Duncan Dam Project Water Use Plan

Lower Duncan River
Riparian Cottonwood Monitoring

Reference: DDMMON#8-1

Year 4 Report

Study Period: April 2013 – January 2014

VAST Resource Solutions Inc.
Cranbrook, B.C.

March 2014

DDMMON#8-1 Lower Duncan River Riparian Cottonwood Monitoring Year 4 Annual Report (2013)

Final Report

Prepared for:
BC Hydro
601-18th Street
Castlegar, B.C., V1N 2N1

Prepared by:
Mary Louise Polzin[1] and Stewart B. Rood[2]
[1]VAST Resource Solutions Inc.
Box 538 Cranbrook, B.C., V1C 4J1 and
[2] University of Lethbridge, Alberta

March 2014

Suggested Citation

Polzin, M.L., and S.B. Rood. 2014. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 4 Report – 2013. Vast Resource Solutions and University of Lethbridge, Alberta. Unpublished report by Vast Resource Solutions, Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, BC. 53 pp. + Apps.

Cover photo

Lower Duncan River, Segment 3, transect line 11 looking at the mid-channel bar that is sampled as part of D3T11, July 22, 2013. Photo © Mary Louise Polzin, Vast Resource Solutions Inc.

EXECUTIVE SUMMARY

A ten-year riparian vegetation monitoring program along the lower Duncan River was initiated in 2009 as part of the implementation of the Duncan Dam Project Water Use Plan (WUP). This study is intended to evaluate the impacts of operating the flow regime Alternative S73 (Alt S73) on black cottonwoods (*Populus trichocarpa*) and other riparian vegetation along the lower Duncan River. The new Alt S73 regime criteria to follow as closely as possible were:

- Sufficient time between spring freshet recession and late summer/fall dam releases to allow seedlings to establish;
- Short duration periods for late summer/fall/winter high flow when they do occur (less than three weeks); and
- Low winter dam release flows relative to spring freshet flows.

The study provides site-specific data to guide the river flow regulation and to improve the understanding of the relationships between flow regime, physical environmental conditions, and riparian vegetation. This report describes Year 4 (2013) of the monitoring project for the study area, which includes the lower Duncan River and the adjacent free-flowing lower Lardeau River that serves as a comparative reference reach. Year 4 is a cottonwood establishment and recruitment monitoring year and we did not inventory riparian vegetation, or juvenile and mature cottonwoods, which occurs every third year (next scheduled: 2015).

To address management questions and associated hypotheses (table following), the floodplain zones, riparian vegetation, and black cottonwood recruitment are being assessed. The performance of Alt S73 on the lower Duncan River riparian community combines all years of the study and this 2013 report represents cottonwood colonization data from 2009, 2010, 2012 and 2013. This fourth year of sampling investigated factors influencing the level of success or failure of cottonwood establishment and recruitment compared to previous years for the lower Duncan River as well as comparative analysis along the reference reach, the lower Lardeau River.

In order to identify key drivers of cottonwood recruitment success, transect profiles were resurveyed so that levels of sediment deposition and erosion could be quantified. Since 2009, 70 percent of change in elevation was due to deposition and 27 percent was from erosion. The maximum deposition was 1.28 m and the maximum erosion was 1.30 m. The majority of the change in elevation was probably the consequence from the long inundation period in 2012. This deposition was found to be responsible for the loss of the following cottonwood seedling classes: 2010 recruitment, 2011 survival and 2012 establishment. The 2012 establishment was impacted by the loss of recruitment zones as they were inundated during seedling establishment and the subsequent growing season. Following from the field observations, preliminary data analyses indicate that the river flow regime is the primary driver affecting black cottonwood seedling establishment and recruitment along the Duncan River. The flood duration and water stage in 2012 reset seedling establishment and recruitment back to zero, after three years with moderate colonization. Seedling establishment in 2013 occurred at reduced levels compared to 2009 and 2010 levels, as well as relative to the reference reach.

The lower Duncan reach had significantly higher densities of cottonwood seedling establishment compared to the Lardeau reach in 2009 and 2010. However, in 2013 the lower Duncan reach had significantly reduced seedling densities compared to the Lardeau reach. This was attributed to the high discharge through July as well as the higher discharges for June and August compared to 2009 and 2010. Since establishment and recruitment was reset to zero in 2012, the following two years will supply establishment survival and recruitment (3 years of survival) data to be compared with the 2009 and 2010 data to assess the Alt S73 flow regime and

address whether flow regime is the primary driver to address H_{03}. To some extent the reset provides for a form of replication of the colonization studies.

It is too early to formally assess the performance of Alt S73. However, important factors were confirmed in 2013, particularly that sediment deposition and erosion are driven by the flow regime and have major impacts on cottonwood establishment and recruitment success. This information confirmed that the impact from prolonged flooding in 2012 resulted in the lack of cottonwood recruitment. Years 1 and 2 indicated that the colonization requirements appeared to be tied particularly to elevational position with reference to stream stage pattern, geomorphic context, sediment substrate, longitudinal position (upstream-to-downstream), influences of tributary inflows, and channel morphology. These factors were supported in 2013. Full vegetation monitoring and mapping in years 2015 and 2018 will provide important data for hypothesis testing to further address the management questions.

Keywords – lower Duncan River, black cottonwood (*Populus trichocarpa*), seedling recruitment, riparian vegetation monitoring, flow regime

DDMMON#8-1 Status of Objectives, Management Questions and Hypotheses after monitoring Year 4.

Objectives	Management Questions	Management Hypotheses	Year 4 (2013) Status
1) To assess the performance of Alt S73 on the lower Duncan River riparian community and specifically black cottonwoods, through comparisons of field-based performance measures.	1) Will the implementation of Alt S73 result in neutral, positive, or negative changes for black cottonwoods and riparian habitat diversity along the lower Duncan River as compared to past-regulated regimes?	H_{01}: There is no change in black cottonwood establishment or survival resulting from the implementation of Alt S73.	Because of the different flow regimes implemented during Alt S73 in 2009 and 2010, compared to 2012 and 213, H_{01} cannot yet be resolved.
2) To quantify the relationships between abiotic influences and biological responses based on analyses of field data.	2) What are the key drivers of black cottonwood recruitment success along the lower Duncan River floodplain? How are these drivers influenced by river regulation?	H_{02}: Black cottonwood establishment and survival along the lower Duncan River are not affected by the river flow regime.	Key factors influencing black cottonwood recruitment appear to be water inundation duration and timing, sediment deposition and erosion, recruitment elevation, and distance from river edge. All of these factors are influenced by river regulation. Other factors appear to be longitudinal location, tributary influences, and channel morphology.
3) To utilize the derived relationships in conceptual models for predicting the long-term response of black cottonwood and other riparian plant communities to a variety of flow regimes		H_{03}: The river flow regime is not the primary driver of black cottonwood establishment and survival along the lower Duncan River.	Year 4 analyses along the lower Duncan River indicated that the river flow regime is a primary driver of black cottonwood establishment and survival along the lower Duncan River.

ACKNOWLEDGEMENTS

Sincere thanks go to the 2013 field data collection team: Brenda Herbison, Ben Meunier, and Aden Stewart. They endured mosquito swarms during the July field visits that challenged field work. The experience and knowledge of Brenda Herbison and Aden Stewart from the start of the project enabled efficient and time saving sampling this season. Special thanks are extended to Aden Stewart and Ben Meunier for their expertise in the navigation and operation of the canoe and raft (respectively) that allowed sampling of transects not accessible by land while keeping costs within the available budget. Funding for the project was provided by BC Hydro Columbia Water License Requirements and in-kind contribution of time and resources from the University of Lethbridge.

Table of Contents

EXECUTIVE SUMMARY III
ACKNOWLEDGEMENTS V
1 INTRODUCTION 10
1.1 Overview 10
1.2 Objectives 11
2 METHODS 12
2.1 Study Area 12
2.2 Sampling Design 15
2.3 Seasonal Weather 18
2.4 Hydrology 18
2.5 Cottonwood Phenology 18
2.6 Elevation Profile Survey 19
2.7 Field Visits 19
2.8 Seedling Establishment and Recruitment 19
2.9 Groundwater Monitoring 20
2.10 Transect-Specific Stage/Discharge Relationships 21
2.11 Data Analyses 21
3 RESULTS 22
3.1 Weather 22
3.2 Hydrology 25
3.2.1 Duncan River 25
3.2.2 Lardeau River 27
3.3 Groundwater Monitoring 28
3.4 Cottonwood Phenology 30
3.5 Cottonwood Establishment and Recruitment along the Lower Duncan and Lardeau Rivers 31
3.5.1 Seedling densities 33
3.5.2 Seedling heights 36
3.5.3 Erosion and deposition 38
3.5.4 Seedling heights, deposition, and erosion 41
4 DISCUSSION 45
4.1 Seasonal Weather 45
4.2 Hydrology 46
4.2.1 Groundwater levels 46
4.3 Cottonwood Phenology 47
4.4 Cottonwood Recruitment 47
5 CONCLUSIONS 49
6 RECOMMENDATIONS 51
6.1 Transect Line Resurveying 51
7 CLOSURE 51
8 REFERENCES 52

List of Figures

Figure 2-1: Study area for the lower Duncan River with stratification of the river study segments. 13
Figure 2-2: Study area for the Lardeau River with stratification of the river study segments. 14
Figure 2-3: Lower Duncan River study transects in 2013.. 16
Figure 2-4: Lardeau River study transects in 2013... 17
Figure 3-1: Duncan Lake Dam weather station at Meadow Creek monthly mean temperature and monthly total precipitation for 2010, 2012, and 2013 (sampling years). 22
Figure 3-2: Canadian Climate Averages (1971 – 2000) for monthly total precipitation for the Duncan Lake Dam weather station with 2013 monthly precipitation for January through August and 2012 monthly precipitation for comparison between years. 23
Figure 3-3: Precipitation (mm) for the month of June 2013 at Duncan Lake Dam weather station. Total precipitation for the month of June was 100.9 mm. 24
Figure 3-4: The minimum, maximum and mean total precipitation for 2010, 2012, and 2013.. 24
Figure 3-5: Snow water equivalent totals for the months February, March, and April at the station 2D07A Duncan Lake No. 2 at 662 m elevation at Marble Head weather station. 25
Figure 3-6: Mean monthly hydrographs for the lower Duncan River for sampling years 2009, 2010, 2012, and 2013 and pre-dam (3 years of data) mean monthly discharges plotted with a smoothed lined. 26
Figure 3-7: Mean daily discharge (m^3/s) for 2009, 2010, 2012, and 2013 (provisional) for the lower Duncan River at Station 08NH118. 26
Figure 3-8: Mean monthly discharge (m^3/s) for the Lardeau River for 2013 and the average for years 2009 and 2010 and the average of 2011 and 2012. 27
Figure 3-9: Well locations for segment D3. 28
Figure 3-10: Duncan River stage at station 08NH118 and groundwater well levels above base stage for D3 deep wells.. 29
Figure 3-11: Duncan River stage at station 08NH118 and groundwater well levels above base stage for D3T15.. 29
Figure 3-12: Duncan River stage at station 08NH118 and groundwater well levels above base stage for segment D5T16. 30
Figure 3-13: The 2010, 2012, and 2013 cottonwood germinant densities for the Duncan (left) and Lardeau (right) study reaches. 34
Figure 3-14: Seedling establishment densities (germinants) for 2013 compared to 2012 and 2010 for each segment along the lower Duncan (D) River. 35
Figure 3-15: Seedling establishment densities (germinants) for 2010, 2012, and 2013 for each segment along the Lardeau (L) River. 36
Figure 3-16: Seedling heights within quadrats grouped by season of growth for first, second and third season heights recorded in each sampling year. 37
Figure 3-17: Erosion and deposition along the Duncan reach since 2009. 38
Figure 3-18: Erosion and deposition along the Lardeau reach since 2009.. 39
Figure 3-19: Erosion and deposition along transects for the lower Duncan River segments.................. 40
Figure 3-20: Deposition along the lower Duncan reach transects grouped by segments. 41
Figure 3-21: The lower Duncan River sampling reach seedling heights grouped by year at initial elevation.. 42
Figure 3-22: The Lardeau sampling reach seedling heights grouped by year at initial elevation.. 42
Figure 3-23: Erosion and deposition for the Duncan segments.. 43
Figure 3-24: Erosion and deposition as it occurred along the Duncan reach transect lines with '0' as the river's edge (top graph) and seedling occurrence along transect lines with heights and '0' indicating river's edge (bottom graph). 44
Figure 3-25: Erosion and deposition as it occurred along the Lardeau reach transect lines with '0' as the river's edge (top graph) and seedling occurrence along transect lines with heights with '0' on the x axis indicating river's edge (bottom graph). 45
Figure 4-1: Photographs showing cottonwood colonization along transect at D3T15 in 2010 (A). The same transect line April 29, 2013 (B) and October 1, 2013 (C). 49

List of Tables

Table 3-1: Peak spring freshet discharge for the Lardeau River from 2009 to 2013 with log Pearson Type lll flood return periods and predicted discharge levels. ... 28
Table 3-2: Seed dispersal events with abundance, maximum temperature for the day, precipitation (rain), and mean maximum temperature for the event. ... 30
Table 3-3: Comparisons of 2010, 2012, and 2013 numbers of quadrats with seedlings and number of germinants for the corresponding year, for each transect along the Duncan River (Dun = Duncan, Seg = Segment, Tran = Transect, Quad = Quadrats, Seed = Seedlings). ... 32
Table 3-4: Comparisons of 2010, 2012, and 2013 numbers of quadrats with seedlings and number of germinants for the corresponding year, for each transect along the Lardeau River (Lard = Lardeau, Seg = Segment, Tran = Transect, Quad = Quadrats, Seed = Seedlings). ... 33
Table 3-5: T-Test results for comparison of mean seedling densities for the Duncan and Lardeau reaches for 2013, 2012, and 2010. ... 34
Table 3-6: T-Test comparison of means for the Duncan segments for 2013 versus 2010. ... 35
Table 3-7: T-Test comparison of means for the Lardeau segments for 2013 versus 2012 and 2010. ... 36
Table 3-8: Statistical results from T-Test for cottonwood seedling heights grouped by seedling growth season sampled in 2009, 2010, 2012 and 2013. ... 37
Table 3-9: T-Test comparison for the erosion and deposition that occurred along the lower Duncan River compared to the Lardeau River. ... 39
Table 3-10: T-Test results for erosion (Er) and deposition (De) comparison between segments for the Duncan reach and comparison for deposition (Depo) between segments (gray shading). ... 40

List of Appendices

Appendix 1: GPS Points 54
Appendix 2: Transect profiles for the Lower Duncan and Lardeau rivers 2009 and 2013 59
Appendix 3: Lower Duncan and Lardeau rivers photo documentation 73
Appendix 4: Duncan and Lardeau rivers contact sheets 89

1 INTRODUCTION

1.1 Overview

In southeastern British Columbia, the Duncan River is the major river flowing into the north end of Kootenay Lake. This river was dammed in 1967 as the first of four major dams that followed the 1964 Columbia River Treaty between Canada and United States. These dams and reservoirs were intended to provide flood control and hydroelectric power generation. The Duncan Dam resulted in the flooding of the 25 km long Duncan Lake and adjacent wetlands and river reaches creating the 45 km long Duncan Reservoir. The Dam has no hydroelectric turbine thereby increasing its operational flexibility. Water is released downstream for storage in Kootenay Lake and subsequent reservoirs and passage through an extensive sequence of turbines along the Kootenay and Columbia Rivers.

Commencing in 2001, BC Hydro, which owns and operates Duncan Dam, commenced a Water Use Planning (WUP) process to consider alternate river regulation regimes. Following hydrologic modeling and consultations with various regional groups, the flow scenario alternative (Alt) 'S73' was selected for implementation. This was intended to balance the flood-control and hydropower objectives with environmental benefits for fish in the Duncan and Lardeau Rivers, and Kootenay Lake, and for reproduction of black cottonwood (*Populus trichocarpa*), the species of cottonwood occurring in the area, which provide the foundation for floodplain forests and associated wildlife along the lower Duncan River. This operations regime was implemented in 2008 and we have been investigating the environmental responses along the Lower Duncan River and along the adjacent and free-flowing Lardeau River as a reference for comparison since 2009. This riparian cottonwood monitoring program was designated as DDMMON#8-1 (BC Hydro 2009).

Past research has demonstrated strong links between cottonwood recruitment, and river flow (Mahoney and Rood 1998), especially below dams (Polzin 1998, Polzin and Rood 2000). Studies have also revealed the links between cottonwoods, wildlife habitat and overall ecosystem function (Naiman et al. 2005). Accordingly, black cottonwood was identified by the WUP as the indicator species for monitoring the effects of Alt S73 on riparian biological diversity for the lower Duncan River. A more detailed description of the background to this project is provided in the initial Year 1 report (Polzin et al. 2010).

Two key management questions were developed by BC Hydro (2009) to help address uncertainty associated with cottonwood hydrograph performance measures:

1) Will the implementation of Alt S73 result in neutral, positive, or negative changes for black cottonwood and riparian habitat diversity along the lower Duncan River, as compared to past-regulated regimes?
2) What are the key drivers of successful black cottonwood recruitment along the lower Duncan River floodplain and how are these drivers influenced by river regulation?

Declines in cottonwood populations downstream from dams along other river systems have been documented (Rood and Mahoney 1990, Polzin and Rood 2000, Merritt and Cooper 2000). The lower Duncan River differs from most other dammed systems studied because 50 to 60 per cent of the flow below the dam comes from the free-flowing Lardeau River, and two smaller creeks. The inputs from the Lardeau River, and Hamill and Copper creeks result in sediment and woody debris contributions below the dam. In contrast, sediment and woody debris deficiencies normally occur along other dammed systems (Williams and Wolman 1984, Dunne 1988, Debano and Schmidt 1990, Rood and Mahoney 1995, Polzin 1998).

Contrary to typical dammed systems where a 'silt shadow' and loss of large woody debris occurs downstream of the dam (Williams and Wolman 1984, Rood and Mahoney 1990) the lower Duncan River experiences increases in sediment deposition and large woody debris. The Duncan Dam has reduced spring peak flows since the start of operation and Alt S73 did not change this. The reduced spring peak freshet cannot move the sediment and woody debris entering the system from the free-flowing tributaries, as it did before the dam was installed. This has resulted in extensive large woody debris deposits along the lower Duncan River as well as increased sediment deposition.

A second factor which differs from many other previously-studied dammed systems is that the lower Duncan River is situated in a humid, hydrologically gaining (alluvial ground water flows into the river), and mountainous region. The data collected during DDMMON#8-1 monitoring project will thus characterize the hydrogeomorphic conditions for the unusual lower Duncan River and the affect it has on black cottonwood (or cottonwood used interchangeable with black cottonwood when referring to cottonwoods in this study) recruitment, and subsequently riparian woodlands.

1.2 Objectives

The objectives of the DDMMON#8-1 monitoring program are designed to be achieved over a 10-year study period (BC Hydro 2009). They are:

- To assess the performance of Alt S73 on the lower Duncan River riparian community and specifically black cottonwood through comparison of field-based performance measures;
- To quantify the relationships between abiotic influences (e.g., river hydrology or groundwater hydrology), and biological responses (i.e., cottonwood recruitment), based on analyses of field data; and
- To utilize the above-derived relationships in conceptual models for predicting the long-term response of black cottonwoods and other riparian plant communities to a variety of flow regimes.

To meet the objectives and address the management questions, BC Hydro (2009) has identified three hypotheses:

Hypothesis 1

H_{01}: There is no change in black cottonwood establishment or survival resulting from the implementation of Alt S73; versus

H_{A1}: The implementation of Alt S73 results in either (a) a positive or (b) a negative influence on black cottonwood survival.

Hypothesis 2

H_{02}: Black cottonwood establishment and survival along the lower Duncan River are not affected by the river flow regime; versus

H_{A2}: Black cottonwood establishment and survival along the lower Duncan River are affected by the river flow regime.

Hypothesis 3

H$_{03}$: The river flow regime is not the primary driver of black cottonwood establishment and survival along the lower Duncan River; versus

H$_{A3}$: The river flow regime is the primary driver of black cottonwood establishment and survival along the lower Duncan River.

Guided by the above long-term objectives and hypotheses, the primary objectives in Year 4 were to:

- Resurvey elevational profiles of transect lines to add deposition and erosion data for transect lines surveyed in Year 1 (2009); and
- Collect cottonwood seedling data to add to the previous data sets (2009 – 2012).

The cottonwood seedling establishment and recruitment analyses at the transect level for Year 4 were interpreted relative to the key management questions. Changes in elevation profiles will be assessed relevant to seedling establishment elevation. By addressing the second management question, the key drivers will be identified and also how these drivers are influenced by river regulation by the end of the 10 year monitoring project. Data from Year 4 will add to the body of knowledge and may suggest the trend for the key drivers and how they are being influenced by Alt S73.

2 Methods

2.1 Study Area

The lower Duncan River is located in the Columbia Mountains region in southeastern British Columbia. It flows south out of the 45 km-long Duncan Reservoir, which was impounded by the Duncan Dam in 1967. Approximately 300 m downstream from the Dam, the lower Duncan River is joined by the free-flowing Lardeau River, and the combined rivers continue south for approximately 11 km to Kootenay Lake where a broad delta is formed (Figure 2-1:). Midway along in Segment 4, the lower Duncan River channel is joined by three free-flowing tributaries: Meadow, Hamill and Cooper creeks. The Lardeau River was selected as the reference reach because of its proximity to the lower Duncan River. The Lardeau River flows out of a nearly parallel watershed with a higher gradient and lower discharge compared to the Duncan River. The Lardeau River study reach starts approximately 3 km upstream of the confluence with the lower Duncan River and extends upstream for approximately 11 km (Figure 2-2).

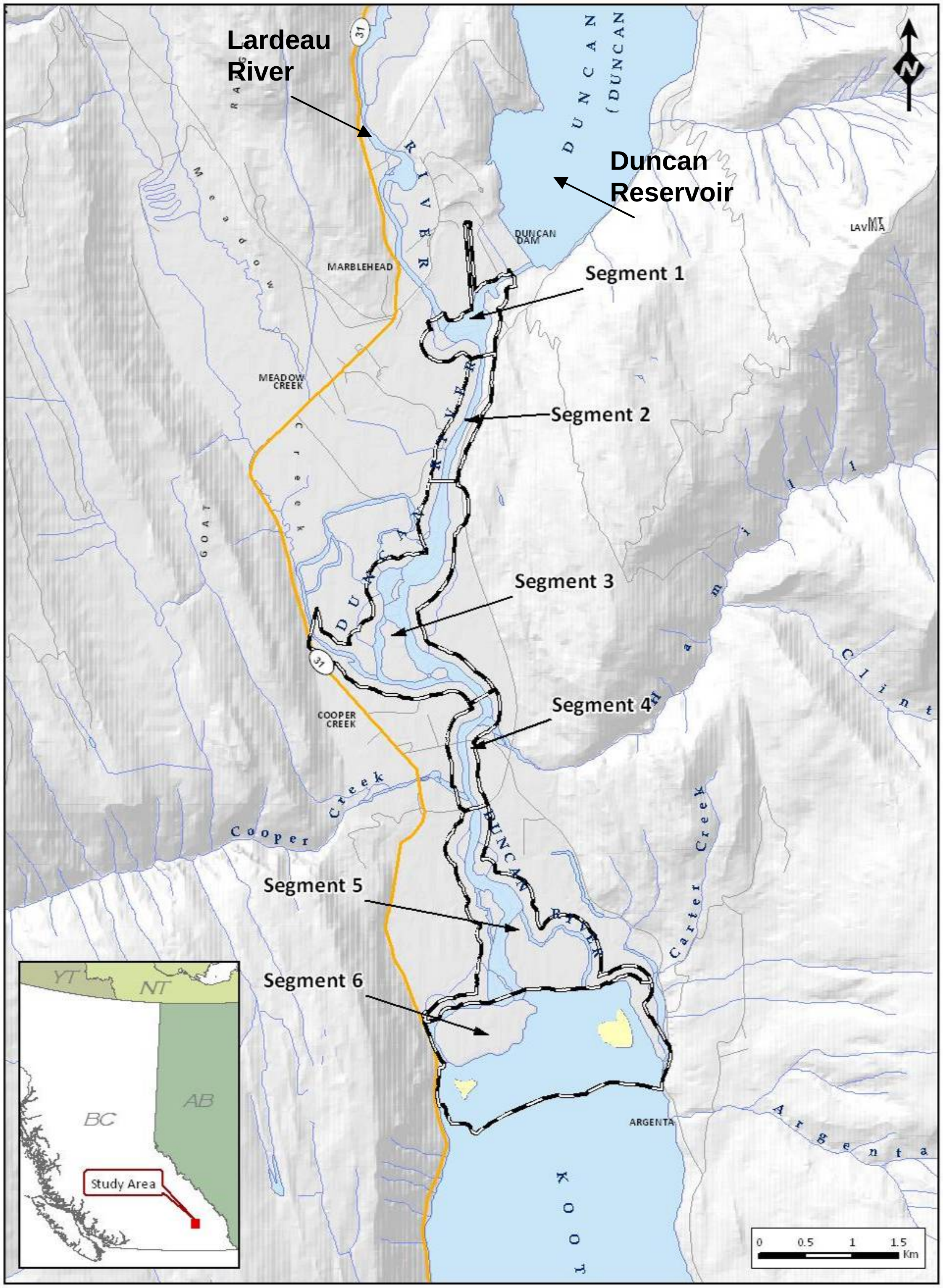


Figure 2-1: **Study area for the lower Duncan River with stratification of the river study segments.**

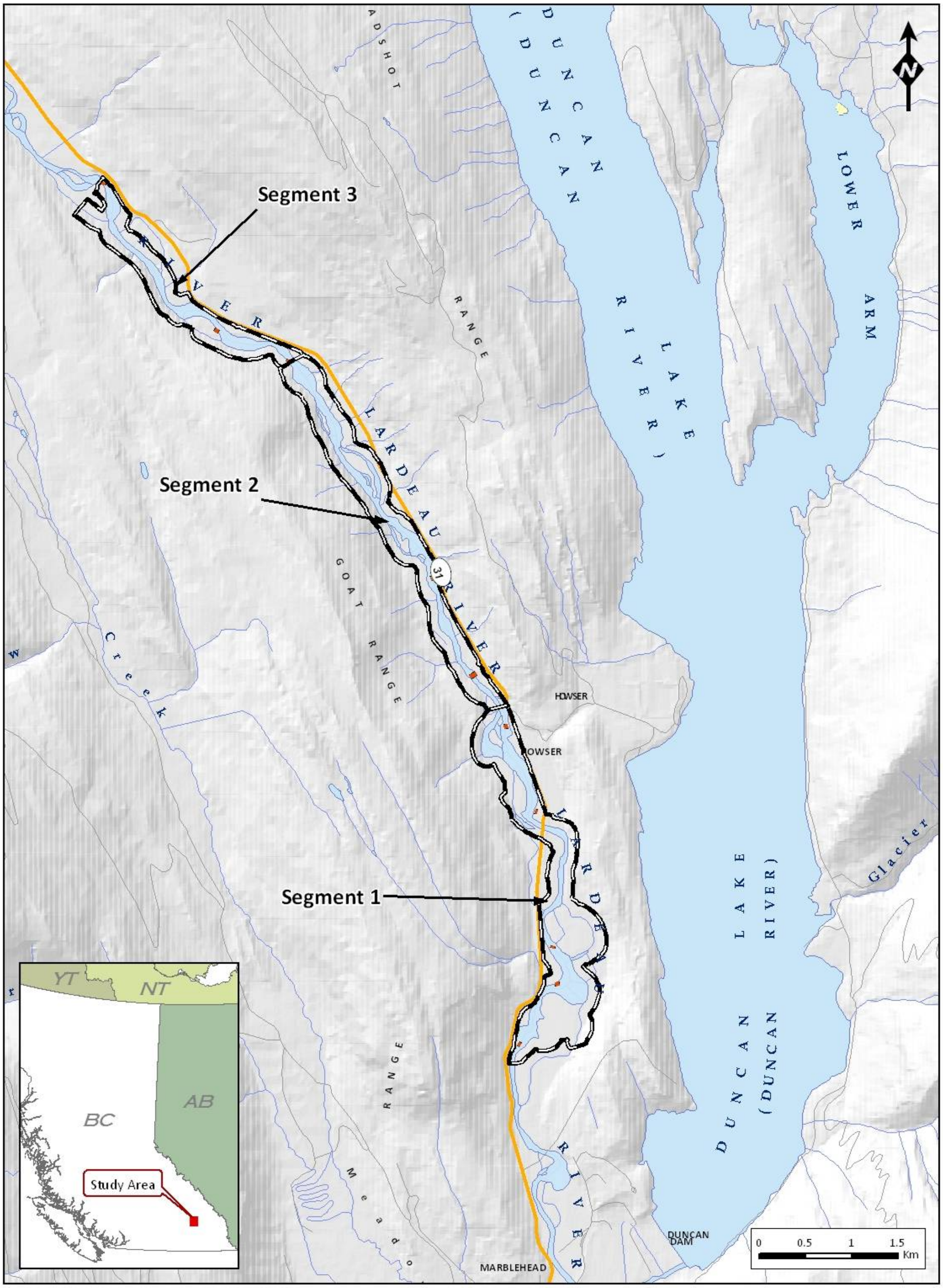


Figure 2-2: Study area for the Lardeau River with stratification of the river study segments.

2.2 Sampling Design

Year 4 (2013) of this study utilized the study design from Year 1 (see Polzin et al. 2010) with the modifications implemented in Year 3 (2012; Polzin and Rood 2013). Additional transect lines were established to replace lines scoured from past flood events. Location selection followed the study design from Year 1, with random selection from the sequence of candidate positions along a particular geomorphic segment. New transect lines were surveyed for elevation profiles and existing transect lines were resurveyed to update elevational profiles and to determine where deposition and erosion occurred along transect lines since 2009. In brief, the sampling design included the following tasks and collection of the following data for 2013:

- Establish new transect lines;
- Complete elevational profile surveys along each transect line;
- Collect seedling information from 2013 cottonwood germinants and previously measured seedlings from 2011 and 2012;
- Collect transect-specific stages at locations with gradually sloping point bars.
- Download hydrometric records from Water Survey of Canada stations 08NH118, and 08NH007 for hydrometric analyses;
- Download precipitation and temperature records (Duncan Lake Dam station at Meadow Creek station 1142574) for climate analyses; and
- Describe cottonwood phenology, timing of development.

The Duncan Reach was stratified into six segments and the Lardeau Reach into three based on channel morphology (Polzin et al. 2010). Each segment was sampled using randomly select transect lines for the Duncan Reach (Figure 2-3) and Lardeau Reach (Figure 2-4; see Polzin et al. 2010 for details).

There were seven new transect lines surveyed in 2013 along the lower Duncan reach. Five new transect lines were randomly selected for the Duncan Reach Segment 3 in the spring of 2013. Utilizing 2012 air photos and knowledge of the river for possible recruitment zones, candidate areas were identified, potential transect lines drawn and five randomly selected transect location coordinates were recorded within these candidate areas. Three of the lines replaced three lines that were dropped in 2010 since they did not actually occur in cottonwood recruitment zones. Two additional lines were selected to replace two lines that were located near the mouth of an anatomising channel of the Duncan River were Meadow Creek inflows. The area where the transect lines occurred were impacted by the stage of the Duncan River with water backing up this channel past the transect lines. Data collected in the past three field seasons indicated no establishment along transect lines or observed cottonwood establishment/recruitment on the point bars post-Alt S73. This zone was very similar to some of the delta area of the Duncan River (D6) with willow recruitment but no cottonwood recruitment. Two new transect lines with locations randomly selected were located on the main stem of the Duncan River in segment 3 (D3) for cottonwood recruitment monitoring. This resulted in 10 transect lines in D3 as originally designed in 2009.

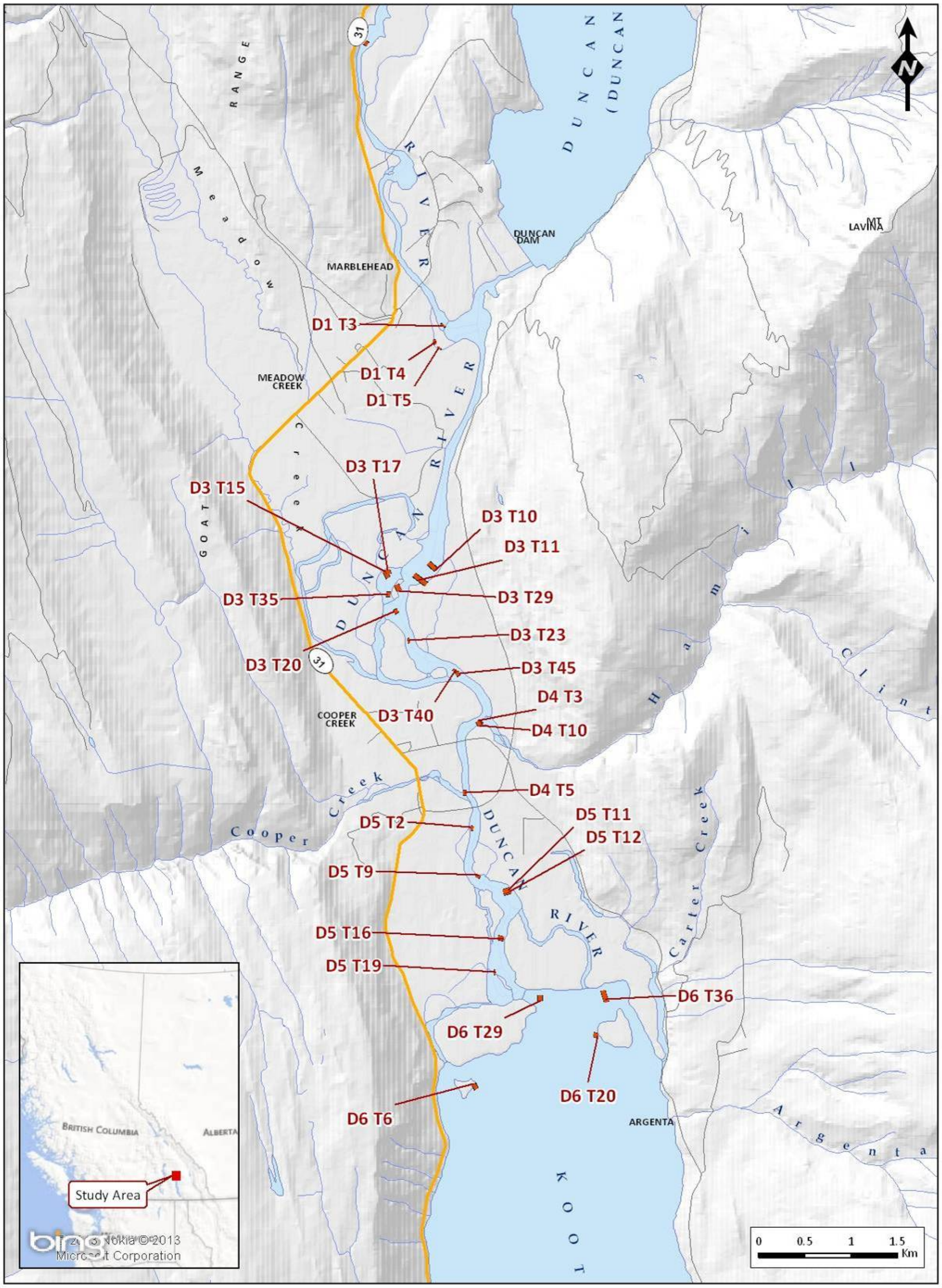


Figure 2-3: **Lower Duncan River study transects in 2013. Segments are indicated by the number following D (Duncan), and transect numbers are indicated after the T (transect).**

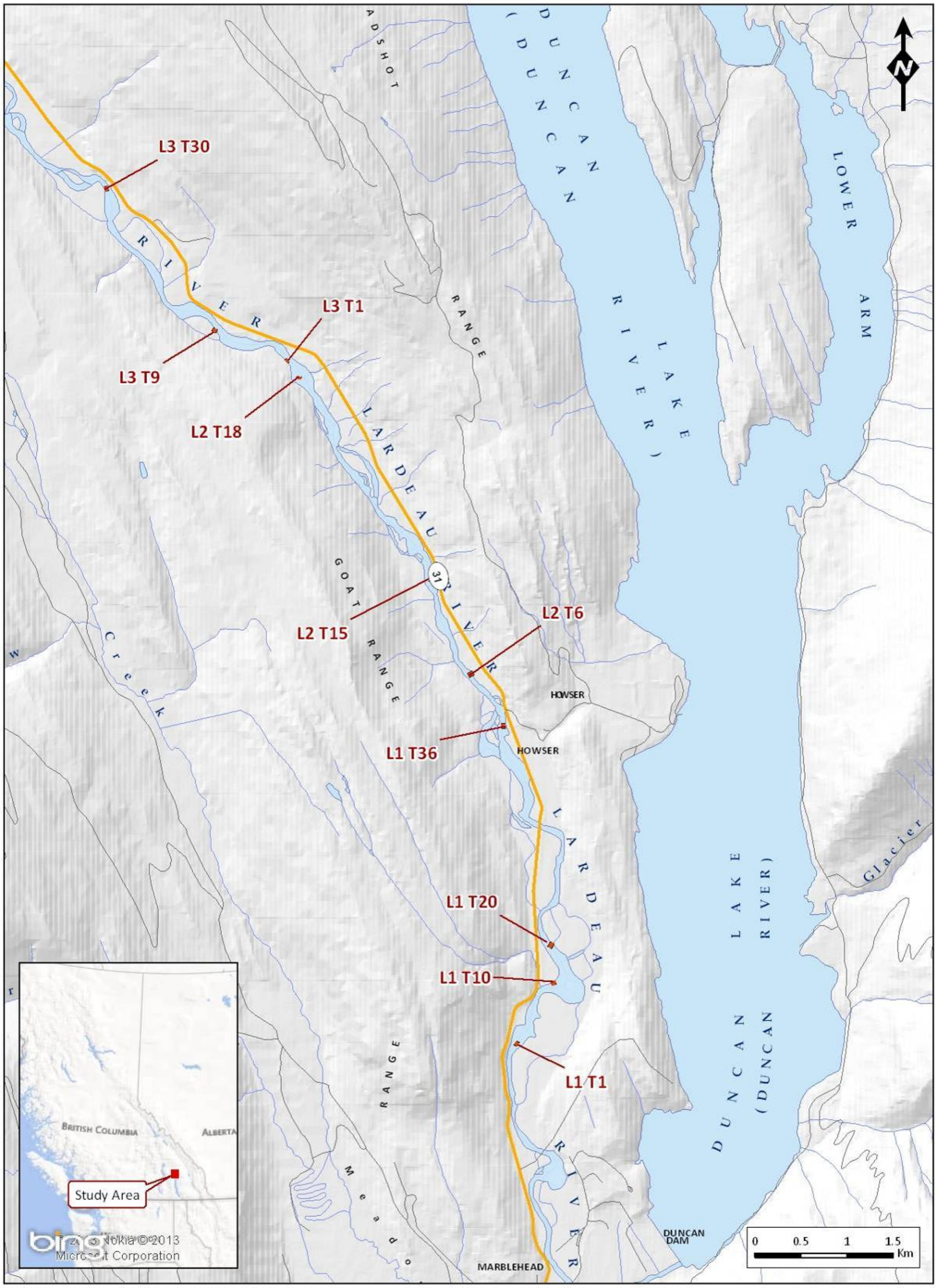


Figure 2-4: **Lardeau River study transects in 2013. Segments are indicated by the number following L (Lardeau), and transect numbers are indicated after the T (transect).**

One new transect line was required in D4 to replace D4T1 which was scoured away by Hamill Creek in 2012. A randomly selected position was chosen between the only two possible point bars in D4. Additionally, one new transect line was established in D6 to replace D6T26 which was buried by a massive log jam. The point bar was constant with a new, randomly selected location acquired so it would represent the same point bar and with similar riparian vegetation and cottonwood recruitment.

The Lardeau reach also required the establishment of two new transect lines in 2013. Segment L3 had T29 that was completely scoured away in 2012. A new transect line location on the same point bar was randomly positioned and T30 was surveyed for elevational profile. This allowed for similar riparian and mature cottonwood zones as recorded in 2009, and will allow for monitoring the remaining project years. The L1T20 transect line was mainly scoured away leaving 6 m of the original 27 m. It was not set up on a point bar in 2009 and so it was dropped and a new transect line location was randomly selected in segment L2 so there would be three transect lines instead of two representing that segment.

2.3 Seasonal Weather

Daily precipitation and temperature data were downloaded from Environment Canada's website for the Duncan Lake Dam station at Meadow Creek, climate ID: 1142574:

http://climate.weather.gc.ca/climateData/dailydata_e.html?timeframe=2&Prov=&StationID=1115

Data were for the years 2010, 2012, and 2013 from January to December except for 2013 as the accessed record ended August 31, 2013 (last checked January 23, 2014). Historical averages for precipitation were also downloaded.

2.4 Hydrology

The 2013 river discharge (*Q*) and stage data were downloaded from Environment Canada's Water Survey website[1] for the lower Duncan hydrometric station. The Lardeau River provisional discharge data were provided by special request from Environment Canada's water office. Hydrometric data were from the following stations:

1) Station 08NH118: located on the lower Duncan River, below the dam and below the confluence of Lardeau River (downstream (d/s) station), the 2013 data are provisional; and
2) Station 08NH007: located on the Lardeau River at Marblehead located approximately 700 m upstream of the confluence with the lower Duncan River, the 2013 data are provisional).

The Lardeau River record was only available to October 8, 2013 when requested November 18, 2013.

2.5 Cottonwood Phenology

We documented cottonwood phenology, the seasonal timing of developmental and reproductive events. This was through visual observations from a fixed vantage point

[1] http://www.wateroffice.ec.gc.ca/graph/graph_e.html?mode=text&stn=08NH118&prm1=3&prm2=-1&syr=2010&smo=1&sday=1&eyr=2010&emo=11&eday=21&y1min=&y1max=&y2min=&y2max=&max=0&min=0&mean=0&median=0&upper=0&lower=0&max2=0&min2=0&mean2=0&median2=0&upper2=0&lower2=0

that provides an excellent overview of the lower Duncan floodplain. Dispersing cottonwood seed release dates were recorded as well as the apparent rate of the dispersal (low, medium, or high quantity of seed).

2.6 Elevation Profile Survey

Elevations along the length of each transect were surveyed in 2009 along the Duncan and Lardeau Rivers (detailed methods in Polzin et al. 2010). The start of the transect line is referred to as the Point of Commencement (POC), the end of the transect (EOT) is at river's edge. Each transect line was re-surveyed in 2013 using a Topcon total station model GTS-225. All survey points from 2009 were resurveyed in 2013 as well as start and end of new deposition, erosion, and changes in the profile since 2009. New replacement lines were established following methods in the Polzin et al. (2010) report. Additionally, a bench mark (BM1) (a large spike was used as a permanent mark established at a known elevation and position from which other elevations were established and serves as a reference in topographic surveys) was established on all lines and a secondary bench mark (BM2) was established for lines completed the first and part of the second day. The second bench mark was proving to be too time consuming so it was dropped for the remaining transects. All POC's, EOT's, BM1's, BM2's, and total station locations were recorded and provided in Appendix 1. These survey data were used to update the elevational profile, develop site-specific stage versus discharge rating curves, and characterize hydrogeomorphic requirements for *seedling safe site* development (see Polzin et al. 2010 and Polzin and Rood 2006). Individual transect line profiles showing 2009 and 2013 profiles are located in Appendix 2.

2.7 Field Visits

Three field visits occurred in 2013: April 29 to May 4, July 22 to 26; and September 30 to October 4. The first 2013 field visit occurred before spring high water, allowing surveying profiles of the recruitment zones and the higher elevations of the active channel. The stage during the field work was above base stage by 0.312 to 0.32 m. Base stage was the typical stage for late September into early October before the Duncan Dam was constructed. The second visit and first cottonwood recruitment monitoring for 2013, occurred during discharges for the Duncan averaging 200 m^3/s to 250 m^3/s. This resulted in many of the recruitment areas being submerged while others had just recently emerged from higher flows. The third and final field visit occurred during low flows to assess the establishment and survival of the seedlings during the 2013 growing season.

2.8 Seedling Establishment and Recruitment

Belt transects were randomly located within pre-stratified segments and pre-identified recruitment areas as described in the Study Design Section 2.2. Cottonwood seedling density and height (10 seedling heights recorded when greater than 10 seedlings occurred within a quadrat, for average height calculations) were collected for 2011, 2012 and 2013 seedlings.

Transect lines were resurveyed from the POC to river's edge in early spring 2013 as well as new transect lines. This procedure allowed us to quantify the amount of erosion and deposition along the transect lines that were established in 2009. The extent of erosion and deposition provides important information for addressing the three hypotheses for this project. Accurate survey profiles in the recruitment zone are also essential for accurate site-specific stage/discharge ratings assessments.

Data for cottonwood establishment for 2013 germinants, and for continuing 2012 and 2011 seedling survival and recruitment were collected during the July and September field visits. The field data collected were tied to distances along the surveyed transect lines, which provided surveyed elevation points from 2013. The link to transect distances will facilitate comparisons over time, by enabling assessment of sediment deposition and erosion, as well as revealing changes in vegetation patterns, including cottonwood colonization and survival.

Seedling occurrences were recorded within 1 m^2 quadrats on the downstream side of the transect lines. Seedling data collected included: height of 10 representative seedlings (if 10 or more seedlings occurred) and the number of seedlings for each year of seedling establishment in 2011, 2012, and 2013.

There was a change in seedling sampling methodology in 2012, details described in Polzin and Rood (2013). This streamlined the sampling in large patches or bands of seedlings. Seedling quadrats were completed where seedling establishment occurred along transect lines. However, in Years 1 and 2 we sampled every metre through the establishment band. In Year 3, and subsequent years, sampling occurs at the start (3 to 5 quadrats), mid-point (3 to 5 quadrats), and end point (3 to 5 quadrats) of each large band of seedlings. Very wide bands had start and mid-section sampled every 10 m (large patches), end points sampled, and mean densities were recorded for the quadrates between sampling points.

The term ‘recruitment’ is used to represent the successful contribution to the floodplain forest population (Rood et al. 2007). Recruitment is the result of two sequential but somewhat independent processes- establishment (or colonization) and survival:

Recruitment = Establishment (colonization) + Survival

The seedlings established in 2011 that survived to the October 2013 field sampling were considered successful recruits and we thus shift from tracking by seedling monitoring to vegetation monitoring utilizing cover by species to track growth and cover expansion.

Photos taken during the 2013 field season are documented in Appendix 3 and contact sheets of photos are located in Appendix 4. Original digital images are supplied on a compact disc (DVD) with the final report.

2.9 Groundwater Monitoring

Groundwater monitoring in the first two years of the study (2009 and 2010) was completed using Solinst 3001 LT Leveloggers (piezometers). These were installed in the groundwater wells established in 2009 and a Solinst 3001 LT barologger provided barometric data for correction. The results revealed almost complete correspondence in the water table elevation across the individual piezometers for both years. Groundwater table elevation also corresponded tightly with river stage at the gauging station 08NH118. This indicated that the alluvial groundwater table is recharged by water freely infiltrating near-horizontally from the river. Following the confirmation in the second year, groundwater monitoring was reduced to every third year. In 2013, piezometers were installed during the spring resurvey of the transect line profiles. Seven loggers were installed at D3T11 at POC, D3T15 at POC, D3T15 at 6.4 m, SH2 at 24.0 m, D5T16 at

POC, and D3 with two located on a high terrace behind D3T11 labelled D3 Deep1 and D3 Deep 2.

2.10 Transect-Specific Stage/Discharge Relationships

The position of the water's edge along each transect was determined at each visit to permit site-specific stage-discharge rating curves. Transect and quadrat positions are subsequently expressed relative to the transect elevation of the river at a base flow of 57.8 m^3/s (1.52 m at Duncan station 08NH118) as described in Polzin et al. 2010. The Lardeau River base flow of 11.1 m^3/s (0.843 m at Lardeau station 08NH007) was used for transect elevation of the river.

2.11 Data Analyses

Data analyses focused on addressing the second key management question in relationship to cottonwood seedling establishment and recruitment. This involved comparisons between seedling establishment and recruitment across the 2011, 2012, and 2013 data sets. Comparisons were conducted between segments and to the free flowing Lardeau River transect lines.

Statistical analyses were conducted using SPSS 12.0 (SPSS Inc., Chicago) and all tests were interpreted with an alpha of 0.05. Descriptive statistics were used with Explore in SPSS. ANOVA and t-tests were used to compare 2013 versus previous year seedling densities, seedling heights, precipitation, and erosion and deposition for the lower Duncan and lower Lardeau reaches and to test for significant differences between the two reaches of the previously mentioned parameters.

3 RESULTS

3.1 Weather

The past sampling year (2013) experienced similar mean temperatures (though slightly warmer) through to August 30, compared to the previous sampling years (Figure 3-1). The mean daily temperature for the growing season (April to end of September) was similar for 2010 (13.3 °C), 2012 (13.9 °C), and 2013 (14.4 °C) with the 2013 season slightly warmer than the past sampling years. Paired T-Tests showed no significant difference between 2010 and 2013 (P = 0.064, *t* = -2.194, *df* = 7) and between 2012 and 2013 (P = 0.422, t = 0.853, *df* = 7).

Total monthly precipitation in 2013 was closer to the average than in 2012 (Figure 3-2). March total precipitation was higher than average and April and May total monthly precipitation were similar to the average. For the month of June, the total monthly precipitation was above average but not the extreme experienced in 2012. This was followed by precipitation that was lower than average for July and above average for August.

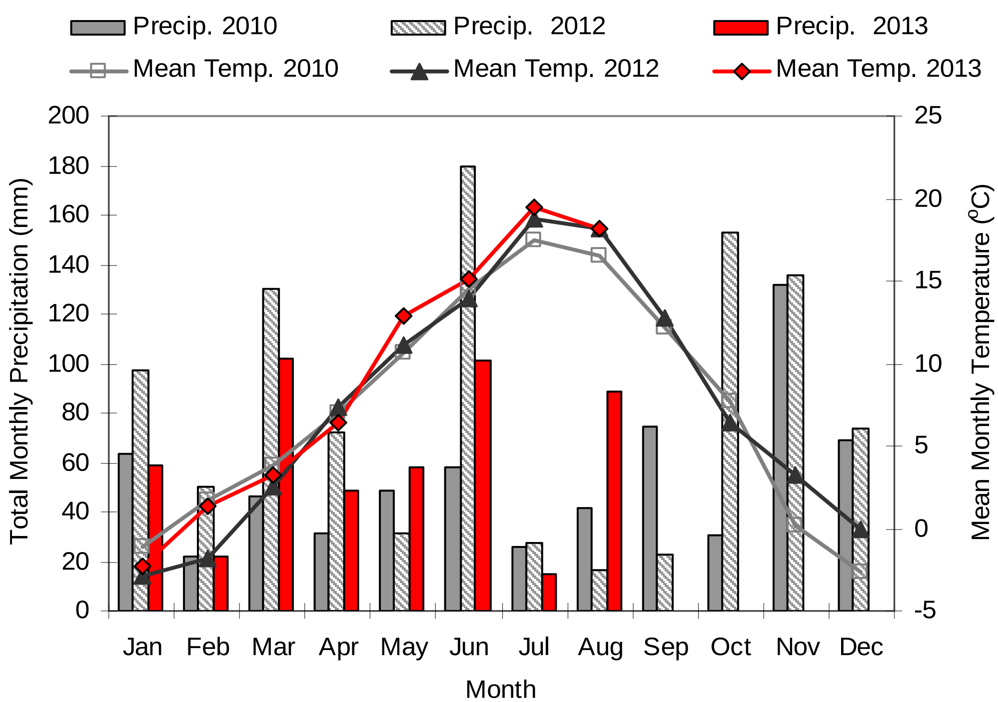


Figure 3-1: Duncan Lake Dam weather station at Meadow Creek monthly mean temperature and monthly total precipitation for 2010, 2012, and 2013 (sampling years). Available records ended August 30, 2013.

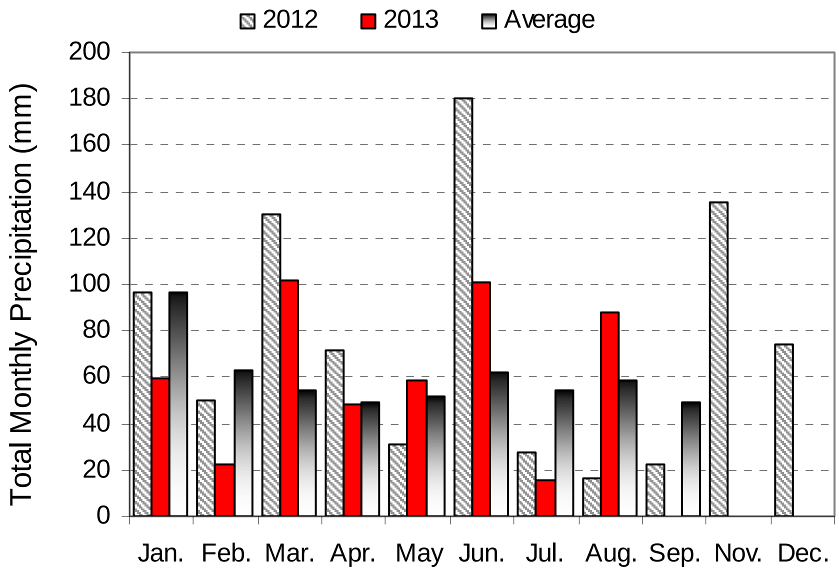


Figure 3-2: Canadian Climate Averages (1971 – 2000) for monthly total precipitation for the Duncan Lake Dam weather station with 2013 monthly precipitation for January through August and 2012 monthly precipitation for comparison between years.

The month of June, 2013, experienced an extreme rain event June 19, with 57 mm of rain (Figure 3-3). The following day experienced 10.7 mm of rain. There was slight difference between 2010, 2012, and 2013 mean precipitation for the full years with 2013 slightly lower than 2010 and 2012 (Figure 3-4; P = 0.064 2013, compared to 2010, and P=0.422, 2013 compared to 2012).

Both the Duncan and Lardeau rivers are snowmelt-dominated systems. As such, seasonal snow pack levels play a role in the extent of freshet flooding. Snow pack plays a role in freshet peak flows but weather determines the rate of snow melt and whether or not flood conditions occur. The Snow Water Equivalent (SWE) for 2012 and 2013 from Duncan Lake station 2D07A (archive manual snow survey data) is at 662 m elevation at the Marble Head Weather station, shows that 2013 had a lower SWE compared to 2012 and snow was melted by April 1st (Figure 3-5) in 2013.

The closest snow-pillow station in the surrounding mountains is 2D08P, north of Meadow Creek and on the east side mountains, with real-time snow pack data and at 2,004 m elevation. On May 1, the SWE level was ~ 990 mm which dropped to ~ 510 mm by May 12 due to above average temperatures with a maximum of 29.5 ^{o}C and a mean of 25.3 ^{o}C (above 27 ^{o}C for 5 days). The SWE for June went from ~500 mm to 100 mm in a gradual decline. This means that the rain event of June 19 was a rain-on-snow event at the higher elevations. Extreme precipitation and particularly the rain on June 19, 2013 during the freshet period resulted in freshet flooding for both the lower Duncan and Lardeau rivers and extreme flash flooding of Hamill and Copper creeks.

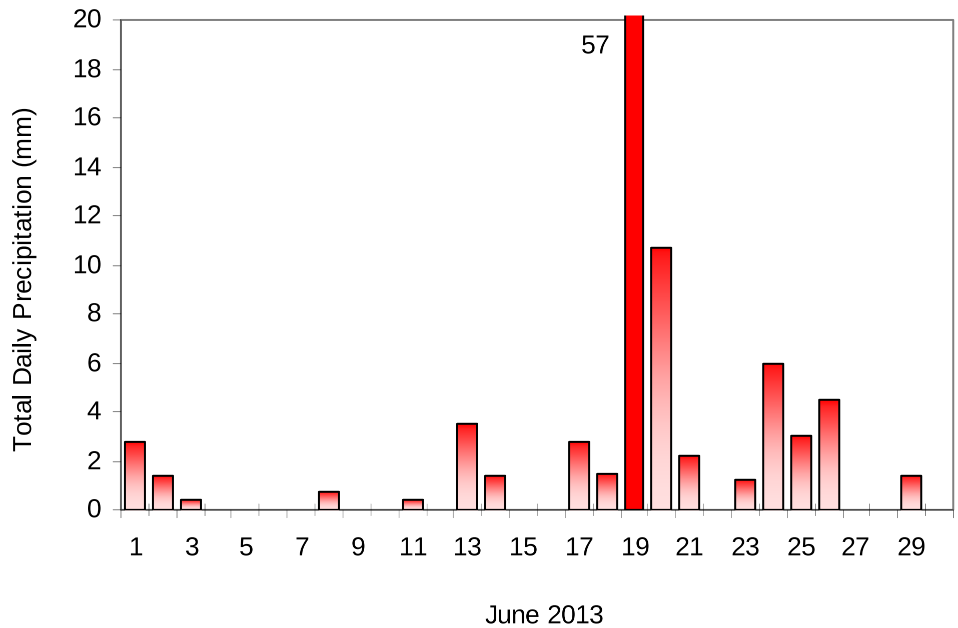


Figure 3-3: **Precipitation (mm) for the month of June 2013 at Duncan Lake Dam weather station. Total precipitation for the month of June was 100.9 mm.**

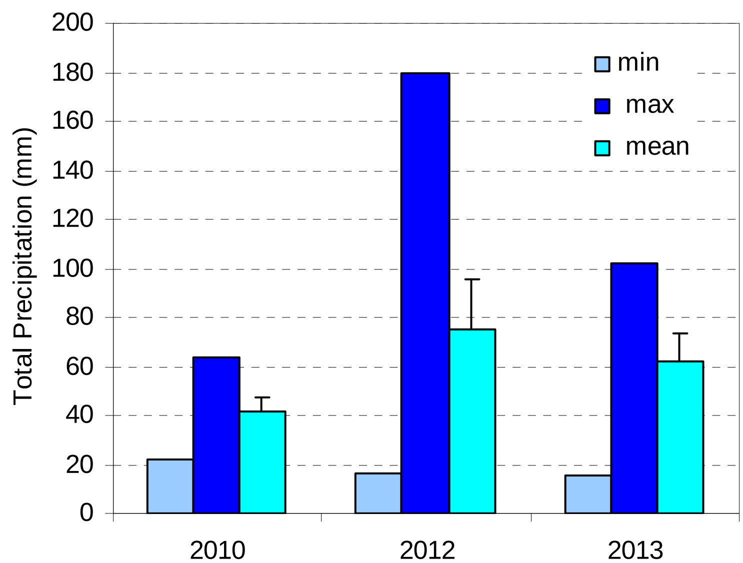


Figure 3-4: **The minimum, maximum and mean total precipitation for 2010, 2012, and 2013. Standard error bars are marked for the mean total precipitation.**

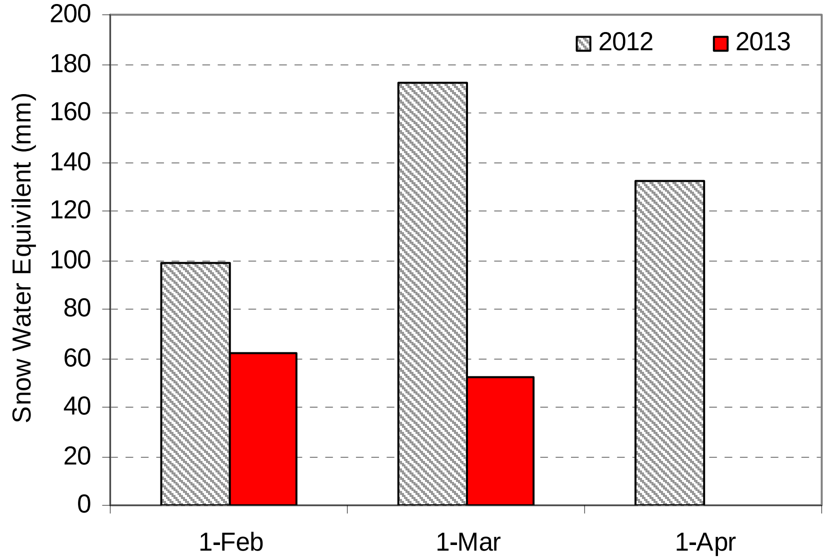


Figure 3-5: Snow water equivalent totals for the months February, March, and April at the station 2D07A Duncan Lake No. 2 at 662 m elevation at Marble Head weather station.

3.2 Hydrology

3.2.1 Duncan River

Mean monthly discharges during 2009 and 2010 were very similar in patterns, peaks, and timing (Figure 3-6). The sampling year of 2012 was an exception with the regular Alt S73 flow regime pre-empted by high snowmelt and rainfall in the Duncan Basin (see Polzin and Rood 2013). The past sampling year, 2013, had higher flows during the growing season compared to the start of Alt S73 but lower than 2012. However, 2013 did not follow a similar discharge pattern to the 2009 and 2010 sampling years. July had the peak flow in 2013 whereas June was the peak flow month for 2009, 2010, and the three year average of peaks before the dam was completed (pre-1967). July is when the initial seed establishment primarily occurs.

The daily mean data shows the variation that occurs during the month which is smoothed out by monthly means (Figure 3-7). The sampling years 2009 and 2010 both had two extended periods of peak flows, one during June and a second during August and September. The discharges from June 19 to September 1, 2013 were higher than 2009 and 2010 with the peak occurring July 8 (369 m^3/s) compared to June 16 (221 m^3/s) and June 23 (201 m^3/s) peaks in 2009 and 2010 respectively. Discharges were similar for 2009, 2010, and 2013 for September with flows slightly higher for 2013 from September 6 to 21 (Figure 3-7).

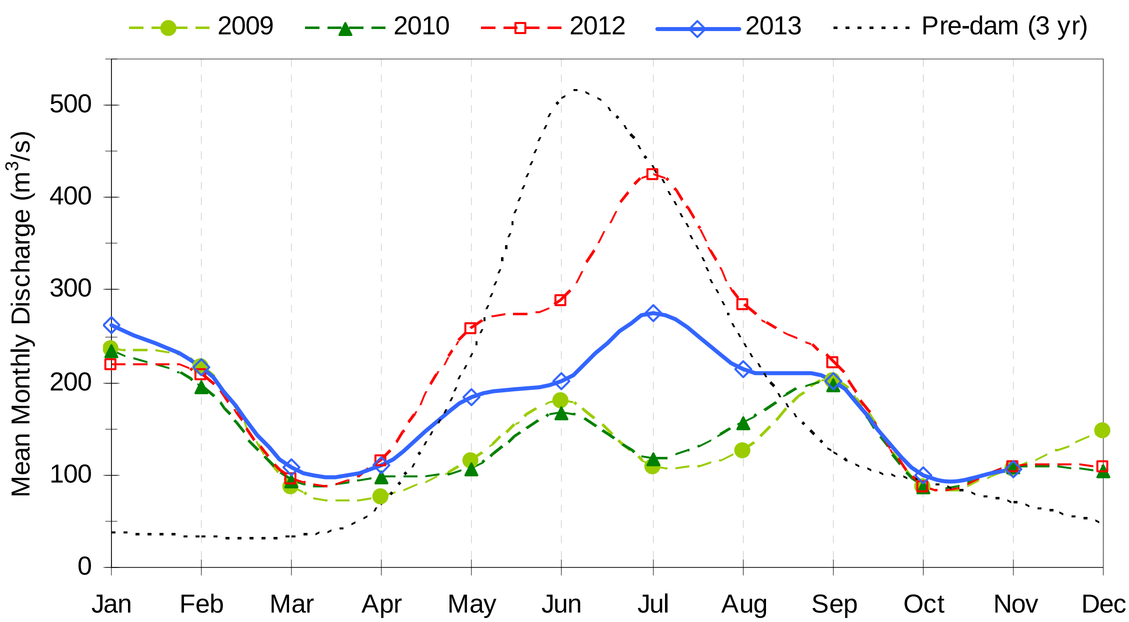


Figure 3-6: **Mean monthly hydrographs for the lower Duncan River for sampling years 2009, 2010, 2012, and 2013 and pre-dam (3 years of data) mean monthly discharges plotted with a smoothed lined.**

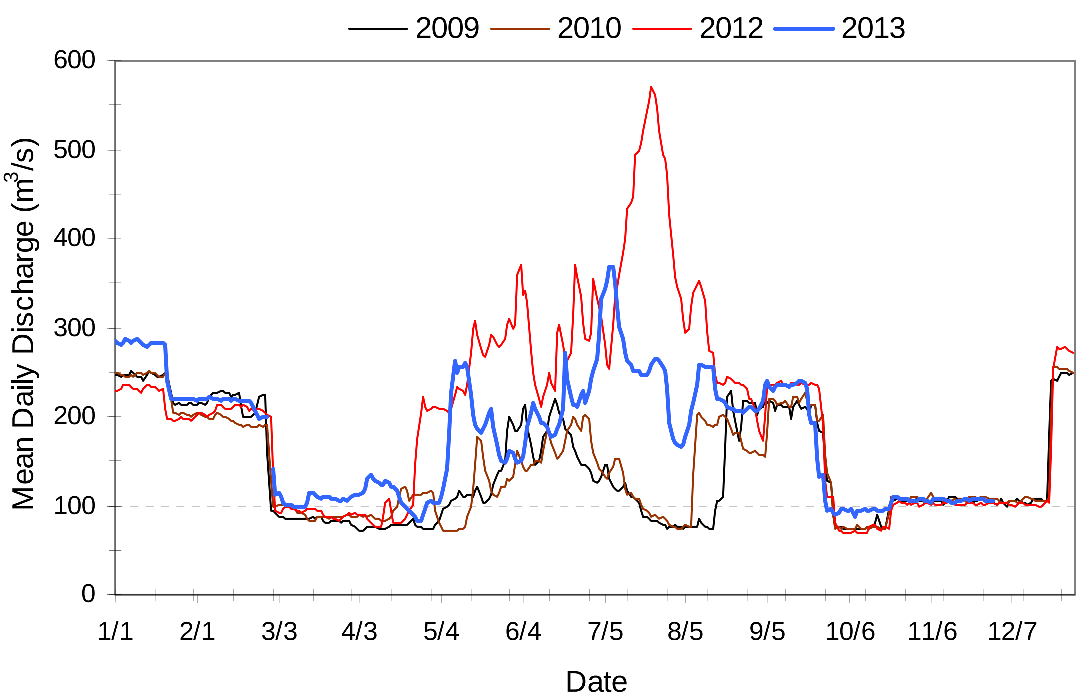


Figure 3-7: **Mean daily discharge (m^3/s) for 2009, 2010, 2012, and 2013 (provisional) for the lower Duncan River at Station 08NH118.**

3.2.2 Lardeau River

The Lardeau River (reference reach for the study) experienced an average spring freshet flood (Q_{max2} is the flood return period of 2 years) with a peak discharge of 269 m^3/s in 2013. This was compared to 2009 and 2010 which had bankfull freshets, and 2011 which had less than Q_{max5} and 2012 with less than Q_{max10} (Figure 3-8). The 2009 and 2010 years were averaged as well as the 2011 and 2012 years as they were very similar discharges (Polzin and Rood 2013). Flow records for the Lardeau River consisted of 70 years of records starting in 1917, with a period of missing records from 1920 through 1945. Flow records from two hydrometric sites were coordinated by regression analysis for the period of overlap for the missing years of 1997 through 2002 (Q_{max} at 08NH007 = Q_{max} at 08NH118 x 0.37, R^2 = 0.96, linear regression forced through origin). Recurrence analysis indicated that the 2013 flood along the Lardeau River was about a 1-in-2 year flood event (Q_2) see Polzin and Rood (2013) for detailed log Pearson Type III analysis. The 2009 and 2010 peak flows were less than Q_2 events that may indicate bank-full freshets.

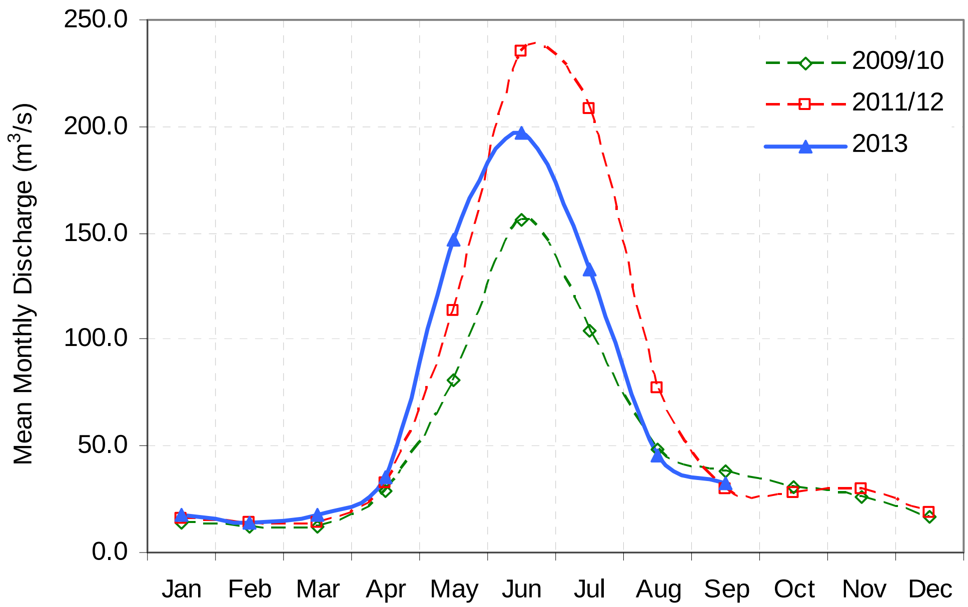


Figure 3-8: Mean monthly discharge (m^3/s) for the Lardeau River for 2013 and the average for years 2009 and 2010 and the average of 2011 and 2012.

The 2013 peak flow occurred on June 20, which was typical timing for the Lardeau River. Historically, 71 per cent of annual peaks have occurred within June. During the research years of this project, spring freshet occurred mid to late June (Table 3-1). The discharge gradually declined from June 20 to September as it approached base flow.

Table 3-1: Peak spring freshet discharge for the Lardeau River from 2009 to 2013 with log Pearson Type III flood return periods and predicted discharge levels.

Year	Month and Day	Peak Discharge	Return Period	Prediction (m^3/s)	Std. Dev.
2009	June 17	201 m^3/s	**10**	349.19	12.08
2010	June 29	183 m^3/s	**5**	319.48	9.46
2011	June 23	297 m^3/s	**3**	293.96	8.21
2012	July 1	314 m^3/s	**2**	269.22	7.43
2013	June 20	269 m^3/s			

3.3 Groundwater Monitoring

Groundwater monitoring in 2009 and 2010 indicated a very close correlation with the river stage. Because of this, well monitoring was reduced to every third year. Results in 2013 were similar to 2009 and 2010 results. The Duncan River hydrometric station 08NH118 is downstream of the Lardeau River confluence and 1 km upstream of segment D3T15. Well locations for D3Deep1, Deep2, D3T11_DE1, D3T15_DE1, SH1, and SH2 are illustrated in Figure 3-9. The close correlation between river stage and ground water for segment D3 wells can be seen in Figure 3-10 and Figure 3-11.

Figure 3-9: Well locations for segment D3Deep1, Deep2, D3T11_DE1, D3T15_DE1, SH1, and SH2.

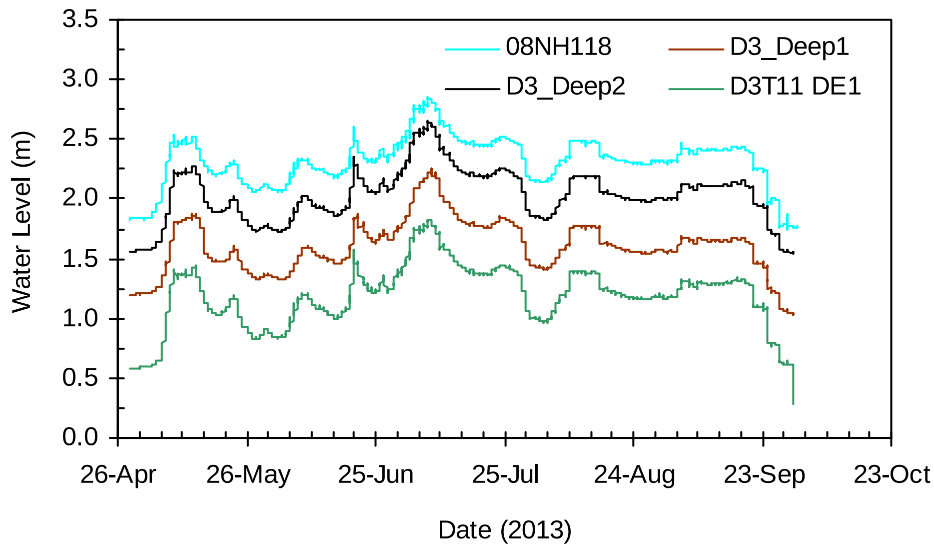


Figure 3-10: Duncan River stage at station 08NH118 and groundwater well levels above base stage for D3 deep wells. D3T11 DE1 is located at the POC for transect line 11. Station 08NH118 is provisional data levels. Well data are below ground levels corrected to base stage. Data have been spaced so 08NH118 would not be on top of D3_Deep2 and so D3_Deep1 would not be on top of D3T11 DE1.

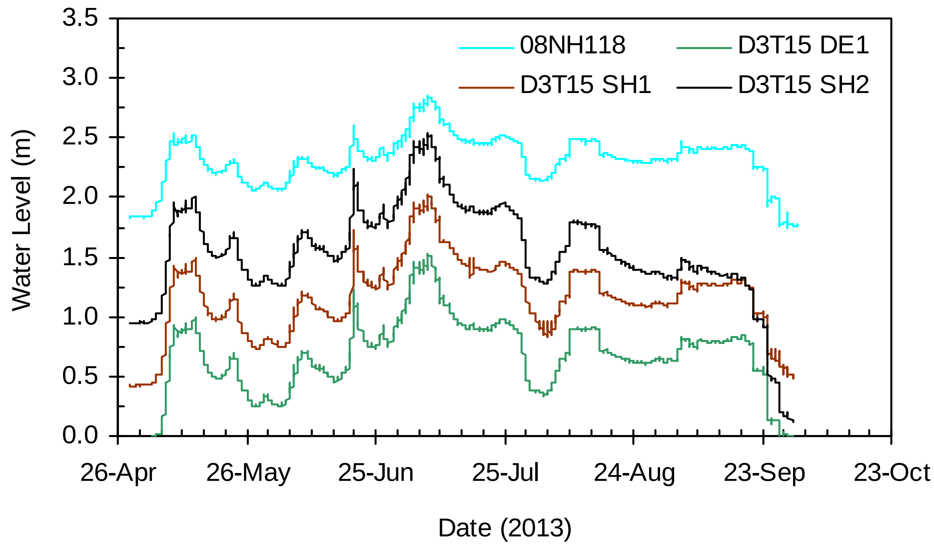


Figure 3-11: Duncan River stage at station 08NH118 and groundwater well levels above base stage for D3T15. D3T15 DE1 is located at the POC, D3T15 SH1 is 6.5 m from the POC, and SH2 is 24 m from POC. Station 08NH118 is provisional data levels. Well data is below ground levels corrected to base stage.

Segment D5 is approximately 6 km downstream of the hydrometric station 08NH118 and downstream of the Hamill and Cooper creeks confluences. The well D5T16 SH1 is located near the POC (0.8 m from POC) with D5T16 DE1 located 7.4 m from POC and is the highest point on the transect line while SH1 is the furthest away from the river's edge. Figure 3-12 illustrates the correlation between the gauging station and the groundwater levels in well D5T16 SH1.

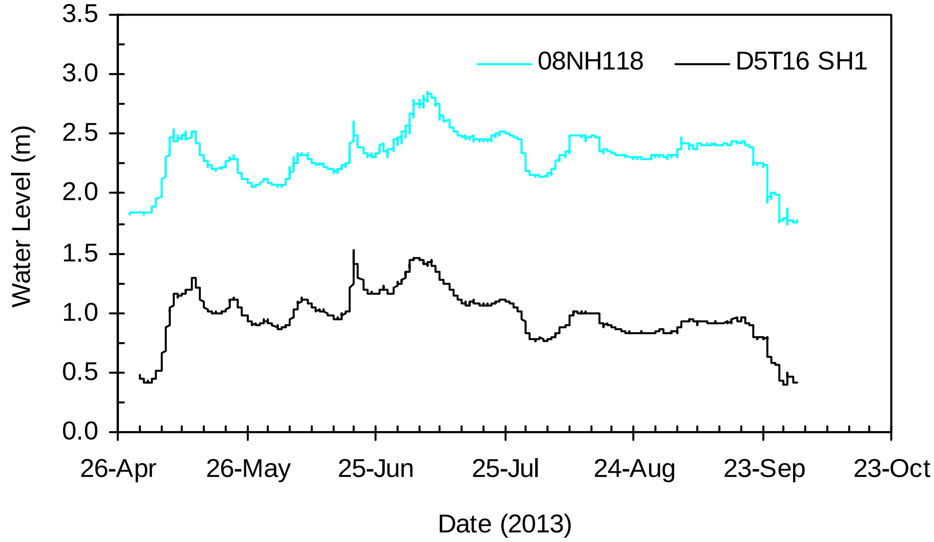


Figure 3-12: Duncan River provisional stage at station 08NH118 and groundwater well levels above base stage for segment D5T16.

3.4 Cottonwood Phenology

The first cottonwood seed dispersal in 2013 occurred from June 8 to 12, when several small seed bursts (events) were noted. Larger dispersal seed events then occurred between June 16 and 24 (Table 3-2).

Table 3-2: Seed dispersal events (seed release) with abundance, maximum temperature for the day, precipitation (rain), and mean maximum temperature for the event period.

Event	Date	Seed Abundance	T_{max} (°C)	Rain (mm)	Event T_{max}	Prior and Post Rain Events
1	Jun 9	Low	22	0	**23.2**	0 mm rain June 4 to 7th
	Jun10	Low	24.5	0		0.7 mm June 8th (rain)
2	Jun 12	Low	23.5	0	**23.5**	0.4 mm June 11
3	Jun 16	Medium	26	0	**22.3**	4.9 mm June 13 – 14th 0 mm June 15th
	Jun17	Medium	20.5	2.8		
	Jun 18	High	20.5	1.5		
4	Jun 22	Low	18	0	**21.0**	69.9 mm June 19 – 21st
	Jun 23	High	24	1.2		13.5 mm June 24 -26th

There was subsequent seed dispersal in early August resulting in seedling germination as revealed during the October field visit. However, that dispersal event was very limited and thus the occurrences were not recorded as part of the major seed release in 2013.

3.5 Cottonwood Establishment and Recruitment along the Lower Duncan and Lardeau Rivers

3.5.1 Seedling Abundance

Following the 2013 field inventories, a total of 334 sampling quadrats along the lower Duncan River had cottonwood seedlings, and these had originated as 2011 to 2013 seedlings. This was within the range of the previous 2009 and 2010 sampling years, with 272 in 2009 and 364 in 2010 (Table 3-3). However, Segment 6 did not have any seedlings while 2009 and 2010 had 83 and 85 quadrats respectively. The number of 2013 quadrats for the Duncan was above the average (245.5) from the four years of sampling, but only slightly above average (323.3) when the flood year of 2012 was removed.

The total number of 2013 germinants (seedlings established in 2013) (14,078) was also lower than observed for the 2009 and 2010 sampling years. The 2013 count was 11 per cent of 2009 seedling and 62 per cent of 2010 seedling counts. The flood year of 2012 had less than 1 per cent (0.87 per cent) of the number of seedlings, as compared to 2013. Seedling counts were below average for 2013 and 2010 with the average germinant count for the three sampling years (2012 removed) of 53,621 for the lower Duncan River.

Table 3-3: Comparisons of 2010, 2012, and 2013 numbers of quadrats with seedlings and number of germinants for the corresponding year, for each transect along the Duncan River (Dun = Duncan, Seg = Segment, Tran = Transect, Quad = Quadrats, Seed = Seedlings).

Dun Seg	Tran	2009		2010		2012		2013	
		# Quad	# Seed	# Quad	# Seed	# Quad	# Seed	# Quad	# Seed
D1	T3	6	18,340	15	3,197	8	52	21	857
	T4	0		0		0		0	
	T5	0		0		0		0	
D3	T10	0		5	139	0		0	
	T11	1	1,200	4	142	0		54	2,084
	T15	63	53,190	61	7,372	1	1	17	1,075
	T17*							14	851
	T29*							28	1,267
	T35*							11	1,221
	T20	11	3,220	13	784	0		13	609
	T23	6	442	3	64	0		0	
	T40*							2	6
	T45*							17	370
	~~T37~~	~~2~~	~~720~~	~~1~~	~~54~~	~~0~~			
	~~T39~~	~~2~~	~~350~~	~~3~~	~~94~~	~~0~~			
D4	~~T1~~	~~3~~	~~40~~	~~20~~	~~553~~	~~2~~	~~4'~~		
	T3	2	59	31	48	1	65	64	3,003
	T10*							35	813
	T5	3	720	32	249	0		0	
D5	T2	14	2,020	12	296	0		11	90
	T9	17	8,860	20	2,276	0		5	571
	T11	11	2,344	5	20	0		22	787
	T12	37	12,048	34	5,260	0		4	8
	T16	3	110	12	5	0		13	260
	T19	8	2,115	8	614	0		3	206
D6	T6	1	1,600	0		0		0	
	~~T26~~	~~19~~	~~2,280~~	~~14~~	~~46~~	~~-----~~			
	T20*							0	
	T29	28	9,748	30	1,400	0		0	
	T36	35	4,550	41	217	0		0	
Totals		**272**	**123,956**	**364**	**22,830**	**12**	**122**	**334**	**14,078**

Note: * indicates new transect lines established 2013.
~~1~~ indicates lines were dropped because of erosion, burial, or lack of cottonwood seedlings (only willow seedlings D3 T37 & D3T39).

We had an increase in the number of quadrats along the Lardeau River (102) with seedlings in 2013 as compared to the flood year of 2012 (42). This was above the average (90.5) for the four sampling years and slightly under the average (106.7) if the flood year of 2012 was removed (Table 3-4). The total germinant counts were higher in 2013 compared to 2012, similar to 2010 and lower than 2009 but only slightly higher than the average count of 5,327 for the four years.

Table 3-4: Comparisons of 2010, 2012, and 2013 numbers of quadrats with seedlings and number of germinants for the corresponding year, for each transect along the Lardeau River (Lard = Lardeau, Seg = Segment, Tran = Transect, Quad = Quadrats, Seed = Seedlings).

Lard Seg	Tran	2009		2010		2012		2013	
		# Quad	# Seed	# Quad	# Seed	# Quad	# Seed	# Quad	# Seed
L1	T1	11	730	17	143	7	2,258	13	523
	T10	20	2,820	28	3,215	18	1,145	20	3,895
	T20	15	1,430	22	785	11	42	19	415
	~~T27~~	~~3~~	~~0~~	~~0~~	~~0~~	~~----~~	~~-----~~		
	T36	0	0	12	138	2	13	17	687
L2	T6	16	1,060	39	1,211	1	4	15	31
	T15	0	0	5	220	3	12	1	1
	T18*							13	122
L3	T1	8	289	14	86	0	0	1	1
	T9	0	0	7	24	0	0	3	7
	T30*							0	0
	~~T29~~	~~0~~	~~0~~	~~1~~	~~1~~	~~----~~	~~-----~~		
Totals		**73**	**6,329**	**145**	**5,823**	**42**	**3,474**	**102**	**5,682**

Note: * indicates new transect lines established 2013.
~~1~~ indicates lines were eroded away

3.5.2 Seedling densities

In 2013, cottonwood germinant densities ('densities' will be used to refer to the germinant densities) along the lower Duncan River were significantly higher than in 2012 and significantly lower than 2010 (Table 3-5). Box plot comparisons between densities for 2010, 2012, and 2013 illustrate the magnitude of differences for the Duncan Reach between years (Figure 3-13). Densities in 2013 had lower counts within 1 m^2 quadrats compared to 2010.

The Duncan segments showed recovery compared to 2012 except for segment D6 which had no seedlings in 2012 or in 2013 (Figure 3-14). Segment D4 had significant increase in densities in 2013 versus 2010 (Table 3-6). Segments D1, D5, and D6 had significant decreases in densities in 2013 compared to 2010. Segment D3 had a decrease in densities but not significant. The Duncan reach had significantly lower densities compared to the Lardeau reach (Table 3-5).

The Lardeau River had a significant decrease in densities in 2013 compared to 2012. However, 2013 was similar to 2010 seedling densities (Table 3-5; Figure 3-13). However, comparisons between segments show that Segment 1 (L1) had the majority of the germinants, and was consistent with 2012 and 2010 monitoring years (Table 3-7). Segments L2 had a slight decrease in mean density in 2013 (5.7 seedlings/quadrat) compared to 2012 (6.0 seedlings/quadrat), however; there were only two quadrats with seedlings in 2012 and 25 quadrats in 2013. L3 had a significant increase from 0 seedlings/quadrat in 2012 to 8 quadrats with seedlings in 2013 (Figure 3-15). L3 had a very dramatic decrease in density from 2013 compared to 2010 (Table 3-7).

Table 3-5: T-Test results for comparison of mean seedling densities for the Duncan and Lardeau reaches for 2013, 2012, and 2010.

Comparison	*t*	*P*	*df*
Duncan 2013 to 2012	10.76	< 0.00	768
Duncan 2013 to 2010	-3.3	0.001	768
Duncan vs Lardeau 2013	-2.78	0.006	475
Lardeau 2013 to 2012	-2.29	0.02	116
Lardeau 2013 to 2010	0.66	0.51	199

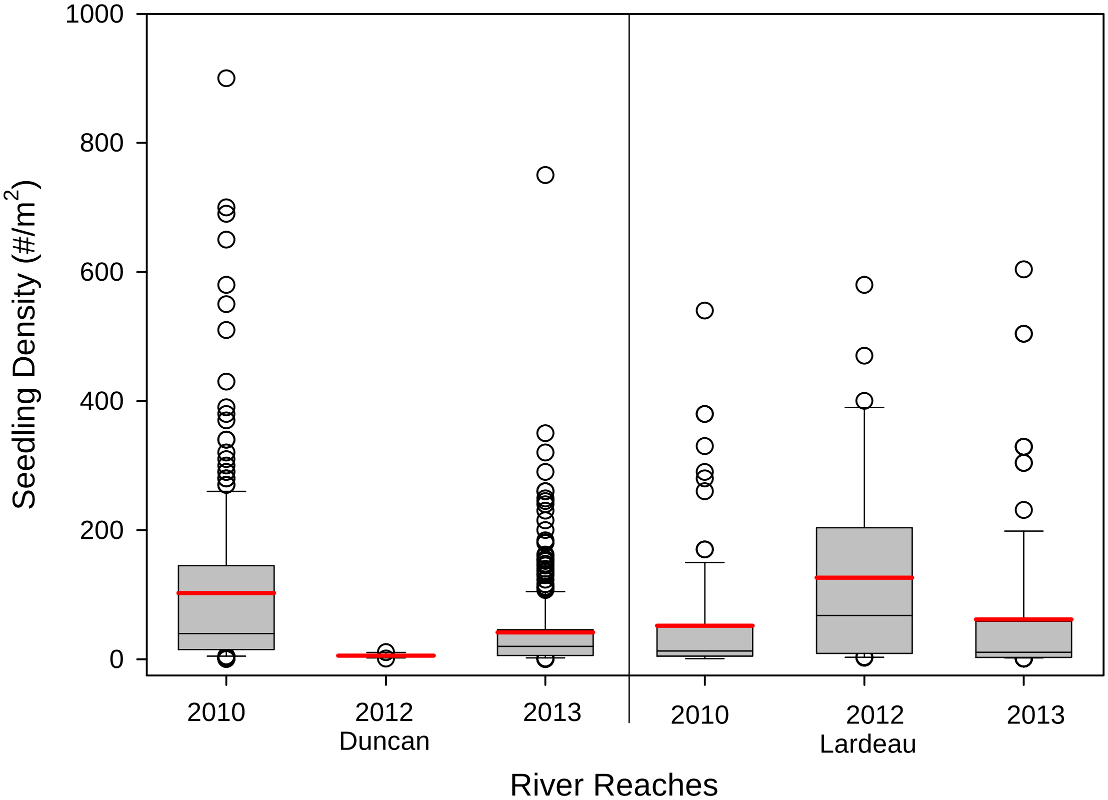


Figure 3-13: The 2010, 2012, and 2013 cottonwood germinant densities for the Duncan (left) and Lardeau (right) study reaches.

For box plots, the lower boundary of the box indicates the 25th percentile, the black line within the box marks the median, the wider red line marks the mean and the upper boundary indicates the 75th percentile. Whiskers above and below the box indicate the 90th and 10th percentiles. Outliers are indicated with an open circle.

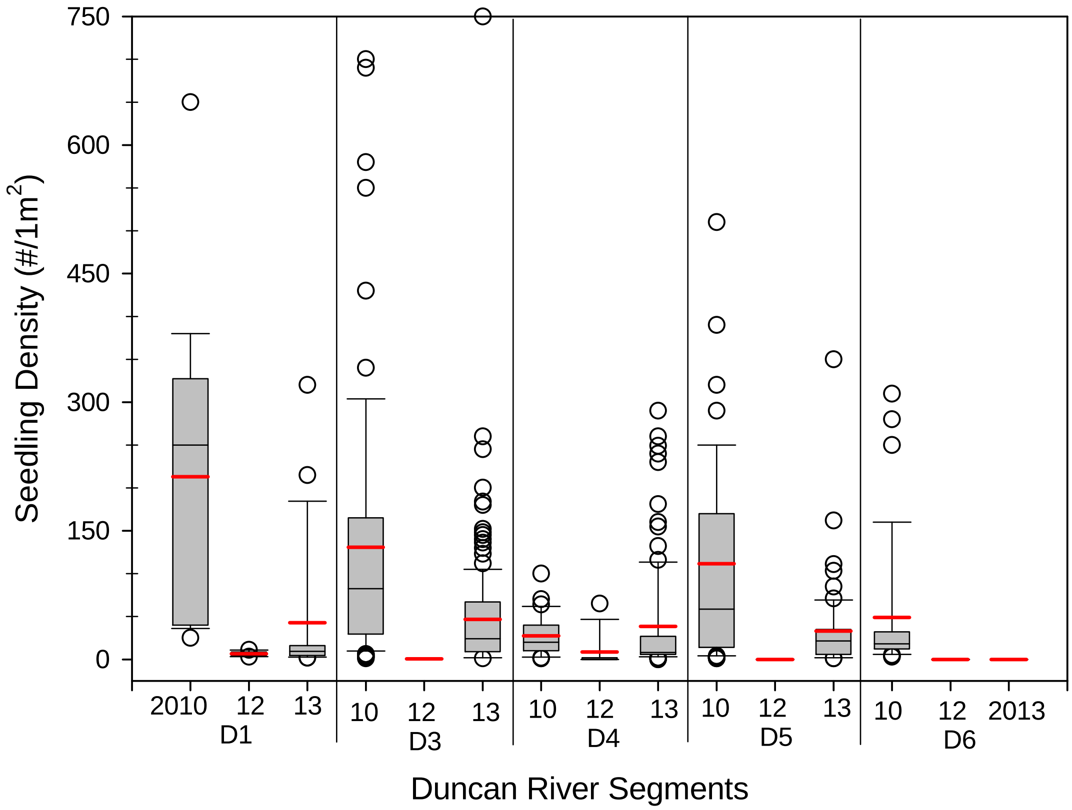


Figure 3-14: **Germinant densities for 2013 compared to 2012 and 2010 for each segment along the lower Duncan (D) River. Segment D5, 2010 has an outlier of 900 stems per m^2 but was cut off to increase detail for the box plots.**

Table 3-6: **T-Test comparison of density means for the Duncan segments for 2013 versus 2010.**

Comparison	*t*	*P*	*df*
D1 2013 to 2010	-2.60	0.01	38
D3 2013 to 2010	-0.62	0.54	310
D4 2013 to 2010	4.60	<0.00	196
D5 2013 to 2010	-5.05	<0.00	150
D6 2013 to 2010	-3.60	<0.00	66

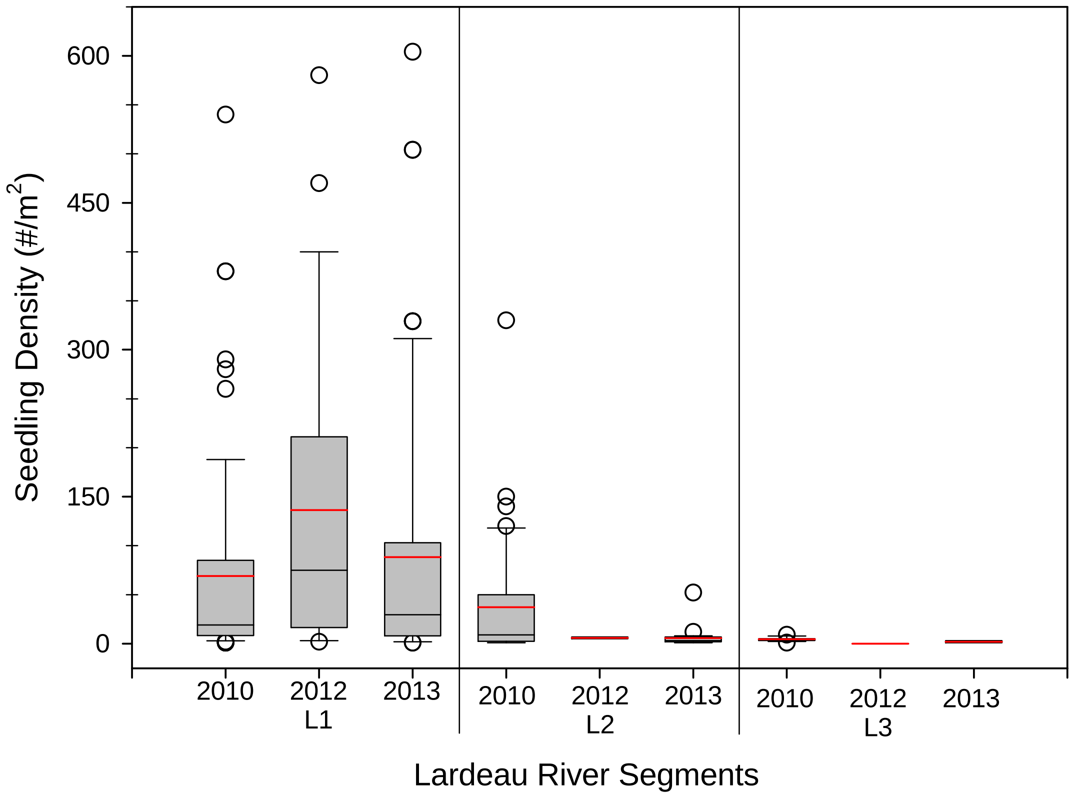


Figure 3-15: Seedling establishment densities (germinants) for 2010, 2012, and 2013 for each segment along the Lardeau (L) River.

Table 3-7: T-Test comparison of density means for the Lardeau segments for 2013 versus 2012 and 2010.

T-Test comparison	*t*	*P*	*df*
L1 2013 to 2012	-1.41	0.16	85
L1 2013 to 2010	0.82	0.41	124
L2 2013 to 2012	-0.039	0.97	25
L2 2013 to 2010	-3.00	0.004	70
L3 2013 to 2012	2.83	0.03	6
L3 2013 to 2010	-5.13	<0.00	20

3.5.3 Seedling heights

Seedling heights data were grouped by seedling age for the first three years of growth. These were compared between years for each age bracket (Figure 3-16). The 2013 germinants (first year) were significantly taller than 2012 and 2009 germinants and significantly shorter compared to 2010 germinants (Table 3-8). The second year age bracket seedling showed that 2013 two year old seedlings were significantly shorter on average compared to 2012, 2010, and 2009 two year old seedlings. This same pattern was repeated for the three year age bracket with significantly shorter three year old seedlings in 2013 compared to 2010 and similar but shorter on average than three year seedling compared to 2012 three year old seedlings.

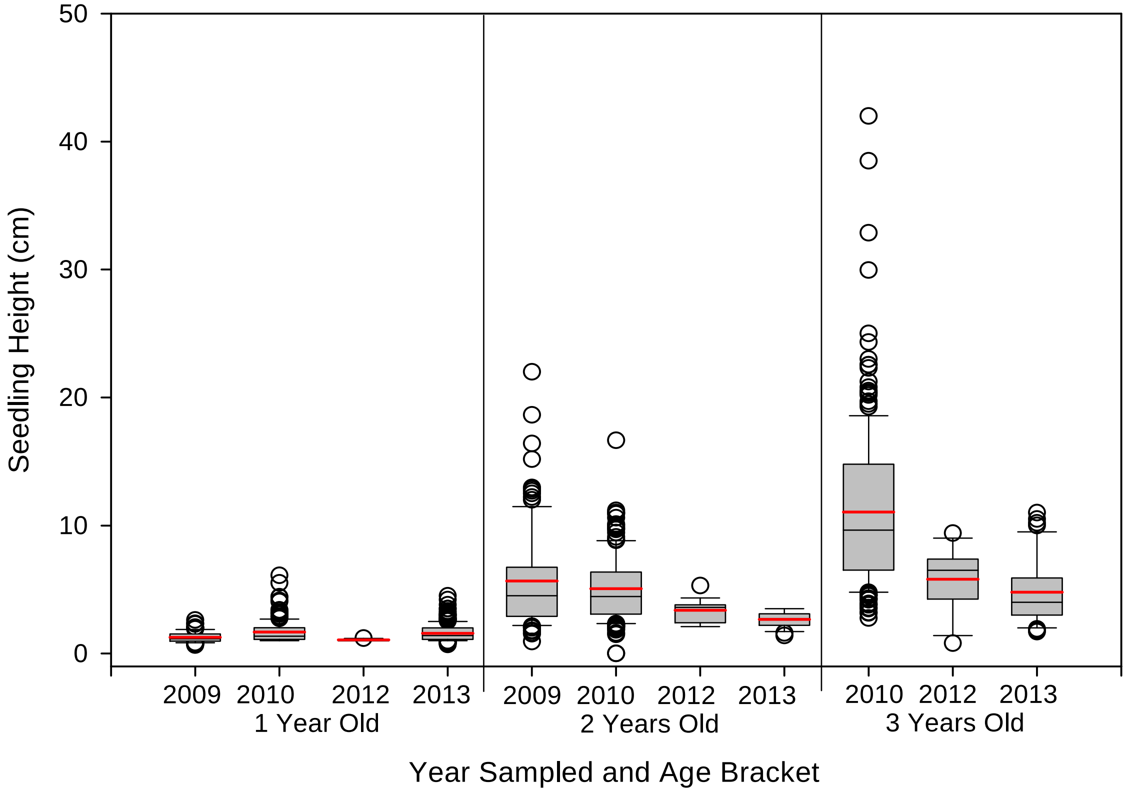


Figure 3-16: Seedling heights (cm) grouped by year of growth for first, second and third year heights recorded in each sampling year.

Seedling heights were similar for the Lardeau for 2012 and 2013. Polzin et al. (2011) showed that mean heights for 2008, 2009, and 2010 were similar for both the Lardeau and Duncan reaches.

Table 3-8: Statistical results from T-Test for cottonwood seedling heights grouped by seedling age bracket sampled in 2009, 2010, 2012 and 2013.

Comparison	*t*	*P*	*df*
1st Year 2013 vs 2012	2.27	0.02	390
1st Year 2013 vs 2010	-1.50	0.13	560
1st Year 2013 vs 2009	4.50	<0.00	473
2nd Year 2013 vs 2012	-2.59	0.02	29
2nd Year 2013 vs 2010	-3.91	<0.00	164
2nd Year 2013 vs 2009	-3.26	0.001	118
3rd Year 2013 vs 2012	-0.94	0.35	45
3rd Year 2013 vs 2010	-6.21	<0.00	232

3.5.4 Erosion and deposition

Following the receding waters of the 2012 flood in late September, extensive deposition and erosion was noted along the majority of the transect lines for the Duncan reach. The majority, 70 per cent of change observed along the lower Duncan reach since 2009 was from deposition, while 27 per cent was from erosion (Figure 3-17) and 3 per cent had no change greater than ± 0.9 cm. The highest amount of deposition occurred along D6T36 with 1.28 m of deposition from the expansion of the point bar compared to 2009. The greatest amount of erosion occurred along D5T11 with -1.30 m of erosion where a previous high water back channel was widened and deepened during 2012 high water. The average deposition level was 0.26 m and average erosion level was 0.21 m with a wide range of variation occurring along individual transect lines.

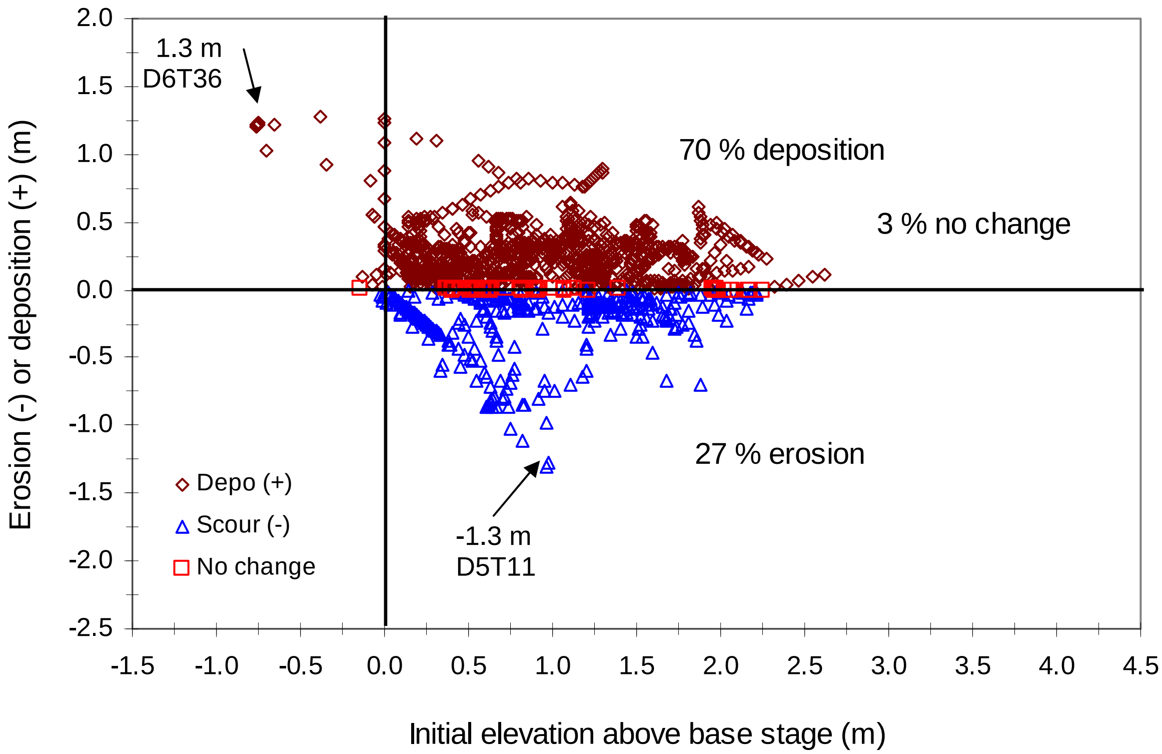


Figure 3-17: Erosion and deposition along the Duncan reach since 2009. The red squares indicate no change which bracketed 0.9 cm to -0.9 cm of change.

The Lardeau reach also experienced a major flood freshet in 2012 (Polzin and Rood 2013). However, unlike the flow-controlled lower Duncan reach, the duration was not extended over the complete growing season. Deposition made up 57 per cent of the change and erosion accounted for 40 per cent of the change experienced since 2009 (Figure 3-18). The Lardeau reach had an average deposition level of 0.33 m and erosion level of 0.51 m with a wide range of variation between transect lines.

The Duncan differed significantly for deposition and erosion combined compared to the Lardeau (Table 3-9). However, the Lardeau reach had significantly higher deposition and the Duncan reach experienced significantly higher average erosion. The Lardeau reach also experienced a higher magnitude of deposition and erosion compared to the Duncan reach. The Duncan reach had a range of -1.3 m to 1.3 m of erosion and deposition while the Lardeau reach had a range of -2.3 m to 1.5 m. The high deposition below 0 initial elevation was due to expansion of a point bar and the high erosion was due to the complete erosion of a transect line and an almost complete erosion of a second line with only 6 m of transect line remaining in 2012.

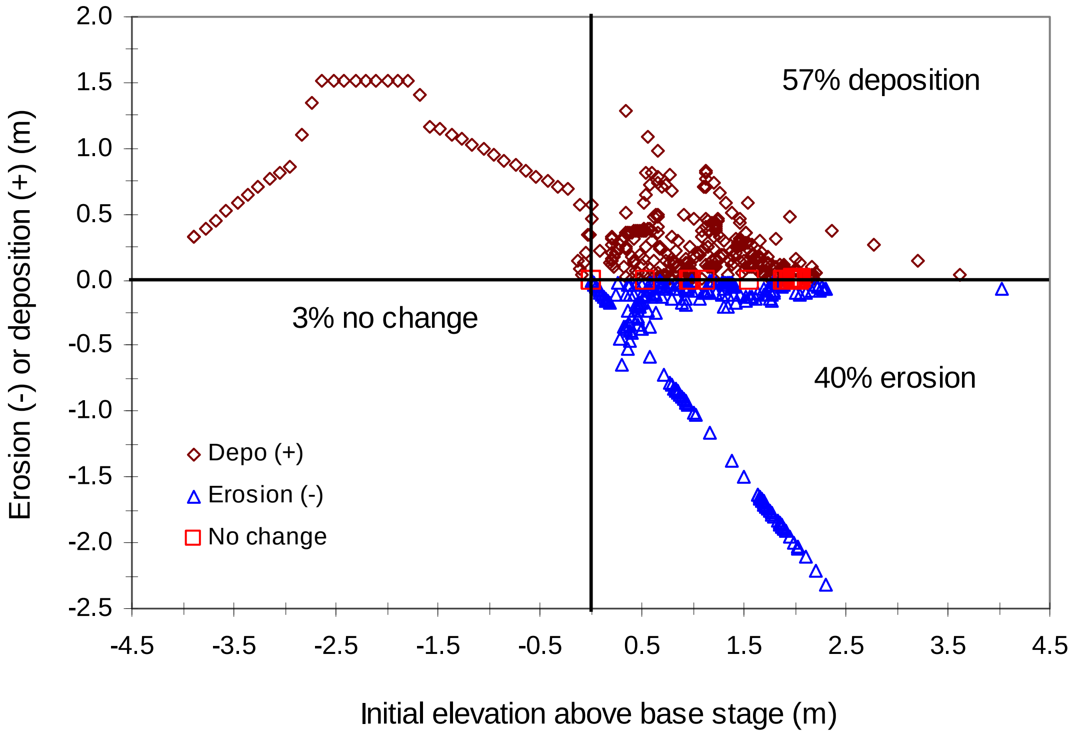


Figure 3-18: Erosion and deposition along the Lardeau reach since 2009. The red squares indicate 'no change' width from +0.9 cm to -0.9 cm of actual measured change.

Table 3-9: T-Test comparison for the erosion and deposition that occurred along the lower Duncan River compared to the Lardeau River.

Comparison	*t*	*P*	*df*
Duncan vs Lardeau overall	6.61	<0.000	2061
Duncan vs Lardeau deposition	-4.68	<0.000	1357
Duncan vs Lardeau erosion	7.04	<0.000	659

The Duncan showed wide variation between segments for erosion and deposition (Table 3-10 and Figure 3-19). Segment D1 had significantly lower levels of erosion and deposition combined, compared to D4, D5, whereas, D1 was similar to D3 (P = 0.97, t = -0.04, df = 680). Segment D6 had significantly higher levels of erosion and deposition combined, compared to the other segments. There was also variation between segments for deposition for the Duncan reach (Table 3-10 (gray shaded boxes) and Figure 3-20). Segment 1 (D1) had significantly lower levels of deposition compared to the other segments while D6 had significantly higher levels of deposition compared D1, D4, and D5. Segment D3 was similar to D6 with no significant difference in deposition (P=0.86, t = 0.18, df = 532). Segment D4 had the majority of the change occurring from deposition (Figure 3-19). This was confirmed by comparing just deposition between segments (Figure 3-20).

Table 3-10: T-Test results for erosion (Er) and deposition (De) combined comparison between segments for the Duncan reach and comparison for deposition (Depo) between segments (gray shading).

D1 vs D3 Er_De		D3 vs D1 Depo		D4 vs D1 Depo		D5 vs D1 Depo		D6 vs D1 Depo	
t value	-0.04	*t* value	3.38	*t* value	3.62	*t* value	1.97	*t* value	3.66
P value	0.97	P value	0.00	P value	0.00	P value	0.05	P value	<0.00
df	680	df	403	df	173	df	404	df	285
D1 vs D4 Er_De		D3 vs D4 Er_De		D4 vs D3 Depo		D5 vs D3 Depo		D6 vs D3 Depo	
t value	-3.22	*t* value	-3.81	*t* value	3.46	*t* value	-1.77	*t* value	0.18
P value	<0.00	P value	<0.00	P value	<0.00	P value	0.08	P value	0.86
df	257	df	707	df	409	df	642	df	532
D1 vs D5 Er_De		D3 vs D5 Er_De		D4 vs D5 Er_De		D5 vs D4 Depo		D6 vs D4 Depo	
t value	-2.17	*t* value	-3.06	*t* value	1.97	*t* value	-5.07	*t* value	-3.14
P value	0.03	P value	0.002	P value	0.05	P value	<0.00	P value	0.002
df	541	df	991	df	568	df	408	df	324
D1 vs D6 Er_De		D3 vs D6 Er_De		D4 vs D6 Er_De		D5 vs D6 Er_De		D6 vs D5 Depo	
t value	-7.73	*t* value	-7.90	*t* value	-2.39	*t* value	-5.83	*t* value	2.41
P value	<0.00	P value	<0.00	P value	0.02	P value	<0.00	P value	0.02
df	332	df	782	df	359	df	643	df	531

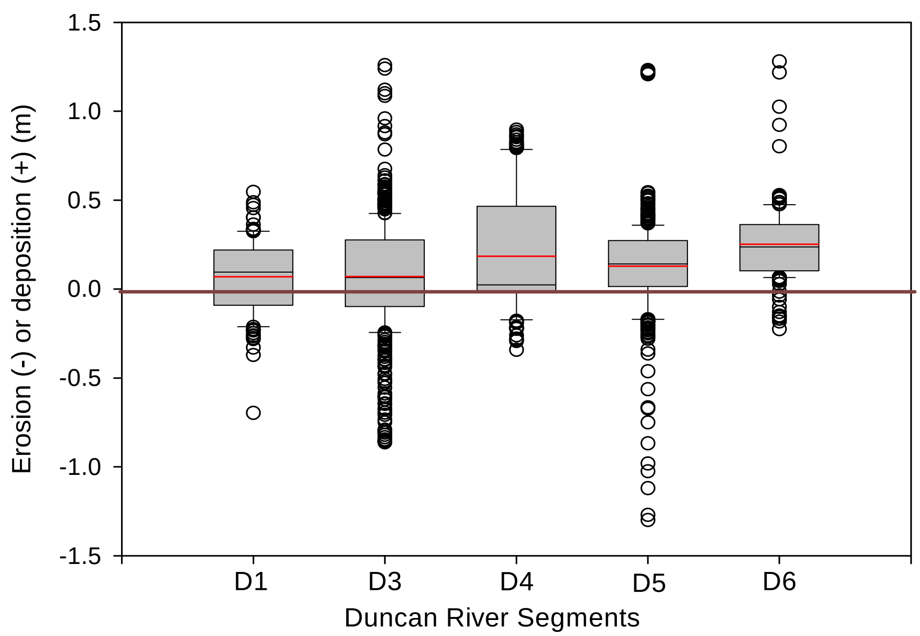


Figure 3-19: Erosion and deposition along transects for the lower Duncan River segments.

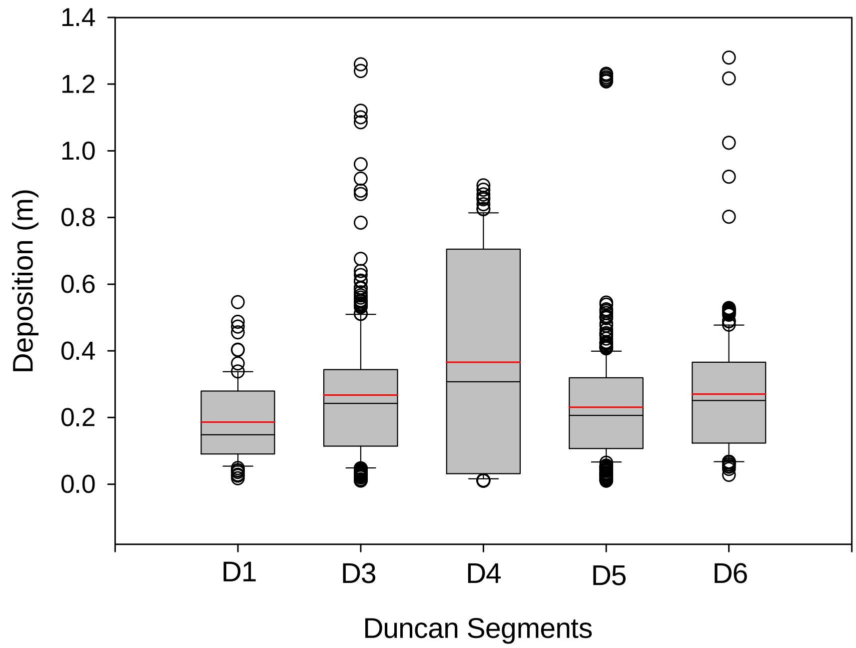


Figure 3-20: Deposition along the lower Duncan reach transects grouped by segments.

3.5.5 Seedling heights, deposition, and erosion

Average seedling height was grouped by years of growth for the Duncan (Figure 3-21) and Lardeau (Figure 3-22) reaches. The three year group includes 2008 seedlings that were two years old at the time of sampling in fall 2009. First year seedling heights were recorded in the fall of the season they were established, second year seedling heights were recorded in the fall of their second growing season, and third year seedling heights were recorded at the end of the third growing season. Since there was no sampling in 2011, the 2009 seedling cohort did not have heights recorded for the third year. First and second year average heights were from all years of data with the majority of second year heights from 2008 and 2009 data for the Duncan reach. Average seedling heights for each age bracket for the Duncan verses the Lardeau showed no significant difference between reaches (P = 0.14 (1 year), P = 0.16 (2 year), P = 0.28 (3 year)). Average seedling heights for first year (fall sampling heights) were 1.1 cm (1 year), 5.4 cm (2 year), and 11.9 cm (3 year).

Seedlings established at a broad range of elevations along the Duncan River, from 0.03 m to 2.3 m (Figure 3-21). In contrast, along the Lardeau seedling establishment occurred from 0.5 m to 2.2 m initial elevation (Figure 3-22). Second and third year seedlings occurred mainly between 0.5 m to 2.0 m for the Duncan and the Lardeau.

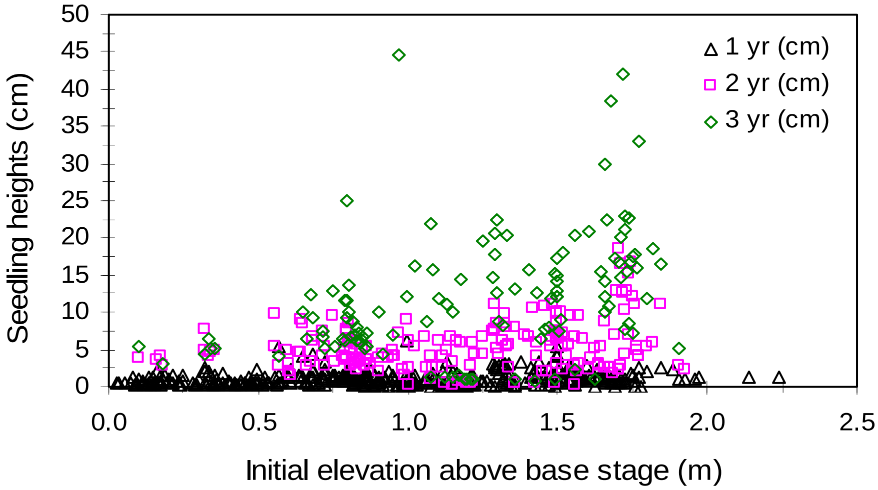


Figure 3-21: **The lower Duncan River sampling reach average seedling heights (cm) grouped by year at initial elevation. The maximum elevation that occurred along transect lines was 2.3 m.**

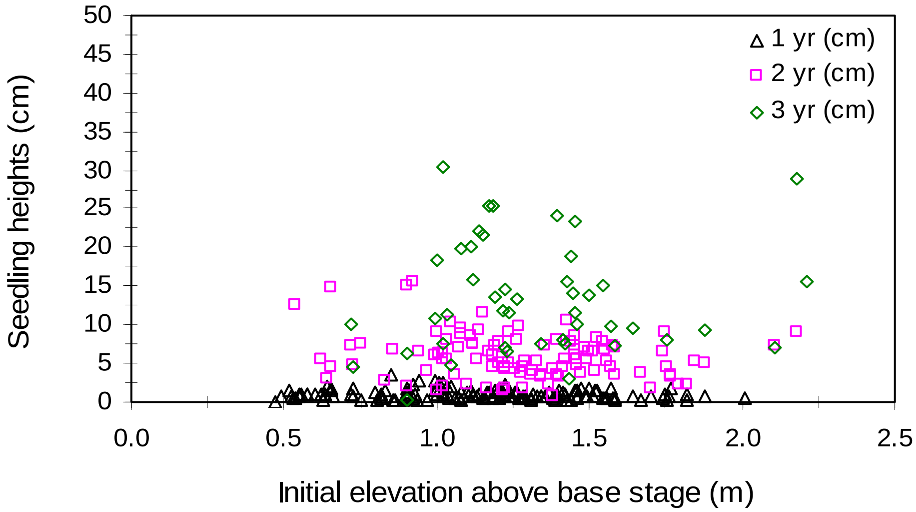


Figure 3-22: **The Lardeau sampling reach average seedling heights (cm) grouped by year at initial elevation. The maximum elevation that occurred along transect lines was 4.0 m at one location. The next maximum elevation was 2.3 m similar to the Duncan reach.**

Since 2009, the average total deposition along the Duncan River has been 26 cm and 33 cm for the Lardeau River. These deposition levels would bury all but the tallest seedlings. However, the deposition was spread over multiple years giving seedlings time to grow between deposition events. The 2008 cottonwood cohorts are now five years old and have grown significantly since the end of their third year illustrated in Figure 3-21 and Figure 3-22. However, four and five year old seedling were not tracked since confirmation of age would require extensive excavation to count growth rings and growth rings become more diffuse as the seedling stalk has been underground for a number of years.

Deposition also varied among individual transects (Figure 3-23). First year seedlings are represented as ‘Establish’ on the graph and were from all first year data collected for 2009 and 2010. Seedlings established in 2012 and 2013 occurred on the new elevation profiles. The 'Survival' seedlings are 2 years old and survived to the end of the growing season of 2010. Four and five year old seedlings were not tracked and no 2010 seedlings survived deposition/erosion along transect lines when surveyed in 2012. Therefore, this graph does not show seedlings that survived the erosion and deposition, but rather it represents where seedlings occurred before the 2012 flood and the level of deposition and erosion that occurred at these elevations above base stage since 2009.

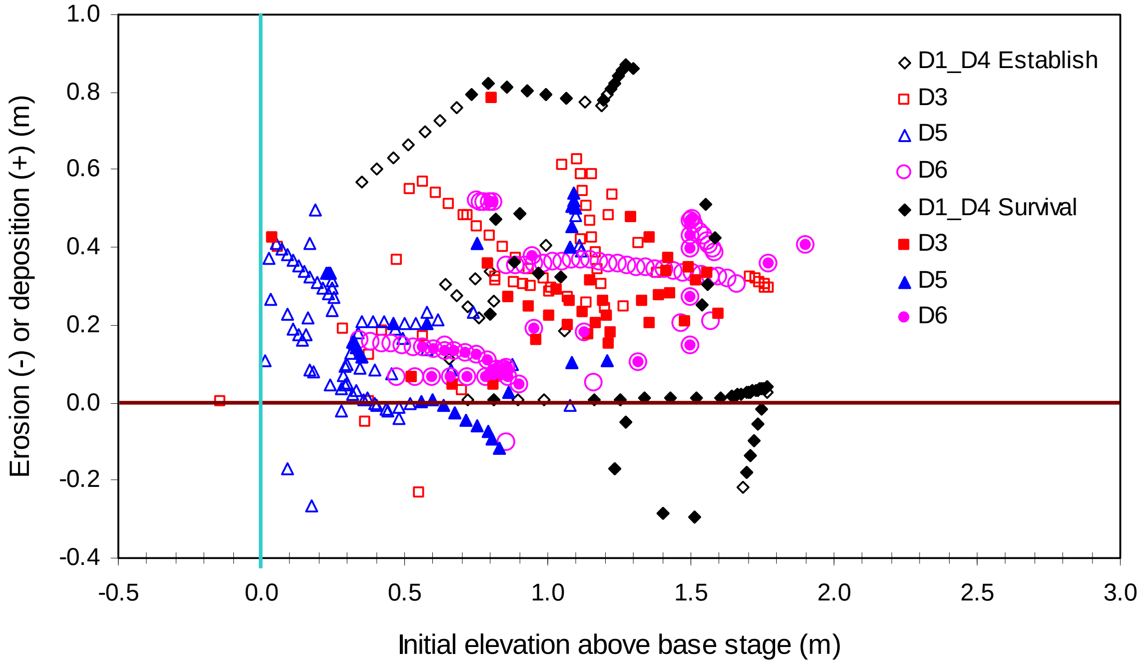


Figure 3-23: Occurrence of cottonwood seedlings in relation to erosion and deposition at various elevations above base stage for the lower Duncan river segments. Establishment year (open symbols) represent sampling quadrats with first year seedling. Survival (filled symbols) represent sampling quadrats with two year old seedling.

Location along transect lines for erosion and deposition was also investigated relative to seedling establishment and survival. The majority of the deposition and erosion occurred along the initial river's edge to about 40 m up the transect lines for the Duncan segments (Figure 3-24 top graph).

Initial seedling establishment (1 year old) occurred near the river's edge up to 135 m from the river (Figure 3-24, bottom graph). The three year old seedlings (recruitment) occurred mainly from 5 m to 50 m along transect lines, with a small group surviving between 80 to 90 m along the transect lines.

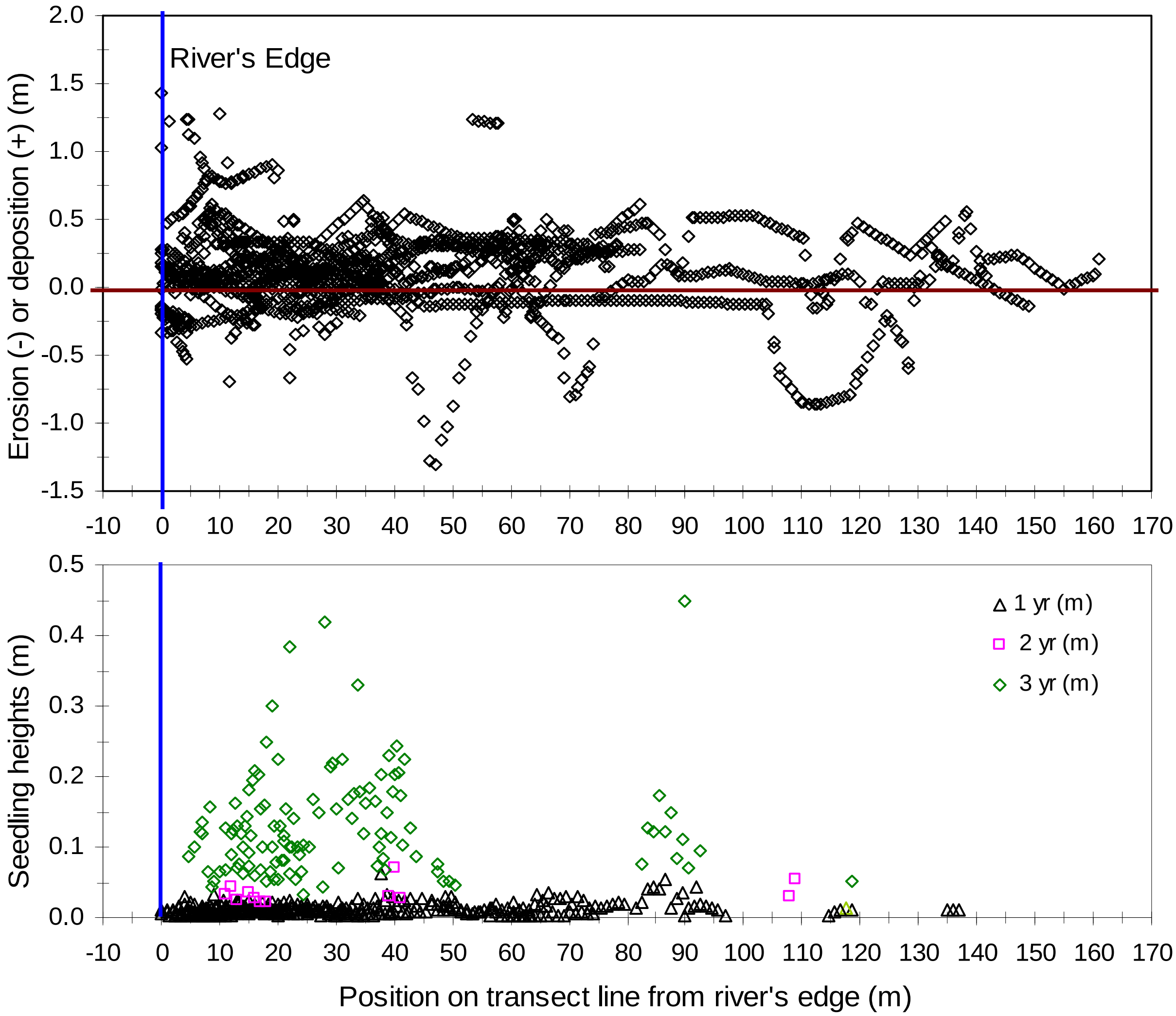


Figure 3-24: **Erosion and deposition as it occurred along the Duncan reach transect lines with '0' as the river's edge (top graph) and seedling occurrence along transect lines with heights and '0' indicating river's edge (bottom graph).**

The locations of erosion and deposition were similar to the Lardeau segments with the majority of the deposition and erosion occurring from the initial river's edge to about 35 m (Figure 3-25 top graph). Seedling establishment occurred close to the river's edge to 65 m along transect lines. Seedling recruitment (3 year old) occurred mainly from 10 m to 60 m along transect lines (Figure 3-25 bottom graph).

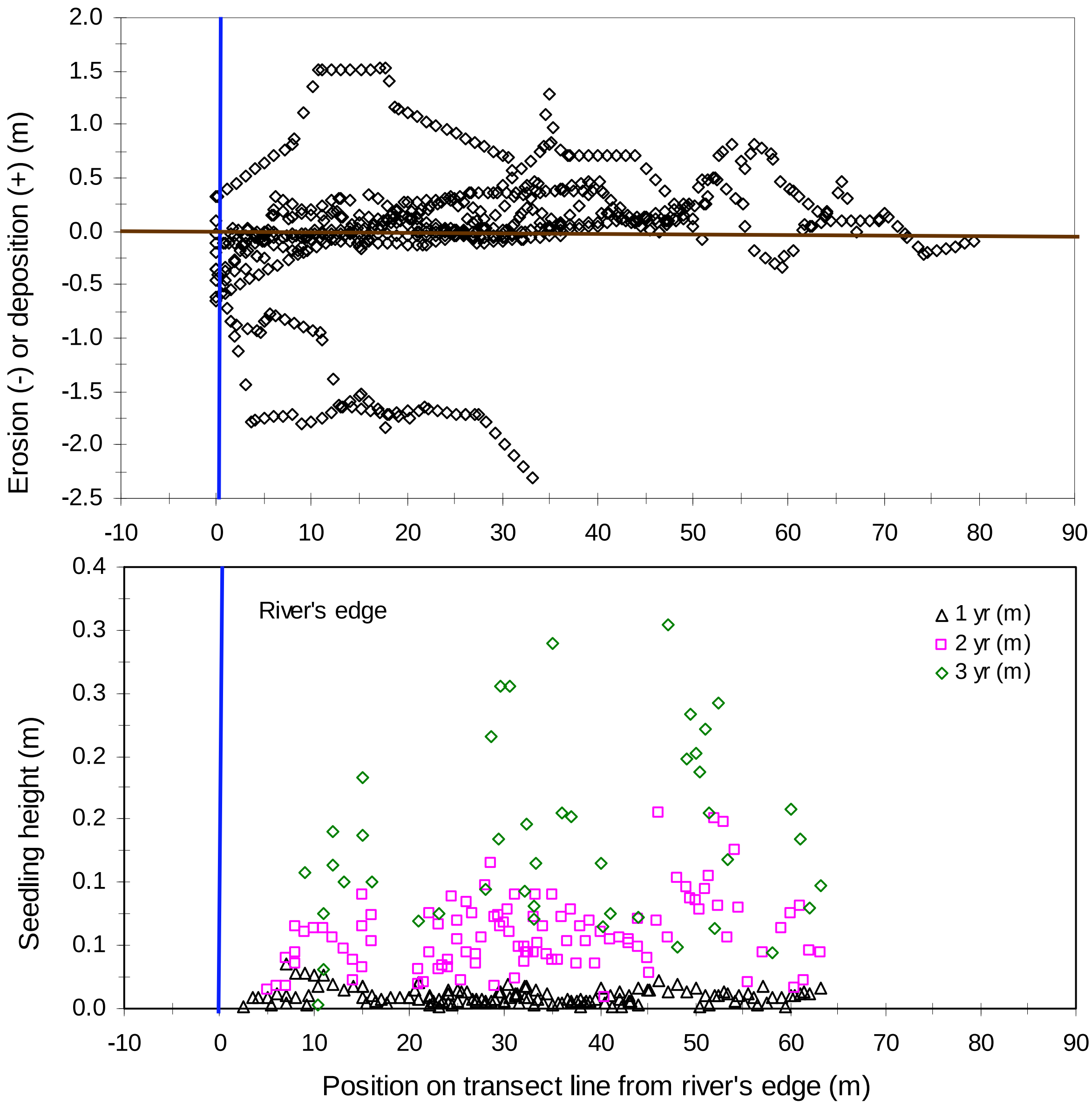


Figure 3-25: **Erosion and deposition as it occurred along the Lardeau reach transect lines with '0' as the river's edge (top graph) and seedling occurrence along transect lines with heights and '0' on the x axis indicating river's edge (bottom graph).**

4 DISCUSSION

4.1 Seasonal Weather

Seasonal weather patterns during 2013 were similar to past monitoring years with no large-scale extreme rain events in June. There were more localized events as June 19 had 57 mm and June 20 had 10.7 mm of rainfall recorded in the valley bottom at Meadow Creek. Some mountain zones may have also experienced an extreme rain event as Hamill Creek experienced a flash flood from this rain event, scouring a new channel bed wider than the bridge spanning Hamill Creek just upstream from the confluence with the Duncan River. This same weather event also caused major flooding east of the Continental Divide in southwestern Alberta in 2013.

In our study zone, this event resulted in new erosion and deposition along transect line D4T3 and T10. Cooper Creek also experienced a flash flood from this rain event and impacted D4T5 transect line. A new profile survey in 2014 for D4 will quantify the extent of the change that occurred resulting from the flash flooding. The Duncan River also experienced some impact from this event. The cut bank opposite the Hamill Creek – lower Duncan River confluence experienced extensive erosion, adding to the sediment transported downstream along with previously buried garbage from the abandoned saw mill. Garbage from this event was found along segment D6 where it settled out on point bars and hung up on submerged logs. Debris was also seen along the north end of Kootenay Lake shoreline.

4.2 Hydrology

The 2013 flow regime (Alt S73) was similar to the 2009 and 2010 sampling years for the fall and winter flows (October 2012 through to April 2013). May was the start of above average flows compared to 2009 and 2010 that continued through September, with the peak in July (Figure 3-6). This peak in July did not meet the criteria established by the Duncan Dam (DDM) Water Use Planning (WUP) Consultative Committee (CC) developed to fit within both the Columbia River Treaty Agreement and local operating constraints developed for Alt S73. This criterion (one of three) was “Sufficient time between spring freshet recession and late summer/fall dam releases to allow seedlings to establish”. The DDM WUP CC set target maximum discharge rates for Alt S73 for specific time brackets. The maximum discharge rate for the May 16 to July 31 time bracket is 400 m^3/s. The peak flow was under this (368 m^3/s with a mean of 304 m^3/s for July 8, 2013) but the high water was just after seed release which reduced/eliminated available seedling recruitment sites and/or the area available for seedling establishment. The 2013 flow regime did not have a peak in June with a gradual decline to base flow, as would be typical for a snowmelt-dominated stream.

The peak in July reduced available seedling sites for the seed release in June. There was seedling establishment but at a reduced level compared to 2009 and 2010 seedling establishment. The August mean discharge was above 2009 and 2010 levels by about 50 m^3/s. The September peak was similar to 2009 and 2010, with a steep decline to base flow over a one week period. This was more gradual than in previous sampling years where discharged was dropped to around base discharge in one to two days.

The Lardeau River experienced a Q_2 flood event in 2013. The peak occurred June 20 with a steady decline in discharge towards base flow in the fall. There was no increase in discharge during July when the Duncan experienced the peak discharge for 2013. There were no rain events in July to account for the peak discharge for the Duncan River and the July 2013 precipitation was below the average for that month.

4.2.1 Groundwater levels

Groundwater monitoring confirmed that the alluvial groundwater table elevation along the lower Duncan River is very closely coordinated with the river stage. The groundwater table is recharged by water infiltrating almost horizontally from the river. Due to the close association, river stage can provide an accurate indication of groundwater depth within the cottonwood colonization zone and the established riparian vegetation zone. The peak Duncan River stage in July meant that the groundwater levels were also high. This may have benefited seedling established at higher elevation in 2012 and 2013, by providing groundwater closer to the surface and thus benefiting the colonizing cottonwoods and other riparian vegetation.

Segment D3T15's well SH2, which was the closest to the river's edge for 2013 sampling, showed a steeper decline in groundwater level than the river stage and the other wells at the site. This did not occur in 2009 or 2010. One possible explanation may be that the substrate has changed but we also know that the well pipes can trap sediments, which can complicate the pressure measurements.

4.3 Cottonwood Phenology

Widespread and readily observable seed dispersal events in 2013 were concentrated entirely within the month of June. This is earlier than previous years. Germinant size and emergence dates indicated that some dispersal also occurred during July and August as it normally does along the lower Duncan River, but the seed release was not prominently observed. At some sites in late June, clumps of sodden seed pods were noted lying on the ground below the trees, the result of heavy rain and wind events on June 19-20 and throughout the last week of June. This probably reduced the quantity of seeds available for late-season dispersal. Balancing this however, may have been improved germination success due to moist site conditions from the 2011-2012 high flow and sediment events along both rivers.

In previous years, we speculated that the first warm days following rainy periods were the most likely days for seed dispersal events to occur. Some results in 2013 support this conclusion. Thus, pulses were either on the first day with no rain, or they followed closely thereafter (e.g., the 4th event June 22 and 23). The low level of seed release on June 22 and the high event June 23 followed 5 days of rain ending on June 21 and 1.2 mm of rain occurred on June 23. However, there were also dispersal events throughout the five days with at least some rain from June 16-18 (Table 3-2). These results indicate that weather influences seed dispersal, with interacting influences of temperature and precipitation.

4.4 Cottonwood Recruitment

This study focuses on the long-term investigation of cottonwood recruitment trends in response to Alt S73. During the late July and early October 2012 field season, 2011 cottonwood seedling recruitment, 2012 cottonwood seedling survival and 2013 cottonwood seedling establishment were monitored. As previously discussed (Rood et al. 2007), the term 'recruitment' is used to represent the successful contribution to the floodplain forest population; the result of two sequential processes, establishment (or colonization), and survival:

Recruitment = Establishment (colonization) + Survival (for 3 years)

Black cottonwoods are prolific seed producers, similar to other cottonwoods, although seed viability declines sharply over a few weeks (Karrenberg et al. 2002). Previous project monitoring observations of abundant seedling establishment were consistent with this. However, seedling establishment was limited in 2012 along the Duncan River, as extreme high water over the growing season flooded all but the very highest elevation recruitment sites. Additionally, there was almost no survival or persistence of the 2010 and 2011 seedlings. Prior to 2012, seedling survival in the second year was 69 per cent and 75 per cent for the third year. During 2012 monitoring there was zero survival of

2010 seedlings and sparse survival of 2011 seedlings although this conclusion is limited since 2011 was not monitored (BC Hydro cancelled 2011 monitoring). It was assumed in 2012 that sediment burial was a primary factor responsible for the very low recruitment observed. It is known that one of the factors contributing to the success or failure of recruitment is the amount of sedimentation and erosion (scour) that occurs (Polzin and Rood 2006). The Duncan River transects experienced 70 per cent increase of deposition with maximum accumulations of 1.3 m from 2009 to 2013, with variation in the extent of deposition and where it occurred along the transect lines. However, the major deposition occurred within the cottonwood colonization zone and this would thus have considerable influence on cottonwood recruitment.

Average seedling heights from monitoring years 2009 and 2010 were considerably lower than heights reported in the literature, typically for more southerly and warmer locations (Polzin and Rood 2006). The 1st year seedlings averaged only 2 cm and 2nd year averaged 5 cm, with year three average height reaching 12 cm (0.12 m). This small size resulted in burial for the majority of the seedlings established since 2010. Above average and even average height seedlings survived if their location experienced lower levels of deposition compared to their height. Individual transect line profiles in Appendix 2 show this variation as well as comparisons illustrated in Figure 3-21, Figure 3-23, and Figure 3-24. Many older seedlings survived deposition as they were taller at the time of the deposition but they were not tracked after the third year. One of the reasons that the average third year heights are shorter than along some other rivers in BC (Polzin and Rood 2006) is because deposition occurred each year so the actual establishment level was a few centimetres or more below the contemporary ground level.

An example of the deposition that occurred along an individual transect line is segment D3 transect line T15. This transect had extensive establishment in 2009 and 2010 (Figure 4-1 A). Survival and recruitment rates were also high in 2009 and 2010. The recruitment zone occurred mainly from the 40 m mark (from the POC) to river’s edge. This section experienced a maximum of 0.64 m deposition at the 47.7 m mark and a maximum of 0.33 m of erosion from 77.3 m to 80.0 m which was adjacent to the river’s edge in 2009. Average deposition for the recruitment zone was 0.41 m. None of the 2010 and 2011 seedlings survived burial along D3T15. The majority of the 2008 and 2009 cottonwood and willow seedlings were also buried except for a 10 m band next to the juvenile willows and cottonwoods that can be seen in Figure 4-1 C. This band had extensive growth of 10 to 50 cm during 2013. There are multiple age classes from pre-Alt S73 and Alt S73 within this band.

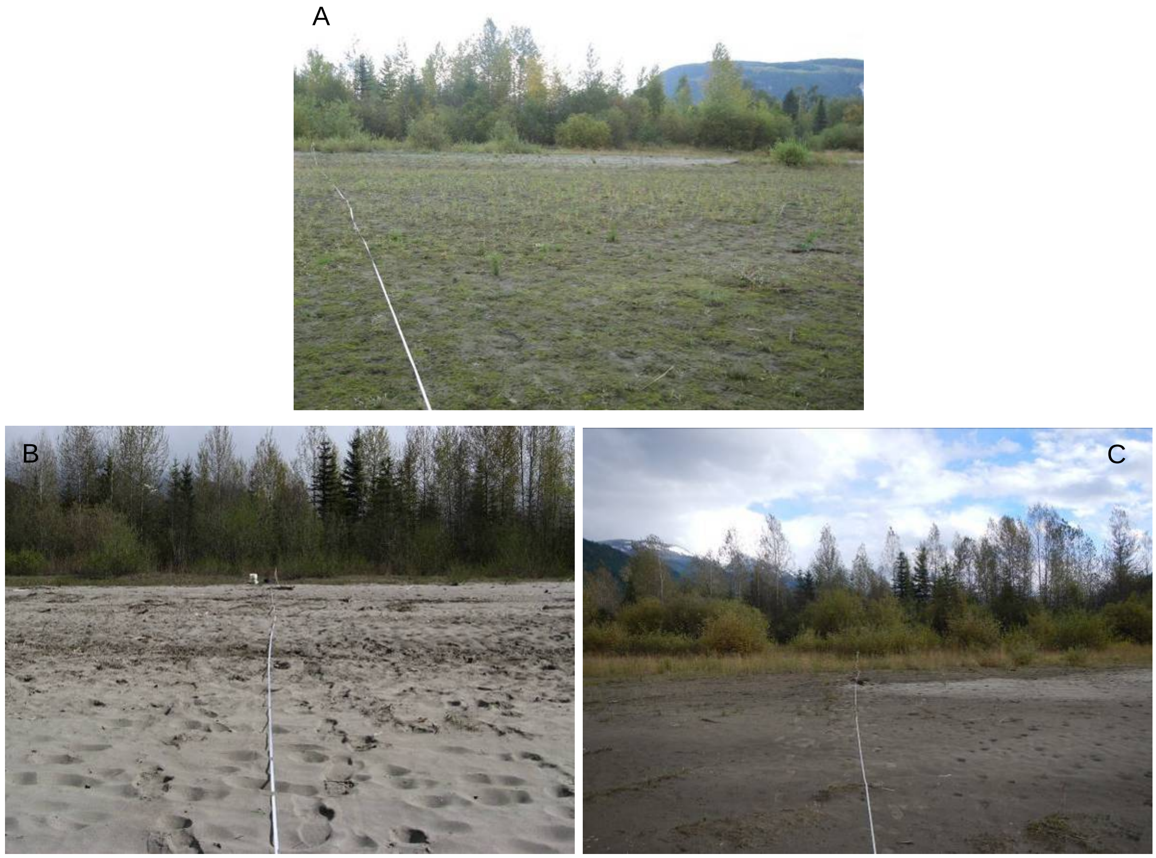


Figure 4-1: Photographs showing cottonwood colonization along transect at D3T15 in 2010 (A). The same transect line April 29, 2013 (B) and October 1, 2013 (C).

Seedling densities were significantly lower for the Duncan reach as compared to the Lardeau reference reach. This was the reverse from 2010 and 2009, when the Duncan reach had significantly higher densities compared to the Lardeau (Polzin et al. 2010 and 2011). One factor that contributed to this decrease in densities was the increased peak stage in July 2013. Subsequently, transect lines along the Duncan reach with suitable elevation recruitment zones were partially submerged during seedling establishment period. The hydrographs in 2009 and 2010 had small peaks in early June and in September, with lower discharge during the establishment period. This pattern was reversed in 2013 with a higher June peak than in 2010 and 2009, while the mean discharge for July 2013 was more than 100 m^3/s greater than the mean discharge for July 2010 or 2009.

5 CONCLUSIONS

Year 4 data collection from the 10-year monitoring program, DDMMON#8-1, occurred from April to October, 2013. The purpose of the Year 4 study was to investigate the effects of the implementation of Alt S73 flow regime on cottonwood establishment and recruitment with respect to the following attributes:

- the extent of cottonwood seedling establishment;
- the extent of cottonwood seedling survival and recruitment, relating to prior-year seedlings; and

- the level of deposition and erosion that occurred since 2009.

The results in this report document cottonwood establishment and recruitment since 2011 along the lower Duncan River and the reference reach, the Lardeau River. The average height of one to three year old black cottonwood seedlings (one year old mean height = 15 mm $\pm$ 6.7 mm SD, Range = 6.6 to 61 mm) was substantially less with the mean height for the three year old cohort (98.6 mm, 62.3 mm SD, Range = 8.0 mm to 420.0 mm). Seedlings occurred from the river's edge to a distance of 135 m from the river's edge, and largely in elevational bands occurring from near the river's edge up to around 2 m above the base (low flow) stage. Older, surviving seedlings were generally found from about 0.5 to 2 m above the base stage as seedlings in lower positions were especially vulnerable to inundation and scour.

The level of sediment deposition along the lower Duncan River was substantial, accounting for 70 per cent of the change experienced in surface elevation above the base stage. Depositional depth had a mean of 0.26 m and a maximum of 1.28 m, and deposition occurred at many locations, from the river's edge to the ends of the colonization bands, more than 160 m from the river's edge.

Mainly sediment deposition, but also some erosion, accounted for the loss of 2010 and 2011 seedlings, which had been observed in 2012. Combined with the loss of the entire 2012 seedling establishment cohort due to prolonged inundation during the growing season, cottonwood establishment and recruitment monitoring was effectively reset to zero with 2013 starting as a new, base data year. Year 4 of the project thus provides the start of a new pulse of seedling establishment, and monitoring 2014 and 2015 will assess this new recruitment cycle. This can be combined with the pre-flood years of 2009 to 2011, to contribute further to the analysis and modeling of the cottonwood recruitment requirements.

The Lardeau River experienced lower levels of seedling establishment in 2013 as compared to 2012 but similar to that of 2010. As noted previously (Polzin et al. 2011), weather patterns and especially heavy rain events in June can reduce seed dispersal by knocking immature seed pods out of trees. The Duncan River is similar to the Lardeau River for this pattern but since it is a larger river with a broader and more extensive floodplain forest, we have usually observed significantly higher seedling densities than along the Lardeau River in past monitoring years. Conversely, in 2013, the Lardeau River had significantly higher densities for cottonwood seedling establishment. This was attributed to the higher stage for the lower Duncan for June, the elevated peak and mean stages in July, and elevated flows in August as compared to the 2009 and 2010 flows.

The Year 4 study components were otherwise consistent with the patterns observed in monitoring Years 1 and 2. This consistency of early cottonwood seedling recruitment distributions supports a deterministic pattern, whereby establishment and survival follow from particular physical conditions and timing. However, flooding dramatically lowered the sampling sizes for seedlings along the lower Duncan River. The above-average river stage and flood events along the lower Duncan and the Lardeau rivers provide a pattern of establishment and recruitment during the naturally irregular or periodic flood years. The level of sediment deposition and erosion that occurred during the flood year adds an additional level of information for the conceptual and hydrogeomophic models and important information for the analyses to address the management questions and the study hypotheses.

6 RECOMMENDATIONS

6.1 Transect Line Resurveying

The unusual and localized flash floods along Hamill and Copper creeks impacted the point bars adjacent to them and along the lower Duncan River. As a result the three transect lines in segment D4 should be resurveyed in 2014 where extensive change was noted. We recommend further resurveys in 2015 for all transect lines to assess the changes to transect profiles through sediment deposition and erosion that would have occurred after the spring 2013 surveys. This will update the transect line elevations and will contribute stage/discharge specific data for these lines as well as the profiles for seedling establishment elevations, thus contributing further to the foundational data needed for the longer term study objectives.

7 CLOSURE

VAST Resource Solutions Inc., trusts that this report satisfied your present requirements. Should you have any comments, please contact us at your convenience.

Vast Resource Solutions Inc.,

Prepared by:

Mary Louise Polzin, PhD, RPBio
Senior Biologist/Riparian Specialist,

Stewart Rood, PhD
Professor and Board of Governors' Research Chair in Environmental Science,

Reviewed by:

Ian Adam, MSc, RPBio
Senior Wildlife Biologist

8 REFERENCES

British Columbia Hydro and Power Authority. (TOR) 2009. Contract Number Q9-9070, Advertisement for Request for Proposals for projects DDMMON#8-1 and 8-2, Duncan Watershed Riparian Monitoring Program. pp. 94.

Debano, L.F. and L.J. Schmidt. 1990. Potential for enhancing riparian habitat in the southwestern United States with watershed practices, *Forest Ecology and Management*, **33**: 385-403.

Dunne, T. 1988. Geomorphological contributions to flood-control planning, *Flood Geomorphology*, V.R. Baler, R.C. Kochel, and P.C. Patton, (eds). John Wiley & Sons, New York. Pp. 421-437.

Government of Canada, Environment Canada, Pacific and Yukon Region, Environment Canada, Hydrometric Archive for British Columbia and Yukon, 2010. Vancouver, British Columbia, Canada Government of Canada, Environment Canada. Data set accessed 2012- multiple times during the year at http://www.wateroffice.ec.gc.ca/index_e.html.

Karrenberg, S., P.J. Edwards, and J. Kollman. 2002. The life history of *Salicaceae* living in the active zone of floodplains. *Freshwater Biology* **47**: 733-748.

Mahoney, J.M. and S.B. Rood. 1998. Stream flow requirements for cottonwood seedling recruitment – an integrative model. *Wetlands* **18**: 634-645.

Merritt, D.M. and D.J. Cooper. 2000. Riparian vegetation and channel change in response to river regulation: a comparative study of regulated and unregulated streams in the Green River Basin, USA. *Regulated Rivers: Research and Management* **16**: 543-564.

Naiman R.J., H. Decamps, and M.E. McClain. 2005. *Riparia: Ecology, Conservation and Management of Streamside Communities.* Elsevier Academic Press: San Diego. pp. 430.

Polzin, M.L. 1998. *River and Riparian Dynamics and Black Cottonwoods in the Kootenay River Basin, British Columbia and Montana.* M.Sc. thesis, University of Lethbridge, Alberta, pp. 224.

Polzin M.L. and S.B. Rood. 2000. Effects of damming and flow stabilization on riparian processes and black cottonwoods along the Kootenay River. *Rivers* **7**:221-232.

Polzin M.L. and S.B. Rood. 2006. Effective disturbance: seedling safe sites and patch recruitment of riparian cottonwoods after a major flood of a mountain river. *Wetlands* **26**:4:965-980.

Polzin, M.L., B. Herbison, K.M, Gill[2], and S.B. Rood[2]. 2010. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 1 Annual Report – 2009, Interior Reforestation Co. Ltd., and [2]University of Lethbridge, Alberta, Unpublished report by Interior Reforestation Co. Ltd., Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, B.C. 110 pp + appendices.

Polzin, M.L., S.B. Rood[2] and B. Herbison. 2011. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 2 Annual Report – 2010, Interior Reforestation Co. Ltd., and [2]University of Lethbridge, Alberta, Unpublished report by Interior Reforestation Co. Ltd., Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, B.C. 74 pp + appendices.

Polzin, M.L., and S.B. Rood. 2013. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 3 Annual Report – 2012. Vast Resource Solutions and University of Lethbridge, Alberta. Unpublished report by Vast Resource Solutions, Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, B.C. 76 pp. + appendices.

Rood, S.B. and J.M. Mahoney. 1990. Collapse of riparian poplar forests downstream from dams in western prairies: probable causes and prospects for mitigation. *Environmental Management* **14**: 451-464.

Rood, S.B., and J.M. Mahoney, 1995. Collapse of riparian poplar forests downstream from dams in western prairies: Probable causes and prospects for mitigation, *Environmental Management*, **14:** 451-464.

Rood S.B., K.J. Berg, and D.W. Pearce. 2007. Localized temperature adaptation of cottonwoods from elevational ecoregions in the Rocky Mountains. *Trees* **21**: 171-180

Williams G.P., and M.G. Wolman. 1984. Downstream effects of dams on alluvial rivers, Geological Survey Professional Paper 1286, United States Government Printing Office, Washington, PP-83.

Appendix 1: GPS Points

for

POCs, EOTs, and Survey Points

GPS points recorded for Points of Commencement (POC) for the Duncan and Lardeau study reaches.

OBJECTID	LOCATION	TYPE	GNSS_Height	Vert_Prec	Horz_Prec	Std_Dev	UTM_N	UTM_E	TRANSECT_ID
1	D3T10 POC	P.O.C.	544.13	1.0	1.3	0.14	5563097.8	502915.2	D3 T10
2	d3t11 poc	P.O.C.	543.09	1.0	1.2	0.15	5562966.9	502761.1	D3 T11
3	d3t15 poc	P.O.C.	543.06	0.8	1.0	0.11	5562940.9	502483.3	D3 T15
4	d3t17 poc shr cot	P.O.C.	540.87	0.8	1.1	0.05	5562975.8	502491.9	D3 T17
5	d1t3 poc	P.O.C.	549.52	0.9	1.1	0.73	5565649.7	503065.4	D1 T3
6	d1t4 poc cottenwood	P.O.C.	548.04	0.9	1.2	0.22	5565490.0	502999.0	D1 T4
7	d1t5 poc alder	P.O.C.	546.89	1.0	1.2	0.05	5565422.5	503032.1	D1 T5
8	d3t29 poc spruce	P.O.C.	542.16	0.8	1.1	0.02	5562795.5	502596.1	D3 T29
9	d3t35 poc Willow	P.O.C.	541.23	0.8	1.1	0.06	5562758.4	502506.1	D3 T35
10	d3t20 poc alder	P.O.C.	542.43	1.8	2.3	0.49	5562587.2	502582.0	D3 T20
11	d3t23 poc downtree	P.O.C.	541.13	0.9	1.1	0.06	5562252.5	502685.5	D3 T23
12	d3t45 poc Willow	P.O.C.	539.41	0.9	1.1	0.04	5561894.2	503208.7	D3 T45
13	d3t40 poc flat top 31	P.O.C.	540.36	0.9	1.1	0.10	5561926.0	503195.3	D3 T40
14	d5t11 poc birch	P.O.C.	534.70	1.1	1.2	0.07	5559550.1	503718.4	D5 T11
15	d5t12 poc	P.O.C.	536.36	1.0	1.1	0.22	5559531.3	503726.0	D5 T12
16	d5t16 poc	P.O.C.	533.92	1.2	1.2	0.73	5559040.1	503726.5	D5 T16
17	d5t19 poc cot down beaver	P.O.C.	535.93	1.0	1.2	0.09	5558679.4	503637.7	D5 T19
18	d6t29 poc alder	P.O.C.	534.93	1.1	1.3	0.31	5558372.5	504120.5	D6 T29
19	d6t36 poc Willow	P.O.C.	533.97	0.8	1.0	0.02	5558360.2	504840.9	D6 T36
20	d6t20 new poc	P.O.C.	533.16	0.9	1.1	0.07	5557994.0	504745.7	D6 T20
21	d6t6 poc alder	P.O.C.	533.72	0.8	1.1	0.09	5557477.2	503398.6	D6 T6
23	L1T20 poc birch	P.O.C.	557.21	1.1	1.2	0.07	5569739.6	502598.2	L1 T20
24	L1T10 poc cot	P.O.C.	559.34	1.5	2.1	2.09	5569377.2	502643.7	L1 T10
25	L1T1 poc alder	P.O.C.	554.27	1.5	1.2	0.37	5568715.5	502229.9	L1 T1
26	D4T3 poc 6 m bearing 330	P.O.C.	542.41	1.3	1.6	2.44	5561351.4	503484.4	D4 T3
27	D4T10 poc cot 1 m infront	P.O.C.	541.40	1.6	2.0	2.97	5561344.2	503470.3	D4 T10
28	D4T5 poc alder	P.O.C.	540.75	1.0	1.2	0.29	5560622.1	503286.4	D4 T5
29	D5T2 poc cot	P.O.C.	541.02	1.0	1.2	0.12	5560235.6	503369.7	D5 T2
30	D5T9 poc aspen	P.O.C.	539.01	1.0	1.2	0.76	5559732.4	503459.6	D5 T9
32	l3t30 poc	P.O.C.	579.04	4.5	2.3	1.05	5577918.2	497774.6	L3 T30
33	L3t9 poc cot	P.O.C.	584.62	1.1	1.3	0.41	5576381.3	498953.3	L3 T9
35	L3T1 poc 2m u/str of cot	P.O.C.	581.51	1.3	1.6	0.39	5576065.1	499738.9	L3 T1
36	L2T18 poc fir tr	P.O.C.	579.70	1.0	1.2	0.15	5575905.9	499883.3	L2 T18
37	L2T15 poc cottenwood	P.O.C.	573.39	1.1	1.1	0.61	5573723.8	501317.1	L2 T15
38	L2T6 poc cot	P.O.C.	568.45	1.1	1.3	0.37	5572702.2	501773.8	L2 T6
39	L1T36 poc fir	P.O.C.	567.66	1.0	1.2	0.23	5572128.0	502074.1	L1 T36

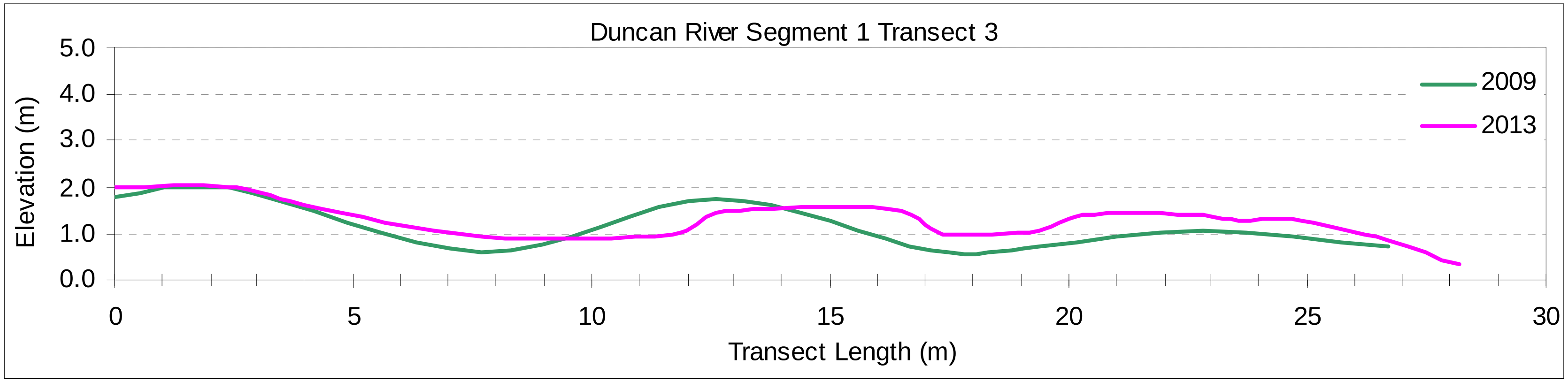
GPS points recorded for End of Transect (EOT) for the Duncan and Lardeau study reaches.

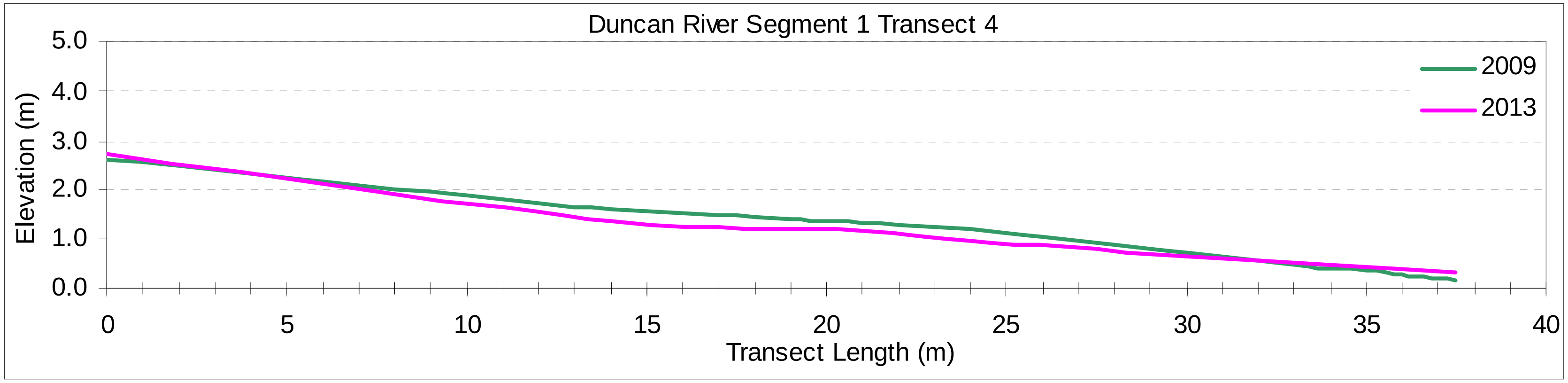
LOCATION	Feat_Name	GNSS_Height	Vert_Prec	Horz_Prec	Std_Dev	Northing	Easting	Point_ID	TRANSECT_ID
D3T10 EOT 110.8 m	E.O.T.	540.415	0.9	1.1	0.03	5563023.0	502994.2	2	D3T10
d3t11 eot river edge	E.O.T.	541.152	1.3	1.7	0.08	5562869.8	502889.5	40	d3t11
d3t15 eot 77.35mBackChEdg	E.O.T.	540.022	0.8	1.0	0.04	5563006.2	502443.5	52	d3t15
d3t17 eot backCh riveredg	E.O.T.	539.367	0.8	1.1	0.20	5563023.4	502470.6	58	d3t17
d1t3 eot river edge	E.O.T.	545.164	0.8	1.1	0.21	5565670.5	503081.5	63	d1t3
d1t4 eot 37.9m backchan	E.O.T.	545.635	1.0	1.2	0.09	5565479.3	502962.6	65	d1t4
d1t5 eot 20.2m backch	E.O.T.	547.591	1.9	1.3	0.23	5565406.2	503024.8	70	d1t5
d3t29 eot 80.7m R edge	E.O.T.	540.846	0.8	1.1	0.10	5562869.1	502565.4	71	d3t29
d3t35 eot 53.3 m	E.O.T.	539.992	0.8	1.1	0.28	5562762.1	502454.5	90	d3t35
d3t20 eot 42.9m	E.O.T.	540.316	0.8	1.0	0.22	5562568.3	502545.2	95	d3t20
d3t23 eot 25 m	E.O.T.	540.872	0.8	1.1	0.13	5562263.1	502706.6	100	d3t23
d3t45 eot 46.5 m	E.O.T.	538.241	0.8	1.1	0.19	5561910.8	503250.4	104	d3t45
d3t40 eot 30.25m	E.O.T.	538.912	0.8	1.1	0.06	5561949.4	503213.5	109	d3t40
d5t11 eot 76 m	E.O.T.	534.557	0.9	1.1	0.28	5559575.7	503788.3	113	d5t11
d5t12 eot 82.4 m on log	E.O.T.	535.274	0.8	1.1	0.05	5559558.8	503803.1	119	d5t12
d5t16 eot 1 Wedge	E.O.T.	532.839	0.8	1.1	0.05	5559048.3	503692.5	122	d5t16
d5t16 eot Wedge iland 2	E.O.T.	533.249	0.8	1.1	0.06	5559052.5	503677.7	123	d5t16
d5t16 eot MainChan 69.5	E.O.T.	533.521	0.9	1.2	0.07	5559056.9	503659.2	124	d5t16
d5t19 eot 15.7 m	E.O.T.	534.727	0.9	1.1	0.12	5558681.0	503622.5	128	d5t19
d6t29 eot 65.6 m	E.O.T.	533.355	0.8	1.1	0.07	5558435.3	504119.3	136	d6t29
d6t36 eot 134 m about	E.O.T.	533.199	0.8	1.0	0.04	5558487.6	504798.4	141	d6t36
d6t20 eot 53.6 m	E.O.T.	532.208	1.0	1.1	0.22	5558004.6	504694.4	147	d6t20
d6t6 eot 66.5 lake bottom	E.O.T.	531.729	0.8	1.0	0.07	5557420.7	503430.9	150	d6t6
D1T5 eot 20.1 m	E.O.T.	546.651	1.2	1.5	0.27	5565406.1	503024.2	156	D1T5
d3t10eot	E.O.T.	915.801	1.1	1.2	0.01	5490074.7	588909.7	158	d3t10
L1T20 eot 67 m	E.O.T.	557.120	1.0	1.1	0.06	5569794.2	502628.7	162	L1T20
L1T10 eot	E.O.T.	555.086	0.8	1.1	0.14	5569331.0	502651.2	166	L1T10
L1T1 eot 38.6 m	E.O.T.	551.950	1.0	1.1	0.11	5568691.9	502259.0	174	L1T1
D4T3 eot	E.O.T.	539.213	0.8	1.1	0.14	5561399.0	503454.0	180	D4T3
D4T10 eot	E.O.T.	538.697	0.8	1.1	0.03	5561388.6	503446.3	183	D4T10
D4T5 eot 42 m	E.O.T.	538.502	0.8	1.0	0.12	5560619.1	503327.9	188	D4T5
D5T2 eot	E.O.T.	537.692	0.8	1.0	0.20	5560227.9	503399.4	194	D5T2
D5T9 eot 35 m	E.O.T.	536.935	0.8	1.1	0.12	5559701.5	503443.4	199	D5T9
l3t30 eot	E.O.T.	592.231	1.0	1.1	0.17	5577936.1	497812.7	207	l3t30
L3t9 eot 47.5 m	E.O.T.	582.462	0.8	1.1	0.10	5576418.0	498981.6	212	L3t9
L3t1 eot 32.6 m	E.O.T.	579.032	0.9	1.1	0.19	5576080.8	499766.1	213	L3t1
L2T18 eot 33.6 m	E.O.T.	578.307	0.9	1.0	0.16	5575874.2	499876.4	222	L2T18
L2T15 correct eot	E.O.T.	569.928	0.8	1.1	0.10	5573715.1	501285.3	231	L2T15
L2T6 eot 60.7 m	E.O.T.	567.489	0.8	1.0	0.17	5572671.9	501722.1	237	L2T6

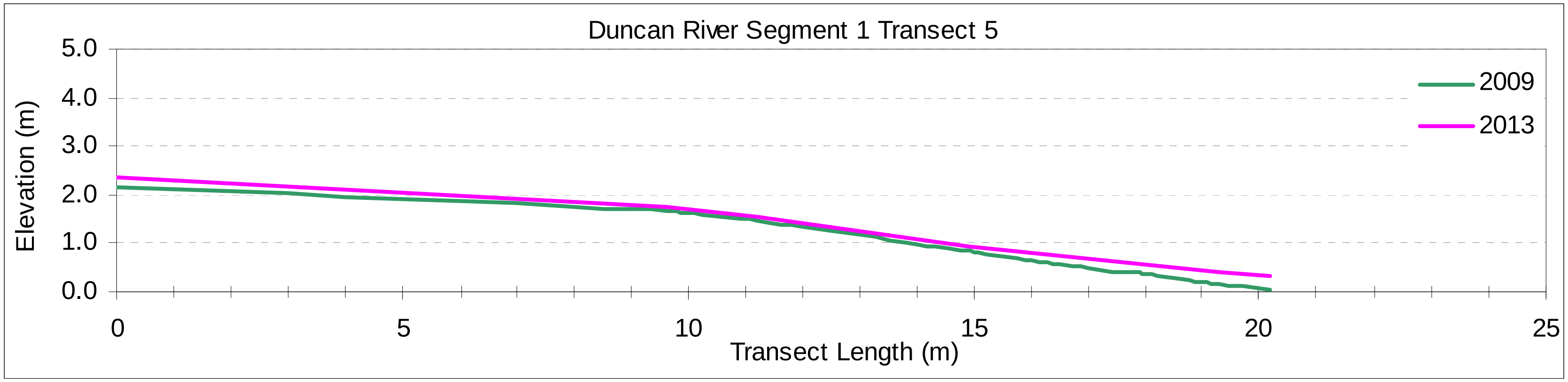
Comment	Feat Name	GNSS Height	Vert Prec	Horz Prec	Std Dev	Northing	Easting	Point ID
d3t10 total st	Point_ge	543.340	0.9	1.1	0.05	5563066.0	502932.1	33
d3t10 refer 1	Point_ge	542.266	1.0	1.1	0.11	5563073.6	502927.4	34
d3t10 bench mark cedar tr	Point_ge	543.117	1.0	1.1	0.18	5563085.5	502910.3	35
d3t11 bench mark fir tr d/st	Point_ge	542.456	0.9	1.2	0.36	5562961.4	502757.1	37
d3t11 ref 1 fir tr up/st side	Point_ge	542.012	0.8	1.1	0.10	5562966.2	502801.8	38
d3t11 120 m last cot shr edge	Point_ge	541.964	1.3	1.9	0.19	5562895.6	502856.7	39
d3t11 total station	Point_ge	542.328	1.2	1.7	0.19	5562935.2	502816.9	41
d3t15 total station	Point_ge	541.371	0.8	1.0	0.02	5562967.9	502475.0	43
d3t15 piez sh4	Point_ge	541.351	0.8	1.0	0.03	5562975.7	502461.4	44
d3t15 bench mark fir behindPOC	Point_ge	543.594	0.9	1.1	0.16	5562932.0	502487.8	53
d3t15 refer fir behind d/stm	Point_ge	543.166	0.8	1.1	0.13	5562932.7	502481.4	54
d3t15 t17	Point_ge	540.630	0.9	1.1	0.02	5562973.6	502582.3	55
d3t15 t17 pic willow up/str end	Point_ge	540.914	0.8	1.1	0.05	5562973.4	502582.2	56
d3t17 rebar 9m	Point_ge	540.821	0.8	1.1	0.07	5562984.3	502488.0	59
d1t3 refer 1 fir tree	Point_ge	548.751	0.9	1.1	0.23	5565650.5	503059.5	61
d1t3 bench mark spruce tr	Point_ge	549.154	0.9	1.1	0.20	5565645.3	503044.6	62
d1t4 benchmark fir tree	Point_ge	545.641	1.0	1.2	0.23	5565447.5	502995.6	66
d1t4 refer 1 spruce tr	Point_ge	546.327	1.0	1.3	0.34	5565470.8	502991.8	67
d1t4 totalstation	Point_ge	547.830	1.1	1.3	0.25	5565455.5	502983.9	68
d3t29 rebar 26.5m inWillow	Point_ge	541.734	0.8	1.1	0.05	5562818.1	502585.8	72
d3t29 rebar 13m	Point_ge	542.811	0.8	1.1	0.05	5562806.8	502591.1	73
d3t29 refer 1 stump	Point_ge	541.757	0.8	1.1	0.03	5562784.6	502574.8	84
d3t29 total station	Point_ge	541.226	0.8	1.1	0.04	5562819.8	502539.5	85
d3t29 benchmark	Point_ge	542.248	1.0	1.2	0.11	5562758.3	502567.1	86
d3t29 benchmark 2 birch	Point_ge	542.113	0.9	1.2	0.08	5562728.8	502527.2	87
d3t35 rebar	Point_ge	541.478	0.8	1.1	0.05	5562759.0	502497.5	89
d3t20 benchmark waterbirch	Point_ge	542.798	0.9	1.1	0.15	5562576.2	502575.0	92
d3t20 totalstation	Point_ge	540.128	0.8	1.0	0.02	5562571.8	502564.4	93
d3t20 rebar 30 m	Point_ge	540.768	0.8	1.0	0.19	5562573.6	502556.1	94
d3t23 benchmark alder	Point_ge	541.367	0.8	1.1	0.24	5562249.8	502687.7	97
d3t23 rebar 18 m	Point_ge	541.685	0.8	1.1	0.05	5562260.5	502701.4	98
d3t23 totalstation	Point_ge	541.488	0.8	1.1	0.05	5562248.4	502703.0	99
d3t45 rebar 4 m	Point_ge	539.639	0.8	1.1	0.03	5561895.8	503211.9	102
d3t45 rebar 27 m	Point_ge	540.109	0.8	1.1	0.05	5561902.9	503233.4	103
d3t45 benchmark aldes	Point_ge	540.616	0.9	1.1	0.18	5561904.8	503199.7	105
d3t45 totalstation	Point_ge	540.748	0.9	1.1	0.07	5561913.6	503233.8	106
d3t40 rebar 18.2 m	Point_ge	538.870	0.8	1.1	0.36	5561939.9	503206.5	108
d5t11 rebar 13 m	Point_ge	535.515	0.9	1.1	0.03	5559554.5	503729.2	111
d5t11 rebar 36 m	Point_ge	535.386	0.8	1.0	0.02	5559562.0	503751.4	112
d5t11 totalstation	Point_ge	536.005	1.1	1.1	0.10	5559532.0	503742.1	114
d5t11 benchmark waterbirch	Point_ge	539.103	1.0	1.1	0.13	5559529.2	503723.1	115
d5t12 rebar 57.4 m	Point_ge	536.047	0.9	1.1	0.09	5559550.1	503779.9	117
d5t12 rebar 14 m	Point_ge	536.262	0.8	1.1	0.03	5559536.1	503738.9	118
d5t16 benchmark piez SH1	Point_ge	533.897	1.0	1.1	0.09	5559039.7	503726.0	121
d5t16 totalstation	Point_ge	535.513	0.9	1.1	0.03	5559036.6	503702.0	125
d5t19 rebar 8.4 m	Point_ge	535.241	0.9	1.2	0.13	5558679.8	503629.4	127
d5t19 totalstation	Point_ge	534.944	0.8	1.1	0.11	5558684.6	503629.3	129
d5t19 benchmark alder	Point_ge	535.208	0.8	1.1	0.15	5558688.6	503633.6	130
d6t29 benchmark sproutingWillow	Point_ge	534.386	0.8	1.1	0.04	5558374.8	504121.8	132
d6t29 rebar 9 m	Point_ge	533.912	0.8	1.1	0.11	5558380.6	504120.4	133
d6t29 totalstation	Point_ge	533.418	1.0	1.4	0.05	5558411.7	504124.1	134
d6t29 rebar 48.3 m	Point_ge	534.056	0.8	1.1	0.13	5558417.7	504119.2	135
d6t36 benchmark old log	Point_ge	534.802	0.8	1.0	0.04	5558360.4	504827.2	138
d6t36 rebar 15 m	Point_ge	534.621	0.8	1.0	0.03	5558374.2	504836.5	139
d6t36 totalstation	Point_ge	534.701	0.8	1.0	0.02	5558399.7	504840.2	140
d6t20 totalstation	Point_ge	532.614	0.8	1.1	0.08	5558005.1	504727.9	143

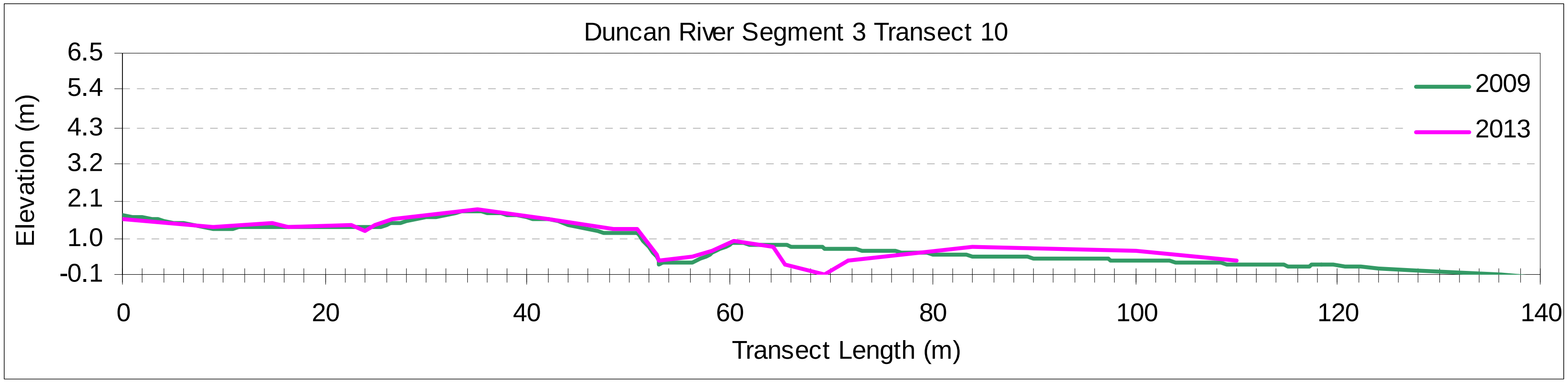
Comment	Feat Name	GNSS Height	Vert Prec	Horz Prec	Std Dev	Northing	Easting	Point ID
d6t20 benchmark L cedar stump	Point_ge	532.785	0.8	1.1	0.02	5558063.3	504747.5	144
d6t20 rebar 5.9m	Point_ge	532.314	0.9	1.1	0.11	5557995.2	504740.8	145
d6t20 rebar 14 m	Point_ge	531.746	0.9	1.1	0.13	5557996.8	504732.9	146
d6t6 rebar 24.2 m	Point_ge	534.065	0.8	1.1	0.06	5557457.5	503410.1	149
d6t6 totalstation	Point_ge	534.607	0.8	1.0	0.02	5557451.9	503424.4	151
d6t6 benchmark WaterBirch	Point_ge	534.140	0.8	1.1	0.04	5557430.1	503364.4	152
D1T5 benchmark	Point_ge	547.552	1.0	1.3	0.27	5565427.3	503015.4	153
D1T5 totalstation	Point_ge	544.953	1.1	1.4	0.28	5565421.7	503019.0	154
D1T5 rebar 11.1	Point_ge	547.254	1.6	2.1	1.30	5565411.3	503027.1	155
L1T20 rebar 3.1 m	Point_ge	557.965	1.4	1.1	0.75	5569739.4	502599.1	160
L1T20 rebar 15.5 m	Point_ge	557.833	1.0	1.1	0.06	5569749.9	502604.9	161
L1T20 totalstation	Point_ge	558.282	1.1	1.1	0.14	5569746.4	502611.7	163
L1T20 benchmark	Point_ge	565.000	1.7	1.2	0.30	5569727.5	502597.7	164
L1T10 rebar 36 m	Point_ge	556.524	0.9	1.1	0.50	5569341.7	502649.2	165
L1T10 totalstation	Point_ge	556.160	0.8	1.1	0.17	5569344.4	502642.0	167
L1T10 rebar 23 m	Point_ge	556.336	0.9	1.1	0.12	5569354.0	502647.1	168
L1T10 benchmark cedar	Point_ge	559.870	2.6	3.0	1.02	5569366.7	502619.6	170
L1T1 rebar 9.5 m	Point_ge	553.764	1.0	1.1	0.04	5568710.9	502237.6	172
L1T1 rebar 12.2 m	Point_ge	554.164	0.9	1.1	0.17	5568709.2	502239.3	173
L1T1 totalstation	Point_ge	553.852	1.0	1.1	0.12	5568700.6	502240.0	175
L1T1 benchmark cottenwood	Point_ge	554.672	1.0	1.1	0.08	5568708.7	502229.1	176
D4T3 rebar 11. m	Point_ge	540.795	1.0	1.2	0.56	5561354.0	503481.7	178
D4T3 totalstation	Point_ge	541.520	0.8	1.1	0.05	5561372.6	503474.8	179
D4T3/T10 benchmark fir	Point_ge	538.117	1.0	1.3	0.38	5561341.3	503458.0	181
D4T10 rebar 13 m	Point_ge	540.323	0.8	1.1	0.09	5561353.7	503464.9	184
D4T10 rebar 6.0 m	Point_ge	540.925	1.1	1.4	0.20	5561348.2	503466.8	185
D4T5 rebar 6.5 m	Point_ge	540.183	0.9	1.1	0.11	5560621.8	503292.7	187
D4T5 totalstation	Point_ge	540.754	0.8	1.0	0.09	5560606.3	503303.0	189
D4T5 benchmark cedar	Point_ge	540.406	1.5	1.7	0.10	5560634.6	503281.5	190
D5T2 benchmark cot	Point_ge	541.083	1.2	1.5	0.34	5560237.5	503370.4	192
D5T2 rebar 4 m	Point_ge	540.658	0.9	1.1	0.36	5560233.9	503374.3	193
D5T2 totalstation	Point_ge	538.552	0.8	1.1	0.08	5560221.5	503385.5	195
D5T9 rebar 3.3 m	Point_ge	533.210	1.3	1.5	0.08	5559727.6	503458.0	197
D5T9 rebar 15.7 m	Point_ge	537.367	0.8	1.1	0.20	5559718.6	503452.1	198
D5T9 totalstation	Point_ge	537.608	0.8	1.1	0.08	5559715.1	503442.3	200
D5T9 benchmark	Point_ge	538.437	1.5	1.7	0.15	5559727.5	503460.3	201
l3t30 totalstation	Point_ge	592.117	5.9	4.4	0.09	5577923.1	497787.9	203
l3t30 rebar 3.5 m	Point_ge	595.765	2.1	1.5	0.47	5577913.9	497777.7	204
l3t30 rebar 10.65 m	Point_ge	593.507	1.6	1.1	0.50	5577917.1	497785.3	206
L3t9 benchmark grand fir	Point_ge	584.225	0.9	1.2	0.19	5576380.8	498960.4	209
l3t9 rebar 10 m	Point_ge	582.949	1.0	1.2	0.23	5576388.1	498959.3	210
L3t9 rebar 22 m	Point_ge	584.172	0.9	1.2	0.67	5576398.2	498966.3	211
L3T1 totalstation	Point_ge	579.723	0.9	1.1	0.06	5576073.5	499759.3	214
L3T1 rebar 8.65 m	Point_ge	579.619	1.7	1.5	0.47	5576067.5	499747.0	216
L3T1 benchmark spruce	Point_ge	583.103	1.8	1.2	0.06	5576078.4	499728.3	217
L2T18 benchmark fir	Point_ge	578.521	1.0	1.1	0.21	5575910.4	499881.8	220
L2T18 totalstation	Point_ge	578.977	0.9	1.1	0.05	5575896.0	499863.1	221
LT18 rebar 19 m	Point_ge	578.660	0.9	1.1	0.12	5575887.5	499879.7	223
L2T18 rebar 7 m	Point_ge	579.643	1.0	1.1	0.09	5575900.1	499883.0	224
L2T15 rebar 19 m	Point_ge	570.712	1.0	1.1	0.54	5573719.4	501299.4	226
L2T15 totalstation	Point_ge	570.852	0.9	1.1	0.06	5573722.7	501287.3	227
L2T15 wrong point	Point_ge	571.565	0.9	1.1	0.23	5573717.6	501290.3	228
L2T15 benchmark	Point_ge	570.062	0.9	1.2	0.10	5573713.5	501304.6	229
L2T15 rebar 29 m	Point_ge	570.613	0.9	1.1	0.02	5573716.7	501289.7	230
L2T6 rebar 9.5 m	Point_ge	568.435	0.9	1.1	0.12	5572696.6	501765.6	233
L2T6 rebar 17.8 m	Point_ge	567.329	1.0	1.3	0.21	5572693.3	501758.8	234
L2T6 totalstation	Point_ge	567.820	0.8	1.0	0.07	5572687.7	501747.8	235
L2T6 benchmark fir	Point_ge	568.340	0.9	1.1	0.21	5572682.6	501772.0	236

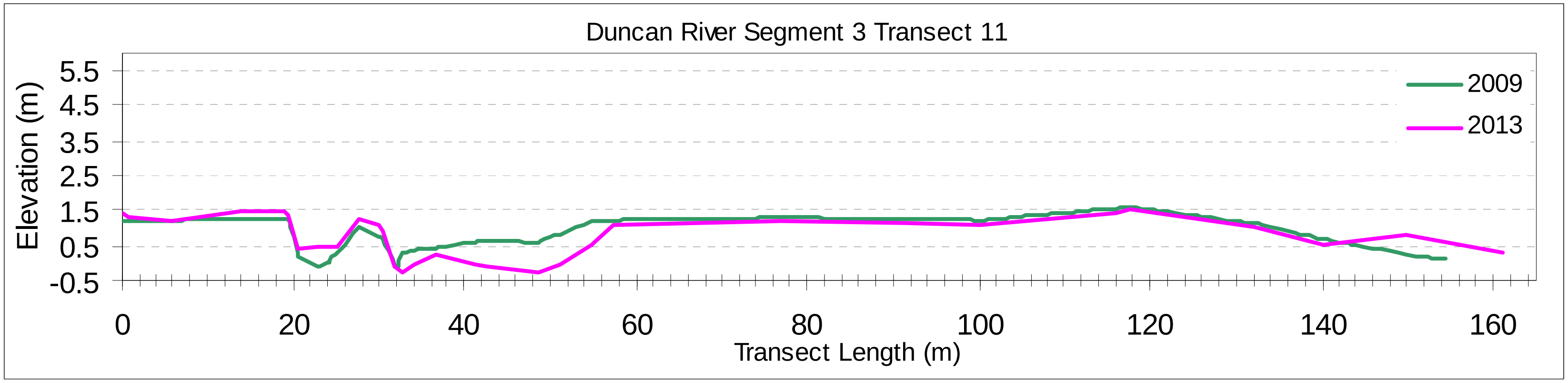
Appendix 2: Transect profiles for the Lower Duncan and Lardeau rivers 2009 and 2013

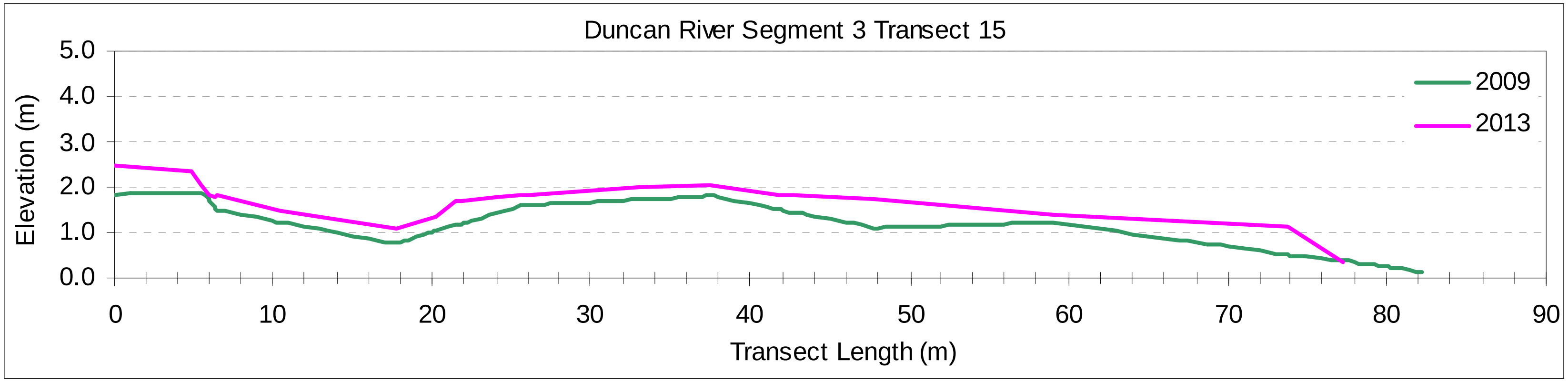

Duncan River Segment 1 Transect 3
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
Transect Length (m)
2009
2013

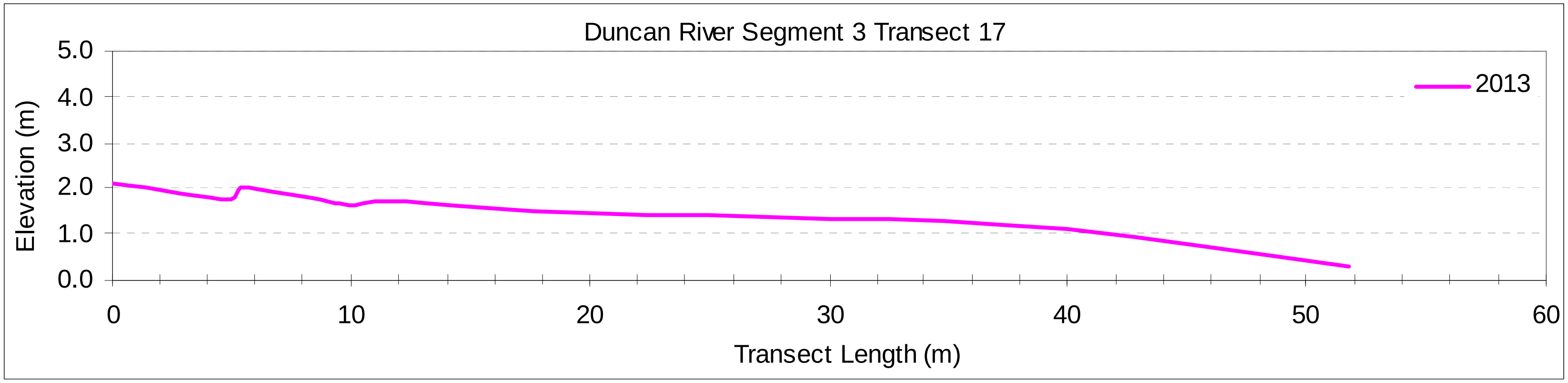

Duncan River Segment 1 Transect 4
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
Transect Length (m)
2009
2013

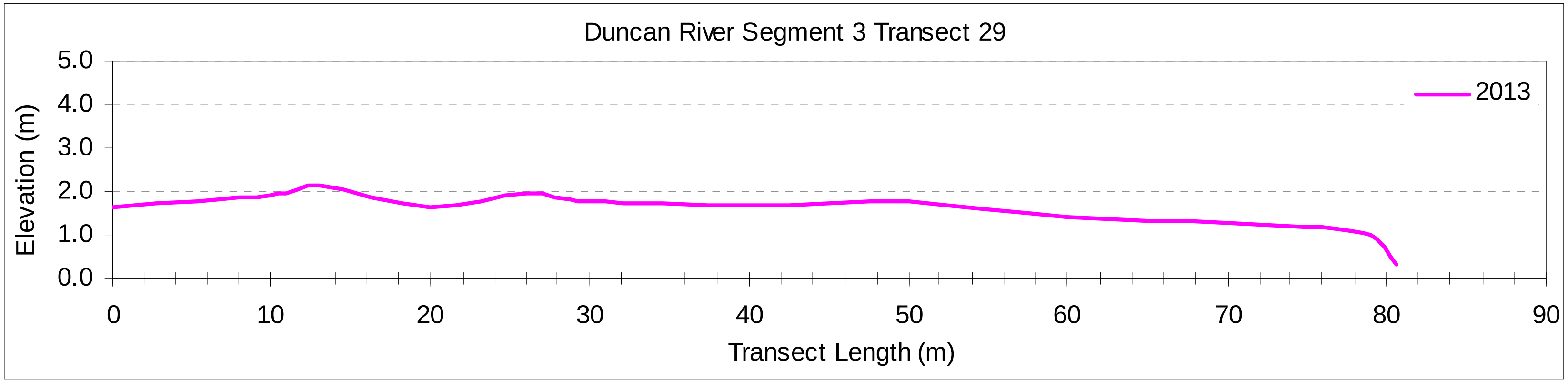

Duncan River Segment 1 Transect 5
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
Transect Length (m)
2009
2013

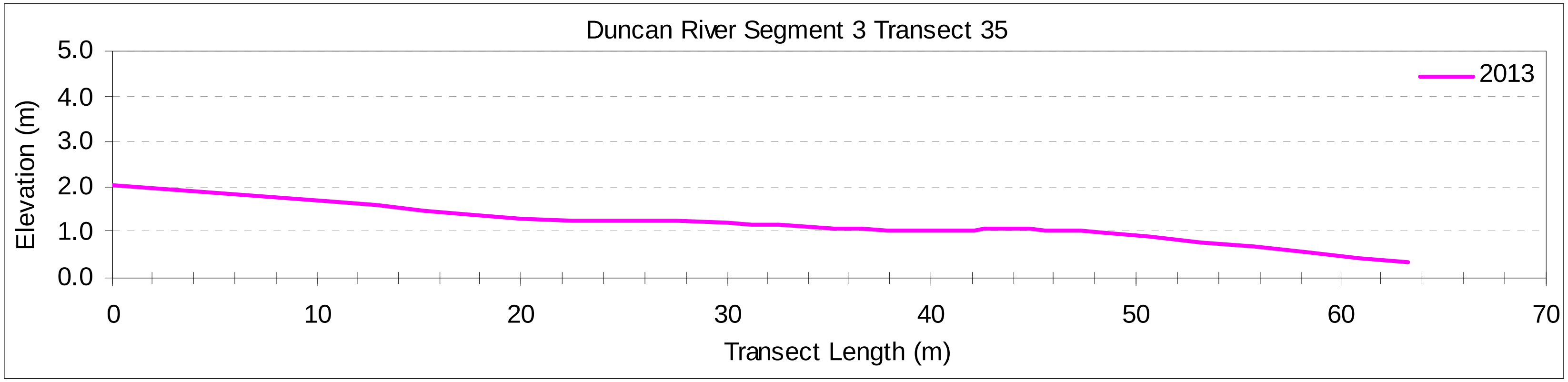

Duncan River Segment 3 Transect 10
Elevation (m)
6.5
5.4
4.3
3.2
2.1
1.0
-0.1
0
20
40
60
80
100
120
140
Transect Length (m)
2009
2013

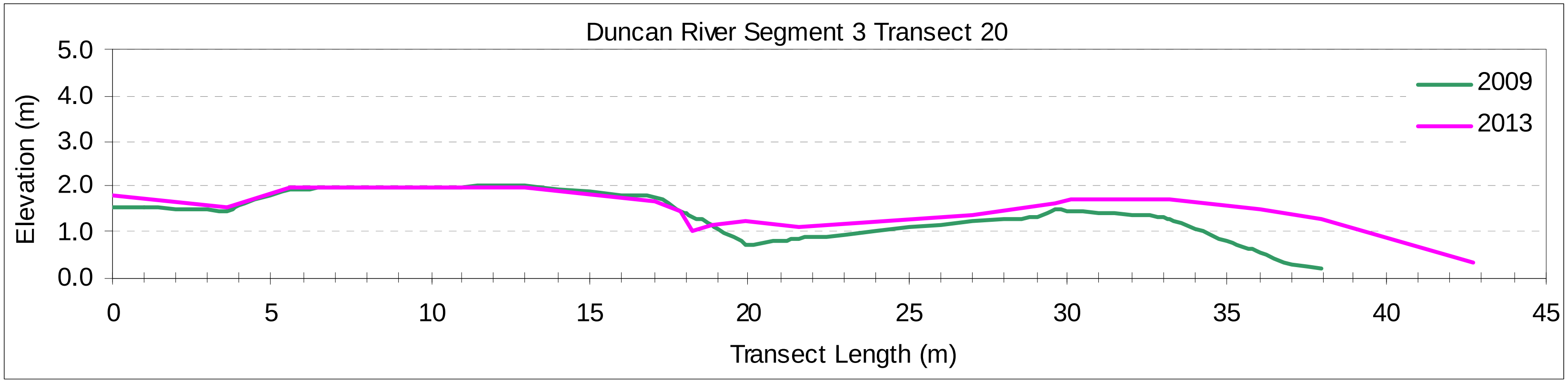

Duncan River Segment 3 Transect 11
Elevation (m)
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
0
20
40
60
80
100
120
140
160
Transect Length (m)
2009
2013

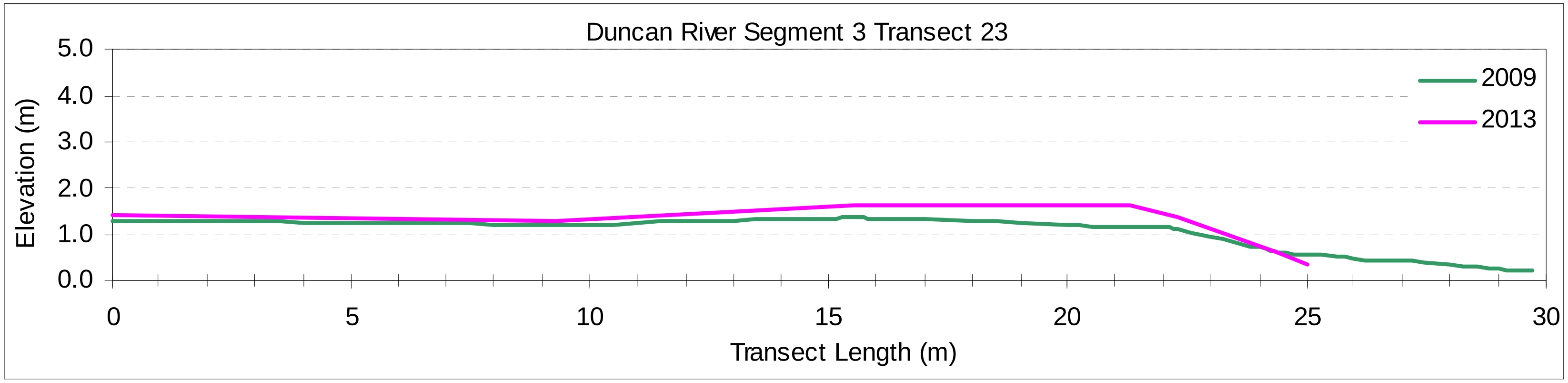

Duncan River Segment 3 Transect 15
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80
90
Transect Length (m)
2009
2013

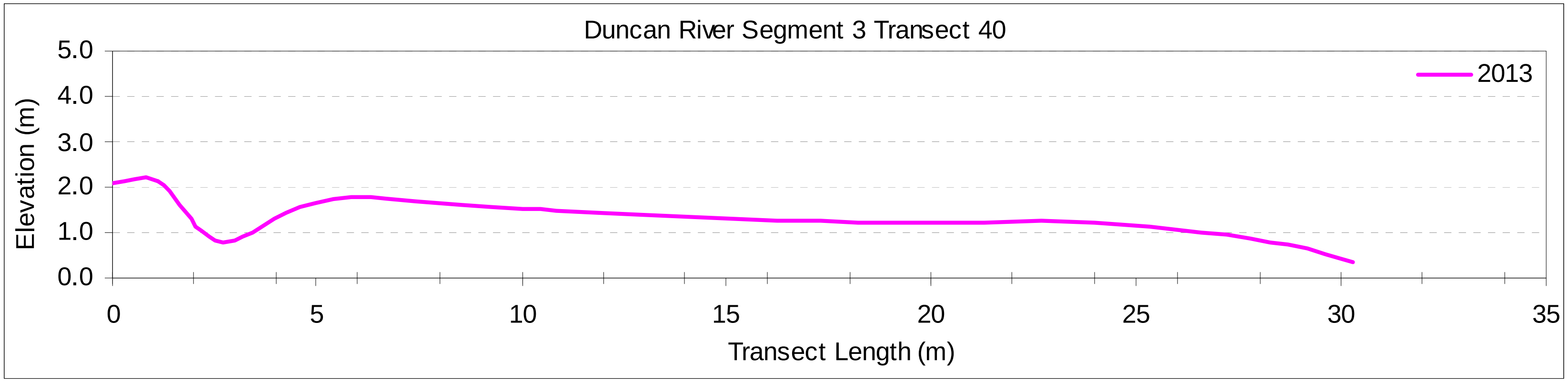

Duncan River Segment 3 Transect 17
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
Transect Length (m)
2013

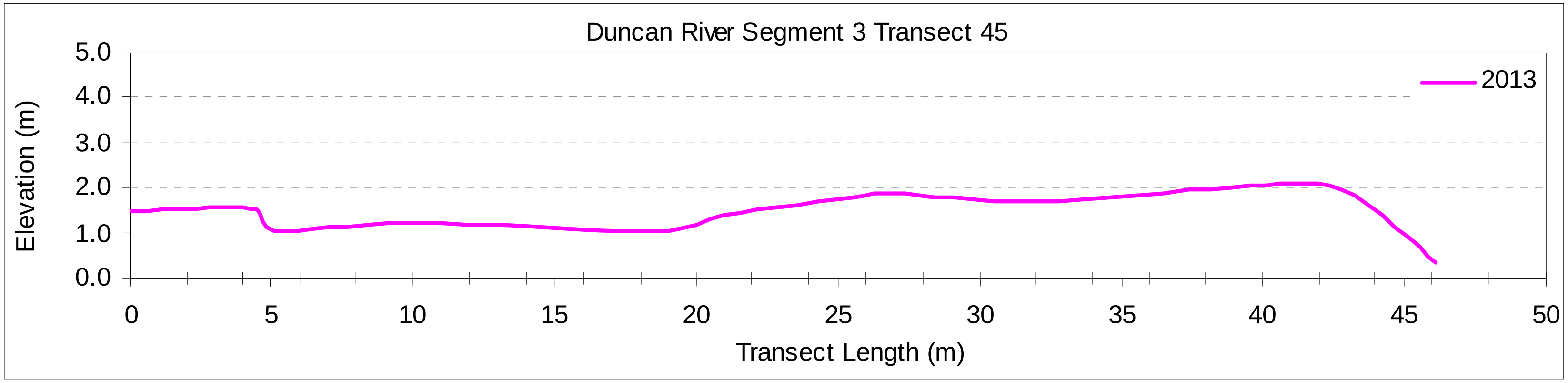

Duncan River Segment 3 Transect 29
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80
90
Transect Length (m)
2013

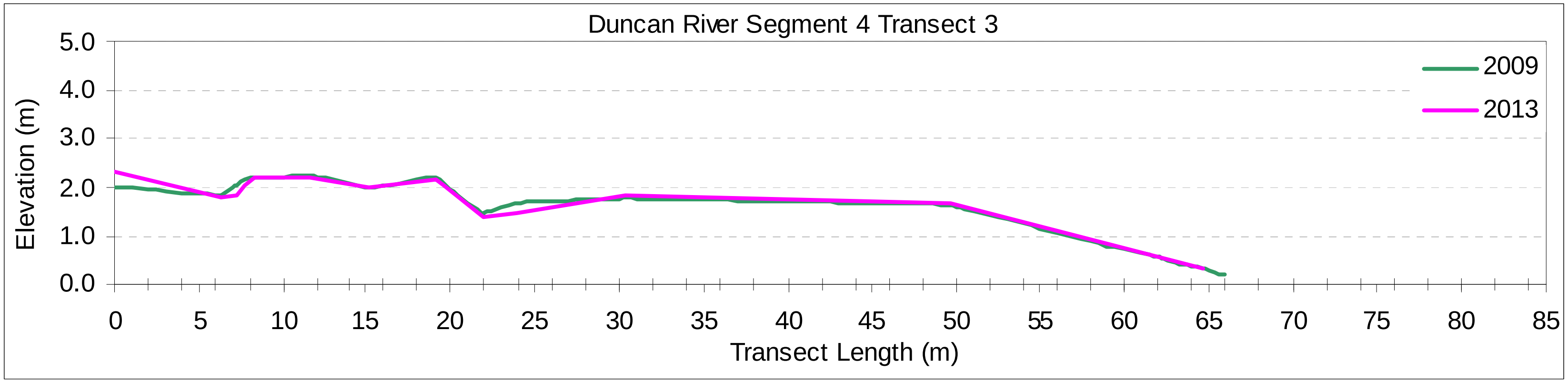

Duncan River Segment 3 Transect 35
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
Transect Length (m)
2013

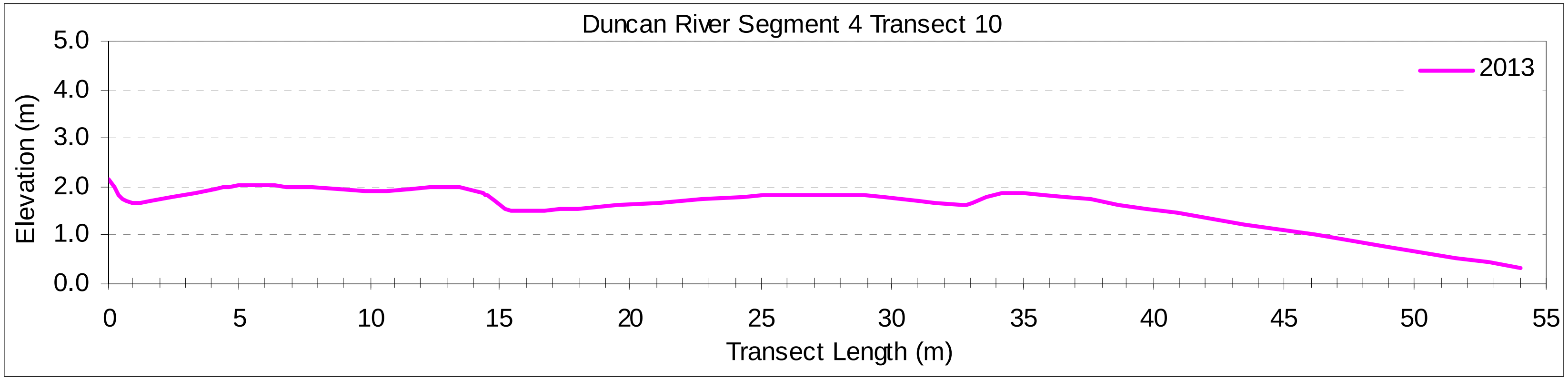

Duncan River Segment 3 Transect 20
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
Transect Length (m)
2009
2013

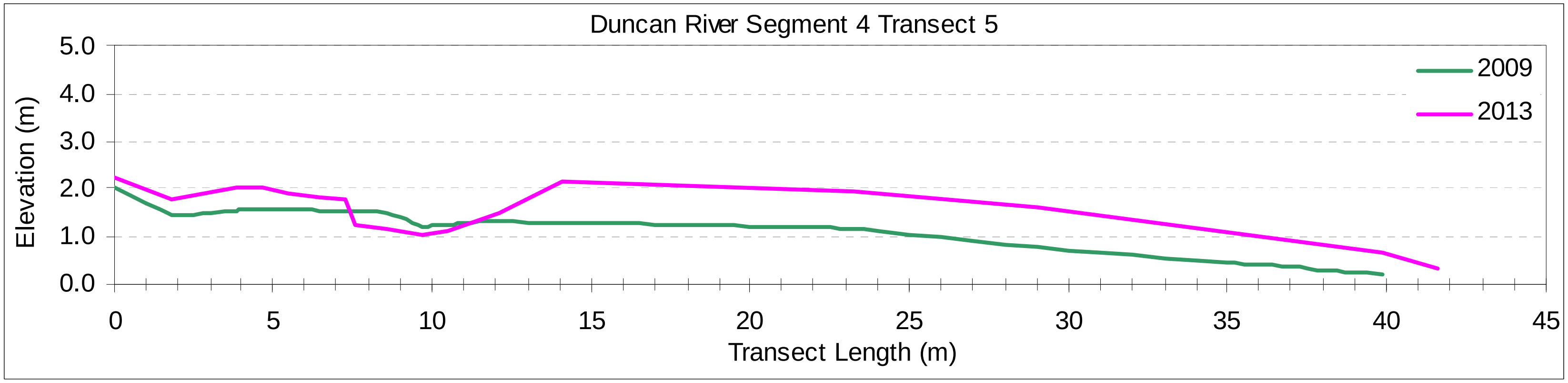

Duncan River Segment 3 Transect 23
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
Transect Length (m)
2009
2013

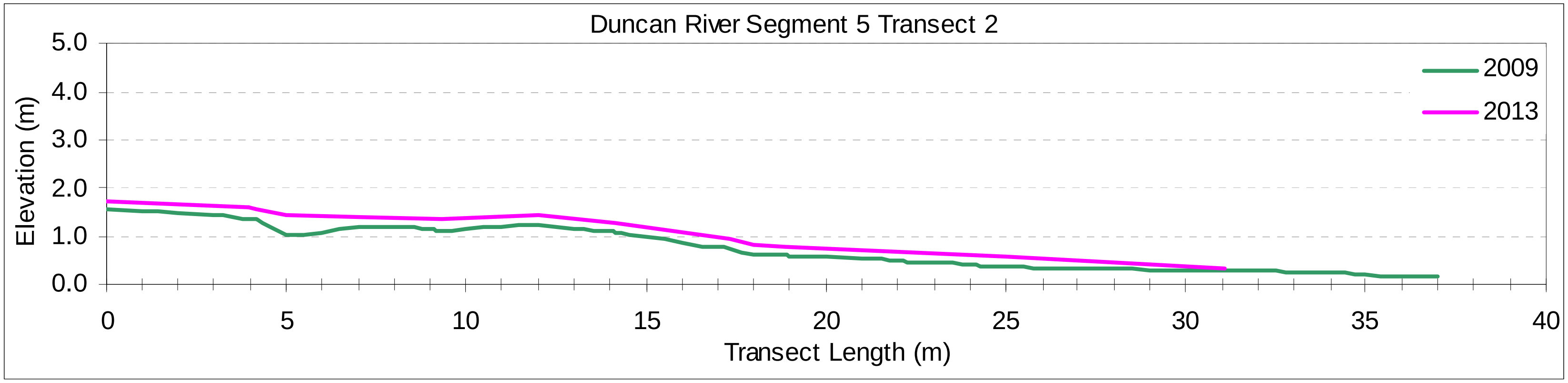

Duncan River Segment 3 Transect 40
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
Transect Length (m)
2013

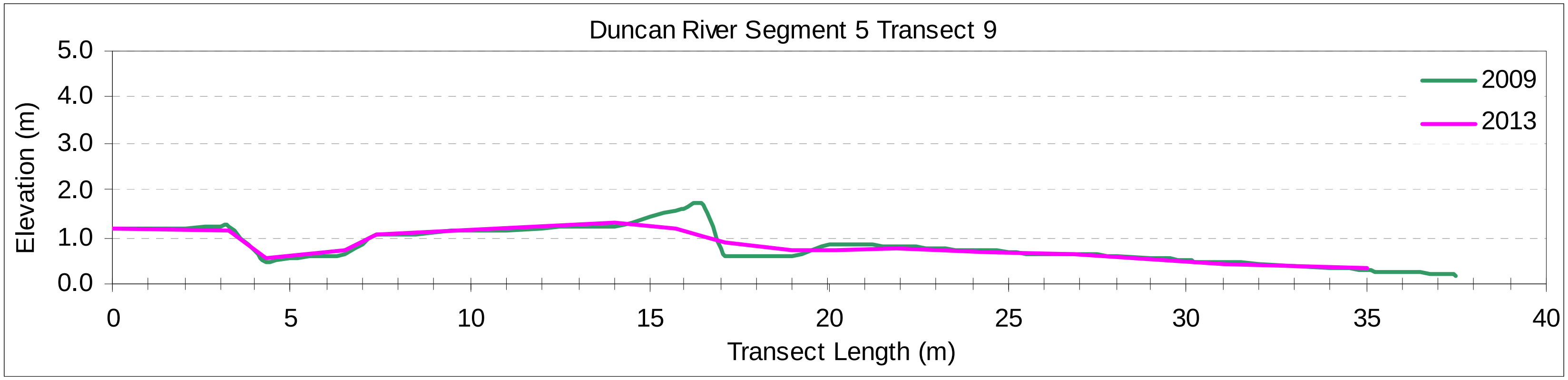

Duncan River Segment 3 Transect 45
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
Transect Length (m)
2013

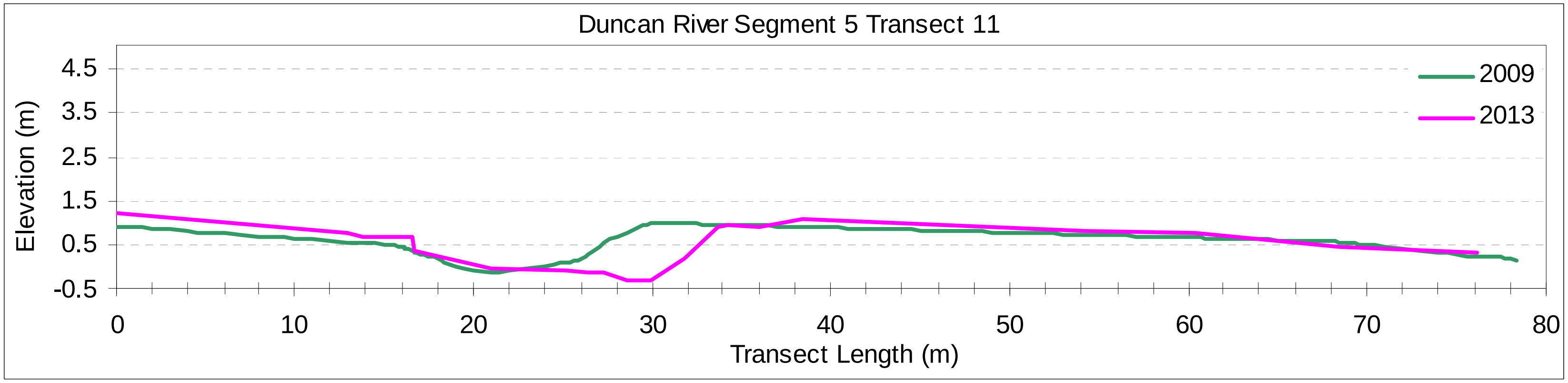

Duncan River Segment 4 Transect 3
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
Transect Length (m)
2009
2013

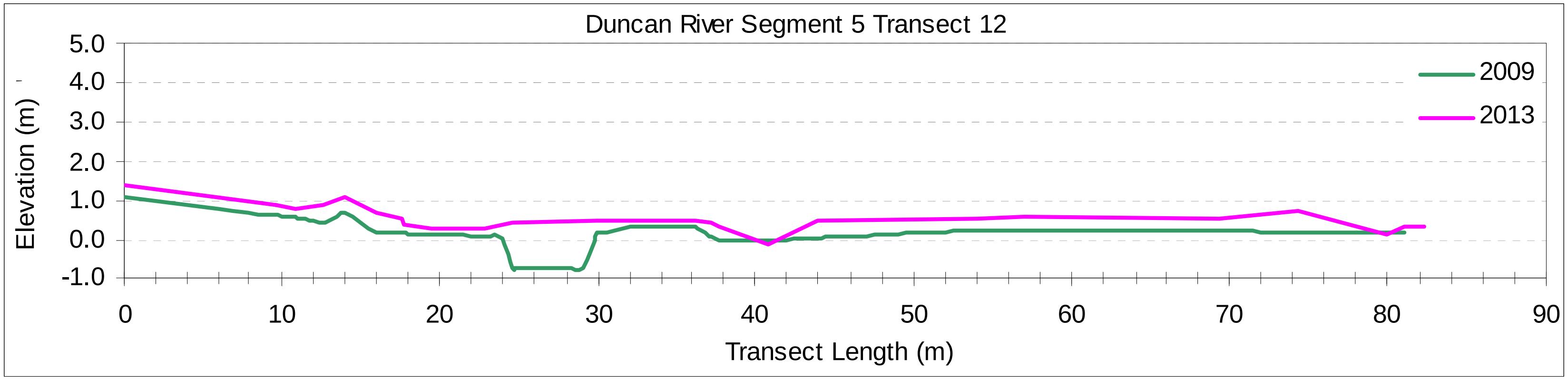

Duncan River Segment 4 Transect 10
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55
Transect Length (m)
2013

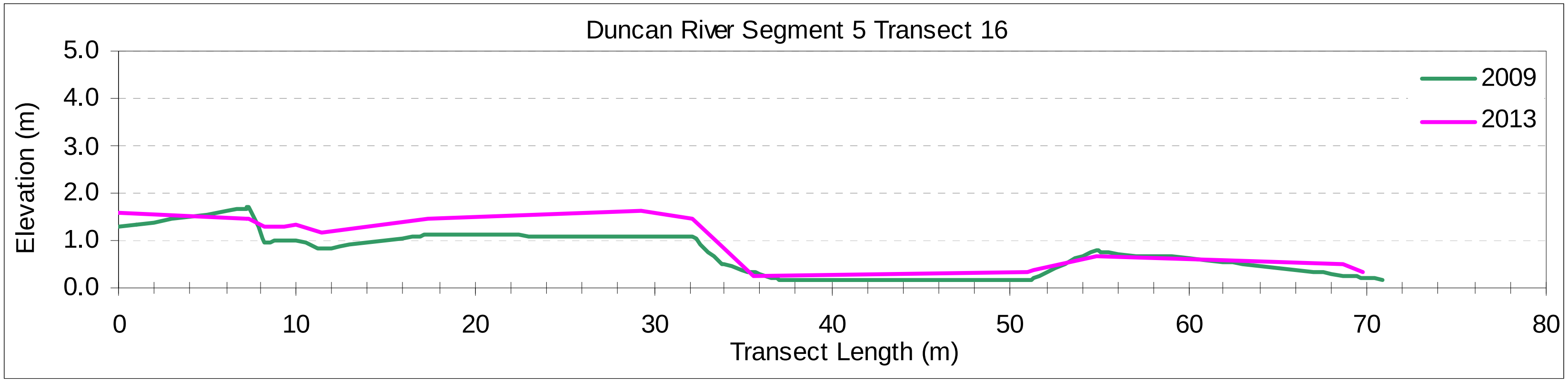

Duncan River Segment 4 Transect 5
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
Transect Length (m)
2009
2013

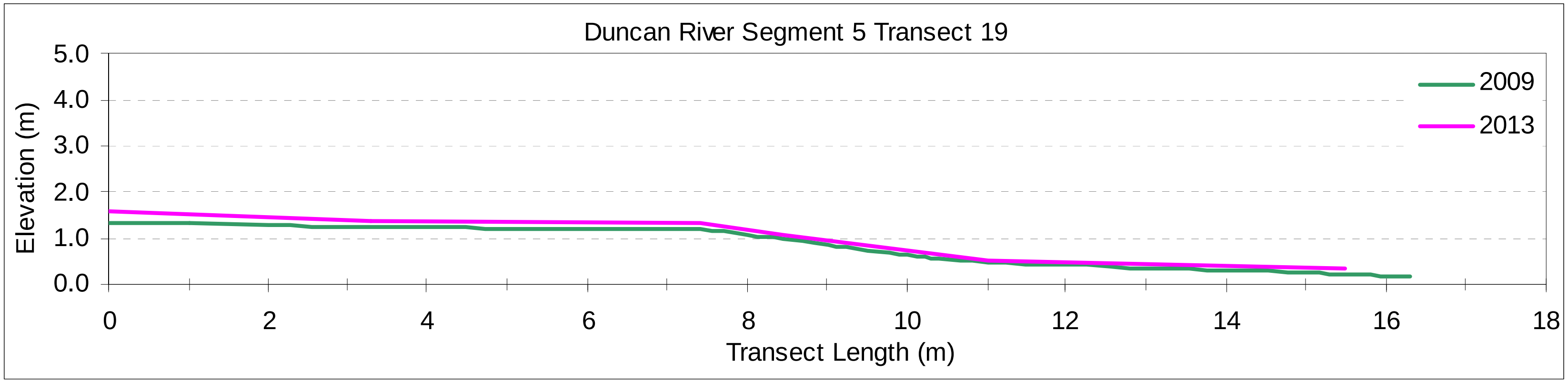

Duncan River Segment 5 Transect 2
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
Transect Length (m)
2009
2013

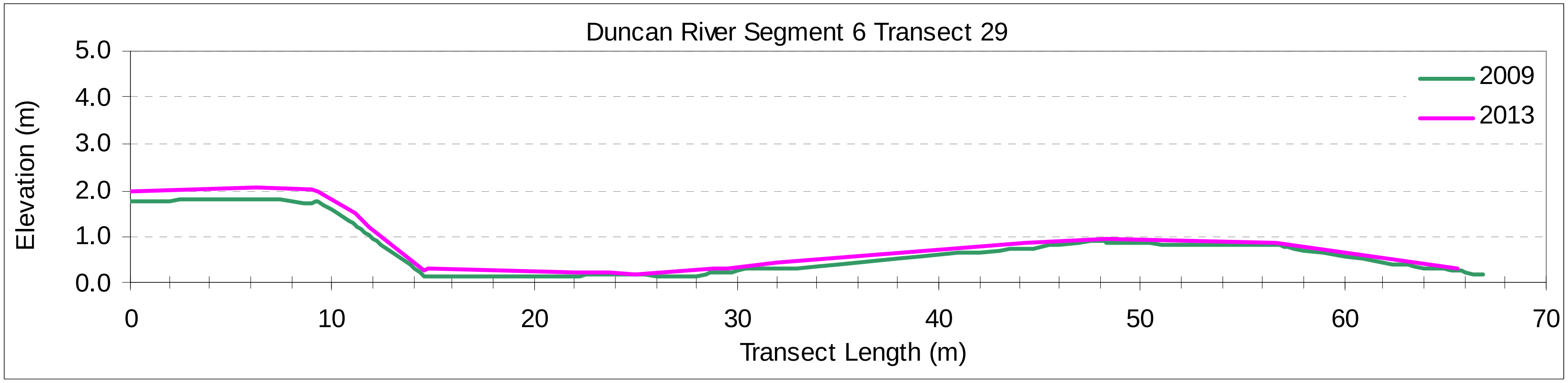

Duncan River Segment 5 Transect 9
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
Transect Length (m)
2009
2013

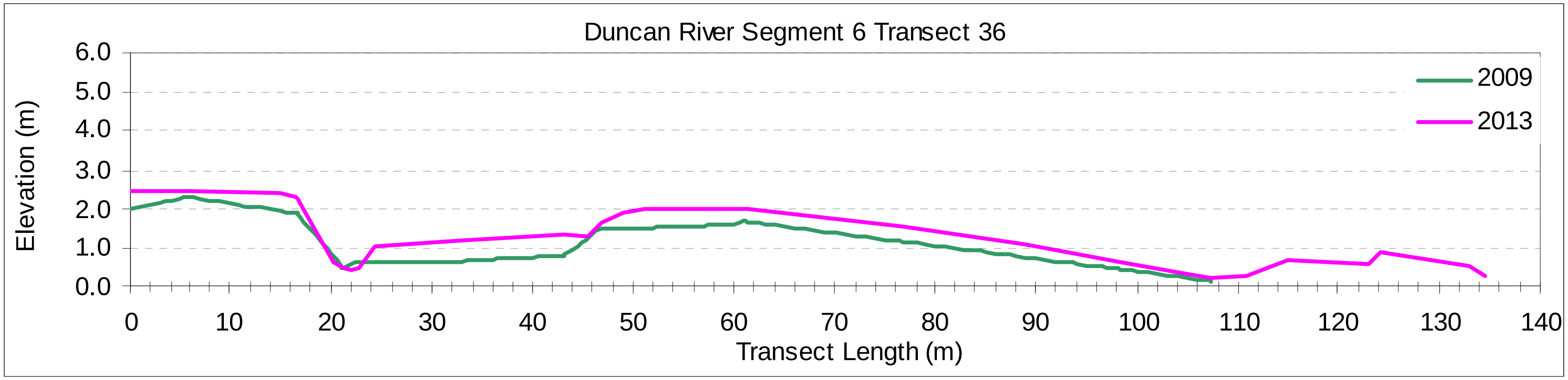

Duncan River Segment 5 Transect 11
Elevation (m)
4.5
3.5
2.5
1.5
0.5
-0.5
0
10
20
30
40
50
60
70
80
Transect Length (m)
2009
2013

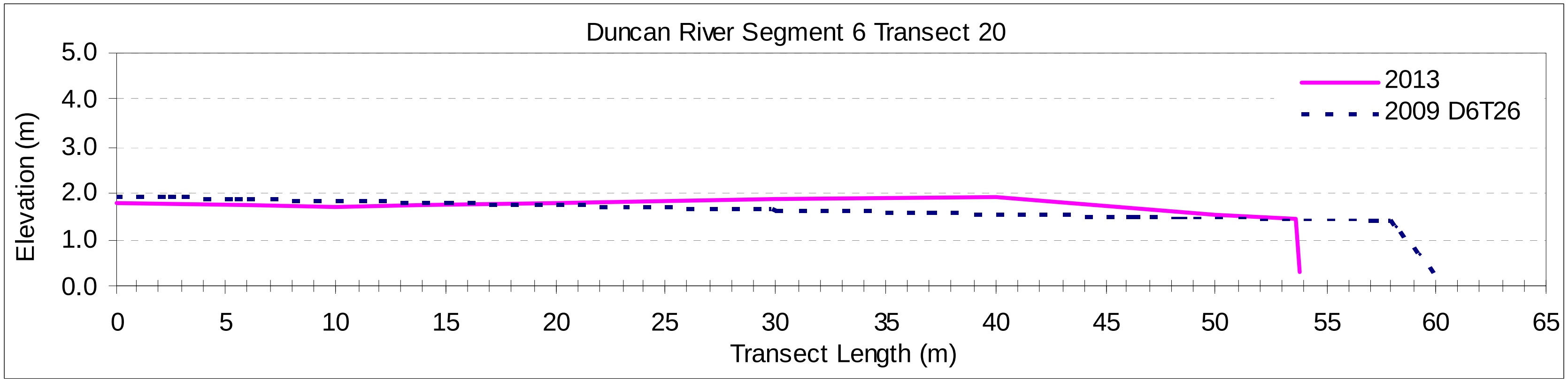

Duncan River Segment 5 Transect 12
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0
10
20
30
40
50
60
70
80
90
Transect Length (m)
2009
2013

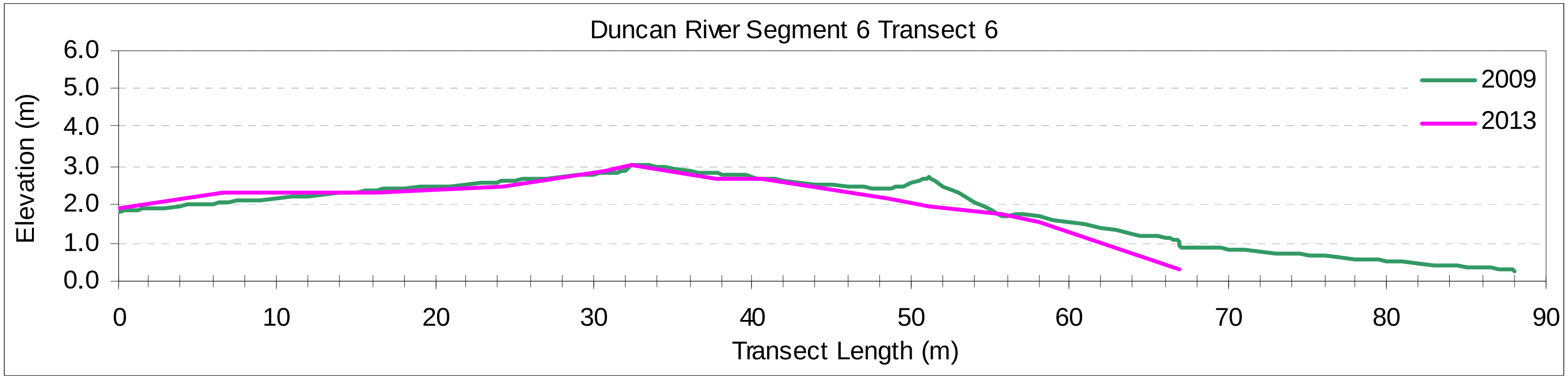

Duncan River Segment 5 Transect 16
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80
Transect Length (m)
2009
2013

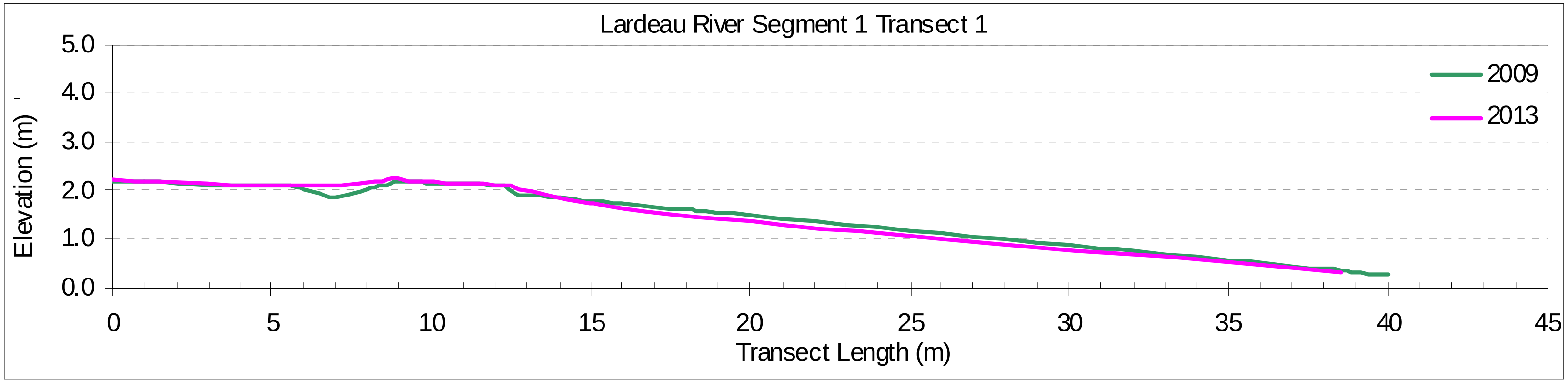

Duncan River Segment 5 Transect 19
Elevation (m)
Transect Length (m)
2009
2013
0.0
1.0
2.0
3.0
4.0
5.0
0
2
4
6
8
10
12
14
16
18

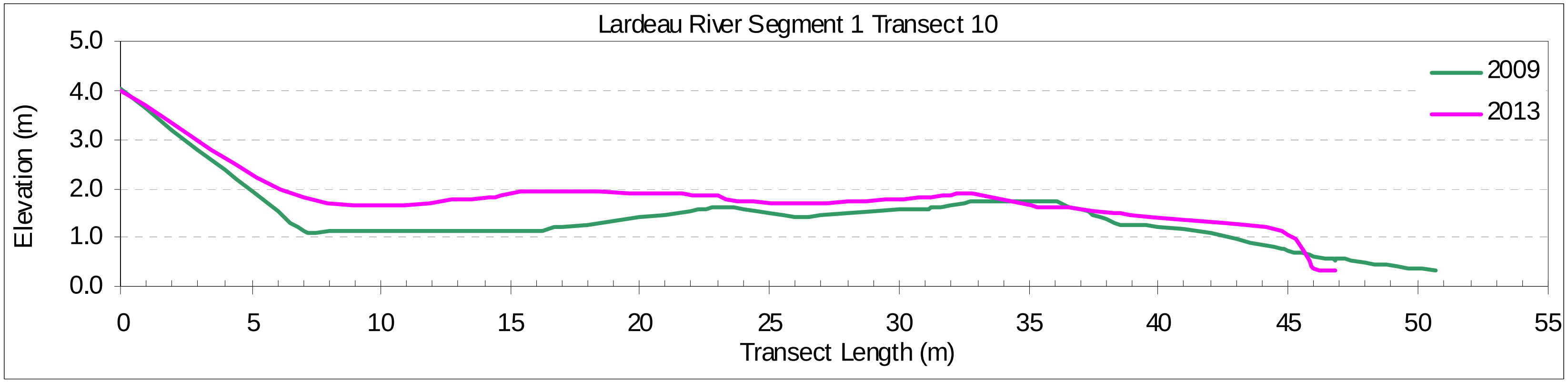

Duncan River Segment 6 Transect 29
Elevation (m)
Transect Length (m)
2009
2013
0.0
1.0
2.0
3.0
4.0
5.0
0
10
20
30
40
50
60
70

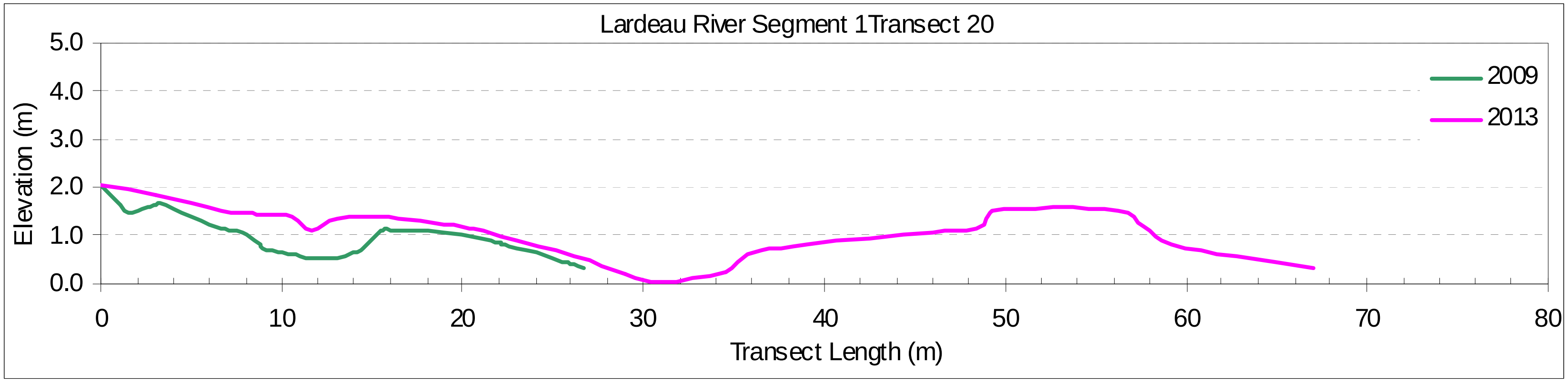

Duncan River Segment 6 Transect 36
Elevation (m)
Transect Length (m)
2009
2013
0.0
1.0
2.0
3.0
4.0
5.0
6.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

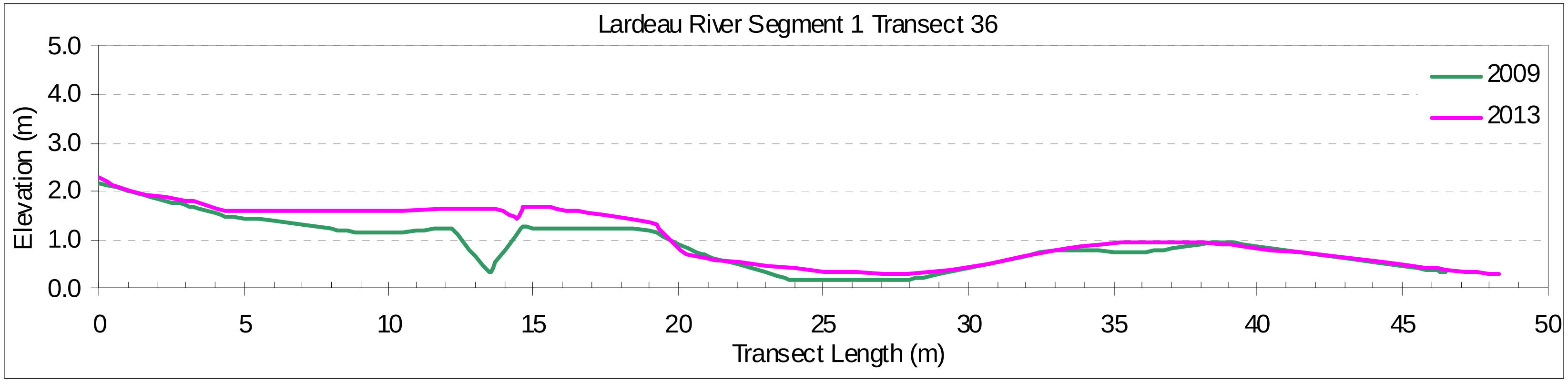

Duncan River Segment 6 Transect 20
Elevation (m)
Transect Length (m)
2013
2009 D6T26
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65

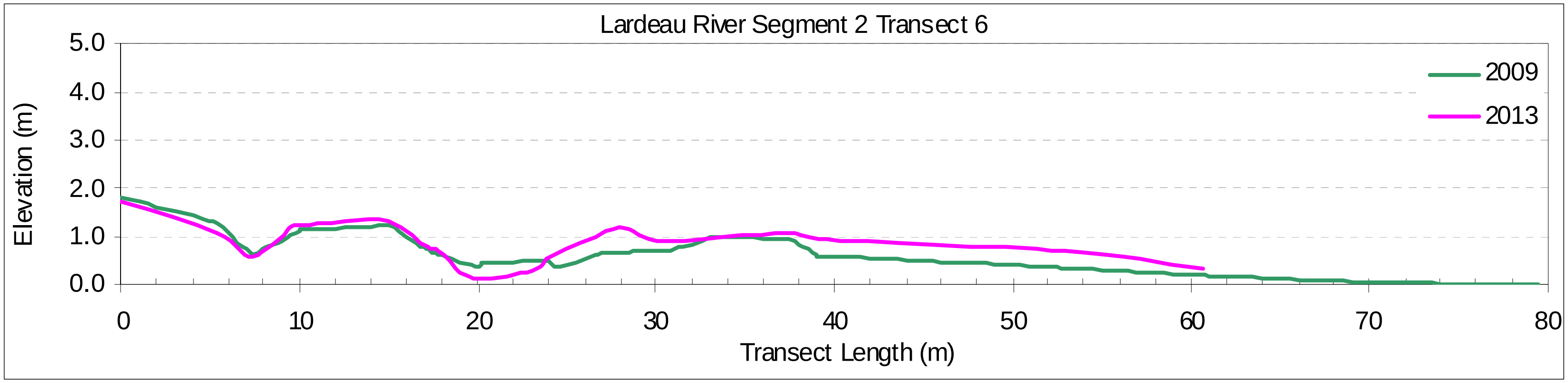

Duncan River Segment 6 Transect 6
Elevation (m)
Transect Length (m)
2009
2013
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80
90

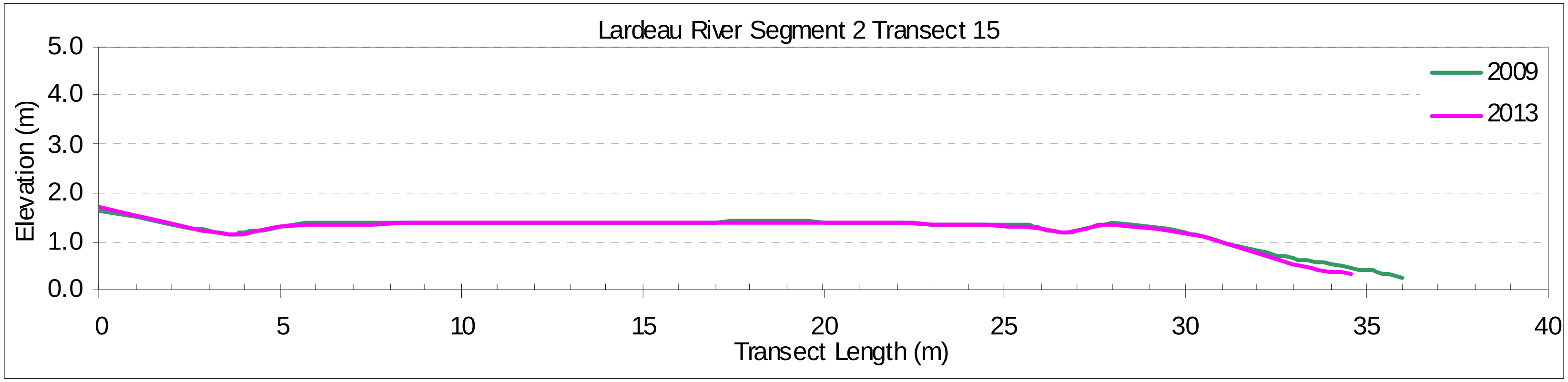

Lardeau River Segment 1 Transect 1
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
Transect Length (m)
2009
2013

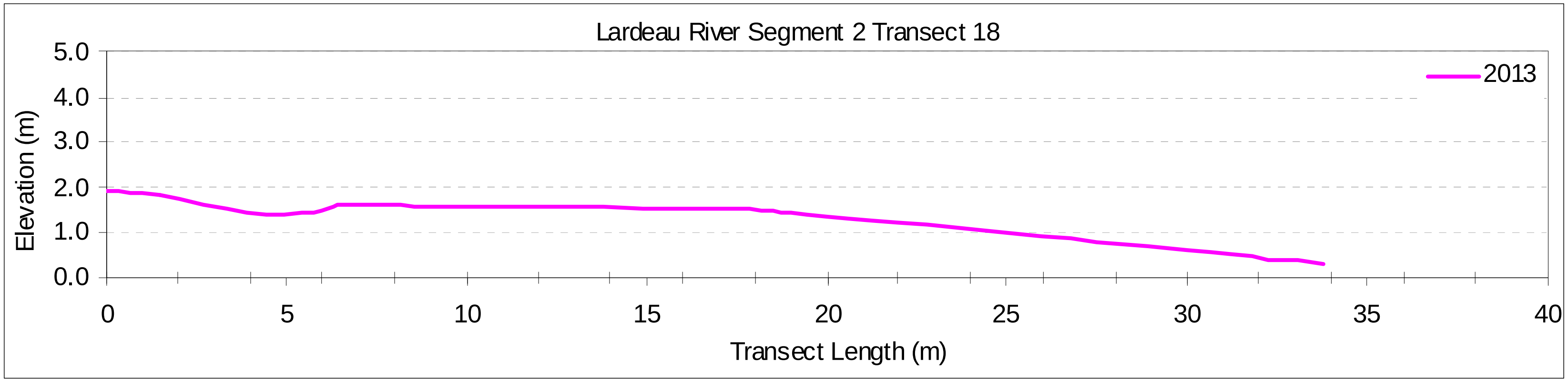

Lardeau River Segment 1 Transect 10
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55
Transect Length (m)
2009
2013

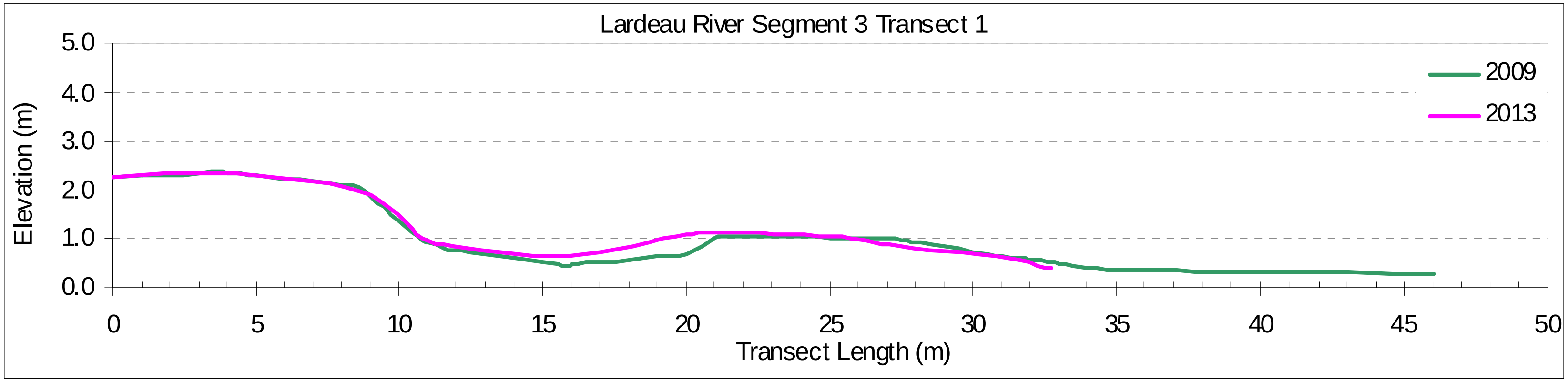

Lardeau River Segment 1Transect 20
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80
Transect Length (m)
2009
2013

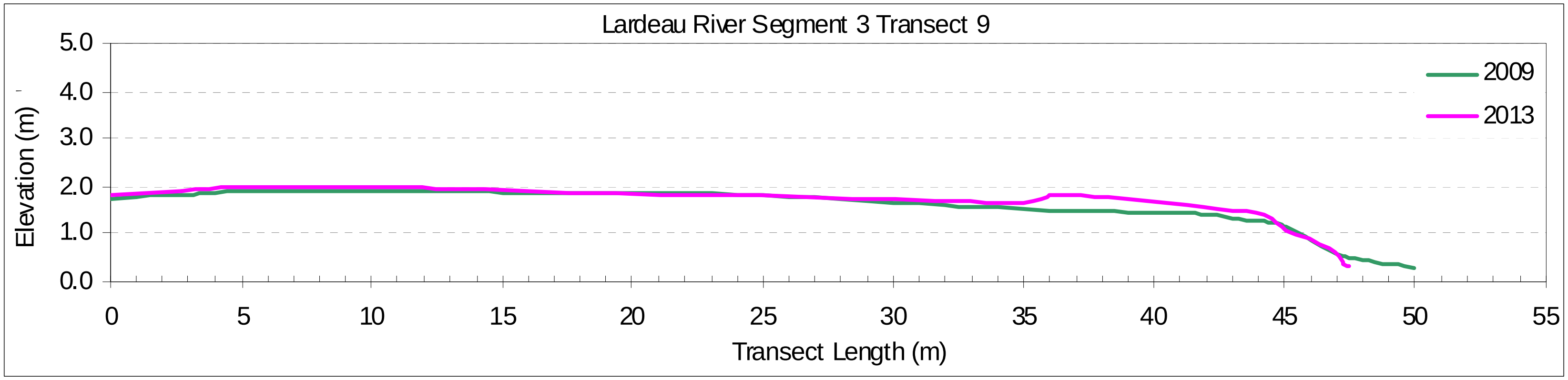

Lardeau River Segment 1 Transect 36
Elevation (m)
Transect Length (m)
2009
2013
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50

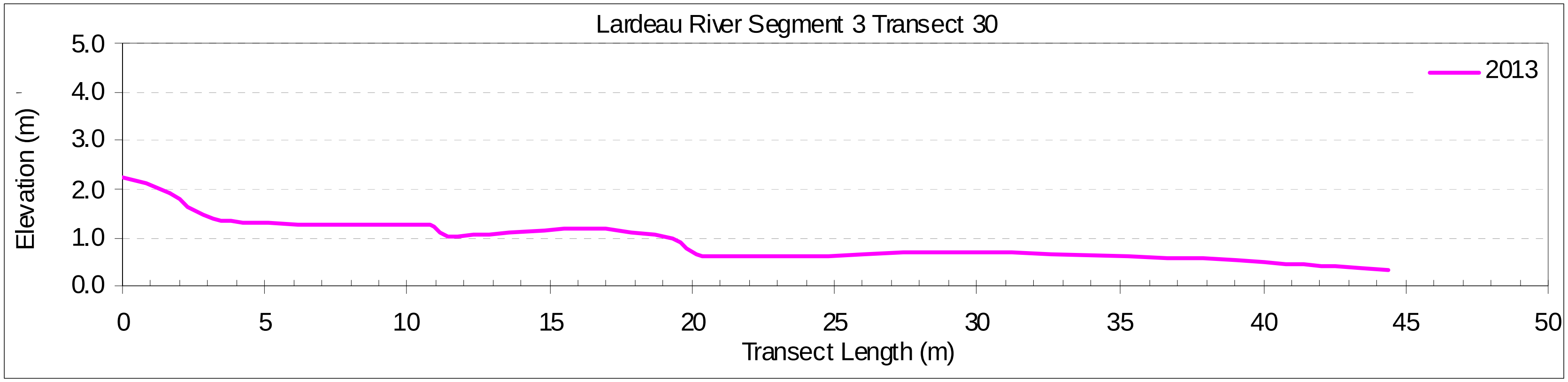

Lardeau River Segment 2 Transect 6
Elevation (m)
Transect Length (m)
2009
2013
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
70
80


Lardeau River Segment 2 Transect 15
Elevation (m)
Transect Length (m)
2009
2013
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40


Lardeau River Segment 2 Transect 18
Elevation (m)
Transect Length (m)
2013
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40


Lardeau River Segment 3 Transect 1
Elevation (m)
Transect Length (m)
2009
2013
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50


Lardeau River Segment 3 Transect 9
Elevation (m)
Transect Length (m)
2009
2013
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55


Lardeau River Segment 3 Transect 30
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
Transect Length (m)
2013

Appendix 3: Lower Duncan and Lardeau rivers photo documentation

Date: April/May 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
30-Apr	IMG_5818	10:44	**D1T3** Looking down line from the tag tree.
30-Apr	IMG_5819	10:51	Looking up line from the rivers edge.
30-Apr	IMG_5820	11:36	**D1T4** Looking up line to POC from the 10 m mark.
30-Apr	IMG_5821	11:36	Looking down line at the EOT from the 10 m mark.
30-Apr	IMG_5822	11:39	Looking up line at the POC from the 24 m mark.
30-Apr	IMG_5823	11:40	Looking down line to the river's edge from the 24 m mark. Looking at ox bow/back channel.
30-Apr	IMG_5824	12:00	**D1T5** Looking up line at the POC from the 8 mark.
30-Apr	IMG_5825	12:00	Looking down line at the waters edge from the 8 m mark. Looking at ox bow/back channel.
4-May	IMG_6040	8:42	Looking up line from the 16 m mark.
4-May	IMG_6041	8:42	Looking down line from the 16 m mark.
4-May	IMG_6042	8:43	Looking up stream from the 16 m mark.
4-May	IMG_6043	8:43	Looking down stream from the 16 m mark.

Date: April/May 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
29-Apr	IMG-5787	12:04	**D3T10** Looking up line at POC.
29-Apr	IMG-5788	12:05	Looking up line from the start of the gravel bar at the floodplain and transect line.
29-Apr	IMG-5789	12:10	Looking up line at the POC from the rivers edge.
29-Apr	IMG-5790	12:10	Looking up line from mid-way up the gravel bar point.
29-Apr	IMG-5791	14:34	**D3T11** Looking at the POC from the edge of the mid-channel bar with Ben on transect line with target for total station.
29-Apr	IMG-5792	14:37	Total station shooting transect line profile.
29-Apr	IMG-5793	14:38	Standing at the 100 m mark looking up the transect line at the POC.
29-Apr	IMG-5794	14:44	Standing at the 118 m mark looking at the EOT River's edge.
29-Apr	IMG-5795	14:44	Standing at the 118 m mark looking up line towards the POC on the mid-channel bar.
29-Apr	IMG-5796	16:33	**D3T15** Standing at the 22 m mark looking at the POC - the downed cottonwood base is the start (beaver activity).
29-Apr	IMG-5797	16:36	Standing at the 22 m mark looking down line at the EOT.
29-Apr	IMG-5798	16:40	At the 44.5 m mark looking up line at the POC.
29-Apr	IMG-5799	16:41	At the 44.5 m mark looking down line at the EOT.
29-Apr	IMG-5800	16:46	At the 44.5 m mark looking down stream.
29-Apr	IMG-5801	16:46	At the 44.5 m mark looking up stream.
29-Apr	IMG-5802	16:50	At the rivers edge looking up line.
29-Apr	IMG-5803	16:51	At the 64 m mark looking at the river's edge. The rivers edge is a back channel water's edge.
29-Apr	IMG-5804	16:53	The total station shooting the line with Ben holding the target on the transect line.
29-Apr	IMG-5805	17:07	The start of a panoramic view of the meander of the recruitment of willows and cottonwoods pre s73 prescription.
29-Apr	IMG-5806	17:07	The continuation of the panoramic view of the recruitment along the meander .
29-Apr	IMG-5807	17:07	

Date: April/May 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
29-Apr	IMG-5808	17:07	**D3T15**The end of the panoramic view of the meander of the recruitment of willows and cottonwoods pre s73 prescription. Sites T15 and T17 are downstream on the other side of the willow/cottonwood recruitment patch.
29-Apr	IMG-5809	17:17	Deposition on willow band from 2012. The willow band was wider in 2009 and 2010
29-Apr	IMG-5810	17:41	**D3T17** Standing at the 15 m mark looking up line at POC with Ben on line survey target a 9 m mark.
29-Apr	IMG-5811	17:41	At the 15 m mark looking down line.
29-Apr	IMG-5812	17:41	At the 15 m mark looking up stream.
29-Apr	IMG-5813	17:41	At the 15 m mark looking down stream
29-Apr	IMG-5814	17:45	At the 15 m mark looking up line without Ben on the line.
29-Apr	IMG-5815	17:50	Behind D3T17 looking at the dry back channel with D3T15 where pink ribbons are. The field gear is on the up stream side of the transect line.
29-Apr	IMG-5816	17:56	A toad on the up stream side of the transect line near the POC
29-Apr	IMG-5817	17:56	same as above.
30-Apr	IMG-5826	13:55	**D3T29** At the 39 m mark looking down line at the EOT rivers edge (1 channel).
30-Apr	IMG-5827	13:56	At the 39 m mark looking up line at the POC. The tag tree is the spruce.
30-Apr	IMG-5828	14:39	**D3T35** At the 10.35 m mark looking up line at the POC.
30-Apr	IMG-5829	14:39	At the 10.35 m mark looking down line at the EOT.
30-Apr	IMG-5830	15:18	**D3T20** Looking at the POC from the 6 m mark.
30-Apr	IMG-5831	15:18	Looking at the EOT from the 6 m mark.
30-Apr	IMG-5832	15:25	Looking up line from the 30 m mark.
30-Apr	IMG-5833	15:25	Looking down line from the 30 m mark.
30-Apr	IMG-5834	15:25	Looking up river from the 30 m mark.
30-Apr	IMG-5835	15:25	Looking down river from the 30 m mark.
30-Apr	IMG-5836	15:29	At the rivers edge looking up line with the total station on the down stream side of the transect line.
30-Apr	IMG-5837	16:21	**D3T23** Looking down line with the POC at my back.
30-Apr	IMG-5838	16:33	Looking down line from the 20 m mark.
30-Apr	IMG-5839	16:34	Looking up line from the 20 m mark.
30-Apr	IMG-5840	16:35	Standing up stream of the line looking down stream at total station at about the 18 m mark.
30-Apr	IMG-5841	16:37	Deposition on the downstream side of transect line. The rebar is at 18 m.
30-Apr	IMG-5842	17:38	**D3T45** Looking up line at the POC from the 27 m mark.
30-Apr	IMG-5843	17:39	Looking down line at the EOT from the 27 m mark.
30-Apr	IMG-5844	17:43	Looking up line from the rivers edge. Note the eroding bank.
30-Apr	IMG-5845	17:59	**D3T40** Standing at the POC looking down line at the EOT.
30-Apr	IMG-5846	18:11	Looking up line from the 27 m mark.
30-Apr	IMG-5847	18:13	Looking down line from the 27 m mark.

Date: April/May 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
3-May	IMG_5990	13:55	**D4T3** Looking up line from the EOT.
3-May	IMG_5991	14:06	Looking down line from POC.
3-May	IMG_5992	14:07	Looking up line from the 11 m mark.
3-May	IMG_5993	14:07	Looking down line from the 11 m mark.
3-May	IMG_5994	14:11	Looking up line from the 22 m mark.
3-May	IMG_5995	14:11	Looking down line from the 22 m mark.
3-May	IMG_5996	14:13	**D4T10** Looking down line from POC.
3-May	IMG_5997	14:18	Looking up line from the 13 m mark.
3-May	IMG_5998	14:18	Looking down line from the 13 m mark.
3-May	IMG_5999	14:20	Looking down stream from the 16 m mark.
3-May	IMG_6000	14:21	Looking up stream from the 16 m mark with total station.
3-May	IMG_6001	14:22	Looking up line from the 16 m mark.
3-May	IMG_6002	14:22	Looking down line from the 16 m mark.
3-May	IMG_6003	14:23	Looking up line from the EOT.
3-May	IMG_6004	14:24	Looking down stream from the EOT.
3-May	IMG_6005	14:24	Looking up stream from the EOT with Hamill creek meeting the Duncan.
3-May	IMG_6006	15:25	**D4T5** Looking down line from POC.
3-May	IMG_6007	15:35	Looking up line from the 6 m mark.
3-May	IMG_6008	15:35	Looking down line from the 6 m mark.
3-May	IMG_6009	15:37	Looking up line at the new channel from Copper Creek from the 12 m mark.
3-May	IMG_6010	15:38	Looking down line from the 12 m mark at a gravel deposit-80 cm.
3-May	IMG_6011	15:40	Looking up line from the 27 m mark.
3-May	IMG_6012	15:40	Looking down line from the 27 m mark.
3-May	IMG_6013	15:41	Looking up stream from the 27 m mark.
3-May	IMG_6014	15:41	Looking down stream from the 27 m mark.
3-May	IMG_6015	15:44	Looking up line from the EOT.
3-May	IMG_6016	15:45	Looking up line from the EOT with total station.
3-May	IMG_6017	15:45	Looking down stream from the EOT.
3-May	IMG_6018	15:45	Looking up stream from the EOT.
3-May	IMG_6019	15:48	Looking up stream at the line from the total station location.
3-May	IMG_6020	15:48	Same as above.
3-May	IMG_6021	15:54	Up stream of the line looking at line and at scour and deposition.
3-May	IMG_6022	15:54	Looking at up stream of the line at the scour and deposition.

Date: April/May 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
3-May	IMG_6029	15:28	**D5T9** Looking down line from POC.
3-May	IMG_6030	17:29	Looking down line from the 3 m mark.
3-May	IMG_6031	17:29	Looking up line from the 3 m mark.
3-May	IMG_6032	17:34	Looking down line from the 16 m mark.
3-May	IMG_6033	17:34	Looking up line from the 16 m mark.
3-May	IMG_6034	17:34	Looking down stream from the 16 m mark.
3-May	IMG_6035	17:34	Looking up stream from the 16 m mark.
3-May	IMG_6036	17:37	Looking up line from the EOT.
3-May	IMG_6037	17:37	Looking down stream from the EOT.
3-May	IMG_6038	17:37	Looking up stream from the EOT.
3-May	IMG_6039	17:37	Looking up stream at the total station from the EOT.
1-May	IMG-5848	10:14	**D5T11** Looking up line from EOT.
1-May	IMG-5849	10:15	Looking down line from the 60 m mark.
1-May	IMG-5850	10:15	Looking up line at 60 m mark.
1-May	IMG-5851	10:17	Looking up line at the 36.5 m mark.
1-May	IMG-5852	10:18	Looking down line at the 36.5 m mark.
1-May	IMG-5853	10:20	Looking down line from the tag tree.
1-May	IMG-5854	10:38	**D5T12** Looking up line towards the POC from the 57.4 m mark.
1-May	IMG-5855	10:38	Looking down line towards the EOT at the 57.4 m mark.
1-May	IMG-5856	10:44	Looking up line from the 14 m mark.
1-May	IMG-5857	10:47	Looking down line from the tag tree.
1-May	IMG-5858	11:45	**D5T16** Looking down line from the tag tree.
1-May	IMG-5859	12:10	Looking up line at the 9.4 m mark.
1-May	IMG-5860	12:21	Looking down line at the 9.4 m mark.
1-May	IMG-5861	12:29	Looking up line from the edge of the river's main channel.
1-May	IMG-5862	12:30	Looking downstream at the line.
1-May	IMG-5863	12:30	Looking up the line at the 28 m mark.
1-May	IMG-5864	13:17	Looking down line at the 28 m mark.
1-May	IMG-5865	13:23	**D5T19** Looking up line at the POC from the edge of the river.
1-May	IMG-5866	13:23	Looking down line from the POC.
1-May	IMG-5867	13:23	Looking up the line from the 8.4 m mark.
1-May	IMG-5868	13:23	Looking down line from the 8.4 m mark.
1-May	IMG-5869	13:24	looking up stream from the 8.4 m mark.
1-May	IMG-5870	13:24	looking down stream from the 8.4 m mark.
1-May	IMG-5871	13:28	Downstream of line looking at line with total station and Ben with target at rivers edge.

Date: April/May 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
1-May	IMG_5877	14:32	**D6T29** Looking down line from the 48 m mark.
1-May	IMG_5878	14:32	Looking down stream at flood trained willow from the 48 m mark.
1-May	IMG_5879	14:32	Looking up stream from the 48 m mark.
1-May	IMG_5880	14:26	Looking up line from the rivers edge.
1-May	IMG_5881	15:26	**D6T36** Looking down line from tag tree.
1-May	IMG_5882	15:38	Looking up line from the 15 m mark.
1-May	IMG_5883	15:38	Looking down line from the 15 m mark.
1-May	IMG_5884	15:40	Looking down line from the 50 m mark.
1-May	IMG_5885	15:40	Looking up line from the 50 m mark.
1-May	IMG_5886	15:41	Looking up stream from the 50 m mark.
1-May	IMG_5887	15:41	Looking down stream from the 50 m mark.
1-May	IMG_5888	15:46	At rivers edge.
1-May	IMG_5889	17:13	**D6T20** Looking down line from tag tree.
1-May	IMG_5890	17:27	Looking down line from the 14 m mark.
1-May	IMG_5891	17:27	Looking up line from the 14 m mark.
1-May	IMG_5892	18:27	**D6T6** Looking down line from tag tree.
1-May	IMG_5893	18:29	Looking up line from the 16 m mark.
1-May	IMG_5894	18:29	Looking down line from the 16 m mark.
1-May	IMG_5895	18:39	Looking from the EOT, at the lake bottom up line.
1-May	IMG_5896	18:39	From the EOT looking at the lake bottom with Kootenay lake edge in the distance.
1-May	IMG_5897	18:48	Looking up line from the 30 m mark.
1-May	IMG_5898	18:48	Looking down line from the 30 m mark.
1-May	IMG_5899	18:49	Looking at the east side of the line with total station from the 30 m mark.
1-May	IMG_5900	18:49	Looking to the west side of the line from the 30 m mark.
1-May	IMG_5901	18:55	Looking at what once was thick willow now is short willow with sparsely covered canary reed grass and willow from the 45 m mark.

Date: July, 2013			**Environmental Crew:** Mary Louise, Aden
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
22-Jul	DSCN0006	13:44	**D3T10** At POC looking down line to EOT.
22-Jul	DSCN0007	13:44	At 25.6 m rebar to POC.
22-Jul	DSCN0008	13:45	At 25.6 m rebar to EOT.
22-Jul	DSCN0009	13:46	At rivers edge looking to POC.
22-Jul	DSCN0010	13:46	At rivers edge looking to EOL.
22-Jul	DSCN0011	13:58	At rivers edge looking up stream.
22-Jul	DSCN0012	13:58	At rivers edge looking down stream.
22-Jul	DSCN0013	16:10	**D3T11** Side channel EOT looking to POC.
22-Jul	DSCN0014	16:10	EOT looking up stream.
22-Jul	DSCN0015	16:10	EOT looking down stream.
22-Jul	DSCN0016	16:11	At POC looking to EOL.
22-Jul	DSCN0017	16:13	15 m up stream at rivers edge looking at mid channel bar.
23-Jul	DSCN0018	9:51	**D3T15** Looking up line to POC.
23-Jul	DSCN0019	9:52	Looking to EOT from POC.
23-Jul	DSCN0020	9:54	Looking to POC from rivers edge.
23-Jul	DSCN0021	9:54	Looking at POC from 41 m.
23-Jul	DSCN0022	9:54	At rivers edge looking up stream.
23-Jul	DSCN0023	9:55	At rivers edge looking downs stream.
23-Jul	DSCN0024	11:37	**D3T17** Looking at POC from 15 m.
23-Jul	DSCN0025	11:37	Looking at EOT from 15 m.
23-Jul	DSCN0026	11:37	Looking up stream at 15 m.
23-Jul	DSCN0027	11:37	Looking down stream at 15 m.
23-Jul	DSCN0028	14:02	**D3T29** Looking at POC from 6 m.
23-Jul	DSCN0029	14:02	Looking at EOT from 9 m.
23-Jul	DSCN0030	14:04	looking at POC from rivers edge.
23-Jul	DSCN0031	14:04	Looking up stream at rivers edge.
23-Jul	DSCN0032	14:04	Looking down stream at rivers edge.
23-Jul	DSCN0033	14:58	**D3T35** Looking at POC from 10.35 m.
23-Jul	DSCN0034	14:58	Looking at EOT (rivers edge) from 10.35 m.
23-Jul	DSCN0035	14:59	Looking up stream at EOT.
23-Jul	DSCN0036	14:59	Looking down stream at EOT.
23-Jul	DSCN0037	16:06	**D3T20** Looking at POC fro EOT.
23-Jul	DSCN0038	16:06	Looking at EOT from 30 m.
23-Jul	DSCN0039	16:07	Looking at POC from 30 m.
23-Jul	DSCN0040	16:07	Looking up stream from EOT.
23-Jul	DSCN0041	16:07	Looking down stream From EOT.
23-Jul	DSCN0042	16:32	**D3T23** looking at EOT form 20 m.
23-Jul	DSCN0043	16:32	Looking at POC from 20 m.
23-Jul	DSCN0044	16:32	Looking up stream from EOT.
23-Jul	DSCN0045	16:32	Looking down stream From EOT.
23-Jul	DSCN0046	16:34	looking at EOT from POC.
23-Jul	DSCN0047	17:14	**D3T45** Looking to the 27 m rebar from the 4 m rebar.
23-Jul	DSCN0048	17:16	Looking to the EOT from the 27 m rebar.
23-Jul	DSCN0049	17:16	looking to the 27 m rebar from the EOT.
23-Jul	DSCN0050	17:16	Looking up stream from EOT.
23-Jul	DSCN0051	17:16	Looking down stream From EOT.

Date: July, 2013			**Environmental Crew:** Ben, Brenda
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
24-Jul	DSCN4814	10:56	**D4T3** At EOT looking up line.
24-Jul	DSCN4815	10:58	At 22 m looking up line.
24-Jul	DSCN4816	10:58	At 22 m looking down line.
24-Jul	DSCN4817	10:59	At 11 m looking up line.
24-Jul	DSCN4818	10:59	At 11 m looking down line.
24-Jul	DSCN4824	13:43	**D4T10** At EOT looking up line.
24-Jul	DSCN4825	13:44	At 16 m looking up line.
24-Jul	DSCN4826	13:44	At 16 m looking down line.
24-Jul	DSCN4827	13:44	At 13 m looking up line.
24-Jul	DSCN4828	13:44	At 13 m looking down line.
24-Jul	DSCN4829	13:45	At Tag tree looking down line.
23-Jul	DSCN4804	13:05	**D4T5** At EOT looking up line.
23-Jul	DSCN4808	13:07	At 11 m looking up line.
23-Jul	DSCN4809	13:07	At 22 m looking down line.
23-Jul	DSCN4810	13:07	At 22 m looking down line.
23-Jul	DSCN4811	13:07	At 11 m looking down line.

Date: July 2013			**Environmental Crew:** Mary Louise, Aden, Ben, Brenda
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
23-Jul	DSCN4800	11:38	**D5T2** At the tag tree looking down line.
23-Jul	DSCN4801	11:40	At 15 m looking down the line.
23-Jul	DSCN4802	11:40	At 15 m looking up the line.
23-Jul	DSCN4797	10:13	**D5T9** At the tag tree looking down line.
23-Jul	DSCN4798	10:15	At the rivers edge looking up line.
23-Jul	DSCN4799	10:15	Seedlings growing on a log near the rivers edge.
24-Jul	DSCN0052	9:17	**D5T11** Temporary rebar to POC.
24-Jul	DSCN0053	9:17	Temporary Rebar to EOT.
24-Jul	DSCN0054	9:18	24.5 m from temporary rebar to temporary rebar.
24-Jul	DSCN0055	9:19	24.5 m from temporary rebar to EOT.
24-Jul	DSCN0056	9:20	Looking from the EOT to the POC.
24-Jul	DSCN0057	10:17	**D5T12** Looking to the approximate EOT.
24-Jul	DSCN0058	10:18	Looking to the POC from the approximate location of EOT.
24-Jul	DSCN0059	10:18	Looking up stream from the approximate location of the EOT.
24-Jul	DSCN0060	10:18	Looking down stream from the approximate location of the EOT.
24-Jul	DSCN0061	10:48	**D5T16** Looking to the POC from 10 m.
24-Jul	DSCN0062	10:49	Looking at the EOT from 12 m.
24-Jul	DSCN0063	10:50	Looking at the POC from the EOT.
24-Jul	DSCN0064	10:50	Looking up stream from the EOT.
24-Jul	DSCN0065	10:50	Looking down stream from the EOT.
24-Jul	DSCN0066	11:34	**D5T19** Looking to the EOT from the 8.44 m rebar.
24-Jul	DSCN0067	11:36	Looking down stream from the EOT.
24-Jul	DSCN0068	11:37	Looking up stream from the EOT.

Date: July, 2013			**Environmental Crew:** Mary Louise, Aden
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
24-Jul	DSCN0069	11:50	**D6T29** From the 9 m rebar to the EOT.
24-Jul	DSCN0070	11:50	Looking up stream from the EOT.
24-Jul	DSCN0071	11:51	Looking down stream at a flooded area from the EOT.
24-Jul	DSCN0072	12:16	**D6T36** Looking at the POC from the EOT.
24-Jul	DSCN0073	12:17	Looking up stream from the EOT.
24-Jul	DSCN0074	12:17	Looking down stream from the EOT.
24-Jul	DSCN0075	12:25	Looking at the EOT from the 15 m rebar.
24-Jul	DSCN0076	12:26	Side channel up stream.
24-Jul	DSCN0077	12:27	Side channel down stream.
24-Jul	DSCN0078	13:11	**D6T20** Looking at the POC from 14 m.
24-Jul	DSCN0079	13:13	At the 14 m rebar.
24-Jul	DSCN0080	13:13	Looking to the river channel from the 14 m rebar.
24-Jul	DSCN0081	13:14	Looking up stream from the 14 m rebar.
24-Jul	DSCN0082	13:14	Looking downstream from the 14 m rebar.
24-Jul	DSCN0083	13:14	MLP on line at the 14 m rebar.
24-Jul	DSCN0084	14:00	**D6T6** Looking at the POC from the EOT.
24-Jul	DSCN0085	14:00	Looking east from the EOT.
24-Jul	DSCN0086	14:00	Looking west from the EOT.
24-Jul	DSCN0087	14:02	Looking at the EOT from the POC.
24-Jul	DSCN0088	14:03	Looking at the EOT from the 24.4 m mark.

Date: Sept/Oct, 2013			**Environmental Crew:** Ben, Brenda
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
30-Sep	DSCN6282	14:48	**D1T3** At the EOT.
30-Sep	DSCN6283	14:49	At the tag tree.
30-Sep	DSCN6279	13:22	**D1T4** At EOT looking up the line.
30-Sep	DSCN6280	13:33	**D1T5** At EOT looking up the line.
30-Sep	DSCN6281	13:33	At the tag tree looking down the line.

Date: Sept/Oct, 2013			**Environmental Crew:** Mary Louise, Aden
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
30-Sep	DSCN0272	13:27	**D3T10** Looking down line from POC.
30-Sep	DSCN0273	13:29	At the 50.9 m rebar looking up line at POC.
30-Sep	DSCN0274	13:30	At the 50.9 m rebar looking down line at.
30-Sep	DSCN0275	13:35	At the 69.7 m mark looking up stream of a back channel.
30-Sep	DSCN0276	13:35	At the 69.7 m mark looking down stream of a back channel.
30-Sep	DSCN0277	13:37	Looking at the transect line crossing large woody debris.
30-Sep	DSCN0278	13:57	**D3T11** At POC looking down line.
30-Sep	DSCN0279	13:57	At the 19 m mark looking up line at the POC.
30-Sep	DSCN0280	15:48	At the EOT looking up line.
30-Sep	DSCN0281	15:49	At EOT looking down line.
30-Sep	DSCN0282	15:52	Seedlings on bar - 1 m^2
30-Sep	DSCN0283	15:53	Up close of the seedlings.

Date: Sept/Oct, 2013			**Environmental Crew:** Mary Louise, Aden
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
30-Sep	DSCN0284	16:18	**D3T15** At POC.
30-Sep	DSCN0285	16:20	At 26 m mark looking up line to POC at Back channel.
30-Sep	DSCN0286	16:41	Seedlings at the 46 m mark.
30-Sep	DSCN0287	16:42	Close-up of seedlings.
30-Sep	DSCN0288	16:56	At the 65 m mark looking up line at the POC.
30-Sep	DSCN0289	16:57	At the 65 m mark looking down line at the EOT and secondary channel.
30-Sep	DSCN0290	17:36	**D3T17** At the 29 m mark looking up line at the POC with Aden standing on the up stream side of the line.
30-Sep	DSCN0291	17:36	At the 29 m mark looking down line at the EOT.
1-Oct	DSCN0293	9:52	**D3T29** Looking up line towards the POC from the 75 m mark.
1-Oct	DSCN0294	9:53	Looking down line towards the POC from the 75 m mark.
1-Oct	DSCN0295	9:54	Looking up line towards the POC from the 30 m mark.
1-Oct	DSCN0296	9:54	Looking down line towards the POC from the 30 m mark.
1-Oct	DSCN0297	9:54	Looking up line towards the POC from the 20 m mark.
1-Oct	DSCN0298	9:55	Looking down line towards the POC from the 20 m mark.
1-Oct	DSCN0299	10:05	**D3T35** At the 10.4 m rebar looking up line.
1-Oct	DSCN0300	10:05	At the 10.4 m rebar looking down line.
1-Oct	DSCN0301	10:21	At the 36 m looking up line.
1-Oct	DSCN0302	10:21	At the 36 m looking down line.
1-Oct	DSCN0303	10:21	At the 36 m looking down stream.
1-Oct	DSCN0304	10:22	At the 36 m looking up stream.
1-Oct	DSCN0305	10:48	**D3T20** At the 30.1 m rebar looking down line at the EOT.
1-Oct	DSCN0306	10:48	At the 30.1 m rebar looking up line at the POC.
1-Oct	DSCN0307	10:48	At the 30.1 m rebar looking down stream.
1-Oct	DSCN0308	10:48	At the 30.1 m rebar looking up stream towards a secondary channel.
1-Oct	DSCN0309	11:41	**D3T23** At new rebar at the 8 m mark looking up line at POC.
1-Oct	DSCN0310	11:41	At the 8 m mark looking down line.
1-Oct	DSCN0311	11:43	At the 22 m mark looking up line.
1-Oct	DSCN0312	11:43	At the 22 m mark looking down line at the EOT.
1-Oct	DSCN0313	12:16	**D3T45** At the 14 m mark looking up line from the middle of a dry back channel.
1-Oct	DSCN0314	12:16	At 14 m looking down line.
1-Oct	DSCN0315	12:43	At 42 m looking up line.
1-Oct	DSCN0316	12:43	At the 42 looking down line.
1-Oct	DSCN0317	12:44	At 42 m looking up Stream.
1-Oct	DSCN0318	12:44	At 42 m looking down stream.
1-Oct	DSCN0319	12:58	**D3T40** At the 18 m rebar looking up line.
1-Oct	DSCN0320	12:58	At the 18 m rebar looking down line.
1-Oct	DSCN0321	12:58	At the 18 m rebar looking down stream.
1-Oct	DSCN0322	12:58	At the 18 m rebar looking up stream.

Date: Sept/Oct, 2013			**Environmental Crew:** Ben, Brenda
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
1-Oct	DSCN6322	14:54	**D4T3** At the EOT.
1-Oct	DSCN6323	16:22	**D4T10** At the EOT.

Date: Sept/Oct, 2013			**Environmental Crew:** Ben, Brenda
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
1-Oct	DSCN6318	10:10	**D5T2** At EOT.
1-Oct	DSCN6319	10:11	At tag tree.
1-Oct	DSCN6320	11:29	**D5T9** At EOT.
1-Oct	DSCN6321	11:30	At tag tree.
1-Oct	DSCN0323	14:31	**D5T11** At the 34 m mark looking up line.
1-Oct	DSCN0324	14:31	At the 34 m mark looking down line.
1-Oct	DSCN0325	14:31	At the 45 m mark looking up line.
1-Oct	DSCN0326	14:31	At the 45 m mark looking down line.
1-Oct	DSCN0327	14:32	At the 66 m mark looking up line.
1-Oct	DSCN0328	14:33	At the 66 m mark looking down line at the EOT.
1-Oct	DSCN0329	14:56	**D5T12** At the 57 m mark looking up line.
1-Oct	DSCN0330	14:56	At the 57 m mark looking down line.
1-Oct	DSCN0331	15:31	**D5T16** Up stream of the 18 m mark looking down stream at transect line.
1-Oct	DSCN0332	15:31	Up stream of the 18 m mark looking up stream.
1-Oct	DSCN0333	15:35	Rebar found buried.
1-Oct	DSCN0334	15:35	Close up - bottom of curve to ground level - 15 cm.
1-Oct	DSCN0335	15:39	At 27 m mark looking up line.
1-Oct	DSCN0336	15:39	At 27 m mark looking down line.
1-Oct	DSCN0337	16:00	**D5T19** At the 8.5 m rebar looking up line.
1-Oct	DSCN0338	16:01	At the 8.5 m rebar looking down line.

Date: Sept/Oct, 2013			**Environmental Crew:** Mary Louise, Aden
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image**	**Time**	**Description**
1-Oct	DSCN0339	16:30	**D6T29** At the 39 m mark looking up line.
1-Oct	DSCN0340	16:30	At the 39 m mark looking down line.
1-Oct	DSCN0341	16:58	**D6T36** At the 41 m mark looking up line.
1-Oct	DSCN0342	16:58	At the 41 m mark looking down line.
1-Oct	DSCN0343	17:02	At the 67 m mark looking down line.
1-Oct	DSCN0344	17:03	At the 67 m mark looking up line.
2-Oct	DSCN0345	9:22	**D6T20** At the 33 m mark looking up line.
2-Oct	DSCN0346	9:22	At the 33 m mark looking down line.
2-Oct	DSCN0347	9:23	At the 33 m mark looking up stream.
2-Oct	DSCN0348	9:23	At the 33 m mark looking down stream.

Date: April/May, 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
3-May	IMG_5985	11:53	**L1T1** Looking down line from the POC.
3-May	IMG_5986	11:55	Looking down line from the 6 m mark.
3-May	IMG_5987	11:59	Looking down line from the 12.2 m mark.
3-May	IMG_5988	11:59	Looking up line from the 12.2 m mark.
3-May	IMG_5989	12:02	Looking up stream from EOT.
3-May	IMG_5973	10:44	**L1T10** Looking down line from the POC.
3-May	IMG_5974	10:52	Looking up line from the 34 m mark.
3-May	IMG_5975	10:52	Looking down line from the 34 m mark.
3-May	IMG_5976	10:52	Looking up stream from the 34 m mark.
3-May	IMG_5977	10:52	Looking down stream from the 34 m mark with total station.
3-May	IMG_5978	10:54	Looking up stream from EOT.
3-May	IMG_5979	10:58	Looking down stream from EOT across secondary river channel that was the main channel in 2009.
3-May	IMG_5980	11:01	Mid channel bar looking north (up stream) of L1T10.
3-May	IMG_5981	11:01	Same place looking down stream.
3-May	IMG_5982	11:15	Seedlings (2012) along one edge on sand deposition.
3-May	IMG_5983	11:15	Close up of seedlings along sand bar deposition.
3-May	IMG_5984	11:16	Other edge of sand dune supporting willow seedlings.
3-May	IMG_5961	9:28	**L1T20** Looking down line from the POC.
3-May	IMG_5962	9:34	Looking up line from the 7 m mark.
3-May	IMG_5963	9:35	Looking down line from the 7 m mark.
3-May	IMG_5964	9:40	Looking up line from the 15.5 m mark.
3-May	IMG_5965	9:40	Looking down line from the 15.5 m mark.
3-May	IMG_5966	9:40	Looking up stream from the 15.5 m mark.
3-May	IMG_5967	9:40	Looking down stream from the 15.5 m mark with total station in the picture.
3-May	IMG_5968	9:42	Looking up line from the 54 m mark.
3-May	IMG_5969	9:42	Looking down line from the 54 m mark.
3-May	IMG_5970	9:42	Looking up stream from the 54 m mark.
3-May	IMG_5971	9:42	Looking down stream from the 54 m mark.
3-May	IMG_5972	9:49	Looking up line from EOT.
2-May	IMG_5952	17:16	**L1T36** Looking down line from tag tree.
2-May	IMG_5953	17:24	Looking down line from the 5 m mark.
2-May	IMG_5954	17:24	Looking up line from the 5 m mark.
2-May	IMG_5955	17:26	Looking down line from the 18 m mark.
2-May	IMG_5956	17:26	Looking up line from the 18 m mark.
2-May	IMG_5957	17:27	Looking up stream from the 18 m mark.
2-May	IMG_5958	17:27	Looking down stream from the 18 m mark.
2-May	IMG_5959	17:29	Looking up line from EOT.
2-May	IMG_5960	17:31	Looking down line from the 43 m mark.

Date: April/May, 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-May	IMG_5939	15:28	**L2T6** Looking down line from POC.
2-May	IMG_5940	15:31	Looking up line from the 10 m mark.
2-May	IMG_5941	15:31	Looking down line from the 10 m mark.
2-May	IMG_5942	15:34	Looking down line from the 17.8 m mark.

Date: April/May, 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-May	IMG_5943	15:34	Looking up line from the 17.8 m mark.
2-May	IMG_5944	15:37	Looking up line from the 29 m mark.
2-May	IMG_5945	15:37	Looking down line from the 29 m mark.
2-May	IMG_5946	15:40	Looking at the line and channel with fresh deposition and scour from down stream of the line.
2-May	IMG_5947	15:44	Downstream end of the meander looking up stream with total station and scour and deposition from 2012.
2-May	IMG_5948	15:48	Same spot as in picture 47 but looking downstream at meander lobe.
2-May	IMG_5949	15:55	Looking up line from the EOT.
2-May	IMG_5950	15:56	Looking up line from the 34 m mark.
2-May	IMG_5951	15:56	Looking down line from the 34 m mark.
2-May	IMG_5931	14:07	**L2 T15** Looking down line from POC.
2-May	IMG_5932	14:09	Looking down line from POC.
2-May	IMG_5933	14:09	Looking down line from the 19 m mark.
2-May	IMG_5934	14:27	Looking up line from the 19 m mark.
2-May	IMG_5935	14:28	Looking up line from the water's edge.
2-May	IMG_5936	14:28	From down stream of the line you are looking at Ben with the target on the line and the total station up stream of it.
2-May	IMG_5937	14:33	Looking down stream from the up stream side of the line but not on it.
2-May	IMG_5938	14:34	Same as above.
2-May	IMG_5923	12:40	**L2T18** Looking down line from POC.
2-May	IMG_5924	12:47	Looking up line from EOT.
2-May	IMG_5925	12:49	Looking up line from the 24 m mark.
2-May	IMG_5926	12:49	Looking down line from the 24 m mark.
2-May	IMG_5927	12:57	Looking down line from the 7 m mark.
2-May	IMG_5928	12:57	Looking up line from the 7 m mark.
2-May	IMG_5929	12:57	Looking up stream from the 7 m mark.
2-May	IMG_5930	12:58	Looking down stream from the 7 m mark.

Date: April/May, 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-May	IMG_5915	11:49	**L3T1** Looking up line from the rivers edge.
2-May	IMG_5916	11:50	Looking down line at deposition from the 18 m mark.
2-May	IMG_5917	11:53	Looking up line from the 18 m mark.
2-May	IMG_5918	11:53	Looking up stream from the 18 m mark.
2-May	IMG_5919	11:53	Looking down stream from the 18 m mark.
2-May	IMG_5920	10:01	Looking down line from the 8.6 m mark with total station and target.
2-May	IMG_5921	12:02	Looking up line from the 8.6 m mark.
2-May	IMG_5922	12:09	Looking down line from the POC.
2-May	IMG_5905	10:58	**L3T9** Looking down line from the POC.
2-May	IMG_5906	11:02	Looking up line from the 13 m mark.
2-May	IMG_5907	11:02	Looking down line from the 13 m mark.
2-May	IMG_5908	11:02	Looking down stream from the 13 m mark.
2-May	IMG_5909	11:02	Looking up stream from the 13 m mark.
2-May	IMG_5910	11:04	Looking down stream from the 22 m mark.

Date: April/May, 2013			**Environmental Crew:** Mary Louise, Aden, Ben
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-May	IMG_5911	11:05	**L3T9** Looking up stream from the 22 m mark.
2-May	IMG_5912	11:09	Looking up line from the rivers edge.
2-May	IMG_5913	11:14	Looking down line at deposition from the 33 m mark.
2-May	IMG_5914	11:15	Looking up line from the 47 m mark at the end of the deposition from picture 5913.
2-May	IMG_5902	9:50	**L3T30** Looking up line from the rivers edge.
2-May	IMG_5903	9:52	Looking up line from the 17 m mark. The POC is behind the large cedars on a cotton wood.
2-May	IMG_5904	9:52	Looking down line from the 17 m mark.

Date: July, 2013			**Environmental Crew:** Mary Louise, Aden, Ben, Brenda
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
24-Jul	DSCN4830	17:00	**L1T1** At the tag tree looking down line.
24-Jul	DSCN4831	17:00	At 6 m looking down line.
24-Jul	DSCN4832	17:01	At 6 m looking up line.
24-Jul	DSCN4833	17:03	At 12.2 m looking down line.
24-Jul	DSCN4834	17:04	At 12.2 m looking up line.
24-Jul	DSCN4835	17:04	At EOL looking up line.
25-Jul	DSCN4838	12:49	**L1T10** EOT looking up stream.
25-Jul	DSCN4839	12:49	At the EOT looking down stream.
25-Jul	DSCN4840	12:49	At the EOT looking up line.
25-Jul	DSCN4841	12:49	At 34 m looking up line.
25-Jul	DSCN4842	12:49	At 34 m looking down line.
25-Jul	DSCN4843	12:51	At the tag tree looking down line.
25-Jul	DSCN4844	14:22	**L1T20** At the tag tree looking down line.
25-Jul	DSCN4845	14:22	At 7 m looking down line.
25-Jul	DSCN4846	14:23	At 7 m looking up line.
25-Jul	DSCN4847	14:23	At 15. 5 m looking down line.
25-Jul	DSCN4848	14:23	At 15. 5 m looking up line.
25-Jul	DSCN4849	14:23	At EOT looking up line.
25-Jul	DSCN4850	14:24	At EOT looking up stream.
25-Jul	DSCN4851	14:24	At EOT looking down stream.
25-Jul	DSCN0114	13:56	**L1T36** Down stream from line showing buried 2013 seedlings.
25-Jul	DSCN0115	13:57	Down stream from line showing buried 2013 seedlings.
25-Jul	DSCN0116	13:57	Down stream from line showing buried 2013 seedlings.
25-Jul	DSCN0117	14:02	Down stream from line showing buried 2013 seedlings.
25-Jul	DSCN0118	14:03	Down stream from line showing buried 2013 seedlings.
25-Jul	DSCN0119	14:09	6 m to end of transect.
25-Jul	DSCN0120	14:10	Up stream at 15 m.
25-Jul	DSCN0121	14:10	Down stream at 15 m.
25-Jul	DSCN0122	14:12	Plot frame at 9 m.
25-Jul	DSCN0123	14:12	Plot frame 1/4 of the bottom left.
25-Jul	DSCN0124	14:55	Looking towards the POC from the EOT.
25-Jul	DSCN0125	14:55	Looking up stream from the EOT.
25-Jul	DSCN0126	14:55	Looking down stream from the EOT.

Date: July, 2013			**Environmental Crew:** Mary Louise, Aden, Ben, Brenda
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
25-Jul	DSCN4852	15:43	**L2T6** At the EOT looking up line.
25-Jul	DSCN4853	15:43	At the 34 m mark looking up line.
25-Jul	DSCN4854	15:43	At the 34 m mark looking down line.
25-Jul	DSCN4855	15:45	At the tag tree looking down line.
25-Jul	DSCN0111	12:49	**L2T15** at the EOT looking towards the POC.
25-Jul	DSCN0112	12:49	Looking up stream from the EOT.
25-Jul	DSCN0113	12:49	Looking down stream from the EOT.
25-Jul	DSCN0107	11:29	**L2T18** At the EOT looking POC.
25-Jul	DSCN0108	11:29	Looking up stream from the EOT.
25-Jul	DSCN0109	11:29	Looking down stream from the EOT.
25-Jul	DSCN0110	11:30	At the POC looking to the EOT.

Date: July 2013			**Environmental Crew:** Mary Louise, Aden
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
25-Jul	DSCN0103	10:56	**L3T1** Looking at the POC from the EOT.
25-Jul	DSCN0104	10:57	Looking up stream from the EOT.
25-Jul	DSCN0105	10:57	Looking down stream from the EOT.
25-Jul	DSCN0106	10:57	10 m to the EOT.
25-Jul	DSCN0097	10:19	**L3T9** Looking at the POC from the EOT.
25-Jul	DSCN0098	10:19	Looking up stream from the EOT.
25-Jul	DSCN0099	10:19	Looking down stream from the EOT.
25-Jul	DSCN0100	10:20	Looking at the EOT from 22 m.
25-Jul	DSCN0101	10:20	Looking at the POC from 22 m.
25-Jul	DSCN0102	10:21	Looking towards the EOT from the POC.
25-Jul	DSCN0092	9:20	**L3T30** Looking at the POC from the EOT.
25-Jul	DSCN0093	9:20	Looking up stream from the EOT.
25-Jul	DSCN0094	9:20	Looking down stream from the EOT.
25-Jul	DSCN0095	9:22	Looking at the POC from 17 m.
25-Jul	DSCN0096	9:22	Looking at the EOT from 17 m.

Date: Sept/Oct 2013			**Environmental Crew:** Mary Louise, Aden, Ben, Brenda
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-Oct	DSCN6324	10:58	**L1T1** At EOT.
2-Oct	DSCN6325	10:59	At tag tree.
2-Oct	DSCN6326	14:35	**L1T10** At tag tree.
2-Oct	DSCN6327	14:27	At EOT.
2-Oct	DSCN6331	16:49	**L1T20** At EOT.
2-Oct	DSCN6332	16:50	At tag tree.
2-Oct	DSCN0371	15:06	**L1T36** At 9 m looking up line.
2-Oct	DSCN0372	15:06	At 9 m looking down line.
2-Oct	DSCN0373	15:07	At 8 m 1m^2 seedling plot frame.
2-Oct	DSCN0374	15:07	At 9 m looking up stream.
2-Oct	DSCN0375	15:07	At 9 m looking down stream.
2-Oct	DSCN0376	15:43	At 38 m looking up line.
2-Oct	DSCN0377	15:43	At 38 m looking down line.

Date: Sept/Oct 2013			**Environmental Crew:** Mary Louise, Aden
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
3-Oct	DSCN0378	9:09	**L2T6** At the 5 m mark looking up line.
3-Oct	DSCN0379	9:09	At the 5 m mark looking down line.
3-Oct	DSCN0380	9:11	At the 38 m mark looking down line.
3-Oct	DSCN0381	9:13	At the 38 m mark looking up line.
3-Oct	DSCN0382	9:13	At the 38 m mark looking down stream.
3-Oct	DSCN0383	9:15	At EOT looking up line.
3-Oct	DSCN0384	9:18	Landscape shot.
2-Oct	DSCN0367	14:15	**L2T15** At the 4 m mark looking at the tag tree.
2-Oct	DSCN0368	14:15	At the 4 m mark looking down line.
2-Oct	DSCN0369	14:33	At the 32 m mark looking up line.
2-Oct	DSCN0370	14:33	at the 30 m mark looking down line at the EOT.
2-Oct	DSCN0363	13:16	**L2T18** At the 10 m looking down line.
2-Oct	DSCN0364	13:16	At the 10 m mark looking up line.
2-Oct	DSCN0365	13:16	At the 10 m mark looking down stream.
2-Oct	DSCN0366	13:16	At the 10 m mark looking up stream.

Date: Sept/Oct 2013			**Environmental Crew:** Mary Louise, Aden
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-Oct	DSCN0359	12:37	**L3T1** At the 24 m mark looking up line.
2-Oct	DSCN0360	12:37	At the 24 m mark looking down line.
2-Oct	DSCN0361	12:37	At the 24 m mark looking down stream.
2-Oct	DSCN0362	12:37	At the 24 m mark looking up stream.
2-Oct	DSCN0353	12:01	**L3T9** At the 13 m mark looking up line to the POC.
2-Oct	DSCN0354	12:01	At the 13 m mark looking down line.
2-Oct	DSCN0355	12:04	At the 22 m mark looking up line.
2-Oct	DSCN0356	12:05	At the 22 m mark looking down line.
2-Oct	DSCN0357	12:06	At the 38 m mark looking up line.
2-Oct	DSCN0358	12:07	At the 38 m mark looking down line.
2-Oct	DSCN0349	11:22	**L3T30** At the 24 m mark looking up line.
2-Oct	DSCN0350	11:23	At the 24 m mark looking down line.
2-Oct	DSCN0351	11:23	At the 24 m mark looking up stream.
2-Oct	DSCN0352	11:23	At the 24 m mark looking down stream.

Appendix 4: Duncan and Lardeau rivers contact sheets

Duncan River 1 Transects 3, 4 and 5 - April/May 2013

IMG_5818_T3

IMG_5819

IMG_5820_T4

IMG_5821

IMG_5822

IMG_5823

IMG_5824_T5

IMG_5825

IMG_6040

IMG_6041

IMG_6042

IMG_6043

Duncan River 3 Transects 10, 11 and 15 - April/May 2013


IMG_5787_D3T10


IMG_5788


IMG_5789


IMG_5790


IMG_5791_D3T11


IMG_5792


IMG_5793


IMG_5794


IMG_5795


IMG_5796_D3T15


IMG_5797


IMG_5798

Duncan River 3 Transect 15 - July 2013


IMG_5799_D3T15


IMG_5800


IMG_5801


IMG_5802


IMG_5803


IMG_5804


IMG_5805


IMG_5806


IMG_5807


IMG_5808


IMG_5809

Duncan River 3 Transects 17, and 29 - April/May 2013

IMG_5810_D3T17

IMG_5811

IMG_5812

IMG_5813

IMG_5814

IMG_5815

IMG_5816

IMG_5817

IMG_5826_D3T29

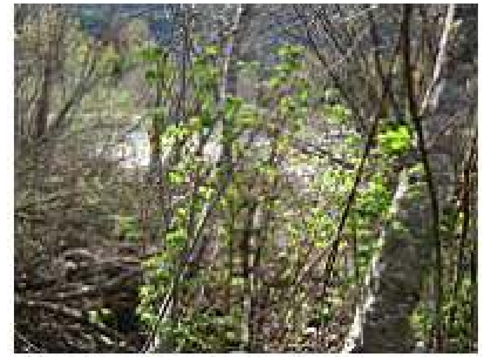
IMG_5827

Duncan River 3 Transects 35, 20, and 23 - April/May 2013


IMG_5828_D3T35


IMG_5829


IMG_5830_D3T20


IMG_5831


IMG_5832


IMG_5833


IMG_5834


IMG_5835


IMG_5836


IMG_5837_D3T23


IMG_5838


IMG_5839

Duncan River 3 Transects 23, 45 and 40 - April/May 2013

IMG_5840__D3T23

IMG_5841

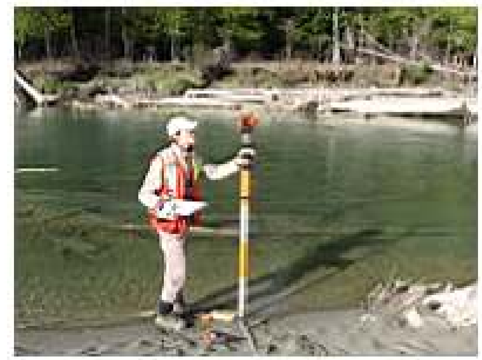
IMG_5842_D3T45

IMG_5843

IMG_5844

IMG_5845_D3T40

IMG_5846



IMG_5847

Duncan River 4 Transects 3 and 10 - April/May 2013


IMG_5990_D4T3


IMG_5991


IMG_5992


IMG_5993


IMG_5994


IMG_5995


IMG_5996_D4T10


IMG_5997


IMG_5998


IMG_5999


IMG_6000


IMG_6001

Duncan River 4 Transects 10 and 5 - April/May 2013


IMG_6002_D4T10


IMG_6003


IMG_6004


IMG_6005


IMG_6006_D4T5


IMG_6007


IMG_6008


IMG_6009


IMG_6010


IMG_6011


IMG_6012


IMG_6013

Duncan River 4 Transect 5 - April/May 2013


IMG_6014_D4T5

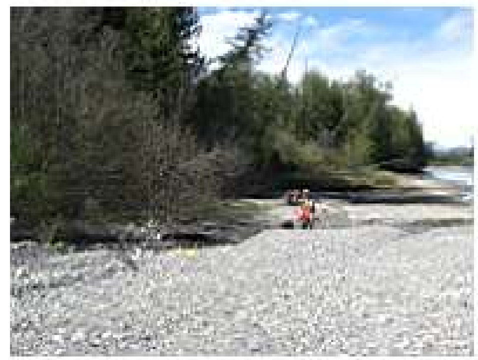

IMG_6015


IMG_6016


IMG_6017


IMG_6018


IMG_6019


IMG_6020


IMG_6021


IMG_6022

Duncan River 5 Transects 2 and 9 - April/May 2013


IMG_6023_D5T2

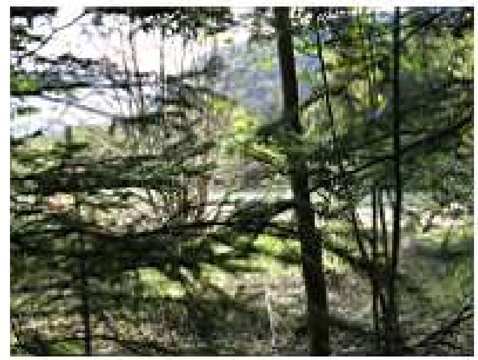

IMG_6024


IMG_6025


IMG_6026


IMG_6027


IMG_6028


IMG_6029_D5T9


IMG_6030


IMG_6031


IMG_6032


IMG_6033


IMG_6034

Duncan River 5 Transects 9 and 11 - April/May 2013


IMG_6035_D5T9


IMG_6036


IMG_6037


IMG_6038


IMG_6039


IMG_5848_D5T11


IMG_5849


IMG_5850


IMG_5851


IMG_5852


IMG_5853

Duncan River 5 Transects 12 and 16 - April/May 2013

IMG_5854_D5T12

IMG_5855

IMG_5856

IMG_5857

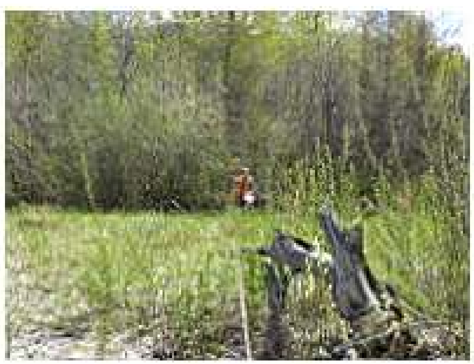
IMG_5858_D5T16

IMG_5859

IMG_5860

IMG_5861

IMG_5862



IMG_5863

IMG_5864

Duncan River 5 Transect 19 - April/May 2013

IMG_5865_D5T19

IMG_5866

IMG_5867

IMG_5868

IMG_5869

IMG_5870

IMG_5871

Duncan River 6 Transects 29 and 36 - April/May 2013


IMG_5872_D6T29


IMG_5873


IMG_5874


IMG_5875


IMG_5876


IMG_5877


IMG_5878


IMG_5879


IMG_5880


IMG_5881_D6T36


IMG_5882


IMG_5883

Duncan River 6 Transects 36, 20 and 6 - April/May 2013

IMG_5884_D6T36

IMG_5885

IMG_5886

IMG_5887

IMG_5888

IMG_5889_D6T20

IMG_5890

IMG_5891

IMG_5892_D6T6

IMG_5893

IMG_5894

IMG_5895

Duncan River 6 Transect 6 - April/May 2013

IMG_5896_D6T6

IMG_5897

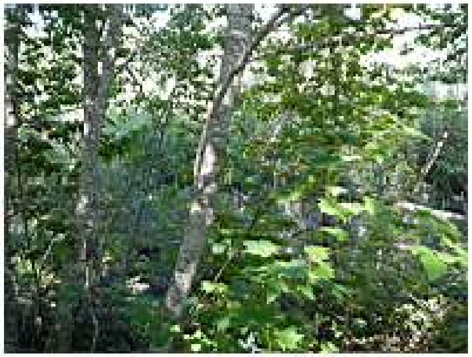
IMG_5898

IMG_5899

IMG_5900

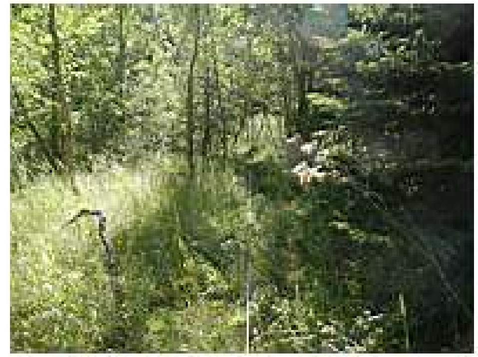
IMG_5901

Duncan River 1 Transects 3, 4 and 5 - July 2013



DSCN4789_D1T3

DSCN4790

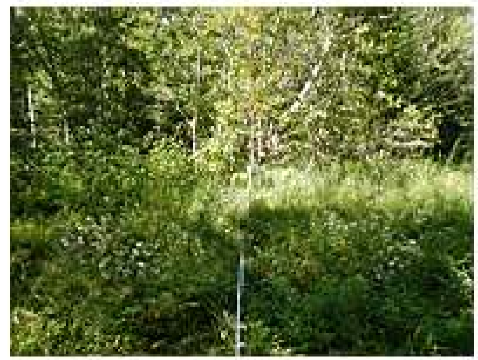


DSCN4791_D1T4

DSCN4792

DSCN4793

DSCN4794



DSCN4795_D1T5

DSCN4796

Duncan River 3 Transects 10 and 11 - July 2013


DSCN0006_D3T10


DSCN0007


DSCN0008


DSCN0009


DSCN0010

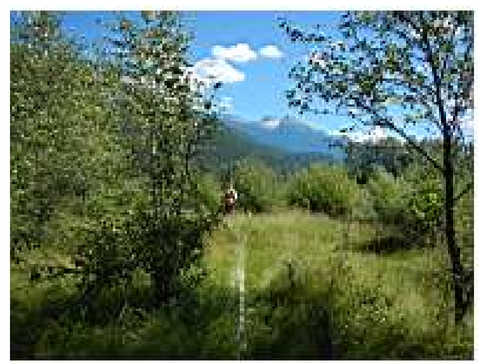

DSCN0011


DSCN0012


DSCN0013_D3T11


DSCN0014


DSCN0015


DSCN0016


DSCN0017

Duncan River 3 Transects 15 and 17- July 2013


DSCN0018_D3T15


DSCN0019


DSCN0020


DSCN0021


DSCN0022


DSCN0023


DSCN0024_D3T17


DSCN0025


DSCN0026


DSCN0027

Duncan River 3 Transects 29, 35 and 20 - July 2013


DSCN0028_D3T29


DSCN0029


DSCN0030


DSCN0031


DSCN0032


DSCN0033_D3T35


DSCN0034


DSCN0035


DSCN0036


DSCN0037_D3T20


DSCN0038


DSCN0039

Duncan River 3 Transects 20, 23 and 45 - July 2013

DSCN0040_D3T20

DSCN0041

DSCN0042_D3T23

DSCN0043

DSCN0044

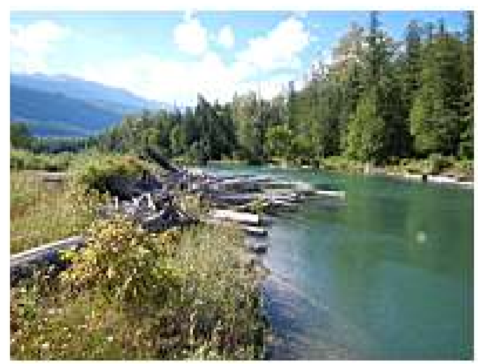
DSCN0045

DSCN0046

DSCN0047_D3T45

DSCN0048

DSCN0049



DSCN0050

DSCN0051

Duncan River 4 Transects 3 and 10 - July 2013

DSCN4814_D4T3

DSCN4815

DSCN4816

DSCN4817

DSCN4818

DSCN4824_D4T10

DSCN4825

DSCN4826

DSCN4827

DSCN4828

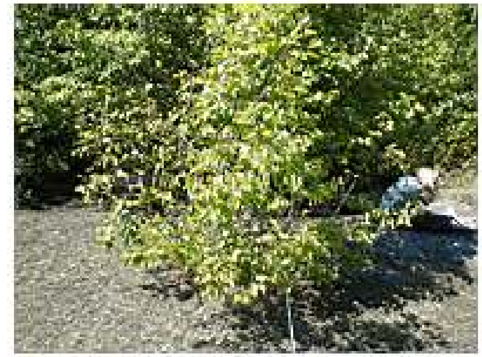
DSCN4829

Duncan River 4 Transect 5 - July 2013

DSCN4804_D4T5

DSCN4808

DSCN4809



DSCN4810

DSCN4811

Duncan River 5 Transects 2, 9 and 11 - July 2013


DSCN4800_D5T2


DSCN4801


DSCN4802


DSCN4797_D5T9


DSCN4798


DSCN4799


DSCN0052_D5T11


DSCN0053


DSCN0054


DSCN0055


DSCN0056

Duncan River 5 Transects 12, 16 and 19 - July 2013


DSCN0057_D5T12


DSCN0058


DSCN0059


DSCN0060


DSCN0061_D5T16


DSCN0062


DSCN0063


DSCN0064


DSCN0065


DSCN0066_D5T19


DSCN0067


DSCN0068

Duncan River 6 Transects 29 and 36 - July 2013

DSCN0069_D6T29

DSCN0070

DSCN0071

DSCN0072_D6T36

DSCN0073

DSCN0074

DSCN0075

DSCN0076

DSCN0077

Duncan River 6 Transects 20 and 6 - July 2013


DSCN0078_D6T20


DSCN0079


DSCN0080


DSCN0081


DSCN0082


DSCN0083


DSCN0084_D6T6


DSCN0085


DSCN0086


DSCN0087


DSCN0088

Duncan River 1 Transects 3, 4 and 5 - Sept/Oct 2013

DSCN6282_D1T3

DSCN6283

DSCN6279_D1T4

DSCN6280_D1T5

DSCN6281

Duncan River 3 Transects 10 and 11 - Sept/Oct 2013


DSCN0272_D3T10


DSCN0273


DSCN0274


DSCN0275


DSCN0276


DSCN0277


DSCN0278_D3T11


DSCN0279


DSCN0280


DSCN0281


DSCN0282


DSCN0283

Duncan River 3 Transects 15 and 17 - Sept/Oct 2013

DSCN0284_D3T15

DSCN0285

DSCN0286

DSCN0287

DSCN0288

DSCN0289

DSCN0290_D3T17

DSCN0291

Duncan River 3 Transects 29 and 35 - Sept/Oct 2013

DSCN0293_D3T29

DSCN0294

DSCN0295

DSCN0296

DSCN0297

DSCN0298

DSCN0299_D3T35

DSCN0300

DSCN0301

DSCN0302

DSCN0303

DSCN0304

Duncan River 3 Transects 20, 23 and 45- Sept/Oct 2013

DSCN0305_D3T20

DSCN0306

DSCN0307

DSCN0308

DSCN0309_D3T23

DSCN0310

DSCN0311

DSCN0312

DSCN0313_D3T45

DSCN0314

DSCN0315

DSCN0316

Duncan River 3 Transects 45 and 40- Sept/Oct 2013

DSCN0317_D3T45

DSCN0318

DSCN0319_D3T40

DSCN0320

DSCN0321

DSCN0322

Duncan River 4 Transects 3 and 10 - Sept/Oct 2013

DSCN6322_D4T3

DSCN6323_D4T10

Duncan River 5 Transects 2, 11 and 12 - Sept/Oct 2013


DSCN6318_D5T2


DSCN6319


DSCN6320_D5T9


DSCN6321


DSCN0323_D5T11


DSCN0324


DSCN0325


DSCN0326


DSCN0327


DSCN0328


DSCN0329_D5T12


DSCN0330

Duncan River 5 Transects 16 and 19 - Sept/Oct 2013

DSCN0331_D5T16

DSCN0332

DSCN0333

DSCN0334

DSCN0335

DSCN0336

DSCN0337_D5T19

DSCN0338

Duncan River 6 Transects 29, 36 and 20- Sept/Oct 2013

DSCN0339_D6T29

DSCN0340

DSCN0341_D6T36

DSCN0342

DSCN0343

DSCN0344

DSCN0345_D6T20

DSCN0346

DSCN0347

DSCN0348

Lardeau River 1 Transects 1 and 10 - April/May 2013

IMG_5985L1T1

IMG_5986

IMG_5987

IMG_5988

IMG_5989

IMG_5973_L1T10

IMG_5974

IMG_5975

IMG_5976

IMG_5977

IMG_5978

IMG_5979

Lardeau River 1 Transects 10 and 20 - April/May 2013


IMG_5980_L1T10


IMG_5981


IMG_5982


IMG_5983


IMG_5984


IMG_5961_L1T20


IMG_5962


IMG_5963


IMG_5964


IMG_5965


IMG_5966


IMG_5967

Lardeau River 1 Transects 20 and 36 - April/May 2013


IMG_5968_L1T20


IMG_5969


IMG_5970


IMG_5971


IMG_5972


IMG_5952_L1T36


IMG_5953


IMG_5954


IMG_5955


IMG_5956


IMG_5957


IMG_5958

Lardeau River 1 Transect 36 - April/May 2013

IMG_5959_L1T36

IMG_5960

Lardeau River 2 Transect 6 - April/May 2013


IMG_5939_L2T6


IMG_5940


IMG_5941


IMG_5942


IMG_5943


IMG_5944


IMG_5945


IMG_5946


IMG_5947


IMG_5948


IMG_5949


IMG_5950

Lardeau River 2 Transects 6 and 15 - April/May 2013

IMG_5951_L2T6

IMG_5931_L2T15

IMG_5932

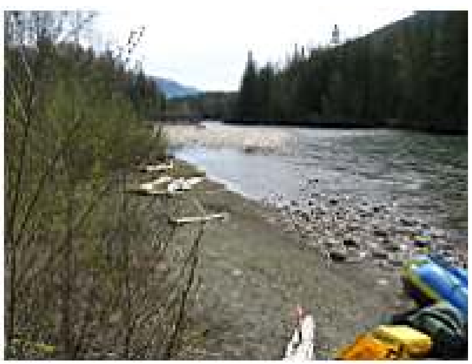
IMG_5933

IMG_5934

IMG_5935

IMG_5936

IMG_5937



IMG_5938

Lardeau River 2 Transect 18 - April/May 2013


IMG_5923_L2T18


IMG_5924


IMG_5925


IMG_5926


IMG_5927


IMG_5928


IMG_5929


IMG_5930

Lardeau River 3 Transects 1 and 9 - April/May 2013


IMG_5915_L3T1


IMG_5916


IMG_5917


IMG_5918


IMG_5919


IMG_5920


IMG_5921


IMG_5922


IMG_5905_L3T9


IMG_5906


IMG_5907


IMG_5908

Lardeau River 3 Transects 9 and 30 - April/May 2013


IMG_5909_L3T9


IMG_5910


IMG_5911


IMG_5912


IMG_5913


IMG_5914


IMG_5902_L3T30


IMG_5903


IMG_5904

Lardeau River 1 Transects 1 and 10 - July 2013

DSCN4830_L1T1

DSCN4831

DSCN4832

DSCN4833

DSCN4834

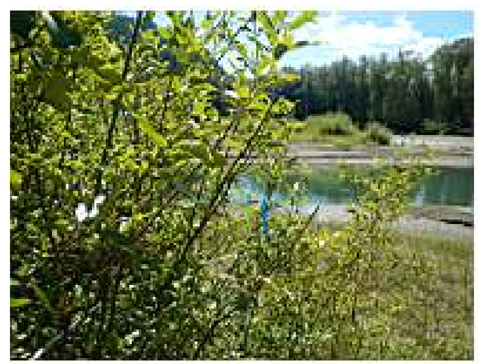
DSCN4835

DSCN4838_L1T10

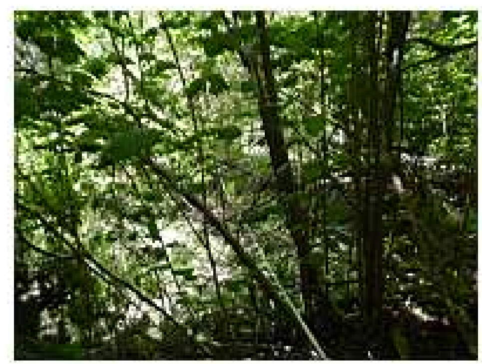
DSCN4839

DSCN4840

DSCN4841



DSCN4842



DSCN4843

Lardeau River 1 Transects 20 and 36 - July 2013

DSCN4844_L1T20

DSCN4845

DSCN4846

DSCN4847

DSCN4848

DSCN4849

DSCN4850

DSCN4851

DSCN0114_L1T36

DSCN0115

DSCN0116

DSCN0117

Lardeau River 1 Transect 36 - July 2013


DSCN0118_L1T36


DSCN0119


DSCN0120


DSCN0121


DSCN0122


DSCN0123

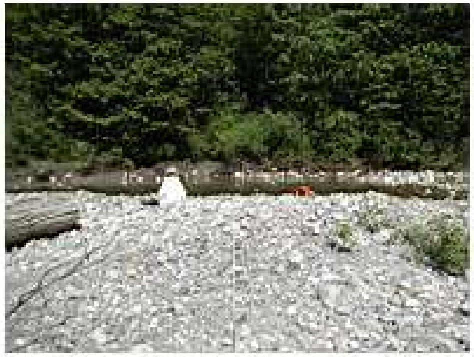

DSCN0124


DSCN0125


DSCN0126

Lardeau River 2 Transects 6, 15 and 18 - July 2013


DSCN4852_L2T6


DSCN4853


DSCN4854


DSCN4855

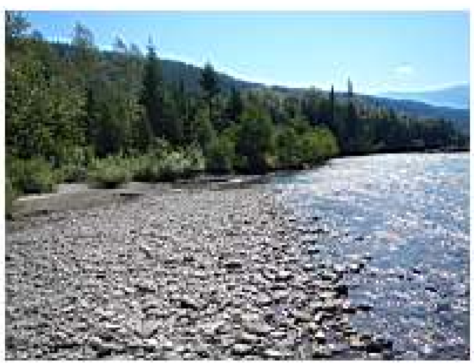

DSCN0111_L2T15


DSCN0112


DSCN0113


DSCN0107_L2T18


DSCN0108


DSCN0109


DSCN0110

Lardeau River 3 Transects 1 and 9 - July 2013


DSCN0103_L3T1

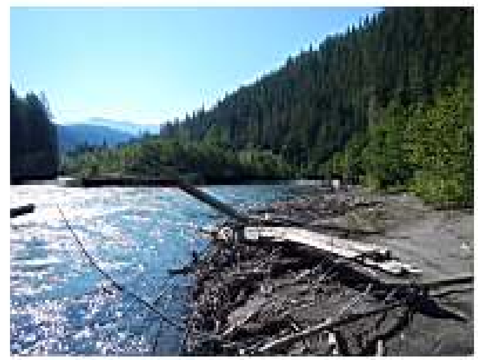

DSCN0104


DSCN0105


DSCN0106

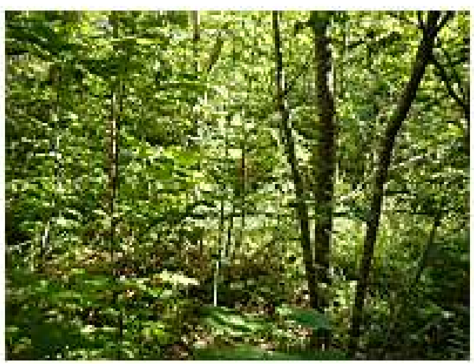

DSCN0097_L3T9


DSCN0098


DSCN0099


DSCN0100


DSCN0101


DSCN0102

Lardeau River 3 Transect 30 - July 2013

DSCN0092_L3T20

DSCN0093

DSCN0094

DSCN0095

DSCN0096

Lardeau River 1 Transects 1, 10 and 20 - Sept/Oct 2013

DSCN6324_L1T1

DSCN6325

DSCN6326_L1T10

DSCN6327

DSCN6331_L1T20

DSCN6332

Lardeau River 1 Transect 36 - Sept/Oct 2013

DSCN0371_L1T36

DSCN0372

DSCN0373

DSCN0374

DSCN0375

DSCN0376

DSCN0377

Lardeau River 2 Transects 6 and 15 - Sept/Oct 2013

DSCN0378_L2T6

DSCN0379

DSCN0380

DSCN0381

DSCN0382

DSCN0383

DSCN0384

DSCN0367_L2T15

DSCN0368

DSCN0369

DSCN0370

Lardeau River 2 Transect 18 - Sept/Oct 2013

DSCN0363_L2T18

DSCN0364

DSCN0365

DSCN0366

Lardeau River 3 Transects 1 and 9 - Sept/Oct 2013


DSCN0359_L3T1

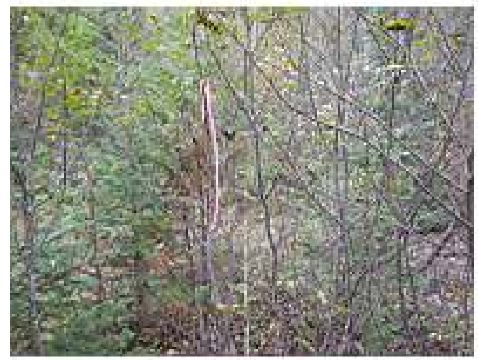

DSCN0360


DSCN0361


DSCN0362


DSCN0353_L3T9


DSCN0354


DSCN0355


DSCN0356


DSCN0357


DSCN0358

Lardeau River 3 Transect 30 - Sept/Oct 2013

DSCN0349_L3T30

DSCN0350

DSCN0351

DSCN0352