NIMPKISH WATERSHED RESTORATION PROJECT

2005 Level 2 Prescriptions For Yookwa Creek Fan

submitted to

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ABSTRACT

A partnership of Canadian Forest Products Limited (Canfor) and the 'Namgis First Nation (the Nimpkish Resource Management Board) are restoring stream habitat in the Nimpkish River watershed. This program began in 1996 as part of Canfor's Forest Renewal BC (FRBC) agreement and continues with funding provided by the Forest Investment Account (FIA). This report describes the stream and fish habitat restoration projects proposed for the summer of 2005 in the Nimpkish Watershed.

The project sites included in this report are located in Reach YK1 of Yookwa Creek. They include (by priority for completion):

- *Yookwa Creek - Site YK1DJ1 – Log Jam Rearrangement*: Partial removal of two log jams located in the right main channel of Yookwa Creek downstream of the 600m Channel (YK1DC1) to encourage high flow in this channel.

- *Yookwa Creek - Site YK1LWD1 – Bank Protection at 800m on Left Bank*: Lateral LWD structures constructed to prevent further erosion of banks and widening of channel.

- *Yookwa Creek - Site YK1LWD3 – Bank Protection at 1000m on Left Bank*: Lateral LWD structures constructed to prevent further erosion of banks and widening of channel.

- *Yookwa Creek - Site YK1BT1 – Bar Top Stabilisation Structures*: Ballasted LWD added to the bar tops to protect existing coarse sediment deposits and encourage further deposition.

- *Yookwa Creek - Site YK1RR1 – Riprap Spurs*: A series of riprap spurs constructed upstream of the Nimpkish mainline logging road to prevent Yookwa Creek from avulsing to the left.

Nimpkish River is a 6th order stream with a total drainage area of approximately 2250km^2. The watershed lies at the Northern end of Vancouver Island, British Columbia draining into Broughton Strait 10km South of Port McNeill. The watershed lies almost completely within Canfor's Tree Farm License (TFL) 37, Englewood Logging Division, and is part of the traditional territories of the 'Namgis First Nation. Yookwa Creek is a tributary to Sebalhall River that joins the river at the outlet of Vernon Lake. It is the main contributor of coarse sediment to the river. In turn Sebalhall River joins Nimpkish River at Nimpkish Island ecological reserve located 18 km upstream from the town of Woss.

Completion of the proposed works in this report is expected to occur in phases over the course of two or more years as budgets allow. The priority for works is as follows:

Priority	Work Site
1	YK1DJ1
2	YK1LWD1
3	YK1LWD3
4	YK1BT1
5	YK1RR1

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IMPORTANT

The present study has been conducted on the basis of available information, previous reports, and field inspections limited by the available time and budget. Numerical estimates provided herein represent attempts to satisfy the requirements of the study on the basis of available information and professional judgement, but in many cases they are subject to uncertainty.

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1 INTRODUCTION

This report presents prescriptions for stream restoration sites on Yookwa Creek in the Nimpkish River Watershed. The prescribed works are part of an overall restoration plan for the Yookwa Creek fan that encourages flow in multiple channels and storage of coarse sediment on the fan to limit downstream transport to the highly valuable Sebalhall River. They also stabilize eroding banks thereby limiting coarse sediment production from the fan itself. The resident and anadromous fish populations in Sebalhall River and Yookwa Creek have been negatively impacted by the increased supply of coarse sediment in Yookwa Creek, which has lead to dewatering of the Yookwa channel and infilling of holding pools downstream in Sebalhall River. The prescriptions are based on site reconnaissance, Overview and Level 1 Assessments, and field surveys.

This report is prepared in support of a Section 9 Approval for work in and around a stream during the 2005 construction window, submitted by the 'Namgis First Nation. The prescriptions included in this report are for Type I and Type II projects, as defined by the FIA Activity Standards Document (FIA, 2003).

Type I projects are defined as:

> "Treatments… (that) typically involve activities that alter the channel plan for only one habitat unit and less than 5 bankfull widths, producing a local effect on the streambed and banks. Examples include: large woody debris (LWD) placements and anchoring, boulder clusters, simple bank protection or stabilization".

Type II projects are defined as:

> "Treatments… (that) typically involve activities that alter the plan and profile of a stream over a reach length greater than 5 bankfull widths. This includes situations where treatments encroach in plan view more than 30% of the bankfull width, or in profile more than 50% of the bankfull depth. Examples include pool/riffle sequence construction, channel/gravel excavation, gravel placement, fishway and weir construction, berm and dike construction, and complex bank stabilization projects."

1.1 FIELD SURVEY AND PRESCRIPTIONS

The work sites included in this report were selected for prescriptions in February 2003 and July 2005. They were surveyed in February 2005 following site visits. The location of the work sites are shown in Figure 1 and are as follows:

1. *Site YK1DJ1 – Log Jam Rearrangement*: Partial removal of two log jams located in the right main channel of Yookwa Creek downstream of the 600m Channel (YK1DC1) to encourage flow in this channel.

2. *Site YK1LWD1 - Bank Stabilisation*: LWD spur structures on left bank at 800m. Prevent further erosion and channel widening of unstable bank.

3. *Site YK1LWD3 - Bank Stabilisation: Bank Protection at 1000m on Left Bank*: Lateral LWD structures constructed to prevent further erosion of banks and widening of channel.

4. *Site YK1BT1 – Bar Top Stabilisation Structures*: Ballasted LWD added to the bar tops to protect existing coarse sediment deposits and encourage further deposition.

5. *Site YK1RR1 – Riprap Spurs*: A series of riprap spurs constructed upstream of the Nimpkish mainline logging road to prevent Yookwa Creek from avulsing to the left.

Construction layouts, profiles and cross sections can be found in the figures section of this report following the site descriptions, hydraulic analysis and construction plans in the main body of the report.

1.2 SCHEDULE

Completion of these proposed works is expected to occur in phases over the course of two or more years as budgets allow. The works will be completed by priority as listed above. Sites YK1LWD1 (LB protection at 800m) and YK1BT1 (bar top stabilizers) are resubmissions of previously approved projects from 2003. The prescription for Site YK1LWD1 has been modified from the 2003 approval while the prescription for site YK1BT1 remains the same.

Instream projects would be completed within the fisheries construction window, extending from approximately July 15 to September 1, 2005 as shown in Tables 1a and 1b.

1.3 ACCESS AND CONSTRUCTION

Access for equipment and crew is discussed for each site in the following sections. Where possible, the access routes are highlighted on the prescription figures.

1.4 ENVIRONMENTAL AND CONSTRUCTION SUPERVISION

We propose to have an environmental monitor and a construction supervisor on-site during the construction of Type I and Type II projects or when large machinery is working.

The main environmental issues are the management of sediment during construction of instream structures and the proper handling of fuels. Any fuel at the site will be stored above the high water mark and any large containers will be enclosed by a berm in case of spills. All re-fuelling will occur away from the wetted portion of the stream using appropriate re-fuelling containers. All excavators or other equipment will be cleaned before entering the stream channel.

Specific plans to prevent or reduce the entry of sediment into the stream during construction are described for the individual projects. Construction at site YK1LWD1 and YK1LWD3 are expected to be constructed in shallow flowing water that is unconnected to Sebalhall River due to downstream drying in Yookwa Creek. Sites YK1DJ1, YK1BT1, and YK1RR1 will likely be dry during construction.

1.5 MATERIALS

Table 2 summarises the materials required for each of the sites.

1.6 COSTS

Approximate costs are provided in Table 3. The estimates are based on our experience in the Nimpkish Watershed and assume that riprap will cost $\$7/m^3$ to develop and logs will cost $\$30/m^3$ for non-merchantable cedar. Delivery charges have been built into the heavy machinery estimates for each site. Due to the highly variable nature of instream work these values should be viewed as estimates only.

1.7 BIOLOGICAL BENEFITS

Unlike the majority of instream works undertaken in the Nimpkish Watershed since 1998, the biological benefits of these works will not be immediately apparent, nor will the benefits be restricted to Reach 1 of Yookwa Creek. The stabilization of Yookwa Creek channel on the fan will eventually result in a channel that maintains wetted refuge pools and even continuous flow during summer low-flow conditions. In contrast, the current situation results in significant fish mortality when the channel rapidly dries out. The downstream benefits from a reduced gravel supply will likewise take time to become apparent, but will include increases to the quality and quantity of instream rearing, holding and spawning habitat in Sebalhall River, and a more stable water surface elevation in Vernon Lake. Consequently, it is not possible to make meaningful numerical estimates of the increase in fish habitat resulting from these works.

2 PRESCRIPTION SITES

The following sections are meant as stand-alone prescriptions for individual sites on the Yookwa Creek fan.

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YOOKWA CREEK - SITE YK1DJ1

Type I Project – Rearrange Log Jams that Span the Right (South) Channel

Location: Two channel spanning log jams located in the right channel 500m from mouth

Access: Access to the site is via the Yookwa Creek logging road and a series of abandoned spurs that traverse the right side of the Yookwa Creek fan. From the spurs, the backhoe will move through the 600m Channel to the main stream then 100 m downstream.

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1. ISSUES AND OBJECTIVES

Reach 1 of Yookwa Creek occupies an alluvial fan built by material depositing at the mouth of the canyon reach. Forest harvesting on the fan has weakened the channel banks and resulted in an over-widened channel with very high coarse sediment load that is delivered downstream to Sebalhall River. This coarse sediment is impacting valuable fish habitat in Sebalhall River and Vernon Lake.

Strategies to stabilize the channel on the fan include 1) encouraging revegetation of extensive coarse sediment deposits, 2) creation of high-flow distributary channels such as are found on undisturbed fans, and 3) protect existing banks against erosion where possible. Two high flow distributary channels were constructed in 2003.

The objective of work at this site is to reopen the right bank (south) channel on the fan so portions of the floods in Yookwa Creek flow along this path to Sebalhall River. Maintaining several high flow channels like the constructed distributary channels will reduce the transport capacity of the now main (left or north) channel during flood conditions. A reduced transport capacity will cause deposition on the fan surface and reduce downstream transport to Sebalhall River.

2. STREAM SURVEYS

A longitudinal survey of Yookwa Creek and detailed sketches of the site were completed in February 2005.

3. SITE DESCRIPTION

The two log jams at this site occur in the lower, multi channelled section of Yookwa Creek. Both span the right (south) main channel about 500m upstream on the fan and are the result of the November and December 2004 floods. Flood flow down this former main channel is pushed out of the channel by these log jams into the left and right riparian forests. Currently more flow is pushed into the left riparian forest than the right. This has lead to channel development and continuity with the left (north) main channel. There has been significant deposition of coarse sediment in the right channel upstream of the log jams.

Figure 2 shows a sketched plan view of the two log jams and current photographs.

4. HYDROLOGY AND HYDRAULICS

There is no hydraulic analysis required for this site.

5. RESTORATION PLAN

The restoration plan for this site would be quite simple. It consists of removing two log jams from the right bank channel and lining the adjacent riparian forest with the LWD. The location of the two log jams is shown in Figure 2. No cable or boulder anchors would be used to hold the logs in place. Instead, high velocity flow down the centre of the channel and flow spilling into the surrounding forest would hold the realigned logs against the channel margins.

6. CONSTRUCTION MATERIALS AND TECHNIQUES

The work at this site would be completed by a backhoe. The machine would approach the site from the end of the right bank spurs, through the 600m Channel inlet, and down the dry right bank channel. Wood realigned from the log jams would be placed between the trees on each side of the main channel where it would be stable.

There are no materials required for this site. The realigned logs would be free to move between the trees during floods.

7. ENVIRONMENTAL MANAGEMENT

It is expected that Yookwa Creek will be dry at this downstream location during the construction period. Therefore we do not anticipate the requirement for sediment control measures or fish salvage and exclusion. Care will be taken to minimise the disturbance to the bank vegetation.

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YOOKWA CREEK - SITE YK1LWD1

Type 2 Project – Bank Protection at 800m on Left Bank

Location: Eroding left bank approximately 800m from mouth

Access: Access to the site is via an abandoned, overgrown spur road on the left side of the fan. This road is accessed from the Nimpkish Mainline near the Sebalhall River bridge.

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1. ISSUES AND OBJECTIVES

Reach 1 of Yookwa Creek occupies an alluvial fan built by material depositing at the mouth of the canyon reach. Forest harvesting on the fan has weakened the channel banks and resulted in an over-widened channel with very high coarse sediment load that is delivered downstream to Sebalhall River. This coarse sediment is impacting valuable fish habitat in Sebalhall River and Vernon Lake.

Strategies to stabilise the channel on the fan include: 1) encouraging revegetation of extensive coarse sediment deposits; 2) creation of high-flow distributary channels such as are found on undisturbed fans; and, 3) protect existing banks against erosion where possible. High flow distributary channels were constructed in 2003.

The objective of work at this site is to stabilize a portion of the left bank of Yookwa Creek that is eroding. This bank represents a significant source of coarse sediment to downstream reaches. Further erosion of this bank may result in a partial or complete shift of the main flow to the left margin of the fan.

2. STREAM SURVEYS

A representative cross section was surveyed in May 2003 and resurveyed in February 2005 (Figure 3, Cross Section 2-YK).

3. SITE DESCRIPTION

Yookwa Creek on its fan is overly wide and covered by extensive gravel bars. At cross section 2-YK (800 m) the channel narrows to 95m, the narrowest point in the middle section of the fan. This point corresponds to some riprap rockwork (placed in 1970) located at the top of a left bank abandoned spur. Below the riprap a 55m length of the bank is eroding as Yookwa Creek widens through this narrow section on the fan. Figure 3 shows a sketched plan view of the eroding bank and a typical section. The bank is approximately 3m to 4m high at the upstream end and tapers down to 2m high at the downstream end. The bank is composed of alluvial gravel and cobbles and is very susceptible to erosion due to its unconsolidated nature.

Floods on November 15th and December 10th, 2004 produced some remarkable changes on Yookwa fan (**nhc** and ALBY, 2005). At cross section 2-YK the main channel shifted from the right to the left bank. This produced up to 10m of erosion along a 55m length of the bank. This steep, unstable gravel-cobble bank now requires protection to prevent further erosion.

4. HYDROLOGY AND HYDRAULICS

Channel Characteristics – Yookwa Creek Reach YK1

Drainage Area to head of reach	37 km^2
Channel (top) width	90 m
Bankfull depth	1.5 m
Average bed slope (for reach)	0.015
Manning's n	0.04
Design Velocity	4 m/s
Design Discharge (50-year instantaneous)	370 m^3/s
Design Froude #	0.9
Stable Bed Material Size	n/a mm

The design discharge was calculated from the drainage area and a Creager's C of 35 for a 50-year instantaneous flood. This C is based on the flood frequency analysis of the Water Survey of Canada gauge *Zeballos River near Zeballos (08HE006)*.

Channel characteristics are based on uniform flow calculations for the typical surveyed sections and typical reach slope. Depths at the design flood are well above the banks on the fan and flood waters are expected to flow over the fan to Vernon Lake along various channels. These calculations would tend to overestimate flow in the channel, as they do not account for flow loss, however the design velocity was increased slightly because of flow concentration along the bank.

5. RESTORATION PLAN

The restoration plan consists of installing two LWD structures along the eroding section of bank – a long lateral log jam and a downstream LWD structure. Their location is shown in Figures 1 and 3. A long lateral log jam is prescribed rather than a series of LWD spurs due to the high, vertical nature of the bank that precludes spur construction. This structure should be about 40m long and wrap around the upstream corner of the bank, extending further upstream than the current erosion The upstream end of the structure should be either attached to a very secure, large tree on the bank or be buried in a trench complete with boulder anchors that would act like deadmen. Ideally riprap would be used to backfill the trench. This upstream attachment will provide much of the lateral stability for the entire structure.

The downstream LWD structure will be square in shape to cover a greater length of bank than a typical spur. Cross bracing in the centre of the structure and attachments to trees on the bank will resist deformation. This structure will have the added benefit of providing more cover in the expected scour pool.

All LWD structures will be constructed from LWD pieces with a minimum diameter of 0.6m. The structures should be attached to the bank with cable and ballasted with rock anchors with a

minimum diameter of 1.2m (5200 lb equivalent). Two 1.2m diameter boulders will be required for every log in the structures and one 1.2m boulder for every stump.

The LWD structures will have the following features:

- All LWD structures will be constructed with logs having a minimum diameter of 0.6m. Use logs with rootwads attached where possible. Two 1.2m diameter boulders will be required for every log in the structures and one 1.2m boulder for every stump.

- The lateral log jam will have a typical projection width from the bank of 2m to 3m. Extra space between the log structure and the bank will be filled with ballast boulders, stumps, and cobble-boulder fill from the nearby fan surface. The fill will prevent high velocity jets from penetrating the structure and eroding the bank. It will also establish a stable toe along the bank that will limit sloughing from the upper bank.

- The upstream end of the lateral log jam will be attached to a large stable tree or trenched into the bank where the upstream log and boulder anchors will be buried by coarse backfill. 900 mm riprap is preferable for the backfill if available.

- The downstream end of the lateral log jam will "flair out" into the channel so that it projects 4m to 5m from the bank. This will allow for a 16m offset between the lateral log jam and downstream LWD structure.

- The lateral log jam will be attached to stable trees on the bank where applicable.

- The downstream LWD structure will be placed where both the upstream and downstream corners can be attached to large, stable trees on the bank. These trees will provide a portion of the lateral stability for the structure. A cross bracing log will be added to provide additional lateral stability.

- Two stumps will be added to the downstream LWD structure to fill holes between the log structure and the bank.

6. CONSTRUCTION MATERIALS AND TECHNIQUES

An excavator and hand crew will complete the work at this site. Material will be delivered to the site by rock truck and self-loading log truck via the abandoned spur. The excavator will place the logs and rock anchors in position from the edge of the opposite bar. The hand crew will work with the excavator to cable the structure together and attach the anchors.

Table 2 summarises the materials required.

7. ENVIRONMENTAL MANAGEMENT

It is expected that the main Yookwa Creek channel will be dry or nearly dry at this location on the fan during the construction period. Consequently, we do not anticipate the requirement for additional sediment control measures although fry salvage from the work site may be required. Care will be taken to minimise the disturbance to the bank vegetation. There should be sufficient space to allow machinery access to all sites on the open bars and dry channel bed. Where

machines are required to drive across the partly vegetated portions of the bars, care will be taken to choose the shortest route with the least disturbance to rooted vegetation.

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YOOKWA CREEK - SITE YK1LWD3

Type 2 Project – Bank Protection at 1000m on Left Bank

Location: Eroding left bank approximately 1000m from mouth

Access: Access to the site is via the Yookwa Creek logging road and a series of abandoned spurs that traverse the right side of the Yookwa Creek fan. From the spurs, the excavator will move through the 900 m Distributary Channel and out onto the partly vegetated Yookwa Creek bars.

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1. ISSUES AND OBJECTIVES

Reach 1 of Yookwa Creek occupies an alluvial fan built by material depositing at the mouth of the canyon reach. Forest harvesting on the fan has weakened the channel banks and resulted in an over-widened channel with very high coarse sediment load that is delivered downstream to Sebalhall River. This coarse sediment is impacting valuable fish habitat in Sebalhall River and Vernon Lake.

Strategies to stabilize the channel on the fan include 1) encouraging revegetation of extensive coarse sediment deposits, 2) creation of high-flow distributary channels such as are found on undisturbed fans, and 3) protect existing banks against erosion where possible. High flow distributary channels were constructed in 2003.

The objective of work at this site (like site YK1LWD1) is to stabilize a portion of the left bank of Yookwa Creek that is eroding. This bank represents an even larger source of coarse sediment to downstream reaches than the eroding bank at 800m.

2. STREAM SURVEYS

A longitudinal survey of Yookwa Creek and detailed sketches of the site were completed in February 2005.

3. SITE DESCRIPTION

The eroding bank at 1000m on Yookwa Creek fan is located near the upstream end of the overly wide middle section of the fan. At this point flow from the upper, partly incised portion of the fan, moves to the extreme left edge of the fan where it contacts a high valley wall. This valley wall is composed of a coarse glacial till that is fairly resistant to erosion. However, the height of the wall produces large volumes of material for even short distances of retreat.

Figure 4 shows a sketched plan view of the eroding bank and current photographs. The bank has two main scarps each 10 to 15m high and till can be seen outcropping into the bed of the channel at a couple of locations along the bank. Currently a 55m long section of the bank is eroding.

4. HYDROLOGY AND HYDRAULICS

Channel Characteristics – Yookwa Creek Reach YK1

Drainage Area to head of reach	37 km^2
Channel (top) width	90 m
Bankfull depth	1.5 m
Average bed slope (for reach)	0.015
Manning's n	0.04
Design Velocity	4 m/s
Design Discharge (50-year instantaneous)	370 m^3/s
Design Froude #	0.9
Stable Bed Material Size	n/a mm

The design discharge was calculated from the drainage area and a Creager's C of 35 for a 50-year instantaneous flood. This C is based on the flood frequency analysis of the Water Survey of Canada gauge *Zeballos River near Zeballos (08HE006)*.

Channel characteristics are based on uniform flow calculations for the typical surveyed sections and typical reach slope. Depths at the design flood are well above the banks on the fan and flood waters are expected to flow over the fan to Vernon Lake along various channels. These calculations would tend to overestimate flow in the channel, as they do not account for flow loss, however the design velocity was increased slightly because of flow concentration along the bank.

5. RESTORATION PLAN

The restoration plan consists of installing two LWD structures along the eroding section of bank – a long lateral log jam and a downstream LWD spur. Their location is shown in Figure 4. Like the downstream bank, a long lateral log jam is prescribed rather than a series of LWD spurs due to the high, vertical nature of the bank that precludes spur construction. This structure should be about 40m long and wrap around the upstream corner of the bank, onto the alder covered floodplain The upstream end of the structure should be either attached to a very secure, large tree on the bank or be buried in a trench complete with boulder anchors that would act like deadmen. This upstream attachment will provide much of the lateral stability for the entire structure.

The downstream LWD spur will have a typical triangular shape. It will be placed at the downstream end of the eroding bank where the bank height falls and large trees occur. In addition to protecting the downstream end of the bank, this structure will have the added benefit of narrowing the left opening onto the downstream bar. This will reduce flood flow in the left channel ensuring that a greater portion of the flow approaches our previously constructed 900 m Distributary Channel. This channel spills floodwaters across the fan surface thereby reducing the stream power of the main flow. Flow across the left bar cannot enter the 900 m Channel.

All LWD structures will be constructed from LWD pieces with a minimum diameter of 0.6m. The structures should be attached to the bank with cable and ballasted with rock anchors with a

minimum diameter of 1.2m (5200 lb equivalent). Two 1.2m diameter boulders will be required for every log in the structures and one 1.2m boulder for every stump.

The LWD structures will have the following features:

- All LWD structures will be constructed with logs having a minimum diameter of 0.6m. Use logs with rootwads attached where possible. Two 1.2m diameter boulders will be required for every log in the structures and one 1.2m boulder for every stump.

- The lateral log jam will have a typical projection width from the bank of 2m to 3m. Extra space between the log structure and the bank will be filled with ballast boulders, stumps, and cobble-boulder fill from the nearby fan surface. The fill will prevent high velocity jets from penetrating the structure and eroding the bank. It will also establish a stable toe along the bank that will limit sloughing from the upper bank.

- The upstream end of the lateral log jam will be attached to a large stable tree or trenched into the bank where the upstream log and boulder anchors will be buried by coarse backfill. 900 mm riprap is preferable for the backfill if available.

- The downstream end of the lateral log jam will "flair out" into the channel so that it projects 4m to 5m from the bank. This will allow for a 16m offset between the lateral log jam and downstream LWD structure.

- The lateral log jam will be attached to stable trees on the bank where applicable.

- The downstream LWD spur will be placed where both the upstream and downstream logs can be attached to large, stable trees on the bank. These trees will provide a portion of the lateral stability for the structure.

- One stump will be added to the downstream LWD structure to fill holes between the log structure and the bank.

6. CONSTRUCTION MATERIALS AND TECHNIQUES

An excavator and hand crew will complete the work at this site. Material will be delivered to the site by helicopter if budgets allow, or rock truck and self-loading log truck via the spurs and 900 m Channel. The excavator will manoeuvre the logs into position and place the rock anchors from the edge of the opposite bar. The hand crew will work with the excavator to cable the structure together and attach the anchors.

Table 2 summarises the materials required.

7. ENVIRONMENTAL MANAGEMENT

It is expected that Yookwa Creek will be flowing at this upstream location during the construction period. However, it is unlikely that this flow will be connected to fish inhabited waters because of the downstream drying during normal summer months. Also, placing logs, stumps and boulder anchors are not likely to generate a lot of fine sediment. However, some fine sediment will be introduced when backfilling the lateral log jam with local cobbles and boulders.

We do not anticipate the requirement for additional sediment control measures because the downstream channel will be dry. Fry salvage at the site will likely be required. Care will be taken to minimise the disturbance to the bank vegetation. There should be sufficient space to allow machinery access to all sites on the open bars and dry channel bed. Where machines are required to drive across the partly vegetated portions of the bar tops, care will be taken to choose the shortest route with the least disturbance to rooted vegetation.

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YOOKWA CREEK - SITE YK1BT1

Type I Project – Install Bar Top Stabilisation Structures

Location: Exposed gravel bars from 550m to 1100m upstream of the mouth of Yookwa Creek

Access: Access to the site is via the Yookwa Creek logging road and a series of abandoned spurs that traverse the right side of the Yookwa Creek fan. From the spurs, the excavator will move through the 900 m Distributary Channel and out onto the partly vegetated Yookwa Creek bars.

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1. ISSUES AND OBJECTIVES

Reach 1 of Yookwa Creek occupies an alluvial fan built by material depositing at the mouth of the canyon reach. Forest harvesting on the fan has weakened the channel banks and resulted in an over-widened channel with very high coarse sediment load that is delivered downstream and is impacting valuable fish habitat in Sebalhall River and Vernon Lake.

Strategies to stabilize the channel on the fan include: 1) encouraging revegetation of extensive coarse sediment deposits, 2) creation of high-flow distributary channels such as are found on undisturbed fans, and 3) protect existing banks against erosion where possible.

The objective of work at these bar sites is to install LWD pieces on the bar surface to increase hydraulic roughness and protect the existing coarse sediment deposits while encouraging further deposition. This site is a resubmission of a previously approved project from 2003 (**nhc** and ALBY, 2003).

2. STREAM SURVEYS

A longitudinal survey of Yookwa Creek and detailed sketches of the site were completed in February 2005.A representative cross section was surveyed in May 2003 (Figure 5).

3. SITE DESCRIPTION

Reach YK1 of Yookwa Creek flows on an average gradient of 1.5% between 550m and 1100m. Bars in this section range from lightly vegetated with alder and willow, to completely exposed. Large stumps still in growth position are occasionally found on the bar tops and represent the remnants of the pre-logging forest. Coarse sediment has accumulated locally in association with LWD pieces that have washed up on the bars during high flows, often against old stumps. High flow events of 2-year return period and smaller generally do not wet the high portions of the bars, however it is expected that flows of 10-year return period or greater would cause general bed mobility despite the willow and alder vegetation that is currently established. Flood events in 2003 and 2004 have produced significant changes on the fan surface.

Four large bars have been identified between 550m and 1100m as having good potential for successful bar top treatment. These bars are shown in Figure 5, numbered consecutively from upstream to downstream. Lightly vegetated areas are shown with a hatched pattern and the approximate position of existing LWD pieces and stable stumps is indicated.

4. HYDROLOGY AND HYDRAULICS

Channel Characteristics – Yookwa Creek Reach YK1

Drainage Area to head of reach	37 km^2
Channel (top) width	90 m
Bankfull depth	1.5 m
Average bed slope (for reach)	0.015
Manning's n	0.04
Design Velocity	3.5 m/s
Design Discharge (50-year instantaneous)	370 m^3/s
Design Froude #	0.9
Stable Bed Material Size	n/a mm

The design discharge was calculated from the drainage area and a Creager's C of 35 for a 50-year instantaneous flood. This C is based on the flood frequency analysis of the Water Survey of Canada gauge *Zeballos River near Zeballos (08HE006)*.

Channel characteristics are based on uniform flow calculations for the typical surveyed sections and typical reach slope. Depths at the design flood are well above the banks on the fan and flood waters are expected to flow over the fan to Vernon Lake along various channels. These calculations would tend to overestimate flow in the channel, as they do not account for flow loss.

5. RESTORATION PLAN

The restoration plan consists of installing single, ballasted LWD pieces on the bar tops to stabilize the existing coarse deposits. The exact location and orientation of LWD pieces will be determined on-site by the construction supervisor. The general strategy of LWD placement is to place pieces upstream, or immediately on top of existing stumps and to orient the pieces so as to be perpendicular to the expected flow direction. We do not recommend altering existing LWD pieces on the fan surface. Two 1m diameter boulder anchors should be attached to each log to counteract the buoyancy of the log under flood flow conditions. It is important to note that at the design flood it is expected that the logs will likely shift downstream until they are hung up on other logs or are pushed to higher portions of the bar surface. The ballasting of the logs is not sufficient to prevent lateral shifting.

The following priority should be given to treatment of the bars:

Priority Order	Bar Number
1	4
2	1&3
3	2

Bar top structures would have the following features:

- Structures will be ballasted for buoyancy only, not the drag force of high flows. At the design flow, some or all of the structures may shift downstream to a higher position on the bar, or be hung up on existing roughness elements. These logs will likely become key logs in new log jams.

- We recommend attaching two (2) 1.1m diameter boulder anchors (2000 kg equivalent) to each log. Place the anchors upstream of the log structure, and where possible, partially bury the anchors in the bar.

- Also, where possible, a shallow trough should be scraped in the bar surface with the excavator to seat the log structure and help prevent flow going underneath.

6. CONSTRUCTION MATERIALS AND TECHNIQUES

An excavator and hand crew will complete the work at this site. Material will be delivered to the individual placement sites by rock truck and self-loading log truck. The excavator will manoeuvre the logs into position and partially bury the rock anchors. Where possible, the bar surface will be levelled along the alignment of the LWD piece to allow it to sit snugly on the bar. The hand crew will work with the excavator to attach the anchors with steel cable.

Although the exact number and location of the structures will be determined in the field it is estimated that approximately 15 logs could be used on each bar and 2 rock anchors will be required per log. Additional rock anchors may be required if existing wood on the bars is deemed worthwhile to anchor.

Table 2 summarises the materials required.

7. ENVIRONMENTAL MANAGEMENT

It is expected that Yookwa Creek channel will be dry during the construction period. Consequently, we do not anticipate the requirement for additional sediment control measures or fry exclusion from the site. Care will be taken to minimise the disturbance to the bar top vegetation that is already established while installing the bar top structures. There should be sufficient space to allow access to machinery to all sites on the open bars and dry channel bed. Where machines are required to drive across the partly vegetated portions of the bar tops, care will be taken to choose the shortest route.

Nimpkish River Watershed
2005 Level 2 Prescriptions

YOOKWA CREEK - SITE YK1RR1

Type 2 Project – Bank Protection at 400m on Left Bank

Location: Eroding left bank approximately 400m from mouth

Access: Access to the site is via the Nimpkish Mainline logging road and an abandoned spur on the left (north) side of the Yookwa Creek fan.

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1. ISSUES AND OBJECTIVES

Reach 1 of Yookwa Creek occupies an alluvial fan built by material depositing at the mouth of the canyon reach. Forest harvesting on the fan has weakened the channel banks and resulted in an over-widened channel with very high coarse sediment load that is delivered downstream to Sebalhall River. The Upper Nimpkish Coarse Sediment Supply report, which included various sources of material in the Yookwa Watershed, rated the fan surface itself as the greatest source of coarse sediment in this system (**nhc**, 1998). This coarse sediment is impacting valuable fish habitat in Sebalhall River and Vernon Lake.

Strategies to stabilize the channel on the fan include: 1) encouraging revegetation of extensive coarse sediment deposits, 2) creation of high-flow distributary channels such as are found on undisturbed fans, and 3) protect existing banks against erosion where possible. High flow distributary channels were constructed in 2003.

The objective of work at this site is to stabilize a portion of the left bank of Yookwa Creek that is eroding. In addition to contributing coarse sediment to downstream reaches, erosion of this bank presents an avulsion hazard in the lower section of the fan. An avulsion at this site would lead directly into the lower Sebalhall River contributing a new, large source of sediment to this heavily aggraded, high value river.

The present hazard of avulsion at this site is low. However, we consider protecting this bank as important for the following reasons:

1. Continued erosion may lead to an increasing hazard,
2. The left (north) channel has recently become the main channel in the lower section of the fan; channel widening, channel incision, and/or changes in channel alignment are expected,
3. The bank is a small, but significant source of coarse sediment located close to Sebalhall River. Material eroded from the bank is transported directly and therefore quickly to the downstream river.

We do not expect to protect this bank during the summer of 2005. Instead, budget constraints will likely delay work until at least 2006. However, submitting this site for approval now will ensure that emergency works, if required, could be completed in a timely manner.

2. STREAM SURVEYS

A longitudinal survey of Yookwa Creek and detailed sketches of the site were completed in February 2005.

3. SITE DESCRIPTION

The eroding bank at 0+400m on Yookwa Creek fan is located on the left bank of the left (north) channel on Yookwa fan (Figure 1, Figure 6). The bank lies just upstream of the Nimpkish Mainline logging road where it impinges directly onto the bank of the river. This section of the creek is widening considerably upstream of where the creek is forced into a narrow channel beside the armoured road. The overwidened section at this site allows encroachment into the channel with protection works without narrowing the channel against the opposite, unprotected right bank.

Recently, upstream changes in the creek alignment have lead to the left channel becoming the main Yookwa Creek channel. This has lead to considerable erosion of both banks between 0+400 m and 0+700 m. Channel widening on the left bank at 0+400m is eroding into a moderately well established second growth riparian forest. This bank, and the forestry road, lie between the current channel alignment and a considerable portion of the north side of Yookwa fan. This area of the fan lies downslope from the current channel and there is therefore a small but real avulsion hazard. Continued erosion of this bank is increasing the erosion hazard and contributing sediment directly to the downstream Sebalhall River.

This area of Yookwa Creek on the fan is changing considerably as upstream sediment migrates through the site. As a result there is a chance that protection works added to the left bank at 0+400 m could be abandoned as Yookwa Creek erodes the upstream right bank. There is an avulsion hazard upstream into the island that separates the right and left channels. An avulsion into the island, unlike the 0+400m bank, would likely lead back to the right (south) channel and therefore is unlikely to cause the habitat degradation in Sebalhall River that an avulsion at the 0+400 m channel could cause.

Figure 6 shows a sketched plan view of the eroding bank and current photographs. Currently a 150m long section of the bank is eroding.

4. HYDROLOGY AND HYDRAULICS

Channel Characteristics – Yookwa Creek Reach YK1

Drainage Area to head of reach	37 km^2
Channel (top) width	90 m
Bankfull depth	1.5 m
Scour depth	3.0 m
Average bed slope (for reach)	0.015
Manning's n	0.04
Design Velocity	6 m/s
Design Discharge (50-year instantaneous)	370 m^3/s
Design Froude #	0.9
Stable Bed Material Size	n/a mm

The design discharge was calculated from the drainage area and a Creager's C of 35 for a 50-year instantaneous flood. This C is based on the flood frequency analysis of the Water Survey of Canada gauge *Zeballos River near Zeballos (08HE006)*.

Channel characteristics are based on uniform flow calculations for the typical surveyed sections and typical reach slope. Depths at the design flood are well above the banks on the fan and flood waters are expected to flow over the fan to Vernon Lake along various channels. These calculations would tend to overestimate flow in the channel, they do not account for flow loss. The design velocity was increased because of flow concentration along the bank and at the tips of the spurs. Local scour depth is based on the depth of an observed scour hole located 50 m downstream of the work site.

5. RESTORATION PLAN

The restoration plan consists of installing a series of riprap spurs along the length of the eroding bank at 0+400m in the left (north) Yookwa fan channel. The upstream spur (Spur 6) will project the shortest distance from the bank and be keyed into the bank 5m to prevent "outflanking". However, if erosion upstream continues maintenance may be required at this structure. The restoration plan does not prevent erosion along the entire bank. Instead it concentrates on preventing erosion on the lower section where continued erosion could lead to an increasing avulsion potential.

We estimate that local velocities will reach 6 m/s in Yookwa Creek during flood conditions - 1100mm riprap is required to be stable under these conditions. In addition, conditions at the spurs tips will be much more severe than on the body of the spur so we recommend concentrating the larger clasts from the gradation (greater than 1100m) in the tips. The side slopes in the tips will be reduced to 2 horizontal to 1 vertical to increase the stability of the riprap.

The riprap will have the following gradation (Class 1100 mm):

at least	15%	larger than	1600mm	or	6000kg
at least	50%	larger than	1100mm	or	2000kg
at least	85%	larger than	500mm	or	200kg

Preliminary estimates of riprap volume and site dimensions are:

- Bank length to protect: 100m.
- Number of spurs: 6.
- Average bank height: 2m, ranges from 1.5 to 2.5 m.
- Approximate scour depth: 2m below the existing bed elevation.
- 10 m^3 of riprap per linear metre of spur (maximum).
- 1,010 m^3 of riprap required.
- D_{50}: 1100mm.

Spur No. (#)	Centre-line Location (m)	Nominal Projection Length (m)	Normal Spur Height (m)	Dist. – Bank to Tip (m)	Key into Bank (m)	Spur Apron Volume (m^3)	Spur Key Volume (m^3)	Approx. Riprap Required (m^3)
1	0+400	6	2.0	10	2	80	20	160
2	0+420	8	2.0	12	2	80	20	180
3	0+440	7	2.0	11	2	80	20	170
4	0+460	7	2.0	11	2	80	20	170
5	0+480	6	2.0	10	2	80	20	160
6	0+500	5	2.0	9	5	80	40	170

Riprap spurs are preferential to riprap revetment at this site. To construct riprap revetment, most of the riparian trees and a substantial portion of the bank itself would have to be removed to reshape the bank to a side slope of 2 horizontal to 1 vertical. All woody debris lying in the river along the edge of the bank would have to be removed and could not be replaced – Trees removed for the spur key can be added to the bank between the spurs. Flow velocities along the edge of a riprap bank would be high preventing fish species from using the bank for habitat during upstream migration. Riprap spurs will provide a variety of hydraulic conditions along the bank during flood that will allow adults an opportunity to rest during upstream migration.

Figure 6 outlines the typical dimensions, slopes, depths, heights, and lengths of the spurs. Table 2 includes the volume of riprap necessary to complete this work.

6. CONSTRUCTION MATERIALS AND TECHNIQUES

Two excavators and two rock trucks complete the work at this site. Riprap will be delivered to the site by rock truck, the main channel is expected to be dry during construction allowing the trucks to deliver the riprap to each spur location. The excavator will excavate the bed for the spur apron and excavate the bank for the spur key. It will then place the riprap in the dimensions specified on the plans.

Table 2 summarises the materials required.

7. ENVIRONMENTAL MANAGEMENT

It is expected that Yookwa Creek will be dry at this site during construction. As a result no sediment containment or fish salvage will be required.

The key environmental concern when working at this site will be the riparian damage inflicted during excavation of the spur key. All work sites and riparian areas to be disturbed will be clearly marked in the field prior to construction. Care will be taken to avoid damaging trees outside the work area.

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TABLES

Table 1a: Instream Work Timing Windows by Species - Vancouver Island Region

Species		Timing Window
Common Name	Latin Name	
Chinook salmon	Oncorhynchus tshawytscha	July 15 - September 15
Coho salmon	Oncorhynchus kisutch	June 15 - September 15
Pink salmon	Oncorhynchus gorbuscha	May 1 - August 1
Chum salmon	Oncorhynchus keta	May 15 - September 15
Sockeye salmon	Oncorhynchus nerka	June 1 - September 15
Kokanee	Oncorhynchus nerka	June 1 - September 15
Steelhead	Oncorhynchus mykiss	June 15 - September 15
Resident rainbow trout	Oncorhynchus mykiss	July 15 - September 15
Resident cutthroat trout	Oncorhynchus clarki	July 15 - September 15
Resident Dolly Varden	Salvelinus malma	June 1 - September 1

Table 1b: Instream Work Timing Windows by Stream

Stream	Known or Suspected Fish Use	Timing Window
Yookwa Creek *	CO, CT, DV, RB	July 15 - September 1

Species Key:

SK - Sockeye salmon	CH - Chinook salmon	PK - Pink salmon
KO - Kokanee	ST - Steelhead	CT - Cutthroat Trout
CO - Coho salmon	RB - Rainbow Trout	DV - Dolly Varden Char

* Note: since Reach 1 of Yookwa Creek is essentially dry during the summer months, the fish window is more likely to be controlled by weather than the presence or absence of fish in the dry channel.

Notes:

1 - From MWLAP 2001.

TABLE 2: Summary of Materials Required for 2005 Construction

Project Sites	Structure Type	Number of Struct.	LWD					Anchors			Riprap		Biological Objective	Physical Objective	Comments
			Type	No.	Diameter (m)	Length (m)	Source (m)	diameter (m)	no. per struct.	total no.	Volume (m^3)	D_{50} (mm)			
Yookwa Creek															
YK1LWD1; Eroding Bank at 0+800 m	Lateral LWD jam - 40m long	1	log	16	0.6-0.8	8	truck to site	1.2 (5200 lb equivalent)	2 per log	32	-	-	Slow channel widening and shallowing; reduce downstream transport of coarse sediment to high fisheries value reach in Sebalhall River	Protect eroding bank	Due to upstream bank height typical spurs are difficult to construct, therefore need the lateral log jam. Backfill with local cobbles and boulders to 1.5 to 2.0 m high.
			stump	8	1.0-1.5	-	truck to site	1.2 (5200 lb equivalent)	1 per stump	8	-	-			
	LWD structure	1	log	5	0.6-0.8	8	truck to site	1.2 (5200 lb equivalent)	2 per log	10	-	-			
			stump	2	1.0-1.5	-	truck to site	1.2 (5200 lb equivalent)	1 per stump	2	-	-			
	Total at Site	**2**	**log stump**	**21 10**						**52**					
YK1LWD3; Eroding Bank at 1+000 m	Lateral LWD jam - 40m long	1	log	16	0.6-0.8	8	fly to site	1.2 (5200 lb equivalent)	2 per log	32	-	-	Slow channel widening and shallowing; reduce downstream transport of coarse sediment to high fisheries value reach in Sebalhall River	Protect eroding bank	Due to upstream bank height typical spurs are difficult to construct, therefore need the lateral log jam. Backfill with local cobbles and boulders to 1.5 to 2.0 m high.
			stump	8	1.0-1.5	-	fly to site	1.2 (5200 lb equivalent)	1 per stump	8	-	-			
	LWD spur	1	log	2	0.6-0.8	8	fly to site	1.2 (5200 lb equivalent)	2 per log	4	-	-			
			stump	1	1.0-1.5	-	fly to site	1.2 (5200 lb equivalent)	1 per stump	1	-	-			
	Ballast Natural LWD	1	-	-	-	-	-	1.2 (5200 lb equivalent)	6	6	-	-			
	Total at Site	**3**	**log stump**	**18 9**						**51**					
YK1DJ1; 2 Log Jams at 400 m in Right Channel	Lateral LWD jam - 40m long	2	No Materials Required										Encourage flow spreading across the fan to limit downstream	Re establish a greater portion of flood flows down the right	Logs removed from jams are not to be ballasted or cabled
YK1BT1; Bar Top Stabilizing Logs on Five Yookwa Fan Bars	Logs on Bar Top 1	15	log	1	0.6-0.8	8	truck to site	1.1 (2000 kg equivalent)	2 per log	30	-	-	Encourage establishment of stable vegetation on bar surface.	Protect and stablise existing deposits of coarse sediment. Reduce mobilisation of existing ghravels and encourgae further deposition.	Logs not ballasted sufficiently to prevent shifting.
	Logs on Bar Top 2	15	log	1	0.6-0.8	8	truck to site	1.1 (2000 kg equivalent)	2 per log	30	-	-			
	Logs on Bar Top 3	15	log	1	0.6-0.8	8	truck to site	1.1 (2000 kg equivalent)	2 per log	30	-	-			
	Logs on Bar Top 4	15	log	1	0.6-0.8	8	truck to site	1.1 (2000 kg equivalent)	2 per log	30	-	-			
	Logs on Bar Top 5	15	log	1	0.6-0.8	8	truck to site	1.1 (2000 kg equivalent)	2 per log	30	-	-			
	Total at Site	**75**	**log**	**75**						**150**					
YK1RR1; Eroding Bank at 0+400 m	Spur 1	1	-	-	-	-	-	-	-	-	160	1100	Slow channel widening and shallowing; reduce downstream transport of coarse sediment to high fisheries value reach in Sebalhall River	Protect eroding bank	Riprap spurs
	Spur 2	1	-	-	-	-	-	-	-	-	180	1100			
	Spur 3	1	-	-	-	-	-	-	-	-	170	1100			
	Spur 4	1	-	-	-	-	-	-	-	-	170	1100			
	Spur 5	1	-	-	-	-	-	-	-	-	160	1100			
	Spur 6	1	-	-	-	-	-	-	-	-	170	1100			
	Total at Site	**6**									**1010**	**1100**			

Table 3: Estimated Construction Costs for Instream Projects

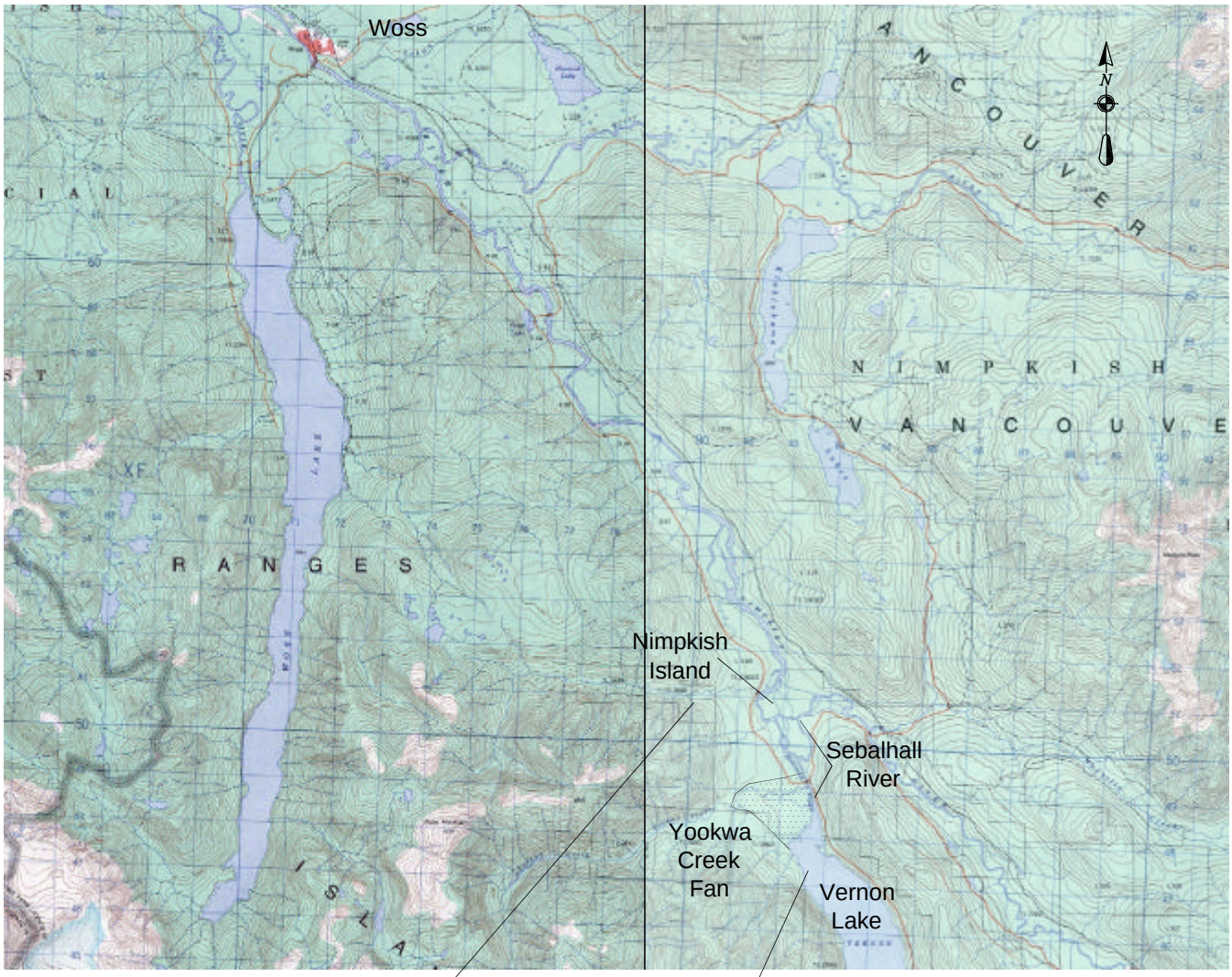
Project Sites	Construction Costs								Labour Tasks	Misc. Materials Required	Comments
	Materials		Labour ($)	Contracted Machines		Misc. Equipment Charges ($)	Project Supervision ($)	**Total ($)**			
	Misc. ($)	Logs and Riprap [1] ($)		Heavy Machinery ($)	Helicopter [2] ($)						
Yookwa Creek											
YK1DJ1	-	-	-	$1,500	-	-	$500	**$2,000**		-	No cabling moved LWD; equipment costs to move logs
YK1LWD1	$1,000	$1,050	$12,000	$9,000	$0	$500	$8,000	**$31,600**	Cable structure together and attach anchor boulders	Cables and clamps	Assume delivery of material along LB access road.
YK1LWD3	$1,000	$900	$12,000	$9,000	$12,750	$500	$8,000	**$44,200**	Cable structure together and attach anchor boulders	Cables and clamps	Helicopter delivery of all rocks and logs to point bar opposite the eroding bank
YK1BT1	$4,000	$2,250	$20,000	$12,000	-	$500	$8,000	**$46,800**	Attach boulder anchors	Cables and clamps	Assume logs delivered to site by self-loading log truck and rock trucks deliver rocks out onto bars.
YK1RR1	$4,000	$7,100	$2,000	$18,000	$0	$500	$9,600	**$41,200**	Remove logs, lay geotextile	Geotextile	Rocks delivered directly to site by rock truck, construction supervisor on-site at all times.

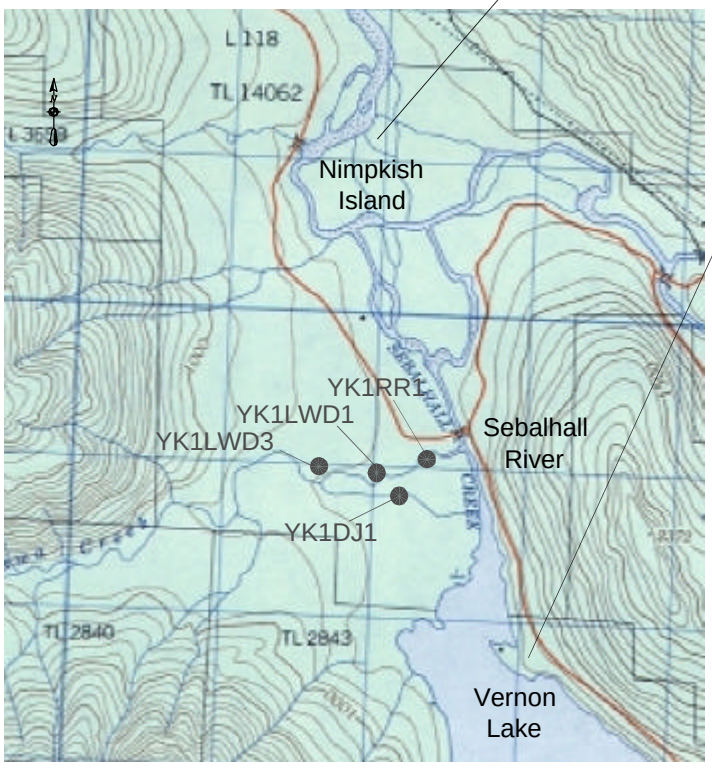
Notes:

1 - Assumes $\$30/m^3$ for logs and $\$7/m^3$ for developing riprap. Contracted machinery costs to deliver materials is included in the heavy machinery estimates.

2 - Helicopter may be substituted for some equipment charges if anchors are flown to sites.

FIGURES





NHCV figure 1

NIMPKISH RESTORATION 2005

Yookwa Creek Restoration Sites
Location Figure

northwest hydraulic consultants

Figure 1

Aerial Photograph: SRS 6345 #5,
Nominal scale: 1:4,000 Approx.

Photo 1: Downstream log jam at 0+500m

Photo 2: Upstream log jam at 0+530m

Legend:

Area of log jam to realign

NHCV log jams

NIMPKISH RESTORATION 2005

Yookwa Creek Prescriptions

YK1DJ1 - Log Jams at 0+500m

Photographs

northwest hydraulic consultants

Figure 2

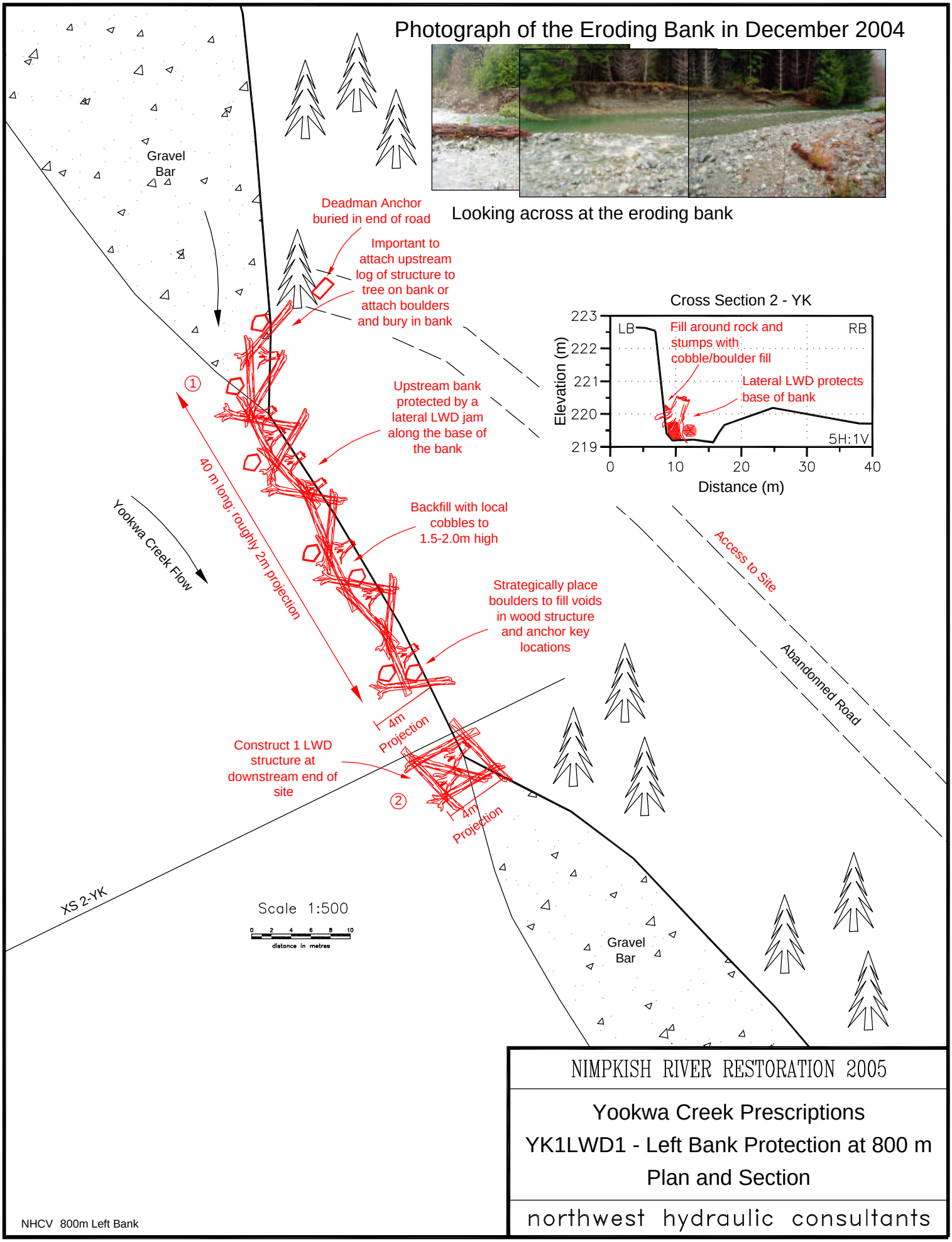

Photograph of the Eroding Bank in December 2004
Looking across at the eroding bank
Gravel Bar
Deadman Anchor buried in end of road
Important to attach upstream log of structure to tree on bank or attach boulders and bury in bank
Upstream bank protected by a lateral LWD jam along the base of the bank
Backfill with local cobbles to 1.5-2.0m high
Strategically place boulders to fill voids in wood structure and anchor key locations
Construct 1 LWD structure at downstream end of site
40 m long; roughly 2m projection
4m Projection
4m Projection
Yookwa Creek Flow
Access to Site
Abandonned Road
XS 2-YK
Scale 1:500
distance in metres
Gravel Bar
Cross Section 2 - YK
LB
RB
Fill around rock and stumps with cobble/boulder fill
Lateral LWD protects base of bank
5H:1V
Elevation (m)
Distance (m)
223
222
221
220
219
0
10
20
30
40
NIMPKISH RIVER RESTORATION 2005
Yookwa Creek Prescriptions
YK1LWD1 - Left Bank Protection at 800 m
Plan and Section
northwest hydraulic consultants
NHCV 800m Left Bank

Figure 3

Photographs of the Eroding Bank in February 2005

Looking across at the bank from the edge of the bar

Looking upstream at the bank

Low alder covered floodplain

Important to attach upstream log of structure to tree on bank or attach boulders and bury in bank

Upstream bank protected by a lateral LWD jam along the base of the bank

① 40 m long; roughly 2m projection

Yookwa Creek Flow

Backfill with local cobbles to 1.5-2.0m high

Strategically place boulders to fill voids in wood structure and anchor key locations

4m Projection

Construct 1 typical LWD spur at downstream end of site

② 4m Projection

Cable and ballast natural LWD

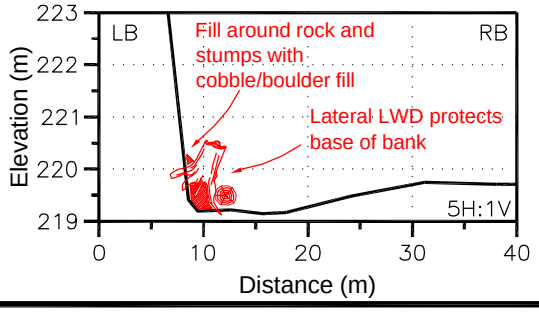
Gravel Bar

Gravel Bar/Some Vegetation

Scale 1:500

0 2 4 6 8 10 distance in metres

Cross Section 2 - YK



NHCV 800m Left Bank

NIMPKISH RIVER RESTORATION 2005

Yookwa Creek Prescriptions

YK1LWD3 - Left Bank Protection at 1000 m

Plan and Section

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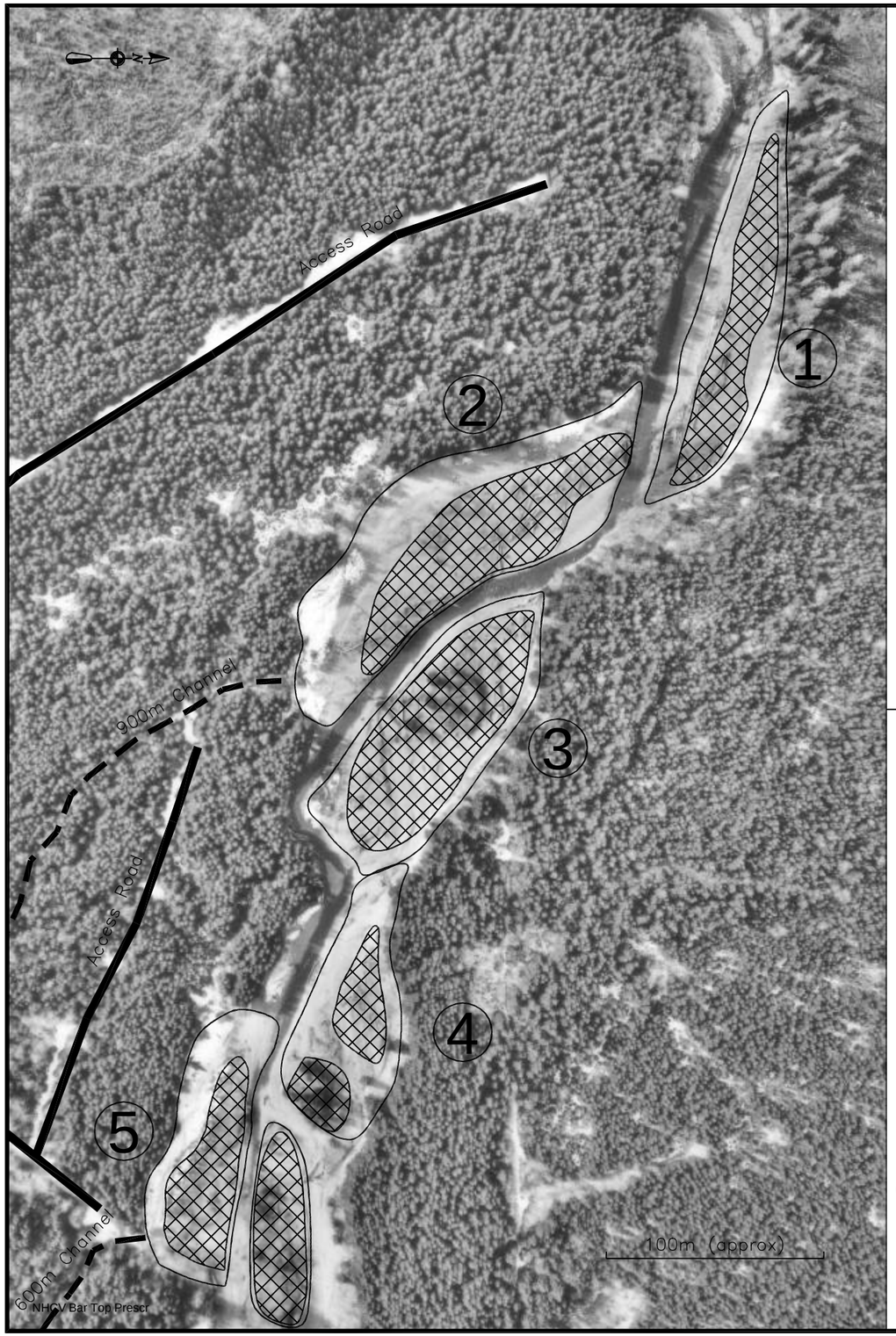
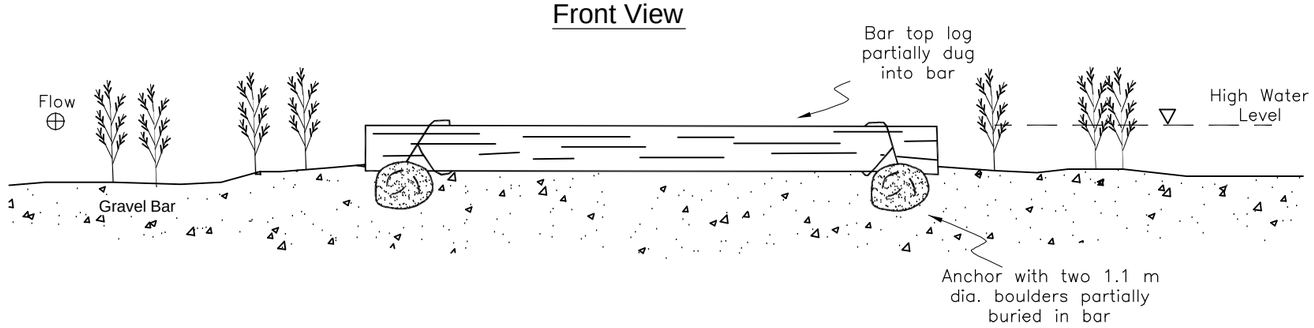
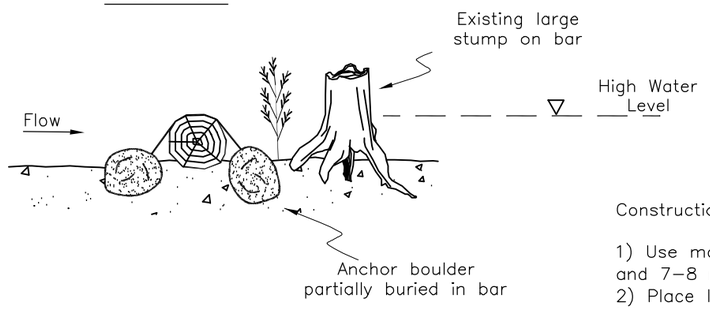
Figure 4



Front View



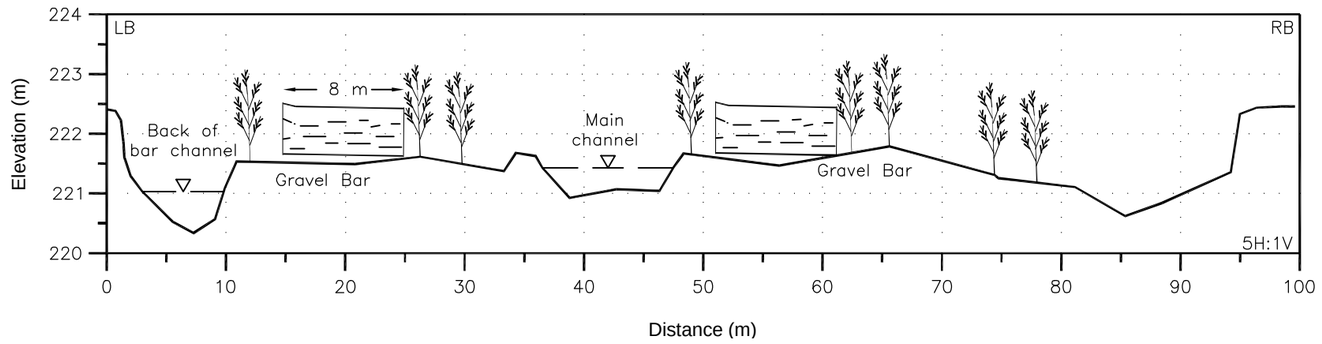
Side View



Construction Notes:

1) Use maximum log size available on bar tops (min. 0.6m diameter and 7–8 m long).
2) Place log on bar perpendicular to expected flow direction. Set log into bar surface using excavator.
3) Attach boulder anchors with steel cable and clamps. Partially bury boulder anchors.

Typical Cross Section



Bar Outline

3 Bar number (See text for priority)

Vegetated portion of bar

NIMPKISH WATERSHED RESTORATION 2005

Yookwa Creek Prescriptions
YK1BT1 - Bar Top Stabilisers
Plan and Typical Section

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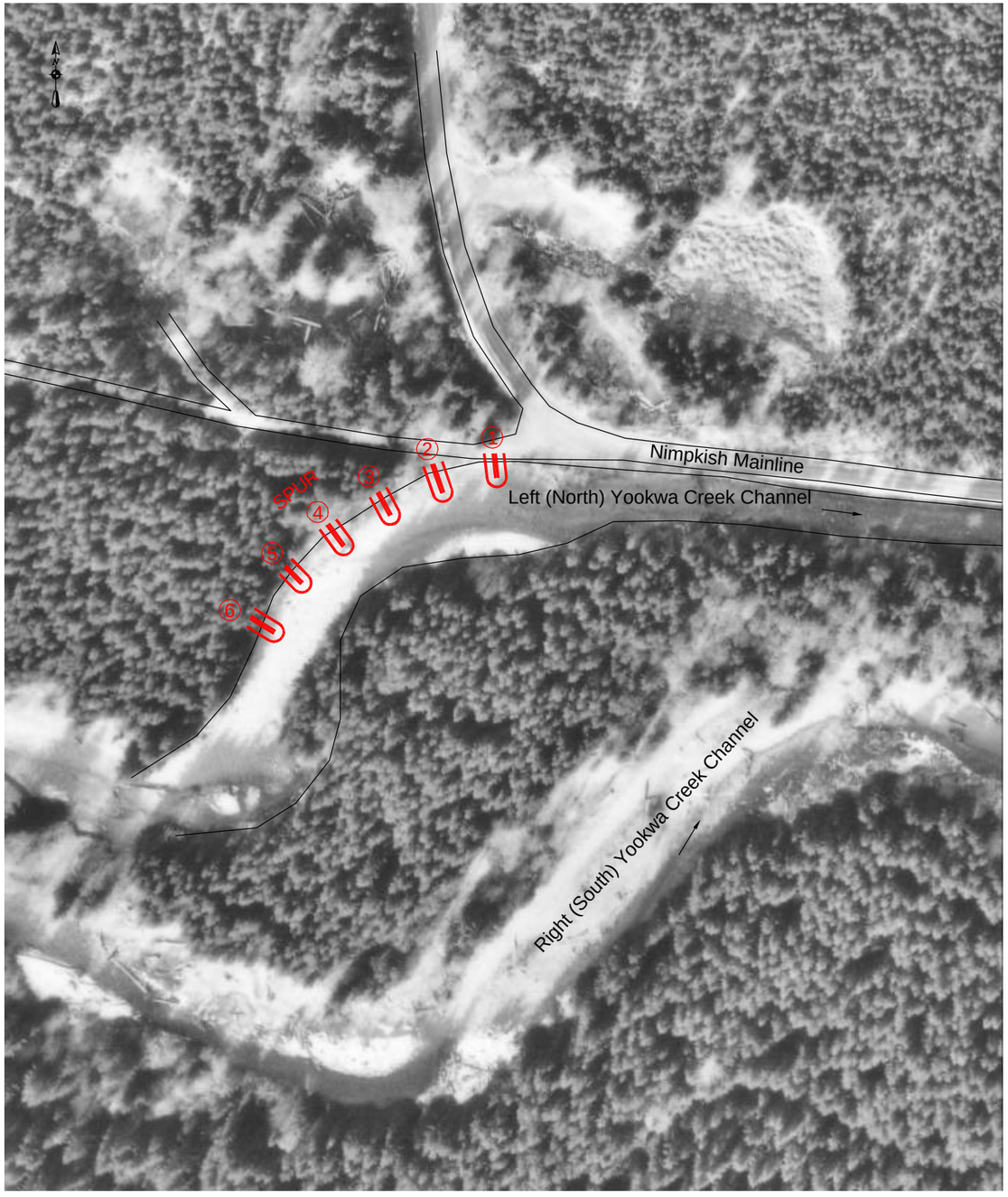
Figure 5

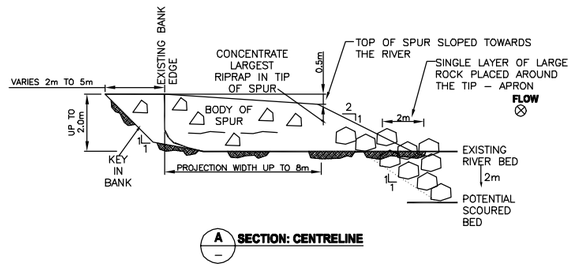


Scale 1:2,000

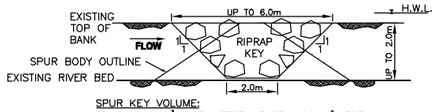
0 10 20 30 40 50

distance in metres

NHCV 400m protection

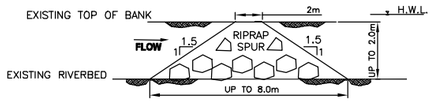


A – SECTION: CENTRELINE



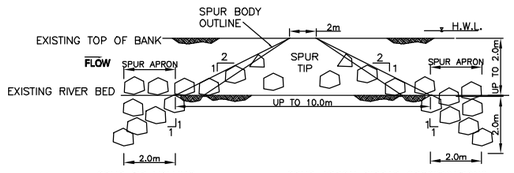
SPUR KEY VOLUME:
SPUR 1: 8 m³ PER METRE LENGTH; 20 m³ TOTAL.
SPUR 2: 8 m³ PER METRE LENGTH; 20 m³ TOTAL.
SPUR 3: 8 m³ PER METRE LENGTH; 20 m³ TOTAL.
SPUR 4: 8 m³ PER METRE LENGTH; 20 m³ TOTAL.
SPUR 5: 8 m³ PER METRE LENGTH; 20 m³ TOTAL.
SPUR 6: 8 m³ PER METRE LENGTH; 40 m³ TOTAL.

B – SECTION: SPUR KEY



SPUR BODY VOLUME:
SPUR 1: 10 m³ PER METRE LENGTH; 60 m³ TOTAL.
SPUR 2: 10 m³ PER METRE LENGTH; 80 m³ TOTAL.
SPUR 3: 10 m³ PER METRE LENGTH; 70 m³ TOTAL.
SPUR 4: 10 m³ PER METRE LENGTH; 70 m³ TOTAL.
SPUR 5: 10 m³ PER METRE LENGTH; 60 m³ TOTAL.
SPUR 6: 10 m PER METRE LENGTH; 50 m³ TOTAL.

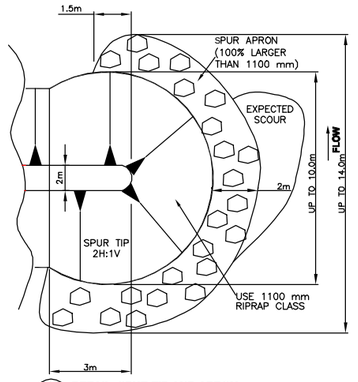
C – SECTION: SPUR BODY



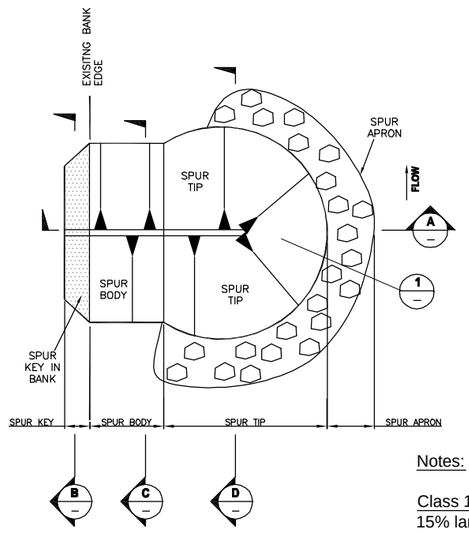
SPUR TIP VOLUME:
SPUR 1 to 6: 80 m³ TOTAL.

SPUR APRON RIPRAP SPECIFICATIONS:
100% LARGER THAN 1100 mm.

D – SECTION: SPUR TIP



1 – DETAIL: SPUR TIP AND APRON



OVERHEAD VIEW: DEFINITIONS
(GENERAL SPUR LAYOUT)
SEE DETAIL 1 FOR ACTUAL LAYOUT.

Notes:

Class 1100 mm
15% larger than 1600 mm
50% larger than 1100 mm
85% larger than 500mm

Spurs

#	Distance	Projection	Volume
1	0+400m	6m	160 m³
2	0+420m	8m	180 m³
3	0+440m	7m	170 m³
4	0+460m	7m	170 m³
5	0+480m	6m	160 m³
6	0+500m	5m	170 m³

Photograph of the Eroding Bank in February 2005

Looking upstream at the eroding bank

NIMPKISH RESTORATION 2005

Yookwa Creek Prescriptions
YK1RR1 - Riprap Spurs at 400m
Plan, Photographs and Typicals

northwest hydraulic consultants

Figure 6