Summary of Monitoring and Evaluation of In-Stream Works at Sites 14 and 15 in the Kitwanga River South Sub-Basin to March, 1999

Prepared for the

Gitsegukla Band Council

by
Alan Gilchrist, Ph.D.
Hydroglyphic Terrain Analysts
and
Glenn Grieve, R.P. Bio.
BioLith Scientific Consultants Inc.

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Introduction

BioLith Scientific Consultants Inc. and Hydroglyphic Terrain Analysts were contracted by the Gitsegukla Band Council to prepare a summary of Monitoring and Evaluation of In-Stream Works as per Schedule A of the Standards Agreement with the Ministry of Environment. The following summary is based on first hand information derived from BioLith's and Hydroglyphics' involvement and on other information provided by the Band.

As a result of a Level I Overview Assessment of the Kitsegukla River watershed (Wild Stone 1995) and subsequent Level I Detailed Field Assessments of the South Sub-Basins of each system (Giesbrecht and Grieve 1998), restorative works in and around the streams were prescribed for a number of sites, including Prescription Sites 14 and 15 in the Kitwanga River South Sub-Basin (see Figure 1).

This report summarizes the monitoring program to assess the effectiveness of the restoration activities. The report includes results of the data gathered to begin the process of monitoring changes that result from the restorative treatments, and provides details of the overall monitoring plan recommended for gathering more data. When more data is gathered in the future, it will be possible to compare that data with the data gathered to date to assess the effectiveness of the treatments applied, to make necessary changes to the restorative works and to beneficially influence plans for other treatments in the future.

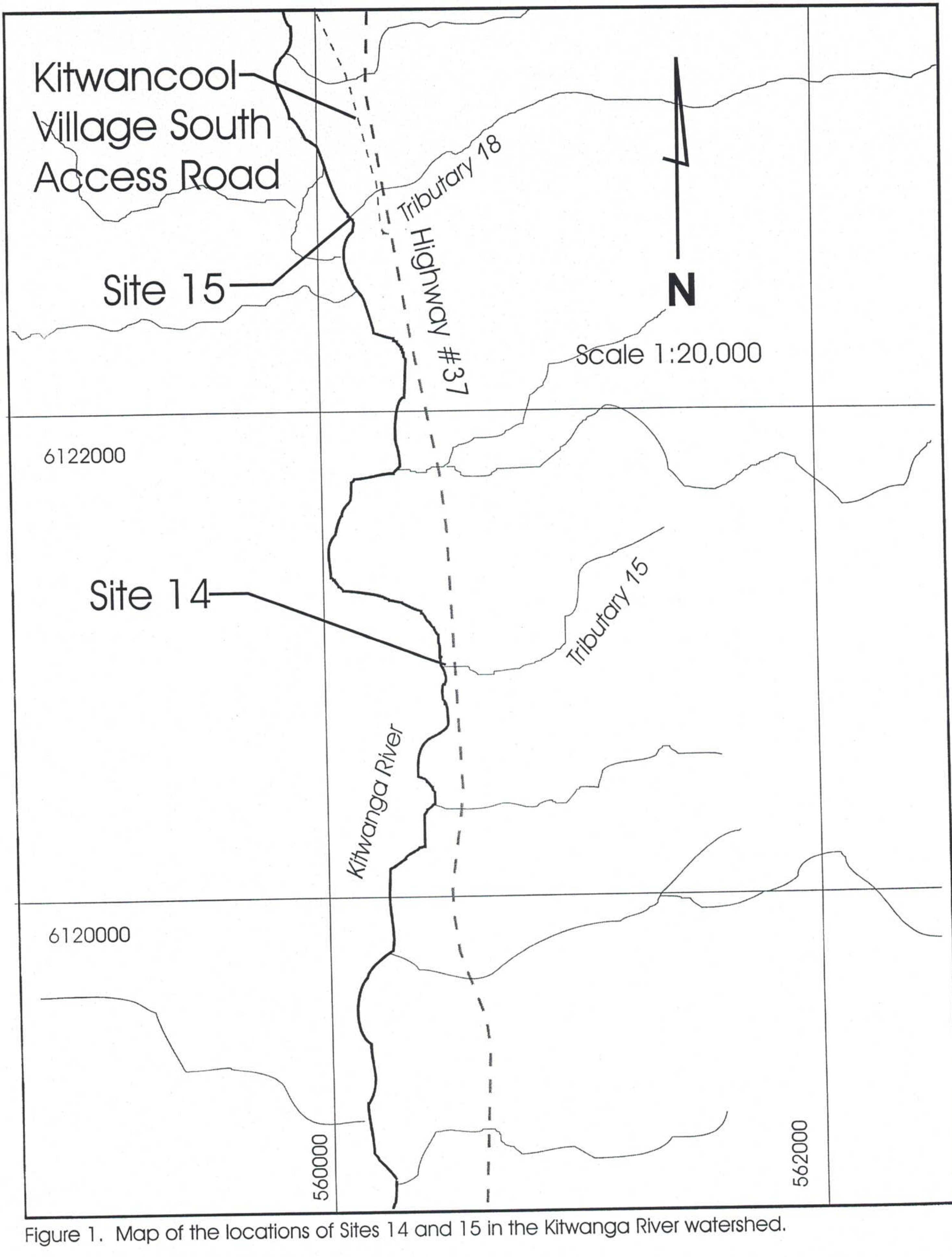


Figure 1. Map of the locations of Sites 14 and 15 in the Kitwanga River watershed.

Monitoring Plan

Biological Monitoring - G. Grieve, R.P. Bio.

The efficacy of the restorative treatments implemented can only be assessed through quantitative comparisons of parameters measured before and then after construction (see also Gilchrist 1998). The two most significant parameters to measure are changes to fish populations and changes to fish habitat. Only limited data on each of these characteristics is available from the Level I assessment, as that process involved sampling of representative parts of a much larger portion of the watershed. A reasonably valid assessment of efficacy will require a more intensive program of measurements. In particular, the construction site should be the subject of an intensive topographic survey of the stream's channel to determine its characteristics over time, along with an intensive fishing program to determine changes in the fish population over time.

Fish Habitat
The physical characteristics of samples of the stream (Giesbrecht et al, 1998), and the pre-construction survey provide some 'before' data. The as-built survey data for all of Site 14 and for the mid-channel bar portion of the lower channel of Site 15, however, are not relevant as 'before' data because these channels were altered significantly during construction.

It is recommended that the stream channels should be the subject of an intensive topographic survey, using a total station, to quantify the shape of the channels before the spring freshet produces the first significant alterations. The same procedure should then be repeated at least once each year for five years and for a minimum of three '1 in 25 year' flood events.

This survey will require x, y and z coordinate information in a grid pattern at a minimum resolution of one datum/m. The survey should extend from the culverts at each site to the mouth and should extend at least 5 horizontal metres 'inland' from the bankfull edge. In the areas immediately adjacent to the installed functional structures, a greater resolution is required to detect significant change. This information should be plotted in the form of a contour map at a scale of at least 1:200 with a contour interval of at least 0.1 m. A total station allows the rapid repeat of these measurements at the same points in future years. This map should then be compared with maps generated using the same methods in future years. It will be necessary to quantify the measurement of change using these maps. This could be done using a random sampling technique and by exploiting the analytical power of 3D software such as a GIS or CAD package. For example, using this technology and the data described above, it would be possible to define an habitat characteristic such as deep pool habitat by establishing numeric criteria and then having the software measure the quantity objectively.

In addition to the survey of the channel topography, the locations and orientations of the LWD structures should also be measured again with a total station. This should begin after the spring freshet during low water in late summer. The same procedure should then be repeated at least once each year for five years and for a minimum of three '1 in 25 year' flood events. If any of the LWD moves, then its fate should be followed by finding it and its identity (each piece was tagged with an aluminum tag placed so that it would not likely come off during movement) so that its history could be reconstructed.

The Fish Habitat Assessment Procedure (FHAP) should be applied to these sites to measure before and after conditions with the same frequency and duration as described above. The FHAP data can also be compared with similar data gathered during the original FHAP done at representative sites within these or other tributaries.

A photographic record of the sites should also be compiled over time using the photo points that were established during construction.

The streams should be walked at least once each year after the spring freshet in order to determine what maintenance or improvements are required.

Fish

Fish data too is limited to that provided by sampling of these and similar streams during the Level I field assessment (Giesbrecht et al, 1998). The sites should be fished intensively to determine species composition, micro-distribution, and relative abundance. Relative abundance could best be determined through a mark-recapture program at each site. This work should be done before the spring freshet to get as much 'before' data as is possible.

Most fishing programs involve intensive fishing once a year. Given that fish are migratory to some degree during all free swimming phases of their life cycle, the fishing program should involve fishing at least three times throughout the year. It is recommended that the site be fished intensively each year for at least four years, as soon after winter as the crew can get to the site and the stream is open, again during high but not peak flows (especially sampling any off channel habitat) and again during late summer low flow conditions when the water temperature is between 8°C and 15°C . Similarly intense repetitions of the methods used should be implemented each year, beginning after the spring freshet in 1999, and continuing for at least four years, in order to produce reasonably valid assessments of the efficacy of the treatments.

The preferred fishing method involves roe baited minnow (Gee) traps set for a maximum of two hours in all habitat types. Such short sets reduce the effects of escape and predation that may bias the results of overnight sets and are more cost effective in that a site does not have to be visited on successive days. It is further recommended that the mark and recapture method of population size estimates include these short sets with no more than one week between the mark and the recapture efforts. No stop nets should be used.

Geomorphological Monitoring - **Dr. A. Gilchrist**

The monitoring and evaluation of aquatic habitat rehabilitation requires the periodic measurement of both biological and physical factors. This section deals with monitoring the physical characteristics, or geomorphology, of streams that are affected primarily by the hydrological regime and the materials that make up the bed of the stream channel. To begin with a general discussion of monitoring procedures is given in this introduction. Subsequent sections explain the physical characteristics of streams that are important in measuring fish habitat values, followed by survey methods and assessment procedures.

A monitoring program to assess instream work is a crucial part of any stream restoration project since it allows the assessment of how effective the restorative measures are in the future and may suggest improved methods if a particular measure does not work very well. Ideally, a monitoring program should include the following basic components:

- Survey before any restoration work has taken place to determine the existing state of the stream.
- Survey of restored stream immediately after restoration work has been completed (as-built survey).
- Periodic surveys after restoration to determine changes to the restored section of stream (Ideally annually just after major floods).

The data collected during this basic procedure is then used to assess the following:

- Determination of the amount of increased fish habitat due to the initial restoration works. This is achieved by comparing the surveys before and immediately after instream works.
- Determination of changes in the amount of fish habitat over a period of time after restoration works. This is achieved by comparing the subsequent surveys with the survey immediately after restoration works were completed, and determines the stability of the restoration works.

The purpose of the monitoring is to determine absolute changes in amounts of fish habitat, which is hopefully improved, and by implication the attendant changes in numbers of fish utilizing the habitat. A second aim is to determine the effectiveness of different restoration measures and provide feedback to improve their implementation in the future. In addition, the information collected can also be used to calculate the efficiency of different restorative measures by relating absolute improvements in fish habitat to the money spent to achieve those gains. This will suggest which methods provide the best value for money in a given situation.

The general discussion in this section has presented the fundamental components of any monitoring program. Before discussing the various types of survey possible and the assessment procedures in more detail, the next section contains a general discussion of stream morphology which ultimately determines the quality of fish habitat in a stream.

Stream Morphology

Various channel properties within watersheds can be used to determine channel morphology (Hogan and Ward, 1997). The most important properties are bankfull width (W_b), bankfull depth (d), maximum bed sediment size (D) and gradient (s). The Channel

Assessment Procedure (CAP) uses these parameters to classify stream channels into three classes (Anon, 1996a; 1996b):

- Riffle-pool morphology
- Cascade-pool morphology
- Step-pool morphology

These three morphologies tend to be found in sequence throughout a watershed. Riffle-pool in the low gradient (< 4%) sections of the lower watershed, cascade-pool in the intermediate gradient (between 4 and 10 %) section of the middle watershed and step-pool in the high gradient (> 10%) section of the headwaters. Riffle-pool morphologies are used by trout and salmon species (pink, chum, coho and sockeye), cascade-pool morphologies are used by trout, char and a few salmon species (chinook and coho), while step-pool morphologies tend to used by resident trout and char. The most important morphologies for fish that are often degraded during forest harvesting are riffle-pool and cascade-pool, and these are usually the target of restoration work.

Once the channel morphology has been identified there are several measures which characterize the physical properties of stream. The most important are:

- Channel width
- Channel depth (both deeper pool areas and shallower riffles or cascades)
- Wetted width and water depth
- Percentage of riffle and pool or cascade and pool areas (depends on water level)
- Channel bed material
- Woody debris

The combination of these stream attributes determine fish habitat quality in association with factors such as instream vegetation and overbank vegetation. Any monitoring program should include the categorization of general channel morphology together with more detailed physical information that helps to quantify the amount and quality of fish habitat at the time of the survey.

Survey Methods

Different types of survey may be used to collect data to be used in the assessment procedure. Several levels of data collection are proposed below.

- Qualitative data collection. Setting up of repeatable ground-based photographic stations for recording oblique views, both upstream and downstream, of the site. In addition, aerial photography should be collected. Province of BC aerial photography is often collected at a scale of 1:15,000 that gives some information on surrounding areas to the site, but is not ideal for monitoring purposes since the scale is so small. Aerial photography by low-level helicopter (~1:5,000) should be obtained.
- Semi-quantitative data collection. Combine photographic data with some quantitative measures (e.g. measurement of W_b, d, D and s to determine channel morphology with

CAP) and qualitative data to determine stability and sediment loading (e.g. field indicators such as eroding banks).

- Quantitative data collection. Collect quantitative data to reflect absolute changes in channel morphology between surveys. Most of these measures can be collected with simple field equipment (e.g. measuring tape and stadia rod) although the level of accuracy, especially the spatial coordinates, is limited. Therefore, it is suggested that more sophisticated survey equipment be used (e.g. total station) so that accurate horizontal and vertical coordinates (with accuracy of at least 5 centimeters) can be recorded for each survey for relation to a set of control points set up during the first survey.

  Upstream and downstream of the site record the following parameters at a minimum in a cross-section through the middle of each pool and riffle/cascade crest:

  - Distance between cross-sections
  - Elevation of top of banks
  - Bankfull and wetted channel width
  - Bankfull channel depth in deepest part of channel, at edge of wetted width, on top of any gravel bars and channel edges (i.e. topographic cross-section)
  - Maximum water depth
  - Maximum sediment size (average of b-axis of ten largest sediment grains)

  Also, record the upstream and downstream extents of each pool and riffle/cascade sub-unit morphology. Ideally, more intensive data sampling than the minimum suggested above should be undertaken. Finally survey the thalweg (deepest portion) of the streambed and water surface from at least 200 meters upstream of the site to 200 meters downstream. Include enough detail to represent variations in gradient along the channel.

An important component of many stream restoration projects is the inclusion of LWD or boulders in the channel. As part of the survey some or all of these installed components should be identified and tagged and their location determined in 3-D (boulder top or both ends of a piece of LWD). Boulders are especially difficult to identify but may be painted with bright metallic paint to help later identification with a metal detector. Other methods include drilling a hole and gluing in a piece of metal. The coordinates of these installed components should subsequently be monitored in addition to stream parameters. This enables the distance of travel for different sized installed components to be determined which indicates the downstream impact.

Obviously, the site that is to be/has been restored has to be surveyed but, in addition, a significant distance upstream and downstream (200 meters or more for small-scale works) should also be surveyed to determine the surrounding impacts of restoration work.

Assessment Procedures

Once survey data has been collected a variety of options are available to help determine the effectiveness of instream works.

- Qualitative. Description of changes based on a sequence of air photos, preferably at a large scale (1:5,000), so that individual logs and riffle-pool or cascade-pool sequences can be identified. In addition, a series of on-the-ground oblique photos of the stream works should be taken from the same point and in the same direction each time. This will provide a time-lapse record of both the site and the downstream impact (good or bad) of the stream restoration works. It will be possible to use the aerial photos to make some quantitative measures of changes in stream parameters (e.g. stream width and locations of LWD that has moved between surveys). In addition, qualitative descriptions of site conditions could be made by the field crew taking the ground photos.
- Semi-quantitative. Quantitative classification of stream morphology change, qualitative description of changes in fish habitat, sediment load etc. This would involve following the CAP procedure to quantitatively assess channel morphology and qualitatively assess whether the system is stable or unstable (aggrading or degrading). The CAP field procedure uses a series of field indicators to qualitatively assess the stability of the stream with reference to a series of keys into one of seven classes (3 degrading, stable and 3 aggrading). The stability class is related to fish habitat quality. As a general rule, stable morphologies have the highest quantity and quality of fish habitat and as the system becomes more degraded/aggraded, the quality and quantity decrease.
- Quantitative. Quantitative description of changes in fish habitat, sediment load etc. This would involve using the quantitative survey data to calculate absolute changes in the following which is possible from the data collected as outlined above.

    - Channel width and depth
    - Areas of pool and riffle/cascade (which depends upon water level)
    - Water depth
    - Sediment stored in the channel and in bars
    - Sediment size
    - Changes in channel location due to bank erosion

  This data will give quantitative data to indicate whether the stream channel is stable, aggrading or degrading. In particular, a sediment budget for the surveyed sections can then be calculated that shows the absolute changes in sediment storage between surveys.

Discussion

There are many options available when designing and implementing a monitoring program. Ultimately, the level of assessment required (i.e. qualitative verses quantitative) and the length of the monitoring program will determine the budget required to allow proper implementation. All monitoring situations are different but a general amount of baseline information should be collected for all sites. This should include repeatable photography at the very least and ideally some form of instream survey over a period of at least 5 - 10 years. The periodic repeating of a CAP will give a good general idea as to the changing physical state of the stream that will indicate when restoration measures have been effective. The greater effort put into collecting quantitative data will be primarily rewarded by contributing to basic research to assess the fundamentals of stream restoration measures and the dynamics of streams.

Results

The data gathered to date includes

- photographs taken on October 15 from various locations (see Appendix A),
- the original FHAP data (Giesbrecht et al, 1998) that was gathered during August, 1997 on fish and fish habitat condition,
- topographic survey data gathered during August, 1997, during the initial pre-construction design phase, along with the associated construction drawing (see Appendix B).
- as built survey data gathered November 7, 1998, including data to construct a longitudinal profile of the thalweg, wetted edges and cross sections, along with the associated as-built drawing (see Appendix C).
- an assessment of the construction by Ministry of Environment biological staff (Fillier and Lough 1999).
- an assessment of the sites and the plans for restorative treatment by a biologist from the US Forest Service (Harkleroad 1998).
- a centreline survey conducted by Cedarvale Resources Ltd. during March, 1999 (see Appendix F).

Permanent reference points for photography were installed in the form of 2 cm x 2 cm x 2 m steel posts driven into the ground to a convenient camera height. These photo points were then tagged with identifying metal tags and their locations were determined using a total station. Locations were chosen such that all structures could be viewed from one or the other of these points. Two such photo points were established at Site 14 and three at Site 15.

Jeff Lough and Darren Fillier, from the Ministry of Environment, Lands and Parks (MoELP), visited the site on November 12, after construction was complete. They have summarized their assessment of the work done at the site in the form of a letter dated March 8, 1999 (see attached copy).

In this letter they expressed concern regarding Site 14 with respect to the pull back of banks, inadequate seeding with grass, loss of low shrub and herb cover, inadequate step pool construction using insufficiently sized and improperly oriented materials and inadequate regulatory agency approvals.

With respect to Site 15, they suggested that, although the LWD was of high quality, branches and tops should be left attached. They further suggested that the LWD be anchored. Concerns were expressed over the stability of the debris catchers, possible end scouring around a channel spanning piece of LWD, riparian area degradation by machine use and the channel excavation.

Sites 14 and 15 were also visited during late September of 1998 before construction, by Jeff Lough and Darren Fillier from the MoELP, and Glenn Harkleroad, a Fisheries Biologist working with the U.S. Forest Service. In a summary of his observations (see attached copy), Mr. Harkleroad suggested that Site 14 was a low priority site, that the fish habitat in this stream was of limited value and that placement of wood in the stream would not likely improve it. Regarding Site 15, Mr. Harkleroad suggested experimenting with anchoring techniques and directing the flow away from the southern bank using log structures.

In addition to the methods outlined in the Monitoring Plan above, particular attention should be paid during the monitoring program to the items of concern addressed above.

The amount of preliminary data gathered was limited by many factors, including the lateness of the season, which resulted in poor fishing success for juvenile fish, and the presence of snow, making visual assessment practically impossible.

Recommendations

It is recommended that the Monitoring and Evaluation program be incorporated as a regular part of the overall watershed restoration program. The activities described above should be scheduled into a five year long plan and this work should be budgeted adequately. The work should be integrated with similar monitoring work in other parts of this and the Kitseguecla watershed so that efficiencies of scale can be realized.

It is recommended that the LWD installed at Site 15 should be anchored to imported boulders >65 cm in their b axis, using steel cable >1.5 cm in diameter epoxied into 15 cm deep holes drilled into the rock using the Hilti Epoxy system. Such boulders may be available along the west Kitwancool Lake FSR.

References

Fillier, D. and J. Lough. 1999. Letter to Bill Fell dated March 8, 1999. A copy is attached to this report as Appendix D.

Giesbrecht, S., G. Grieve and M. Prins. 1998. Level I detailed assessment of fish and fish habitat in the south Kitwanga River and its tributaries. Report for the Gitsegukla Band Council, available at the Regional Library, Ministry of Environment, 3726 Alfred Ave., Smithers, B.C.

Gilchrist, A. 1998. Kitwanga River and Kitseguecla River Watershed Restoration Program: Hydrological and channel stability assessments of specific impact sites. Prepared for the Gitsegukla Band Council.

Harkleroad, G.R. 1998. British Columbia Stream Restoration Project Review Report, 1998. A copy is attached to this report as Appendix E.

Wildstone Resources Ltd. 1995. Level I Assessment of the Kitwanga River Watershed. Prepared for Skeena Cellulose Inc. Available in the library, Ministry of Environment, 3726 Alfred Ave., Smithers, B.C., V0J 2N0

Appendix A. Photographs.

Site 14

Photo 1. This mosaic looks north during the construction at Site 14. Visible from the perched culvert downstream, are the excavated plunge pool, a small rock weir, another plunge pool and the pulled back bank.

Site 15

Photo 2. Looking downstream from atop the perched culvert. The upstream limit of treatment was located at the red flag, where a cluster of complete trees was prescribed with root wads upstream.

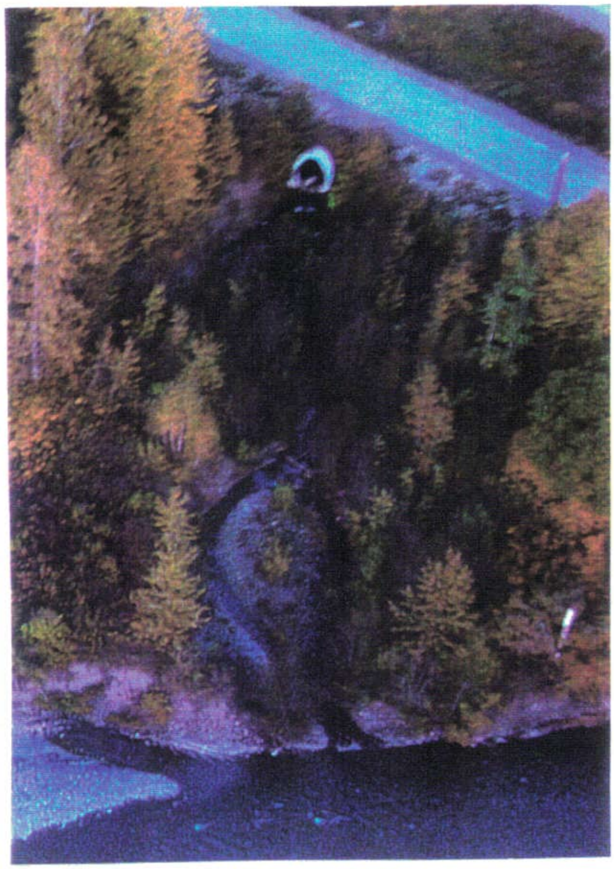


Photo 3. An aerial view of Site 15.

Photo 4. Looking upstream toward the complete tree with root wad attached that was one of two pieces of LWD that were installed across the channel.

Photo 5. Looking downstream. The technicians are standing on the LWD installed furthest upstream.

Appendix B. Pre-Construction Survey Data and Drawings.

Site 14 Pre-Construction Survey Data

This site is ~ 19 m long from the culvert lip to the mainstem Kitwanga

The thalweg has <1 m sinuosity.

The channel is incised ~ 2 m below an old road grade in fine material.

The channel is ~ 2 m at Wb

X-Section @ 5 m below culvert, starting from s side

0	3.6
5	3.5
7	2.4
8	2.2
9	0.4
10	0
12	0
13	0.4
14	2.2
15	2.4
16	3.5
21	3.6

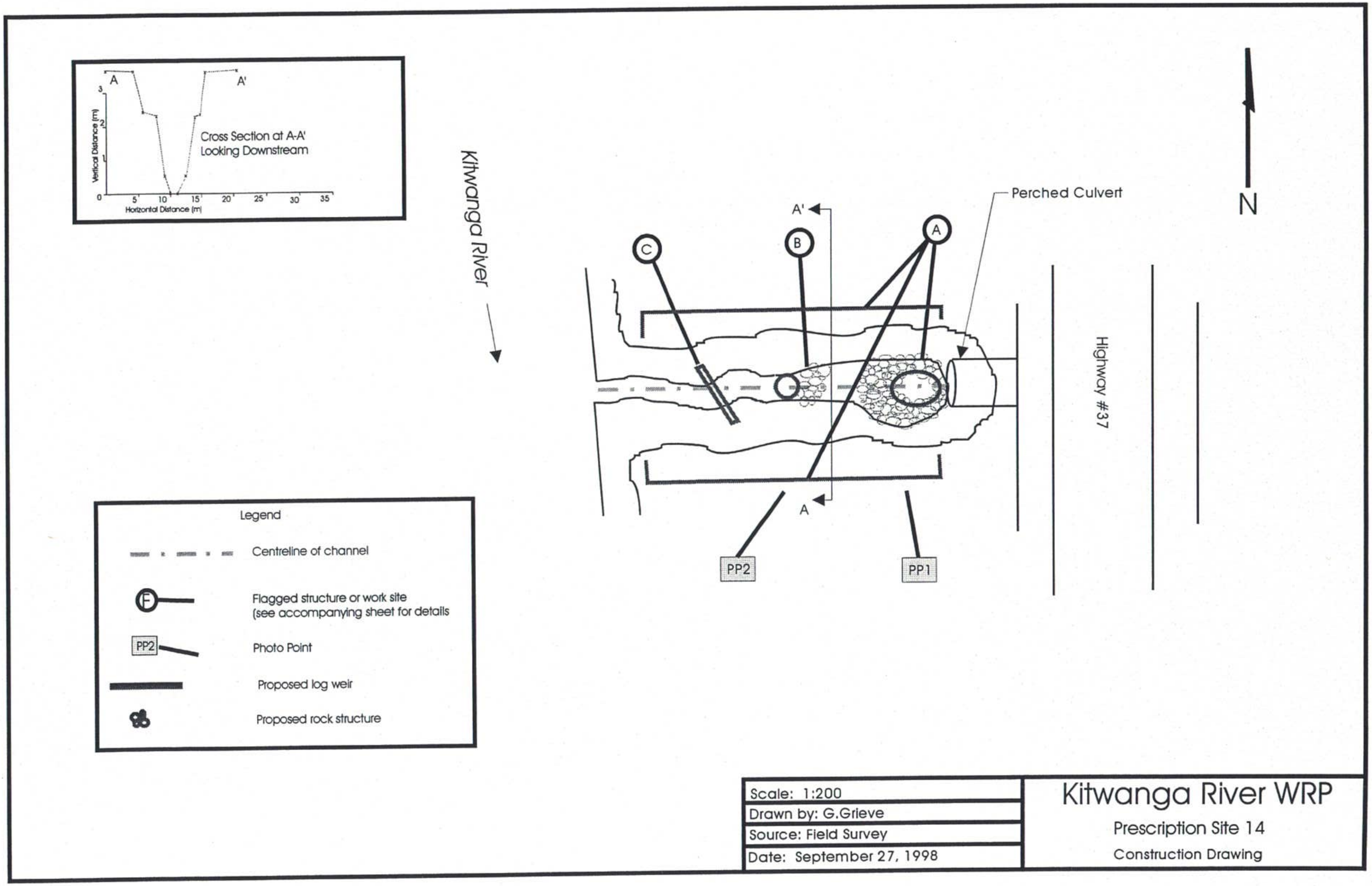


Figure 2. Construction drawing for Site 14, Kitwanga River.

Survey of Kitwanga Prescription Site 15 using clinometer, compass and tape.

Shot	Comment	Slope Distanc	% Slope	HD	HA						VD
Number				m	deg	min	Dec Deg	sec	Dec Deg	Dec Brg	m
POC is a metal tag facing east, nailed to a 20 cm DBH cottonwood											
located on the north bank above the cree's mouth. Reference point is at base of tree.											
POC	Description										
1	to mouth of cr.	15.8	-19	15.6244	168	0	0.00000	0	0.00000	168.00000	-2.3490
2	s bank at mou	16.6	-10	16.5488	152	0	0.00000	0	0.00000	152.00000	-1.3024
3	on n	8.5	-20	8.3954	176	0	0.00000	0	0.00000	176.00000	-1.3297
	moved to sta 1 (mouth)										
4		7.75	4	7.7462	8	0	0.00000	0	0.00000	8.00000	0.2434
5		19.6	4	19.5903	9		0.00000		0.00000	9.00000	0.6157
	moved to sta 4										
6		15.4	2.5	15.3970	64		0.00000		0.00000	64.00000	0.3024
7		9.2	2.5	9.1982	73		0.00000		0.00000	73.00000	0.1806
8		4.9	10	4.8849	314		0.00000		0.00000	314.00000	0.3844
9		12.9	27	12.6110	314		0.00000		0.00000	314.00000	2.7151
10		18	20	17.7784	314		0.00000		0.00000	314.00000	2.8158
11		13	20	12.8399	344		0.00000		0.00000	344.00000	2.0336
12		13.3	20	13.1363	4		0.00000		0.00000	4.00000	2.0806
13		12.6	11	12.5530	18		0.00000		0.00000	18.00000	1.0872
14	e side of old rc	13.2	8	13.1740	29		0.00000		0.00000	29.00000	0.8288
15	at stump in ch	9.2	5	9.1929	30		0.00000		0.00000	30.00000	0.3612
16		8.9	14	8.8463	51		0.00000		0.00000	51.00000	0.9766
17		2.1	44	1.9758	144		0.00000		0.00000	144.00000	0.7113
18		10.3	12	10.2543	144		0.00000		0.00000	144.00000	0.9693
19		12.1	28	11.8086	142		0.00000		0.00000	142.00000	2.6395
	moved to sta 15 at stump										
20		9.4	1	9.3997	72		0.00000		0.00000	72.00000	0.0738
21	on bank above	9.7	11	9.6638	78		0.00000		0.00000	78.00000	0.8370
22		18.5	3	18.4949	54		0.00000		0.00000	54.00000	0.4359
	moved to sta 22										
23	junction	5.9	2.5	5.8989	357		0.00000		0.00000	357.00000	0.1158
24		10.1	5	10.0922	360		0.00000		0.00000	360.00000	0.3965
25		4.9	6	4.8946	316		0.00000		0.00000	316.00000	0.2308

Pole Heigh	HI	X=easting	Y=northing	Z
m	m	m	m	m
Earl	Glenn			
		X	Y	Z
		x	y	z
1.70000	1.70000	3.2485	-15.2830	-2.35
1.70000	1.70000	7.7692	-14.6117	-1.30
1.70000	1.70000	0.5856	-8.3749	-1.33
1.70000	1.70000	4.3266	-7.6122	0.24
1.70000	1.70000	6.3131	4.0661	0.62
1.70000	1.70000	18.1654	-0.8626	0.30
1.70000	1.70000	13.1229	-4.9229	0.18
1.70000	1.70000	0.8127	-4.2189	0.38
1.70000	1.70000	-4.7450	1.1482	2.72
1.70000	1.70000	-8.4621	4.7377	2.82
1.70000	1.70000	0.7874	4.7304	2.03
1.70000	1.70000	5.2429	5.4921	2.08
1.70000	1.70000	8.2057	4.3264	1.09
1.70000	1.70000	10.7135	3.9100	0.83
1.70000	1.70000	8.9231	0.3491	0.36
1.70000	1.70000	11.2014	-2.0451	0.98
1.70000	1.70000	5.4880	-9.2107	0.71
1.70000	1.70000	10.3539	-15.9081	0.97
1.70000	1.70000	11.5967	-16.9175	2.64
1.70000	1.70000	17.8628	3.2538	0.07
1.70000	1.70000	18.3757	2.3583	0.84
1.70000	1.70000	23.8858	11.2201	0.44
1.70000	1.70000	23.5771	17.1109	0.12
1.70000	1.70000	23.8858	21.3123	0.40
1.70000	1.70000	20.4858	14.7410	0.23

26		14.4	6	14.3840	315		0.00000		0.00000	315.00000	0.6783
27	top of bank	18.9	19	18.6900	318		0.00000		0.00000	318.00000	2.8099
28	5m back	24	15	23.8336	318		0.00000		0.00000	318.00000	2.8209
29	s bank at mou	1.2	22	1.1821	141		0.00000		0.00000	141.00000	0.2063
30		3.3	25	3.2366	144		0.00000		0.00000	144.00000	0.6438
31		7.1	30	6.9038	144		0.00000		0.00000	144.00000	1.6575
32		12	18	11.8803	139		0.00000		0.00000	139.00000	1.6908
33		11.2	2	11.1986	90		0.00000		0.00000	90.00000	0.1759
34		9.9	2	9.8988	106		0.00000		0.00000	106.00000	0.1555
35		10.2	32	9.8795	58		0.00000		0.00000	58.00000	2.5366
36		17.2	38	16.4396	58		0.00000		0.00000	58.00000	5.0575

1.70000	1.70000	13.7148	21.3911	0.68
1.70000	1.70000	11.3798	25.1094	2.81
1.70000	1.70000	7.9380	28.9319	2.82
1.70000	1.70000	24.6297	10.3014	0.21
1.70000	1.70000	25.7882	8.6016	0.64
1.70000	1.70000	27.9438	5.6348	1.66
1.70000	1.70000	31.6800	2.2539	1.69
1.70000	1.70000	35.0844	11.2201	0.18
1.70000	1.70000	33.4011	8.4916	0.16
1.70000	1.70000	32.2641	16.4555	2.54
1.70000	1.70000	37.8274	19.9318	5.06

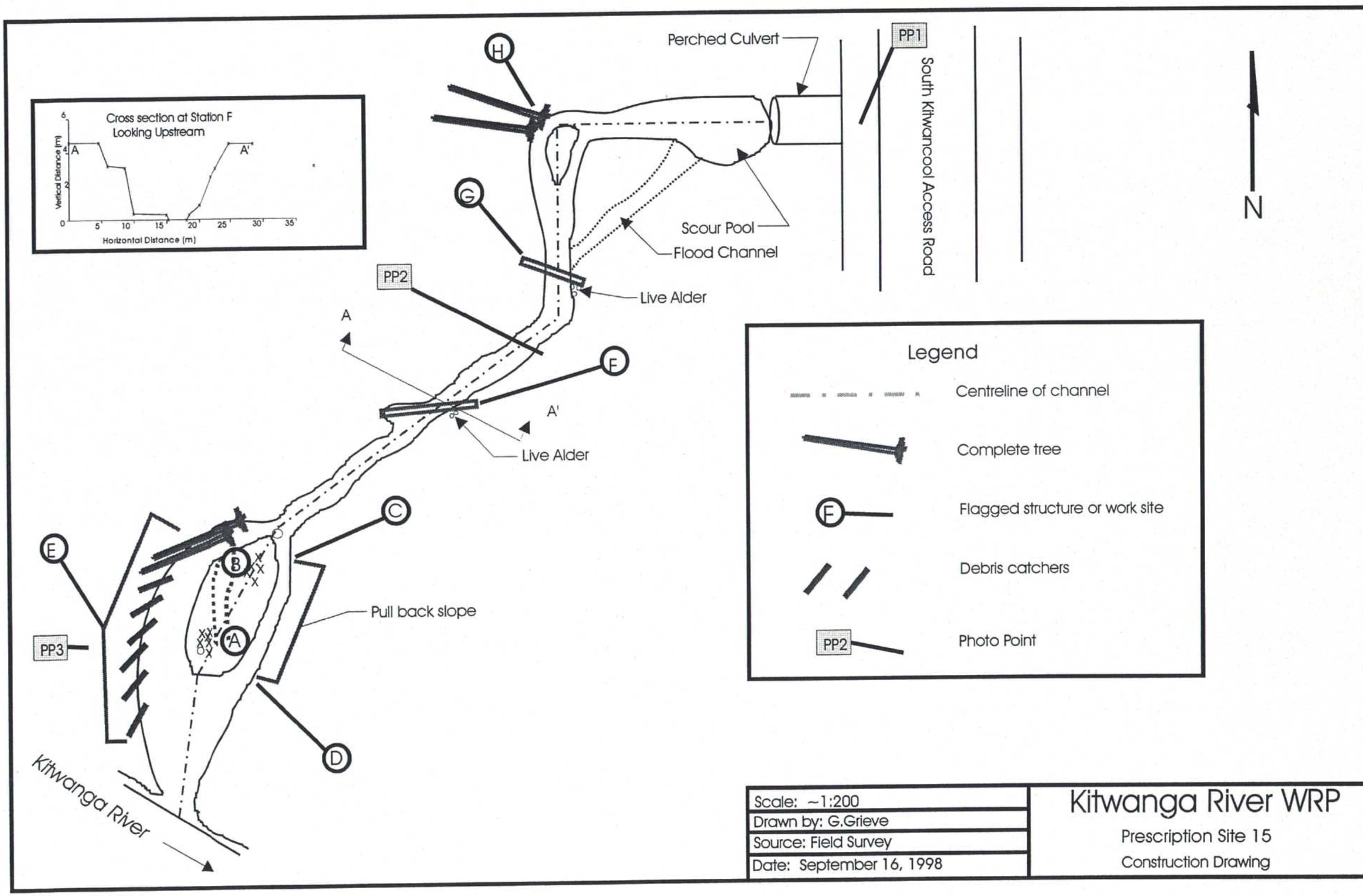


Figure 2. Pre-Construction plan for Site 15.

Appendix C. As-Built Survey Data and Drawings.

Total Station Survey of 'As-Built' Site 14, Reach 1, Trib 15, South Kitwanga River

BioLith Scientific Consultants Inc.

250-635-5378		Temp		9								
		WX	cool	overcast								
		Date of Survey:				Nov.2	1998					
Crew												
Pentax PCS 325-W		Barom Pres:	986									

All measurements taken from BM#48.

Measurements to Large Woody Debris pieces taken with respect to nails driven into each end of the log.

Measurements to photo points taken to the top of the reference post or metal pipe.

Missing shot numbers indicate no data recorded.

Shot #	Description	HD	HA			Decimal	VD	RH	HI			
			Degr	Minu	Seco	Degrees				x	y	z
0	BM48 & SP									0.000	0.000	0.000
1	Photo Poin	15.16	143	20	45	143.346	-0.82	1.676	1.66	9.050	-12.162	-0.840
2	Photo Poin	16.82	169	51	50	169.864	-0.24	1.676	1.66	2.960	-16.557	-0.260
3	Pool 1 Refe	13.63	129	11	50	129.197	-3.13	1.676	1.66	10.563	-8.614	-3.150
4	Pool 2 Refe	11.54	138	38	20	138.639	-3.41	1.676	1.66	7.626	-8.661	-3.430
5	Culvert Lip	14.18	116	46	35	116.776	-2.60	1.674	1.66	12.660	-6.388	-2.618
6	Thalweg (T	13.83	117	51	35	117.86	-3.57	1.676	1.66	12.227	-6.463	-3.590
7	TH 2	13.17	121	46	25	121.774	-4.03	1.676	1.66	11.196	-6.935	-4.050
8	TH 3	12.28	125	41	30	125.692	-3.55	1.674	1.66	9.973	-7.164	-3.568
9	TH 4	11.09	133	2	30	133.042	-3.92	1.674	1.66	8.105	-7.569	-3.938
10	TH 5	9.88	134	9	30	134.158	-4.31	1.674	1.66	7.088	-6.883	-4.328
11	TH 6	8.8	141	41	20	141.689	-3.69	1.76	1.66	5.455	-6.905	-3.794
12	TH 7	8.56	147	25	30	147.425	-3.80	1.76	1.66	4.609	-7.213	-3.904
13	TH 8	8.59	159	38	0	159.633	-3.83	1.76	1.66	2.990	-8.053	-3.934
14	TH 9	8.58	159	42	25	159.707	-3.83	1.76	1.66	2.976	-8.047	-3.934
15	TH 10	10.13	177	38	50	177.647	-4.41	1.76	1.66	0.416	-10.121	-4.514
16	TH 11	10.02	185	28	40	185.478	-4.57	1.76	1.66	-0.957	-9.974	-4.674
17	TH 12	9.81	192	3	55	192.065	-4.58	1.76	1.66	-2.051	-9.593	-4.684
18	TH 13	11.07	209	37	0	209.617	-4.86	1.76	1.66	-5.471	-9.624	-4.964
19	TH 14	11.68	216	56	15	216.938	-4.94	1.76	1.66	-7.019	-9.336	-5.044
20	TH 15	17.49	229	45	0	229.75	-5.46	1.76	1.66	-13.349	-11.301	-5.564

21	Wetted Wid	14.5	118	46	5	118.768	-3.27	1.75	1.66	12.710	-6.978	-3.364	
22	WW RL 2	14.62	122	50	25	122.84	-3.34	1.75	1.66	12.284	-7.928	-3.434	
23	WW RL 3	13.88	127	18	20	127.306	-3.31	1.75	1.66	11.040	-8.412	-3.404	
24	WW RL 4	13.07	128	29	40	128.494	-3.26	1.75	1.66	10.229	-8.135	-3.354	
25	WW RL 5	12.26	125	58	25	125.974	-3.23	1.75	1.66	9.922	-7.202	-3.324	
26	WW RL 6	11.6	133	17	20	133.289	-3.61	1.75	1.66	8.444	-7.954	-3.704	
27	WW RL 7	10.41	141	22	55	141.382	-3.64	1.75	1.66	6.497	-8.134	-3.734	
28	WW RL 8	9.24	142	2	30	142.042	-3.69	1.75	1.66	5.683	-7.285	-3.784	
29	WW RL 9	9.05	150	25	45	150.429	-3.79	1.75	1.66	4.466	-7.871	-3.884	
30	WW RL 10	9.4	156	51	45	156.863	-3.75	1.75	1.66	3.694	-8.644	-3.844	
31	WW RL 11	8.94	160	4	10	160.069	-4.10	1.75	1.66	3.047	-8.405	-4.194	
32	WW RL 12	10.28	175	21	25	175.357	-4.17	1.75	1.66	0.832	-10.246	-4.264	
33	WW RL 13	10.35	183	40	25	183.674	-4.35	1.656	1.66	-0.663	-10.329	-4.350	
34	WW RL 14	10.74	196	14	40	196.244	-4.49	1.656	1.66	-3.004	-10.311	-4.490	
35	WW RL 15	11.67	207	47	5	207.785	-4.75	1.656	1.66	-5.440	-10.325	-4.750	
36	WW RL 16	11.45	212	31	40	212.528	-4.79	1.656	1.66	-6.157	-9.654	-4.790	
37	WW RL 17	15.91	226	17	10	226.286	-5.29	1.656	1.66	-11.500	-10.995	-5.290	
38	WW RL 18	17.28	227	3	35	227.06	-5.36	1.656	1.66	-12.650	-11.772	-5.360	
39	WW 19 R/F	16.31	231	37	40	231.628	-5.25	1.652	1.66	-12.787	-10.125	-5.246	
40	WW RR 20	10.86	219	39	30	219.658	-4.86	1.652	1.66	-6.931	-8.361	-4.856	
41	WW RR 21	10.41	211	45	30	211.758	-4.76	1.652	1.66	-5.479	-8.851	-4.756	
42	WW RR 22	10.23	206	43	35	206.726	-4.72	1.652	1.66	-4.601	-9.137	-4.716	
43	WW RR 23	9.19	182	52	15	182.871	-4.36	1.652	1.66	-0.460	-9.178	-4.356	
44	WW RR 24	8.2	164	16	35	164.276	-4.05	1.652	1.66	2.222	-7.893	-4.046	
45	WW RR 25	7.51	156	23	0	156.383	-3.84	1.652	1.66	3.009	-6.881	-3.836	
46	WW RR 26	7.5	148	10	55	148.182	-3.86	1.652	1.66	3.954	-6.373	-3.856	
47	WW RR 27	8.29	145	23	55	145.399	-3.76	1.652	1.66	4.708	-6.824	-3.756	
48	WW RR 28	8.42	138	6	50	138.114	-3.64	1.652	1.66	5.622	-6.268	-3.636	
49	WW RR 29	9.04	129	7	30	129.125	-3.66	1.652	1.66	7.013	-5.704	-3.656	
50	WW RR 30	9.66	128	7	50	128.131	-3.63	1.652	1.66	7.599	-5.965	-3.626	
51	WW RR 31	11.29	128	29	40	128.494	-3.48	1.652	1.66	8.836	-7.027	-3.476	
52	WW RR 32	11.93	125	24	5	125.401	-3.27	1.652	1.66	9.724	-6.911	-3.266	
53	WW RR 33	11.46	118	39	25	118.657	-3.31	1.652	1.66	10.056	-5.496	-3.306	
54	WW RR 34	12.65	114	42	15	114.704	-3.28	1.652	1.66	11.492	-5.287	-3.276	
55	WW RR 35	13.78	114	32	5	114.535	-3.30	1.652	1.66	12.536	-5.722	-3.296	
56	CROSS SE	36.6	161	15	45	161.263	-0.05	1.652	1.66	11.757	-34.660	-0.046	
57	C/S 2	29.16	160	7	55	160.132	0.81	1.652	1.66	9.910	-27.424	0.814	

58	C/S 3	20.8	158	33	30	158.558	0.11	1.652	1.66	7.604	-19.360	0.114	
59	C/S 4	15.47	159	21	5	159.351	-0.38	1.652	1.66	5.455	-14.476	-0.376	
60	C/S 5	10.58	156	55	35	156.926	-3.55	1.652	1.66	4.146	-9.734	-3.546	
61	C/S 6	9.17	153	38	15	153.638	-3.79	1.652	1.66	4.072	-8.216	-3.786	
62	C/S 7	7.5	152	22	40	152.378	-3.53	1.652	1.66	3.477	-6.645	-3.526	
63	C/S 8	2.03	94	1	5	94.0181	0.10	1.652	1.66	2.025	-0.142	0.104	
64	C/S 9	7.2	352	24	55	352.415	0.00	1.652	1.66	-0.950	7.137	0.004	
65	C/S 10	19.96	347	40	20	347.672	-1.26	1.652	1.66	-4.262	19.500	-1.256	
66	lwd U/S TA	9.69	156	18	0	156.3	-3.68	1.652	1.66	3.895	-8.873	-3.676	
67	LWD D/S	7.9	161	38	20	161.639	-3.78	1.652	1.66	2.489	-7.498	-3.776	
68	CHANNEL	18.22	194	40	50	194.681	-0.73	1.652	1.66	-4.617	-17.625	-0.726	
69	cb #2	15.31	152	6	30	152.108	-0.40	1.652	1.66	7.162	-13.531	-0.396	
70	CB #3	14.95	140	12	45	140.213	-0.93	1.652	1.66	9.567	-11.488	-0.926	
71	cb #4	16.49	127	38	5	127.635	-1.30	1.652	1.66	13.059	-10.069	-1.296	
72	#5 Top of (	15.35	112	16	5	112.268	-1.03	1.652	1.66	14.205	-5.817	-1.026	
73	channel bre	11.71	106	2	45	106.046	-1.44	1.652	1.66	11.254	-3.237	-1.436	
74	CB r/r #2	10.22	110	9	30	110.158	-1.73	1.652	1.66	9.594	-3.522	-1.726	
75	CB R/R #3	8.53	102	20	10	102.336	-1.29	1.652	1.66	8.333	-1.822	-1.286	
76	CB r/R #4	6.57	83	20	40	83.3444	-0.05	1.652	1.66	6.526	0.761	-0.046	
77	CB R/R #5	2.99	240	14	5	240.235	-0.35	1.652	1.66	-2.596	-1.484	-0.346	
78	cb R/R #6	6.31	269	0	50	269.014	-0.61	1.652	1.66	-6.309	-0.109	-0.606	
79	POOL #1-1	13.98	118	28	40	118.478	-3.77	1.656	1.66	12.288	-6.666	-3.770	
80	POOL #1-2	13.16	120	35	55	120.599	-4.11	1.656	1.66	11.328	-6.699	-4.110	
81	POOL #1-3	12.79	123	40	50	123.681	-3.76	1.656	1.66	10.643	-7.093	-3.760	
82	POOL #1-4	12.53	120	3	0	120.05	-3.72	1.656	1.66	10.846	-6.274	-3.720	
83	POOL #1-5	13.92	124	25	45	124.429	-3.74	1.656	1.66	11.482	-7.870	-3.740	
84	POOL #2 D	9.96	133	52	55	133.882	-4.32	1.656	1.66	7.179	-6.904	-4.320	

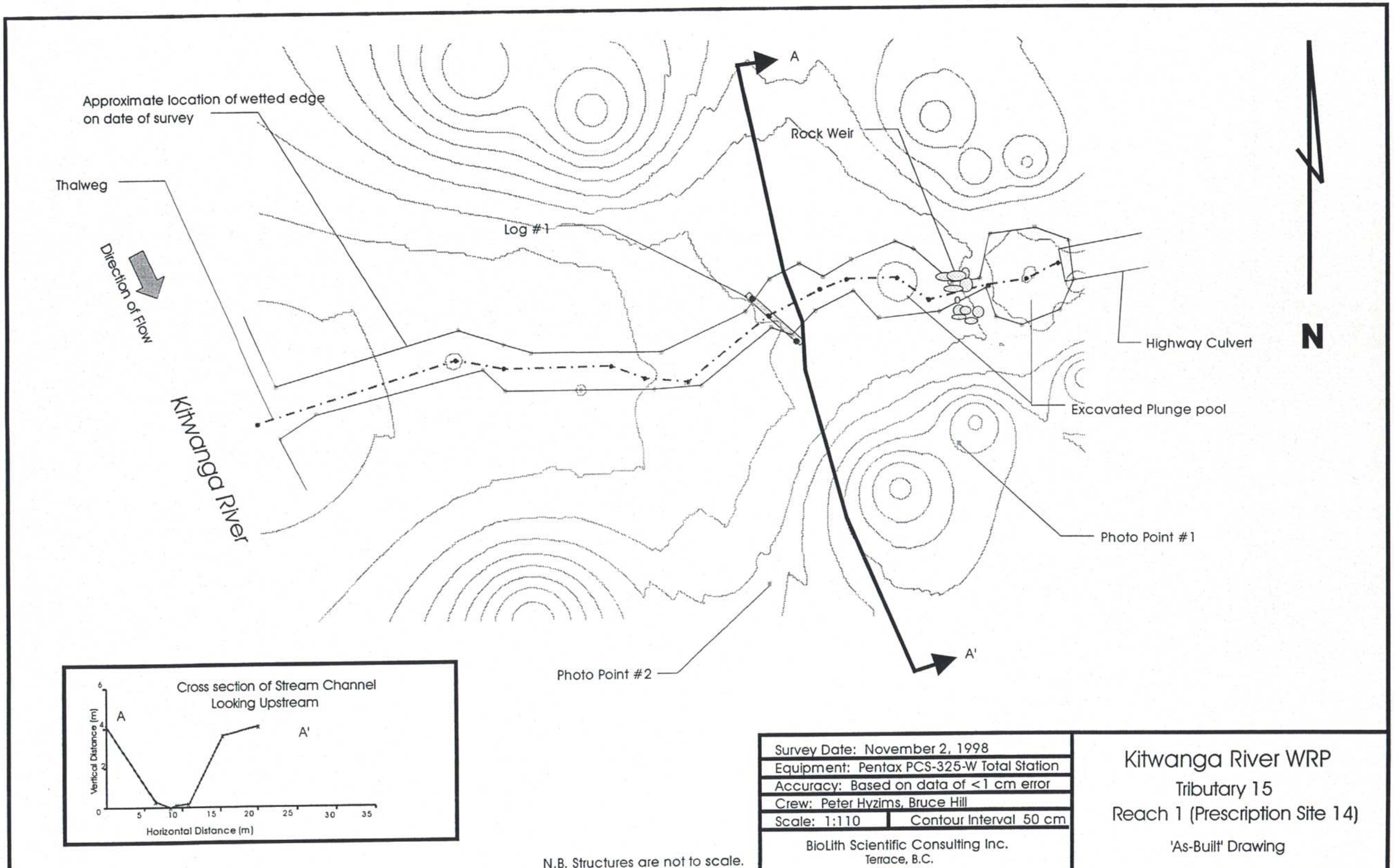


Figure 3. As-Built drawing of the construction at Site 14 on Tributary 15 in the Kitwanga River South Sub-Basin.

Total Station Survey of 'As-Built' Site 15, Reach 1, Trib 18, South Kitwanga River

BioLith Scientific Consultants Inc.

250-635-5378 Temp 8

Crew EW/GG

Pentax PCS 325-W Barom Press. 981

All measurements taken from BM#56.

Measurements to Large Woody Debris pieces taken with respect to nails driven into each end of the log. Debris catcher measurements were taken with respect to one nail driven into the highest point on the piece.

Measurements to photo points taken to the top of the reference post or metal pipe.

Missing shot numbers indicate no data recorded.

First : First SP tag #55

Shot #		HD	Degr	Minu	Secc	Dec. Deg.	VD	RH	HI	x	y	z	Description
										0.000	0.000	0.000	BM55
1	to tag # 54	29.74	217	8	35	217.143	-2.38	1.52	1.55	-17.957	-23.707	-2.346	to tag # 54
2	edge of hig	31.6	227	42	45	227.713	-1.52	1.52	1.55	-23.377	-21.262	-1.486	edge of highest bank on N
3	edge of hig	23.01	235	20	25	235.340	-1.35	1.52	1.55	-18.927	-13.086	-1.316	edge of highest bank on N
4	edge of hig	15.82	251	1	35	251.026	-0.71	1.66	1.55	-14.960	-5.144	-0.822	edge of highest bank on N
5	edge of hig	6.59	252	52	20	252.872	-0.46	1.66	1.55	-6.298	-1.941	-0.572	edge of highest bank on N
6	edge of hig	2.09	282	37	55	282.632	0.13	1.66	1.55	-2.039	0.457	0.018	edge of highest bank on N
7	edge of hig	3.23	195	30	50	195.514	-1.01	1.66	1.55	-0.864	-3.112	-1.122	edge of highest bank on N
8	edge of hig	3.6	131	53	5	131.885	-0.76	1.66	1.55	2.680	-2.403	-0.872	edge of highest bank on N
9	edge of hig	10.75	93	59	50	93.997	-0.07	1.66	1.55	10.724	-0.749	-0.180	edge of highest bank on N
10	w.edge N s	11.47	114	7	40	114.128	-3.35	1.66	1.55	10.468	-4.689	-3.460	w.edge N side
11	w.edge N s	8.57	127	34	45	127.579	-3.36	1.66	1.55	6.792	-5.226	-3.467	w.edge N side
12	w.edge N s	6.01	148	50	5	148.835	-3.49	1.65	1.55	3.110	-5.143	-3.594	w.edge N side
13	Outside of	8.47	188	17	50	188.297	-3.83	1.65	1.55	-1.222	-8.381	-3.933	Outside of first bend
14	alder clump	11.55	185	17	55	185.299	-4.12	1.65	1.55	-1.067	-11.501	-4.223	alder clump
15	w.edge N s	18.22	187	44	45	187.746	-4.18	1.65	1.55	-2.456	-18.054	-4.283	w.edge N side
16	w.edge N s	21.77	191	2	55	191.049	-4.15	1.65	1.55	-4.172	-21.366	-4.253	w.edge N side
17	w.edge N s	25.4	199	50	50	199.847	-4.29	1.65	1.55	-8.624	-23.891	-4.393	w.edge N side
18	S end of we	24.87	185	25	20	185.422	-4.21	1.65	1.55	-2.350	-24.759	-4.310	S end of weir log working u/s
19	w. edge S :	22.1	182	6	55	182.115	-4.2	1.6	1.55	-0.816	-22.085	-4.246	w. edge S. side
20	w. edge S :	19.94	179	14	35	179.243	-4.14	1.64	1.55	0.263	-19.938	-4.234	w. edge S. side

21	w. edge S	17.45	176	7	45	176.129	-4.15	1.64	1.55	1.178	-17.410	-4.236	w. edge S. side
22	w. edge S	13.81	174	39	5	174.651	-4	1.64	1.55	1.287	-13.750	-4.086	w. edge S. side
23	w. edge S	10.65	168	1	10	168.019	-3.7	1.63	1.55	2.211	-10.418	-3.780	w. edge S. side
24	w. edge S	10	141	28	25	141.474	-3.41	1.63	1.55	6.229	-7.823	-3.488	w. edge S. side
25	w. edge S	13.66	135	36	40	135.611	-3.35	1.63	1.55	9.556	-9.762	-3.427	w. edge S. side
26	w. edge S	14.19	121	37	20	121.622	-3.4	1.63	1.55	12.083	-7.440	-3.475	w. edge S. side
27	top of culve	13.87	111	46	10	111.769	0.84	1.62	1.55	12.881	-5.144	0.766	top of culvert
28	bottom of c	13.71	112	17	40	112.294	-0.43	2.51	1.55	12.685	-5.201	-1.388	bottom of culvert 2 m in from edge
29	top of phot	16.95	116	13	10	116.219	2.13	1.52	1.55	15.206	-7.489	2.162	top of photo point 1
30	thalweg fro	9.53	135	39	45	135.663	-3.74	1.52	1.55	6.660	-6.816	-3.707	thalweg from culvert plunge pool tail out d/s
31	thalweg	7.98	155	5	55	155.099	-3.8	1.52	1.55	3.360	-7.238	-3.767	thalweg
32	thalweg	10.68	175	8	15	175.138	-4.19	1.52	1.55	0.905	-10.642	-4.157	thalweg
33	u/s of log 1	14.72	180	12	35	180.210	-4.25	1.52	1.55	-0.054	-14.720	-4.217	u/s of log 1 in thalweg
34	top of phot	24.19	181	49	25	181.824	-2.09	1.52	1.55	-0.770	-24.178	-2.056	top of photo point 2
35		23.28	187	55	5	187.918	-4.45	1.52	1.55	-3.207	-23.058	-4.416	
36	middle of lo	24.79	191	9	40	191.161	-4.4	1.52	1.55	-4.799	-24.321	-4.366	middle of log 5
37	S end of lo	25.01	185	41	55	185.699	-4.1	1.52	1.55	-2.483	-24.886	-4.066	S end of log 5
38	N end of lo	25.1	198	36	20	198.606	-4.07	1.52	1.55	-8.008	-23.788	-4.036	N end of log 5
39	N end of tr	14.23	205	3	25	205.057	-3.35	1.52	1.55	-6.027	-12.891	-3.316	N end of tree 4
40	S end of tr	15.39	176	18	30	176.308	-3.43	1.52	1.55	0.991	-15.358	-3.396	S end of tree 4
41	rootwad en	6.98	188	32	45	188.546	-3.02	1.52	1.55	-1.037	-6.903	-2.986	rootwad end of S most log of group of 3-tree #3
42	middle log-	6.05	175	38	25	175.640	-3.08	1.52	1.55	0.460	-6.032	-3.046	middle log-tree #2
43	N log-tree	5.36	170	22	40	170.378	-2.54	1.66	1.55	0.896	-5.285	-2.648	N log-tree #1
44	single debr	5.98	149	17	0	149.283	-2.84	1.66	1.55	3.055	-5.141	-2.947	single debris catcher
45	S log-tree	19.44	238	7	35	238.126	-2.3	1.66	1.55	-16.509	-10.265	-2.406	S log-tree #3
46	N log-tree	17.91	242	30	10	242.503	-2.22	1.66	1.55	-15.887	-8.269	-2.326	N log-tree #1
47	Middle log-	14.45	237	55	25	237.924	-2.86	1.66	1.55	-12.244	-7.674	-2.966	Middle log-tree #2
48	N end of cr	11.79	241	56	25	241.940	-2.3	1.66	1.55	-10.404	-5.546	-2.406	N end of crossed log
49		11.72	205	4	5	205.068	-3.21	1.65	1.55	-4.966	-10.616	-3.310	
50	cross secti	21.64	148	2	25	148.040	-1.63	1.58	1.55	11.455	-18.360	-1.664	cross section from S to N
51	cross secti	20.47	152	7	50	152.131	-2.29	1.58	1.55	9.569	-18.096	-2.323	cross section from S to N
52	cross secti	19.19	155	59	50	155.997	-3.12	1.58	1.55	7.806	-17.531	-3.153	cross section from S to N
54	cross secti	15.65	174	37	45	174.629	-4.17	1.57	1.55	1.465	-15.581	-4.192	cross section from S to N
55	cross secti	14.07	199	10	5	199.168	-3.67	1.57	1.55	-4.620	-13.290	-3.692	cross section from S to N
56	cross secti	15.99	227	56	25	227.940	-3.35	1.57	1.55	-11.872	-10.712	-3.372	cross section from S to N
57	cross secti	18.66	237	51	35	237.860	-3.04	1.57	1.55	-15.800	-9.927	-3.062	cross section from S to N
58	cross secti	20.4	242	12	50	242.214	-0.93	1.57	1.55	-18.048	-9.510	-0.950	cross section from S to N

59	cross secti	26.04	254	49	10	254.819	-1.03	1	1.55	-25.131	-6.819	-0.480	cross section from S to N
60	channel bo	7.21	157	42	30	157.708	-3.1	2.16	1.55	2.735	-6.671	-3.712	channel bottom near bundled trees
61	channel bo	8.38	173	48	15	173.804	-3.2	2.16	1.55	0.904	-8.331	-3.806	channel bottom near bundled trees
62	channel bo	7.89	185	8	0	185.133	-3.37	2.15	1.55	-0.706	-7.858	-3.973	channel bottom near bundled trees
63	channel bo	8.51	198	18	5	198.301	-3.03	2.15	1.55	-2.672	-8.080	-3.630	channel bottom near bundled trees
64	channel bo	14.47	176	13	5	176.218	-3.6	2.15	1.55	0.954	-14.438	-4.200	channel bottom u/s tree #4 rootwad end
65	channel bo	13.38	168	31	45	168.529	-3.47	2.02	1.55	2.661	-13.113	-3.943	channel bottom u/s log 1 rootwad end
66	channel bo	16.98	177	47	50	177.797	-3.7	2.02	1.55	0.653	-16.967	-4.170	channel bottom u/s log 1 rootwad end
67	channel bo	16.45	177	35	40	177.594	-3.81	2.02	1.55	0.690	-16.436	-4.280	channel bottom u/s log 1 rootwad end
68	channel bo	15.86	179	53	20	179.889	-3.82	2.02	1.55	0.031	-15.860	-4.286	channel bottom u/s log 1 rootwad end
69	channel bo	23.64	187	15	15	187.254	-4.11	1.95	1.55	-2.985	-23.451	-4.510	channel bottom log #5
70	channel bo	24.61	190	22	10	190.369	-4.06	1.95	1.55	-4.430	-24.208	-4.460	channel bottom log 2
71	channel bo	24.47	194	1	10	194.019	-4.09	1.95	1.55	-5.928	-23.741	-4.490	channel bottom log 2
72	channel bo	26.85	193	42	45	193.713	-4.13	1.95	1.55	-6.365	-26.085	-4.530	channel bottom log 2
73	N end log #	26.48	197	46	35	197.776	-4.1	1.95	1.55	-8.084	-25.216	-4.500	N end log #5
74		26.31	190	3	15	190.054	-4.23	1.93	1.55	-4.593	-25.906	-4.611	
75	SW edge o	32.96	135	27	15	135.454	2.26	1.93	1.55	23.121	-23.490	1.884	SW edge of pavement
76	S centerlin	35.05	130	44	10	130.736	2.37	1.93	1.55	26.558	-22.873	1.994	S centerline of road
77	N centrelin	26.61	50	34	35	50.576	3.14	1.92	1.55	20.555	16.899	2.768	N centreline of road
78	W edge of	23.62	46	16	10	46.269	3.03	1.92	1.55	17.068	16.328	2.658	W edge of pavement
80	Backshot fr	29.8	37	8	35	37.143	2.57	1.6	1.36	0.036	0.047	-0.016	Backshot from BM 54 to BM 55
81	C/L from lo	11.65	99	24	15	99.404	-1.98	1.6	1.36	-6.464	-25.611	-4.566	C/L from log #5
82	C/L	8.67	116	8	15	116.138	-2.19	1.6	1.36	-10.174	-27.526	-4.776	C/L
83	C/L at u/s e	6.21	135	57	0	135.950	-2.48	1.6	1.36	-13.639	-28.170	-5.066	C/L at u/s edge of stump
84	C/L of S dis	9.96	151	4	45	151.079	-2.54	1.6	1.36	-13.140	-32.425	-5.126	C/L of S distributary
85	C/L of S dis	13.45	174	0	30	174.008	-2.64	1.6	1.36	-16.553	-37.084	-5.226	C/L of S distributary
86	C/L of S dis	17.56	193	5	45	193.096	-2.81	1.6	1.36	-21.936	-40.810	-5.396	C/L of S distributary
87	C/L conflue	20.1	202	25	15	202.421	-2.99	1.6	1.36	-25.623	-42.288	-5.576	C/L confluence
88	confluence	26.73	200	37	45	200.629	-3.33	1.6	1.36	-27.374	-48.723	-5.916	confluence w/ Kitwanga R
89	C/L of N dis	19.5	205	19	20	205.322	-3.1	1.6	1.36	-26.297	-41.333	-5.686	C/L of N distributary @ confluence of S dist.
90	C/L of N dis	10.97	215	31	25	215.524	-2.7	1.6	1.36	-24.331	-32.635	-5.286	C/L of N distrubutary
91	C/L of N dis	6.95	219	49	5	219.818	-2.5	1.6	1.36	-22.407	-29.045	-5.086	C/L of N distrubutary
92	C/L of N dis	3.4	171	39	40	171.661	-2.3	1.6	1.36	-17.464	-27.071	-4.886	C/L of N distrubutary
93	u/s end of c	4.98	155	17	20	155.289	-2.29	1.6	1.36	-15.875	-28.231	-4.876	u/s end of dug channel C/L
94	u/s end of c	15.99	192	49	0	192.817	-2.75	1.6	1.36	-21.504	-39.299	-5.336	u/s end of dug channel C/L
95	bole of S lo	15.55	221	34	55	221.582	-1.88	1.6	1.36	-28.277	-35.339	-4.466	bole of S log-tree #7
96	DC most w	11.2	227	37	20	227.622	-1.42	1.6	1.36	-26.231	-31.256	-4.006	DC most westerly # 1

97	bole of N lc	7.69	209	21	50	209.364	-1.91	1.6	1.36	-21.728	-30.409	-4.496	bole of N log-tree #6		
98	DC # 2	8.02	223	11	45	223.196	-1.7	1.6	1.36	-23.447	-29.554	-4.286	DC # 2		
99	DC # 3	6.26	223	0	20	223.006	-1.67	1.6	1.36	-22.227	-28.285	-4.256	DC # 3		
100	DC # 4	3.24	213	11	55	213.199	-1.43	1.6	1.36	-19.731	-26.418	-4.016	DC # 4		
101	rootwad en	3.1	145	49	20	145.822	-1.53	1.6	1.36	-16.216	-26.272	-4.116	rootwad end of N log-tree #6		
102	rootwad en	3.77	148	31	35	148.526	-1.56	1.6	1.36	-15.989	-26.922	-4.146	rootwad end of S log-tree #7		
103	S Bank	10.33	120	28	45	120.479	-1.94	1.6	1.36	-9.054	-28.947	-4.526	S Bank		
104	S Bank	8.68	136	40	25	136.674	-2.33	1.6	1.36	-12.001	-30.021	-4.916	S Bank		
105	S Bank	11.72	157	49	0	157.817	-2.55	1.6	1.36	-13.532	-34.559	-5.136	S Bank		
106	S Bank	15.9	182	45	0	182.750	-2.63	1.6	1.36	-18.720	-39.589	-5.216	S Bank		
107	S bank poi	20.9	201	21	45	201.363	-2.95	1.6	1.36	-25.570	-43.171	-5.536	S bank point		
108	N Bank poi	25.37	203	43	5	203.718	-3.09	1.6	1.36	-28.162	-46.934	-5.676	N Bank point		
109	N Bank by	9.16	222	57	50	222.964	-2.54	1.6	1.36	-24.200	-30.410	-5.126	N Bank by DC #2		
110	N Bank by	3.32	203	42	20	203.706	-2.31	1.6	1.36	-19.292	-26.747	-4.896	N Bank by DC #3		
111	N Bank ups	4.74	119	12	30	119.208	-2.13	1.6	1.36	-13.820	-26.020	-4.716	N Bank upstream of rootwads		
112	channel sh	5.23	134	15	40	134.261	-2.33	1.6	1.36	-14.211	-27.357	-4.916	channel shape out from rootwads		
113	S edge of c	5.65	151	6	30	151.108	-2.2	1.6	1.36	-15.227	-28.654	-4.786	S edge of dug channel E		
114	S edge of D	13.59	188	17	55	188.299	-2.56	1.6	1.36	-19.918	-37.155	-5.146	S edge of DC W		
115	N edge of D	13.24	193	6	25	193.107	-2.56	1.6	1.36	-20.959	-36.602	-5.146	N edge of DC W		
116	N edge of D	4.15	157	3	40	157.061	-2.2	1.6	1.36	-16.340	-27.529	-4.786	N edge of DC E		
117	Photo Poin	10.32	240	42	45	240.713	-2.08	1.6	1.36	-26.958	-28.755	-4.666	Photo Point 3		

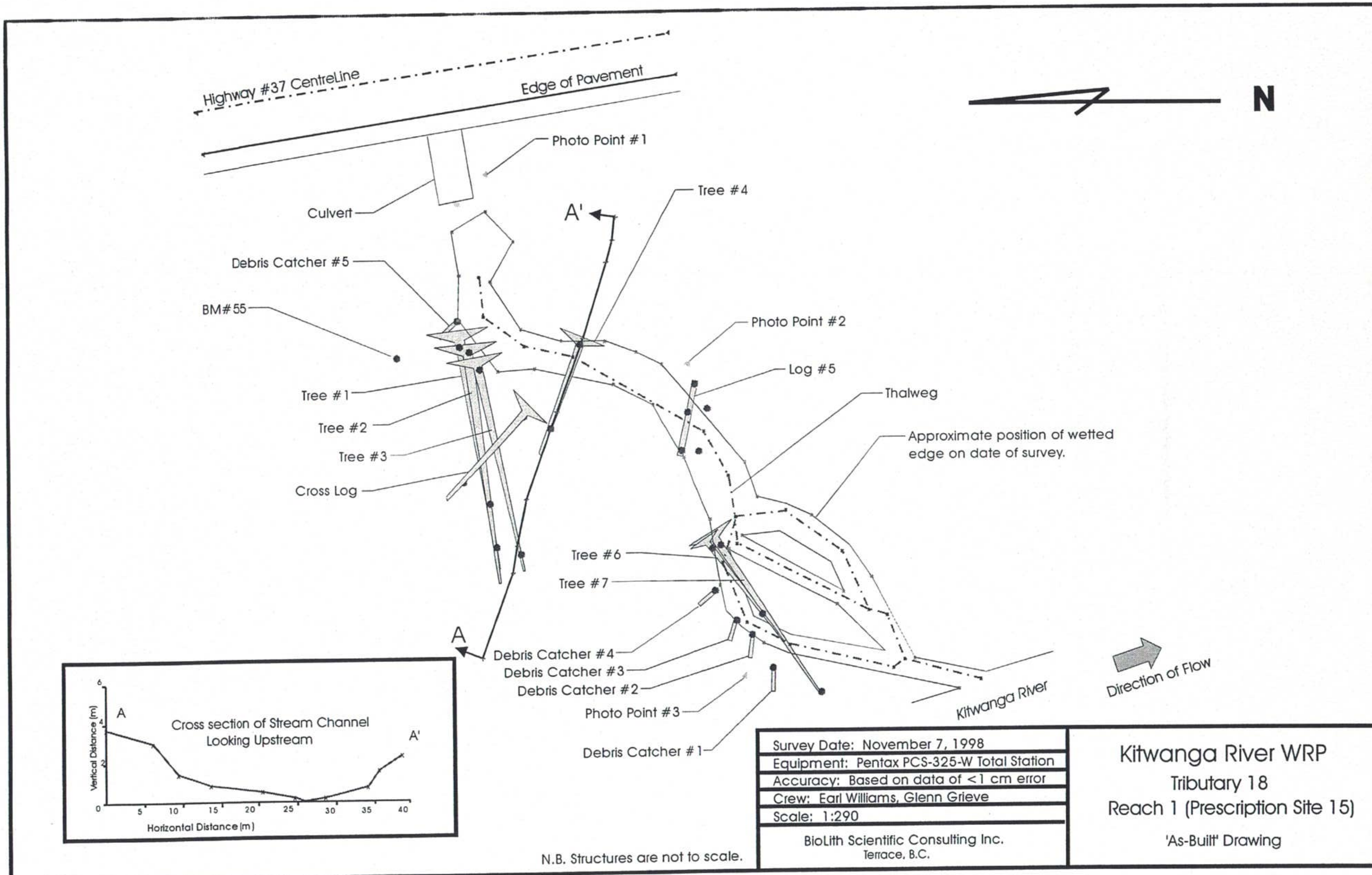


Figure 3. As-Built drawing of construction at Site 15 on Tributary 18 of the Kitwanga River South Sub-Basin.

Appendix D. Fillier and Lough Letter.

BRITISH COLUMBIA

March 8, 1999

BCE File: 36780-30/Kitseguecla WRP
36780-30/Kitwanga WRP
Your File: Annual Agmt. 0000128
Activity 101462
Activity 12395

Bill Fell, Cedarvale Resources Ltd.
WRP Coordinator
Gitseguecla Band Council
36 Cascade Avenue
South Hazelton, BC V0J 2R0

Dear Bill Fell:

As stated in the letter dated 02/16/99, a technical review of instream rehabilitation work in the Kitwanga and Kitseguecla Watershed Restoration Program (WRP) projects were pending draft report submissions (not received to date). We are providing these preliminary comments in lieu of the draft report submissions. The purpose of this letter is to facilitate an estimate of percentage of work completed in the Kitseguecla and Kitwanga watersheds stream rehabilitation (SR) activities for 1998/99.

Site visits to the Kitseguecla and Kitwanga stream rehabilitation activity areas were conducted on November 12, 1998. In attendance for these field visits were both Jeff Lough and Darren Fillier. We delayed our comments until draft document changes for prescription alteration approval requests, "As-Builts" with supporting documentation, and Compendium Report submissions were submitted for our review.

Both Kitseguecla and Kitwanga Standard Agreements for WRP SR activity, and respective Schedule "A"s, outlined a pertinent course of action in dealing with substantive prescription changes. Specifically, Section 4.1 of the Aquatic Habitat Rehabilitation (Works) Schedule "A" delineates that changes to the prescription, stemming from a pre-work review, were to be incorporated, in writing, into the design and then submitted to the Technical Monitor for approval. This clearly did not occur.

Ministry of Environment, Lands and Parks

Environment and Lands
Skeena Region

Mail Address: Kispiox Forest District, Bag 5000, Smithers, BC V0J 2N0

Location Address: 2210, Highway 62 W, Hazelton, BC

Telephone: (250) 842-7615
Facsimile: (250) 842-7676

<u>Activity Number 12395 - SR - Restoration Prescription Implementation for Prescription Sites 14 and 15 Kitwanga River South Sub-Basin</u>

Site 14 - Our first concern with this project is in regard to the pull back of the banks. This activity was not initially prescribed nor approved for work at the site. The pull back that was undertaken is of concern given its proximity to the highway and, specifically, within the road right of way. Was the Ministry of Highways consulted regarding this change?

Prescription implementation was to be as per the BioLith's 1997-98 report as delineated within the Water Act Regulations Section 9 Letter of Notification. Such prescription alteration and associated pull back to the suggested angle of repose must have been submitted for consideration by the Technical Monitor, or designate, prior to any work commencing at this site. Adherence with Section 4.1 of the Schedule "A" for Site 14 is paramount. Deviation from the prescription must follow the process as outlined within the Standard Agreement and the respective Schedule(s). Regardless of holding a Letter of Notification for specific in stream "timing windows" for work to be undertaken, the prescription alteration must be submitted for review and incorporation into a revised Letter of Notification. Clearly work should not have commenced without fulfilling all these requirements and, as such, violates Section 4.2 of the Schedule "A" and that is unacceptable to the Ministry.

Construction of the step pool system at Site 14 does not appear to be adequate to meet the goal of better facilitating fish access through the culvert. We are also concerned about the size and orientation of the materials used to construct the weirs (their long term stability is questionable). Close monitoring of this site at various flow levels, and associated modifications, will be required to fulfil the goal of creating long term fish access through the culvert.

Finally, the loss of the riparian low shrub and herb cover at Site 14 associated with the work undertaken last fall has increased surface erosion and will continue to deliver sediment into the Kitwanga River until inevitable revegitation takes place. On that note, the grass seeding that was planted seemed sporadic. In addition this surface erosion will not be mitigated by the silt fence given that its' installation was done incorrectly. This will require correction if not already done so. Again monitoring of this aspect of the project will be conducted this Spring after snowmelt.

Given the problems outlined above, no quality certificate will be issued until the site is monitored and appropriate changes are completed this Spring.

Site 15 - The Recipient provided a good source of Large Woody Debris (LWD) by species and by size. Root wad presence was good but it would be advantageous, in future, to leave branches and tops attached to the LWD pieces to increase their stability. If the objective of using rope to tie the structures together was to increase their stability, then we suggest rock anchoring would help better achieve your objective.

Sincerely,

Darren J. Fillier, RPF, RPBio.
Forest Ecosystem Specialist
Kispiox Forest District

Jeff Lough
WRP Fisheries Specialist
Skeena Region, MELP

DJF& JL/djf & jl

attachments

cc: Doug Johnston, WRP Coordinator, Skeena Region, MELP
Dionys deLeeuw, Senior Habitat Protection Biologist, Skeena Region, MELP
Brian Fuhr, Habitat Protection Section Head, Skeena Region, MELP
Bob Purdon, Skeena-Bulkley Region, Forest Renewal BC
Bert Mast, Skeena-Bulkley Region, Forest Renewal BC
Eero Karanka, Habitat Biologist, Department of Fisheries and Oceans, Smithers, BC
Darlene Morgan, Gitsegukla Band Council

Appendix E. Harkleroad Letter.

Darren Fillier
Rec'd Nov. 12/98
D. Fillier

British Columbia Stream Restoration Project Review Report 1998

USFS Contact: Glenn R. Harkleroad, Fisheries Biologist

BC Contact: Jeff Lough, Fisheries Specialist

This report will be divided into two parts. The first part will be a review of the projects Jeff and I, as well as other Ministry personnel, reviewed while I was visiting in British Columbia the week of September 21 – 25, 1998. The second part of this report will be an overview of potential monitoring activities that could be used to evaluate instream restoration activities.

Photos of sites that were reviewed in the field have been forwarded to Jeff Lough.

Project Reviews

River System: Kitwonga Stream system: Tea Creek

Site review by: Jeff Lough, Darren Fillier, and Glenn Harkleroad

Project Background: This project consisted of 10 to 12 channel spanning weirs created by cement "lock-blocks" below a 1.5 meter culvert. The "lock-blocks" were placed to raise the level of the streambed with the intent of helping pass fish through the upstream highway culvert. The "lock-blocks" had been placed and re-enforced by rock riprap ranging in size from 15 to 60 cm. The "lock-block" weirs were placed approximately 4 to 5 meters apart and were placed perpendicular to the stream channel. The local highway authority had completed this work.

Stream Conditions: The stream passed through a 1.5 meter culvert below highway 16. The structures began immediately below the culvert and continued down stream approximately 30 meter. The stream was bordered on the right by a small access road. When this road was constructed the road cut/base material had been sidecast into the floodprone and bankfull stream channel. Most of the immediate stream side vegetation in the local area had been removed during highway and access road construction. Some vegetative recovery had occurred.

Restoration Design Concerns: While reviewing this site a number of project design concerns surfaced. These concerns included the following:

1) "Lock-block" weirs appeared to be placed too close together. The plunge created by the upstream weirs may have a scouring effect on weirs immediately downstream resulting in design failure.
2) The perpendicular placement of the weirs may result in channel widening, thereby increasing the localized channel width to depth ratio. This may eventually result in bank erosion and "end cutting" around the weir structures.

One other item that was discussed at this site was the alteration of road design to reduce channel diversion potential associated with culvert plugging. As the road is currently designed, if the culvert plugs, water will be diverted out the left side of the channel, down the road and will eventually cross the road approximately 25 meters from the stream channel (Figure 1). This would result in the loss of road fill and the potential to deliver road fill associated sediment to Tea Creek. Altering the road grade in the vicinity of the culvert could mitigate this concern. The creation of a dip above the culvert, would allow water and debris to pass over the road and directly back onto Tea Creek in the event the culvert became plugged. This would minimize potential sediment delivery to Tea Creek as well as reduce road repair cost since only the fill immediately above the culvert would have the potential to be lost. If this fill was made of primarily of large rock with a driving surface cap, fine sediment delivery and repair cost could be kept to a minimum.

River System: Kitwonga Stream system: un-named tributary #1 (Kitwanga Pres. site #15.)

Site review by: Jeff Lough, Darren Fillier, and Glenn Harkleroad

Project Background: This project site was an approximate 90 to 100 meter length of stream below a highway culvert that fed directly into the Kitwonga River. This area had been identified for large wood placement in order to improve juvenile salmonid rearing habitat. This relatively small project would also serve as a trial run project for a new contractor.

The proposed wood placement locations had been flagged and consisted primarily of placing single logs in more or less and alternating pattern down the length of the channel. The logs would be anchored to streamside trees with cable. Boulders and rootwads currently present within the stream would also be used to help stabilize the placed wood.

Project Comments: While in the field at this site we talked about a number of different design options. The first of these options was to consider experimenting with log anchoring techniques. The option of cable anchoring some logs, while just using channel features and streamside trees to stabilize other logs was discussed. If this is done during the project implementation, this project could serve as an area to compare the effectiveness of both techniques.

We also discussed specific project designs for the lower 20 to 25 meters of the stream channel. Figure 2 displays the project design that was discussed for this location in the field. The idea was to direct the water toward the right side of the channel with the idea of reducing the bank cutting / mass wasting which was occurring along the left bank. There would be some bank cutting expected along the right bank, but it would be expected to be fairly minor and well within the range of natural channel adjustment. The placement of a log complex along the left bank was recommended to further discourage cutting along this bank. The use of log complexes, instead of just single logs, was suggested to more closely mimic natural wood accumulation within the channel.

Recommendations: While at this site, we also discussed some potential monitoring items. These included photo points, topographic surveys of the channel, and sketching desired post-project channel conditions. Since this project would be completed by a relatively inexperienced contractor, I would recommend having him take photo points and having him sketch what he envisions the post-project channel will look like.

River System: Kitwonga Stream system: un-named tributary #2 (Kitwanga Pres. Site #14)

Site review by: Jeff Lough, Darren Fillier, and Glenn Harkleroad

Project Background: This project was similar to the project proposed for un-named tributary #1 in that it was an approximate 30 to 35 meter length of stream below a highway culvert which fed directly into the Kitwonga River. This area had been identified for large wood placement in order to improve juvenile salmonid rearing habitat. This relatively small project would also serve as a trial run project for a new contractor. However the stream channel in this area was much higher gradient and lacked the channel diversity seen in the first tributary.

This project also involved trying to create a series of step pools for trying to raise the streambed, in order to pass fish through the highway culvert. Channel conditions and available habitat above the culvert were unknown.

Project Comments: The stream channel below the culvert was relatively steep and appeared to provide little fish habitat. Placing wood in this channel would be expected to have low chance of success for meeting the goal of increasing fish habitat. This is because the natural condition of this channel does not lend itself to providing good spawning or rearing habitat.

Passage at the culvert should be delayed until fish habitat values above the culvert are determined. Without this information, it is possible that time and money could be spent providing fish access to an area with very little habitat value.

Recommendations: I would recommend determining if there are other higher priority areas where work could be done. Initial field review of this project would suggest that it would be low priority.

River System: Kispiox Stream system: un-named tributary #1 (Dale ck).

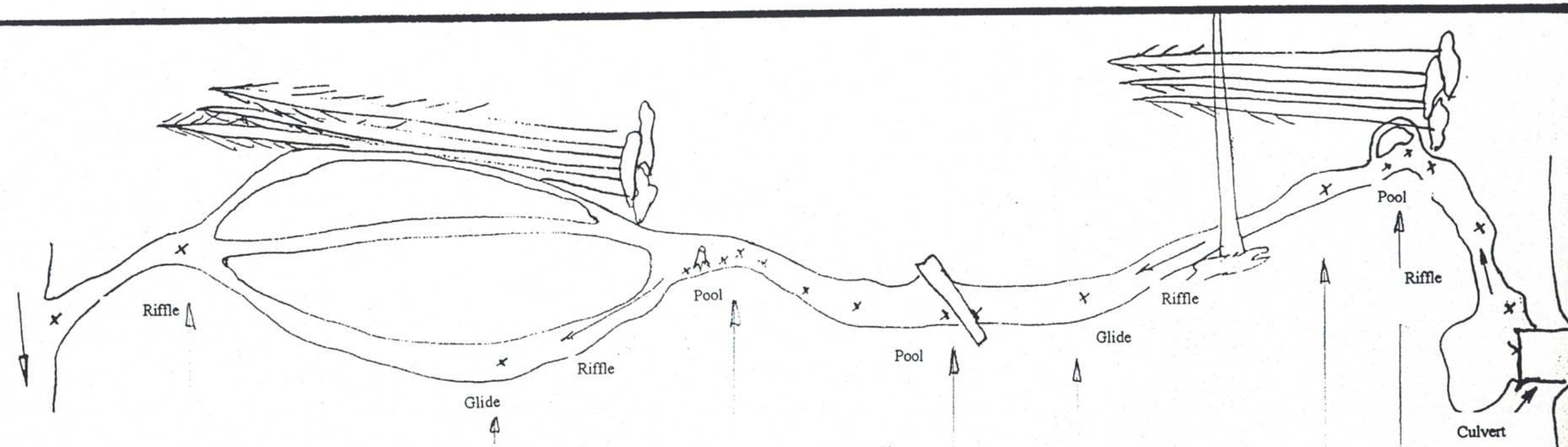
Site review by: Jeff Lough, Darren Fillier, and Glenn Harkleroad

Project Background: This project consisted of two rows of "lock blocks" which were placed in a small tributary of the Kispiox River with the intent of raising the streambed level below two culverts. This was done in order to help facilitate fish passage through the culverts. We were reviewing this project because the design used was not authorized by Ministry fisheries personnel and was going to be changed.

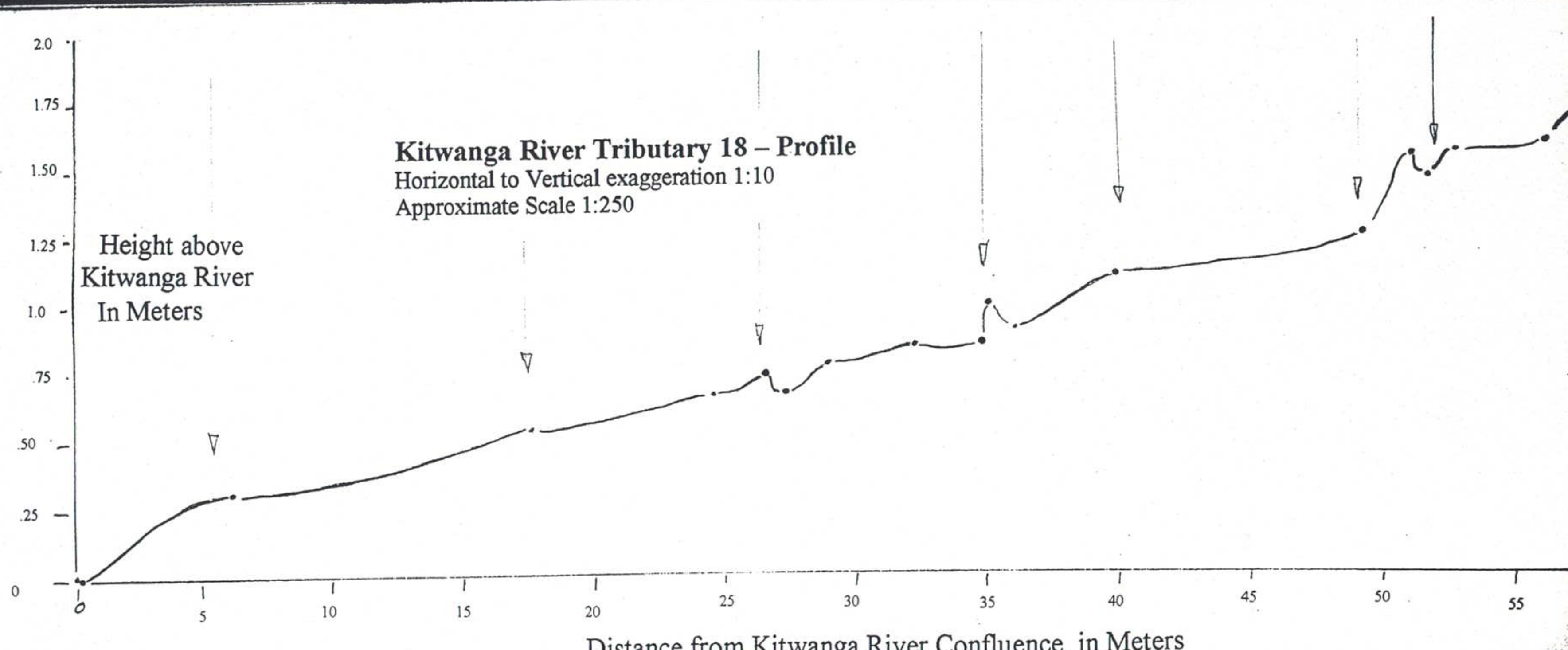
The "lock block" weirs were placed approximately 6 to 7 meters apart and were arranged perpendicular to the stream flow. There were concerns that this design would increase the stream channel width to depth ratio and result in end cutting around the weirs. Excessive fine sediment deposition had already begun above the upper weir. This was resulting in the filling of the jump pool necessary for fish passage through the culverts. There was also a concern that the weirs were too placed close together and that the scour created by the upper weir would undermine the lower one.

While reviewing the project we also discovered that the inlets of both culverts were blocked by a log that had backed up sediment. making fish passage difficult during most flows..

Appendix F. Centreline Survey, March, 1999.



Kitwanga River Tributary 18, Site 15 - Plan View
Scale approximate 1:250
Drawn by B. Fell



Kitwanga River Tributary 18 – Profile
Horizontal to Vertical exaggeration 1:10
Approximate Scale 1:250

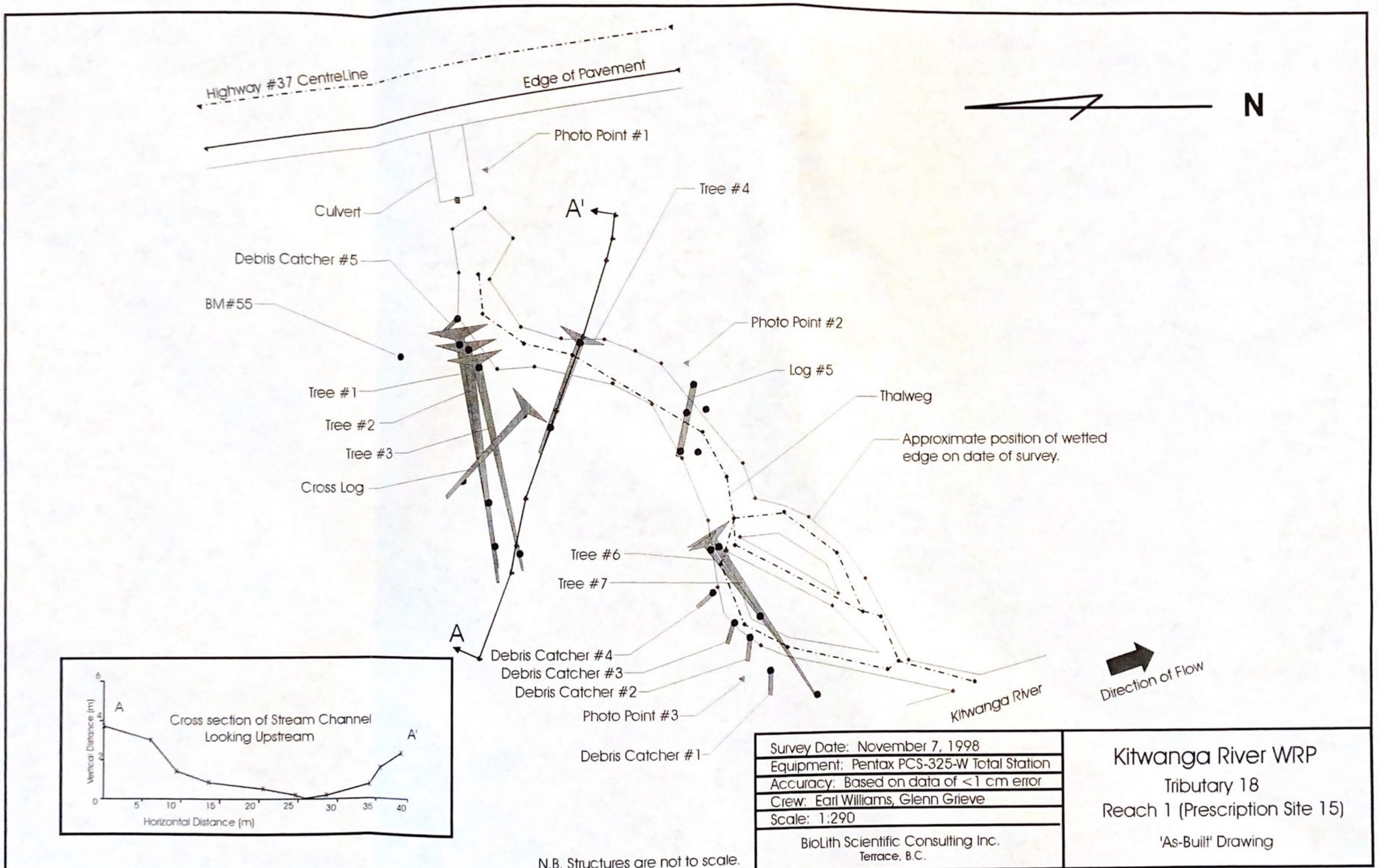


Figure 3. As-Built drawing of construction at Site 15 on Tributary 18 of the Kitwanga River South Sub-Basin.

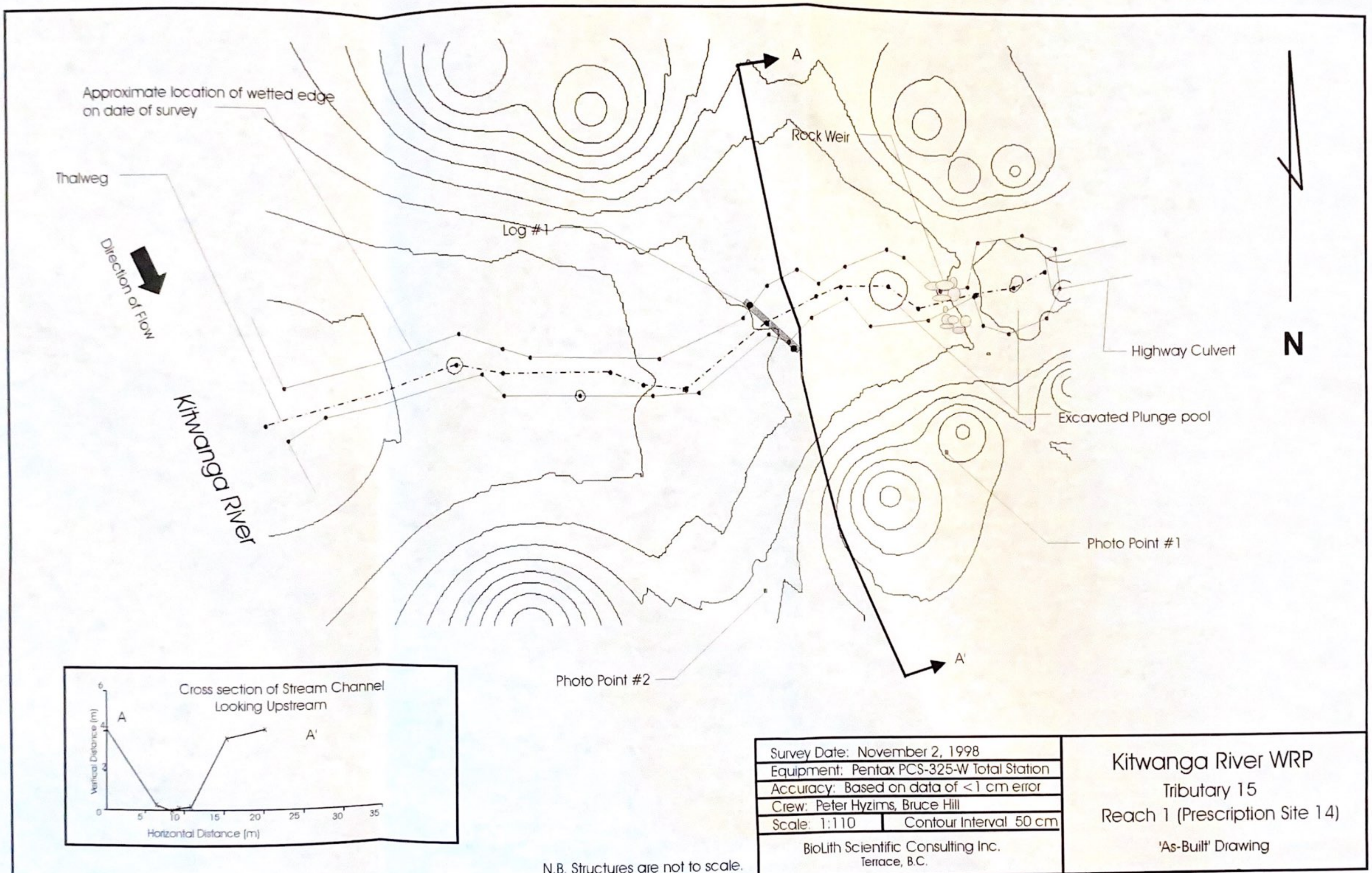


Figure 3. As-Built drawing of the construction at Site 14 on Tributary 15 in the Kitwanga River South Sub-Basin.