EBENEZER FLATS/KIDD ROAD
EROSION PROTECTION STUDY
DRAFT

SUBMITTED TO
REGIONAL DISTRICT OF BULKLEY-NECHAKO

Submitted by

McElhanney Consulting Services Ltd.
1633 First Avenue
Prince George BC V2L 2Y8

October 2008
Our File: 2331-00650-0

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Appendices

1. Introduction

McElhanney Consulting Services Ltd. (MCSL) was retained by the Regional District of Bulkley-Nechako to conduct an erosion protection study for the Ebenezer Flats/Kidd Road area along the Bulkley River northeast of the Town of Smithers. The Terms of Reference for this report are dated December 2007 and also detailed in MCSL's proposal dated January 11, 2008.

2. General Site Description

The Bulkley River flows in a northerly directly through the Town of Smithers and past the Ebenezer Flats and Kidd Road area (Figure 1). Several large rural properties are located on the right bank of the Bulkley River along with undeveloped treed areas. The area is generally flat floodplain and property use is rural residential and light farming. The main roads in the area are Lower Viewmount Road on which a school is located, Columbia Street, 22nd Avenue, Scotia Street and Kidd Road.

The study area focuses on the right bank but it should be noted that the proposed erosion protection works may have impacts on the left bank.

3. Scope of Work

The project is divided into two distinct phases. The first phase is covered by this report and includes

- Identification of erosion protection works:
  - Identification of areas subject to erosion
  - Recommendations of types and locations of erosion protection works
  - Recommendations regarding maintenance works required
  - Identification of constraints, limitations and difficulties associated with the erosion protection works
- Identification of costs
- Identification of property owner implications
- Presentation of the above to the Regional District Board

The second phase of the project will depend on the support of the Regional District Board and will include:

- Identification of project support, including public consultation and polling
- Identification of right-of-way access requirements

The second phase is not covered in this report.

4. Available Information

The identification of necessary erosion protection works requires an understanding of the processes involved in erosion including the historical movement of the river, riverbank soil types, hydrology of the Bulkley River, and anecdotal evidence from local residents and observers.

4.1. Airphotos

Hard copies of airphotos covering the project area were ordered from the GeoBC, the Provincial Crown Land registry and geographic base. The airphotos covered the following

REGIONAL DISTRICT OF BULKLEY NECHAKO
EBENEEZER FLATS & KIDD ROAD

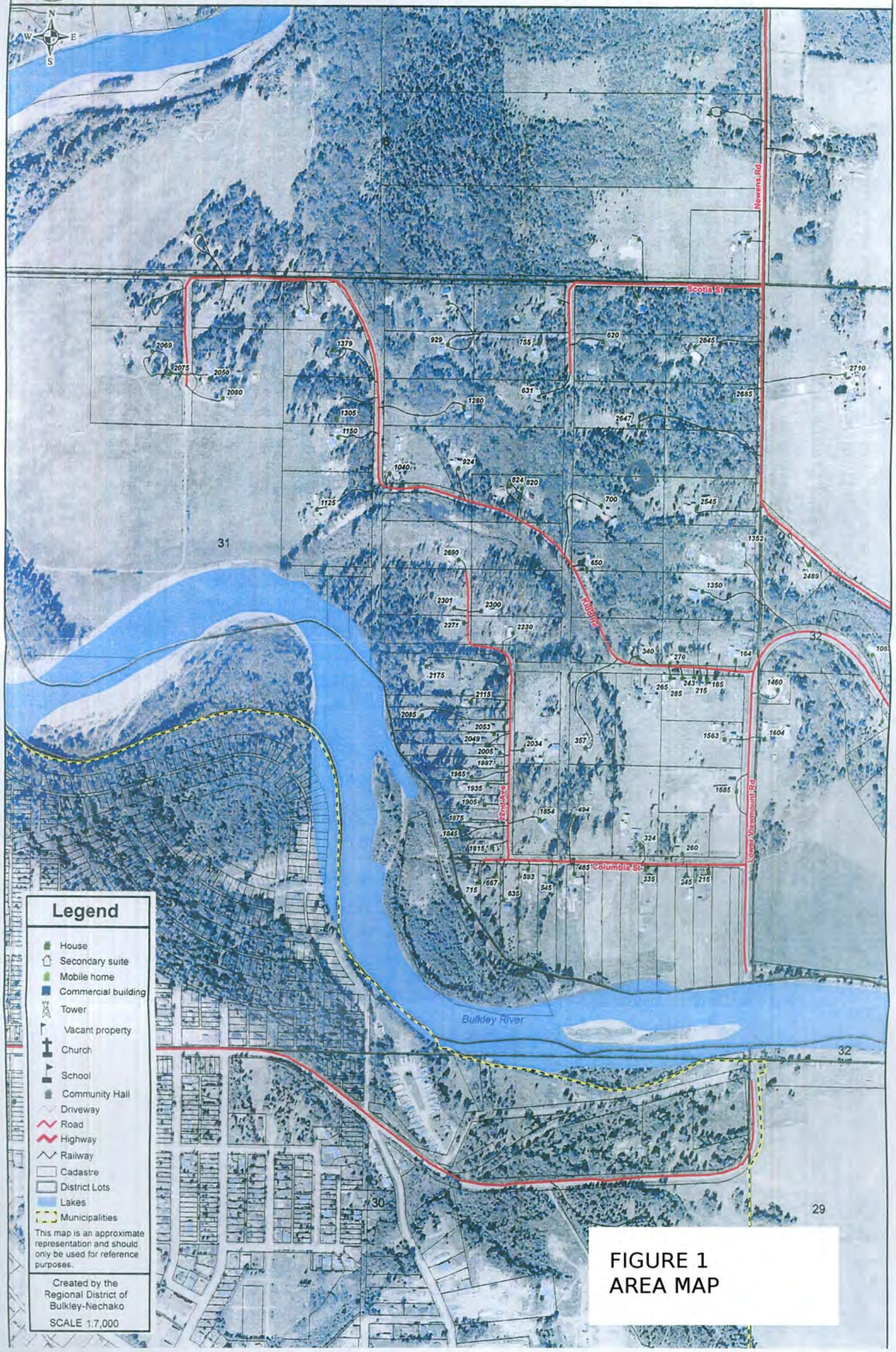


FIGURE 1
AREA MAP

years: 1952, 1953, 1956, 1969, 1978, 1982, 1992, 1993, 2003, and 2006. The airphotos were then scanned digitally and photo-mosaics were created to allow for review of the entire area.

The banks of the Bulkley River from each photo-mosaic were then traced in AutoCAD and reduced to a common scale. This allowed a graphical representation of the bank movement of the Bulkley River from 1952 to 2006. The results of this mapping are shown in Appendix A. General observations from the airphotos are discussed in a later section of this report.

4.2. Previous Documents

The Regional District of Bulkley Nechako forwarded a copy of the document “Flood Protection Request for the Ebenezer Flats and Kidd Road Area” prepared by Gil Cobb and Geri Brown. This document was reviewed for background information. The document contains useful anecdotal data from the 2007 flood including photos of the areas of concern.

4.3. Water Survey of Canada Data

The Bulkley River is gauged by the Water Survey of Canada (WSC) at five separate locations. Some of the stations are not relevant as they are located too far upstream or downstream of Smithers, or contain too few years of data. The stations that were used to determine the flood flows for the Ebenezer Flats area were:

08EE004 Bulkley River at Quick, 1930 to 2008, drainage area 7350 sq.km
08EE005 Bulkley River at Smithers, 1946 to 1971, drainage area 8940 sq.km

The extrapolation of the Quick station data to Smithers is described in a later section.

4.4. Residents Questionnaire

A letter was circulated by the Regional District to request information from private land owners regarding past flood events on their properties. So far 15 forms have been received. To protect privacy concerns, names, addresses and specific responses related to properties have not been included in this public report.

The residents were asked if their properties had experienced flooding and in which years. They were also asked if loss of property due to bank erosion had been experienced. Obviously the responses depended on the location of the property.

A summary of the responses is shown on the following table.

Question	Yes	No
1. Experienced flooding previously?	12	3
2. Bank erosion?	8	7
3. Bank erosion caused property or building loss?	6	9
4. Work done to protect property?	8	7

Of the locations that experienced flooding, one respondent on Kidd Road noted that the flooding at their location was not a direct result of surface water but was due to high groundwater as a result of the flood.

5. Field Investigation

A site visit was conducted by William Cheung PEng on August 26, 2008. He was accompanied for a portion of the site visit by Mr Jeremy Penninga, Area A Director for the Regional District of Bulkley Nechako. The site visit began at the foot of Lower Viewmount Road at the old bridge abutment and followed the bank of the Bulkley River to the west. This area was noted by Mr Penninga as one of two sites of major erosion concern. The other main area of concern is at the end of Kidd Road.

During the site visit, photos were taken of the important features and coordinates of the photos were recorded using a handheld GPS. Reference maps showing the locations of the GPS waypoints are included in Appendix B along with the numbers of photos taken at each location. Site photos are included in Appendix C. When site photos are referenced in this report the "IMG_" portion of the filename will be omitted.

5.1. Riverbank from Lower Viewmount Road to approx 22nd Avenue

A review of the bank of the Bulkley River began at the old bridge abutment and proceeded west. Near the old bridge abutment, the bank and river bed material consist of gravels and cobbles to approximately 200mm in diameter. Further down the channel the bank and bed material appears to change to a finer sandy silt and no cobbles are seen. This change in bank material can be seen in photos 3736 and 3751 in Appendix C. The change in bank material also appears to coincide with the increased bank erosion seen in this area. This location also coincides with report of property loss from property owners.

The fine bank material can also be found in the treed area seen in photos 3769 to 3782. This area is vegetated and looks like it is the end of the major erosion. It is likely that the roots of the vegetation and trees are preventing some of the erosion from taking place, although evidence of the onset of erosion can be seen from the leaning trees.

From speaking with one of the landowners, this treed area is the upstream end of what was known as Beaver Island. Part of the channel between Beaver Island and the mainland is now dry for most of the year and can be seen in photo 3786.

5.2. Riverbank at the end of Kidd Road

Photos and measurements were also taken at the end of Kidd Road on the bank of the Bulkley River (see GPS waypoint 41 in Appendix B). At this location the Bulkley River has eroded the banks such that there is a vertical or undercut face at depths ranging from 1.2 to 1.6 metres. The overburden on top of the cobbles and gravel is similar to the material found at the end of Lower Viewmount Road. At this location the river jumped its banks and flowed north through the field, eventually making its way back into the main channel. A sandbag dike setback from the river was built during the flood.

5.3. Columbia Street and 22nd Avenue

Columbia Street and 22nd Avenue were reviewed with Jeremy Penninga. He described how the water had jumped the banks of the river and flowed down 22nd Avenue on its way back to the main channel. The extent of flooding on each property depended on the elevation of the houses. In this area the water was slow-moving and erosion was not a problem.

5.4. South end of old Bulkley River Bridge Crossing

A review of the south end of the old Bulkley River crossing gave some interesting insight into the current behaviour of the river channel and allowed an overview of the right bank which is our area of interest in this project. There is a large gravel bar in the channel (photo 3824) and there is lateral flow from the right side of the channel toward the left side over top of the beginning of the gravel bar. Photo 3821 shows this lateral flow. Velocities in the left channel are approximately 2.5 to 3 m/s while the right channel is seeing velocities of around 1 m/s. The left bank is also experiencing bank erosion. The left bank is higher than the right bank and so the extent of erosion damage is greater.

5.5. Riverside Park

Just before the entrance into Riverside Park there is a bank failure that has been flagged off for safety reasons (photo 3828). This side of the river is being reviewed since there is a possibility that erosion protection works on the right bank may impact the left bank.

A portion of the riverbank of Riverside Park has some small (approx Class 5kg) riprap or shot rock placed on the bank. (photos 3838 and 3839).

5.6. Rosenthal Road

The Town of Smithers had advised us that one residence on Rosenthal Road along the left bank of the Bulkley River had experienced serious bank erosion and had already been relocated further away from the bank previously. The bank continues to fail and the property is the subject of a separate report by AMEC. (photos 3842 to 3850)

For purposes of this report, as stated previously, it is important to realize sensitive areas on the left bank even though it is outside of our study area.

6. Historical Floods and Analysis of Water Survey of Canada Data

6.1. General

Two Water Survey of Canada stations provide river flow data for our subject area. The Bulkley River gauge located at Smithers operated from 1946 to 1971. The Bulkley River gauge at Quick operated from 1930 to present, including the ability to show real-time data. However, the drainage area of the Bulkley River at Quick is 7350 square kilometres and the drainage area at Smithers, further downstream, is 8940 sq.km. In order to use the longer-term data in Smithers, the measured flows at Quick were increased by a ratio determined by correlating the flow data from years that both stations provided data. For example, in 1947 the peak flow at Quick was 538 cu.m/s while the flow the same day in Smithers was 714 cu.m/s. The average increase in Smithers flow over the Quick flow was 25%. Therefore, all Quick data was increased by this factor to synthesize peak flows in Smithers.

A graph of historic flows from 1931 to 2008 is shown in Appendix D.

6.2. Determination of Overbank Flow

Generally the determination of when flow is expected to overtop a river bank requires the use of detailed survey information, including bathymetric (stream bottom) information and computational hydraulic modelling. This is usually the case when the goal is to determine the 1 in 200 year floodplain or flood construction level. However, in this situation, the purpose of the hydrology was to determine a flow volume at which the Ebenezer Flats and Kidd Road areas typically became inundated. This was one of the purposes of the questionnaire which included a question asking which years the properties experienced flooding. The following years were mentioned by most residents:

1986, 1997, 2002, 2007

One respondent stated that their flood years were 1995, 1998, 2004 and 2008, which did not correspond to historic flow data or to other responses received.

The graph in Appendix D shows river flows for the period from 1931 to 2008. Reference to this graph shows that the year that flooding was reported by the majority of residents correspond to peak flow years. Further, as nobody stated that 1985 was a flood year in this area, we can assume that the flow volume which would be considered a flood would be something between 1985 and 1986 since the two years are quite close in flow magnitude. The flow rate that triggers the onset of overbank flow is assumed to be 850 cu.m/s. This flow is shown as the pink line on the historical flood graph.

6.3. Previous Overbank Flows

According to the analysis in Section 6.2, we can now determine previous years which may have had flooding in the Ebenezer Flats area based on the Water Survey of Canada data. The years that have measured flood peaks in excess of 850 cu.m/s are:

1934, 1935, 1936, 1942, 1948, 1957, 1962, 1964, 1968, 1972, 1976, 1986, 1997, 2002, and 2007.

It should be noted here that these are mainly freshet floods. The mechanism of ice jam floods can create overbank conditions at much lower flows. For example, a breakup ice jam in the Bulkley River destroyed the old Highway 16 bridge in April 1966[1] but this year did not experience excessive peak flows.

6.4. Return Period of Overbank Flows

The flow data from 1931 to 2008 were ranked in order of magnitude and plotted such that a linear regression relationship could be found between the flow and the probability of exceedence of each flow. Using this statistical method the following returns periods were estimated:

1 in 200 year flow = 1580 cu.m/s
1 in 100 year flow = 1444 cu.m/s
1 in 50 year flow = 1306 cu.m/s

This statistical analysis estimated that the 850 cu.m/s flow corresponds roughly to a 1 in 5 year return period. In comparison, the 2007 flood of 1250 cu.m/s corresponds to a 1 in 35 year return period.

"[1] Rainstorm and Flood Damage:Northwest British Columbia 1891–1991", D. Septer and J.W. Schwab, Land Management Handbook 31, BC MOF1995

7. Airphoto Review and Bank Movement Mapping

A review of the available airphotos from 1952 to 2006 showed that the Bulkley River has undergone significant changes in bank location. Rivers naturally meander within their banks and the Bulkley River shows this meander pattern. The process of meandering channels involves adjacent river reaches of aggradation and degradation.

Mapping of the riverbank changes was carried out using the airphotos and is shown in Appendix A. It should be noted that the edge of water was digitized in the mapping and variances can in part be attributed to differing water levels throughout the years.

Also notable is the original townsite cadastral or property line information near the bank of the river which is significantly different from the current river bank outline.

8. Identification of Erosion Protection Works

8.1. Locations of Erosion

There are two areas identified as having erosion leading to major property loss. These locations have been confirmed in the field and through air photo and mapping reviews. The first location is the right bank of the Bulkley River south of Columbia Street (centred on waypoint 32 Appendix B). Bulkley River flows are possibly deflected off the mid-stream gravel bar toward the bank.

The second location is at the end of Kidd Road (waypoint 41). This location is also on the outside of a bend in the river.

It should be noted here that a review of the 1993 airphotos shows clearly the old paths of the river channel through the fields. These paths were filled with water during the 2007 flood as could be seen in the photos in the report submitted by the residents. Although they will not be considered as dikes, any erosion protection work will need to take into consideration the possibility of deflecting flows into these channels. It is also understood that the mandate of this study is erosion protection, and that there is no possibility of preventing flooding within this floodplain area, especially given the permeable gravel soils.

8.2. Types of Erosion Protection Works

There are several alternate methods for erosion protection of the areas identified above. The list below is by no means exhaustive but has been coarse-filtered to remove those which are not considered relevant to this site. For example, concrete lining of the channel is not discussed.

Each method has its advantages and disadvantages which will be discussed briefly. The potential maintenance requirements will also be discussed.

8.2.1. Rock Riprap Bank Protection

Direct protection of the bank using blasted quarry rock riprap is the most basic and traditional method of bank protection. However, approvals for instream works may be difficult to obtain from the Ministry of Environment and the Department of Fisheries and Oceans. Instream work is necessary because the toe of the riprap slope needs to be keyed into the channel bottom for stability. Compensation works would likely be demanded of the project in the form of possible off channel habitat enhancement. Construction would take place during low water and possibly within a fisheries window. However, this method would result in minimal loss of usable property.

An important design consideration in the implementation of rock riprap is the crest or top height of the rock. If the rock is placed such that high flows are maintained within the river channel, careful review of potential downstream effects is necessary. This will be discussed in detail in a later section.

Maintenance of the rock riprap would require annual inspections and replacement of slumped or failed areas with additional gravel and rock. A dedicated service road would be needed to access the riprap bank with sufficient room for equipment mobilization.

8.2.2. Gabion Baskets

Gabion baskets consist of wire baskets filled with rock and anchored together on the bank of the river. Some considerations are similar to the concerns with rock riprap including the need for approvals if the baskets are constructed within the river channel. The advantage of the gabion basket system is that smaller diameter rock could be used to provide a similar level of protection to that of rock riprap. However, placement of the baskets and filling is more labour-intensive than placement of rock riprap. Another disadvantage of the gabion basket system is a less natural aesthetic.

Maintenance of the gabion baskets would require annual inspections and replacement as required of broken system components such as wire baskets and rock. Service road access to the gabion baskets would also be required.

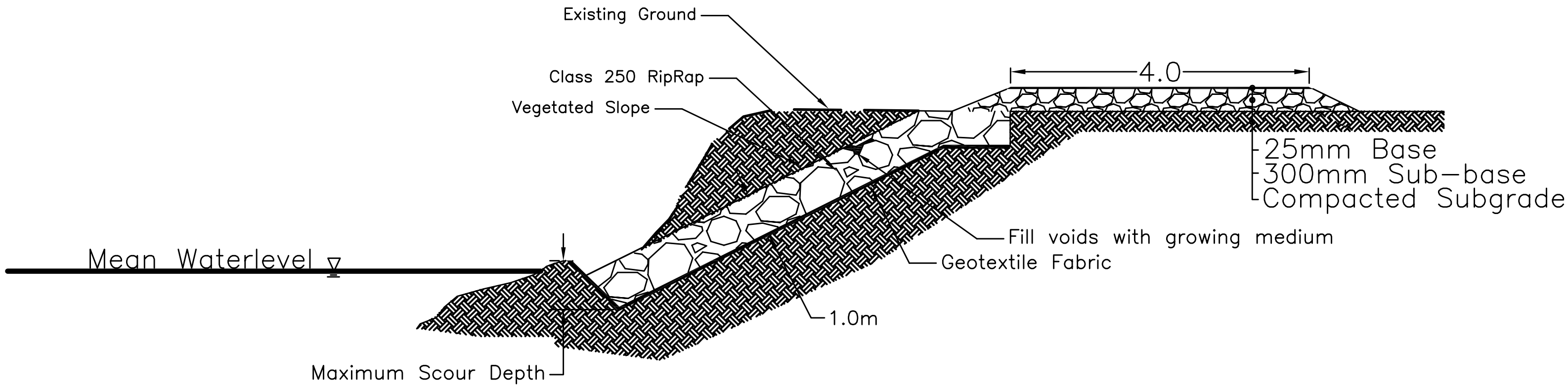
8.2.3. Setback Structures

Both the rock riprap and the gabion baskets can be constructed either along the stream bank or setback from the bank. The advantage of the setback structure is that there is no need to construct within the channel of the river and thus the approvals from MOE and DFO may be easier to obtain. There may also be less or no requirement for fisheries habitat compensation.

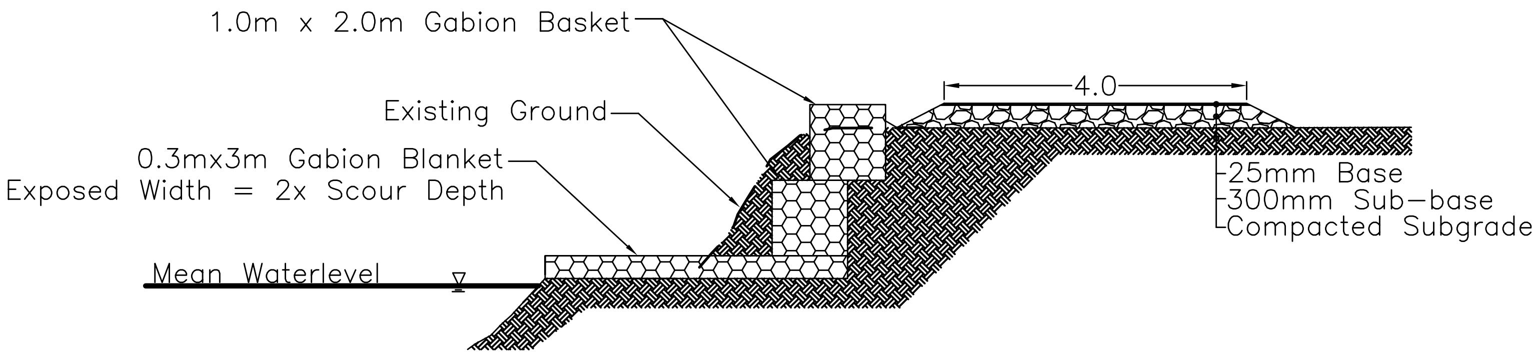
A setback structure will need to be keyed into the ground. During a flood situation the setback structure will not function until the water reaches it. The design of the setback structure should carefully consider the crest of height of the structure and the potential downstream effects of deflecting flows.

The major disadvantages of a setback structure include immediate loss of usable property on the river side of the structure, and potentially permanent loss of land that is not protected. There is a potential for the structure to eventually become the bank of the river as erosion progresses. Initial costs for a setback structure will be higher than surface placement of rock due to the need to excavate and then backfill the rock with native material.

A setback structure, whether constructed of rock riprap or gabion baskets, would have less annual maintenance requirements than a riverside structure since it is not constantly exposed to flow. Access to both sides of the structure would be possible during annual inspections, and replacement of components is simplified due to improved access.



Option A − Rip Rap



Option B − Gabion Baskets

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Regional District of Bulkley -Nechako

Erosion Protection Study

Bank Stabilization Options

Client Project No 2331-650-0
Client Drawing No
MCSL Project No. 2331−00650−0
Drawing No. 2331-650-1
Sheet 1 of 2
Revision

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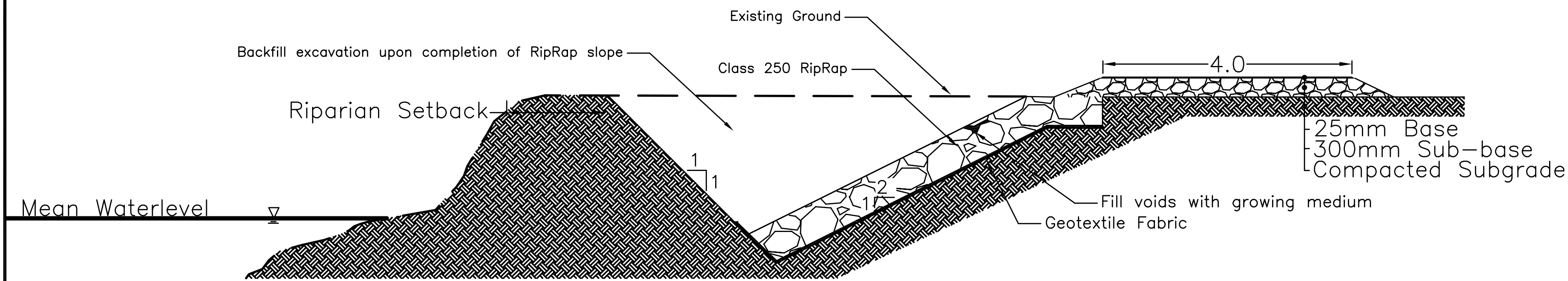
Option D – BioStabilization



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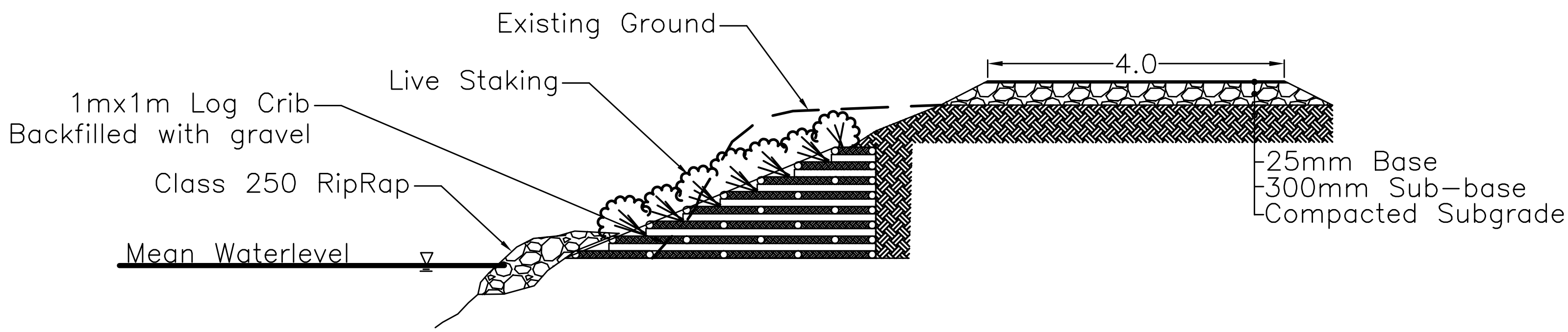

Option D – BioStabilization

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Erosion Protection Study

Bank Stabilization Options

Client Project No 2331-650-0
Client Drawing No
MCSL Project No. 2331–00650–0
Drawing No. 2331-650-2
Sheet 2 of 2
Revision

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8.2.4. Bioengineered Stabilization

Bioengineered stabilization is the use of live native vegetation by itself or in combination with other structural methods such as rock riprap or gabion baskets. The use of bundles of live willow shoots staked into the bank is one method of bioengineered stabilization. Live staking in gabion baskets is also a possibility.

One of the disadvantages of bioengineered stabilization is that the full results may not be immediate if used on their own. A growth period is required for the live vegetation to take root to stabilize the bank. Also, the implementation is more labour-intensive and requires specialized knowledge and experience for the choice of plant species and techniques. For use in high flow situations, such as the Bulkley River, a toe structure constructed with rock riprap is still recommended.

The main advantage of bioengineered stabilization is the creation of or the maintenance of natural habitat for fish and other wildlife. In a document prepared for the Watershed Restoration Program of the BC Ministry of Environment[2] the author shows a table of wildlife that utilize the vegetated riparian areas.

The Ministry of Environment and DFO may be more receptive to bank treatments using bioengineered stabilization than riprap or gabion baskets. There is also a possibility that the requirement for additional habitat compensation would be reduced.
Maintenance of the bioengineered stabilization system would require annual inspections and replacement of damaged vegetation as needed. A service road would be required to access the area.

9. Constraints and Limitations

9.1. Flood Protection

The erosion protection measures discussed in the previous section will not constitute a diking system. Flood protection for this area is difficult due to the permeable nature of the soils. Even if a river side dike were to be constructed, groundwater due to high river levels will still likely inundate the floodplain unless some form of impermeable cutoff trench were to be constructed. With the knowledge that the soils are permeable gravel to an unknown depth, it is unlikely that a cutoff trench would work.

9.2. Downstream and Opposite Bank Effects

One of the main concerns regarding hard armouring or bank erosion protection on the right bank of the river is the downstream and opposite bank effects. There have been anecdotal reports of erosion worsening on the right bank after the Town of Smithers placed rock riprap on the left side banks at Riverside Park.

If a dike were to be constructed on the right bank which constrained overbank flood flows to the main channel, it is very likely that increased erosion would occur on the opposite bank due to the increased flow diverted during high flood flows. To confirm or refute this conclusion would require a detailed three-dimensional computer or physical model which is beyond the scope of this study.

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[2] "Bioengineering Techniques for Streambank Restoration", Watershed Restoration Project Report No. 2, Martin Donat, 1995

Erosion protection that is not higher than the normal bank height of the river poses less of a risk to the opposite bank since overland flows through the old channel areas can still take place.

9.3. Water Act Approval

Construction of new bank erosion protection requires an Approval under Section 9 of the Water Act. Approvals are submitted to the Water Stewardship Division of the Ministry of Environment. There are differences between instream works which require "Notifications" and instream works which require "Approvals". Repair or maintenance of existing erosion control or bank protection would require Notification. However, since the work for Ebenezer Flats and Kidd Road would be considered new construction an Approval would be required.

"Failure to obtain an Approval, provide Notification, meet the conditions in an Approval, or meet the standards or requirements under the Water Act Regulation would be considered non-compliance with the Water Act and could result in significant penalties including imprisonment, pursuant to the Act."[3]

The steps required to submit an application for an Approval begin with contacting the Regional Water Stewardship office in Smithers.

10. Cost Estimates

10.1. General

Preliminary Class D cost estimates in 2008 dollars were prepared for each of the options described in the previous section. These cost estimates are based on rough material quantities determined using a typical cross section and estimate of length of proposed works. The unit costs used in the estimates are based on recent construction projects in Northern British Columbia. A 35 percent allowance for contingency and engineering has been included in the cost estimates.

We realize that there are possible savings in materials and labour from sources other than the commercial marketplace (i.e. donations, volunteer labour, etc.) but these have not been reflected in the pricing.

Cost estimates have been separated into the Ebenezer Flats and Kidd Road areas. Further discussion with the Regional District is necessary to determine the distribution of these costs to specific residences.

Cost estimate spreadsheets are included in Appendix E. A summary of costs rounded to the nearest thousand dollars is shown below.

[3] "Standards and Best Practices for Instream Works" MWLAP, 2004

10.2. Class D Cost Estimate Summary

A - Riverside Rock Riprap	
Ebenezer Flats	$293,000
Kidd Road	$377,000
B – Riverside Gabions	
Ebenezer Flats	$327,000
Kidd Road	$417,000
C – Setback Dike	
Ebenezer Flats	$368,000
Kidd Road	$499,000
D – Bioengineered Stabilization	
Ebenezer Flats	$395,000
Kidd Road	$474,000

11. Conclusions

Historically flooding has occurred on a regular basis on the Bulkley River near Smithers, specifically in the areas of Ebenezer Flats and Kidd Road. A relatively long period of low flood events seems to coincide with the increased development of the Bulkley Valley from 1973 to 1985. Kidd Road development does not appear on the 1982 airphotos and the 1978 airphotos shows no houses on 22nd Avenue. These areas can be considered to be relatively recently developed, considering the period of record that we have for streamflows. Obviously with increased habitation of the floodplain there are increased reports of flood events that affect property.

Flood protection of these properties is not within the scope of work of this report. Flood protection, however, given the permeable nature of the soils, is likely only possible by raising the main floor of the houses to above the Provincial 1 in 200 Year Flood Construction Level. Some residences have already done this and report no damage during a flood event.

Erosion protection of the lands directly adjacent to the Bulkley River is possible using different methods. This erosion protection needs to be carefully carried out to avoid downstream and opposite bank damage. However, prevention of large overland flows, especially those which can carry additional debris into properties should be considered since there is now a concentration of private residences within the former flood channels. The Town of Smithers should be given an opportunity to review any proposed riverbank works prior to construction to assess impacts on the left bank of the Bulkley River.

12. Closing

This report has been prepared by McElhanney Consulting Services Ltd. for the benefit of the Regional District of Bulkley-Nechako. The information and data contained herein represent MCSL's best professional judgement in light of the knowledge and information available to MCSL at the time of preparation. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the client, its officers and employees.

McElhanney Consulting Services Ltd. denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this document or any of its contents without the express written consent of MCSL and the RDBN.

Please contact us if you have any questions on the above.

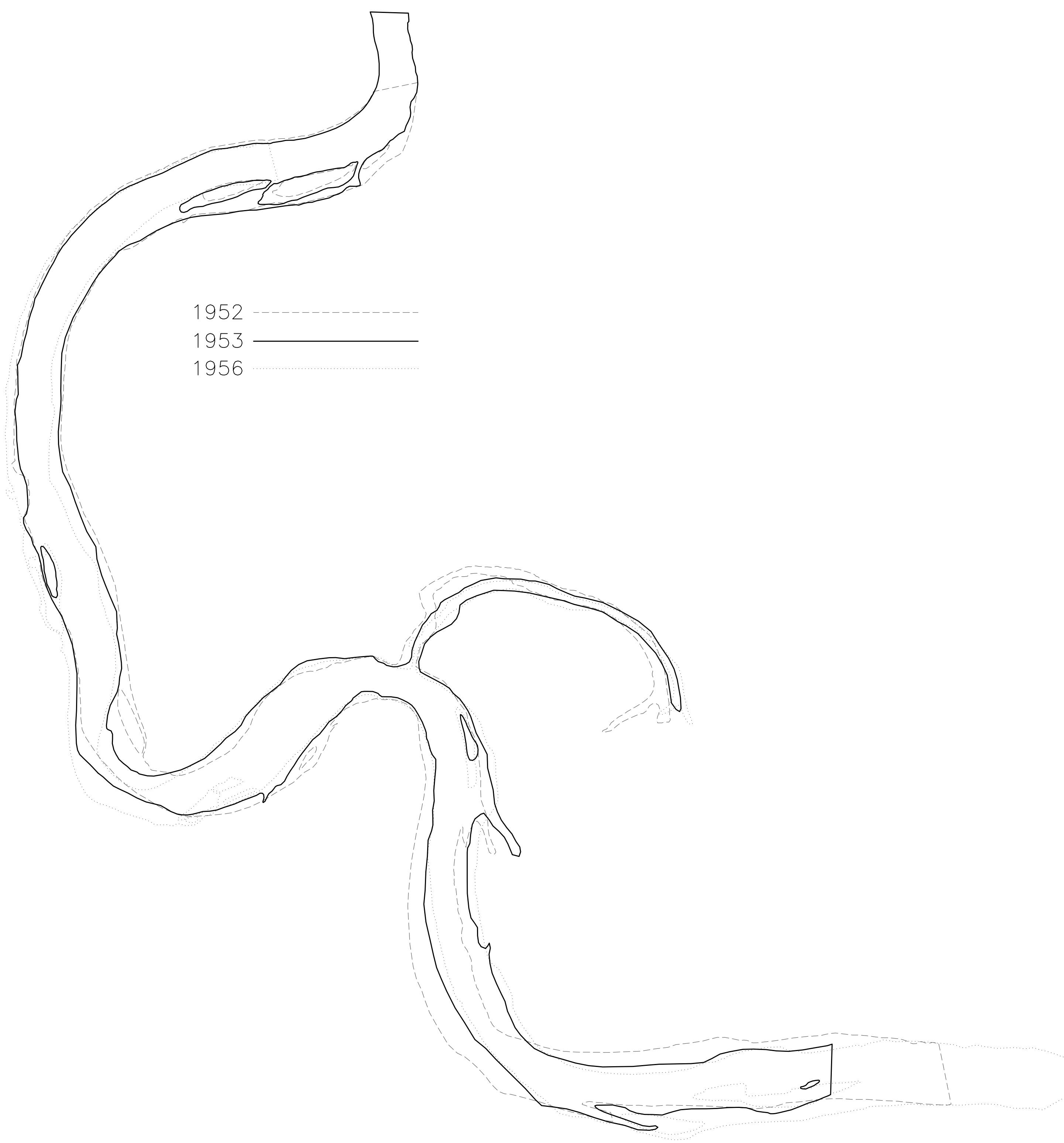
Respectfully submitted,

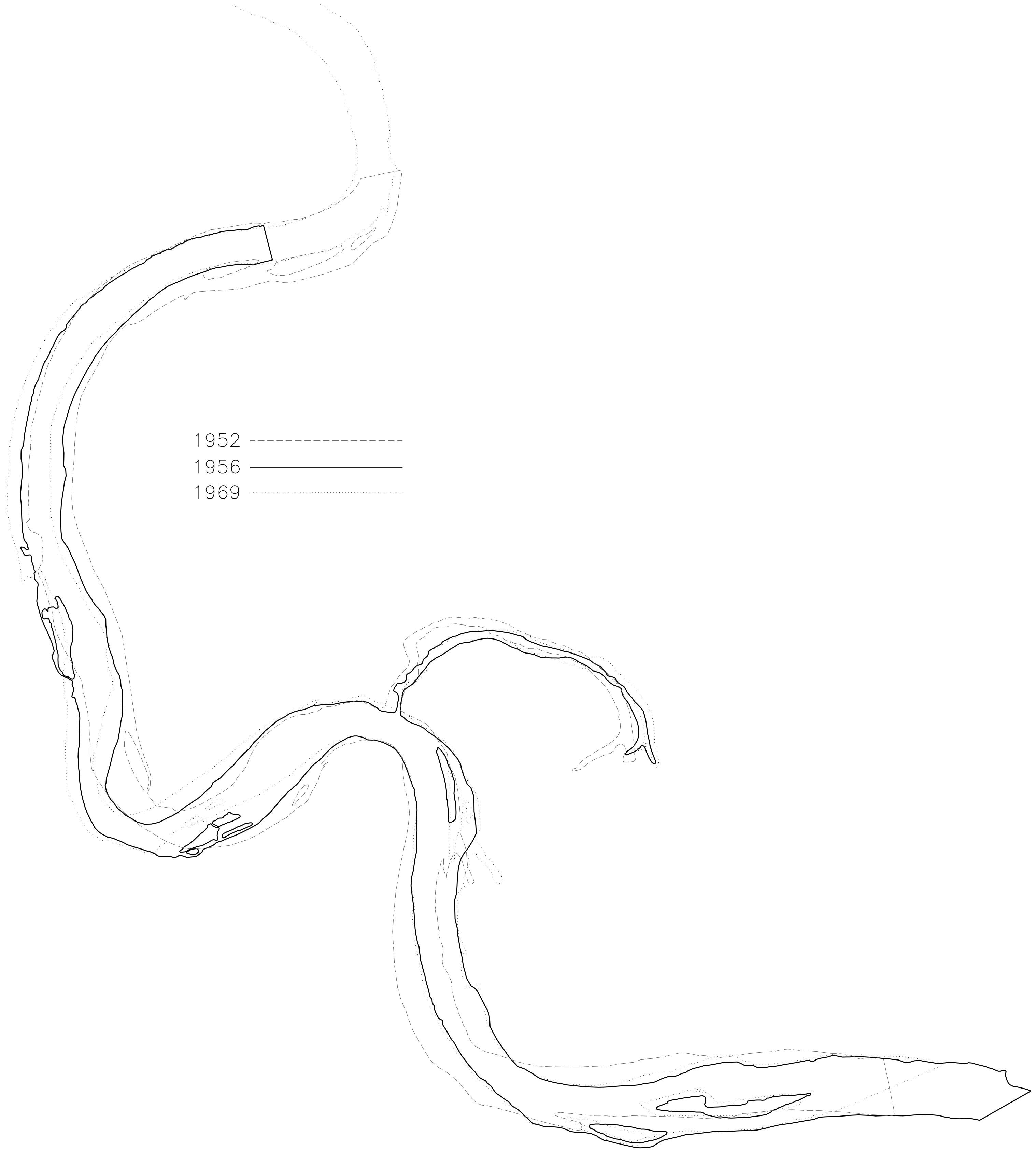
McElhanney Consulting Services Ltd.

William Cheung PEng
Assistant Branch Manager
Prince George Branch

APPENDIX A

Bulkley River Bank Movement Maps





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REGIONAL DISTRICT OF BULKLEY-NECHAKO

EBENEZER FLATS / KIDD ROAD
HISTORIC MIGRATION OF THE BULKLEY RIVER
1953 TO 1969

Client Project No
Client Drawing No
MCSL Project No. 2331–0650–0
Drawing No. 0650-01
Sheet 1 of 4
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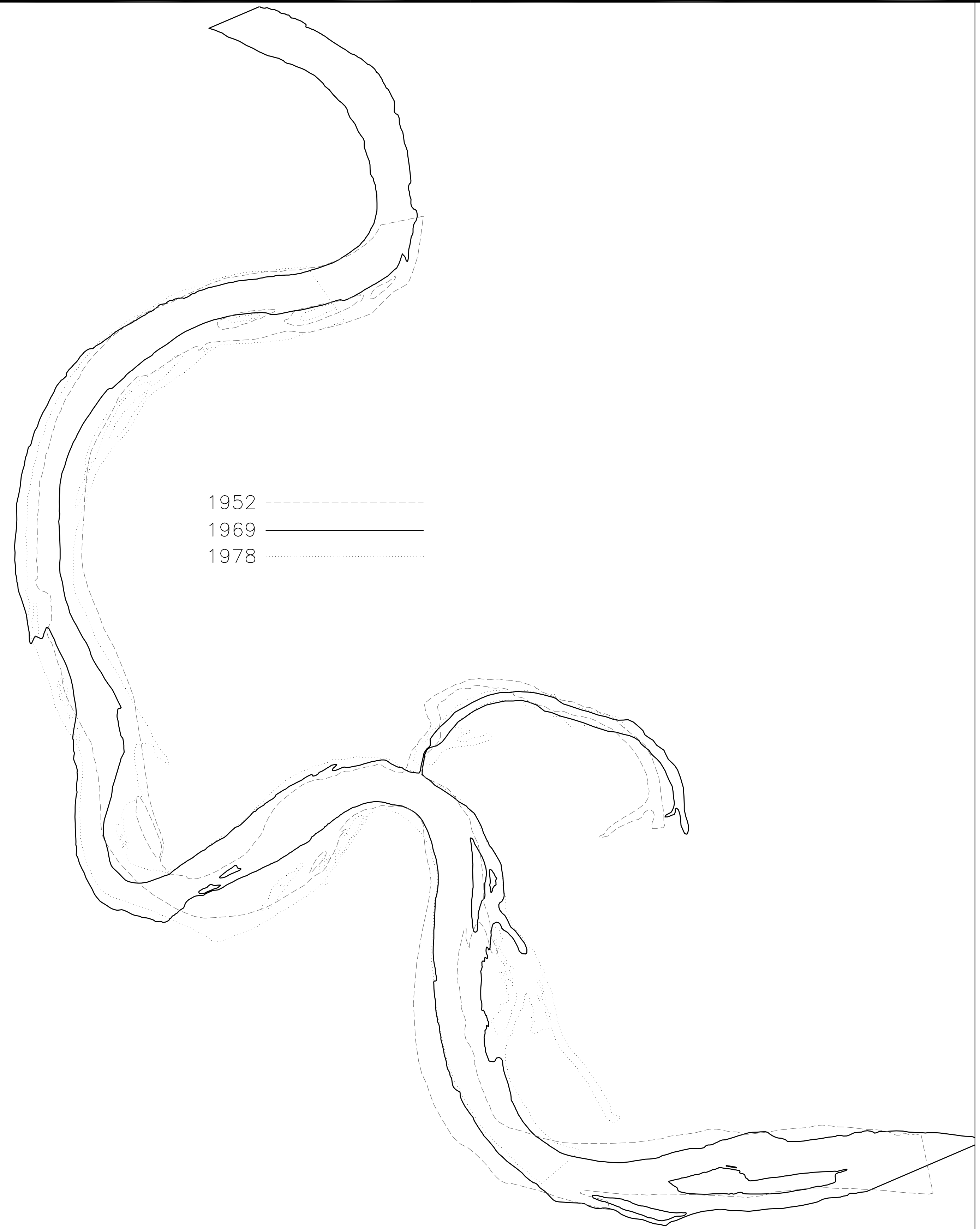

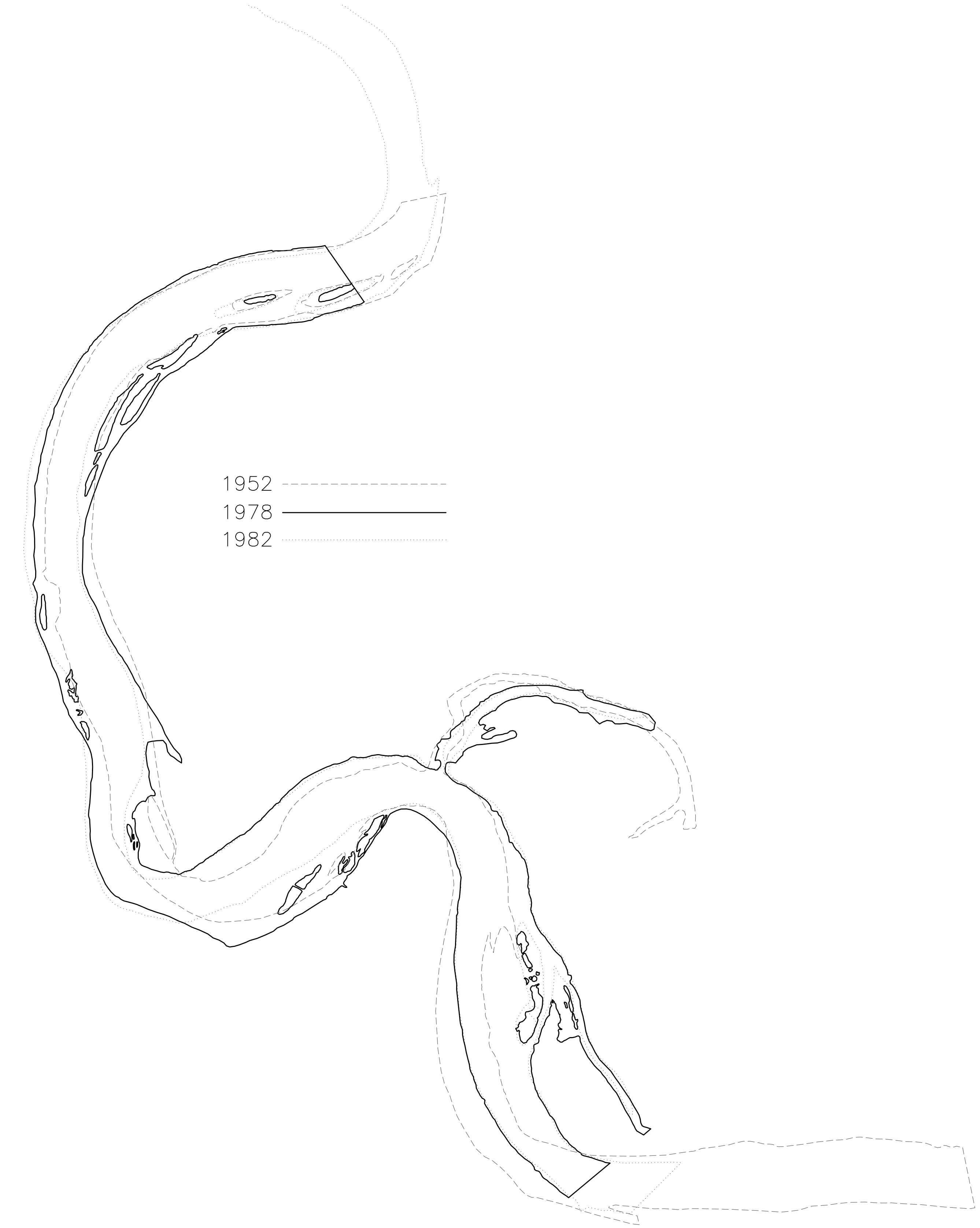

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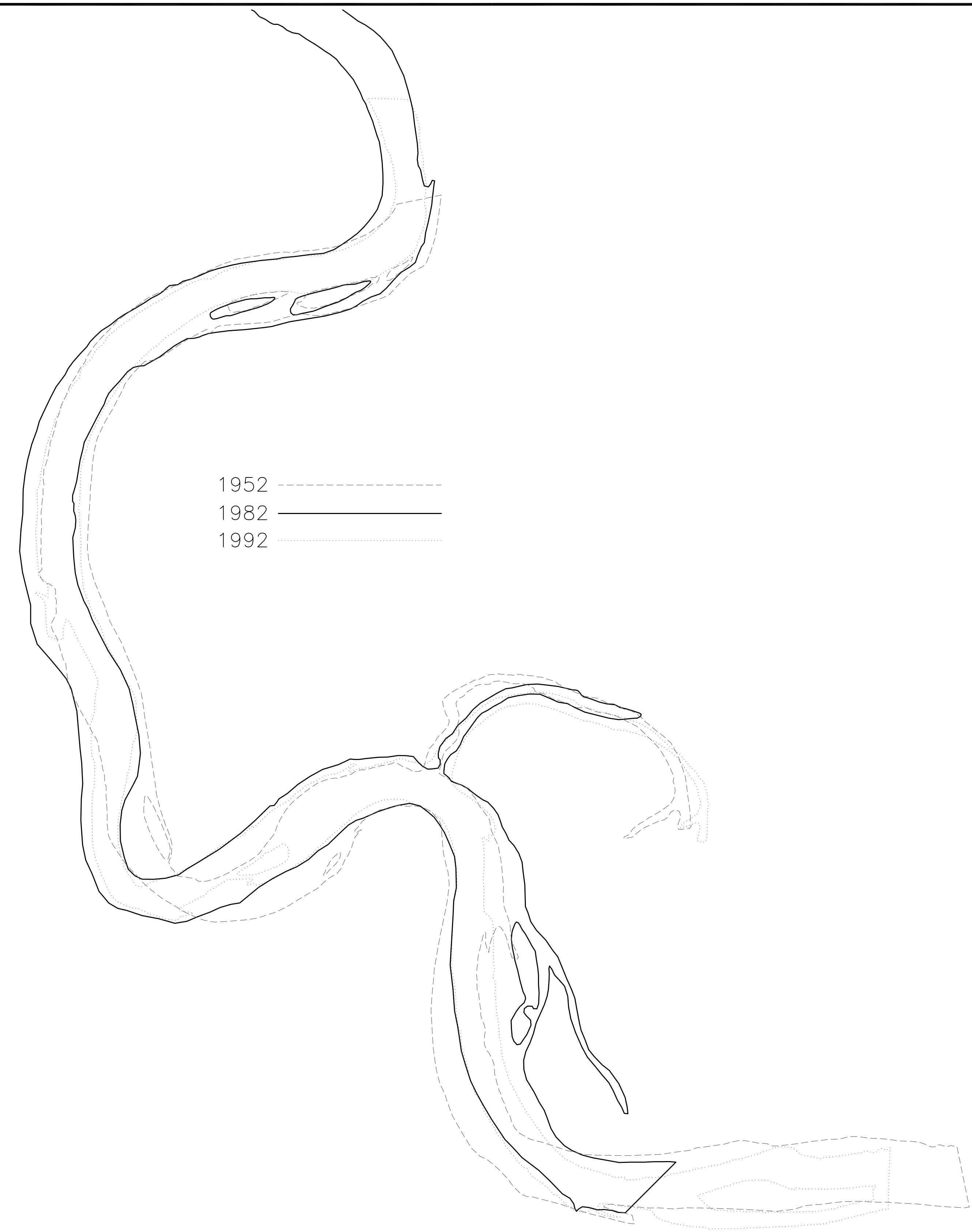
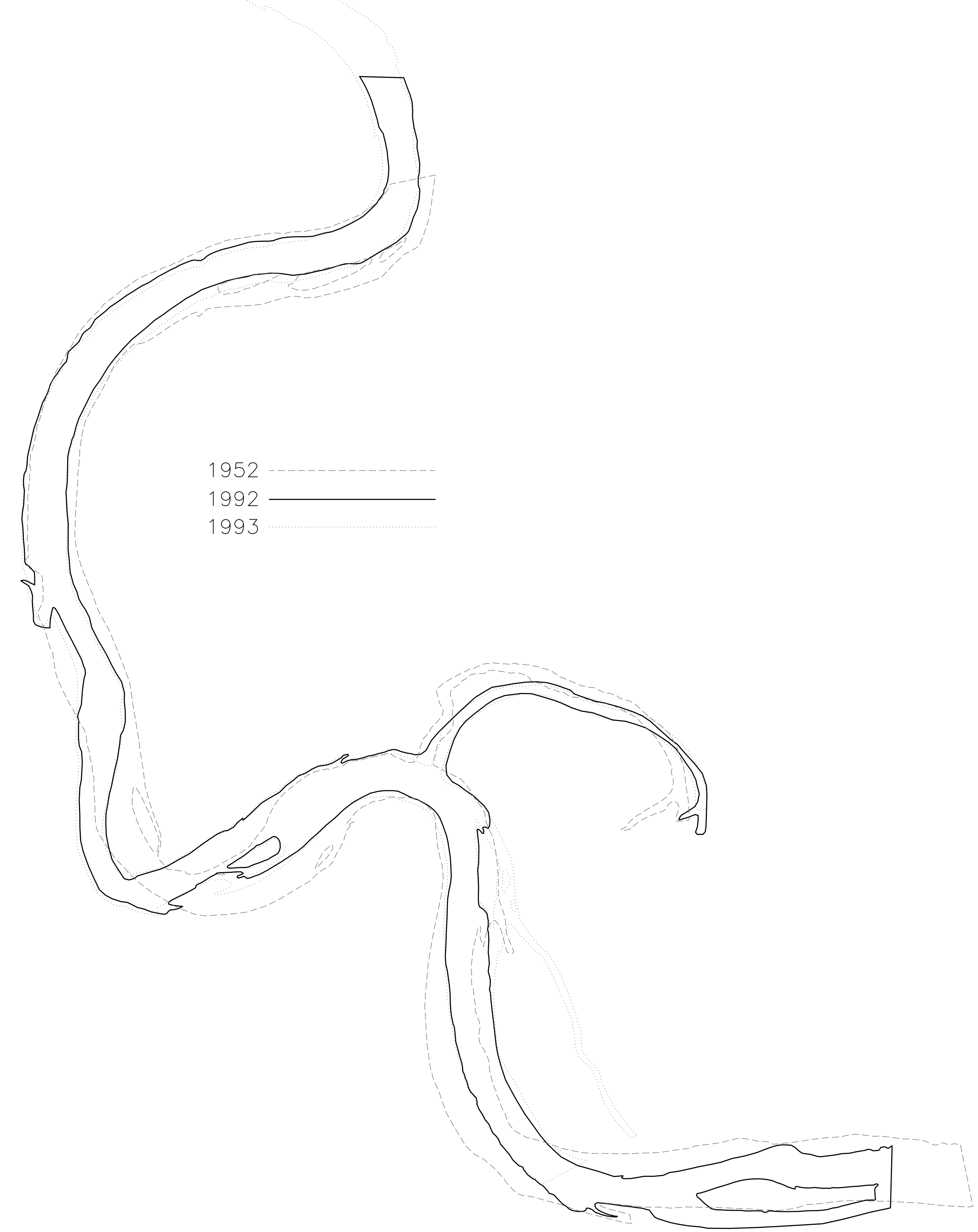
EBENEZER FLATS / KIDD ROAD
HISTORIC MIGRATION OF THE BULKLEY RIVER
1969 TO 1982

Client Project No
Client Drawing No
MCSL Project No. 2331–0650–0
Drawing No. 0650-02
Sheet 2 of 4
Revision

Destroy all prints bearing previous number ▲





No.	Date	Revision	Dr.	Ck'd

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Drawn: TLL | Date: JULY 15, 2008
Scale: 1:10,000

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REGIONAL DISTRICT OF BULKLEY-NECHAKO

EBENEZER FLATS / KIDD ROAD
HISTORIC MIGRATION OF THE BULKLEY RIVER
1982 TO 1993

Client Project No
Client Drawing No
MCSL Project No. 2331–0650–0
Drawing No. 0650-03
Sheet 3 of 4
Revision

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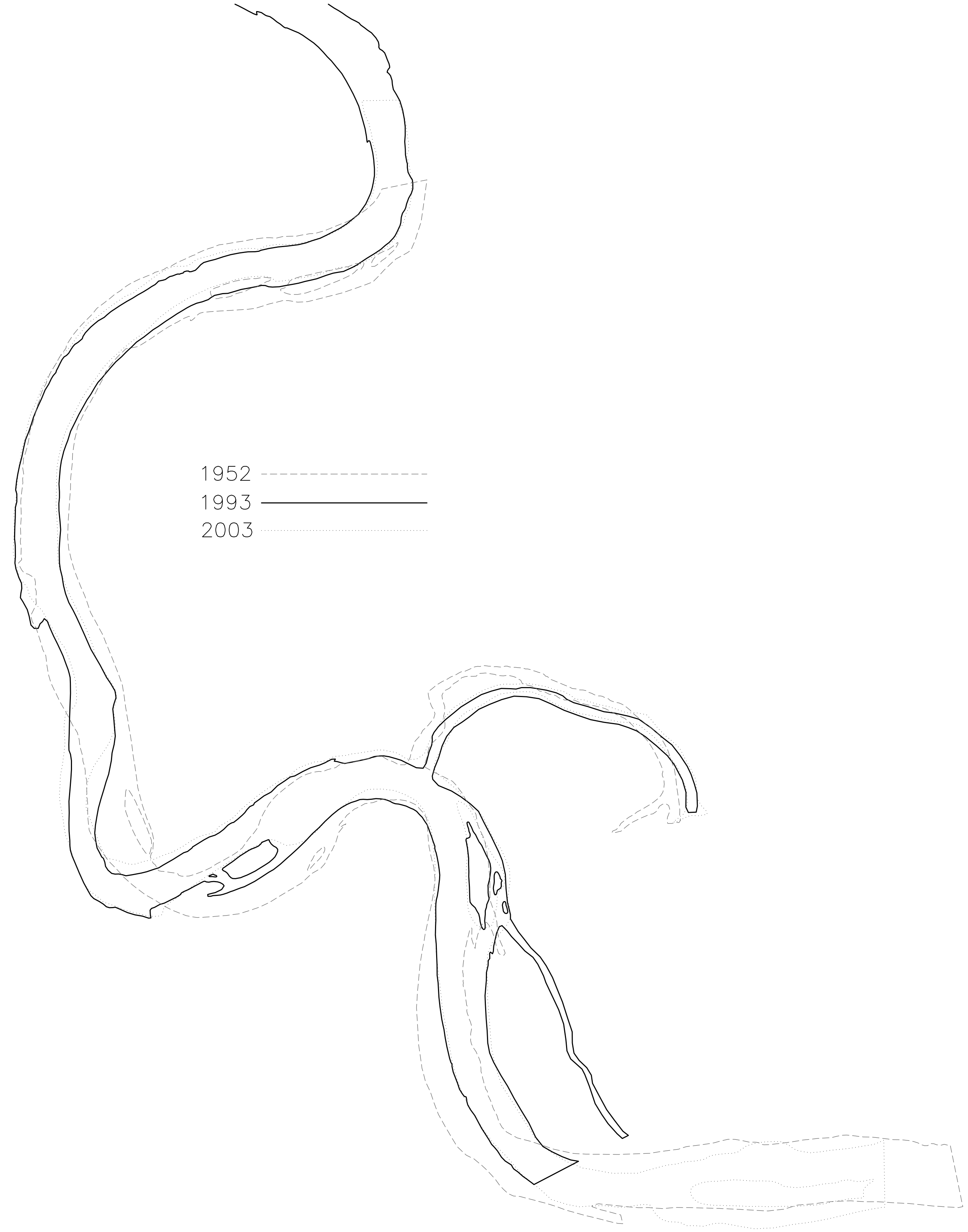

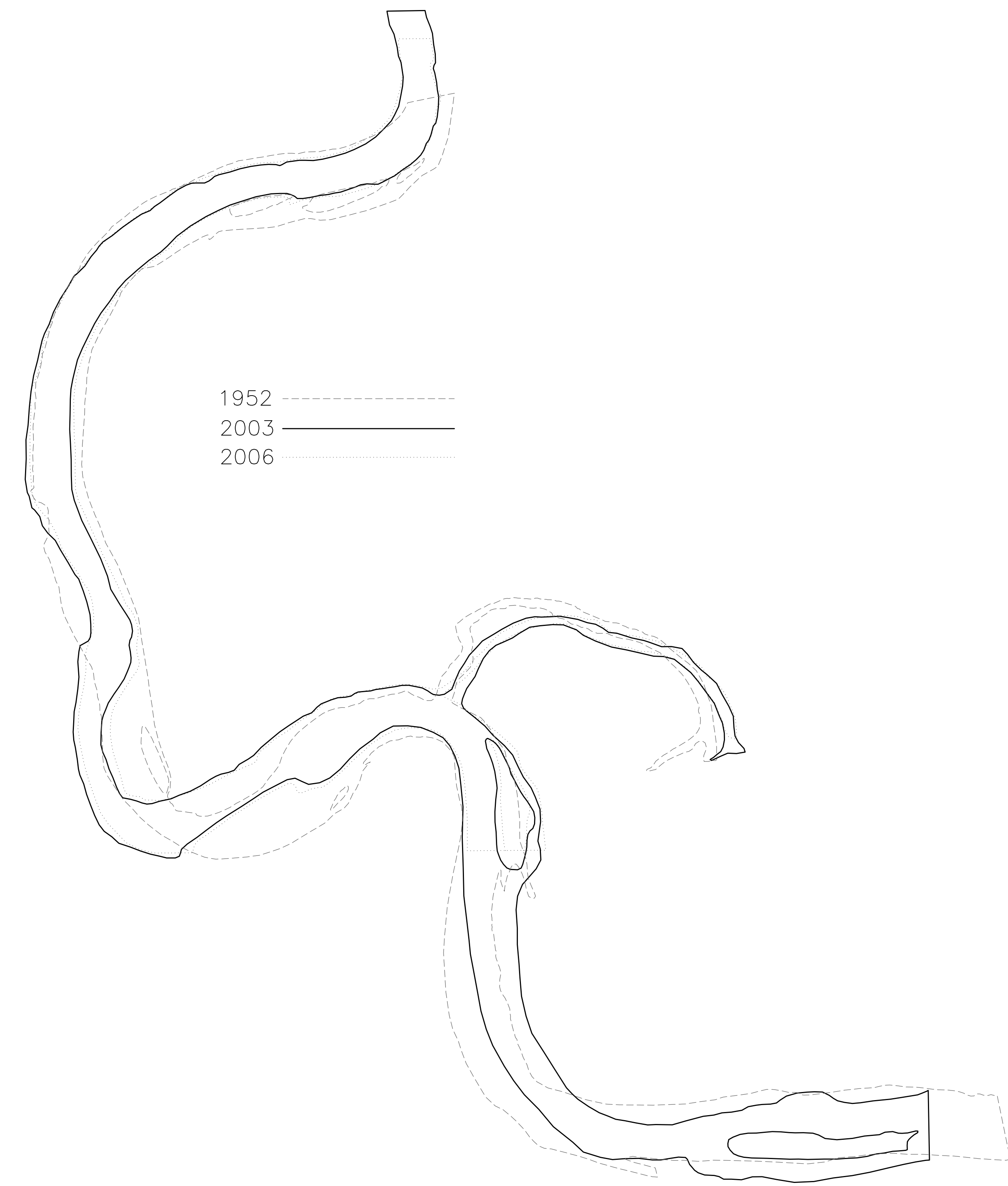

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REGIONAL DISTRICT OF BULKLEY-NECHAKO

EBENEZER FLATS / KIDD ROAD
HISTORIC MIGRATION OF THE BULKLEY RIVER
1993 TO 2006

Client Project No
Client Drawing No
MCSL Project No. 2331–0650–0
Drawing No. 0650-04
Sheet 4 of 4
Revision

Destroy all prints bearing previous number ▲

APPENDIX B

GPS Waypoint Maps and Table

Ebenzer Flats/Kidd Road
Erosion Protection Study

GPS Waypoints and Photo Listing

Waypoint	Lat	Long	Photos	Comments
24	54.7834	-127.1345	3732-3741	old bridge site
25	54.7833	-127.1360	3742-3746	old field - increase in bank rock size and sloughing
26	54.7834	-127.1364	3747-3749	start of outside bend - no undercutting noted, logs and woody debris, banks mostly vegetated
27	54.7835	-127.1370	3750-3752	sandy banks, mostly vegetated approx 1.2m above pwl
28	54.7838	-127.1368	3753	start of sandbag dike
29	54.7837	-127.1370	3754-3756	point on dike, avg ht 1 m
30	54.7837	-127.1372		point on dike, avg ht 1 m
31	54.7837	-127.1378	3757-3762	point on dike along fenceline
32	54.7836	-127.1383	3763-3766	location of irrigation pump
33	54.7836	-127.1387	3767-3768	point on dike
34	54.7836	-127.1388	3769-3771	point on dike
35	54.7836	-127.1392	3772-3773	point on dike
36	54.7835	-127.1395	3774-3777	point on dike - fenceline
37	54.7833	-127.1396	3778-3783	fine bank material, undercutting
38	54.7835	-127.1400	3784	
39	54.7835	-127.1406	3785-3786	back channel location - former Beaver Island
40	54.7909	-127.1546	3787-3801	Kidd Road - eroded bank, heights range from 1.2 to 1.6 m
41	54.7913	-127.1527	3805-3806	
42	54.7820	-127.1341	3807-3825	Smithers town side of old bridge
43	54.7820	-127.1348	3826-3827	approx 2.4 m washout
44	54.7839	-127.1478	3828-3837	Riverside Park - steep unstable bank
45	54.7863	-127.1487	3838-3841	Riverside Park - campsite - class 5 riprap
46	54.7906	-127.1623	3842-3852	Rosenthal Road - steep eroded bank and residence
47	54.7944	-127.1635	3853-3862	Rosenthal Road - bridge over creek

039
038
037
036
034
033
032
031
029
028
027
026
025
024
043
042
Riverside Dr
Ebenezer Flats/Kidd Road
GPS Location Key 1
Image © 2008 Province of British Columbia
© 2008 Tele Atlas
Google
lat 54.782401° lon -127.136614°
elev 464 m
2006
Eye alt 998 m


Ebenezer Flats/Kidd Road
GPS Location Key 2
047
041
040
046
045
044
033 029
037
025
024
043
042
Yellowhead Hwy
Smithers
Image © 2008 Province of British Columbia
© 2008 Tele Atlas
Google
lat 54.787654° lon -127.150486°
elev 461 m
2006
Eye alt 3.16 km

APPENDIX C

Site Photos

8/26/2008
IMG_3732.JPG

Old Bulkley River Crossing at foot of Lower Viewmount Road

8/26/2008
IMG_3733.JPG

Old bridge wingwall

Looking west at right bank of Bulkley River

Typical bank material – cobbles to 200mm

Typical bank material

Bridge abutment at old crossing

View of left (south) bank

View of left (south) bank showing old abandoned bridge piers

View of left bank showing bank erosion

Closeup of typical bed material

Typical overburden on field showing erosion and sloughing

Substantial increase in bank rock size in this location

Deposition of woody debris

8/26/2008
IMG_3748.JPG

8/26/2008
IMG_3749.JPG

Beginning of undercutting of bank – bank material is silty sand

Sandy bank and bed material – note difference from bank material further east

Deposition of woody debris

Start of sandbag dike

Sandbag dike looking west

Sandbag dike looking east


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IMG_3757.JPG

8/26/2008
IMG_3758.JPG

Fenceline

8/26/2008
IMG_3759.JPG

8/26/2008
IMG_3760.JPG

Dike looking west

8/26/2008
IMG_3761.JPG

8/26/2008
IMG_3762.JPG

Dike looking east

8/26/2008
IMG_3763.JPG


8/26/2008
IMG_3764.JPG


8/26/2008
IMG_3765.JPG

8/26/2008
IMG_3766.JPG

8/26/2008
IMG_3767.JPG

Flood debris caught in trees

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IMG_3770.JPG

8/26/2008
IMG_3771.JPG

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IMG_3772.JPG

8/26/2008
IMG_3773.JPG


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IMG_3774.JPG


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IMG_3775.JPG

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8/26/2008
IMG_3777.JPG

Note bank sloughing and soils with weak resistance to erosion

Leaning trees indicate continued erosion and bank failure


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8/26/2008
IMG_3783.JPG


8/26/2008
IMG_3784.JPG


8/26/2008
IMG_3785.JPG

Dry channel of “Beaver Island”

End of Kidd Road

8/26/2008
IMG_3790.JPG

End of Kidd Road

8/26/2008
IMG_3791.JPG

Bank erosion at end of Kidd Road

8/26/2008
IMG_3794.JPG

8/26/2008
IMG_3795.JPG

8/26/2008
IMG_3796.JPG

8/26/2008
IMG_3797.JPG

8/26/2008
IMG_3798.JPG

8/26/2008
IMG_3799.JPG

Silty sand overlying cobbles at end of Kidd Road

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IMG_3802.JPG

8/26/2008
IMG_3803.JPG

Bank undercutting at end of Kidd Road

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IMG_3804.JPG

8/26/2008
IMG_3805.JPG

Sandbag dike at the end of Kidd Road

Bulkley crossing from south side – note old bridge piers

mid stream gravel bar – flow was higher velocity on this side

Lateral flow was noticed coming over the bridge piers and shallow gravel bar

View of previously walked bank


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IMG_3818.JPG

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IMG_3823.JPG

8/26/2008
IMG_3824.JPG

8/26/2008
IMG_3825.JPG

8/26/2008
IMG_3827.JPG

Slope failure east of Riverside Park

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8/26/2008
IMG_3830.JPG

8/26/2008
IMG_3831.JPG

8/26/2008
IMG_3832.JPG

8/26/2008
IMG_3833.JPG

8/26/2008
IMG_3834.JPG

Riverside park entrance – steep and unstable bank

Riprap at Riverside Park

8/26/2008
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8/26/2008
IMG_3840.JPG

8/26/2008
IMG_3841.JPG

8/26/2008
IMG_3842.JPG

8/26/2008
IMG_3843.JPG

Rosenthal Road – steep eroded bank and abandoned buildings

8/26/2008
IMG_3844.JPG

8/26/2008
IMG_3845.JPG

8/26/2008
IMG_3846.JPG

8/26/2008
IMG_3847.JPG

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IMG_3848.JPG

8/26/2008
IMG_3849.JPG

Rosenthal Road

8/26/2008
IMG_3851.JPG

8/26/2008
IMG_3852.JPG


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IMG_3854.JPG

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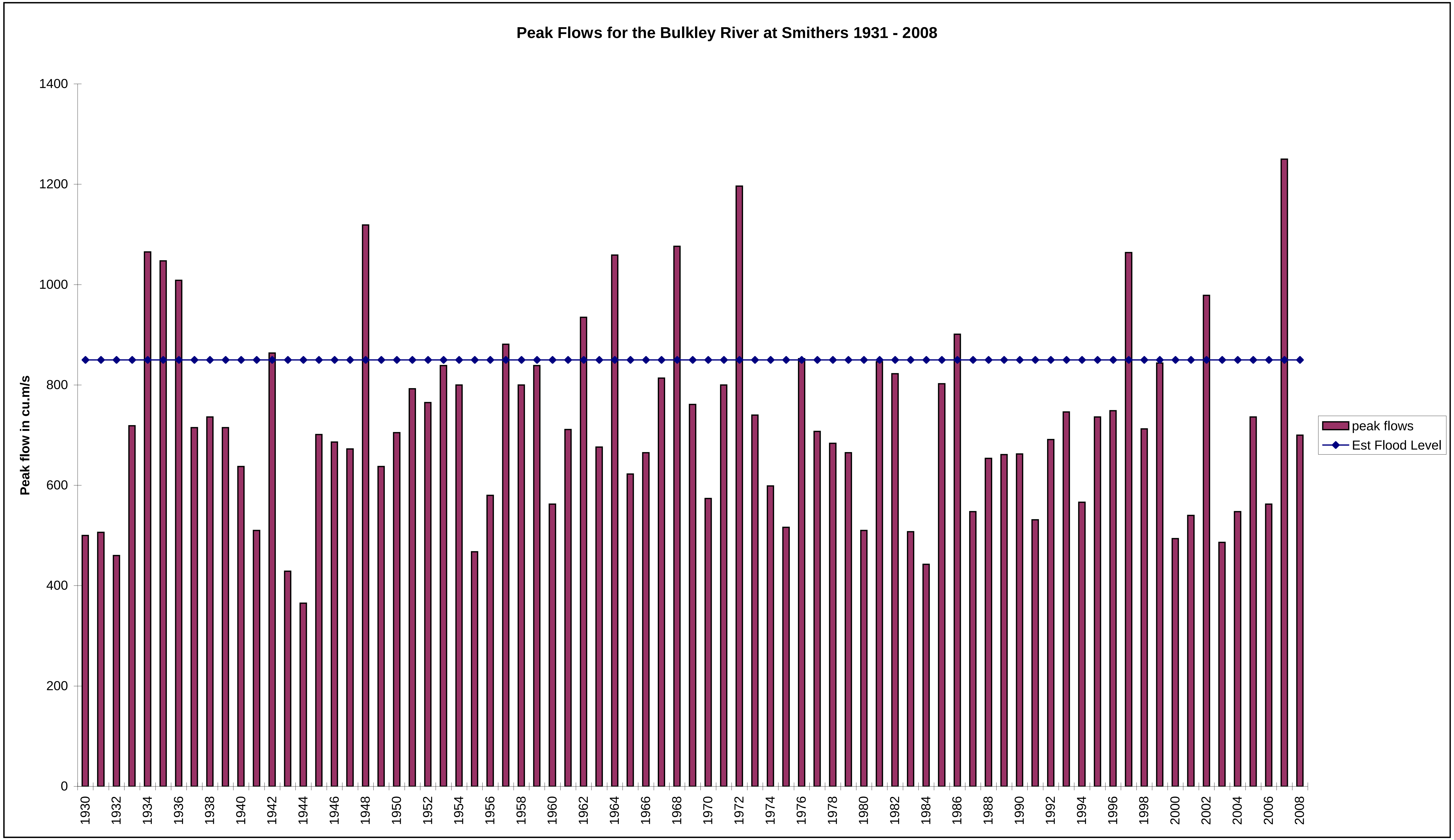
IMG_3862.JPG

APPENDIX D

Graph of Historic Bulkley River Peak Flows



Peak Flows for the Bulkley River at Smithers 1931 - 2008
Peak flow in cu.m/s
1400
1200
1000
800
600
400
200
0
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
peak flows
Est Flood Level

APPENDIX E

Cost Estimate Spreadsheets

Ebenezer Flats - Columbia Ave Erosion Protection

Item	Description	Estimated Quantity	Units	Unit Rate	Subtotal
A	**Riverside Rock Riprap**				
	Ebenezer Flats				
1	Mobilization/Demobilization	1	LS	$ 35,000	$ 35,000
2	Clearing and Grubbing	4660	m^2	$ 5	$ 23,300
3	Road Subbase	557	m^3	$ 28	$ 15,596
4	Road Base	40	m^3	$ 105	$ 4,200
5	bank slope shaping	1875	m^2	$ 8	$ 15,000
6	toe keyway excavation	375	lin.m	$ 20	$ 7,500
7	Class 250 Rip Rap	1875	m^3	$ 50	$ 93,750
8	400mm depth granular fill over riprap(from stockpile)	750	m3	$ 12	$ 9,150
9	filter fabric	1875	m^2	$ 3	$ 5,625
10	TopSoil Seeding	1	LS	$ 4,000	$ 4,000
11	Est. Fisheries Compensation	1	LS	$ 4,000	$ 4,000
				Subtotal	$ 217,121
12	Contingency and engineering 35%				$ 75,992
				Total	**$ 293,113**
	Kidd Road				
1	Mobilization/Demobilization	1	LS	$ 35,000	$ 35,000
2	Clearing and Grubbing	6920	m^2	$ 5	$ 34,600
3	Road Subbase	888	m^3	$ 28	$ 24,864
4	Road Base	64	m^3	$ 105	$ 6,720
5	bank slope shaping	2350	m^2	$ 8	$ 18,800
6	toe keyway excavation	470	lin.m	$ 20	$ 9,400
7	Class 250 Rip Rap	2350	m^3	$ 50	$ 117,500
8	400mm depth granular fill over riprap(from stockpile)	940	m3	$ 12	$ 11,468
9	filter fabric	3700	m^2	$ 3	$ 11,100
10	TopSoil Seeding	1	LS	$ 6,000	$ 6,000
11	Est. Fisheries Compensation	1	LS	$ 4,000	$ 4,000
				Subtotal	$ 279,452
12	Contingency and engineering 35%				$ 97,808
				Total	**$ 377,260**

Item	Description	Estimated Quantity	Units	Unit Rate	Subtotal
B	**Riverside Gabions**				
	Ebenezer Flats				
1	Mobilization/Demobilization	1	LS	$ 20,000	$ 20,000
2	Clearing and Grubbing	4660	m^2	$ 5	$ 23,300
3	Road Subbase	557	m^3	$ 28	$ 15,596
4	Road Base	40	m^3	$ 105	$ 4,200
5	bank slope shaping	1500	m^2	$ 8	$ 12,000
7	Gabion Basket supply	385	each	$ 160	$ 61,600
	Gabion Blanket supply	375	Lin.m	$ 150	$ 56,250
8	Gabion Backfilling / installation	1108	m^3	$ 33	$ 36,564
9	filter fabric	1500	m^2	$ 3	$ 4,500
10	Seeding	1	LS	$ 4,000	$ 4,000
11	Est. Fisheries Compensation	1	LS	$ 4,000	$ 4,000
				Subtotal	$ 242,010
12	Contingency and engineering 35%				$ 84,704
				Total	**$ 326,714**
	Kidd Road				
1	Mobilization/Demobilization	1	LS	$ 20,000	$ 20,000
2	Clearing and Grubbing	6920	m^2	$ 5	$ 34,600
3	Road Subbase	888	m^3	$ 28	$ 24,864
4	Road Base	64	m^3	$ 105	$ 6,720
5	bank slope shaping	1900	m^2	$ 8	$ 15,200
6	Gabion Basket Supply	485	each	$ 160	$ 77,600
7	Gabion Blanket Supply	470	lin.m	$ 150	$ 70,500
8	Gabion Backfilling/ Installation	1393	m^3	$ 33	$ 45,969
9	filter fabric	1900	m^2	$ 3	$ 5,700
10	TopSoil Seeding	1	LS	$ 4,000	$ 4,000
11	Est. Fisheries Compensation	1	LS	$ 4,000	$ 4,000
				Subtotal	$ 309,153
12	Contingency and engineering 35%				$ 108,204
				Total	**$ 417,357**

Item	Description	Estimated Quantity	Units	Unit Rate	Subtotal
D	**Bio Stabilization**				
	Ebeneezer Flats				
1	Mobilization/Demobilization	1	LS	$ 20,000	$ 20,000
2	Clearing and Grubbing	4660	m^2	$ 5	$ 23,300
3	Road Subbase	557	m^3	$ 28	$ 15,596
4	Road Base	40	m^3	$ 105	$ 4,200
5	Log Crib Construction	375	lin.m	$ 300	$ 112,500
6	Log Crib Backfill	1500	each	$ 33	$ 49,500
7	Filter Fabric	1875	m^2	$ 3	$ 5,625
8	Live Staking	1125	m^2	$ 23	$ 25,875
9	RipRap Toe	560	m^3	$ 50	$ 28,000
10	Seeding	1	LS	$ 4,000	$ 4,000
11	Est. Fisheries Compensation	1	LS	$ 4,000	$ 4,000
				Subtotal	$ 292,596
12	Contingency and engineering 35%				$ 102,409
				Total	**$ 395,005**
	Kidd Road				
1	Mobilization/Demobilization	1	LS	$ 20,000	$ 20,000
2	Clearing and Grubbing	4660	m^2	$ 5	$ 23,300
3	Road Subbase	557	m^3	$ 28	$ 15,596
4	Road Base	40	m^3	$ 105	$ 4,200
5	Log Crib Construction	470	lin.m	$ 300	$ 141,000
7	Log Crib Backfill	1880	m^3	$ 33	$ 62,040
8	Filter Fabric	2350	m^2	$ 3	$ 7,050
9	Live Staking	1410	m^2	$ 23	$ 32,430
10	Rip Rap Toe	705	m^3	$ 50	$ 35,250
10	Seeding	1	LS	$ 6,000	$ 6,000
11	Est. Fisheries Compensation	1	LS	$ 4,000	$ 4,000
				Subtotal	$ 350,866
12	Contingency and engineering 35%				$ 122,803
				Total	**$ 473,669**

Item	Description	Estimated Quantity	Units	Unit Rate	Subtotal
C	**Setback Dike**				
	Ebenezer Flats				
1	Mobilization/Demobilization	1	LS	$ 35,000	$ 35,000
2	Clearing and Grubbing	4660	m^2	$ 5	$ 23,300
3	Road Subbase	557	m^3	$ 28	$ 15,596
4	Road Base	40	m^3	$ 105	$ 4,200
5	bank slope shaping	1875	m^2	$ 8	$ 15,000
6	Common Excavation (stockpiling)	3940	m^3	$ 14	$ 55,160
7	Class 250 Rip Rap	1875	m^3	$ 50	$ 93,750
8	Backfilling Excavation	2065	m3	$ 10	$ 20,650
9	filter fabric	1875	m^2	$ 3	$ 5,625
10	TopSoil Seeding	1	LS	$ 4,000	$ 4,000
				Subtotal	$ 272,281
12	Contingency and engineering 35%				$ 95,298
				Total	**$ 367,579**
	Kidd Road				
1	Mobilization/Demobilization	1	LS	$ 35,000	$ 35,000
2	Clearing and Grubbing	6920	m^2	$ 5	$ 34,600
3	Road Subbase	888	m^3	$ 28	$ 24,864
4	Road Base	64	m^3	$ 105	$ 6,720
5	bank slope shaping	2350	m^2	$ 8	$ 18,800
6	Common Excavation (stockpiling)	4935	lin.m	$ 18	$ 88,830
7	Class 250 Rip Rap	2350	m^3	$ 50	$ 117,500
8	Backfilling Excavation	2585	m3	$ 10	$ 25,850
9	filter fabric	3700	m^2	$ 3	$ 11,100
10	TopSoil Seeding	1	LS	$ 6,000	$ 6,000
				Subtotal	$ 369,264
12	Contingency and engineering 35%				$ 129,242
				Total	**$ 498,506**