EMBRO DAM
CLASS ENVIRONMENTAL ASSESSMENT
FLUVIAL GEOMORPHOLOGY REPORT

Prepared for:
UPPER THAMES RIVER CONSERVATION AUTHORITY

Prepared by:
MATRIX SOLUTIONS INC.

Version 0.1
November 2022
Kitchener, Ontario

171 Victoria St. N
Kitchener, ON, Canada N2H 5C5
T 519.621.1500
www.matrix-solutions.com

EMBRO DAM

CLASS ENVIRONMENTAL ASSESSMENT

FLUVIAL GEOMORPHOLOGY REPORT

Prepared for Upper Thames River Conservation Authority, March 2023

Bryce Miller, M.Sc.
Fluvial Specialist

reviewed by
Mariëtte Pushkar, M.Sc., P.Geo
Principal Fluvial Geomorphologist

VERSION CONTROL

Version	Date	Issue Type	Filename	Description
V0.1	10-March-2023	Draft	33549-528 Geomorph R 2023-03-10 draft V0.1.docx	Issued to client for review

TABLE OF CONTENTS

1 INTRODUCTION 1
2 HISTORICAL ASSESSMENT 1
3 EXISTING CONDITIONS 5
3.1 Reach 1: Downstream of Embro Pond 8
3.2 Reach 2. Embro pond inlet to 85 m upstream of Road 84 9
3.3 Reach 3. From 85 m to 235 m upstream of Road 84 12

IN-TEXT FIGURES

FIGURE 1a Overview of Historical Channel Change along Youngsville Drain in Proximity to Embro Pond 2
FIGURE 1b Overview of Historical Channel Change along Youngsville Drain in Proximity to Embro Pond 3
FIGURE 1c Overview of Historical Channel Change along Youngsville Drain in Proximity to Embro Pond 4
FIGURE 2 Reach Delineation along Youngsville Drain 6
FIGURE 3 Surveyed Channel Bed Profile along Youngsville Drain 7
FIGURE 4 Reach 1 Photos Illustrating Site Conditions 9
FIGURE 5 Reach 2 Photos Illustrating Site Conditions 11

IN-TEXT TABLES

TABLE 1 Observations of Change Based on Historical Photo Overview 1
TABLE 2 Overview of Reach 2 Cross-section Parameters 12
TABLE 3 Overview of Reach 3 Cross-section Parameters 15
TABLE 4 Channel Bed Profile Characteristics along Reach 3 15

1 INTRODUCTION

The intent of the fluvial geomorphic assessment was to characterize channel form and gain insight into channel processes along Youngsville Drain in the vicinity of Embro Pond. Youngsville Drain is a tributary of Mud Creek and flows from a north to southerly direction. The assessment included both a desktop review and data collection through field investigations; data collection completed by ERI was supplemented by UTRCA's topographic survey of the channel bed profile. Findings from the geomorphic assessment are presented by sub-section in this report.

2 HISTORICAL ASSESSMENT

A review of historical channel conditions was completed to gain insight into changes that have occurred within the study area. UTRCA provided airphotos dated from 1955, 1972, 1989, 2000, 2010; additional aerial imagery was available from Google Earth (2015). Key observations are summarized in Table 1**;** a collection of historical airphotos of the study area is provided in Figures 1a to 1c.

TABLE 1 Observations of Change Based on Historical Photo Overview

Year	Observation
1955	Embro pond was not yet constructed south of Road 84 and Youngsville Drain meandered within its floodplain. Upstream of Road 84, Youngsville Drain was sinuous and appears to be situated in a field (grasses, herbaceous plants) with few trees. A hedgerow occurs east of the creek and separates the creek from active landuse.
1972	Construction of Embro pond was complete (note: pond was completed in 1959) Channel realignment/straightening occurred, beginning at ~ 95 m north of Road 84. Channel modifications appear to have occurred at the outlet of the dam (widening, deepening, and straightening).
1989	Floodplain vegetation west of Youngsville Drain, and north of Road 84, appears to be naturalizing and increasing in diversity Some channel planform development appears to be occurring at the upstream limit of the channel straightening
2000	A row of trees appears to have been planted to the west of Youngsville Drain, north of Road 84. The row of trees to the east of the watercourse appears to have been extended further north. No change in planform configuration is evident in comparison to the 1989 image.
2010	Vegetation/tree growth north of Road 84 is notable. Portions of Youngsville Drain are obscured from view on the photo. Overall, no change in planform configuration is evident in comparison to the 2000 image.

FIGURE 1a Overview of Historical Channel Change along Youngsville Drain in Proximity to Embro Pond

FIGURE 1b Overview of Historical Channel Change along Youngsville Drain in Proximity to Embro Pond

FIGURE 1c Overview of Historical Channel Change along Youngsville Drain in Proximity to Embro Pond

3 EXISTING CONDITIONS

A geomorphic field investigation was undertaken on June 11, 2015 to assess existing conditions along Youngsville Drain, both upstream and downstream of Embro Pond. The field investigation included both reconnaissance level observations and detailed data collection.

During the field assessment, three reaches were identified. Reaches are defined as lengths of channel along which there is relative homogeneity of controlling and modifying influences and thus channel form and processes are similar. A description of dominant channel characteristics is provided by reach below. Although intended for urban watercourses, the Rapid Geomorphic Assessment (RGA) was applied to gain insight into overall channel stability and to identify dominant channel processes. The focus of field data collection/measurements was predominantly upstream of the dam's backwater influence.

The focus of field data collection/measurements was predominantly upstream of the dam's backwater influence and included cross-section profiles and substrate characterization. A topographic survey of the channel bed morphology was undertaken by UTRCA and provided to the ERI team for analysis and integration into the fluvial geomorphic assessment. The reach delineation is demonstrated on Figure 2 the surveyed channel bed profile is illustrated in Figure 3 which includes a profile through Embro Pond based on 2015 water depth mapping provided by the UTRCA.

A subsequent field visit was completed on November 18. 2022 to review existing conditions and determine if there were any notable changes that could have occurred since the initial field investigation. Photo comparisons between 2015 and 2022 can be found in Appendix A.

FIGURE 2 Reach Delineation along Youngsville Drain

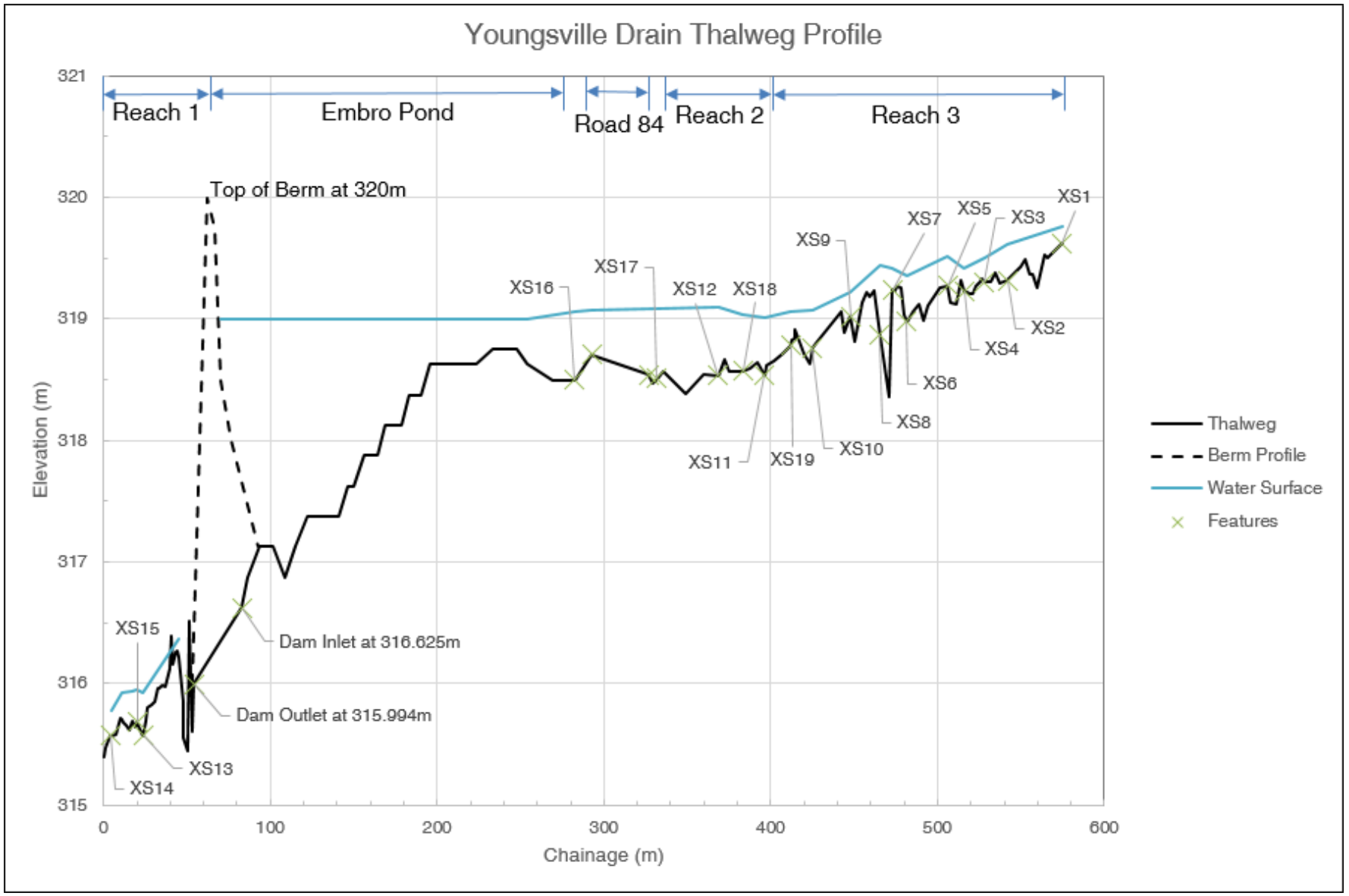

FIGURE 3 Surveyed Channel Bed Profile along Youngsville Drain

3.1 Reach 1: Downstream of Embro Pond

3.1.1 2015 Field Investiation

From the outlet of Embro pond to the end of the UTRCA property, the watercourse was relatively straight; a slight meander was beginning to form near the downstream limit of the reach (Figure 4). The creek was likely straightened in conjunction with construction of the dam.

The channel cross-sections were generally symmetrical in shape and trapezoidal. The cross-sections were set within a larger channel. The active channel was ~ 3.70m wide with an average water depth of 0.29m. Riparian vegetation consisted of dense grasses and herbaceous plants; roots extended to the bottom of the banks. Towards the downstream end of the reach, shrubs and trees were overhanging into the creek.

A deep pool (0.93 m) occurred within 5 m downstream of the Embro Dam outlet. The dominant bed morphology along the entire reach was riffle/run with shallow pools. A deeper pool where vegetation was overhanging into the watercourse. The channel bed consisted primarily of cobbles and gravel. Glacial till was exposed along the toe of the bank along a pool.

Overall, the Youngsville Drain appeared to be stable throughout the reach.

3.1.2 2022 Site Visit

From the outlet of Embro pond, Reach 1 maintained a relatively straight planform, but maintained some bends towards the downstream extent. The banks were well vegetated with grasses, shrubs, and trees. Cut faces were noted on some banks, particularly the western bank downstream of the dam outlet pool. The channel bed remained primarily riffles and runs with shallow pools, measuring up to 0.35 m deep. The bed material consisted of gravels and cobbles, with some sand deposits. The scour pool downstream of the dam outlet was measured to be 0.89 m deep.

The RGA completed for Reach 1 indicated the creek is considered to be ‘in transition’ through the dominant processes of degradation/incision.

View downstream from dam outlet (2015).

Downstream view along creek, towards property line at trees (2015).

View downstream from dam outlet (2022).

Downstream view along creek, towards property line at trees (2015).

FIGURE 4 Reach 1 Photos Illustrating Site Conditions

3.2 Reach 2: Embro pond inlet to 85 m upstream of Road 84

3.2.1 2015 Field Investigation

In this portion of the watercourse, Youngsville Drain appeared to be under backwater conditions and influenced by water levels from Embro Pond (Figure 5). In 2015, the backwater conditions extended 85 m upstream of Road 84; the channel was straight. Measurements of channel cross-section parameters and substrate materials were made at two locations within this reach in 2015 (Table 2).

The cross-sections were well-connected to the floodplain. The cross-section configuration was generally trapezoidal and did include a defined thalweg position. The channel width increased in the downstream direction as expected in a backwater condition; the width:depth ratio for the two cross-sections was relatively narrow and ranged from 6.66 to 9.32. Average water depth was relatively consistent and

ranged from 0.25 - 0.30 m. Gradual widening of the cross-section is expected due to the hydration effect typically associated with backwater conditions.

Channel banks were well vegetated with grasses and herbaceous plants; the fine and dense rooting network extended to the water surface. The bank configuration was generally irregular which is characteristic of banks influenced by backwater conditions in which hydration of bank materials leads to erosion; the rooting network of bankside vegetation holds the banks together in 'clumps'. Undercutting of the banks occurred near the water surface and was consistently measured as 7 - 8 cm deep. The relatively low banks indicate good floodplain accessibility during high flows.

The channel bed morphology was poorly developed and was relatively uniform in configuration. Channel bed materials consisted primarily of silt and sand sized particles with few gravels. The bed materials were 'soft' due to their hydrated condition. Submerged aquatic plants were observed on the channel bed.

In 2022, overall channel conditions remained similar to those observed in 2015. Water levels in the pond appeared lower than they had in 2015; communication with UTRCA indicated that the seasonal lowering had already occurred. Application of the Rapid Geomorphic Assessment (RGA) for this reach in indicated that the channel was considered to be 'in regime'. The dominant process within the reach was deposition; this is reflective of the backwater condition created by the dam.

	
View downstream along Youngsville Drain to Road 84	**Substrate materials within the channel and submerged aquatic vegetation growth.**
	
Irregular banks with minor undercutting near the water surface. Banks are subjec to hydration processes.	**Some bank undercutting was observed along the banks.**

FIGURE 5 Reach 2 Photos Illustrating Site Conditions

TABLE 2 Overview of Reach 2 Cross-section Parameters

Parameter	Range	Parameter	Range
BANKFULL		**LOW FLOW WATER**	
Width (m)	3.8	Width (m)	3.51
Depth (m) Max. Avg.	 0.66 0.50	Depth (m) Max. Avg.	 0.42 0.27
Width:depth ratio (m/m)	8.0	Width:depth ratio (m/m)	13.00
Area (m^2)	1.92	Area (m^2)	0.96
Perimeter (m)	6.33	Wetted perimeter (m)	3.78
Bank Height (m)	0.38		
Bank undercutting (m)	0.07-0.08		
Bank Vegetation and rooting influence	grasses along both banks		
Floodplain connectivity	well-connected		
Substrate Gradation (mm) D90 D84 D50 D16 D10	All substrate consisted of sand and silt sized materials.		

3.2.2 2022 Site Visit

This reach maintained it's backwatered condition due to Embro pond, but lower water levels at the time of the site visit reduced the upstream extent of the backwatering.

Downstream of Road 84 the channel had a wetted width of 2.94 m and a defined bankfull width of 6.74. The channel had fine sediment depth measured to 0.19 m within the centre of the channel. Banks remained well vegetated with trees, grasses, and shrubs. The sediment deposition within the channel continued into the culvert under Road 84, which had large deposits of fine sediment up to 0.26 m, directing low flows to the western side of the outlet.

Upstream of Road 84, the channel maintains a meandering thalweg within the channel between alternating bars of dense aquatic vegetation. Within the thalweg, the channel bed is primarily sand with fine gravel, and shows some developed bedforms such as dunes, while the aquatic vegetation is seated within organic material and silts. Towards the middle of the reach, the channel was measured to have a wetted width of 3.93 m, a bankfull width of 6.65 m, and a water depth of 0.37 m. The channel dimensions increased towards the upstream extent of the reach to a wetted width of 4.37 m and a water depth of 0.43 m, but taller, vertical banks decreased the bankfull width.

An RGA completed for this reach resulted in a Stability Index rating of 0.313 (transitioning) with the primary characteristic of this reach being aggradation.

3.3 Reach 3: From 85 m to 235 m upstream of Road 84

3.3.1 2015 Field Investigation

In Reach 3, Youngsville Drain was a meandering watercourse that was situated towards the west side of an ~ 30 m wide channel corridor that was separated from adjoining agricultural land uses by a row of cedar trees (Figure 6). The watercourse was situated towards the west side of this corridor. Riparian vegetation typically consisted of grasses and herbaceous plants along the east bank, and cedar or willow trees along the west bank. The vegetation and fine dense rooting network typically extended to the water surface.

Along the east side of the channel, two locations were identified at which surface drainage was actively being conveyed over the bank into the creek. The source of water was not investigated.

Field data collection was undertaken at ten cross-sections, which included 4 pools and six riffle/run configurations. A summary of cross-sectional characteristics is presented in Table 3.

The cross-sections were generally uniform in configuration and well-connected to the channel banks. Average pool width was only slightly wider than riffles and the width:depth ratios were similar (Table 3). This reflects the control of grassy and herbaceous bankside vegetation on channel form. Although the average channel depth was similar between pools and riffles, pools attained a somewhat higher depth at both bankfull and low flow stages.

Banks were generally steep. No active erosion was noted. Undercutting of the banks was generally minimal (up to 8 cm), but measured up to 24 cm underneath a root wad 17 cm and occurred at the bottom of the rooting zone and/or the interface with underlying stratigraphic materials. Along the lower bank, a soft rock was observed which resembled a conglomerate rock type (i.e., round gravels situated within a fine matrix of silt and sand sized particles. The cobble and gravel sized sediment observed on the channel bed consisted of this conglomerate material; pressure exerted onto the particles would cause it to break into smaller pieces.

The channel bed morphology has developed into the soft conglomerate sedimentary rock. Field measurements revealed that from distance from the top of this unit to the channel bed was 30 cm, suggesting that the channel has incised this depth into the materials. The dominance of riffle/run features along the channel bed is a result of this resistant bed material. Shallow pools have formed and occur along the outside bends of meanders. The underlying bedrock controls profile development and reflects the relatively small difference in depth between pool and riffle sections (Table 3). The deepest pool evident on Figure 3 was 0.87 m deep; in general, all other pool depths were considered to be shallow (i.e.,, residual depths ranged from 0.15-0.28 m).

Active drainage channels discharge into the creek.

Channel is well connected to its floodplain

Bank stratigraphy includes a lower unit that provides bedrock control on profile development.

Substrate consisted of cobbles on a gravel-sandy bed

Riparian vegetation includes both grasses/herbaceous plants and trees (cedar/willow)

FIGURE 6 Reach 3 Photos Illustrating Site Conditions

TABLE 3 Overview of Reach 3 Cross-section Parameters

Parameter	Riffle		Pool	
	Range	Average	Range	Average
Bankfull				
Width (m)	2.85-4.74	3.90	3.29-5.15	4.09
Depth (m) Max. Avg.	 0.42-0.53 0.33-0.41	 0.44 0.34	 0.45-0.74 0.31-0.42	 0.56 0.35
Width:depth ratio (m/m)	8.65-18.05	11.74	9.46-16.82	11.81
Area (m^2)	0.93-1.92	1.33	1.06-1.71	1.44
Perimeter (m)	3.99-6.99	4.96	3.96-5.62	4.64
Low Flow Water				
Width (m)	2.59-3.83	3.28	2.97-4.16	3.34
Depth (m) Max. Avg.	 0.16-0.25 0.11-0.18	 0.21 0.14	 0.28-0.58 0.18-0.34	 0.40 0.25
Width:depth ratio (m/m)	14.76-29.24	24.04	9.40-22.88	14.33
Area (m^2)	0.33-0.56	0.46	0.66-1.10	0.83
Wetted perimeter (m)	3.11-4.24	3.53	3.25-4.32	3.76
Substrate Gradation (mm) D90 D84 D50 D16 D10	 50 35 10 0.5 0.1			

TABLE 4 Channel Bed Profile Characteristics along Reach 3

Parameter	Range	Average
Max. residual pool depth (m)	0.15-0.28 One pool was uncharacteristically deep at 0.87 m	0.33
Pool area (2D along profile) (m^2)	0.28-1.27	0.79
Pool length (m)	8.28-27.48	16.48
Avg. pool depth	0.10-0.32	0.17
Riffle length (m)	4.91-12.35	9.12
Riffle grade (%)	0.39-2.08	1.32
Inter-riffle spacing	16.35-47.01	27.52

Analysis of the topographic channel bed profile, provided by UTRCA, was undertaken. This revealed that the average water surface grade during the field survey (June 11, 2015) was 0.32 % and the average bankfull grade was 0.43 %. Quantification of riffle and pool parameters, for Reach 3 is provided in Table 4.

Application of the RGA for this reach indicated that the channel is 'in transition' and is dominated by aggradational processes. Indicators of aggradation include lateral bars of silt and very fine sands which were observed along the channel.

3.3.2 2022 Site Visit

Within Reach 3, the channel maintains a meandering planform through a narrow riparian corridor between agricultural lands. The banks are well vegetated with grasses, shrubs, and trees which have deposited large amounts of woody debris into the channel. A small drainage channel was noted coming from the property to the east, out letting into the floodplain and continuing into the main channel.

The channel is well connected to the floodplain within the riparian corridor. Undercutting of banks was occurring towards the downstream extent of the channel, measuring 0.22 m deep in some locations. The substrate increased in roughness further upstream, and was primarily large and cobbles which formed small, submerged riffles, along with occasions boulders within the channel.

A series of cross sections were investigated along some of the sections surveyed in 2015. A summary of the locations, and dimensions is displayed in Table 5.

TABLE 5 Summary of channel geometry measured during the 2022 site visit. Cross-section locations are approximate relative to 2015 survey locations.

	Cross Section 2	Upstream of Cross - section 2	Cross Section 3	Cross Section 4	Cross Section 5	Cross Section 6	Cross Section 9
Wetted Width (m)	4.75	3.72	3.3	3.2	4.65	3.7	4.0
Bankfull Width (m)	5.45	3.9	4.4	3.7			
Water Depth (m)	0.23	0.21	0.30	0.33	0.2	0.19	0.14

The RGA for this reach indicated the channel was in transition (0.348), and is primarily widening, which can explain the undercutting and large amounts of woody debris in the form of fallen trees.