Nil			
Floodplain	Highly modified grazing land.			
Contextual Notes	Recently constructed channel for 100 m downstream. Upstream slight erosive area/head cut adjacent to the culvert treated with ballast.			

Upstream view

Downstream view

Waterway Crossing – W24				
Waterway	Unnamed tributary of Lochinvar Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined/Dam	Downstream	Valley Fill/Channelised Fill
Land Use	Grazing			
Catchment Area	4.3 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Partly confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	N/A			
Adjustment potential	Low potential for downstream scour due to cohesive soils and flow dissipation.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Disturbed native vegetation upstream. Highly modified grazing land downstream.			
Contextual Notes	Downstream – some slight channelising of Valley Fill. Upstream – dam.			

Upstream view



Downstream view

Waterway Crossing – W25				
Waterway	Unnamed tributary of Bishops Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined/Valley Fill	Downstream	Dam/undefined
Land Use	Grazing			
Catchment Area	9.4 ha			
Stream Order	Second			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Confined to Partly Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	N/A			
Adjustment potential	Low potential for scour downstream.			
Banks	N/A			
Instream Features	Nil			
Floodplain	Cleared, modified grazing land.			
Contextual Notes	Upstream – grassed drainage line into multiple culvert inlets. Downstream – Channelising upon exiting culvert, and then flowing overland into dam. Between dam and culvert there is a rock structure across drainage line.			

Upstream view

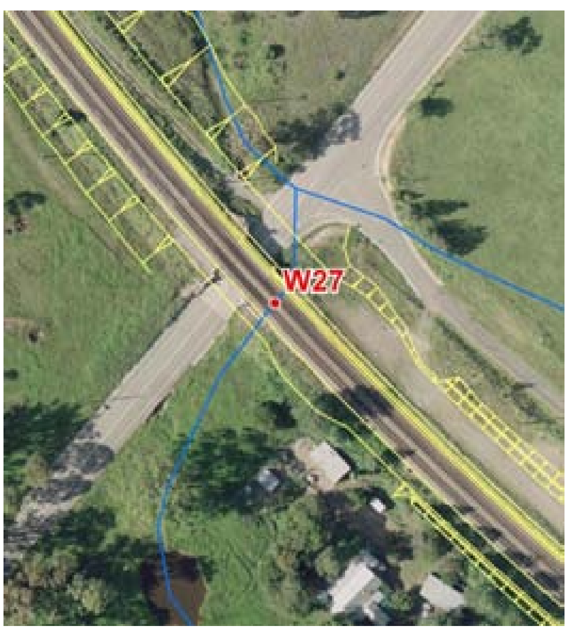
Downstream view

Waterway Crossing – W26				
Waterway	Unnamed tributary of Bishops Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Confined/Channelised Fill
Land Use	Upstream – grazing, Downstream - forest			
Catchment Area	1.3 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	07/10/09			
Valley Confinement	Downstream - confined			
Channel dimensions	Downstream: < 5 m wide, 1 - 2 m deep			
Channel sinuosity	Low			
Average slope	N/A			
Adjustment potential	Moderate potential for bank erosion downstream.			
Banks	Lower banks downstream are vertical and largely devoid of vegetation.			
Instream Features	Downstream channel is trapezoidal in cross-section with probably excavated inset low flow channel.			
Floodplain	Highly modified grazing upstream. Disturbed native woodland downstream.			
Contextual Notes				


Upstream view


Downstream view

Waterway Crossing – W27				
Waterway	Anvil Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Valley Fill – dam	Downstream	Partly Confined, Low Sinuosity Fine Grained
Land Use	Upstream – grazing, Downstream			
Catchment Area	162.5 ha			
Stream Order	Third			
Flow Frequency	Ephemeral – permanent pools			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined downstream.			
Channel dimensions	Downstream: 8 m wide, 1.5 m deep.			
Channel sinuosity	Low			
Average slope	1.3 %			
Adjustment potential	Upstream has limited potential to adjust due to flow dissipation over wide area. Downstream has limited potential to adjust laterally due to cohesive and grassed banks.			
Banks	Grassed and stable banks downstream comprised of fine grained sediments.			
Instream Features	Pools with fringing macrophytes downstream.			
Floodplain	Modified grazing land.			
Contextual Notes	The creek is confined to below ground drainage at the point of Allandale Road crossing and the rail crossing.			

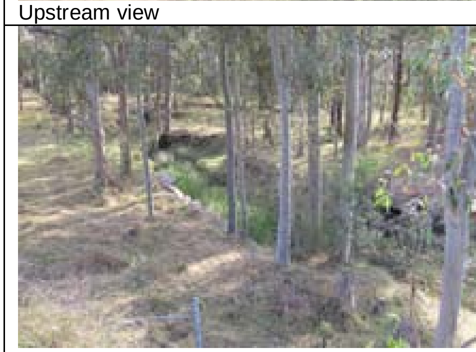



Upstream view


Downstream view

Waterway Crossing – W28				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Valley Fill	Downstream	Channelised Fill
Land Use	Rural			
Catchment Area	72.3 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Confined			
Channel dimensions	Downstream - 5 metres width, 1 metre depth			
Channel sinuosity	Low			
Average slope	3.9 %			
Adjustment potential	Downstream has a moderate potential to adjust due to sandy nature of the banks downstream.			
Banks	Steep banks consisting of sandy clays, moderately stable.			
Instream Features	Small, shallow pools.			
Floodplain	Disturbed native vegetation with limited understorey.			
Contextual Notes	Macrophytes in channel, rock protection on downstream culvert outlet, upstream good condition, dam 50 metres upstream			


Upstream view


Downstream view

Waterway Crossing – W29				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Undefined
Land Use	Rural			
Catchment Area				
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	-			
Adjustment potential	N/A			
Banks	N/A			
Instream Features	N/A			
Floodplain	N/A			
Contextual Notes	Runs east along rail to culvert W28			


Downstream view

Waterway Crossing – W30				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Partly Confined/ Channelised Fill	Downstream	Partly Confined/ Channelised Fill
Land Use	Forest			
Catchment Area	292.1 ha			
Stream Order	Third			
Flow Frequency	Ephemeral – no standing water			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	2 metres wide, 1 metre deep			
Channel sinuosity	Low			
Average slope	1.1 %			
Adjustment potential	Moderate potential for continued channel expansion and scour.			
Banks	Banks comprised of sandy silt and are eroding and being undercut.			
Instream Features	Woody debris, scour pools, undercut banks.			
Floodplain	Native vegetation with grass understorey.			
Contextual Notes	Incised, poor condition, scour holes.			


Upstream view


Downstream view

Waterway Crossing – W31				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Channelised Fill	Downstream	Partly Confined, Low Sinuosity Fine Grained
Land Use	Rural			
Catchment Area	285 ha			
Stream Order	Third			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	2 metres width, 1 metre depth			
Channel sinuosity	Moderate			
Average slope	3 %			
Adjustment potential	Moderate potential for ongoing bank erosion due to limited bank vegetation.			
Banks	Vertical banks comprised of sandy silt, undercut at scour pools.			
Instream Features	Scour pools, woody debris, undercut banks.			
Floodplain	Disturbed native vegetation with understorey dominated by lantana and other exotic species.			
Contextual Notes	Enters Anvil Creek 20 metres downstream of rail, standing water under culvert			


Upstream view


Downstream view

Waterway Crossing – W32				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Valley Fill/Undefined	Downstream	Valley Fill
Land Use	Grazing			
Catchment Area	37.8 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Unconfined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	2.7 %			
Adjustment potential	Low potential to adjust downstream due to flow dissipation created by excavation adjacent to culvert			
Banks	N/A			
Instream Features	N/A			
Floodplain	Modigfied grazing land.			
Contextual Notes	The culvert outlet exists below the level of the Valley Fill that connects the culvert and Anvil Creek.			


Upstream view


Downstream view

Waterway Crossing – W33				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Valley Fill
Land Use	Grazing			
Catchment Area	2.2 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	N/A			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	5.9 %			
Adjustment potential	Low potential for downstream scour due to flow dissipation over wide area.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Upstream is grazing land, downstream forested land adjacent to Anvil Creek.			
Contextual Notes	Approximately 70 metres downstream well forested Valley Fill joins Anvil Creek			


Upstream view

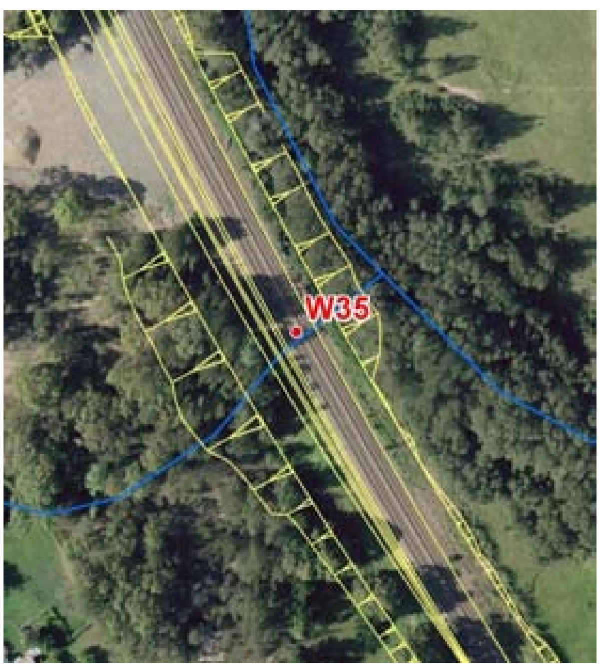

Downstream view

Waterway Crossing – W34				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Chain of Ponds	Downstream	Channelised Fill
Land Use	Rural			
Catchment Area	122 ha			
Stream Order	Second			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	< 8 metres width, 1 metre depth			
Channel sinuosity	Low			
Average slope	1.8 %			
Adjustment potential	The upstream ponds system has a high potential due to limited riparian vegetation and non cohesive soils. As a result, the pond exhibit banks erosion and incision of connecting sections.			
Banks	Eroding and steep, consisting of sandy silts.			
Instream Features	Ponds progressing to scour holes			
Floodplain	The floodplain is connected and consists of modified grazing land			
Contextual Notes	Ponds and headward incision in upstream extent			


Upstream view


Downstream view

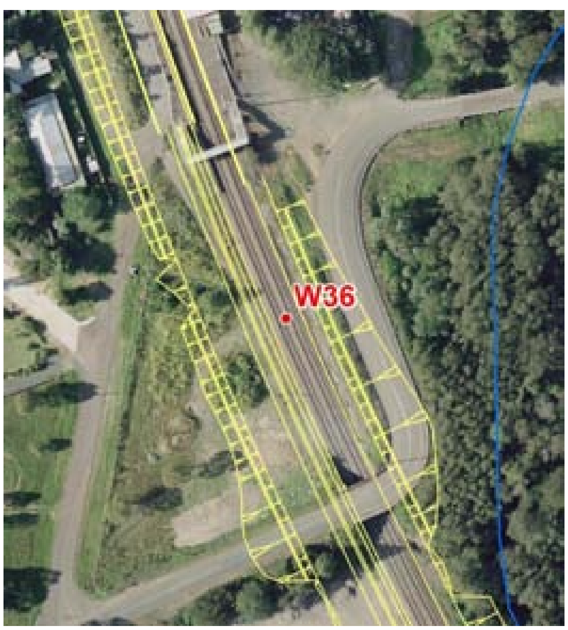
Waterway Crossing – W35				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Chain of Ponds	Downstream	Anvil Creek - Partly Confined Low Sinuosity Fine Grained
Land Use	Forest			
Catchment Area	33.9 ha			
Stream Order	Second			
Flow Frequency	Ephemeral, dry			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	Downstream: < 5 metres width, < 1 metres depth			
Channel sinuosity	Low			
Average slope	-			
Adjustment potential	This system is in fairly good condition, well vegetated and has limited potential to adjust.			
Banks	Downstream banks consist of cohesive, fine grained sediments and are stable.			
Instream Features	Dry ponds with undercut banks.			
Floodplain	Well vegetated with native species.			
Contextual Notes	Ballast in channel on downstream side of the rail.			




Upstream view


Downstream view

Waterway Crossing – W36				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Channelised Fill	Downstream	Channelised Fill
Land Use	Rural			
Catchment Area	5.1 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Unconfined upstream, downstream is incorporated into Anvil Creek channel and floodplain.			
Channel dimensions	1 metre width, 1 metre depth			
Channel sinuosity	Low			
Average slope	7.1 %			
Adjustment potential	Minimal as channel exists in an urban/ rural setting and is controlled to an extent by roads.			
Banks	Banks are well vegetated and stable.			
Instream Features	Nil			
Floodplain	Modified upstream due to roads.			
Contextual Notes	Down/Up ramp of road bridge over rail exists parallel to the rail corridor in this section and the culvert extends beneath these two structures and into Anvil Creek.			

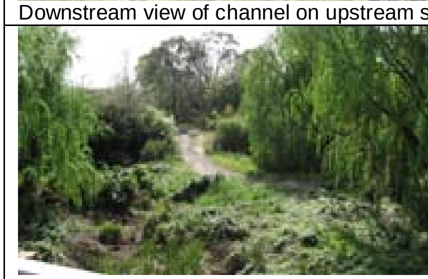


Upstream view

Downstream view

Waterway Crossing – W37				
Waterway	Sawyers Creek (tributary of Anvil Creek)			
Waterway Classification	Major Creek			
Stream Type	Upstream	Partly Confined Low Sinuosity Fine Grained	Downstream	Partly Confined Low Sinuosity Fine Grained
Land Use	Rural			
Catchment Area	578.2 ha			
Stream Order	Third			
Flow Frequency	Ephemeral – permanent pools.			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly Confined			
Channel dimensions	5 m width, 1 m depth			
Channel sinuosity	Moderate			
Average slope	1.5 %			
Adjustment potential	Low due to cohesive banks and bedrock control.			
Banks	Banks are stable due to cohesive fine grained sediments and well vegetated			
Instream Features	Bedrock base in sections, pools and benches.			
Floodplain	Floodplain is well vegetated and exhibits a flood channel on the upstream side.			
Contextual Notes	The 30-metre bedrock base channel is acting as a stabilising point to maintain a good condition creek upstream. It is preventing possible head-cut retreat upstream while providing the stability necessary for good condition riparian vegetation.			


Downstream view of channel on upstream side against rail.


Downstream view

Waterway Crossing – W38				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Chain of Ponds	Downstream	Channelised Fill
Land Use	Upstream forest, downstream grazing.			
Catchment Area	30.7 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Confined			
Channel dimensions	Trapezoidal shape downstream < 5 metres width and < 1 metre deep.			
Channel sinuosity	Low			
Average slope	-			
Adjustment potential	Downstream there is moderate potential to adjust due to lack of stabilising riparian vegetation.			
Banks	Currently stable consisting of clay.			
Instream Features	Nil			
Floodplain	Highly modified grazing land downstream. Native vegetation with pasture grass understorey upstream.			
Contextual Notes	Constructed channel downstream.			


Upstream view


Downstream view

Waterway Crossing – W39				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Valley Fill
Land Use	Grazing			
Catchment Area	7.1 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	-			
Adjustment potential	Low potential for adjustment due to dissipation of flow downstream over large area.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Forest and grazing			
Contextual Notes	Dam on downstream side of rail.			


Upstream view

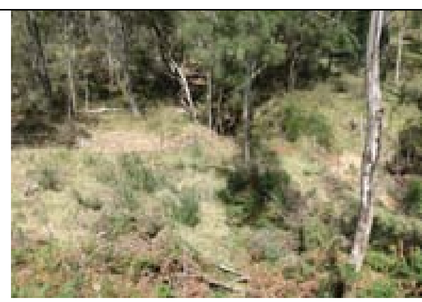

Downstream view

Waterway Crossing – W40				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Valley Fill	Downstream	Channelised Fill
Land Use	Forest			
Catchment Area	51.2 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	Downstream: 1 m wide, 0.5 m deep			
Channel sinuosity	Low			
Average slope	-			
Adjustment potential	Although well vegetated, downstream banks have moderate erosion potential due to sandy clay composition.			
Banks	Low banks composed of sandy clay and well vegetated with grasses.			
Instream Features	Nil			
Floodplain	Well vegetated with native tree species, understorey consist of native and exotic grasses.			
Contextual Notes	Slightly channelised downstream with bedrock outcrop below culvert outlet. Upstream good condition Valley Fill.			


Upstream view


Downstream view

Waterway Crossing – W41				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Partly Confined Low Sinuosity Sand	Downstream	Partly Confined Low Sinuosity Sand
Land Use	Forest			
Catchment Area	207.5 ha			
Stream Order	Second			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	Downstream - 15 m wide, 2-3 m deep. Upstream – 2 to 3 m wide, 1 m deep			
Channel sinuosity	Low – moderate			
Average slope	0.2 %			
Adjustment potential	Moderate potential for bank erosion downstream if vegetation disturbed.			
Banks	Banks are comprised of sandy silt, well vegetated and are currently stable			
Instream Features	Bedrock bars, pools, sand bars			
Floodplain	Well forested with native woodland species.			
Contextual Notes	Downstream – crossed by raill access bridge and private track causeway, bedrock exposed in bed. Upstream - moderate condition			


Upstream view


Downstream view

Waterway Crossing – W42				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Channelised
Land Use	Grazing			
Catchment Area	4.4 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Unconfined			
Channel dimensions	Downstream: < 4 metres wide, 1 metre deep			
Channel sinuosity	Low			
Average slope	-			
Adjustment potential	Moderate potential to adjust due to lack of riparian vegetation			
Banks	Downstream banks are well graded and vegetated with grasses.			
Instream Features	Nil			
Floodplain	Modified grazing land.			
Contextual Notes	Constructed channel downstream.			


Downstream view

Waterway Crossing – W43				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Valley Fill	Downstream	Valley Fill
Land Use	Upstream forested, downstream grazing.			
Catchment Area	11.7 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	-			
Adjustment potential	Moderate potential for scour downstream due to existing gully.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Native forest upstream. Highly modified grazing land downstream.			
Contextual Notes	Gully 50 m downstream and scour hole at culvert outlet.			


Upstream view


Downstream view

Waterway Crossing – W44				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Partly Confined Low Sinuosity Fine Grained	Downstream	Partly Confined Low Sinuosity Fine Grained
Land Use	Rural			
Catchment Area	312.1 ha			
Stream Order	Third			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	< 10 m width, < 4 m depth			
Channel sinuosity	Moderate			
Average slope	0.9 %			
Adjustment potential	Low potential due to stable, vegetated banks.			
Banks	Banks are comprised of sandy silt and are well vegetated and stable			
Instream Features	Pools, runs, low flow channel.			
Floodplain	Floodplain consists of predominantly grazing area with small native vegetation stands.			
Contextual Notes	Flow is carried through two culverts 20 metres apart.			


Upstream view


Downstream view of culvert

Waterway Crossing – W45				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Undefined
Land Use	Upstream consists of forested areas, downstream urban			
Catchment Area	6.5 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	-			
Adjustment potential	No adjustment potential due to urban setting and trackside nature of the drainage line.			
Banks	N/A			
Instream Features	N/A			
Floodplain	N/A			
Contextual Notes	Drainage line significantly disturbed by existing rail.			


View of culvert


Track drain

Waterway Crossing – W46				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Undefined
Land Use	Upstream consists of forested areas, downstream urban			
Catchment Area	1 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	N/A			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	0.04 %			
Adjustment potential	No adjustment potential due to urban setting and trackside nature of the drainage line.			
Banks	N/A			
Instream Features	N/A			
Floodplain	N/A			
Contextual Notes	Trackside depressions have the potential to hold large volumes of standing water should drainage performance deteriorate			


View of culvert

Waterway Crossing – W47				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Undefined
Land Use	Upstream consists of forested areas, downstream urban and grazing			
Catchment Area	18.3 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Partly confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	0.04 %			
Adjustment potential	Downstream, moderate potential for scour on grazing land.			
Banks	N/A			
Instream Features	N/A			
Floodplain	N/A			
Contextual Notes	Sand deposits in trackside drainage upstream.			


Upstream view


Downstream view

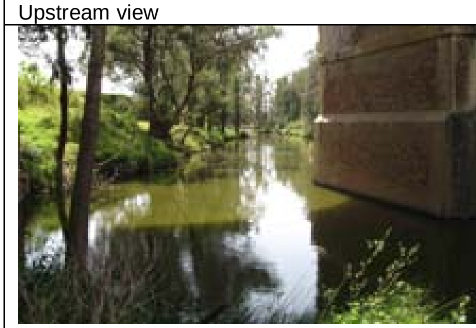
Waterway Crossing – W48				
Waterway	Unnamed tributary of Anvil Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Undefined	Downstream	Valley Fill/Channelised Fill
Land Use	Upstream forest, downstream grazing			
Catchment Area	31.5 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral, some standing water			
Site Inspection				
Date	Not inspected			
Valley Confinement	Downstream unconfined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	-			
Adjustment potential	There is a moderate potential to adjust due to the disturbed grazing pastures			
Banks	N/A			
Instream Features	N/A			
Floodplain	Well vegetated upstream with grasses.			
Contextual Notes	Some channelling immediately adjacent to the culvert upstream			


Upstream view


View of culvert

Waterway Crossing – W49				
Waterway	Black Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Partly Confined Low Sinuosity Fine Grained	Downstream	Partly Confined Low Sinuosity Fine Grained
Land Use	Rural			
Catchment Area	30401.6 ha			
Stream Order	Sixth			
Flow Frequency	Permanent			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	50 metres width, 8 m depth			
Channel sinuosity	Low			
Average slope	0.5 %			
Adjustment potential	Limited potential to adjust laterally due to cohesive banks being well grassed and good condition riparian vegetation			
Banks	Stable banks consisting of a sandy silt			
Instream Features	Long pools, benches, woody debris			
Floodplain	Largely cleared for agricultural purposes.			
Contextual Notes				


Upstream view


Downstream view

Waterway Crossing – W50				
Waterway	Unnamed tributary of Sweetwater/Black Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined	Downstream	Sweetwater
Land Use	Upstream grazing land, downstream Sweetwater floodplain and channel zone.			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	-			
Adjustment potential	N/A			
Banks	N/A			
Instream Features	N/A			
Floodplain	Upstream largely cleared for grazing purposes.			
Contextual Notes	Flows immediately into Sweetwater Creek on downstream side. This is a Low Sinuosity Fine Grained system with permanent pools separated by muddy bars (some gravel). Dimensions – 8 m wide, 2 m deep.			


Upstream view

Waterway Crossing – W51				
Waterway	Unnamed tributary of Sweetwater/Black Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Valley Fill	Downstream	Sweetwater
Land Use	Rural			
Catchment Area	19.3 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	2 %			
Adjustment potential	N/A			
Banks	N/A			
Instream Features	N/A			
Floodplain	Upstream largely cleared for grazing purposes.			
Contextual Notes	Flows immediately into Sweetwater Creek on downstream side. This is a Low Sinuosity Fine Grained system with permanent pools separated by muddy bars (some gravel). Dimensions – 8 m wide, 2 m deep.			

Upstream view

Upstream view of Sweetwater Creek

Waterway Crossing – W52				
Waterway	Unnamed tributary of Sweetwater/Black Creek			
Waterway Classification	Minor Creek			
Stream Type	Upstream	Valley Fill	Downstream	Valley Fill
Land Use	Grazing			
Catchment Area	42.1 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	02/10/09			
Valley Confinement	Unconfined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	1.9 %			
Adjustment potential	Limited potential to adjust due to flow dissipation over wide area and low gradient.			
Banks	N/A			
Instream Features	N/A			
Floodplain	Largely cleared with pockets of native vegetation.			
Contextual Notes	Scour pool on downstream outlet			


Upstream view


Downstream view

Waterway Crossing – W53				
Waterway	Unnamed tributary of Sweetwater/Black Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Chain of Ponds	Downstream	Chain of Ponds
Land Use	Grazing upstream. Vineyard downstream.			
Catchment Area	196.6 ha			
Stream Order	Third			
Flow Frequency	Near permanent pools			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	3 metres width, 1 metres depth			
Channel sinuosity	Moderate			
Average slope	0.7 %			
Adjustment potential	Moderate potential to adjust due to moderate stability of bank ponds, grazing usage and not continuous riparian vegetation.			
Banks	Composed of sandy clay			
Instream Features	Ponds separated by floodplain.			
Floodplain	Largely cleared for grazing.			
Contextual Notes	Some incision of connectors between ponds, moderate to good condition. Scour hole downstream leading into large dam.			


Upstream view


Downstream view

Waterway Crossing – W54				
Waterway	Unnamed tributary of Sweetwater/Black Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Chain of Ponds	Downstream	Chain of Ponds
Land Use	Grazing			
Catchment Area	148.2 ha			
Stream Order	Third			
Flow Frequency	Near permanent pools			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	< 8 metres width, < 3 metres depth.			
Channel sinuosity	Low			
Average slope	19.3 %			
Adjustment potential	Low potential to adjust due to good condition and sufficient stream bank vegetation.			
Banks	N/A			
Instream Features	Ponds separated by floodplain.			
Floodplain	Native woodland/riparian species with grass understorey downstream.			
Contextual Notes	Good condition			


Upstream view


Downstream view

Waterway Crossing – W55				
Waterway	Unnamed tributary of Sweetwater/Black Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined/Dam	Downstream	Channelised Fill
Land Use	Upstream grazing, Downstream Forested			
Catchment Area	11.4 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Confined			
Channel dimensions	< 8 metres width, < 3 metres depth			
Channel sinuosity	Low			
Average slope	2.1 %			
Adjustment potential	Limited potential to laterally adjust due to confinement however scour can occur vertically			
Banks	Sandy Clay			
Instream Features	Nil			
Floodplain	N/A			
Contextual Notes	Dam on upstream side, downstream man made channel adjacent to rail			


View of culvert


Downstream view

Waterway Crossing – W56				
Waterway	Unnamed tributary of Jump Up Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Undefined/Dams	Downstream	Undefined
Land Use	Forest and Grazing			
Catchment Area	14.7 ha			
Stream Order	Unmapped			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Confined			
Channel dimensions	N/A			
Channel sinuosity	N/A			
Average slope	1.8 %			
Adjustment potential	Low			
Banks	N/A			
Instream Features	N/A			
Floodplain	N/A			
Contextual Notes	Significantly disturbed by existing rail.			

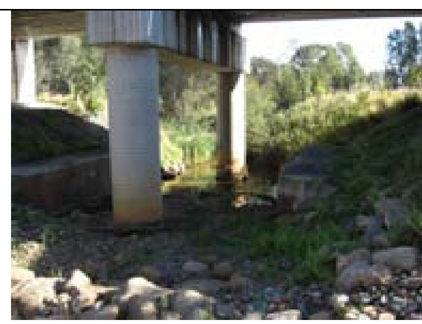

Upstream view

Waterway Crossing – W57				
Waterway	Unnamed tributary of Jump Up Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Valley Fill	Downstream	Partly confined/Channelised fill
Land Use	Upstream grazing, downstream rural			
Catchment Area	309.1 ha			
Stream Order	Third			
Flow Frequency	Ephemeral – permanent standing water			
Site Inspection				
Date	02/10/09			
Valley Confinement	Partly confined			
Channel dimensions	Downstream pool 5 – 10 metres wide, < 2 metres deep			
Channel sinuosity	Low			
Average slope	3.1 %			
Adjustment potential	Partly confined section adjacent to the rail has minimal adjustment potential and abuts the channel margin. High adjustment potential further downstream due gully.			
Banks	Sections of channelised fill bank are vertical, unstable and highly eroded in parts.			
Instream Features	Large pool downstream of existing rail.			
Floodplain	Modified grazing land.			
Contextual Notes	Bedrock exposed in channelised section 50 metres downstream of existing rail. Salt scalding evident in upstream valley fill.			


Downstream view of pool


Upstream view

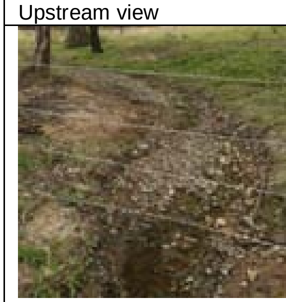
Waterway Crossing – W58				
Waterway	Jump Up Creek			
Waterway Classification	Major Creek			
Stream Type	Upstream	Low Sinuosity Fine Grained	Downstream	Low Sinuosity Fine Grained
Land Use	Rural/Vineyards			
Catchment Area	3028.4 ha			
Stream Order	Fourth			
Flow Frequency	Permanent standing water, no flow.			
Site Inspection				
Date	07/10/09			
Valley Confinement	Unconfined			
Channel dimensions	20 to 30 m wide, 4 to 5 m deep			
Channel sinuosity	Low			
Average slope	0.7 %			
Adjustment potential	Low due to cohesive nature of the banks.			
Banks	The banks are stable and consist of clay and are in good condition			
Instream Features	Reeds, some woody debris, pools, benches			
Floodplain	Connected, vineyards			
Contextual Notes	No flow due to causeway and associated culvert existing above water level. Fish passage obstruction. Well-established riparian vegetation. Site recently disturbed through construction of existing rail bridge.			


Downstream view


Upstream view

Waterway Crossing – W59				
Waterway	Unnamed tributary of Jump Up Creek			
Waterway Classification	Drainage Line			
Stream Type	Upstream	Valley Fill / Dam	Downstream	Channelised Fill/Valley Fill
Land Use	Grazing			
Catchment Area	18.1 ha			
Stream Order	First			
Flow Frequency	Ephemeral			
Site Inspection				
Date	Not inspected			
Valley Confinement	Partly confined			
Channel dimensions	Downstream: < 3 metres, < 1 metres depth (channelised fill)			
Channel sinuosity	Low			
Average slope	4.4 %			
Adjustment potential	Some lateral and vertical adjustment potentialdownstream due to current poor condition of the channel and lack of vegetation.			
Banks	Shallow, convex banks in moderate condition but with potential to become further eroded.			
Instream Features	Nil			
Floodplain	Predominantly grazing pasture			
Contextual Notes	Concrete flume on upstream side of rail.			


Upstream view


Downstream view

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Appendix B

Stony Creek Hydrologic and Hydraulic Models

Catchment Plan

Summary of XP-RAFTS inputs

XP-RAFTS Results

HEC-RAS Results

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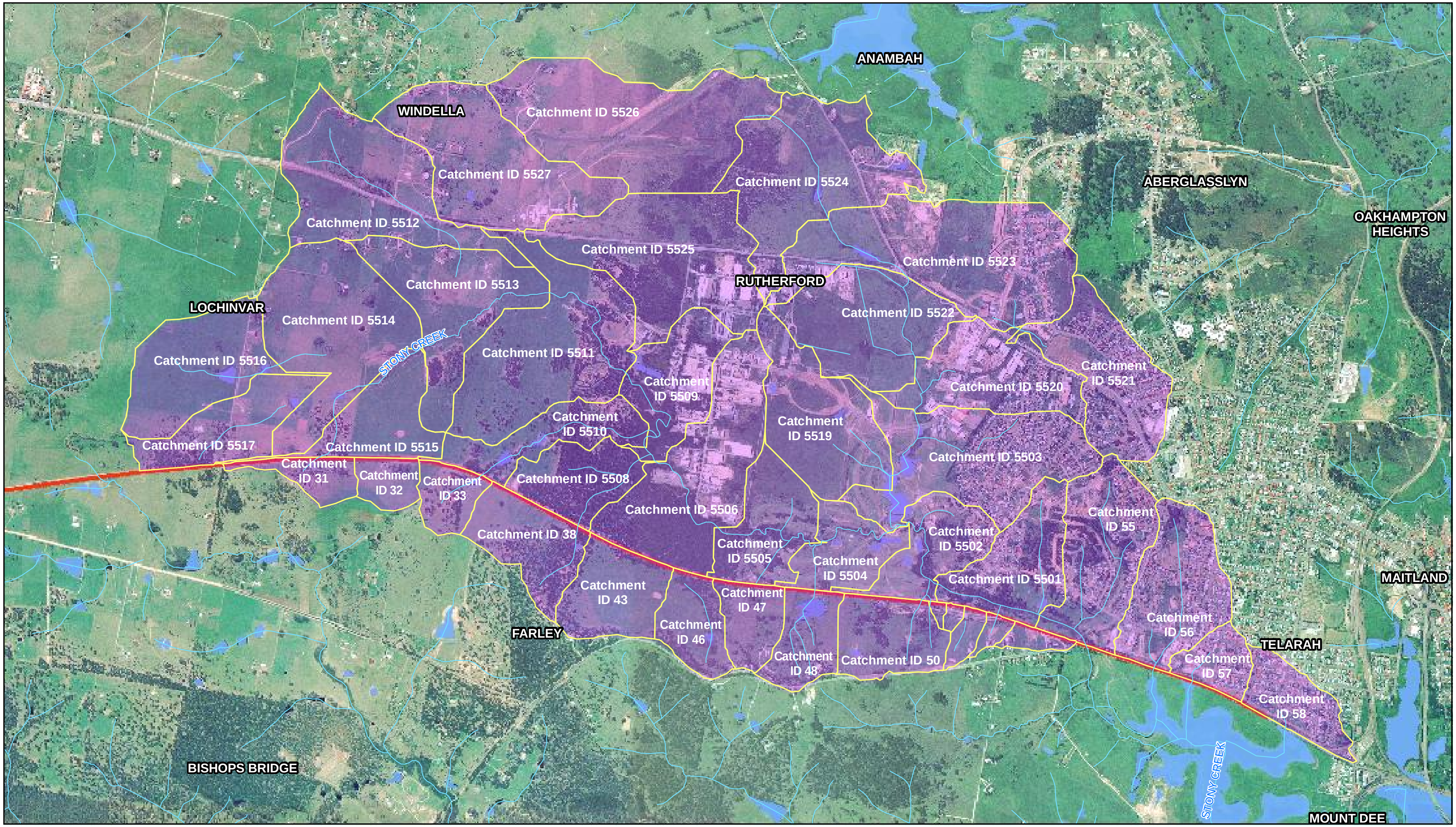

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0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Cadastre
- Subcatchment
- Watercourse Areas
- Watercourse

Maitland To Minimbah Third Track
Surface Water Assessment

Job Number	22-14471
Revision	A
Date	MAY 2010

Stony Creek Catchment Plan

Figure B1

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Stoney_Crk_Catchment_Plan_20091015_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski, gmcdiarmid

Stony Creek XP-RAFTS Model Inputs

Catchment	Area (ha)	Slope %	Percentage Impervious
31	11.37	5.3	10%
32	10.20	5.1	10%
33	13.02	7.4	10%
38	29.62	7.6	10%
43	28.75	10.6	10%
46	19.56	12.1	10%
47	16.36	8.0	10%
48	19.83	10.2	20%
49	1.02	14.6	20%
50	27.22	8.4	20%
51	1.51	14.7	20%
52	4.90	10.9	20%
53	2.99	11.2	30%
54	4.50	8.3	70%
55	47.71	11.6	30%
5501	35.70	13.0	70%
5502	27.52	7.8	70%
5503	68.35	5.4	50%
5504	23.63	4.1	20%
5505	31.82	3.2	20%
5506	67.30	2.3	50%
5508	26.12	3.7	10%
5509	32.98	2.3	30%
5510	27.08	3.6	10%

Catchment	Area (ha)	Slope %	Percentage Impervious
5511	74.70	1.5	10%
5512	66.19	6.1	10%
5513	52.14	2.2	10%
5514	68.99	4.4	10%
5515	29.48	2.9	10%
5516	45.97	5.2	10%
5517	30.73	3.3	10%
5519	49.59	1.3	50%
5520	42.27	3.7	50%
5521	45.82	6.3	70%
5522	52.02	1.3	50%
5523	87.78	3.5	30%
5524	68.70	1.1	10%
5525	73.00	0.5	30%
5526	87.25	1.5	10%
5527	66.46	4.1	20%

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 Run started at:  2nd  November  2009  11:48:46


#####################################################################################
                        RUNTIME          RESULTS
#####################################################################################


Max. no. of links allowed =       1500


Max. no. of routng increments allowed =     250000


Max. no. of rating curve points =     250000


Max. no. of storm temporal points =     250000


Max. no. of channel subreaches =         25


Max link stack level =         25


Input Version number =          700


 LINK n200.12           1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                      13.45
 ESTIMATED PEAK FLOW         (CUMECS) =                      1.8
 ESTIMATED TIME TO PEAK         (MINS) =                  120.00

 LINK n199.85           1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                      12.06
 ESTIMATED PEAK FLOW         (CUMECS) =                      1.7
 ESTIMATED TIME TO PEAK         (MINS) =                  120.00

 LINK n5515             1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                      60.33
 ESTIMATED PEAK FLOW         (CUMECS) =                      7.3
 ESTIMATED TIME TO PEAK         (MINS) =                  138.00

 LINK n5517             1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                      36.36
 ESTIMATED PEAK FLOW         (CUMECS) =                      4.1
 ESTIMATED TIME TO PEAK         (MINS) =                  135.00

 LINK n5516             1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                      90.70
 ESTIMATED PEAK FLOW         (CUMECS) =                      11.
 ESTIMATED TIME TO PEAK         (MINS) =                  120.00

 LINK n5514             1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                      232.6
 ESTIMATED PEAK FLOW         (CUMECS) =                      26.
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ESTIMATED TIME TO PEAK         (MINS) =              150.00

LINK n5513              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  294.1
ESTIMATED PEAK FLOW         (CUMECS) =                  30.
ESTIMATED TIME TO PEAK         (MINS) =              203.00

LINK n5512              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  78.27
ESTIMATED PEAK FLOW         (CUMECS) =                  9.5
ESTIMATED TIME TO PEAK         (MINS) =              120.00

LINK n5511              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  460.3
ESTIMATED PEAK FLOW         (CUMECS) =                  38.
ESTIMATED TIME TO PEAK         (MINS) =              241.00

LINK n198.56            1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  35.03
ESTIMATED PEAK FLOW         (CUMECS) =                  4.7
ESTIMATED TIME TO PEAK         (MINS) =              120.00

LINK n5508              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  526.0
ESTIMATED PEAK FLOW         (CUMECS) =                  40.
ESTIMATED TIME TO PEAK         (MINS) =              286.00

LINK n199.24            1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  15.40
ESTIMATED PEAK FLOW         (CUMECS) =                  2.2
ESTIMATED TIME TO PEAK         (MINS) =              120.00

LINK n5510              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  47.40
ESTIMATED PEAK FLOW         (CUMECS) =                  5.7
ESTIMATED TIME TO PEAK         (MINS) =              146.00

LINK n5509              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  87.86
ESTIMATED PEAK FLOW         (CUMECS) =                  9.8
ESTIMATED TIME TO PEAK         (MINS) =              149.00

LINK n197.909           1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  23.13
ESTIMATED PEAK FLOW         (CUMECS) =                  3.3
ESTIMATED TIME TO PEAK         (MINS) =              120.00

LINK n198.04            1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  34.00
ESTIMATED PEAK FLOW         (CUMECS) =                  4.8
ESTIMATED TIME TO PEAK         (MINS) =              120.00

LINK n5506              1.000
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ESTIMATED VOLUME (CU METRES*10**3) =                       756.3
ESTIMATED PEAK FLOW         (CUMECS) =                       47.
ESTIMATED TIME TO PEAK         (MINS) =                   321.00

LINK n197.487          1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       19.27
ESTIMATED PEAK FLOW         (CUMECS) =                       2.7
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n5505             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       813.9
ESTIMATED PEAK FLOW         (CUMECS) =                       48.
ESTIMATED TIME TO PEAK         (MINS) =                   321.00

LINK n197.165          1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       23.89
ESTIMATED PEAK FLOW         (CUMECS) =                       3.4
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n5504             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       866.1
ESTIMATED PEAK FLOW         (CUMECS) =                       49.
ESTIMATED TIME TO PEAK         (MINS) =                   353.00

LINK n196.561          1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       32.80
ESTIMATED PEAK FLOW         (CUMECS) =                       4.5
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n196.481          1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       1.228
ESTIMATED PEAK FLOW         (CUMECS) =                      0.18
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n5521             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       60.30
ESTIMATED PEAK FLOW         (CUMECS) =                       8.1
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n5527             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       80.01
ESTIMATED PEAK FLOW         (CUMECS) =                       9.0
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n5526             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       182.6
ESTIMATED PEAK FLOW         (CUMECS) =                       17.
ESTIMATED TIME TO PEAK         (MINS) =                   176.00

LINK n5525             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       89.06
ESTIMATED PEAK FLOW         (CUMECS) =                       6.4
ESTIMATED TIME TO PEAK         (MINS) =                   150.00
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LINK n5524              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       352.5
ESTIMATED PEAK FLOW         (CUMECS) =                       27.
ESTIMATED TIME TO PEAK         (MINS) =                   216.00

LINK n5523              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       459.9
ESTIMATED PEAK FLOW         (CUMECS) =                       31.
ESTIMATED TIME TO PEAK         (MINS) =                   266.00

LINK n5522              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       525.7
ESTIMATED PEAK FLOW         (CUMECS) =                       32.
ESTIMATED TIME TO PEAK         (MINS) =                   300.00

LINK n5520              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       639.6
ESTIMATED PEAK FLOW         (CUMECS) =                       36.
ESTIMATED TIME TO PEAK         (MINS) =                   291.00

LINK n5519              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       702.3
ESTIMATED PEAK FLOW         (CUMECS) =                       38.
ESTIMATED TIME TO PEAK         (MINS) =                   323.00

LINK n5503              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       789.0
ESTIMATED PEAK FLOW         (CUMECS) =                       39.
ESTIMATED TIME TO PEAK         (MINS) =                   339.00

LINK n5502              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       1725.
ESTIMATED PEAK FLOW         (CUMECS) =                       88.
ESTIMATED TIME TO PEAK         (MINS) =                   373.00

LINK n196.069           1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       3.669
ESTIMATED PEAK FLOW         (CUMECS) =                      0.52
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n196.280           1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       5.904
ESTIMATED PEAK FLOW         (CUMECS) =                      0.85
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n196.340           1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       1.819
ESTIMATED PEAK FLOW         (CUMECS) =                      0.26
ESTIMATED TIME TO PEAK         (MINS) =                   120.00

LINK n5501              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                       1782.
ESTIMATED PEAK FLOW         (CUMECS) =                       88.
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ESTIMATED TIME TO PEAK (MINS) = 412.00

LINK n54 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 5.922
ESTIMATED PEAK FLOW (CUMECS) = 0.80
ESTIMATED TIME TO PEAK (MINS) = 120.00

LINK n195.550 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 1846.
ESTIMATED PEAK FLOW (CUMECS) = 88.
ESTIMATED TIME TO PEAK (MINS) = 433.00

###
Stony Creek Hydrologic Model

Results for period from 0: 1.0 28/ 7/2009
to 15: 1.0 28/ 7/2009
###

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 360.
RETURN PERIOD (YRS) = 100.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (ha) = 1121.65
TOTAL OF SECOND SUB-AREAS (ha) = 398.44
TOTAL OF ALL SUB-AREAS (ha) = 1520.09

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
n200.12	10.230	1.140	5.300	5.300	0.000	100.0	.050	.015	.0632	.0007	1.000
n199.85	9.180	1.020	5.100	5.100	0.000	100.0	.050	.015	.0609	.0007	2.000
n5515	26.500	2.950	2.900	2.900	0.000	100.0	.050	.015	.1400	.0015	1.001
n5517	27.660	3.100	3.300	3.300	0.000	100.0	.050	.015	.1342	.0015	3.000
n5516	41.370	4.600	5.200	5.200	0.000	100.0	.050	.015	.1319	.0014	3.001
n5514	62.090	6.900	4.400	4.400	0.000	100.0	.050	.015	.1770	.0019	1.002
n5513	46.930	5.200	2.200	2.200	0.000	100.0	.050	.015	.2163	.0024	1.003
n5512	59.600	6.600	6.100	6.100	0.000	100.0	.050	.015	.1472	.0016	4.000
n5511	67.230	7.470	1.500	1.500	0.000	100.0	.050	.015	.3156	.0035	1.004
n198.56	26.660	2.960	7.600	7.600	0.000	100.0	.050	.015	.0868	.0010	5.000
n5508	23.510	2.610	3.700	3.700	0.000	100.0	.050	.015	.1165	.0013	1.005
n199.24	11.720	1.300	7.400	7.400	0.000	100.0	.050	.015	.0574	.0006	6.000
n5510	24.370	2.710	3.600	3.600	0.000	100.0	.050	.015	.1203	.0013	6.001
n5509	23.090	9.890	2.300	2.300	0.000	100.0	.035	.015	.1112	.0032	6.002
n197.909	17.600	1.960	12.10	12.10	0.000	100.0	.050	.015	.0555	.0006	7.000
n198.04	25.870	2.880	10.60	10.60	0.000	100.0	.050	.015	.0724	.0008	8.000
n5506	33.650	33.650	2.300	2.300	0.000	100.0	.035	.015	.1352	.0061	1.006
n197.487	14.700	1.600	8.000	8.000	0.000	100.0	.050	.015	.0621	.0007	9.000
n5505	25.460	6.360	3.200	3.200	0.000	100.0	.035	.015	.0992	.0022	1.007
n197.165	15.860	3.970	10.20	10.20	0.000	100.0	.050	.015	.0572	.0010	10.00
n5504	18.900	4.730	4.100	4.100	0.000	100.0	.035	.015	.0751	.0017	1.008
n196.561	21.780	5.440	8.400	8.400	0.000	100.0	.050	.015	.0743	.0012	11.00
n196.481	0.8200	0.2000	14.60	14.60	0.000	100.0	.050	.015	.0103	.0002	12.00
n5521	13.750	32.070	6.300	6.300	0.000	100.0	.035	.015	.0514	.0036	13.00
n5527	53.170	13.290	4.100	4.100	0.000	100.0	.050	.015	.1691	.0028	14.00
n5526	78.520	8.730	1.500	1.500	0.000	100.0	.050	.015	.3421	.0038	14.00

n5525	51.100	21.900	.5000	.5000	0.000	100.0	.035	.015	.3598	.0105	15.00
n5524	61.830	6.870	1.100	1.100	0.000	100.0	.035	.015	.2681	.0039	14.00
n5523	61.450	26.330	3.500	3.500	0.000	100.0	.035	.015	.1500	.0044	14.00
n5522	26.010	26.010	1.300	1.300	0.000	100.0	.035	.015	.1572	.0071	14.00
n5520	21.130	21.140	3.700	3.700	0.000	100.0	.035	.015	.0837	.0038	13.00
n5519	24.790	24.800	1.300	1.300	0.000	100.0	.035	.015	.1533	.0069	13.00
n5503	34.180	34.170	5.400	5.400	0.000	100.0	.035	.015	.0890	.0040	13.00
n5502	8.260	19.260	7.800	7.800	0.000	100.0	.035	.015	.0354	.0025	1.009
n196.069	2.090	0.9000	11.20	11.20	0.000	100.0	.050	.015	.0190	.0004	16.00
n196.280	3.920	0.9800	10.90	10.90	0.000	100.0	.050	.015	.0268	.0004	17.00
n196.340	1.210	0.3000	14.70	14.70	0.000	100.0	.050	.015	.0125	.0002	18.00
n5501	10.710	24.990	13.00	13.00	0.000	100.0	.035	.015	.0314	.0022	1.010
n54	1.350	3.150	8.300	8.300	0.000	100.0	.050	.015	.0176	.0009	19.00
n195.550	33.400	14.310	11.60	11.60	0.000	100.0	.035	.015	.0601	.0017	1.011

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2 (mm)	Cont. Loss #1 (mm/h)	Cont. Loss #2 (mm/h)	Excess Rain #1 (mm)	Excess Rain #2 (mm)	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
n200.12	23.221	10.00	1.000	2.500	0.000	116.03	138.32	1.847	120.0	21.00
n199.85	23.221	10.00	1.000	2.500	0.000	116.03	138.32	1.656	120.0	18.00
n5515	23.221	10.00	1.000	2.500	0.000	116.03	138.32	7.269	138.0	0.000
n5517	23.221	10.00	1.000	2.500	0.000	116.03	138.32	4.058	135.0	0.000
n5516	23.221	10.00	1.000	2.500	0.000	116.03	138.32	10.611	120.0	32.00
n5514	23.221	10.00	1.000	2.500	0.000	116.03	138.32	25.905	150.0	53.00
n5513	23.221	10.00	1.000	2.500	0.000	116.03	138.32	29.676	203.0	44.00
n5512	23.221	10.00	1.000	2.500	0.000	116.03	138.32	9.493	120.0	44.00
n5511	23.221	10.00	1.000	2.500	0.000	116.03	138.32	37.886	241.0	45.00
n198.56	23.221	10.00	1.000	2.500	0.000	116.03	138.32	4.725	120.0	18.00
n5508	23.221	10.00	1.000	2.500	0.000	116.03	138.32	40.045	286.0	35.00
n199.24	23.221	10.00	1.000	2.500	0.000	116.03	138.32	2.186	120.0	28.00
n5510	23.221	10.00	1.000	2.500	0.000	116.03	138.32	5.678	146.0	9.000
n5509	23.221	10.00	1.000	2.500	0.000	116.03	138.32	9.763	149.0	35.00
n197.909	23.221	10.00	1.000	2.500	0.000	116.03	138.32	3.332	120.0	29.00
n198.04	23.221	10.00	1.000	2.500	0.000	116.03	138.32	4.790	120.0	29.00
n5506	23.221	10.00	1.000	2.500	0.000	116.03	138.32	46.775	321.0	0.000
n197.487	23.221	10.00	1.000	2.500	0.000	116.03	138.32	2.716	120.0	33.00
n5505	23.221	10.00	1.000	2.500	0.000	116.03	138.32	48.313	321.0	34.00
n197.165	23.221	10.00	1.000	2.500	0.000	116.03	138.32	3.379	120.0	53.00
n5504	23.221	10.00	1.000	2.500	0.000	116.03	138.32	49.475	353.0	26.00
n196.561	23.221	10.00	1.000	2.500	0.000	116.03	138.32	4.496	120.0	4.000
n196.481	23.221	10.00	1.000	2.500	0.000	116.03	138.32	0.1782	120.0	4.000
n5521	23.221	10.00	1.000	2.500	0.000	116.03	138.32	8.117	120.0	52.00
n5527	23.221	10.00	1.000	2.500	0.000	116.03	138.32	8.955	120.0	56.00
n5526	23.221	10.00	1.000	2.500	0.000	116.03	138.32	16.849	176.0	40.00
n5525	23.221	10.00	1.000	2.500	0.000	116.03	138.32	6.436	150.0	38.00
n5524	23.221	10.00	1.000	2.500	0.000	116.03	138.32	27.102	216.0	50.00
n5523	23.221	10.00	1.000	2.500	0.000	116.03	138.32	30.658	266.0	40.00
n5522	23.221	10.00	1.000	2.500	0.000	116.03	138.32	32.458	300.0	12.00
n5520	23.221	10.00	1.000	2.500	0.000	116.03	138.32	36.293	291.0	32.00
n5519	23.221	10.00	1.000	2.500	0.000	116.03	138.32	37.690	323.0	16.00
n5503	23.221	10.00	1.000	2.500	0.000	116.03	138.32	38.891	339.0	34.00
n5502	23.221	10.00	1.000	2.500	0.000	116.03	138.32	88.267	373.0	39.00
n196.069	23.221	10.00	1.000	2.500	0.000	116.03	138.32	0.5242	120.0	16.00
n196.280	23.221	10.00	1.000	2.500	0.000	116.03	138.32	0.8545	120.0	30.00
n196.340	23.221	10.00	1.000	2.500	0.000	116.03	138.32	0.2638	120.0	34.00
n5501	23.221	10.00	1.000	2.500	0.000	116.03	138.32	88.308	412.0	21.00
n54	23.221	10.00	1.000	2.500	0.000	116.03	138.32	0.8017	120.0	2.000
n195.550	23.221	10.00	1.000	2.500	0.000	116.03	138.32	88.345	433.0	0.000

LINK n200.12 2.000

ESTIMATED VOLUME (CU METRES*10**3) = 15.48

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ESTIMATED PEAK FLOW         (CUMECS) =                   1.6
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n199.85           2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   13.89
ESTIMATED PEAK FLOW         (CUMECS) =                   1.4
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n5515             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   69.40
ESTIMATED PEAK FLOW         (CUMECS) =                   6.5
ESTIMATED TIME TO PEAK         (MINS) =                321.00

LINK n5517             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   41.84
ESTIMATED PEAK FLOW         (CUMECS) =                   3.7
ESTIMATED TIME TO PEAK         (MINS) =                325.00

LINK n5516             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   104.4
ESTIMATED PEAK FLOW         (CUMECS) =                   9.4
ESTIMATED TIME TO PEAK         (MINS) =                319.00

LINK n5514             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   267.5
ESTIMATED PEAK FLOW         (CUMECS) =                   24.
ESTIMATED TIME TO PEAK         (MINS) =                330.00

LINK n5513             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   338.2
ESTIMATED PEAK FLOW         (CUMECS) =                   27.
ESTIMATED TIME TO PEAK         (MINS) =                383.00

LINK n5512             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   90.06
ESTIMATED PEAK FLOW         (CUMECS) =                   8.3
ESTIMATED TIME TO PEAK         (MINS) =                315.00

LINK n5511             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   529.0
ESTIMATED PEAK FLOW         (CUMECS) =                   34.
ESTIMATED TIME TO PEAK         (MINS) =                427.00

LINK n198.56           2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   40.31
ESTIMATED PEAK FLOW         (CUMECS) =                   4.1
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n5508             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                   604.4
ESTIMATED PEAK FLOW         (CUMECS) =                   35.
ESTIMATED TIME TO PEAK         (MINS) =                472.00

LINK n199.24           2.000
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ESTIMATED VOLUME (CU METRES*10**3) =                    17.72
ESTIMATED PEAK FLOW         (CUMECS) =                    1.9
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n5510             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    54.56
ESTIMATED PEAK FLOW         (CUMECS) =                    5.2
ESTIMATED TIME TO PEAK         (MINS) =                328.00

LINK n5509             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    101.4
ESTIMATED PEAK FLOW         (CUMECS) =                    9.1
ESTIMATED TIME TO PEAK         (MINS) =                330.00

LINK n197.909          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    26.63
ESTIMATED PEAK FLOW         (CUMECS) =                    2.9
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n198.04           2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    39.13
ESTIMATED PEAK FLOW         (CUMECS) =                    4.2
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n5506             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    870.4
ESTIMATED PEAK FLOW         (CUMECS) =                    45.
ESTIMATED TIME TO PEAK         (MINS) =                357.00

LINK n197.487          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    22.19
ESTIMATED PEAK FLOW         (CUMECS) =                    2.4
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n5505             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    936.9
ESTIMATED PEAK FLOW         (CUMECS) =                    49.
ESTIMATED TIME TO PEAK         (MINS) =                357.00

LINK n197.165          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    27.57
ESTIMATED PEAK FLOW         (CUMECS) =                    3.0
ESTIMATED TIME TO PEAK         (MINS) =                300.00

LINK n5504             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    996.6
ESTIMATED PEAK FLOW         (CUMECS) =                    53.
ESTIMATED TIME TO PEAK         (MINS) =                364.00

LINK n196.561          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    37.86
ESTIMATED PEAK FLOW         (CUMECS) =                    3.9
ESTIMATED TIME TO PEAK         (MINS) =                300.00
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LINK n196.481          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 1.417
ESTIMATED PEAK FLOW         (CUMECS) =                0.16
ESTIMATED TIME TO PEAK         (MINS) =             299.00

LINK n5521             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 70.50
ESTIMATED PEAK FLOW         (CUMECS) =                 7.2
ESTIMATED TIME TO PEAK         (MINS) =             300.00

LINK n5527             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 92.32
ESTIMATED PEAK FLOW         (CUMECS) =                 8.0
ESTIMATED TIME TO PEAK         (MINS) =             327.00

LINK n5526             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 210.2
ESTIMATED PEAK FLOW         (CUMECS) =                 15.
ESTIMATED TIME TO PEAK         (MINS) =             356.00

LINK n5525             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 102.8
ESTIMATED PEAK FLOW         (CUMECS) =                 7.1
ESTIMATED TIME TO PEAK         (MINS) =             330.00

LINK n5524             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 405.8
ESTIMATED PEAK FLOW         (CUMECS) =                 26.
ESTIMATED TIME TO PEAK         (MINS) =             369.00

LINK n5523             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 529.8
ESTIMATED PEAK FLOW         (CUMECS) =                 29.
ESTIMATED TIME TO PEAK         (MINS) =             419.00

LINK n5522             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 605.8
ESTIMATED PEAK FLOW         (CUMECS) =                 30.
ESTIMATED TIME TO PEAK         (MINS) =             459.00

LINK n5520             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 738.5
ESTIMATED PEAK FLOW         (CUMECS) =                 37.
ESTIMATED TIME TO PEAK         (MINS) =             352.00

LINK n5519             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 810.8
ESTIMATED PEAK FLOW         (CUMECS) =                 40.
ESTIMATED TIME TO PEAK         (MINS) =             384.00

LINK n5503             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 911.4
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ESTIMATED PEAK FLOW         (CUMECS) =                  42.
ESTIMATED TIME TO PEAK         (MINS) =             390.00

LINK n5502             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 1987.
ESTIMATED PEAK FLOW         (CUMECS) =                  95.
ESTIMATED TIME TO PEAK         (MINS) =             412.00

LINK n196.069          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 4.248
ESTIMATED PEAK FLOW         (CUMECS) =                0.46
ESTIMATED TIME TO PEAK         (MINS) =             300.00

LINK n196.280          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 6.818
ESTIMATED PEAK FLOW         (CUMECS) =                0.75
ESTIMATED TIME TO PEAK         (MINS) =             300.00

LINK n196.340          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 2.100
ESTIMATED PEAK FLOW         (CUMECS) =                0.23
ESTIMATED TIME TO PEAK         (MINS) =             300.00

LINK n5501             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 2051.
ESTIMATED PEAK FLOW         (CUMECS) =                  96.
ESTIMATED TIME TO PEAK         (MINS) =             451.00

LINK n54               2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 6.924
ESTIMATED PEAK FLOW         (CUMECS) =                0.71
ESTIMATED TIME TO PEAK         (MINS) =             300.00

LINK n195.550          2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 2122.
ESTIMATED PEAK FLOW         (CUMECS) =                  97.
ESTIMATED TIME TO PEAK         (MINS) =             472.00


#####################################################################################
Stony Creek Hydrologic Model

Results for period from  0: 1.0 28/ 7/2009
                     to 15: 1.0 28/ 7/2009
#####################################################################################

                               ROUTING INCREMENT (MINS) =       1.00
                               STORM DURATION (MINS)    =       540.
                               RETURN PERIOD (YRS)      =       100.
                               BX                       =     1.0000
                               TOTAL OF FIRST SUB-AREAS  (ha) =    1121.65
                               TOTAL OF SECOND SUB-AREAS (ha) =     398.44
                               TOTAL OF ALL SUB-AREAS (ha)    =    1520.09
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SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
n200.12	10.230	1.140	5.300	5.300	0.000	100.0	.050	.015	.0632	.0007	1.000
n199.85	9.180	1.020	5.100	5.100	0.000	100.0	.050	.015	.0609	.0007	2.000
n5515	26.500	2.950	2.900	2.900	0.000	100.0	.050	.015	.1400	.0015	1.001
n5517	27.660	3.100	3.300	3.300	0.000	100.0	.050	.015	.1342	.0015	3.000
n5516	41.370	4.600	5.200	5.200	0.000	100.0	.050	.015	.1319	.0014	3.001
n5514	62.090	6.900	4.400	4.400	0.000	100.0	.050	.015	.1770	.0019	1.002
n5513	46.930	5.200	2.200	2.200	0.000	100.0	.050	.015	.2163	.0024	1.003
n5512	59.600	6.600	6.100	6.100	0.000	100.0	.050	.015	.1472	.0016	4.000
n5511	67.230	7.470	1.500	1.500	0.000	100.0	.050	.015	.3156	.0035	1.004
n198.56	26.660	2.960	7.600	7.600	0.000	100.0	.050	.015	.0868	.0010	5.000
n5508	23.510	2.610	3.700	3.700	0.000	100.0	.050	.015	.1165	.0013	1.005
n199.24	11.720	1.300	7.400	7.400	0.000	100.0	.050	.015	.0574	.0006	6.000
n5510	24.370	2.710	3.600	3.600	0.000	100.0	.050	.015	.1203	.0013	6.001
n5509	23.090	9.890	2.300	2.300	0.000	100.0	.035	.015	.1112	.0032	6.002
n197.909	17.600	1.960	12.10	12.10	0.000	100.0	.050	.015	.0555	.0006	7.000
n198.04	25.870	2.880	10.60	10.60	0.000	100.0	.050	.015	.0724	.0008	8.000
n5506	33.650	33.650	2.300	2.300	0.000	100.0	.035	.015	.1352	.0061	1.006
n197.487	14.700	1.600	8.000	8.000	0.000	100.0	.050	.015	.0621	.0007	9.000
n5505	25.460	6.360	3.200	3.200	0.000	100.0	.035	.015	.0992	.0022	1.007
n197.165	15.860	3.970	10.20	10.20	0.000	100.0	.050	.015	.0572	.0010	10.00
n5504	18.900	4.730	4.100	4.100	0.000	100.0	.035	.015	.0751	.0017	1.008
n196.561	21.780	5.440	8.400	8.400	0.000	100.0	.050	.015	.0743	.0012	11.00
n196.481	0.8200	0.2000	14.60	14.60	0.000	100.0	.050	.015	.0103	.0002	12.00
n5521	13.750	32.070	6.300	6.300	0.000	100.0	.035	.015	.0514	.0036	13.00
n5527	53.170	13.290	4.100	4.100	0.000	100.0	.050	.015	.1691	.0028	14.00
n5526	78.520	8.730	1.500	1.500	0.000	100.0	.050	.015	.3421	.0038	14.00
n5525	51.100	21.900	.5000	.5000	0.000	100.0	.035	.015	.3598	.0105	15.00
n5524	61.830	6.870	1.100	1.100	0.000	100.0	.035	.015	.2681	.0039	14.00
n5523	61.450	26.330	3.500	3.500	0.000	100.0	.035	.015	.1500	.0044	14.00
n5522	26.010	26.010	1.300	1.300	0.000	100.0	.035	.015	.1572	.0071	14.00
n5520	21.130	21.140	3.700	3.700	0.000	100.0	.035	.015	.0837	.0038	13.00
n5519	24.790	24.800	1.300	1.300	0.000	100.0	.035	.015	.1533	.0069	13.00
n5503	34.180	34.170	5.400	5.400	0.000	100.0	.035	.015	.0890	.0040	13.00
n5502	8.260	19.260	7.800	7.800	0.000	100.0	.035	.015	.0354	.0025	1.009
n196.069	2.090	0.9000	11.20	11.20	0.000	100.0	.050	.015	.0190	.0004	16.00
n196.280	3.920	0.9800	10.90	10.90	0.000	100.0	.050	.015	.0268	.0004	17.00
n196.340	1.210	0.3000	14.70	14.70	0.000	100.0	.050	.015	.0125	.0002	18.00
n5501	10.710	24.990	13.00	13.00	0.000	100.0	.035	.015	.0314	.0022	1.010
n54	1.350	3.150	8.300	8.300	0.000	100.0	.050	.015	.0176	.0009	19.00
n195.550	33.400	14.310	11.60	11.60	0.000	100.0	.035	.015	.0601	.0017	1.011

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
n200.12	18.195	10.00	1.000	2.500	0.000	133.21	162.76	1.592	300.0	21.00
n199.85	18.195	10.00	1.000	2.500	0.000	133.21	162.76	1.431	300.0	18.00
n5515	18.195	10.00	1.000	2.500	0.000	133.21	162.76	6.503	321.0	0.000
n5517	18.195	10.00	1.000	2.500	0.000	133.21	162.76	3.730	325.0	0.000
n5516	18.195	10.00	1.000	2.500	0.000	133.21	162.76	9.425	319.0	32.00
n5514	18.195	10.00	1.000	2.500	0.000	133.21	162.76	23.514	330.0	53.00
n5513	18.195	10.00	1.000	2.500	0.000	133.21	162.76	27.087	383.0	44.00
n5512	18.195	10.00	1.000	2.500	0.000	133.21	162.76	8.254	315.0	44.00
n5511	18.195	10.00	1.000	2.500	0.000	133.21	162.76	34.306	427.0	45.00
n198.56	18.195	10.00	1.000	2.500	0.000	133.21	162.76	4.059	300.0	18.00
n5508	18.195	10.00	1.000	2.500	0.000	133.21	162.76	35.389	472.0	35.00
n199.24	18.195	10.00	1.000	2.500	0.000	133.21	162.76	1.901	300.0	28.00
n5510	18.195	10.00	1.000	2.500	0.000	133.21	162.76	5.205	328.0	9.000
n5509	18.195	10.00	1.000	2.500	0.000	133.21	162.76	9.074	330.0	35.00

n197.909	18.195	10.00	1.000	2.500	0.000	133.21	162.76	2.925	300.0	29.00
n198.04	18.195	10.00	1.000	2.500	0.000	133.21	162.76	4.159	300.0	29.00
n5506	18.195	10.00	1.000	2.500	0.000	133.21	162.76	44.704	357.0	0.000
n197.487	18.195	10.00	1.000	2.500	0.000	133.21	162.76	2.371	300.0	33.00
n5505	18.195	10.00	1.000	2.500	0.000	133.21	162.76	48.881	357.0	34.00
n197.165	18.195	10.00	1.000	2.500	0.000	133.21	162.76	2.967	300.0	53.00
n5504	18.195	10.00	1.000	2.500	0.000	133.21	162.76	52.658	364.0	26.00
n196.561	18.195	10.00	1.000	2.500	0.000	133.21	162.76	3.911	300.0	4.000
n196.481	18.195	10.00	1.000	2.500	0.000	133.21	162.76	0.1576	299.0	4.000
n5521	18.195	10.00	1.000	2.500	0.000	133.21	162.76	7.184	300.0	52.00
n5527	18.195	10.00	1.000	2.500	0.000	133.21	162.76	7.986	327.0	56.00
n5526	18.195	10.00	1.000	2.500	0.000	133.21	162.76	15.356	356.0	40.00
n5525	18.195	10.00	1.000	2.500	0.000	133.21	162.76	7.060	330.0	38.00
n5524	18.195	10.00	1.000	2.500	0.000	133.21	162.76	25.807	369.0	50.00
n5523	18.195	10.00	1.000	2.500	0.000	133.21	162.76	28.847	419.0	40.00
n5522	18.195	10.00	1.000	2.500	0.000	133.21	162.76	30.105	459.0	12.00
n5520	18.195	10.00	1.000	2.500	0.000	133.21	162.76	37.158	352.0	32.00
n5519	18.195	10.00	1.000	2.500	0.000	133.21	162.76	39.931	384.0	16.00
n5503	18.195	10.00	1.000	2.500	0.000	133.21	162.76	42.418	390.0	34.00
n5502	18.195	10.00	1.000	2.500	0.000	133.21	162.76	95.400	412.0	39.00
n196.069	18.195	10.00	1.000	2.500	0.000	133.21	162.76	0.4638	300.0	16.00
n196.280	18.195	10.00	1.000	2.500	0.000	133.21	162.76	0.7549	300.0	30.00
n196.340	18.195	10.00	1.000	2.500	0.000	133.21	162.76	0.2333	300.0	34.00
n5501	18.195	10.00	1.000	2.500	0.000	133.21	162.76	96.353	451.0	21.00
n54	18.195	10.00	1.000	2.500	0.000	133.21	162.76	0.7104	300.0	2.000
n195.550	18.195	10.00	1.000	2.500	0.000	133.21	162.76	97.297	472.0	0.000

LINK n200.12 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 17.09
ESTIMATED PEAK FLOW (CUMECS) = 1.7
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK n199.85 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 15.33
ESTIMATED PEAK FLOW (CUMECS) = 1.5
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK n5515 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 76.67
ESTIMATED PEAK FLOW (CUMECS) = 6.0
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK n5517 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 46.22
ESTIMATED PEAK FLOW (CUMECS) = 3.9
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK n5516 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 115.3
ESTIMATED PEAK FLOW (CUMECS) = 10.
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK n5514 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 295.7
ESTIMATED PEAK FLOW (CUMECS) = 20.
ESTIMATED TIME TO PEAK (MINS) = 438.00

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LINK n5513              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    374.0
ESTIMATED PEAK FLOW         (CUMECS) =                    23.
ESTIMATED TIME TO PEAK         (MINS) =                 474.00

LINK n5512              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    99.43
ESTIMATED PEAK FLOW         (CUMECS) =                    8.9
ESTIMATED TIME TO PEAK         (MINS) =                 420.00

LINK n5511              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    585.6
ESTIMATED PEAK FLOW         (CUMECS) =                    29.
ESTIMATED TIME TO PEAK         (MINS) =                 518.00

LINK n198.56            3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    44.53
ESTIMATED PEAK FLOW         (CUMECS) =                    4.3
ESTIMATED TIME TO PEAK         (MINS) =                 420.00

LINK n5508              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    669.3
ESTIMATED PEAK FLOW         (CUMECS) =                    34.
ESTIMATED TIME TO PEAK         (MINS) =                 564.00

LINK n199.24            3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    19.56
ESTIMATED PEAK FLOW         (CUMECS) =                    1.9
ESTIMATED TIME TO PEAK         (MINS) =                 420.00

LINK n5510              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    60.25
ESTIMATED PEAK FLOW         (CUMECS) =                    4.7
ESTIMATED TIME TO PEAK         (MINS) =                 420.00

LINK n5509              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    112.2
ESTIMATED PEAK FLOW         (CUMECS) =                    8.8
ESTIMATED TIME TO PEAK         (MINS) =                 420.00

LINK n197.909           3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    29.40
ESTIMATED PEAK FLOW         (CUMECS) =                    3.0
ESTIMATED TIME TO PEAK         (MINS) =                 420.00

LINK n198.04            3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    43.21
ESTIMATED PEAK FLOW         (CUMECS) =                    4.3
ESTIMATED TIME TO PEAK         (MINS) =                 420.00

LINK n5506              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    964.9
ESTIMATED PEAK FLOW         (CUMECS) =                    45.
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ESTIMATED TIME TO PEAK         (MINS) =              600.00

LINK n197.487          3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  24.50
ESTIMATED PEAK FLOW         (CUMECS) =                  2.4
ESTIMATED TIME TO PEAK         (MINS) =              420.00

LINK n5505             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  1038.
ESTIMATED PEAK FLOW         (CUMECS) =                  48.
ESTIMATED TIME TO PEAK         (MINS) =              600.00

LINK n197.165          3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  30.52
ESTIMATED PEAK FLOW         (CUMECS) =                  3.0
ESTIMATED TIME TO PEAK         (MINS) =              420.00

LINK n5504             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  1105.
ESTIMATED PEAK FLOW         (CUMECS) =                  50.
ESTIMATED TIME TO PEAK         (MINS) =              634.00

LINK n196.561          3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  41.89
ESTIMATED PEAK FLOW         (CUMECS) =                  4.0
ESTIMATED TIME TO PEAK         (MINS) =              420.00

LINK n196.481          3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  1.567
ESTIMATED PEAK FLOW         (CUMECS) =                 0.16
ESTIMATED TIME TO PEAK         (MINS) =              414.00

LINK n5521             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  78.75
ESTIMATED PEAK FLOW         (CUMECS) =                  7.3
ESTIMATED TIME TO PEAK         (MINS) =              420.00

LINK n5527             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  102.3
ESTIMATED PEAK FLOW         (CUMECS) =                  8.6
ESTIMATED TIME TO PEAK         (MINS) =              420.00

LINK n5526             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  233.3
ESTIMATED PEAK FLOW         (CUMECS) =                  13.
ESTIMATED TIME TO PEAK         (MINS) =              476.00

LINK n5525             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  114.9
ESTIMATED PEAK FLOW         (CUMECS) =                  7.4
ESTIMATED TIME TO PEAK         (MINS) =              420.00

LINK n5524             3.000
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ESTIMATED VOLUME (CU METRES*10**3) =                       451.3
ESTIMATED PEAK FLOW         (CUMECS) =                       23.
ESTIMATED TIME TO PEAK         (MINS) =                    458.00

LINK n5523             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       589.5
ESTIMATED PEAK FLOW         (CUMECS) =                       28.
ESTIMATED TIME TO PEAK         (MINS) =                    540.00

LINK n5522             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       675.1
ESTIMATED PEAK FLOW         (CUMECS) =                       31.
ESTIMATED TIME TO PEAK         (MINS) =                    580.00

LINK n5520             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       823.5
ESTIMATED PEAK FLOW         (CUMECS) =                       38.
ESTIMATED TIME TO PEAK         (MINS) =                    592.00

LINK n5519             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       905.1
ESTIMATED PEAK FLOW         (CUMECS) =                       39.
ESTIMATED TIME TO PEAK         (MINS) =                    624.00

LINK n5503             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       1018.
ESTIMATED PEAK FLOW         (CUMECS) =                       41.
ESTIMATED TIME TO PEAK         (MINS) =                    600.00

LINK n5502             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       2214.
ESTIMATED PEAK FLOW         (CUMECS) =                       91.
ESTIMATED TIME TO PEAK         (MINS) =                    634.00

LINK n196.069          3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       4.710
ESTIMATED PEAK FLOW         (CUMECS) =                      0.47
ESTIMATED TIME TO PEAK         (MINS) =                    420.00

LINK n196.280          3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       7.539
ESTIMATED PEAK FLOW         (CUMECS) =                      0.76
ESTIMATED TIME TO PEAK         (MINS) =                    420.00

LINK n196.340          3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       2.322
ESTIMATED PEAK FLOW         (CUMECS) =                      0.24
ESTIMATED TIME TO PEAK         (MINS) =                    420.00

LINK n5501             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       2289.
ESTIMATED PEAK FLOW         (CUMECS) =                       92.
ESTIMATED TIME TO PEAK         (MINS) =                    674.00
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LINK n54 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 7.733
ESTIMATED PEAK FLOW (CUMECS) = 0.72
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK n195.550 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 2372.
ESTIMATED PEAK FLOW (CUMECS) = 92.
ESTIMATED TIME TO PEAK (MINS) = 696.00

###
Stony Creek Hydrologic Model

Results for period from 0: 1.0 28/ 7/2009
to 6: 1.0 29/ 7/2009
###

ROUTING INCREMENT (MINS) = 2.00
STORM DURATION (MINS) = 720.
RETURN PERIOD (YRS) = 100.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (ha) = 1121.65
TOTAL OF SECOND SUB-AREAS (ha) = 398.44
TOTAL OF ALL SUB-AREAS (ha) = 1520.09

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
n200.12	10.230	1.140	5.300	5.300	0.000	100.0	.050	.015	.0632	.0007	1.000
n199.85	9.180	1.020	5.100	5.100	0.000	100.0	.050	.015	.0609	.0007	2.000
n5515	26.500	2.950	2.900	2.900	0.000	100.0	.050	.015	.1400	.0015	1.001
n5517	27.660	3.100	3.300	3.300	0.000	100.0	.050	.015	.1342	.0015	3.000
n5516	41.370	4.600	5.200	5.200	0.000	100.0	.050	.015	.1319	.0014	3.001
n5514	62.090	6.900	4.400	4.400	0.000	100.0	.050	.015	.1770	.0019	1.002
n5513	46.930	5.200	2.200	2.200	0.000	100.0	.050	.015	.2163	.0024	1.003
n5512	59.600	6.600	6.100	6.100	0.000	100.0	.050	.015	.1472	.0016	4.000
n5511	67.230	7.470	1.500	1.500	0.000	100.0	.050	.015	.3156	.0035	1.004
n198.56	26.660	2.960	7.600	7.600	0.000	100.0	.050	.015	.0868	.0010	5.000
n5508	23.510	2.610	3.700	3.700	0.000	100.0	.050	.015	.1165	.0013	1.005
n199.24	11.720	1.300	7.400	7.400	0.000	100.0	.050	.015	.0574	.0006	6.000
n5510	24.370	2.710	3.600	3.600	0.000	100.0	.050	.015	.1203	.0013	6.001
n5509	23.090	9.890	2.300	2.300	0.000	100.0	.035	.015	.1112	.0032	6.002
n197.909	17.600	1.960	12.10	12.10	0.000	100.0	.050	.015	.0555	.0006	7.000
n198.04	25.870	2.880	10.60	10.60	0.000	100.0	.050	.015	.0724	.0008	8.000
n5506	33.650	33.650	2.300	2.300	0.000	100.0	.035	.015	.1352	.0061	1.006
n197.487	14.700	1.600	8.000	8.000	0.000	100.0	.050	.015	.0621	.0007	9.000
n5505	25.460	6.360	3.200	3.200	0.000	100.0	.035	.015	.0992	.0022	1.007
n197.165	15.860	3.970	10.20	10.20	0.000	100.0	.050	.015	.0572	.0010	10.00
n5504	18.900	4.730	4.100	4.100	0.000	100.0	.035	.015	.0751	.0017	1.008
n196.561	21.780	5.440	8.400	8.400	0.000	100.0	.050	.015	.0743	.0012	11.00
n196.481	0.8200	0.2000	14.60	14.60	0.000	100.0	.050	.015	.0103	.0002	12.00
n5521	13.750	32.070	6.300	6.300	0.000	100.0	.035	.015	.0514	.0036	13.00
n5527	53.170	13.290	4.100	4.100	0.000	100.0	.050	.015	.1691	.0028	14.00
n5526	78.520	8.730	1.500	1.500	0.000	100.0	.050	.015	.3421	.0038	14.00
n5525	51.100	21.900	.5000	.5000	0.000	100.0	.035	.015	.3598	.0105	15.00
n5524	61.830	6.870	1.100	1.100	0.000	100.0	.035	.015	.2681	.0039	14.00

n5523	61.450	26.330	3.500	3.500	0.000	100.0	.035	.015	.1500	.0044	14.00
n5522	26.010	26.010	1.300	1.300	0.000	100.0	.035	.015	.1572	.0071	14.00
n5520	21.130	21.140	3.700	3.700	0.000	100.0	.035	.015	.0837	.0038	13.00
n5519	24.790	24.800	1.300	1.300	0.000	100.0	.035	.015	.1533	.0069	13.00
n5503	34.180	34.170	5.400	5.400	0.000	100.0	.035	.015	.0890	.0040	13.00
n5502	8.260	19.260	7.800	7.800	0.000	100.0	.035	.015	.0354	.0025	1.009
n196.069	2.090	0.9000	11.20	11.20	0.000	100.0	.050	.015	.0190	.0004	16.00
n196.280	3.920	0.9800	10.90	10.90	0.000	100.0	.050	.015	.0268	.0004	17.00
n196.340	1.210	0.3000	14.70	14.70	0.000	100.0	.050	.015	.0125	.0002	18.00
n5501	10.710	24.990	13.00	13.00	0.000	100.0	.035	.015	.0314	.0022	1.010
n54	1.350	3.150	8.300	8.300	0.000	100.0	.050	.015	.0176	.0009	19.00
n195.550	33.400	14.310	11.60	11.60	0.000	100.0	.035	.015	.0601	.0017	1.011

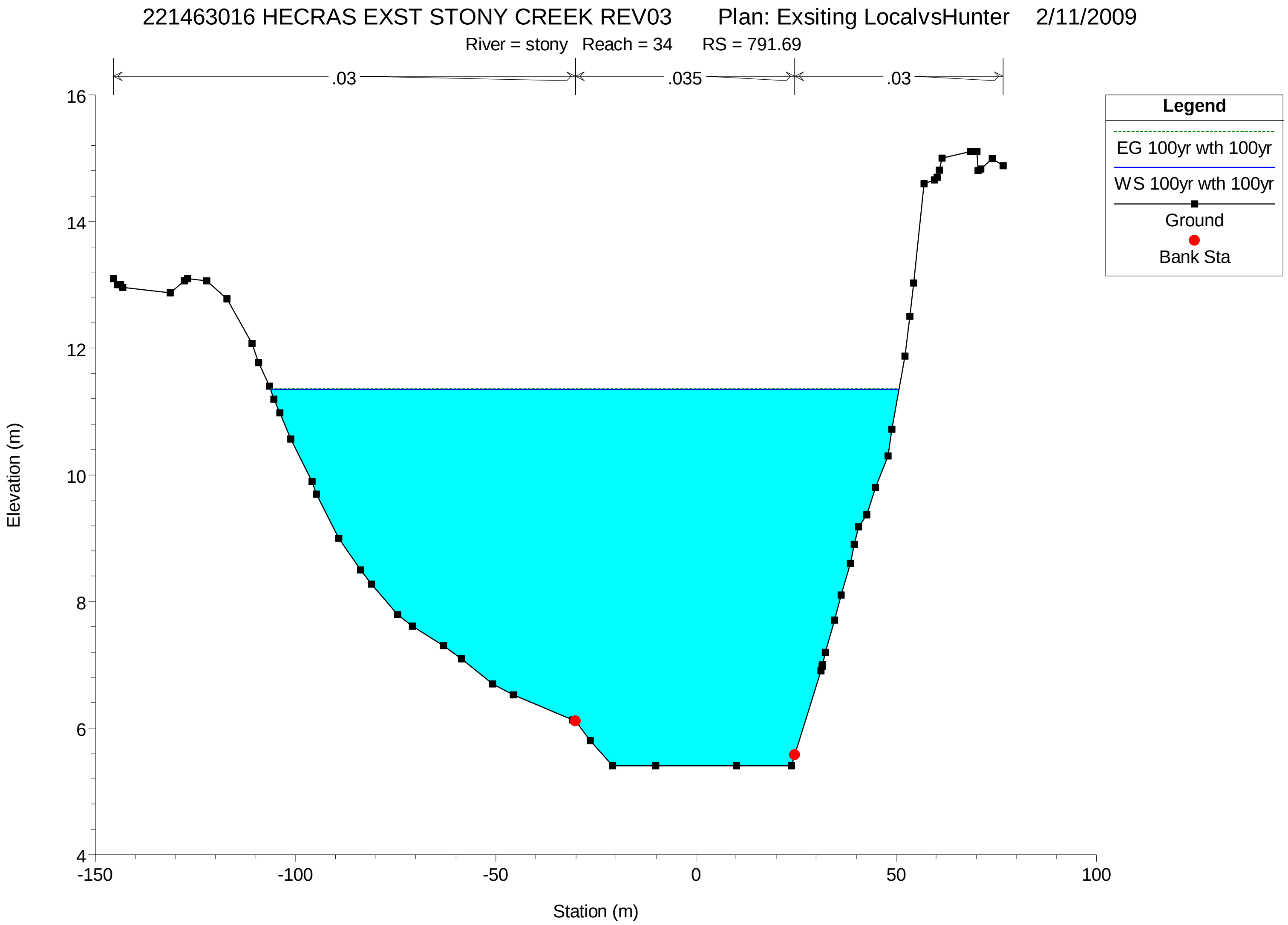
Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2 (mm)	Cont. Loss #1 (mm/h)	Cont. Loss #2 (mm/h)	Excess Rain #1 (mm)	Excess Rain #2 (mm)	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
n200.12	15.309	10.00	1.000	2.500	0.000	146.73	182.71	1.656	420.0	21.00
n199.85	15.309	10.00	1.000	2.500	0.000	146.73	182.71	1.487	420.0	18.00
n5515	15.309	10.00	1.000	2.500	0.000	146.73	182.71	6.047	420.0	0.000
n5517	15.309	10.00	1.000	2.500	0.000	146.73	182.71	3.887	420.0	0.000
n5516	15.309	10.00	1.000	2.500	0.000	146.73	182.71	10.017	420.0	32.00
n5514	15.309	10.00	1.000	2.500	0.000	146.73	182.71	20.390	438.0	53.00
n5513	15.309	10.00	1.000	2.500	0.000	146.73	182.71	22.992	474.0	44.00
n5512	15.309	10.00	1.000	2.500	0.000	146.73	182.71	8.855	420.0	44.00
n5511	15.309	10.00	1.000	2.500	0.000	146.73	182.71	29.213	518.0	45.00
n198.56	15.309	10.00	1.000	2.500	0.000	146.73	182.71	4.251	420.0	18.00
n5508	15.309	10.00	1.000	2.500	0.000	146.73	182.71	33.656	564.0	35.00
n199.24	15.309	10.00	1.000	2.500	0.000	146.73	182.71	1.946	420.0	28.00
n5510	15.309	10.00	1.000	2.500	0.000	146.73	182.71	4.722	420.0	9.000
n5509	15.309	10.00	1.000	2.500	0.000	146.73	182.71	8.760	420.0	35.00
n197.909	15.309	10.00	1.000	2.500	0.000	146.73	182.71	2.973	420.0	29.00
n198.04	15.309	10.00	1.000	2.500	0.000	146.73	182.71	4.274	420.0	29.00
n5506	15.309	10.00	1.000	2.500	0.000	146.73	182.71	45.338	600.0	0.000
n197.487	15.309	10.00	1.000	2.500	0.000	146.73	182.71	2.431	420.0	33.00
n5505	15.309	10.00	1.000	2.500	0.000	146.73	182.71	47.993	600.0	34.00
n197.165	15.309	10.00	1.000	2.500	0.000	146.73	182.71	3.021	420.0	53.00
n5504	15.309	10.00	1.000	2.500	0.000	146.73	182.71	49.541	634.0	26.00
n196.561	15.309	10.00	1.000	2.500	0.000	146.73	182.71	4.031	420.0	4.000
n196.481	15.309	10.00	1.000	2.500	0.000	146.73	182.71	0.1588	414.0	4.000
n5521	15.309	10.00	1.000	2.500	0.000	146.73	182.71	7.255	420.0	52.00
n5527	15.309	10.00	1.000	2.500	0.000	146.73	182.71	8.605	420.0	56.00
n5526	15.309	10.00	1.000	2.500	0.000	146.73	182.71	13.155	476.0	40.00
n5525	15.309	10.00	1.000	2.500	0.000	146.73	182.71	7.389	420.0	38.00
n5524	15.309	10.00	1.000	2.500	0.000	146.73	182.71	23.371	458.0	50.00
n5523	15.309	10.00	1.000	2.500	0.000	146.73	182.71	27.908	540.0	40.00
n5522	15.309	10.00	1.000	2.500	0.000	146.73	182.71	30.879	580.0	12.00
n5520	15.309	10.00	1.000	2.500	0.000	146.73	182.71	38.125	592.0	32.00
n5519	15.309	10.00	1.000	2.500	0.000	146.73	182.71	39.481	624.0	16.00
n5503	15.309	10.00	1.000	2.500	0.000	146.73	182.71	41.090	600.0	34.00
n5502	15.309	10.00	1.000	2.500	0.000	146.73	182.71	91.344	634.0	39.00
n196.069	15.309	10.00	1.000	2.500	0.000	146.73	182.71	0.4678	420.0	16.00
n196.280	15.309	10.00	1.000	2.500	0.000	146.73	182.71	0.7617	420.0	30.00
n196.340	15.309	10.00	1.000	2.500	0.000	146.73	182.71	0.2351	420.0	34.00
n5501	15.309	10.00	1.000	2.500	0.000	146.73	182.71	91.784	674.0	21.00
n54	15.309	10.00	1.000	2.500	0.000	146.73	182.71	0.7167	420.0	2.000
n195.550	15.309	10.00	1.000	2.500	0.000	146.73	182.71	92.063	696.0	0.000

Run completed at: 2nd November 2009 11:49:16

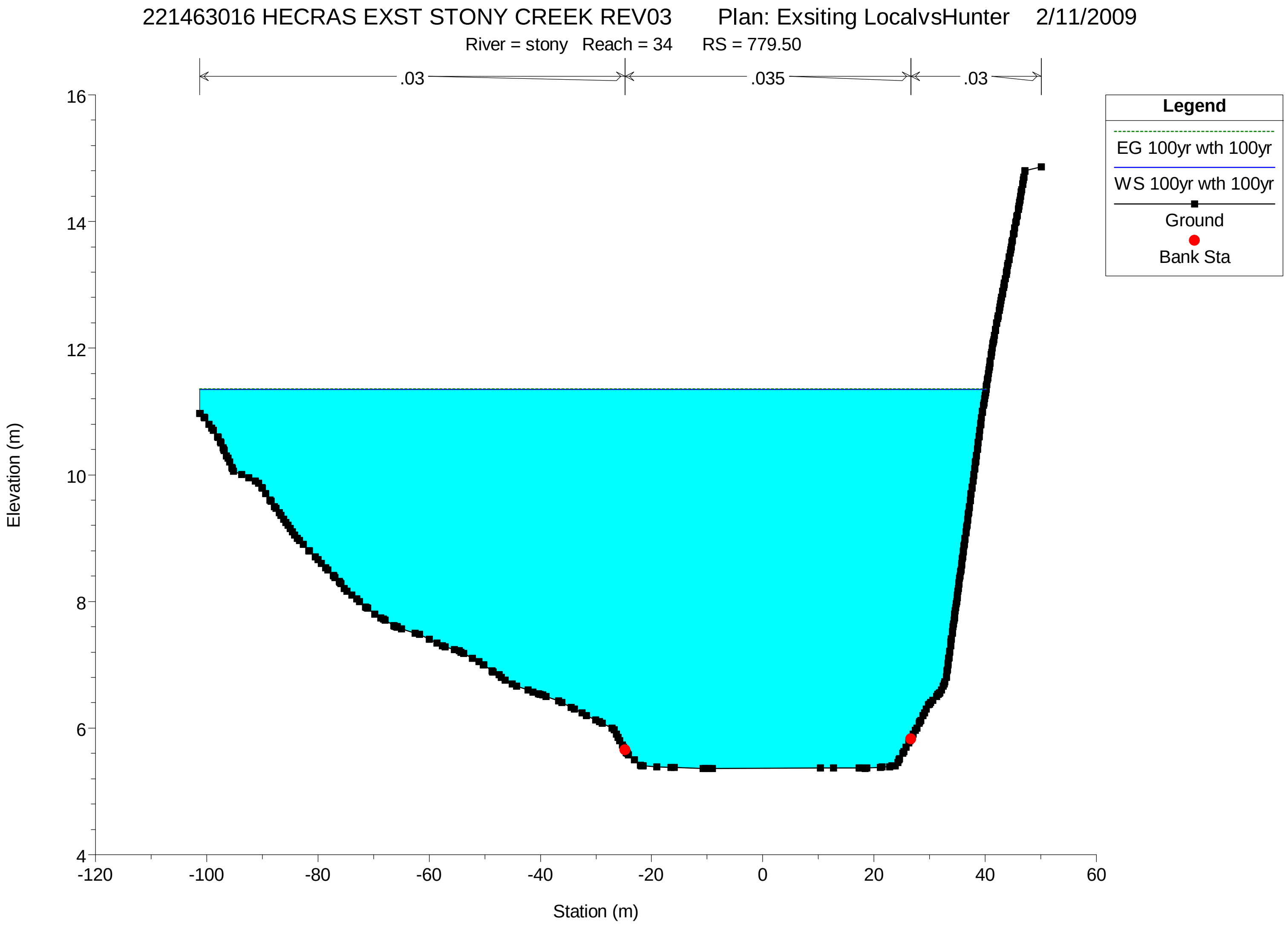
mik open 0

HEC-RAS Plan: ExistLocalvsHR Profile: 100yr wth 100yr

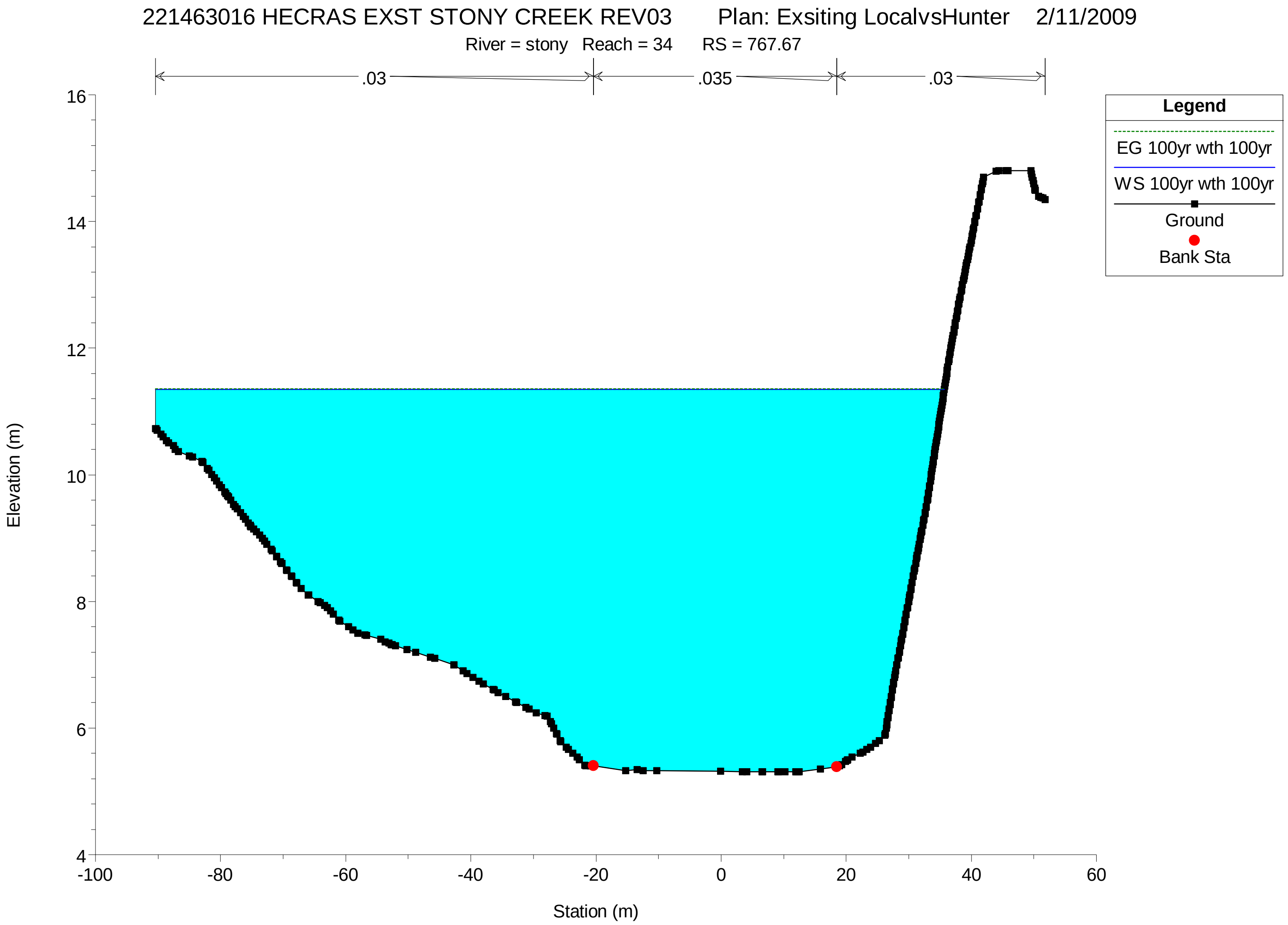
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
trib2	69	567.65	100yr wth 100yr	96.40	37.33	39.00	39.00	39.46	0.012760	3.03	31.82	34.76	1.01
trib2	69	508.19	100yr wth 100yr	96.40	32.00	32.81	33.59	37.11	0.219848	9.19	10.49	18.28	3.87
trib2	69	421.43	100yr wth 100yr	96.40	26.00	27.38	27.96	29.21	0.042878	5.99	16.10	15.28	1.86
trib2	69	324.18	100yr wth 100yr	96.40	22.00	22.98	23.47	24.56	0.051844	5.57	17.31	21.61	1.99
trib2	69	247.21	100yr wth 100yr	96.40	18.00	18.90	19.35	20.37	0.056351	5.38	17.92	25.21	2.03
trib2	69	156.27	100yr wth 100yr	96.40	13.46	14.91	15.31	16.24	0.036716	5.11	18.85	20.38	1.70
trib2	69	116.95	100yr wth 100yr	96.40	10.00	10.73	11.45	13.66	0.124260	7.57	12.73	19.24	2.97
trib2	69	69.21	100yr wth 100yr	96.40	10.60	11.56	11.56	11.99	0.012667	2.91	33.17	38.35	1.00
trib1	56	814.30	100yr wth 100yr	97.30	41.50	42.69	42.69	43.07	0.009607	2.63	35.76	48.24	0.88
trib1	56	658.98	100yr wth 100yr	97.30	28.00	29.87	29.87	30.50	0.009652	3.35	28.12	23.89	0.93
trib1	56	585.26	100yr wth 100yr	97.30	22.00	22.42	23.22	27.87	0.434900	10.34	9.41	23.52	5.16
trib1	56	512.73	100yr wth 100yr	97.30	18.00	18.79	19.42	21.21	0.031921	3.91	18.48	27.79	1.52
trib1	56	435.22	100yr wth 100yr	97.30	16.00	16.83	17.48	19.12	0.022841	3.20	18.88	28.00	1.28
trib1	56	338.88	100yr wth 100yr	97.30	14.00	14.96	15.33	16.15	0.032879	4.74	20.26	25.54	1.61
trib1	56	264.99	100yr wth 100yr	97.30	14.00	15.30	14.95	15.48	0.003305	1.83	52.39	51.67	0.54
trib1	56	213.15	100yr wth 100yr	97.30	13.54	14.88	14.88	15.24	0.005920	2.15	38.43	54.66	0.70
trib1	56	166.20	100yr wth 100yr	97.30	10.00	10.45	11.09	14.07	0.279601	8.47	11.67	29.57	4.17
trib1	56	126.25	100yr wth 100yr	97.30	8.41	11.33	9.97	11.37	0.000396	0.99	116.26	77.00	0.21
trib1	56	96.93	100yr wth 100yr	97.30	7.50	11.35	8.64	11.36	0.000054	0.37	267.87	120.47	0.08
trib1	56	74.67	100yr wth 100yr	97.30	6.92	11.35		11.36	0.000032	0.42	292.87	105.38	0.07
trib1	56	56.12	100yr wth 100yr	97.30	6.21	11.35		11.35	0.000015	0.31	400.01	124.63	0.05
stony	1064	1554.25	100yr wth 100yr	97.30	6.80	11.36	8.60	11.39	0.000134	0.82	154.56	59.76	0.13
stony	1064	1502.92	100yr wth 100yr	97.30	6.70	11.36		11.38	0.000083	0.65	181.71	64.00	0.10
stony	1064	1420.04	100yr wth 100yr	97.30	5.80	11.37		11.38	0.000031	0.45	262.21	75.09	0.07
stony	1064	1351.57	100yr wth 100yr	97.30	5.50	11.36		11.37	0.000050	0.62	202.28	51.36	0.08
stony	1064	1296.63	100yr wth 100yr	97.30	5.50	11.35		11.37	0.000065	0.68	190.15	50.25	0.10
stony	1064	1209.59	100yr wth 100yr	97.30	5.50	11.35		11.36	0.000036	0.53	262.42	68.36	0.07
stony	1064	1127.99	100yr wth 100yr	97.30	5.40	11.35		11.36	0.000026	0.46	296.04	78.23	0.06
stony	1064	1064.42	100yr wth 100yr	97.30	5.40	11.35		11.36	0.000026	0.47	307.98	79.05	0.06
stony	827	989.28	100yr wth 100yr	97.30	5.40	11.35	6.34	11.36	0.000009	0.28	398.48	101.58	0.04
stony	827	961.63	100yr wth 100yr	97.30	5.40	11.35		11.35	0.000006	0.23	470.31	107.70	0.03
stony	827	920.71	100yr wth 100yr	97.30	5.40	11.35		11.35	0.000006	0.23	475.59	117.26	0.03
stony	827	885.61	100yr wth 100yr	97.30	5.40	11.35		11.35	0.000008	0.25	422.58	105.46	0.03
stony	827	849.81	100yr wth 100yr	97.30	5.40	11.35		11.35	0.000007	0.24	453.55	109.93	0.03
stony	827	827.45	100yr wth 100yr	97.30	5.40	11.35		11.35	0.000005	0.21	532.42	130.61	0.03
stony	34	791.69	100yr wth 100yr	97.30	5.40	11.35		11.35	0.000003	0.16	665.60	156.98	0.02
stony	34	779.50	100yr wth 100yr	97.30	5.36	11.35		11.35	0.000003	0.17	623.10	141.37	0.02
stony	34	767.67	100yr wth 100yr	97.30	5.31	11.35		11.35	0.000004	0.20	554.31	126.06	0.03
stony	34	764.20	100yr wth 100yr	97.30	5.30	11.35		11.35	0.000005	0.21	531.32	131.65	0.03
stony	34	761.64	100yr wth 100yr	97.30	5.30	11.35		11.35	0.000006	0.22	503.53	126.69	0.03
stony	34	759.08	100yr wth 100yr	97.30	5.20	11.35		11.35	0.000007	0.25	457.77	121.36	0.03
stony	34	752.31	100yr wth 100yr	97.30	5.27	11.35	7.36	11.35	0.000009	0.26	323.22	130.86	0.04
stony	34	746.82		Bridge									
stony	34	741.33	100yr wth 100yr	97.30	5.10	11.35		11.35	0.000005	0.18	438.13	187.89	0.03
stony	34	738.80	100yr wth 100yr	97.30	5.10	11.34	7.19	11.35	0.000034	0.45	300.97	106.42	0.07
stony	34	730.98	100yr wth 100yr	97.30	5.10	11.34		11.35	0.000028	0.44	292.40	94.91	0.06
stony	34	725.22	100yr wth 100yr	97.30	5.08	11.34	6.64	11.35	0.000026	0.45	289.56	90.31	0.06
stony	34	720.95	100yr wth 100yr	97.30	4.85	11.34	6.44	11.35	0.000030	0.53	283.27	85.90	0.07
stony	34	704.49	100yr wth 100yr	97.30	4.60	11.34	6.36	11.35	0.000020	0.43	339.82	85.90	0.06
stony	34	698.66	100yr wth 100yr	97.30	5.30	11.31	7.99	11.34	0.000129	0.89	162.89	66.60	0.13
stony	34	680.46		Culvert									
stony	34	662.07	100yr wth 100yr	97.30	4.30	10.30		10.30	0.000026	0.44	278.08	107.49	0.06
stony	34	627.22	100yr wth 100yr	97.30	4.30	10.30		10.30	0.000008	0.24	463.53	132.50	0.03
stony	34	582.95	100yr wth 100yr	97.30	4.10	10.30		10.30	0.000009	0.26	420.70	112.44	0.04
stony	34	538.52	100yr wth 100yr	97.30	3.80	10.30	5.56	10.30	0.000006	0.23	495.81	126.72	0.03
stony	34	429.93	100yr wth 100yr	97.30	4.82	10.30		10.30	0.000002	0.11	945.11	253.90	0.02
stony	34	365.68	100yr wth 100yr	97.30	4.00	10.30		10.30	0.000001	0.08	1364.79	293.79	0.01
stony	34	189.51	100yr wth 100yr	97.30	4.00	10.30		10.30	0.000001	0.08	1350.48	281.53	0.01
stony	34	159.33	100yr wth 100yr	97.30	4.00	10.30		10.30	0.000001	0.09	1234.37	261.85	0.01
stony	34	33.81	100yr wth 100yr	97.30	3.10	10.30	3.79	10.30	0.000000	0.04	2202.89	540.44	0.01

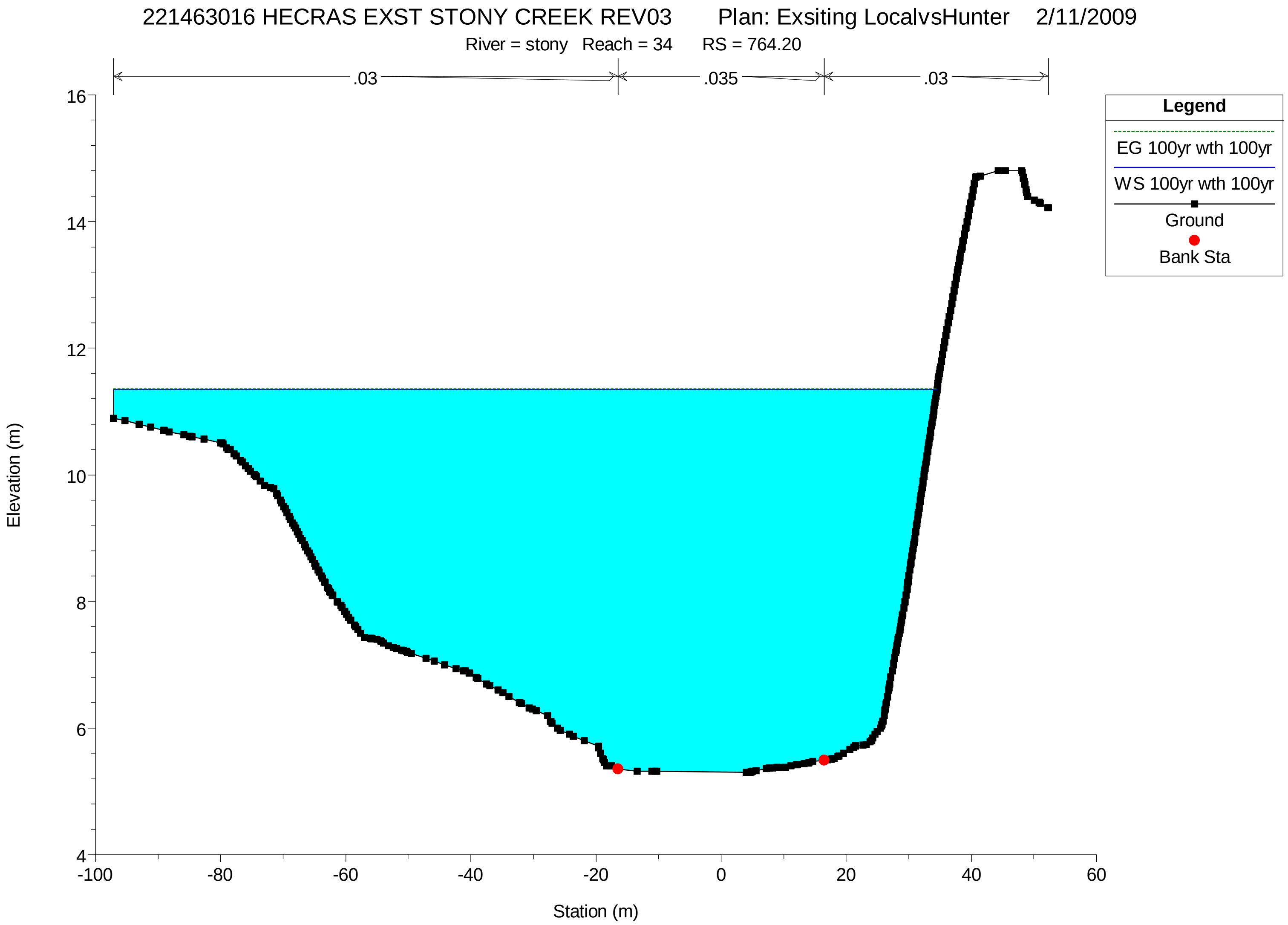


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 791.69
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)



221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 779.50
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 767.67
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-100
-80
-60
-40
-20
0
20
40
60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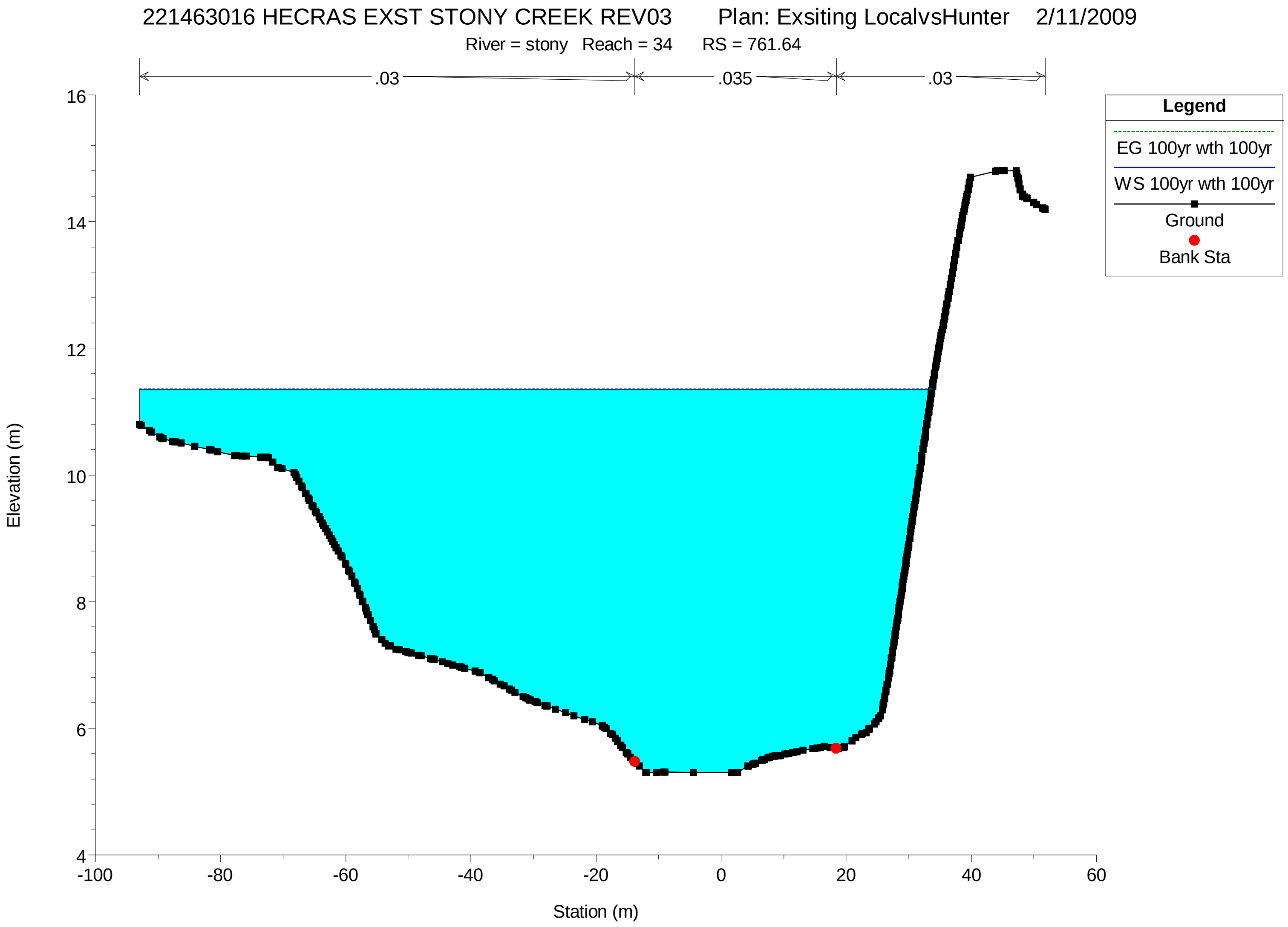
River = stony Reach = 34 RS = 764.20
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-100
-80
-60
-40
-20
0
20
40
60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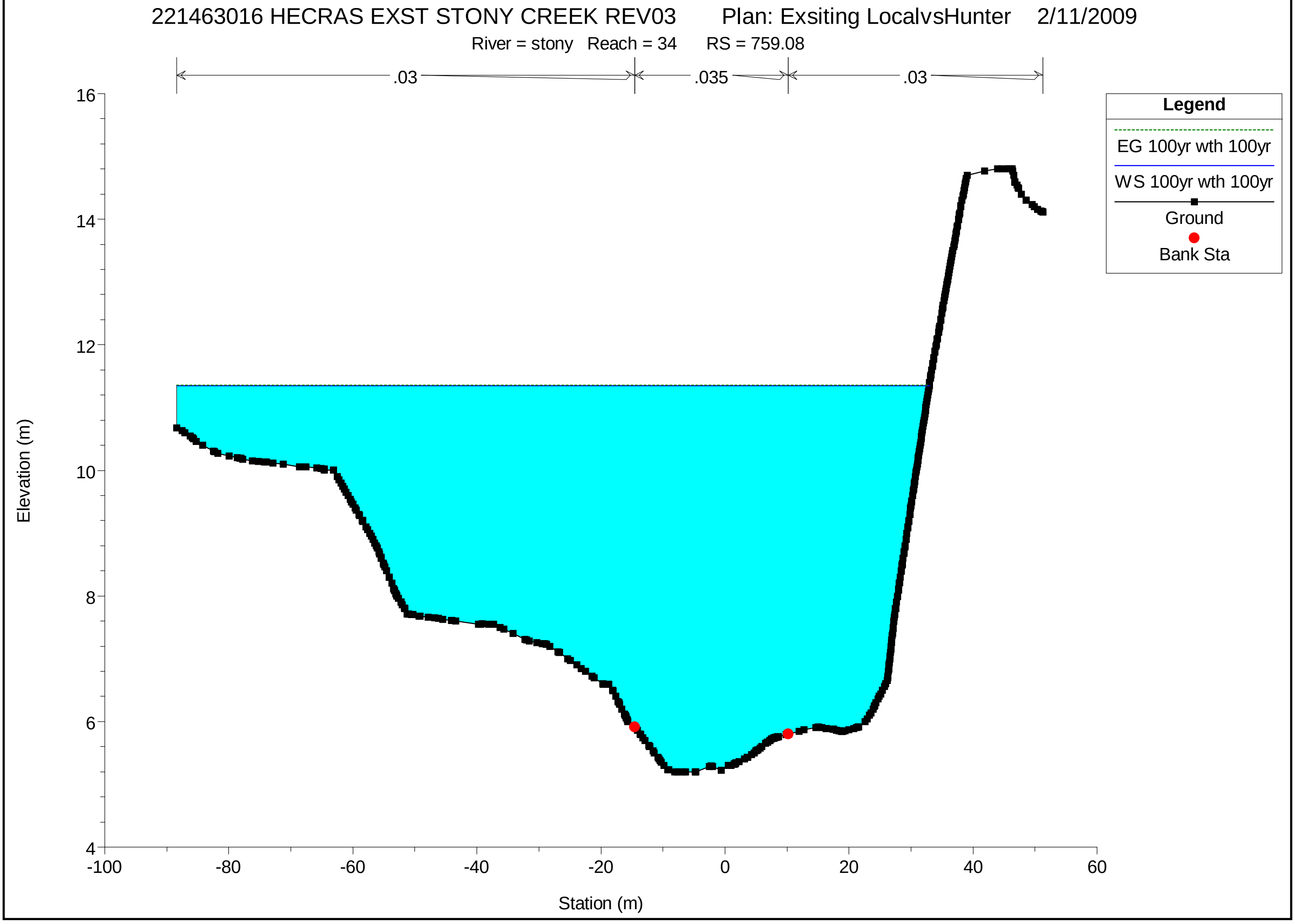
River = stony Reach = 34 RS = 761.64
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-100
-80
-60
-40
-20
0
20
40
60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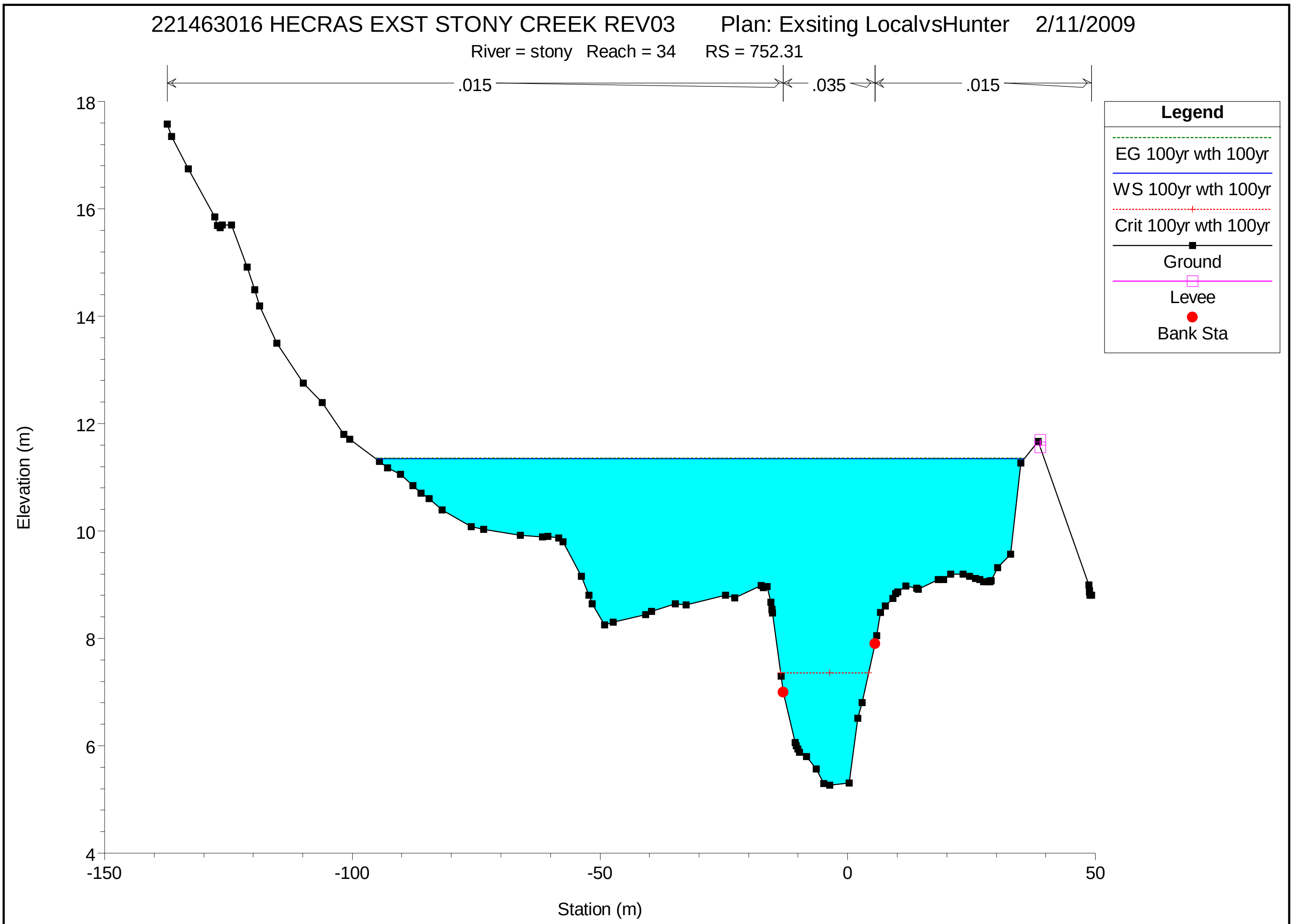
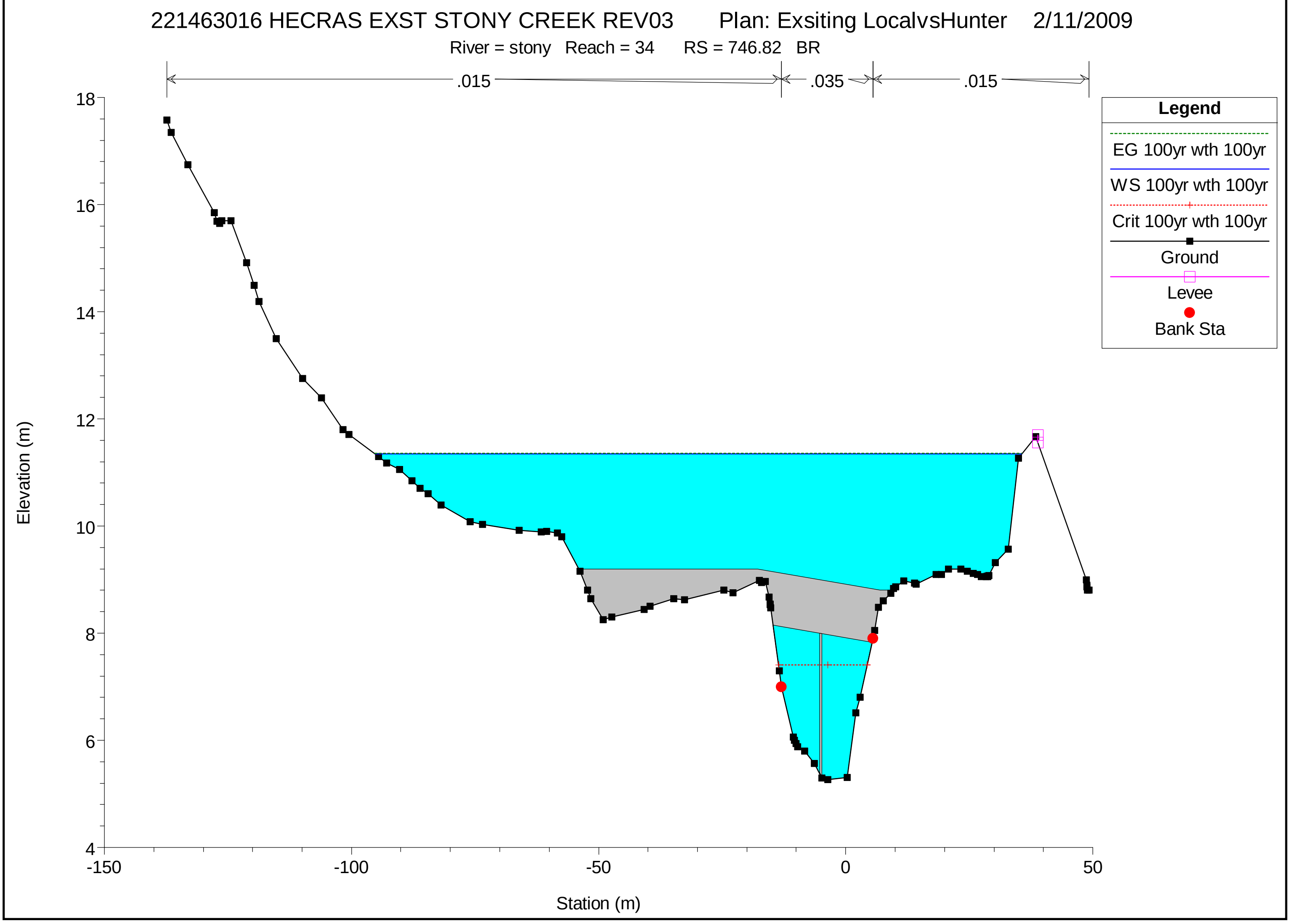
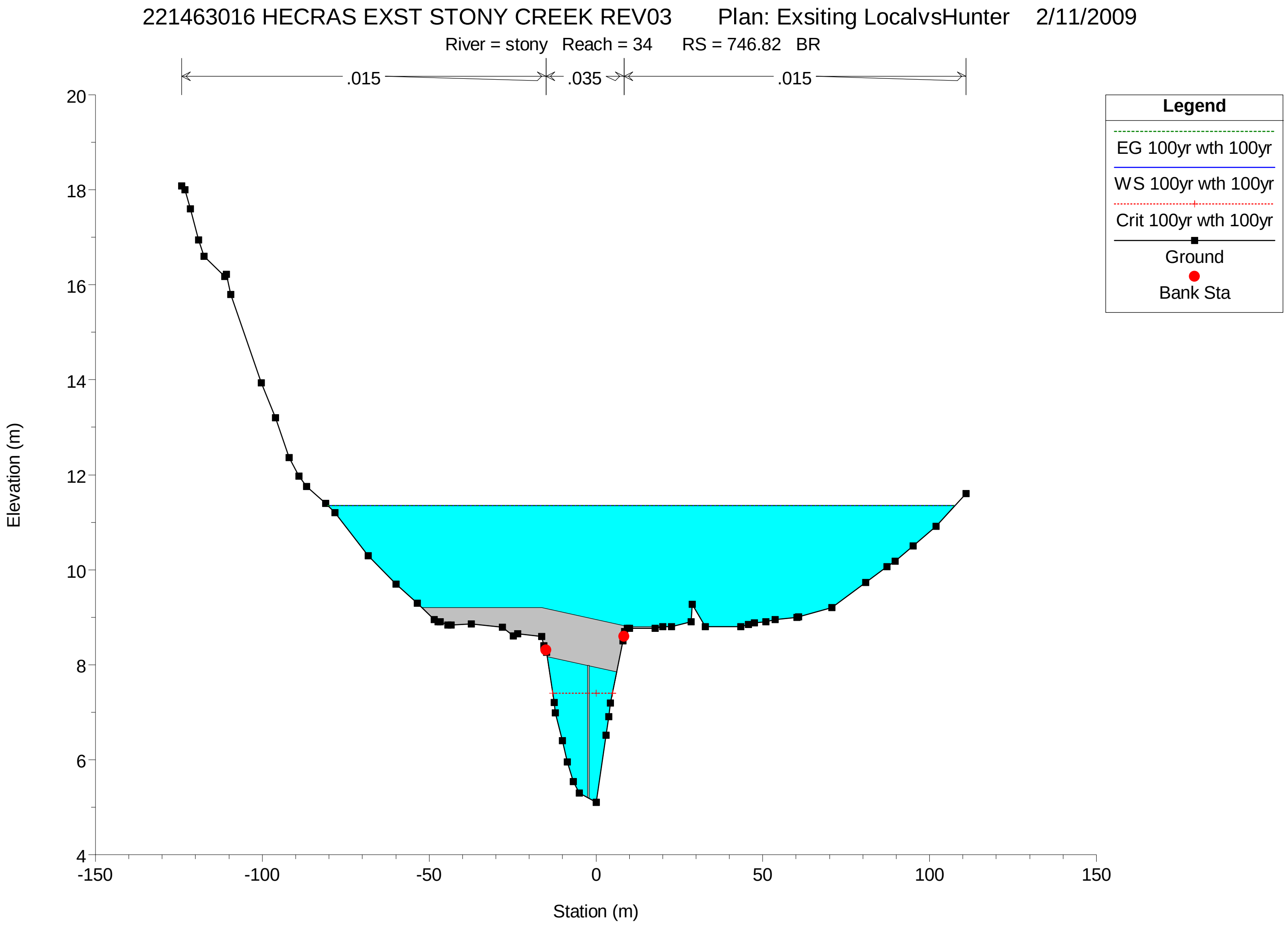
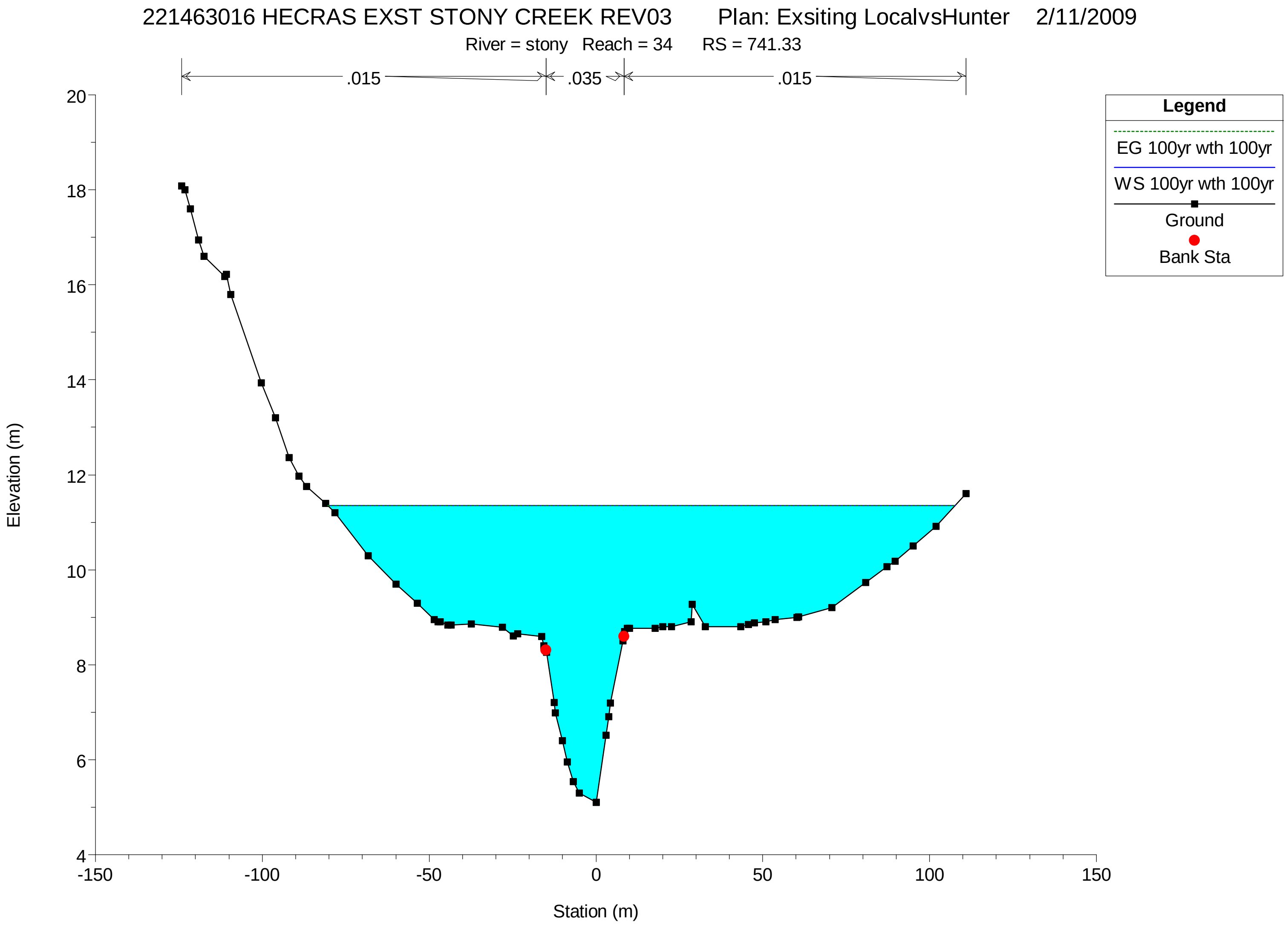
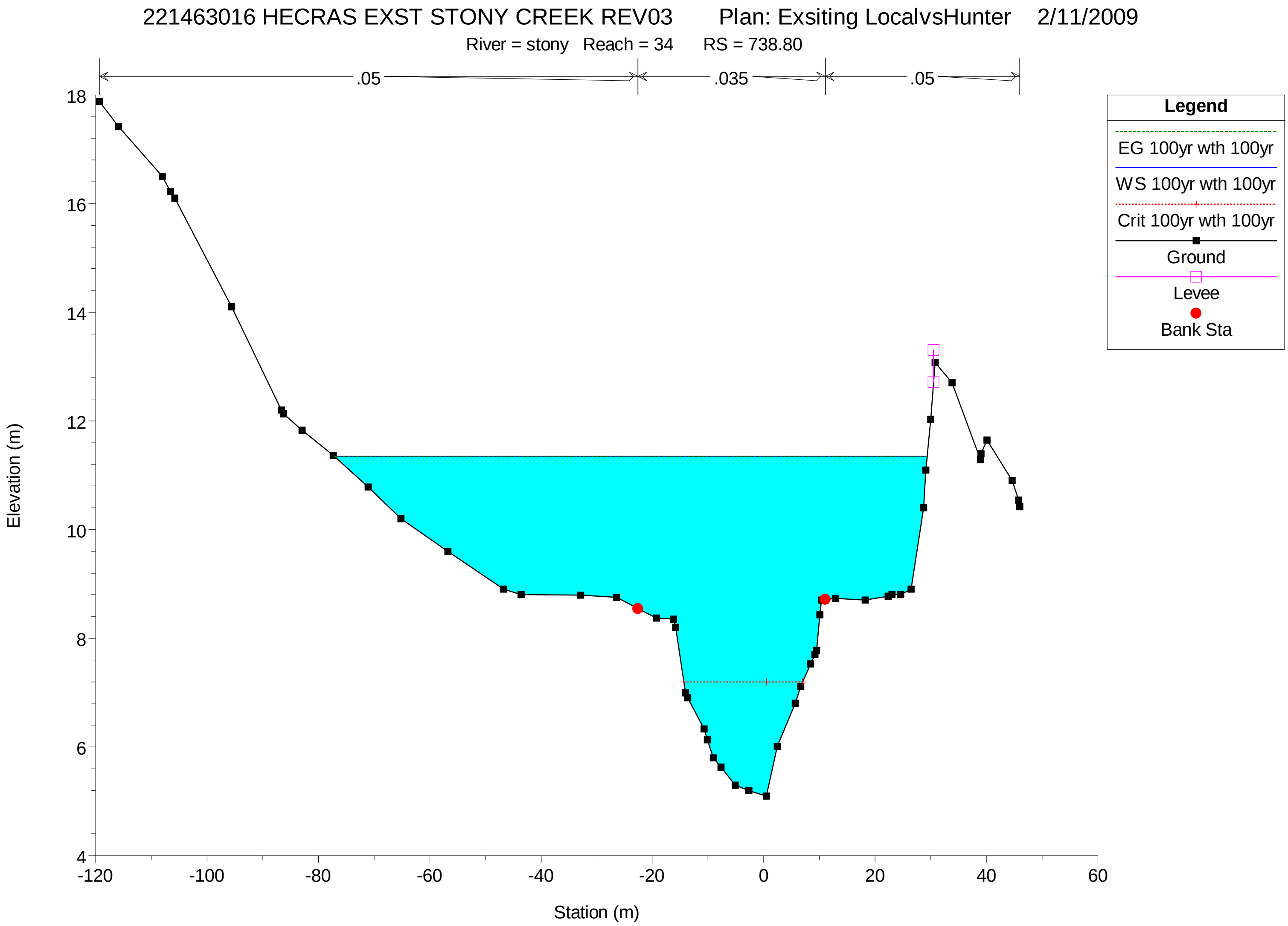
River = stony Reach = 34 RS = 759.08
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-100
-80
-60
-40
-20
0
20
40
60


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 752.31
.015
.035
.015
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
18
16
14
12
10
8
6
4
-150
-100
-50
0
50

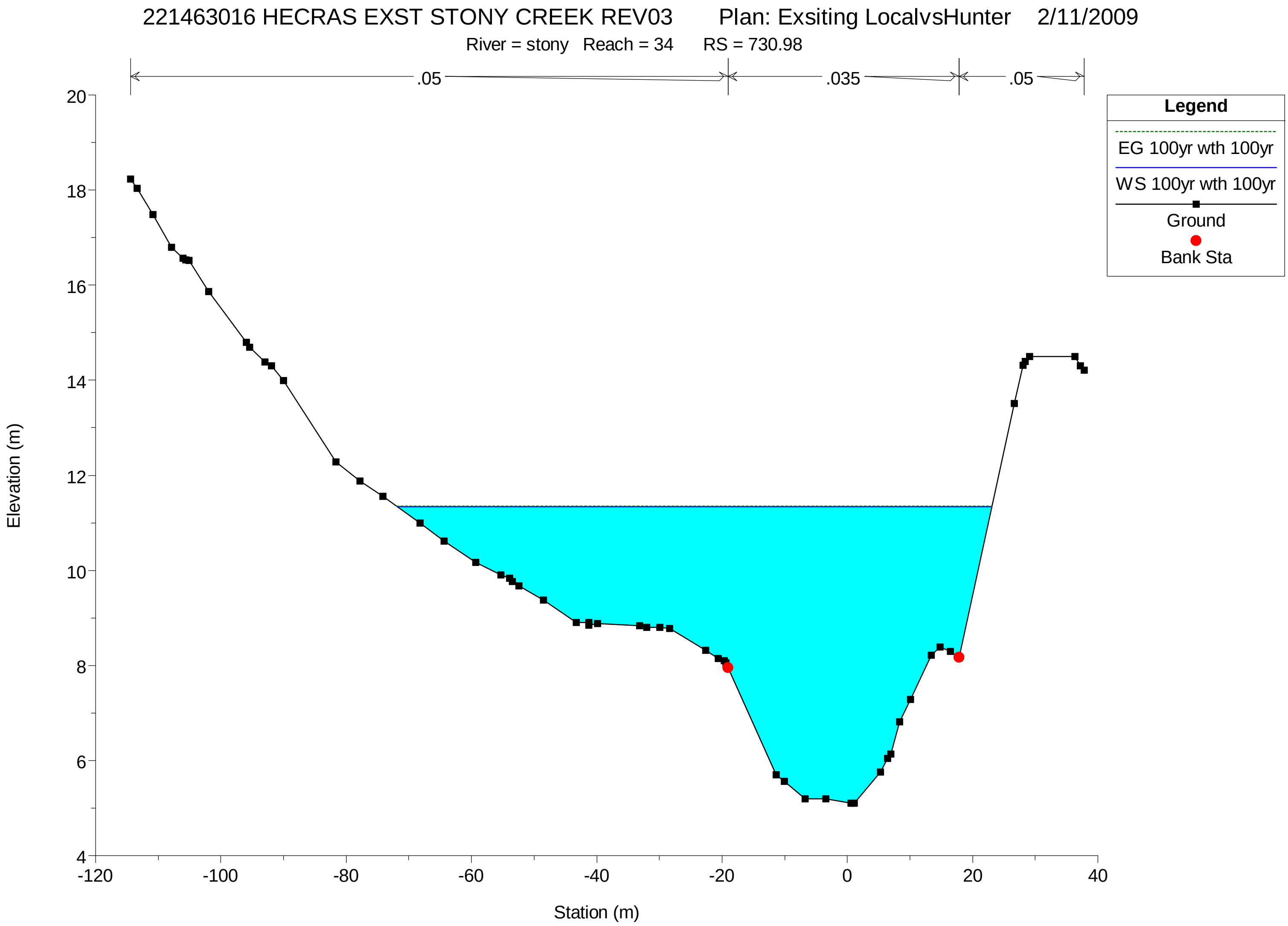

221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 746.82 BR
.015
.035
.015
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
18
16
14
12
10
8
6
4
-150
-100
-50
0
50


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 746.82 BR
.015
.035
.015
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
20
18
16
14
12
10
8
6
4
-150
-100
-50
0
50
100
150

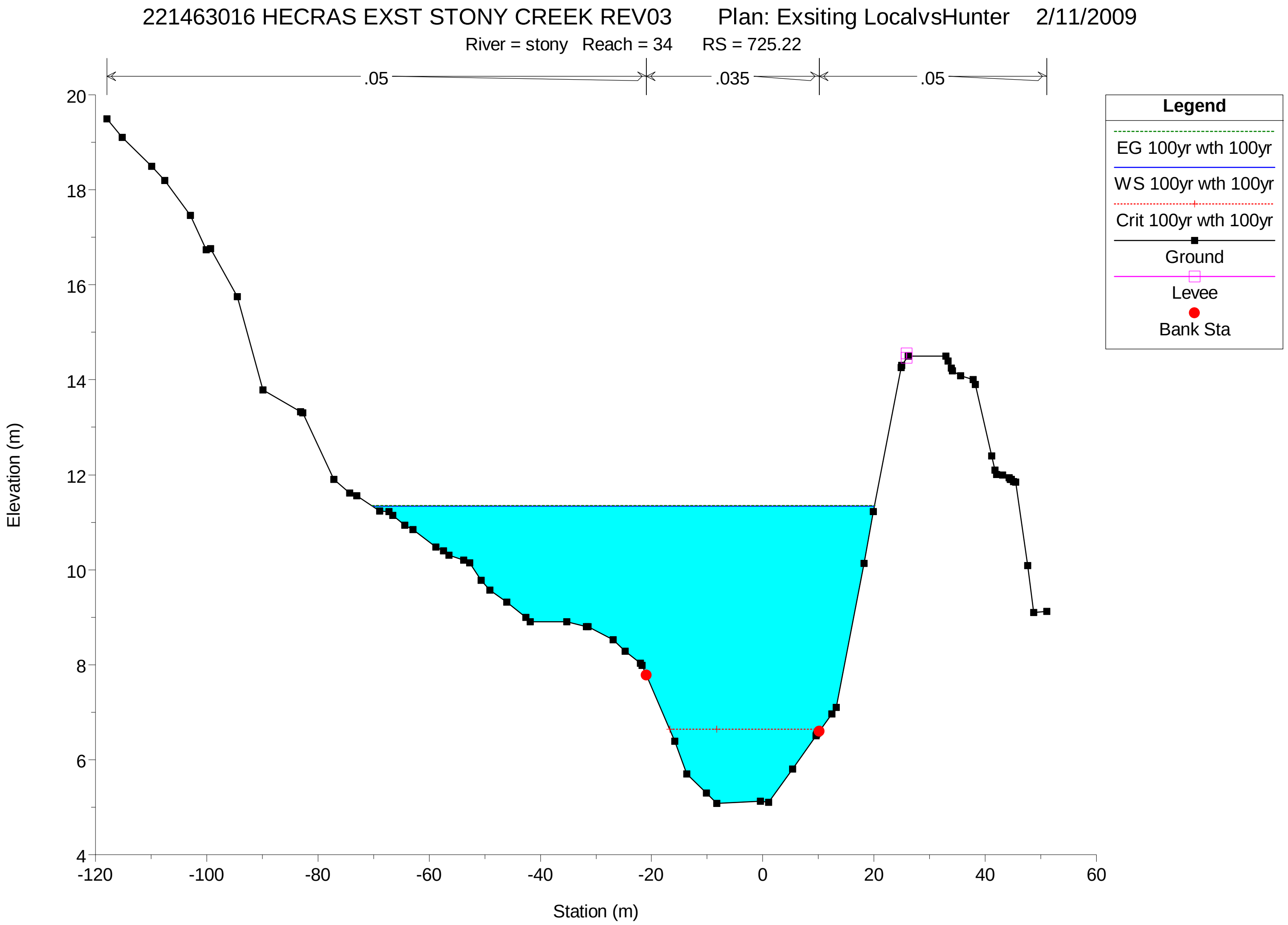

221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 741.33
.015
.035
.015
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
20
18
16
14
12
10
8
6
4
-150
-100
-50
0
50
100
150



221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 738.80
.05
.035
.05
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)



221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 730.98
.05
.035
.05
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)



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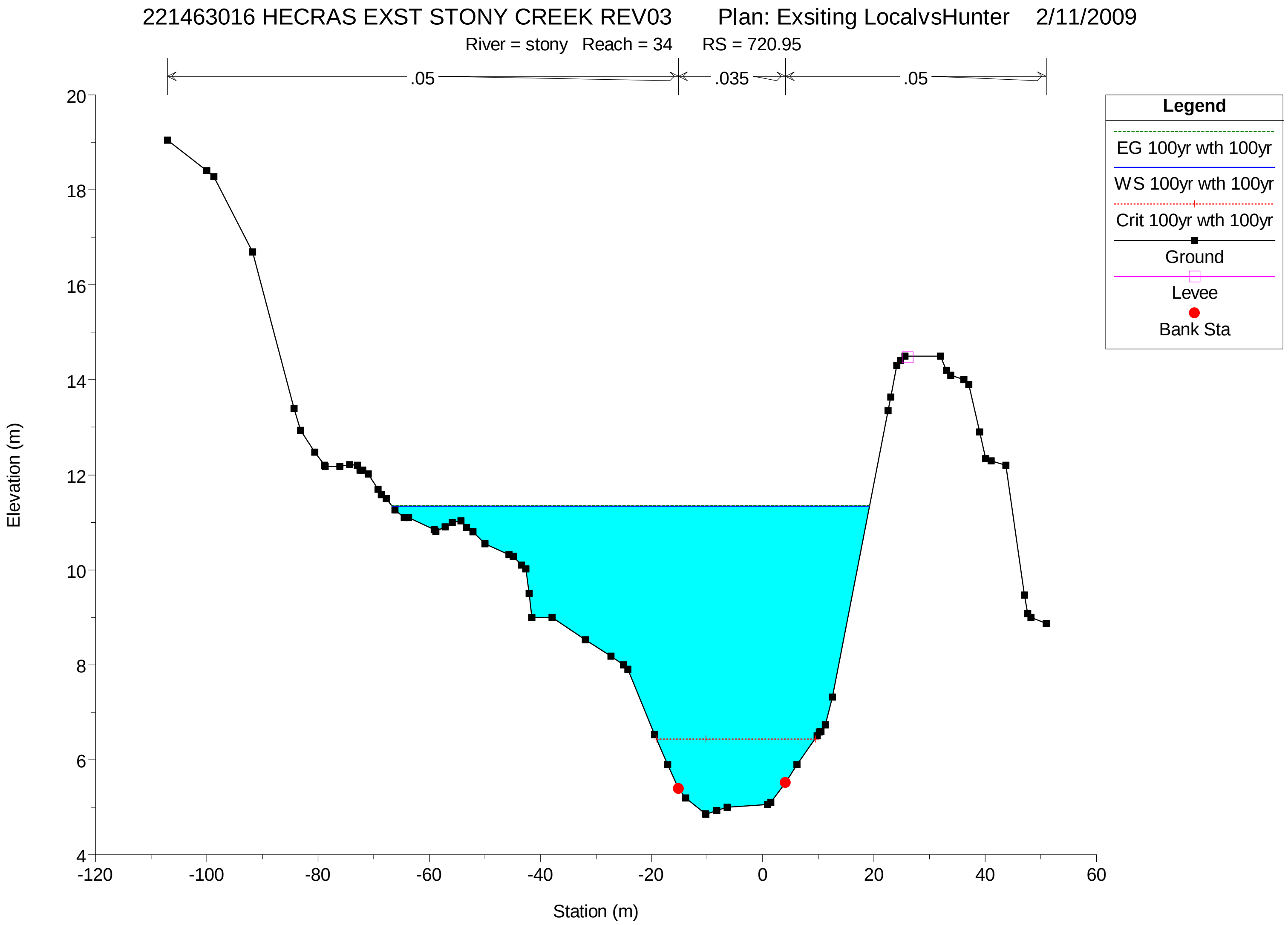
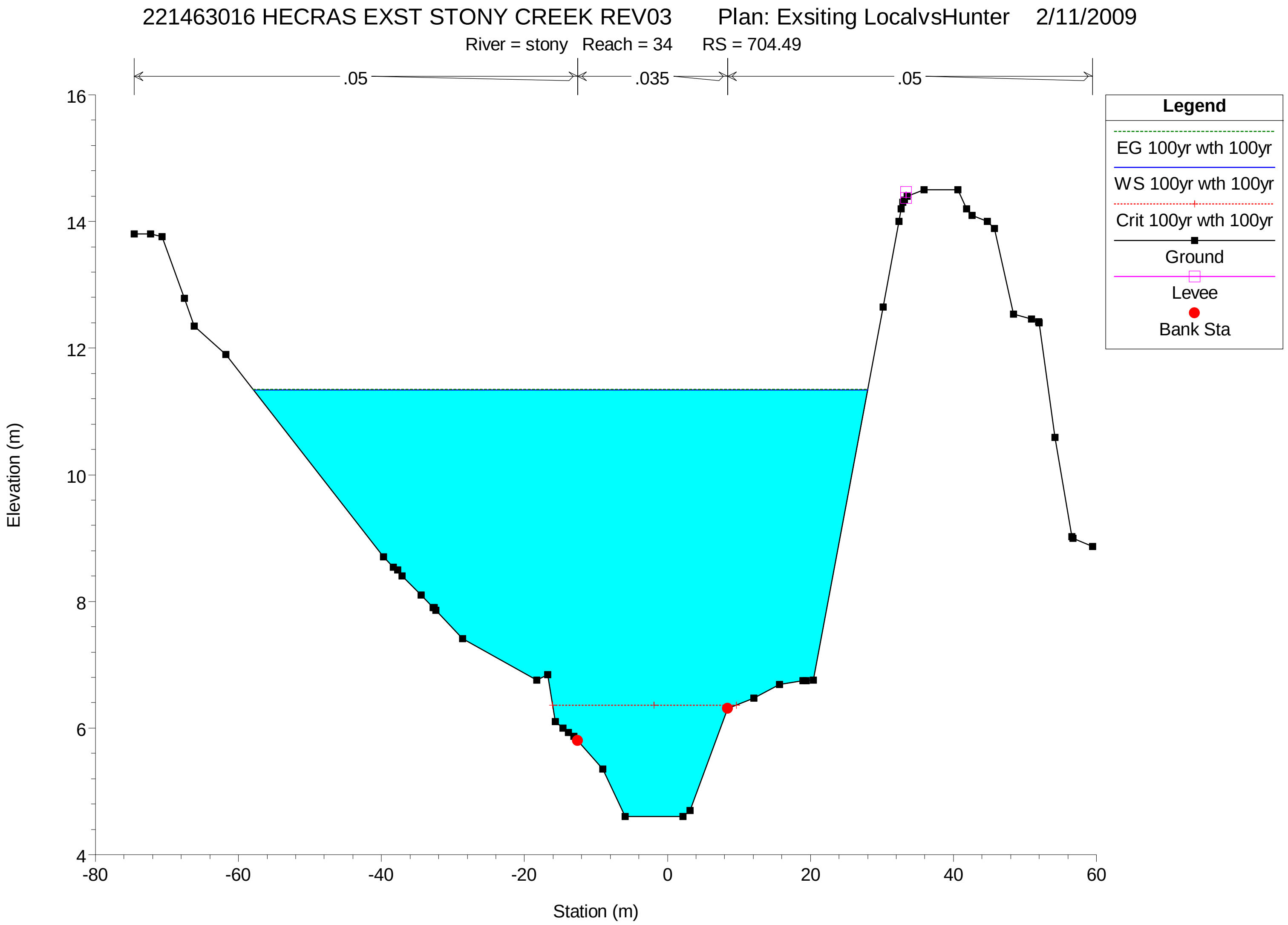
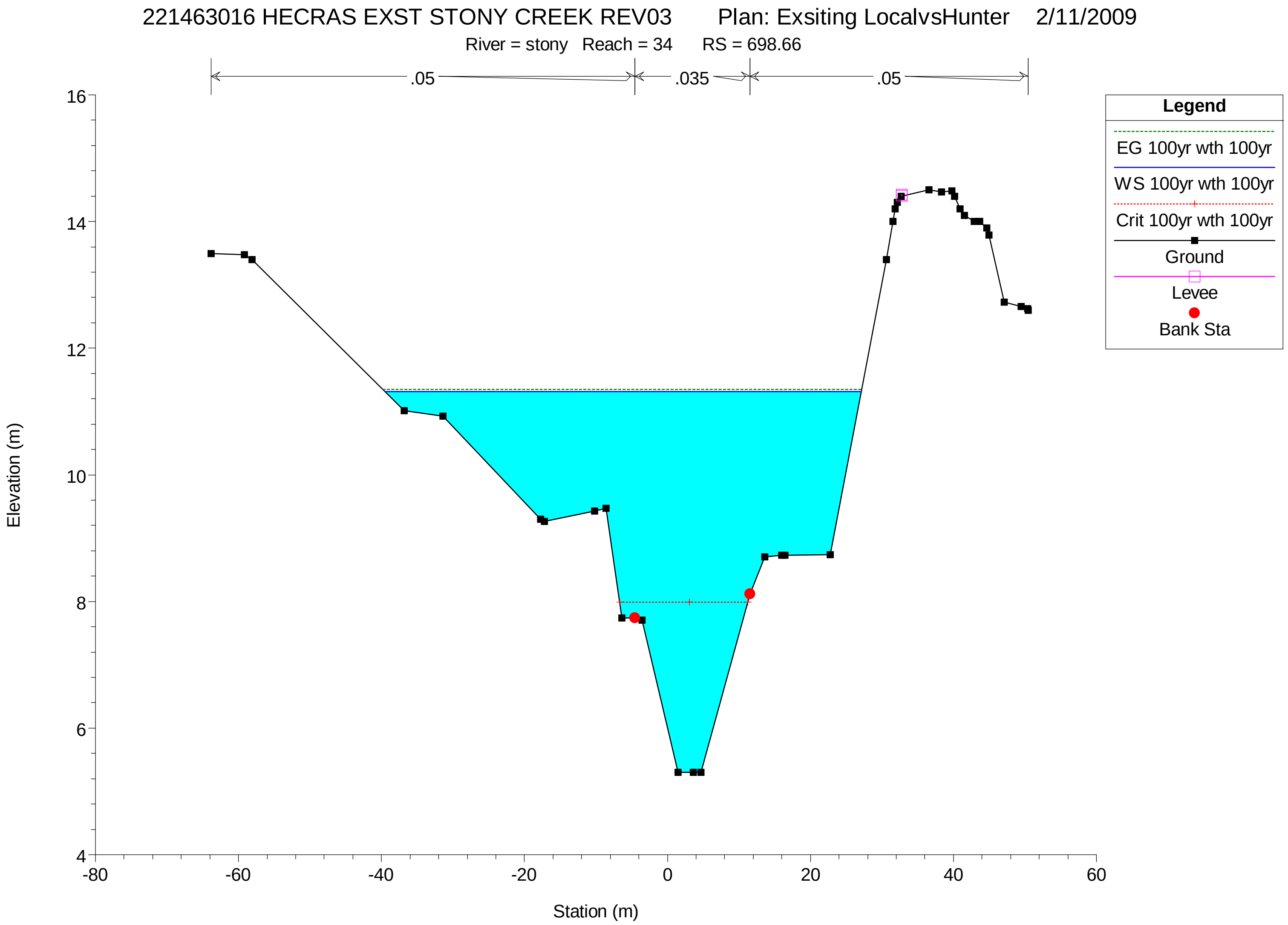
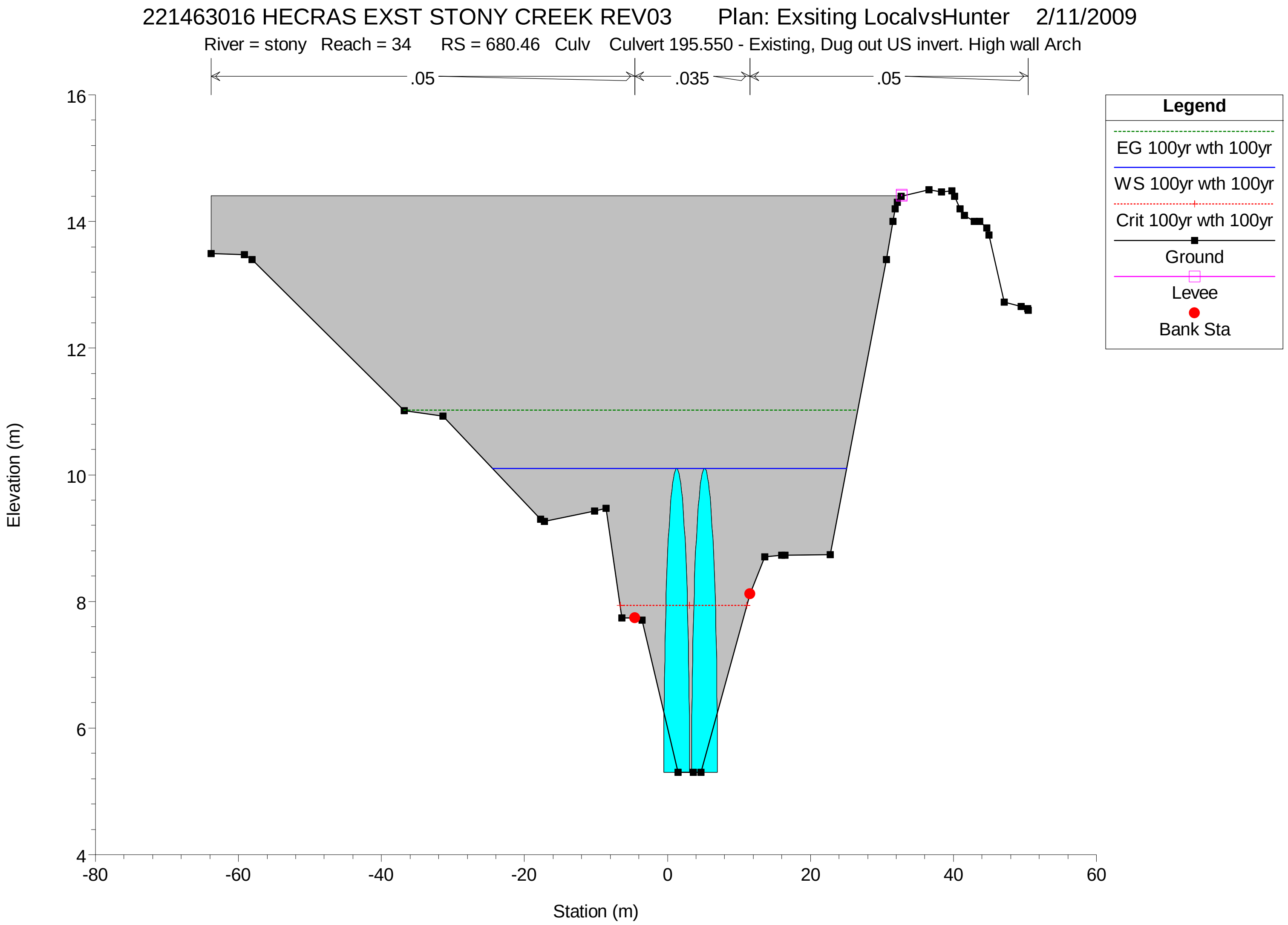
River = stony Reach = 34 RS = 725.22
.05
.035
.05
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

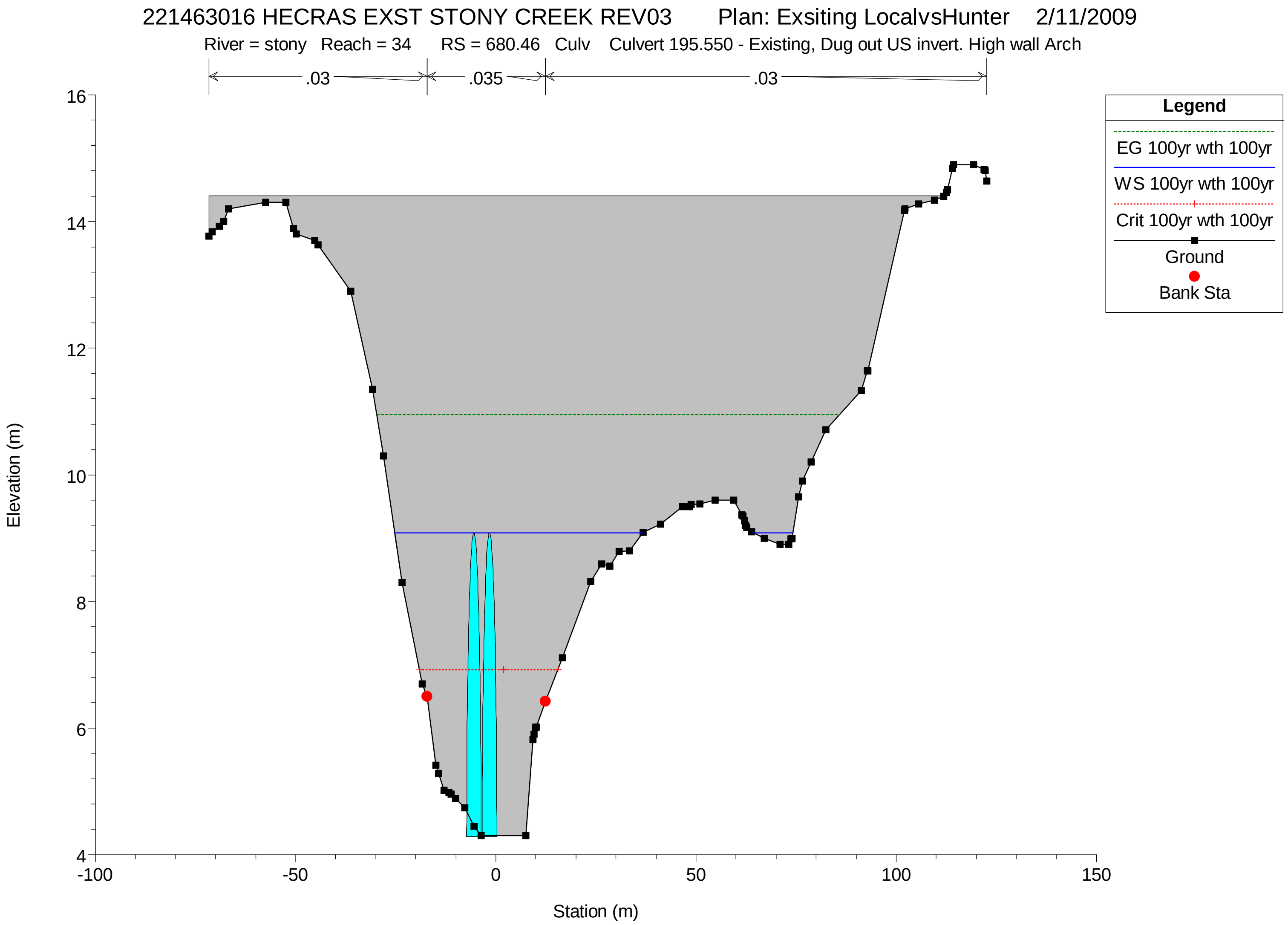


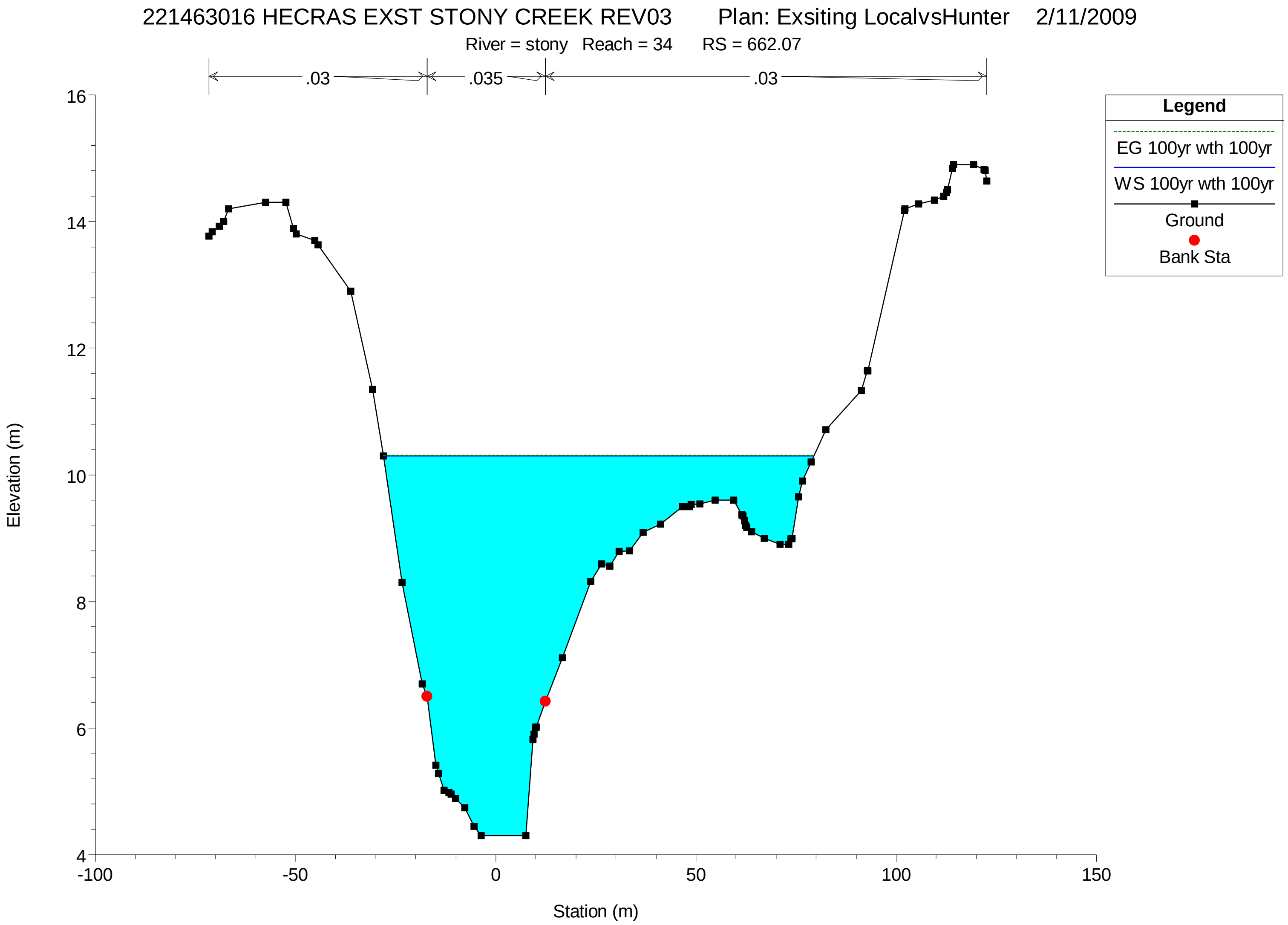
221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 720.95
.05
.035
.05
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 704.49
.05
.035
.05
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-80
-60
-40
-20
0
20
40
60


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 698.66
.05
.035
.05
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-80
-60
-40
-20
0
20
40
60


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 680.46 Culv Culvert 195.550 - Existing, Dug out US invert. High wall Arch
.05
.035
.05
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-80
-60
-40
-20
0
20
40
60


221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 680.46 Culv Culvert 195.550 - Existing, Dug out US invert. High wall Arch
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-100
-50
0
50
100
150



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River = stony Reach = 34 RS = 662.07
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.035
.03
Legend
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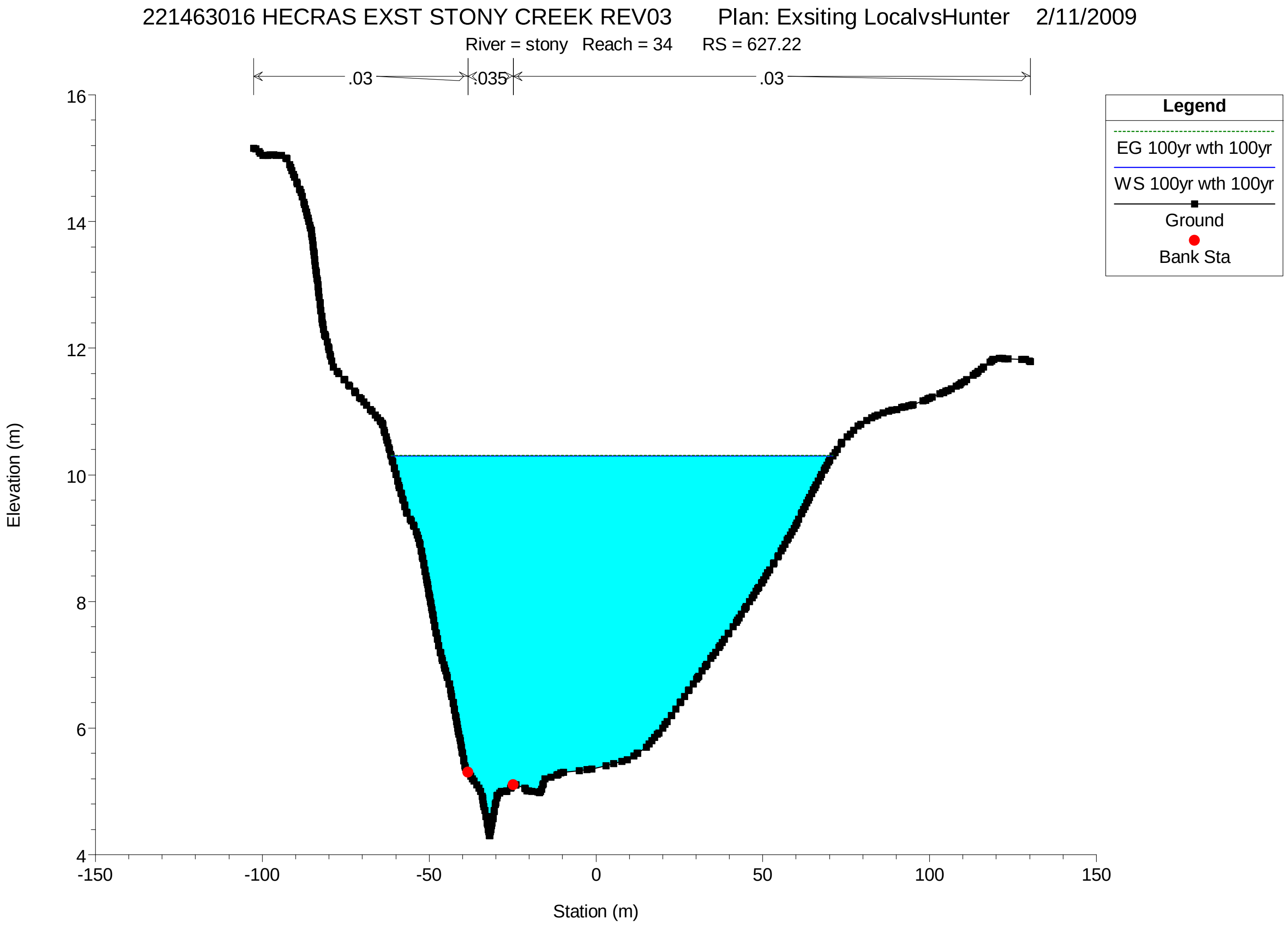
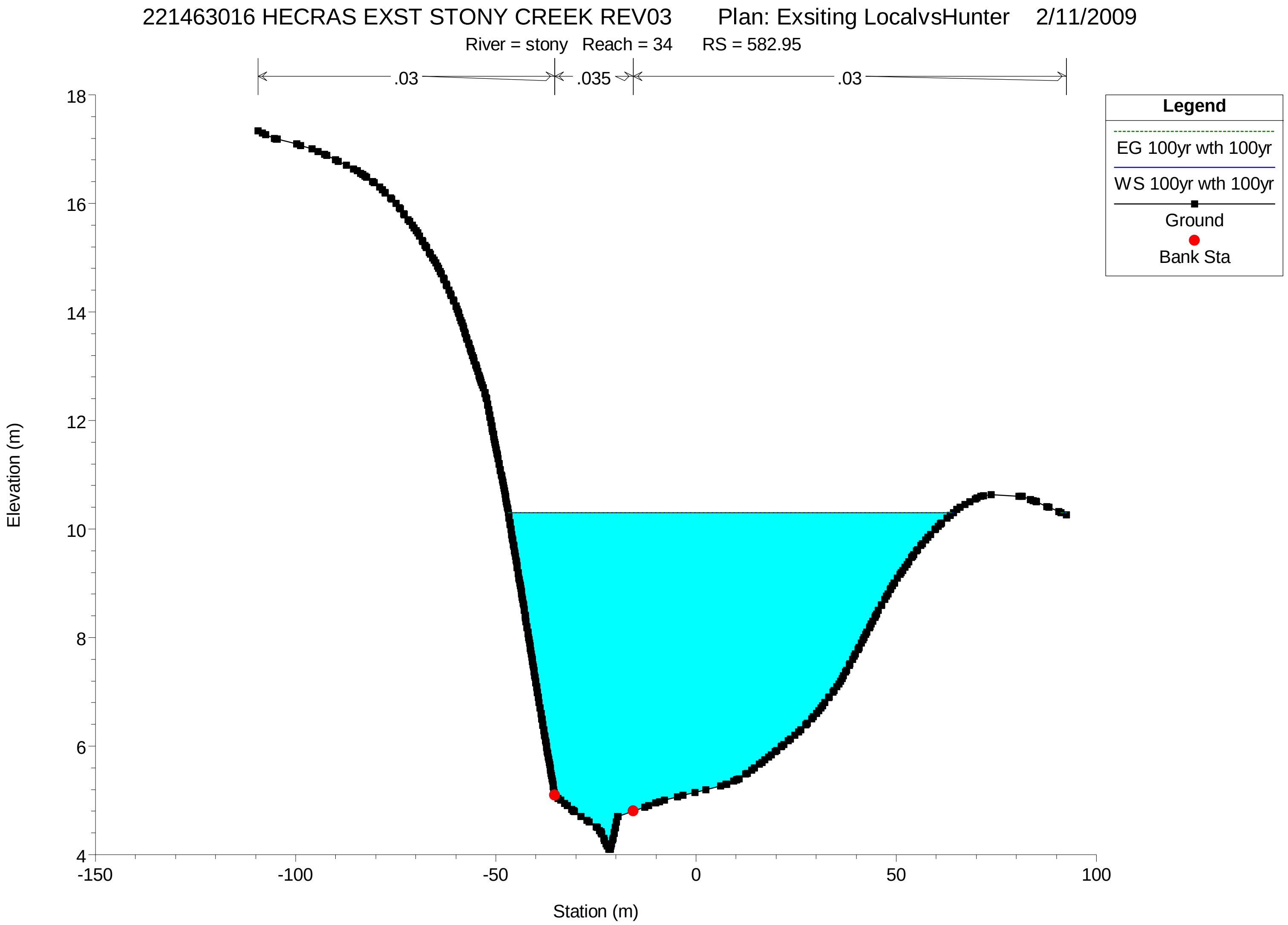
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)



221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 627.22
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)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River = stony Reach = 34 RS = 582.95
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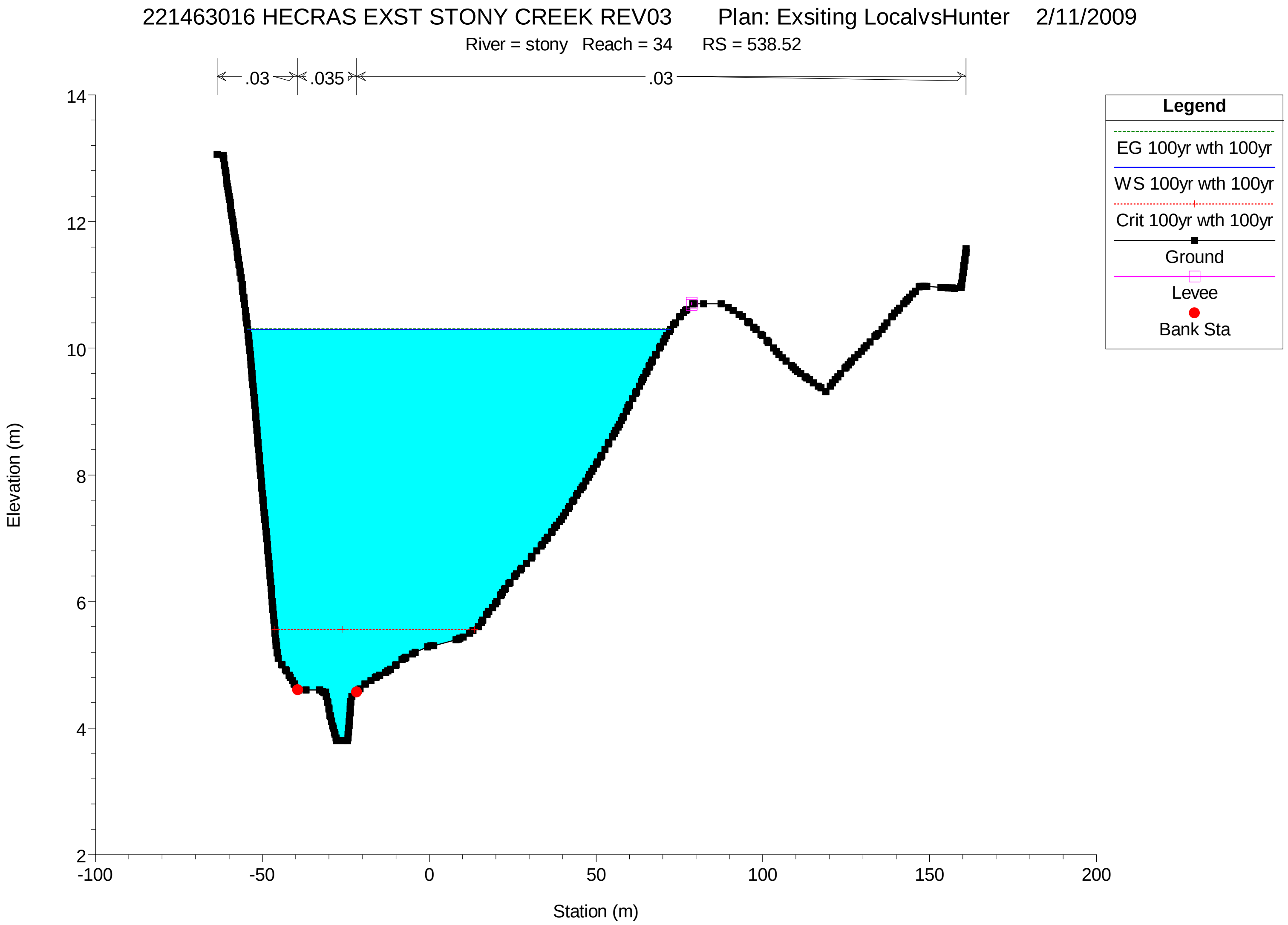
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)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River = stony Reach = 34 RS = 538.52
.03
.035
.03
Legend
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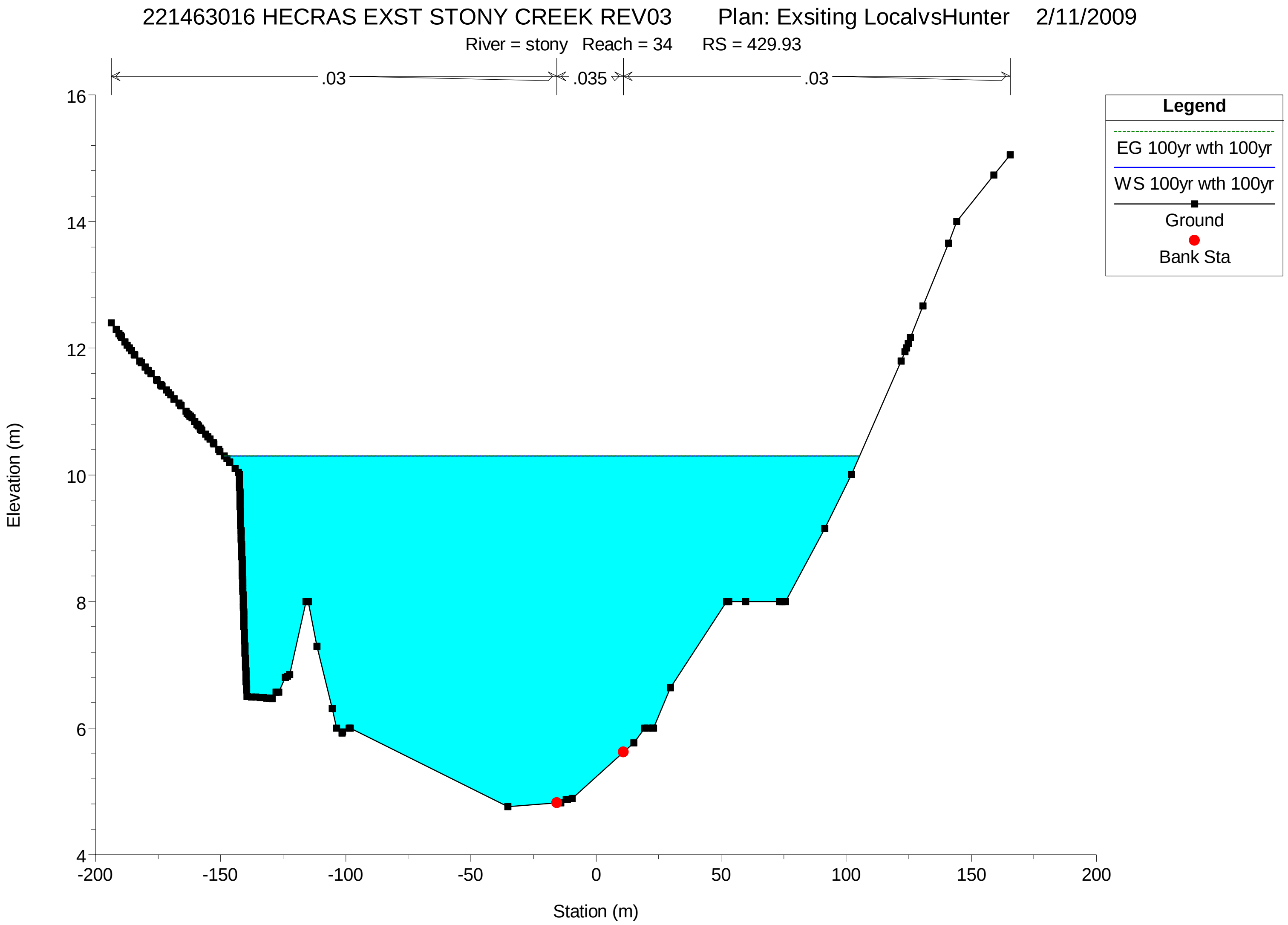
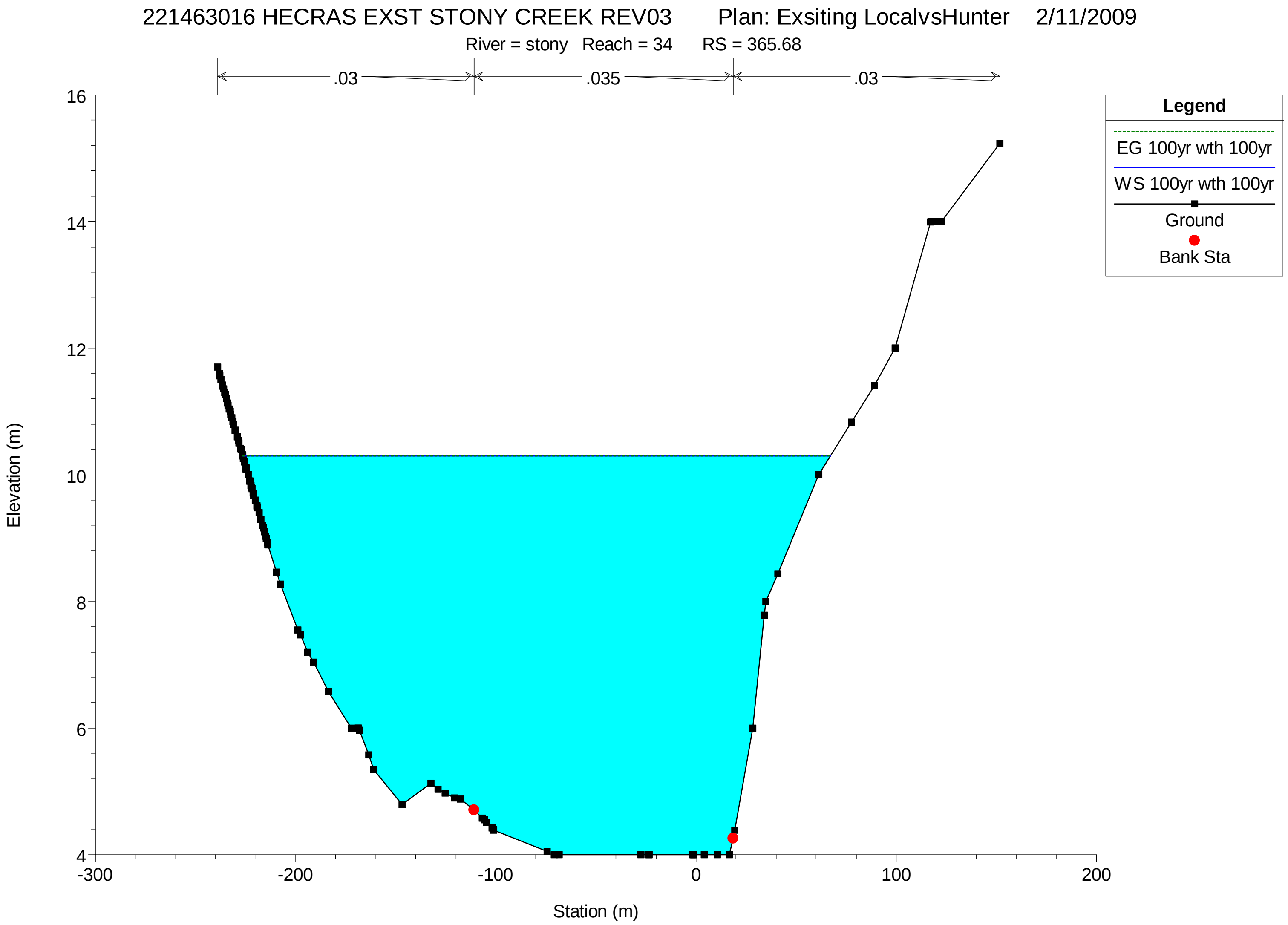
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)



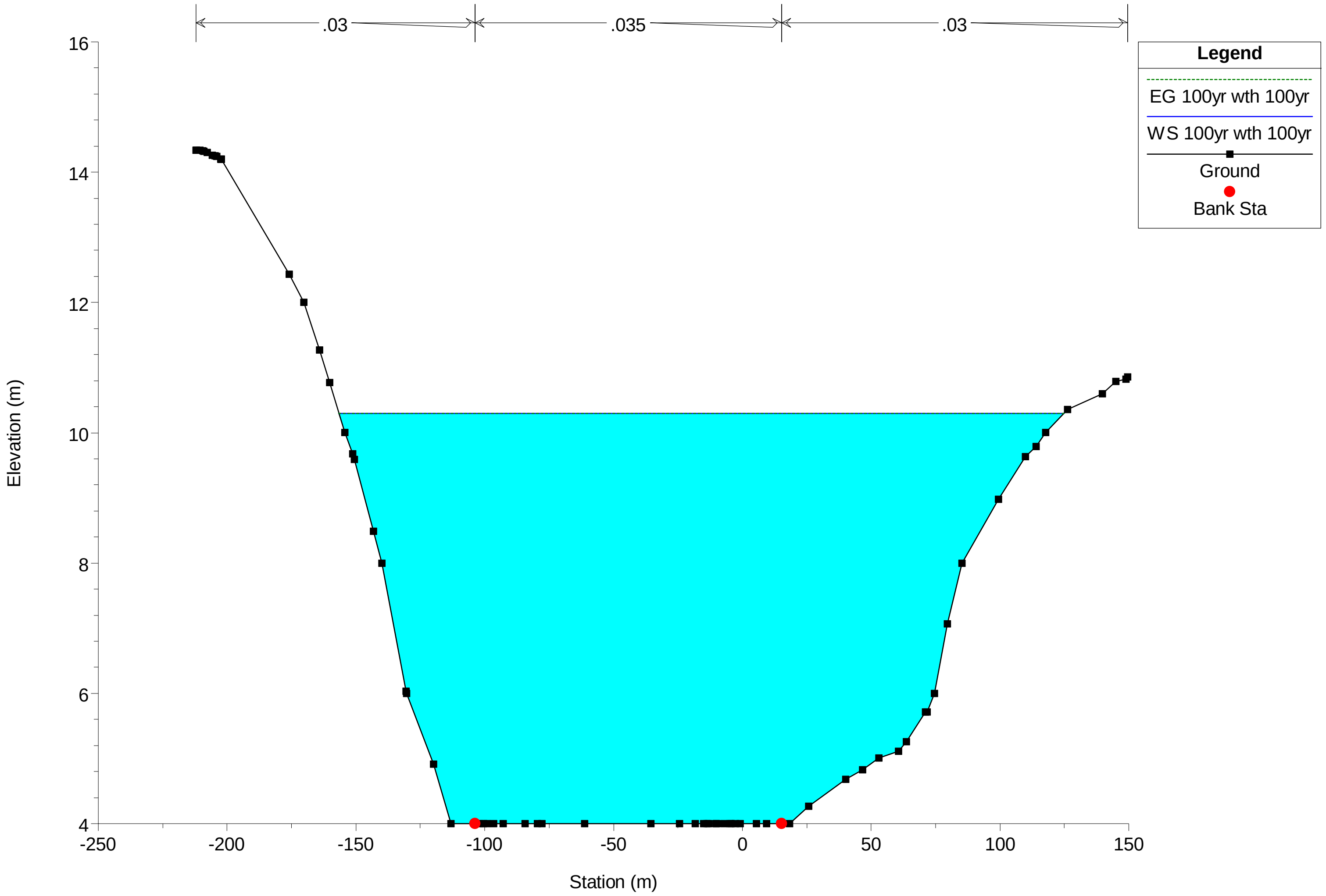
221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 429.93
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-200
-150
-100
-50
0
50
100
150
200



221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009
River = stony Reach = 34 RS = 365.68
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Ground
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
-300
-200
-100
0
100
200

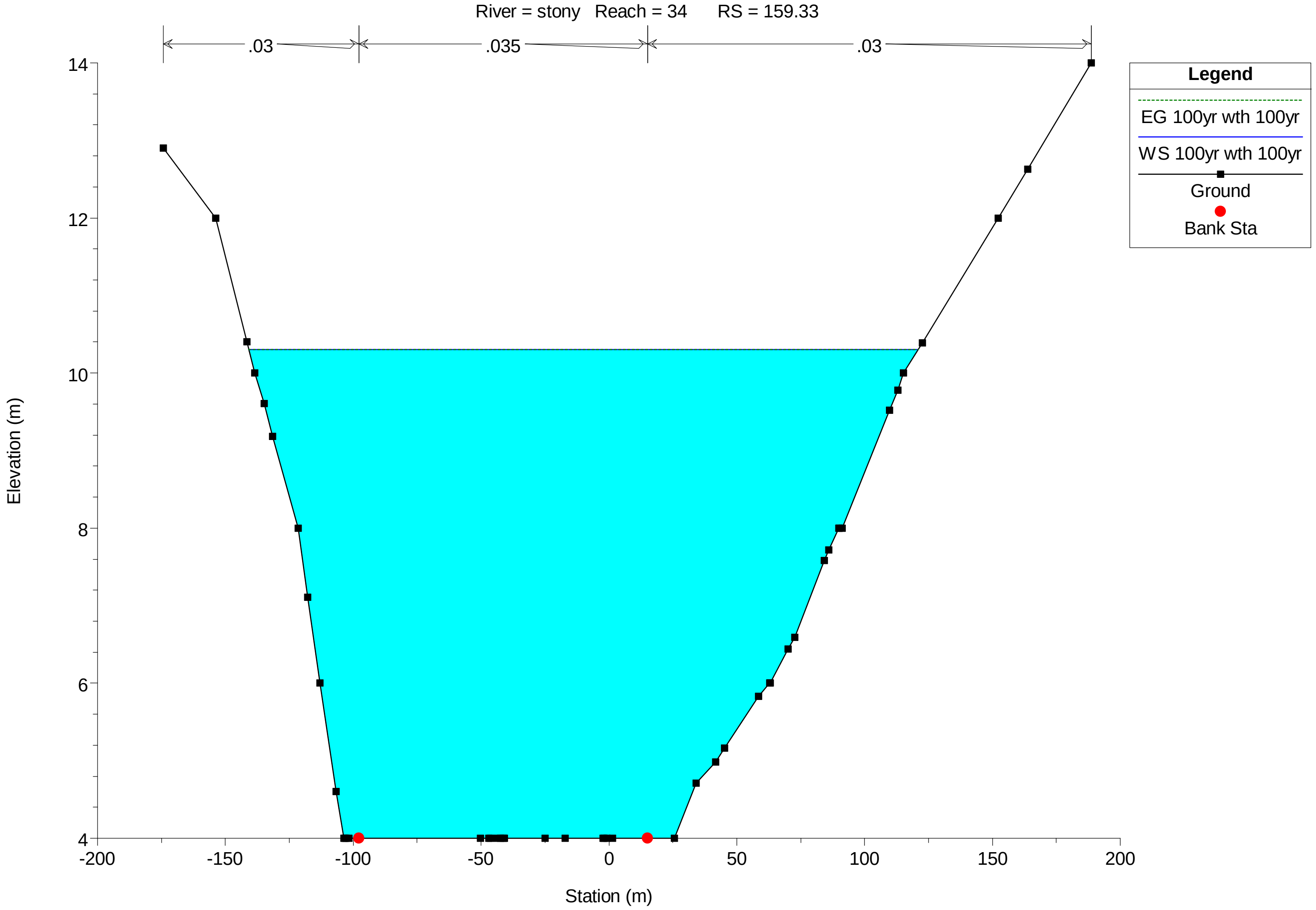
221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009

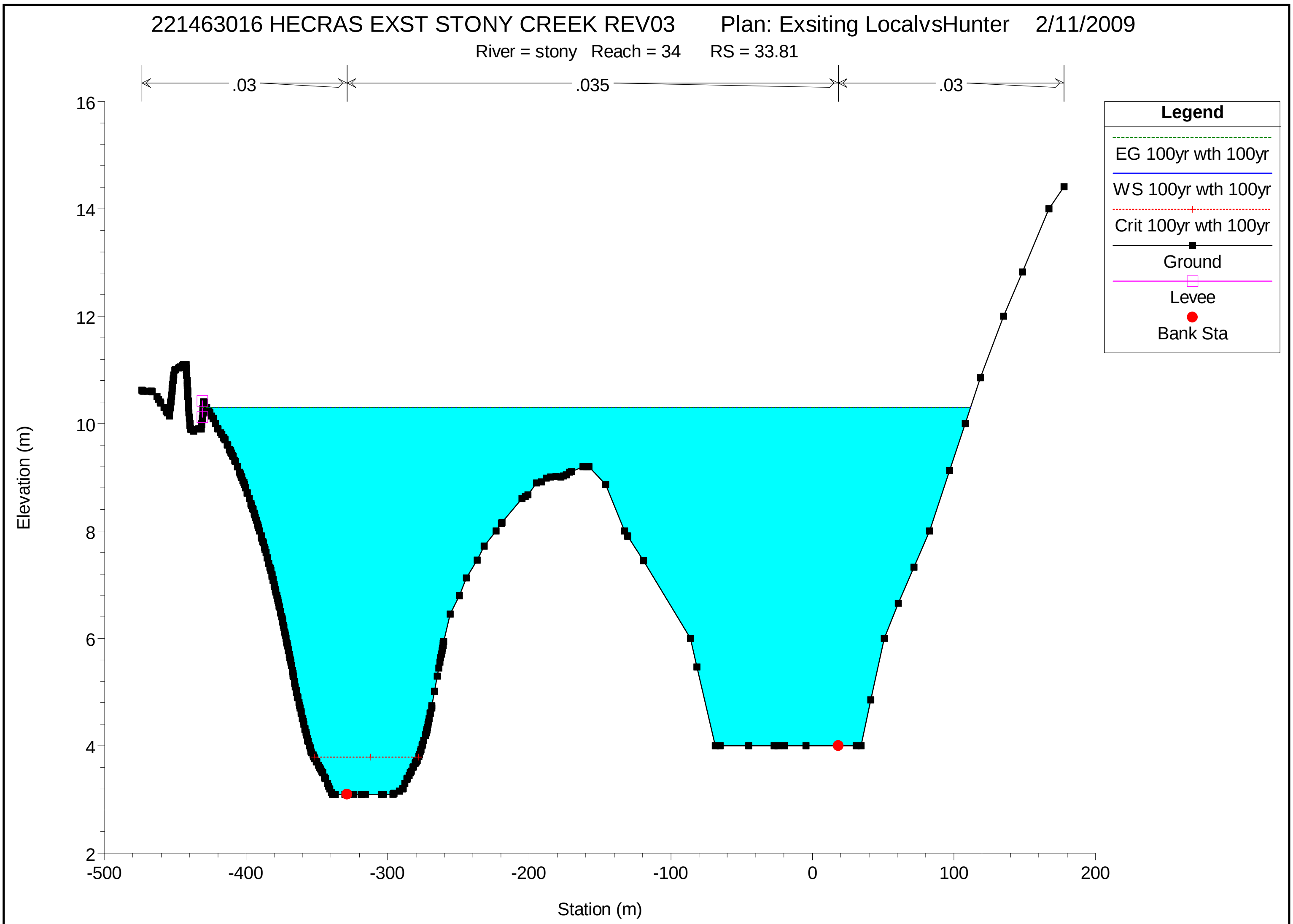
River = stony Reach = 34 RS = 189.51



221463016 HECRAS EXST STONY CREEK REV03 Plan: Exsiting LocalvsHunter 2/11/2009

River = stony Reach = 34 RS = 159.33

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River = stony Reach = 34 RS = 33.81
.03
.035
.03
Legend
EG 100yr wth 100yr
WS 100yr wth 100yr
Crit 100yr wth 100yr
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
16
14
12
10
8
6
4
2
-500
-400
-300
-200
-100
0
100
200

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Appendix C

Anvil and Sawyers Creek Hydrologic and Hydraulic Model

Catchment Plan

Summary of XP-RAFTS Inputs

XP-RAFTS Results

HEC-RAS Results

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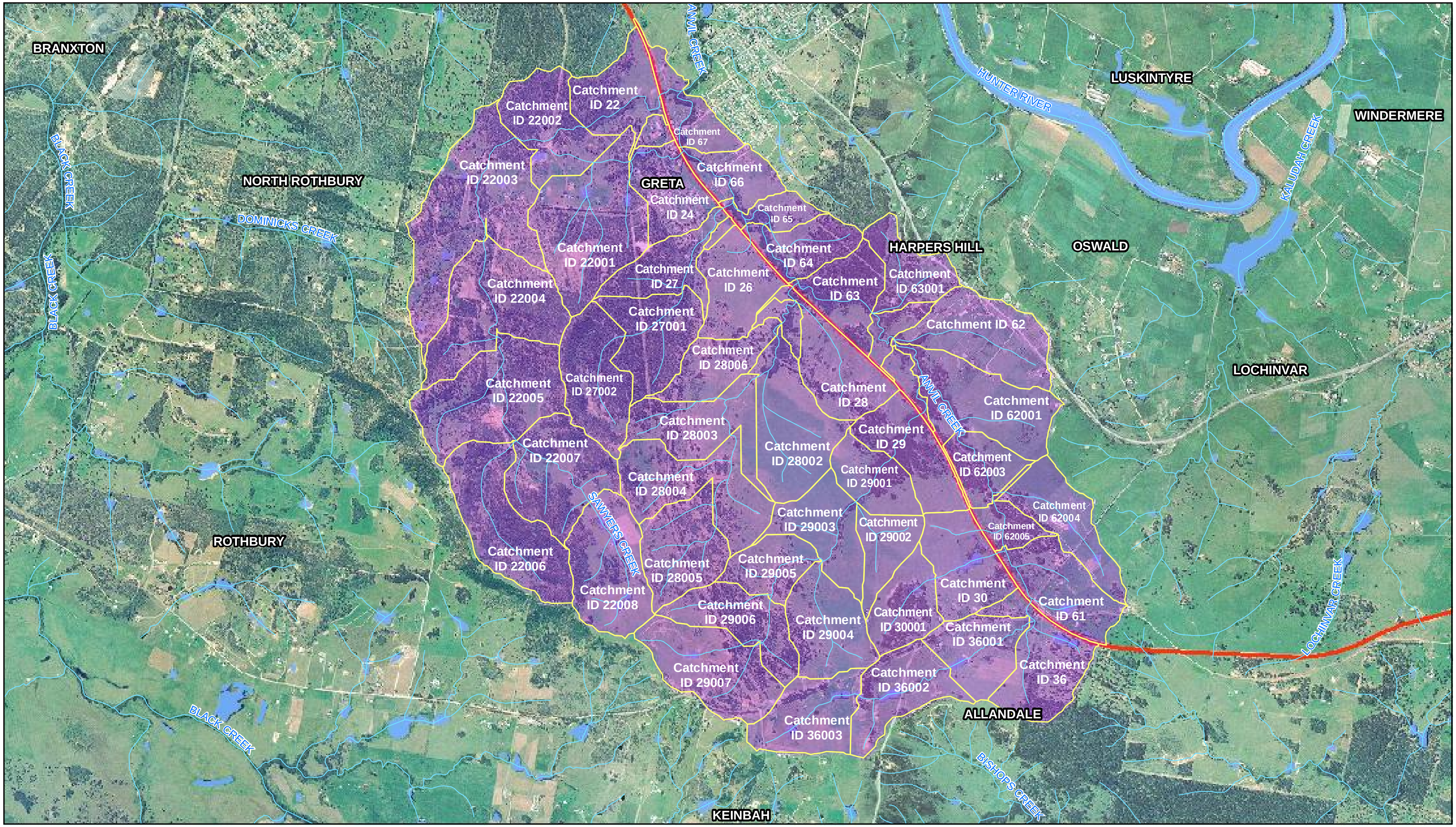

1:40,000 (at A4)

0 170 340 680 1,020 1,360

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Cadastre
- Subcatchment
- Watercourse
- Watercourse Areas

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Maitland To Minimbah Third Track
Surface Water Assessment

Job Number 22-14471
Revision A
Date MAY 2010

Anvil Creek Catchment Plan

Figure C1

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_AnvilCk_Catchment_Plan_20091015_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski, gmcdiarmid

Anvil Creek XP-RAFTS Model Inputs

Catchment	Area (ha)	Slope %	Percentage Impervious
36003	41.28	5%	10%
36002	40.09	6%	10%
36001	34.7	4%	10%
36	46.43	5%	10%
61	42.73	7%	10%
62004	38.9	7%	10%
62005	15.3	6%	10%
62003	23.52	6%	10%
62001	59.5	7%	20%
63002	11.64	5%	10%
62002	8.54	6%	10%
62	54.17	7%	20%
63001	29.2	6%	10%
63	33.4	7%	10%
64	28.27	8%	10%
65	14.4	6%	10%
66	24.9	6%	20%
67	25.33	6%	20%
30	41.7	5%	10%
30001	30.65	6%	10%
29007	55.14	8%	10%
29006	38.9	7%	10%
29005	25.9	5%	10%
29004	43.5	6%	10%
29003	37.9	5%	10%
29002	23.8	4%	10%
29001	28.2	6%	10%
29	38.9	6%	10%

Catchment	Area (ha)	Slope %	Percentage Impervious
28	42.3	5%	10%
28001	8.06	3%	10%
28002	58.43	3%	10%
28006	29.53	4%	10%
28003	44.8	6%	10%
28004	57.94	9%	10%
28005	44	9%	10%
26	37.8	4%	10%
25	2.2	2%	10%
27	31.3	6%	10%
27001	43.5	7%	10%
27002	47.11	17%	10%
24	33.94	5%	40%
23	5.1	3%	40%
22	36.94	6%	10%
22001	77.76	7%	20%
22002	45.4	3%	10%
22003	99.08	6%	10%
22004	70.4	10%	10%
22005	72.8	14%	10%
22006	63.9	20%	10%
22007	56.1	19%	10%
22008	55.9	17%	20%

```
 Run started at:  2nd  November  2009  14:15:43


#####################################################################################
                         RUNTIME          RESULTS
#####################################################################################


Max. no. of links allowed =       1500


Max. no. of routng increments allowed =     250000


Max. no. of rating curve points =     250000


Max. no. of storm temporal points =     250000


Max. no. of channel subreaches =        25


Max link stack level =         25


Input Version number =          700


 LINK c23                 1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                  3.047
 ESTIMATED PEAK FLOW         (CUMECS) =                  1.3
 ESTIMATED TIME TO PEAK         (MINS) =               30.00

 LINK 24                  1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                  20.73
 ESTIMATED PEAK FLOW         (CUMECS) =                  8.4
 ESTIMATED TIME TO PEAK         (MINS) =               30.00

 LINK 28005               1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                  24.57
 ESTIMATED PEAK FLOW         (CUMECS) =                  10.
 ESTIMATED TIME TO PEAK         (MINS) =               33.00

 LINK 28004               1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                  56.96
 ESTIMATED PEAK FLOW         (CUMECS) =                  21.
 ESTIMATED TIME TO PEAK         (MINS) =               42.00

 LINK 28003               1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                  82.00
 ESTIMATED PEAK FLOW         (CUMECS) =                  27.
 ESTIMATED TIME TO PEAK         (MINS) =               52.00

 LINK 28002               1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                  114.5
 ESTIMATED PEAK FLOW         (CUMECS) =                  32.
 ESTIMATED TIME TO PEAK         (MINS) =               79.00

 LINK 28006               1.000
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ESTIMATED VOLUME (CU METRES*10**3) =                    16.81
ESTIMATED PEAK FLOW         (CUMECS) =                    5.4
ESTIMATED TIME TO PEAK         (MINS) =                 40.00

LINK 28001              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    135.8
ESTIMATED PEAK FLOW         (CUMECS) =                    35.
ESTIMATED TIME TO PEAK         (MINS) =                 85.00

LINK 28                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    159.4
ESTIMATED PEAK FLOW         (CUMECS) =                    36.
ESTIMATED TIME TO PEAK         (MINS) =                 95.00

LINK 63001              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    16.34
ESTIMATED PEAK FLOW         (CUMECS) =                    6.2
ESTIMATED TIME TO PEAK         (MINS) =                 35.00

LINK 36003              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    23.07
ESTIMATED PEAK FLOW         (CUMECS) =                    7.6
ESTIMATED TIME TO PEAK         (MINS) =                 39.00

LINK 36002              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    45.46
ESTIMATED PEAK FLOW         (CUMECS) =                    10.
ESTIMATED TIME TO PEAK         (MINS) =                 79.00

LINK 36001              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    64.86
ESTIMATED PEAK FLOW         (CUMECS) =                    13.
ESTIMATED TIME TO PEAK         (MINS) =                 52.00

LINK 36                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    90.80
ESTIMATED PEAK FLOW         (CUMECS) =                    19.
ESTIMATED TIME TO PEAK         (MINS) =                 53.00

LINK 30001              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    1.713
ESTIMATED PEAK FLOW         (CUMECS) =                   0.95
ESTIMATED TIME TO PEAK         (MINS) =                 31.00

LINK 30                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    25.02
ESTIMATED PEAK FLOW         (CUMECS) =                    7.7
ESTIMATED TIME TO PEAK         (MINS) =                 39.00

LINK 61                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    139.5
ESTIMATED PEAK FLOW         (CUMECS) =                    25.
ESTIMATED TIME TO PEAK         (MINS) =                 82.00

LINK 62005              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    147.9
ESTIMATED PEAK FLOW         (CUMECS) =                    25.
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ESTIMATED TIME TO PEAK          (MINS) =              107.00

LINK 62004              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    21.76
ESTIMATED PEAK FLOW          (CUMECS) =                  8.3
ESTIMATED TIME TO PEAK          (MINS) =               34.00

LINK 62003              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    182.3
ESTIMATED PEAK FLOW          (CUMECS) =                  26.
ESTIMATED TIME TO PEAK          (MINS) =              141.00

LINK 62001              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    213.0
ESTIMATED PEAK FLOW          (CUMECS) =                  26.
ESTIMATED TIME TO PEAK          (MINS) =              188.00

LINK 62                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    30.33
ESTIMATED PEAK FLOW          (CUMECS) =                  15.
ESTIMATED TIME TO PEAK          (MINS) =               31.00

LINK 29007              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    30.77
ESTIMATED PEAK FLOW          (CUMECS) =                  12.
ESTIMATED TIME TO PEAK          (MINS) =               35.00

LINK 29006              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    52.52
ESTIMATED PEAK FLOW          (CUMECS) =                  16.
ESTIMATED TIME TO PEAK          (MINS) =               54.00

LINK 29005              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    67.02
ESTIMATED PEAK FLOW          (CUMECS) =                  19.
ESTIMATED TIME TO PEAK          (MINS) =               65.00

LINK 29004              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    24.34
ESTIMATED PEAK FLOW          (CUMECS) =                  8.6
ESTIMATED TIME TO PEAK          (MINS) =               37.00

LINK 29003              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    112.5
ESTIMATED PEAK FLOW          (CUMECS) =                  25.
ESTIMATED TIME TO PEAK          (MINS) =               79.00

LINK 29002              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    13.34
ESTIMATED PEAK FLOW          (CUMECS) =                  4.4
ESTIMATED TIME TO PEAK          (MINS) =               39.00

LINK 29001              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    141.5
ESTIMATED PEAK FLOW          (CUMECS) =                  29.
ESTIMATED TIME TO PEAK          (MINS) =               82.00

LINK 29                 1.000
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ESTIMATED VOLUME (CU METRES*10**3) =                    163.2
ESTIMATED PEAK FLOW         (CUMECS) =                    30.
ESTIMATED TIME TO PEAK         (MINS) =                 105.00

LINK 62002              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    167.8
ESTIMATED PEAK FLOW         (CUMECS) =                    30.
ESTIMATED TIME TO PEAK         (MINS) =                 121.00

LINK 63002              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    414.6
ESTIMATED PEAK FLOW         (CUMECS) =                    50.
ESTIMATED TIME TO PEAK         (MINS) =                 160.00

LINK 63                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    589.3
ESTIMATED PEAK FLOW         (CUMECS) =                    76.
ESTIMATED TIME TO PEAK         (MINS) =                  90.00

LINK 26                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    21.16
ESTIMATED PEAK FLOW         (CUMECS) =                    6.5
ESTIMATED TIME TO PEAK         (MINS) =                  41.00

LINK 64                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    580.4
ESTIMATED PEAK FLOW         (CUMECS) =                    76.
ESTIMATED TIME TO PEAK         (MINS) =                 134.00

LINK 25                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    1.235
ESTIMATED PEAK FLOW         (CUMECS) =                   0.48
ESTIMATED TIME TO PEAK         (MINS) =                  33.00

LINK 27002              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    26.39
ESTIMATED PEAK FLOW         (CUMECS) =                    14.
ESTIMATED TIME TO PEAK         (MINS) =                  31.00

LINK 27001              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    50.70
ESTIMATED PEAK FLOW         (CUMECS) =                    21.
ESTIMATED TIME TO PEAK         (MINS) =                  47.00

LINK 27                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    68.18
ESTIMATED PEAK FLOW         (CUMECS) =                    22.
ESTIMATED TIME TO PEAK         (MINS) =                  88.00

LINK 65                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    633.2
ESTIMATED PEAK FLOW         (CUMECS) =                    79.
ESTIMATED TIME TO PEAK         (MINS) =                 147.00

LINK 66                 1.000

ESTIMATED VOLUME (CU METRES*10**3) =                    579.4
ESTIMATED PEAK FLOW         (CUMECS) =                    80.
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ESTIMATED TIME TO PEAK         (MINS) =              184.00

LINK 22006             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  35.78
ESTIMATED PEAK FLOW         (CUMECS) =                  19.
ESTIMATED TIME TO PEAK         (MINS) =               31.00

LINK 22008             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  31.32
ESTIMATED PEAK FLOW         (CUMECS) =                  19.
ESTIMATED TIME TO PEAK         (MINS) =               31.00

LINK 22007             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  62.73
ESTIMATED PEAK FLOW         (CUMECS) =                  22.
ESTIMATED TIME TO PEAK         (MINS) =               76.00

LINK 22005             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  139.3
ESTIMATED PEAK FLOW         (CUMECS) =                  39.
ESTIMATED TIME TO PEAK         (MINS) =               82.00

LINK 22004             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  178.6
ESTIMATED PEAK FLOW         (CUMECS) =                  40.
ESTIMATED TIME TO PEAK         (MINS) =              103.00

LINK 22003             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  233.7
ESTIMATED PEAK FLOW         (CUMECS) =                  41.
ESTIMATED TIME TO PEAK         (MINS) =              145.00

LINK 22002             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  258.8
ESTIMATED PEAK FLOW         (CUMECS) =                  41.
ESTIMATED TIME TO PEAK         (MINS) =              164.00

LINK 22001             1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  43.58
ESTIMATED PEAK FLOW         (CUMECS) =                  19.
ESTIMATED TIME TO PEAK         (MINS) =               31.00

LINK 22                1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  321.8
ESTIMATED PEAK FLOW         (CUMECS) =                  41.
ESTIMATED TIME TO PEAK         (MINS) =              191.00

LINK 67                1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  822.0
ESTIMATED PEAK FLOW         (CUMECS) =                  94.
ESTIMATED TIME TO PEAK         (MINS) =              218.00


################################################################################
#####
Anvil Creek
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Results for period from 0: 0.0 1/ 1/1990
to 5: 0.0 1/ 1/1990

##

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 90.
RETURN PERIOD (YRS) = 100.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (ha) = 1957.94
TOTAL OF SECOND SUB-AREAS (ha) = 16.00
TOTAL OF ALL SUB-AREAS (ha) = 1973.94

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
c23	3.000	2.000	3.000	3.000	.0100	100.0	.050	.025	.0443	.0025	1.000
24	20.000	14.000	4.700	4.700	.0100	100.0	.050	.025	.0950	.0054	2.000
28005	44.000	0.000	9.000	0.000	10.00	0.000	.050	0.00	.0685	0.000	3.000
28004	58.000	0.000	9.000	0.000	10.00	0.000	.050	0.00	.0790	0.000	3.001
28003	44.800	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0846	0.000	3.002
28002	58.430	0.000	3.000	0.000	10.00	0.000	.050	0.00	.1373	0.000	3.003
28006	30.000	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0841	0.000	4.000
28001	8.060	0.000	3.000	0.000	10.00	0.000	.050	0.00	.0490	0.000	3.004
28	42.300	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0899	0.000	3.005
63001	29.200	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0677	0.000	5.000
36003	41.280	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0888	0.000	6.000
36002	40.090	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0799	0.000	6.001
36001	34.700	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0907	0.000	6.002
36	46.400	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0944	0.000	6.003
30001	3.065	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0210	0.000	7.000
30	41.700	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0893	0.000	7.001
61	42.700	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0764	0.000	6.004
62005	15.300	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0484	0.000	6.005
62004	38.900	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0728	0.000	8.000
62003	23.520	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0605	0.000	6.006
62001	59.500	0.000	7.000	0.000	20.00	0.000	.050	0.00	.0645	0.000	6.007
62	54.170	0.000	7.000	0.000	20.00	0.000	.050	0.00	.0615	0.000	9.000
29007	55.140	0.000	8.000	0.000	10.00	0.000	.050	0.00	.0817	0.000	10.00
29006	38.900	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0728	0.000	10.00
29005	25.900	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0697	0.000	10.00

29004	43.500	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0833	0.000	11.00
29003	37.900	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0850	0.000	10.00
29002	23.800	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0746	0.000	12.00
29001	28.200	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0665	0.000	10.00
29	38.900	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0786	0.000	10.01
62002	8.540	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0357	0.000	10.01
63002	11.640	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0460	0.000	6.008
63	33.400	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0673	0.000	3.006
26	37.800	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0948	0.000	13.00
64	28.300	0.000	8.000	0.000	10.00	0.000	.050	0.00	.0577	0.000	3.007
25	2.200	0.000	2.000	0.000	10.00	0.000	.050	0.00	.0305	0.000	14.00
27002	47.110	0.000	17.00	0.000	10.00	0.000	.050	0.00	.0517	0.000	15.00
27001	43.500	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0772	0.000	15.00
27	31.300	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0702	0.000	15.00
65	14.400	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0469	0.000	3.008
66	24.900	0.000	6.000	0.000	20.00	0.000	.050	0.00	.0443	0.000	2.001
22006	63.900	0.000	20.00	0.000	10.00	0.000	.050	0.00	.0558	0.000	16.00
22008	55.900	0.000	17.20	0.000	20.00	0.000	.050	0.00	.0399	0.000	17.00
22007	56.070	0.000	19.00	0.000	10.00	0.000	.050	0.00	.0535	0.000	17.00
22005	72.820	0.000	14.00	0.000	10.00	0.000	.050	0.00	.0714	0.000	16.00
22004	70.360	0.000	9.800	0.000	10.00	0.000	.050	0.00	.0838	0.000	16.00
22003	99.000	0.000	6.000	0.000	10.00	0.000	.050	0.00	.1278	0.000	16.00
22002	45.400	0.000	3.000	0.000	10.00	0.000	.050	0.00	.1204	0.000	16.00
22001	77.800	0.000	6.600	0.000	20.00	0.000	.050	0.00	.0764	0.000	18.00
22	36.950	0.000	5.500	0.000	10.00	0.000	.050	0.00	.0799	0.000	16.00
67	25.300	0.000	6.000	0.000	20.00	0.000	.050	0.00	.0447	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
c23	46.230	10.00	1.000	2.500	0.000	56.054	68.345	1.292	30.00	1.500
24	46.230	10.00	1.000	2.500	0.000	56.054	68.345	8.409	30.00	.2000
28005	46.230	10.00	0.000	2.500	0.000	56.054	0.000	10.163	33.00	11.00
28004	46.230	10.00	0.000	2.500	0.000	56.054	0.000	21.128	42.00	10.00
28003	46.230	10.00	0.000	2.500	0.000	56.054	0.000	27.273	52.00	28.00
28002	46.230	10.00	0.000	2.500	0.000	56.054	0.000	32.028	79.00	5.500

28006	46.230	10.00	0.000	2.500	0.000	56.054	0.000	5.363	40.00	5.500
28001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	34.512	85.00	10.00
28	46.230	10.00	0.000	2.500	0.000	56.054	0.000	36.200	95.00	1.500
63001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	6.170	35.00	42.00
36003	46.230	10.00	0.000	2.500	0.000	56.054	0.000	7.633	39.00	43.00
36002	46.230	10.00	0.000	2.500	0.000	56.054	0.000	10.114	79.00	18.60
36001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	12.787	52.00	3.400
36	46.230	10.00	0.000	2.500	0.000	56.054	0.000	19.160	53.00	29.00
30001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	0.9531	31.00	33.00
30	46.230	10.00	0.000	2.500	0.000	56.054	0.000	7.700	39.00	2.000
61	46.230	10.00	0.000	2.500	0.000	56.054	0.000	24.783	82.00	25.00
62005	46.230	10.00	0.000	2.500	0.000	56.054	0.000	25.053	107.0	34.00
62004	46.230	10.00	0.000	2.500	0.000	56.054	0.000	8.324	34.00	34.00
62003	46.230	10.00	0.000	2.500	0.000	56.054	0.000	25.913	141.0	47.00
62001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	25.948	188.0	16.70
62	46.230	10.00	0.000	2.500	0.000	56.054	0.000	14.546	31.00	16.70
29007	46.230	10.00	0.000	2.500	0.000	56.054	0.000	11.601	35.00	21.00
29006	46.230	10.00	0.000	2.500	0.000	56.054	0.000	16.211	54.00	13.00
29005	46.230	10.00	0.000	2.500	0.000	56.054	0.000	18.597	65.00	14.00
29004	46.230	10.00	0.000	2.500	0.000	56.054	0.000	8.563	37.00	14.00
29003	46.230	10.00	0.000	2.500	0.000	56.054	0.000	25.209	79.00	25.30
29002	46.230	10.00	0.000	2.500	0.000	56.054	0.000	4.412	39.00	25.00
29001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	29.385	82.00	23.00
29	46.230	10.00	0.000	2.500	0.000	56.054	0.000	30.315	105.0	16.00
62002	46.230	10.00	0.000	2.500	0.000	56.054	0.000	30.367	121.0	16.70
63002	46.230	10.00	0.000	2.500	0.000	56.054	0.000	50.432	160.0	42.00
63	46.230	10.00	0.000	2.500	0.000	56.054	0.000	75.805	90.00	44.00
26	46.230	10.00	0.000	2.500	0.000	56.054	0.000	6.507	41.00	3.600
64	46.230	10.00	0.000	2.500	0.000	56.054	0.000	76.335	134.0	13.00
25	46.230	10.00	0.000	2.500	0.000	56.054	0.000	0.4779	33.00	1.500
27002	46.230	10.00	0.000	2.500	0.000	56.054	0.000	13.820	31.00	16.00
27001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	20.705	47.00	41.00
27	46.230	10.00	0.000	2.500	0.000	56.054	0.000	22.194	88.00	2.500
65	46.230	10.00	0.000	2.500	0.000	56.054	0.000	79.496	147.0	37.00
66	46.230	10.00	0.000	2.500	0.000	56.054	0.000	79.568	184.0	34.00

22006	46.230	10.00	0.000	2.500	0.000	56.054	0.000	18.911	31.00	52.00
22008	46.230	10.00	0.000	2.500	0.000	56.054	0.000	18.737	31.00	45.00
22007	46.230	10.00	0.000	2.500	0.000	56.054	0.000	22.040	76.00	51.00
22005	46.230	10.00	0.000	2.500	0.000	56.054	0.000	38.686	82.00	21.00
22004	46.230	10.00	0.000	2.500	0.000	56.054	0.000	40.316	103.0	42.00
22003	46.230	10.00	0.000	2.500	0.000	56.054	0.000	40.996	145.0	19.00
22002	46.230	10.00	0.000	2.500	0.000	56.054	0.000	41.255	164.0	27.00
22001	46.230	10.00	0.000	2.500	0.000	56.054	0.000	19.101	31.00	27.00
22	46.230	10.00	0.000	2.500	0.000	56.054	0.000	41.400	191.0	5.000
67	46.230	10.00	0.000	2.500	0.000	56.054	0.000	94.277	218.0	0.000

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 LINK c23                2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 3.428
 ESTIMATED PEAK FLOW         (CUMECS) =                 1.1
 ESTIMATED TIME TO PEAK         (MINS) =              35.00

 LINK 24                 2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 23.32
 ESTIMATED PEAK FLOW         (CUMECS) =                 7.5
 ESTIMATED TIME TO PEAK         (MINS) =              35.00

 LINK 28005              2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 27.81
 ESTIMATED PEAK FLOW         (CUMECS) =                 11.
 ESTIMATED TIME TO PEAK         (MINS) =              41.00

 LINK 28004              2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 64.39
 ESTIMATED PEAK FLOW         (CUMECS) =                 21.
 ESTIMATED TIME TO PEAK         (MINS) =              51.00

 LINK 28003              2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 92.64
 ESTIMATED PEAK FLOW         (CUMECS) =                 28.
 ESTIMATED TIME TO PEAK         (MINS) =              57.00

 LINK 28002              2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 129.1
 ESTIMATED PEAK FLOW         (CUMECS) =                 33.
 ESTIMATED TIME TO PEAK         (MINS) =              85.00

 LINK 28006              2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 18.94
 ESTIMATED PEAK FLOW         (CUMECS) =                 5.7
 ESTIMATED TIME TO PEAK         (MINS) =              46.00

 LINK 28001              2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                 153.1
 ESTIMATED PEAK FLOW         (CUMECS) =                 36.
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ESTIMATED TIME TO PEAK          (MINS) =              91.00

LINK 28                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 179.7
ESTIMATED PEAK FLOW          (CUMECS) =                38.
ESTIMATED TIME TO PEAK          (MINS) =             101.00

LINK 63001              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 18.40
ESTIMATED PEAK FLOW          (CUMECS) =                6.6
ESTIMATED TIME TO PEAK          (MINS) =              43.00

LINK 36003              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 26.04
ESTIMATED PEAK FLOW          (CUMECS) =                8.1
ESTIMATED TIME TO PEAK          (MINS) =              45.00

LINK 36002              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 51.29
ESTIMATED PEAK FLOW          (CUMECS) =                11.
ESTIMATED TIME TO PEAK          (MINS) =              86.00

LINK 36001              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 73.12
ESTIMATED PEAK FLOW          (CUMECS) =                13.
ESTIMATED TIME TO PEAK          (MINS) =              61.00

LINK 36                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 102.4
ESTIMATED PEAK FLOW          (CUMECS) =                20.
ESTIMATED TIME TO PEAK          (MINS) =              63.00

LINK 30001              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 1.941
ESTIMATED PEAK FLOW          (CUMECS) =               0.95
ESTIMATED TIME TO PEAK          (MINS) =              40.00

LINK 30                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 28.24
ESTIMATED PEAK FLOW          (CUMECS) =                8.2
ESTIMATED TIME TO PEAK          (MINS) =              45.00

LINK 61                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 157.4
ESTIMATED PEAK FLOW          (CUMECS) =                26.
ESTIMATED TIME TO PEAK          (MINS) =              91.00

LINK 62005              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 166.6
ESTIMATED PEAK FLOW          (CUMECS) =                26.
ESTIMATED TIME TO PEAK          (MINS) =             116.00

LINK 62004              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 24.56
ESTIMATED PEAK FLOW          (CUMECS) =                8.9
ESTIMATED TIME TO PEAK          (MINS) =              43.00

LINK 62003              2.000
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ESTIMATED VOLUME (CU METRES*10**3) =                  204.9
ESTIMATED PEAK FLOW         (CUMECS) =                  28.
ESTIMATED TIME TO PEAK         (MINS) =              135.00

LINK 62001              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  236.5
ESTIMATED PEAK FLOW         (CUMECS) =                  28.
ESTIMATED TIME TO PEAK         (MINS) =              182.00

LINK 62                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  34.25
ESTIMATED PEAK FLOW         (CUMECS) =                  15.
ESTIMATED TIME TO PEAK         (MINS) =               41.00

LINK 29007              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  34.81
ESTIMATED PEAK FLOW         (CUMECS) =                  12.
ESTIMATED TIME TO PEAK         (MINS) =               43.00

LINK 29006              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  59.35
ESTIMATED PEAK FLOW         (CUMECS) =                  17.
ESTIMATED TIME TO PEAK         (MINS) =               62.00

LINK 29005              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  75.69
ESTIMATED PEAK FLOW         (CUMECS) =                  20.
ESTIMATED TIME TO PEAK         (MINS) =               75.00

LINK 29004              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  27.45
ESTIMATED PEAK FLOW         (CUMECS) =                  9.2
ESTIMATED TIME TO PEAK         (MINS) =               45.00

LINK 29003              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  127.0
ESTIMATED PEAK FLOW         (CUMECS) =                  26.
ESTIMATED TIME TO PEAK         (MINS) =               89.00

LINK 29002              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  15.03
ESTIMATED PEAK FLOW         (CUMECS) =                  4.7
ESTIMATED TIME TO PEAK         (MINS) =               45.00

LINK 29001              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  159.6
ESTIMATED PEAK FLOW         (CUMECS) =                  30.
ESTIMATED TIME TO PEAK         (MINS) =               88.00

LINK 29                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  183.9
ESTIMATED PEAK FLOW         (CUMECS) =                  32.
ESTIMATED TIME TO PEAK         (MINS) =              111.00

LINK 62002              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  189.0
ESTIMATED PEAK FLOW         (CUMECS) =                  32.
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ESTIMATED TIME TO PEAK          (MINS) =               127.00

LINK 63002              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    461.7
ESTIMATED PEAK FLOW          (CUMECS) =                   54.
ESTIMATED TIME TO PEAK          (MINS) =               168.00

LINK 63                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    648.8
ESTIMATED PEAK FLOW          (CUMECS) =                   80.
ESTIMATED TIME TO PEAK          (MINS) =               100.00

LINK 26                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    23.82
ESTIMATED PEAK FLOW          (CUMECS) =                   6.8
ESTIMATED TIME TO PEAK          (MINS) =                46.00

LINK 64                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    624.4
ESTIMATED PEAK FLOW          (CUMECS) =                   81.
ESTIMATED TIME TO PEAK          (MINS) =               144.00

LINK 25                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    1.390
ESTIMATED PEAK FLOW          (CUMECS) =                  0.51
ESTIMATED TIME TO PEAK          (MINS) =                41.00

LINK 27002              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    29.81
ESTIMATED PEAK FLOW          (CUMECS) =                   14.
ESTIMATED TIME TO PEAK          (MINS) =                40.00

LINK 27001              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    57.29
ESTIMATED PEAK FLOW          (CUMECS) =                   21.
ESTIMATED TIME TO PEAK          (MINS) =                56.00

LINK 27                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    76.98
ESTIMATED PEAK FLOW          (CUMECS) =                   22.
ESTIMATED TIME TO PEAK          (MINS) =                97.00

LINK 65                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    680.9
ESTIMATED PEAK FLOW          (CUMECS) =                   85.
ESTIMATED TIME TO PEAK          (MINS) =               157.00

LINK 66                 2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    613.7
ESTIMATED PEAK FLOW          (CUMECS) =                   85.
ESTIMATED TIME TO PEAK          (MINS) =               194.00

LINK 22006              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                    40.42
ESTIMATED PEAK FLOW          (CUMECS) =                   19.
ESTIMATED TIME TO PEAK          (MINS) =                40.00

LINK 22008              2.000
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 ESTIMATED VOLUME (CU METRES*10**3) =                     35.35
 ESTIMATED PEAK FLOW         (CUMECS) =                     18.
 ESTIMATED TIME TO PEAK         (MINS) =                  40.00

 LINK 22007             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     70.82
 ESTIMATED PEAK FLOW         (CUMECS) =                     22.
 ESTIMATED TIME TO PEAK         (MINS) =                  84.00

 LINK 22005             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     157.2
 ESTIMATED PEAK FLOW         (CUMECS) =                     40.
 ESTIMATED TIME TO PEAK         (MINS) =                  92.00

 LINK 22004             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     201.6
 ESTIMATED PEAK FLOW         (CUMECS) =                     42.
 ESTIMATED TIME TO PEAK         (MINS) =                 113.00

 LINK 22003             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     263.4
 ESTIMATED PEAK FLOW         (CUMECS) =                     43.
 ESTIMATED TIME TO PEAK         (MINS) =                 155.00

 LINK 22002             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     290.8
 ESTIMATED PEAK FLOW         (CUMECS) =                     44.
 ESTIMATED TIME TO PEAK         (MINS) =                 174.00

 LINK 22001             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     49.19
 ESTIMATED PEAK FLOW         (CUMECS) =                     20.
 ESTIMATED TIME TO PEAK         (MINS) =                  41.00

 LINK 22                2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     358.9
 ESTIMATED PEAK FLOW         (CUMECS) =                     44.
 ESTIMATED TIME TO PEAK         (MINS) =                 201.00

 LINK 67                2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                     884.7
 ESTIMATED PEAK FLOW         (CUMECS) =                     0.10E+03
 ESTIMATED TIME TO PEAK         (MINS) =                 228.00


################################################################################
#####
Anvil Creek

Results for period from  0: 0.0  1/ 1/1990
                     to  5: 0.0  1/ 1/1990
################################################################################
#####


                               ROUTING INCREMENT (MINS) =       1.00
                               STORM DURATION (MINS)    =       120.
                               RETURN PERIOD (YRS)      =       100.
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BX                                =     1.0000
TOTAL OF FIRST SUB-AREAS  (ha) =    1957.94
TOTAL OF SECOND SUB-AREAS (ha) =      16.00
TOTAL OF ALL SUB-AREAS (ha)    =    1973.94
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SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
c23	3.000	2.000	3.000	3.000	.0100	100.0	.050	.025	.0443	.0025	1.000
24	20.000	14.000	4.700	4.700	.0100	100.0	.050	.025	.0950	.0054	2.000
28005	44.000	0.000	9.000	0.000	10.00	0.000	.050	0.00	.0685	0.000	3.000
28004	58.000	0.000	9.000	0.000	10.00	0.000	.050	0.00	.0790	0.000	3.001
28003	44.800	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0846	0.000	3.002
28002	58.430	0.000	3.000	0.000	10.00	0.000	.050	0.00	.1373	0.000	3.003
28006	30.000	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0841	0.000	4.000
28001	8.060	0.000	3.000	0.000	10.00	0.000	.050	0.00	.0490	0.000	3.004
28	42.300	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0899	0.000	3.005
63001	29.200	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0677	0.000	5.000
36003	41.280	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0888	0.000	6.000
36002	40.090	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0799	0.000	6.001
36001	34.700	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0907	0.000	6.002
36	46.400	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0944	0.000	6.003
30001	3.065	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0210	0.000	7.000
30	41.700	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0893	0.000	7.001
61	42.700	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0764	0.000	6.004
62005	15.300	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0484	0.000	6.005
62004	38.900	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0728	0.000	8.000
62003	23.520	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0605	0.000	6.006
62001	59.500	0.000	7.000	0.000	20.00	0.000	.050	0.00	.0645	0.000	6.007
62	54.170	0.000	7.000	0.000	20.00	0.000	.050	0.00	.0615	0.000	9.000
29007	55.140	0.000	8.000	0.000	10.00	0.000	.050	0.00	.0817	0.000	10.00
29006	38.900	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0728	0.000	10.00
29005	25.900	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0697	0.000	10.00
29004	43.500	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0833	0.000	11.00
29003	37.900	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0850	0.000	10.00
29002	23.800	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0746	0.000	12.00
29001	28.200	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0665	0.000	10.00
29	38.900	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0786	0.000	10.01

62002	8.540	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0357	0.000	10.01
63002	11.640	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0460	0.000	6.008
63	33.400	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0673	0.000	3.006
26	37.800	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0948	0.000	13.00
64	28.300	0.000	8.000	0.000	10.00	0.000	.050	0.00	.0577	0.000	3.007
25	2.200	0.000	2.000	0.000	10.00	0.000	.050	0.00	.0305	0.000	14.00
27002	47.110	0.000	17.00	0.000	10.00	0.000	.050	0.00	.0517	0.000	15.00
27001	43.500	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0772	0.000	15.00
27	31.300	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0702	0.000	15.00
65	14.400	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0469	0.000	3.008
66	24.900	0.000	6.000	0.000	20.00	0.000	.050	0.00	.0443	0.000	2.001
22006	63.900	0.000	20.00	0.000	10.00	0.000	.050	0.00	.0558	0.000	16.00
22008	55.900	0.000	17.20	0.000	20.00	0.000	.050	0.00	.0399	0.000	17.00
22007	56.070	0.000	19.00	0.000	10.00	0.000	.050	0.00	.0535	0.000	17.00
22005	72.820	0.000	14.00	0.000	10.00	0.000	.050	0.00	.0714	0.000	16.00
22004	70.360	0.000	9.800	0.000	10.00	0.000	.050	0.00	.0838	0.000	16.00
22003	99.000	0.000	6.000	0.000	10.00	0.000	.050	0.00	.1278	0.000	16.00
22002	45.400	0.000	3.000	0.000	10.00	0.000	.050	0.00	.1204	0.000	16.00
22001	77.800	0.000	6.600	0.000	20.00	0.000	.050	0.00	.0764	0.000	18.00
22	36.950	0.000	5.500	0.000	10.00	0.000	.050	0.00	.0799	0.000	16.00
67	25.300	0.000	6.000	0.000	20.00	0.000	.050	0.00	.0447	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
c23	38.784	10.00	1.000	2.500	0.000	63.276	76.568	1.150	35.00	1.500
24	38.784	10.00	1.000	2.500	0.000	63.276	76.568	7.545	35.00	.2000
28005	38.784	10.00	0.000	2.500	0.000	63.276	0.000	10.856	41.00	11.00
28004	38.784	10.00	0.000	2.500	0.000	63.276	0.000	21.340	51.00	10.00
28003	38.784	10.00	0.000	2.500	0.000	63.276	0.000	27.603	57.00	28.00
28002	38.784	10.00	0.000	2.500	0.000	63.276	0.000	33.088	85.00	5.500
28006	38.784	10.00	0.000	2.500	0.000	63.276	0.000	5.707	46.00	5.500
28001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	36.030	91.00	10.00
28	38.784	10.00	0.000	2.500	0.000	63.276	0.000	38.365	101.0	1.500
63001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	6.567	43.00	42.00
36003	38.784	10.00	0.000	2.500	0.000	63.276	0.000	8.141	45.00	43.00

36002	38.784	10.00	0.000	2.500	0.000	63.276	0.000	11.008	86.00	18.60
36001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	13.477	61.00	3.400
36	38.784	10.00	0.000	2.500	0.000	63.276	0.000	19.797	63.00	29.00
30001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	0.9498	40.00	33.00
30	38.784	10.00	0.000	2.500	0.000	63.276	0.000	8.206	45.00	2.000
61	38.784	10.00	0.000	2.500	0.000	63.276	0.000	25.752	91.00	25.00
62005	38.784	10.00	0.000	2.500	0.000	63.276	0.000	26.266	116.0	34.00
62004	38.784	10.00	0.000	2.500	0.000	63.276	0.000	8.889	43.00	34.00
62003	38.784	10.00	0.000	2.500	0.000	63.276	0.000	27.999	135.0	47.00
62001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	28.083	182.0	16.70
62	38.784	10.00	0.000	2.500	0.000	63.276	0.000	15.023	41.00	16.70
29007	38.784	10.00	0.000	2.500	0.000	63.276	0.000	12.456	43.00	21.00
29006	38.784	10.00	0.000	2.500	0.000	63.276	0.000	17.233	62.00	13.00
29005	38.784	10.00	0.000	2.500	0.000	63.276	0.000	19.586	75.00	14.00
29004	38.784	10.00	0.000	2.500	0.000	63.276	0.000	9.174	45.00	14.00
29003	38.784	10.00	0.000	2.500	0.000	63.276	0.000	26.219	89.00	25.30
29002	38.784	10.00	0.000	2.500	0.000	63.276	0.000	4.715	45.00	25.00
29001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	30.184	88.00	23.00
29	38.784	10.00	0.000	2.500	0.000	63.276	0.000	31.764	111.0	16.00
62002	38.784	10.00	0.000	2.500	0.000	63.276	0.000	31.967	127.0	16.70
63002	38.784	10.00	0.000	2.500	0.000	63.276	0.000	54.182	168.0	42.00
63	38.784	10.00	0.000	2.500	0.000	63.276	0.000	79.903	100.0	44.00
26	38.784	10.00	0.000	2.500	0.000	63.276	0.000	6.819	46.00	3.600
64	38.784	10.00	0.000	2.500	0.000	63.276	0.000	80.944	144.0	13.00
25	38.784	10.00	0.000	2.500	0.000	63.276	0.000	0.5144	41.00	1.500
27002	38.784	10.00	0.000	2.500	0.000	63.276	0.000	13.945	40.00	16.00
27001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	20.542	56.00	41.00
27	38.784	10.00	0.000	2.500	0.000	63.276	0.000	22.170	97.00	2.500
65	38.784	10.00	0.000	2.500	0.000	63.276	0.000	85.020	157.0	37.00
66	38.784	10.00	0.000	2.500	0.000	63.276	0.000	85.150	194.0	34.00
22006	38.784	10.00	0.000	2.500	0.000	63.276	0.000	19.086	40.00	52.00
22008	38.784	10.00	0.000	2.500	0.000	63.276	0.000	18.229	40.00	45.00
22007	38.784	10.00	0.000	2.500	0.000	63.276	0.000	22.005	84.00	51.00
22005	38.784	10.00	0.000	2.500	0.000	63.276	0.000	39.600	92.00	21.00

22004	38.784	10.00	0.000	2.500	0.000	63.276	0.000	42.285	113.0	42.00
22003	38.784	10.00	0.000	2.500	0.000	63.276	0.000	43.487	155.0	19.00
22002	38.784	10.00	0.000	2.500	0.000	63.276	0.000	43.855	174.0	27.00
22001	38.784	10.00	0.000	2.500	0.000	63.276	0.000	20.240	41.00	27.00
22	38.784	10.00	0.000	2.500	0.000	63.276	0.000	44.139	201.0	5.000
67	38.784	10.00	0.000	2.500	0.000	63.276	0.000	102.17	228.0	0.000

```
LINK c23               3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 4.005
ESTIMATED PEAK FLOW         (CUMECS) =                0.86
ESTIMATED TIME TO PEAK         (MINS) =              45.00

LINK 24                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 27.23
ESTIMATED PEAK FLOW         (CUMECS) =                 5.4
ESTIMATED TIME TO PEAK         (MINS) =              45.00

LINK 28005             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 32.50
ESTIMATED PEAK FLOW         (CUMECS) =                 8.5
ESTIMATED TIME TO PEAK         (MINS) =              46.00

LINK 28004             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 75.34
ESTIMATED PEAK FLOW         (CUMECS) =                 17.
ESTIMATED TIME TO PEAK         (MINS) =              55.00

LINK 28003             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 108.4
ESTIMATED PEAK FLOW         (CUMECS) =                 22.
ESTIMATED TIME TO PEAK         (MINS) =              64.00

LINK 28002             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 151.4
ESTIMATED PEAK FLOW         (CUMECS) =                 28.
ESTIMATED TIME TO PEAK         (MINS) =              90.00

LINK 28006             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 22.16
ESTIMATED PEAK FLOW         (CUMECS) =                 4.4
ESTIMATED TIME TO PEAK         (MINS) =              50.00

LINK 28001             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 179.5
ESTIMATED PEAK FLOW         (CUMECS) =                 31.
ESTIMATED TIME TO PEAK         (MINS) =              92.00

LINK 28                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 210.6
ESTIMATED PEAK FLOW         (CUMECS) =                 34.
ESTIMATED TIME TO PEAK         (MINS) =             102.00

LINK 63001             3.000
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ESTIMATED VOLUME (CU METRES*10**3) =                   21.55
ESTIMATED PEAK FLOW         (CUMECS) =                   5.2
ESTIMATED TIME TO PEAK         (MINS) =                46.00

LINK 36003             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   30.42
ESTIMATED PEAK FLOW         (CUMECS) =                   6.3
ESTIMATED TIME TO PEAK         (MINS) =                49.00

LINK 36002             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   59.97
ESTIMATED PEAK FLOW         (CUMECS) =                   9.8
ESTIMATED TIME TO PEAK         (MINS) =                90.00

LINK 36001             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   85.56
ESTIMATED PEAK FLOW         (CUMECS) =                   12.
ESTIMATED TIME TO PEAK         (MINS) =               108.00

LINK 36                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   119.8
ESTIMATED PEAK FLOW         (CUMECS) =                   17.
ESTIMATED TIME TO PEAK         (MINS) =                68.00

LINK 30001             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   2.267
ESTIMATED PEAK FLOW         (CUMECS) =                  0.68
ESTIMATED TIME TO PEAK         (MINS) =                45.00

LINK 30                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   33.00
ESTIMATED PEAK FLOW         (CUMECS) =                   6.3
ESTIMATED TIME TO PEAK         (MINS) =                49.00

LINK 61                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   184.2
ESTIMATED PEAK FLOW         (CUMECS) =                   24.
ESTIMATED TIME TO PEAK         (MINS) =                96.00

LINK 62005             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   195.3
ESTIMATED PEAK FLOW         (CUMECS) =                   25.
ESTIMATED TIME TO PEAK         (MINS) =               121.00

LINK 62004             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   28.74
ESTIMATED PEAK FLOW         (CUMECS) =                   7.0
ESTIMATED TIME TO PEAK         (MINS) =                46.00

LINK 62003             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   241.1
ESTIMATED PEAK FLOW         (CUMECS) =                   28.
ESTIMATED TIME TO PEAK         (MINS) =               155.00

LINK 62001             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                   283.7
ESTIMATED PEAK FLOW         (CUMECS) =                   28.
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ESTIMATED TIME TO PEAK         (MINS) =              202.00

LINK 62                 3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  39.98
ESTIMATED PEAK FLOW          (CUMECS) =                 11.
ESTIMATED TIME TO PEAK         (MINS) =               45.00

LINK 29007              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  40.73
ESTIMATED PEAK FLOW          (CUMECS) =                 9.8
ESTIMATED TIME TO PEAK         (MINS) =               46.00

LINK 29006              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  69.46
ESTIMATED PEAK FLOW          (CUMECS) =                 14.
ESTIMATED TIME TO PEAK         (MINS) =               67.00

LINK 29005              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  88.59
ESTIMATED PEAK FLOW          (CUMECS) =                 17.
ESTIMATED TIME TO PEAK         (MINS) =               80.00

LINK 29004              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  32.13
ESTIMATED PEAK FLOW          (CUMECS) =                 7.2
ESTIMATED TIME TO PEAK         (MINS) =               46.00

LINK 29003              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  148.6
ESTIMATED PEAK FLOW          (CUMECS) =                 25.
ESTIMATED TIME TO PEAK         (MINS) =               93.00

LINK 29002              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  17.58
ESTIMATED PEAK FLOW          (CUMECS) =                 3.6
ESTIMATED TIME TO PEAK         (MINS) =               49.00

LINK 29001              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  187.0
ESTIMATED PEAK FLOW          (CUMECS) =                 28.
ESTIMATED TIME TO PEAK         (MINS) =              118.00

LINK 29                 3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  215.5
ESTIMATED PEAK FLOW          (CUMECS) =                 30.
ESTIMATED TIME TO PEAK         (MINS) =              141.00

LINK 62002              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  221.7
ESTIMATED PEAK FLOW          (CUMECS) =                 30.
ESTIMATED TIME TO PEAK         (MINS) =              157.00

LINK 63002              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                  552.7
ESTIMATED PEAK FLOW          (CUMECS) =                 55.
ESTIMATED TIME TO PEAK         (MINS) =              171.00

LINK 63                 3.000
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ESTIMATED VOLUME (CU METRES*10**3) =                 802.4
ESTIMATED PEAK FLOW         (CUMECS) =                 68.
ESTIMATED TIME TO PEAK         (MINS) =              104.00

LINK 26                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 27.88
ESTIMATED PEAK FLOW         (CUMECS) =                 5.3
ESTIMATED TIME TO PEAK         (MINS) =               51.00

LINK 64                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 830.9
ESTIMATED PEAK FLOW         (CUMECS) =                 71.
ESTIMATED TIME TO PEAK         (MINS) =              148.00

LINK 25                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 1.629
ESTIMATED PEAK FLOW         (CUMECS) =                0.40
ESTIMATED TIME TO PEAK         (MINS) =               46.00

LINK 27002             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 34.78
ESTIMATED PEAK FLOW         (CUMECS) =                 10.
ESTIMATED TIME TO PEAK         (MINS) =               45.00

LINK 27001             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 66.91
ESTIMATED PEAK FLOW         (CUMECS) =                 16.
ESTIMATED TIME TO PEAK         (MINS) =               61.00

LINK 27                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 89.97
ESTIMATED PEAK FLOW         (CUMECS) =                 18.
ESTIMATED TIME TO PEAK         (MINS) =              100.00

LINK 65                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 922.4
ESTIMATED PEAK FLOW         (CUMECS) =                 78.
ESTIMATED TIME TO PEAK         (MINS) =              161.00

LINK 66                3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 918.9
ESTIMATED PEAK FLOW         (CUMECS) =                 79.
ESTIMATED TIME TO PEAK         (MINS) =              198.00

LINK 22006             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 47.15
ESTIMATED PEAK FLOW         (CUMECS) =                 14.
ESTIMATED TIME TO PEAK         (MINS) =               45.00

LINK 22008             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 41.26
ESTIMATED PEAK FLOW         (CUMECS) =                 13.
ESTIMATED TIME TO PEAK         (MINS) =               45.00

LINK 22007             3.000

ESTIMATED VOLUME (CU METRES*10**3) =                 82.64
ESTIMATED PEAK FLOW         (CUMECS) =                 17.
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 ESTIMATED TIME TO PEAK         (MINS) =              89.00

 LINK 22005            3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                183.5
 ESTIMATED PEAK FLOW         (CUMECS) =                31.
 ESTIMATED TIME TO PEAK         (MINS) =              96.00

 LINK 22004            3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                235.4
 ESTIMATED PEAK FLOW         (CUMECS) =                35.
 ESTIMATED TIME TO PEAK         (MINS) =             117.00

 LINK 22003            3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                308.3
 ESTIMATED PEAK FLOW         (CUMECS) =                39.
 ESTIMATED TIME TO PEAK         (MINS) =             159.00

 LINK 22002            3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                341.6
 ESTIMATED PEAK FLOW         (CUMECS) =                40.
 ESTIMATED TIME TO PEAK         (MINS) =             178.00

 LINK 22001            3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                57.42
 ESTIMATED PEAK FLOW         (CUMECS) =                15.
 ESTIMATED TIME TO PEAK         (MINS) =              46.00

 LINK 22               3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                425.7
 ESTIMATED PEAK FLOW         (CUMECS) =                42.
 ESTIMATED TIME TO PEAK         (MINS) =             205.00

 LINK 67               3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                1300.
 ESTIMATED PEAK FLOW         (CUMECS) =               0.10E+03
 ESTIMATED TIME TO PEAK         (MINS) =             232.00


################################################################################
#####
Anvil Creek

Results for period from  0: 0.0  1/ 1/1990
                     to  6:40.0  1/ 1/1990
################################################################################
#####


                               ROUTING INCREMENT (MINS) =      1.00
                               STORM DURATION (MINS)    =      180.
                               RETURN PERIOD (YRS)      =      100.
                               BX                       =    1.0000
                               TOTAL OF FIRST SUB-AREAS  (ha) =    1957.94
                               TOTAL OF SECOND SUB-AREAS (ha) =      16.00
                               TOTAL OF ALL SUB-AREAS (ha)    =    1973.94


     SUMMARY OF CATCHMENT AND RAINFALL DATA
 Link      Catch. Area      Slope    % Impervious     Pern        B        Link
 Label      #1     #2     #1    #2      #1   #2     #1    #2    #1   #2     No.
```

	(ha)		(%)			(%)					
c23	3.000	2.000	3.000	3.000	.0100	100.0	.050	.025	.0443	.0025	1.000
24	20.000	14.000	4.700	4.700	.0100	100.0	.050	.025	.0950	.0054	2.000
28005	44.000	0.000	9.000	0.000	10.00	0.000	.050	0.00	.0685	0.000	3.000
28004	58.000	0.000	9.000	0.000	10.00	0.000	.050	0.00	.0790	0.000	3.001
28003	44.800	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0846	0.000	3.002
28002	58.430	0.000	3.000	0.000	10.00	0.000	.050	0.00	.1373	0.000	3.003
28006	30.000	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0841	0.000	4.000
28001	8.060	0.000	3.000	0.000	10.00	0.000	.050	0.00	.0490	0.000	3.004
28	42.300	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0899	0.000	3.005
63001	29.200	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0677	0.000	5.000
36003	41.280	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0888	0.000	6.000
36002	40.090	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0799	0.000	6.001
36001	34.700	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0907	0.000	6.002
36	46.400	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0944	0.000	6.003
30001	3.065	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0210	0.000	7.000
30	41.700	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0893	0.000	7.001
61	42.700	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0764	0.000	6.004
62005	15.300	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0484	0.000	6.005
62004	38.900	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0728	0.000	8.000
62003	23.520	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0605	0.000	6.006
62001	59.500	0.000	7.000	0.000	20.00	0.000	.050	0.00	.0645	0.000	6.007
62	54.170	0.000	7.000	0.000	20.00	0.000	.050	0.00	.0615	0.000	9.000
29007	55.140	0.000	8.000	0.000	10.00	0.000	.050	0.00	.0817	0.000	10.00
29006	38.900	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0728	0.000	10.00
29005	25.900	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0697	0.000	10.00
29004	43.500	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0833	0.000	11.00
29003	37.900	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0850	0.000	10.00
29002	23.800	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0746	0.000	12.00
29001	28.200	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0665	0.000	10.00
29	38.900	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0786	0.000	10.01
62002	8.540	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0357	0.000	10.01
63002	11.640	0.000	5.000	0.000	10.00	0.000	.050	0.00	.0460	0.000	6.008
63	33.400	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0673	0.000	3.006
26	37.800	0.000	4.000	0.000	10.00	0.000	.050	0.00	.0948	0.000	13.00

64	28.300	0.000	8.000	0.000	10.00	0.000	.050	0.00	.0577	0.000	3.007
25	2.200	0.000	2.000	0.000	10.00	0.000	.050	0.00	.0305	0.000	14.00
27002	47.110	0.000	17.00	0.000	10.00	0.000	.050	0.00	.0517	0.000	15.00
27001	43.500	0.000	7.000	0.000	10.00	0.000	.050	0.00	.0772	0.000	15.00
27	31.300	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0702	0.000	15.00
65	14.400	0.000	6.000	0.000	10.00	0.000	.050	0.00	.0469	0.000	3.008
66	24.900	0.000	6.000	0.000	20.00	0.000	.050	0.00	.0443	0.000	2.001
22006	63.900	0.000	20.00	0.000	10.00	0.000	.050	0.00	.0558	0.000	16.00
22008	55.900	0.000	17.20	0.000	20.00	0.000	.050	0.00	.0399	0.000	17.00
22007	56.070	0.000	19.00	0.000	10.00	0.000	.050	0.00	.0535	0.000	17.00
22005	72.820	0.000	14.00	0.000	10.00	0.000	.050	0.00	.0714	0.000	16.00
22004	70.360	0.000	9.800	0.000	10.00	0.000	.050	0.00	.0838	0.000	16.00
22003	99.000	0.000	6.000	0.000	10.00	0.000	.050	0.00	.1278	0.000	16.00
22002	45.400	0.000	3.000	0.000	10.00	0.000	.050	0.00	.1204	0.000	16.00
22001	77.800	0.000	6.600	0.000	20.00	0.000	.050	0.00	.0764	0.000	18.00
22	36.950	0.000	5.500	0.000	10.00	0.000	.050	0.00	.0799	0.000	16.00
67	25.300	0.000	6.000	0.000	20.00	0.000	.050	0.00	.0447	0.000	1.001

Link	Average	Init. Loss		Cont. Loss		Excess Rain		Peak	Time	Link
Label	Intensity	#1	#2	#1	#2	#1	#2	Inflow	to	Lag
	(mm/h)	(mm)		(mm/h)		(mm)		(m^3/s)	Peak	mins
c23	30.194	10.00	1.000	2.500	0.000	73.875	89.583	0.8576	45.00	1.500
24	30.194	10.00	1.000	2.500	0.000	73.875	89.583	5.364	45.00	.2000
28005	30.194	10.00	0.000	2.500	0.000	73.875	0.000	8.501	46.00	11.00
28004	30.194	10.00	0.000	2.500	0.000	73.875	0.000	16.809	55.00	10.00
28003	30.194	10.00	0.000	2.500	0.000	73.875	0.000	22.257	64.00	28.00
28002	30.194	10.00	0.000	2.500	0.000	73.875	0.000	27.896	90.00	5.500
28006	30.194	10.00	0.000	2.500	0.000	73.875	0.000	4.400	50.00	5.500
28001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	31.371	92.00	10.00
28	30.194	10.00	0.000	2.500	0.000	73.875	0.000	34.472	102.0	1.500
63001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	5.216	46.00	42.00
36003	30.194	10.00	0.000	2.500	0.000	73.875	0.000	6.295	49.00	43.00
36002	30.194	10.00	0.000	2.500	0.000	73.875	0.000	9.816	90.00	18.60
36001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	12.188	108.0	3.400
36	30.194	10.00	0.000	2.500	0.000	73.875	0.000	16.640	68.00	29.00
30001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	0.6813	45.00	33.00

30	30.194	10.00	0.000	2.500	0.000	73.875	0.000	6.345	49.00	2.000
61	30.194	10.00	0.000	2.500	0.000	73.875	0.000	23.708	96.00	25.00
62005	30.194	10.00	0.000	2.500	0.000	73.875	0.000	24.596	121.0	34.00
62004	30.194	10.00	0.000	2.500	0.000	73.875	0.000	7.008	46.00	34.00
62003	30.194	10.00	0.000	2.500	0.000	73.875	0.000	27.711	155.0	47.00
62001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	28.078	202.0	16.70
62	30.194	10.00	0.000	2.500	0.000	73.875	0.000	11.334	45.00	16.70
29007	30.194	10.00	0.000	2.500	0.000	73.875	0.000	9.814	46.00	21.00
29006	30.194	10.00	0.000	2.500	0.000	73.875	0.000	14.246	67.00	13.00
29005	30.194	10.00	0.000	2.500	0.000	73.875	0.000	16.885	80.00	14.00
29004	30.194	10.00	0.000	2.500	0.000	73.875	0.000	7.162	46.00	14.00
29003	30.194	10.00	0.000	2.500	0.000	73.875	0.000	24.513	93.00	25.30
29002	30.194	10.00	0.000	2.500	0.000	73.875	0.000	3.636	49.00	25.00
29001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	28.202	118.0	23.00
29	30.194	10.00	0.000	2.500	0.000	73.875	0.000	29.976	141.0	16.00
62002	30.194	10.00	0.000	2.500	0.000	73.875	0.000	30.249	157.0	16.70
63002	30.194	10.00	0.000	2.500	0.000	73.875	0.000	55.005	171.0	42.00
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26	30.194	10.00	0.000	2.500	0.000	73.875	0.000	5.336	51.00	3.600
64	30.194	10.00	0.000	2.500	0.000	73.875	0.000	71.123	148.0	13.00
25	30.194	10.00	0.000	2.500	0.000	73.875	0.000	0.3984	46.00	1.500
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27001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	15.722	61.00	41.00
27	30.194	10.00	0.000	2.500	0.000	73.875	0.000	17.933	100.0	2.500
65	30.194	10.00	0.000	2.500	0.000	73.875	0.000	78.222	161.0	37.00
66	30.194	10.00	0.000	2.500	0.000	73.875	0.000	78.742	198.0	34.00
22006	30.194	10.00	0.000	2.500	0.000	73.875	0.000	13.970	45.00	52.00
22008	30.194	10.00	0.000	2.500	0.000	73.875	0.000	12.680	45.00	45.00
22007	30.194	10.00	0.000	2.500	0.000	73.875	0.000	17.183	89.00	51.00
22005	30.194	10.00	0.000	2.500	0.000	73.875	0.000	31.305	96.00	21.00
22004	30.194	10.00	0.000	2.500	0.000	73.875	0.000	35.492	117.0	42.00
22003	30.194	10.00	0.000	2.500	0.000	73.875	0.000	39.170	159.0	19.00
22002	30.194	10.00	0.000	2.500	0.000	73.875	0.000	40.450	178.0	27.00
22001	30.194	10.00	0.000	2.500	0.000	73.875	0.000	15.462	46.00	27.00
22	30.194	10.00	0.000	2.500	0.000	73.875	0.000	42.327	205.0	5.000

```
67        30.194 10.00 0.000  2.500 0.000  73.875  0.000  102.77  232.0 0.000


 Run completed at:  2nd  November  2009  14:16:03


 mik open         0
```

HEC-RAS Plan: EXISTING River: 1 Reach: 1044 Profile: 100 year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1044	1585.35	100 year	85.15	46.73	49.64		49.78	0.004349	1.67	51.03	35.57	0.44
1044	1568.39	100 year	85.15	46.74	49.56		49.71	0.004556	1.73	51.51	50.08	0.45
1044	1546.28	100 year	85.15	46.74	49.54		49.62	0.002001	1.29	73.61	70.56	0.30
1044	1530.07	100 year	85.15	46.78	49.54		49.59	0.001270	0.97	91.96	72.26	0.25
1044	1516.04	100 year	85.15	46.77	49.54		49.57	0.000837	0.79	108.96	74.03	0.20
1044	1501.93	100 year	85.15	47.00	49.53		49.55	0.000773	0.77	111.54	72.28	0.19
1044	1483.79	100 year	85.15	46.86	49.44		49.53	0.002892	1.29	65.88	50.53	0.36
1044	1461.82	100 year	85.15	47.12	49.30		49.43	0.006339	1.58	54.76	72.82	0.51
1044	1453.29	100 year	85.15	46.82	49.28		49.38	0.004076	1.44	65.17	97.58	0.42
1044	1443.94	100 year	85.15	46.36	49.28		49.35	0.001704	1.26	96.59	101.67	0.29
1044	1426.95	100 year	85.15	46.24	49.25		49.32	0.001657	1.53	125.21	102.66	0.30
1044	1418.55	100 year	85.15	45.97	49.22	48.07	49.30	0.001703	1.37	97.63	94.29	0.30
1044	1410		Bridge									
1044	1403.80	100 year	85.15	45.73	49.01		49.17	0.003069	1.77	48.15	22.42	0.39
1044	1399.09	100 year	85.15	45.65	49.02		49.15	0.002727	1.65	53.95	34.46	0.37
1044	1384.40	100 year	85.15	46.12	48.88	48.43	49.08	0.007260	2.02	45.33	49.59	0.56
1044	1371.37	100 year	85.15	46.05	48.87	48.39	48.97	0.004961	1.54	82.63	150.68	0.46
1044	1351.03	100 year	85.15	45.96	48.79	47.96	48.87	0.004084	1.31	86.47	177.51	0.41
1044	1043.73	100 year	85.15	44.95	48.34	46.66	48.39	0.000840	1.13	129.01	100.68	0.22

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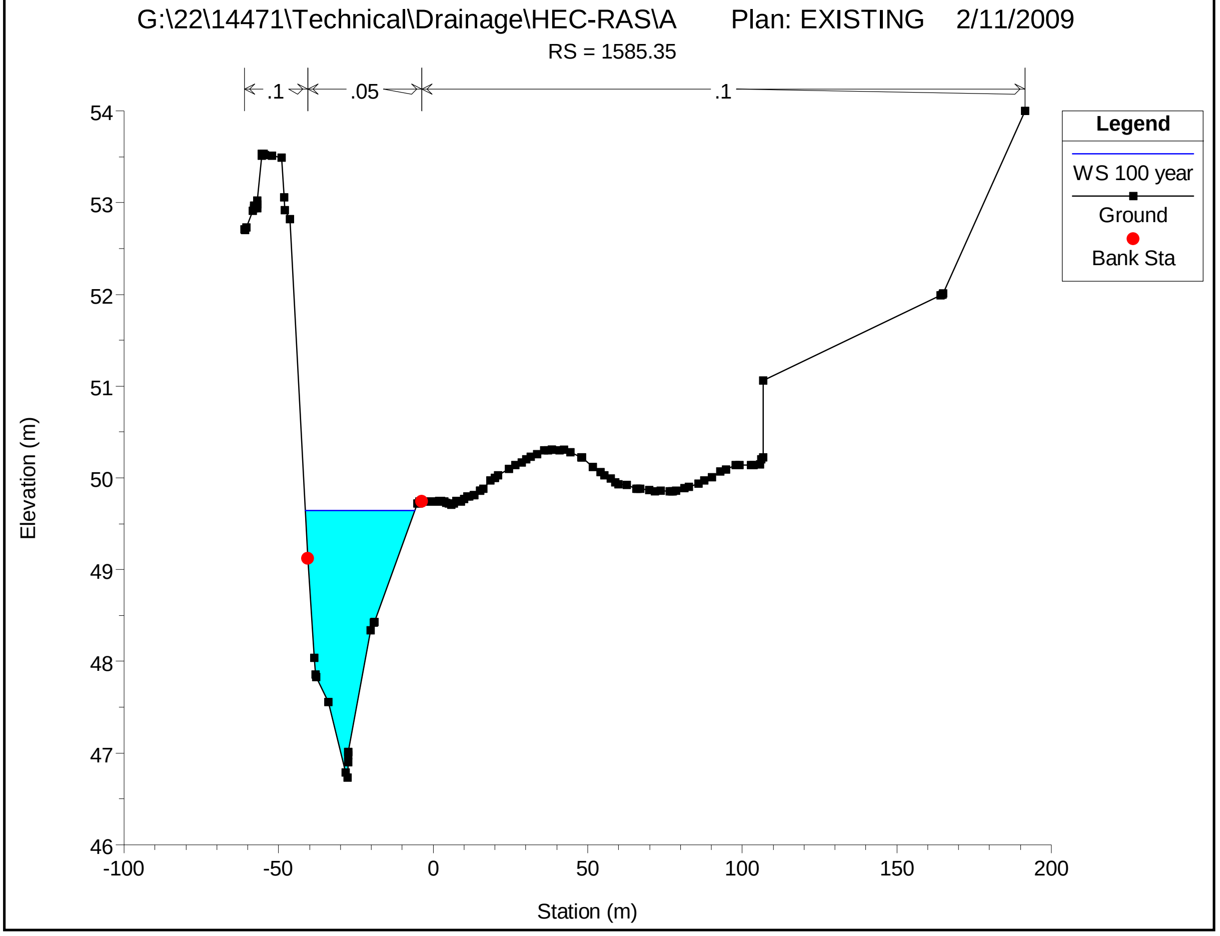

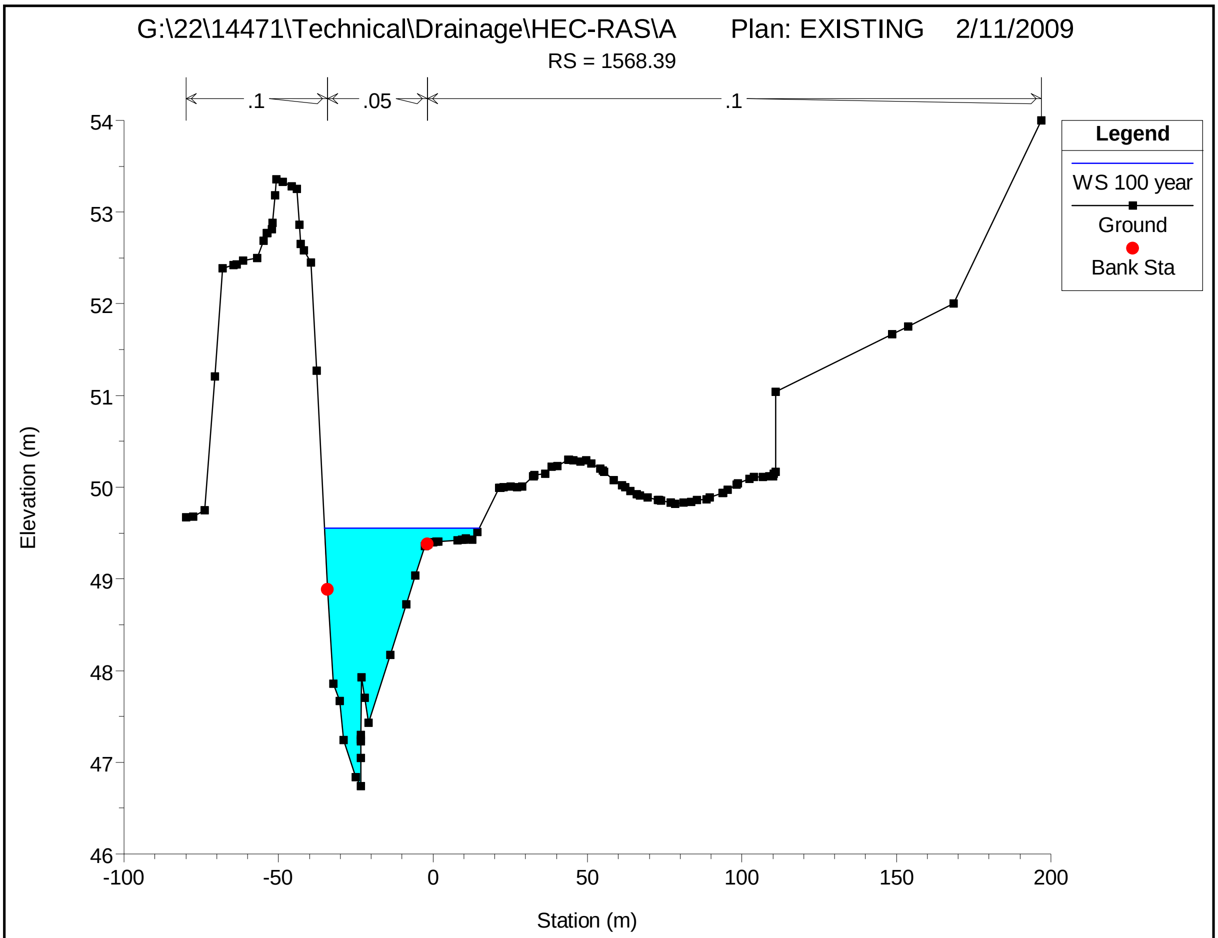

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.05
.1
Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
Station (m)
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53
52
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0
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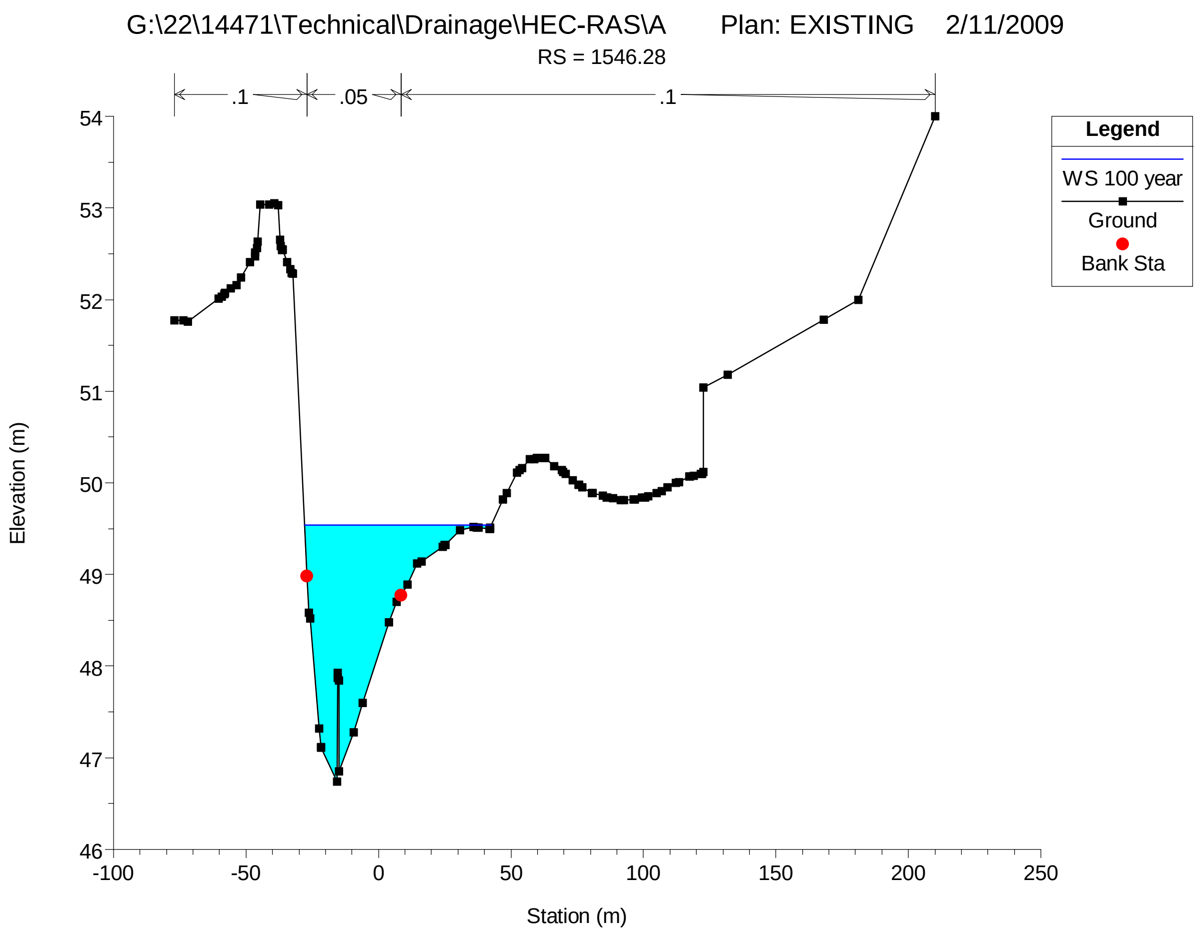
100
150
200



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Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
Station (m)
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100
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200
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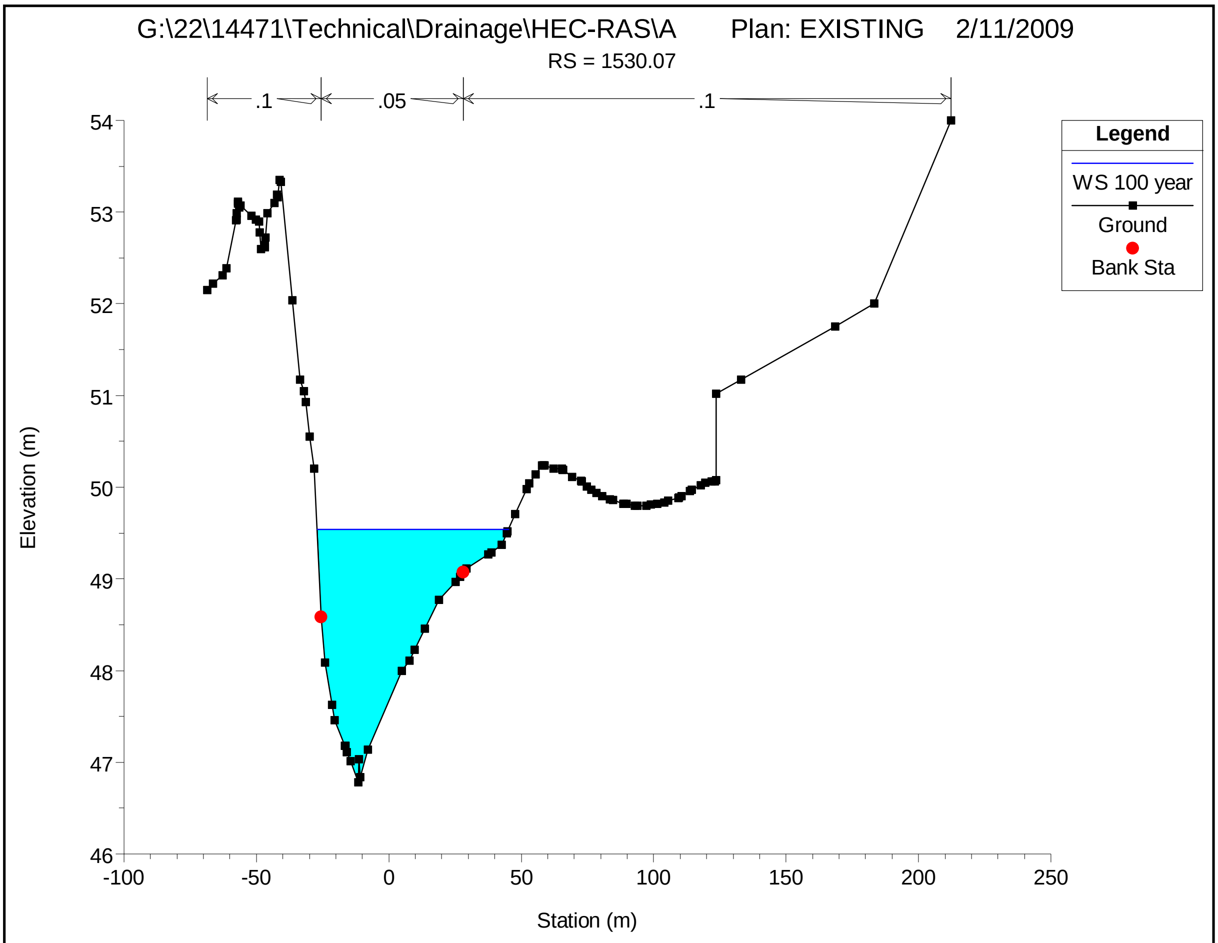
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Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
Station (m)
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51
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0
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100
150
200
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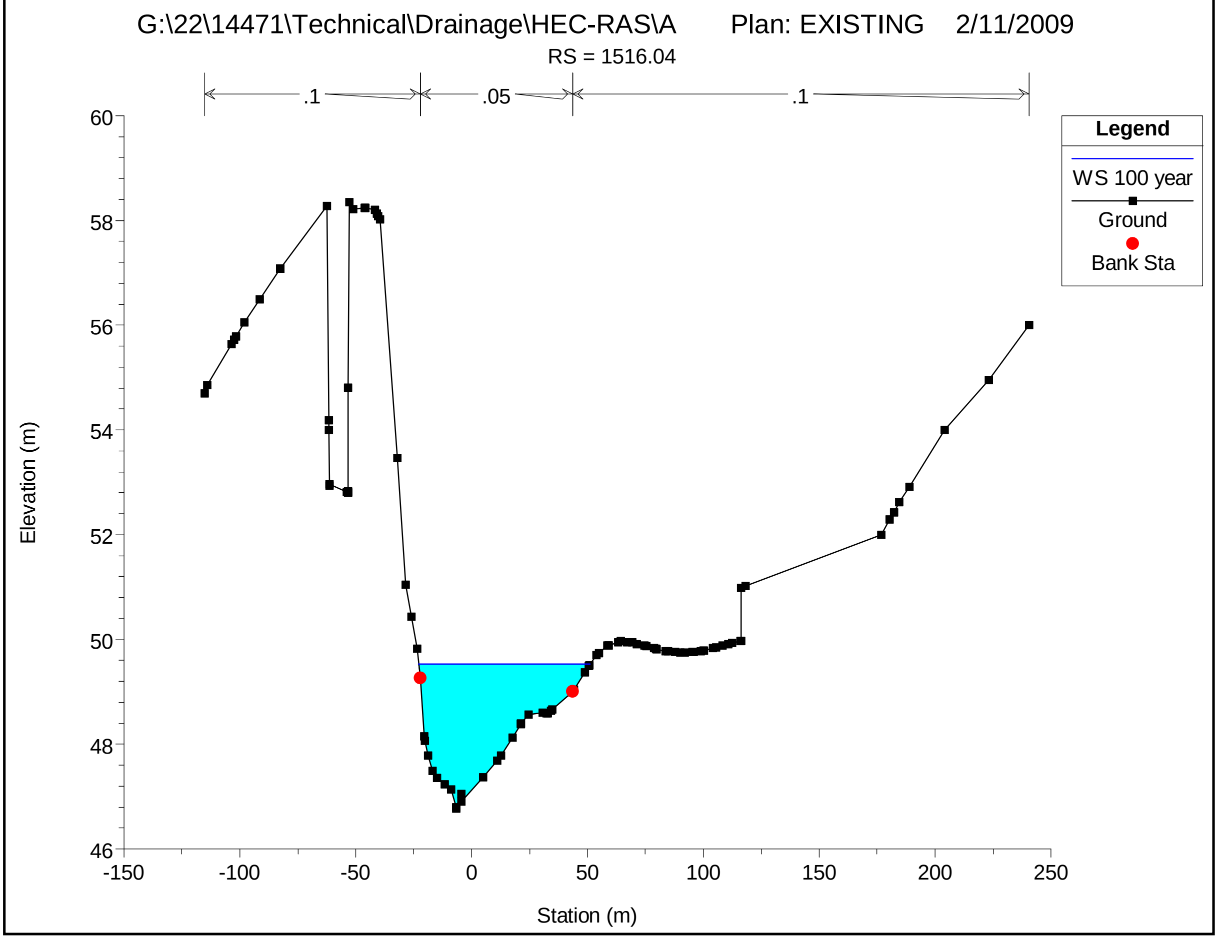
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WS 100 year
Ground
Bank Sta
Elevation (m)
Station (m)
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56
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52
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-50
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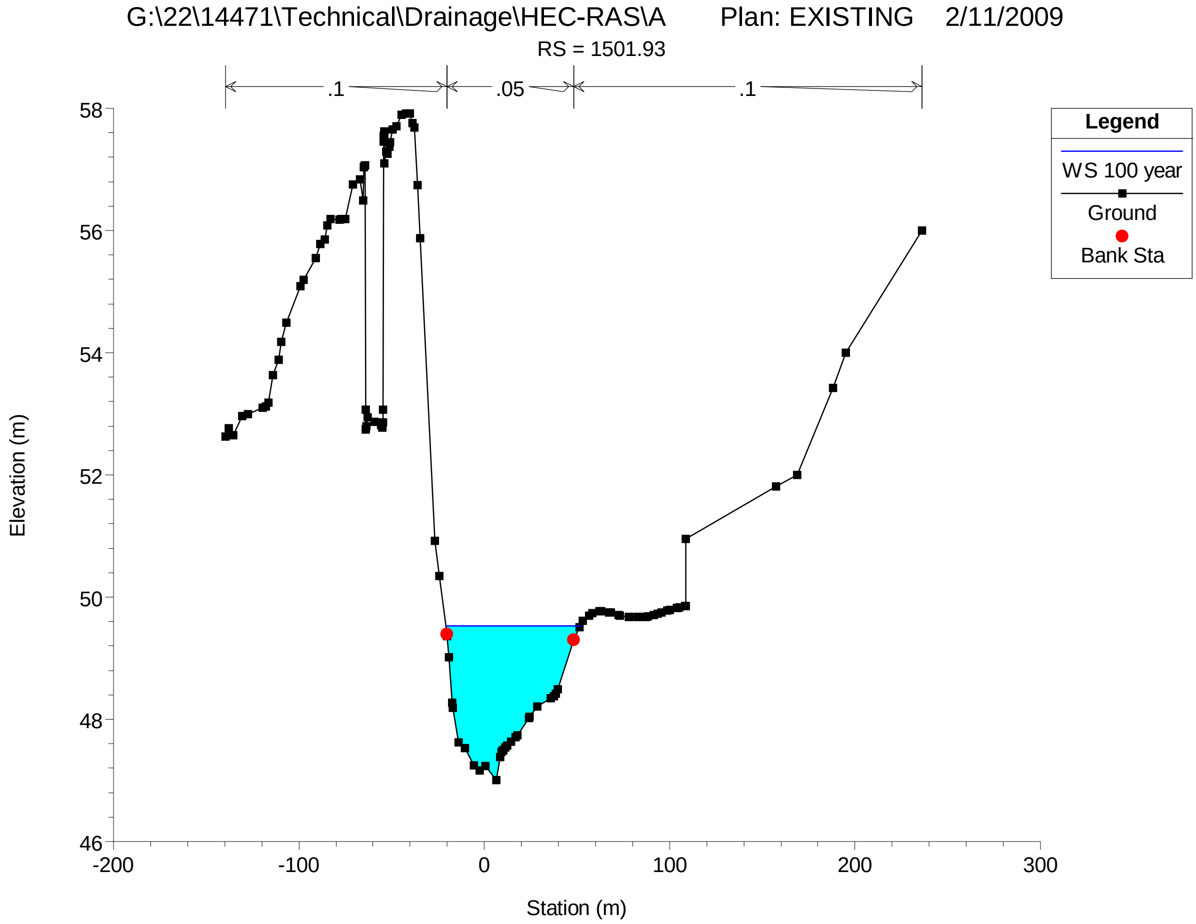
50
100
150
200
250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Legend
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Ground
Bank Sta
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Station (m)
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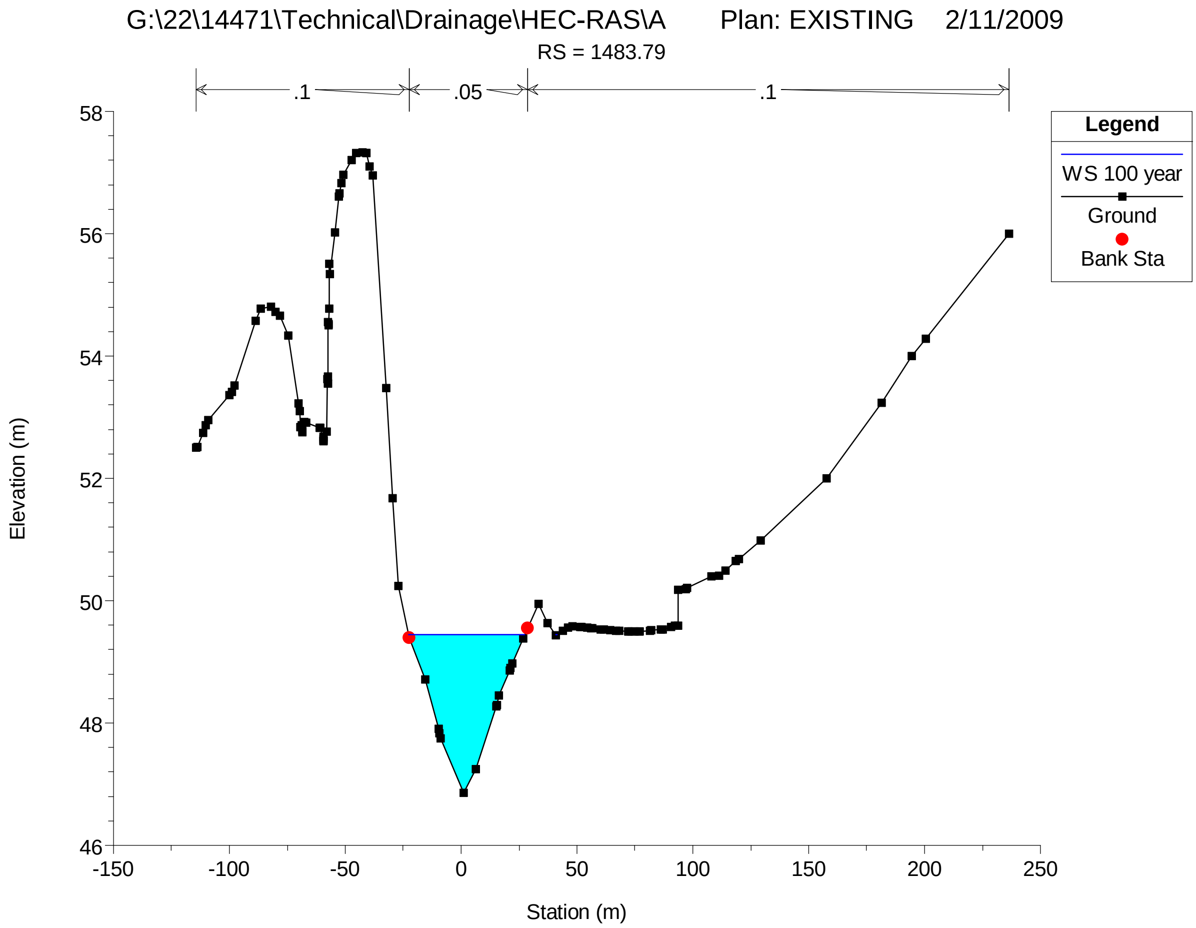
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WS 100 year
Ground
Bank Sta
Elevation (m)
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56
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100
150
200
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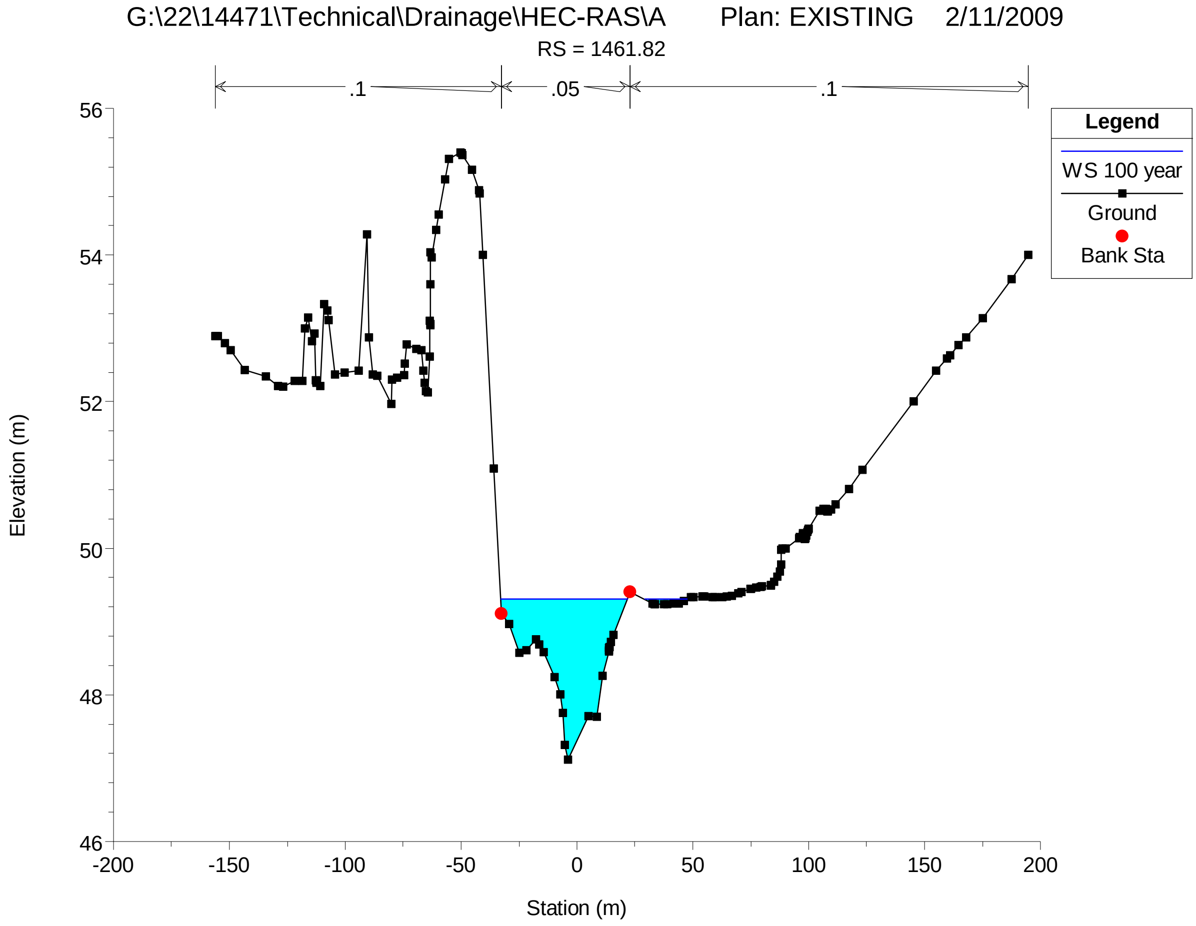
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Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
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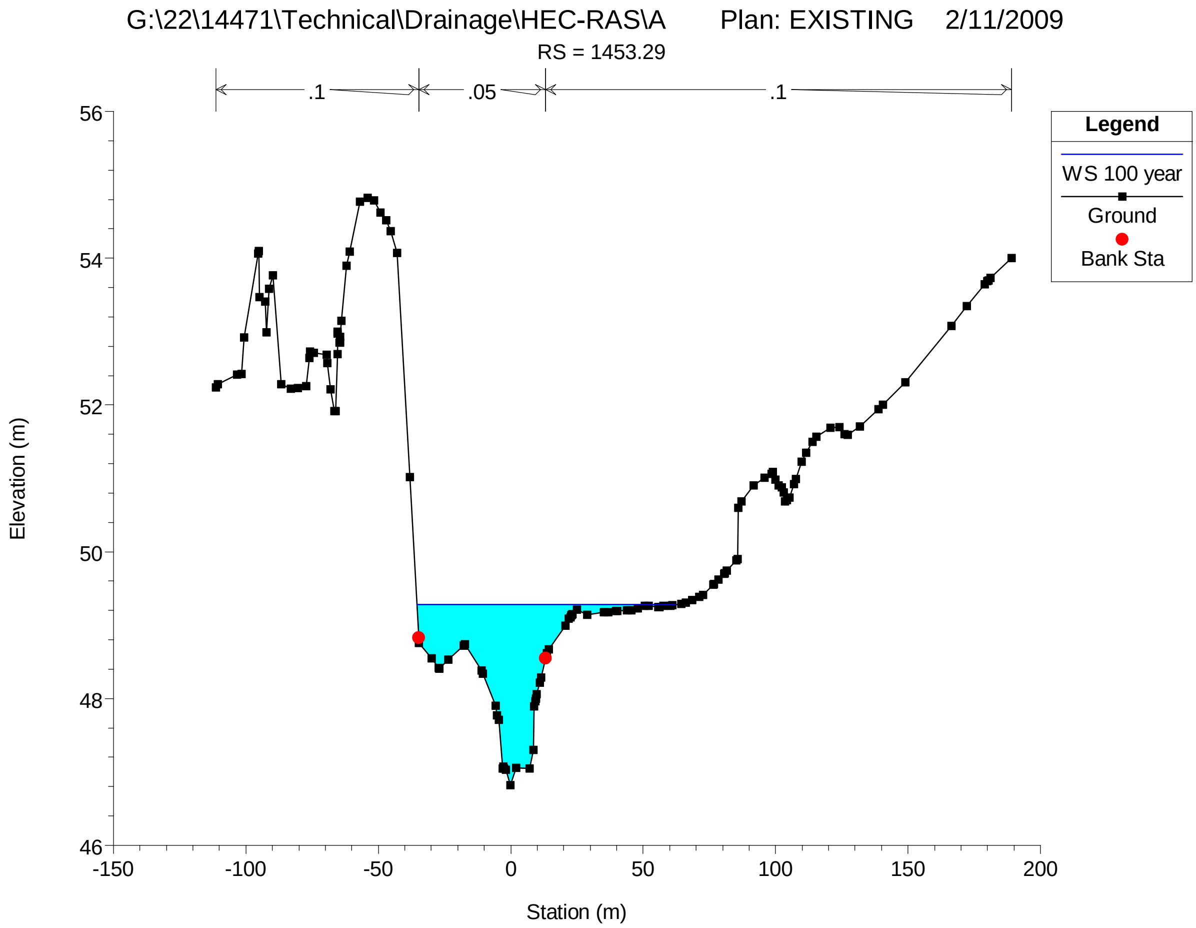
-50
0
50
100
150
200
Station (m)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.1
Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
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54
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50
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46
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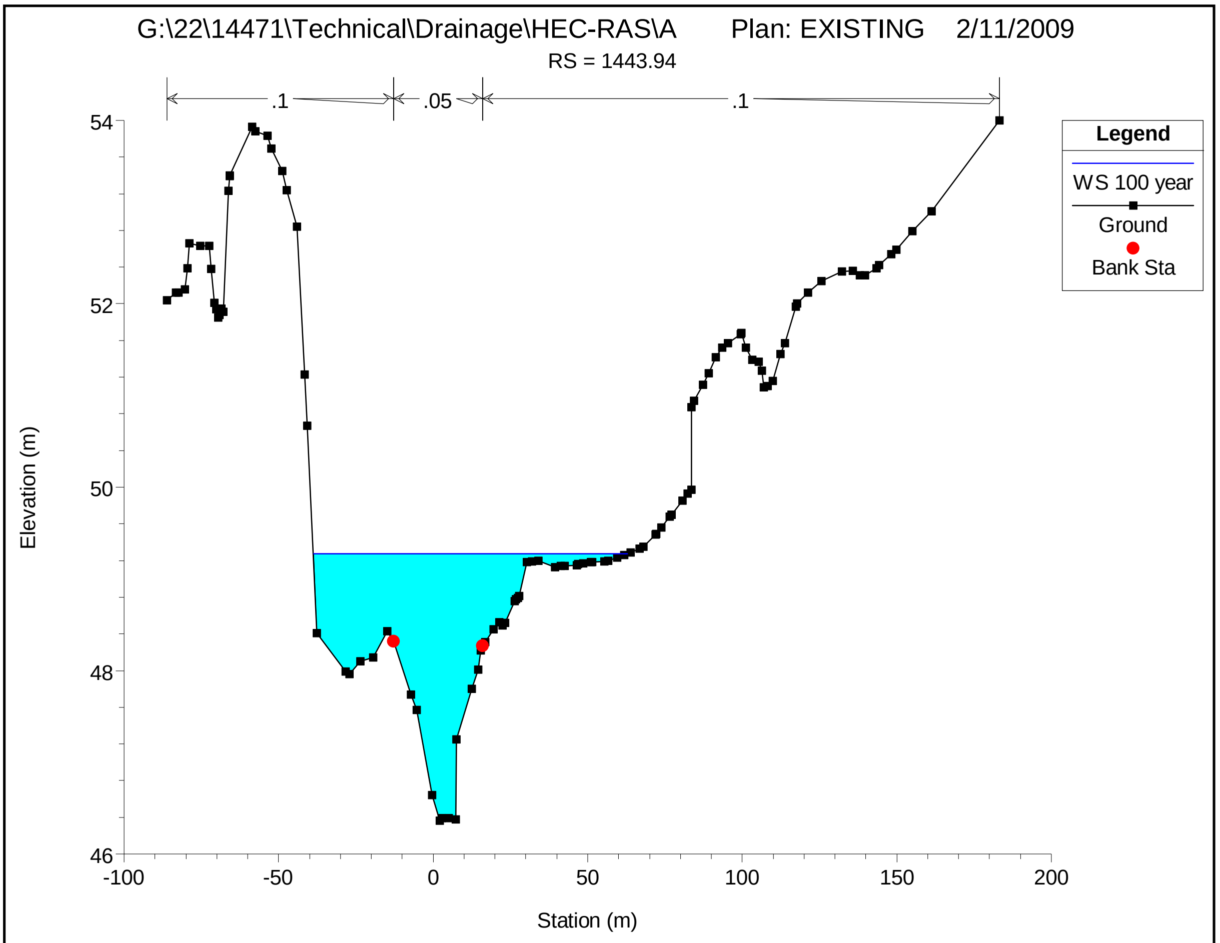
-50
0
50
100
150
200
Station (m)



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.05
.1
Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
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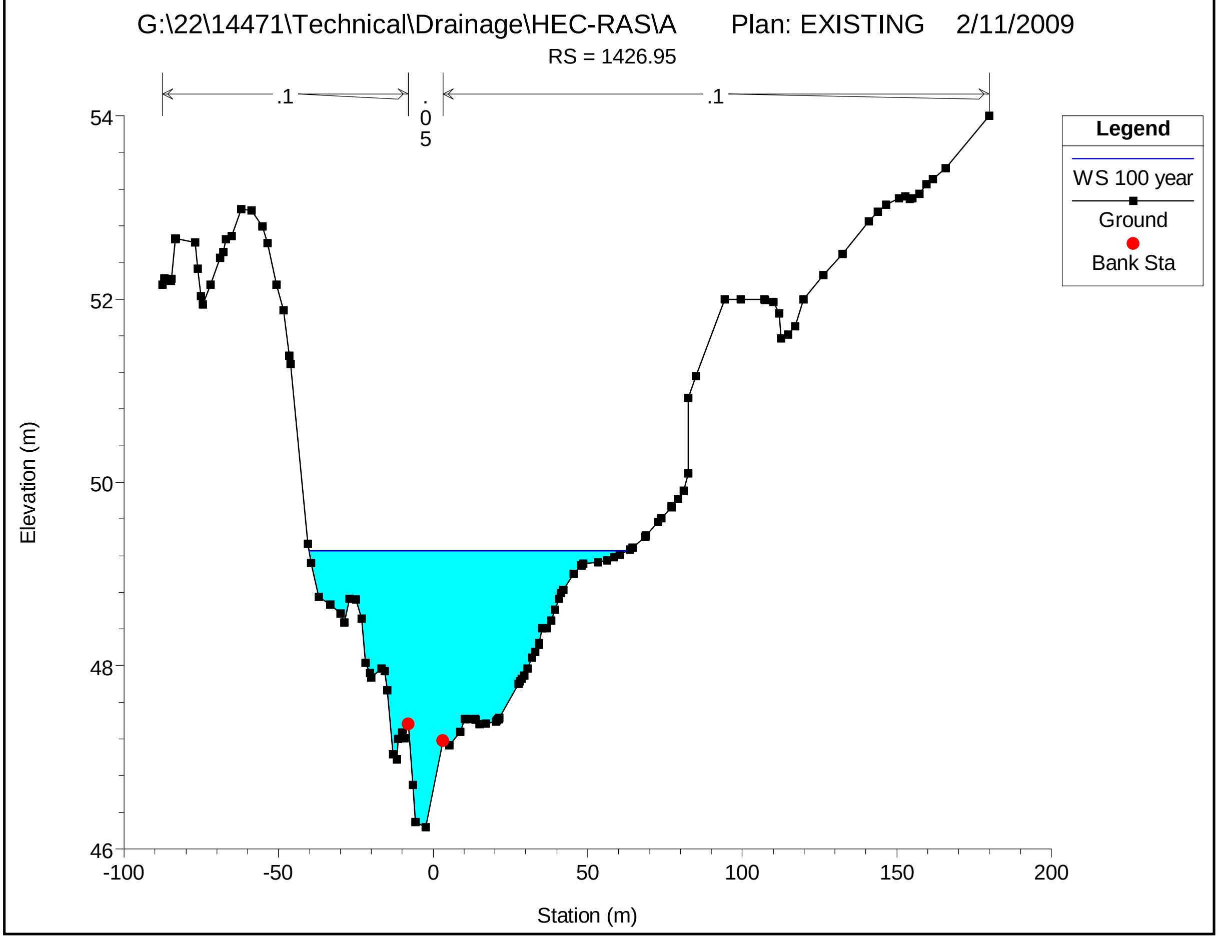
52
50
48
46
-100
-50
0
50
100
150
200
Station (m)



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.05
.1
Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
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52
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46
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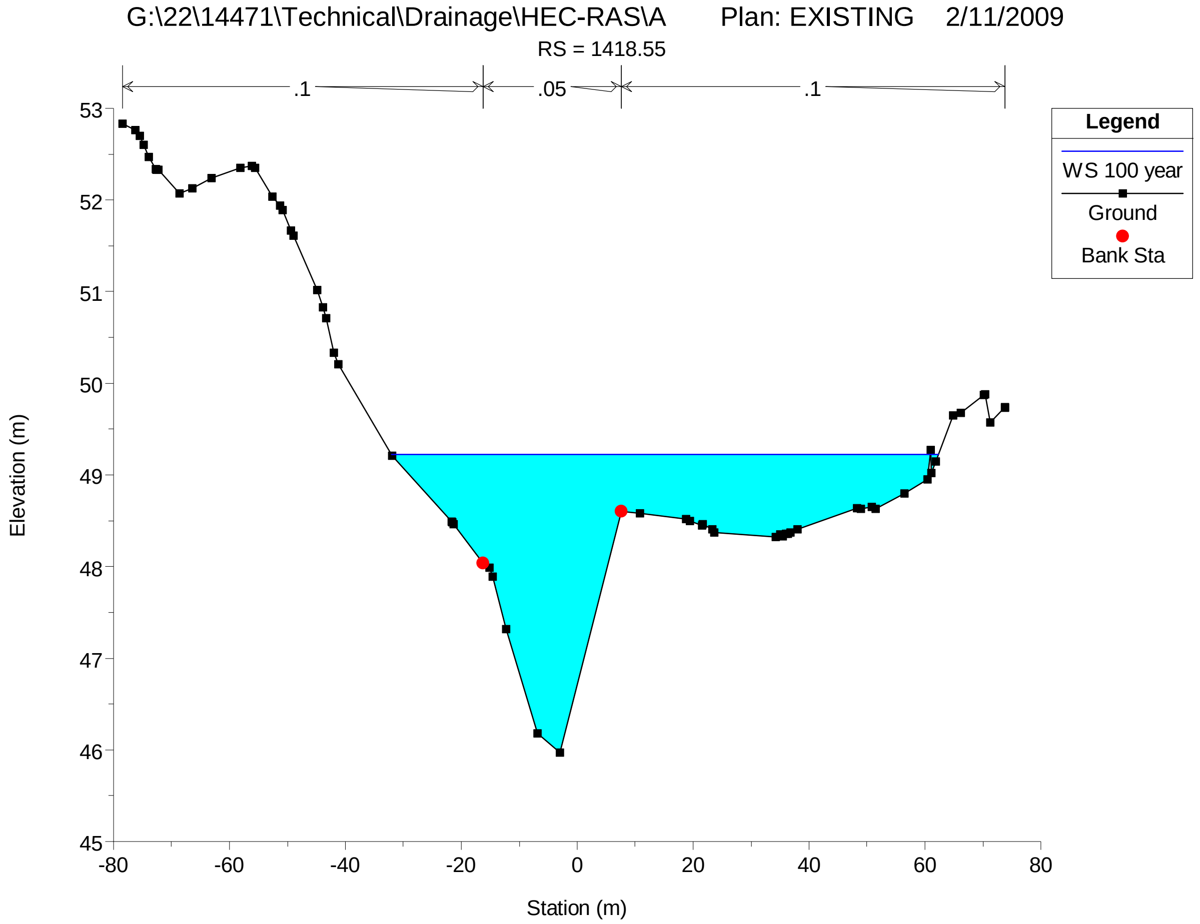
-50
0
50
100
150
200
Station (m)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.1
Legend
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Ground
Bank Sta
Elevation (m)
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46
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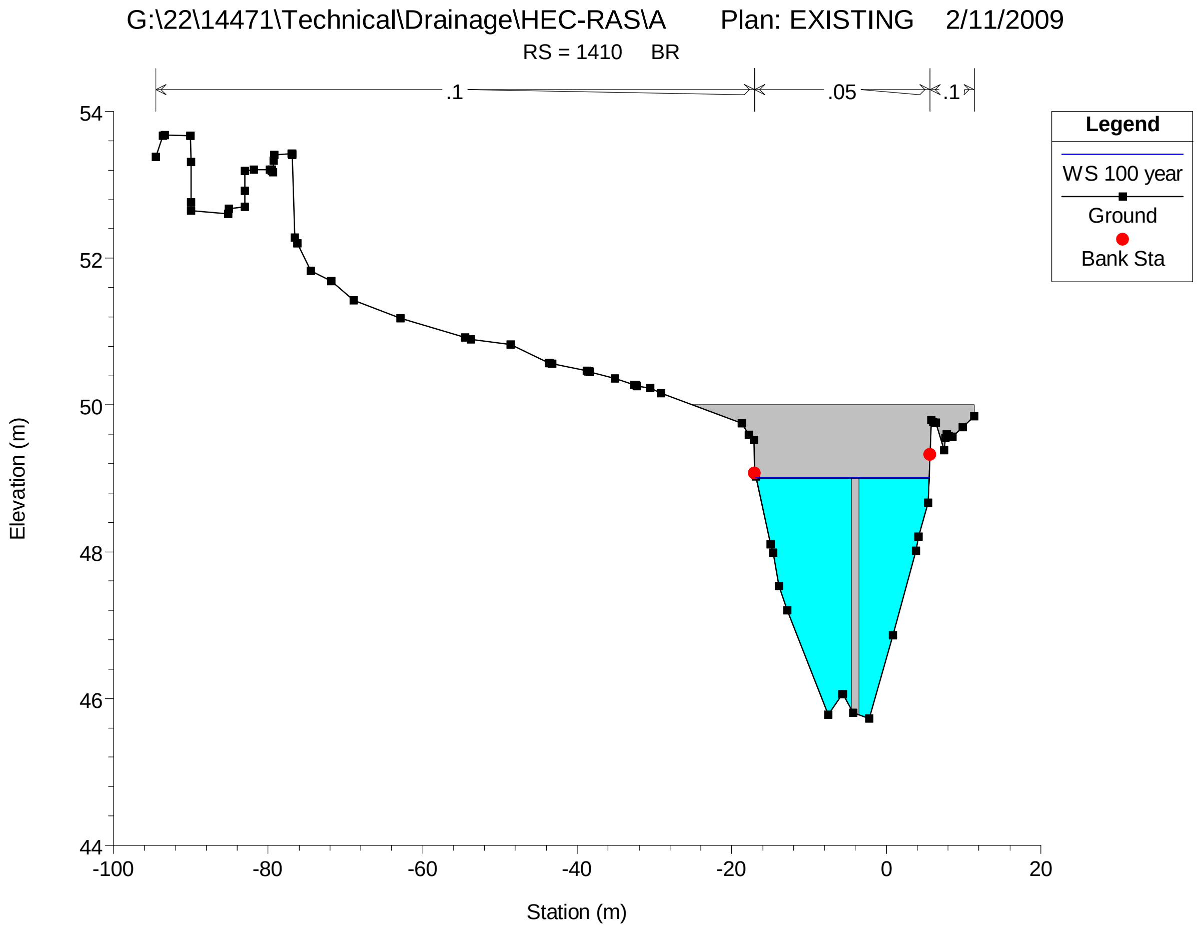
-80
-60
-40
-20
0
20
40
60
80
Station (m)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.05
.1
Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
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52
50
48
46
44
-100
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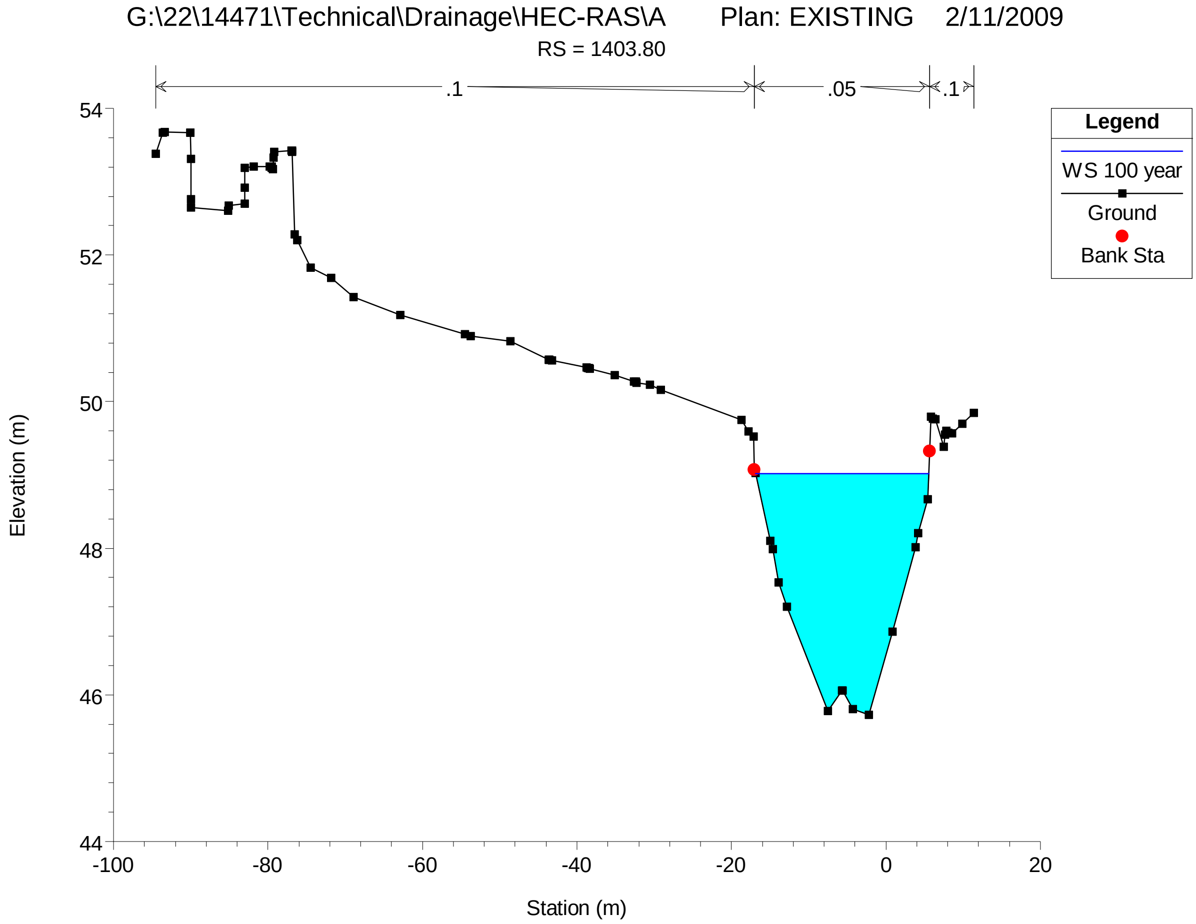
-60
-40
-20
0
20
Station (m)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Legend
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Ground
Bank Sta
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Station (m)
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50
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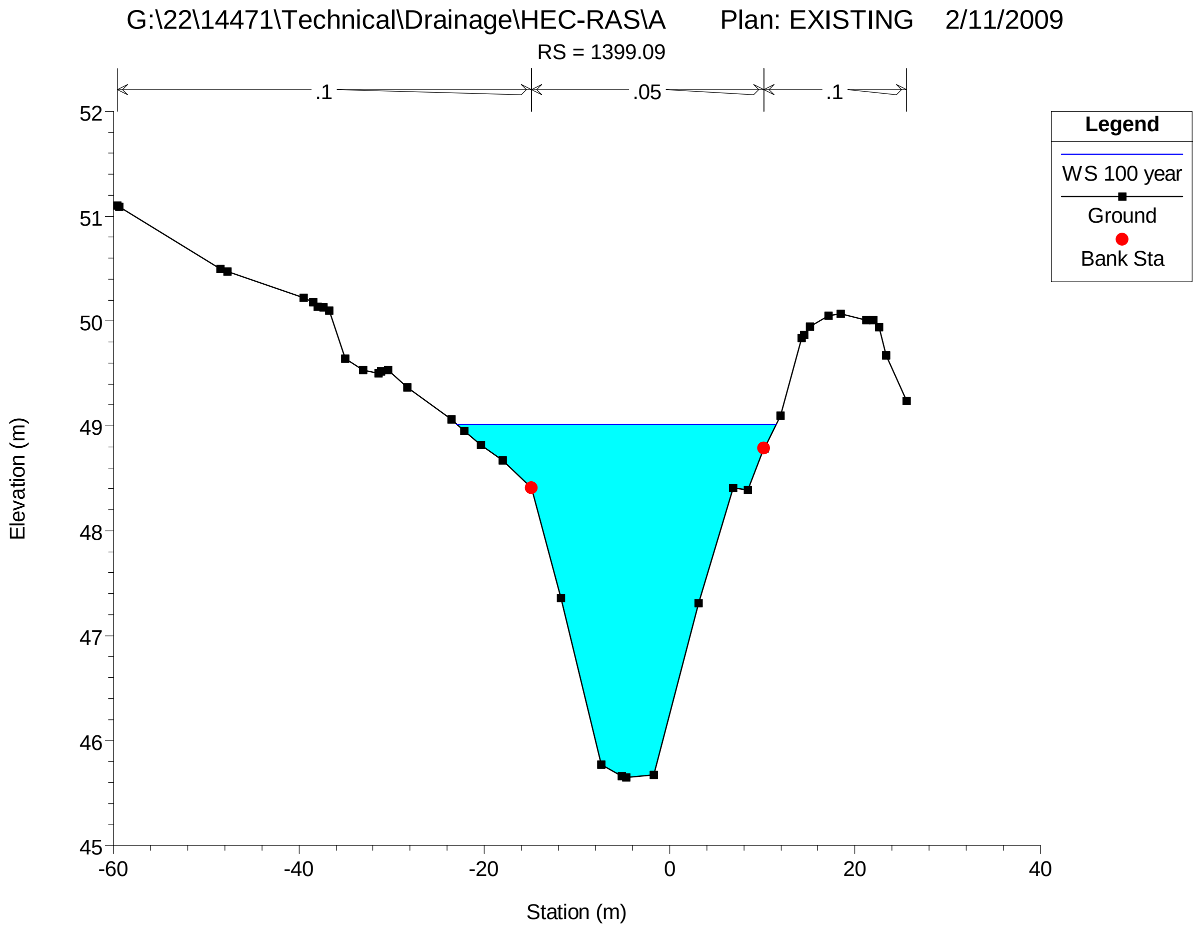
46
44
-100
-80
-60
-40
-20
0
20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.05
.1
Legend
WS 100 year
Ground
Bank Sta
Elevation (m)
Station (m)
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51
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49
48
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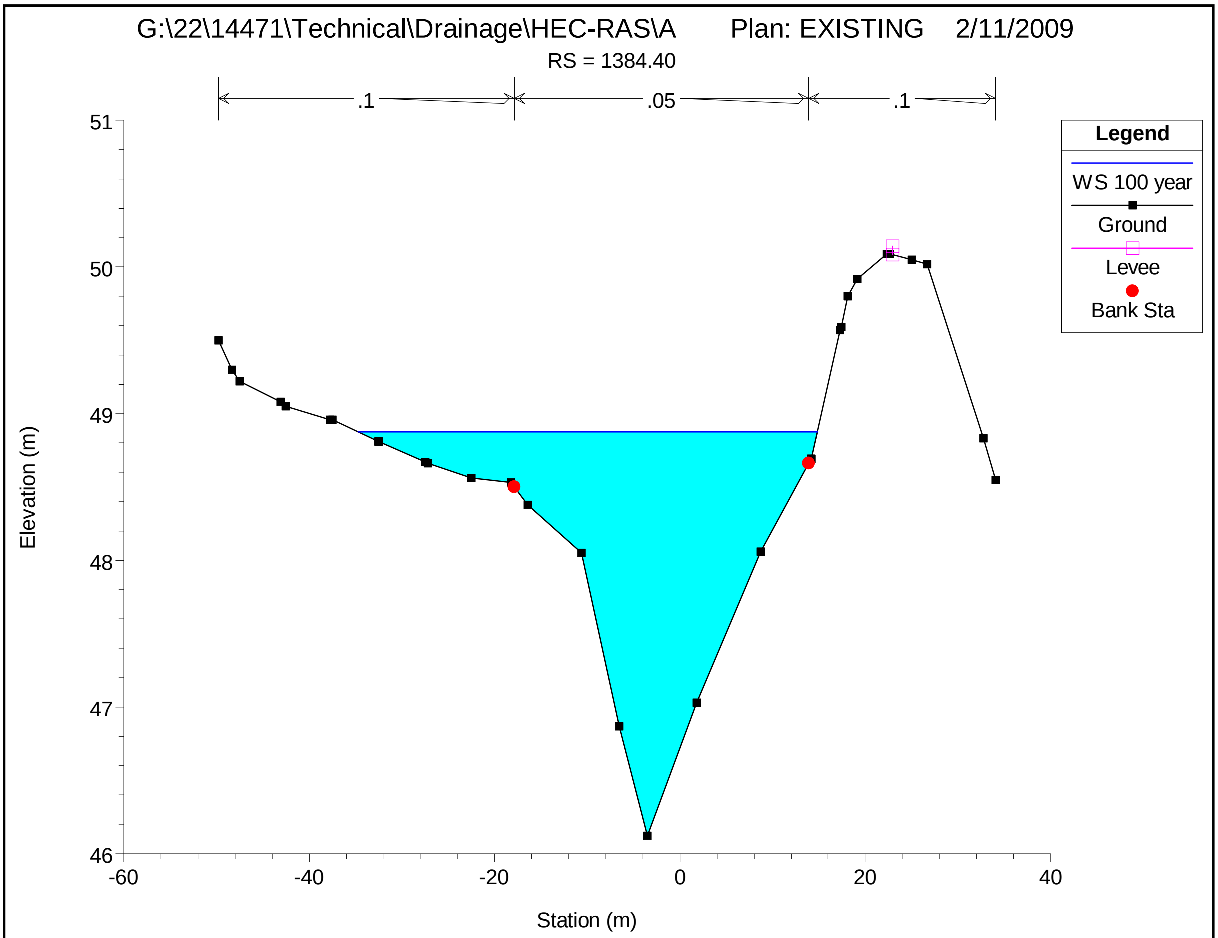
46
45
-60
-40
-20
0
20
40



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.05
.1
Legend
WS 100 year
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
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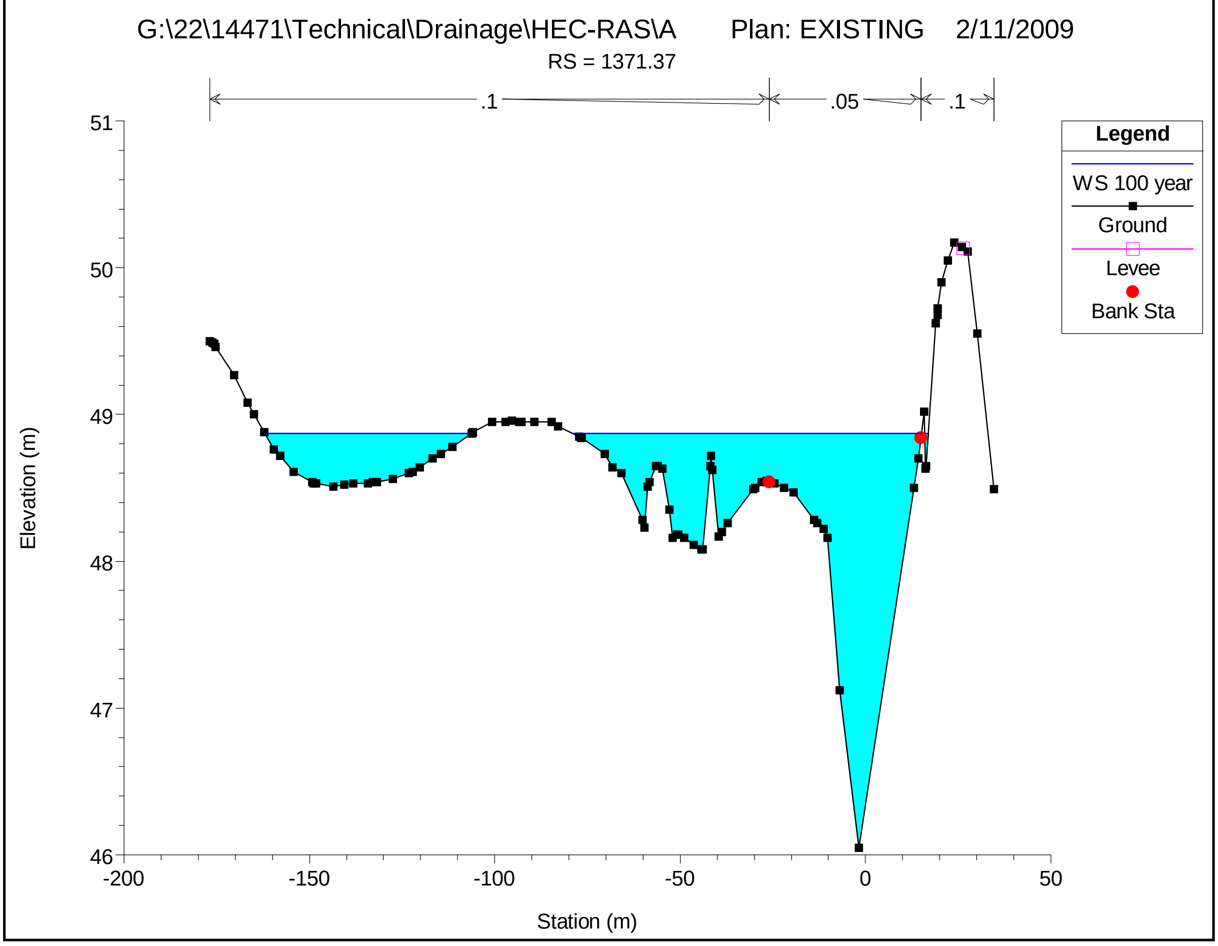
50
49
48
47
46
-60
-40
-20
0
20
40



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.05
.1
Legend
WS 100 year
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
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50
49
48
47
46
-200
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0
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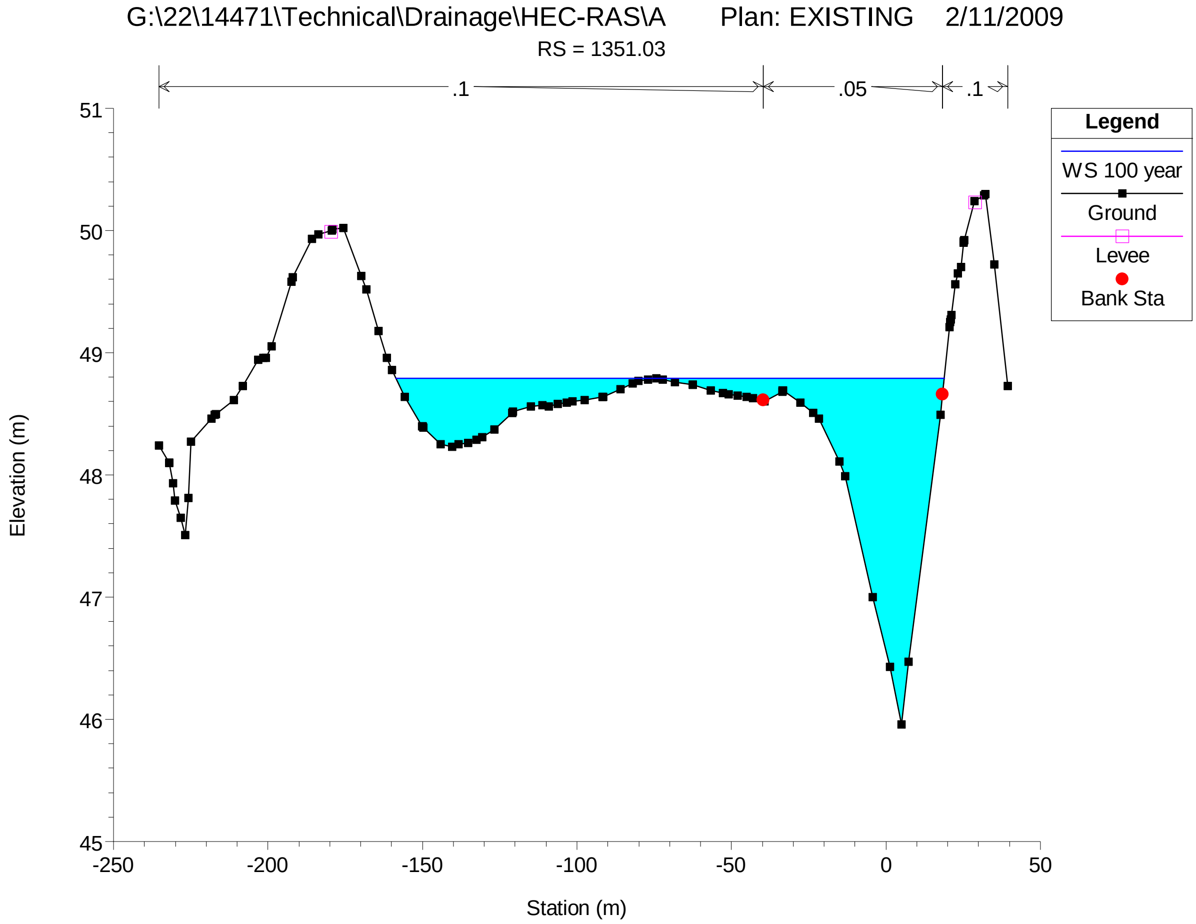
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.05
.1
Legend
WS 100 year
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
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48
47
46
45
-250
-200
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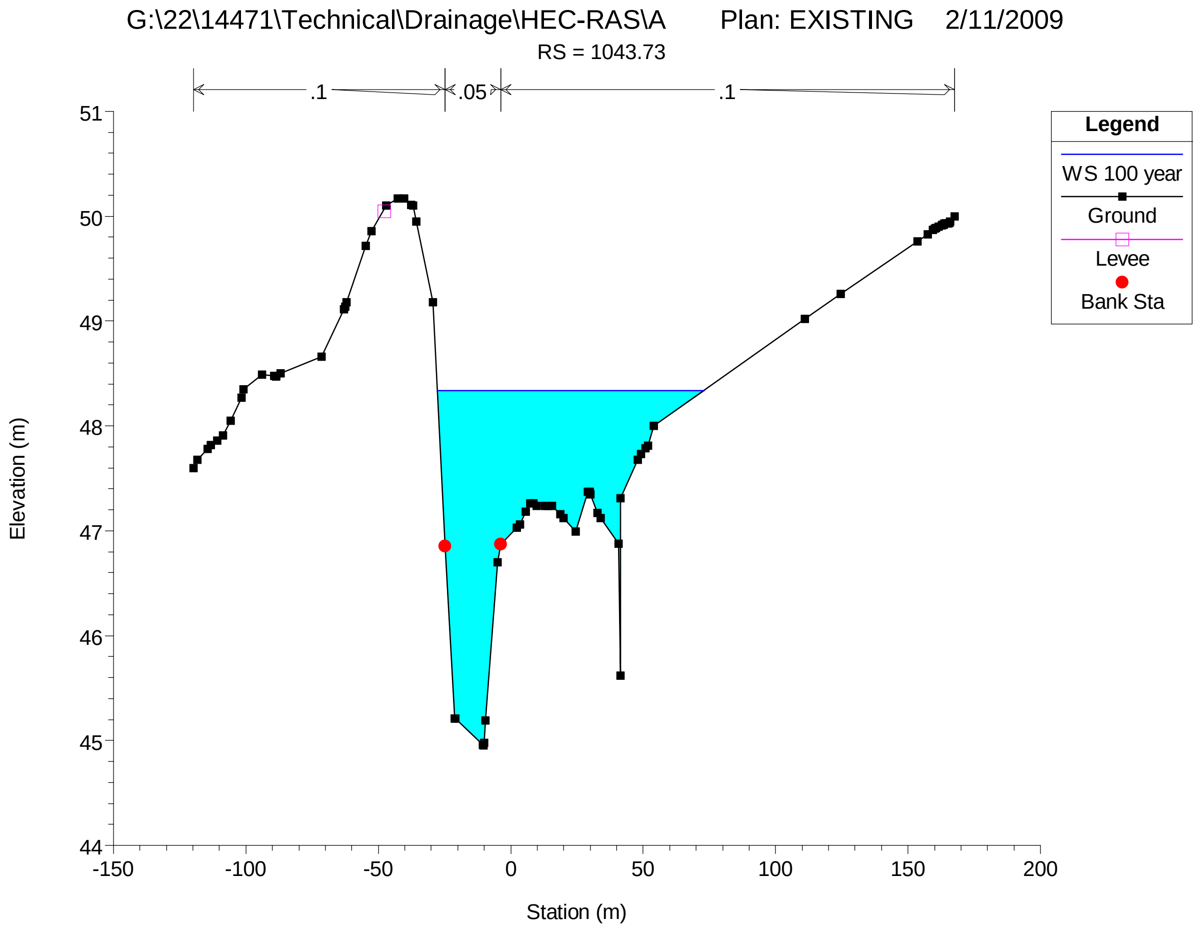
-50
0
50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.05
.1
Legend
WS 100 year
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
51
50
49
48
47
46
45
44
-150
-100
-50
0
50
100
150
200

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Appendix D

Black Creek Hydrologic and Hydraulic Model

Summary of WMA Hydrologic model outputs

WBNM Results including catchment plan

HEC-RAS Results

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Black Creek Peak Flows (from WMA Water)

Storm Event (years)	Peak Flow (m^3/s)
2	246
5	408
10	510
20	647
50	785
100	925
2000	1,517

wma water

GHD
Hunter 8 Alliance

29048/GHD_091003_MW

3 September 2009

Attention: **Mr Jason Clements**

Dear Jason,

Re: Provision of Flows for Black Creek near Branxton

WMAwater was requested to determine design flows for Black Creek at the intersection with the Great Northern Railway (approximately 2kms west of Branxton – refer Figure 1) for the 2, 5, 10, 20, 50, 100 and 2000 year ARI design rainfall events.

A WBNM hydrologic model established for the Branxton to Green Rocks Flood Study (in preparation for Maitland City Council) was used to determine the design flows. The sub-catchment areas used in the model are shown on Figure 1 and the WBNM model was calibrated against historical flow records as shown on Figure 2.

As a result of the calibration, the following parameter values were adopted for the design runs:

Initial Loss:	20 mm
Continuing Loss:	2.5 mm/h
Lag parameter, C:	1.29

The resulting design hydrographs have been provided in an Excel spreadsheet.

Yours faithfully,
WMAwater

Michael Wyk
Project Engineer

Webb, McKeown & Associates Pty Ltd (trading as WMAwater)

ABN 50 366 075 980

DIRECTORS
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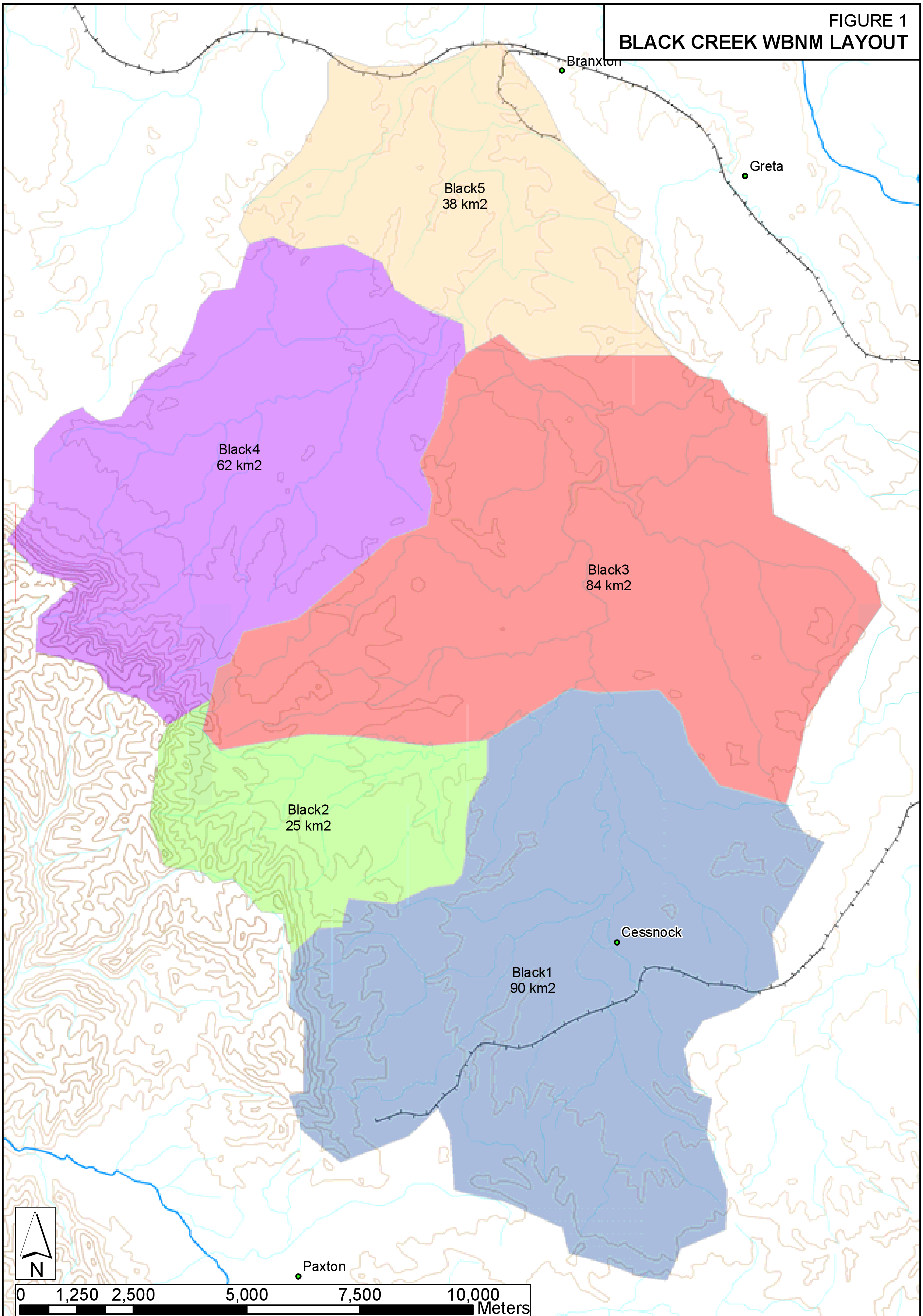
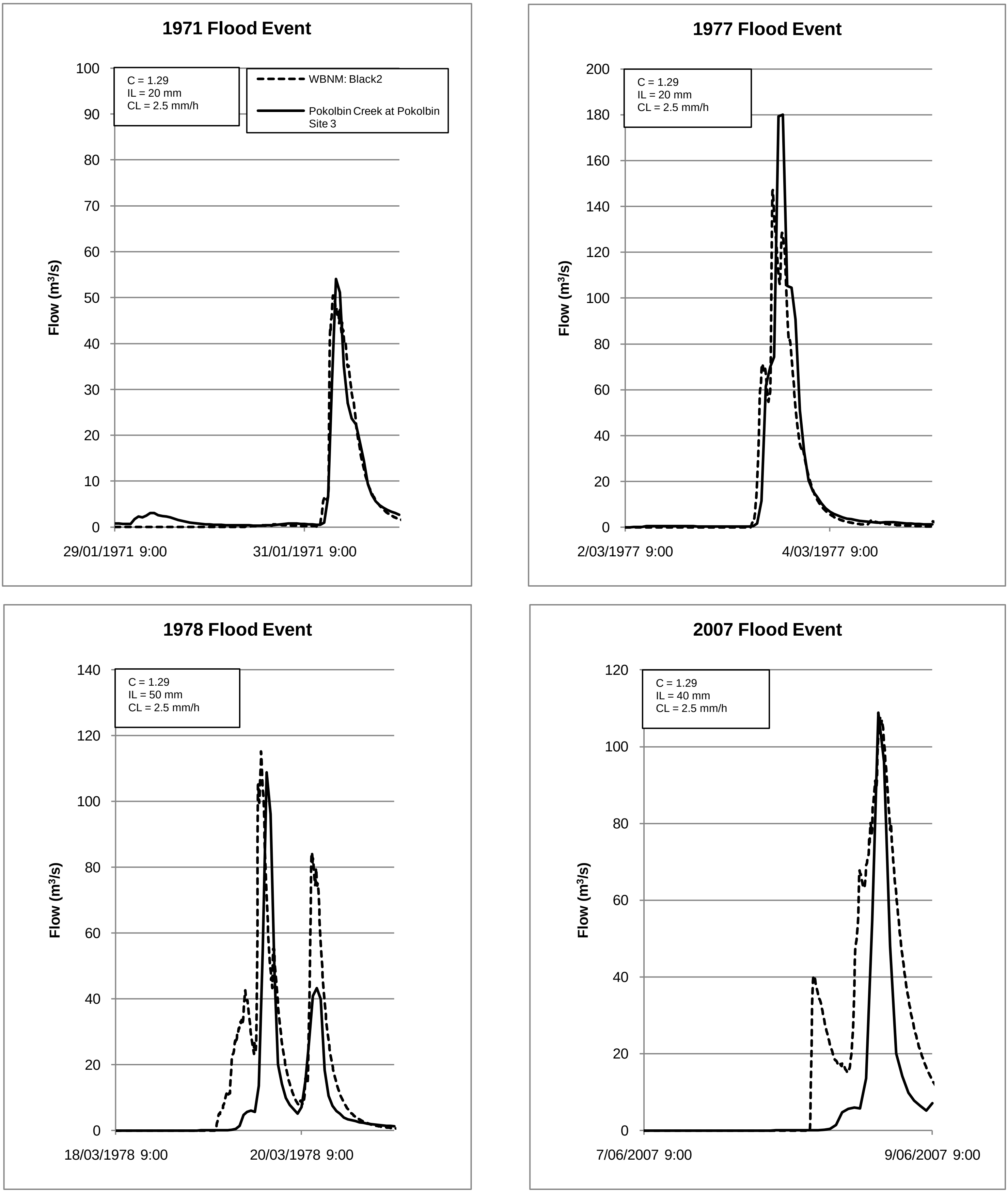
FIGURE 1
BLACK CREEK WBNM LAYOUT



J:\\Jobs\29048\ArcGIS\Maps\BlackCreek_WBNM_Layout.mxd

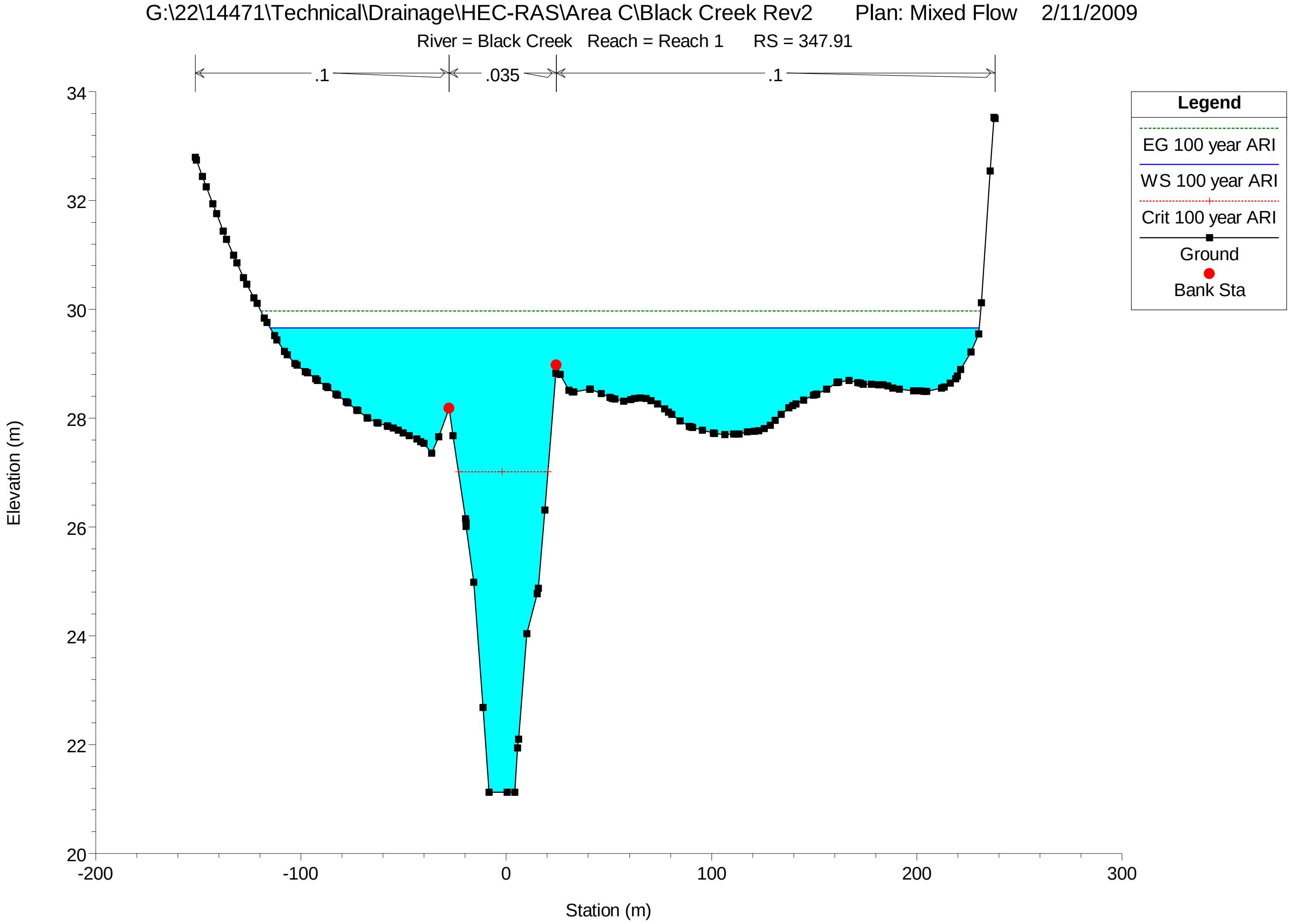
FIGURE 2

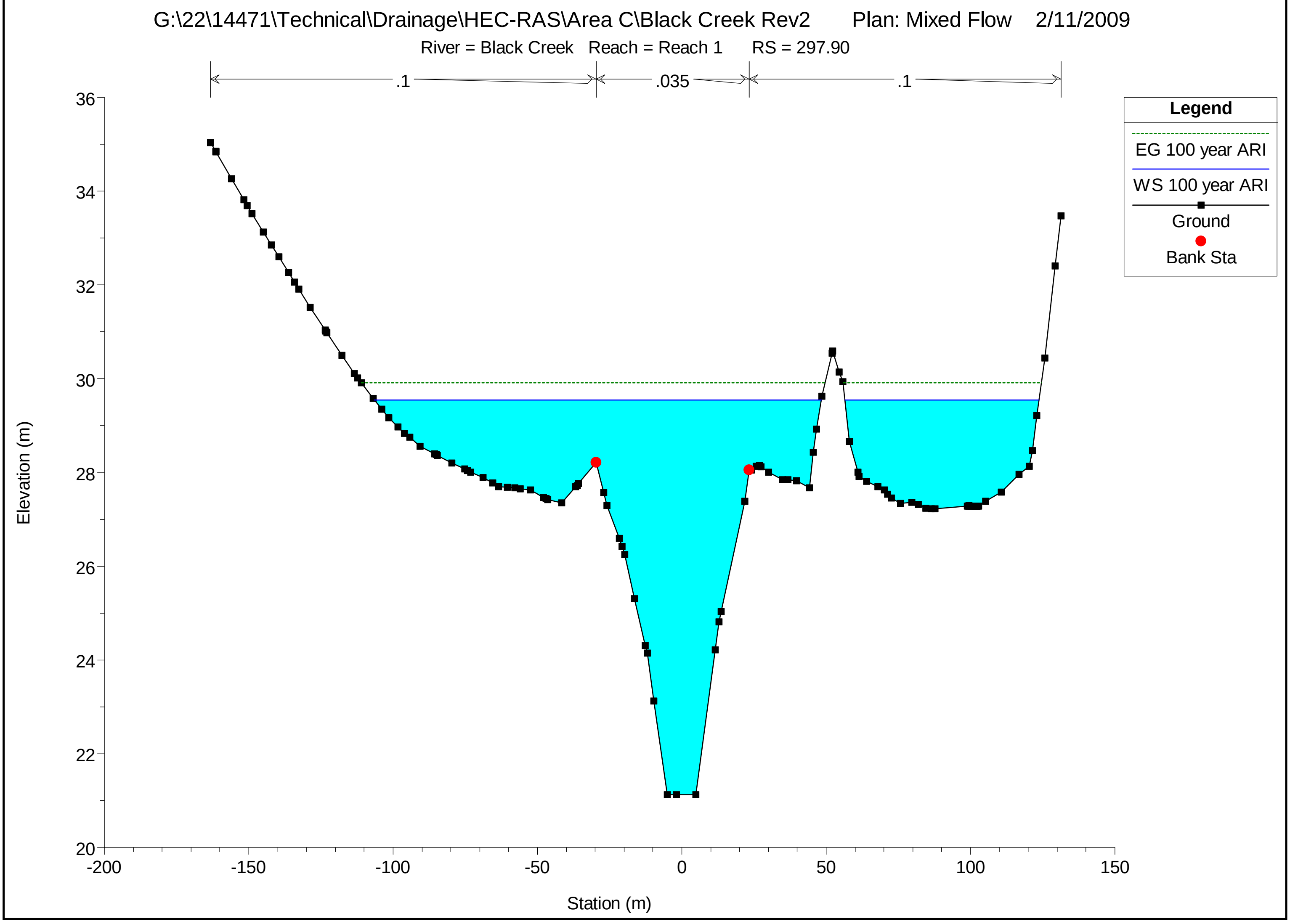
CALIBRATION OF HYDROLOGIC MODEL FOR BLACK CREEK



HEC-RAS Plan: Mixed   River: Black Creek   Reach: Reach 1   Profile: 100 year ARI

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach 1	347.91	100 year ARI	925.00	21.13	29.66	27.02	29.97	0.000989	2.69	680.15	345.49	0.37
Reach 1	297.90	100 year ARI	925.00	21.13	29.55		29.91	0.001194	2.87	553.21	222.04	0.40
Reach 1	253.35	100 year ARI	925.00	21.13	29.44		29.85	0.001144	2.93	407.55	127.65	0.40
Reach 1	234.40	100 year ARI	925.00	21.13	29.45	25.97	29.82	0.000732	2.76	396.96	72.70	0.34
Reach 1	232		Bridge									
Reach 1	226.77	100 year ARI	925.00	21.13	29.44	26.00	29.81	0.000730	2.74	384.59	70.10	0.34
Reach 1	224		Bridge									
Reach 1	214.75	100 year ARI	925.00	21.13	29.26	25.99	29.76	0.000949	3.26	369.13	66.89	0.38
Reach 1	209		Bridge									
Reach 1	199.04	100 year ARI	925.00	21.13	29.13		29.63	0.001134	3.19	341.01	70.37	0.40
Reach 1	174.57	100 year ARI	925.00	21.13	29.23		29.55	0.000859	2.65	623.97	309.91	0.35
Reach 1	125.00	100 year ARI	925.00	21.13	27.45	27.45	29.30	0.008156	6.03	155.46	110.20	0.98
Reach 1	100.00	100 year ARI	925.00	21.13	27.06	27.23	29.07	0.009561	6.28	147.39	78.63	1.06
Reach 1	50.00	100 year ARI	925.00	21.13	26.63	26.70	28.63	0.008541	6.27	148.93	63.37	1.02


G:\22\14471\Technical\Drainage\HEC-RAS\Area C\Black Creek Rev2 Plan: Mixed Flow 2/11/2009
River = Black Creek Reach = Reach 1 RS = 347.91
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
34
32
30
28
26
24
22
20
-200
-100
0
100
200
300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River = Black Creek Reach = Reach 1 RS = 297.90
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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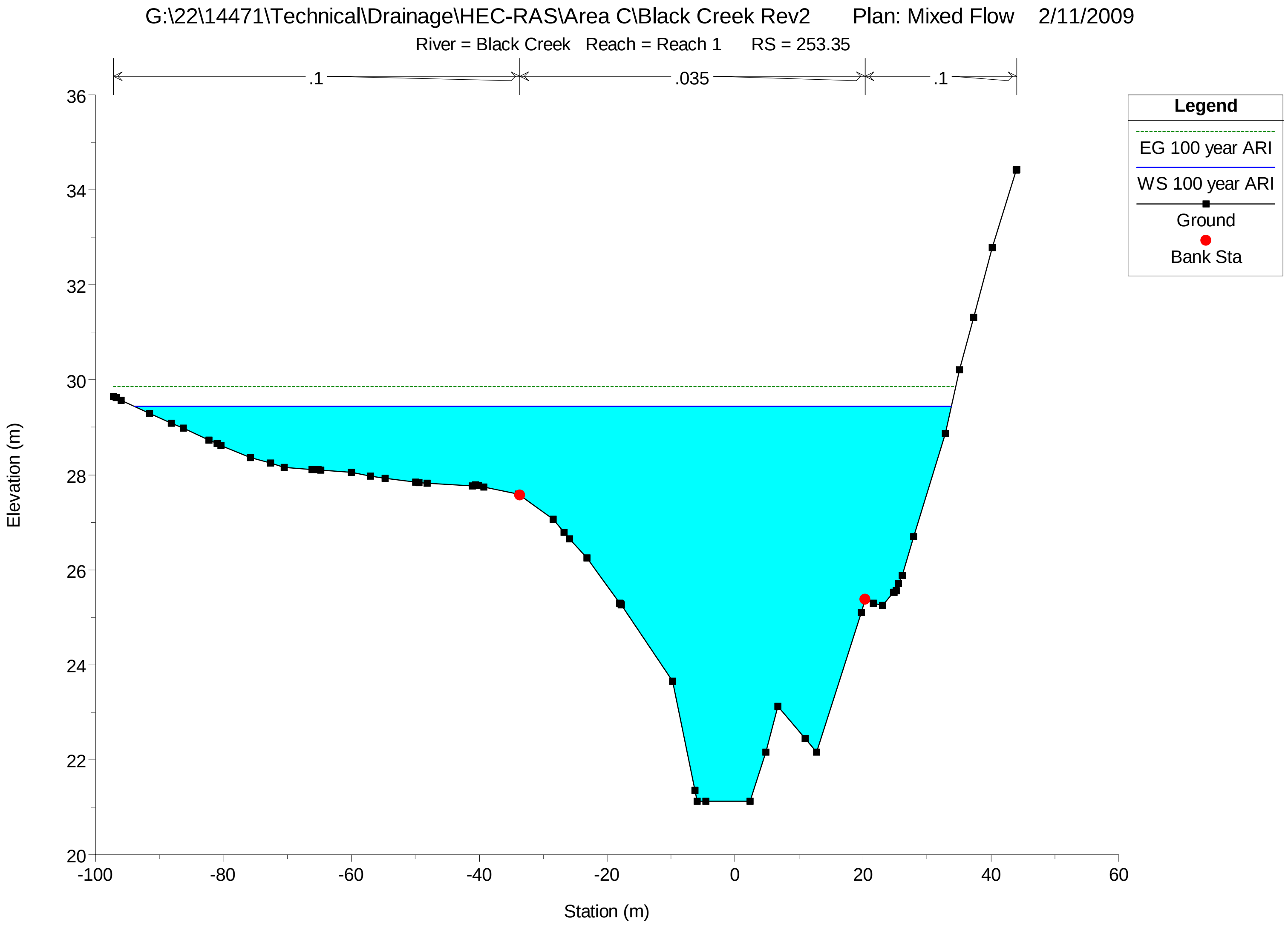
34
32
30
28
26
24
22
20
-200
-150
-100
-50
0
50
100
150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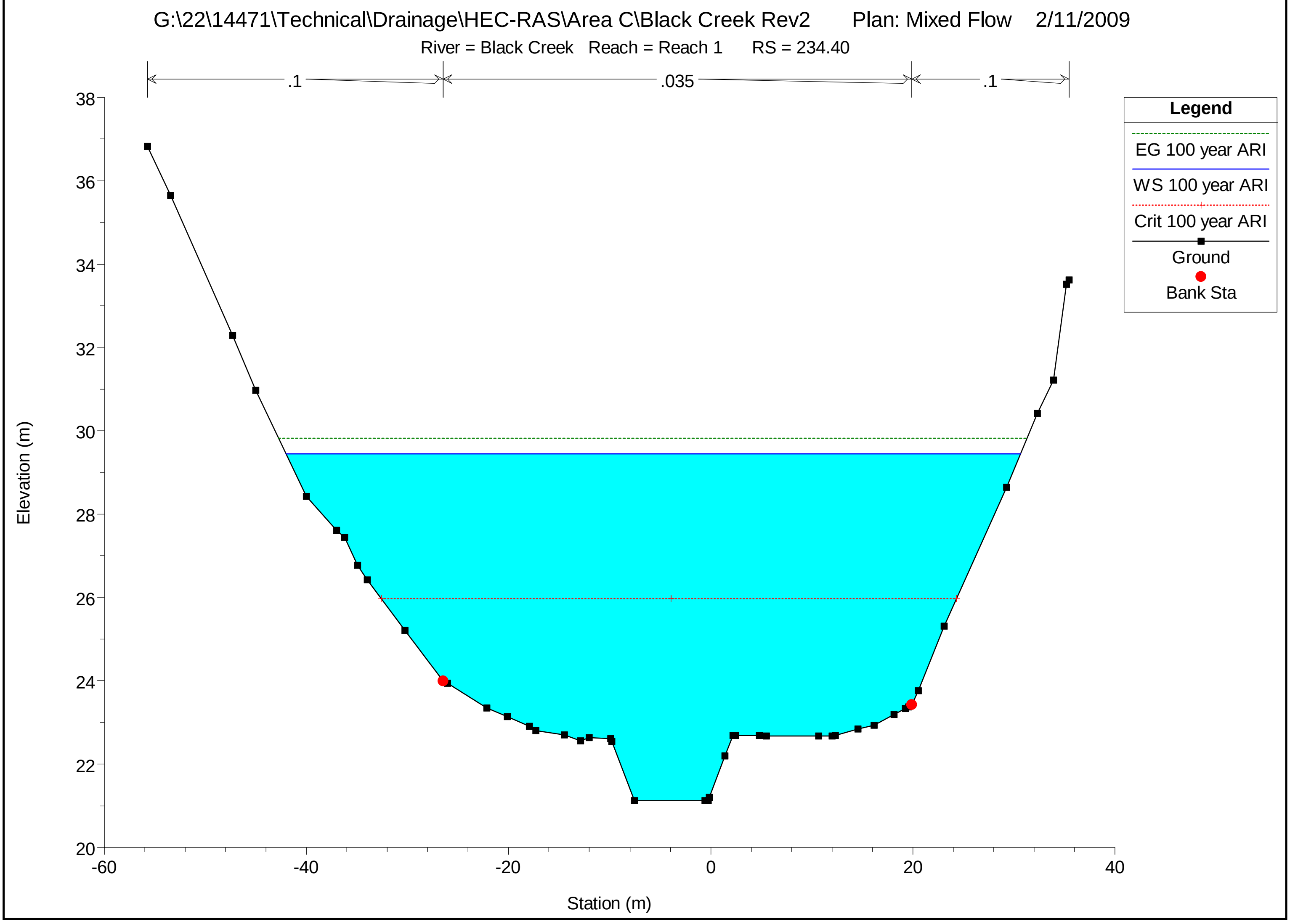
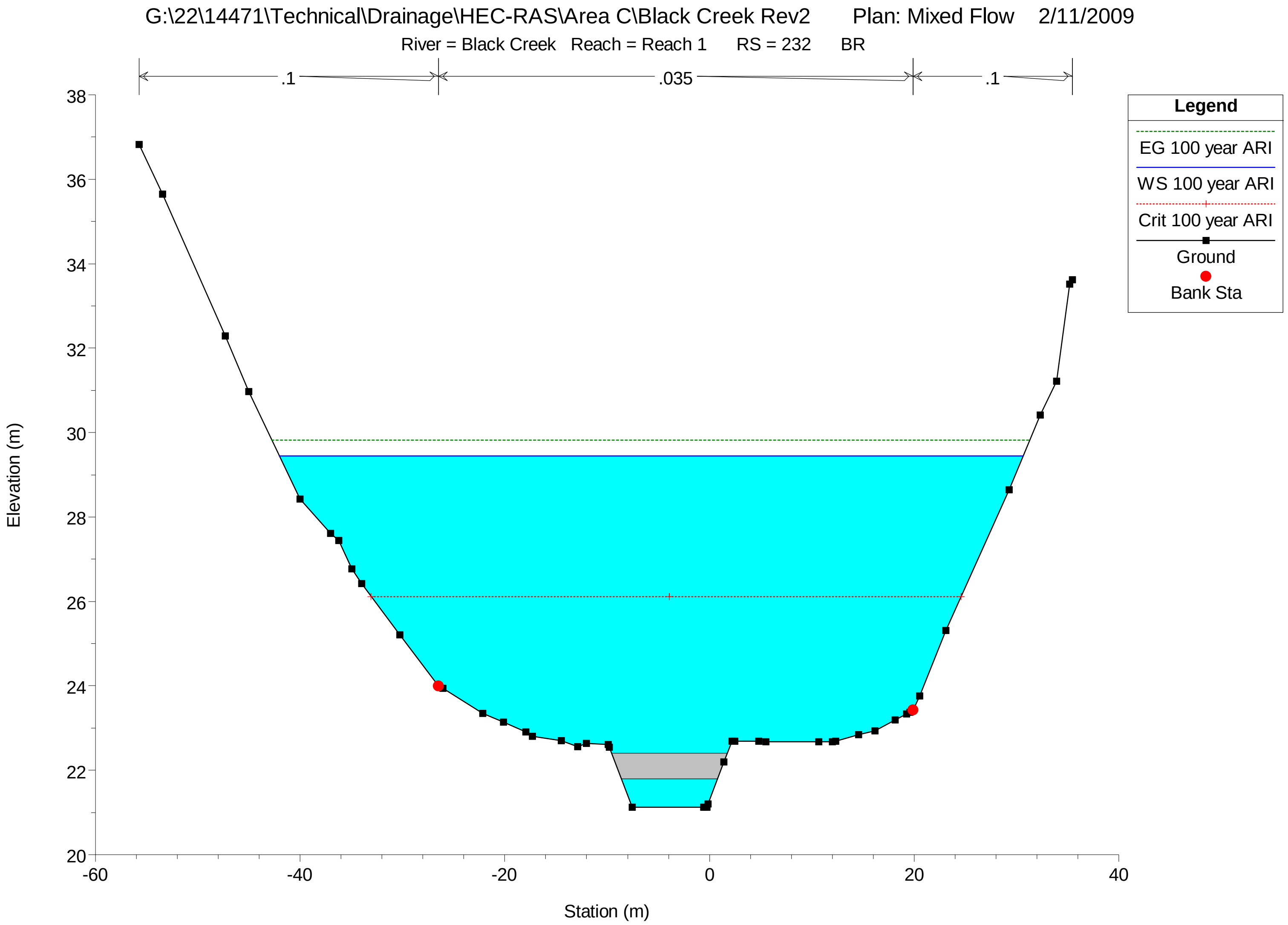
River = Black Creek Reach = Reach 1 RS = 253.35
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
36
34
32
30
28
26
24
22
20
-100
-80
-60
-40
-20
0
20
40
60


G:\22\14471\Technical\Drainage\HEC-RAS\Area C\Black Creek Rev2 Plan: Mixed Flow 2/11/2009
River = Black Creek Reach = Reach 1 RS = 234.40
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
38
36
34
32
30
28
26
24
22
20
-60
-40
-20
0
20
40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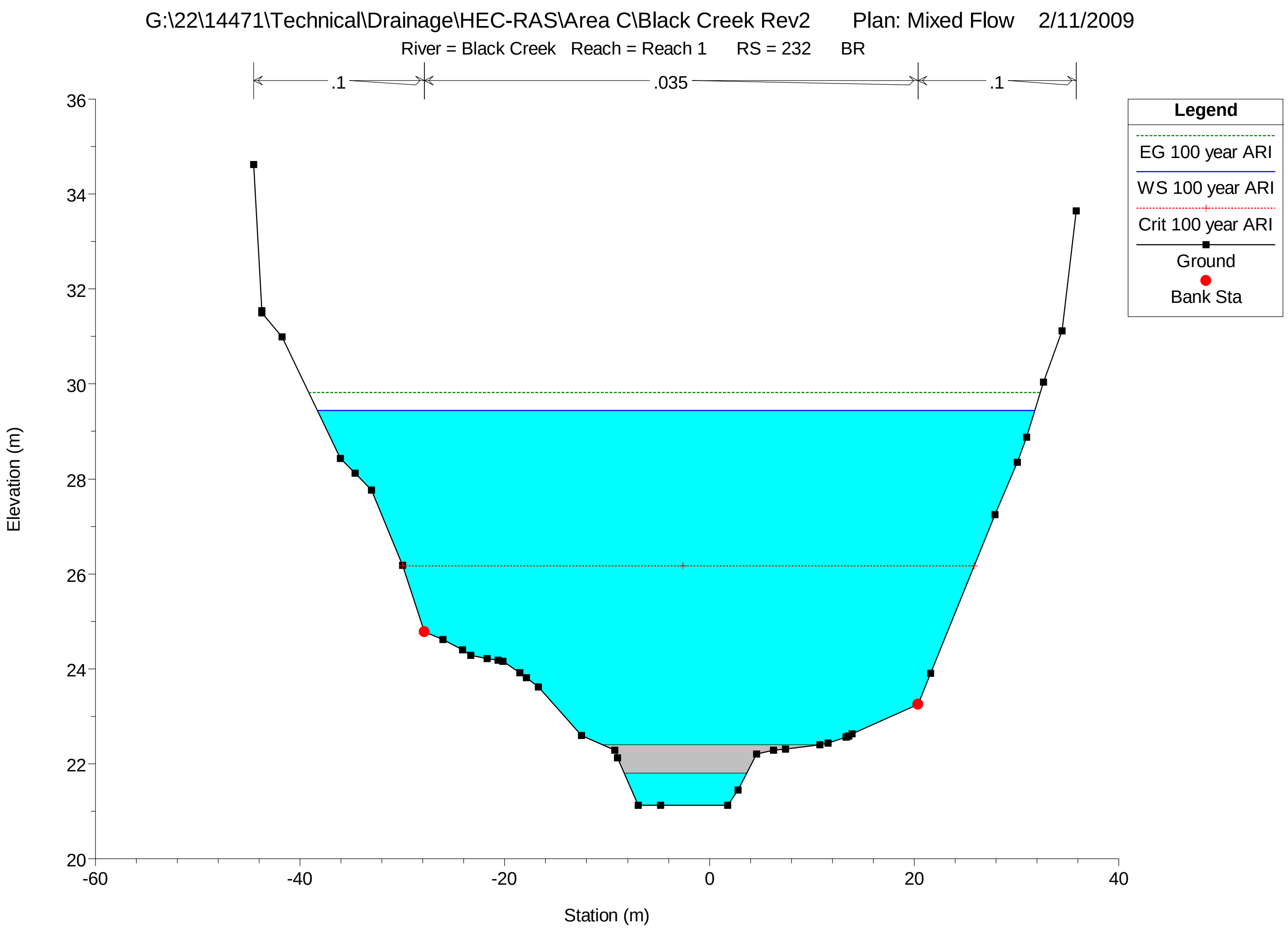
River = Black Creek Reach = Reach 1 RS = 232 BR
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
38
36
34
32
30
28
26
24
22
20
-60
-40
-20
0
20
40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River = Black Creek Reach = Reach 1 RS = 232 BR
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
36
34
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-60
-40
-20
0
20
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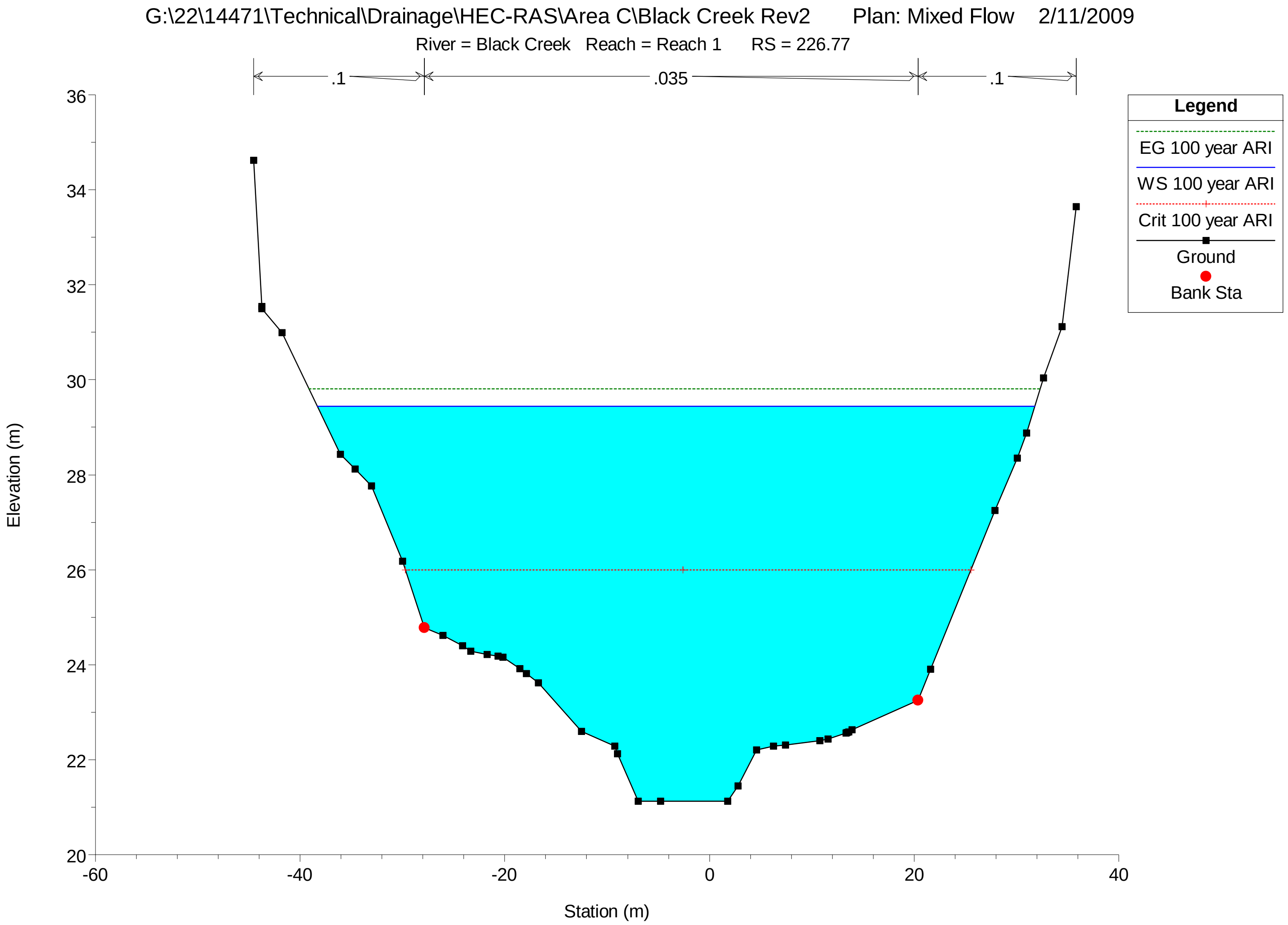
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.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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34
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-60
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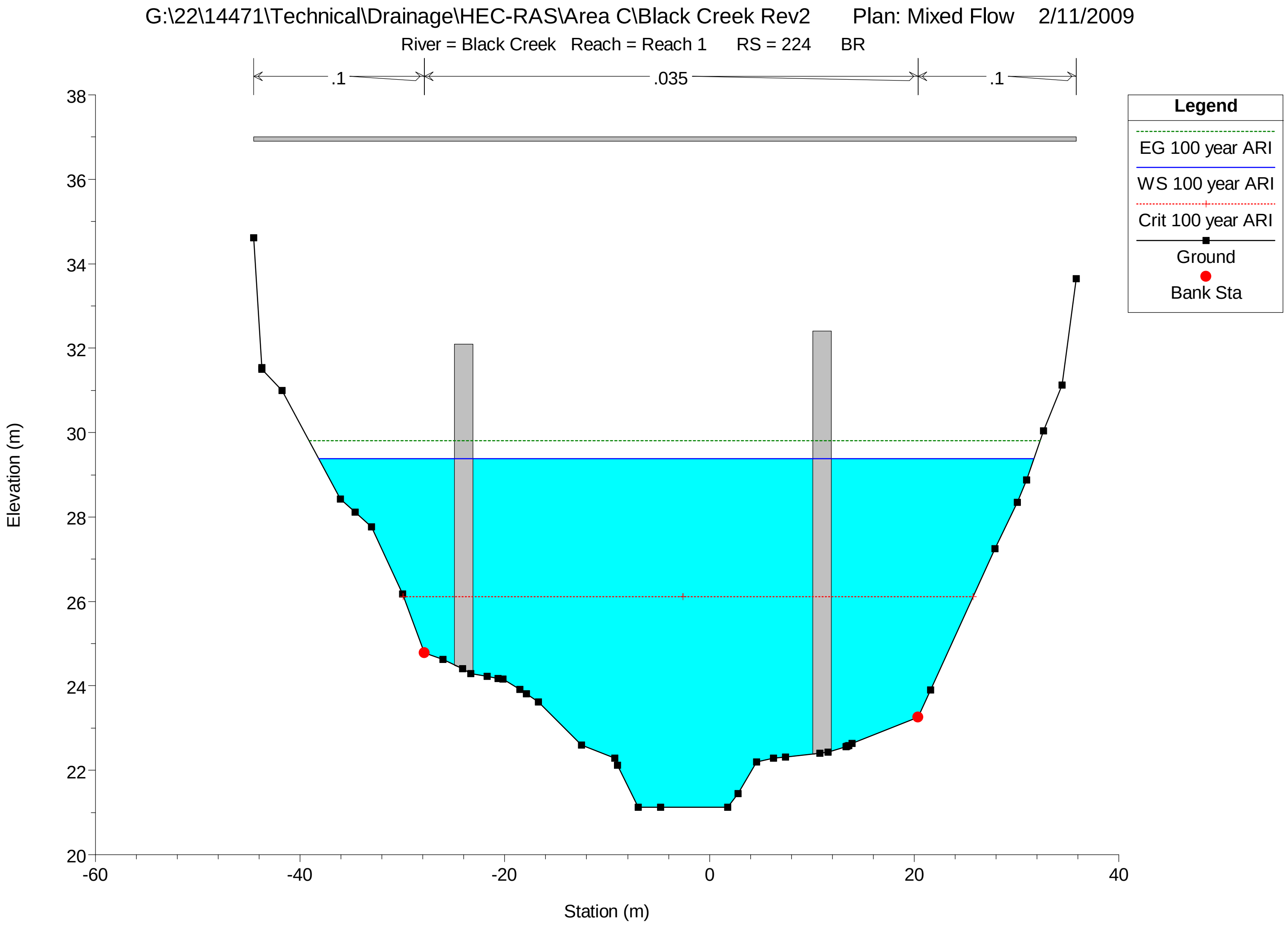
-20
0
20
40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River = Black Creek   Reach = Reach 1   RS = 224   BR
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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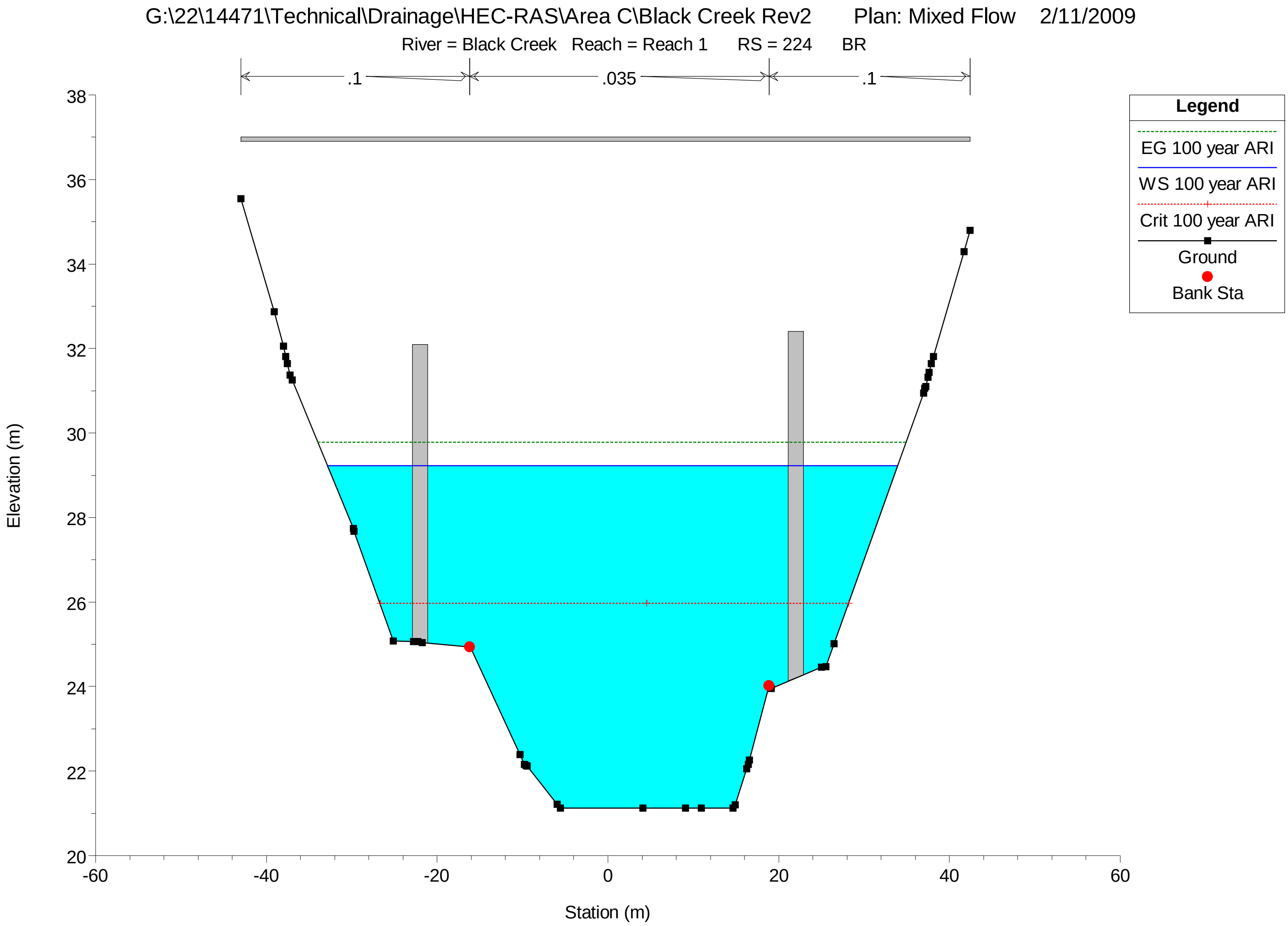
36
34
32
30
28
26
24
22
20
-60
-40
-20
0
20
40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River = Black Creek Reach = Reach 1 RS = 224 BR
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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36
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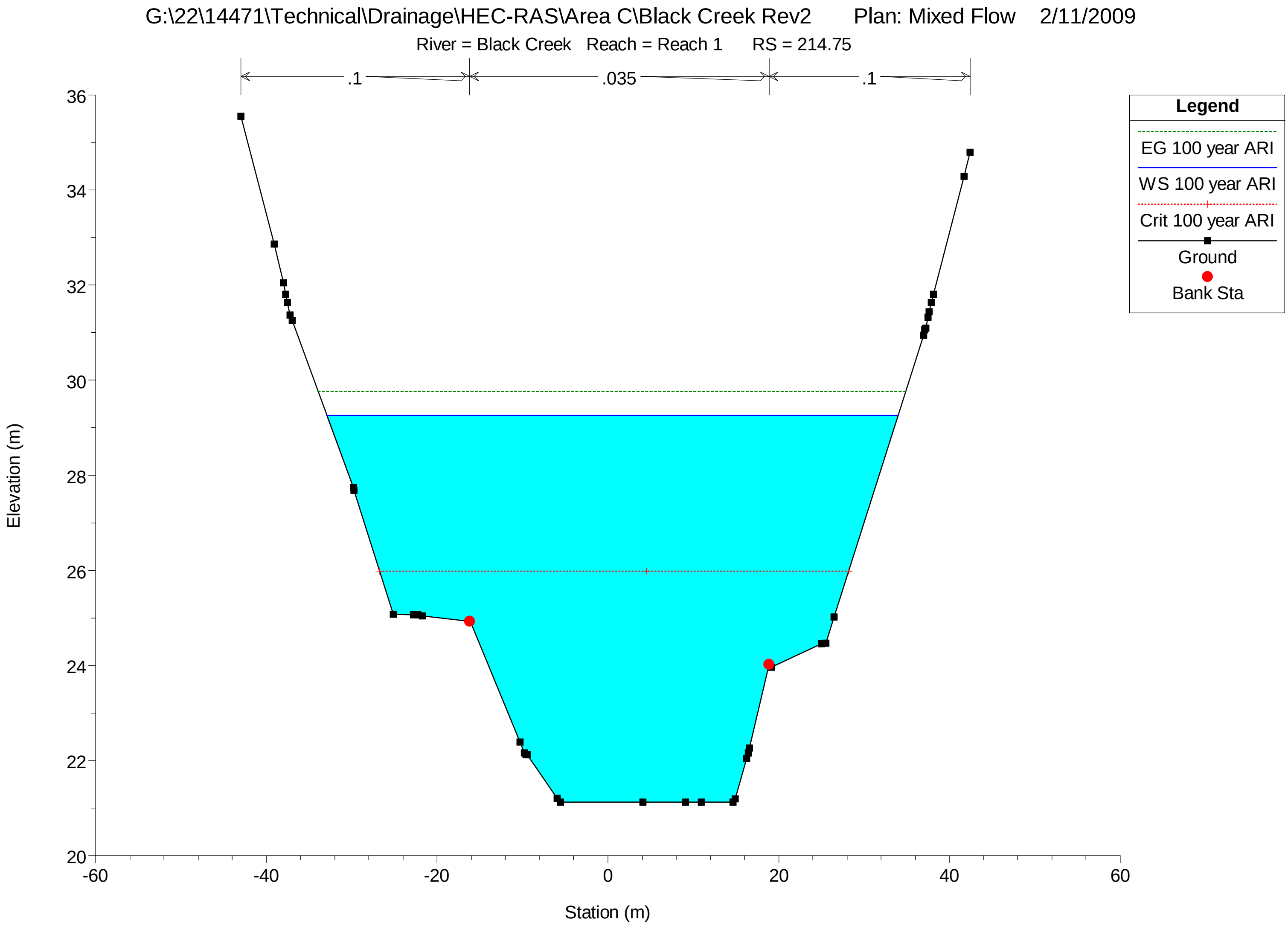
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.035
.1
Legend
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WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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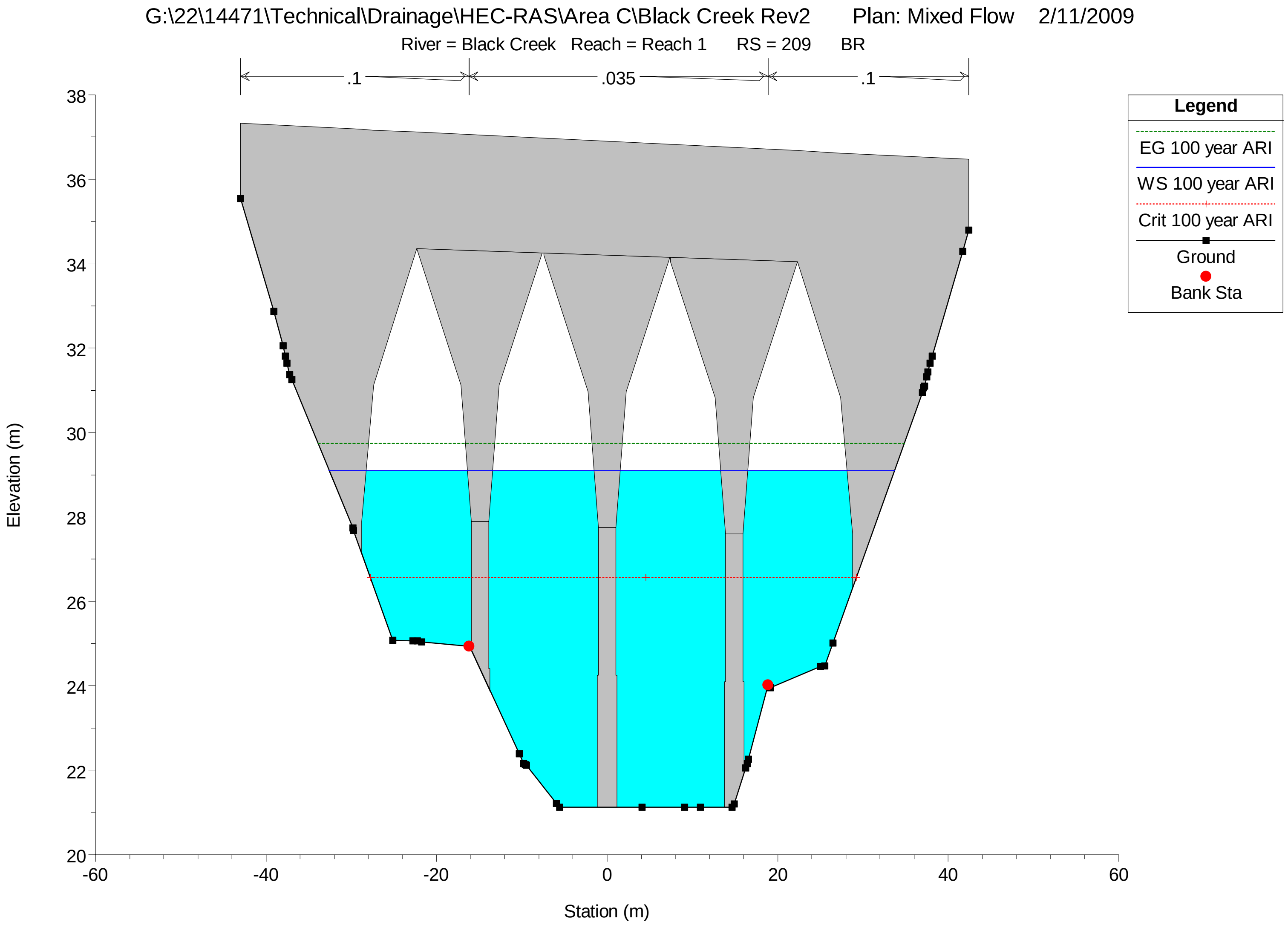

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River = Black Creek Reach = Reach 1 RS = 209 BR
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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36
34
32
30
28
26
24
22
20
-60
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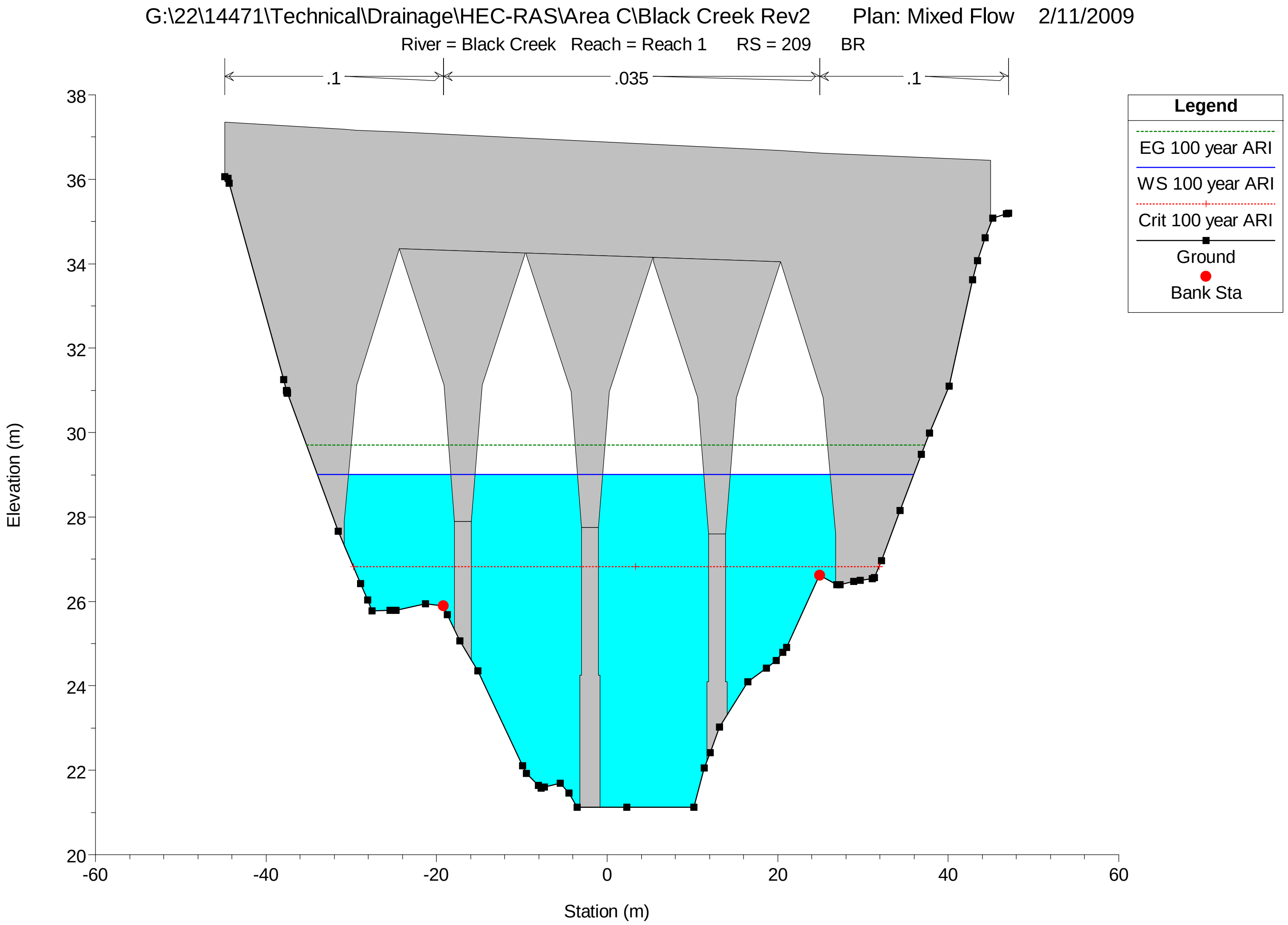
-20
0
20
40
60



G:\22\14471\Technical\Drainage\HEC-RAS\Area C\Black Creek Rev2 Plan: Mixed Flow 2/11/2009
River = Black Creek Reach = Reach 1 RS = 209 BR
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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36
34
32
30
28
26
24
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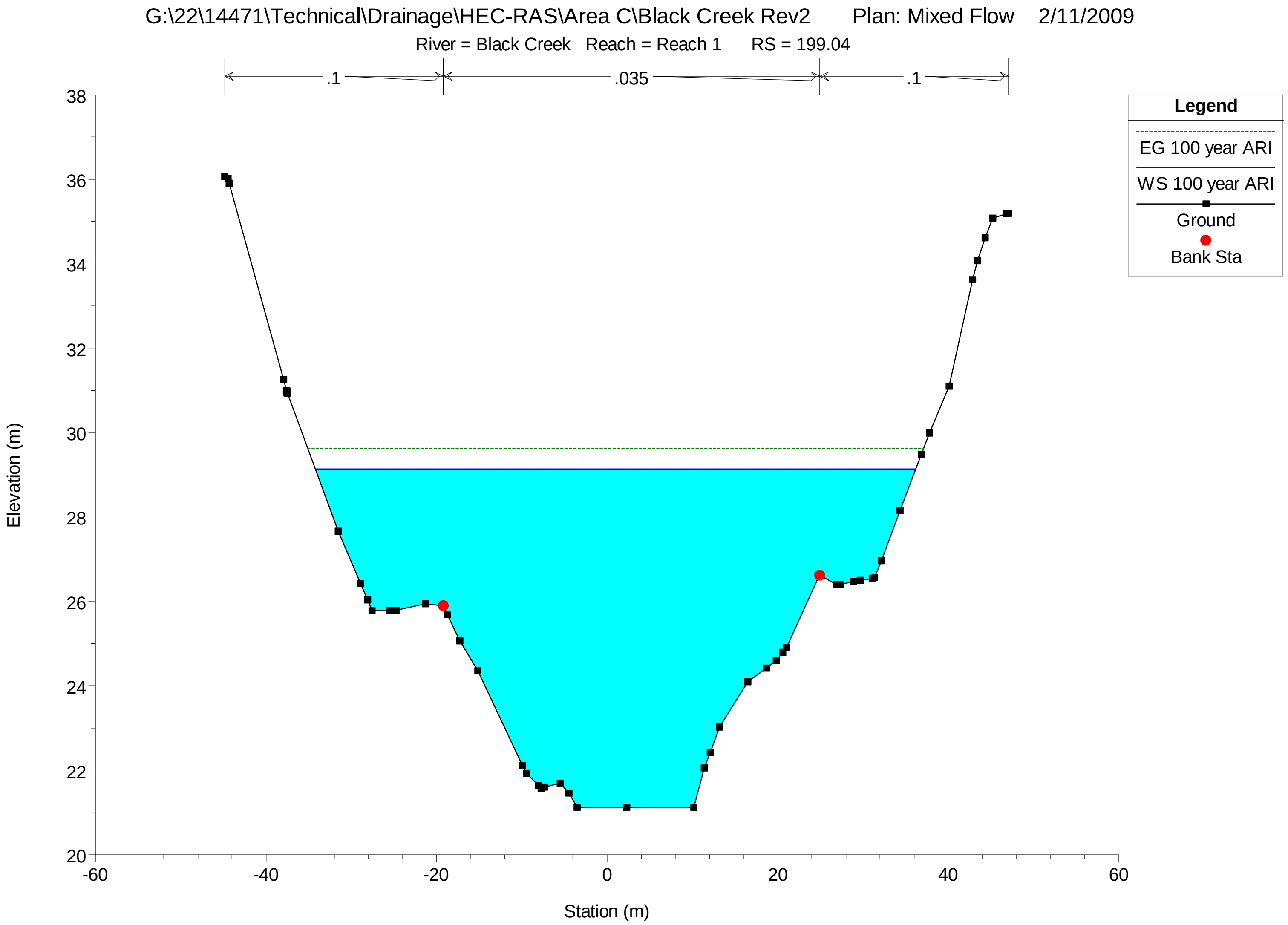
20
-60
-40
-20
0
20
40
60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River = Black Creek Reach = Reach 1 RS = 199.04
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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-60
-40
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0
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40
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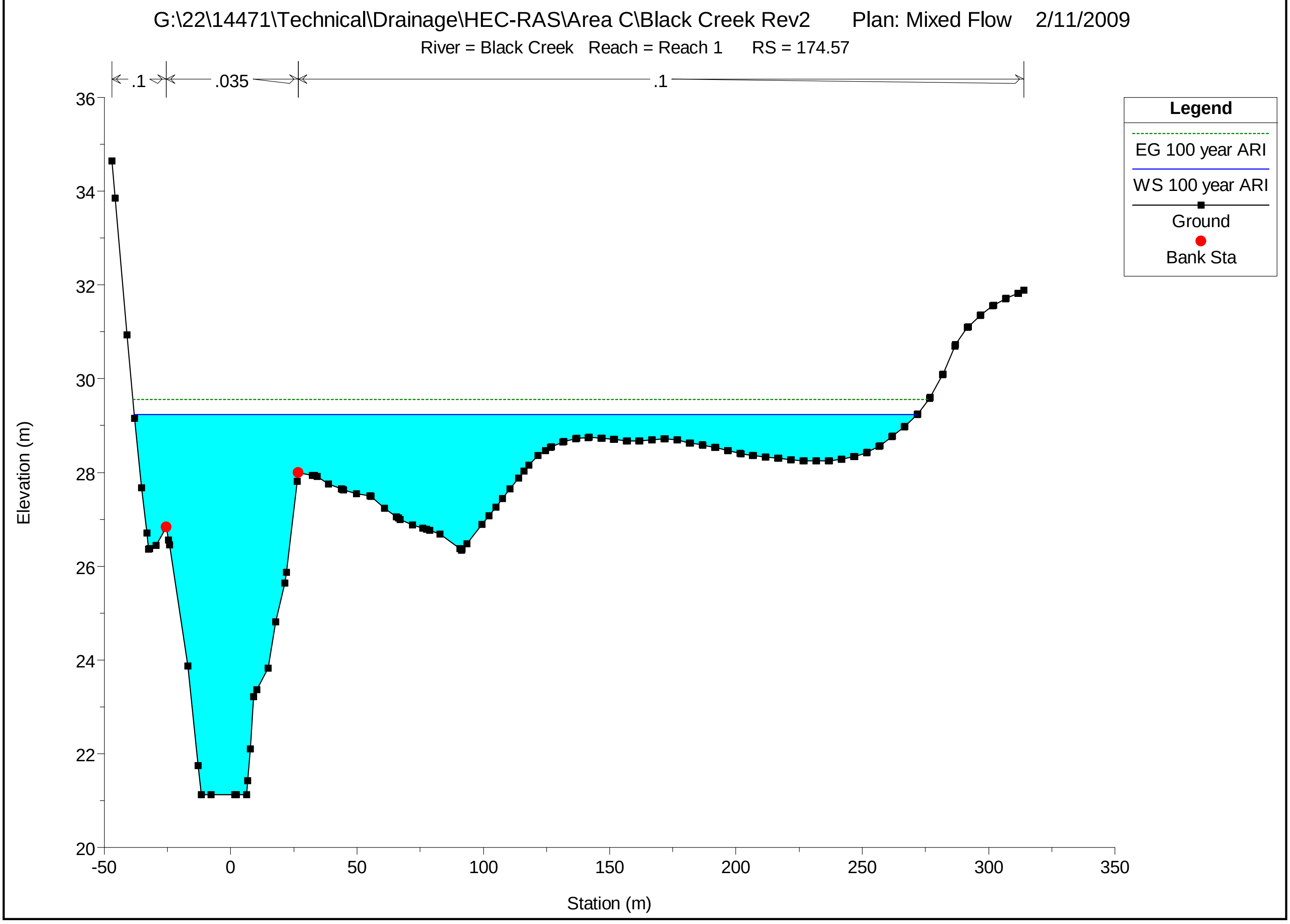
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River = Black Creek Reach = Reach 1 RS = 174.57
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.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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24
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0
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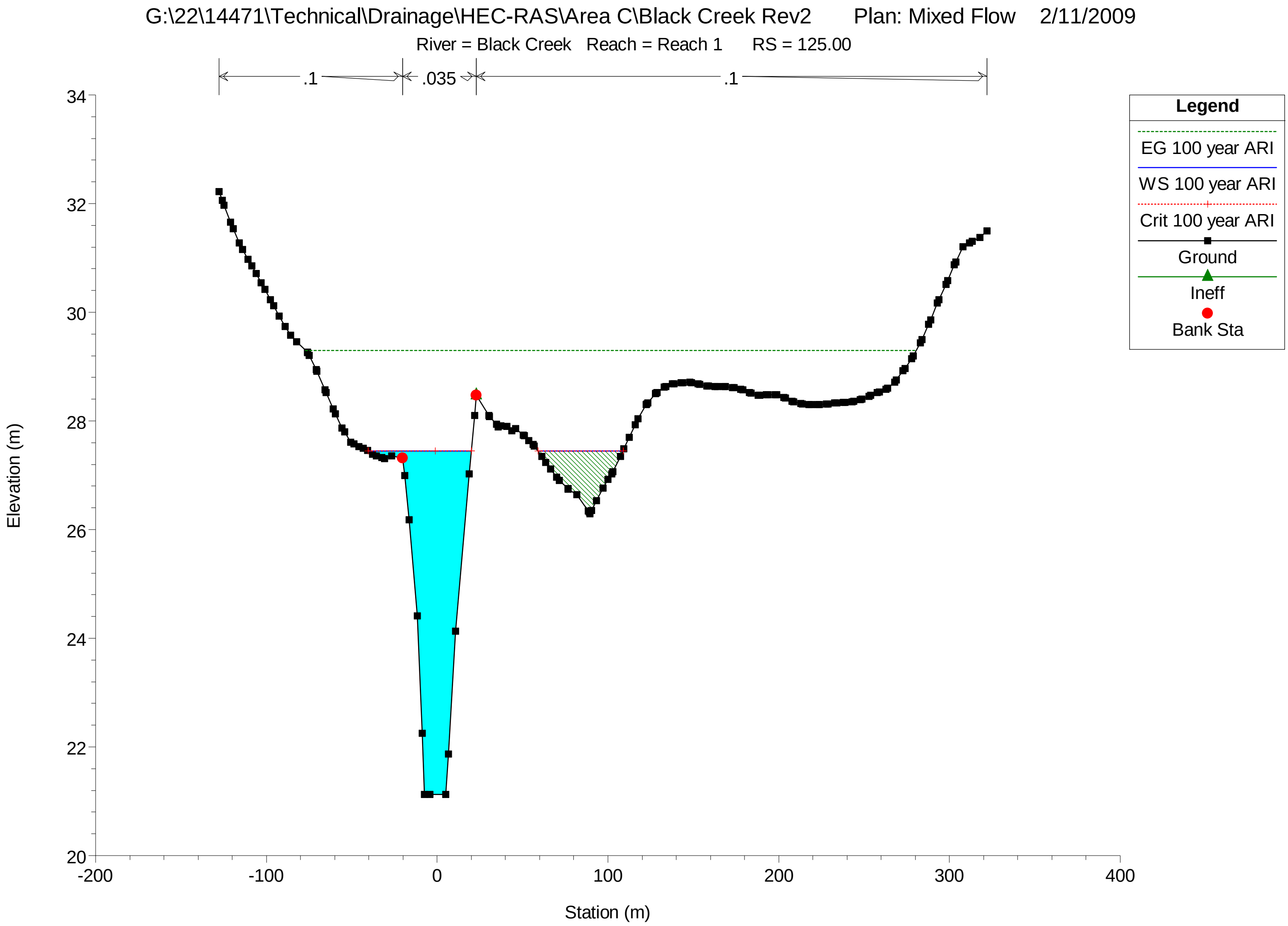
100
150
200
250
300
350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River = Black Creek Reach = Reach 1 RS = 125.00
.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Ineff
Bank Sta
Elevation (m)
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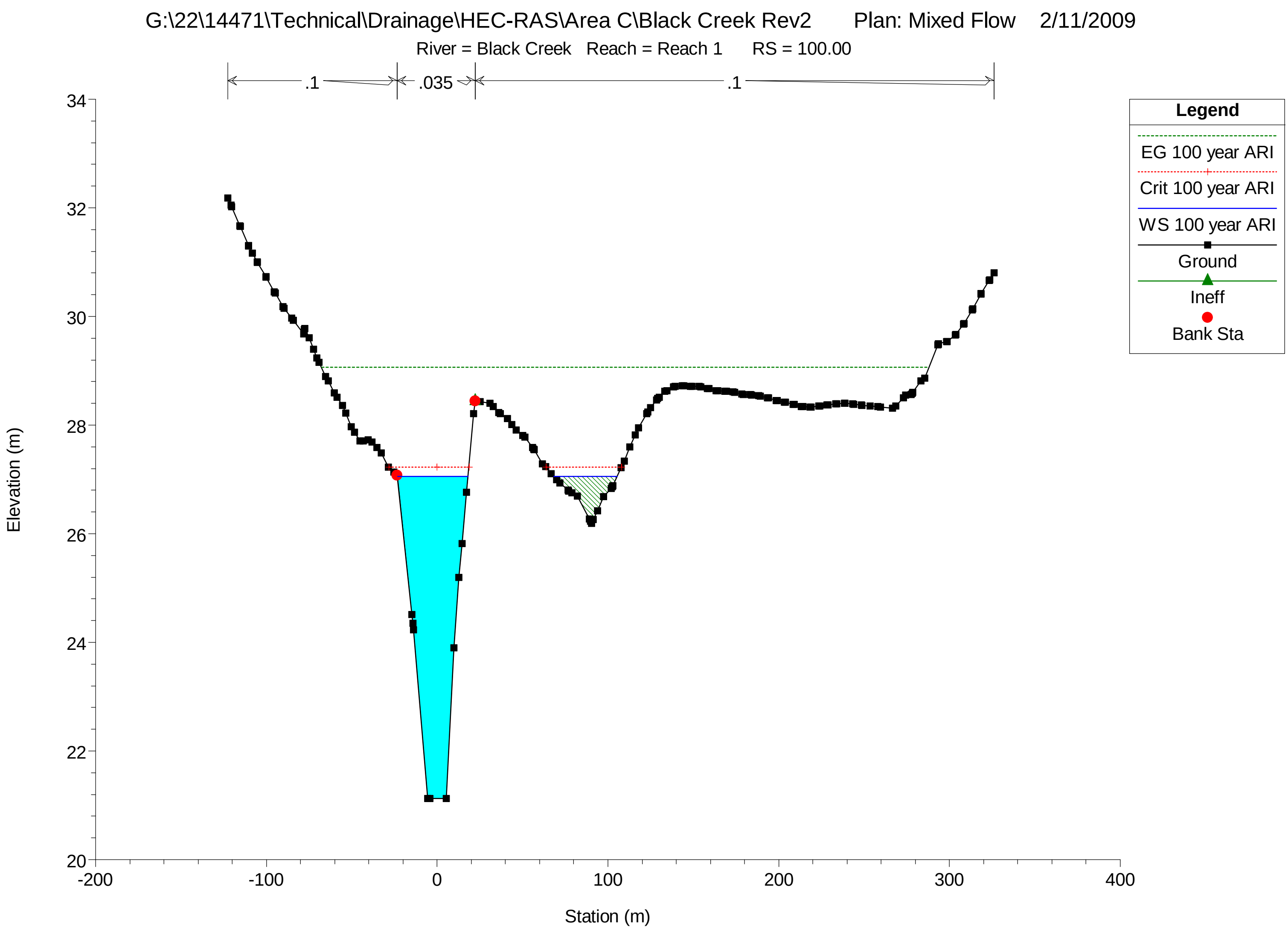
32
30
28
26
24
22
20
-200
-100
0
100
200
300
400
Station (m)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.1
.035
.1
Legend
EG 100 year ARI
Crit 100 year ARI
WS 100 year ARI
Ground
Ineff
Bank Sta
Elevation (m)
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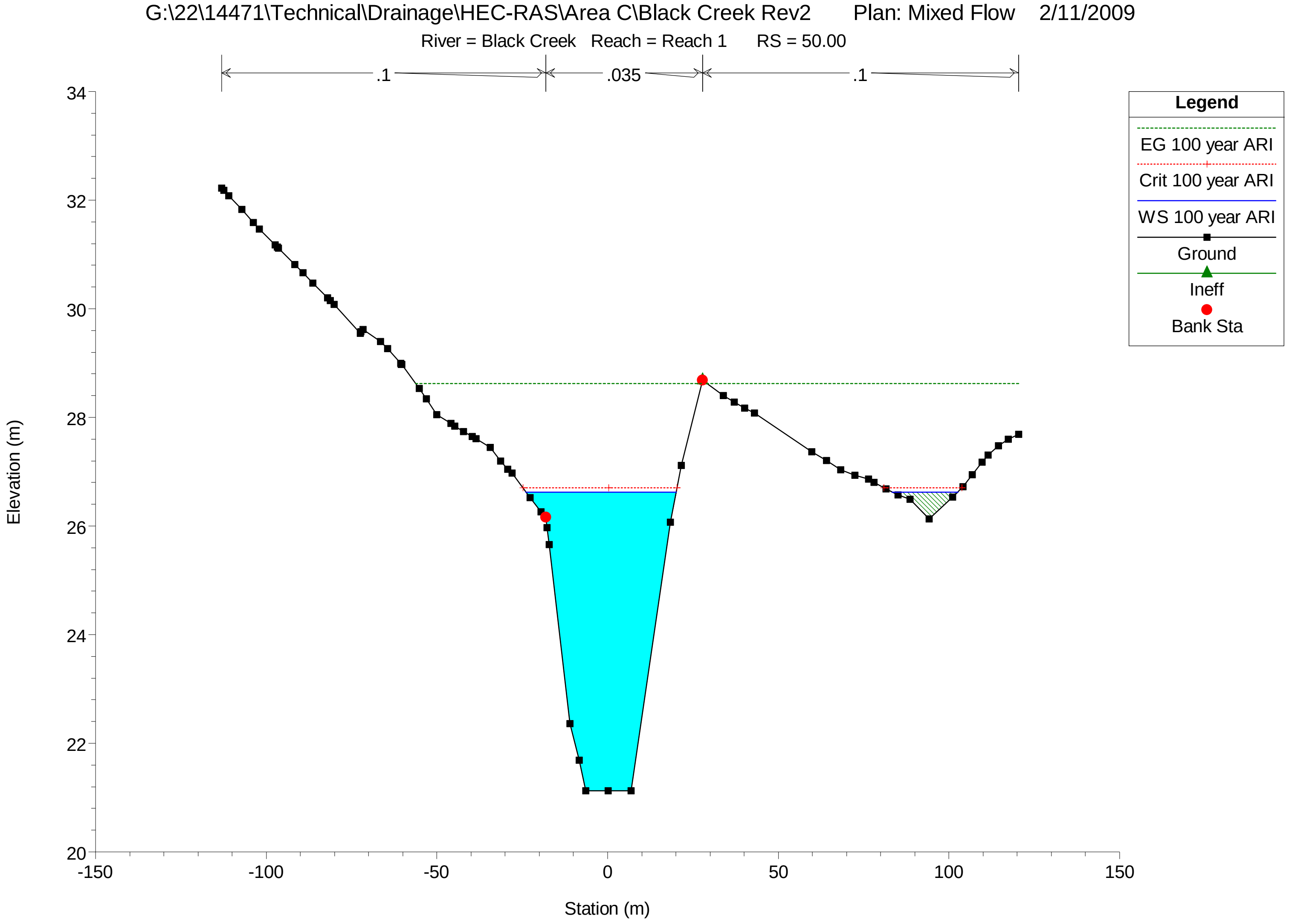
32
30
28
26
24
22
20
-200
-100
0
100
200
300
400
Station (m)



G:\22\14471\Technical\Drainage\HEC-RAS\Area C\Black Creek Rev2 Plan: Mixed Flow 2/11/2009
River = Black Creek Reach = Reach 1 RS = 50.00
.1
.035
.1
Legend
EG 100 year ARI
Crit 100 year ARI
WS 100 year ARI
Ground
Ineff
Bank Sta
Elevation (m)
34
32
30
28
26
24
22
20
-150
-100
-50
0
50
100
150
Station (m)

Appendix E

Jump Up Creek Hydrologic and Hydraulic Model

Catchment Plan

Summary of XP-RAFTS inputs

XP-RAFTS Results

HEC-RAS Results

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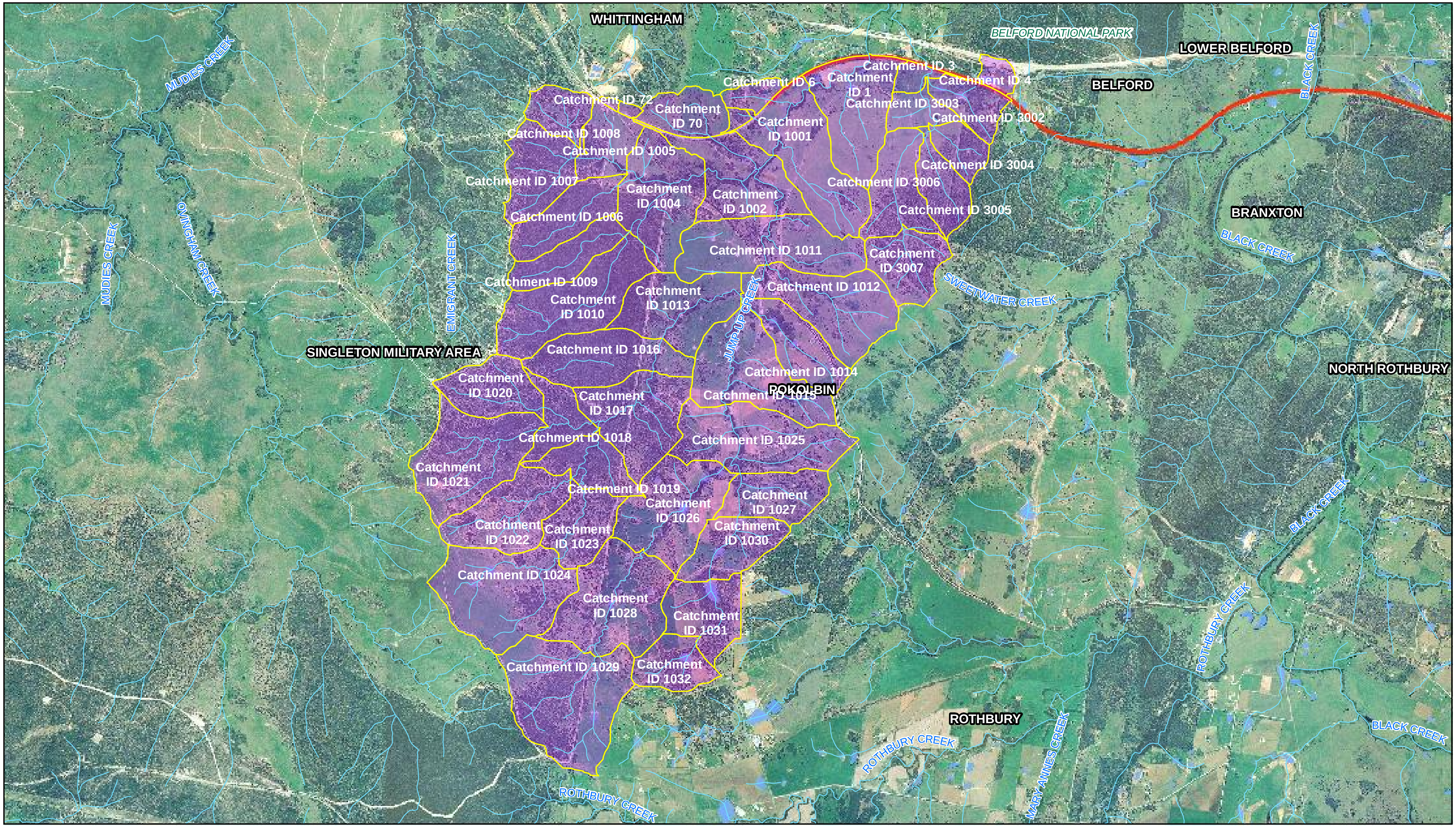

1:60,000 (at A4)

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Cadastre
- Subcatchment
- Watercourse
- Watercourse Area

Maitland To Minimbah Third Track
Surface Water Assessment

Job Number 22-14471
Revision A
Date MAY 2010

Jump-Up Creek Catchment Plan

Figure E1

G:\22\14471\GIS\Maps\Deliverables\EA\Surface Water Assessment\SWA_Jump_Catchment_Plan_20091015_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

Data Source: Geoscience Australia: Topography - 2003; Department Of Lands: Aerial & Cadastre - 2005; Fugro: Aerial - 2008. Created by: fmackay, msmiljkovski, gmcdiarmid

Jump Up Creek XP-RAFTS Model Inputs

Catchment	Area (ha)	Slope %	Percentage Impervious
1	107.5	4.5	10
6	77.6	7.8	10
1001	126.0	4.6	10
1002	100.5	4.3	10
1004	114.3	5.7	10
1005	47.3	3.8	10
1006	65.1	2.8	10
1007	72.8	3.3	10
1008	38	4.3	10
1009	52	3.3	10
1010	123.7	3.3	10
1011	125.5	5.5	10
1012	116	6.3	10
1013	97.9	4.8	10
1014	63.2	5.9	10
1015	124.5	6.4	10
1016	93.2	3.5	10
1017	104.3	3.1	10
1018	41.7	2.5	10
1019	51	2.0	10
1020	63.9	4.1	10
1021	128.7	4.0	10
1022	93.7	3.6	10
1023	60.6	2.9	10
1024	148.4	6.2	10
1025	128.1	6.6	10
1026	115.2	3.7	10
1027	62.2	5.6	10

Catchment	Area (ha)	Slope %	Percentage Impervious
1028	134.3	3.6	10
1029	169.5	4.6	10
1030	64	4.2	10
1031	67.6	2.2	10
1032	47.3	2.0	10

```
 Run started at:  2nd  November  2009  12:26:29


########################################################################################
                        RUNTIME          RESULTS
########################################################################################


Max. no. of links allowed =       1500


Max. no. of routng increments allowed =     250000


Max. no. of rating curve points =     250000


Max. no. of storm temporal points =     250000


Max. no. of channel subreaches =         25


Max link stack level =         25


Input Version number =          700


 LINK 1010              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    122.4
 ESTIMATED PEAK FLOW         (CUMECS) =                    15.
 ESTIMATED TIME TO PEAK         (MINS) =              132.00

 LINK 1007              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    72.03
 ESTIMATED PEAK FLOW         (CUMECS) =                    9.0
 ESTIMATED TIME TO PEAK         (MINS) =              125.00

 LINK 1008              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    37.61
 ESTIMATED PEAK FLOW         (CUMECS) =                    5.3
 ESTIMATED TIME TO PEAK         (MINS) =              121.00

 LINK 1005              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    156.4
 ESTIMATED PEAK FLOW         (CUMECS) =                    18.
 ESTIMATED TIME TO PEAK         (MINS) =              140.00

 LINK 1006              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    64.44
 ESTIMATED PEAK FLOW         (CUMECS) =                    7.9
 ESTIMATED TIME TO PEAK         (MINS) =              128.00

 LINK 1009              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    51.45
 ESTIMATED PEAK FLOW         (CUMECS) =                    6.6
```

```
ESTIMATED TIME TO PEAK         (MINS) =              122.00

LINK 1004              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  507.8
ESTIMATED PEAK FLOW        (CUMECS) =                   54.
ESTIMATED TIME TO PEAK         (MINS) =              185.00

LINK 1014              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  62.58
ESTIMATED PEAK FLOW        (CUMECS) =                   8.9
ESTIMATED TIME TO PEAK         (MINS) =              121.00

LINK 1032              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  46.85
ESTIMATED PEAK FLOW        (CUMECS) =                   5.5
ESTIMATED TIME TO PEAK         (MINS) =              134.00

LINK 1031              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  113.8
ESTIMATED PEAK FLOW        (CUMECS) =                   12.
ESTIMATED TIME TO PEAK         (MINS) =              160.00

LINK 1030              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  177.1
ESTIMATED PEAK FLOW        (CUMECS) =                   15.
ESTIMATED TIME TO PEAK         (MINS) =              199.00

LINK 1027              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  238.7
ESTIMATED PEAK FLOW        (CUMECS) =                   17.
ESTIMATED TIME TO PEAK         (MINS) =              227.00

LINK 1029              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  167.7
ESTIMATED PEAK FLOW        (CUMECS) =                   21.
ESTIMATED TIME TO PEAK         (MINS) =              126.00

LINK 1028              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  300.7
ESTIMATED PEAK FLOW        (CUMECS) =                   28.
ESTIMATED TIME TO PEAK         (MINS) =              198.00

LINK 1026              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  414.7
ESTIMATED PEAK FLOW        (CUMECS) =                   32.
ESTIMATED TIME TO PEAK         (MINS) =              285.00

LINK 5 Junction        1.000

ESTIMATED VOLUME (CU METRES*10**3) =                  653.4
ESTIMATED PEAK FLOW        (CUMECS) =                   43.
ESTIMATED TIME TO PEAK         (MINS) =              284.00

LINK 1025              1.000
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```
ESTIMATED VOLUME (CU METRES*10**3) =                      780.2
ESTIMATED PEAK FLOW         (CUMECS) =                      46.
ESTIMATED TIME TO PEAK         (MINS) =                  332.00

LINK 1015              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      903.4
ESTIMATED PEAK FLOW         (CUMECS) =                      47.
ESTIMATED TIME TO PEAK         (MINS) =                  402.00

LINK 1024              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      146.9
ESTIMATED PEAK FLOW         (CUMECS) =                      20.
ESTIMATED TIME TO PEAK         (MINS) =                  121.00

LINK 1023              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      206.8
ESTIMATED PEAK FLOW         (CUMECS) =                      24.
ESTIMATED TIME TO PEAK         (MINS) =                  180.00

LINK 1022              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      92.73
ESTIMATED PEAK FLOW         (CUMECS) =                      12.
ESTIMATED TIME TO PEAK         (MINS) =                  126.00

LINK 1019              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      350.0
ESTIMATED PEAK FLOW         (CUMECS) =                      33.
ESTIMATED TIME TO PEAK         (MINS) =                  213.00

LINK 1021              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      127.4
ESTIMATED PEAK FLOW         (CUMECS) =                      16.
ESTIMATED TIME TO PEAK         (MINS) =                  127.00

LINK 1020              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      63.21
ESTIMATED PEAK FLOW         (CUMECS) =                      8.4
ESTIMATED TIME TO PEAK         (MINS) =                  121.00

LINK 1018              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      231.9
ESTIMATED PEAK FLOW         (CUMECS) =                      28.
ESTIMATED TIME TO PEAK         (MINS) =                  155.00

LINK 4 Junction        1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      581.9
ESTIMATED PEAK FLOW         (CUMECS) =                      54.
ESTIMATED TIME TO PEAK         (MINS) =                  159.00

LINK 1017              1.000

ESTIMATED VOLUME (CU METRES*10**3) =                      685.2
ESTIMATED PEAK FLOW         (CUMECS) =                      59.
ESTIMATED TIME TO PEAK         (MINS) =                  211.00
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 LINK 1016              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   777.5
 ESTIMATED PEAK FLOW         (CUMECS) =                   63.
 ESTIMATED TIME TO PEAK         (MINS) =              233.00

 LINK 1013              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   874.4
 ESTIMATED PEAK FLOW         (CUMECS) =                   66.
 ESTIMATED TIME TO PEAK         (MINS) =              301.00

 LINK 3 Junction        1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   1840.
 ESTIMATED PEAK FLOW         (CUMECS) =                  0.11E+03
 ESTIMATED TIME TO PEAK         (MINS) =              327.00

 LINK 1012              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   1955.
 ESTIMATED PEAK FLOW         (CUMECS) =                  0.11E+03
 ESTIMATED TIME TO PEAK         (MINS) =              345.00

 LINK 1011              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   2081.
 ESTIMATED PEAK FLOW         (CUMECS) =                  0.11E+03
 ESTIMATED TIME TO PEAK         (MINS) =              376.00

 LINK 1002              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   2689.
 ESTIMATED PEAK FLOW         (CUMECS) =                  0.13E+03
 ESTIMATED TIME TO PEAK         (MINS) =              408.00

 LINK 6                 1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   76.81
 ESTIMATED PEAK FLOW         (CUMECS) =                   11.
 ESTIMATED TIME TO PEAK         (MINS) =              120.00

 LINK 1001              1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   2890.
 ESTIMATED PEAK FLOW         (CUMECS) =                  0.13E+03
 ESTIMATED TIME TO PEAK         (MINS) =              465.00

 LINK 1                 1.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   2997.
 ESTIMATED PEAK FLOW         (CUMECS) =                  0.13E+03
 ESTIMATED TIME TO PEAK         (MINS) =              501.00


#####################################################################################
Jump Creek - Existing

Results for period from  0: 0.0  1/ 1/1990
                     to  9:20.0  2/ 1/1990
#####################################################################################
```

ROUTING INCREMENT (MINS)	=	1.00
STORM DURATION (MINS)	=	360.
RETURN PERIOD (YRS)	=	100.
BX	=	1.0000
TOTAL OF FIRST SUB-AREAS (ha)	=	3027.45
TOTAL OF SECOND SUB-AREAS (ha)	=	0.00
TOTAL OF ALL SUB-AREAS (ha)	=	3027.45

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
1010	123.72	0.000	3.310	0.000	10.00	0.000	.050	0.00	.1931	0.000	1.000
1007	72.780	0.000	3.340	0.000	10.00	0.000	.050	0.00	.1459	0.000	2.000
1008	38.000	0.000	4.340	0.000	10.00	0.000	.050	0.00	.0913	0.000	3.000
1005	47.280	0.000	3.810	0.000	10.00	0.000	.050	0.00	.1092	0.000	2.001
1006	65.124	0.000	2.790	0.000	10.00	0.000	.050	0.00	.1506	0.000	4.000
1009	52.000	0.000	3.300	0.000	10.00	0.000	.050	0.00	.1232	0.000	5.000
1004	114.28	0.000	5.730	0.000	10.00	0.000	.050	0.00	.1409	0.000	1.001
1014	63.240	0.000	5.890	0.000	10.00	0.000	.050	0.00	.1022	0.000	6.000
1032	47.336	0.000	1.980	0.000	10.00	0.000	.050	0.00	.1514	0.000	7.000
1031	67.600	0.000	2.230	0.000	10.00	0.000	.050	0.00	.1717	0.000	7.001
1030	64.000	0.000	4.190	0.000	10.00	0.000	.050	0.00	.1218	0.000	7.002
1027	62.200	0.000	5.570	0.000	10.00	0.000	.050	0.00	.1042	0.000	7.003
1029	169.50	0.000	4.570	0.000	10.00	0.000	.050	0.00	.1936	0.000	8.000
1028	134.30	0.000	3.630	0.000	10.00	0.000	.050	0.00	.1924	0.000	8.001
1026	115.17	0.000	3.740	0.000	10.00	0.000	.050	0.00	.1750	0.000	8.002
5 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	7.004
1025	128.08	0.000	6.590	0.000	10.00	0.000	.050	0.00	.1394	0.000	7.005
1015	124.49	0.000	6.400	0.000	10.00	0.000	.050	0.00	.1394	0.000	7.006
1024	148.35	0.000	6.150	0.000	10.00	0.000	.050	0.00	.1558	0.000	9.000
1023	60.600	0.000	2.890	0.000	10.00	0.000	.050	0.00	.1426	0.000	9.001
1022	93.660	0.000	3.630	0.000	10.00	0.000	.050	0.00	.1596	0.000	10.00
1019	51.000	0.000	2.010	0.000	10.00	0.000	.050	0.00	.1562	0.000	9.002
1021	128.70	0.000	3.960	0.000	10.00	0.000	.050	0.00	.1802	0.000	11.00
1020	63.890	0.000	4.130	0.000	10.00	0.000	.050	0.00	.1226	0.000	12.00
1018	41.680	0.000	2.540	0.000	10.00	0.000	.050	0.00	.1252	0.000	11.00
4 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	9.003
1017	104.31	0.000	3.060	0.000	10.00	0.000	.050	0.00	.1838	0.000	9.004
1016	93.200	0.000	3.500	0.000	10.00	0.000	.050	0.00	.1621	0.000	9.005
1013	97.850	0.000	4.780	0.000	10.00	0.000	.050	0.00	.1423	0.000	9.006
3 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	6.001
1012	116.00	0.000	6.330	0.000	10.00	0.000	.050	0.00	.1351	0.000	6.002
1011	127.48	0.000	5.460	0.000	10.00	0.000	.050	0.00	.1528	0.000	6.003
1002	100.50	0.000	4.260	0.000	10.00	0.000	.050	0.00	.1528	0.000	1.002
6	77.600	0.000	7.830	0.000	10.00	0.000	.050	0.00	.0986	0.000	13.00
1001	126.03	0.000	4.630	0.000	10.00	0.000	.050	0.00	.1649	0.000	1.003
1	107.50	0.000	4.510	0.000	10.00	0.000	.050	0.00	.1538	0.000	1.004

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
1010	20.352	10.00	0.000	2.500	0.000	98.987	0.000	14.568	132.0	62.70
1007	20.352	10.00	0.000	2.500	0.000	98.987	0.000	9.030	125.0	0.000
1008	20.352	10.00	0.000	2.500	0.000	98.987	0.000	5.260	121.0	29.90
1005	20.352	10.00	0.000	2.500	0.000	98.987	0.000	18.493	140.0	51.40
1006	20.352	10.00	0.000	2.500	0.000	98.987	0.000	7.863	128.0	51.40
1009	20.352	10.00	0.000	2.500	0.000	98.987	0.000	6.641	122.0	62.70
1004	20.352	10.00	0.000	2.500	0.000	98.987	0.000	53.569	185.0	56.80
1014	20.352	10.00	0.000	2.500	0.000	98.987	0.000	8.850	121.0	6.000
1032	20.352	10.00	0.000	2.500	0.000	98.987	0.000	5.479	134.0	40.00

1031	20.352	10.00	0.000	2.500	0.000	98.987	0.000	11.690	160.0	47.70
1030	20.352	10.00	0.000	2.500	0.000	98.987	0.000	14.684	199.0	28.30
1027	20.352	10.00	0.000	2.500	0.000	98.987	0.000	17.257	227.0	0.000
1029	20.352	10.00	0.000	2.500	0.000	98.987	0.000	20.744	126.0	77.20
1028	20.352	10.00	0.000	2.500	0.000	98.987	0.000	27.891	198.0	87.30
1026	20.352	10.00	0.000	2.500	0.000	98.987	0.000	31.727	285.0	0.000
5 Junction	20.352	10.00	0.000	2.500	0.000	98.987	0.000	43.498	284.0	48.10
1025	20.352	10.00	0.000	2.500	0.000	98.987	0.000	46.264	332.0	69.90
1015	20.352	10.00	0.000	2.500	0.000	98.987	0.000	46.772	402.0	6.000
1024	20.352	10.00	0.000	2.500	0.000	98.987	0.000	19.682	121.0	58.70
1023	20.352	10.00	0.000	2.500	0.000	98.987	0.000	23.787	180.0	33.60
1022	20.352	10.00	0.000	2.500	0.000	98.987	0.000	11.517	126.0	33.60
1019	20.352	10.00	0.000	2.500	0.000	98.987	0.000	32.645	213.0	0.000
1021	20.352	10.00	0.000	2.500	0.000	98.987	0.000	15.663	127.0	33.70
1020	20.352	10.00	0.000	2.500	0.000	98.987	0.000	8.414	121.0	33.70
1018	20.352	10.00	0.000	2.500	0.000	98.987	0.000	28.089	155.0	0.000
4 Junction	20.352	10.00	0.000	2.500	0.000	98.987	0.000	53.794	159.0	52.40
1017	20.352	10.00	0.000	2.500	0.000	98.987	0.000	58.908	211.0	22.20
1016	20.352	10.00	0.000	2.500	0.000	98.987	0.000	62.885	233.0	68.10
1013	20.352	10.00	0.000	2.500	0.000	98.987	0.000	66.062	301.0	0.000
3 Junction	20.352	10.00	0.000	2.500	0.000	98.987	0.000	107.47	327.0	24.80
1012	20.352	10.00	0.000	2.500	0.000	98.987	0.000	109.13	345.0	33.80
1011	20.352	10.00	0.000	2.500	0.000	98.987	0.000	110.22	376.0	42.40
1002	20.352	10.00	0.000	2.500	0.000	98.987	0.000	125.35	408.0	58.00
6	20.352	10.00	0.000	2.500	0.000	98.987	0.000	11.107	120.0	33.61
1001	20.352	10.00	0.000	2.500	0.000	98.987	0.000	125.67	465.0	36.20
1	20.352	10.00	0.000	2.500	0.000	98.987	0.000	125.74	501.0	0.000

LINK 1010 2.000

ESTIMATED VOLUME (CU METRES*10**3) = 142.4
ESTIMATED PEAK FLOW (CUMECS) = 13.
ESTIMATED TIME TO PEAK (MINS) = 321.00

LINK 1007 2.000

ESTIMATED VOLUME (CU METRES*10**3) = 83.80
ESTIMATED PEAK FLOW (CUMECS) = 8.1
ESTIMATED TIME TO PEAK (MINS) = 314.00

LINK 1008 2.000

ESTIMATED VOLUME (CU METRES*10**3) = 43.76
ESTIMATED PEAK FLOW (CUMECS) = 4.6
ESTIMATED TIME TO PEAK (MINS) = 301.00

LINK 1005 2.000

ESTIMATED VOLUME (CU METRES*10**3) = 182.0
ESTIMATED PEAK FLOW (CUMECS) = 17.
ESTIMATED TIME TO PEAK (MINS) = 330.00

LINK 1006 2.000

ESTIMATED VOLUME (CU METRES*10**3) = 74.99
ESTIMATED PEAK FLOW (CUMECS) = 7.1
ESTIMATED TIME TO PEAK (MINS) = 317.00

LINK 1009 2.000

ESTIMATED VOLUME (CU METRES*10**3) = 59.89
ESTIMATED PEAK FLOW (CUMECS) = 5.9
ESTIMATED TIME TO PEAK (MINS) = 310.00

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LINK 1004              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  590.9
ESTIMATED PEAK FLOW         (CUMECS) =                  49.
ESTIMATED TIME TO PEAK         (MINS) =             373.00

LINK 1014              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  72.83
ESTIMATED PEAK FLOW         (CUMECS) =                  7.8
ESTIMATED TIME TO PEAK         (MINS) =             301.00

LINK 1032              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  54.51
ESTIMATED PEAK FLOW         (CUMECS) =                  5.1
ESTIMATED TIME TO PEAK         (MINS) =             324.00

LINK 1031              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  132.3
ESTIMATED PEAK FLOW         (CUMECS) =                  11.
ESTIMATED TIME TO PEAK         (MINS) =             340.00

LINK 1030              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  206.0
ESTIMATED PEAK FLOW         (CUMECS) =                  14.
ESTIMATED TIME TO PEAK         (MINS) =             379.00

LINK 1027              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  277.6
ESTIMATED PEAK FLOW         (CUMECS) =                  18.
ESTIMATED TIME TO PEAK         (MINS) =             330.00

LINK 1029              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  195.1
ESTIMATED PEAK FLOW         (CUMECS) =                  19.
ESTIMATED TIME TO PEAK         (MINS) =             315.00

LINK 1028              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  349.7
ESTIMATED PEAK FLOW         (CUMECS) =                  25.
ESTIMATED TIME TO PEAK         (MINS) =             385.00

LINK 1026              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  482.3
ESTIMATED PEAK FLOW         (CUMECS) =                  27.
ESTIMATED TIME TO PEAK         (MINS) =             470.00

LINK 5 Junction        2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  760.0
ESTIMATED PEAK FLOW         (CUMECS) =                  41.
ESTIMATED TIME TO PEAK         (MINS) =             331.00

LINK 1025              2.000

ESTIMATED VOLUME (CU METRES*10**3) =                  907.4
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ESTIMATED PEAK FLOW        (CUMECS) =                  47.
ESTIMATED TIME TO PEAK        (MINS) =             378.00

LINK 1015             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 1051.
ESTIMATED PEAK FLOW        (CUMECS) =                  49.
ESTIMATED TIME TO PEAK        (MINS) =             448.00

LINK 1024             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 170.8
ESTIMATED PEAK FLOW        (CUMECS) =                  17.
ESTIMATED TIME TO PEAK        (MINS) =             307.00

LINK 1023             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 240.6
ESTIMATED PEAK FLOW        (CUMECS) =                  21.
ESTIMATED TIME TO PEAK        (MINS) =             361.00

LINK 1022             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 107.9
ESTIMATED PEAK FLOW        (CUMECS) =                  10.
ESTIMATED TIME TO PEAK        (MINS) =             314.00

LINK 1019             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 407.2
ESTIMATED PEAK FLOW        (CUMECS) =                  30.
ESTIMATED TIME TO PEAK        (MINS) =             393.00

LINK 1021             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 148.2
ESTIMATED PEAK FLOW        (CUMECS) =                  14.
ESTIMATED TIME TO PEAK        (MINS) =             316.00

LINK 1020             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 73.56
ESTIMATED PEAK FLOW        (CUMECS) =                  7.4
ESTIMATED TIME TO PEAK        (MINS) =             307.00

LINK 1018             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 269.8
ESTIMATED PEAK FLOW        (CUMECS) =                  25.
ESTIMATED TIME TO PEAK        (MINS) =             341.00

LINK 4 Junction       2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 677.0
ESTIMATED PEAK FLOW        (CUMECS) =                  52.
ESTIMATED TIME TO PEAK        (MINS) =             345.00

LINK 1017             2.000

ESTIMATED VOLUME (CU METRES*10**3) =                 797.1
ESTIMATED PEAK FLOW        (CUMECS) =                  56.
ESTIMATED TIME TO PEAK        (MINS) =             393.00

LINK 1016             2.000
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 ESTIMATED VOLUME (CU METRES*10**3) =                   904.5
 ESTIMATED PEAK FLOW        (CUMECS) =                    59.
 ESTIMATED TIME TO PEAK        (MINS) =               413.00

 LINK 1013             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   1017.
 ESTIMATED PEAK FLOW        (CUMECS) =                    61.
 ESTIMATED TIME TO PEAK        (MINS) =               480.00

 LINK 3 Junction       2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   2141.
 ESTIMATED PEAK FLOW        (CUMECS) =                   0.11E+03
 ESTIMATED TIME TO PEAK        (MINS) =               477.00

 LINK 1012             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   2274.
 ESTIMATED PEAK FLOW        (CUMECS) =                   0.11E+03
 ESTIMATED TIME TO PEAK        (MINS) =               501.00

 LINK 1011             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   2421.
 ESTIMATED PEAK FLOW        (CUMECS) =                   0.11E+03
 ESTIMATED TIME TO PEAK        (MINS) =               535.00

 LINK 1002             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   3128.
 ESTIMATED PEAK FLOW        (CUMECS) =                   0.14E+03
 ESTIMATED TIME TO PEAK        (MINS) =               420.00

 LINK 6                2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   89.36
 ESTIMATED PEAK FLOW        (CUMECS) =                    9.8
 ESTIMATED TIME TO PEAK        (MINS) =               301.00

 LINK 1001             2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   3362.
 ESTIMATED PEAK FLOW        (CUMECS) =                   0.14E+03
 ESTIMATED TIME TO PEAK        (MINS) =               478.00

 LINK 1                2.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   3486.
 ESTIMATED PEAK FLOW        (CUMECS) =                   0.14E+03
 ESTIMATED TIME TO PEAK        (MINS) =               514.00


#####################################################################################
Jump Creek - Existing

Results for period from  0: 0.0  1/ 1/1990
                     to  9:20.0  2/ 1/1990
#####################################################################################
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ROUTING INCREMENT (MINS)	=	1.00
STORM DURATION (MINS)	=	540.
RETURN PERIOD (YRS)	=	100.
BX	=	1.0000
TOTAL OF FIRST SUB-AREAS (ha)	=	3027.45
TOTAL OF SECOND SUB-AREAS (ha)	=	0.00
TOTAL OF ALL SUB-AREAS (ha)	=	3027.45

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
1010	123.72	0.000	3.310	0.000	10.00	0.000	.050	0.00	.1931	0.000	1.000
1007	72.780	0.000	3.340	0.000	10.00	0.000	.050	0.00	.1459	0.000	2.000
1008	38.000	0.000	4.340	0.000	10.00	0.000	.050	0.00	.0913	0.000	3.000
1005	47.280	0.000	3.810	0.000	10.00	0.000	.050	0.00	.1092	0.000	2.001
1006	65.124	0.000	2.790	0.000	10.00	0.000	.050	0.00	.1506	0.000	4.000
1009	52.000	0.000	3.300	0.000	10.00	0.000	.050	0.00	.1232	0.000	5.000
1004	114.28	0.000	5.730	0.000	10.00	0.000	.050	0.00	.1409	0.000	1.001
1014	63.240	0.000	5.890	0.000	10.00	0.000	.050	0.00	.1022	0.000	6.000
1032	47.336	0.000	1.980	0.000	10.00	0.000	.050	0.00	.1514	0.000	7.000
1031	67.600	0.000	2.230	0.000	10.00	0.000	.050	0.00	.1717	0.000	7.001
1030	64.000	0.000	4.190	0.000	10.00	0.000	.050	0.00	.1218	0.000	7.002
1027	62.200	0.000	5.570	0.000	10.00	0.000	.050	0.00	.1042	0.000	7.003
1029	169.50	0.000	4.570	0.000	10.00	0.000	.050	0.00	.1936	0.000	8.000
1028	134.30	0.000	3.630	0.000	10.00	0.000	.050	0.00	.1924	0.000	8.001
1026	115.17	0.000	3.740	0.000	10.00	0.000	.050	0.00	.1750	0.000	8.002
5 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	7.004
1025	128.08	0.000	6.590	0.000	10.00	0.000	.050	0.00	.1394	0.000	7.005
1015	124.49	0.000	6.400	0.000	10.00	0.000	.050	0.00	.1394	0.000	7.006
1024	148.35	0.000	6.150	0.000	10.00	0.000	.050	0.00	.1558	0.000	9.000
1023	60.600	0.000	2.890	0.000	10.00	0.000	.050	0.00	.1426	0.000	9.001
1022	93.660	0.000	3.630	0.000	10.00	0.000	.050	0.00	.1596	0.000	10.00
1019	51.000	0.000	2.010	0.000	10.00	0.000	.050	0.00	.1562	0.000	9.002
1021	128.70	0.000	3.960	0.000	10.00	0.000	.050	0.00	.1802	0.000	11.00
1020	63.890	0.000	4.130	0.000	10.00	0.000	.050	0.00	.1226	0.000	12.00
1018	41.680	0.000	2.540	0.000	10.00	0.000	.050	0.00	.1252	0.000	11.00
4 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	9.003
1017	104.31	0.000	3.060	0.000	10.00	0.000	.050	0.00	.1838	0.000	9.004
1016	93.200	0.000	3.500	0.000	10.00	0.000	.050	0.00	.1621	0.000	9.005
1013	97.850	0.000	4.780	0.000	10.00	0.000	.050	0.00	.1423	0.000	9.006
3 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	6.001
1012	116.00	0.000	6.330	0.000	10.00	0.000	.050	0.00	.1351	0.000	6.002
1011	127.48	0.000	5.460	0.000	10.00	0.000	.050	0.00	.1528	0.000	6.003
1002	100.50	0.000	4.260	0.000	10.00	0.000	.050	0.00	.1528	0.000	1.002
6	77.600	0.000	7.830	0.000	10.00	0.000	.050	0.00	.0986	0.000	13.00
1001	126.03	0.000	4.630	0.000	10.00	0.000	.050	0.00	.1649	0.000	1.003
1	107.50	0.000	4.510	0.000	10.00	0.000	.050	0.00	.1538	0.000	1.004

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
1010	16.170	10.00	0.000	2.500	0.000	115.15	0.000	13.375	321.0	62.70
1007	16.170	10.00	0.000	2.500	0.000	115.15	0.000	8.114	314.0	0.000
1008	16.170	10.00	0.000	2.500	0.000	115.15	0.000	4.610	301.0	29.90
1005	16.170	10.00	0.000	2.500	0.000	115.15	0.000	17.372	330.0	51.40
1006	16.170	10.00	0.000	2.500	0.000	115.15	0.000	7.136	317.0	51.40
1009	16.170	10.00	0.000	2.500	0.000	115.15	0.000	5.902	310.0	62.70
1004	16.170	10.00	0.000	2.500	0.000	115.15	0.000	48.900	373.0	56.80
1014	16.170	10.00	0.000	2.500	0.000	115.15	0.000	7.796	301.0	6.000
1032	16.170	10.00	0.000	2.500	0.000	115.15	0.000	5.072	324.0	40.00
1031	16.170	10.00	0.000	2.500	0.000	115.15	0.000	10.852	340.0	47.70

1030	16.170	10.00	0.000	2.500	0.000	115.15	0.000	13.865	379.0	28.30
1027	16.170	10.00	0.000	2.500	0.000	115.15	0.000	17.990	330.0	0.000
1029	16.170	10.00	0.000	2.500	0.000	115.15	0.000	18.744	315.0	77.20
1028	16.170	10.00	0.000	2.500	0.000	115.15	0.000	25.027	385.0	87.30
1026	16.170	10.00	0.000	2.500	0.000	115.15	0.000	26.928	470.0	0.000
5 Junction	16.170	10.00	0.000	2.500	0.000	115.15	0.000	41.353	331.0	48.10
1025	16.170	10.00	0.000	2.500	0.000	115.15	0.000	47.169	378.0	69.90
1015	16.170	10.00	0.000	2.500	0.000	115.15	0.000	49.467	448.0	6.000
1024	16.170	10.00	0.000	2.500	0.000	115.15	0.000	17.231	307.0	58.70
1023	16.170	10.00	0.000	2.500	0.000	115.15	0.000	21.086	361.0	33.60
1022	16.170	10.00	0.000	2.500	0.000	115.15	0.000	10.396	314.0	33.60
1019	16.170	10.00	0.000	2.500	0.000	115.15	0.000	29.585	393.0	0.000
1021	16.170	10.00	0.000	2.500	0.000	115.15	0.000	14.188	316.0	33.70
1020	16.170	10.00	0.000	2.500	0.000	115.15	0.000	7.399	307.0	33.70
1018	16.170	10.00	0.000	2.500	0.000	115.15	0.000	25.054	341.0	0.000
4 Junction	16.170	10.00	0.000	2.500	0.000	115.15	0.000	51.560	345.0	52.40
1017	16.170	10.00	0.000	2.500	0.000	115.15	0.000	56.057	393.0	22.20
1016	16.170	10.00	0.000	2.500	0.000	115.15	0.000	59.154	413.0	68.10
1013	16.170	10.00	0.000	2.500	0.000	115.15	0.000	60.583	480.0	0.000
3 Junction	16.170	10.00	0.000	2.500	0.000	115.15	0.000	105.82	477.0	24.80
1012	16.170	10.00	0.000	2.500	0.000	115.15	0.000	106.99	501.0	33.80
1011	16.170	10.00	0.000	2.500	0.000	115.15	0.000	107.81	535.0	42.40
1002	16.170	10.00	0.000	2.500	0.000	115.15	0.000	139.73	420.0	58.00
6	16.170	10.00	0.000	2.500	0.000	115.15	0.000	9.826	301.0	33.61
1001	16.170	10.00	0.000	2.500	0.000	115.15	0.000	142.99	478.0	36.20
1	16.170	10.00	0.000	2.500	0.000	115.15	0.000	143.96	514.0	0.000

LINK 1010 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 159.0
ESTIMATED PEAK FLOW (CUMECS) = 14.
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK 1007 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 93.52
ESTIMATED PEAK FLOW (CUMECS) = 8.6
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK 1008 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 48.83
ESTIMATED PEAK FLOW (CUMECS) = 4.9
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK 1005 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 203.1
ESTIMATED PEAK FLOW (CUMECS) = 17.
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK 1006 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 83.66
ESTIMATED PEAK FLOW (CUMECS) = 7.5
ESTIMATED TIME TO PEAK (MINS) = 420.00

LINK 1009 3.000

ESTIMATED VOLUME (CU METRES*10**3) = 66.81
ESTIMATED PEAK FLOW (CUMECS) = 6.3
ESTIMATED TIME TO PEAK (MINS) = 420.00

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LINK 1004              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       659.4
ESTIMATED PEAK FLOW         (CUMECS) =                       45.
ESTIMATED TIME TO PEAK         (MINS) =                   474.00

LINK 1014              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       81.26
ESTIMATED PEAK FLOW         (CUMECS) =                       8.2
ESTIMATED TIME TO PEAK         (MINS) =                   420.00

LINK 1032              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       60.82
ESTIMATED PEAK FLOW         (CUMECS) =                       5.2
ESTIMATED TIME TO PEAK         (MINS) =                   420.00

LINK 1031              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       147.7
ESTIMATED PEAK FLOW         (CUMECS) =                       10.
ESTIMATED TIME TO PEAK         (MINS) =                   422.00

LINK 1030              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       229.9
ESTIMATED PEAK FLOW         (CUMECS) =                       12.
ESTIMATED TIME TO PEAK         (MINS) =                   422.00

LINK 1027              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       309.8
ESTIMATED PEAK FLOW         (CUMECS) =                       16.
ESTIMATED TIME TO PEAK         (MINS) =                   422.00

LINK 1029              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       217.8
ESTIMATED PEAK FLOW         (CUMECS) =                       20.
ESTIMATED TIME TO PEAK         (MINS) =                   420.00

LINK 1028              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       390.3
ESTIMATED PEAK FLOW         (CUMECS) =                       23.
ESTIMATED TIME TO PEAK         (MINS) =                   498.00

LINK 1026              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       538.2
ESTIMATED PEAK FLOW         (CUMECS) =                       29.
ESTIMATED TIME TO PEAK         (MINS) =                   586.00

LINK 5 Junction        3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       848.1
ESTIMATED PEAK FLOW         (CUMECS) =                       40.
ESTIMATED TIME TO PEAK         (MINS) =                   586.00

LINK 1025              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                       1013.
ESTIMATED PEAK FLOW         (CUMECS) =                       46.
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ESTIMATED TIME TO PEAK          (MINS) =               588.00

LINK 1015              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    1173.
ESTIMATED PEAK FLOW          (CUMECS) =                   50.
ESTIMATED TIME TO PEAK          (MINS) =               540.00

LINK 1024              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    190.6
ESTIMATED PEAK FLOW          (CUMECS) =                   18.
ESTIMATED TIME TO PEAK          (MINS) =               420.00

LINK 1023              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    268.4
ESTIMATED PEAK FLOW          (CUMECS) =                   20.
ESTIMATED TIME TO PEAK          (MINS) =               478.00

LINK 1022              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    120.4
ESTIMATED PEAK FLOW          (CUMECS) =                   11.
ESTIMATED TIME TO PEAK          (MINS) =               420.00

LINK 1019              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    454.3
ESTIMATED PEAK FLOW          (CUMECS) =                   28.
ESTIMATED TIME TO PEAK          (MINS) =               456.00

LINK 1021              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    165.3
ESTIMATED PEAK FLOW          (CUMECS) =                   15.
ESTIMATED TIME TO PEAK          (MINS) =               420.00

LINK 1020              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    82.08
ESTIMATED PEAK FLOW          (CUMECS) =                   7.9
ESTIMATED TIME TO PEAK          (MINS) =               420.00

LINK 1018              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    300.9
ESTIMATED PEAK FLOW          (CUMECS) =                   25.
ESTIMATED TIME TO PEAK          (MINS) =               454.00

LINK 4 Junction        3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    755.2
ESTIMATED PEAK FLOW          (CUMECS) =                   53.
ESTIMATED TIME TO PEAK          (MINS) =               454.00

LINK 1017              3.000

ESTIMATED VOLUME (CU METRES*10**3) =                    889.3
ESTIMATED PEAK FLOW          (CUMECS) =                   56.
ESTIMATED TIME TO PEAK          (MINS) =               506.00

LINK 1016              3.000
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 ESTIMATED VOLUME (CU METRES*10**3) =                    1009.
 ESTIMATED PEAK FLOW         (CUMECS) =                    60.
 ESTIMATED TIME TO PEAK         (MINS) =                530.00

 LINK 1013              3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    1135.
 ESTIMATED PEAK FLOW         (CUMECS) =                    65.
 ESTIMATED TIME TO PEAK         (MINS) =                596.00

 LINK 3 Junction        3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    2389.
 ESTIMATED PEAK FLOW         (CUMECS) =                   0.11E+03
 ESTIMATED TIME TO PEAK         (MINS) =                598.00

 LINK 1012              3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    2538.
 ESTIMATED PEAK FLOW         (CUMECS) =                   0.11E+03
 ESTIMATED TIME TO PEAK         (MINS) =                622.00

 LINK 1011              3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    2701.
 ESTIMATED PEAK FLOW         (CUMECS) =                   0.11E+03
 ESTIMATED TIME TO PEAK         (MINS) =                656.00

 LINK 1002              3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    3490.
 ESTIMATED PEAK FLOW         (CUMECS) =                   0.14E+03
 ESTIMATED TIME TO PEAK         (MINS) =                650.00

 LINK 6                 3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                   99.71
 ESTIMATED PEAK FLOW         (CUMECS) =                    10.
 ESTIMATED TIME TO PEAK         (MINS) =                420.00

 LINK 1001              3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    3752.
 ESTIMATED PEAK FLOW         (CUMECS) =                   0.14E+03
 ESTIMATED TIME TO PEAK         (MINS) =                706.00

 LINK 1                 3.000

 ESTIMATED VOLUME (CU METRES*10**3) =                    3890.
 ESTIMATED PEAK FLOW         (CUMECS) =                   0.14E+03
 ESTIMATED TIME TO PEAK         (MINS) =                622.00


#####################################################################################
Jump Creek - Existing

Results for period from  0: 0.0  1/ 1/1990
                     to 18:40.0  3/ 1/1990
#####################################################################################

                               ROUTING INCREMENT (MINS) =      2.00
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STORM DURATION (MINS) = 720.
RETURN PERIOD (YRS) = 100.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (ha) = 3027.45
TOTAL OF SECOND SUB-AREAS (ha) = 0.00
TOTAL OF ALL SUB-AREAS (ha) = 3027.45

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
1010	123.72	0.000	3.310	0.000	10.00	0.000	.050	0.00	.1931	0.000	1.000
1007	72.780	0.000	3.340	0.000	10.00	0.000	.050	0.00	.1459	0.000	2.000
1008	38.000	0.000	4.340	0.000	10.00	0.000	.050	0.00	.0913	0.000	3.000
1005	47.280	0.000	3.810	0.000	10.00	0.000	.050	0.00	.1092	0.000	2.001
1006	65.124	0.000	2.790	0.000	10.00	0.000	.050	0.00	.1506	0.000	4.000
1009	52.000	0.000	3.300	0.000	10.00	0.000	.050	0.00	.1232	0.000	5.000
1004	114.28	0.000	5.730	0.000	10.00	0.000	.050	0.00	.1409	0.000	1.001
1014	63.240	0.000	5.890	0.000	10.00	0.000	.050	0.00	.1022	0.000	6.000
1032	47.336	0.000	1.980	0.000	10.00	0.000	.050	0.00	.1514	0.000	7.000
1031	67.600	0.000	2.230	0.000	10.00	0.000	.050	0.00	.1717	0.000	7.001
1030	64.000	0.000	4.190	0.000	10.00	0.000	.050	0.00	.1218	0.000	7.002
1027	62.200	0.000	5.570	0.000	10.00	0.000	.050	0.00	.1042	0.000	7.003
1029	169.50	0.000	4.570	0.000	10.00	0.000	.050	0.00	.1936	0.000	8.000
1028	134.30	0.000	3.630	0.000	10.00	0.000	.050	0.00	.1924	0.000	8.001
1026	115.17	0.000	3.740	0.000	10.00	0.000	.050	0.00	.1750	0.000	8.002
5 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	7.004
1025	128.08	0.000	6.590	0.000	10.00	0.000	.050	0.00	.1394	0.000	7.005
1015	124.49	0.000	6.400	0.000	10.00	0.000	.050	0.00	.1394	0.000	7.006
1024	148.35	0.000	6.150	0.000	10.00	0.000	.050	0.00	.1558	0.000	9.000
1023	60.600	0.000	2.890	0.000	10.00	0.000	.050	0.00	.1426	0.000	9.001
1022	93.660	0.000	3.630	0.000	10.00	0.000	.050	0.00	.1596	0.000	10.00
1019	51.000	0.000	2.010	0.000	10.00	0.000	.050	0.00	.1562	0.000	9.002
1021	128.70	0.000	3.960	0.000	10.00	0.000	.050	0.00	.1802	0.000	11.00
1020	63.890	0.000	4.130	0.000	10.00	0.000	.050	0.00	.1226	0.000	12.00
1018	41.680	0.000	2.540	0.000	10.00	0.000	.050	0.00	.1252	0.000	11.00
4 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	9.003
1017	104.31	0.000	3.060	0.000	10.00	0.000	.050	0.00	.1838	0.000	9.004
1016	93.200	0.000	3.500	0.000	10.00	0.000	.050	0.00	.1621	0.000	9.005
1013	97.850	0.000	4.780	0.000	10.00	0.000	.050	0.00	.1423	0.000	9.006
3 Junction	.00001	0.000	.0010	0.000	0.000	0.000	.050	0.00	.0034	0.000	6.001
1012	116.00	0.000	6.330	0.000	10.00	0.000	.050	0.00	.1351	0.000	6.002
1011	127.48	0.000	5.460	0.000	10.00	0.000	.050	0.00	.1528	0.000	6.003
1002	100.50	0.000	4.260	0.000	10.00	0.000	.050	0.00	.1528	0.000	1.002
6	77.600	0.000	7.830	0.000	10.00	0.000	.050	0.00	.0986	0.000	13.00
1001	126.03	0.000	4.630	0.000	10.00	0.000	.050	0.00	.1649	0.000	1.003
1	107.50	0.000	4.510	0.000	10.00	0.000	.050	0.00	.1538	0.000	1.004

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
1010	13.739	10.00	0.000	2.500	0.000	128.52	0.000	13.890	420.0	62.70
1007	13.739	10.00	0.000	2.500	0.000	128.52	0.000	8.562	420.0	0.000
1008	13.739	10.00	0.000	2.500	0.000	128.52	0.000	4.868	420.0	29.90
1005	13.739	10.00	0.000	2.500	0.000	128.52	0.000	17.137	420.0	51.40
1006	13.739	10.00	0.000	2.500	0.000	128.52	0.000	7.498	420.0	51.40
1009	13.739	10.00	0.000	2.500	0.000	128.52	0.000	6.254	420.0	62.70
1004	13.739	10.00	0.000	2.500	0.000	128.52	0.000	45.279	474.0	56.80
1014	13.739	10.00	0.000	2.500	0.000	128.52	0.000	8.153	420.0	6.000
1032	13.739	10.00	0.000	2.500	0.000	128.52	0.000	5.224	420.0	40.00
1031	13.739	10.00	0.000	2.500	0.000	128.52	0.000	10.070	422.0	47.70
1030	13.739	10.00	0.000	2.500	0.000	128.52	0.000	12.262	422.0	28.30

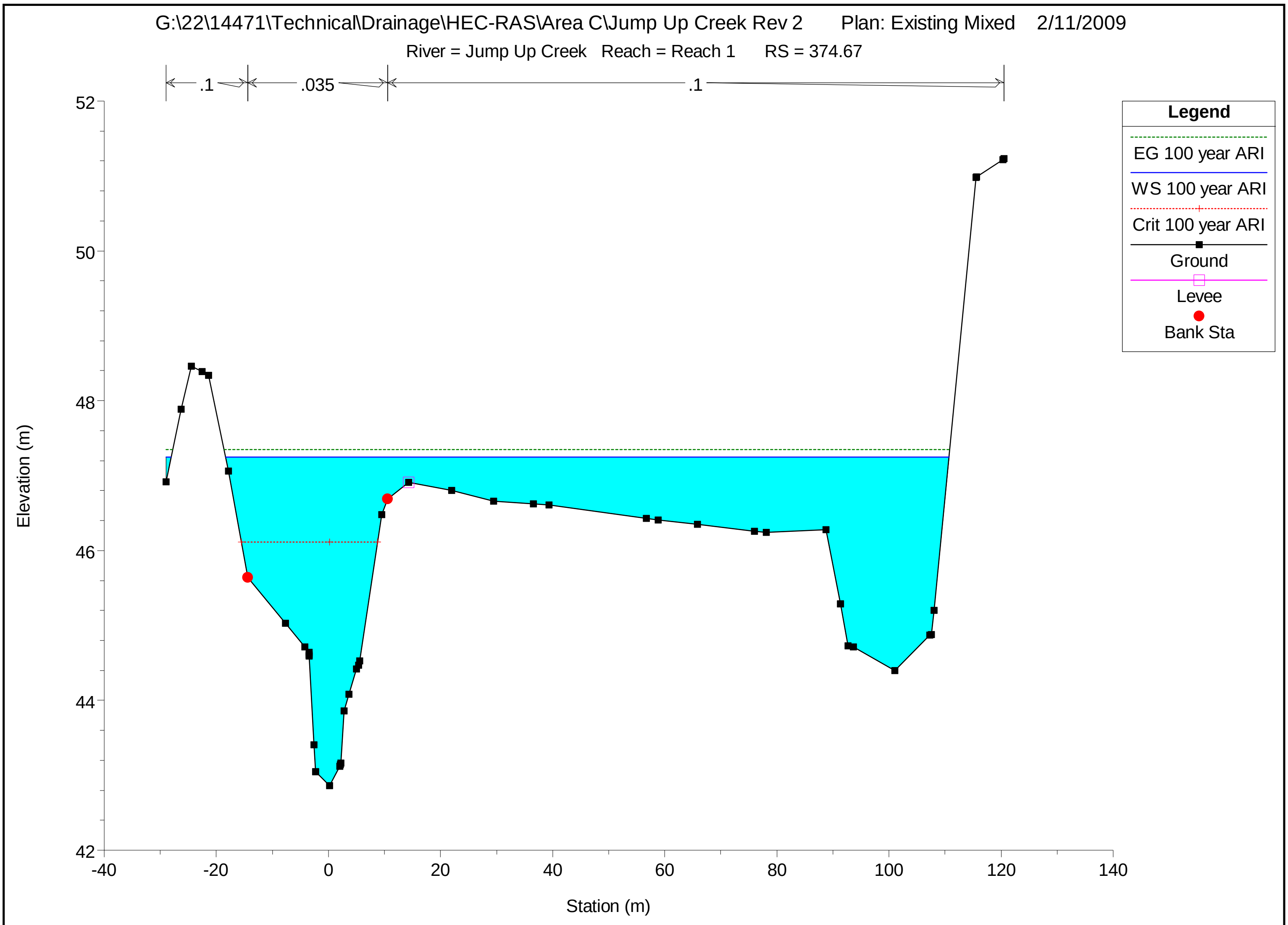
1027	13.739	10.00	0.000	2.500	0.000	128.52	0.000	15.966	422.0	0.000
1029	13.739	10.00	0.000	2.500	0.000	128.52	0.000	19.795	420.0	77.20
1028	13.739	10.00	0.000	2.500	0.000	128.52	0.000	23.075	498.0	87.30
1026	13.739	10.00	0.000	2.500	0.000	128.52	0.000	29.117	586.0	0.000
5 Junction	13.739	10.00	0.000	2.500	0.000	128.52	0.000	40.049	586.0	48.10
1025	13.739	10.00	0.000	2.500	0.000	128.52	0.000	46.021	588.0	69.90
1015	13.739	10.00	0.000	2.500	0.000	128.52	0.000	49.718	540.0	6.000
1024	13.739	10.00	0.000	2.500	0.000	128.52	0.000	18.307	420.0	58.70
1023	13.739	10.00	0.000	2.500	0.000	128.52	0.000	19.802	478.0	33.60
1022	13.739	10.00	0.000	2.500	0.000	128.52	0.000	10.938	420.0	33.60
1019	13.739	10.00	0.000	2.500	0.000	128.52	0.000	28.053	456.0	0.000
1021	13.739	10.00	0.000	2.500	0.000	128.52	0.000	14.891	420.0	33.70
1020	13.739	10.00	0.000	2.500	0.000	128.52	0.000	7.873	420.0	33.70
1018	13.739	10.00	0.000	2.500	0.000	128.52	0.000	25.150	454.0	0.000
4 Junction	13.739	10.00	0.000	2.500	0.000	128.52	0.000	53.127	454.0	52.40
1017	13.739	10.00	0.000	2.500	0.000	128.52	0.000	55.755	506.0	22.20
1016	13.739	10.00	0.000	2.500	0.000	128.52	0.000	60.228	530.0	68.10
1013	13.739	10.00	0.000	2.500	0.000	128.52	0.000	64.597	596.0	0.000
3 Junction	13.739	10.00	0.000	2.500	0.000	128.52	0.000	106.22	598.0	24.80
1012	13.739	10.00	0.000	2.500	0.000	128.52	0.000	109.21	622.0	33.80
1011	13.739	10.00	0.000	2.500	0.000	128.52	0.000	111.43	656.0	42.40
1002	13.739	10.00	0.000	2.500	0.000	128.52	0.000	140.49	650.0	58.00
6	13.739	10.00	0.000	2.500	0.000	128.52	0.000	10.201	420.0	33.61
1001	13.739	10.00	0.000	2.500	0.000	128.52	0.000	142.21	706.0	36.20
1	13.739	10.00	0.000	2.500	0.000	128.52	0.000	142.62	622.0	0.000

Run completed at: 2nd November 2009 12:27:10

mik open 0

HEC-RAS Plan: Exist Mix River: Jump Up Creek Reach: Reach 1 Profile: 100 year ARI

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach 1	374.67	100 year ARI	143.96	42.86	47.24	46.11	47.35	0.001055	1.66	174.52	129.95	0.33
Reach 1	324.79	100 year ARI	143.96	42.82	47.23	45.82	47.30	0.000667	1.32	198.10	141.62	0.27
Reach 1	275.00	100 year ARI	143.96	41.98	47.18	45.71	47.26	0.000781	1.51	181.83	109.07	0.29
Reach 1	230.16	100 year ARI	143.96	41.74	47.16	45.56	47.23	0.000552	1.41	212.95	104.67	0.25
Reach 1	221.38	100 year ARI	143.96	43.60	46.78		47.18	0.005172	2.85	55.37	38.27	0.70
Reach 1	211.04	100 year ARI	143.96	42.98	46.74	45.77	47.14	0.002787	2.82	54.08	27.42	0.54
Reach 1	206		Bridge									
Reach 1	198.84	100 year ARI	143.96	42.04	46.10		46.63	0.004358	3.23	44.61	18.00	0.65
Reach 1	175.08	100 year ARI	143.96	42.62	46.45	44.69	46.47	0.000163	0.61	441.81	280.47	0.13
Reach 1	150.00	100 year ARI	143.96	40.99	46.21	45.17	46.43	0.002170	2.24	110.47	115.83	0.46
Reach 1	100.00	100 year ARI	143.96	41.82	46.06	45.33	46.31	0.002674	2.36	94.79	104.81	0.51
Reach 1	50.00	100 year ARI	143.96	41.22	45.96	44.97	46.18	0.002195	2.11	100.65	152.88	0.47
Reach 1	0.00	100 year ARI	143.96	41.63	45.23	45.15	45.93	0.010016	3.69	39.01	25.18	0.95



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River = Jump Up Creek Reach = Reach 1 RS = 374.67
.1
.035
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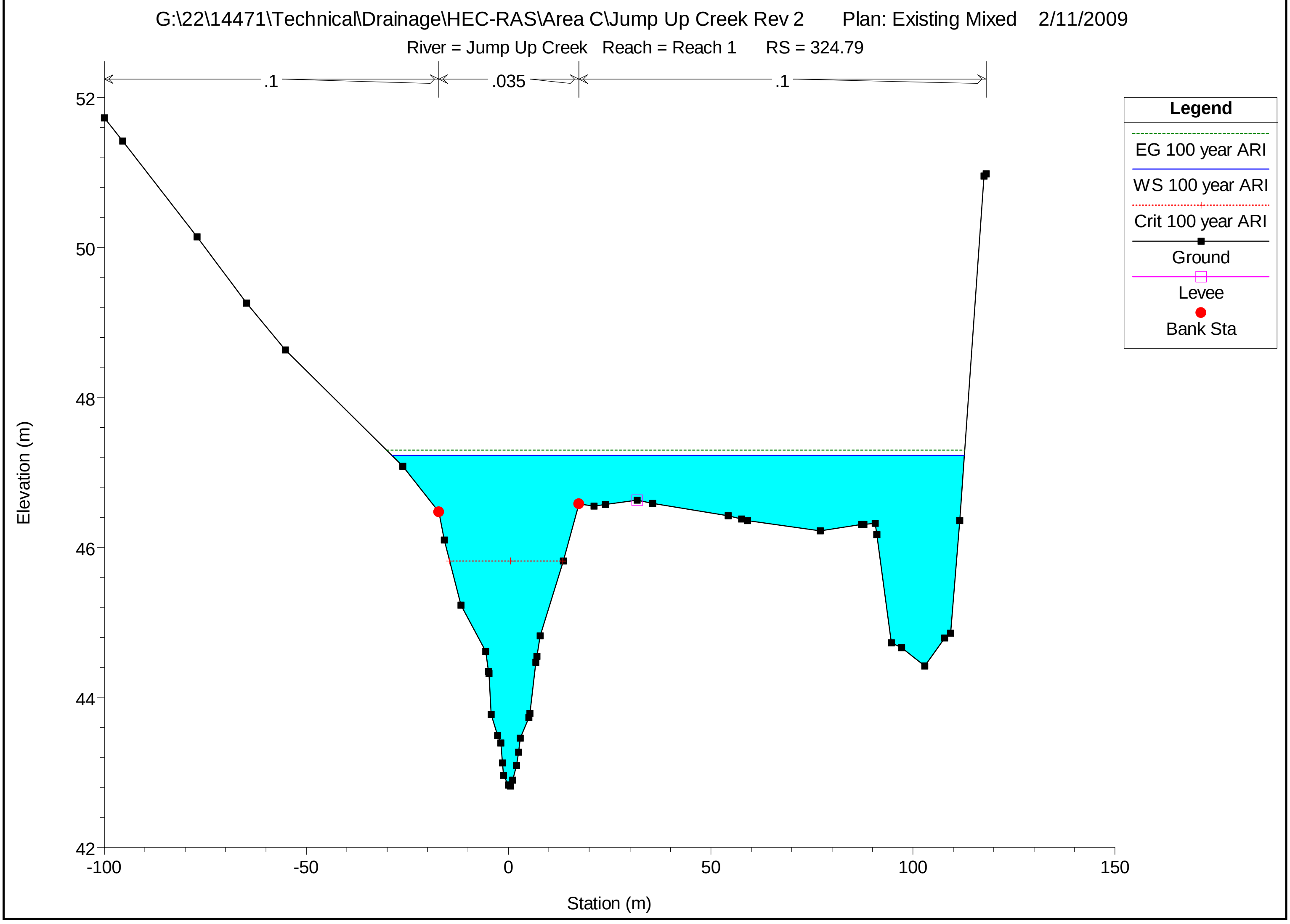
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)



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Legend
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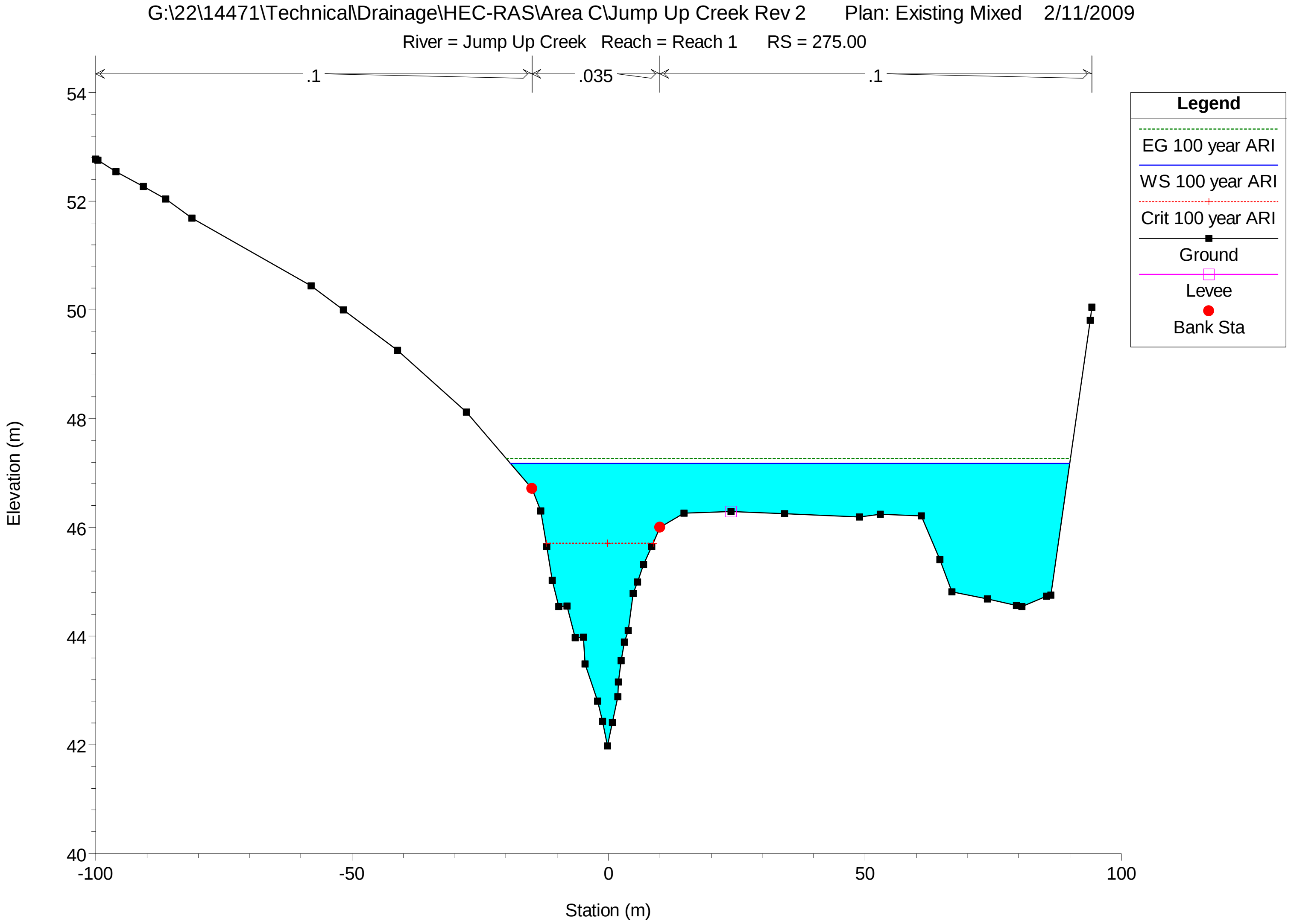
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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.035
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Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Bank Sta
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Station (m)
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52
50
48
46
44
42
40
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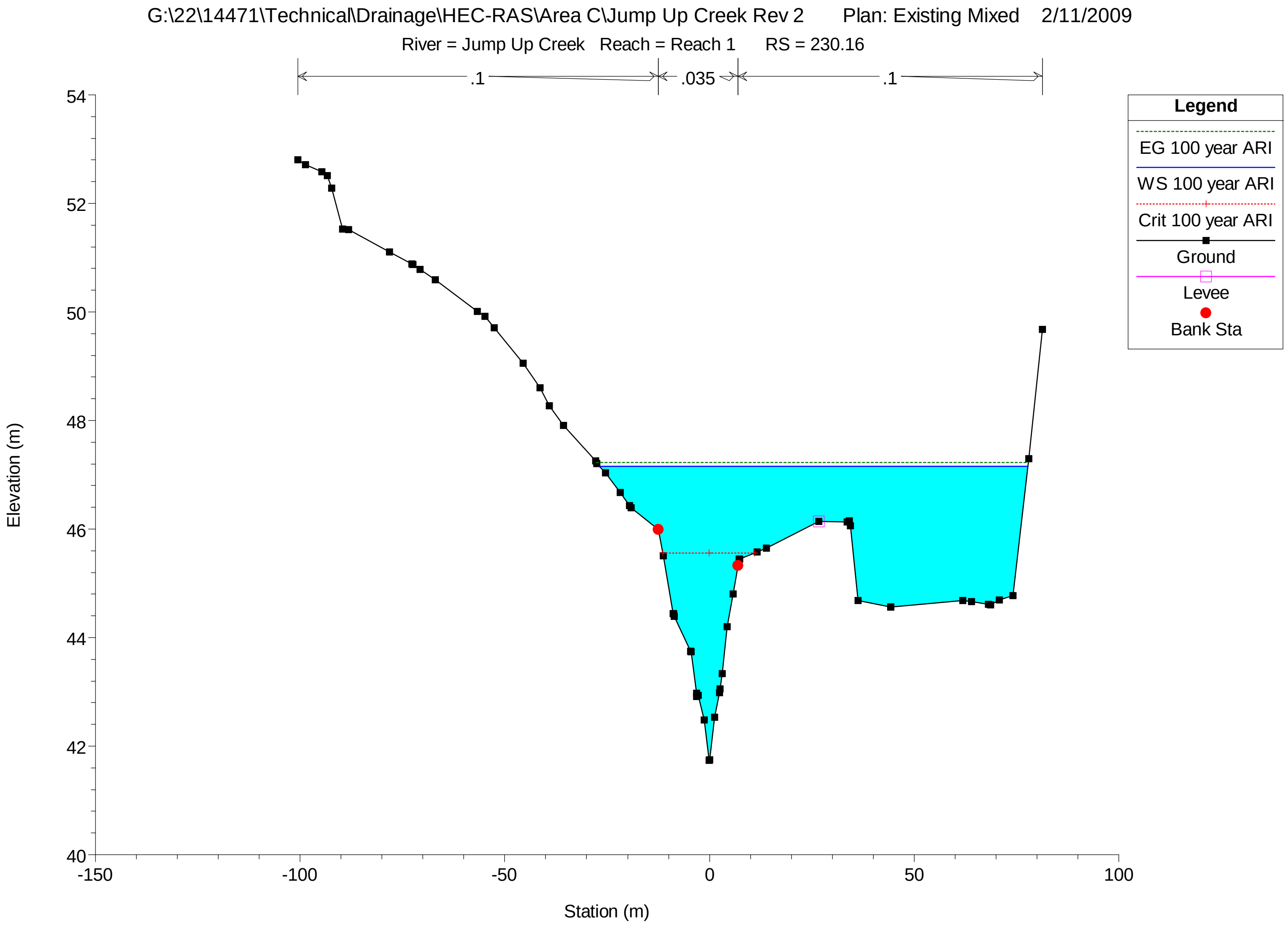
-50
0
50
100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.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
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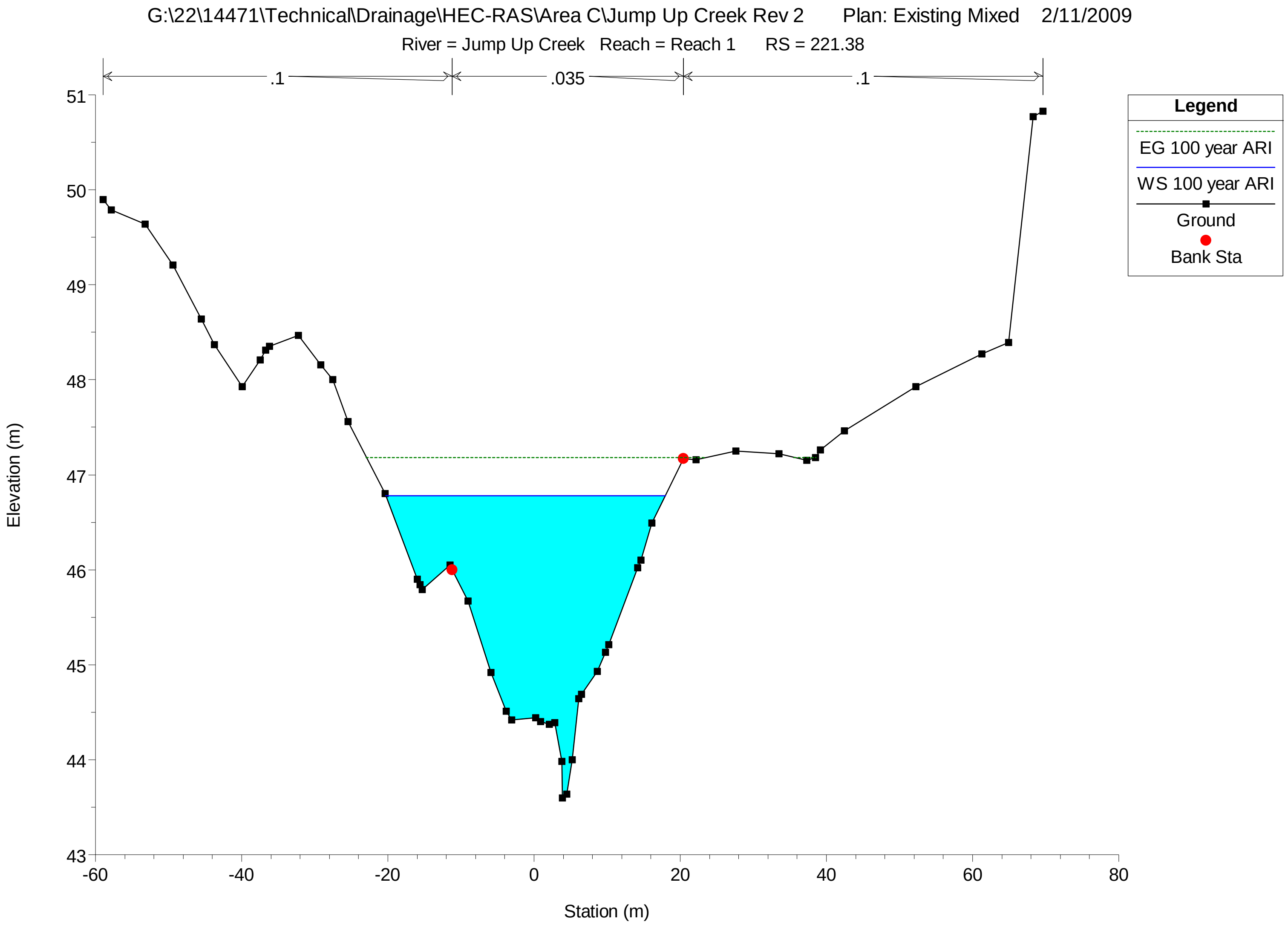
48
46
44
42
40
-150
-100
-50
0
50
100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.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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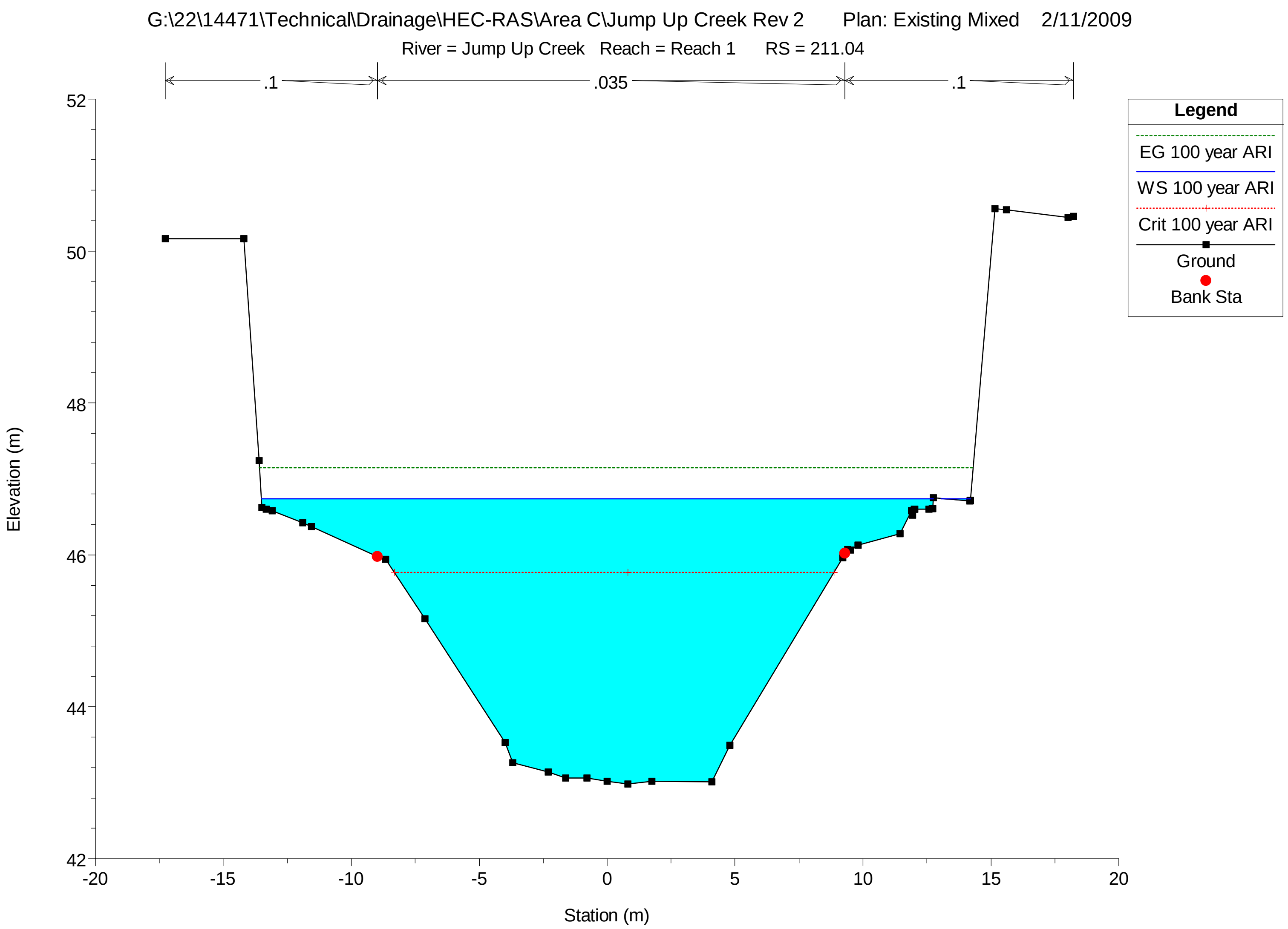
50
49
48
47
46
45
44
43
-60
-40
-20
0
20
40
60
80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.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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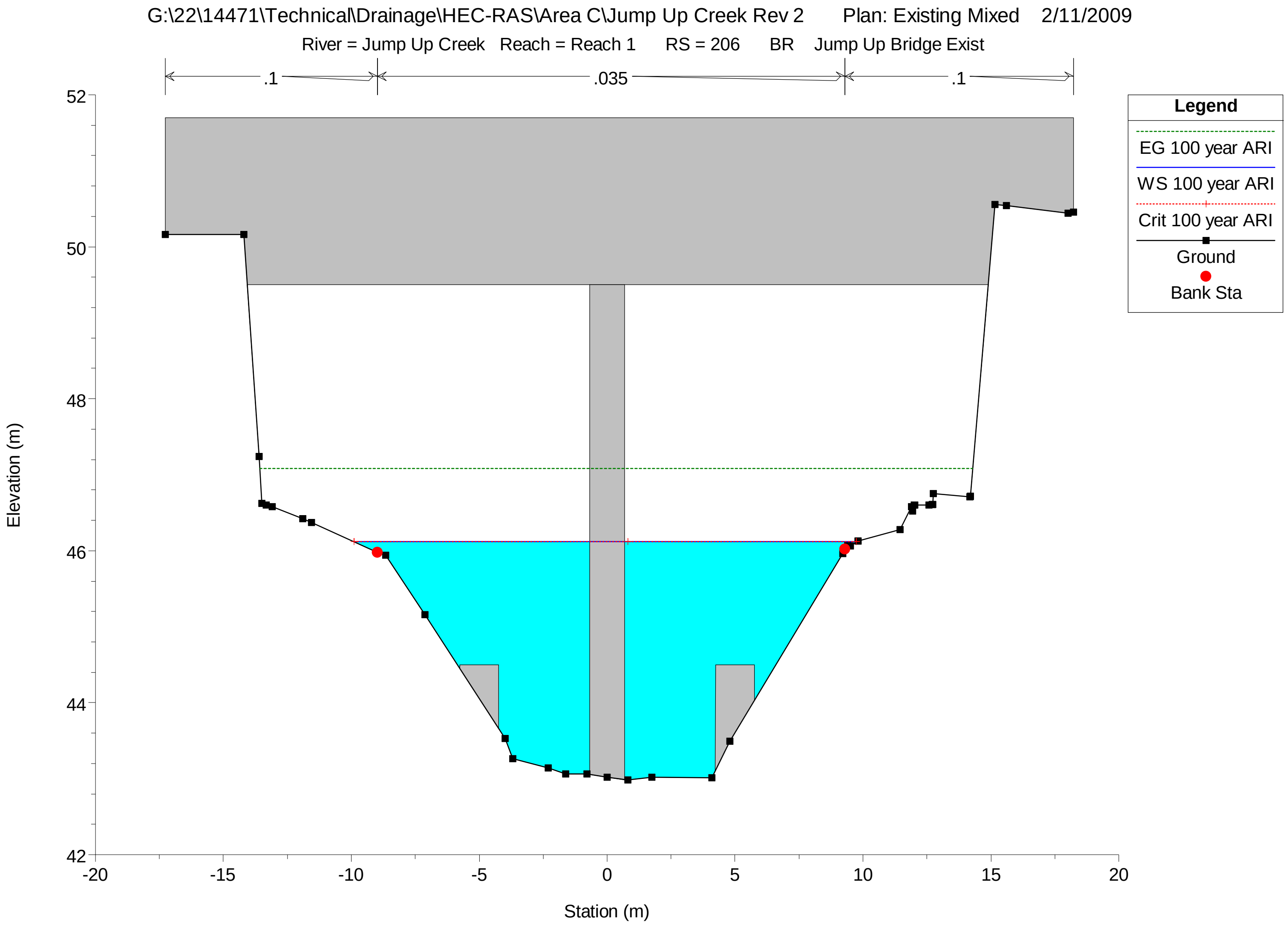
48
46
44
42
-20
-15
-10
-5
0
5
10
15
20



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.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Bank Sta
Elevation (m)
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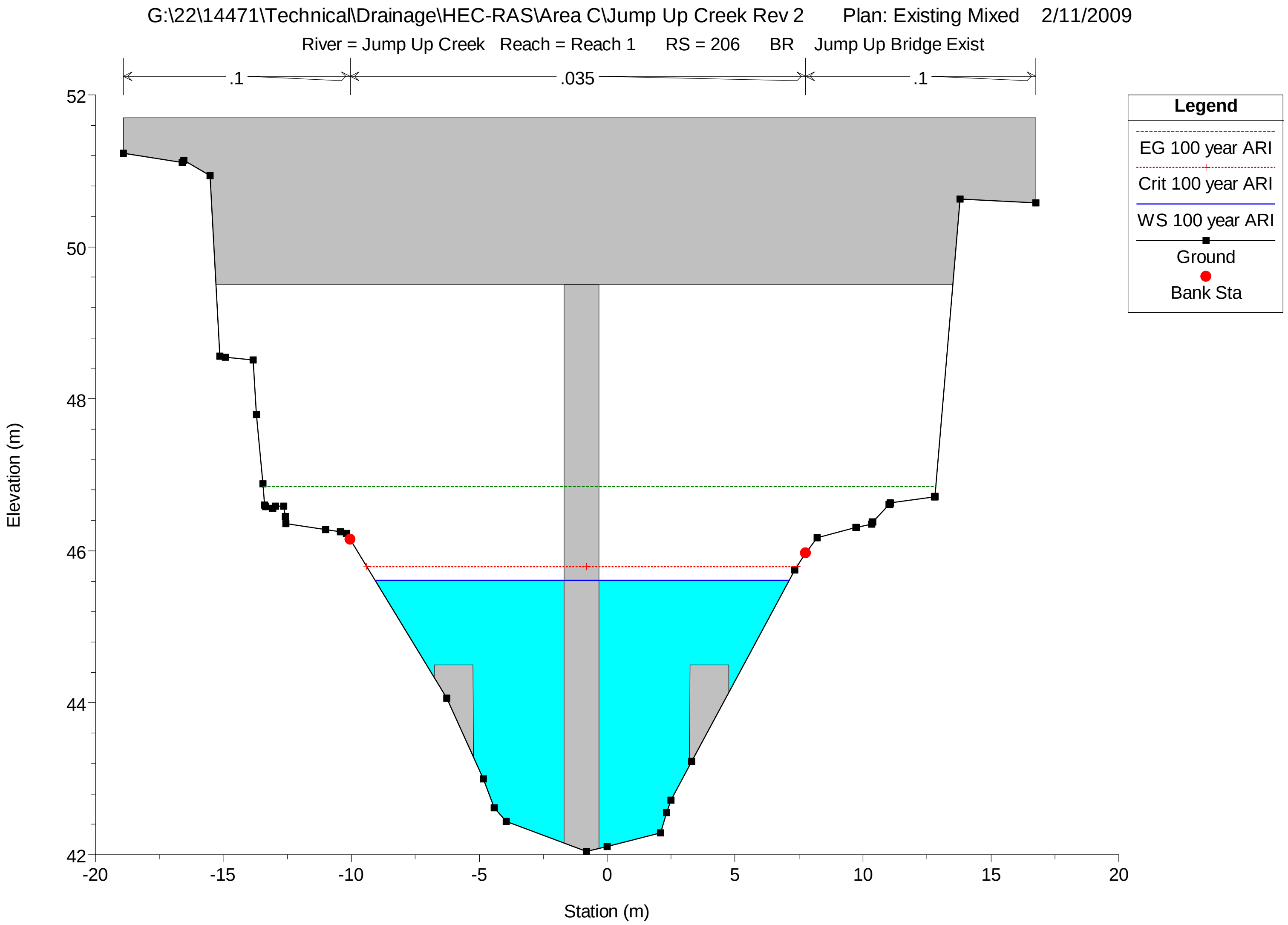
50
48
46
44
42
-20
-15
-10
-5
0
5
10
15
20
Station (m)



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.035
.1
Legend
EG 100 year ARI
Crit 100 year ARI
WS 100 year ARI
Ground
Bank Sta
Elevation (m)
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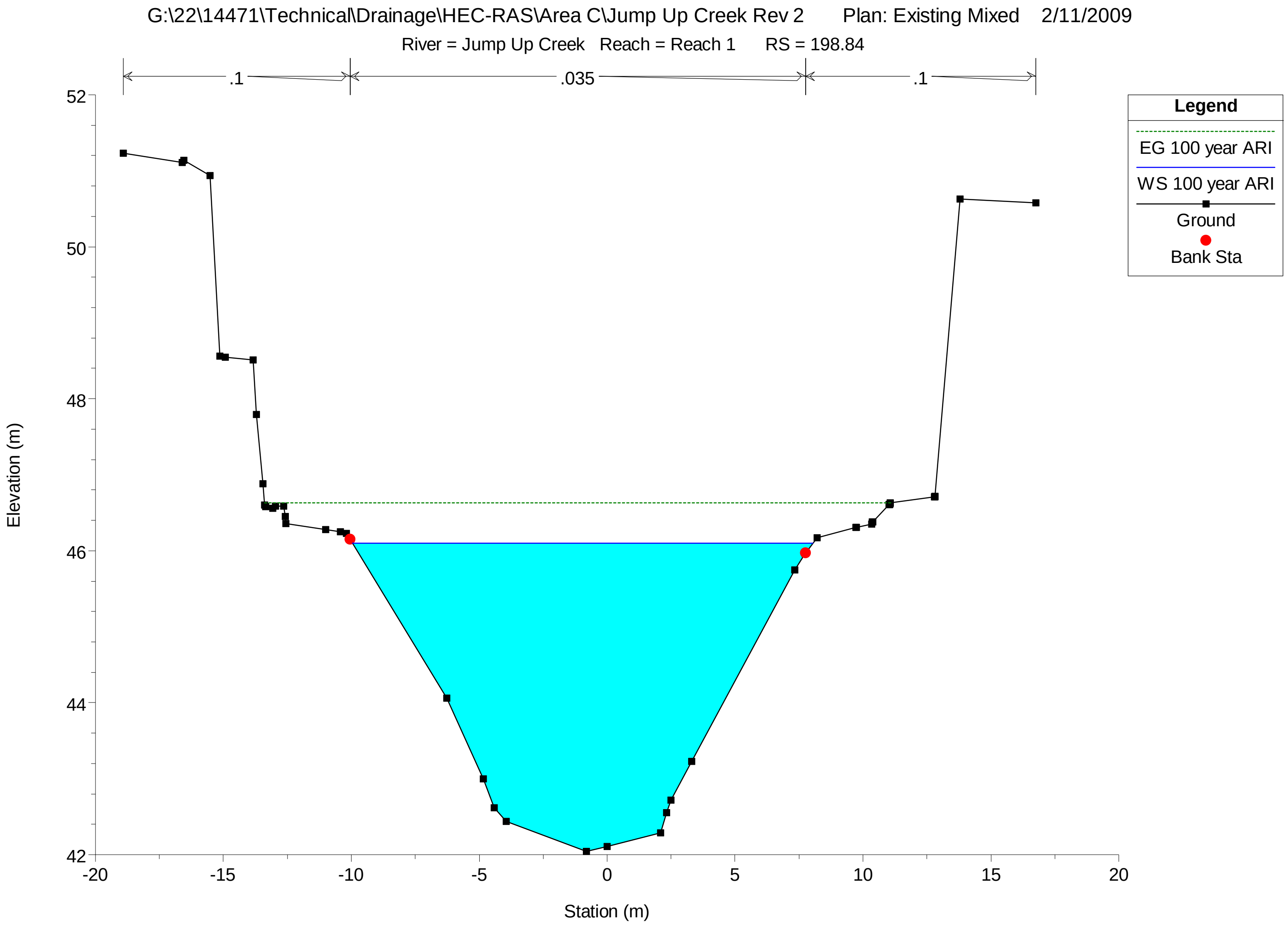
48
46
44
42
-20
-15
-10
-5
0
5
10
15
20
Station (m)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.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Ground
Bank Sta
Elevation (m)
Station (m)
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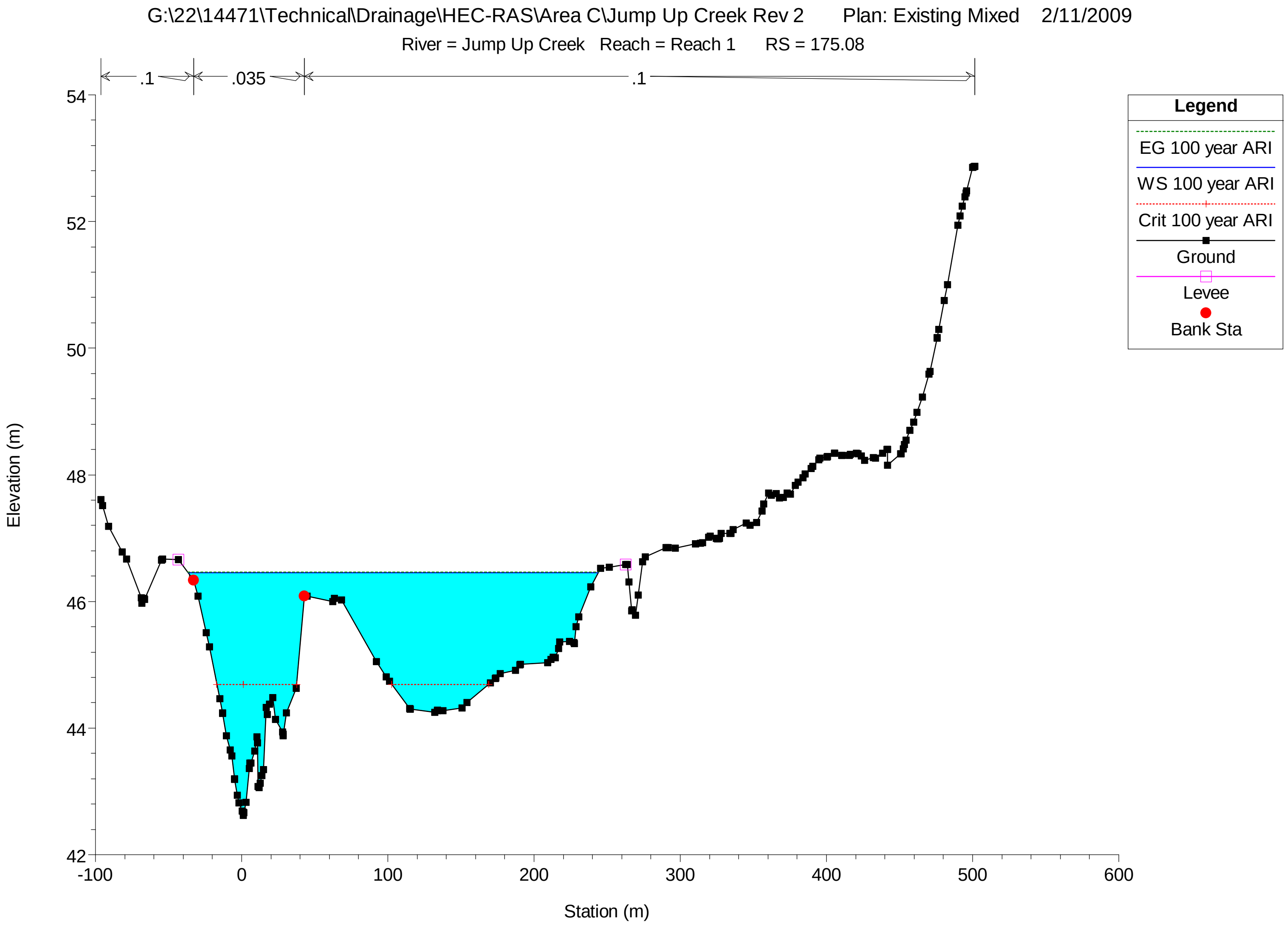
48
46
44
42
-20
-15
-10
-5
0
5
10
15
20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.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
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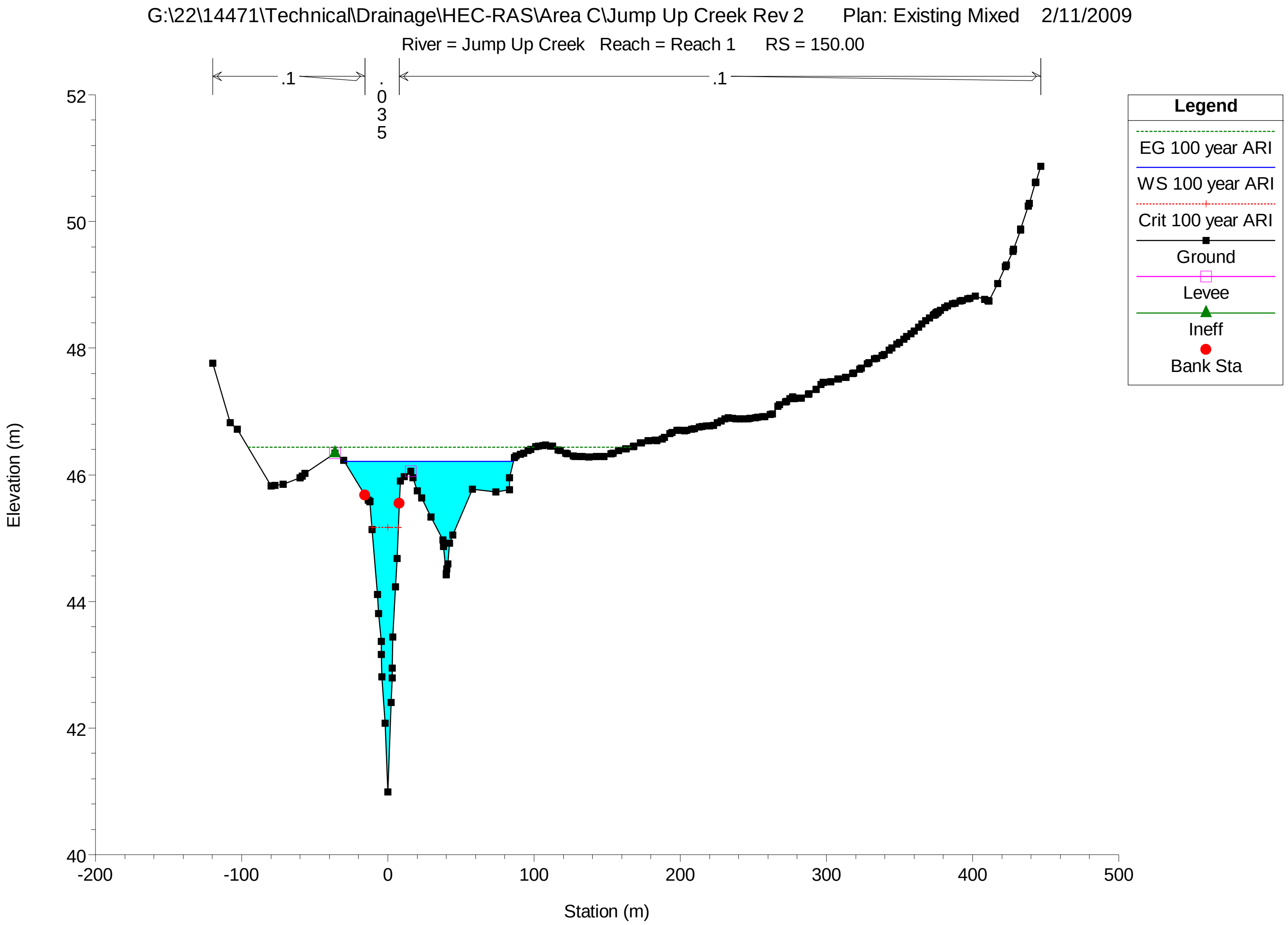
50
48
46
44
42
-100
0
100
200
300
400
500
600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.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Ineff
Bank Sta
Elevation (m)
Station (m)
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48
46
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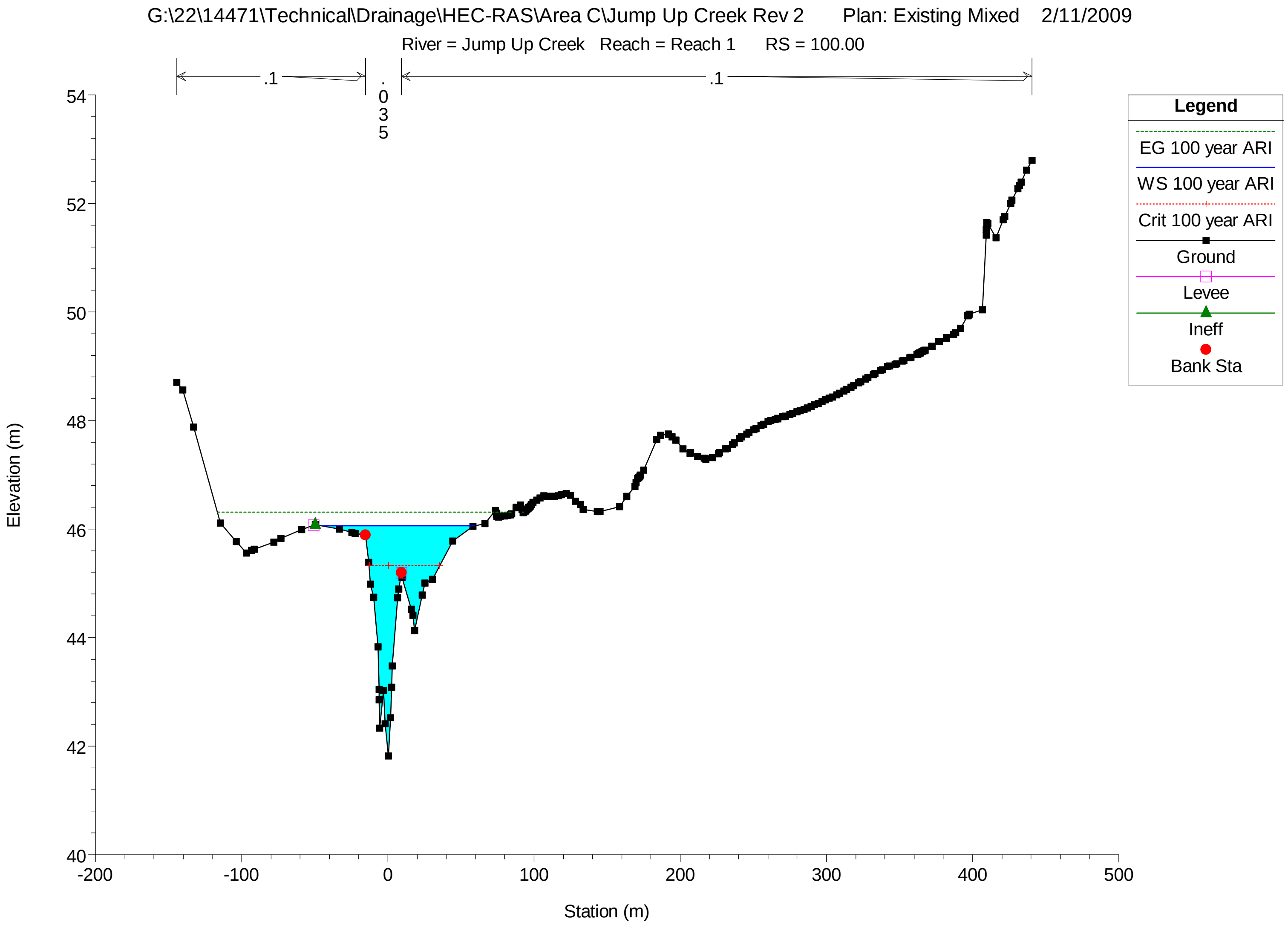
-100
0
100
200
300
400
500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.1
.035
.1
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Ineff
Bank Sta
Elevation (m)
Station (m)
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52
50
48
46
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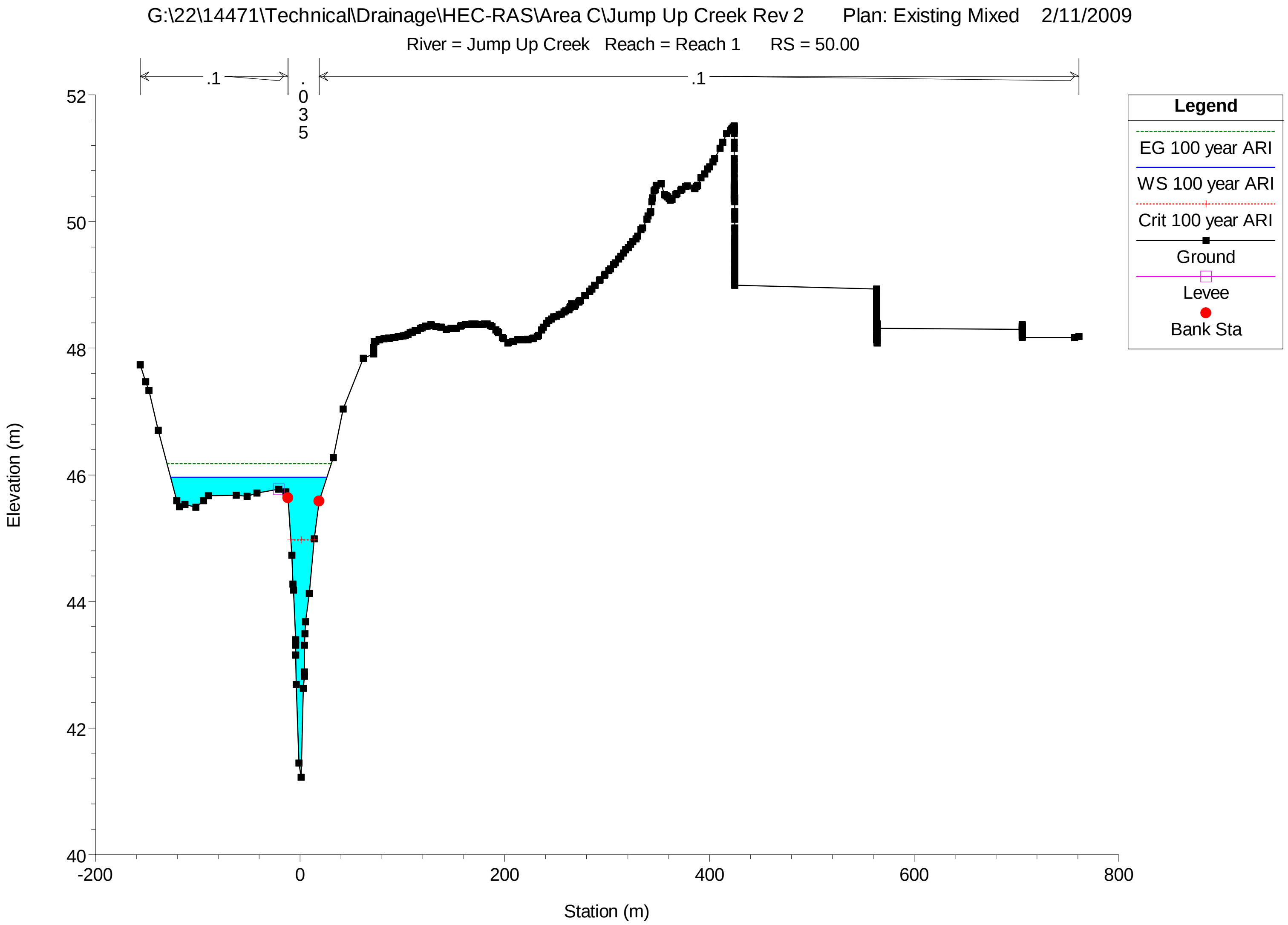
-100
0
100
200
300
400
500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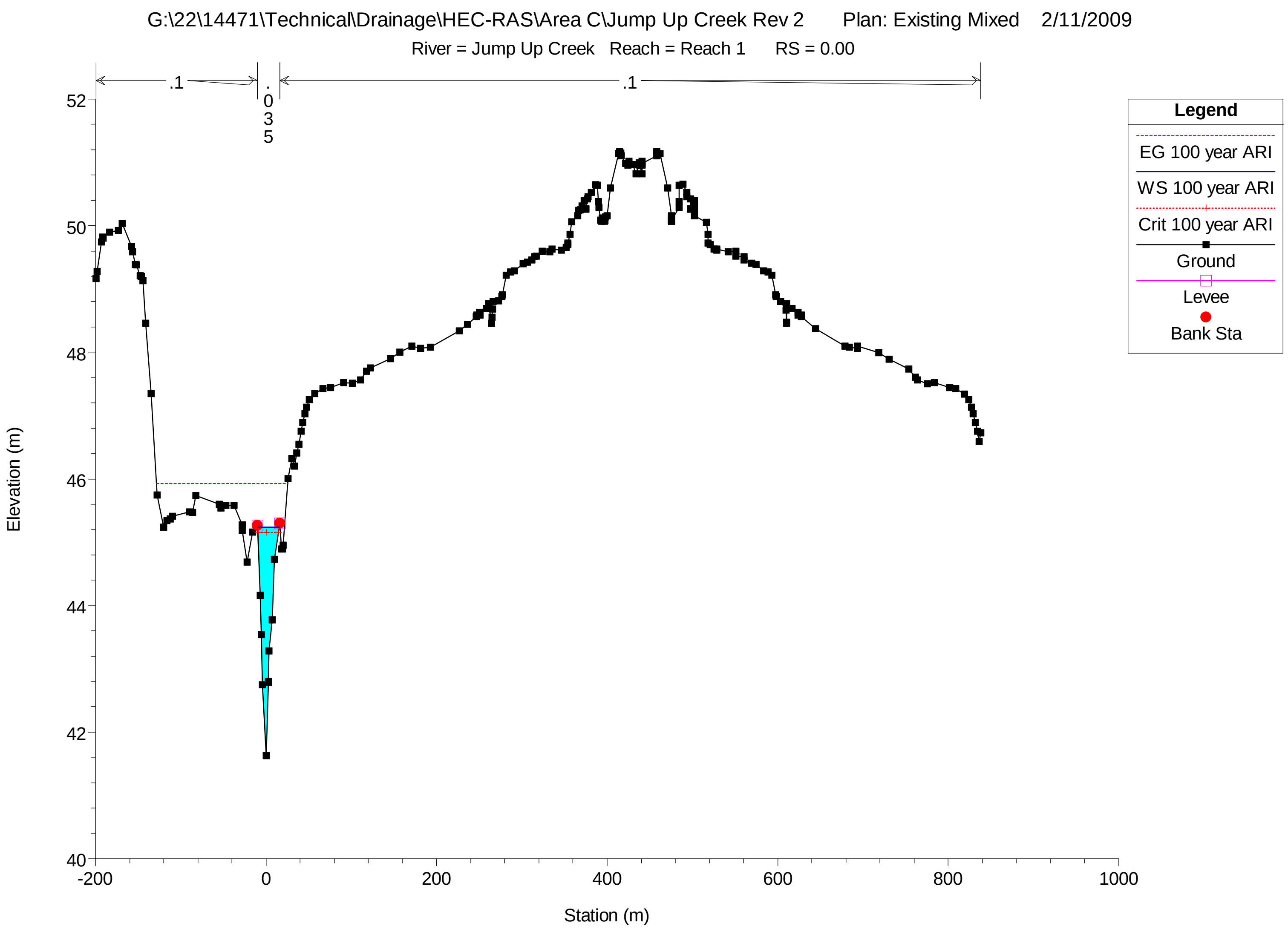
.035
.1
Elevation (m)
Station (m)
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Bank Sta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River = Jump Up Creek Reach = Reach 1 RS = 0.00
.1
.035
.1
Elevation (m)
Station (m)
Legend
EG 100 year ARI
WS 100 year ARI
Crit 100 year ARI
Ground
Levee
Bank Sta

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Appendix F

Floodway Structures

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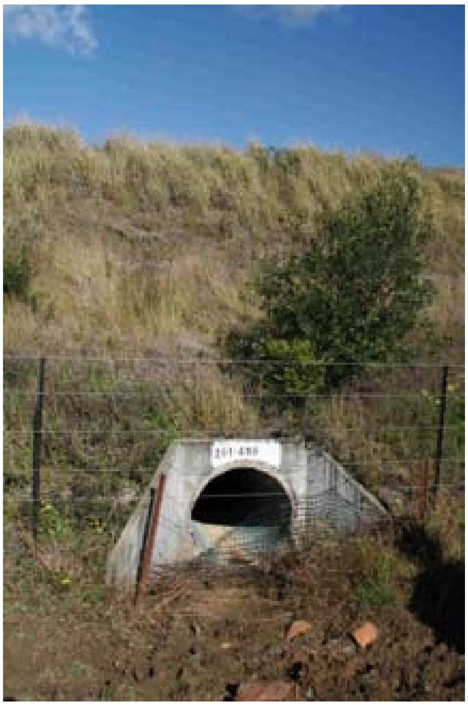
Structure Location	Waterway	Description	Photograph
194.912	W1	1 x 0.9	
195.133	W2	1 x 1.2	
195.555	W3	2 x 3.66 x 4.8 (Stony Creek)	
196.069	W4	1 x 1.52	

Structure Location	Waterway	Description	Photograph
196.280	W5	1 x 1.52	
196.340	W6	1 x 1.52	
196.481	W7	1 x 1.52	
196.561	W8	1 x 1.52	

Structure Location	Waterway	Description	Photograph
197.165	W9	1 x 1.05	
197.487	W10	1 x 1.22	
197.909	W11	1 x 1.2	

Structure Location	Waterway	Description	Photograph
198.040	W12	1 x 1.52	
198.561	W13	1 x 1.8	
199.242	W14	1 x 1.52	
199.850	W15	1 x 0.9	

Structure Location	Waterway	Description	Photograph
200.122	W16	1 x 1.52	
201.480	W17	1 x 0.9	
202.103	W18	1 x 0.9	

Structure Location	Waterway	Description	Photograph
202.550	W19	1 x 0.9	
202.858	W20	1 x 0.9	
203.044	W21	1 x 0.85	

Structure Location	Waterway	Description	Photograph
203.597	W22	1 x 0.9	
203.844	W23	1 x 1.52	
204.528	W24	1 x 0.9	
205.091	W25	1 x 1.2	

Structure Location	Waterway	Description	Photograph
205.342	W26	1 x 0.61	
206.090	W27	1 x 2.4 x 1.2	
206.519	W28	1 x 2.44	
206.745	W29	Waterway	No Photo

Structure Location	Waterway	Description	Photograph
207.776	W30	2 x 2.92	
209.174	W31	1 x 4.58 x 3.55	
209.637	W32	1 x 1.52	
209.889	W33	1 x 0.9	

Structure Location	Waterway	Description	Photograph
209.989	W34	Anvil Creek (Un-named tributary)	
210.522	W35	1 x 2.44	
210.703	W36	1 x 0.9	
211.010	W37	Sawyers Creek	

Structure Location	Waterway	Description	Photograph
211.941	W38	1 x 1.52	
212.333	W39	1 x 091	
212.735	W40	1 x 0.91	
213.158	W41	1 x 2.5	

Structure Location	Waterway	Description	Photograph
213.691	W42	1 x 0.75 x 0.6	
213.892	W43	1 x 0.9	
214.566	W44	1 x 2.44	
214.586		1 x 1.52	

Structure Location	Waterway	Description	Photograph
215.189	W45	1 x 0.76 x 0.46	
215.487	W46	1 x 0.3	
215.671	W47	1 x 0.45	
215.853	W48	1 x 1.2	

Structure Location	Waterway	Description	Photograph
217.175	W49	Black Creek	
218.318	W50	1 x 0.91	
218.448	W51	1 x 1.52	
219.071	W52	1 x 1.2	

Structure Location	Waterway	Description	Photograph
219.615	W53	1 x 2.44	
220.439	W54	1 x 1.2	
220.942	W55	2 x 0.45	
221.486	W56	1 x 0.9	

Structure Location	Waterway	Description	Photograph
222.190	W57	1 x 2.4	
222.848	W58	Jump Up Creek	
224.141	W59	1 x 1.52	

Appendix G

Environmental Risk Assessment Tables

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Consequence Table

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Waterways and floodplain function	Negligible change to existing waterway condition and flow regime.	Minor changes to existing waterway condition or flow regime.	Moderate changes to existing waterway condition or flow regime.	Existing conditions of waterway or floodplain significantly compromised.	Existing condition of waterway irreversibly disturbed or extensive impact to floodplain function.
Water quality	Applicable water quality standards met across the region.	Isolated exceedence of water quality standards that is short lived.	Exceedence of applicable water quality standards in a local area.	Exceedence of applicable water quality standards in a number of local areas.	Widespread exceedence of applicable water quality standards across the region.

Likelihood Table

Likelihood	Description
Almost Certain	The event is expected to occur in most circumstances.
Likely	The event will probably occur in most circumstances.
Possible	The event could occur.
Unlikely	The event could occur but not expected.
Rare	The event occurs only in exceptional circumstances.

Risk Matrix

Likelihood Level	Consequence Level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Negligible	Low	Medium	High	High
Unlikely	Negligible	Low	Medium	Medium	High
Rare	Negligible	Negligible	Low	Medium	Medium

Environmental Risk Register – Surface Water

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
1	Construction of the project results in discharge of polluted runoff to stormwater/rivers /Waterways resulting in decline in water quality.	Refer to Aquatic Assessment (Potential damage to aquatic habitat). Impact to downstream water users.	Erosion and sedimentation controls to be incorporated as part of EMP. This is to include a response plan and monitoring.	Moderate	Possible	Medium				
2	Extent of works associated with the project results in increasing existing flood levels at Major waterways.	Increased extent of inundation on adjacent properties.	Undertake flood modelling to determine existing conditions and develop design to minimise potential increase. Design to minimise extent of impact.	Moderate	Possible	Medium	Property acquisition	Minor	Unlikely	Low

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
3	Construction of the project results in scour at culvert outlets, along existing waterways and embankments.	Undermining of structures, erosion of downstream system.	Design protection measures to minimise the potential for scour and maximise stability.	Moderate	Unlikely	Medium				
4	Construction of the project results in re-direction of Sawyers Creek.	Altered flow path. Impact aquatic habitat.	Review existing flow paths and maintain flow direction.	Minor	Unlikely	Low				
5	Construction of the project results in minor changes to flow regimes of waterways.	Altered flow paths.	Design embankments to minimise encroachment on waterways. Review existing flow paths and design to maintain.	Minor	Unlikely	Low				

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
6	Construction of the Project results in encroachment into existing wetlands.	Removal of EEC vegetation and habitat - see Flora assessment.								
7	Flooding during project construction resulting in equipment damage.	Damage to equipment or persons.	Emergency response plan. Store plant and equipment above 20 year flood level.	Minor	Unlikely	Low				
8	Construction of the project results in blockages in low flow zones such as in creeks at causeway crossings.	Restriction of base flows to downstream system.	Design to have causeways in creek beds or include low flow pipes to maintain base flows.	Moderate	Unlikely	Medium				