Irene Weiland, P.Geo

Consultant in Terrain Sciences

Box 4222
Smithers, B.C. V0J 2N0
phone: (250) 847-3351
fax: (250) 847 2854
email: iweiland@mail.bulkley.net

Alan Harrison
Watershed Restoration Technician
B.C. Ministry of Forests, Kispiox Forest District
Bag 5000
Smithers, B.C. V0J 2N0

October 30, 1998

Re: KM 34 Stream Crossing, Suskwa FSR

Dear Alan,

enclosed please find the geomorphic assessment for the km 34 stream crossing site. Please note that this is an assessment exploring the possibility and approximate cost to re-establish fish passage at the stream crossing. Additional work will be required to prepare a design. However, I believe the assessment is sufficiently detailed to serve as a basis for a design for channel restoration.

Although it appears that the culvert is oversized for the stream, alterations to the culvert (installations of baffles) require input from a professional engineer. After talking to you last week, I talked to Don John in the Engineering Section, MoF Region and I got the impression that he was interested to provide the expertise regarding the culvert.

I am submitting a separate copy to Mike Jacobs, Suskwa Restoration Society.

I believe the assessment meets your requirements at the present time. Please contact me if you wish to discuss any aspect of the assessment or the recommendations.

Regards,

Irene Weiland

Irene Weiland, P.Geo

enclosure

34 KM, SUSKWA MAIN FSR

STREAM RESTORATION, CULVERT OUTLET

HYDROLOGIC AND GEOMORPHIC ASSESSMENT

(W.C. 46 - 700 - 30-130)

Prepared for: Suskwa Restoration Society,
Hazelton, B.C.
and Watershed Restoration Program, Kispiox District,
B.C. Ministry of Forests,
Hazelton, B.C.

Prepared by: Irene Weiland, P.Geo
Weiland Terrain Sciences
Box 4222,
Smithers, BC V0J 2N0

October 30, 1998

Table of Contents

1.0 Introduction

At km 34, the Suskwa Forest Service Road crosses a 5 to 6 m wide fish-bearing stream. In 1988, a bridge was replaced with a multi-plate pipe arch culvert 3890 x 2690 mm. In WRP reports for 1996 and 1997, prepared by Mike Jacobs and the Suskwa Restoration Society, the culvert on this unnamed tributary to Natlan Creek was identified as a barrier to fish migration. Downcutting at the culvert outlet has left the pipe 1.5 m perched above the present stream bed, with a 0.8 m deep pool. A fish habitat assessment conducted over the summer 1998 by Mike Jacobs identified approximately 2500 m of fish habitat above the culvert. The Watershed Restoration Program, Kispiox Forest District, and the Suskwa Restoration Society are interested in re-establishing fish access to the habitat upstream of the road.

1.1. Objectives

- Assess basin morphology and stream channel morphology to evaluate bedload mobility and channel activity upstream of the crossing site and impacts to the crossing site.
- Explore options for stream rehabilitation and re-establishment of fish passage through the culvert to open up access to 2.5 km of fish habitat upstream of the culvert.

2. Methods

The assessment was based on air photo interpretation and two site visits on May 17 and June 16, 1998. During the site visit in June, a reconnaissance site survey was conducted. Cross sections were measured at three sites within 50 m upstream of the crossing. Discharge estimates were derived from (1) basin comparison with gauged Station Creek and (2) measurement of cross sectional area upstream of the culvert. Flow velocity was measured using the floating object method over a distance of 10 m. Manning's roughness coefficient n for the shallow depths observed during the survey on June 16, 1998 was calculated by resolving Manning's equation for n. Manning's n for bankfull depths (Q_2) was determined using the composite n-approach (BC Ministry of Forests, 1997).

3.0 Observations

3.1. Drainage Basin Morphology

The 34 km Creek drains a catchment area of 9.4 km^2. Headwaters are non-glaciated and consist of long, mostly uniform, steeply sloping colluvial slopes and sharply defined rock ridges. Snow avalanche tracks are frequent with active debris flow tracks in the avalanche starting and transport zones. Snow avalanches commonly hit the narrow valley floor, but debris flows run-out on mid slope elevations, before debris reaches the valley bottom stream. Near the headwaters, the valley floor consists of partially vegetated, moderately sloping avalanche cones, which have been partially re-worked by stream activity.

The mid-valley section is formed by uniform, steep and long, forested slopes consisting of shallow colluvium overlying bedrock. Snow avalanche tracks running from ridge top to valley bottom are frequent; starting zones are gullied with shallow colluvium failing over bedrock on gully side walls. Debris from the shallow slope failures is transported to the downslope end of the gullies, where it is deposited. Steep, vegetated colluvial cones form the lower part of the valley walls. No valley flat exists. Localized disturbance and widening in the valley bottom stream near the toe of the avalanche tracks was interpreted to be a result of temporary channel damming by snow and avalanche debris during snow melt in late spring.

In the lower section of the valley, within 2000 m upstream of the road, a very narrow alluvial valley flat has developed between steep, uniform valley walls; snow avalanches starting on gullied, somewhat unstable upper slopes on the eastern valley walls run out on moderately sloping, vegetated, colluvial cones which border the stream channel and the alluvial valley flat. Channel gradient in this section ranges from 7 to 12 %. This section is part of the fish habitat identified by Mike Jacobs. Some disturbance of the stream side vegetation pattern (alder and other deciduous trees instead of conifers) is evident on the air photographs, indicating periodic (20 to 50 year) stream bank disturbance during high flows.

Where the tributary valley walls open up into the Natlan Valley, the stream gradient steepens to 10 to 19 % over a length of approximately 500 m upstream of the road. The channel is mostly confined by hummocky terrain and benches (mostly glacial till, some colluvium and glaciofluvial material) along the lower valley walls of Natlan Creek valley. Some scattered, inactive and revegetated landslide scars were identified along the morainal scarp slopes. A few short and narrow alluvial terraces exist along the channel. The stream channel has a step-pool morphology; large woody debris in small log jams is frequent and plays an important role in bedload storage and formation of gradient steps. Fish habitat throughout this section is described by Mike Jacobs, Suskwa Restoration Society.

Below the road, the stream flows over a gently sloping terrace surface parallel to Natlan Creek. The confluence with Natlan Creek is 150 m below the road.

Bedload input into the stream occurs in the alpine headwaters at a moderate rate and at the toe of snow avalanche tracks at a slow rate. Bedload movement through the system occurs at a moderate rate and in equilibrium with established channel cross sections and channel curvature. Channel banks have dense vegetation with a high percentage of mature conifers providing continuous recruitment of large woody debris as structural elements in the stream bed to aid in bedload storage. It is expected that bedload transport to the crossing site continues at the present rate. At the present rate, it is not expected that bedload movement will have a negative effect on the proposed channel restoration at the culvert outlet.

Table 1: Geomorphic basin characteristics

	Station Creek above Diversion WSC 08EE028	34 KM Creek
General location	North end of Rocher Deboule Range	North Babine Mountains
Size (km^2)	10.8	9.4
Size of alpine area (km^2)	5.75	4.9
Glacier?	small glacier	none
Elevation range (m ASL)	500 to 2300	970 to 1900
Valley length (km)	6.8	5.9
Average slope (%)	26 %	16 %
Aspect	North	North, West, East

3.2. Stream Crossing Site

Channel width upstream of the crossing site is 5 to 6 m. Gradients are 8 to 12 % above the road right-of-way, 5 % in the right-of way clearing and 3 to 10 % in the forest below (reconnaissance site plan, Appendix 3). Mean bed material size (d_{50}) measured within 50 m upstream of the culvert in the undisturbed channel bed was 23 cm.

In the 3,890 x 2,690 mm multi plate arch culvert, the natural channel width is reduced to less than 4 m. Flow is accelerated, causing erosion and scour at the outlet of the culvert. Presently, the culvert outlet is .85 m perched above an 0.8 m deep scour pool. Continuing erosion at the outlet slowly enlarges the scour pool, and has caused 0.9 m wide undercutting under the culvert invert. Bedload is mobilized from the 1.5 m high channel banks just below the culvert and is deposited in the gentler channel section in the forest downstream. Two logs were placed perpendicular to the stream flow, 4.5 m downstream of the culvert, spanning the entire channel width. The logs may have been partly embedded in a 5 % channel bed when the culvert outlet was built in 1988. They are now undermined and have approximately 0.7 m clearance above the channel bottom. The down-cut channel section extends over a length of 16 m below the culvert. Downstream of that point, the pre-construction channel banks remain intact. Bank height is 30 to 70 cm.

The culvert has a gradient of 5 %, over a length of 21.5 m. It is placed level with the stream bed at the inlet. No sediment or woody debris was deposited in the culvert; however, during the second site visit in June, a 66 x 39 x 29 cm boulder was found inside the culvert near the outlet. This boulder was not there during the site visit in May. This observation is evidence that large size bedload moved through the culvert, possibly during a flood event on May 26, 1998, which affected other streams in the Suskwa Watershed.

3.3 Flow

Bankfull discharge and Q_{100} were estimated to be 4.8 m^3/s and 14.4 m^3/s respectively (Appendix 1). This may be a somewhat high estimate compared to results from basin comparison with Station Creek and from calculations using "critical flow velocity" formula. (Appendix 1). A large run-off event on May 26, 1998 caused channel widening and bedload mobilization on the Suskwa River main stem and the Harold Price Creek. The event appears to have had little impact on the 34 km Creek, but may have led to some channel widening resulting in a cross-sectional area slightly larger than the bankfull discharge requires.

3.4 Fish Passage

The culvert presently blocks fish passage because (1) the jump at the outlet is too high (+/- 0.9 m) and because (2) flow velocity in the culvert is too fast. A recommended height for vertical jumps is 0.15 m for trout and 0.3 m for adult salmon (p. 19, Stream Crossing Guidebook for Fish Streams, BC Ministry of Forests, 1997). Flow velocity measured in the culvert on June 16, 98 was 1.54 m/s during the relatively low discharge of 0.82 m^3/s. Adult Dolly Varden and Bulltrout require flow velocities less than 0.9 m/s to swim upstream through a culvert for a distance of greater than 18 m (p. 18, Stream Crossing Guidebook for Fish Streams).

4.0 Options and Recommendations

In order to restore access to the fish habitat upstream of the culvert, flow velocity in the culvert has to be reduced to 0.9 m/s during fish migration seasons and the jump at the culvert outlet has to be eliminated or reduced to less than 0.3 m.

Reduction of flow velocity through the culvert could be attempted by installing baffles, possibly combined with coarse granular sediment fill between baffles. Sediment may become trapped between baffles naturally. Reduced flow velocities in the culvert will allow fish passage at certain flow levels and will reduce the erosive forces at the culvert outlet. Engineering expertise will be required to evaluate the effectiveness of various baffle types at fish passage flow levels and the reduction in flow velocity that can be achieved. While the culvert appears oversized for the stream, the hydraulic capacity of the altered culvert area with respect to Q_{100} must also be assessed by a Professional Engineer. Pre-fabricated baffles can be ordered from Armtec (pers. communication, Al Harrison). Engineering Section, Prince Rupert Forest Region, may be available to provide engineering expertise (telephone conversation, Don John, 30/10/1998).

Creating a tailwater effect in the culvert by raising the weir at the culvert outlet is not recommended. Natural, pre-construction channel banks starting 16 - 20 m downstream of the culvert, near the edge of the right-of-way clearing, are low (0.3 to 0.7 m). The start of the low banks sets the limit for the downstream extent of the raised channel bed. The height of the weir required to create a tailwater effect would bring the gradient of the 20 m long, built-up channel section to more than 9 %. This was considered undesirable because the higher flow velocity on the steeper gradient reduces fish passage and the higher erosive force reduces channel bed stability.

Two options are presented to build-up the access to the culvert outlet. These options should be discussed with a fish biologist and a professional engineer.

Option 1: Build-up the channel bed at a 7 % gradient over a distance of 20 m to reach the level of the baffles. Channel banks along the 20 m section are presently 0.7 m to 1.4 m high and the build-up channel bed can be contained within the existing banks with small adjustments to the bank height. The 7 % gradient mimics the natural gradient upstream of the culvert.

At 7 % gradient and with a cross-sectional area similar to the surveyed cross-sections upstream of the right-of way clearing, average bankfull flow velocity would be near 2 m/s (Appendix 2). During summer flows similar to the flow on June 16 1998, flow velocities would be near 0.8 m/s. The 7 % approach should be broken up into several smaller boulder weirs spaced approximately 3 m apart with shallow resting pools between weir crests, similar to natural boulder steps upstream (Reconnaissance Profile, Appendix 3).

The weirs should be built from coarse granular material, with angular particles larger than 60 cm diameter forming the weir crests. Calculation of required particle size will be part of the design. The base of the fill can be constructed with impervious, unsorted fill material containing clay and silt and more than 50 % large boulders or blocks. The two fill material types should be separated with geotextile. Volume of fill material required was estimated to be 115 m^3.

Option 2: Maintain a jump and resting pool at the culvert outlet with a jump height of no more than 0.3 m. Construct the channel bed downstream of the pool with a gradient of 9 %, broken up in several weirs/steps with shallow pools between weir crests. This culvert approach would join the existing channel bed 17 m downstream of the culvert. Flow velocity during bankfull discharge was estimated to be 2.3 m/s. During summer flows similar to the discharge on June 16, 1998, flow velocity would be 1 m/s. Placement and characteristics of fill material (90 m^3) would be the same as for Option 1.

4.1 Cost Estimate

The following is a rough cost estimate, put together for planning purposes and to assist in a cost-benefit comparison with other solutions, e.g. replacement of culvert with bridge, or rip-rap protection at culvert outlet only without re-establishing access to fish habitat.

Design:	
Detailed gradient survey	$ 600[1]
Fish biologist 2 days @ $400	$ 800
Culvert hydraulics and baffle installation	
Professional engineer, 3 days @ $ 800	$ 2400[1]
Build-up of culvert outlet:	
Professional geoscientist/engineer 2 days @ $500	$ 1000
Mileage and miscellaneous 400 km @ $ 0.35	$ 400
	$ 5200
Construction:	
Construction supervision 2.5 days @ $ 800	$ 2000
Survey assistant 2 day @ $ 250	$ 500
Excavator: 15 hrs @ $ 150	$ 2250
115 m^3 fill material, blasting and trucking (14 loads)	$ 4500
Geotextile	$ 700
7 baffles, purchase and installation @$ 800	$ 5600
Mileage and miscellaneous 600 km @$ 0.35	$ 500
	$16050
Total	**$21250**

1 May be available through co-operation with Engineering Section, MoF, Prince Rupert Region.

5.0 References

BC Ministry of Environment. 1997. Fish habitat rehabilitation procedures. Watershed Restoration Technical Circular No. 9. Watershed Restoration Program, B.C. Ministry of Environment. Lands and Parks and Ministry of Forests.

BC Ministry of Forests et al. 1997. Stream crossing guidebook for fish streams. Prepared by: V.A. Poulin, Vancouver, BC and H.W. Argent, Anmore, BC

Dane, B.G. 1978. Culvert Guidelines: Recommendations for the design and installation of culverts in British Columbia to avoid conflict with anadromous fish. Fisheries and Marine Service Technical Report No. 811. Land Use Unit, Habitat Protection Division, Resource Services Branch and Department of Fisheries and Environment, Pacific Region Fisheries and Marine Service, Vancouver, BC

Environment Canada, 1990. Water Survey of Canada

Aerial Photographs:

BCB93070 # 34, 35	scale 1:16,000, B+W
BCB93072 # 155, 156	

Maps:

93M/6	scale 1:50,000, NTS
93M.035, 93M.045	scale 1:20,000 BCGS

Appendix 1: Flow Calculations

Table A1.1 Cross sectional area method

	Cross-section 3	**Cross-section 2**	**Cross-section 1**
Distance above culvert	15 m	25 m	40 m
Survey date	16/06/98	16/06/98	16/06/98
A_w	1.25 m2	1.06 m2	0.816 m2
$W_w \times D_w$	4.9m x 0.25m	4.6m x 0.23m	4.8 x 0.17m
V_w	(0.82 m/s)	0.82 m/s	(0.82 m/s)
Q_w	(1.025)	0.87 m3/s	(0.67 m3/s)
Slope	10.5 %	11.5 %	N/D
Manning's n_w[2]		0.137	
d50		0.23 m	
$W_2 \times D_2$	5.5 m x 0.45m	5.2 m x 0.51m	5.4 m x 0.45m
A_2	2.48 m2	2.65 m2	2.43 m2
n_2[3]		0.093	
V_2		1.92 m/s	
Q_2	4.76 m3/s	5.09	4.67
Q_2 (mean)		**4.8 m^3/s**	
Q_{100} (3 x Q_2)		**14.4 m^3/s**	

Table A1.2 Basin comparison approach

	Station Creek above Diversion WSC 08EE028	34 KM Creek
Years of flow records (maximum daily discharge)	1985 to 1995	none
Q_{d2} (m^3/s) (2 year return discharge)	2.05	9.4 * 0.189 = 1.78
Q_{d2} unit discharge ($m^3/s/km^2$)	0.189	
Q_{i2} (estim. =2 x Q_{d2}) m^3/s extrapolated for instantaneous Q		**3.56 m^3/s**

Table A1.3 "Critical Flow Formula" Approach[4]

Bankfull discharge	$Q_{bf} = 2.5\ (A^3\ W_{bf}^{-1})^{.5} = 2.5\ (2.52^3\ 5.36^{-1})^{.5} =$ **4.3 m^3/s**
100 year flood	Q_{100} = 12.9 m3/s

2 Calculated from Manning's formula
3 Determined from composite n-approach (Stream Crossing Guidebook, 1997)
4 Presented by Dennis Russell, Professor emeritus, UBC, During FCSN course, spring 1998

Appendix 2.: Estimate of Velocities on the Built-up Culvert Approach

Option 1:

Q_2: 4.8 m^3/s
$A_2 = 2.5\ m^2$; W x D = 5.4 x 0.48; R = 0.4 S = 0.07; n = 0.07 (boulder substrate, no logs))
$V_{estim.} = 0.07^{-1} (0.4^{.67} \times 0.07^{.5}) = 2.0$ m/s

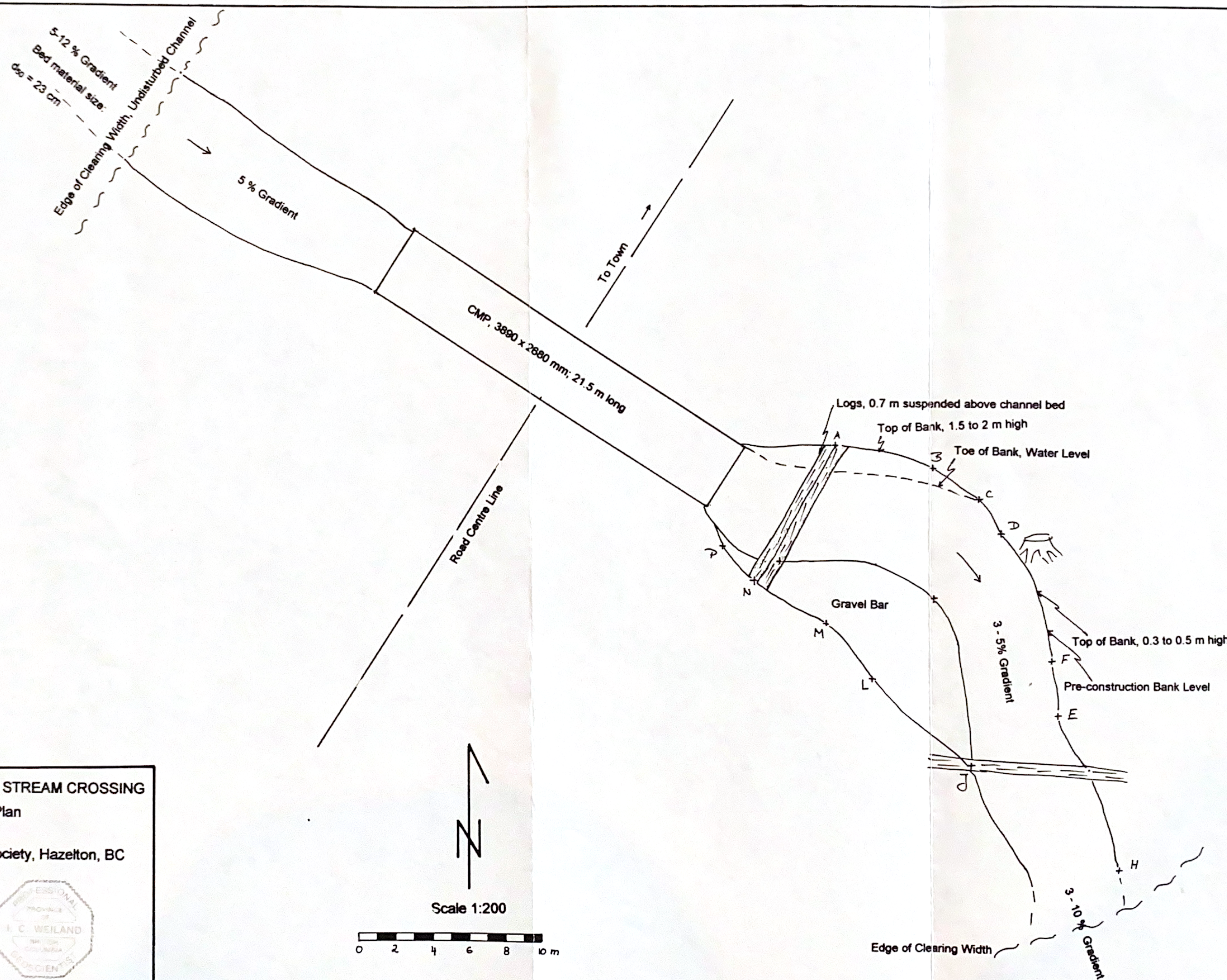
Q_{summer}: 0.87 m^3/s
$A = 1.08\ m^2$; W x D = 4.7 x 0.23; R = 0.21; S = 0.07; n = 0.11 (boulder substrate, no logs, shallow depth)
$V_{estim.} = 0.09^{-1} (0.21^{.67} \times 0.07^{0.5}) = 0.8$ m/s

Option 2:

Q_2 : 4.8 m3/s
$A_2 = 2.5\ m^2$; W x D = 5.4 x 0.48; R = 0.4 S = 0.09; n = 0.07 (boulder substrate, no logs))
$V_{estim.} = 0.07^{-1} (0.4^{.67} \times 0.09^{.5}) = 2.3$ m/s

Q_{summer}: 0.87 m^3/s
$A = 1.08\ m^2$; W x D = 4.7 x 0.23; R = 0.21; S = 0.09; n = 0.11 (boulder substrate, no logs, shallow depth)
$V_{estim.} = 0.09^{-1} (0.21^{.67} \times 0.09^{0.5}) = 0.95$ m/s

Appendix 3: Reconnaissance Site Plan and Profile



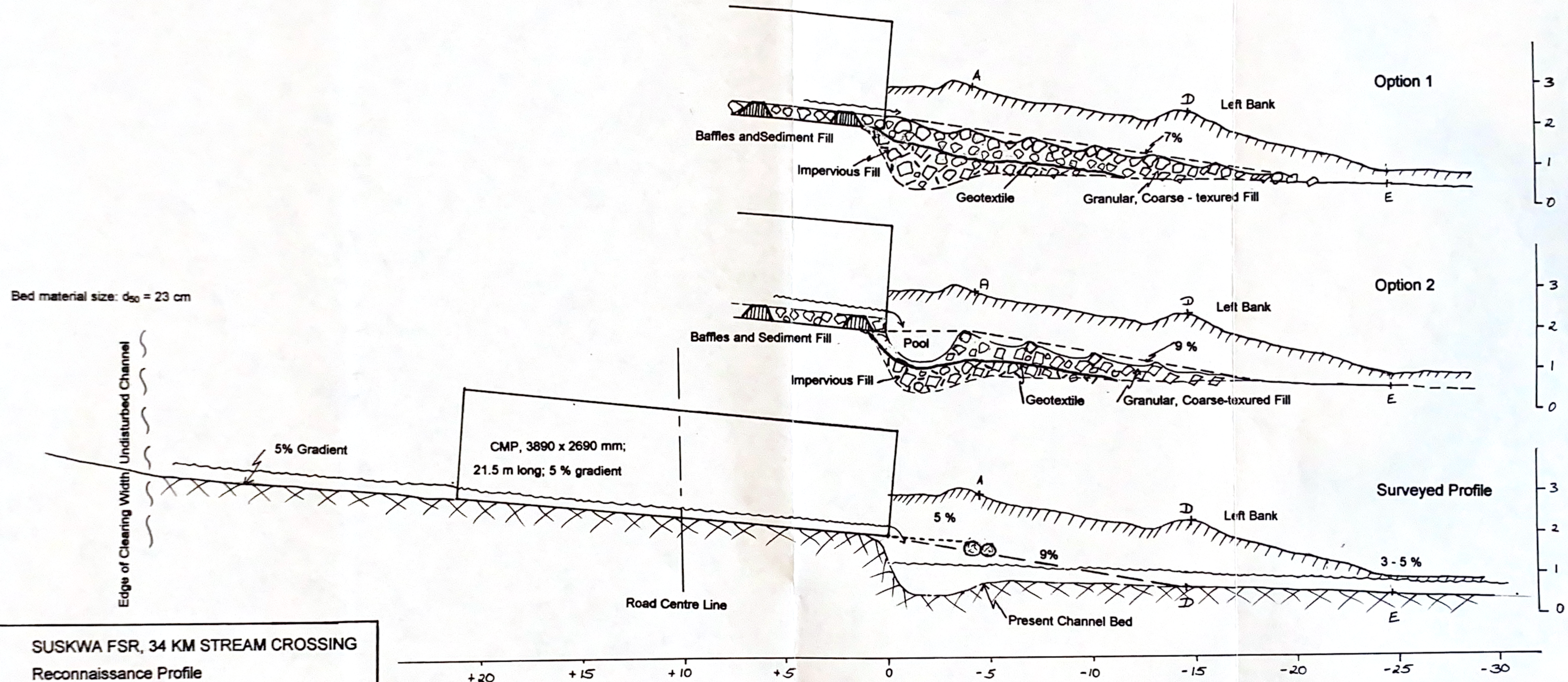
SUSKWA FSR, 34 KM STREAM CROSSING

Reconnaissance Site Plan

Prepared for:
Suskwa Restoration Society, Hazelton, BC

Prepared by:
Irene Weiland, P.Geo

October 1998



Horizontal Scale 1:200

Vertical Scale 1:100

Date of Recce Site Survey: 16/06/98

SUSKWA FSR, 34 KM STREAM CROSSING

Reconnaissance Profile

Prepared for:
Suskwa Restoration Society, Hazelton, BC

Prepared by:
Irene Weiland, P.Geo

October 1998

PROFESSIONAL PROVINCE OF BRITISH COLUMBIA I. C. WEILAND GEOSCIENTIST

Photo1: Boulder step, 15 m upstream of the culvert; looking upstream; 16/06/98

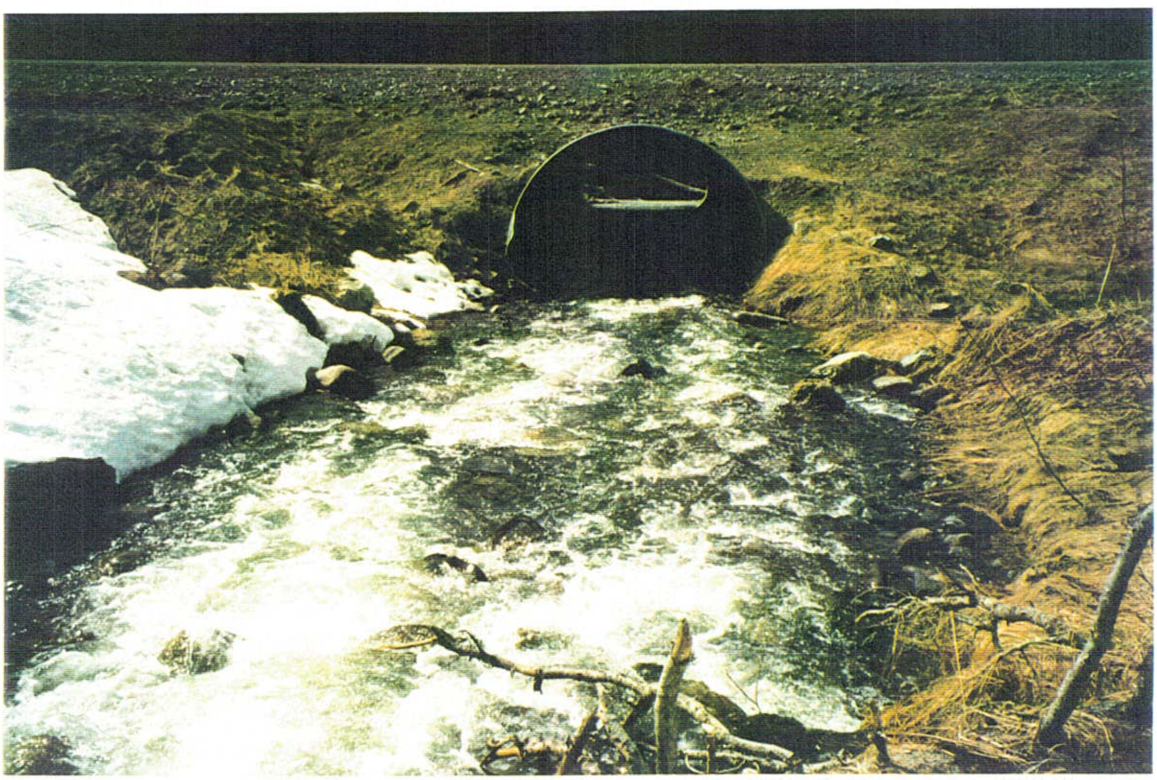


Photo 2: Culvert inlet; looking downstream; 17/05/98

Photo 3: Culvert outlet; looking upstream; 17/05/98

Photo 4: Transition from scoured channel bed with high left bank to low pre-construction left channel bank; looking downstream; 16/06/98