Duncan Dam Project Water Use Plan

Duncan Reservoir Riparian Vegetation Monitoring

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Year 2 Report

Study Period: April 2012 – January 2013

Vast Resource Solutions Inc.
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Final Report

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Cover photo

Site 4 Transect 705 looking down line towards reservoir. All photos © Mary Louise Polzin, Vast Resource Solutions.

Executive Summary

A ten-year vegetation monitoring study of the drawdown zone of Duncan Reservoir 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 alternative S73, on vegetation within the drawdown zone. The study provides site-specific data to guide reservoir management and improve the understanding of the relationships between reservoir management, physical environmental conditions, and riparian vegetation. The information will assist in determining areas that could be enhanced and will also contribute to the assessment of prospective wildlife habitat consequences from alternative S73.

To address the management question and associated hypotheses (table following), vegetation community dynamics are analyzed every three years using transect line quadrat sampling and ortho-rectified colour aerial photography analysis.

Change-detection mapping showed a slight reduction in vegetation from 2009 to 2012. Four vegetation communities were missing, and new communities resulted from secondary and tertiary species moving to the primary positions. One of these communities had the dominant species *Populus trichocarpa* that grew from the herbaceous type (< 0.5 m in height) to shrub type (> 0.5 m to 2 m in height).

This second interval of monitoring revealed that the vegetated area increased as the duration of inundation decreased. Reservoir drawdown zone elevation was directly linked with inundation time and was associated with 90% of the variation in vegetated covered for the reservoir zone. However, with only two time points, the study could not correlate the changes in the community types with the inundation durations. Some changes could also reflect unusual seasonal weather variation that occurred in 2012. Future monitoring could resolve the influences of weather versus inundation duration.

There was a trend of decreasing species richness in the drawdown zone with a reduction from 70 to 65 total plant species. Statistical analyses investigated factors associated with the vegetation cover for individual species, and total cover of all species. These indicated significant influences from particular physical factors, with vegetation cover increasing with elevation, finer substrate, and with shallower slope of the drawdown bank.

Changes occurred in plant distribution patterns, species diversity, and predominant plant species in 2012 compared to 2009. The second-ranked species in 2009, *Carex utriculata* (beaked sedge), dropped to fifth position in 2012. This wetland graminoid may be a useful indicator species to assess the effect of the alternative S73 regime on previously established vegetation communities.

We collected quantitative and qualitative data on vegetation species, community occurrences, and environmental influences specific to the Duncan Reservoir drawdown zone but should also provide more general outcomes that would be applicable to other reservoirs in British Columbia and the Pacific Northwest. These data and analyses will be instructive for developing dam operations patterns that could benefit reservoir environments and riparian community success, as well as assisting key species for reservoir enhancement projects. This ongoing study will provide information on physical factors such as elevation, inundation tolerances, substrate and slope preferences, for the favoured species as well as for disfavoured plants such as invasive weeds.

Objectives	Management Questions	Management Hypotheses	Year 4 (2012) Status
1) To assess the riparian productivity for hectares of riparian habitat in the reservoir drawdown zone during the growing season.	1) Will the implementation of Alt S73 result in neutral, positive, or negative changes to riparian vegetation communities within the drawdown zone.	H_{01}: Alternative S73 will not result in decreases in area, and alterations in the species composition, of wetland and riparian vegetation communities.	Based on assessment in 2012 versus 2009, there was no significant difference in vegetated area following implementation of Alt S73. There was a slight decrease in vegetation cover by area. There was also an apparent alteration in species composition but this may reflect different seasonal weather patterns between the two years. Future sampling may indicate what factor or combination of factors resulted in the slight change to some vegetation communities.
2) To assess the inundation tolerance through riparian productivity potential in the reservoir drawdown zone during the growing season.		H_{02}: Reservoir elevations will not affect riparian distribution and abundance through the duration and frequency of root-zone flooding.	Based on assessment in 2012 versus 2009, there were similar patterns relative to the distribution and abundances of the riparian plants along the elevational bands within the reservoir draw-down zones. Physical factors affecting riparian plant distributions included substrate texture, site, and slope

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1.0 INTRODUCTION

1.1 Project Overview

This report summarizes Year 4 (2012) of the riparian vegetation monitoring study (DDMMON#8-2) for the Duncan Reservoir drawdown zone. The Duncan Reservoir is located north of the Duncan Dam, 11 km upstream from Kootenay Lake Reservoir, in the central Columbia Mountains of south eastern British Columbia (Figure 1). It is 45 km long, averages 1.5 km in width, and is fed by a rugged, high-elevation 2,010 km^2 drainage (Miles 2002).

Operational changes were recommended in 2005 by BC Hydro's Duncan Dam Water Use Plan Consultative Committee Report (DDWUP CC). This was part of a larger process for the lower Duncan River and Duncan reservoir that seeks to address previously under-recognized environmental and social issues (BC Hydro 2005). The recommended new operating alternative S73 (Alt S73) regime has been implemented since January 2008.

Alt S73 was expected to have a negative effect on the wildlife habitat along the Duncan Reservoir as a result of decreasing vegetation distribution and abundance (BC Hydro 2005). Consequently a long-term wetland and riparian vegetation monitoring program was recommended by the DDM WUP CC to assess Alt S73. This would involve analyses of riparian vegetation distribution and abundance, and testing of hypotheses underlying the approach taken in the WUP.

This study is designed to sample and analyze the conditions of existing vegetation communities every third year for 10 years and to track changes that may occur in vegetation distribution and abundance under the implementation of Alt S73. The second vegetation survey was deferred from Year 3 (2011) to Year 4 (2012) of the 10 year project.

The Duncan Dam is one of the facilities that provide flood control under the term of the Columbia River Treaty. As such, the dam was operated to minimize flooding impacts downstream. In terms of reservoir operation, Alt S73 differs from the 1968-2007 operating regime in the following ways for 2012:

Pre-2008: The average reservoir level from 1968 to 2007 reached a fill level of 575.7 m by July 29 and stayed at this level to August 30. From September 1 to early December there was gradual draining to 569.8 m. The levels dropped rapidly from December through March 20 to 550.5 m. Levels were stable at 550 m (approximately) for the remaining time in March until April 30, when levels rose quickly to 575.7 m (one metre below full-pool). Figure 2 shows substantial annual variation during pre-Alt S73 years.

Alt S73: In January 2012, the reservoir level was at 566.6 m and continued a steep decline, similar to pre-Alt S73, extending to April 15 at 547.0 m. It was relatively level until the reservoir started to fill May 12. Filling was affected by above average monthly total precipitation for March and June in 2012. March total precipitation was more than double the historical average. Total precipitation in June was just under triple the historic average and this filled the reservoir quicker than in previous Alt S73 years. The reservoir reached full-pool (576.68 m) earlier (July 21), than previous years (2008 – Aug. 9, 576.5 m, 2009 – Aug. 21, 575.8 m, 2010 – Aug. 1, 576.7 m, 2011 – Aug. 1, 576.7 m). The reservoir rose above full-pool July 22 (576.85 m), reached a maximum height of 576.89 m on July 23 and dropped to full-pool by July 25, at 576.67 m (BC Hydro 2012). The reservoir drained from August 24 through September 27 when it levelled off at approximately 571.6 m with minor fluctuation until October 31 (the end of the growing season) (Figure 2).

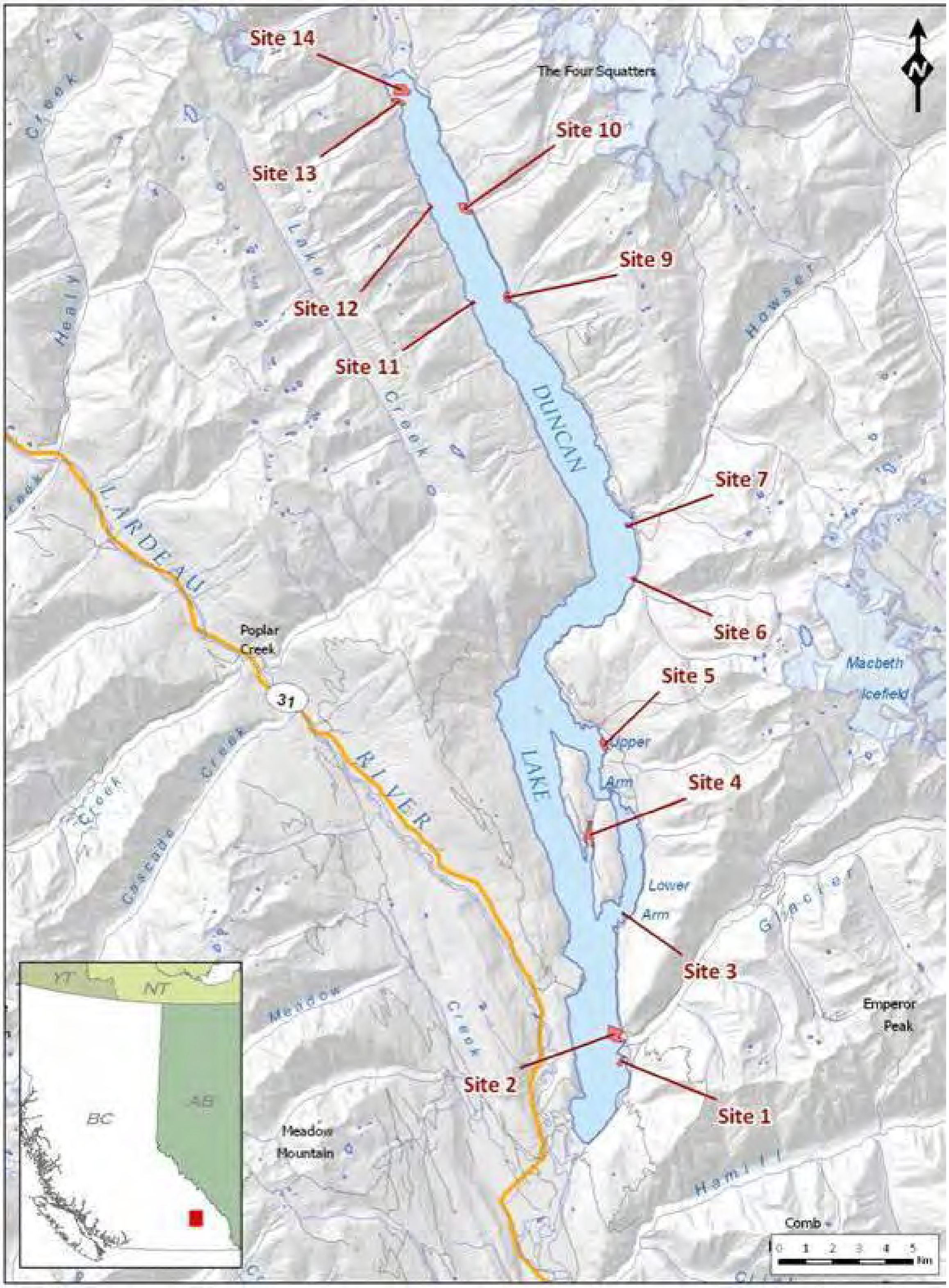


Figure 1: **The location of Duncan Reservoir and the 2012 sampling sites.**

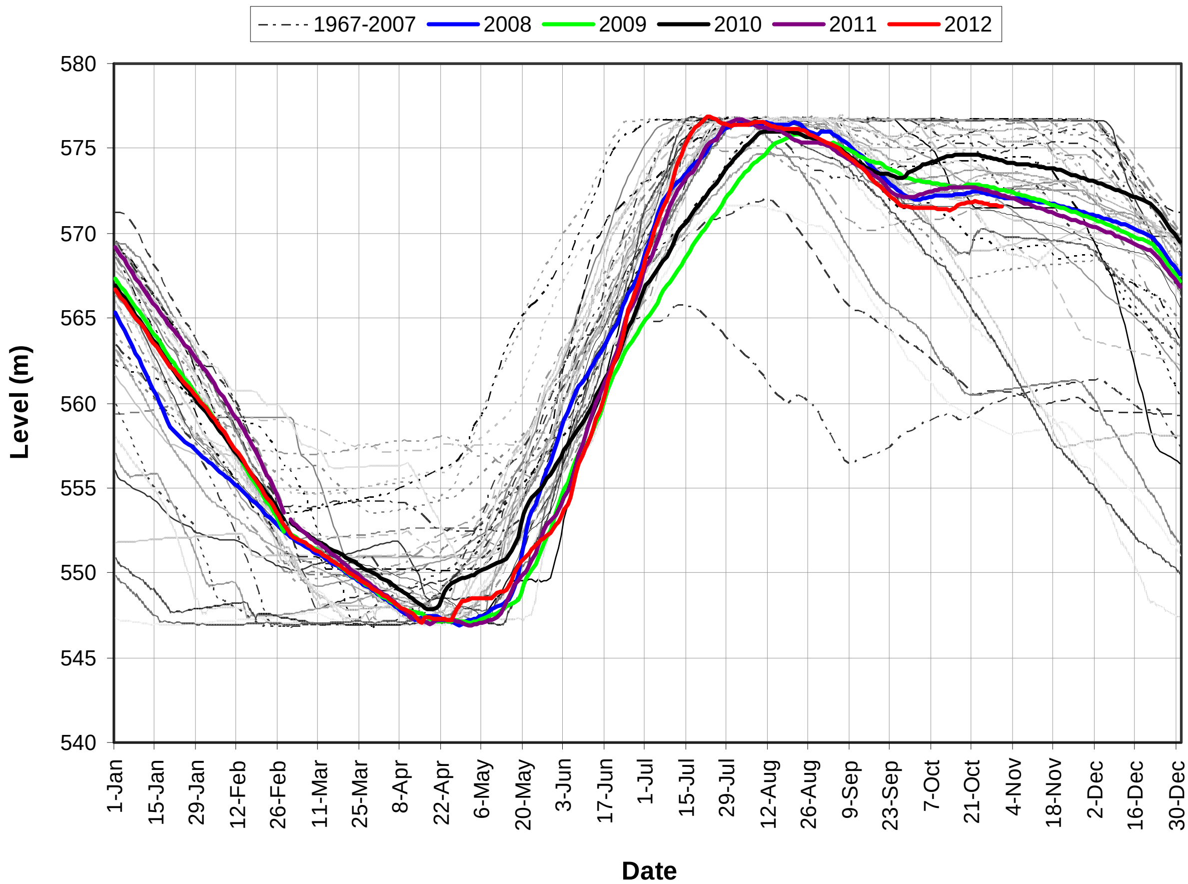


Figure 2: Mean Daily Water Levels (m) for Duncan Reservoir at Duncan Dam (WSC Station 08NH127) 1967 – 2012.

1.2 Background

Data from storage reservoirs world-wide indicate that *reservoir drawdown zones impose physically stressful environments for vegetation* (Nilsson and Keddy 1988 and Hill et al. 1998). Drawdown or storage reservoirs are very common worldwide and are managed to trap flows during certain intervals with subsequent controlled release of the stored water. These reservoirs provide deliberate strategies to reduce downstream flooding; enable hydroelectric power generation; provide off-stream water for agricultural, urban and industrial uses; and enable environmental in-stream flows for aquatic or riparian ecosystems and various other applications.

Accompanying the deliberate manipulation of seasonal river flows and water supplies, there is periodic filling and drawdown of the storage reservoir pools. When full, reservoir banks are completely inundated, while during drawdown, those same zones become fully exposed. Aquatic plants are able to withstand inundation, but are unable to survive in dry conditions. Conversely, terrestrial plants are generally intolerant of complete inundation, particularly when such inundation lasts for days, weeks, or months.

Wetland and riparian plants are better able to withstand cycles of inundation, but these same plants are generally drought-intolerant. Thus, there is a general trade-off relative to the capacity of plants to survive in very wet versus very dry environments.

Consequently, few if any plants are able to survive in reservoir drawdown zones, and these areas are typically almost barren of vegetation (Nilsson et al. 1997, Jansson et al. 2000). The exceptions generally involve ruderal annuals, which are species that rapidly colonize disturbed areas, since they are able to complete their life cycle within the limited drawdown interval (Braatne et al. 2003). Seedlings or occasionally clonal propagules of these plants are able to establish in the newly-exposed moist reservoir shorelines and the successful plants are able to quickly grow and reproduce, producing seeds prior to the subsequent inundation. The ruderal annuals are commonly weedy plants that are able to establish quickly and often have prolific reproductive potential. Such plants are often alien species that have typically been unintentionally introduced into a region and their prolific reproductive capacities may allow them to colonize areas characterized by disturbance or abrupt physical change, as is present in reservoir drawdown zones.

Despite the global abundance of drawdown reservoirs, there have been far fewer scientific studies of associated vegetation than has been the case for many other environments, such as wetland and riparian zones (Hill et al. 1998). Many of the same physical factors likely underlie vegetation establishment, survival and expansion in reservoirs, wetland and riparian zones (Jansson et al. 2000), and the distinctive and severe reservoir environments may even provide opportunities for scientific study (Nilsson and Keddy 1988, Braatne et al. 2008). Since these zones are relatively impoverished, there are fewer species to investigate and fewer interspecific interactions (e.g., competition). Since the zones are dominated by ruderal annuals, the process of colonization is critical and may yield useful information about the life history components of the associated plants, as well as insight into the fundamental nature of weedy and invasive plants.

Distribution patterns predicted prior to baseline data analyses were found to be generally accurate (Polzin et al. 2010) with some possible factors better understood as the project progresses and more data are collected (Figure 3). In addition to the influences due to reservoir regulation, biological processes are affected by yearly fluctuations in temperature, precipitation, and storm events that cannot be controlled in a natural setting.

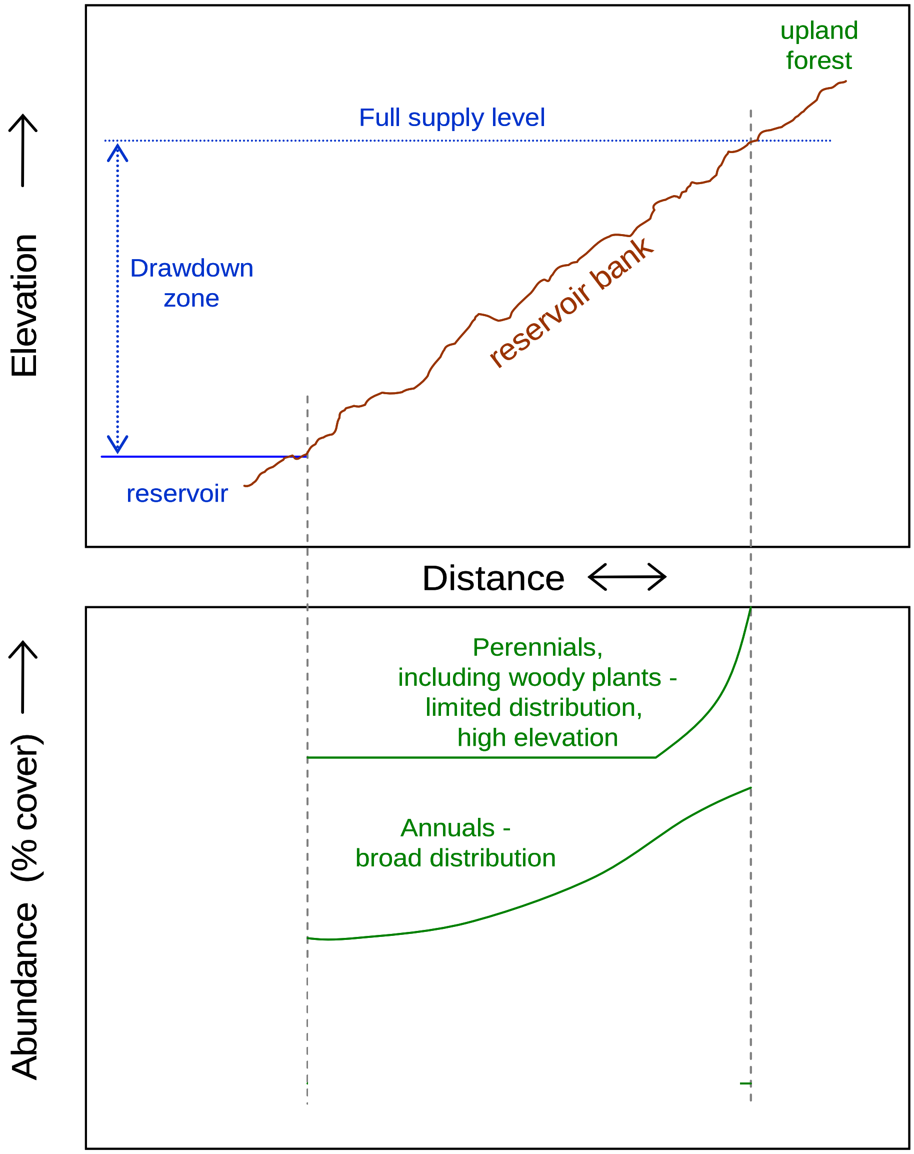


Figure 3: The generalized distributions of different plant types through the drawdown zone of Duncan reservoir in 2009.

1.3 Project Description and Objectives

The DDM WUP CC identified two performance measures for testing the effects of Alt 73 on existing vegetation communities in the Duncan Reservoir (BC Hydro 2005). These are:

- **Riparian habitat productivity** - *long term median*: hectares of herbaceous riparian habitat in the reservoir drawdown zone to an elevation of approximately 8 m below full-pool during growing season (1 April to 31 October); and
- **Riparian vegetation** - *inundation tolerance*: hectares of *potential* herbaceous and shrub areas in the reservoir drawdown zone in the growing season (1 April to 31 October).

There is an expectation that Alt S73 will decrease the area of riparian vegetation around the reservoir drawdown zone compared to the prior operating regime (BC Hydro 2009), because the reservoir level will be held higher throughout late summer and early fall. However, the zone around the upper elevations may be exposed longer in the spring/early summer due to a slower fill rate, thereby potentially providing a slightly longer pre-inundation growing season.

The two hypotheses to be tested as part of this monitoring program in Year 10 (2018) are:

> "**H_{01}**: Alt S73 will not result in a decrease to the area and alterations in the species composition of both wetland and riparian vegetation communities"; and
>
> "**H_{02}**: Reservoir elevations will not affect riparian distribution and abundance through the duration and frequency of root-zone flooding".

H_{02} is designed to investigate species-elevation relationships, and results should facilitate predictions regarding plant community response to a given operating regime.

The objectives of the monitoring program are to collect and analyze field data on riparian vegetation around the reservoir at sites predetermined by BC Hydro (2009) to test the null hypotheses, and to compare performance measures over time.

The specific program objectives are (BC Hydro 2009):

- To map the distribution of wetland and riparian vegetation within the drawdown zone of Duncan Reservoir using aerial photography, starting in Year 1 of the monitoring program;
- To make special note of any traditional use plant species that occur within the drawdown zone of Duncan Reservoir;
- To monitor changes over time in the area coverage and plant species composition of vegetated communities within the drawdown zone of Duncan Reservoir under operating regime alternative S73; and
- To provide the basis for assessing potential wildlife community changes resulting from the WUP constraints.

The objectives for Year 4 (this report), expressed as null hypotheses, were:

  - H_{01} objective: Monitor changes in the area coverage and plant species composition of vegetated communities by mapping the distribution of riparian vegetation within the drawdown zone of Duncan Reservoir using aerial photography; and
  - H_{02} objective: Monitor changes over time to vegetation composition, distribution and abundance by repeating belt transect surveys.

2.0 METHODS

2.1 Aerial Photography

Aerial photography captured the thirteen sites around the reservoir identified in 2009. The June 25, 2012 flight enabled 10 cm (pixel size) aerial photo acquisition, and subsequent orthorectification, colour balancing, image sharpening and mosaic production were subcontracted to Terrasaurus Aerial Photography Ltd. At the time of aerial photo acquisition, the reservoir level was at 565.4 m, which was below the maximum target level of 566.7 m. In 2009, reservoir photo acquisition occurred June 1 to accommodate the need to establish pre-field boundaries and plant community distribution at each site. This preceded the transect line selection and still provided time to sample before the reservoir level was above the required sampling zone. Due to cooler than average May temperature in 2009, vegetation growth was delayed, resulting in difficulties delineating vegetation communities from the air photos. Subsequently, photo acquisition in 2012 was scheduled as late as possible so it would occur when plants were at their tallest just before reservoir levels inundated the bottom of the sampling elevation band (566.7 m). This was accomplished with the reservoir fill level 1.3 m below the transect end points. Inundation was rapid and the reservoir level was above transect bottom elevation three days later (June 28, 2012).

The air photos were analysed using a Planar Stereo/3D Monitor for stereoscopic viewing on a computer monitor. Delineation of plant communities utilizing the ortho-rectified aerial photographs provided measurement of the area colonized by different plant communities and the areas of bare ground. A comparison between years addresses the first null hypothesis of whether changes in vegetation cover and plant community composition occurred within the drawdown zone. This determination will be enabled by documenting and measuring changes in area and distribution of plant communities over a ten-year period.

2.2 GIS Method

The use of GIS with the ortho-rectified aerial photographs allowed analyses of plant community area calculations, plant community types, and inundation times that occur at the sampling sites. GIS analysis generated the data needed to address H_{01}.

The contour, mass point, and break-line data for the study area were provided by BC Hydro in MicroStation V8 DGN format with the following data limitation:

“Please be advised that the 1 Metre contours that have been sent for Duncan and Kootenay Lake are not edited, and far exceed the vertical accuracy in some areas. The data was a combination of source material including LiDAR, photogrammetry and TRIM. The area covered is only from water line at time of photography up to 580 M. Coordinates are in NAD83 Z1” (L. Giles, pers. comm., 2009).

Thus data derived using source elevation are only as accurate as the source data. All acquired elevation data were converted to ArcGIS shapefile format and imported into an ArcGIS geodatabase. Utilizing the 3D Analyst extension, elevation data were used to generate a Triangular Irregular Network (TIN) to represent surface morphology. The TIN was used to perform an analysis of the drawdown zone surface area, in which the surface area above the weekly average reservoir elevation was calculated for each week during the growing season, for each of the 12 sites. Also calculated during this analysis were the surface areas of the drawdown zone exposed for 85 to 100 per cent of the growing season (April 1 - September 30) at each of the 12 sites. The TIN created for each site was used for 2012 elevation based analyses. GIS data submission is digital and was submitted separately from this document, but is referenced in Appendix 7.

2.3 Sampling Design

The overall sampling design for site selection, size of sites, and four sampling periods was pre-set by BC Hydro. The ground sampling design from 2009 (Polzin et al. 2010) with the minor modifications in 2012 builds upon a literature-based hydrogeomorphic framework, in which riparian plants have particular water and substrate requirements for successful colonization (Auble et al. 1994, Mahoney and Rood 1998, and Polzin and Rood 2006). This approach implements a composite study design that includes both temporal and spatial comparisons (Braatne et al. 2008). The analysis of the key management question, whether Alt S73 influences riparian habitat productivity, is addressed by monitoring the relationship between the reservoir regime (Alt S73) and riparian success. A composite study design involving analyses of vegetation, surface sediments, and inundation time, with temporal and spatial comparisons through the sequence of monitoring years, was chosen. This sampling design has a more extensive sampling component with the use of the belt-transect for vegetation data collection. The introduction of surveyed transects connected to vegetation quadrats captures the elevational patterns of the sampled quadrats and ensures comprehensive analyses of the inundation intervals. It also ties all the information gathered in the field, including the photo-monitoring, to the elevation profile. The field study design, combined with the air-photo-monitoring, enables extensive monitoring at all sites, thereby supplying a robust study design. The vegetation monitoring at sites enables change detection, which is needed to address the second null hypothesis.

The number of monitoring sites was determined by the budget available for field sampling and by ease of access by BC Hydro, with a higher proportion of sites selected in areas with high enhancement potential (BC Hydro 2009). Site selection by BC Hydro was based on Moody (2002) with numbering changed to start from the south to the north along each side of the lake (BC Hydro 2009). The 12 sites monitored in 2009 had monitoring repeated in 2012. Site 14 was added to the aerial photography assessment in 2009 and was not part of the field site monitoring component (Polzin et al. 2010).

The use of transverse or cross-sectional belt transects within sites is a common and efficient strategy to sample riparian systems (Johnson et al. 1976, Stromberg et al. 1996, Braatne et al. 2003, Rood et al. 2010). Reservoir shorelines, sediments and vegetation are typically structured in elevational bands that parallel the reservoir shoreline. Belt transects consisted of quadrats sampling vegetation communities and this study system deliberately transects the reservoir shoreline perpendicular to the reservoir water edge, intersecting the bands with different substrates and vegetation, allowing for the detection and characterization of elevational patterns.

We used a stratified random sampling design for selecting transect locations, with quadrat sampling along transects from 576.68 m (full-pool) elevation to 568.68 m. Transect lines ran perpendicular to the reservoir fill level. The sampling design and supporting criteria for how it was implemented are described in the Polzin et al. (2010). Changes to the sampling design were initiated in 2012 to improve the study and address problems identified in the 2010 report. Changes to the design are described in the following sections.

Transects were extended 2 m upwards, to include the transition to the upland vegetation. This would more completely capture the transitional zone from the reservoir zone to the non-inundated upland and this also allowed for the contrast between the native, upland forest communities and the altered vegetation communities that had developed following the woodland clearing and subsequent flooding.

We maintained the original transect line point of commencement (POC) for the drawdown zone of the reservoir utilizing the tagged tree or rebar from 2009. Upland transects were run on the same bearing, and extended two metres upslope (Figure 4).

This resulted in the POC now being within each transect, instead of at one end. The upland data also provide information about the upland forest communities to address any changes that may occur above full-pool. Thus, we considered the prospect that as well as the direct impact due to reservoir flooding, there could also be indirect effects such as edge effects, whereby the upland forest zone would have greater exposure to sun, wind and other influences. There was also the prospect that plants such as invasive species could extend from the reservoir zone into the adjacent upland, thus providing another possible indirect effect from the reservoir development. Although these adjacent upland zones were not inventoried in 2009, we do have some archival photographs and no disturbance to the upland vegetation was noted while in the field in 2012, as compared to 2009 images and observations.

Sites 3, 5, and 6 had only one transect line established per site in 2009. This was because those plant communities occurred in a simpler pattern; with all of the local community types occurring in sequential bands that paralleled the reservoir shoreline allowing all plant communities to be bisected by one transect line. In 2012 a second transect line was randomly selected using the same criteria as in 2009 (Polzin et al. 2010) for each of these sites. The new transect lines were surveyed using a Nikon Automatic Level/AC-2s for a span of 10 m change in elevation. The tag numbers for the new POC trees were 812, 813, and 814. These additional transects provided replicate transect lines at each site, providing for another form of internal replication and strengthening the design relative to some quantitative and statistical analyses.

In 2009, sampling of sites with multiple transect lines was terminated once additional transects bisected a different plant community and entered a plant community already sampled by the full length transect line; or reached bare ground. In 2012, all lines were extended to cover the full 10 m change in elevation regardless of conditions. The additional lengths were surveyed with a Nikon Automatic Level to determine the where two metre change in elevation occurred and the end points for a 10 m change in elevation. A precision Trimble GPS (Pathfinder Pro XT) was used to mark the POC and end points (EOT) of transect lines. These extensions of the multiple transects provided additional quadrats and also provided replicate transect lines for each site, again strengthening the quantitative and statistical opportunities.

The additional transects and transect extensions provided replication within each site but this also increased the sampling time requirement. To streamline sampling along the individual transects, we revised the quadratic sampling, to match an efficient design that has been used by others (e.g. Stromberg et al. 2009). Sampling in 2009 involved the use of sequentially placed quadrats along each transect line. This supplied a continuous data series for each transect line sequence (Polzin et al. 2010). This dense data collection allows long-term reference through this project for actual abundance and richness along the complete transect lines. However, in 2012, sampling occurred at the beginning, mid-point, and end of each plant community or band. When plant communities covered large areas, sampling between the start and end of a community was spaced at 10 or 20 m intervals depending on the size of the patch or band. Because of the sequential sampling in 2009, this modified 2012 sampling can be directly compared to the 2009 baseline data that occurred at the same metre marks. In subsequent years, community area shifts and/or changes in species composition can be directly compared to the baseline data wherever the changes occur in future years. However, the extension to transect lines and the additional new lines added in 2012 were not sampled sequentially so the detailed baseline data is only available for the 2009 transect lines. We have thus refined the transect sampling protocol to streamline the sampling time and emphasize the key sampling at transitional positions for the sequential community types. We anticipate this streamlined transect sampling protocol for subsequent intervals but there is always the option of inventorying the full transect line at any future date.

Quadrat sizes (after Braatne et al. 2008) were: 5 x 10 m for all woody plants > 2 m tall (e.g. trees and tall shrubs) and labelled ‘Tree’; 2 x 4 m for woody plants 0.5 to 2 m tall labelled ‘Shrub; and 1 x 1 m for all herbaceous species including graminoids, moss and ferns (no height restriction) and any woody species < 0.5 m tall labelled ‘Herb’. Note that respective quadrat label names ‘Tree, Shrub, Herb’ quadrats does not necessarily refer to the species sampled within them.

Analyses of data from belt transects

The transects were randomly positioned and consequently the statistical analysis of data that are compiled by transect are relatively direct. The sequential quadrats along each transect are not independent and this psuedoreplication can complicate statistical analysis. Therefore, sequential quadrat sampling was modified in 2012 to address this complication and still have the information to address change at a fine scale. Riparian researchers typically use a combination of analyses of individual transects as the sampling unit and individual quadrats with the sampling unit to address particular questions. Some recent studies that have utilized transects and analyzed both transect and quadrat data include Lite et al. (2005), Braatne et al. (2007), Stromberg et al. (2009), and Rood et al. (2010).

As a general reference, Table 1 illustrates treatments relative to transect – versus quadrat-based data and how it can be used to address different considerations or questions for a particular project.

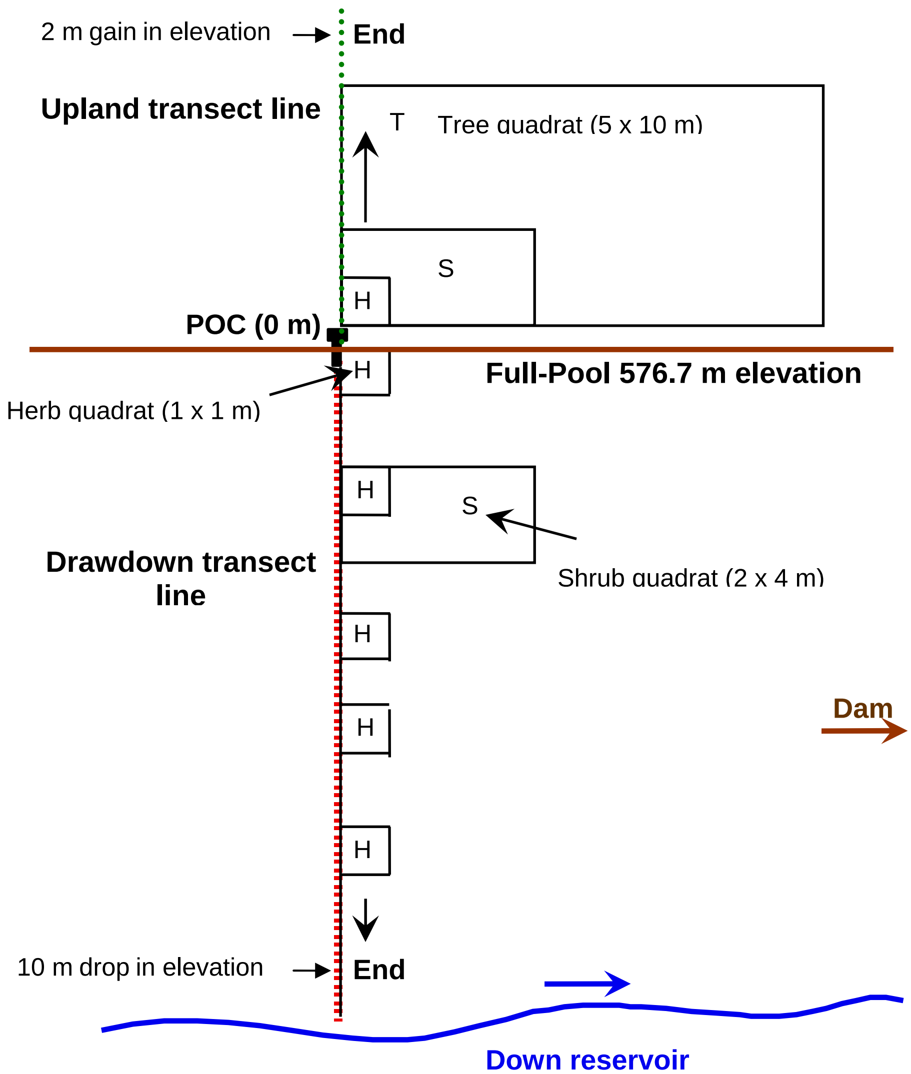


Figure 4: **An illustration of the belt-transects with sampling quadrats used along the reservoir and upland sampling above full-pool. "Down reservoir" refers to the direction of water flow.**

Table 1: Treatments relative to transect- versus quadrat-based data.

Investigation	Consideration or question	Study unit
Longitudinal pattern	Are there differences in characteristics along a river or reservoir corridor, or across rivers or river segments?	Transects – values from multiple quadrats are typically averaged or summed by transect. Summation provides integration over distance, which varies due to the different slopes and hence, transect lengths.
Transverse pattern	Are there differences along the elevational profile?	Quadrats or grouped quadrats – values from individual quadrats are considered or quadrat values are averaged or summed within elevation ranges. In addition, factor analysis considers effects of river, segment, or transect, and possible interactions between these and elevation. This factor analysis investigates differentiation in the transverse patterns along the longitudinal corridor.
Temporal change	Are there differences over time, and especially across years?	Transects, quadrats and grouped quadrats - for characteristics with strong longitudinal patterns, transect-based data are often most useful. Each quadrat also provides a prospective study unit for repetitive comparison. Quadrats from particular transects with common characteristics such as elevation, substrate and/or slope are also often combined.
Plant community analyses	What plant species are associated in particular communities, and what environmental factors influence these distributions and associations?	Transects and quadrats - ordination often considers quadrat data but those data can also be aggregated by transect, or for cover classes or community types based on air photo interpretation. Ordination often provides a useful tool to visual patterns and consequently multiple ordination approaches may be undertaken.
Hydrogeomorphic requirements	What are the water and substrate requirements for the establishment and survival of particular plant species?	Quadrats or grouped quadrats – these analyses benefit from the consideration of small plots that have specific conditions relative to elevation, substrate and other environmental factors.

2.4 Field Sampling of Vegetation Communities

The field monitoring of the reservoir drawdown zone and upland zone took place between June 18 and June 22, 2012. The 2012 monitoring crew members were the same senior riparian specialist, intermediate biologist, and senior technician as in 2009 with a different technician. The sampling occurred between the elevations of 576.7 m and 566.7 m for the reservoir drawdown zone and 576.7 m and 578.7 m for the upland zone. Established POCs were located and transect lines running down from full-pool (drawdown zone) and running upland were setup using tape measures and bearings, repeating the same process used in Polzin et al. (2010).

Tasks completed by the four/two person field crews included:

- new transect surveys;
- the surveys of the extensions of shorter transect lines from 2009;
- surface substrate texture (class size) sampling along the complete length of the transect lines by area with start and end points where change occurred recorded at the corresponding metre mark;
- substrate texture was divided into the following five class sizes according to the Field Manual for Describing Terrestrial Ecosystems (Luttmerding et al. 1998):
    - sand (0.062-2.00 mm);
    - silt (0.002-0.062 mm);
    - gravel (2-64 mm);
    - cobble (64-256 mm); and
    - boulders (>256 mm).
- photographs were taken at the same photo monitoring points set up in 2009;
- Sampling of vegetation species along the drawdown and upland sampling zone with the use of three sizes of quadrats mainly 'Herb' size (1 m x 1 m) used in drawdown zone and all three sizes used in the upland zone; and
- POC and endpoints were also recorded with the Trimble GPS.

The Daubenmire (1959) per cent cover sampling method was used for quadrat sampling (1 m^2, 8 m^2 and 50 m^2). Per cent cover of each plant species was recorded using per cent cover codes (Table 2) with an additional bracket added for trace cover (less than 1 per cent), similar to 2009. Codes were recorded in the field and the mid-point was the data entry amount. Vigour was recorded using codes as per Luttmerding et al. (1998), plant heights were measured in centimetres, and utilization of vegetation by wildlife was noted using the utilization ratings code indicated in Table 2.

Table 2: Per cent cover codes, utilization ratings, and vigour codes with description of the codes.

Vegetation Per Cent Cover Codes			Utilization Ratings			Coding for Vigour	
	Per cent Coverage		*Code*	*% Utilization*	*Description*	*Code*	*Description*
Code	*Range*	*Mid-point*	0	0	Nil	0	Dead
1	< 1	0.1	1	1-5	Slight	1	Poor
2	>1 - 5	2.5	2	16-36	Light	2	Fair
3	>5 - 25	15	3	36-65	Moderate	3	Good
4	>25 - 50	37.5	4	66-80	Heavy	4	Excellent
5	>50 - 75	62.5	5	>80	Extreme		
6	>75 - 95	85					
7	>95 - 100	97.5					

2.5 Vegetation Mapping

Vegetation mapping utilized the baseline data parameters and TIN created in 2009. Using the polygons delineated in 2009, any changes in size, position, or composition of plant communities were updated to reflect 2012 plant communities. The vegetation type (herbaceous, shrub, tree, bare) and community (community composition by dominant cover) codes established in 2009 were used in the 2012 analysis with secondary or tertiary cover changed when required (Table 3). The dominant species (highest per cent cover regardless if it was vegetation, bare ground, wood, etc) was used to distinguish between communities within a vegetation type. The original codes were utilized; however, codes H5, H7, H8 and H12 did not occur in 2012 and three new communities with species that were second and third for dominance in 2009 now dominated these communities. The additional communities were:

- H13 – *Cinna latifolia*;
- H14 – *Erysimum cheiranthoides*; and
- H15 – *Cerastium vulgatum*.

Bare ground was given a vegetation type code (Bare) and broken into two communities, Bare one (B1) was bare ground with dominant cover by wood, watercourse, etc., and Bare two (B2) was bare ground with trace amounts of vegetation with species listed in dominant 2nd and/or 3rd (Table 3). This was consistent with 2009 methods. An example of the GIS attribute table used to map the communities is provided in Table 4. The dominant species are listed using the seven letter code, first four letters of genus and first three letters of scientific species name. A complete list of common and scientific names and codes are included in Appendix 1.

The vegetation type and communities polygons from 2009 were layered over 2012 orthophotos and codes utilizing an ArcGIS geodatabase. Polygons were changed to record new size and/or any changes in dominant species noted on the ortho-rectified photos. The major attributes included: plant community (vegetation type); communities dominant species one, two, and three; polygon area; site area; site aspect; transect line location (UTM coordinates); and transect line aspect (recorded as magnetic north bearings). The complete list of fields is located in the meta-data imbedded in the GIS files. This was consistent with the methods used in 2009 (Polzin et al. 2010).

Vegetation type and community area, vegetation per cent cover, and species richness by elevation were graphed into one metre increments utilizing the drawdown zone elevations. They were labelled with the start elevation from full-pool down to 10 m below full pool. This facilitated the visualization of the elevation relative to reservoir fill levels. Elevation brackets were:

- 576.7 m = 576.7 – 575.7 m;
- 575.7 m = 575.7 – 574.7 m;
- 574.7 m = 574.7 – 573.7 m;
- 573.7 m = 573.7 – 572.7 m;
- 572.7 m = 572.7 – 571.7 m;
- 571.7 m = 571.7 – 570.7 m;
- 570.7 m = 570.7 – 569.7 m;
- 569.7 m = 569.7 – 568.7 m;
- 568.7 m = 568.7 – 567.7 m; and
- 567.7 m = 567.7 – 566.7 m.

Table 3: Vegetation type and community codes used for air photo mapping and the main dominant species associated with the code.

Vegetation Type	Code	Community
Herbaceous (H)	H1	*Equisetum arvense* (Equi_arv.) (1)
	H2	*Carex utriculata* (Care_utr) (2)
	H3	*Polygonum lapathifolium* (Poly_lap) (3)
	H4	Grass (any species without a code) (4)
	H5	*Collomia linearis* (Coll_lin) (5)
	H6	*Scirpus microcarpus* (Scir_mic) (6)
	H7	*Chenopodium album* (Chen_alb) (7)
	H8	*Centaurea maculosa* (Cent_mac) (8)
	H9	*Dryas drummondii (*Drya_dru) (9)
	H10	*Oenothera villosa* (Oeno_vil) (10)
	H11	*Mimulus guttatus* (Mimu_gut) (11)
	H12	*Populus trichocarpa* (Popu_tri) (<50cm tall) (12)
	H13	*Cinna latifolia* (Cinn_lat) (13)
	H14	*Erysimum cheiranthoides* (Erys_che) (14)
	H15	*Cerastium vulgatum* (Cera_vul) (15)
Shrubs (SH)	SH1	*P. trichocarpa* (>50 cm <200 cm tall) (1)
	SH2	Salix sp. – *Salix scouleriana* (2)
	SH3	All other top dominant species (3)
Trees (TR)	TR1	*P. trichocarpa* (>200 cm) and shrubs (1)
Bare (B)	B1	Bare ground – type listed under Dom1, 2, &/or 3 by abundance (wood – watercourse – bare ground) (1)
	B2	Bare ground with trace vegetation – dominant trace species listed 2nd and 3rd (2)

Table 4: An example of the attribute table in GIS showing the vegetation type and community code, with the dominant species within the community for sites.

Site	Code	Dominant Species 1	Dominant Species 2	Dominant Species 3
1	H8	Cera_vul	Poly_lap	
2	H5	Cinn_lat	Oeno_vil	
4	H1	Equi_arv	Medi_lup	
5	H6	Scir_mic	Care_utr	Equi_arv
7	H2	Care_utr	Popu_tri	
9	H3	Poly_lap	Care_utr	
10	B1	Wood	Bare ground	
12	B2	Bare ground	Erys_che	Poly_lap
13	SH2	Sali_sco	Corn_sto	Alnu_cri

***** Note vegetation type codes are in Table 3 and species codes are in Appendix 1.

Analysis using the summaries for areas (ha) for each vegetation type (herb, shrub, tree, and bare) and each community from the mapping data was completed. The summaries for analysis were organized by two factors, by individual sites and total of the 13 sites combined. Data summaries for the drawdown zone from vegetation mapping included:

1) Areas (ha) for each vegetation type and each community that occurred at each site;
2) Areas (ha) for each vegetation type and each community that occurred for the reservoir study sites; and
3) Total area (ha) of all vegetation at each site.

A summary of the Duncan Reservoir elevation analysis was completed for the 2011 growing season to determine "high" potential for enhancement sites as identified in the TOR (BC Hydro 2009). The 2011 growing season was selected as it was the last inundation cycle the vegetation sampled in 2012 experienced. The 2011 Alt S73 operating regime influenced the vegetation patterns from 2009 through 2011 and represents the variation from 2009 results. The 2009 data summaries reflect 2008 operating regime impacts since the vegetation mapping was completed before initial inundation from the 2009 regime. As a result, baseline data is not from pre-Alt S73 rather it is from after the first year of initiation. A qualifying statement explaining this was included in the Polzin et al. (2010) report.

Summary analysis was also completed for community (each community total area (ha)) distribution by reservoir elevation with elevation grouped into one metre brackets as explained above. Total vegetated area (ha) by each elevation bracket was included in the summary and graphed by elevation and inundation time (week of inundation level). This allowed for comparison of communities and total vegetated area by reservoir elevation.

2.6 Ground Level Photo-Monitoring Points

The photo-monitoring methods used in 2009 (Polzin et al. 2010) were followed for the new transect lines and lines that were extended. The photo-monitoring points set-up on transect lines established in 2009 had repeat photography in 2012. These consisted of a photo of the quadrat frame (1 m^2) at a specified metre mark (distance from the POC) where a two metre change in elevation occurred. Four photos were taken from a standing position at the end of the quadrat frame: 1) looking up the transect line, 2) looking down the transect line, 3) looking up reservoir (roughly north, away from dam) and 4) looking down reservoir (roughly south, towards dam), with a total of five pictures at each elevation interval. Photo-points from the 12 m elevation mark were not repeated in 2012. This procedure documents any visual change in vegetation. Only three photos per site from 2009 were compared with 2012 in this report, but all photos for 2012 are on contact sheets in Appendix 6.

Upland photo monitoring was not structured the same as the reservoir. Due to the dense canopy cover and shrub layers photo's were taken to show the vegetation as best as possible. The recorded position and direction of photos will be repeated in 2015 monitoring year. Comparison of the photos will also be presented in 2015. The 2012 photos are included in the photo documentation and contact sheets in Appendix 5 and Appendix 6.

2.7 Data Analysis

The data analysis was limited to comparison to 2009 results. Factor analysis for multivariate analysis of variance was not required for this intermediate report. Summary analysis concentrated on the three main factors identified from full factor analysis in 2009 (Polzin et al. 2010). These were elevation, site, and substrate texture index. Elevation analysis was the main focus as vegetation elevation is directly linked to the reservoir level.

2.7.1 Summary and Comparative Data Analysis

Statistical analysis was conducted using SPSS 12.0 (SPSS Inc., Chicago) and all tests were run at an alpha of 0.05. Descriptive statistics were used utilizing Explore in SPSS. At the reservoir level all site data combined vegetation cover measured as per cent cover and species richness (number of species) were compared to 2009 data using ANOVA Paired-Samples T-Tests. Comparison testing involved comparing quadrat locations in 2012 to the same quadrat location in 2009. For example, only quadrat at 10 m on transect line #700 was compared with the quadrat at 10 m on transect line #700 in 2009, Herb (1 m^2) quadrats were compared to Herb, Shrub (8 m^2) quadrats with shrub and Tree (50 m^2) quadrats with the same size quadrats. When total vegetation cover for a transect line was required for analysis, Shrub and Tree quadrate cover was transformed to cover per square metre. Species richness count data was transformed using square root transformation.

Comparison between years had a reduced data size because three new transect lines were added that could not be directly compared and extensions to transect lines in 2012 had no comparison to 2009 data.

Analysis of 2012 data used the complete data set for comparison between elevation, site, and substrate texture index. A One-Sample T-Test was used for comparison between perennial heights with the mean height target value used being the mean height at the lowest elevation they occurred at and between annual heights.

Comparison of cover and richness between years (reduced data set to match sampling points) versus a factor (elevation, site, substrate texture index) used one-way ANOVA. Comparison of cover and richness for 2012 data versus a factor also utilized one-way ANOVA with the complete data set. Post Hoc Tests utilized Scheffé's test for multiple comparison for within group comparisons.

As noted earlier, of the seven independent factors identified in 2009 the top three factors were assessed and compared between years in 2012 (Table 5).

Table 5: Independent factors and dependent variables identified for use in analyses of variance.

Independent Factors	Dependent Variables
Site	% vegetation cover, all species and species richness
Substrate texture index	
Elevation	
Slope	% cover by individual species or groups of species and species richness
Aspect	
Distance from POC	
Side (east or west side of reservoir)	Species richness

2.7.2 Physical factors

Physical factors were not investigated in 2012. The 2009 investigation into the physical factors identified three primary factors, elevation, site, and substrate texture. These were used for the summary analysis for 2012 and the comparison testing to 2009 data. For complete methods used for physical factor investigation see Polzin et al. (2010).

Elevation was developed into two elevation measures. The elevational positions were grouped within 1 m increments, providing an ordinal measure. This approach provided a more complete factorial matrix, which enabled the detection of interactions between elevation and other physical factors. The grouped elevations were as follows:

- -1 m = 0 (full-pool) to 1 m (below full-pool therefore -1 m)
- -2 m = -1 – -2 m;
- -3 m = -2 – -3 m;
- -4 m = -3 – -4 m;
- -5 m = -4 – -5 m;
- -6 m = -5 – -6 m;
- -7 m = -6 – -7 m;
- -8 m = -7 – -8 m;
- -9 m = -8 – -9 m; and
- -10m = -9 – -10 m.

This resulted in each elevation band represented by the end elevation when represented in a graph for 1 to 10 m change in elevation.

Elevation was estimated for each quadrat based on linear interpolation between the survey points that were measured at periodic intervals along the transects and any position of substantial profile change (a depression or deposition greater than 30 cm). The interpolated elevation for each quadrat with precision to 0.01 m (= cm) was considered as a continuous scale measure. This information was used to create the grouped elevations above. Elevations surveyed in 2009 were used in 2012 data interpolations; only new transect lines and extensions to existing lines were surveyed in 2012

Site was the term for each of the 12 spatial locations and study areas along the reservoir, at which two to four transects were implemented. This physical factor utilized all of the quadrats from two or more transects for each particular site. Twelve sites were investigated, but we retained previous numbering and thus included Sites 1 through 7, and 9 through 13, since the pre-assigned Site 8 was excluded from field sampling. Site 8 was excluded due to an error in the TOR (2009) for the site coordinates, which resulted in the upland outside of the reservoir edge being captured by aerial photography. For factor analysis, site was treated as a nominal measure, since site numbering would not reflect a systemic, incremental sequence relative to the physical conditions and influences on reservoir vegetation.

Substrate Texture Index (STI) used for substrate factor analysis was calculated for area based on field estimated per cent cover of silt, sand, gravel, cobble, and boulder along transects (referenced to metre distance from POC). These sediments were assigned scores of 1 to 5, respectively, and the STI was calculated as the sum of the proportion cover (decimal value) x score, for the five sediment classes. The STI value was rounded to 0.1 and was treated as a scale measure, with 41 possible values (1.0 to 5.0). This was consistent with the methods used in 2009.

2.7.3 Species Biodiversity

Computation of the Shannon-Wiener (H') or "Shannon" indices for the sites was completed to provide an integrative measure of biodiversity. Midpoints of per cent cover classes were used as the measure of abundance. While some diversity measures require count data, the Shannon Index can be used with any form of data (MVSP, v.3.1, Kovach Computing). For diversity, the statistical software was used to calculate the Shannon-Wiener Index (H'), as follows:

$$H' = -\sum_{i=1}^{s} p_i \log_e p_i$$

where: p_i = proportion of the i^{th} species
s = the number of species in the community

This index increases with increasing species richness (number of species) and with increasing species evenness, the relative representation across the species.

3.0 RESULTS

3.1 Vegetation Mapping

Shrub and tree species were assessed at three categories based on height. Table 6 shows all species noted and the vegetation type they were recorded in but only the dominant species are listed for communities for each vegetation type. The three vegetation types for woody vegetation are Herb <0.5 m, Shrub >0.5 m to <2.0 m, and Tree >2.0 m tall. The data summaries of the mapped vegetation communities using the ortho-rectified aerial photographs are listed in Table 7 (polygon boundaries from air photo interpretation with ground-truthing and field data to help refine them; see Section 2.5 Vegetation Mapping).

Site 2 was the only site with a stand of young black cottonwood trees (*Populus trichocarpa*) within the drawdown zone (see Appendix 1 for scientific and common names, as well as codes for each species). The 'Tree Community' expanded by 50 times the area covered in 2009 (0.0032 ha) to cover an area of 0.16 ha (Table 7). The zone in which they occurred was strongly influenced by Glacier Creek. Site 1 had a narrow band right at full-pool where trees were recorded but were mainly from overhanging branches for tree growing just above full-pool elevation.

The vegetation type 'Shrub' also had an increase in area covered compared to 2009 (Table 7). There were five sites with no shrubs in 2009 (Sites 3, 6, 11, 12, and 14) while three sites in 2012 had no shrubs (Sites 6, 12, 14). Shrubs increased in area from 1.52 ha (2009) to 2.76 ha in 2012.

The vegetation type 'Herbaceous' experienced a decrease in cover compared to 2009 from 85.4 ha to 75.4 ha in 2012 (Table 7). There were four communities that changed the dominant species from 2009 while the area remained vegetated. The vegetation type community 'H5' occurred at Site 1 in 2009. There were no polygons with *Collomia linearis* as the dominant species in 2012. Some areas had *C. linearis* move to third dominant species while others had the second dominant become the dominant (*Equisetum arvense*) species and *C. linearis* no longer a dominant species or absent from the dominant species list. The vegetation type community 'H7' – *Chenopodium album* was the second community that was no longer present in 2012. It was prominent at Site 4 and a small area at Site 11 in 2009. The second and third dominant species for this vegetation type community in 2009 became dominant species in 2012 with *C. album* occurring as third dominant species at Site 9 covering 0.5 per cent of site. The third community was 'H8' – *Centaurea maculosa*, occurring at Site 7 in 2009. The second dominant species *Cinna latifolia* became the dominant species in 2012 at this site and *C. maculosa* was not one of the top three dominant species in 2012 at Site 7. The fourth community 'H12' – *Populus trichocarpa* occurred at Site 7 in 2009. In 2012 *P. trichocarpa* was second dominant species in H2 and H13.

Table 6: Shrub and tree species recorded at the sampling sites and the plant communities they were sampled in.

Common Name	Life-form Group	Plant Community		
		Herb	Shrub	Tree
Douglas maple	Shrub		✓	
Saskatoon	Shrub		✓	
Oregon-grape	Shrub	✓		
Red-osier dogwood	Shrub	✓	✓	
Black twinberry	Shrub		✓	
Black gooseberry	Shrub	✓		
Thimbleberry	Shrub		✓	
Bebb's willow	Shrub	✓	✓	
Pacific willow	Shrub		✓	
Scouler's willow	Shrub	✓	✓	
Buffalo berry	Shrub		✓	
Black huckleberry	Shrub	✓		
Water birch	Tree		✓	
Paper birch	Tree		✓	✓
Lodgepole pine	Tree			✓
Trembling aspen	Tree	✓	✓	
Black cottonwood	Tree	✓	✓	✓
Interior Douglas fir	Tree	✓	✓	
Western redcedar	Tree	✓	✓	
Western hemlock	Tree	✓		

Vegetation type 'Bare' was split into two categories, one that was bare ground 'B1' and 'B2', bare ground with trace vegetation. B2 areas had patches of higher vegetation cover but the average was very low per cent cover per polygon area. There was a slight increase in B1 from 15.56 ha in 2009 to 16.32 ha in 2012 a 4.6 per cent increase in bare ground (Table 7). There was an increase in B2 area from 0.11 ha (at Site 3) in 2009 to 7.91 ha in 2012 for Sites 1, 2, 3, 4, 5, 6, 10, 11, and 12 combined. Total vegetated area excluding B1 and B2 results in 78.4 ha in 2012 and 86.9 ha in 2009. Because B2 has some vegetation it was included in total vegetation for both years resulting in similar totals between years (86.3 ha in 2012 and 87.0 ha in 2009). The total area increase in bare ground in 2012 was 0.76 ha, a 0.74 per cent increase in bare ground since 2009.

Table 7: **Data summaries for areas (ha) of each vegetation type for the sites and total area (ha) for each community by site, as well as the grand totals for 2012. Last column is 2009 grand totals for each vegetation type and community.**

Vegetation Type	Community *(#1 dominant species)	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Grand Total	Grand Total 2009
Bare (ha)	B1 (bare)		3.16		0.25	0.78	1.92	0.31	2.44	6.32	0.50	0.64			16.32	15.56
	B2 (bare, trace vegetation)	0.05	0.33	0.60	2.39	0.12	0.19	0.00		2.60	0.66	0.97			7.91	0.11
Bare Total		**0.05**	**3.49**	**0.60**	**2.64**	**0.90**	**2.11**	**0.31**	**2.44**	**8.92**	**1.16**	**1.61**			**24.23**	**15.67**
Shrub (ha)	SH1 (shrub 1, cottonwood <2 m tall)	0.05	1.13			0.20		0.02		0.03					1.43	0.35
	SH2 (shrub 2, willow)								0.03				0.71		0.74	0.64
	SH3 **(shrub 3, other species)			0.02	0.50						0.03		0.04		0.59	0.53
Shrub Total		**0.05**	**1.13**	**0.02**	**0.50**	**0.20**		**0.02**	**0.03**	**0.03**	**0.03**		**0.75**		**2.76**	**1.52**
Tree (ha)	TR1 (tree, cottonwood > 2 m tall)		0.16												0.16	0.0032
Tree Total			**0.16**												**0.16**	**0.0032**
Herbaceous	H1 (herb 1, common horsetail)	0.29		0.33	1.06	0.31		0.05	0.25	0.02	0.08	0.07	5.38	19.79	27.64	28.58
(ha)	H2 (herb 2, beaked sedge)		0.51					0.04	0.36	0.29	0.00	0.02			1.23	1.40
	H3 (herb 3, green smartweed)				3.46	1.28			2.42	2.09	0.05				9.30	11.92
	H4 (herb 4, grasses)					0.72									0.72	30.70
	H5 (herb 5, narrow-leaved collomia)															1.85
	H6 (herb 6, small-flowered bulrush)					0.93			0.03						0.96	0.15
	H7 (herb 7, lamb's-quarters)															7.09
	H8 (herb 8, spotted knapweed)															0.07
	H9 (herb 9, yellow mountain avens)									0.05					0.05	0.06
	H10 (herb 10, evening primrose)		0.06												0.06	0.03
	H11 (herb 11, yellow monkey-flower)					3.14									3.14	3.52
	H12 (herb 12, cottonwood < 0.5 m tall)															0.03
	H13 (herb 13, nodding wood-reed)	1.13	3.85					0.08		0.59			0.67		6.32	
	H14 (herb 14, wormseed mustard)	0.27										0.01			0.28	
	H15 (herb 15, mouse-eared chickweed)	4.22	14.83	0.07	6.30	0.24						0.09			25.75	
Herbaceous Total (ha)		**5.91**	**19.24**	**0.40**	**10.82**	**6.61**		**0.18**	**3.05**	**3.06**	**0.14**	**0.20**	**6.05**	**19.79**	**75.45**	**85.40**
Grand Total (= site area)		***6.01***	***24.02***	***1.03***	***13.95***	***7.72***	***2.11***	***0.50***	***5.52***	***12.01***	***1.33***	***1.80***	***6.80***	***19.79***	***102.60***	***102.59***

*Species listed for each community number one dominant species.
**SH3 = dominant shrub species other than cottonwood or willow.

Table 8: The dominant species associated with the vegetation type and community for each site and the per cent cover.

		Community			
Site #	**Code**	**Dominant 1**	**Dominant 2**	**Dominant 3**	**Cover of Site (%)**
1	H13	Cinn_lat	Trif.arv	Coll.lin	18.8
	H14	Erys.che	Poly_lap		4.8
	H15	Cera.vul	Poly_lap		6.7
	H15	Cera.vul	Poly_lap	Erys.che	63.5
	SH1	Popu_tri			0.8
	B2	Rip rap	Rume.cri		0.78
2	H2	Care_utr	Equi_arv	Cinn_lat	2.1
	H10	Oeno_vil			0.2
	H13	Cinn_lat	Oeno_vil		0.5
	H13	Cinn_lat			15.6
	H15	Cera_vul	Poly_lap		45.2
	H15	Cera_vul	Erys.che		16.5
	SH1	Popu_tri	Popu_tre	Amel_aln	4.7
	TR1	Popu_tri			0.7
	B1	sand			13.1
	B2	wood	Equi_arv	Cinn_lat	1.4
3	H1	Equi_arv	Cinn_lat		32.2
	H15	Cera.vul	Aira_car		7.0
	SH3	Thuj_pli	Shep_can	Acer_gla	2.4
	B2	Bare ground	Equi_arv	Cinn_lat	41.0
	B2	Bare ground	Cinn_lat		6.1
	B2	Bare ground	Cera_vul	Poly_lap	7.6
	B2	Bare ground	Cinn_lat	Aira_car	3.8
4	H1	Equi_arv			0.6
	H1	Equi_arv	Medi_lup		6.3
	H3	Poly_lap	Aira_car		8.0
	H3	Poly_lap	Erys_che	Coll_lin	8.2
	H15	Cera_vul	Erys.che	Poly_lap	45.1
	SH3	Popu_tre	Thuj_pli		3.6
	B1	rock			1.6
	B2	rock	Cinn_lat	Aira_car	2.9
5	H1	Equi_arv	Medi_lup		4.0
	H3	Poly_lap	Aira_car		16.6
	H4	Aira_car	Cinn_lat		9.3
	H6	Scir_mic	Equi_arv		2.3
	H6	Scir_mic	Care_utr	Equi_arv	9.7
	H11	Mimu_gut	Poly_lap		40.7
	H15	Cera_vul	Poly_lap		3.1
	SH1	Popu_tri	Shep_can	Amel_aln	2.6
	B1	bare ground			5.1
	B1	water			5.0
	B2	wood	Equi_arv	Cinn_lat	1.6
6	B1	bare ground			91.1
	B2	bare ground	Equi_arv		5.0
	B2	bare ground	Poly_lap		3.9

		Community			
Site #	**Code**	**Dominant 1**	**Dominant 2**	**Dominant 3**	**Cover of Site (%)**
7	H1	Equi_arv			10.8
	H2	Care_utr	Popu_tri		8.5
	H13	Cinn_lat	Popu_tri		15.9
	SH1	Popu_tri			3.5
	B1	bare ground			61.2
9	H1	Equi_arv			4.5
	H2	Care_utr	Equi_arv		6.5
	H3	Poly_lap	Care_utr		9.9
	H3	bare ground	Poly_lap	Chen_alb	0.5
	H3	Poly_lap			33.4
	H6	Scir_mic	Equi_arv		0.5
	SH2	Sali_luc			0.2
	SH2	Sali_luc	Sali_beb		0.2
	B1	bare ground	water course		4.7
	B1	bare ground			35.8
	B1	wood			3.8
10	H1	Equi_arv			0.2
	H2	Care_utr	Equi_arv		2.4
	H3	Poly_lap			9.8
	H3	Poly_lap	Erys_che		7.4
	H3	bare ground	Poly_lap		0.2
	H9	Drya_dru	Oeno_vil	Cent_mac	0.4
	H13	Cinn_lat	Care_utr	Cala_can	0.2
	H13	Cinn_lat	Equi_arv		4.8
	SH1	Popu_tri	Thuj_pli	Pseu_men	0.2
	SH1	Popu_tri	Sali_sco	Rubu_par	0.1
	B1	wood	bare ground		2.7
	B1	bare ground			1.8
11	H1	Equi_arv	Cala_can		5.5
	H1	Equi_arv			0.8
	H2	Care_utr	Cala_can		0.4
	H3	Poly_lap			3.6
	SH3	Corn_sto	wood		2.2
	B1	cobble	gravel		22.8
	B1	bare ground	water course		13.6
	B1	wood			1.2
	B2	bare ground	Poly_lap	Cera_vul	8.6
	B2	bare ground	Equi_arv	Cala_can	14.1
	B2	bare ground	Poly_lap		27.3
12	H1	Equi_arv			4.1
	H2	Care_utr	Equi_arv	Poly_lap	1.3
	H14	Erys_che	Equi_arv		0.6
	H15	Cera_vul	Poly_lap		4.9
	B1	wood			5.7
	B1	water course	bare ground		29.7
	B2	bare ground	Poly_lap	Care_utr	9.1
	B2	bare ground	Erys_che	Poly_lap	44.6

		Community			
Site #	Code	Dominant 1	Dominant 2	Dominant 3	Cover of Site (%)
13	H1	wood	Equi_arv	Care_utr	4.3
	H1	Equi_arv	Care_utr	Cinn_lat	44.9
	H1	Equi_arv	Care_utr		2.3
	H1	bare/water/wood	Equi_arv	Care_utr	12.9
	H1	Equi_arv	Cinn_lat		11.8
	H1	bare ground	Equi_arv	Poa_pra	2.9
	H13	Cinn_lat	*Sali_sco	Equi_arv	6.5
	H13	bare/wood	Cinn_lat	Care_utr	3.4
	SH2	Sali_sco	Corn_sto	Alnu_cri	6.2
	SH2	Sali_sco	Popu_tri		2.2
	SH2	Sali_sco	Alnu_cri	Corn_sto	2.2
	SH3	Tsug_het	Thuj_pli	Opla_hor	0.5
14	H1	Equi_arv	Care_utr		100

* Note: Sali_sco is <0.5 m tall in this area.

B1 area changes between 2009 and 2012 were variable by site (Figure 5). Site 10 had an increase in B1 area from 5.76 ha in 2009 to 6.32 ha in 2012. This was mainly due to mechanical disturbance from removal of woody debris. Site 5 had an increase from 0.42 ha in 2009 to 0.78 ha in 2012. Site 4 had a reduction in B1 from 0.58 ha in 2009 to 0.25 ha in 2012. The rest of the sites had slight increases or decreases in B1 area while Sites 1, 3, 13, and 14 remained the same with no B1 occurring.

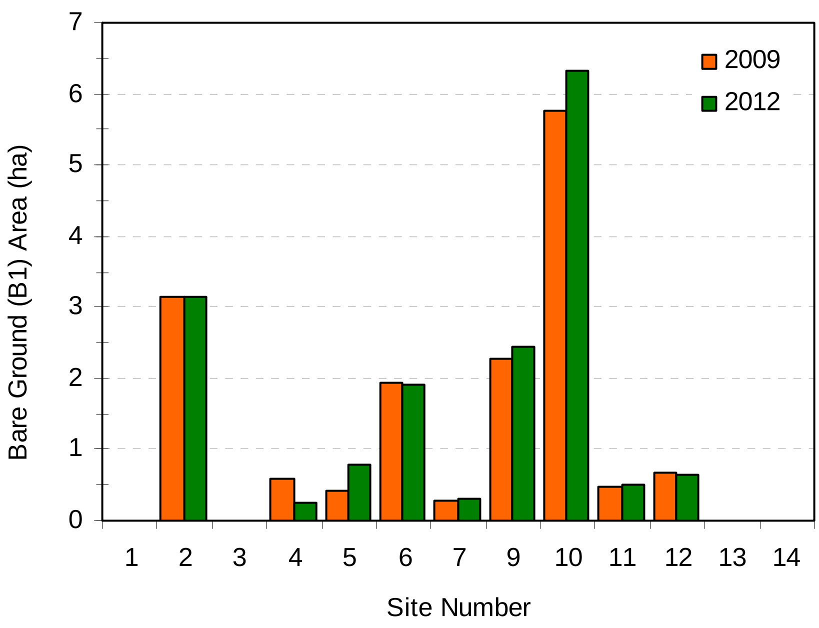


Figure 5: Total area (ha) of Bare 1 for each site for 2009 compared to 2012.

The majority (73.5 per cent) of vegetation cover within the drawdown zone was herbaceous compared to Bare with 23.61 per cent, Shrub with 2.69 per cent and Tree with 0.16 per cent cover. Table 8 shows the per cent cover of area for each site covered by communities delineated on the air photos. Up to three dominant species are listed for each community.

Total area for each vegetation type community was compared with 2009 total area. There was no significant difference between the two years with a $P = 0.999$, $t = 0.001$, and $df = 16$ using a Paired Samples T-Test.

3.1.1 Reservoir Levels 2011

The 2012 assessment used the 2011 reservoir levels as they represent the most recent inundation cycle for the 2012 vegetation. Reservoir fill levels were analysed for the growing season, starting in April 2011 and extending to the end of September 2011. The reservoirs mean weekly levels have been graphed to show the timing and duration of inundation related to the reservoir drawdown zone elevations (Figure 6).

Digital elevation model mapping was used to determine the area (m^2) above the weekly average reservoir elevation for each week in the growing season for the nine “high” enhancement potential sites identified in the TOR (BC Hydro 2009). The reservoir average stage for each week provided the corresponding area (m2) and the percentage of the site area exposed. Determination of the area of the drawdown zone that was exposed for 85 to 100 per cent of the growing season was also completed for each of the nine sites (Table 9).

The water level at the 85^{th} percentile was 575.5 m for 2011 and 574.9 in 2009. The areas for each site exposed for 85 to 100 per cent of the growing season for the high riparian potential for enhancement sites were compared between years. There was a significant decrease in area per site in 2011 compared to 2009 ($P = 0.031$, $t = -2.62$, $df = 8$). There was also a significant decrease in percentage of the site exposed for 85 to 100 per cent of the growing season compared to 2009 ($P = 0.001$, $t = -4.93$, $df = 8$).

The mean weekly reservoir filling levels for the growing season were numbered, with Week 1 starting April 1 and ending at Week 26 (September 30, 2012). Table 9 provides the elevation analysis for ‘high potential for enhancement sites’, showing weeks 9 to 21 with corresponding reservoir mean water level, inundation times, and the percentage of exposed site area (ha) with all data for the high potential for enhancement sites in Appendix 2.

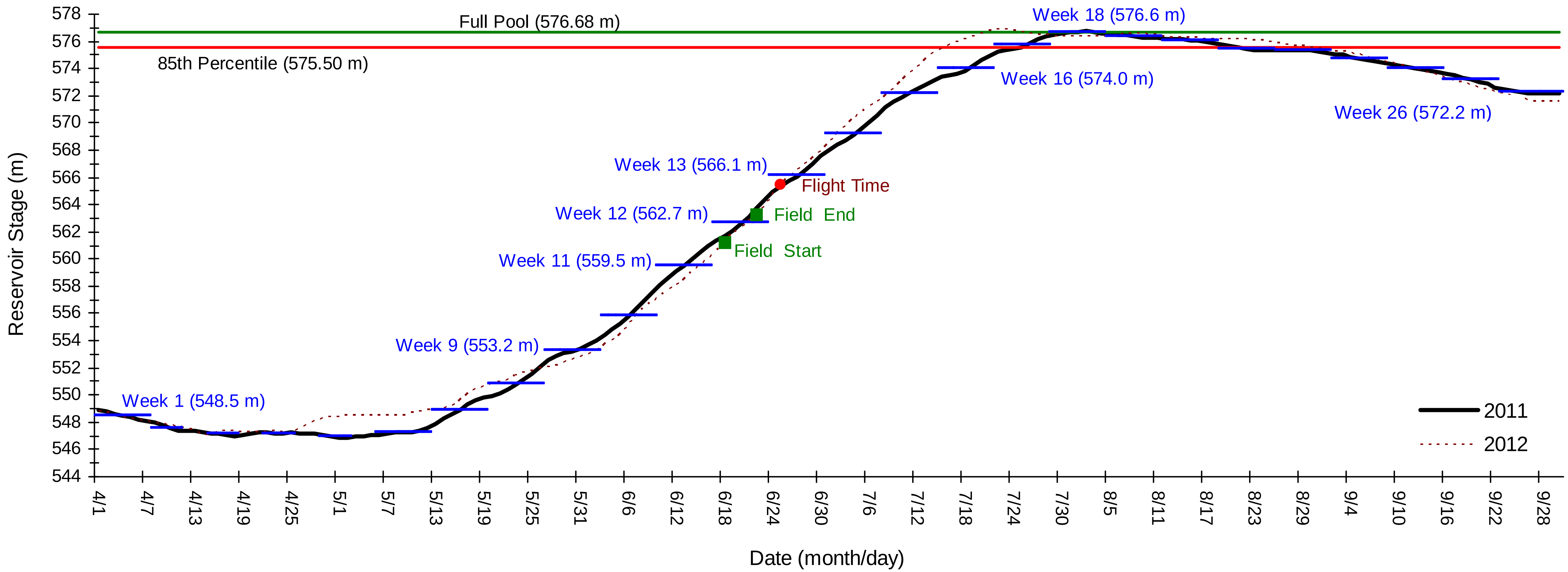


Figure 6: **2011 reservoir stage during the growing season (April to September 29) (solid black line) with the average weekly stage (26 weeks; short blue line (W1 = Week 1)) and the 85th percentile level. Flight times relative to reservoir stage, as well as field data collection times are indicated as red and green dots, respectively and correspond to the 2012 reservoir stage (dashed line). Full-pool, which is upper limit of the reservoir water level and the start of the study area, is shown as a green line.**

Table 9: **Summary of the Duncan Reservoir elevation analysis for the "high" potential for enhancement sites identified in the TOR (BC Hydro 2009) for the 2011 growing season. Week 1 started April 1 and continued until Week 26, which ended September 29. Week number indicates which week the mean water level was recorded, i.e., Week 20 is the 20th week since April 1. Site columns are the percentage of the site area exposed at the mean water level. Inundation time indicates the length of time the 1 m elevation zone was inundated. Realizing that each 1 m zone is a 1 m drop in elevation, the first metre zone has been divided in half– top half and bottom, elevation range. The metre brackets are labelled with the top edge elevation for each bracket (full-pool edge 576.7 m).**

Drawdown Zone Elevation	Week	Mean Water Level		Inundation Time	% of Site 1 area exposed	% of Site 2 area exposed	% of Site 3 area exposed	% of Site 4 area exposed	% of Site 5 area exposed	% of Site 6 area exposed	% of Site 7 area exposed	% of Site 10 area exposed	% of Site 13 area exposed
1 m (576.7 m)	21	575.49		0 days/week for full zone	2	6	4	3	4	7	24	6	6
1 m (576.7 m)	20	576.06	Top half	0 days (0-0.5 m)	1	2	1	2	2	6	16	4	2
			Bottom	3 weeks (0.5-1.0 m)									
1 m (576.7 m)	19	576.36	Top half	12 days (0-0.5 m)	0	1	1	1	2	6	11	2	1
			Bottom	2 weeks (0.5-1.0 m)									
1 m (576.7 m)	18	576.63	Top half	4 days (0-0.5 m)	0	0	0	1	1	5	6	1	0
			Bottom	1 week (0.5-1.0 m)									
2 m (575.7 m)	17	575.71		3 weeks, 3 days	2	4	2	3	4	7	21	5	4
3 m (574.7 m)	16	574.01		6 weeks, 5 days	7	16	12	9	10	11	41	14	27
4 m (573.7 m)	15	572.19		8 weeks, 3 days	14	32	26	18	19	15	56	22	93
5 m (572.7 m)	14	569.19		10 weeks, 1 day	27	53	43	41	50	29	74	40	100
6 m (571.7 m)	13	566.13		** 11 weeks, 5 days	44	71	57	64	71	52	88	75	100
7 m (570.7 m)	12	562.68		** 12 weeks	68	94	72	97	87	86	100	99	100
8 m (569.7 m)	11	559.53		** 12 weeks, 2 days	92	100	92	100	94	100	100	100	100
9 m (568.7 m)	10	555.88		** 12 weeks, 5 days	100	100	100	100	99	100	100	100	100
10 m (567.7 m)	9	553.26		** 13 weeks	100	100	100	100	100	100	100	100	100
85% exposed	17	575.50	July 25	4 weeks	2	6	4	3	4	7	24	6	6
Area (ha) exposed 85 – 100%					0.1	1.4	0.04	0.4	0.3	0.2	0.1	0.7	0.43
Site Area (ha)					6.0	24.0	10.2	14.0	7.7	2.1	0.5	12.0	6.8

Note: Site boundaries were established in 2009 and the bottom boundary of the delineated site is lower than the -10 m (566.7 m) change in elevation.
** Inundation time listed is up to the end of week 26 but sites are still inundated after Week 26 for all elevation brackets with ** at the start of inundation time.

Site 6 was identified as a 'high potential for enhancement' which does not appear to be a good site for enhancement. There was very low vegetation cover in 2009 with the majority of the site and area adjacent to the site was bare ground. None of the vegetated polygon areas increased in size or cover by 2012.

As inundation times decrease vegetation cover increases significantly (P <0.001, t = 5.7, F = 32.8 df = 9). Regression analysis had a R^2 = 0.897 indicating that reservoir level accounts for approximately 90 per cent of the variation in vegetation cover for the reservoir (Figure 7 and Figure 8). Figure 7 shows reservoir filling levels with mean cover levels and Figure 8 shows reservoir drawdown levels with mean vegetation cover.

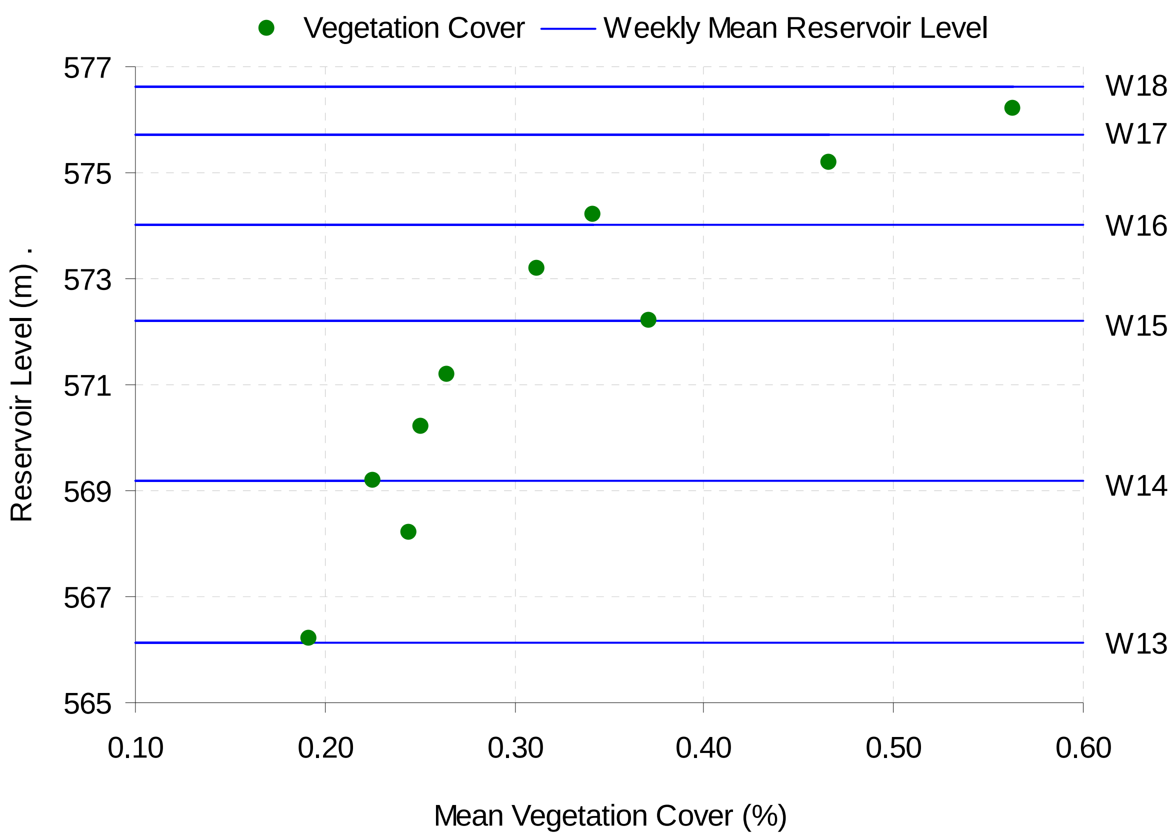


Figure 7: **Mean vegetation cover (grouped into 1 m elevation increments) versus elevation during reservoir filling from July 24 (start of week 13 (W13)) to July 29 (start of week 18 (W18)).**

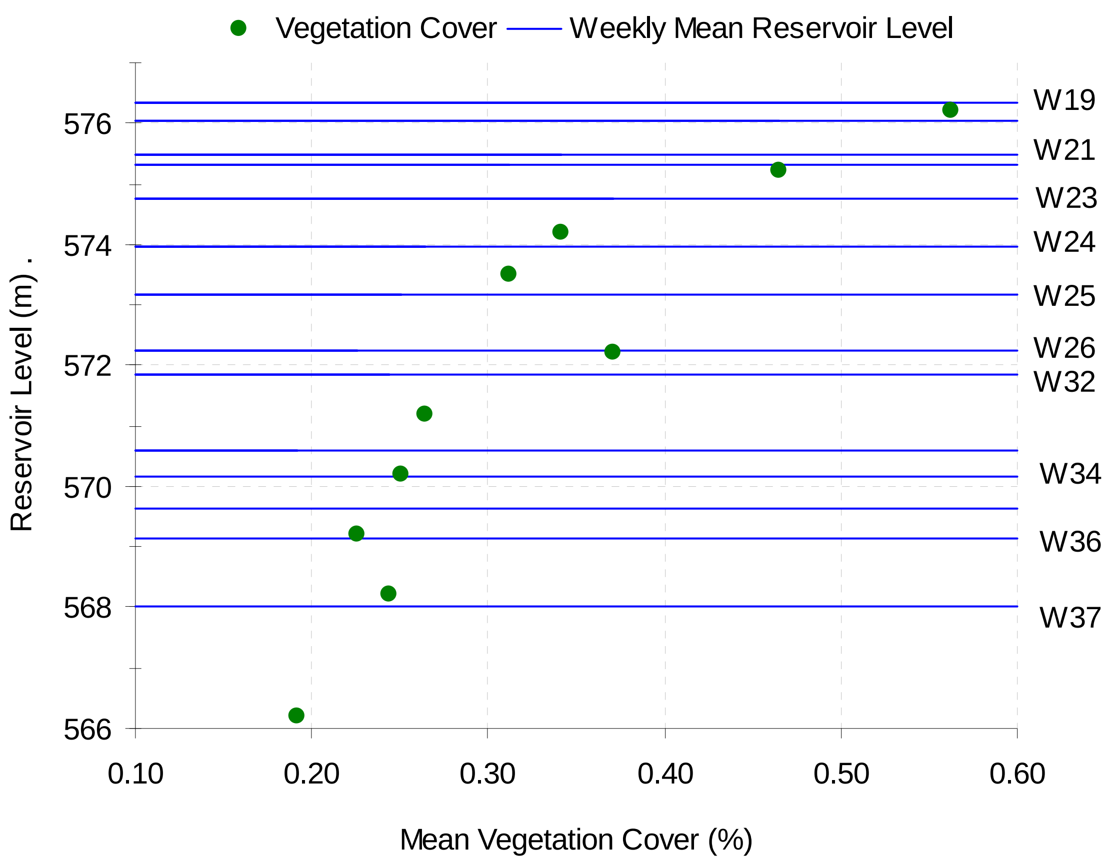
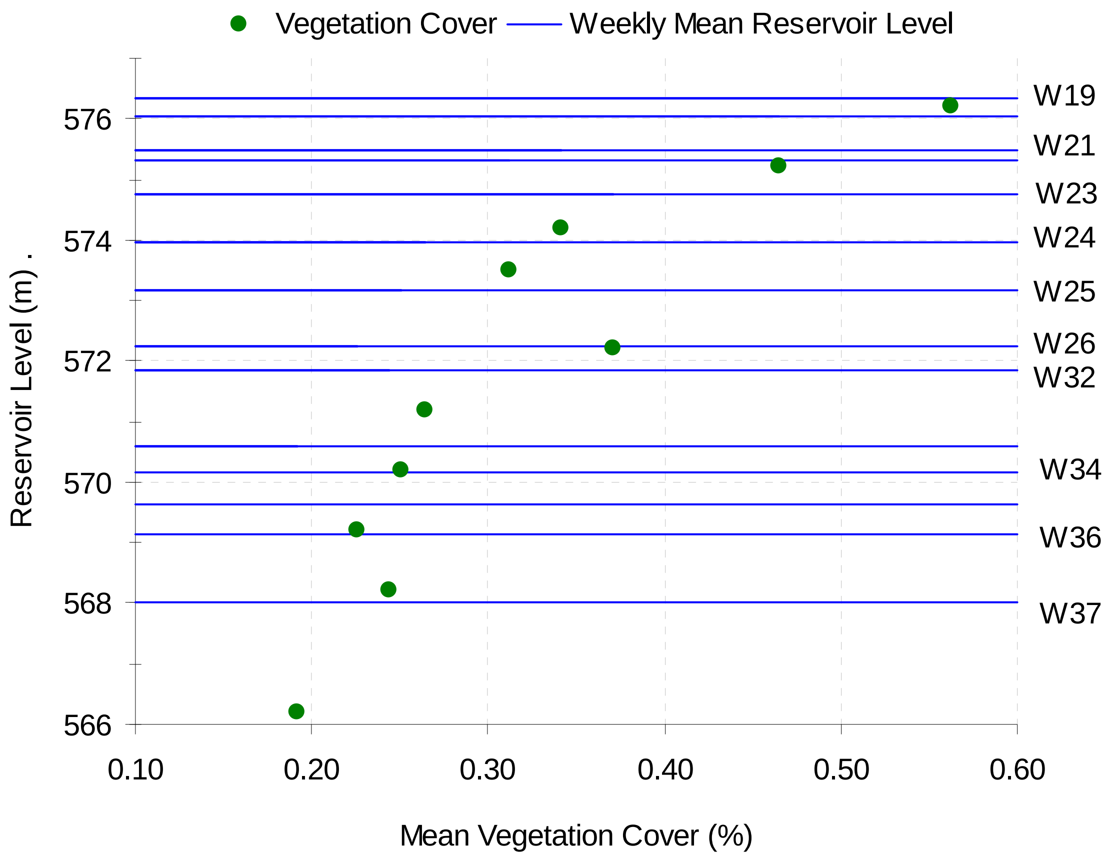


Figure 8: **Mean vegetation cover (grouped into 1 m elevation increments) versus elevation during reservoir drawdown from August 5 (start of week 19 (W19)) to December 9 (start of week 37 (W37)).**

3.1.2 Reservoir Levels 2012

Precipitation patterns in 2012 resulted in flood control measures to help reduce flooding downstream of the Duncan Reservoir. Extreme precipitation levels in June resulted in the reservoir reaching full-pool July 21, one week and four days earlier than in 2011 and 2010, four weeks earlier than in 2009 and two weeks five days earlier than in 2008. The reservoir fill level exceeded full-pool July 22 and stayed above full-pool until July 25 in 2012 Figure 6. Full-pool was exceeded by 0.22 m on July 23, the maximum fill level (576.89 m). Levels returned to full-pool level by July 25 and stayed near full-pool with up to 0.3 m variation in levels until August 13 when levels started to drop from 0.3 m below full-pool to 1.2 m below by August 31, 2012. The effect of the reservoir fill levels on vegetation could be assessed in 2013 but no monitoring is scheduled until 2015. Monitoring in 2015 will not be able to directly detect the effect of 2012 fill levels to changes within the first metre change in elevation from possible affects from 2013, and 2014. Assessment in 2015 could only correlate possible affect from the three years combined if no data from 2013 is available.



3.2 Site Description Summaries

Site descriptions were provided by Polzin et al. (2010).These include site position on the reservoir, as well as aspect, number of transect lines, slope and length of the transect lines. Changes to transect line lengths and additional transect lines added to some sites have been included in Table 10 to update the site description summaries for 2012. Transect lines covering a 12 m change in elevation in 2009 were reduced to 10 m change in 2012 and transect lines not covering the full 10 m change in elevation in 2009 were extended in 2012. Sites 3, 5, and 6 had additional transect lines added so all sites had a minimum of two transect lines. Individual transect profiles for each site are provided in Appendix 3 and are from transect lines surveyed in 2009 with only the additional new transect lines and extensions to existing transect lines surveyed in 2012.

3.3 Ground Level Photo Monitoring Points and Upland Vegetation Summaries

Photo monitoring occurred at every two metre change in elevation along transect lines. Five pictures were taken at each point, resulting in a large volume of photos, which are provided as contact sheets Appendix 6. Comparison photos between 2009 and 2012 at the same photo points are included. A summary table for each site includes 2009 data for comparison indicating differences or similarities between years illustrated with the photo comparisons.

The reservoir sampling summary tables list the six dominant species for the site and the cumulative cover for the site, the percentage it represents at the reservoir level, reservoir six dominant species, cumulative cover at the reservoir level, species richness by vegetation type, and reservoir species richness. Species richness for the site and the reservoir as a whole was split into vegetation types; herb, shrub, and trees (Table 11 to Table 22). Species richness for 2009 is also provided for comparison. A "W" prior to the species code name indicates weedy species (Royer and Dickinson 1999).

Upland summary tables for each site include dominant species, cumulative cover, species richness, and site cover by upland for Tree, Shrub, and Herb plots.

Table 10: Site descriptions, characteristics, and possible influences in the drawdown zone of the Duncan Reservoir in 2012. Grey-shaded cells highlight changes from 2009, with additional transect lines and line extensions.

Site #	Side	Aspect	Camp-ground	Main Road Influence	Creek Influence	Transects		
						Tran. #	Length (m)	2009
1	East	SW	Yes	No	No	1	0-320	377
						700	0-134	30
2	East	NW-W	No	Secondary Rd	No	701	0-304	312
						702	0-388	60
						703	0-360	44
3	East	N-NE	No	No	No	704	0-52	71
						812	0-48	
4	East	NW-W	Yes	No	No	705	0-71	88
		E-SE				706	0-54	54
5	East	SW-W	No	No	No	707	0-130	145
						813	0-71	
6	East	NW-W	No	Yes	Yes	708	0-101	124
						814	35	
7	East	NW-N	Yes	No	No	2	0-40	45
						3	0-55	27
9	East	SW-W	Yes	No	No	709	0-92	124
			No	No	No	710	0-107	39
		NW-W				711	0-151	61
						712	0-168	55
10	East	NW-W	Yes	No	Yes	6	0-185	237
		S-SW	No	Yes	No	713	0-90	56
						714	0-84	24
11	West	N-NE	No	No	No	715	0-67	94
			No	No	Yes	716	0-71	26
12	West	NE-E	No	No	No	5	0-60	80
						718	0-52	19
13	West	N-NE	No	No	Yes	717	0-100	100
						4	0-100	55
		NE-E				719	0-100	100
						720	0-100	158

<u>*Site 1*</u> was the most southern site (closest to the Dam) and has the developed Glacier Creek Forest Recreation Site in the undisturbed (by the reservoir) upland above full-pool. Since 2009, rock groins were installed with one paralleling the start of transect number 700. This disturbance changes the elevational profile at the start of the transect line by an external factor not related to the reservoir S73 flow regime. Site 1 summary is located in Table 11.

Table 11: The six top dominant species, cumulative cover, species richness, and overall reservoir totals for Site 1 in 2012. Site cover by reservoir cover is the percentage of the individual site's species cumulative cover contributed to the reservoir cumulative cover (site species, cumulative cover/reservoir specie cumulative cover).

<table>
<tr><th>Top 6 Dominant Species for Site 1</th><th colspan="2">Cumulative Cover</th><th>Site cover by reservoir cover (%)</th><th>Reservoir Top 6 Dominant Species</th><th>Cumulative Cover</th></tr>
<tr><td>h_W_Equi_arv (N)</td><td colspan="2">355.1</td><td>9.4</td><td>h_W_Equi_arv (N)</td><td>3790.6</td></tr>
<tr><td>h_W_Erys_che (N)</td><td colspan="2">216.6</td><td>31.6</td><td>g_Cinn_lat (N)</td><td>1623.8</td></tr>
<tr><td>h_Coll_lin (N)</td><td colspan="2">175.4</td><td>50.6</td><td>h_W_Poly_lap (N)</td><td>1412.5</td></tr>
<tr><td>g_Cinn_lat (N)</td><td colspan="2">162.8</td><td>10.0</td><td>h_W_Cera_vul (N)</td><td>995.1</td></tr>
<tr><td>h_W_Cera_vul (N)</td><td colspan="2">133.1</td><td>13.4</td><td>h_Care_utr (N)</td><td>993.0</td></tr>
<tr><td>g_Aira_car (E)</td><td colspan="2">75</td><td>14.1</td><td>h_W_Erys_che (N)</td><td>684.4</td></tr>
<tr><td rowspan="2">Vegetation Type</td><td colspan="2">Richness</td><td rowspan="2">Reservoir Species Richness</td><td colspan="2" rowspan="6">Coding: h = herb, g = grass, W = weed, s = shrub, t = tree, (N) = native, (E) = exotic. All species names are located in Appendix 1 and species codes are the first 4 letters of the genus and first 3 letters of species.</td></tr>
<tr><td>09</td><td>12</td></tr>
<tr><td>Herb</td><td>20</td><td>17</td><td>43</td></tr>
<tr><td>Shrub</td><td>4</td><td>0</td><td>14</td></tr>
<tr><td>Tree</td><td>5</td><td>3</td><td>8</td></tr>
<tr><td>Total</td><td>29</td><td>20</td><td>65</td></tr>
</table>

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 1. Upland transect line lengths were: #1 – 0-31m, #700 – 0-24 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Pseu_men	105	11.2	T = 5
	Pinu_con	17.5	100.0	
	Betu_pap	15	4.3	
8 m^2	Rubu_par	90	36.7	Sh = 11
	Berb_aqu	40	100.0	
	Shep_can	30	13.8	
	Arct_uva-urs	15	100.0	
1 m^2	Fest ssp	67.5	100.0	H = 13
	Clin_uni	40	66.6	
	Aral_nud	37.6	50.1	
	Pter_aqu	20	88.9	
	Linn_bor	17.5	22.6	
	Berb_aqu	15	85.7	
	Medi_lup	15	24.0	
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Site 1 had two transect lines, Transect #1 (320 m long), and Transect #700 (134 m long).

Site 1 - Transect #1 (320 m long)

2009 Herb quadrat at 86.6 m mark.

2012 Herb quadrat at 86.6 m mark.

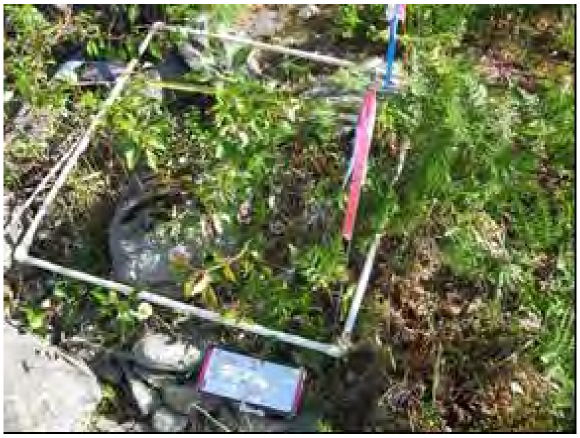
2009 Looking down line at 87.6 m.

2012 Looking down line at 87.6 m.

2009 Looking down reservoir at 87.7 m.

2012 Looking down reservoir at 87.7 m.

Site 1 - Transect #700 (134 m long)



2009 Herb quadrat at 0 m mark.

2012 Herb quadrat at 1 m mark.

2009 Looking down line at 1 m.

2012 Looking down line at 1 m.

2009 Looking up reservoir (south) at 1 m.

2012 Looking up reservoir (south) at 1 m.

Site 2 was located to the north and on the opposite side of Glacier Creek from Site 1, (Table 10) with an established recreational road access to the site. This area was frequently utilized by off road vehicles, as evidenced by the numerous tire tracks that were present in the drawdown zone. Evening primrose (Oeno_vil) was the third ranked dominant species for the site, but it occurred mainly in one large patch and the majority (95%) of the total reservoir cover for this species was located at Site 2.

Table 12: The six top dominant species, cumulative cover, species richness and overall reservoir totals for Site 2 in 2012.

Top 6 Dominant Species for Site	Cumulative Cover	Site cover by Reservoir cover (%)	Reservoir Top 5 Dominant Species	Cumulative Cover
g_Cinn_lat (N)	615.1	37.9	h_W_Equi_arv (N)	3790.6
h_W_Cera_vul (N)	402.7	40.5	g_Cinn_lat (N)	1623.8
h_Oeno_vil (N)	337.5	95.0	h_W_Poly_lap (N)	1412.5
T_Popu_tri (N)	325.0	89.7	h_W_Cera_vul (N)	995.1
h_W_Poly_lap (N)	190.0	13.5	h_Care_utr (N)	993.0
h_W_Ranu_acr (E)	190.0	79.9	h_W_Erys_che (N)	684.4

Vegetation Type	Richness* 09	Richness* 12	Reservoir Species Richness	See Table 11 for codes.
Herb	19	17	43	
Shrub	4	3	14	
Tree	3	3	8	
Total	26	23	65	

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 2. Upland transect line lengths were: #701 – 0-25m, #702 – 0-20 m, and #703 – 0-24 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Pseu_men	287.5	30.7	T = 6
	Popu_tri	187.5	69.4	
	Betu_pap	55	15.9	
	Thuj_pli	30	1.9	
8 m^2	Popu_tri	62.5	21.9	Sh = 8
	Amel_aln	30	57.0	
	Loni_uta	15	85.7	
	Popu_tre	15	85.2	
1 m^2	Moss	247.5	31.9	H = 11
	Aral_nud	30	39.9	
	Linn_bor	30	38.7	
	Clin_uni	17.5	29.1	
	Pyro_asa	15	100.0	
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 2 had three transect lines, Transect #701 (304 m long), Transect #702 (388 m long) and Transect #703 (360 m long).

Site 2 - Transect #701 (304 m long)


2009 Looking down the line at 6 m mark.


2012 Looking down the line at 6 m mark.


2009 Looking up reservoir at 1 m.


2012 Looking up reservoir at 1 m.


2009 Looking down reservoir at 6 m.


2012 Looking down reservoir at 29 m.

Site 2 –Transect #702 (388 m long)


2009 Looking up line at POC at 31 m.


2012 Looking up line at POC at 31 m.


2009 Looking up reservoir (north) at 31 m.


2012 Looking up reservoir (north) at 29 m.


2009 Looking down reservoir (south) at 31 m.


2012 Looking down reservoir (south) at 29 m.

Site 2 –Transect #703 (360 m long)

2009 Looking up line at POC at 11 m.

2012 Looking up line at POC at 11 m.

2009 Herb quadrat at 29 m.

2012 Herb quadrat at 29 m.

2009 Looking down line at 30 m.

2012 Looking down line at 30 m.

Site 3 was located on a peninsula in an area referred to as the "Lower Arm", which occurs between Duncan Island and the eastern shore of Duncan Reservoir. No external influences were noted for this site.

Site 3 was identified incorrectly in 2009. The correct site was monitored in 2012 and an additional transect line number 812 was established. The transect line 704 was set up in 2012 and surveyed to match as closely as possible the topography and vegetation community of the incorrect site and transect line in 2009. Analysis between the 2009 and 2012 transect lines showed that the two transect lines were similar in vegetation, soil, and bedrock though the correct Site 3 has bedrock starting closer to the POC than the incorrect site. Direct comparison of photos is included but will be discontinued in subsequent years. See Table 13 for summaries of cover and species richness.

Table 13: The six top dominant species, cumulative cover, species richness and overall reservoir totals for Site 3 in 2012.

Top 6 Dominant Species for Site	Cumulative Cover	Site cover by Reservoir cover (%)	Reservoir Top 6 Dominant Species	Cumulative Cover
h_W_Equi_arv (N)	262.5	6.9	h_W_Equi_arv (N)	3790.6
g_Cinn_lat (N)	202.5	12.5	g_Cinn_lat (N)	1623.8
h_W_Cera_vul (N)	88	8.8	h_W_Poly_lap (N)	1412.5
h_W_Poly_lap (N)	62.5	4.4	h_W_Cera_vul (N)	995.1
g_Aira_car (E)	45	8.4	h_Care_utr (N)	993.0
h_W_Ranu_acr (E)	32.5	13.7	h_W_Erys_che (N)	684.4

Vegetation Type	Richness		Reservoir Species Richness	See Table 11 for codes.
	09	12		
Herb	11	15	43	
Shrub	0	6	14	
Tree	0	1	8	
Total	11	22	65	

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 3. Upland transects lengths were: #704 – 0-25 m and #812 – 0-6 m

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Thuj_pli	162.5	10.0	Tree =4
	Pseu_men	127.5	13.6	
	Acer_glab	17.5	20.6	
	Betu_pap	15	4.3	
8 m^2	Acer_glab	15	85.7	Shrub = 4
1 m^2	Moss	100	12.9	Herb = 4
Upland Species for Reservoir = 63 – Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 3 had two transect lines, Transect # 704 (52 m long) and a new transect surveyed, Transect # 812 (48 m long)

Site 3 – Transect #704 (52 m long)

2009 Herb quadrat at 10 m.

2012 Herb quadrat at 10 m.

2009 Looking up reservoir at 11 m.

2012 Looking up reservoir at 11 m.

2009 Looking down reservoir at 11 m.

2012 Looking down reservoir at 11 m.

Site 3 – Transect #812 (48 m long)

2012 Herb quadrat at 47 m.

2012 Looking down the line at 8 m.

2012 Looking up line at 48 m.

2012 Looking up reservoir at 48 m

2012 Looking down reservoir at 48 m.

2012 Looking down line at 48 m.

Site 4 was located on a long, narrow bay on the western side of a large island (Duncan Island). Duncan Island supports a private woodlot, and a number of permanent residences are located in the undisturbed upland above full-pool. Several docks associated with the residences were present in the drawdown zone, although none were encountered on transects. Although the site was not identified as being "creek influenced" (Table 10), a small creek was present along the bottom of the bay, and there was an appreciable amount of ephemeral drainage from runoff in the upland. Transect #705 was influenced by this type of seepage. See Table 14 for cover and species richness summary. An alligator lizard was found in the drawdown zone between TR 705 and 706. Photographs are located in Appendix 6.

Table 14: The six top dominant species, cumulative cover, species richness and overall reservoir totals for Site 4 in 2012.

<table>
<tr><th>Top 6 Dominant Species for Site</th><th colspan="2">Cumulative Cover</th><th>Site cover by Reservoir cover (%)</th><th>Reservoir Top 6 Dominant Species</th><th>Cumulative Cover</th></tr>
<tr><td>h_W_Equi_arv (N)</td><td colspan="2">402.5</td><td>10.6</td><td>h_W_Equi_arv (N)</td><td>3790.6</td></tr>
<tr><td>h_W_Poly_lap (N)</td><td colspan="2">237.6</td><td>16.8</td><td>g_Cinn_lat (N)</td><td>1623.8</td></tr>
<tr><td>h_Mimu_gut (N)</td><td colspan="2">82.5</td><td>100.0</td><td>h_W_Poly_lap (N)</td><td>1412.5</td></tr>
<tr><td>g_Aira_car (E)</td><td colspan="2">77.9</td><td>14.6</td><td>h_W_Cera_vul (N)</td><td>995.1</td></tr>
<tr><td>h_W_Medi_lup (E)</td><td colspan="2">52.5</td><td>38.1</td><td>h_Care_utr (N)</td><td>993.0</td></tr>
<tr><td>h_W_Cera_vul (N)</td><td colspan="2">40.4</td><td>4.1</td><td>h_W_Erys_che (N)</td><td>684.4</td></tr>
<tr><th rowspan="2">Vegetation Type</th><th colspan="2">Richness*</th><th rowspan="2">Reservoir Species Richness</th><td colspan="2" rowspan="6">See Table 11 for codes.</td></tr>
<tr><th>09</th><th>12</th></tr>
<tr><td>Herb</td><td>15</td><td>11</td><td>43</td></tr>
<tr><td>Shrub</td><td>2</td><td>1</td><td>14</td></tr>
<tr><td>Tree</td><td>2</td><td>2</td><td>8</td></tr>
<tr><td>Total</td><td>19</td><td>14</td><td>65</td></tr>
</table>

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall

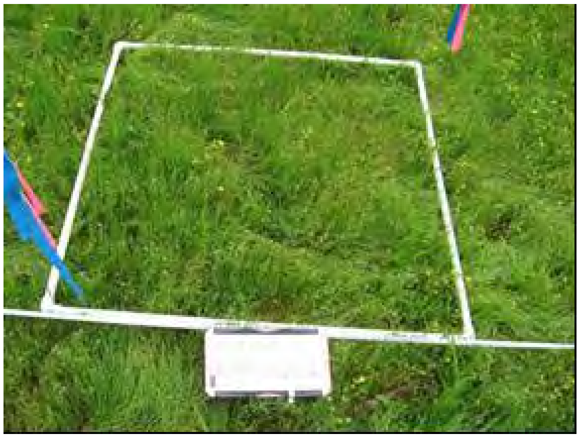
The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 4. Upland transect line lengths were: #705 – 0-12 m and #706 – 0-6 m

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Thuj_pli	185	11.4	T = 3
	Pseu_men	67.5	7.2	
	Betu_pap	55	15.9	
8 m^2	Shep_can	77.5	35.6	Sh =4
	Thuj_pli	32.5	22.0	
1 m^2	Moss	85	11.0	H = 5
	Linn_bor	17.5	22.6	
	Arct_uva-urs	15	99.3	
Upland Species for Reservoir = 63 – Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 4 had two transect lines, Transect # 705 (71 m long) and Transect #706 (54.0 m long).

Site 4 – Transect #705 (71 m long)


2009 Herb quadrat at 29.5 m.


2012 Herb quadrat at 29.5 m.


2009 Looking up line at 30.5 m.


2012 Looking up line at 30.5 m.


2009 Looking down line at 30.5 m.


2012 Looking down line at 30.5 m.

Site 4 – Transect #706 (54.0 m long)


2009 Looking up reservoir at 22 m.


2012 Looking up reservoir at 22 m.


2009 Looking up line at 37 m.


2012 Looking up line from 37 m.


2009 Looking down reservoir at 51 m.


2012 Looking down reservoir at 51 m.

Site 5 was located in an area referred to as the “Upper Arm”, which occurs between Duncan Island and the eastern shore of Duncan Reservoir. There was little evidence of recent human activity in the upland, since access to the site required “bushwhacking” through a previously logged area that was quite grown in. Well used game trails were evident and several mule deer were observed while accessing the site. No creek influence was noted; however, there were large quantities of water seeping from the upland, forming extensive saturated areas that did not support vegetation. See Table 15 for cover and species richness summaries.

Table 15: The five top dominant species, cumulative cover, species richness and overall reservoir totals for Site 5 in 2009.

Top 6 Dominant Species for Site	Cumulative Cover	Site cover by Reservoir cover (%)	Reservoir Top 6 Dominant Species	Cumulative Cover
g_Aira_car (E)	302.5	56.8	h_W_Equi_arv (N)	3790.6
g_Cinn_lat (N)	220	13.5	g_Cinn_lat (N)	1623.8
h_W_Equi_arv (N)	205	5.4	h_W_Poly_lap (N)	1412.5
h_W_Poly_lap (N)	142.5	10.1	h_W_Cera_vul (N)	995.1
h_W_Cera_vul (N	115	11.6	h_Care_utr (N)	993.0
h_W_Medi_lup (E)	82.6	60.0	h_W_Erys_che (N)	684.4

Vegetation Type	Richness		Reservoir Species Richness	See Table 11 for codes.
	09	12		
Herb	16	10	43	
Shrub	0	6	14	
Tree	1	1	8	
Total	17	17	65	

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 5. Upland transect line lengths were: #707 – 0-10 m and #813 – 0-12 m

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Thuj_pli	352.5	21.8	T = 5
	Betu_pap	70	20.3	
	Tsug_het	67.5	12.3	
8 m^2	Shep_can	85	39.1	Sh = 4
	Rubu_par	57.5	23.5	
1 m^2	Equi_arv	15	46.2	H = 6
Upland Species for Reservoir = 63 – Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 5 had one transect line, Transect #707 (130 m) with a second line Transect #813 (71 m) established in 2012.

Site 5 – Transect #707 (130 m long)

2009 Herb quadrat at 37 m.

2012 Herb quadrat at 37 m.

2009 Looking up line at 38 m.

2012 Looking up line at 38 m.

2009 Looking down reservoir at 106 m.

2012 Looking down reservoir at 106 m.

Site 5 – Transect #813 (71 m long)


2012 Herb quadrat at 4 m.


2012 Looking down line at 5 m.


2012 Herb quadrat at 23.4 m.


2012 Looking up reservoir at 24.4 m.


2012 Looking down reservoir at 24.4 m.


2012 Looking up line at 60.7 m.

Site 6 was located on the southern side of "Little Glacier Creek". The site was influenced by the creek and proximal to the Duncan River Forest Service Road (Table 10). A well used skid trail and an abandoned camper indicated that this area was regularly visited by people. Vegetation on the site was sparse with the majority of the transect line covering bare ground (Table 16). A second transect line (#814) was surveyed in 2012 with the location randomly selected using the protocol from 2009. The new line was similar to the established line with the majority of the line running through bare ground.

Table 16: The six top dominant species, cumulative cover, species richness and overall reservoir totals for Site 6 in 2012.

Top 6 Dominant Species for Site	Cumulative Cover	Site cover by Reservoir cover (%)	Reservoir Top 6 Dominant Species	Cumulative Cover
h_W_Poly_lap (N)	17.6	54.2	h_W_Equi_arv (N)	3790.6
h_Moss (N)	15.0	3.9	g_Cinn_lat (N)	1623.8
h_W_Equi_arv (N)	2.6	0.1	h_W_Poly_lap (N)	1412.5
g_Cinn_lat (N)	0.1	0.006	h_W_Cera_vul (N)	995.1
			h_Care_utr (N)	993.0
			h_W_Erys_che (N)	684.4

Vegetation Type	Richness 09	Richness 12	Reservoir Species Richness	See Table 11 for codes.
Herb	3	4	43	
Shrub	0	0	14	
Tree	0	0	8	
Total	3	4	65	

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 6. Upland transect line lengths were: #708 – 0-27 m and #814 – 0-3 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Thuj_pli	210	13.0	T = 5
	Tsug_het	107.5	19.5	
	Betu_pap	42.5	12.3	
	Pseu_men	32.5	3.5	
8 m^2	Thuj_pli	37.5	32.6	Sh = 6
	Tsug_het	32.5	92.9	
	Shep_can	17.5	8.0	
	Pach_myr	15	13.0	
1 m^2	Moss	260	33.5	H = 4
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 6 had one transect line, Transect #708 (101 m) in 2009 and a second line, Transect #814 (35 m) was established in 2012.

Site 6 - Transect #708 (128.0 m long)


2009 Looking down line at 8 m.


2012 Looking down line at 8 m.


2009 Looking up line at 27 m.


2012 Looking up line at 27 m.


2009 Looking down reservoir at 27 m.


2012 Looking down reservoir at 27 m.

Site 6 - Transect #814 (35 m long)

2012 Looking down line at 8 m.

2012 Herb quadrat at 12 m.

2009 Looking up line at 13 m.

2012 Looking up reservoir at 19 m.

2009 Looking down reservoir at 19 m.

2012 Looking up line at 36 m.

Site 7 was located on a point of land bounded by Howser Creek to the north and the reservoir to west. An unofficial, but well used camp site was located in the upland above full-pool. Although Howser Creek is nearby, no creek influence was noted on the site itself (Table 10). The slope leading from the upland to the reservoir fell away quickly into a steep area of large, rounded cobbles and boulders. See Table 17 for cover and species richness summaries.

Table 17: The six top dominant species, cumulative cover, species richness, and overall reservoir totals for Site 7 in 2012.

Top 6 Dominant Species for Site	Cumulative Cover	Site cover by Reservoir cover (%)	Reservoir Top 6 Dominant Species	Cumulative Cover
h_W_Equi_arv (N)	60	1.6	h_W_Equi_arv (N)	3790.6
g_Cinn_lat (N)	37.5	2.3	g_Cinn_lat (N)	1623.8
t_Popu_tri (N)	15	18.7	h_W_Poly_lap (N)	1412.5
h_W_Poly_lap (N)	2.5	0.2	h_W_Cera_vul (N)	995.1
h_Care_utr (N)	2.5	0.3	h_Care_utr (N)	993.0
h_W_Erys_che (N)	2.5	0.4	h_W_Erys_che (N)	684.4

Vegetation Type	Richness* 09	Richness* 12	Reservoir Species Richness
Herb	10	7	43
Shrub	2	0	14
Tree	1	1	8
Total	13	8	65

See Table 11 for codes.

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 7. Upland transect line lengths were: #2 – 0-24 m and #3 – 0-7 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Pseu_men	100	10.7	T = 3
	Popu_tri	37.5	13.9	
8 m^2	Popu_tri	70	24.6	Sh =6
	Corn_sto	37.5	25.4	
	Rubu_par	37.5	15.3	
	Rosa_gym	30	92.3	
1 m^2	Sum of Frag_vir	177.5	100.0	H = 11
	Sum of Cent_mac	95	73.1	
	Sum of Medi_lup	47.5	76.0	
	Sum of Trif_pra	45	58.0	
	Sum of Oeno_vil	40	100.0	
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 7 consisted of two transect lines: Transect #2 (40 m long) and Transect #3 (55 m long).

Site 7 - Transect #2 (40 m long)

2009 Herb quadrat at 20 m.

2012 Herb quadrat at 20 m.

2009 Looking down reservoir at 21 m.

2012 Looking down reservoir at 21 m.

2009 Looking up line at 43 m.

2012 Looking up line at 43 m.

Site 7 - Transect #3 (55 m long)

2009 Looking up line at 28 m.

2012 Looking up line at 26 m.

2009 Looking down line at 28 m.

2012 Looking down line at 26 m.

2009 Looking up reservoir at 28 m.

2012 Looking up reservoir at 26 m.

Site 9 was located on the north side of Clancy Creek. An unofficial camp site was located on the south side of the creek in the upland above full-pool and was accessed by an old road. The bridge across Clancy Creek was washed out, and on the north side, the road was almost entirely grown in during field visit in 2009. The road could not be found in 2012 though parts were crossed while bushwhacking to the site. Although Clancy Creek was nearby, no creek influence was noted on the site itself (Table 10). See Table 18 for cover and species richness summaries.

Table 18: The six top dominant species, cumulative cover, species richness, and overall reservoir totals for Site 9 in 2012.

Top 6 Dominant Species for Site	Cumulative Cover		Site cover by Reservoir cover (%)	Reservoir Top 6 Dominant Species	Cumulative Cover
h_W_Equi_arv (N)	492.7		13.0	h_W_Equi_arv (N)	3790.6
h_W_Poly_lap (N)	313.3		22.2	g_Cinn_lat (N)	1623.8
h_Care_utr (N)	262.6		26.4	h_W_Poly_lap (N)	1412.5
h_W_Erys_che (N)	75.1		11.0	h_W_Cera_vul (N)	995.1
h_W_Chen_alb (N)	45		70.8	h_Care_utr (N)	993.0
g_Cinn_lat (N)	32.9		2.0	h_W_Erys_che (N)	684.4
Vegetation Type	**Richness***		**Reservoir Species Richness**	See Table 11 for codes.	
	09	**12**			
Herb	14	8	43		
Shrub	5	3	14		
Tree	2	1	8		
Total	21	12	65		

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 9. Upland transect line lengths were: #709 – 0-7 m, #710 – 0-13.5 m, #711 – 0-14 m, and #712 – 0-13 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Thuj_pli	415	25.7	T = 8
	Pseu_men	77.5	8.3	
	Betu_pap	70	20.3	
	Acer_glab	52.5	61.7	
8 m^2	Pach_myr	52.5	45.7	Sh = 19
	Thuj_pli	17.5	15.2	
	Opla_hor	15	42.9	
	Rubu_par	15	6.1	
1 m^2	Moss	82.5	10.6	H = 6
	Pach_myr	62.5	96.2	
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 9 had four transect lines: Transect #709 (92 m), Transect #710 (107 m), Transect #711 (151 m) and Transect#712 (168 m). Transect #711 was influenced by Clancy Creek.

Site 9 -Transect #709 (92 m long)

2009 Herb quadrat at 17 m.

2012 Herb quadrat at 17 m.

2009 Looking up reservoir at 18 m.

2012 Looking up reservoir at 18 m.

2009 Looking up line at 56 m.

2012 Looking up line at 56 m.

Site 9 - Transect #710 (107 m long)

2009 Herb quadrat at 14 m.

2012 Herb quadrat at 14 m.

2009 Looking up reservoir at 14 m.

2012 Looking up reservoir at 14 m.

2009 Looking up line at 35 m.

2012 Looking up line at 35 m.

Site 9 - Transect #711 (151 m long)

2009 Herb quadrat at 2 m.

2012 Herb quadrat at 2 m.

2009 Looking at POC from 45 m

2012 Looking at POC from 45 m

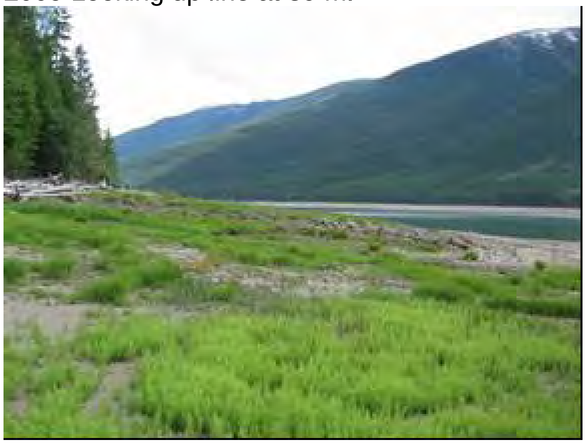
2009 Looking down reservoir at 45 m

2012 Looking down reservoir at 45 m

Site 9 - Transect #712 (168 m long)

2009 Looking up line at 39 m.

2012 Looking up line at 39 m.



2009 Looking down reservoir at 39 m.

2012 Looking down reservoir at 39 m.

2009 Looking up reservoir at 52 m.

2012 Looking up reservoir at 39 m.

Site 10 was located on both the north and south sides of Cockle Creek, although none of the transect lines intercepted the creek. An unofficial camp site was located on the north side of the creek in the upland above full-pool and was accessed by an old road, which ended at the reservoir, but did not cross the creek. Transect line 6 had mechanical removal of woody debris resulting in disturbance to vegetation along the area near full-pool. The southernmost transects (#713 and #714) did not have this mechanical disturbance. Clancy Creek, which intersected the site, and was noted as influencing transect #6, but not transects #713 and #714 (Table 10). See Table 19 for cover and species richness summaries.

Table 19: The six top dominant species, cumulative cover, species richness, and overall reservoir totals for Site 10 in 2012.

<table>
<tr><th>Top 6 Dominant Species for Site</th><th colspan="2">Cumulative Cover</th><th>Site cover by Reservoir cover (%)</th><th>Reservoir Top 6 Dominant Species</th><th>Cumulative Cover</th></tr>
<tr><td>h_Drya_dru (N)</td><td colspan="2">187.5</td><td>100.0</td><td>h_W_Equi_arv (N)</td><td>3790.6</td></tr>
<tr><td>h_Care_utr (N)</td><td colspan="2">177.6</td><td>17.9</td><td>g_Cinn_lat (N)</td><td>1623.8</td></tr>
<tr><td>h_W_Erys_che (N)</td><td colspan="2">135.1</td><td>19.7</td><td>h_W_Poly_lap (N)</td><td>1412.5</td></tr>
<tr><td>h_W_Cera_vul (N)</td><td colspan="2">107.6</td><td>10.8</td><td>h_W_Cera_vul (N)</td><td>995.1</td></tr>
<tr><td>h_W_Poly_lap (N)</td><td colspan="2">105.3</td><td>7.5</td><td>h_Care_utr (N)</td><td>993.0</td></tr>
<tr><td>h_W_Equi_arv (N)</td><td colspan="2">75</td><td>2.0</td><td>h_W_Erys_che (N)</td><td>684.4</td></tr>
<tr><th rowspan="2">Vegetation Type</th><th colspan="2">Richness*</th><th rowspan="2">Reservoir Species Richness</th><td colspan="2" rowspan="6">See Table 11 for codes.</td></tr>
<tr><th>09</th><th>12</th></tr>
<tr><td>Herb</td><td>16</td><td>16</td><td>43</td></tr>
<tr><td>Shrub</td><td>2</td><td>2</td><td>14</td></tr>
<tr><td>Tree</td><td>3</td><td>3</td><td>8</td></tr>
<tr><td>Total</td><td>21</td><td>21</td><td>65</td></tr>
</table>

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 10. Upland transect line lengths were: #713 – 0-14 m, #714 – 0-11 m, and #6 – 0-24 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Pseu_men	137.5	14.7	T = 6
	Tsug_het	102.5	18.6	
	Thuj_pli	80	4.9	
	Pice_gla	52.5	91.3	
8 m^2	Popu_tri	152.5	53.5	Sh = 10
	Pach_myr	32.5	28.3	
	Alnu_cri	20	27.5	
	Pseu_men	20	80.0	
	Rubu_par	20	8.2	
1 m^2	Drya_dru	260	100.0	H = 7
	Trif_pra	55	55.0	
	Cent_mac	35	26.9	
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 10 had three transect lines: Transect #6 (185 m), Transect #713 (90 m) and Transect #714 (84 m).

Site 10 - Transect #6 (185 m long)

2009 Herb quadrat at 0 m.

2012 Herb quadrat at 0 m.

2009 Looking down line at 1 m.

2012 Looking down line at 1 m.

2009 Looking down reservoir at 57 m.

2012 Looking down reservoir at 45 m.

Site 10 - Transect #713 (90 m long)

2009 Looking down line at 56 m.

2012 Looking down line at 52 m.

2009 looking up reservoir at 56 m.

2012 looking up reservoir at 52 m.

2009 Looking down reservoir at 56 m.

2012 Looking down reservoir at 52 m.

Site 10 - Transect #714 (84 m long)

2009 Looking up line at 16 m.

2012 Looking up line at 16 m.

2009 Looking up reservoir at 16 m.

2012 Looking up reservoir at 16 m.

2009 Looking down reservoir at 16 m.

2012 Looking down reservoir at 16 m.

<u>Site 11</u> was located on the west side of Duncan Reservoir and was accessible only by boat. The site spanned both sides (north and south) of Idaho Creek, although none of the transect lines intercepted the creek. There was very little evidence of human activity, although there were traces of cedar shake cutting in the upland. Grasses on this site exhibited signs of extensive grazing, and numerous goose droppings were scattered throughout the area. Idaho Creek, which intersected the site, was noted as an influence on the northernmost transect (#716), but not on the southernmost transect (#715) (Table 10). See Table 20 for cover and species richness summaries.

Table 20: The six top dominant species, cumulative cover, species richness, and overall reservoir totals for Site 11 in 2012.

Top 6 Dominant Species for Site	**Cumulative Cover**		**Site cover by Reservoir cover (%)**	**Reservoir Top 6 Dominant Species**	**Cumulative Cover**
h_W_Equi_arv (N)	132.5		3.5	h_W_Equi_arv (N)	3790.6
h_Care_utr (N)	115.1		11.6	g_Cinn_lat (N)	1623.8
g_Cala_can (N)	97.5		43.8	h_W_Poly_lap (N)	1412.5
h_W_Poly_lap (N)	6.2		0.4	h_W_Cera_vul (N)	995.1
g_W_Phal_aru (N)	5.2		67.5	h_Care_utr (N)	993.0
h_W_Cera_vul (N)	3		0.3	h_W_Erys_che (N)	684.4
Vegetation Type	**Richness***		**Reservoir Species Richness**	See Table 11 for codes.	
	09	**12**			
Herb	10	10	43		
Shrub	0	1	14		
Tree	0	0	8		
Total	10	11	65		

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 11. Upland transect line lengths were: #715 – 0-7 m and #716 – 0-7 m.

Quadrat Area	**Dominant Species for Site**	**Cumulative Cover (%)**	**Site Cover by Reservoir Upland (%)**	**Specie Richness**
50 m^2	Thuj_pli	52.5	3.2	T = 5
	Acer_glab	15.1	17.7	
	Betu_pap	15	4.3	
8 m^2	Ribe_lac	15	85.2	Sh = 6
	Rubu_par	15	6.1	
1 m^2	Aral_nud	5	6.7	H = 3
	Gymn_dry	2.5	49.0	
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 11 had two transects lines: Transect #715 (67 m long) and #716 (71 m long).

Site 11 - Transect #715 (67 m long)

2009 Herb quadrat at 14 m.

2012 Herb quadrat at 14 m.

2009 Looking up line at 14 m.

2012 Looking up line at 14 m.

2009 Looking up reservoir at 14 m.

2012 Looking up reservoir at 14 m.

Site 11 - Transect #716 (71 m long)


2009 Looking down line at 27 m.


2012 Looking down line at 27 m.


2009 Looking up reservoir at 27 m.


2012 Herb quadrat at 13 m.


2009 Looking down reservoir at 27 m.


2012 Looking up line at 14 m.

Site 12 was located on the west side of Duncan Reservoir, immediately south of La Barie Creek and was accessible only by boat. There was very little evidence of recent human activity except for the large booms used to collect woody debris washed down by the river. La Barie Creek runs through the north end of the site and had no influence on either transect (#5 or #718) (Table 10). See Table 21 for cover and species richness summaries.

Table 21: The six top dominant species, cumulative cover, species richness, and overall reservoir totals for Site 12 in 2012.

Top 6 Dominant Species for Site	Cumulative Cover	Site cover by Reservoir cover (%)	Reservoir Top 6 Dominant Species	Cumulative Cover
h_W_Poly_lap (N)	260.8	18.5	h_W_Equi_arv (N)	3790.6
h_W_Cera_vul (N)	87.8	8.8	g_Cinn_lat (N)	1623.8
h_Care_utr (N)	77.7	7.8	h_W_Poly_lap (N)	1412.5
h_W_Equi_arv (N)	60.2	1.6	h_W_Cera_vul (N)	995.1
h_W_Erys_che (N)	15.4	2.3	h_Care_utr (N)	993.0
h_Care_lan (N)	2.5	100.0	h_W_Erys_che (N)	684.4

Vegetation Type	Richness* 09	Richness* 12	Reservoir Species Richness	See Table 11 for codes.
Herb	12	8	43	
Shrub	0	0	14	
Tree	0	0	8	
Total	12	8	65	

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 12. Upland transect line lengths were: #718 – 0-7 m and #5 – 0-12 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Thuj_pli	62.5	3.9	T = 4
	Tsug_het	52.5	9.5	
8 m^2	Vacc_ova	37.5	93.8	Sh = 7
	Pach_myr	15	13.0	
1 m^2	Corn_can	2.5	50.0	H = 4
	Opla_hor	2.5	100.0	
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 12 had two transects lines: Transect #5 (60 m long) and Transect #718 (52 m long).

Site 12 - Transect #5 (60 m long)

2009 Herb quadrat at 31 m.

2012 Herb quadrat at 31 m.

2009 Looking down line at 31 m.

2012 Looking down line at 32 m.

2009 Looking down reservoir at 31 m.

2012 Looking down reservoir at 32 m.

Site 12 - Transect #718 (52 m long)

2009 Looking down line at 1 m.

2012 Looking down line at 1 m.

2009 Looking up reservoir at 10 m.

2012 Looking up reservoir at 10 m.

2009 Looking down reservoir at 10 m.

2012 Looking down reservoir at 10 m.

Site 13 was located on the west side of Duncan Reservoir at the extreme north end, at the confluence of Puddingbowl Creek and the reservoir. The site was accessed by foot via a small maintained path, which is used to access a private cabin and associated camp sites situated in the upland. During the site visit, a number of campers were encountered along with numerous free ranging horses associated with the previously mentioned camp. Grasses on this site exhibited signs of grazing by the horses. Puddingbowl Creek intersected the site and was noted as an influence on all transects, since its channel was extremely braided and variable (Table 10). Site 13 did not have the 10 m change in elevation surveyed due to the gradual sloping ground, which would have resulted in transect lines in excess of 1 km long. The full-pool edge scour that was easily identified for all previous sites was difficult to determine where transect lines should start. During our second visit (Year 4) it was determined that transect lines 4, 717, and 719 started above full-pool. See Table 22 for cover and species richness summaries.

Table 22: The six top dominant species, cumulative cover, species richness, and overall reservoir totals for Site 13 in 2012.

Top 6 Dominant Species for Site	Cumulative Cover	Site cover by Reservoir cover (%)	Reservoir Top 6 Dominant Species	Cumulative Cover
h_W_Equi_arv (N)	1815	47.9	h_W_Equi_arv (N)	3790.6
g_Cinn_lat (N)	285.1	17.6	g_Cinn_lat (N)	1623.8
h_Care_utr (N)	202.5	20.4	h_W_Poly_lap (N)	1412.5
s_Sali_beb (N)	110	100.0	h_W_Cera_vul (N)	995.1
s_Sali_luc (N)	96.25	82.4	h_Care_utr (N)	993.0
g_Cala_can (N)	90.1	40.5	h_W_Erys_che (N)	684.4

Vegetation Type	Richness*		Reservoir Species Richness	See Table 11 for codes.
	09	**12**		
Herb	18	15	43	
Shrub	9	5	14	
Tree	5	3	8	
Total	32	23	65	

*Species Richness is the number of species recorded for the vegetation type and is provided by site and for the reservoir overall.

The following summary is for the upland vegetation above full-pool that occurs within a two metre change in elevation above full-pool for Site 13. Upland transect line lengths were: #717 – 0-13 m, #719 – 0-20 m, #720 – 0-11 m, and #4 – 0-13 m.

Quadrat Area	Dominant Species for Site	Cumulative Cover (%)	Site Cover by Reservoir Upland (%)	Specie Richness
50 m^2	Sali_sco	390	99.4	T = 10
	Tsug_het	197.5	35.9	
	Thuj_pli	67.5	4.2	
	Popu_tri	42.5	15.7	
8 m^2	Sali_sco	365	94.2	Sh = 6
	Corn_sto	102.5	69.5	
	Alnu_cri	47.5	65.4	
1 m^2	Equi_arv	15	46.2	H = 9
Upland Species for Reservoir = 63 - Tree = 10 Shrub = 21 Herb = 32				

Note: T = tree species, Sh = shrub species, and H = herbaceous species.

Site 13 had four transect lines: Transect #717 (100.0 m), Transect #719 (100 m), Transect #720 (100 m) and Transect #4 (100 m).

Site 13 - Transect #717 (100.0 m long)

2009 Looking up line at 54 m.

2012 Looking up line at 54 m.

2009 Herb quadrat at 40 m.

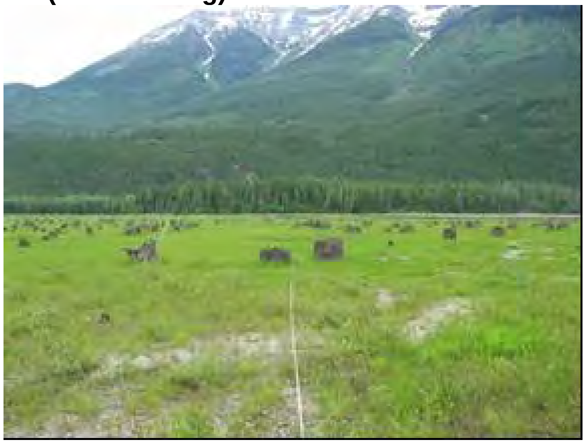
2012 Herb quadrat at 40 m.

2009 Looking down line at 41 m.

2012 Looking down line at 54 m.

Site 13 - Transect #719 (100.0 m long)

2009 Looking down line at 55 m.



2012 Looking down line at 56 m.

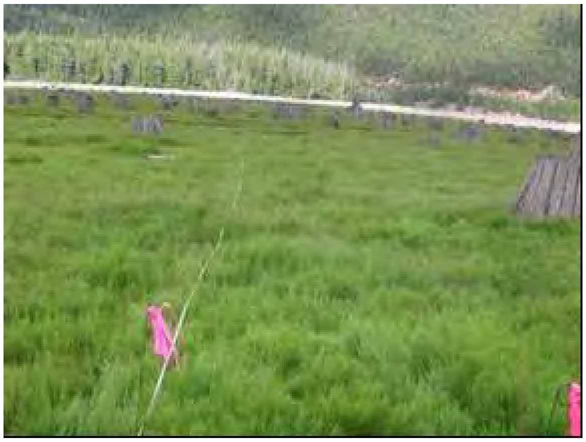
2009 Looking up line at 55 m.

2012 Looking up line at 56 m.

2009 Looking down reservoir at 55 m.

2012 Looking down reservoir at 56 m.

Site 13 - Transect #720 (100 m long)



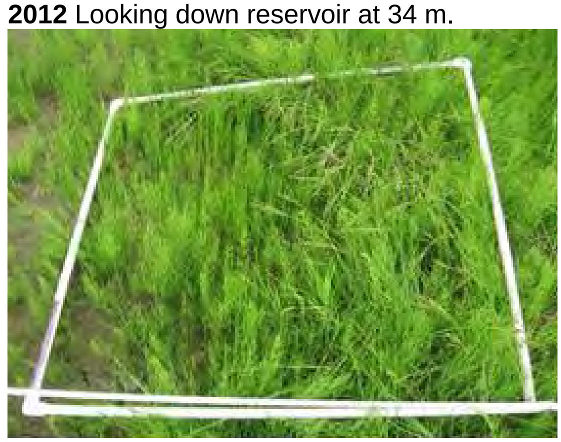
2009 Looking down line at 34 m.

2012 Looking down line at 34 m.

2009 Looking down reservoir at 34 m.

2012 Looking down reservoir at 34 m.

2009 Herb quadrat at 54 m.



2012 Herb quadrat at 54 m.

Site 13 - Transect #4 (100 m long)

2009 Looking down line at 24 m.

2012 Looking down line at 24 m.

2009 Herb quadrat at 40 m.

2012 Herb quadrat at 40 m.

2009 Looking down reservoir at 41 m.

2012 Looking down reservoir at 41 m.

3.4 Vegetation Analysis: Vegetation Cover and Species Richness

Two integrative measures: total vegetation shoot cover and species richness (number of species) were identified in 2009 for addressing the two null hypotheses. Three main factors were identified that affected vegetation cover and species richness. These were; elevation, site, and substrate. Results from the 2012 vegetation surveys are presented as well as comparisons between baseline and Year 4 findings.

3.4.1 Elevation

Cover

Generally higher vegetation cover was noted with progress up the elevation gradient to 576.68 m (full-pool (-1)), (Figure 9). Vegetation types were grouped together, requiring transformation of the larger quadrat sampling data (tree and shrub quadrates) to reflect cover per square metre, which allowed the cumulative cover for all vegetation to be assessed. Per cent cover was higher in 2012 compared to 2009 cover but not significantly (P = 0.061, t = 1.879, df = 305).

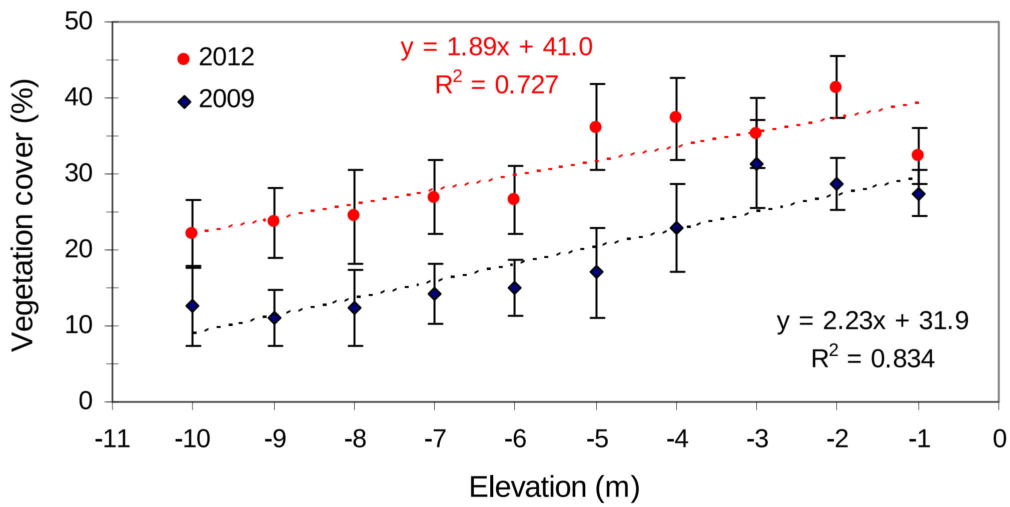


Figure 9: **Mean (±s.e.) vegetation per cent (cumulative) versus elevation for quadrat data grouped in 1 m elevational intervals for 2009 and 2012.**

Vegetation was split into vegetation types and graphed to investigate vegetation type versus elevation. Tree and shrub data is presented as the cover within the respective quadrat size. Figure 10 shows that grass species generally had higher cover starting within the 572.7 bracket up to full-pool. It also showed that tree and the majority of shrub quadrat data occurred within the first metre of change in elevation.

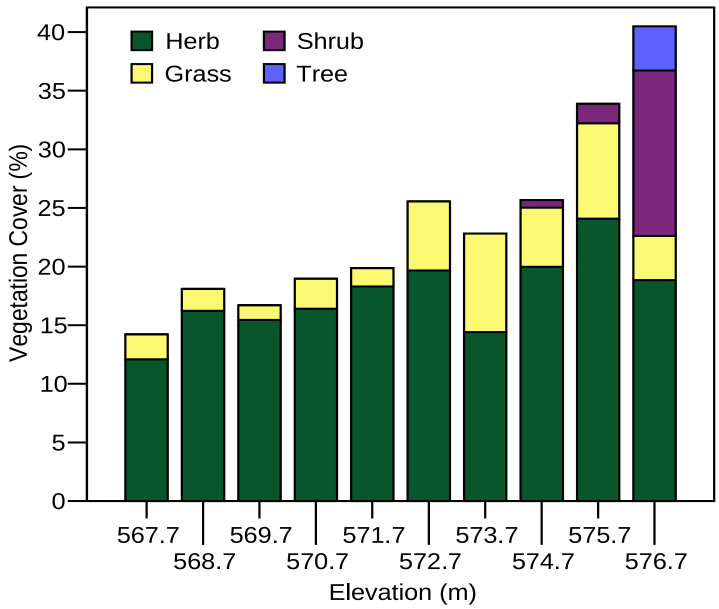


Figure 10: Mean cover of herbaceous plants, grasses, shrubs, and trees versus reservoir drawdown zone elevation (in 1 m elevation brackets) in 2012.

As illustrated in 2009, there was a very steep decline in woody plants as the elevation from the top of the drawdown zone decreased. The shrub and tree species were generally most dense from the transect origin to the first metre drop in elevation. When just tree quadrat data is graphed this very steep decline is evident in 2012 (Figure 11). There were eight species of trees recorded, but only three species were tall enough to be sampled within a tree quadrate. Black cottonwood (*Populus trichocarpa*) was the dominant tree within tree plots with a cumulative cover of 362.5 (mean 0.6). Two other tree species occurred but made minor contribution to overall cover. Paper birch (*Betula papyrifera*) had 2.5 per cent cumulative cover (mean 0.004) and lodgepole pine (*Pinus contorta* var*. latifolia*) with 15 per cent cumulative cover (mean 0.026). All trees occurred within the first metre change in elevation from full-pool (576.7 m bracket) (Figure 11).

The shrub community was similar to the tree community with the highest densities occurring between the transect origin and the first metre drop in elevation (Figure 12). There were nine shrub species plus five of the nine tree species (no lodgepole pine) recorded within shrub quadrats (woody species height >0.5 m and <2.0 m). The dominant species, *Salix scouleriana* (Scouler's willow) and black cottonwood had cumulative per cent covers of 575.0 and 242.5 respectively. There were four other species which were main contributors to shrub cover: Bebb's willow, western red cedar, red-osier dogwood, and trembling aspen with cumulative covers of 152.5, 117.5, and 112.0 respectively. A list of all species, common and scientific names and codes used are located in Appendix 1

Not included in the shrub plots was woody species recorded within the herb quadrats (heights <0.5 m). These were recorded within the first metre drop in elevation and accounted for a combined total cumulative cover for the reservoir of 205 per cent with three species having 2.5 per cent cover for all transects sampled.

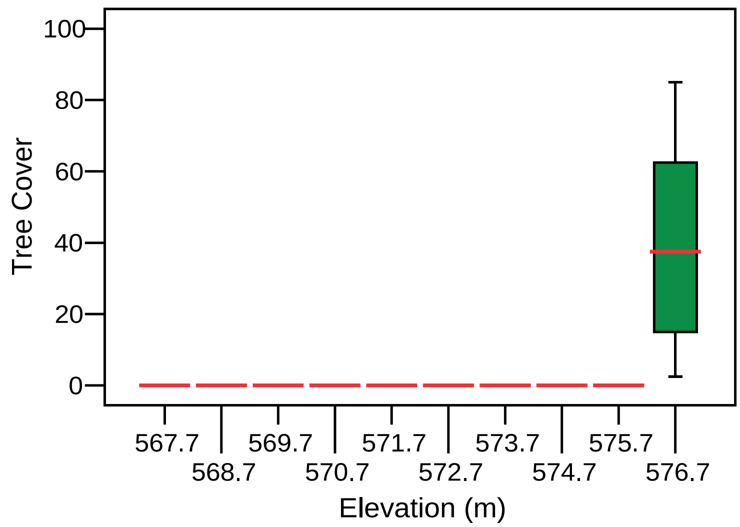


Figure 11: **Per cent cover for tree species sampled within tree quadrats (50 m² area) versus elevation drop.**

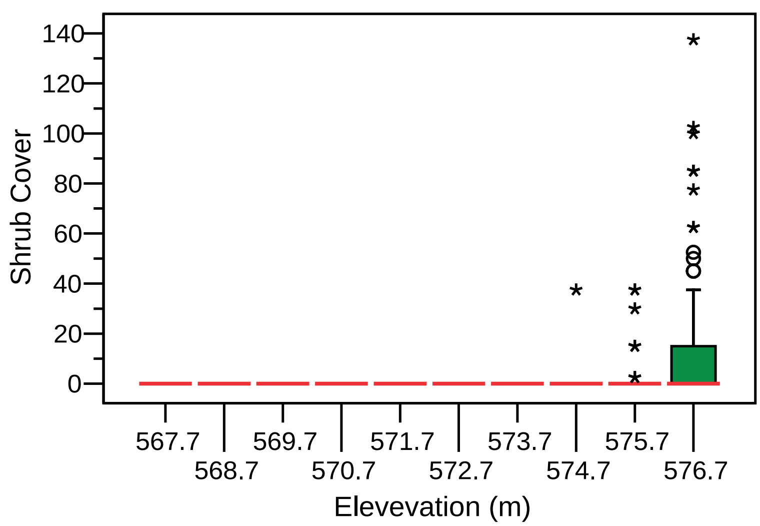


Figure 12: **Cumulative per cent cover of all woody species sampled within shrub quadrats (8 m² area) versus elevation drop. Box indicates the 25th percentile (bottom) to the 75th percentile (top). Whiskers above indicate the 90th percentile. Circles are outliers 1.5 to 3 box lengths from the upper edge of the box and stars are extreme outliers >3 box lengths.**

Because the majority of tree and shrub species occurred within the first metre change in elevation the 576.7 m bracket was split into 20 cm increments of elevation change (Figure 13). The upper edge of this elevation bracket is where trees greater than 2.0 m in height occur while shrub and young trees (<2.0 m) are established through the first metre drop in elevation with low cover (extreme outliers) for shrubs occurring in the adjacent two metres of change below full-pool (Figure 12).

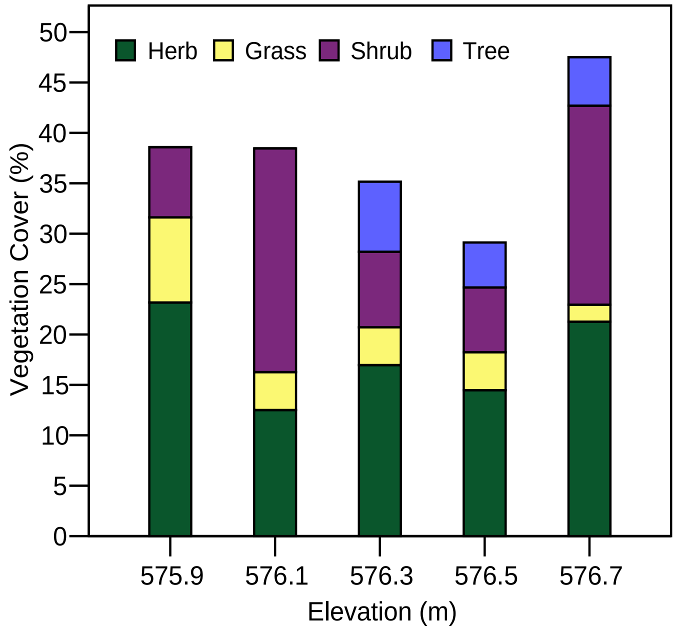


Figure 13: **Mean cover by vegetation type occurring in the 576.7 m bracket (576.7 to 575.7 m) in 0.2 m elevation increments. Full-pool is 576.7 m.**

The six dominant species for the reservoir were identified in 2012 (Table 23). Cumulative cover for each species was included in the summary tables for each site in section 3.2 (see Table 11 to Table 22). The six species were selected for the highest cumulative vegetation cover and high distribution within the reservoir. The dominant species in 2009 were similar but ranked in a different order. The large difference in cover between the 5th and the 6th ranking species resulted in only the top five being used. The change in the dominant species composition may have been due to sampling change from sequential to vegetation community sampling. Figure 14 shows these species listed in their ranked order from highest to lowest versus the elevation gradient.

Table 23: **Top 6 dominant species by cover for 2012, and top 5 dominant species by cover for 2009. Perennials are indicated with a (P) and annuals with a (A).**

Species (Common Name)	Scientific Name	2012	2009
Common Horsetail (P)	*Equisetum arvense*	1	1
Nodding Wood-reed (P)	*Cinna latifolia*	2	4
Green Smartweed (A)	*Polygonum lapathifolium*	3	5
Mouse-eared Chickweed (A)	*Cerastium vulgatum*	4	
Beaked Sedge (P)	*Carex utriculata*	5	2
Wormseed Mustard (A)	*Erysimum cheiranthoides*	6	
Silver Hairgrass (A)	*Aira caryophyllea*		3

The annual species (green smartweed, mouse-eared chickweed, and wormseed mustard) dominated the lower elevation gradient. Cover by these species was greatly reduced at higher elevation gradients and almost absent from 574.7 to 576.7m (575.7 and 576.7 brackets). The elevation bracket between 570.9 to 571.7 m is where the three annual species almost drop out and perennial species (common horsetail, nodding wood-reed, and beaked sedge), decrease in cover with beaked sedge dropping out in the following metre elevation bracket (570.7 to 571.7 m).

For the six dominant species it appears that perennials decrease as elevation decreases from full-pool while the three annual species have a reverse gradient with cover decreasing as elevation increases toward full-pool.

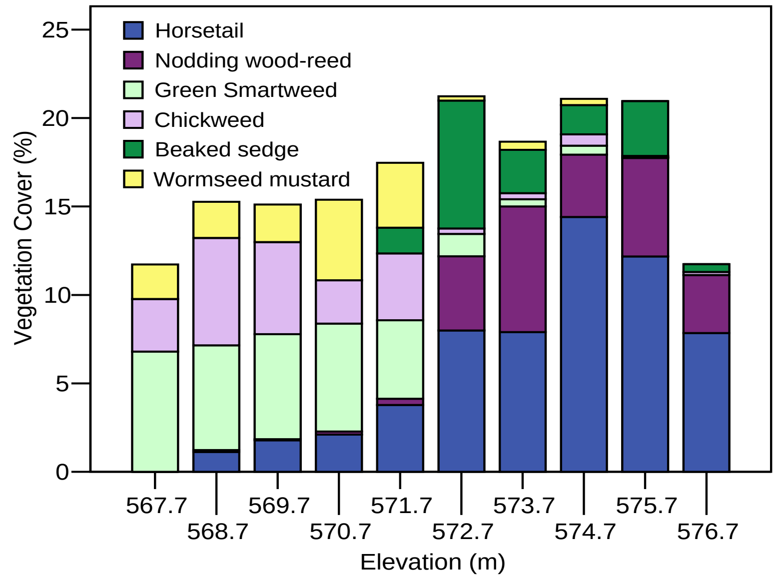


Figure 14: **Mean cover for the six dominant species versus elevation brackets within the drawdown zone of Duncan Reservoir in 2012.**

All perennial species cover followed the predicted pattern of decreasing cover as the elevation decreased in the drawdown zone found for the six dominant species. No perennial species occurred within the 567.7 m bracket (566.7 to 567.7 m). All annual species had the reverse pattern with increasing cover as the elevation decreased from full-pool (576.7 m) (Figure 15).

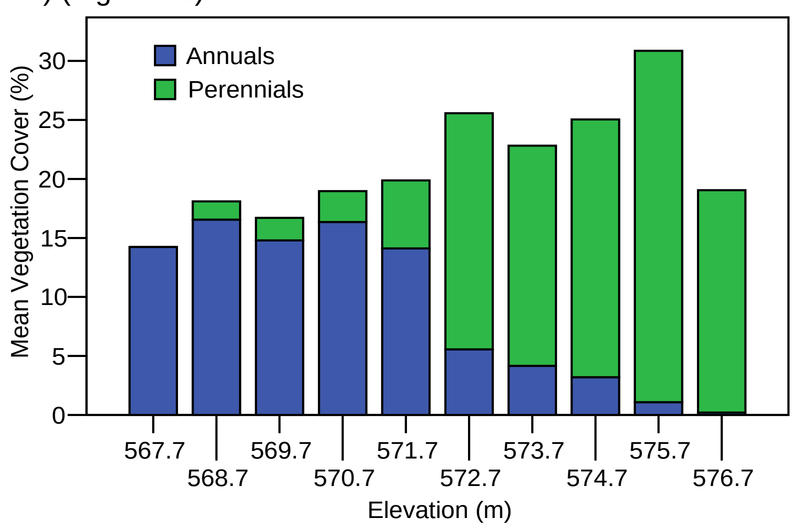


Figure 15: **The mean per cent cover for annuals and perennials and the elevation brackets at which they occurred within the Duncan Reservoir drawdown zone in 2012.**

There was significant variation in per cent cover for both annuals (Figure 16) and perennials (Figure 17). The high mean cover for annuals recorded at 569.7 m bracket may be influenced by all of the outliers with median cover actually lower than the elevation brackets above and below it (Figure 16). Elevation bracket 571.7 m for annuals also displays a number of quadrats with cover (outliers) greater than the 95th percentile. Perennial cover did not have as many outliers along the upper end of the elevation gradient (Figure 17). However, the lower elevations mean cover is skewed by the extreme outliers below 571.7 m elevation.

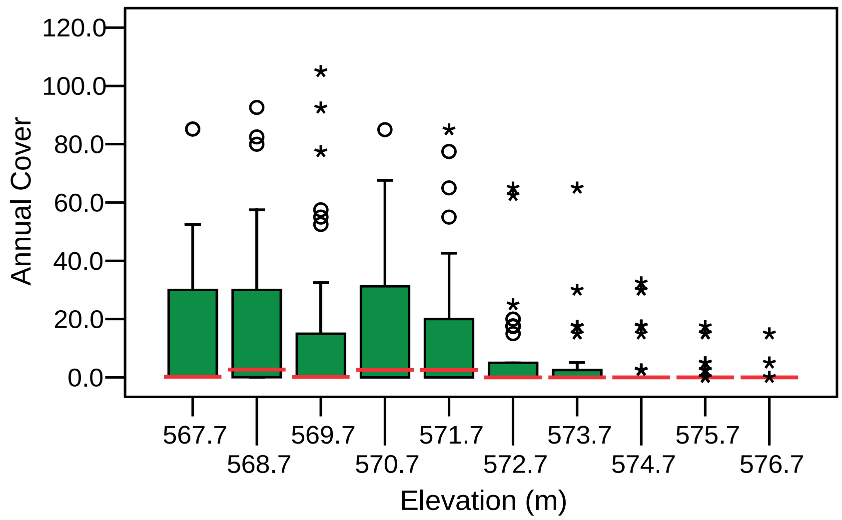


Figure 16: **Cumulative cover for all annual species versus elevation. Outliers (open circles) and extreme outliers (stars) are indicated on graph.**

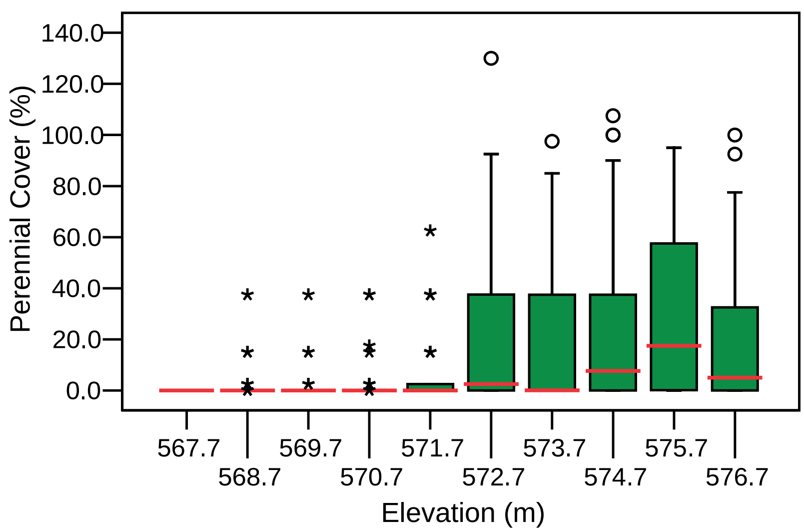


Figure 17: **Cumulative cover for all perennial species versus elevation.**

Comparison between 2009 and 2012 results found no significant difference (Table 24) in cover between the two years (Figure 18).

Table 24: Statistical results from ANOVA Paired sample T-Test mean vegetation cover for 2012 versus 2009.

	Annual	Perennial	Total
P	0.54	0.67	0.63
t	0.611	0.428	0.478
df	395	395	395

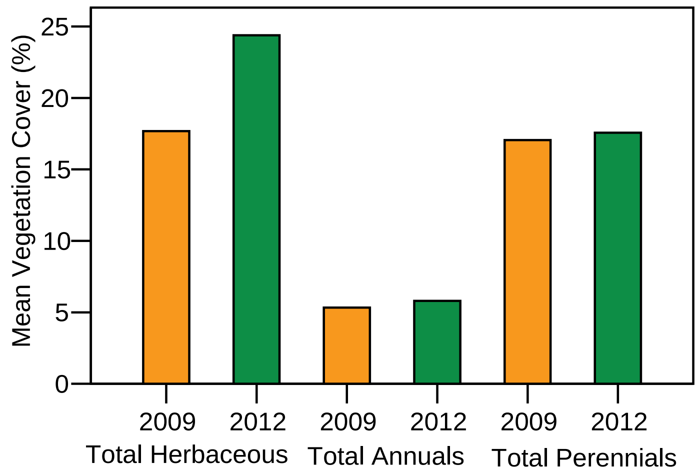


Figure 18: Paired quadrat sampling for mean vegetation cover in 2009 compared to 2012.

Height

Vegetation height at lower elevations zones was considerably less than for the same species at higher elevations. Reduced plant height usually indicates newly established individuals, especially for perennials. Heights also correlate to moisture availability and individual species phenology. Heights along the elevation gradient were highest above 571.7 m (bracket 572.7 = 571.7 to 572.7) for the three dominant perennial species and lowest for the three annual species (Figure 19). Perennial height was significantly higher than annual height (P <0.001, t = 16.3, df = 416). Beaked sedge, a perennial that did not occur below 570.7 m, had a significant increase in height between 571.7 m and 572.7 m (Scheffé multiple comparison P = 0.001, F = 5.59, df = 407). Mean height for the three dominant annual species followed a similar reverse pattern as seen with the vegetation cover. This did not follow the expected gradual reduction of vegetation height as elevation decreased from full-pool as observed in the field in 2009 and 2012. This relationship to elevation may be specific to the six dominant species. The relationship among height for all annual and perennial species was investigated further to see if a similar gradient relationship occurs when all herbaceous species were combined.

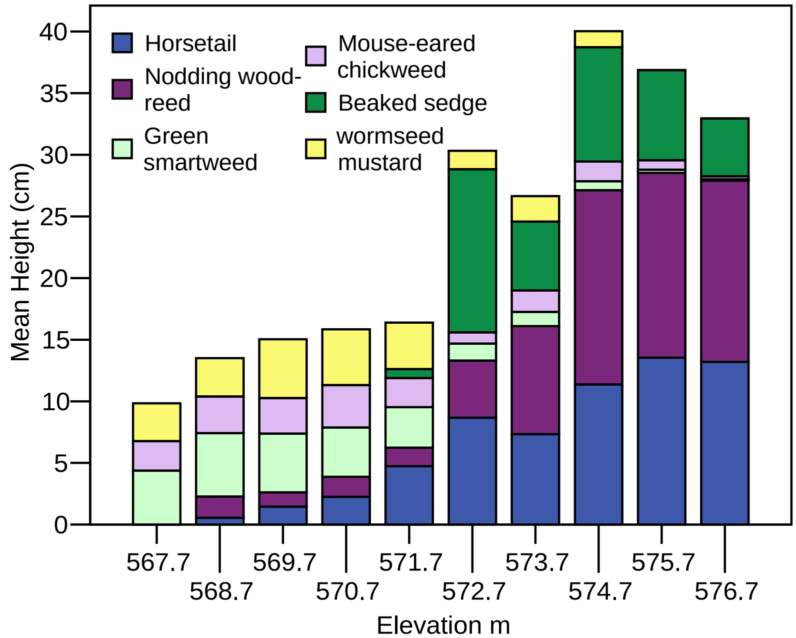


Figure 19: **Mean heights for the six dominant plant species in the drawdown zone of Duncan Reservoir and the elevation brackets at which they occurred in 2012.**

Total annual species mean heights did not show the same reverse gradient relationship as the three dominant species did. Mean height of both annual and perennial plants increased with elevation, with both peaking above 575.7 m to full-pool (Figure 20). Annual species height had significant difference between elevation (*P* <0.001, *F* = 10.2, *df* = 569). The multiple range test revealed elevation bracket below 572.7 m had significant difference in heights versus heights within the 576.7 m bracket (Table 25).

Perennials height was also significantly different between elevation brackets (*P* <0.001, *F* = 12.9, *df* = 569). The multiple range test revealed that perennials had mean heights significantly taller within the 572.7 bracket and higher to full-pool compared to elevation bracket 575.7 (Table 26). Both annuals and perennials had similar heights within 572.7 and 573.7 brackets and 574.7 and 575.7 m brackets. The contrast between the three dominant annual species and annual species in general shows how variation between individual species can change responses to the elevation gradient. For complete multiple range test results for both annuals and perennials see Appendix 4.

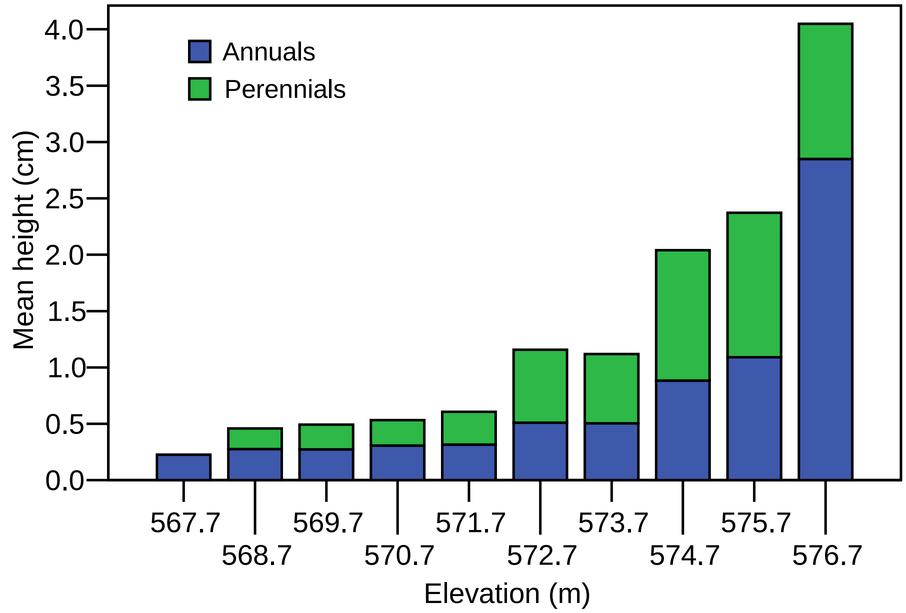


Figure 20: **Mean heights for annuals and perennials in 2012.**

Table 25: **Multiple comparison test (Scheffé) between mean annual heights and their occurrence within the elevation bracketed gradient compared to 576.7 m elevation bracket along the drawdown zone of the Duncan Reservoir.**

(I) Elevation Bracket	(J) Elevation Bracket	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
576.7	567.7	-14.0	2.84	0.004	-25.7	-2.3
	568.7	-16.3	2.86	0.000	-28.1	-4.5
	569.7	-14.6	3.08	0.008	-27.3	-1.9
	570.7	-16.2	2.92	0.000	-28.2	-4.1
	571.7	-13.9	2.95	0.009	-26.1	-1.7
	572.7	-5.36	2.70	0.913	-16.5	5.8
	573.7	-3.96	2.80	0.991	-15.5	7.6
	574.7	-2.99	2.65	0.998	-13.9	8.0
	575.7	-0.880	2.39	1.000	-10.7	9.0

The mean difference is significant at the .05 level.

Table 26: Multiple comparison test (Scheffé) between mean annual heights and their occurrence within the elevation bracketed gradient compared to 575.7 m elevation bracket along the drawdown zone of the Duncan Reservoir.

(I) Elevation Bracket	(J) Elevation Bracket	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
575.7	567.7	29.8	4.13	0.000	12.7	46.8
	568.7	28.2	4.16	0.000	11.0	45.4
	569.7	27.9	4.46	0.000	9.43	46.3
	570.7	27.2	4.25	0.000	9.60	44.7
	571.7	24.0	4.28	0.000	6.33	41.7
	572.7	9.77	3.94	0.724	-6.50	26.0
	573.7	11.1	4.08	0.592	-5.73	28.0
	574.7	7.93	3.88	0.898	-8.09	24.0
	576.7	10.9	3.37	0.314	-3.01	24.9

The mean difference is significant at the .05 level.

Comparison between 2009 and 2012 results for plant height found no significant difference between years (Table 27 and Figure 21).

Table 27: Statistical results from ANOVA Paired sample T-Test mean heights for 2012 versus 2009.

	Annual	Perennial	Total
P	0.061	0.37	0.80
t	-1.88	0.89	-0.247
df	302	302	302

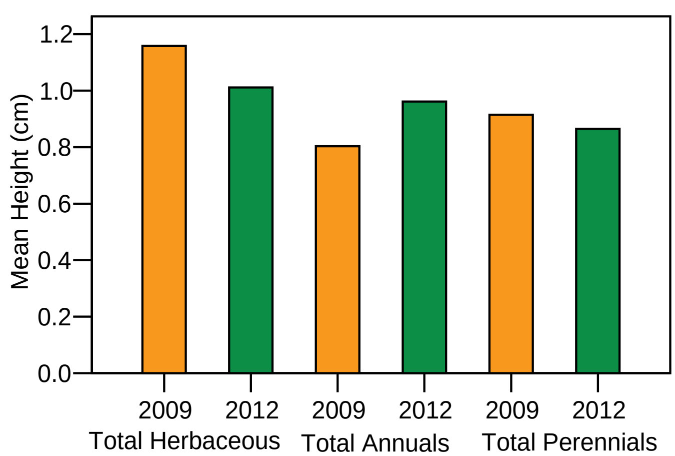


Figure 21: Paired quadrat sampling for heights in 2012 versus 2009.

Species Richness

There were 65 species recorded within the reservoir drawdown zone for the 12 sites sampled. These species were split into three categories: 43 herbs made up of forbs, graminoids, mosses (mosses grouped), and ferns and grouped as 'Herb'; 14 species of shrubs; and 8 species of trees. The complete list of species common and scientific names as well as codes (first 4 letters of genius and first 3 letters of species) are located in Appendix 1.

Species richness also followed an elevation gradient from high (fifty three species) within the first metre of full-pool elevation (576.7 m) to very low (six species) at 567.7 m elevation (Figure 22). Species richness was calculated for the one metre drop in elevation of all species that occurred within the one metre elevation zone. There were over twice as many species in the first meter drop in elevation (576.7 m to 575.7 m) compared to the second meter drop in elevation (575.7 m to 574.7 m). The top metre bracket (575.7 to 576.7 m) is the zone where the majority of the tree and shrub species occurred. From 575.7 m to 566.7 m, there was a gradual decline in species richness from twenty five species to six species. There was variation between elevation brackets 568.7 to 571.7 m but the trend was a decline in species richness along the elevation gradient.

Comparison between 2009 and 2012 showed there was a decrease in species richness from 2009 measured within first metre drop in elevation with 59 species (2009) compared to 53 species (2012). The same pattern can be seen for all of the elevation brackets accept for the 569.7 m where 2012 matches 2009 for species richness (11 species).

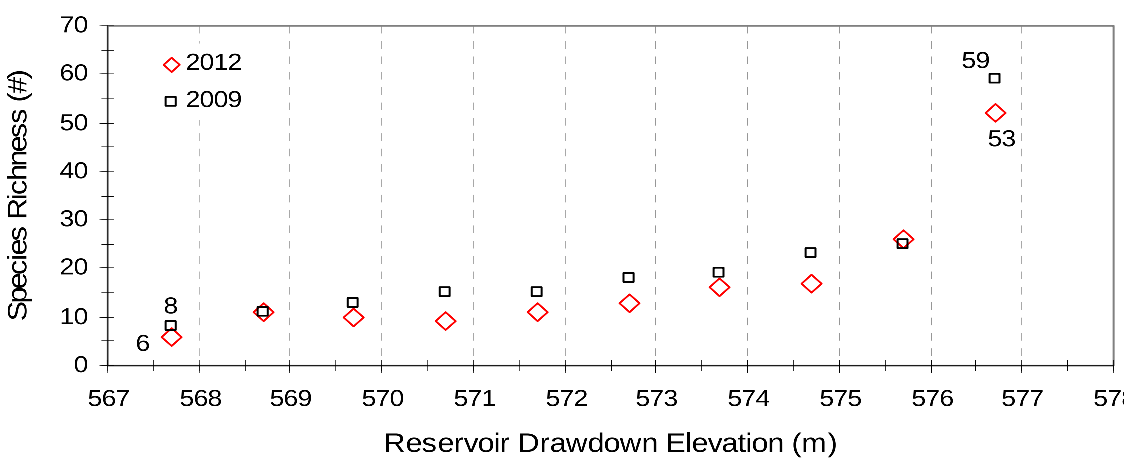


Figure 22: **Species richness versus elevation in the Duncan Reservoir drawdown zone in 2012 and 2009. The number of plant species is next to the data point on the graph for the high (53, 59) and low (6, 8) data points. Reservoir elevations are in one meter increments, starting at full-pool (576.7 m) and decreasing to 10 metre (566.7 m) below full-pool.**

The change from 2009 to 2012 species richness versus one metre elevation brackets was significantly different (P = 0.001, t = -4.59, df = 9) with count data transformed using square root transformation.

The above assessments recorded the actual count of species occurring within each metre elevation drop and not mean richness by quadrat data. Utilizing the number of species per quadrate results in data converted to means, which introduces variation associated with mean populations but allows it to be used when developing models and hypothesis testing. Because model assessment requires data measured within quadrats (greater number of data per elevation bracket than one as the above assessment used), species richness was also assessed by quadrat richness versus elevation.

The gradient is not as apparent for mean quadrat counts as when actual species richness counts were used (Figure 23). Species richness was higher in 2009 (71 species) compared to 2012 (65 species). The large increase in species richness in the mid-elevation zone found in 2009 was no longer present in 2012. Rather, there was a flatter s-shaped distribution of species richness in 2012. There was a gradual decrease in species richness to 572.7 (the bottom of 1 m elevation bracket 573.7 m) shown with a green dash line with arrow in graph, but then a slight increase in species richness occurs and flattens out between 571.7 m and 568.7 m (green dash line in Figure 23). Statistical analysis utilizing paired samples test T-Test found no significant difference between years (P = 0.096, t = 1.670, df = 334) when count data was transformed using square root transformation. It was graphed using mean species richness (count) in Figure 23.

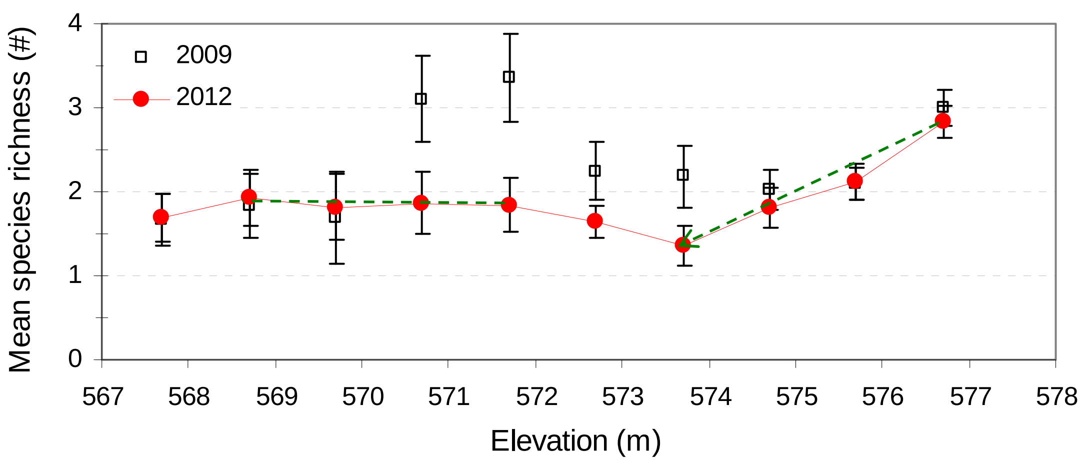


Figure 23: **Mean (± s.e.) species richness (count) versus elevation for 2009 and 2012. The green dashed lines show the decrease in richness for the higher elevations and the area where no significant increase or decrease occurred for the lower elevations. Note 2012 does not have the huge increase at elevation brackets 570.7 m and 571.7 m as 2009 did.**

3.4.2 Site

There was a significant difference between sites in 2012 (**Error! Not a valid bookmark self-reference.**, P <0.001, F = 14.6, df = 571). Sites 6 and 7 were significantly different from Sites 1, 2, 3, 4, 5, and 13. Site 13 was significantly different from Sites, 6, 7, 9, 10, 11, and 12 (Post Hoc test – Scheffé multiple comparisons results are in Appendix 4.

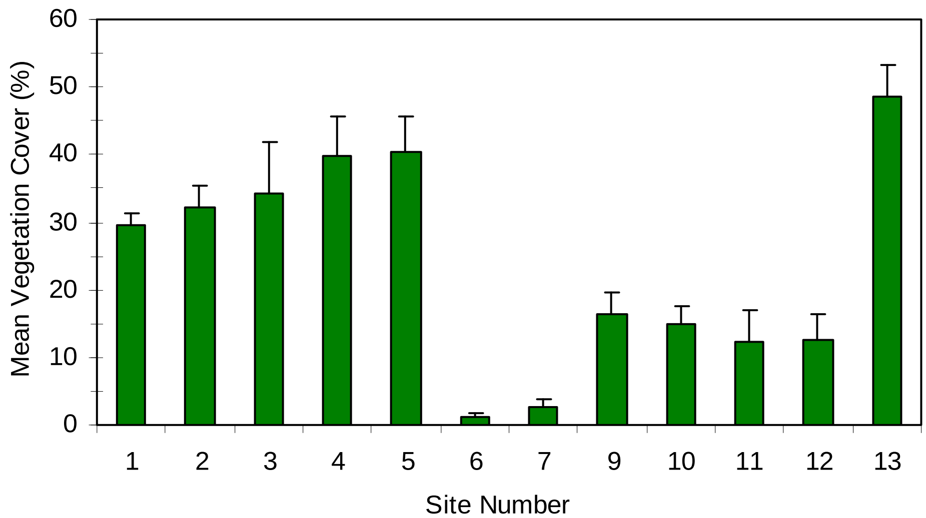


Figure 24 **Total mean (+ s.e.) vegetation cover for each site 2012.**

To compare analyses at the site level between 2009 and 2012, a reduced data set was required to match quadrats (Figure 25). Overall, there was no significant different between the two years (P = 0.061, t = 1.88, df = 305).

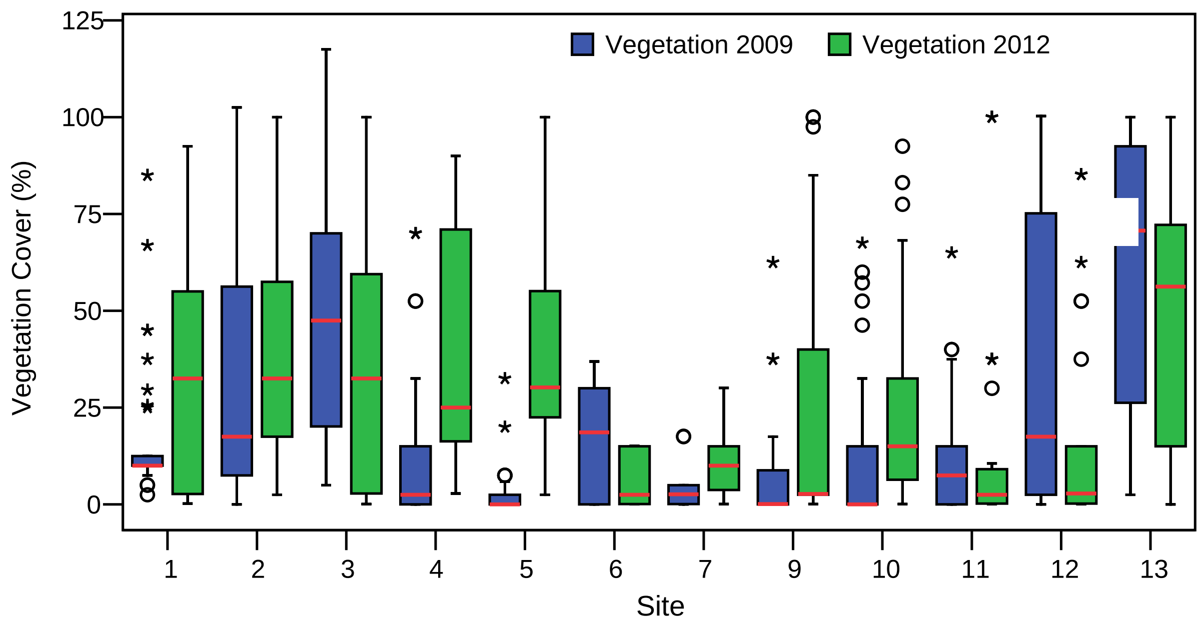


Figure 25: **Cumulative vegetation cover by site for 2009 and 2012. Greater than 100 per cent cover occurs when layers of vegetation occur.**

Richness significantly differed among sites (P <0.001, F = 32.5, df = 571). Species richness was split between the dam end of the reservoir (Sites 1, 2, 3, 4, and 5) and the delta end of the reservoir (Sites 7, 9, 10, 11, 12, and 13). Site 6 was the clear division between the two reservoir positions (Figure 26). Comparison between sites showed that there were significant differences for Sites 6 and 7 compared to Sites 1, 2, 3, 4, and 5 (lower position of reservoir), and Sites 11 and 13 for the upper reservoir position. Site 13 was significantly different from Sites 1, 6, 7, and 9. For a complete list of Post Hoc test – Scheffé multiple comparisons results see Appendix 4.

There was no significant difference between species richness in 2012 compared to 2009 (P = 0.096, t = 1.67, df = 334). Comparison between years shows a similar pattern for downstream, middle, and upstream sites (Figure 27). Richness is lower or similar for all sites except Sites 10 and 11, which had higher richness in 2012. Site 10 is on the east side and Site 11 is across from it on the west side of the reservoir. There was significance difference between years for these two sites. Site 1 and Site 13 had significantly lower richness in 2012 compared to 2009 site richness (P = 0.001, t = 3.46, df = 38 and P < 0.001, t = 4.70, df = 49 respectively). There was no significant difference by site between years for the remaining sites.

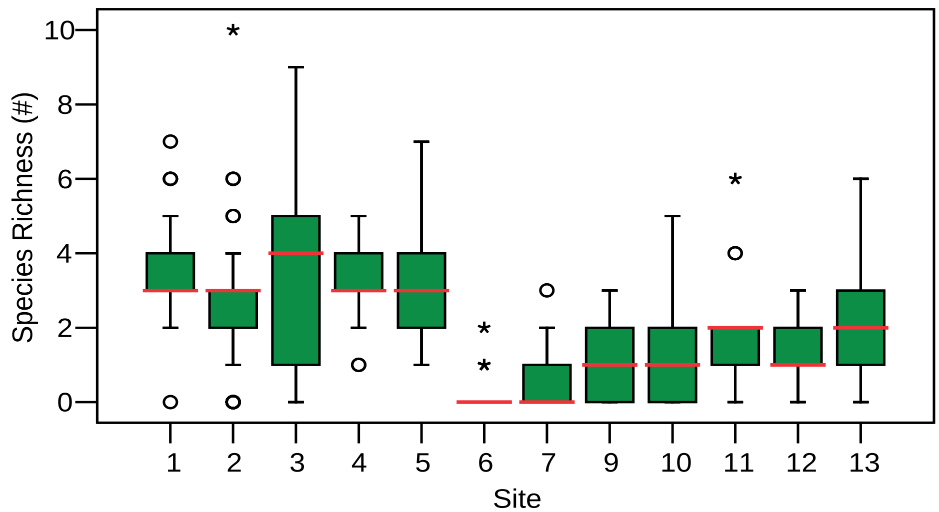


Figure 26: Species richness measured within quadrats by site in 2012.

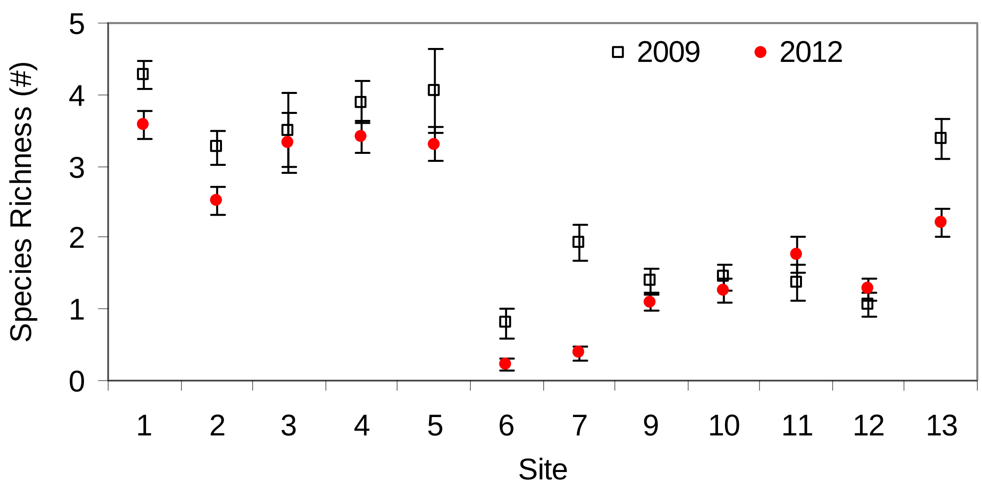


Figure 27: Mean (± s.e.) species richness by site for 2009 and 2012.

3.4.3 Substrate

Substrate texture was found to be significantly different between 2009 and 2012 (P < 0.001, t = -3.96 and df = 2294) (Figure 28). Variation between sites occurred but most of the sites had an increase in particle size compared to 2009. Site 13 was the exception with a decrease in particle size. Sites 1 and 9 also had slight decreases in particle size.

Vegetation abundances were strongly correlated (P<0.001, F = 2.52, df = 571) with the substrate texture index across the quadrats 2012 (Figure 29A). Species richness did not show as clear of a response but had a significant correlation (P < 0.001, F = 3.47, and df = 571) (Figure 29B). As substrate texture increases species richness declines.

There were six top dominant species analyzed for abundance versus substrate texture in 2009 (Polzin et al. 2010). These were common horse tail (*Equisetum arvense),* beaked sedge *(Carex utriculata),* silver hairgrass (*Aira caryophyllea),* nodding wood-reed *(Cinna latifolia),* lamb's-quarters (*Chenopodium album)*, and green smartweed (*Polygonum lapathifolium*). There was a shift in dominant species in 2012 with four of the six remaining though in slightly different order (see Table 23). The six dominant species in 2009 had significant correlation with substrate texture with decreasing cover with increasing substrate texture index. Two of the dominant six species in 2012 that were not part of the top six dominant species in 2009; mouse-eared chickweed (*Cerastium vulgatum*) and wormseed mustard (*Erysimum cheiranthoides)*, replacing silver hairgrass and lamb's-quarters. Therefore, they were graphed and analysed in 2012 (Figure 30). Mouse-eared chickweed had a reverse significant correlation with increasing cover with increasing substrate texture index (P = 0.001, F = 2.40, df = 105) (Figure 30A). Wormseed mustard did not have a significant correlation with substrate texture size making it equally likely to establish in fine or courser substrate texture; however, there was a slight trend for higher cover in courser substrate (Figure 30B).

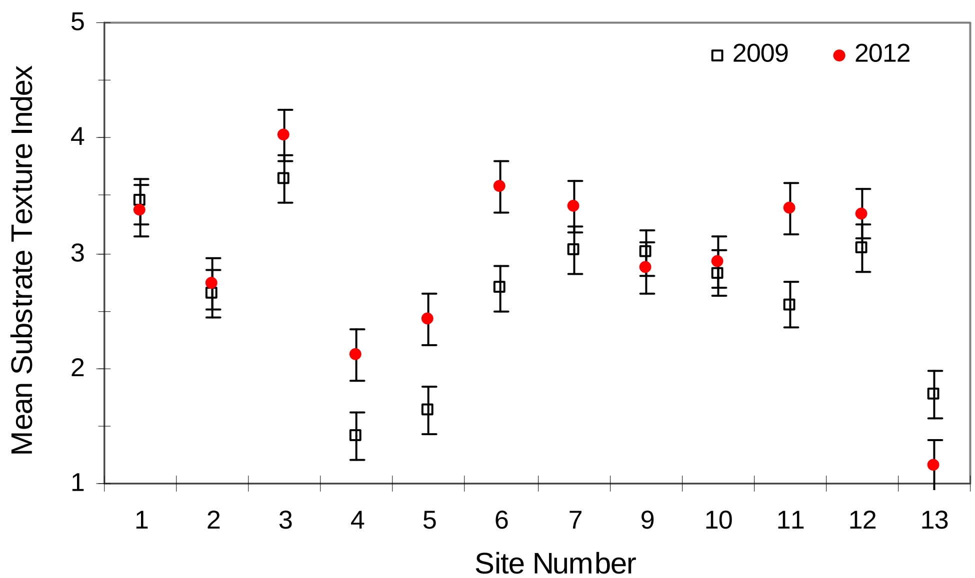


Figure 28: Mean (± s.e.) substrate texture index (1 = silt (very fine) to 5 = bolder (very coarse)) versus site for 2009 and 2012.

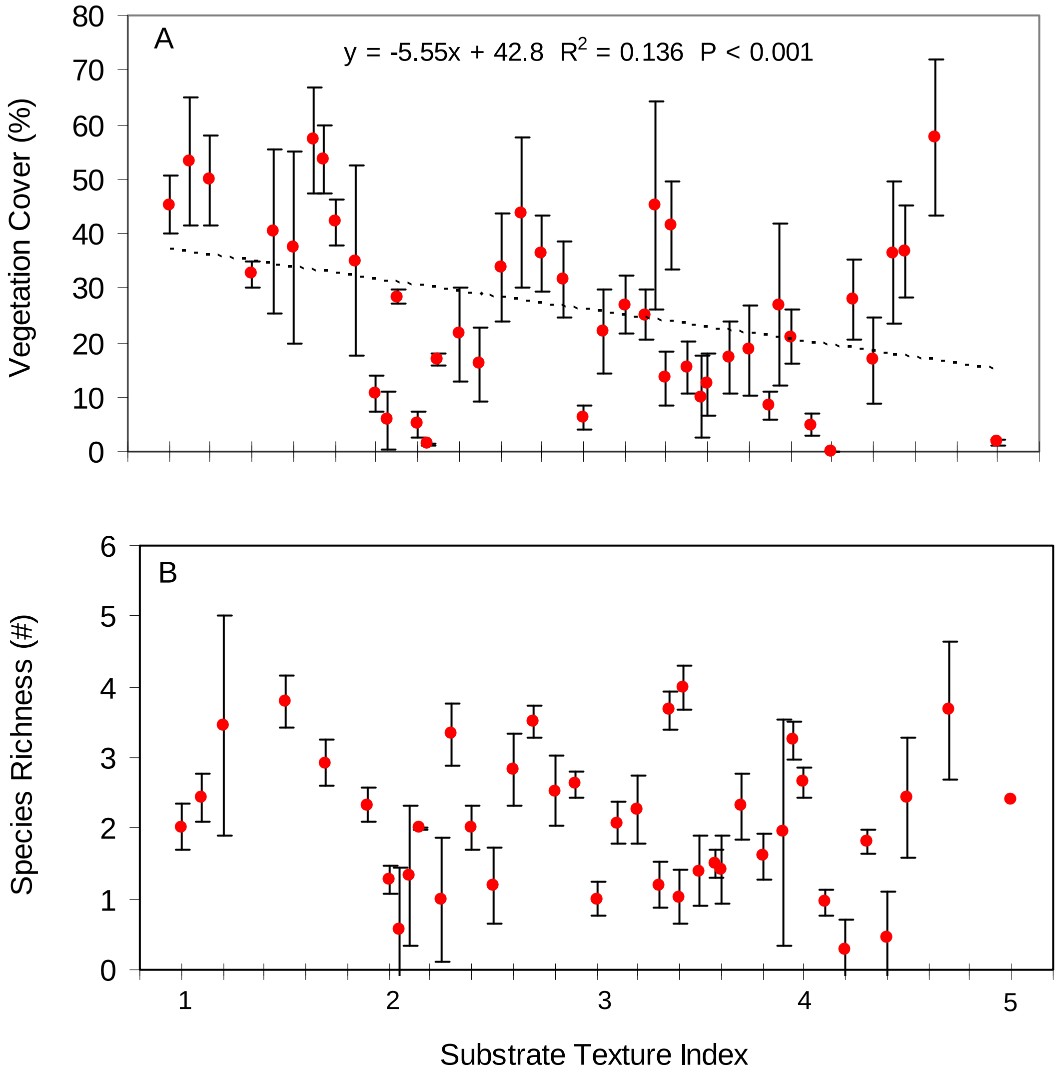


Figure 29: **Mean (± s.e.) vegetation cover (A) species richness (B) versus the substrate texture index for all sites in the drawdown zone of Duncan reservoir.**

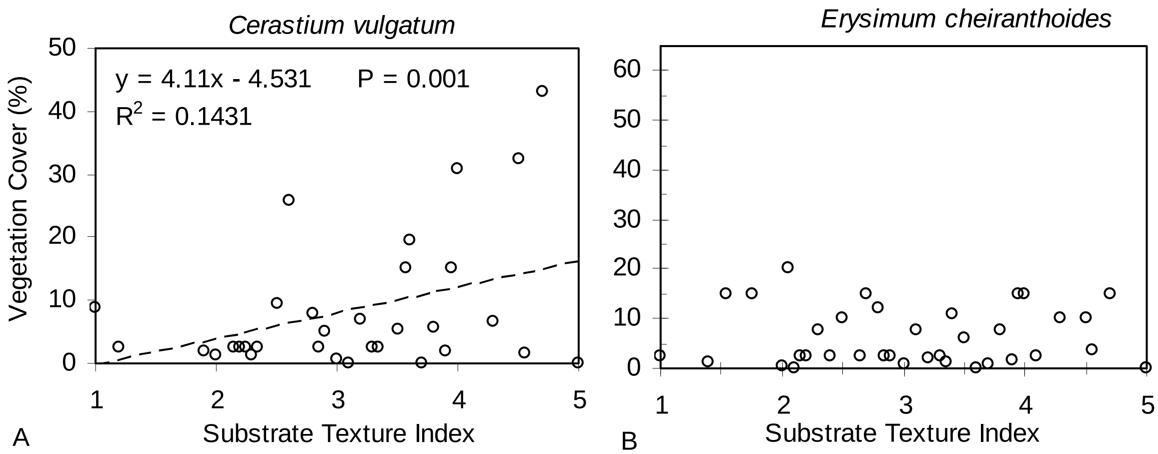


Figure 30: **Vegetation cover (per cent cover) versus substrate texture indices for the two new species in 2012 two of the six most common (# of occurrences) and abundant (per cent cover) in the drawdown zone of Duncan Reservoir.**

Substrate texture index showed a steady increase of particle size with decreasing elevation (Figure 31). There was a significant correlation for substrate by elevation (*P*<0.001, *F* = 4.09, *df* = 571) indicating a strong association of about 61 per cent correspondence.

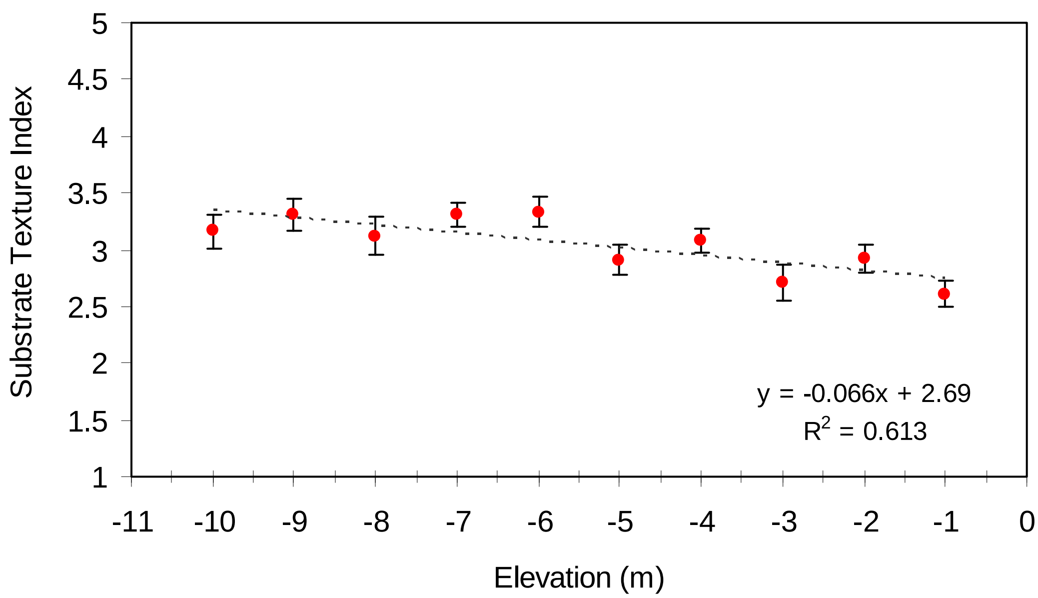


Figure 31: **Mean (± s.e.) substrate texture index versus elevation grouped into 1 m elevational intervals.**

Correlation tests for the other three minor factors identified in 2009; slope, aspect, and distance were completed. All tests had an N of 572. Both vegetation cover and species richness had highly significant correlation with slope (*P*<0.001). Vegetation cover had significant correlation with aspect (*P*<0.001) while species richness did not (*P* = 0.456).

There was no significant correlation between distance and vegetation cover and species richness (*P* = 0.749 and *P* = 0.052 respectively).

3.5 Distributional Patterns by Site

As another means of simultaneously considering vegetation abundance and species richness, the mean values for these two measures were plotted for each site (Figure 32). This graphical approach is similar to ordination, although only two measures are included. Along with the plotting, we have identified apparent clusters of sites with similar vegetation characteristics. This was noted during variable assessment with site as a factor above. This plotting suggests similarity of neighbouring sites and a variation along the longitudinal reservoir corridor. Thus, Sites 1, 3, 4, and 5 were quite similar and were situated at the downstream (dam) end of the reservoir. Site 2 was relatively similar to Sites 1 and 3 with respect to vegetation abundance but species richness was lower. Sites 6 and 7 were relatively similar, with very low vegetation abundance and species richness and occurred at the middle region of the reservoir. Sites 9 through 12 were apparently relatively similar at the upstream end of the reservoir, even though these sites occurred along both sides of the reservoir. Finally, Site 13 was relatively unique, with high vegetation abundance but moderate species richness.

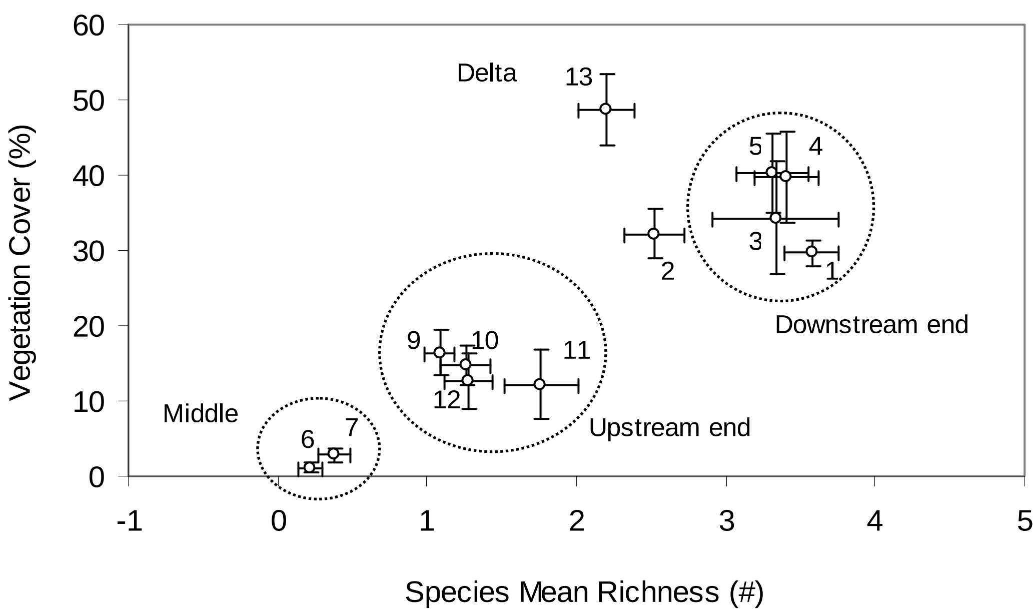


Figure 32: Mean (± s.e.) vegetation cumulative per cent cover versus mean (± s.e.) species richness for quadrats at 12 sites (site # next to point) in the drawdown zone of Duncan Reservoir. Apparently similar sites are enclosed in the dashed circles and ovals.

As noted earlier species mean richness at the quadrat sampling level has some problems associated with it. When actual counts of species for each site are used a different pattern emerges (Figure 33). The downstream sites are not as tightly grouped with Site 2 grouped with Sites 1 and 3. Sites 4 and 5 have the similar vegetation cover but species richness is further apart (Site 4 with 14 species and Site 5 with 17 species). The downstream end could be grouped by similar richness, which split the downstream end into two groups, Sites 1, 2, and 3 together and Sites 4 and 5 together by similar cover. The upstream end has Sites 7, 9, 11, and 12 loosely grouped with Site 10 with similar cover as the upstream sites, but similar species richness with the downstream end sites. Site 6 is not similar to any other sites for cover or richness.

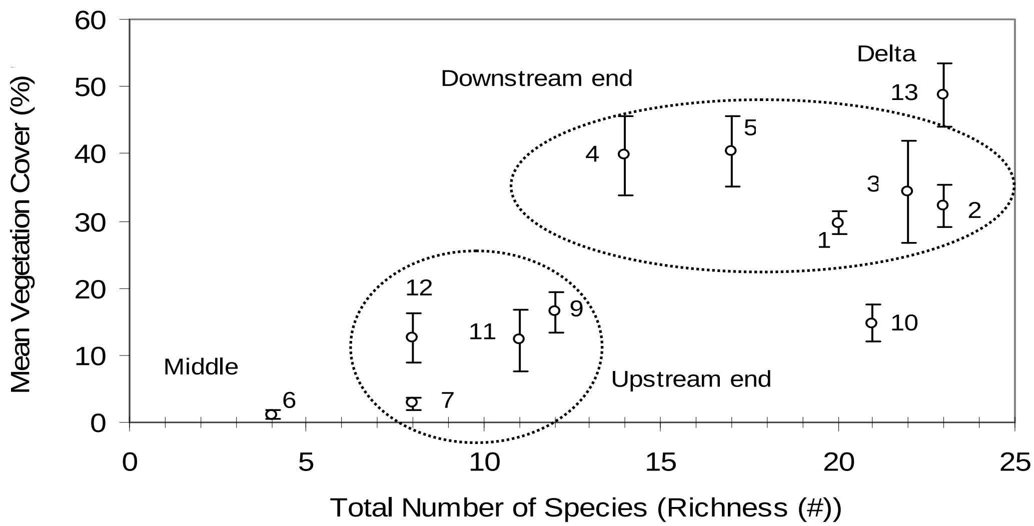


Figure 33: **Mean (± s.e.) vegetation cumulative per cent cover versus actual number of species (richness for site) at 12 sites (site # next to point) in the drawdown zone of Duncan Reservoir. Apparently similar sites are enclosed in the dashed circles and ovals.**

Square root transformation is used for whole number count data and was used for statistical analysis involving species richness (Osborne 2002). The transformed data for the actual number of species per site resulted in tighter groups without changing the correlation between sites (Figure 34). Site 13 moves into the downstream end though it is at the delta end of the reservoir. Site 10 is still similar to the upstream end sites for cover but similar to the downstream end for species richness and Site 6 does not fit within any group.

Integrative Measure of Biodiversity

The Shannon-Wiener (H’) or “Shannon” indices for the sites was completed in 2012 to provide a measure of biodiversity. This index varied across the sites, with the lowest (Site 6; H = 0.001) having a two and half order magnitude difference between the highest (Site 5; H = 0.808) (Figure 35). The highest H values were observed for Sites 1 through 5, near the downstream (dam) end of the Duncan Reservoir. Site 13 transect lines did not cover a 10 m change in elevation so caution should be used with direct comparison between it and the other sites. There appears to be a longitudinal pattern in 2012, which was not apparent in 2009 (Figure 35). Values near zero indicate very low diversity (site dominated by one or two species) while higher values indicate a more even occurrence among species. In 2009 Shannon-Wiener index covered a range from 0 – 2.6 while 2012 the scale is less than 1. This indicates that biodiversity has decreased along the reservoir.

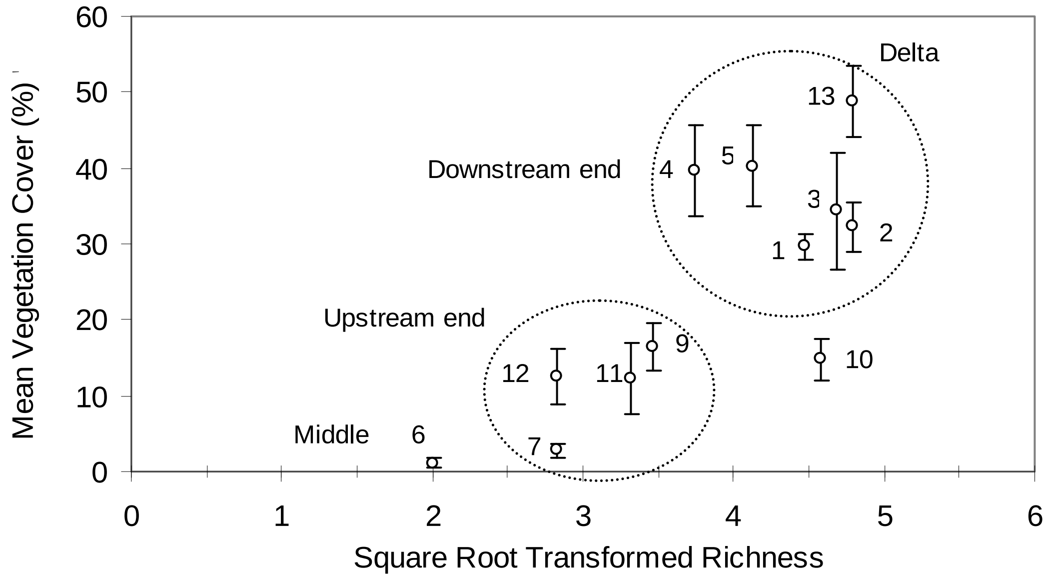


Figure 34: **Mean (± s.e.) vegetation cumulative per cent cover versus square root transformed actual species richness per site (site # next to point) in the drawdown zone of Duncan Reservoir. Apparently similar sites are enclosed in the dashed circles and ovals.**

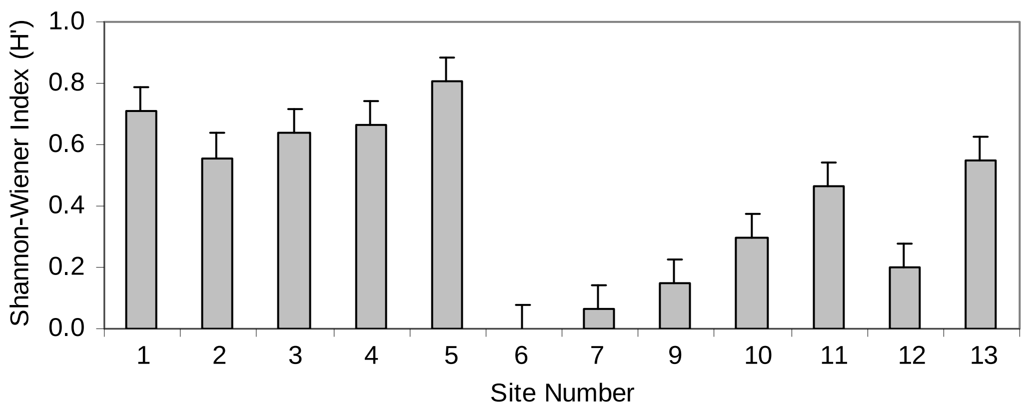


Figure 35: **Mean (+ s.e.) Shannon-Wiener indices of biodiversity (*H’*) for the 12 sites in the study area (original Site 8 was not sampled in this study).**

The pattern for diversity across varying elevations (Figure 36) was similar to that for species richness (Figure 23). Given the importance of richness in generating the Shannon index, this was expected. However, a similar increase in species richness with quadrat data at the lower elevation bracket occurs with biodiversity as well.

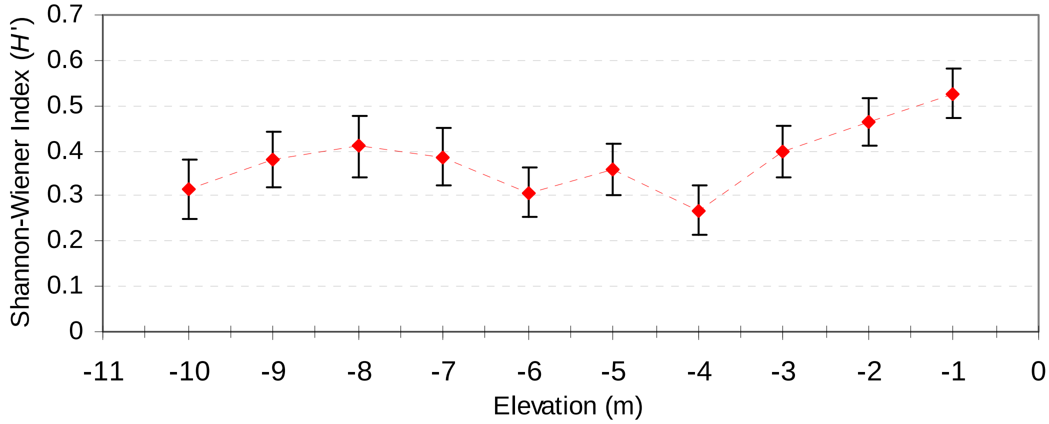


Figure 36: Mean (± s.e.) biodiversity (Shannon-Wiener diversity (*H'*)) versus elevation 2012.

4.0 DISCUSSION

The DDMMON#8-2 study is designed to sample and analyze the conditions of vegetation communities in years 1 (baseline data) 4, 7, and 10 of the monitoring period. Monitoring will enable tracking of potential changes that may occur under the implementation of operating alternative S73 (Alt S73) within the riparian vegetation community in the drawdown zone of the Duncan Reservoir. The two null hypotheses to be tested during this monitoring program are:

- H_{01}: Alt S73 will not result in decreases to the area and alterations in the species composition of both wetland and riparian vegetation communities; and
- H_{02}: Reservoir elevations do not affect riparian distribution and abundance through the duration and frequency of root- and shoot-zone flooding.

These hypotheses will be more formally tested after the year 7 sampling. In this Year 4 report, we present the data collected and provide descriptive statistics with limited analyses. We continued to consider the physical factors that were identified in 2009 as being associated with the occurrence and abundances of the different plant species and communities.

This Duncan Reservoir study investigated the draw-down zone from full-pool (576.7 m) to 10 m below full-pool (566.7 m). The two main objectives for 2012 monitoring year were:

1. Map the distribution of wetland and riparian vegetation within the drawdown zone of Duncan Reservoir using aerial photography; and
2. Monitor changes over time in the area coverage and plant species composition of vegetated communities within the drawdown zone of Duncan Reservoir under operating regime Alt S73.

A third objective is to provide the basis for assessing potential wildlife community changes resulting from the WUP constraints under Alt S73. This analysis will involve the multiple-year data, after all of the sampling years.

4.1 Vegetation Mapping

Vegetation mapping in 2012 involved change-detection from 2009 distributions. One notable change was the dominant species for four plant communities. Three of these communities were replaced with new dominant species that were present in 2009 but usually as second or third dominant species. One community type no longer present had *Centaurea maculosa* (spotted knapweed) as the number one dominant species. This exotic noxious weed occurred within the drawdown zone at Sites 2, 7, and 10 in 2009 adjacent to full-pool zone. In 2012, it was no longer one of the three dominant species at Sites 2 and 7, and at Site 10 it went from the number one dominant species to third dominant occurring in H9 community. The inundation durations within the first metre below the full-pool during the 2009 to 2011 growing seasons appears to have reduced spotted knapweed within the drawdown zone. We suggested in 2009 that *C. maculosa* could not tolerate long inundation times as it occurred only where ground was exposed 100 per cent of the time in 2009. The fourth community was *Populus trichocarpa* (< 0.5 m tall) Herb vegetation type. These polygons had changed to ‘Shrub’ vegetation type, community 1 (SH1) where *P. trichocarpa* was greater than 50 cm and less than 200 cm tall. This change represented growth of these plants to produce a transition from seedlings or small saplings, to larger saplings that even approached tree size.

Change was apparent across the two sampling years but this was somewhat ambiguous and statistical effects were slight. The area covered by Herb-type vegetation decreased in 2012 from 85.40 ha in 2009 to 75.45 ha in 2012. In contrast, the shrub-type vegetation increased from 1.52 ha in 2009 to 2.76 ha in 2012. The area where woody species expanded was adjacent to the full-pool shoreline, and particularly in the area exposed for 85% of the growing season. This overall expansion was not observed at all individual sites and at some sites this band involved narrow zone that was often occupied by woody debris. During intervals when the reservoir is at full-pool, the woody debris may reduce woody vegetation through scour, which is induced by wave action. Additionally, first year establishment of woody species in this band may end up under woody debris once the water recedes.

The area for vegetation type Bare 2 (B2), which had very sparse vegetation, also increased from 0.11 ha in 2009 to 7.91 ha in 2012. This was due to air photo interpretation difference from 2009 compared to 2012. The 2009 air photos where taken when vegetation was just emerging because of a cold late spring in 2009. This resulted in very faint vegetation colour on the photos. Ground truthing and transect line data were used to help in the delineation process. It was assumed that if the photo acquisition had occurred later in the growth cycle that some of the areas delineated as Herb would have shown denser vegetation cover. However, the 2012 clearly showed these same areas with similar cover recorded on the ground in 2009 as in 2012 should have been classified as B2 and not Herb as bare ground was the dominant cover for these polygons. Combining vegetation type B2 with other vegetation types resulted in very similar vegetated area between years (86.3 ha in 2012 and 87.40 ha in 2009). This indicates that the overall area with some vegetation cover changed slightly once compensation for difficult interpretation of 2009 air photos was taken into account. There was a net gain of bare ground (B1) of 0.76 ha in 2012. This gain in bare ground occurred in vegetated polygons adjacent to B1 in 2009 that were reduced slightly in size in 2012 at some sites. Site 10 had the largest increase in bare ground area that was attributed to mechanical removal of woody debris. This resulted in resurfacing of the area and it is expected that vegetation will re-establish in these areas in subsequent years.

Site 6 was identified as a ‘high’ potential for enhancement in the TOR (BC Hydro 2009) but it was the site with the highest proportion of bare ground and the lowest cover of vegetation when it occurred. It was originally identified by Moody (2002) for potential enhancement but it appears that it has changed since then. There was no change in cover from 2009 suggesting that the changes that occurred at this site were before Alt-S73. Of the sites monitored it has a relatively low potential for enhancement at this time.

Vegetation mapping confirmed a very strong correlation between vegetation cover and reservoir elevation. Elevation is directly related to inundation time. Subsequently, length of inundation explained approximately 90 per cent of the variation in vegetation cover by area for the study sites. Because of this strong correlation it would be beneficial to the project to complete a none scheduled field survey in 2013 to monitor 575.7 m to 576.7 m elevation bracket zone to record if any, change that may have occurred resulting from the 2012 reservoir levels initiated to minimize flooding downstream of the dam.

Based on two years of data collection, H_{01} can not be supported or rejected at this interim time. Slight decreases to vegetated area and alterations in species composition have occurred resulting in changes in riparian species distribution and abundance. This is based on the baseline data collected in 2009 which was after the first year of Alt S73 so it is unknown what the vegetation area and community types were pre Alt S73. However, the change of 0.74 per cent increase in bare ground area is not significant. This slight change in area cannot be attributed to any specific factor, including Alt S73, especially with only two sampling periods. At the mapping scale, H_{02} is not supported: reservoir elevations did affect riparian distribution and abundance through the duration and frequency of root- and shoot-zone flooding. Elevation strongly affects riparian distribution and abundance accounting for 89.7 per cent of the variation in vegetation cover by area for the reservoir.

4.2 Vegetation Analysis: Vegetation Cover and Species Richness

Vegetation abundance, as measured by per cent vegetation cover, and species richness (the number of different species within an area) were the two primary measures for assessing vegetation within the reservoir drawdown zone along permanent transect lines utilizing quadrat sampling. Site was the term for each of the 12 spatial locations and study areas along the reservoir, at which two to four transects were implemented. This represented one of the physical factors that were investigated, and all of the quadrats from the two or more transects were considered for each particular site. Twelve sites were investigated, but we retained previous numbering and thus included Sites 1 through 7, and 9 through 13 consistent with 2009.

Analysis of 2012 data focused on important factors identified in 2009. The three main factors influencing these metrics identified in 2009 data were 1) elevation, 2) site, and 3) substrate. Slope, aspect, and distance were also considered as factors for hypothesis testing (Polzin et al. 2010) in 2009 but were not the focus for 2012 analysis.

<u>Comparison between 2009 and 2012</u>

Vegetation abundance for the study area was higher in 2012 compared to 2009 (field sampling level) and species richness declined significantly versus elevation by area. Species richness measured at the quadrat level declined slightly but not significantly from 2009.

Elevation was one of the physical factors identified in 2009 and investigated in 2012. There was a general decline in vegetation cover and richness with decreasing elevation from full pool. There was an increase in vegetation abundance between the first and second metre drop in elevation compared with the first metre drop in elevation bracket zone. A combination of factors affecting these two zones resulted in the increase at the second metre drop in elevation. One factor was the amount of woody debris on some transects adjacent to the full-pool edge. This reduced the amount of available open ground for vegetation colonization. A second factor at some sites within these two zones was the increase in woody species in the first metre drop in elevation zone. Woody vegetation between 0.5 and 2.0 m in height occurred in some of these areas. Shading by the larger woody vegetation also limited colonization under the woody vegetation to shade tolerant species with low density thereby reducing overall cover though there was increase species richness in the upper zone.

Species richness clearly decreased with lowering elevation gradient in both years. Richness decreased significantly in 2012 compared to 2009 when species counts for elevation brackets were used (count was transformed using square root transformation for statistical analysis). In 2009, species richness dropped from 59 species within the first metre drop in elevation to 25 species within the second metre drop from full-pool. In 2012, the species richness over the same elevation brackets was 53 to 26 species. In 2012, the change over the same interval was a similar pattern with 53 to 26 species. Overall a similar pattern was observed for both years with some variability.

Site was one of the main factors correlated to vegetation abundance and species richness (Polzin et al. 2010). There was significant difference among sites in 2012 but no significant difference between 2009 and 2012. The south end of the reservoir had consistently higher mean vegetation cover per site than the north end except for Site 13 which had the highest cover of all sites. Site 13 has very low (less than 10 per cent) fine substrate texture and transect lines did not cover the 10 m change in elevation as the lines would have been to long to sample realistically with the four lines needing to be over 800 m to 1,000 m long. This skews this site as all sites have higher vegetation cover at the upper elevation zones and lower vegetation cover as the reservoir elevation decreases. Considering information gathered to this time, it was expected that Site 13 should have the highest vegetation cover.

Sites 6 and 7 have very low vegetation cover with Site 6 having the lowest. This was similar to 2009. These two sites occur approximately at the mid-way point of the reservoir. All sites were selected from work completed in 2002. However, Site 6 was not confirmed as a suitable site prior to initiation of the study in 2009. It appears that by 2009 it was no longer a suitable site for this study, with steep slopes, coarse substrate texture, and almost completely devoid of vegetation in the drawdown zone. Site 7 was not as extreme, with no strong indicator as to why this site has significantly lower vegetation cover compared to other sites.

Species richness was also significantly different between sites with a similar pattern as vegetation cover except that Site 6 was the clear division between the south and north ends of the reservoir. There was no significant difference between years with a similar pattern noted in 2009.

Substrate texture index, one of the main factors correlated to vegetation abundance and species richness, was found to have changed significantly since 2009. Substrate texture index had an average increase in particle size compared to 2009 for most sites. Vegetation abundance was strongly correlated with substrate texture index with abundance decreasing as texture coarseness increased. In 2009 individual species displayed decreasing abundance with increasing substrate texture for the six dominant species tested. The six dominant species in 2012 had two species replacing two in 2009. These two new dominant species, mouse-eared chickweed and wormseed mustard (annuals) had a reverse correlation to the other four dominant species. The mouse-eared chickweed had a strong correlation of increased abundance to coarser substrate texture. Wormseed mustard did not have a strong correlation but a slight trend to increased cover as substrate texture increased. It had similar cover regardless of substrate texture. This particular species may be more affected by available moisture or only colonizes where moisture is available regardless of substrate texture. June had record precipitation, almost three times the historical average, which may have been responsible for the increase in cover by both of these species, moving them to the dominant species group. Also, the correlation to coarser texture may have been a factor in the move to dominant species since substrate texture had increased in coarseness in 2012.

The increase in substrate texture could indicate that scour and/or deposition is occurring at the study sites that has changed the substrate texture and may have the potential of changing the elevation gradient. However, no large scale gradient changes were noted. Rather, the change in substrate texture from scour and deposition is probably at a small scale, on the order of a few centimetres. This change has the potential to affect vegetation composition, cover, and species richness but not elevation at the one metre elevation increment scale being used in the study.

Distribution Patterns by Elevation

In 2009 there was a peak in vegetation abundance between 573.7 m and 572.7 m in the drawdown zone, similar to first metre drop. Site 13 contributed to the majority of this peak and when Site 13 vegetation cover was removed from the data set the peak disappeared. No peak occurred over this elevation interval in 2012, even with Site 13 included.. A change in sampling method in 2012 may account for this correction difference. In 2009, quadrat sampling was continuous along the transect lines. In 2012, quadrat sampling occurred at the beginning of a plant community, midway, and end. If the community covered a large area it was sampled every 10 or 20 m depending on the size. This resulted in a good representation of the community cover without having quadrats linked to the ones above and below. Site 13 was dominated by common horsetail and beaked sedge in 2009 and the four sampling transect lines may have over-represented this site. Results from 2012 has an increase in the same zone but not as exaggerated as 2009.

Vegetation cover from different community types also displayed a decline in complexity as elevation decreased. Tree, shrub, and herbaceous vegetation type occupied the first metre drop in elevation from full-pool. Shrub and herbaceous vegetation type occurred through the drop in elevation to 573.7 m. The remaining elevation gradient from 573.7 m to 566.7 m (10 m below full-pool) was occupied by herbaceous species. There was an increase in shrub and tree cover in 2012 compared to 2009. Shrubs recorded in 2009 had expanded in area and in height, resulting in some quadrats moving from herb (woody species < 0.5 m in height) to shrub quadrats.

The herbaceous community was split into annual and perennial species. Perennial species were most abundant at the higher elevations, near full-pool and their cover decreased with elevation drop. No perennials were observed between 567.7 m to 566.7 m elevation. Conversely, annuals were more abundant at the lower elevation, declining in abundance as elevation increased to full-pool. This inverse relationship occurs because as perennial cover decreases there is more open ground for establishment of annual species. Elevations below 571.7 m are mainly barren in the spring because of the long inundation time from the reservoir filling and draining. This open ground is readily available for annuals to be established, free from competition with established perennials. Many of the perennials that occur in this zone are grasses and herbaceous species that die back in the fall or have a basal rosette in the fall. Large established perennials like beaked sedge did not occur at the lower elevations although some other perennial species did occur.

Both annuals and perennials display greater growth rates, as measured by height, following the elevation gradient from full-pool. The tallest vegetation occurs at full-pool elevations dominated by perennials and heights decrease to 566.7 m elevation where only annuals occur. Heights are correlated to particular plant species growth habits. Many annual species have a growth habit shorter than many perennial species; subsequently annual species dominated the lower elevation zones.

Based on abundance and distribution, the six dominant species identified in 2012 were, in order: common horsetail, nodding wood-reed, green smartweed, mouse-eared chickweed, beaked sedge, and wormseed mustard. This is a change from the 2009 top five, in order: common horsetail, beaked sedge, silver hairgrass, nodding wood-weed and green smartweed. One factor that may have accounted for the change in the dominant species was the two metre reduction in elevation change that was sampled in 2012 (10 m change) versus 2009 (12 m change). Some transect lines were reduced by 100 to 200 m in length by the lower elevation gradient in 2012. The two metre difference was taken off the lower portion of transects, where only annuals grow, many of them weedy species quick to colonize bare ground.

Common horsetail ranked first both years but beaked sedge dropped to 5th from 2nd in abundance and silver hairgrass did not have sufficient abundance or distribution to be included in the top ranking. Beaked sedge may be a candidate as an indicator species for the new fill regime because of the decline in absolute abundance since 2009. When beaked sedge occurs below the first two metre drop in elevation they are mature clumps with many of the clumps raised above the substrate surface from erosion of the substrate from previous levels. The decline may indicate the erosion of the established communities. Monitoring in subsequent years will quantify if the Alt S73 regime is effectively reducing beaked sedge from some elevation zones.

Seasonal weather changes may also be a factor in this variation especially for the annuals and short lived perennials that establish in the fall and grow the following spring but never advance to established communities. The snow pack was above average this year with high precipitation levels in April and extreme precipitation in June resulting in a high precipitation spring during the colonization of the drawdown zone. This could have influenced species richness, reducing species by moisture tolerance or poor seed release during rain periods.

Mean species richness was analysed from quadrat sampling. These data can be utilized in hypothesis testing while the above analyses counts all species that occur within the data set for each elevation bracket resulting in only one number per elevation gradient. Species richness at the quadrat level showed an increase through the mid- to lower elevation zones where annuals and perennials overlap, resulting in a 3rd order polynomial best fit trend line. This contrasts with the overall decrease in species richness with elevation that occurred at the higher elevation zones. However, annual and perennial species overlap was counted at the elevation bracket level so this does not explain why there was an increase in this area compared to actual number of species occurring within the elevation bracket.

Species richness does not track how often the same species are being counted between quadrats within an elevation bracket. The first metre drop in elevation adjacent to full-pool had 53 species though the average number of species per quadrat for this bracket is just under three (2.83). In the second metre bracket there were 26 species recorded but the average richness by quadrat was 2.12. In the zone where richness increases after decreasing to an average of 1.36, actual species richness is 9 to 11 species but the mean richness in these elevation brackets is between 1.64 and 1.93. At the 10 m drop in elevation zone there is six species recorded but the mean richness is 1.69. Taking the mean number of species occurring within quadrats does not represent species richness, rather the average number of species recorded within quadrats at each elevation bracket. There was a slight species richness variation occurring in this zone as seen when the actual number of species that occur within an elevation bracket are counted. This occurred at the eight metre drop in elevation zone where species richness went from nine to 10 species and then to 11 species at the nine metre drop in elevation bracket before dropping to six species at the 10 m bracket.

The distribution partly reflects the timing of availability of viable seeds, which varies considerably by species. The lower zone area was colonized with more annuals at trace cover levels resulting in higher species richness with very marginal contribution to area cover. We thus observed that species richness displayed a similar response to elevation as vegetation abundance but with slightly higher richness at the lower elevation the adjacent seven metre elevation bracket.

Vegetation abundance and species richness showed similar trends as noted in 2009. This builds on the initial year of monitoring indication that H_{o2} is not supported as reservoir elevation does affect riparian abundance and species richness. There was a decline in species richness from 2009 and an increase in vegetation cover per field sampling by quadrat. The increase was slight and varied between sites. The sight increase may be mainly due to seasonal weather fluctuations; 2009 had a cold, late spring and 2012 had extreme precipitation levels in June and above average precipitation in April.

Distribution Patterns by Site

Plotting vegetation abundance (as measured by mean per cent cover) against mean species richness (within quadrats) by site suggested similarity among neighbouring sites and variation along the longitudinal reservoir corridor. The cluster of Sites 1, 3, 4, and 5 occurred along the downstream end of the reservoir. Together, they had the highest abundance and the highest species richness. Site 2, though in the same geographic area, was just outside of this group with similar abundance but lower species richness. The next group of similar sites for abundance and richness occurred at the upstream end of the reservoir, with Sites 9, 10, 11, and 12. These sites had lower abundance and richness compared to the downstream sites. The upstream group covered both sides of the reservoir with Sites 9 and 10 on the east side and Sites 11 and 12 on the west side. Sites 6 and 7 occurred in the middle region of the reservoir. Both had very low vegetation abundance and species richness. Site 13 stands alone with the highest vegetation abundance of all the sites but intermediate species richness. It was the only site occurring in the delta area of the reservoir and did not have the full 10 m drop in elevation for transect lines.

When actual species richness for each site was assessed, results were similar but there was some variation in the groupings. The downstream sites were similar and Site 13 was included in this group, with similar species richness and slightly higher vegetation cover. The upstream end of the reservoir no longer had Site 10 within the group as it was similar in cover but not richness. Site 6 was alone which reflects the 2009 assessment at that site. Site 6 had the fewest species (four) and lowest vegetation covers and would not be characterized as similar to Site 7 which had more vegetation cover near full-pool, but no vegetation at the lower elevations and double the species richness. The grouping by actual site richness appeared closer to what was observed in the field than the mean richness graph showed. This poses a problem in that there were only 12 data points for site richness and this would not be sufficient for modeling or hypothesis testing.

Observed abundance differences at the site level (upstream Sites, 9 to 12 were similar to sites 4 and 5) were consistent with the other analyses. Site 13, at the inflow delta displayed the greatest abundance despite not extending through the full 10 m elevational range. Site 13 was dominated by finer sediments, with silts and some sand/silt sections, and had the lowest slopes at <5 per cent. Both of these physical factors favour increased vegetation abundance across the study positions and would thus favour the increased vegetation at Site 13.

Species richness and diversity showed a similar longitudinal gradient from the downstream (dam) end of the reservoir to the upstream end. Diversity values support the pattern observed in the abundance versus richness plot. This is expected because diversity represents a combination of these two factors. Diversity was lower at the upstream end, with very low diversity and richness at Site 6, which was dominated by green smartweed. This was also where the abrupt drop in richness and abundance occurred. Diversity also shifted Site 13 into the upstream end cluster of sites similar to the shift noted when actual site richness values were used when graphing cover versus richness.

Site-level disturbance may account for the low abundance and richness observed in both years at Site 6. The original site selection was base on the 2002 assessment, which identified the site as having a high potential for enhancement (Moody 2002). Moody (2002) classified sites as high potential if slopes were < 10 per cent. The transect line established in 2009 had a 17 per cent slope and the additional transect line established in 2012 had an average slope of 29.5 per cent. There was no observational change in the transect line profile from 2009. Additionally, the locations of very small low density patches of vegetation in 2009 were still there in 2012 so scour and/deposition did not occur at a significant level that would impact vegetation abundance in the three years between sampling.

Site 13 was also unique with vegetation abundance greater than both the upstream and downstream ends of the reservoir, with intermediate species richness levels. Although diversity values were similar to the upstream sites, *H* was only slightly lower than Site 2 (*H* = 0.55 and 0.56 respectively). Site 13 had the greatest vegetation abundance, possibly due to high groundwater influence from Puddingbowl Creek, which washes over the site during spring freshet. Site 13 is also unique because it does not cover the 10 m drop in elevation and the associated reduction in vegetation cover at the lower elevations experienced by all of the other sampling sites. Three of the four 100 m long transect lines have a three metre drop in elevation and the fourth line had a five metre drop in elevation. The slopes for the four lines ranged from 2.7 per cent to 5.4 per cent.

Distribution Patterns by Substrate Texture

Vegetation abundance was correlated with the substrate texture index across the quadrats. Thus, abundance tended to be highest in quadrats with silt and sand substrate. Site 13 substrate texture index was 1 (silt) for three of the four transect lines and 1.7 for the fourth which may have contributed to the increased vegetation cover for this site. The remaining sites had sections along the line with silt and/sand but sites had a combination of all textures and were not dominated by silt like Site 13.

Species richness was also correlated with substrate texture but not as strongly correlated as vegetation abundance. Some species were strongly correlated with fine texture while other species were correlated with coarser substrate that had fines mixed with the larger coarser substrate. The change in dominant species may have been related to this variation within species. The two annual species that were dominant in 2012 and not in 2009 had a significant correlation (mouse-eared chickweed) and a trend (wormseed mustard) to increased vegetation cover with increased substrate coarseness. The significant increase to coarser substrate texture in 2012 may have contributed to the increased cover of these two species that displaced silver hairgrass and lamb's-quarters that had a very strong correlation to fine substrate texture (Polzin et al. 2010).

Substrate texture showed a strong correlation to elevation with particle size inversely proportional to elevation. Annuals dominate where substrate is the coarsest, at the lower elevations from 571.7 m to 566.7 m where cover is the lowest; particle size was at its greatest, and inundation times the longest (Figure 31).

Vegetation abundance, species richness and distribution patterns at sites showed similar trends as noted in 2009. This builds on the initial year of monitoring indication that H_{o2} is not supported. Reservoir elevation, substrate texture, as well as site are affecting distribution patterns and species richness. The other factors not extensively explored this season accounted for some of the variation as well with slope being a significant factor in 2012. Aspect and reservoir positions do not change between years and therefore they were not re-investigated in 2012 at an in-depth level but correlation tests found no correlation between species richness or vegetation cover with either of these two factors.

5.0 CONCLUSION

The vegetation in the Duncan Reservoir drawdown zone was similar to 2009 with a slight decrease in vegetation abundance by area monitored by aerial photography. There was a shift in community type with three new herbaceous communities and the reduction of four communities (herbaceous) from 2009. Area covered by vegetation was significantly correlated with reservoir elevation, which explained approximately 90 per cent of the variation of vegetated area within the study drawdown zone. The vegetation abundance was similar to 2009 with a slight increase in vegetation abundance by per cent cover monitored along transect lines. Species richness by elevation had a significant decrease compared to 2009 by area. At the quadrat level there was no significant difference but a slight decrease in richness occurred.

There were 65 species recorded in the study quadrats, with 43 herbaceous species including; graminoids, mosses, and ferns, 14 shrub species, and eight tree species. The 10 most abundant plant species were (sequentially):

1) *Equisetum arvense* (common horsetail);

2) *Cinna latifolia* (nodding wood-reed);
3) *Polygonium lapathifolium* (green smartweed);
4) *Cerastium vulgatum* (mouse-eared chickweed);
5) *Carex utriculata* (beaked sedge);
6) *Erysimum cheiranthoides (*wormseed mustard);
7) *Aira caryophyllea* (silver hairgrass);
8) *Oenothera villosa* (evening primrose);
9) *Collomia linearis* (narrow-leaved collomia); and
10) *Calamagrostis Canadensis* (blue-joint grass).

The total number of plant species decreased with decreasing elevation from full-pool. Many of the species occurring within the drawdown zone were annuals, including ruderal annuals which are typically weedy species with the capacity for prolific reproduction. *Centaurea maculsa* (spotted knapweed) was the only invasive, noxious, exotic species recorded in the study area. Its cover was reduced from 2009 and occurred only at the highest elevation zone adjacent to full-pool. An apparent intolerance of inundation has kept this species from spreading within the drawdown zone. Woody species had low abundances, and were restricted mainly to the upper-end of the one metre elevation zone (575.7 to 576.7 m). Abundance had increased from 2009 within this elevation zone. No woody species were recorded below 574.5 m elevation. Limited new recruitment of woody species was recorded within the drawdown zone and mature trees were sparse. The young stand of black cottonwood trees at Site 2 had expanded in size and in height from 2009 levels but no new seedling recruitment within the stand was noted in 2012 from the 2011 season.

Elevation was a major environmental factor influencing vegetation cover and richness. Shrubs and trees were restricted to the upper-most band, (575.7 to 576.7 m elevation) and herbaceous perennials were more common along the upper zones. In contrast, the annuals occurred over more extensive areas of the drawdown zone, and some species were most abundant at the lowest elevation, near the reservoir water level at the time of study. Annuals dominated the lower study drawdown zone from 566.7 m to 571.7 m elevation and perennials the upper drawdown zone from 571.7 to 576.7 m (full-pool).

There was significant differences among sites in vegetation cover in 2012 with higher vegetation cover occurring at Sites 2, 3, and 13. Species diversity was higher at the southern end of the reservoir compared to the northern end with Site 6 in the mid-reservoir zone having the lowest diversity and cover.

The third most prominent environmental factor was substrate: vegetation cover and richness increased on sites with finer texture substrate. There were differences in the substrate patterns across the plant species, with some species more and some less responsive to substrate texture.

6.0 RECOMMENDATIONS

The above average precipitation levels experienced in 2012 led to the reservoir reaching full-pool earlier and going above full-pool for a week. During the month of August, reservoir levels stayed close to full-pool, which was a longer period of time than in previous post-Alt S73 flow regime years. We recommend a non-scheduled field visit in 2013 to record vegetation cover and species richness within the first metre drop in elevation from full-pool to document any change that may have been the result of the high water in 2012. Leaving it until the scheduled 2015 monitoring of the complete sites will reduce the ability to isolate any effect on vegetation change to 2012 reservoir stage for the upper elevation zone.

We suggest that a stage reading occur at all of the sites when the reservoir reaches full-pool in early August. This will allow for a check of the recorded elevation at the dam compared to individual site stage. Differences between the sites on the southern end and the dam stage are not anticipated, but differences may occur for the northern sites, especially Site 13.

7.0 CLOSURE

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

Vast Resource Solutions

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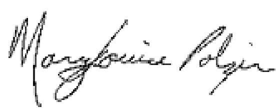

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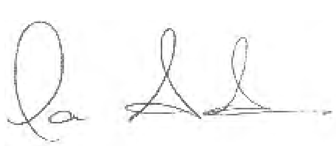

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Appendix 1: Reservoir and Upland Plants and Classifications

Reservoir Plants Identified Below Full-Pool (576.7 m to 566.7 m elevation).

Abbreviations for tables:

Vegetation Classes:
AG – Annual Grass
PG – Perennial Grass
AH – Annual Herb
PH – Perennial Herb
WS – Woody Shrub
WT – Woody Tree
M – Moss
F – Ferns

Vegetation Group:
NOL – Upland
UPL – Obligate Upland
OBL – Obligate Riparian
FAC – Facultative
FACR – Facultative Riparian
FACU – Facultative Upland
(R) – Ruderal

Status:
N – Native
E – Exotic
(NOX) – Noxious
(W) – Weed
Spp D – (depends on species)

Vegetation Group Descriptions

NOL – Upland species that does not occur in wetlands/riparian in another region. It is not on the national list (NOL).

UPL – Obligate upland species that occurs in wetlands in another region (estimated probability greater than 99%), but almost always occurs under natural conditions in non-riparian/wetlands in the region specified.

OBL – Obligate riparian species that almost always occurs under natural conditions in riparian zones (estimated probability greater than 99%).

FAC – Facultative species that is equally likely to occur in wetlands/riparian or uplands (estimated probability 34% - 66%).

FACR – Facultative riparian species that usually occurs in riparian/wetland habitat (estimated probability 67% - 99%), but is occasionally found in non-riparian/wetland habitat.

FACU – Facultative upland species that usually occurs in uplands (estimated probability 67% - 99%), but is occasionally found in wetland/riparian habitats (estimated probability 1% - 33%).

(R) – Ruderal species are first to colonize disturbed lands.

(+) & (-) Signs – used with facultative indicator categories to specify frequency toward the higher end of the category (+) more frequently found or the lower end of the category (-) less frequently found.

Grass:

Scientific Name	**Common Name**	**Species Code**	**Veg Class**	**Status**	**Veg Group**
Agrostis gigantea	redtop	Agro_gig	PG	E	FACR (R)
Aira caryophyllea	silver hairgrass	Aira_car	AG	E	NOL
Bromus inermis	smooth broom	Brom_ine	PG	E	FAC+ (R)
Calamagrostis canadensis	blue-joint	Cala_can	PG	N	OBL(R)
Cinna latifolia	nodding wood-reed	Cinn_lat	PG	N	OBL(R)
Elymus repens	quackgrass	Elym_rep	PG	E (W)	NOL(R)
Festuceae species	fescue tribe	Fest spp	PG	Spp D	NOL
Phalaris arundinacea	reed-canary grass	Phal_aru	PG	N (W)	OBL
Poa pratensis	Kentucky bluegrass	Poa_pra	PG	E	FACU

Herbaceous:

Scientific Name	Common Name	Species Code	Veg Class	Status	Veg Group
Apocynum androsaemifolium	spreading dogbane	Apoc_and	PH	N	NOL
Aster conspicuus	showy aster	Aste_con	PH	N	NOL
Athyrium filix-femina	lady fern	Athy_fil	F	N	FAC
Carex lanuginosa	woolly sedge	Care_lan	PH	N	OBL
Carex utriculata	beaked sedge	Care_utr	PH	N	OBL
Centaurea maculosa	spotted knapweed	Cent_mac	PH	E(NOX)	UPL (R)
Cerastium vulgatum	mouse-eared chickweed	Cera_vul	AH	N(W)	FACU (R)
Chenopodium album	lamb's-quarters	Chen_alb	AH	N(W)	FACU(R)
Chrysanthemum leucanthemum	oxeye daisy	Chry_leu	PH	E(W)	NOL(R)
Collomia linearis	narrow-leaved collomia	Coll_lin	AH	N	FACU
Dryas drummondii	yellow mountain avens	Drya_dru	PH	N	FACU
Epilobium angustifolium	fireweed	Epil_ang	PH	N(W)	FACU
Equisetum arvense	common horsetail	Equi_arv	PH	N(W)	FACR
Erysimum cheiranthoides	wormseed mustard	Erys_che	AH	N(W)	FACU
Fragaria virginiana	wild strawberry	Frag_vir	PH	N	FACU
Galium boreale	northern bedstraw	Gali_bor	PH	N	FACU
Geum macrophyllum	large-leaved avens	Geum_mac	PH	N	OBL
Heuchera cylindrica	round-leaved alumroot	Heuc_cyl	PH	N	NOL
Hieracium aurantiacum	orange hawkweed	Hier_aur	PH	E(NOX)	NOL
Matricaria discoidea	pineapple weed	Matr_dis	AH	E(W)	FACU(R)
Medicago lupulina	black medick	Medi_lup	PH	E(W)	FACU
Mimulus guttatus	yellow monkey-flower	Mimu_gut	AH	N	OBL
	All moss species (2012)	Moss spp	M	N	OBL
Myosotis laxa	small-flower forget-me-not	Myos_lax	PH	N	OBL
Oenothera villosa	evening primrose	Oeno_vil	PH	N	FAC
Polygonum lapathifolium	green smartweed	Poly_lap	AH	N(W)	OBL
Prunella vulgaris	self-heal	Prun_vul	PH	N	FACR
Pteridium aquilinum	bracken	Pter_aqu	F	N(W)	FACU
Ranunculus acris	meadow buttercup	Ranu_acr	PH	E(W)	FACR-
Rumex crispus	curly dock	Rume_cri	PH	E(W)	FACR
Taraxacum officinale	dandelion	Tara_off	PH	E(W)	FACU
Trifolium arvense	hare's-foot clover	Trif_arv	AH	E	NOL
Trifolium pratense	red clover	Trif_pre	PH	E(W)	FACU
Vicia americana	American vetch	Vici_ame	PH	N	FACU

Shrubs:

Scientific Name	Common Name	Species Code	Veg Class	Status	Veg Group
Acer glabrum	Douglas maple	Acer_glab	WS	N	FACU+
Amelanchier alnifolia	Saskatoon	Amel_aln	WS	N	FACU
Berberis aquifolium	Oregon-grape	Berb_aqu	WS	N	FACU
Chimaphila umbellata	prince's-pine	Chim_umb	WS	N	NOL
Cornus stolonifera	red-osier dogwood	Corn_sto	WS	N	FACR
Linnaea borealis	twinflower	Linn_bor	WS	N	FACU-
Lonicera involucrata	black twinberry	Loni_inv	WS	N	FAC
Ribes lacustre	black gooseberry	Ribe_lac	WS	N	FACR
Rubus parviflorus	thimbleberry	Rubu_par	WS	N	FAC
Salix bebbiana	Bebb's willow	Sali_beb	WS	N	FACR
Salix lucida	Pacific willow	Sali_luc	WS	N	FACR
Salix scouleriana	Scouler's willow	Sali_sco	WS	N	FAC
Shepherdia canadensis	buffalo berry	Shep_can	WS	N	NOL
Vaccinium membranaceum	black huckleberry	Vacc_mem	WS	N	FACU

Trees:

Scientific Name	Common Name	Species Code	Veg Class	Status	Veg Group
Betula occidentalis	water birch	Betu_occ	WT	N	FACR
Betula papyrifera	paper birch	Betu_pap	WT	N	FACU
Pinus contorta var. *latifolia*	lodgepole pine	Pinu_con	WT	N	FACU
Populus tremuloides	trembling aspen	Popu_tre	WT	N	FACU
Populus trichocarpa	black cottonwood	Popu_tri	WT	N	FACR
Pseudotsuga menziessii var. *glauca*	interior Douglas fir	Pseu_men	WT	N	FACU
Thuja plicata	western redcedar	Thuj_pli	WT	N	FACU
Tsuga heterophylla	western hemlock	Tsug_het	WT	N	FACU+

Upland species sampled from 576.7 m to 578.7 m elevation above full-pool.

Herbaceous:

Scientific Name	Common Name	Species Code
Agrostis gigantea	redtop	Agro_gig
Apocynum androsaemifolium	spreading dogbane	Apoc_and
Aralia nudicaulis	wild sarsaparilla	Aral_nud
Athyrium filix-femina	lady fern	Athy_fil
Carex utriculata	beaked sedge	Care_utr
Centaurea maculosa	spotted knapweed	Cent_mac
Chrysanthemum leucanthemum	oxeye daisy	Chry_leu
Cinna latifolia	nodding wood-reed	Cinn_lat
Clintonia uniflora	queen's cup	Clin_uni
Cornus canadensis	bunchberry	Corn_can
Dryas drummondii	yellow mountain avens	Drya_dru
Epilobium angustifolium	fireweed	Epil_ang
Equisetum arvense	common horsetail	Equi_arv
Goodyera oblongifolia	rattlesnake plantain	Good_obl
Gymnocarpium dryopteris	oak fern	Gymn_dry
Hieracium aurantiacum	orange hawkweed	Hier_aur
Hieracium umbellatum	narrow-leaved hawkweed	Hier_umb.
Maianthemun racemosum	false-solomon's seal	Maia_rac
Medicago lupulina	black medick	Medi_lup
	All moss species (2012)	Moss spp
Oenothera villosa	evening primrose	Oeno_vil
Prunella vulgaris	self-heal	Prun_vul
Pteridium aquilinum	bracken	Pter_aqu
Pyrola asarifolia	pink wintergreen	Pyro_asa
Rhinanthus minor	yellow rattle	Rhin_min
Trifolium repens	white clover	Trif_rep
Trifolium pratense	red clover	Trif_pre

Shrubs:

Scientific Name	Common Name	Species Code
Acer glabrum	Douglas maple	Acer_glab
Alnus crispa	Sitka alder	Alnu_cri
Amelanchier alnifolia	Saskatoon	Amel_aln
Arctostaphylos uva-ursi	kinnikinnick	Arct_uva-urs
Berberis aquifolium	Oregon-grape	Berb_aqu
Chimaphila umbellata	prince's-pine	Chim_umb
Cornus stolonifera	red-osier dogwood	Corn_sto
Linnaea borealis	twinflower	Linn_bor
Lonicera involucrata	black twinberry	Loni_inv
Lonicera utahensis	Utah honeysuckle	Loni. uta.
Oplopanax horridus	devil's club	Opla_hor
Pachistima myrsinites	falsebox	Pach_myr
Prunus virginiana	choke cherry	Prun_vir
Ribes lacustre	black gooseberry	Ribe_lac
Rosa species	rose species	Rosa spp
Rubus parviflorus	thimbleberry	Rubu_par
Salix scouleriana	Scouler’s willow	Sali_sco
Sambucus species	eldeberry species	Samb spp
Shepherdia canadensis	buffalo berry	Shep_can
Spiraea betulifolia	birch-leaved spirea	Spir_bet
Taxus brevifolia	western yew	Taxu_bre
Vaccinium ovalifolium	oval-leaved blueberry	Vacc_ova
Vaccinium membranaceum	black huckleberry	Vacc_mem

Trees:

Scientific Name	Common Name	Species Code
Betula occidentalis	water birch	Betu_occ
Betula papyrifera	paper birch	Betu_pap
Larix occidentalis	western larch	Lari_occ
Picea glauca	white spruce	Pice_gla
Pinus contorta var. *latifolia*	lodgepole pine	Pinu_con
Pinus monticola	western white pine	Pinu_mon
Populus tremuloides	trembling aspen	Popu_tre
Populus trichocarpa	black cottonwood	Popu_tri
Pseudotsuga menziessii var. *glauca*	interior Douglas fir	Pseu_men
Thuja plicata	western redcedar	Thuj_pli
Tsuga heterophylla	western hemlock	Tsug_het

Appendix 2: Reservoir Elevation Analysis Table

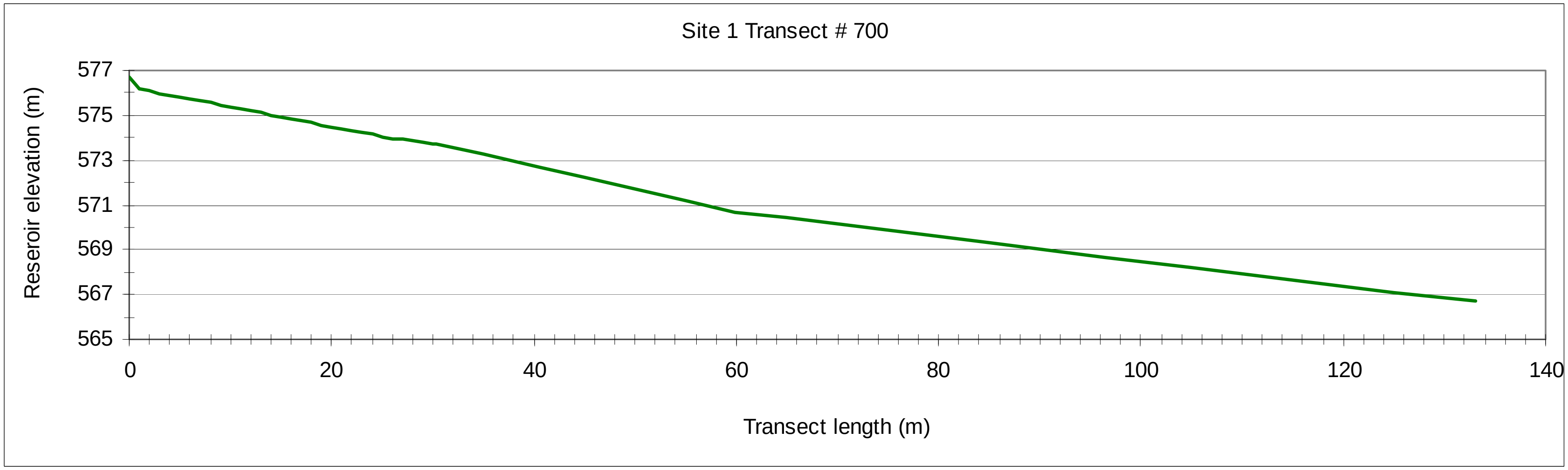
Duncan Reservoir elevation analysis for high riparian potential sites - 2011 growing season

Week #	Average Elevation (m)	2D surface area above average weekly reservoir elevation by site (m^2 and % of site)																	
		Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 10		Site 13	
		Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%
1	548.49	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
2	547.53	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
3	547.13	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
4	547.19	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
5	546.97	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
6	547.28	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
7	548.90	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
8	550.86	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
9	553.26	60112.5	100	240242.6	100	10193.2	100	139546.4	100	77153.7	100	21094.2	100	5047.6	100	120070.3	100	67950.8	100
10	555.88	60112.5	100	240242.6	100	10193.2	100	139546.4	100	76427.8	99	21094.2	100	5047.6	100	120070.3	100	67950.8	100
11	559.53	55047.3	92	240242.6	100	9335.2	92	139546.4	100	72829.1	94	21094.2	100	5047.6	100	120070.3	100	67950.8	100
12	562.68	40848.0	68	225744.9	94	7384.9	72	135452.1	97	67014.4	87	18098.6	86	5028.9	100	118887.9	99	67950.8	100
13	566.13	26405.8	44	171007.8	71	5793.6	57	89442.6	64	55088.1	71	11025.8	52	4444.1	88	89970.5	75	67950.8	100
14	569.19	16413.7	27	126333.2	53	4335.9	43	57382.2	41	38368.0	50	6143.0	29	3736.1	74	48196.0	40	67950.8	100
15	572.19	8712.7	14	77063.6	32	2653.7	26	25695.9	18	14455.1	19	3163.3	15	2806.0	56	26782.4	22	62856.6	93
16	574.01	4401.6	7	39562.8	16	1258.6	12	12413.5	9	7610.6	10	2261.2	11	2050.5	41	16216.3	14	18245.5	27
17	575.71	966.8	2	10218.7	4	240.6	2	3498.2	3	2761.4	4	1470.0	7	1052.4	21	6067.9	5	2706.0	4
18	576.64	5.3	0	489.0	0	22.7	0	1324.4	1	771.8	1	1070.5	5	312.2	6	1436.2	1	123.5	0
19	576.36	100.2	0	2474.5	1	65.6	1	1711.3	1	1276.3	2	1198.7	6	547.8	11	2654.0	2	463.2	1
20	576.06	406.9	1	5210.4	2	136.3	1	2401.5	2	1922.0	2	1326.9	6	786.5	16	4285.5	4	1184.8	2
21	575.49	1349.5	2	13884.6	6	396.0	4	4394.7	3	3339.1	4	1561.8	7	1214.7	24	7424.6	6	4275.4	6
22	575.31	1652.3	3	16867.0	7	513.3	5	5183.8	4	3826.9	5	1636.5	8	1338.7	27	8923.0	7	5503.3	8
23	574.74	2693.2	4	26368.3	11	779.1	8	8092.2	6	5442.1	7	1878.2	9	1689.9	33	12421.1	10	9283.3	14
24	573.98	4472.6	7	40141.7	17	1281.7	13	12626.8	9	7713.1	10	2278.8	11	2065.6	41	16374.1	14	18815.1	28
25	573.15	6398.0	11	56672.1	24	1901.1	19	18364.2	13	10400.7	13	2693.2	13	2425.5	48	21302.8	18	39879.9	59
26	572.25	8581.4	14	76019.7	32	2605.7	26	25187.4	18	14138.6	18	3132.1	15	2782.3	55	26423.0	22	61395.4	90
* 85^{th} Percentile	575.50	1321.6	2	13600.2	6	382.2	4	4322.8	3	3293.6	4	1554.7	7	1202.6	24	7311.3	6	4154.0	6

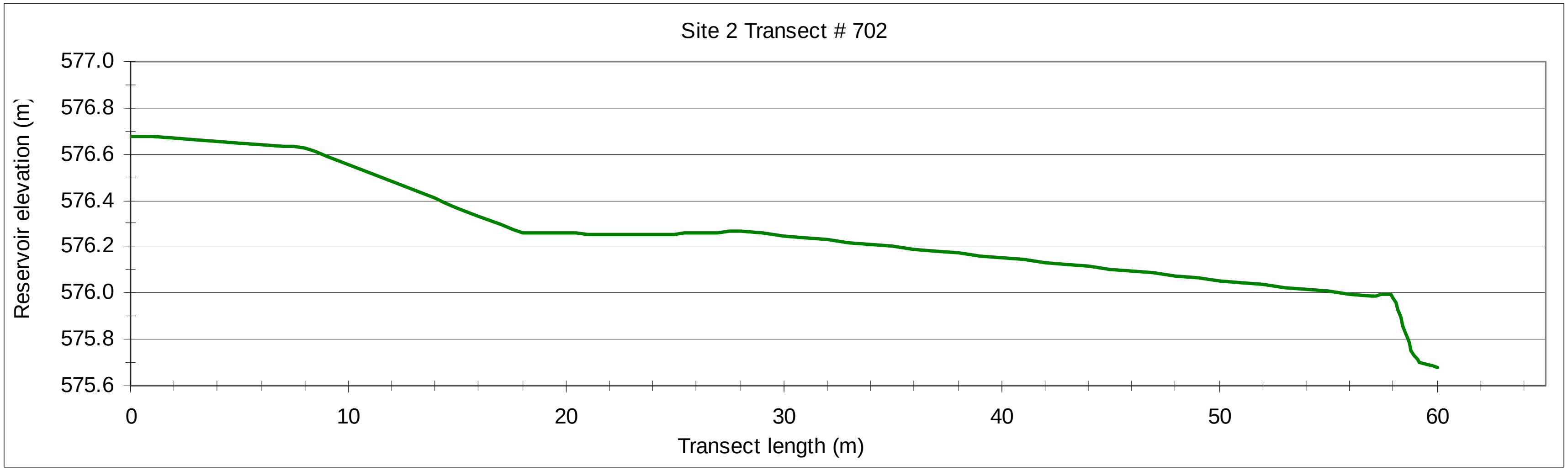
* Represents the elevation at which the drawdown zone is exposed for 85 - 100% of the growing season

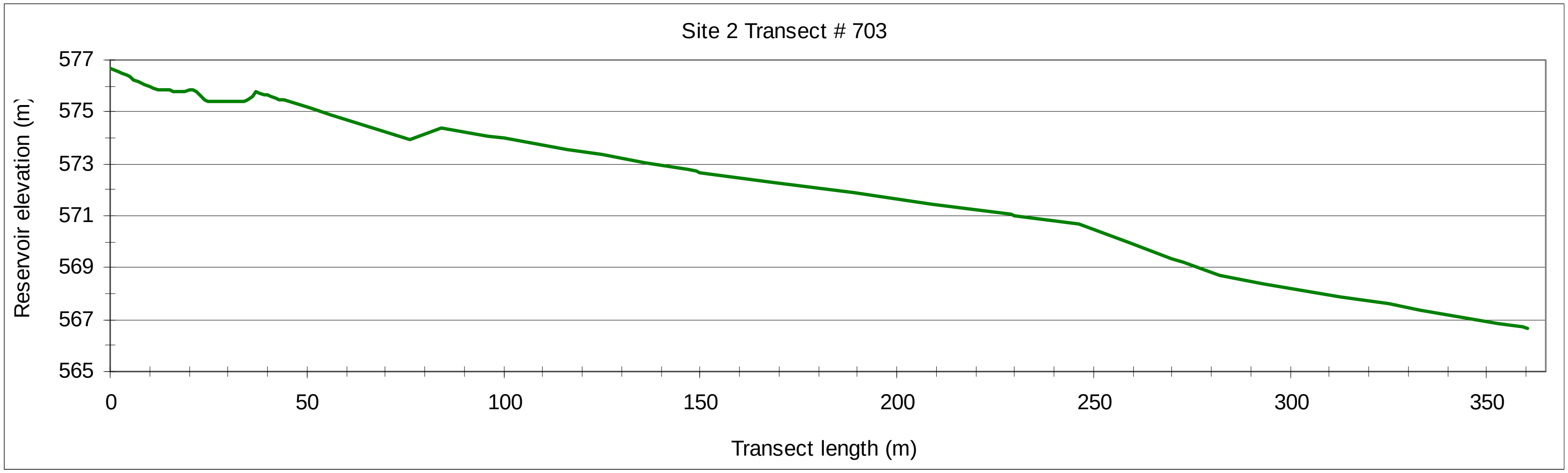
Appendix 3: Study Area Site Profiles

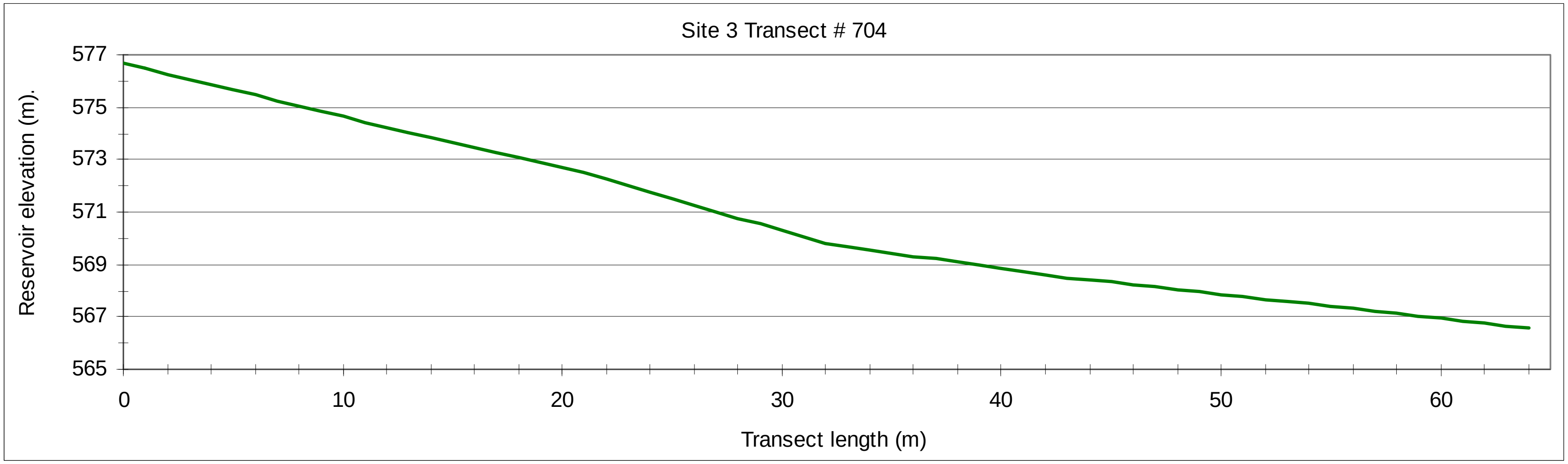

Site 1 Transect # 1
Reservoir elevation (m).
577
575
573
571
569
567
565
0
50
100
150
200
250
300
Transect length (m)

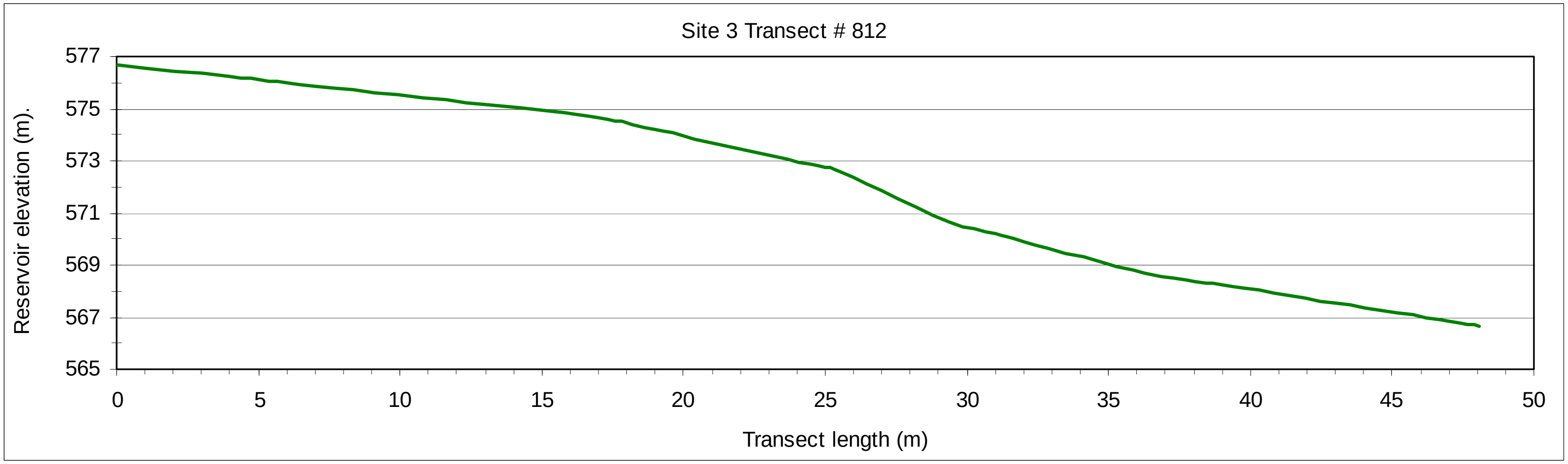

Site 1 Transect # 700
Reseroir elevation (m)
577
575
573
571
569
567
565
0
20
40
60
80
100
120
140
Transect length (m)

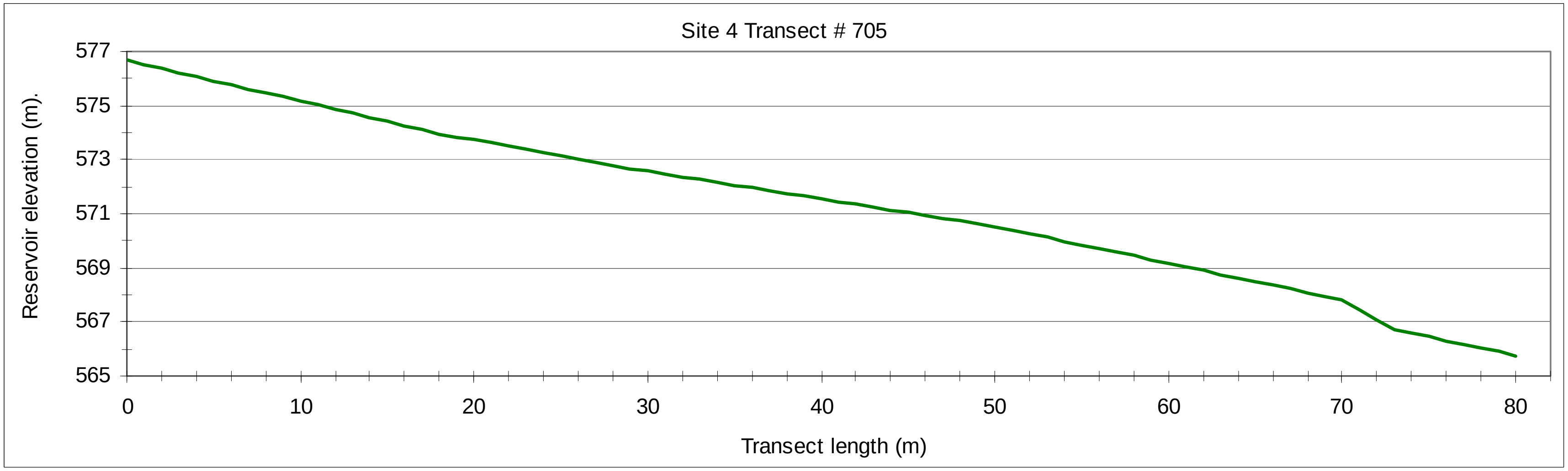

Site 2 Transect # 701
Reservoir elevation (m)
577
575
573
571
569
567
565
0
50
100
150
200
250
300
Transect lenght (m)

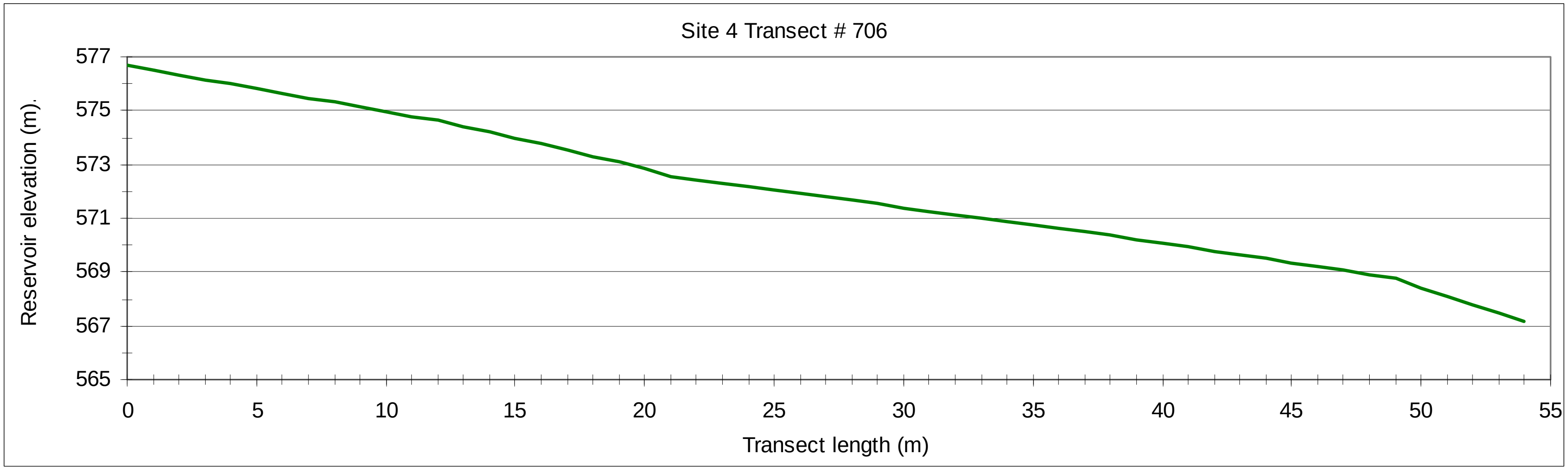

Site 2 Transect # 702
Reservoir elevation (m)
577.0
576.8
576.6
576.4
576.2
576.0
575.8
575.6
0
10
20
30
40
50
60
Transect length (m)

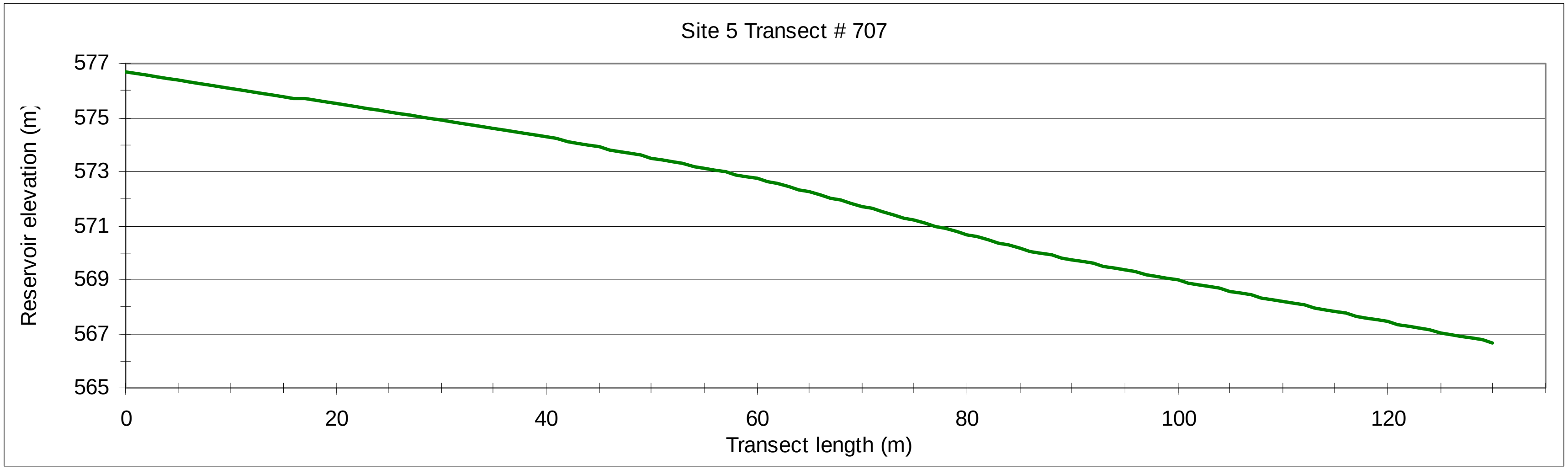

Site 2 Transect # 703
Reservoir elevation (m)
577
575
573
571
569
567
565
0
50
100
150
200
250
300
350
Transect length (m)


Site 3 Transect # 704
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
Transect length (m)

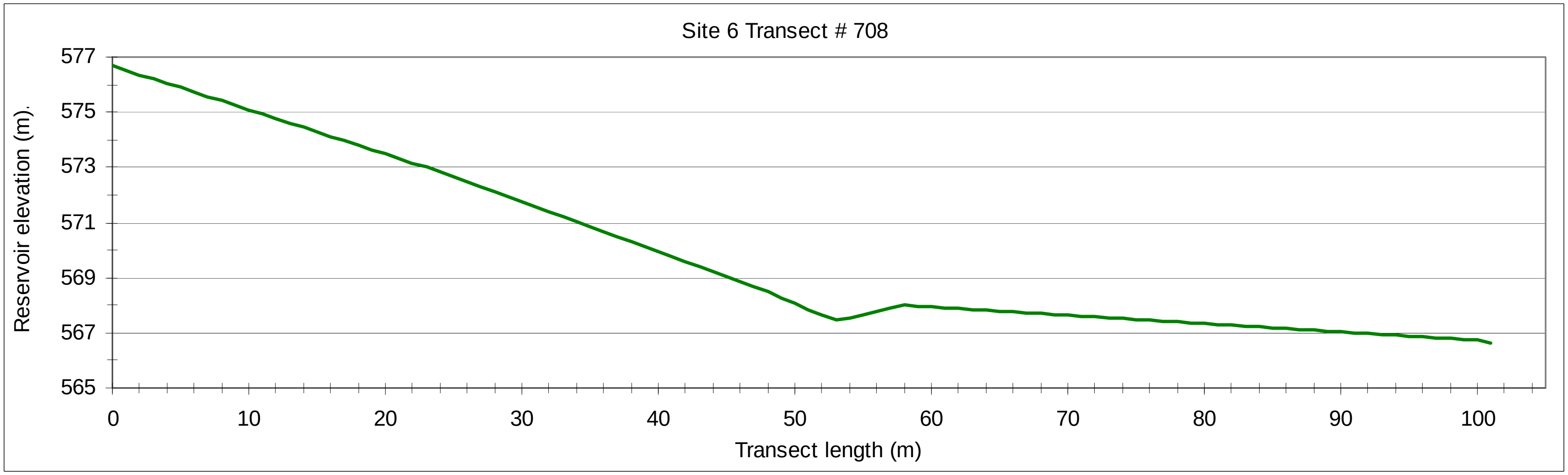

Site 3 Transect # 812
Reservoir elevation (m).
577
575
573
571
569
567
565
0
5
10
15
20
25
30
35
40
45
50
Transect length (m)

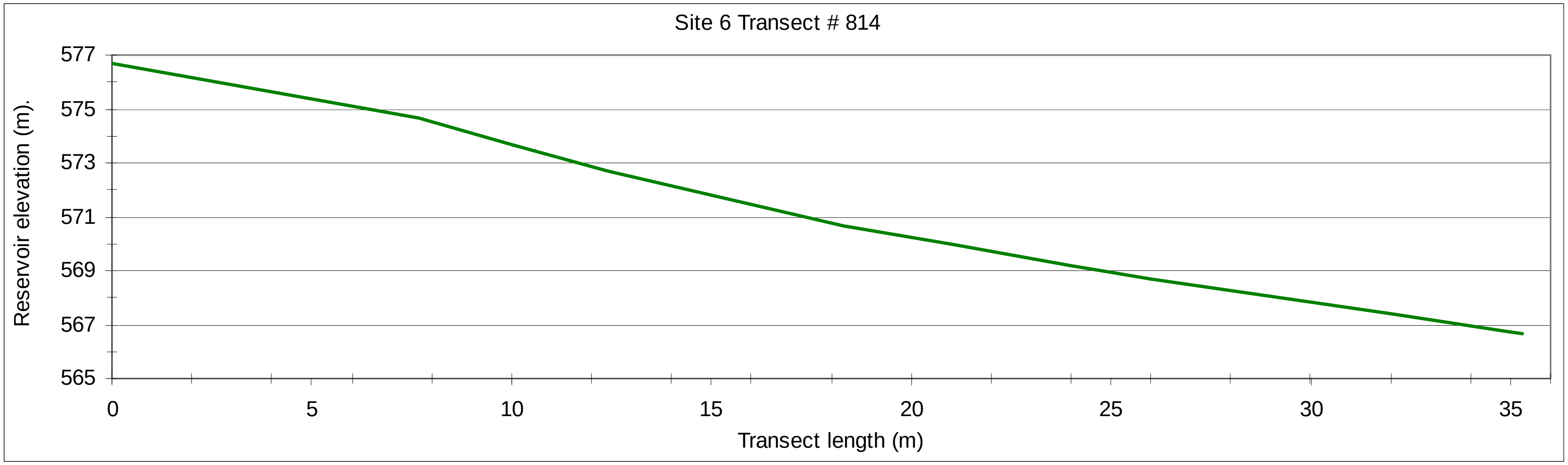

Site 4 Transect # 705
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
Transect length (m)

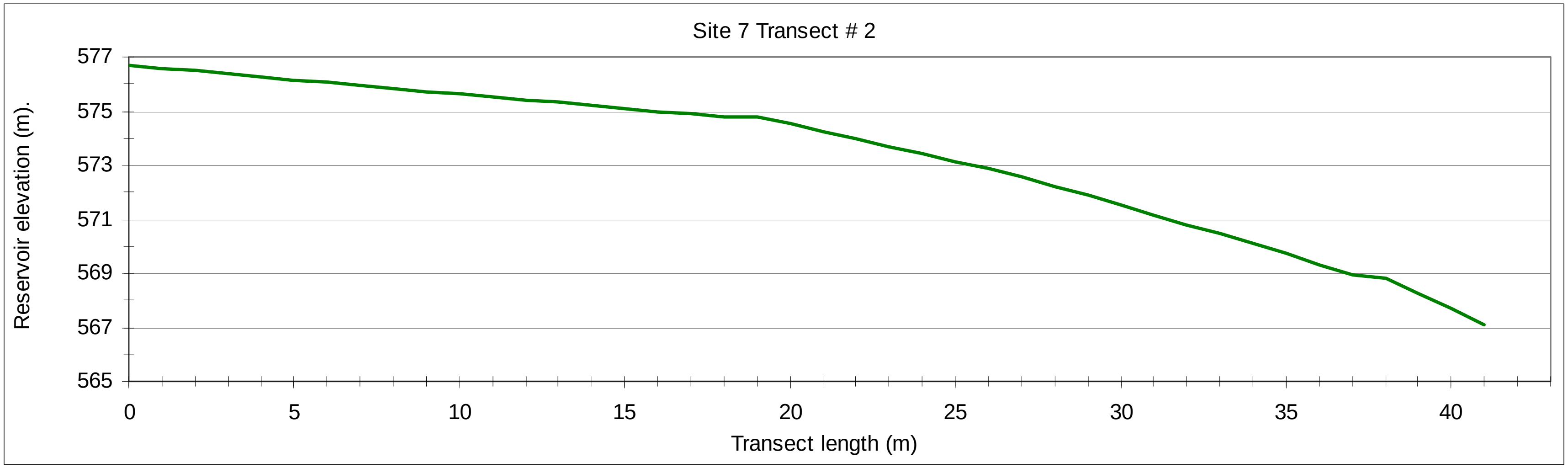

Site 4 Transect # 706
Reservoir elevation (m)
577
575
573
571
569
567
565
0
5
10
15
20
25
30
35
40
45
50
55
Transect length (m)


Site 5 Transect # 707
Reservoir elevation (m)
577
575
573
571
569
567
565
0
20
40
60
80
100
120
Transect length (m)

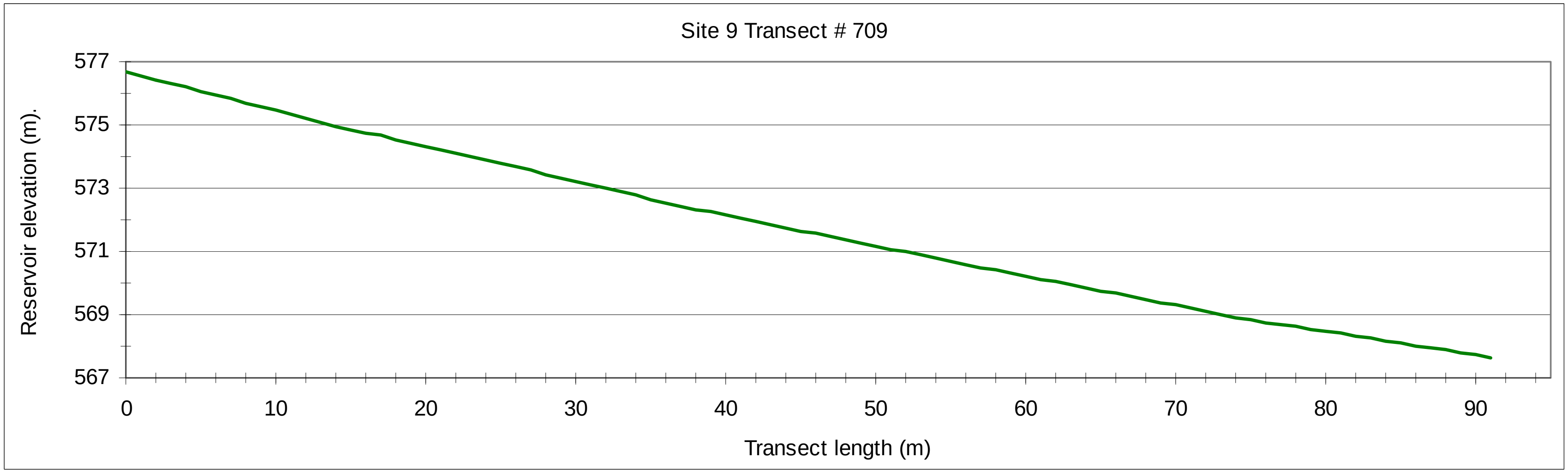

Site 5 Transect # 813
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
Transect length (m)

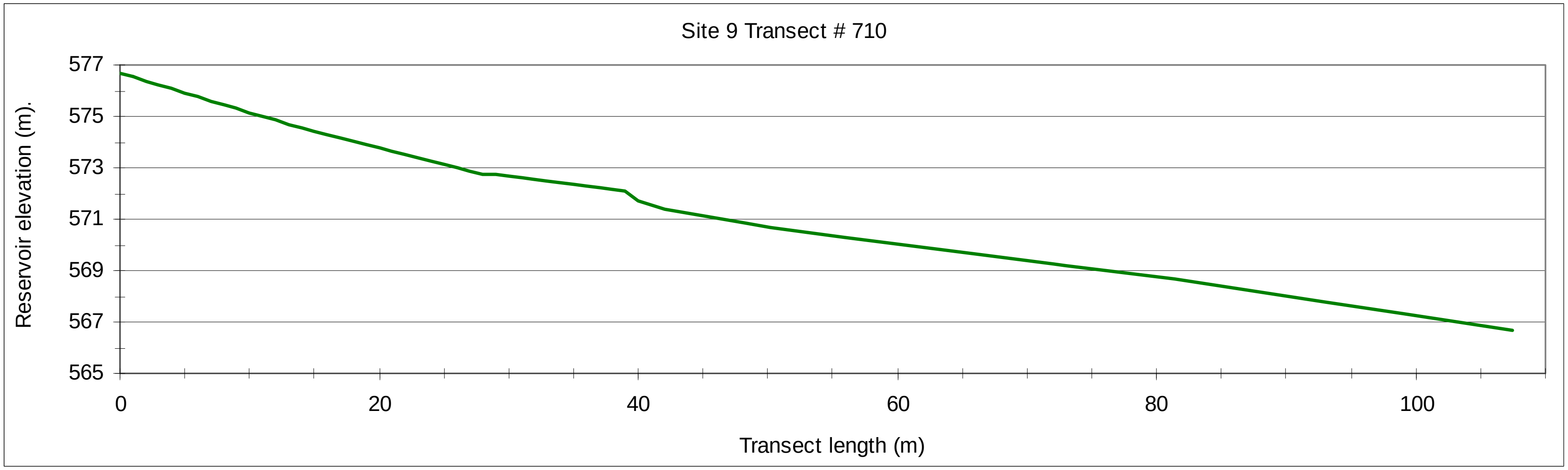

Site 6 Transect # 708
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
90
100
Transect length (m)

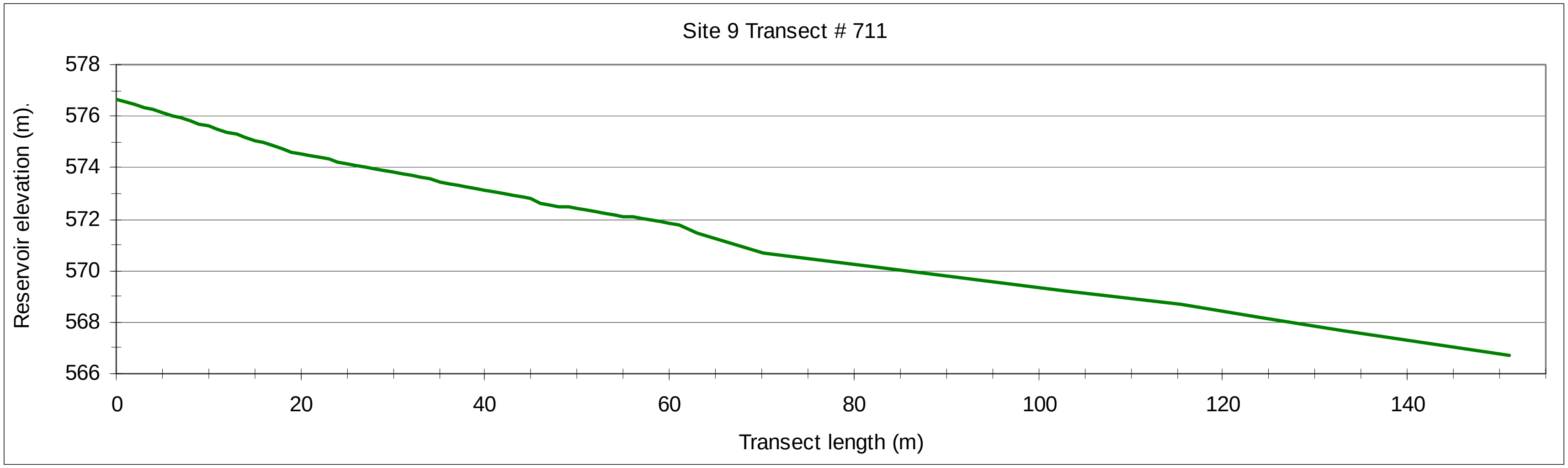

Site 6 Transect # 814
Reservoir elevation (m).
577
575
573
571
569
567
565
0
5
10
15
20
25
30
35
Transect length (m)

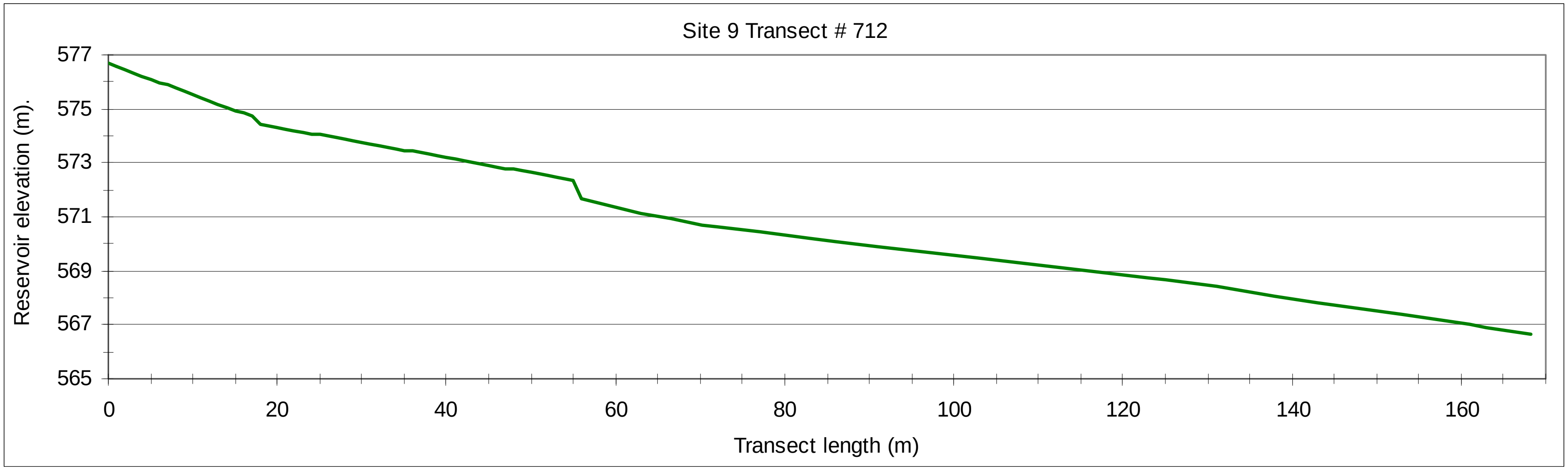

Site 7 Transect # 2
Reservoir elevation (m).
577
575
573
571
569
567
565
0
5
10
15
20
25
30
35
40
Transect length (m)

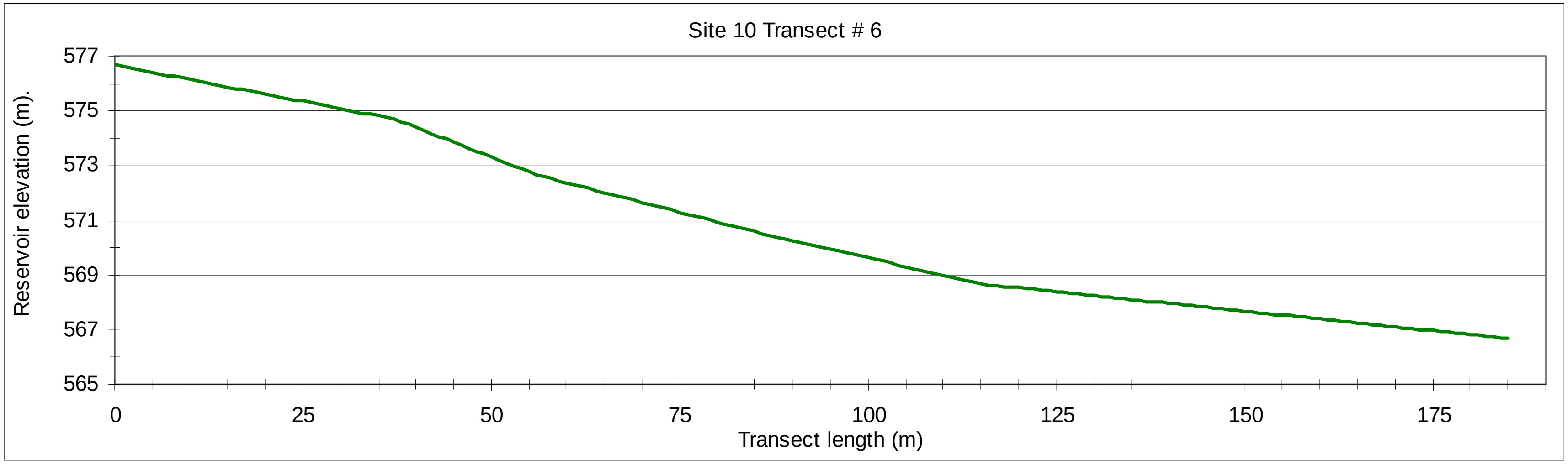

Site 7 Transect # 3
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
Transect length (m)

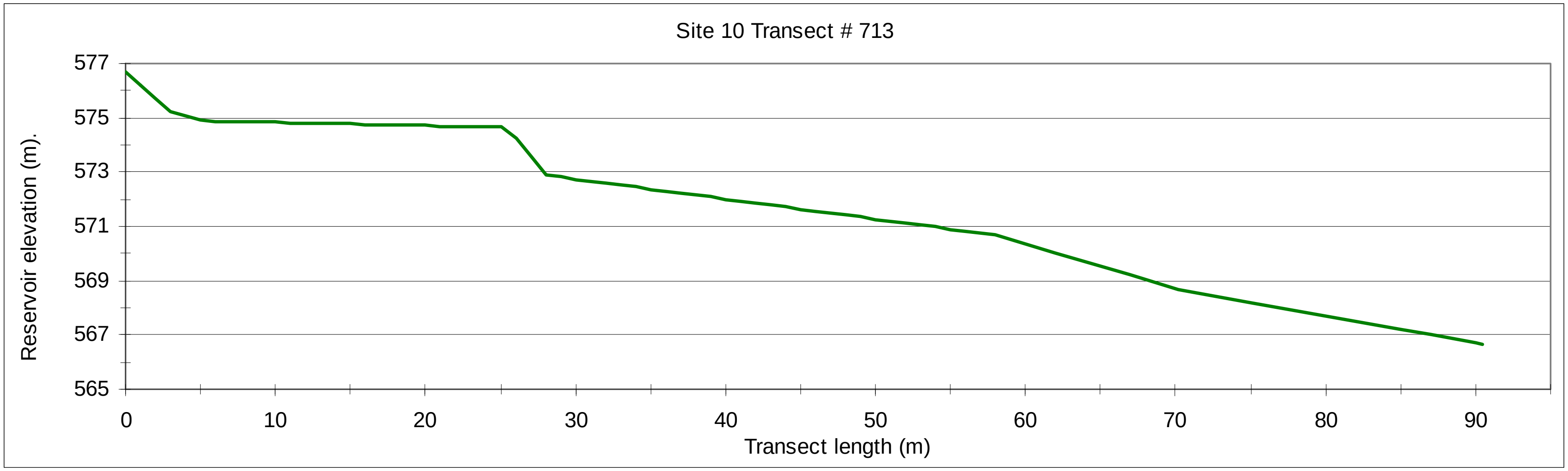

Site 9 Transect # 709
Reservoir elevation (m).
577
575
573
571
569
567
0
10
20
30
40
50
60
70
80
90
Transect length (m)

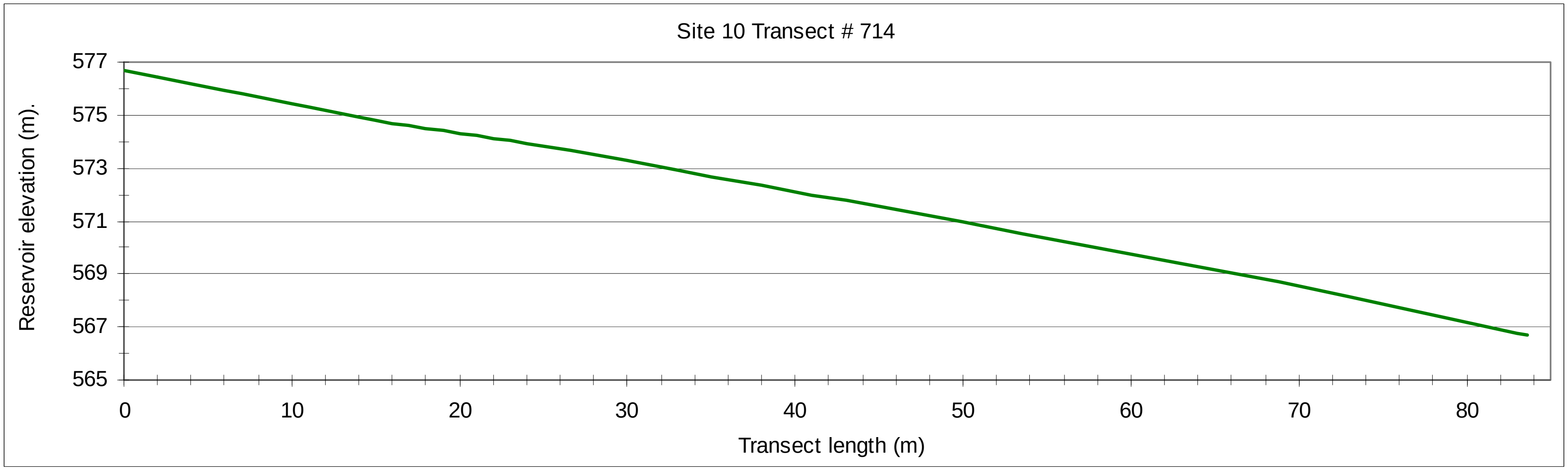

Site 9 Transect # 710
Reservoir elevation (m).
577
575
573
571
569
567
565
0
20
40
60
80
100
Transect length (m)


Site 9 Transect # 711
Reservoir elevation (m).
578
576
574
572
570
568
566
0
20
40
60
80
100
120
140
Transect length (m)

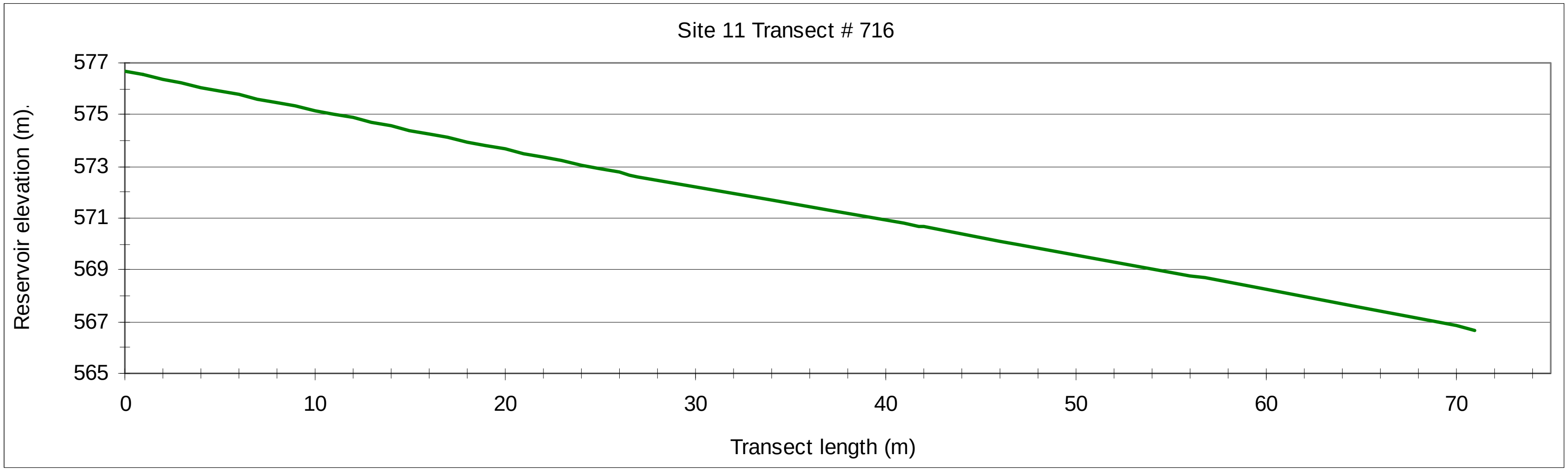

Site 9 Transect # 712
Reservoir elevation (m).
577
575
573
571
569
567
565
0
20
40
60
80
100
120
140
160
Transect length (m)

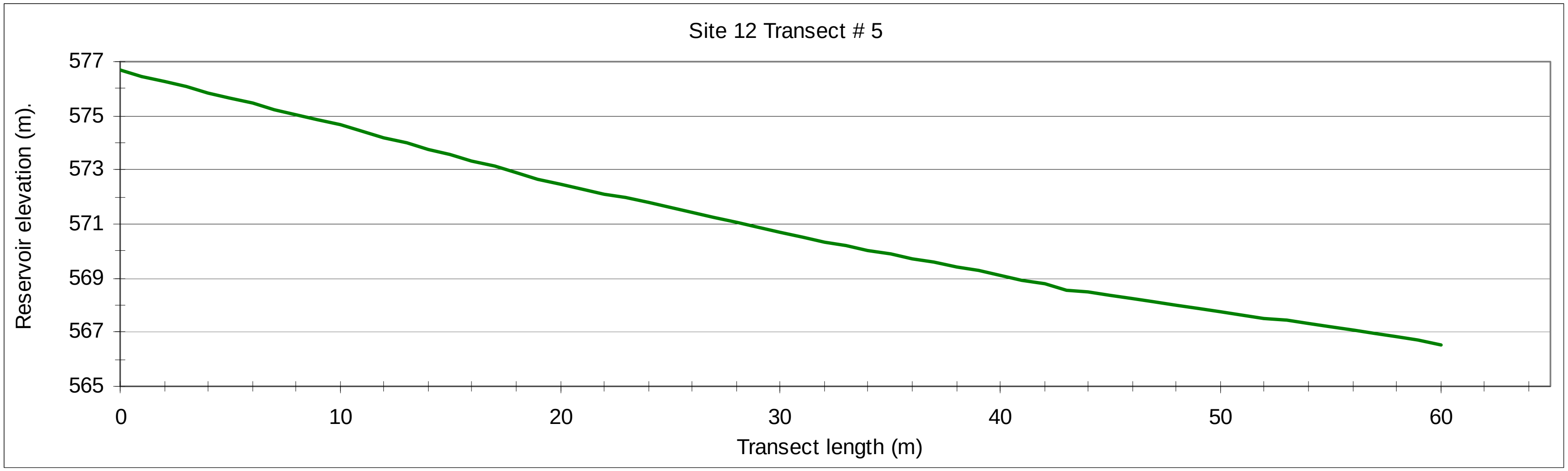

Site 10 Transect # 6
Reservoir elevation (m).
577
575
573
571
569
567
565
0
25
50
75
100
125
150
175
Transect length (m)


Site 10 Transect # 713
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
90
Transect length (m)

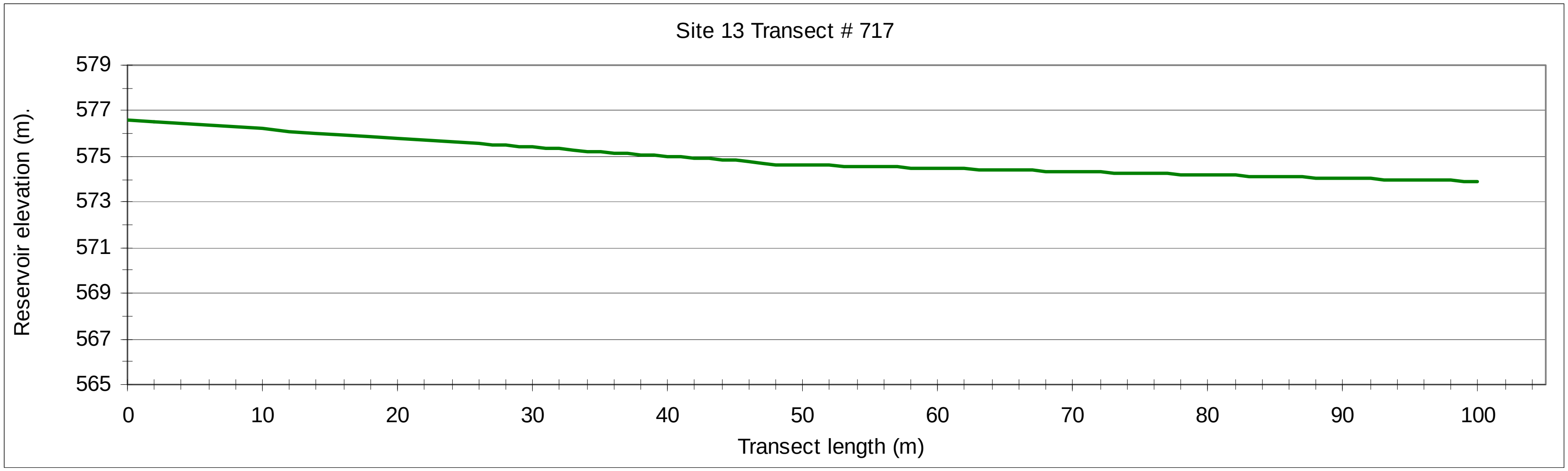

Site 10 Transect # 714
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
Transect length (m)

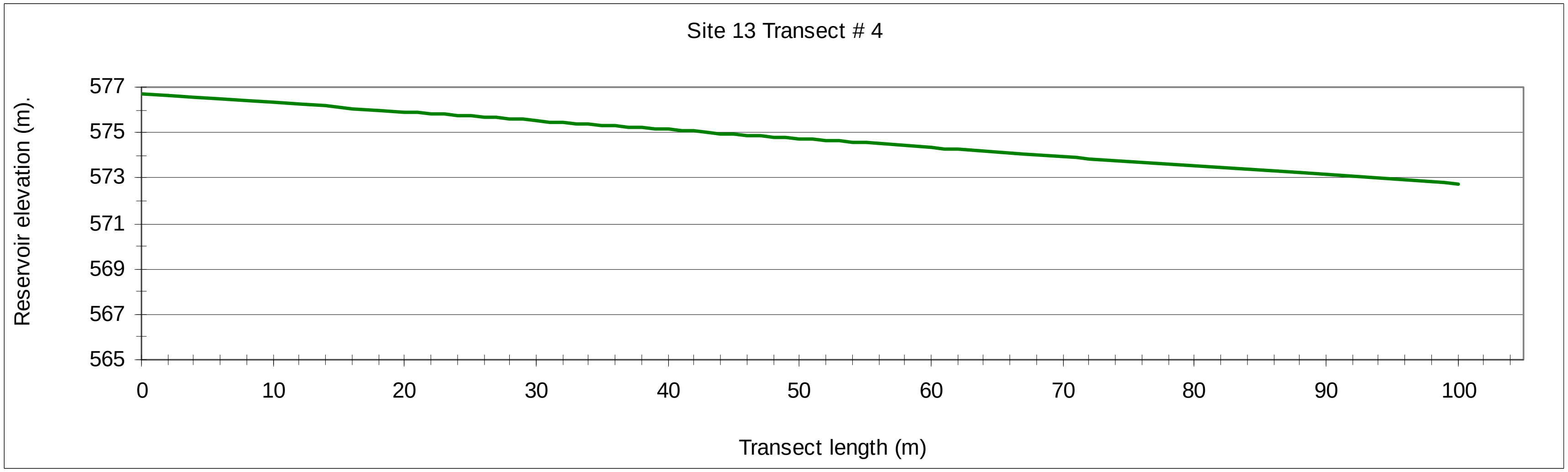

Site 11 Transect # 715
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
Transect length (m)

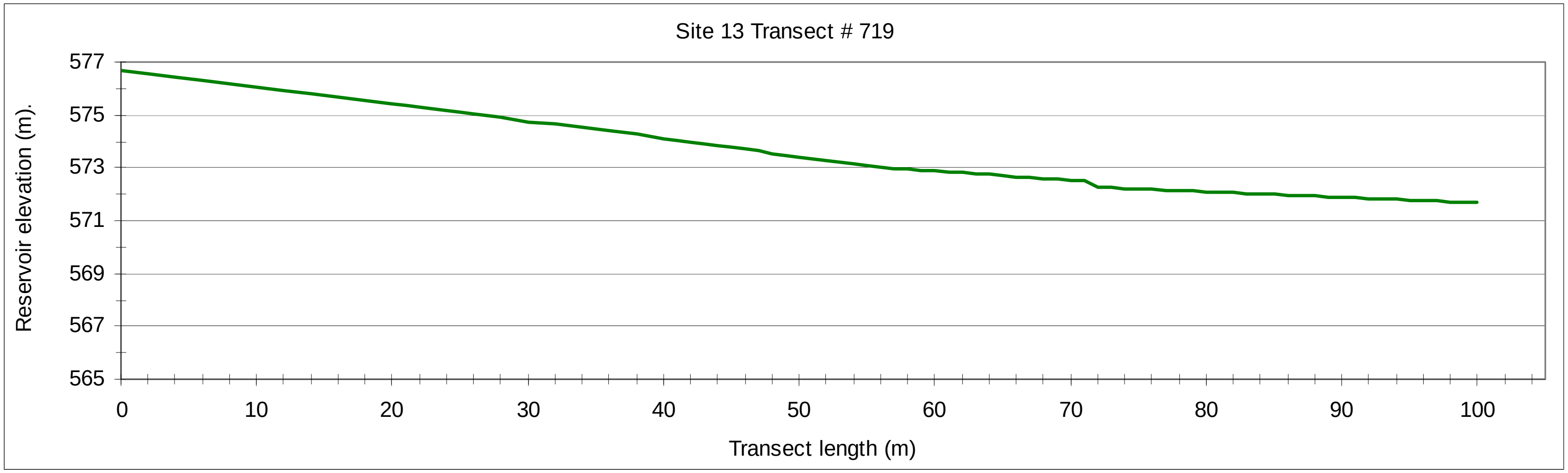

Site 11 Transect # 716
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
Transect length (m)

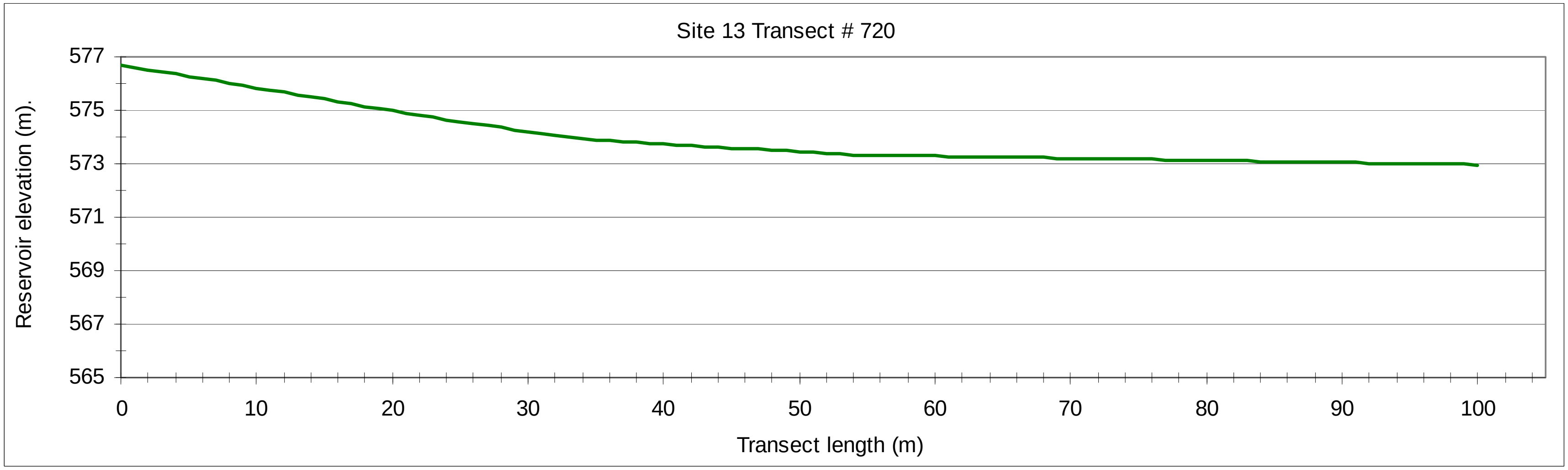

Site 12 Transect # 5
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
Transect length (m)


Site 12 Transect # 718
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
Transect length (m)


Site 13 Transect # 717
Reservoir elevation (m).
579
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
90
100
Transect length (m)


Site 13 Transect # 4
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
90
100
Transect length (m)


Site 13 Transect # 719
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
90
100
Transect length (m)


Site 13 Transect # 720
Reservoir elevation (m).
577
575
573
571
569
567
565
0
10
20
30
40
50
60
70
80
90
100
Transect length (m)

Appendix 4: Statistical Analysis Tables

Comparison for vegetation by site for the three sites with significant differences to the other sites.

Multiple Comparisons

Dependent Variable: Vegetation Cover
Scheffe

(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
6	1	-28.5479(*)	6.2010	.034	-56.185	-.911
	2	-31.1319(*)	5.6907	.002	-56.494	-5.770
	3	-33.2069(*)	6.8760	.017	-63.852	-2.562
	4	-38.6117(*)	7.0704	.002	-70.123	-7.100
	5	-39.1589(*)	6.9369	.001	-70.075	-8.243
	7	-1.6680	6.2566	1.000	-29.552	26.216
	9	-15.3152	5.6395	.767	-40.450	9.819
	10	-13.6826	5.7736	.897	-39.415	12.049
	11	-11.1233	6.6639	.993	-40.823	18.577
	12	-11.5169	6.4170	.987	-40.116	17.083
	13	-47.5901(*)	5.9401	.000	-74.064	-21.116
7	1	-26.8800(*)	5.6430	.021	-52.030	-1.730
	2	-29.4640(*)	5.0769	.001	-52.091	-6.837
	3	-31.5389(*)	6.3773	.012	-59.961	-3.116
	4	-36.9437(*)	6.5865	.001	-66.298	-7.589
	5	-37.4910(*)	6.4429	.000	-66.206	-8.776
	6	1.6680	6.2566	1.000	-26.216	29.552
	9	-13.6472	5.0195	.766	-36.018	8.724
	10	-12.0146	5.1697	.909	-35.055	11.026
	11	-9.4554	6.1481	.997	-36.856	17.946
	12	-9.8489	5.8796	.993	-36.053	16.355
	13	-45.9221(*)	5.3550	.000	-69.788	-22.056
13	1	19.0422	5.2899	.299	-4.534	42.618
	2	16.4582	4.6814	.340	-4.406	37.322
	3	14.3832	6.0671	.896	-12.657	41.423
	4	8.9784	6.2866	.998	-19.040	36.997
	5	8.4312	6.1361	.999	-18.916	35.778
	6	47.5901(*)	5.9401	.000	21.116	74.064
	7	45.9221(*)	5.3550	.000	22.056	69.788
	9	32.2749(*)	4.6190	.000	11.689	52.861
	10	33.9075(*)	4.7818	.000	12.596	55.219
	11	36.4667(*)	5.8257	.000	10.503	62.431
	12	36.0732(*)	5.5416	.000	11.375	60.771

* The mean difference is significant at the .05 level.

Comparison for species richness by site with Post Hoc Scheffé test.

Multiple Comparisons

Dependent Variable: Species Rich
Scheffé
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(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	1.0550	.2480	.083	-.051	2.160
	3	.2411	.3131	1.000	-1.155	1.637
	4	.1671	.3236	1.000	-1.275	1.609
	5	.2641	.3164	1.000	-1.146	1.674
	6	3.3557(*)	.3071	.000	1.987	4.724
	7	3.1967(*)	.2795	.000	1.951	4.442
	9	2.4891(*)	.2452	.000	1.396	3.582
	10	2.3173(*)	.2527	.000	1.191	3.444
	11	1.8098(*)	.3017	.000	.465	3.154
	12	2.2995(*)	.2883	.000	1.015	3.584
	13	1.3711(*)	.2620	.005	.203	2.539
2	1	-1.0550	.2480	.083	-2.160	.051
	3	-.8139	.2884	.716	-2.099	.472
	4	-.8879	.2997	.642	-2.224	.448
	5	-.7909	.2920	.770	-2.092	.510
	6	2.3007(*)	.2818	.000	1.045	3.557
	7	2.1417(*)	.2514	.000	1.021	3.262
	9	1.4341(*)	.2126	.000	.486	2.382
	10	1.2623(*)	.2213	.001	.276	2.249
	11	.7548	.2759	.758	-.475	1.985
	12	1.2445(*)	.2612	.021	.080	2.408
	13	.3161	.2319	.999	-.717	1.349
3	1	-.2411	.3131	1.000	-1.637	1.155
	2	.8139	.2884	.716	-.472	2.099
	4	-.0741	.3555	1.000	-1.658	1.510
	5	.0230	.3490	1.000	-1.532	1.578
	6	3.1146(*)	.3405	.000	1.597	4.632
	7	2.9556(*)	.3158	.000	1.548	4.363
	9	2.2480(*)	.2859	.000	.974	3.522
	10	2.0762(*)	.2924	.000	.773	3.379
	11	1.5686(*)	.3357	.028	.073	3.065
	12	2.0583(*)	.3236	.000	.616	3.501
	13	1.1299	.3005	.229	-.209	2.469

(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
4	1	-.1671	.3236	1.000	-1.609	1.275
	2	.8879	.2997	.642	-.448	2.224
	3	.0741	.3555	1.000	-1.510	1.658
	5	.0971	.3584	1.000	-1.500	1.694
	6	3.1887(*)	.3502	.000	1.628	4.749
	7	3.0296(*)	.3262	.000	1.576	4.483
	9	2.3220(*)	.2973	.000	.997	3.647
	10	2.1503(*)	.3036	.000	.797	3.503
	11	1.6427(*)	.3454	.022	.103	3.182
	12	2.1324(*)	.3338	.000	.645	3.620
	13	1.2040	.3114	.188	-.184	2.592
5	1	-.2641	.3164	1.000	-1.674	1.146
	2	.7909	.2920	.770	-.510	2.092
	3	-.0230	.3490	1.000	-1.578	1.532
	4	-.0971	.3584	1.000	-1.694	1.500
	6	3.0916(*)	.3436	.000	1.560	4.623
	7	2.9326(*)	.3191	.000	1.510	4.355
	9	2.2250(*)	.2895	.000	.935	3.515
	10	2.0532(*)	.2959	.000	.734	3.372
	11	1.5456(*)	.3387	.038	.036	3.055
	12	2.0353(*)	.3268	.000	.579	3.492
	13	1.1070	.3039	.279	-.247	2.461
6	1	-3.3557(*)	.3071	.000	-4.724	-1.987
	2	-2.3007(*)	.2818	.000	-3.557	-1.045
	3	-3.1146(*)	.3405	.000	-4.632	-1.597
	4	-3.1887(*)	.3502	.000	-4.749	-1.628
	5	-3.0916(*)	.3436	.000	-4.623	-1.560
	7	-.1590	.3099	1.000	-1.540	1.222
	9	-.8666	.2793	.565	-2.111	.378
	10	-1.0384	.2859	.284	-2.313	.236
	11	-1.5460(*)	.3300	.027	-3.017	-.075
	12	-1.0563	.3178	.441	-2.473	.360
	13	-1.9846(*)	.2942	.000	-3.296	-.673
7	1	-3.1967(*)	.2795	.000	-4.442	-1.951
	2	-2.1417(*)	.2514	.000	-3.262	-1.021
	3	-2.9556(*)	.3158	.000	-4.363	-1.548
	4	-3.0296(*)	.3262	.000	-4.483	-1.576
	5	-2.9326(*)	.3191	.000	-4.355	-1.510
	6	.1590	.3099	1.000	-1.222	1.540
	9	-.7076	.2486	.704	-1.816	.400
	10	-.8794	.2560	.381	-2.020	.262
	11	-1.3869(*)	.3045	.039	-2.744	-.030
	12	-.8972	.2912	.577	-2.195	.401
	13	-1.8256(*)	.2652	.000	-3.008	-.644

(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
9	1	-2.4891(*)	.2452	.000	-3.582	-1.396
	2	-1.4341(*)	.2126	.000	-2.382	-.486
	3	-2.2480(*)	.2859	.000	-3.522	-.974
	4	-2.3220(*)	.2973	.000	-3.647	-.997
	5	-2.2250(*)	.2895	.000	-3.515	-.935
	6	.8666	.2793	.565	-.378	2.111
	7	.7076	.2486	.704	-.400	1.816
	10	-.1718	.2181	1.000	-1.144	.800
	11	-.6793	.2733	.860	-1.898	.539
	12	-.1896	.2584	1.000	-1.341	.962
	13	-1.1180(*)	.2288	.015	-2.138	-.098
10	1	-2.3173(*)	.2527	.000	-3.444	-1.191
	2	-1.2623(*)	.2213	.001	-2.249	-.276
	3	-2.0762(*)	.2924	.000	-3.379	-.773
	4	-2.1503(*)	.3036	.000	-3.503	-.797
	5	-2.0532(*)	.2959	.000	-3.372	-.734
	6	1.0384	.2859	.284	-.236	2.313
	7	.8794	.2560	.381	-.262	2.020
	9	.1718	.2181	1.000	-.800	1.144
	11	-.5076	.2801	.986	-1.756	.741
	12	-.0179	.2656	1.000	-1.202	1.166
	13	-.9462	.2368	.146	-2.002	.109
11	1	-1.8098(*)	.3017	.000	-3.154	-.465
	2	-.7548	.2759	.758	-1.985	.475
	3	-1.5686(*)	.3357	.028	-3.065	-.073
	4	-1.6427(*)	.3454	.022	-3.182	-.103
	5	-1.5456(*)	.3387	.038	-3.055	-.036
	6	1.5460(*)	.3300	.027	.075	3.017
	7	1.3869(*)	.3045	.039	.030	2.744
	9	.6793	.2733	.860	-.539	1.898
	10	.5076	.2801	.986	-.741	1.756
	12	.4897	.3126	.996	-.903	1.883
	13	-.4387	.2885	.997	-1.725	.847
12	1	-2.2995(*)	.2883	.000	-3.584	-1.015
	2	-1.2445(*)	.2612	.021	-2.408	-.080
	3	-2.0583(*)	.3236	.000	-3.501	-.616
	4	-2.1324(*)	.3338	.000	-3.620	-.645
	5	-2.0353(*)	.3268	.000	-3.492	-.579
	6	1.0563	.3178	.441	-.360	2.473
	7	.8972	.2912	.577	-.401	2.195
	9	.1896	.2584	1.000	-.962	1.341
	10	.0179	.2656	1.000	-1.166	1.202
	11	-.4897	.3126	.996	-1.883	.903
	13	-.9284	.2745	.409	-2.152	.295

(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
13	1	-1.3711(*)	.2620	.005	-2.539	-.203
	2	-.3161	.2319	.999	-1.349	.717
	3	-1.1299	.3005	.229	-2.469	.209
	4	-1.2040	.3114	.188	-2.592	.184
	5	-1.1070	.3039	.279	-2.461	.247
	6	1.9846(*)	.2942	.000	.673	3.296
	7	1.8256(*)	.2652	.000	.644	3.008
	9	1.1180(*)	.2288	.015	.098	2.138
	10	.9462	.2368	.146	-.109	2.002
	11	.4387	.2885	.997	-.847	1.725
	12	.9284	.2745	.409	-.295	2.152

ANOVA test of mean vegetation cover with site as the factor for 2012.

ANOVA

Veg_Cov_1m2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	117722.7	11	10702.064	14.619	.000
Within Groups	409953.6	560	732.060		
Total	527676.3	571			

ANOVA test of mean species richness with site as the factor for 2012.

ANOVA

Species Rich

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	641.698	11	58.336	32.487	.000
Within Groups	1005.575	560	1.796		
Total	1647.273	571			

Correlations between vegetation cover and species richness with substrate texture index.

Correlations

		Veg_ Cov_1m2	Species Rich	Substrate
Veg_Cov_1m2	Pearson Correlation	1	.603**	-.159**
	Sig. (2-tailed)	.	.000	.000
	N	572	572	572
Species Rich	Pearson Correlation	.603**	1	-.047
	Sig. (2-tailed)	.000	.	.261
	N	572	572	572
Substrate	Pearson Correlation	-.159**	-.047	1
	Sig. (2-tailed)	.000	.261	.
	N	572	572	572

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between substrate texture index and elevation

Correlations

		Substrate	Elev_1m
Substrate	Pearson Correlation	1	.553**
	Sig. (2-tailed)	.	.000
	N	572	572
Elev_1m	Pearson Correlation	.553**	1
	Sig. (2-tailed)	.000	.
	N	572	572

**. Correlation is significant at the 0.01 level (2-tailed).

Oneway ANOVA test for annuals height for elevation factor

ANOVA

Annuals

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24058.161	9	2673.129	10.215	.000
Within Groups	146549.4	560	261.695		
Total	170607.6	569			

Multiple-comparison test for annual heights for each elevation bracket.

Multiple Comparisons

Dependent Variable: Annuals
Scheffé

(I) Elev_Bracket	(J) Elev_Bracket	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
567.7	568.7	-2.3197	3.3196	1.000	-16.035	11.395
	569.7	-.5677	3.5126	1.000	-15.080	13.945
	570.7	-2.1252	3.3763	1.000	-16.075	11.824
	571.7	.1155	3.3968	1.000	-13.918	14.149
	572.7	8.6664	3.1820	.594	-4.480	21.813
	573.7	10.0631	3.2689	.396	-3.442	23.569
	574.7	11.0356	3.1444	.199	-1.956	24.027
	575.7	13.1485(*)	2.9270	.018	1.056	25.241
	576.7	14.0281(*)	2.8360	.004	2.311	25.745
568.7	567.7	2.3197	3.3196	1.000	-11.395	16.035
	569.7	1.7521	3.5291	1.000	-12.829	16.333
	570.7	.1945	3.3935	1.000	-13.826	14.215
	571.7	2.4352	3.4138	1.000	-11.669	16.539
	572.7	10.9861	3.2002	.229	-2.235	24.208
	573.7	12.3828	3.2866	.119	-1.196	25.961
	574.7	13.3553(*)	3.1628	.039	.288	26.423
	575.7	15.4682(*)	2.9468	.001	3.294	27.643
	576.7	16.3478(*)	2.8564	.000	4.547	28.149
569.7	567.7	.5677	3.5126	1.000	-13.945	15.080
	568.7	-1.7521	3.5291	1.000	-16.333	12.829
	570.7	-1.5575	3.5825	1.000	-16.359	13.244
	571.7	.6831	3.6018	1.000	-14.198	15.564
	572.7	9.2340	3.4000	.598	-4.813	23.281
	573.7	10.6307	3.4815	.410	-3.753	25.014
	574.7	11.6032	3.3649	.222	-2.299	25.505
	575.7	13.7162(*)	3.1626	.029	.650	26.783
	576.7	14.5957(*)	3.0786	.008	1.876	27.315
570.7	567.7	2.1252	3.3763	1.000	-11.824	16.075
	568.7	-.1945	3.3935	1.000	-14.215	13.826
	569.7	1.5575	3.5825	1.000	-13.244	16.359
	571.7	2.2406	3.4689	1.000	-12.091	16.573
	572.7	10.7916	3.2589	.281	-2.673	24.256
	573.7	12.1883	3.3439	.153	-1.627	26.004
	574.7	13.1607	3.2223	.056	-.152	26.474
	575.7	15.2737(*)	3.0105	.003	2.836	27.712
	576.7	16.1533(*)	2.9221	.000	4.081	28.226
571.7	567.7	-.1155	3.3968	1.000	-14.149	13.918
	568.7	-2.4352	3.4138	1.000	-16.539	11.669
	569.7	-.6831	3.6018	1.000	-15.564	14.198

	570.7	-2.2406	3.4689	1.000	-16.573	12.091
	572.7	8.5509	3.2801	.658	-5.001	22.103
	573.7	9.9476	3.3645	.463	-3.953	23.848
	574.7	10.9201	3.2437	.256	-2.481	24.321
	575.7	13.0331(*)	3.0334	.032	.501	25.565
	576.7	13.9126(*)	2.9457	.009	1.743	26.083
572.7	567.7	-8.6664	3.1820	.594	-21.813	4.480
	568.7	-10.9861	3.2002	.229	-24.208	2.235
	569.7	-9.2340	3.4000	.598	-23.281	4.813
	570.7	-10.7916	3.2589	.281	-24.256	2.673
	571.7	-8.5509	3.2801	.658	-22.103	5.001
	573.7	1.3967	3.1475	1.000	-11.607	14.401
	574.7	2.3692	3.0181	1.000	-10.100	14.838
	575.7	4.4821	2.7908	.978	-7.048	16.012
	576.7	5.3617	2.6952	.913	-5.774	16.497
573.7	567.7	-10.0631	3.2689	.396	-23.569	3.442
	568.7	-12.3828	3.2866	.119	-25.961	1.196
	569.7	-10.6307	3.4815	.410	-25.014	3.753
	570.7	-12.1883	3.3439	.153	-26.004	1.627
	571.7	-9.9476	3.3645	.463	-23.848	3.953
	572.7	-1.3967	3.1475	1.000	-14.401	11.607
	574.7	.9725	3.1096	1.000	-11.875	13.820
	575.7	3.0854	2.8895	.999	-8.853	15.023
	576.7	3.9650	2.7973	.991	-7.592	15.522
574.7	567.7	-11.0356	3.1444	.199	-24.027	1.956
	568.7	-13.3553(*)	3.1628	.039	-26.423	-.288
	569.7	-11.6032	3.3649	.222	-25.505	2.299
	570.7	-13.1607	3.2223	.056	-26.474	.152
	571.7	-10.9201	3.2437	.256	-24.321	2.481
	572.7	-2.3692	3.0181	1.000	-14.838	10.100
	573.7	-.9725	3.1096	1.000	-13.820	11.875
	575.7	2.1130	2.7479	1.000	-9.240	13.466
	576.7	2.9925	2.6508	.998	-7.959	13.944
575.7	567.7	-13.1485(*)	2.9270	.018	-25.241	-1.056
	568.7	-15.4682(*)	2.9468	.001	-27.643	-3.294
	569.7	-13.7162(*)	3.1626	.029	-26.783	-.650
	570.7	-15.2737(*)	3.0105	.003	-27.712	-2.836
	571.7	-13.0331(*)	3.0334	.032	-25.565	-.501
	572.7	-4.4821	2.7908	.978	-16.012	7.048
	573.7	-3.0854	2.8895	.999	-15.023	8.853
	574.7	-2.1130	2.7479	1.000	-13.466	9.240
	576.7	.8796	2.3888	1.000	-8.990	10.749
576.7	567.7	-14.0281(*)	2.8360	.004	-25.745	-2.311
	568.7	-16.3478(*)	2.8564	.000	-28.149	-4.547
	569.7	-14.5957(*)	3.0786	.008	-27.315	-1.876
	570.7	-16.1533(*)	2.9221	.000	-28.226	-4.081
	571.7	-13.9126(*)	2.9457	.009	-26.083	-1.743

	572.7	-5.3617	2.6952	.913	-16.497	5.774
	573.7	-3.9650	2.7973	.991	-15.522	7.592
	574.7	-2.9925	2.6508	.998	-13.944	7.959
	575.7	-.8796	2.3888	1.000	-10.749	8.990

* The mean difference is significant at the .05 level.

Oneway ANOVA test for perennial heights by elevation factor

ANOVA

Perennials

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	60745.947	9	6749.550	12.949	.000
Within Groups	291891.6	560	521.235		
Total	352637.5	569			

Multiple-comparison test for perennial heights for each elevation bracket.

Multiple Comparisons

Dependent Variable: Perennials
Scheffé

(I) Elev_Bracket	(J) Elev_Bracket	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
567.7	568.7	-1.5468	4.6850	1.000	-20.903	17.809
	569.7	-1.9079	4.9574	1.000	-22.389	18.574
	570.7	-2.6182	4.7650	1.000	-22.305	17.068
	571.7	-5.7605	4.7938	.997	-25.566	14.045
	572.7	-20.0018(*)	4.4907	.020	-38.555	-1.448
	573.7	-18.6540	4.6134	.063	-37.714	.406
	574.7	-21.8407(*)	4.4377	.005	-40.175	-3.506
	575.7	-29.7738(*)	4.1309	.000	-46.841	-12.707
	576.7	-18.8525(*)	4.0025	.009	-35.389	-2.316
568.7	567.7	1.5468	4.6850	1.000	-17.809	20.903
	569.7	-.3611	4.9806	1.000	-20.939	20.216
	570.7	-1.0714	4.7892	1.000	-20.858	18.715
	571.7	-4.2137	4.8179	1.000	-24.119	15.691
	572.7	-18.4550	4.5164	.056	-37.114	.205
	573.7	-17.1072	4.6384	.140	-36.271	2.056
	574.7	-20.2939(*)	4.4637	.015	-38.736	-1.852
	575.7	-28.2270(*)	4.1588	.000	-45.409	-11.045
	576.7	-17.3057(*)	4.0312	.032	-33.961	-.651
569.7	567.7	1.9079	4.9574	1.000	-18.574	22.389
	568.7	.3611	4.9806	1.000	-20.216	20.939
	570.7	-.7103	5.0560	1.000	-21.599	20.179

	571.7	-3.8526	5.0832	1.000	-24.854	17.148
	572.7	-18.0939	4.7984	.118	-37.918	1.731
	573.7	-16.7461	4.9134	.239	-37.046	3.554
	574.7	-19.9328(*)	4.7488	.042	-39.552	-.313
	575.7	-27.8659(*)	4.4634	.000	-46.306	-9.425
	576.7	-16.9446	4.3448	.088	-34.895	1.006
570.7	567.7	2.6182	4.7650	1.000	-17.068	22.305
	568.7	1.0714	4.7892	1.000	-18.715	20.858
	569.7	.7103	5.0560	1.000	-20.179	21.599
	571.7	-3.1423	4.8957	1.000	-23.369	17.084
	572.7	-17.3836	4.5993	.116	-36.386	1.619
	573.7	-16.0358	4.7192	.243	-35.533	3.462
	574.7	-19.2225(*)	4.5476	.039	-38.011	-.434
	575.7	-27.1556(*)	4.2487	.000	-44.709	-9.602
	576.7	-16.2343	4.1240	.081	-33.272	.804
571.7	567.7	5.7605	4.7938	.997	-14.045	25.566
	568.7	4.2137	4.8179	1.000	-15.691	24.119
	569.7	3.8526	5.0832	1.000	-17.148	24.854
	570.7	3.1423	4.8957	1.000	-17.084	23.369
	572.7	-14.2413	4.6292	.397	-33.367	4.884
	573.7	-12.8935	4.7483	.599	-32.511	6.724
	574.7	-16.0802	4.5778	.198	-34.993	2.833
	575.7	-24.0133(*)	4.2810	.000	-41.700	-6.326
	576.7	-13.0920	4.1572	.359	-30.268	4.084
572.7	567.7	20.0018(*)	4.4907	.020	1.448	38.555
	568.7	18.4550	4.5164	.056	-.205	37.114
	569.7	18.0939	4.7984	.118	-1.731	37.918
	570.7	17.3836	4.5993	.116	-1.619	36.386
	571.7	14.2413	4.6292	.397	-4.884	33.367
	573.7	1.3478	4.4421	1.000	-17.005	19.700
	574.7	-1.8389	4.2594	1.000	-19.436	15.759
	575.7	-9.7720	3.9386	.724	-26.045	6.501
	576.7	1.1493	3.8037	1.000	-14.566	16.865
573.7	567.7	18.6540	4.6134	.063	-.406	37.714
	568.7	17.1072	4.6384	.140	-2.056	36.271
	569.7	16.7461	4.9134	.239	-3.554	37.046
	570.7	16.0358	4.7192	.243	-3.462	35.533
	571.7	12.8935	4.7483	.599	-6.724	32.511
	572.7	-1.3478	4.4421	1.000	-19.700	17.005
	574.7	-3.1867	4.3885	1.000	-21.318	14.945
	575.7	-11.1198	4.0780	.592	-27.968	5.728
	576.7	-.1985	3.9478	1.000	-16.509	16.112
574.7	567.7	21.8407(*)	4.4377	.005	3.506	40.175
	568.7	20.2939(*)	4.4637	.015	1.852	38.736
	569.7	19.9328(*)	4.7488	.042	.313	39.552
	570.7	19.2225(*)	4.5476	.039	.434	38.011
	571.7	16.0802	4.5778	.198	-2.833	34.993

	572.7	1.8389	4.2594	1.000	-15.759	19.436
	573.7	3.1867	4.3885	1.000	-14.945	21.318
	575.7	-7.9331	3.8781	.898	-23.956	8.089
	576.7	2.9882	3.7410	1.000	-12.468	18.444
575.7	567.7	29.7738(*)	4.1309	.000	12.707	46.841
	568.7	28.2270(*)	4.1588	.000	11.045	45.409
	569.7	27.8659(*)	4.4634	.000	9.425	46.306
	570.7	27.1556(*)	4.2487	.000	9.602	44.709
	571.7	24.0133(*)	4.2810	.000	6.326	41.700
	572.7	9.7720	3.9386	.724	-6.501	26.045
	573.7	11.1198	4.0780	.592	-5.728	27.968
	574.7	7.9331	3.8781	.898	-8.089	23.956
	576.7	10.9213	3.3713	.314	-3.007	24.850
576.7	567.7	18.8525(*)	4.0025	.009	2.316	35.389
	568.7	17.3057(*)	4.0312	.032	.651	33.961
	569.7	16.9446	4.3448	.088	-1.006	34.895
	570.7	16.2343	4.1240	.081	-.804	33.272
	571.7	13.0920	4.1572	.359	-4.084	30.268
	572.7	-1.1493	3.8037	1.000	-16.865	14.566
	573.7	.1985	3.9478	1.000	-16.112	16.509
	574.7	-2.9882	3.7410	1.000	-18.444	12.468
	575.7	-10.9213	3.3713	.314	-24.850	3.007

* The mean difference is significant at the .05 level.

Based on the exploratory analysis from 2009, the main factors that contributed to the variation of abundance and richness were: 1) site, 2) substrate, and 3) elevation. A general linear multivariate model was run at the exploratory level only to see how the 2012 data fit. This is not supplied as a result but just at the exploratory level. The resulting model showed that vegetation per cent cover by site had a significance level of P = 0.025. Vegetation cover by substrate was not significant with P = 0.230 nor was it significant by elevation P = 0.0.266. Species richness by site had a significance level of P <0.001 and by substrate of P = 0.022. Richness was not significant by elevation P = 0.455. This model explains 68.4 per cent of the variation found within the vegetation cover and 75.6 per cent of the species richness. Slope was tested as a single factor which showed it was significant for both dependent variables but is strongly associated with elevation. When the model was run with factors; site, slope, and substrate it was not as good a fit as the above. Rigours testing of all six factors was not pursued or required for this report.

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Species Richness	1245.490(a)	312	3.992	2.573	.000
	Vegetation Cover	360934.741(b)	312	1156.842	1.797	.000
Intercept	Species Richness	1162.935	1	1162.935	749.660	.000
	Vegetation Cover	159958.468	1	159958.468	248.464	.000
Site	Species Richness	91.977	10	9.198	5.929	.000
	Vegetation Cover	13532.608	10	1353.261	2.102	.025
Substrate	Species Richness	126.740	55	2.304	1.485	.022
	Vegetation Cover	40876.536	55	743.210	1.154	.230
Elevation	Species Richness	13.722	9	1.525	.983	.455
	Vegetation Cover	7228.685	9	803.187	1.248	.266
Site * Substrate	Species Richness	18.920	15	1.261	.813	.663
	Vegetation Cover	9934.037	15	662.269	1.029	.426
Site * Elevation	Species Richness	34.573	24	1.441	.929	.563
	Vegetation Cover	12393.610	24	516.400	.802	.733
Substrate * Elevation	Species Richness	75.699	63	1.202	.775	.887
	Vegetation Cover	36030.977	63	571.920	.888	.708
Site * Substrate * Elevation	Species Richness	.000	0	.	.	.
	Vegetation Cover	.000	0	.	.	.
Error	Species Richness	401.783	259	1.551		
	Vegetation Cover	166741.568	259	643.790		
Total	Species Richness	3732.000	572			
	Vegetation Cover	845332.980	572			
Corrected Total	Species Richness	1647.273	571			
	Vegetation Cover	527676.308	571			

a R Squared = .756 (Adjusted R Squared = .462)
b R Squared = .684 (Adjusted R Squared = .303)

Even though hypothesis testing was not part of the year 4 report, the above variables and factor analysis along with the model suggests that change to vegetation abundance and biodiversity is detected by the data collected in each sampling year. Additional factor investigation and additional data will help to identify factors affecting vegetation and identify what level of variation occurs from seasonal variation between years. With only two data sets for analysis assigning affect accurately is not possible though very strong trends are becoming apparent. When modeling and hypothesis testing analysis is completed all factors will be rigorously tested using multiple analysis tools.

Appendix 5: Photo Documentation

Date: June 18, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S1 TR 1	0	0	IMG_4453	Herb quadrat
	1		IMG_4454	Looking at POC
	1		IMG_4455	Looking down line
	1		IMG_4456	Up reservoir
	1		IMG_4457	Down reservoir
	86	-2	IMG_4458	Herb quadrat
	87		IMG_4459	Looking at POC
	87		IMG_4460	Looking down line
	87		IMG_4461	Up reservoir
	87		IMG_4462	Down reservoir
	140	-4	IMG_4463	Herb quadrat
	141		IMG_4464	Looking at POC
	141		IMG_4465	Looking down line
	141		IMG_4466	Up reservoir
	141		IMG_4467	Down reservoir
	177	-6	IMG_4468	Herb quadrat
	178		IMG_4469	Looking at POC
	178		IMG_4470	Looking down line
	178		IMG_4471	Up reservoir
	178		IMG_4472	Down reservoir
	212	-8	IMG_4473	Herb quadrat
	212		IMG_4474	Looking at POC
	212		IMG_4475	Looking down line
	212		IMG_4476	Up reservoir
	212		IMG_4477	Down reservoir
	278	-10	IMG_4478	Herb quadrat
	279		IMG_4479	Looking at POC
	279		IMG_4480	Looking down line
	279		IMG_4481	Up reservoir
	279		IMG_4482	Down reservoir
Upland	0	0	IMG_4483	Looking at start of upland line POC tree
	-15		IMG_4484	Looking into tree plot area
	-15		IMG_4485	Herb quadrat
	-18		IMG_4486	Looking at EOT
	-31	2		End point in photo 4486 2 m change in elev
S1 TR 700	0	0	IMG_4487	Herb quadrat
	1		IMG_4488	Looking at POC
	1		IMG_4489	Looking down line
	1		IMG_4490	Up reservoir
	1		IMG_4491	Down reservoir
	17	-2	IMG_4492	Herb quadrat
	18		IMG_4493	Looking at POC
	18		IMG_4494	Looking down line
	18		IMG_4495	Up reservoir
	18		IMG_4496	Down reservoir
	30.4	-4	IMG_4497	Herb quadrat

Date: June 18, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S1 TR 700	31.4	-4	IMG_4498	Looking at POC
	31.4		IMG_4499	Looking down line
	31.4		IMG_4500	Up reservoir
	31.4		IMG_4501	Down reservoir
	59.9	-6	IMG_4502	Herb quadrat
	60.9		IMG_4503	Looking at POC
	60.9		IMG_4504	Looking down line
	60.9		IMG_4505	Up reservoir
	60.9		IMG_4506	Down reservoir
	96.5	-8	IMG_4507	Herb quadrat
	97.5		IMG_4508	Looking at POC
	97.5		IMG_4509	Looking down line
	97.5		IMG_4510	Up reservoir
	97.5		IMG_4511	Down reservoir
	133.6	-10	IMG_4512	Herb quadrat
	133.6		IMG_4513	Looking at POC
	133.6		IMG_4514	Looking down line
	133.6		IMG_4515	Up reservoir
	133.6		IMG_4516	Down reservoir
Upland	0	0	IMG_4517	Looking down line
	-4		IMG_4518	Looking down line
	-9		IMG_4519	Looking down line
	-9		IMG_4520	Looking up reservoir
	-19		IMG_4521	Looking down line
	-19		IMG_4522	Looking up reservoir
	-19		IMG_4523	Looking down reservoir
	-24	2		Line ends 2 m change in elevation

Date: June 19, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S2 TR 701	0	0	IMG_4559	Herb quadrat
	1		IMG_4560	Looking at POC
	1		IMG_4561	Looking down line
	1		IMG_4562	Up reservoir
	1		IMG_4563	Down reservoir
	28	-2	IMG_4564	Herb quadrat
	29		IMG_4565	Looking at POC
	29		IMG_4566	Looking down line
	29		IMG_4567	Up reservoir
	29		IMG_4568	Down reservoir
	57	-4	IMG_4569	Herb quadrat
	58		IMG_4570	Looking at POC
	58		IMG_4571	Looking down line
	58		IMG_4572	Up reservoir
	58		IMG_4573	Down reservoir
	162	-6	IMG_4574	Herb quadrat
	163		IMG_4575	Looking at POC
	163		IMG_4576	Looking down line
	163		IMG_4577	Up reservoir
	163		IMG_4578	Down reservoir
	237	-8	IMG_4579	Herb quadrat
	238		IMG_4580	Looking at POC
	238		IMG_4581	Looking down line
	238		IMG_4582	Up reservoir
	238		IMG_4583	Down reservoir
	287	-10	IMG_4584	Herb quadrat
	288		IMG_4585	Looking at POC
	288		IMG_4586	Looking down line
	288		IMG_4587	Up reservoir
	288		IMG_4588	Down reservoir
Upland	-6	0	IMG_4589	Looking down line
	-6		IMG_4590	Up reservoir
	-6		IMG_4591	Down reservoir
	-15		IMG_4592	Looking down line
	-15		IMG_4593	Up reservoir
	-15		IMG_4594	Down reservoir
	-25	2		Line ends at 2 m change in elevation
S2 TR 702	0	0	IMG_4595	Herb quadrat
	1		IMG_4596	Looking at POC
	1		IMG_4597	Looking down line
	1		IMG_4598	Up reservoir
	1		IMG_4599	Down reservoir
	28		IMG_4600	Herb quadrat
	29		IMG_4601	Looking at POC
	29		IMG_4602	Looking down line
	29		IMG_4603	Up reservoir

Date: June 19, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S2 TR 702	29	0	IMG_4604	Down reservoir
	60	-1	IMG_4605	Herb quadrat
	61		IMG_4606	Looking at POC
	61		IMG_4607	Looking down line
	61		IMG_4608	Up reservoir
	61		IMG_4609	Down reservoir
	84	-2	IMG_4610	Herb quadrat
	85		IMG_4611	Looking at POC
	85		IMG_4612	Looking down line
	85		IMG_4613	Up reservoir
	85		IMG_4614	Down reservoir
	150	-4	IMG_4615	Herb quadrat
	151		IMG_4616	Looking at POC
	151		IMG_4617	Looking down line
	151		IMG_4618	Up reservoir
	151		IMG_4619	Down reservoir
	168		IMG_4620	Herb quadrat
	169		IMG_4621	Looking at POC
	169		IMG_4622	Looking down line
	169		IMG_4623	Up reservoir
	169		IMG_4624	Down reservoir
	225	-6	IMG_4625	Herb quadrat
	226		IMG_4626	Looking at POC
	226		IMG_4627	Looking down line
	226		IMG_4628	Up reservoir
	226		IMG_4629	Down reservoir
	294	-8	IMG_4630	Herb quadrat
	295		IMG_4631	Looking at POC
	295		IMG_4632	Looking down line
	295		IMG_4633	Up reservoir
	295		IMG_4634	Down reservoir
	388	-10	IMG_4635	Herb quadrat
	389		IMG_4636	Looking at POC
	389		IMG_4637	Looking down line
	389		IMG_4638	Up reservoir
	389		IMG_4639	Down reservoir
Upland	0	0	IMG_4640	Looking into start of upland
	-15		IMG_4641	Last herb plot
	-21		IMG_4642	Looking up line towards POC standing just past end of line
	-20	2		End of line, 2 m change in elevation
S2 TR 703	10	0	IMG_4524	Herb quadrat
	11		IMG_4525	Looking at POC
	11		IMG_4526	Looking down line
	11		IMG_4527	Up reservoir
	11		IMG_4528	Down reservoir

Date: June 19, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S2 TR 703	29	-2	IMG_4529	Herb quadrat
	30		IMG_4530	Looking at POC
	30		IMG_4531	Looking down line
	30		IMG_4532	Up reservoir
	30		IMG_4533	Down reservoir
	150	-4	IMG_4534	Herb quadrat
	151		IMG_4535	Looking at POC
	151		IMG_4536	Looking down line
	151		IMG_4537	Up reservoir
	151		IMG_4538	Down reservoir
	246	-6	IMG_4539	Herb quadrat
	247		IMG_4540	Looking at POC
	247		IMG_4541	Looking down line
	247		IMG_4542	Up reservoir
	247		IMG_4543	Down reservoir
	282	-8	IMG_4544	Herb quadrat
	283		IMG_4545	Looking at POC
	283		IMG_4546	Looking down line
	283		IMG_4547	Up reservoir
	283		IMG_4548	Down reservoir
	360	-10	IMG_4549	Herb quadrat
	361		IMG_4550	Looking at POC
	361		IMG_4551	Looking down line
	361		IMG_4552	Up reservoir
	361		IMG_4553	Down reservoir
Upland	0	0	IMG_4554	Looking at tag tree from drawdown side
	-5		IMG_4555	Looking up line
	-5		IMG_4556	Looking down line
	-19		IMG_4557	Looking down line
	-24	2	IMG_4558	Looking up line
	-24			Line ends, 2 m change in elevation

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S3 TR 704	0	0	IMG_4668	Herb quadrat
	1		IMG_4669	Looking at POC
	1		IMG_4670	Looking down line
	1		IMG_4671	Up reservoir
	1		IMG_4672	Down reservoir
	10	-2	IMG_4643	Herb quadrat
	11		IMG_4644	Looking at POC
	11		IMG_4645	Looking down line
	11		IMG_4646	Up reservoir
	11		IMG_4647	Down reservoir
	16	-4	IMG_4648	Herb quadrat
	17		IMG_4649	Looking at POC
	17		IMG_4650	Looking down line
	17		IMG_4651	Up reservoir
	17		IMG_4652	Down reservoir
	31	-6	IMG_4653	Herb quadrat
	32		IMG_4654	Looking at POC
	32		IMG_4655	Looking down line
	32		IMG_4656	Up reservoir
	32		IMG_4657	Down reservoir
	43	-8	IMG_4658	Herb quadrat
	44		IMG_4659	Looking at POC
	44		IMG_4660	Looking down line
	44		IMG_4661	Up reservoir
	44		IMG_4662	Down reservoir
	64	-10	IMG_4663	Herb quadrat
	65		IMG_4664	Looking at POC
	65		IMG_4665	Looking down line
	65		IMG_4666	Up reservoir
	65		IMG_4667	Down reservoir
Upland	-1	0	IMG_4673	Looking up line away form POC
	-5		IMG_4674	Looking up reservoir
	-5		IMG_4675	Looking down reservoir
	-25	2		Line ends at 2 m change in elevation
S3 TR 812	7	0	IMG_4701	Herb quadrat
	8		IMG_4702	Looking at POC
	8		IMG_4703	Looking down line
	8		IMG_4704	Up reservoir
	8		IMG_4705	Down reservoir
	17	-2	IMG_4696	Herb quadrat
	18		IMG_4697	Looking at POC
	18		IMG_4698	Looking down line
	18		IMG_4699	Up reservoir
	18		IMG_4700	Down reservoir
	25.3	-4	IMG_4691	Herb quadrat
	26.3		IMG_4692	Looking at POC

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S3 TR 812	26.3	-4	IMG_4693	Looking down line
	26.3		IMG_4694	Up reservoir
	26.3		IMG_4695	Down reservoir
	29.4	-6	IMG_4686	Herb quadrat
	30.4		IMG_4687	Looking at POC
	30.4		IMG_4688	Looking down line
	30.4		IMG_4689	Up reservoir
	30.4		IMG_4690	Down reservoir
	36.3	-8	IMG_4681	Herb quadrat
	37.3		IMG_4682	Looking at POC
	37.3		IMG_4683	Looking down line
	37.3		IMG_4684	Up reservoir
	37.3		IMG_4685	Down reservoir
	47.0	-10	IMG_4676	Herb quadrat
	48.0		IMG_4677	Looking at POC
	48.0		IMG_4678	Looking down line
	48.0		IMG_4679	Up reservoir
	48.0		IMG_4680	Down reservoir
Upland	-1	0	IMG_4706	Looking up line
	-1		IMG_4707	Looking down line
	-5		IMG_4708	Looking up line
	-5		IMG_4709	Looking down line
	-6	2		Line ends for 2 m change in elevation

Date: June 20, 2012	**Project Leader:** Mary Louise Polzin			
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S4 TR 705	0	0	IMG_4710	Herb quadrat
	1		IMG_4711	Looking at POC
	1		IMG_4712	Looking down line
	1		IMG_4713	Up reservoir
	1		IMG_4714	Down reservoir
	13	-2	IMG_4715	Herb quadrat
	14		IMG_4716	Looking at POC
	14		IMG_4717	Looking down line
	14		IMG_4718	Up reservoir
	14		IMG_4719	Down reservoir
	29.5	-4	IMG_4720	Herb quadrat
	30.5		IMG_4721	Looking at POC
	30.5		IMG_4722	Looking down line
	30.5		IMG_4723	Up reservoir
	30.5		IMG_4724	Down reservoir
	49.5	-6	IMG_4725	Herb quadrat
	50.5		IMG_4726	Looking at POC
	50.5		IMG_4727	Looking down line
	50.5		IMG_4728	Up reservoir
	50.5		IMG_4729	Down reservoir
	61.5	-8	IMG_4730	Herb quadrat
	62.5		IMG_4731	Looking at POC
	62.5		IMG_4732	Looking down line
	62.5		IMG_4733	Up reservoir
	62.5		IMG_4734	Down reservoir
	73.5	-10	IMG_4735	Herb quadrat
	74.5		IMG_4736	Looking at POC
	75.5		IMG_4737	Looking down line
	74.5		IMG_4738	Up reservoir
	74.5		IMG_4739	Down reservoir
Upland	-4	0	IMG_4745	Looking down line towards POC
	-4		IMG_4741	Looking up line pink ribbon is -5 m mark edge of tree plot
	-4		IMG_4740	Up reservoir
	-4		IMG_4742	Down reservoir
	-7		IMG_4743	Looking down line
	-7		IMG_4744	Looking up line
	-12	2		Line ends at 2 m change in elevation
			IMG_4746	Aligator Lizard found in drawdown zone of reservoir
			IMG_4747	
			IMG_4748	
			IMG_4749	
			IMG_4750	

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S4 TR 706	1	0	IMG_4751	Herb quadrat
	2		IMG_4752	Looking at POC
	2		IMG_4753	Looking down line
	2		IMG_4754	Up reservoir
	2		IMG_4755	Down reservoir
	7	-2	IMG_4756	Herb quadrat
	8		IMG_4757	Looking at POC
	8		IMG_4758	Looking down line
	8	-2	IMG_4759	Up reservoir
	8		IMG_4760	Down reservoir
	21	-4	IMG_4761	Herb quadrat
	22		IMG_4762	Looking at POC
	22		IMG_4763	Looking down line
	22		IMG_4764	Up reservoir
	22		IMG_4765	Down reservoir
	36	-6	IMG_4766	Herb quadrat
	37		IMG_4767	Looking at POC
	37		IMG_4768	Looking down line
	37		IMG_4769	Up reservoir
	37		IMG_4770	Down reservoir
	50	-8	IMG_4771	Herb quadrat
	51		IMG_4772	Looking at POC
	51		IMG_4773	Looking down line
	51		IMG_4774	Up reservoir
	51		IMG_4775	Down reservoir
	54	-10	IMG_4776	Herb quadrat
	55		IMG_4777	Looking at POC
	55		IMG_4778	Looking down line
	55		IMG_4779	Up reservoir
	55		IMG_4780	Down reservoir
Upland	-1	0	IMG_4781	Looking up line
	-1		IMG_4783	Looking down reservoir
	-5		IMG_4782	Looking down line
	-5		IMG_4784	Looking up reservoir
	-5		IMG_4785	Looking down line towards POC
	-6	2		Line ends at 2 m change in elevation

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S5 TR 707	0	0	IMG_4786	Herb quadrat
	1		IMG_4787	Looking at POC
	1		IMG_4788	Looking down line
	1		IMG_4789	Up reservoir
	1		IMG_4790	Down reservoir
	37	-2	IMG_4791	Herb quadrat
	38		IMG_4792	Looking at POC
	38		IMG_4793	Looking down line
	38		IMG_4794	Up reservoir
	38		IMG_4795	Down reservoir
	60	-4	IMG_4796	Herb quadrat
	61		IMG_4797	Looking at POC
	61		IMG_4798	Looking down line
	61		IMG_4799	Up reservoir
	61		IMG_4800	Down reservoir
	83	-6	IMG_4801	Herb quadrat
	84		IMG_4802	Looking at POC
	84		IMG_4803	Looking down line
	84		IMG_4804	Up reservoir
	84		IMG_4805	Down reservoir
	105	-8	IMG_4806	Herb quadrat
	106		IMG_4807	Looking at POC
	106		IMG_4808	Looking down line
	106		IMG_4809	Up reservoir
	106		IMG_4810	Down reservoir
	128	-10	IMG_4811	Herb quadrat
	129		IMG_4812	Looking at POC
	129		IMG_4813	Looking down line
	129		IMG_4814	Up reservoir
	129		IMG_4815	Down reservoir
Upland	-2	0	IMG_4816	Looking down line away from POC
	-4		IMG_4817	Looking up line towards POC
	-4		IMG_4818	Looking down line away from POC
	-8		IMG_4819	Looking up reservoir
	-8		IMG_4820	Looking down reservoir
	-10	2		Line ends at 2 m change in elevation
S5 TR 813	4	0	IMG_4821	Herb quadrat
	5		IMG_4822	Looking at POC
	5		IMG_4823	Looking down line
	5		IMG_4824	Up reservoir
	5		IMG_4825	Down reservoir
	23.4	-2	IMG_4826	Herb quadrat
	24.4		IMG_4827	Looking at POC
	24.4		IMG_4828	Looking down line
	24.4		IMG_4829	Up reservoir
	24.4		IMG_4830	Down reservoir

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S5 TR 813	35.6	-4	IMG_4831	Herb quadrat
	36.6		IMG_4832	Looking at POC
	36.6		IMG_4833	Looking down line
	36.6		IMG_4834	Up reservoir
	36.6		IMG_4835	Down reservoir
	47	-6	IMG_4836	Herb quadrat
	48		IMG_4837	Looking at POC
	48		IMG_4838	Looking down line
	48		IMG_4839	Up reservoir
	48		IMG_4840	Down reservoir
	59.7	-8	IMG_4841	Herb quadrat
	60.7		IMG_4842	Looking at POC
	60.7		IMG_4843	Looking down line
	60.7		IMG_4844	Up reservoir
	60.7		IMG_4845	Down reservoir
	71.4	-10	IMG_4846	Herb quadrat
	72.4		IMG_4847	Looking at POC
	72.4		IMG_4848	Looking down line
	72.4		IMG_4849	Up reservoir
	72.4		IMG_4850	Down reservoir
Upland	-1	0	IMG_4851	Looking down line
	-5		IMG_4852	Looking down reservoir
	-6		IMG_4853	Looking up reservoir
	-12	2	IMG_4854	Looking up line towards POC
	-12			Line ends at 2 m change in elevation

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S6 TR 708	7	0	IMG_4855	Herb quadrat
	8		IMG_4856	Looking at POC
	8		IMG_4857	Looking down line
	8		IMG_4858	Up reservoir
	8		IMG_4859	Down reservoir
	13	-2	IMG_4860	Herb quadrat
	14		IMG_4861	Looking at POC
	14		IMG_4862	Looking down line
	14		IMG_4863	Up reservoir
	14		IMG_4864	Down reservoir
	26	-4	IMG_4865	Herb quadrat
	27		IMG_4866	Looking at POC
	27		IMG_4867	Looking down line
	27		IMG_4868	Up reservoir
	27		IMG_4869	Down reservoir
	37	-6	IMG_4874	Herb quadrat
	38		IMG_4870	Looking at POC
	38		IMG_4871	Looking down line
	38		IMG_4872	Up reservoir
	38		IMG_4873	Down reservoir
	48	-8	IMG_4875	Herb quadrat
	49		IMG_4876	Looking at POC
	49		IMG_4877	Looking down line
	49		IMG_4878	Up reservoir
	49		IMG_4879	Down reservoir
	55	-10	IMG_4880	Herb quadrat
	56		IMG_4881	Looking at POC
	56		IMG_4882	Looking down line
	56		IMG_4883	Up reservoir
	56		IMG_4884	Down reservoir
Upland	-12		IMG_4885	Looking up line towards POC
	-12		IMG_4886	Looking down line away from POC
	-12		IMG_4887	Looking down reservoir
	-12		IMG_4888	Looking up reservoir
	-27			Line ends for 2 m change in elevation
S6 TR 814	1	0	IMG_4916	Looking down line
	1		IMG_4917	Up reservoir
	1		IMG_4918	Down reservoir
	7.7	-2	IMG_4889	Herb quadrat
	8.7		IMG_4890	Looking at POC
	8.7		IMG_4891	Looking down line
	8.7		IMG_4892	Up reservoir
	8.7		IMG_4893	Down reservoir
	12.4	-4	IMG_4894	Herb quadrat
	13.4		IMG_4895	Looking at POC
	13.4		IMG_4896	Looking down line

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S6 TR 814	13.4	-4	IMG_4897	Up reservoir
	13.4		IMG_4898	Down reservoir
	18.3	-6	IMG_4899	Herb quadrat
	19.3		IMG_4900	Looking at POC
	19.3		IMG_4901	Looking down line
	19.3		IMG_4902	Up reservoir
	19.3		IMG_4903	Down reservoir
	26	-8	IMG_4904	Herb quadrat
	27		IMG_4905	Looking at POC
	27		IMG_4906	Looking down line
	27		IMG_4907	Up reservoir
	27		IMG_4908	Down reservoir
	35.3	-10	IMG_4909	Herb quadrat
	36.3		IMG_4910	Looking at POC
	36.3		IMG_4911	Looking down line
	36.3		IMG_4912	Up reservoir
	36.3		IMG_4913	Down reservoir
Upland	0	0	IMG_4914	Herb quadrat
	-1		IMG_4915	Looking down line
	8		IMG_4919	Looking at upland from reservoir 8 m mark
	8		IMG_4920	Same as above - steep bank most of upland
	8		IMG_4921	Same as above.
	8		IMG_4922	Same as above.
	-2.3	2		Line ends for 2 m change in elevation

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S7 TR 2	0	0	IMG_4923	Herb quadrat
	1		IMG_4924	Looking at POC which is on the ground at full-pool upland vegetation in photo.
	1		IMG_4925	Looking down line
	1		IMG_4926	Up reservoir
	1		IMG_4927	Down reservoir mainly upland in photo.
	20	-2	IMG_4928	Herb quadrat
	21		IMG_4929	Looking at POC
	21		IMG_4930	Looking down line
	21		IMG_4931	Up reservoir
	21		IMG_4932	Down reservoir
	27	-4	IMG_4933	Herb quadrat
	28		IMG_4934	Looking at POC
	28		IMG_4935	Looking down line
	28		IMG_4936	Up reservoir
	28		IMG_4937	Down reservoir
	32	-6	IMG_4938	Herb quadrat
	33		IMG_4939	Looking at POC
	33		IMG_4940	Looking down line
	33		IMG_4941	Up reservoir
	33		IMG_4942	Down reservoir
	37	-8	IMG_4943	Herb quadrat
	38		IMG_4944	Looking at POC
	38		IMG_4945	Looking down line
	38		IMG_4946	Up reservoir
	38		IMG_4947	Down reservoir
	42	-10	IMG_4948	Herb quadrat
	43		IMG_4949	Looking at POC
	43		IMG_4950	Looking down line
	43		IMG_4951	Up reservoir
	43		IMG_4952	Down reservoir
Upland	0	0	IMG_4953	Standing on POC looking down line
	-4		IMG_4954	Looking up reservoir
	-10		IMG_4955	Standing on down reservoir side out side of quadrats looking at line.
	-12		IMG_4956	Looking at line from up reservoir side past line.
	-19		IMG_4957	Looking down reservoir near end of line standing on the up reservoir side outside of line.
	-24	2		Lind ends at 2 m change in elevation
S7 TR 3	0	0	IMG_4958	Herb quadrat
	1		IMG_4959	Looking at POC
	1		IMG_4960	Looking down line
	1		IMG_4961	Up reservoir
	1		IMG_4962	Down reservoir
	9	-2	IMG_4963	Herb quadrat

Date: June 20, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S7 TR 3	10	-2	IMG_4964	Looking at POC
	10		IMG_4965	Looking down line
	10		IMG_4966	Up reservoir
	10		IMG_4967	Down reservoir
	25	-4	IMG_4968	Herb quadrat
	26		IMG_4969	Looking at POC
	26		IMG_4970	Looking down line
	26		IMG_4971	Up reservoir
	26		IMG_4972	Down reservoir
	32	-6	IMG_4973	Herb quadrat
	33		IMG_4974	Looking at POC
	33		IMG_4975	Looking down line
	33		IMG_4976	Up reservoir
	33		IMG_4977	Down reservoir
	41	-8	IMG_4978	Herb quadrat
	42		IMG_4979	Looking at POC
	42		IMG_4980	Looking down line
	42		IMG_4981	Up reservoir
	42		IMG_4982	Down reservoir
	45	-10	IMG_4983	Herb quadrat
	46		IMG_4984	Looking at POC
	46		IMG_4985	Looking down line
	46		IMG_4986	Up reservoir
	46		IMG_4987	Down reservoir
Upland	-5	0	IMG_4988	Looking down line
	-5		IMG_4989	Looking at tree plot area
	-7	2	IMG_4990	Looking line towards POC standing at end of line
	-7		IMG_4991	Same as above
	-7			Line ends with 2 m change in elevation

Date: June 21, 2012	**Project Leader:** Mary Louise Polzin			
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S9 TR 709	0	0	IMG_5022	Herb quadrat
	1		IMG_5023	Looking at POC
	1		IMG_5024	Looking down line
	1		IMG_5025	Up reservoir
	1		IMG_5026	Down reservoir
	10		IMG_5017	Herb quadrat
	11		IMG_5018	Looking at POC
	11		IMG_5019	Looking down line
	11		IMG_5020	Up reservoir
	11		IMG_5021	Down reservoir
	17	-2	IMG_5012	Herb quadrat
	18		IMG_5013	Looking at POC
	18		IMG_5014	Looking down line
	18		IMG_5015	Up reservoir
	18		IMG_5016	Down reservoir
	34	-4	IMG_5007	Herb quadrat
	35		IMG_5008	Looking at POC
	35		IMG_5009	Looking down line
	35		IMG_5010	Up reservoir
	35		IMG_5011	Down reservoir
	55	-6	IMG_5002	Herb quadrat
	56		IMG_5003	Looking at POC
	56		IMG_5004	Looking down line
	56		IMG_5005	Up reservoir
	56		IMG_5006	Down reservoir
	77	-8	IMG_4997	Herb quadrat
	78		IMG_4998	Looking at POC
	78		IMG_4999	Looking down line
	78		IMG_5000	Up reservoir
	78		IMG_5001	Down reservoir
	91	-10	IMG_4992	Herb quadrat
	92		IMG_4993	Looking at POC
	92		IMG_4994	Looking down line
	92		IMG_4995	Up reservoir
	92		IMG_4996	Down reservoir
Upland	6	0	IMG_5027	Looking at upland from drawdown level
	-5		IMG_5028	Looking at upland edge at very large fir
	-7		IMG_5029	Looking at down reservoir side of transect line
	-7	2		Line ends at 2 m change in elevation
S9 TR 710	0	0	IMG_5030	Herb quadrat
	1		IMG_5031	Looking at POC
	1		IMG_5032	Looking down line
	1		IMG_5033	Up reservoir
	1		IMG_5034	Down reservoir
	13	-2	IMG_5035	Herb quadrat
	14		IMG_5036	Looking at POC

Date: June 21, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S9 TR 710	14	-2	IMG_5037	Looking down line
	14		IMG_5038	Up reservoir
	14		IMG_5039	Down reservoir
	34	-4	IMG_5040	Herb quadrat
	35		IMG_5041	Looking at POC
	35		IMG_5042	Looking down line
	35		IMG_5043	Up reservoir
	35		IMG_5044	Down reservoir
	50.2	-6	IMG_5045	Herb quadrat
	51.2		IMG_5046	Looking at POC
	51.2		IMG_5047	Looking down line
	51.2		IMG_5048	Up reservoir
	51.2		IMG_5049	Down reservoir
	81.4	-8	IMG_5050	Herb quadrat
	82.4		IMG_5051	Looking at POC
	82.4		IMG_5052	Looking down line
	82.4		IMG_5053	Up reservoir
	82.4		IMG_5054	Down reservoir
	107.5	-10	IMG_5055	Herb quadrat
	108.5		IMG_5056	Looking at POC
	108.5		IMG_5057	Looking down line
	108.5		IMG_5058	Up reservoir
	108.5		IMG_5059	Down reservoir
Uplands	0	0	IMG_5060	Looking down line away from POC
	-2		IMG_5061	Looking down line away from POC
	-8		IMG_5062	Looking down reservoir
	-8		IMG_5063	Looking up reservoir
	-10		IMG_5064	Looking towards POC
	-13.5	2		Line ends at 2 m change in elevation
S9 TR 711	2	0	IMG_5100	Herb quadrat
	3		IMG_5101	Looking at POC
	3		IMG_5102	Looking down line
	3		IMG_5103	Up reservoir
	3		IMG_5104	Down reservoir
	17	-2	IMG_5105	Herb quadrat
	18		IMG_5106	Looking at POC
	18		IMG_5107	Looking down line
	18		IMG_5108	Up reservoir
	18		IMG_5109	Down reservoir
	44	-4	IMG_5110	Herb quadrat
	45		IMG_5111	Looking at POC
	45		IMG_5112	Looking down line
	45		IMG_5113	Up reservoir
	45		IMG_5114	Down reservoir
	70.2	-6	IMG_5115	Herb quadrat
	71.2		IMG_5116	Looking at POC

Date: June 21, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S9 TR 711	71.2	-6	IMG_5117	Looking down line
	71.2		IMG_5118	Up reservoir
	71.2		IMG_5119	Down reservoir
	115.5	-8	IMG_5120	Herb quadrat
	116.5		IMG_5121	Looking at POC
	116.5		IMG_5122	Looking down line
	116.5		IMG_5123	Up reservoir
	116.5		IMG_5124	Down reservoir
	151	-10	IMG_5125	Herb quadrat
	152		IMG_5126	Looking at POC
	152		IMG_5127	Looking down line
	152		IMG_5128	Up reservoir
	152		IMG_5129	Down reservoir
Upland	-8	0	IMG_5130	Looking down line away from POC
	-8		IMG_5131	Looking down line away from POC
	-8		IMG_5132	Looking up line towards POC
	-12		IMG_5133	Looking up line towards POC
	-14	2		Line ends at 2 m change in elevation
S9 TR 712	1	0	IMG_5090	Herb quadrat
	2		IMG_5091	Looking at POC
	2		IMG_5092	Looking down line
	2		IMG_5093	Up reservoir
	2		IMG_5094	Down reservoir
	18	-2	IMG_5085	Herb quadrat
	19		IMG_5086	Looking at POC
	19		IMG_5087	Looking down line
	19		IMG_5088	Up reservoir
	19		IMG_5089	Down reservoir
	32	-4	IMG_5080	Herb quadrat
	33		IMG_5081	Looking at POC
	39		IMG_5082	Looking down line
	39		IMG_5083	Up reservoir
	39		IMG_5084	Down reservoir
	70.2	-6	IMG_5075	Herb quadrat
	71		IMG_5076	Looking at POC
	71		IMG_5077	Looking down line
	71		IMG_5078	Up reservoir
	71		IMG_5079	Down reservoir
	125	-8	IMG_5070	Herb quadrat
	126		IMG_5071	Looking at POC
	126		IMG_5072	Looking down line
	126		IMG_5073	Up reservoir
	126		IMG_5074	Down reservoir
	168.2	-10	IMG_5065	Herb quadrat
	129		IMG_5066	Looking at POC
	129		IMG_5067	Looking down line

Date: June 21, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S9 TR 712	129	-10	IMG_5068	Up reservoir
	129		IMG_5069	Down reservoir
Upland	-1	0	IMG_5095	Looking down line away from POC
	-4		IMG_5096	Looking down line away from POC
	-4		IMG_5097	Looking down line away from POC
	-8		IMG_5098	Looking down line away from POC
	-8		IMG_5099	Looking p line towards POC
	-13	2		Line ends at 2 m change in elevation

Date: June 21, 2012 | **Project Leader:** Mary Louise Polzin
Location: Duncan Reservoir

S_TR#	Metre Mark	Elevation	Image #	Description
S10 TR 6	2	0	IMG_5201	Herb quadrat
	3		IMG_5202	Looking at POC
	3		IMG_5203	Looking down line
	3		IMG_5204	Up reservoir
	3		IMG_5205	Down reservoir
	17	-2	IMG_5206	Herb quadrat
	18		IMG_5207	Looking at POC
	18		IMG_5208	Looking down line
	18		IMG_5209	Up reservoir
	18		IMG_5210	Down reservoir
	44	-4	IMG_5211	Herb quadrat
	45		IMG_5212	Looking at POC
	45		IMG_5213	Looking down line
	45		IMG_5214	Up reservoir
	45		IMG_5215	Down reservoir
	70	-6	IMG_5217	Herb quadrat
	71		IMG_5218	Looking at POC
	71		IMG_5219	Looking down line
	71		IMG_5220	Up reservoir
	71		IMG_5221	Down reservoir
	100	-8	IMG_5222	Herb quadrat
	100		IMG_5223	Herb quadrat
	101		IMG_5224	Looking at POC
	101		IMG_5225	Looking down line
	101		IMG_5226	Up reservoir
	101		IMG_5227	Down reservoir
	150	-10	IMG_5228	Herb quadrat
	151		IMG_5229	Looking at POC
	151		IMG_5230	Looking down line
	151		IMG_5231	Up reservoir
	151		IMG_5232	Down reservoir
Upland	-1	0	IMG_5233	Looking down line
	-1		IMG_5238	Looking Down Reservoir
	-5		IMG_5234	Looking down line
	-10		IMG_5235	Looking down line
	-10		IMG_5236	Looking Up Reservoir
	-10		IMG_5237	Looking up line towards POC
	-24	2		Line ends at 2 m change in elevation
S10 TR 713	1	0	IMG_5171	Herb quadrat
	2		IMG_5172	Looking at POC
	2		IMG_5173	Looking down line
	2		IMG_5174	Up reservoir
	2		IMG_5175	Down reservoir
	11	-2	IMG_5176	Herb quadrat
	12		IMG_5177	Looking at POC
	12		IMG_5178	Looking down line

Date: June 21, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S10 TR 713	12	-2	IMG_5179	Up reservoir
	12		IMG_5180	Down reservoir
	25	-4	IMG_5181	Herb quadrat
	26		IMG_5182	Looking at POC
	26		IMG_5183	Looking down line
	26		IMG_5184	Up reservoir
	26		IMG_5185	Down reservoir
	51	-6	IMG_5186	Herb quadrat
	52		IMG_5187	Looking at POC
	52		IMG_5188	Looking down line
	52		IMG_5189	Up reservoir
	52		IMG_5190	Down reservoir
	70.2	-8	IMG_5191	Herb quadrat
	71.2		IMG_5192	Looking at POC
	71.2		IMG_5193	Looking down line
	71.2		IMG_5194	Up reservoir
	71.2		IMG_5195	Down reservoir
	83.6	-10	IMG_5196	Herb quadrat
	84.6		IMG_5197	Looking at POC
	84.6		IMG_5198	Looking down line
	84.6		IMG_5199	Up reservoir
	84.6		IMG_5200	Down reservoir
Upland	-1	0	IMG_5170	Looking down line
	-4		IMG_5168	Looking up line towards POC
	-4		IMG_5169	Looking down line
	-8		IMG_5167	Looking up line towards POC
	-14	2		Line ends at 2 m change in elevation
S10 TR 714	0	0	IMG_5134	Herb quadrat
	1		IMG_5135	Looking at POC
	1		IMG_5136	Looking down line
	1		IMG_5137	Up reservoir
	1		IMG_5138	Down reservoir
	15	-2	IMG_5139	Herb quadrat
	16		IMG_5140	Looking at POC
	16		IMG_5141	Looking down line
	16		IMG_5142	Up reservoir
	16		IMG_5143	Down reservoir
	35.6	-4	IMG_5144	Herb quadrat
	36.6		IMG_5145	Looking at POC
	36.6		IMG_5146	Looking down line
	36.6		IMG_5147	Up reservoir
	36.6		IMG_5148	Down reservoir
	52.5	-6	IMG_5149	Herb quadrat
	53.5		IMG_5150	Looking at POC
	53.5		IMG_5151	Looking down line
	53.5		IMG_5152	Up reservoir

Date: June 21, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S10 TR 714	53.5	-6	IMG_5153	Down reservoir
	68.8	-8	IMG_5154	Herb quadrat
	69.8		IMG_5155	Looking at POC
	69.8		IMG_5156	Looking down line
	69.8		IMG_5157	Up reservoir
	69.8		IMG_5158	Down reservoir
	83.7	-10	IMG_5159	Herb quadrat
	84.7		IMG_5160	Looking at POC
	84.7		IMG_5161	Looking down line
	84.7		IMG_5162	Up reservoir
	84.7		IMG_5163	Down reservoir
Upland	-2	0	IMG_5164	Looking down line
	-8		IMG_5165	Looking down line
	-8		IMG_5166	Looking up line towards POC
	-11	2		Line ends at 2 m change in elevation

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S11 TR 715	0	0	P6222712	Herb quadrat
	1		P6222713	Looking at POC
	1		P6222714	Looking down line
	1		P6222715	Up reservoir
	1		P6222716	Down reservoir
	13	-2	P6222717	Herb quadrat
	14		P6222718	Looking at POC
	14		P6222719	Looking down line
	14		P6222720	Up reservoir
	14		P6222721	Down reservoir
	26	-4	P6222722	Herb quadrat
	27		P6222723	Looking at POC
	27		P6222724	Looking down line
	27		P6222725	Up reservoir
	27		P6222726	Down reservoir
	38	-6	P6222727	Herb quadrat
	39		P6222728	Looking at POC
	39		P6222729	Looking down line
	39		P6222730	Up reservoir
	39		P6222731	Down reservoir
	58	-8	P6222732	Herb quadrat
	59		P6222733	Looking at POC
	59		P6222734	Looking down line
	59		P6222735	Up reservoir
	59		P6222736	Down reservoir
	72	-10	P6222737	Herb quadrat
	73		P6222738	Looking at POC
	73		P6222739	Looking down line
	73		P6222740	Up reservoir
	73		P6222741	Down reservoir
Upland	-2	0	P6222742	Looking down line away from POC
	-2		P6222743	Looking down line away from POC
	-8		P6222744	Looking up line towards POC
	-8		P6222745	Looking up line towards POC
	-7	2		Line ends at 2 m change in elevation
S11 TR 716	0	0	P6222746	Herb quadrat
	1		P6222747	Looking at POC
	1		P6222748	Looking down line
	1		P6222749	Up reservoir
	1		P6222750	Down reservoir
	13	-2	P6222751	Herb quadrat
	14		P6222752	Looking at POC
	14		P6222753	Looking down line
	14		P6222754	Up reservoir
	14		P6222755	Down reservoir
	26	-4	P6222756	Herb quadrat

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S11 TR 716	27	-4	P6222757	Looking at POC
	27		P6222758	Looking down line
	27		P6222759	Up reservoir
	27		P6222760	Down reservoir
	41.8	-6	P6222761	Herb quadrat
	42.8		P6222762	Looking at POC
	42.8		P6222763	Looking down line
	42.8		P6222764	Up reservoir
	42.8		P6222765	Down reservoir
	56.8	-8	P6222766	Herb quadrat
	57.8		P6222767	Looking at POC
	57.8		P6222768	Looking down line
	57.8		P6222769	Up reservoir
	57.8		P6222770	Down reservoir
	71	-10	P6222775	Herb quadrat
	72		P6222776	Looking at POC
	72		P6222777	Looking down line
	72		P6222778	Up reservoir
	72		P6222779	Down reservoir
Upland	-1	0	P6222780	Looking away from POC
	-1		P6222781	Looking away from POC
	-5		P6222782	Looking away from POC
	-5		P6222783	Looking towards POC
	-7	2		Line ends at 2 m change in elevation
S11 TR 716			P6222771	Near 8 m change in elevation size of stumps
			P6222772	Same as above
			P6222773	Same as above
			P6222774	Same as above

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S12 TR 718	0	0	P6222645	Herb quadrat
	1		P6222646	Looking at POC
	1		P6222647	Looking down line
	1		P6222648	Up reservoir
	1		P6222649	Down reservoir
	9	-2	P6222650	Herb quadrat
	10		P6222651	Looking at POC
	10		P6222652	Looking down line
	10		P6222653	Up reservoir
	10		P6222654	Down reservoir
	19	-4	P6222655	Herb quadrat
	20		P6222656	Looking at POC
	20		P6222657	Looking down line
	20		P6222658	Up reservoir
	20		P6222659	Down reservoir
	27	-6	P6222660	Herb quadrat
	28		P6222661	Looking at POC
	28		P6222662	Looking down line
	28		P6222663	Up reservoir
	28		P6222664	Down reservoir
	43	-8	P6222665	Herb quadrat
	44		P6222666	Looking at POC
	44		P6222667	Looking down line
	44		P6222668	Up reservoir
	44		P6222669	Down reservoir
	52.4	-10	P6222670	Herb quadrat
	53.4		P6222671	Looking at POC
	53.4		P6222672	Looking down line
	53.4		P6222673	Up reservoir
	53.4		P6222674	Down reservoir
Upland	-7		P6222675	Looking towards POC
	-7		P6222676	Looking away from POC down reservoir side
	-7		P6222677	Looking away from POC up reservoir side
	-7	2		Line ends at 2 m change in elevation
S12 TR 5	0	0	P6222678	Herb quadrat
	1		P6222679	Looking at POC
	1		P6222680	Looking down line
	1		P6222681	Up reservoir
	1		P6222682	Down reservoir
	11	-2	P6222683	Herb quadrat
	12		P6222684	Looking at POC
	12		P6222685	Looking down line
	12		P6222686	Up reservoir
	12		P6222687	Down reservoir
	19	-4	P6222688	Herb quadrat
	20		P6222689	Looking at POC

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre Mark**	**Elevation**	**Image #**	**Description**
S12 TR 5	20	-4	P6222690	Looking down line
	20		P6222691	Up reservoir
	20		P6222692	Down reservoir
	31	-6	P6222693	Herb quadrat
	32		P6222694	Looking at POC
	32		P6222695	Looking down line
	32		P6222696	Up reservoir
	32		P6222697	Down reservoir
	44	-8	P6222698	Herb quadrat
	45		P6222699	Looking at POC
	45		P6222700	Looking down line
	45		P6222701	Up reservoir
	45		P6222702	Down reservoir
	58	-10	P6222703	Herb quadrat
	59		P6222704	Looking at POC
	59		P6222705	Looking down line
	59		P6222706	Up reservoir
	59		P6222707	Down reservoir
Upland	-4		P6222708	Looking away from POC
	-4		P6222709	Looking away from POC
	-12	2	P6222710	Looking away from POC up reservoir side
	-12		P6222711	Looking away from POC down line
	-12	2		Line ends at 2 m change in elevation

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre**	**Elevation**	**Image #**	**Description**
S13 TR 4	0	0	IMG_5286	Herb quadrat
	1		IMG_5287	Looking at POC
	1		IMG_5288	Looking down line
	1		IMG_5289	Up reservoir
	1		IMG_5290	Down reservoir
	11		IMG_5296	Herb quadrat
	12		IMG_5297	Looking at POC
	12		IMG_5298	Looking down line
	12		IMG_5299	Up reservoir
	12		IMG_5300	Down reservoir
	14		IMG_5291	Herb quadrat
	15		IMG_5292	Looking at POC
	15		IMG_5293	Looking down line
	15		IMG_5294	Up reservoir
	15		IMG_5295	Down reservoir
	23	-1	IMG_5301	Herb quadrat
	24		IMG_5302	Looking at POC
	24		IMG_5303	Looking down line
	24		IMG_5304	Up reservoir
	24		IMG_5305	Down reservoir
	40		IMG_5306	Herb quadrat
	41		IMG_5307	Looking at POC
	41		IMG_5308	Looking down line
	41		IMG_5309	Up reservoir
	41		IMG_5310	Down reservoir
	46	-2	IMG_5311	Herb quadrat
	47		IMG_5312	Looking at POC
	47		IMG_5313	Looking down line
	47		IMG_5314	Up reservoir
	47		IMG_5315	Down reservoir
	65	-3	IMG_5316	Herb quadrat
	66		IMG_5317	Looking at POC
	66		IMG_5318	Looking down line
	66		IMG_5319	Up reservoir
	66		IMG_5320	Down reservoir
	99		IMG_5321	Herb quadrat
	100		IMG_5322	Looking at POC
	100		IMG_5323	Looking down line
	100		IMG_5324	Up reservoir
	100		IMG_5325	Down reservoir
	100		IMG_5326	Horses visit on line owners camped on site.
Upland	-10		IMG_5282	Looking at POC
	-10		IMG_5283	Looking down reservoir
	-13		IMG_5284	Looking down line at EOT
	-10		IMG_5285	Looking up reservoir
	-13			Line ends - not 2 m change in elevation

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre**	**Elevation**	**Image #**	**Description**
S13 TR 717	0	0	IMG_5243	Herb quadrat
	1		IMG_5244	Looking at POC
	1		IMG_5245	Looking down line
	1		IMG_5246	Up reservoir
	1		IMG_5247	Down reservoir
	14		IMG_5248	Herb quadrat
	15		IMG_5249	Looking at POC
	15		IMG_5250	Looking down line
	15		IMG_5251	Up reservoir
	15		IMG_5252	Down reservoir
	31	-2	IMG_5253	Herb quadrat
	32		IMG_5254	Looking at POC
	32		IMG_5255	Looking down line
	32		IMG_5256	Up reservoir
	32		IMG_5257	Down reservoir
	40		IMG_5258	Herb quadrat
	41		IMG_5259	Looking at POC
	41		IMG_5260	Looking down line
	41		IMG_5261	Up reservoir
	41		IMG_5262	Down reservoir
	48	-3	IMG_5263	Herb quadrat
	49		IMG_5264	Looking at POC
	49		IMG_5265	Looking down line
	49		IMG_5266	Up reservoir
	49		IMG_5267	Down reservoir
	53		IMG_5268	Herb quadrat
	54		IMG_5269	Looking at POC
	54		IMG_5270	Looking down line
	54		IMG_5271	Up reservoir
	54		IMG_5272	Down reservoir
	100		IMG_5277	Herb quadrat
	101		IMG_5278	Looking at POC
	101		IMG_5279	Looking down line
	101		IMG_5280	Up reservoir
	101		IMG_5281	Down reservoir
Upland	-1	0	IMG_5239	At tag tree edge looking into tree quadrat start edge.
	-1		IMG_5240	Looking into tree quadrat on down reservoir side.
	-1		IMG_5241	Looking at up reservoir side of line of tree quadrat.
	-1		IMG_5242	Looking up reservoir
	-10			End of line not 2 m change in elevation
			IMG_5273	Photos of horse impact on both sides of transect line with similar impacts beyond line.
			IMG_5274	
			IMG_5275	
			IMG_5276	

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre**	**Elevation**	**Image #**	**Description**
S13 TR 719	0	0	IMG_5329	Herb quadrat
	1		IMG_5330	Looking at POC
	1		IMG_5331	Looking down line
	1		IMG_5332	Up reservoir
	1		IMG_5333	Down reservoir
	35	-2	IMG_5334	Herb quadrat
	36		IMG_5335	Looking at POC
	36		IMG_5336	Looking down line
	36		IMG_5337	Up reservoir
	36		IMG_5338	Down reservoir
	55		IMG_5339	Herb quadrat
	56		IMG_5340	Looking at POC
	56		IMG_5341	Looking down line
	56		IMG_5342	Up reservoir
	56		IMG_5343	Down reservoir
	70	-4	IMG_5344	Herb quadrat
	71		IMG_5345	Looking at POC
	71		IMG_5346	Looking down line
	71		IMG_5347	Up reservoir
	71		IMG_5348	Down reservoir
	82		IMG_5349	Herb quadrat
	83		IMG_5350	Looking at POC
	83		IMG_5351	Looking down line
	83		IMG_5352	Up reservoir
	83		IMG_5353	Down reservoir
	89		IMG_5354	Herb quadrat
	90		IMG_5355	Looking at POC
	90		IMG_5356	Looking down line
	90		IMG_5357	Up reservoir
	90		IMG_5358	Down reservoir
	100	-5	IMG_5359	Herb quadrat
	101		IMG_5360	Looking at POC
	101		IMG_5361	Looking down line
	101		IMG_5362	Up reservoir
	101		IMG_5363	Down reservoir
Upland	-5		IMG_5327	Looking at the back of tag tree.
	-5		IMG_5328	Looking up line on the down reservoir side.
	-20			Line ends - not 2 m change in elevation

Date: June 22, 2012		**Project Leader:** Mary Louise Polzin		
Location: Duncan Reservoir				
S_TR#	**Metre**	**Elevation**	**Image #**	**Description**
S13 TR 720	0	0	IMG_5369	Herb quadrat
	1		IMG_5370	Looking at POC
	1		IMG_5371	Looking down line
	1		IMG_5372	Up reservoir
	1		IMG_5373	Down reservoir
	20	-2	IMG_5374	Herb quadrat
	21		IMG_5375	Looking at POC
	21		IMG_5376	Looking down line
	21		IMG_5377	Up reservoir
	21		IMG_5378	Down reservoir
	33	-3	IMG_5379	Herb quadrat
	34		IMG_5380	Looking at POC
	34		IMG_5381	Looking down line
	34		IMG_5382	Up reservoir
	34		IMG_5383	Down reservoir
	54	-4	IMG_5384	Herb quadrat
	55		IMG_5385	Looking at POC
	55		IMG_5386	Looking down line
	55		IMG_5387	Up reservoir
	55		IMG_5388	Down reservoir
	85		IMG_5389	Herb quadrat
	86		IMG_5390	Looking at POC
	86		IMG_5391	Looking down line
	86		IMG_5392	Up reservoir
	86		IMG_5393	Down reservoir
	90			EOT because of creek.
Upland	-5		IMG_5364	Looking at tag tree POC
	-5		IMG_5365	Looking at tree plot down reservoir side
	-5		IMG_5366	Looking at EOT
	-7		IMG_5367	Looking up reservoir side of tree quadrat
	-7		IMG_5368	Tree quadrat looking down line towards EOT
	-11			Line ends 2 m change in elevation

Appendix 6: Photo Contact Sheets

Duncan Reservoir 2012_Site 1 Transect 1


IMG_4453


IMG_4454


IMG_4455

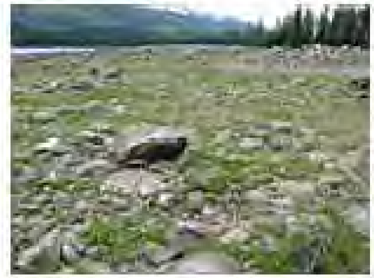

IMG_4456


IMG_4457


IMG_4458


IMG_4459


IMG_4460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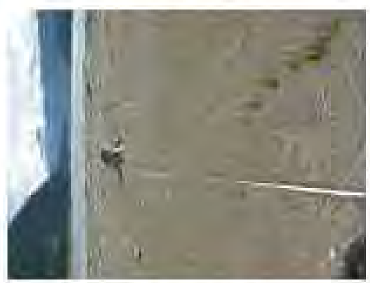
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Duncan Reservoir 2012_Site 1 Transect 1


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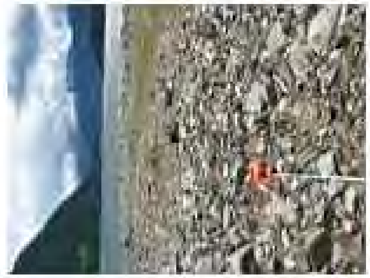
IMG_4476


IMG_4477


IMG_4478


IMG_4479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IMG_4483


IMG_4484


IMG_4485


IMG_4486

Duncan Reservoir 2012_Site 1 Transect 700


IMG_4487


IMG_4488

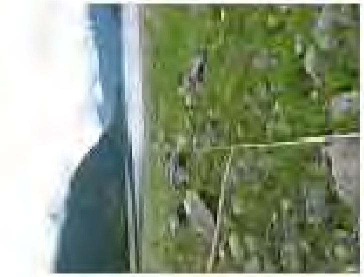

IMG_4489


IMG_4490


IMG_4491


IMG_4492


IMG_4493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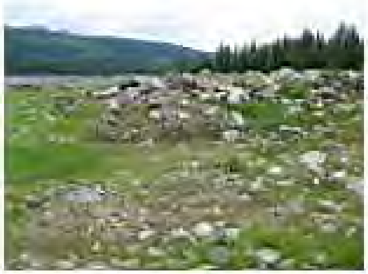
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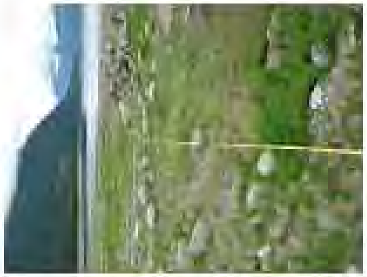
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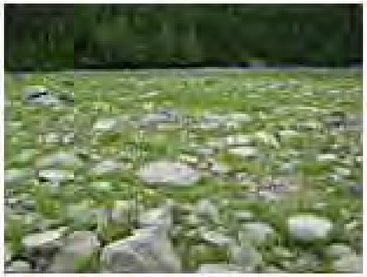
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Duncan Reservoir 2012_Site 1 Transect 700


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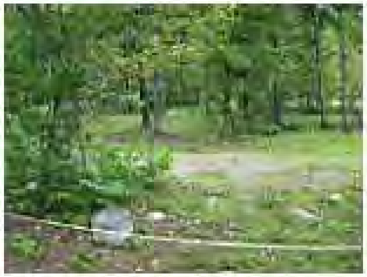
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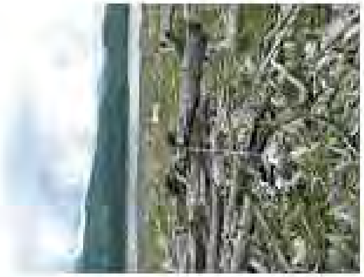
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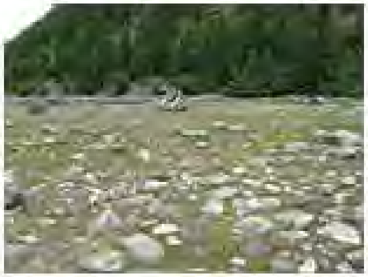
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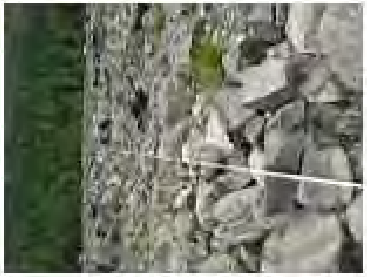
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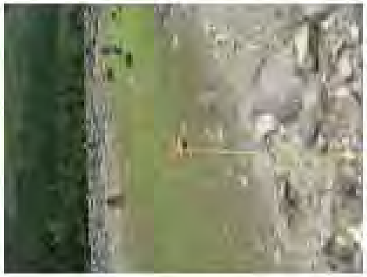

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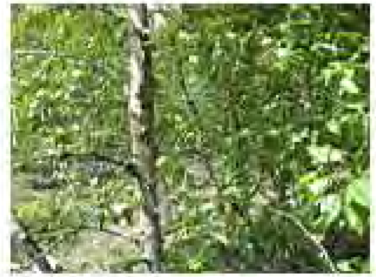
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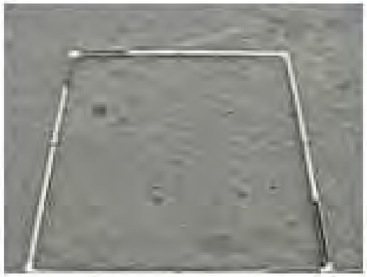
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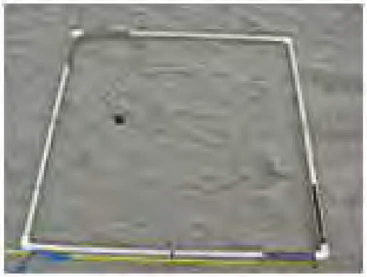
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Duncan Reservoir 2012_Site 2 Transect 702


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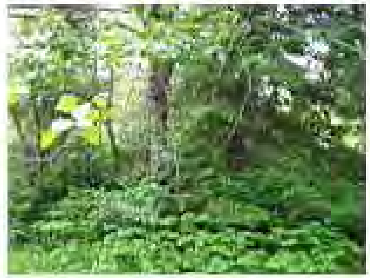
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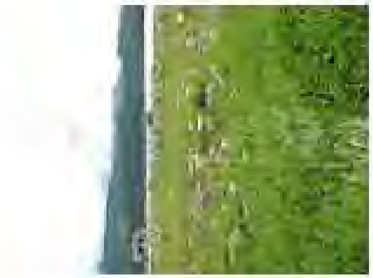
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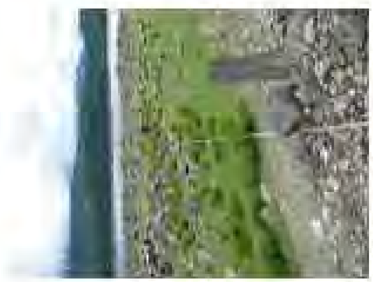
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Duncan Reservoir 2012_Site 2 Transect 703


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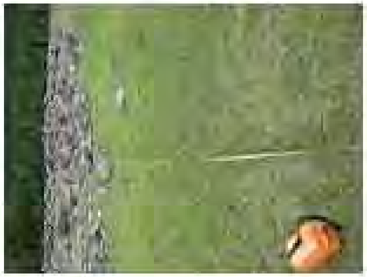
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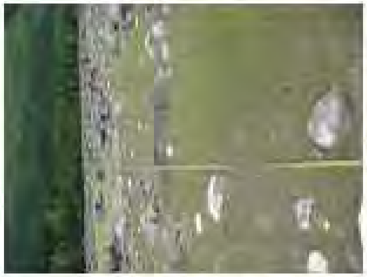
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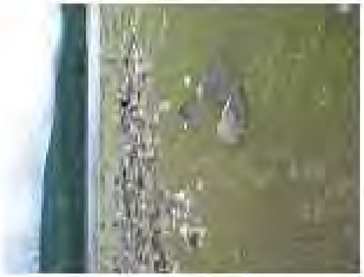
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Duncan Reservoir 2012_Site 3 Transect 704


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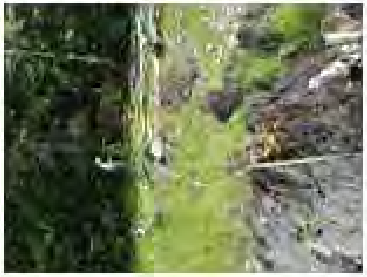
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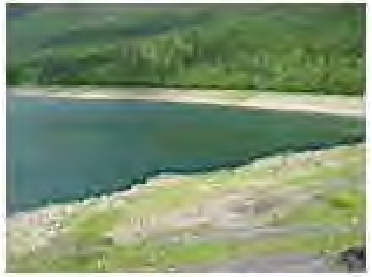
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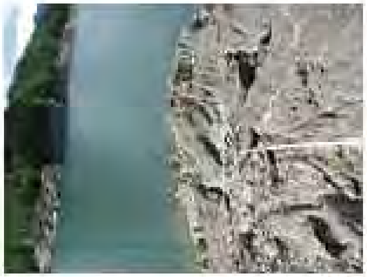
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Duncan Reservoir 2012_Site 3 Transect 704

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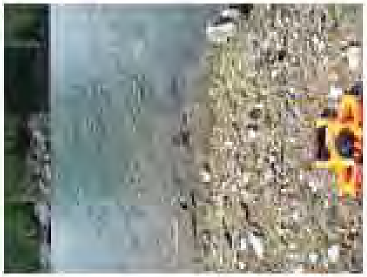

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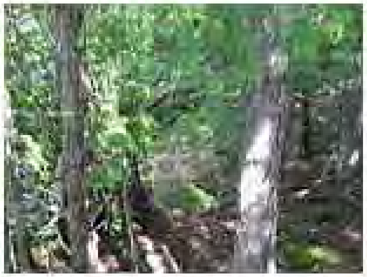

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Duncan Reservoir 2012_Site 3 Transect 812


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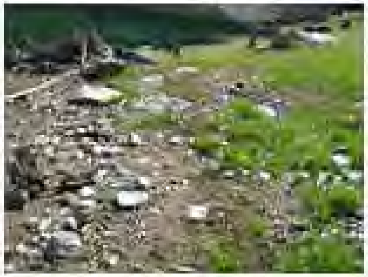
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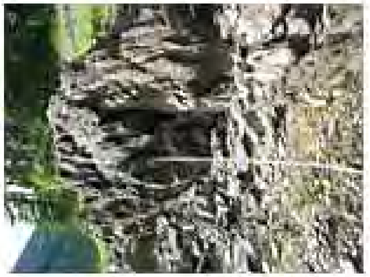
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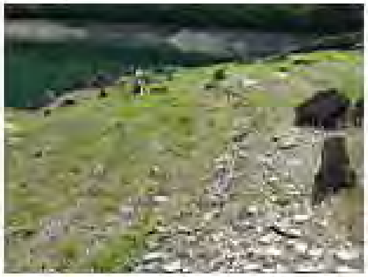
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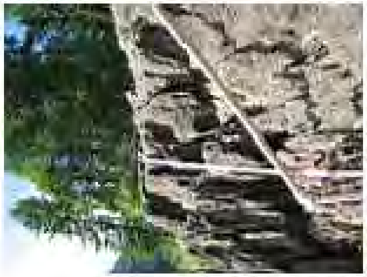
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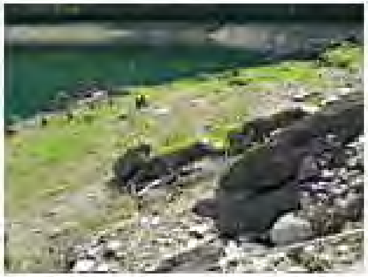
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Duncan Reservoir 2012_Site 3 Transect 812


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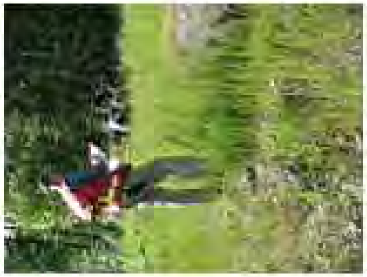
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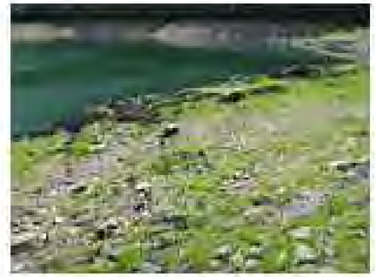
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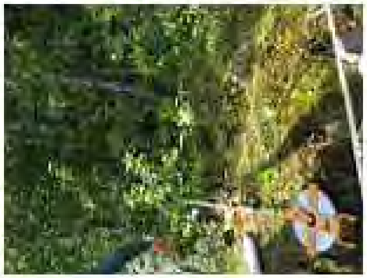
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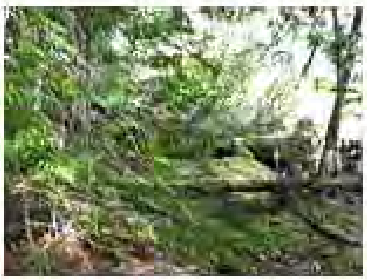
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Duncan Reservoir 2012_Site 4 Transect 705


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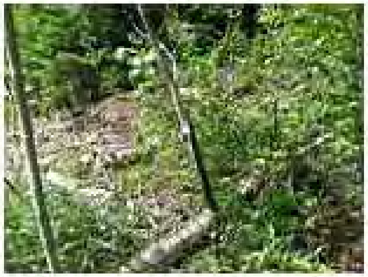
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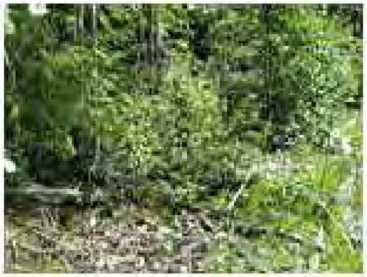
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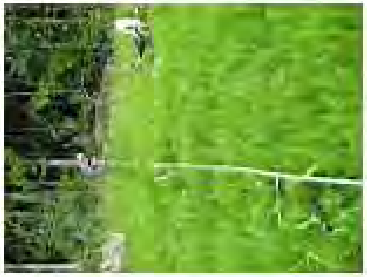
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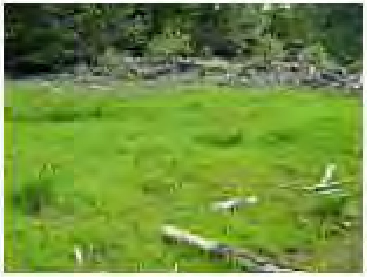
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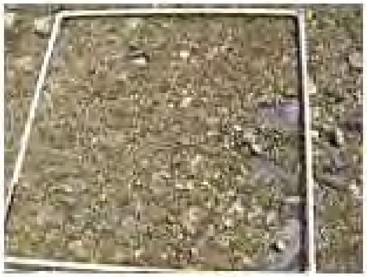
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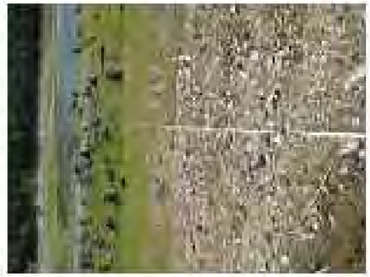
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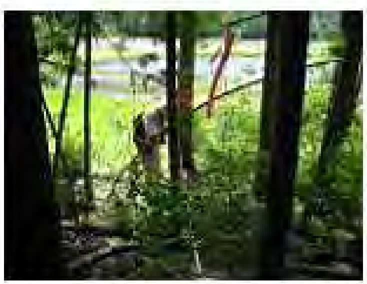
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Duncan Reservoir 2012_Site 4 Transect 705

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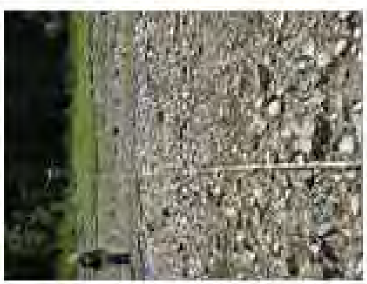
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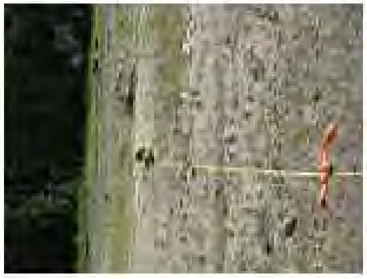
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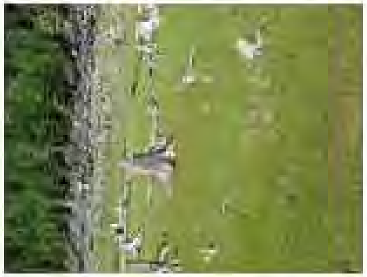
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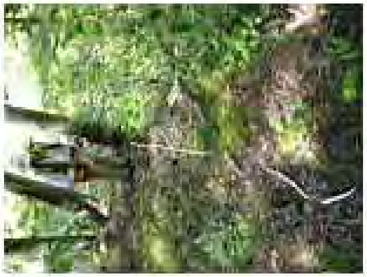
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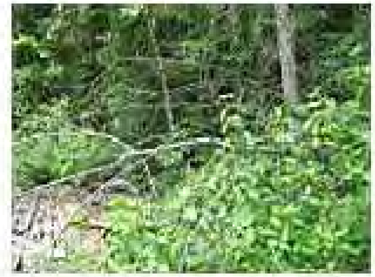
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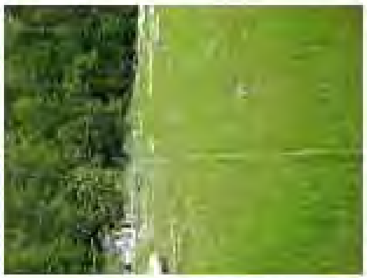
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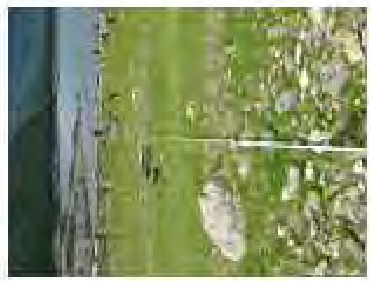
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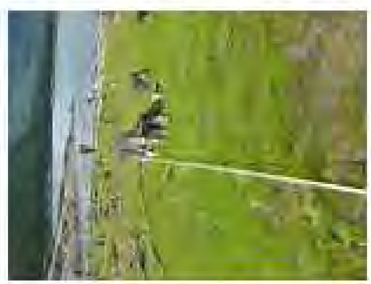
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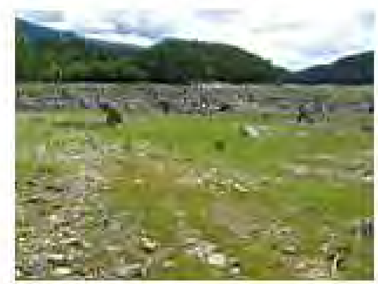
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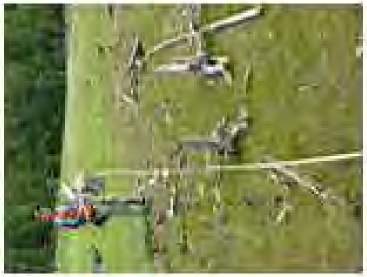
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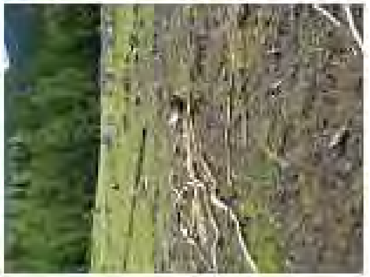
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Duncan Reservoir 2012_Site 5 Transect 813


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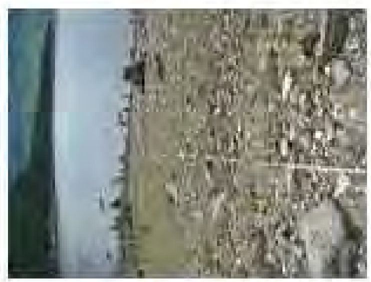
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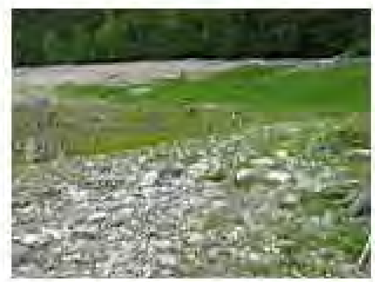
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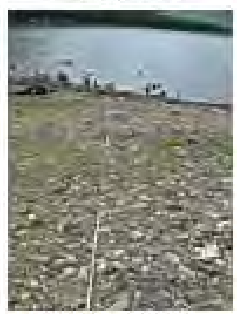
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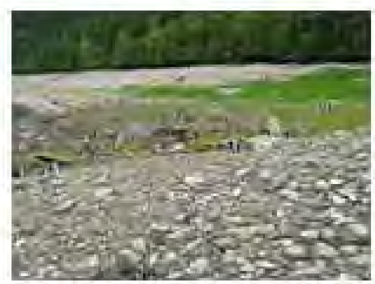
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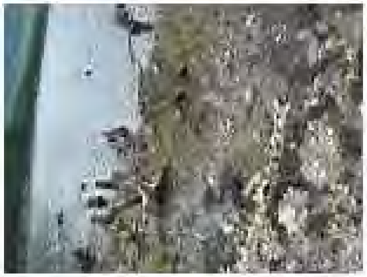
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Duncan Reservoir 2012_Site 6 Transect 708


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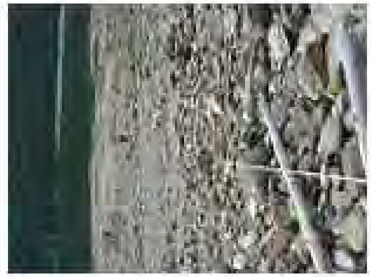
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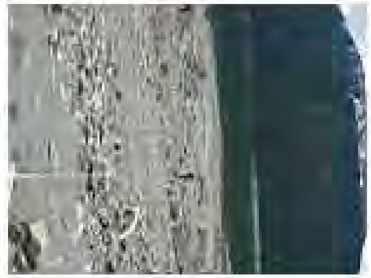
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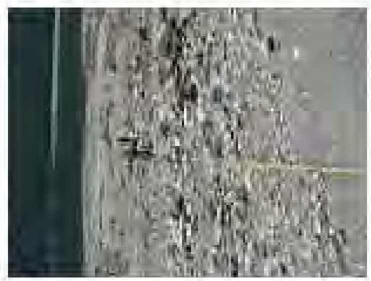
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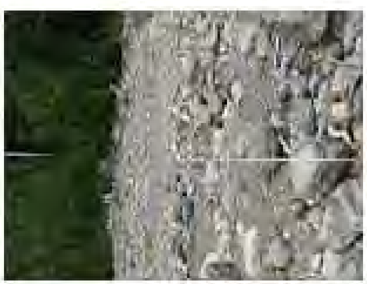
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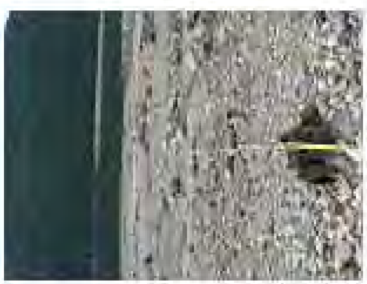
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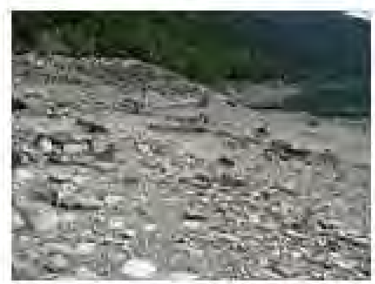
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Duncan Reservoir 2012_Site 6 Transect 708

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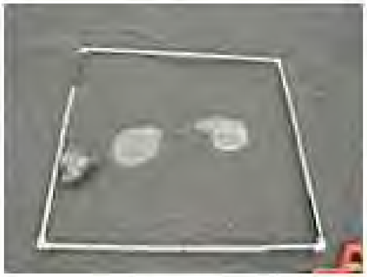

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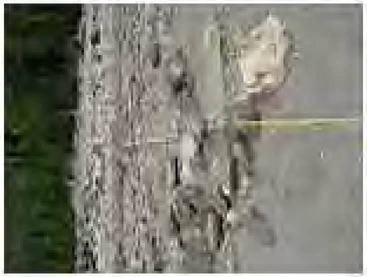

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Duncan Reservoir 2012_Site 6 Transect 814


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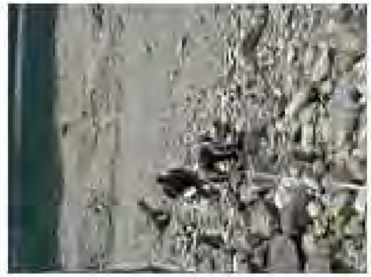
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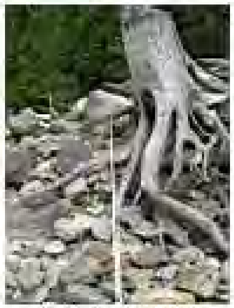
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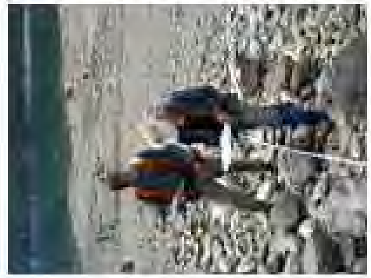
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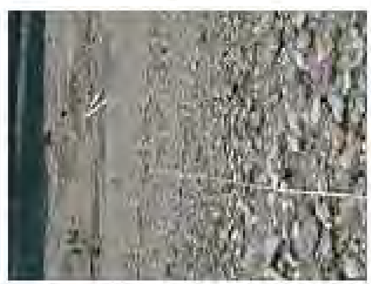
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Duncan Reservoir 2012_Site 6 Transect 814


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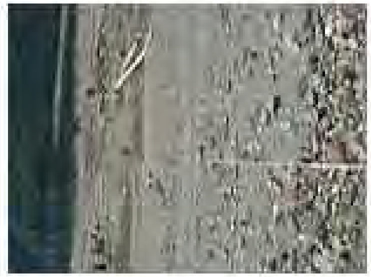
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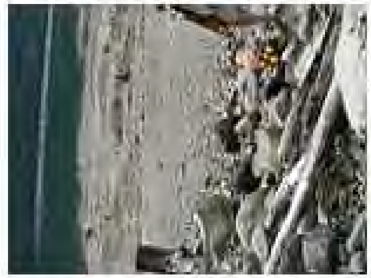
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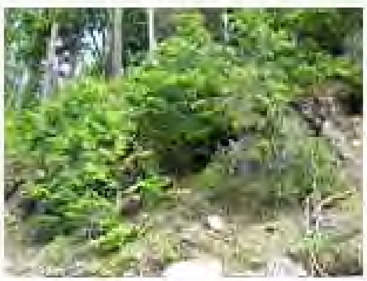
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Duncan Reservoir 2012_Site 7 Transect 2


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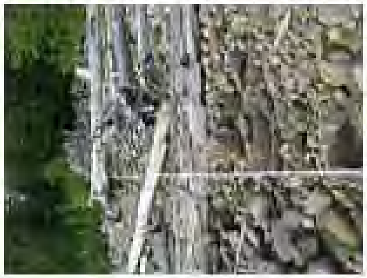
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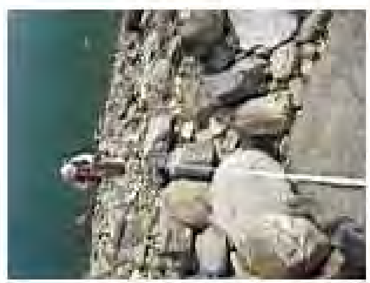
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Duncan Reservoir 2012_Site 7 Transect 2


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Duncan Reservoir 2012_Site 7 Transect 3


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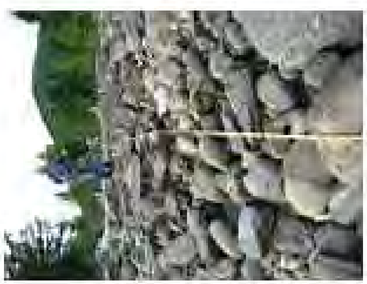
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Duncan Reservoir 2012_Site 7 Transect 3


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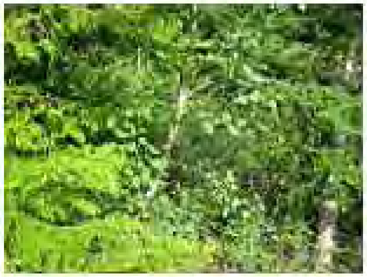
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Duncan Reservoir 2012_Site 9 Transect 709


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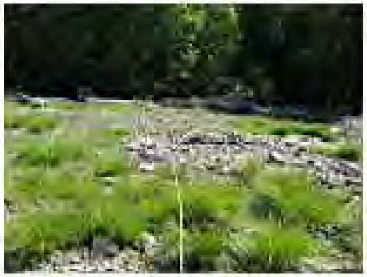
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Duncan Reservoir 2012_Site 9 Transect 709

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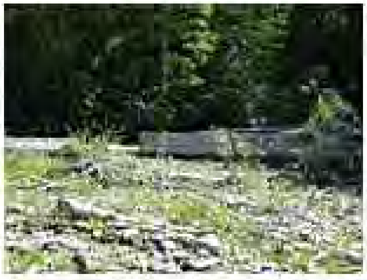

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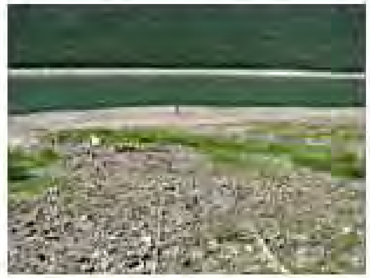

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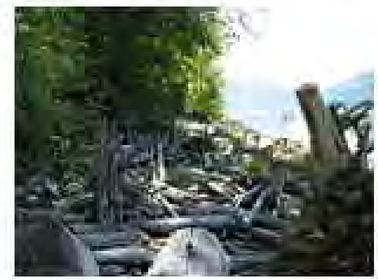

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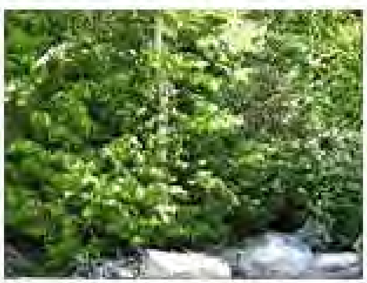

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Duncan Reservoir 2012_Site 9 Transect 710


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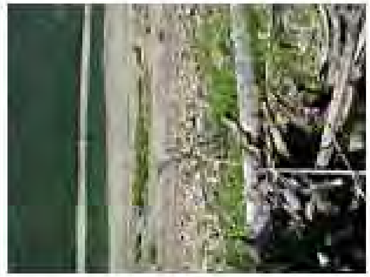
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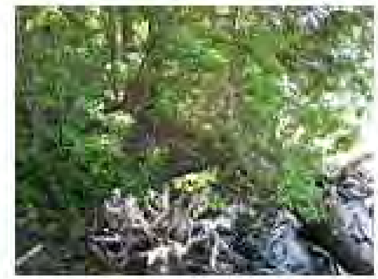
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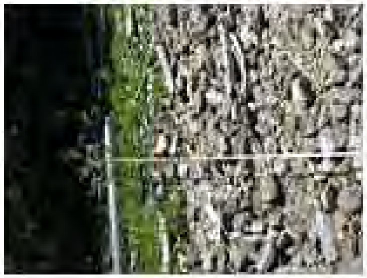
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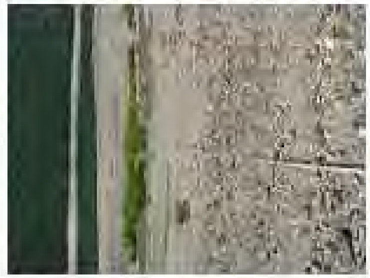
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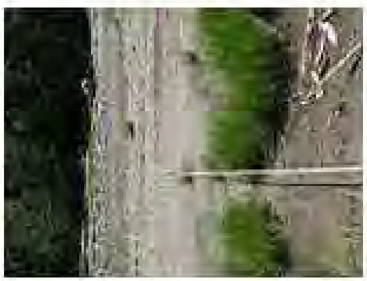
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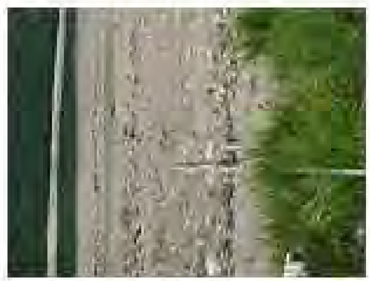
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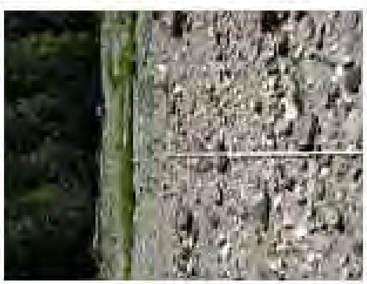
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Duncan Reservoir 2012_Site 9 Transect 710


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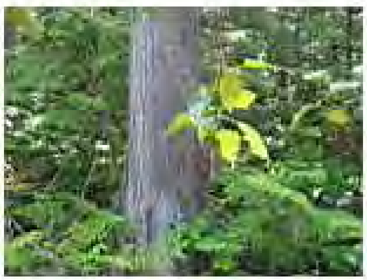
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Duncan Reservoir 2012_Site 9 Transect 711


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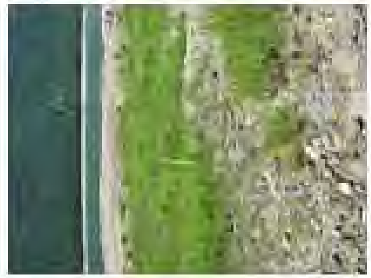
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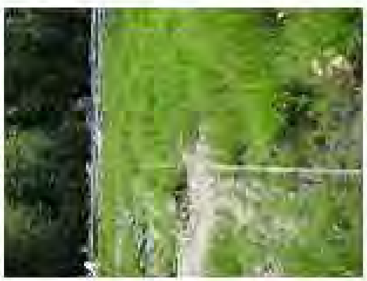
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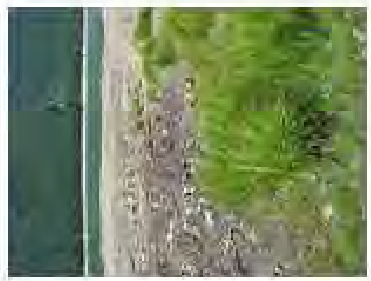
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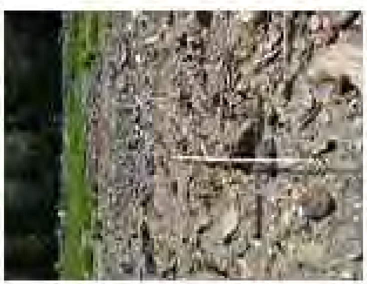
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Duncan Reservoir 2012_Site 9 Transect 711


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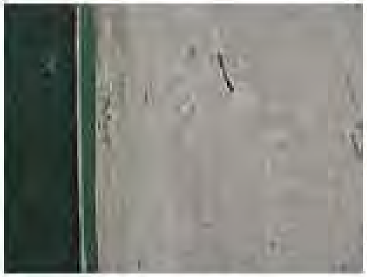
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Duncan Reservoir 2012_Site 9 Transect 712


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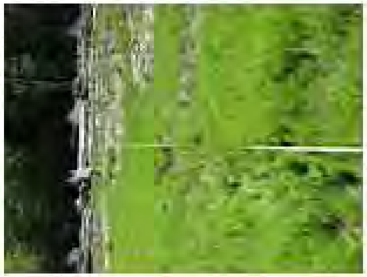
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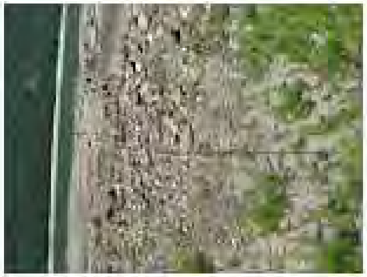
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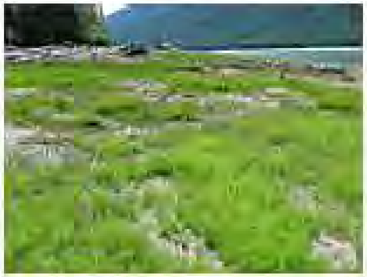
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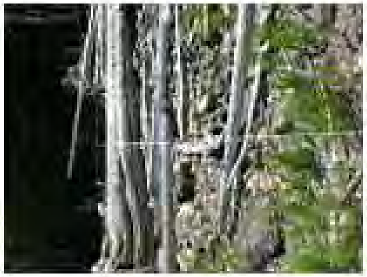
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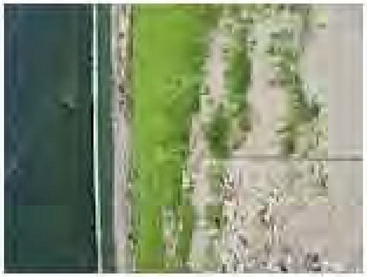
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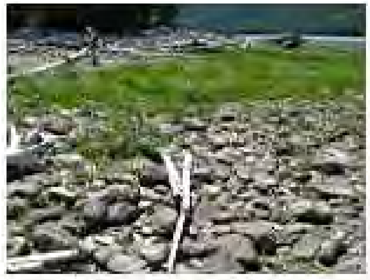
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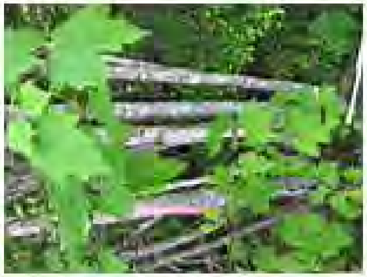
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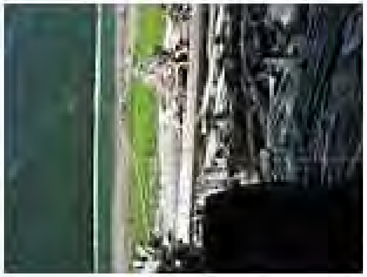
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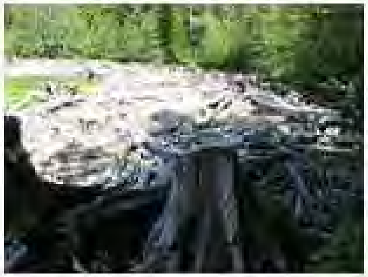
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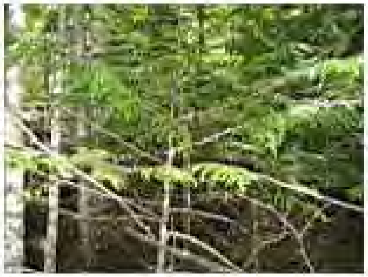
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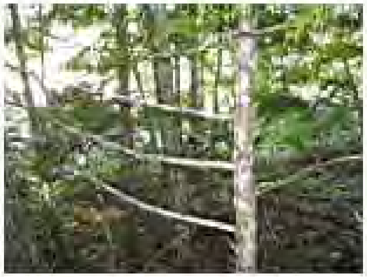
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Duncan Reservoir 2012_Site 10 Transect 6


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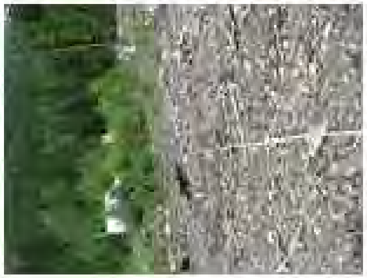
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Duncan Reservoir 2012_Site 10 Transect 6


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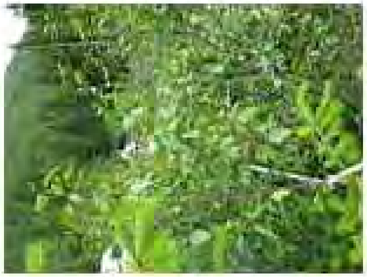
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Duncan Reservoir 2012_Site 10 Transect 713


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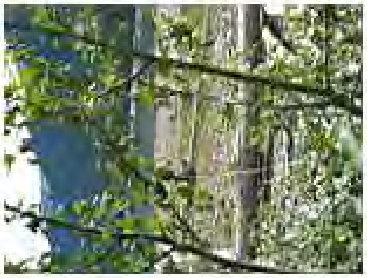
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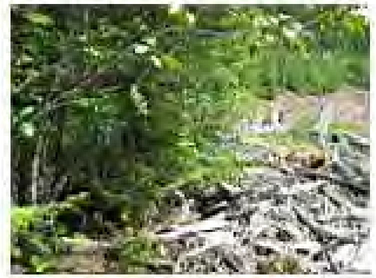
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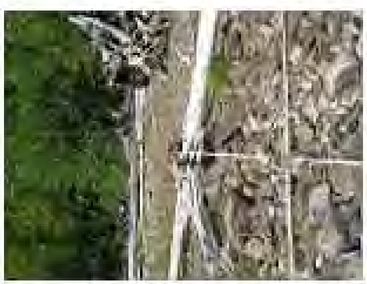
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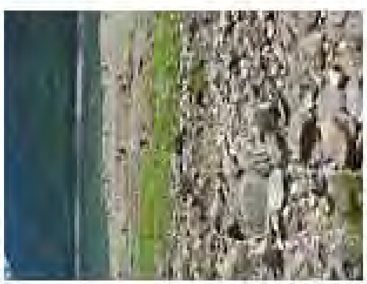
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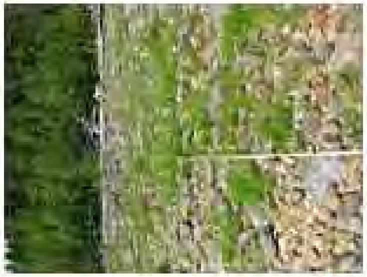
Duncan Reservoir 2012_Site 10 Transect 713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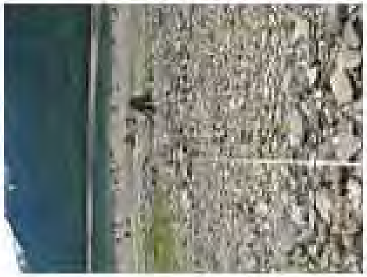
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Duncan Reservoir 2012_Site 10 Transect 714


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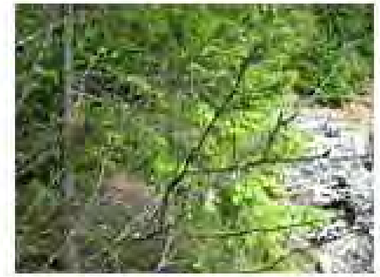
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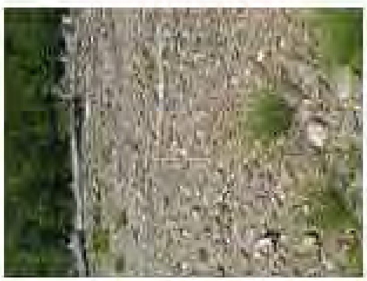
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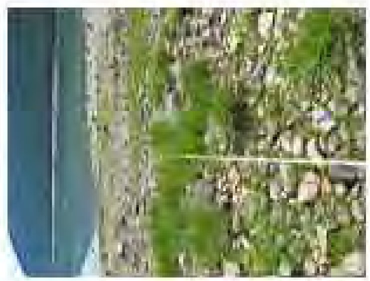
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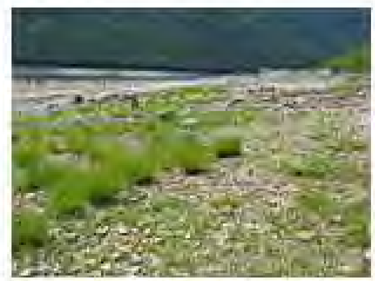
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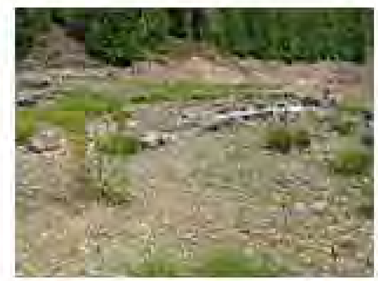
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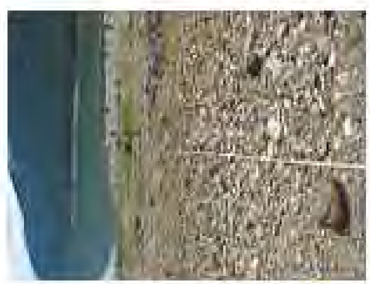
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Duncan Reservoir 2012_Site 10 Transect 714


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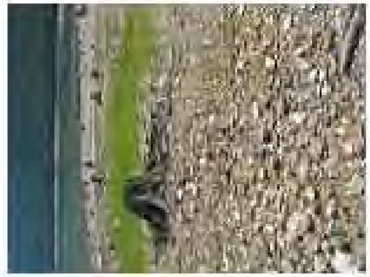
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Duncan Reservoir 2012_Site 11 Transect 715


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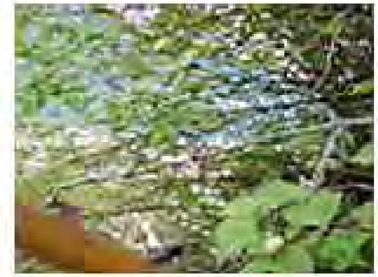
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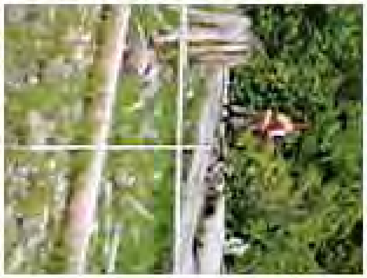
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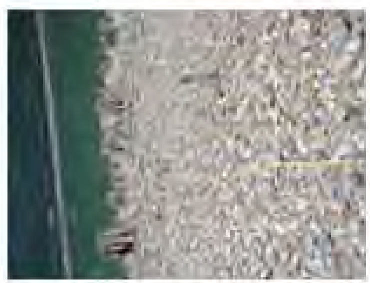
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Duncan Reservoir 2012_Site 11 Transect 715


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Duncan Reservoir 2012_Site 11 Transect 716


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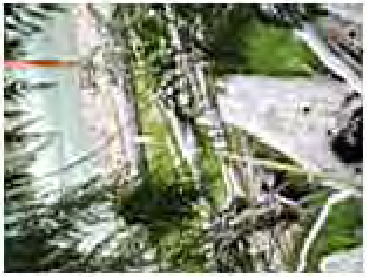
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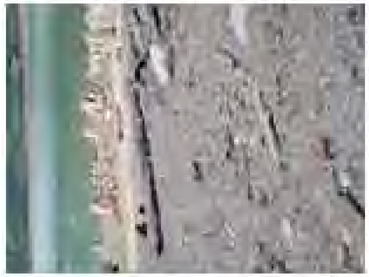
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Duncan Reservoir 2012_Site 11 Transect 716


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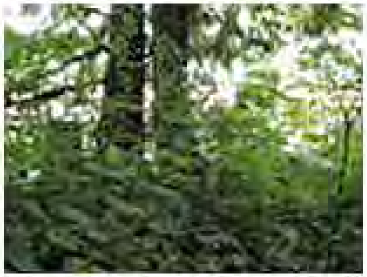
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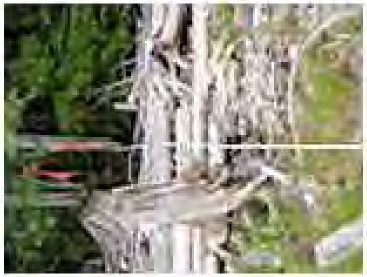
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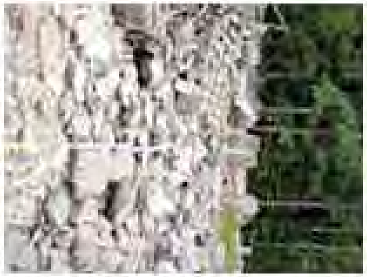
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Duncan Reservoir 2012_Site 12 Transect 718


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Duncan Reservoir 2012_Site 12 Transect 5


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Duncan Reservoir 2012_Site 12 Transect 5

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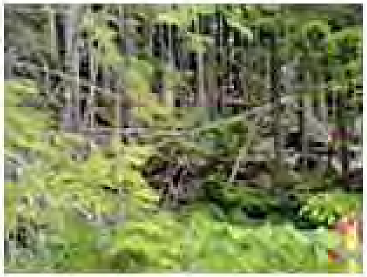

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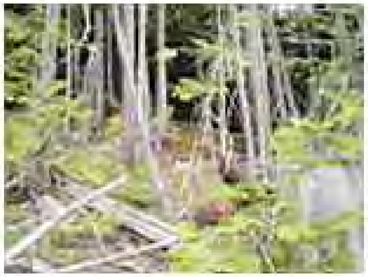

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Duncan Reservoir 2012_Site 13 Transect 4


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Duncan Reservoir 2012_Site 13 Transect 4


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Duncan Reservoir 2012_Site 13 Transect 717


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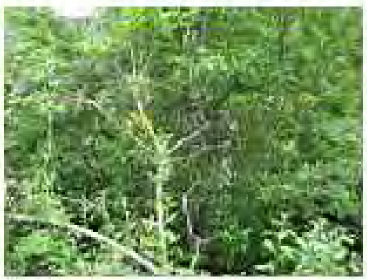
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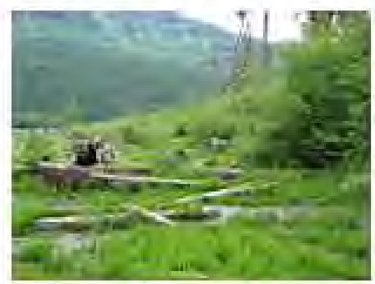
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Duncan Reservoir 2012_Site 13 Transect 717

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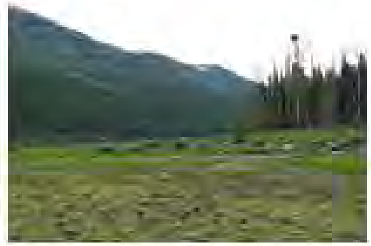

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Duncan Reservoir 2012_Site 13 Transect 719


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Duncan Reservoir 2012_Site 13 Transect 719


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Duncan Reservoir 2012_Site 13 Transect 720


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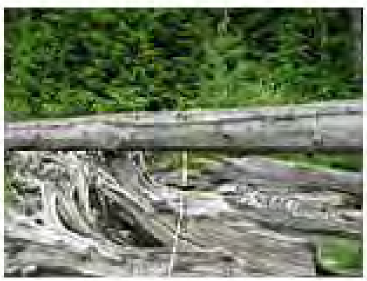
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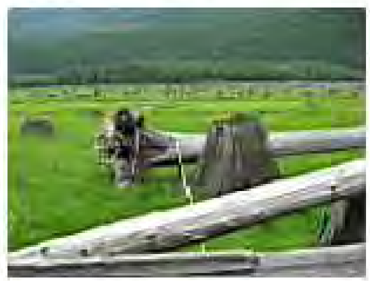
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Duncan Reservoir 2012_Site 13 Transect 720

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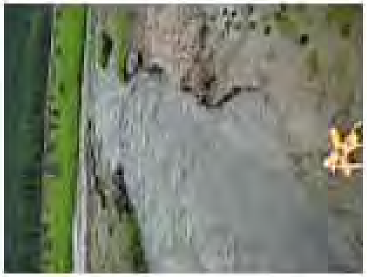

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Appendix 7: GIS Data Submission (digital)