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REPORT ON

1997 SUMMER DATA COLLECTION PROGRAM AND BASELINE HYDROLOGIC AND HYDRAULIC STUDIES FOR THE MUSKEG RIVER MINE PROJECT

Submitted to:

Shell Canada Limited
400 - 4th Avenue SW
P.O. Box 100, Station M
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December 1997

972-2237

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January 22, 1998

Proj. No. 972-2237

Dr. Doug Mead
Senior Environmental Scientist
Safety and Environmental Resources
Shell Canada Limited.
400 - 4th Avenue SW
P.O. Box 100, Station M
Calgary, AB T2P 2H5

RE: Final report - 1997 Summer Data Program - Hydrology

Dear Doug

Attached is the final report for the 1997 summer data collection program and baseline hydraulic studies for the Muskeg River Mine Project. This report provides a review of the Surface Water Hydrology program completed for Shell during the summer of 1997. It includes details on: a) stream geomorphic assessment; b) summer streamflow measurements; c) total suspended sediment measurements and analysis; d) water level measurements; e) floodplain mapping; and f) hydrologic modelling.

The data collected during the summer of 1997 provided information valuable to the completion of the surface water hydrology component of the Muskeg River Mine Project Environmental Impact Assessment.

Should you have any questions about this report, please contact me at 299-5640.

Yours very truly,

GOLDER ASSOCIATES LTD.

John R. Gulley, M.Sc., P. Biol.
Oil Sands Project Director

attachment

cc. Judy Smith (Shell)
Ian Mackenzie (EIA Project Manager)

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1. INTRODUCTION

purpose of the '97 summer work program

This surface water hydrology component of the summer work program for the period from June to October, 1997 was commissioned by Shell Canada Limited (Shell) to obtain additional baseline hydrologic data for an environmental impact assessment (EIA) and to provide a sound basis for future design of the Muskeg River Mine Project shown in Figure 1.1. These additional data are needed to expand the existing surface water hydrologic database which has been developed for the Muskeg River Mine Project and Syncrude's Aurora Project.

'97 winter work program is presented in a separate report

The 1997 summer data collection program is a continuation of the 1997 winter data collection program, which are presented in the report entitled "Lease 13 Surface Water Hydrology 1997 Winter Data Collection Program" (Golder 1997). The 1997 data collection program builds upon the existing hydrologic database for the project area to develop a database to suit the requirements of the EIA and future operations.

scope of the '97 summer work program

The scope of the summer data collection program included the collection of baseline stream geomorphologic data in the local study area (LSA) shown in Figure 1.1, hydrologic and hydraulic data, as well as total suspended sediment (TSS) data at the existing six streamflow gauging stations in the Muskeg River basin. The specific objectives of this summer data collection program included the following:

stream geomorphic survey task

- Conduct stream geomorphic surveys at selected locations in the Muskeg River watershed. These survey data are used to characterize the baseline river or creek channel geomorphic conditions and to provide natural analogues for designing closure reclamation drainage systems.

streamflow measurement task

- Measure, process and compile summer streamflows at the existing six streamflow gauging stations (S1 to S6). Manual streamflow measurements are required to develop reliable stage-discharge rating curves and to derive continuous streamflow hydrographs based on automatic water level measurements at the stations.

TSS measurements task

- Measure, process and compile TSS data at the existing six streamflow gauging stations (S1 to S6). These data are required to supplement the existing baseline TSS data for establishing TSS permit allowances for any future flow releases from the Muskeg River Mine Project and to assist in calibrating a water quality model.

water level measurement task

- Conduct water level measurements at eight staff gauge locations (G1 to G8) on the Muskeg River and Jackpine Creek. The water level

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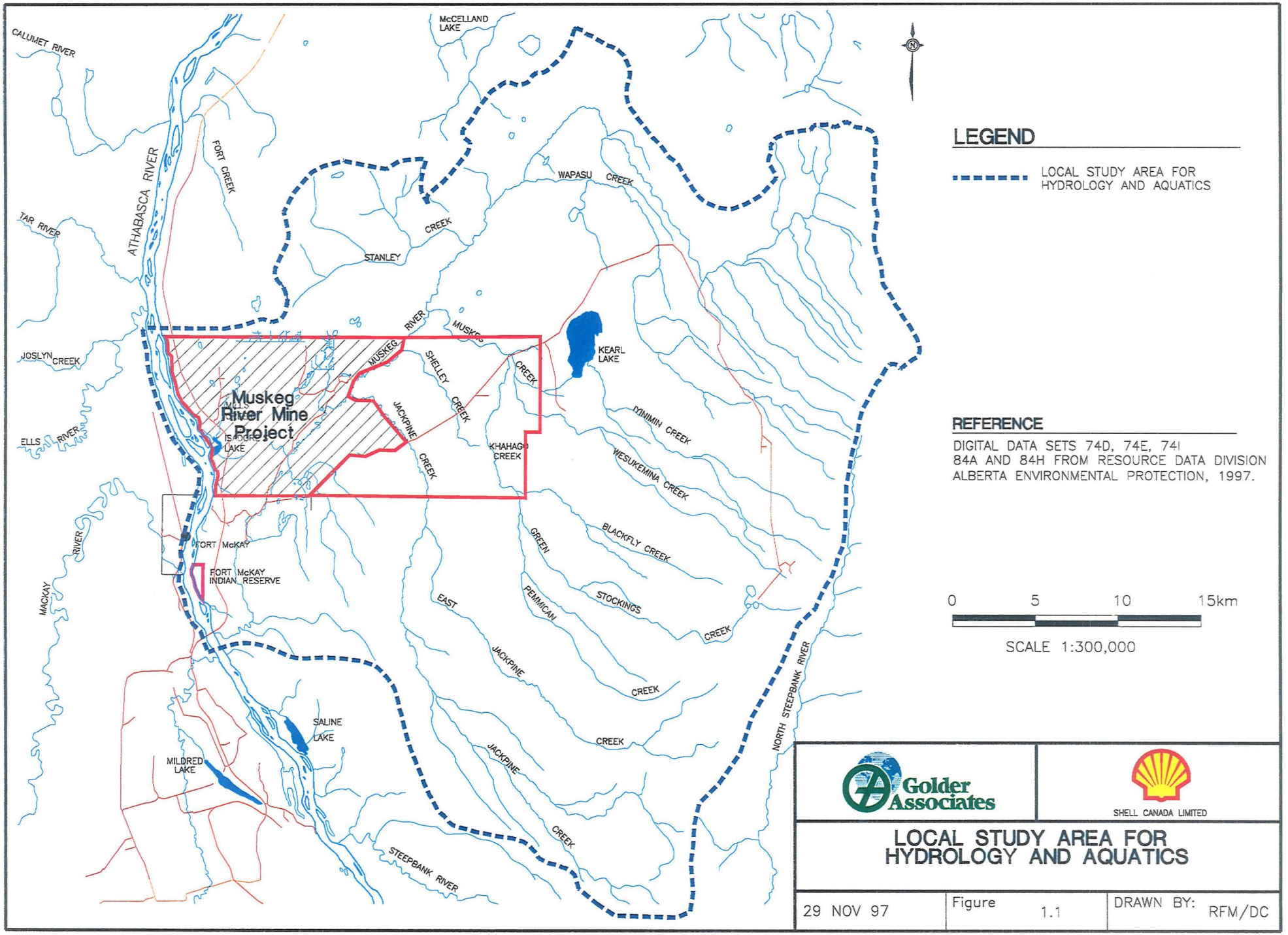

measurements are required to calibrate a backwater hydraulic model for floodplain analysis and mapping along the study reaches of the streams.

types of baseline data presented in this report

This report documents the geomorphic survey data at selected stream locations in the Muskeg River watershed and presents the results of the summer streamflow measurements and TSS measurements at the six stream gauging stations. The report presents the derived stage-discharge rating curves and measured streamflows at the six stream gauging stations located in the study area and documents the measured water level data at the eight staff gauge locations on the Muskeg River and Jackpine Creek.

objectives and scope of the baseline hydrologic and hydraulic studies

In addition to data collection as described above, the 1997 summer work program included hydraulic and hydrologic studies including the following tasks.

- Conduct floodplain analysis and delineate the flood risk boundaries for the 10 and 100 year flood events along the study reaches of the Muskeg River and Jackpine Creek. The floodplain mapping is needed to characterize the baseline flood conditions, to provide a basis for evaluating any potential impacts of extreme flood events on the proposed Muskeg River Mine Project and for design of the mining facilities along the streams.

- Calibrate a dynamic (continuous simulation) hydrologic model that can be used to derive long-term historic flow series for various types of natural terrain conditions. These long-term flow series provide a basis for the design of reclamation drainage systems and for evaluating the impacts of the proposed Muskeg River Mine Project on water quantities and quality of the receiving streams.

results of the baseline hydrologic and hydraulic studies

This report presents the methodology of the hydraulic modelling analysis and the results of the delineated flood risk boundaries along the study reaches of the Muskeg River and Jackpine Creek. The report documents the results of the hydrologic model calibration and presents the derived natural flows for various types of terrain conditions in the LSA.

2. STREAM GEOMORPHIC ASSESSMENT

2.1 PURPOSES OF STREAM GEOMORPHIC ASSESSMENT

purpose of stream geomorphic assessment

A geomorphic assessment of local streams were conducted as part of the 1997 summer baseline data collection program. The assessment was completed to: a) characterize the stream geomorphic conditions including characteristic channel depth, width, slope and meander patterns, in and adjacent to the Muskeg River Mine Project area; b) classify the streams for assessing stream sensitivity to potential disturbances; and c) provide natural analogues for designing reclamation drainage channels.

this site-specific investigation is supplemental to previous studies in the region

Previous geomorphic studies in the region included the survey and assessment of the headwater streams in the Muskeg River basin conducted for the OSLO Project (W-E-R 1989) and a survey and assessment of the streams in the Beaver River basin conducted for Syncrude (AGRA 1995a). This geomorphic study for the Muskeg River Mine Project was to provide site-specific information and data for defining the geomorphic characteristics of other local streams which were not included in the previous investigations.

2.2 GEOMORPHIC SURVEY

locations of survey sites

Figure 2.1 shows the locations of twenty-one sites where geomorphic surveys were conducted. These sites were selected in advance of a field reconnaissance based on an understanding of the available geomorphic data for the LSA, topographic maps and air photographs. The selected sites were divided into representative natural stream reaches and disturbed stream reaches such as upstream and downstream of road crossings. Figure 2.1 also shows the site locations along the study reaches of the Muskeg River and Jackpine Creek where detailed cross-sectional surveys were undertaken to determine the channel and floodplain cross-sections.

access to survey sites

Table 2.1 lists the survey sites visited by truck and helicopter. Sites M8 and M11 were not visited due to access difficulties. The location of each site was referenced using a global positioning system (GPS) for remote sites and topographic maps for sites at road crossings.

collected geomorphic data

Photographs were taken at each site to illustrate the geomorphic conditions of the surveyed stream reach. Measured stream geomorphic data and surveyed stream cross-section profiles are presented in Appendix I. Stream bed soil samples were taken at several sites for grain size analysis. Table 2.2 summarizes the stream hydraulic parameters of the surveyed sites M1 to M23.

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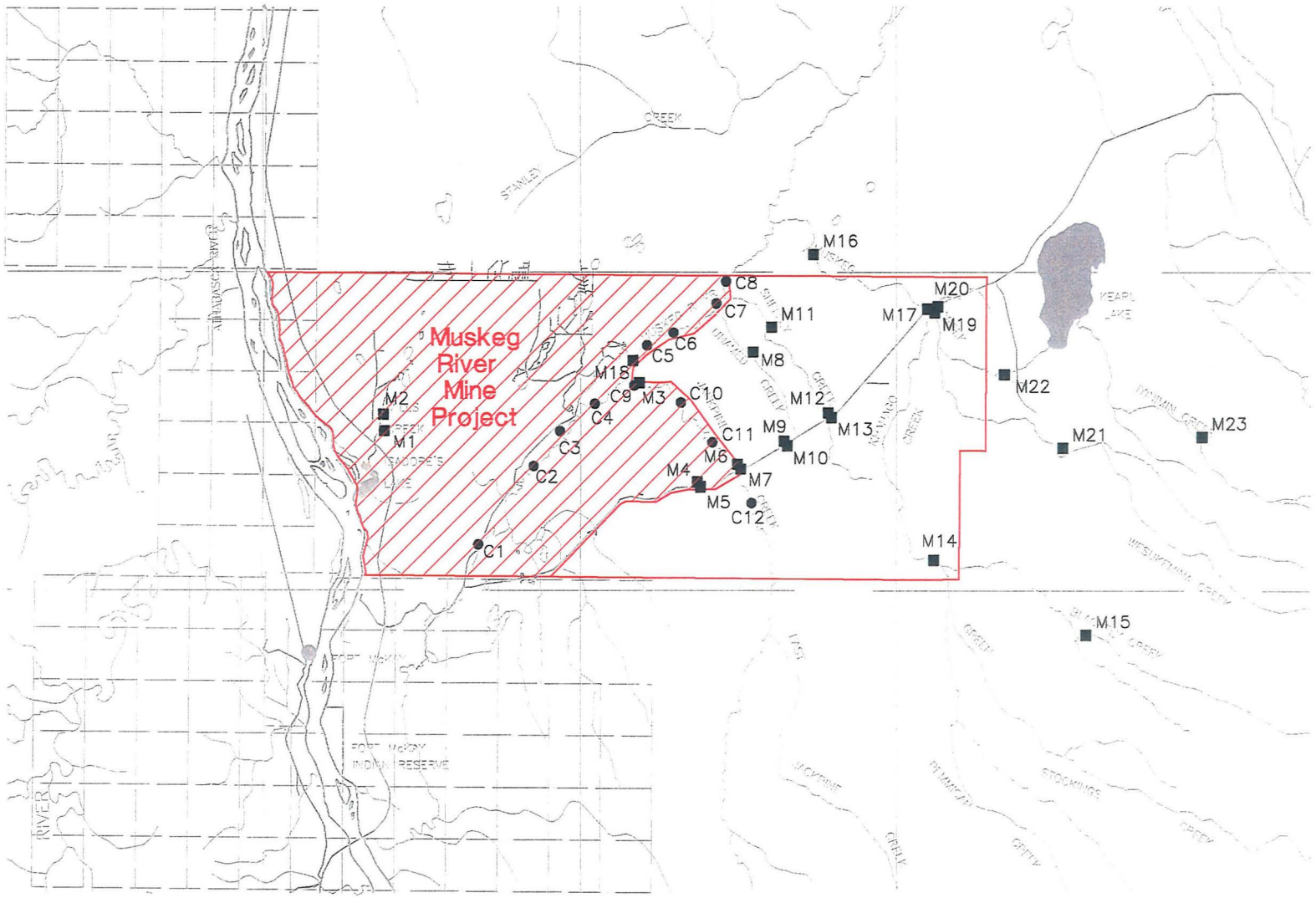

LEGEND

- M1 — GEOMORPHIC ASSESSMENT SITES
- C1 — DETAILED CROSS-SECTIONAL SURVEY SITES
- LEASE 13 BOUNDARY

0 2000 4000 6000 8000 10000(m)

SCALE 1:200,000

REFERENCE

DIGITAL DATA SETS 74D, 74E, 74I
84A AND 84H FROM RESOURCE DATA DIVISION
ALBERTA ENVIRONMENTAL PROTECTION, 1997.

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GEOMORPHIC ASSESSMENT SITE MAP

29 NOV 97	Figure 2.1	DRAWN BY: BM/DC

Table 2.1 Stream Geomorphic Survey – Locations and Access Conditions

Site Number	Stream Name	Northing (UTM)	Easting (UTM)	Access From	Bed Sample Taken	Comments on Site Selection and Location
M1	Lower Mills Creek	6344400	464350	Ground	Yes	at stream gauging station S6; upstream of Isadore's Lake
M2	Upper Mills Creek	6345500	464500	Air	No	upstream of Isadore's Lake
M3	Jackpine Creek	6346500	471850	Ground	Yes	at stream gauging station S2; downstream from road
M4	Unnamed Creek	6343400	473680	Ground	Yes	downstream from road
M5	Unnamed Creek	6343400	473680	Ground	No	upstream from road
M6	Jackpine Creek	6343950	474950	Ground	No	downstream from road
M7	Jackpine Creek	6343800	475050	Ground	Yes	upstream from road
M8	Unnamed Creek 2	6347150	475400	Not visited	No	-
M9	Unnamed Creek 2	6344530	476572	Ground	No	downstream from road
M10	Unnamed Creek 2	6344530	476572	Ground	No	upstream from road
M11	Shelley Creek	6348250	476200	Not Visited	No	-
M12	Shelley Creek	6345404	477920	Ground	No	downstream from road
M13	Shelley Creek	6345404	477920	Ground	Yes	upstream from road
M14	Khahago Creek	6340950	481175	Ground	No	natural conditions
M15	Blackfly Creek	6338600	486000	Ground	No	natural conditions
M16	Muskeg Creek	6349475	480300	Ground	Yes	downstream from road
M17	Muskeg Creek	6348825	480975	Ground	No	downstream from road
M18	Muskeg River	6346492	471614	Ground	Yes	upstream from road
M19	Unnamed Creek 3	6348700	481200	Ground	No	upstream from road
M20	Unnamed Creek 4	6348900	481300	Ground	No	upstream from road
M21	Wesukemina Creek	6343900	485200	Ground	No	natural conditions
M22	Kearl Lake Outlet	6346750	483400	Ground	No	upstream from road
M23	Iyinimin Creek	6344800	489650	Ground	No	upstream from road

Table 2.2 Stream Geomorphic Survey – Channel Hydraulic Parameters

Site No.	Stream Name	Basin Area (km^2)	Bed Slope	Valley Slope	Mean Depth[a] (m)	Bankfull Width[b] (m)	Sinuosity[c]	Entrenchment Ratio[d]	Width/ Depth[e] Ratio	D_{50}[f] (mm)	D_{100}[g] (mm)
M1	Lower Mills Creek	23.8	0.0190	0.0286	0.28	4.9	1.5	1.5	17	0.22	1.25
M2	Upper Mills Creek	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
M3	Jackpine Creek	358	0.0033	0.0083	1.1	8.6	2.5	> 2.2	7.6	0.15	0.63
M4	Unnamed Creek	6.75	0.0102	0.0143	0.4	1.05	1.4	n/a	7.6		
M5	Unnamed Creek	6.75	0.0095	0.0143	0.26	2.4	1.5	n/a	7.6		
M6	Jackpine Creek	342	0.0029	0.0034	0.31	11.3	1.2	1.6	35		
M7	Jackpine Creek	342	n/a	n/a	0.55	13	n/a	2.1	23	0.07	0.63
M9	Unnamed Creek 2	8.8	0.0044	0.0053	0.26	1.9	1.2	> 2.2	7.3		
M10	Unnamed Creek 2	8.8	0.0044	0.0053	n/a	n/a	1.2	n/a	n/a		
M12	Shelley Creek	7.6	0.0051	0.0077	0.45	4	1.5	> 2.2	8.8		
M13	Shelley Creek	7.6	0.0055	0.0077	0.24	3.2	1.4	> 2.2	13	0.29	2
M14	Khahago Creek	156.5	0.0020	0.0029	1.5	12	1.5	> 2.2	8.0		
M15	Blackfly Creek	27	0.0048	0.0071	0.44	4.7	1.5	1.3	10		
M16	Muskeg Creek	331	0.0018	0.0045	1.3	7.8	2.5	> 2.2	6.0	0.24	0.63
M17	Muskeg Creek	329	0.0031	0.0040	1	8.1	1.3	> 2.2	6.9		
M18	Muskeg River	938	0.0006	n/a	n/a	n/a	n/a	n/a	n/a	0.35	2
M19	Unnamed Creek 3	187.8	0.0024	0.0041	2	5	1.7	> 2.2	12		
M20	Unnamed Creek 4	131.5	0.0047	0.0061	0.36	4.4	1.3	1.3	12		
M21	Wesukemina Creek	> 2	0.0035	0.0043	0.26	1	1.2	> 2.2	3.8		
M22	Kearl Lake Outlet	72.5	0.0039	0.0042	0.57	4.6	1.1	> 2.2	8.0		
M23	Iyinimin Creek	24.5	0.0148	0.0222	0.57	3.7	1.5	1.2	6.5		
C1	Muskeg River	1351	0.0006	0.0007	1.63	40	1.2	> 2.2	24		
C2	Muskeg River	1323	0.0004	0.0005	0.94	12.5	1.3	> 2.2	13		
C3	Muskeg River	1306	0.0004	0.0006	1.88	24	1.5	> 2.2	13		
C4	Muskeg River	1272	0.0006	0.0008	1.94	33	1.3	> 2.2	17		
C5	Muskeg River	1233	0.0004	0.0006	1.0	15	1.5	> 2.2	15		
C6	Muskeg River	1224	0.0002	0.0004	0.69	20	2.4	> 2.2	29		

Table 2.2 Stream Geomorphic Survey - Channel Hydraulic Parameters (cont'd)

Site No.	Stream Name	Basin Area (km^2)	Bed Slope	Valley Slope	Mean Depth[a] (m)	Bankfull Width[b] (m)	Sinuosity[c]	Entrenchment Ratio[d]	Width/ Depth[e] Ratio	D_{50}[f] (mm)	D_{100}[g] (mm)
C7[h]	Muskeg River	1202	0.0002	0.0005	0.69	15	2.9	> 2.2	22		
C8[h]	Muskeg River	1177	0.0003	0.0008	0.63	10.5	3.1	> 2.2	17		
C9[h]	Jackpine Creek	350	0.0015	0.0025	0.9	12.8	2.2	> 2.2	23		
C10[h]	Jackpine Creek	344	0.0021	0.0035	0.7	22.4	1.7	> 2.2	29		
C11[h]	Jackpine Creek	342	0.0030	0.0048	0.9	17.5	1.6	> 2.2	20		
C12[h]	Jackpine Creek	340	0.0028	0.0037	0.74	8.6	1.3	> 2.2	24		
C13[h]	Jackpine Creek	337	0.0027	0.0029	0.70	15.5	1.1	> 2.2	25		

[a] Mean Depth: mean bankfull depth across a stream channel
[b] Bankfull Width: width of channel measured at bankfull stage
[c] Sinuosity: ratio of stream length to valley length
[d] Entrenchment Ratio: (width of the flood prone area at an elevation twice the maximum bankfull depth) / (bankfull width)
[e] Width/Depth ratio: bankfull width / mean bankfull depth
[f] D_{50} = median particle size of channel bed soil
[g] D_{100} = maximum particle size of channel bed soil
[h] Sites C1 to C13 are cross-sections surveyed for floodplain mapping.

stream classification based on Rosgen system

The survey data and information were entered into a geomorphic database shown in Table 2.3, which facilitates easy retrieval of the information and a classification of each stream using the Rosgen classification system (Rosgen 1996) to indicate the degree of stream channel stability and sensitivity to disturbance or change in flow regime.

2.3 STREAM GEOMORPHOLOGIC CHARACTERISTICS

basin and valley characteristics

The basin topography upstream of most survey sites is characterized by little relief and is classified as lowland area. The basin vegetation cover consists mainly of coniferous forests. The surficial geology of the area is of lacustrine origin. Most valley walls are moderately to heavily forested with either mixed deciduous or coniferous trees on both sides. No valley wall slumping was evident. The valley flats are mainly covered by grass and moderately forested. Some valley flats are characterized by muskeg swamp.

stream bank characteristics

The stream bank material consists of varying proportions of sand, silt and clay, with the occasional presence of gravel/cobbles. The thickness of the alluvial deposits varies between 0.1 and 0.3 m. Most banks are vegetated and majority are rated as having a low erodability rating.

floodplain characteristics

The minimum entrenchment ratio (ratio of width at 2 times maximum bankfull depth to bankfull width) was found to be 1.2. However, most streams have an entrenchment ratio of 2.2 or greater, typical of streams with low, wide floodplain. The minimum entrenchment ratio was observed at Iyinimin Creek, at a stream cross section through a steep and confining valley.

channel width and depth characteristics

The measured width to depth ratio (ratio of mean bankfull width to mean bankfull depth) varies from 3.8 to 35.5. As shown in Figures 2.2 and 2.3, both mean bankfull width and depth are correlated with basin area (A), as indicated by the following equations:

$$W_{bkf} = 1.1697\ A^{0.3962} \quad (r^2 = 0.76)$$

$$d_{bkf} = 0.1779\ A^{0.2531} \quad (r^2 = 0.49)$$

where W_{bkf} is the bankfull width and d_{bkf} is the bankfull depth.

Table 2.3 Rosgen Classification of Stream Channels and Sensitivity Rating

Geomorphic Site and Stream Crossing Name	Basin Area (km^2)	Downstream of Crossing	Stream Type	Sensitivity to Disturbances	Recovery Potential	Sediment Supply Potential	Streambank Erosion Potential	Influence of Vegetation on Bank Stability
M1 - Lower Mills Creek	23.8	No	B5	moderate	excellent	moderate	moderate	moderate
M2 - Upper Mills Creek	n/a	No	n/a	n/a	n/a	n/a	n/a	n/a
M3 - Jackpine Creek	358	Yes	E6	very high	good	low	moderate	very high
M4 - Unnamed Creek	6.75	Yes	E5	very high	good	moderate	high	very high
M5 - Unnamed Creek	6.75	No	E5	very high	good	moderate	high	very high
M6 - Jackpine Creek	342	Yes	B5c	moderate	excellent	moderate	moderate	moderate
M7 - Jackpine Creek	342	No	C5	very high	fair	very high	very high	very high
M9 - Unnamed Creek 2	8.8	Yes	E5	very high	good	moderate	high	very high
M10 - Unnamed Creek 2	8.8	No	n/a	n/a	n/a	n/a	n/a	n/a
M12 - Shelley Creek	7.6	Yes	E5/6	very high	good	moderate	high	very high
M13 - Shelley Creek	7.6	No	C5	very high	fair	very high	very high	very high
M14 - Khahago Creek	156.5	No	E3	high	good	low	moderate	very high
M15 - Blackfly Creek	27	No	G5c	extreme	very poor	very high	very high	high
M16 - Muskeg Creek	331	Yes	E5	very high	good	moderate	high	very high
M17 - Muskeg Creek	329	Yes	E5	very high	good	moderate	high	very high
M18 - Muskeg River	938	No	E5	very high	good	moderate	high	very high
M19 - Unnamed Creek 3	187.8	No	E5	very high	good	moderate	high	very high
M20 - Unnamed Creek 4	131.5	No	G5c	extreme	very poor	very high	very high	high
M21 - Wesukemina Creek	> 2	No	E6	very high	good	low	moderate	very high
M22 - Kearl Lake Outlet	72.5	No	E5	very high	good	moderate	high	very high
M23 - Iyinimin Creek	24.5	No	G5c	extreme	very poor	very high	very high	high

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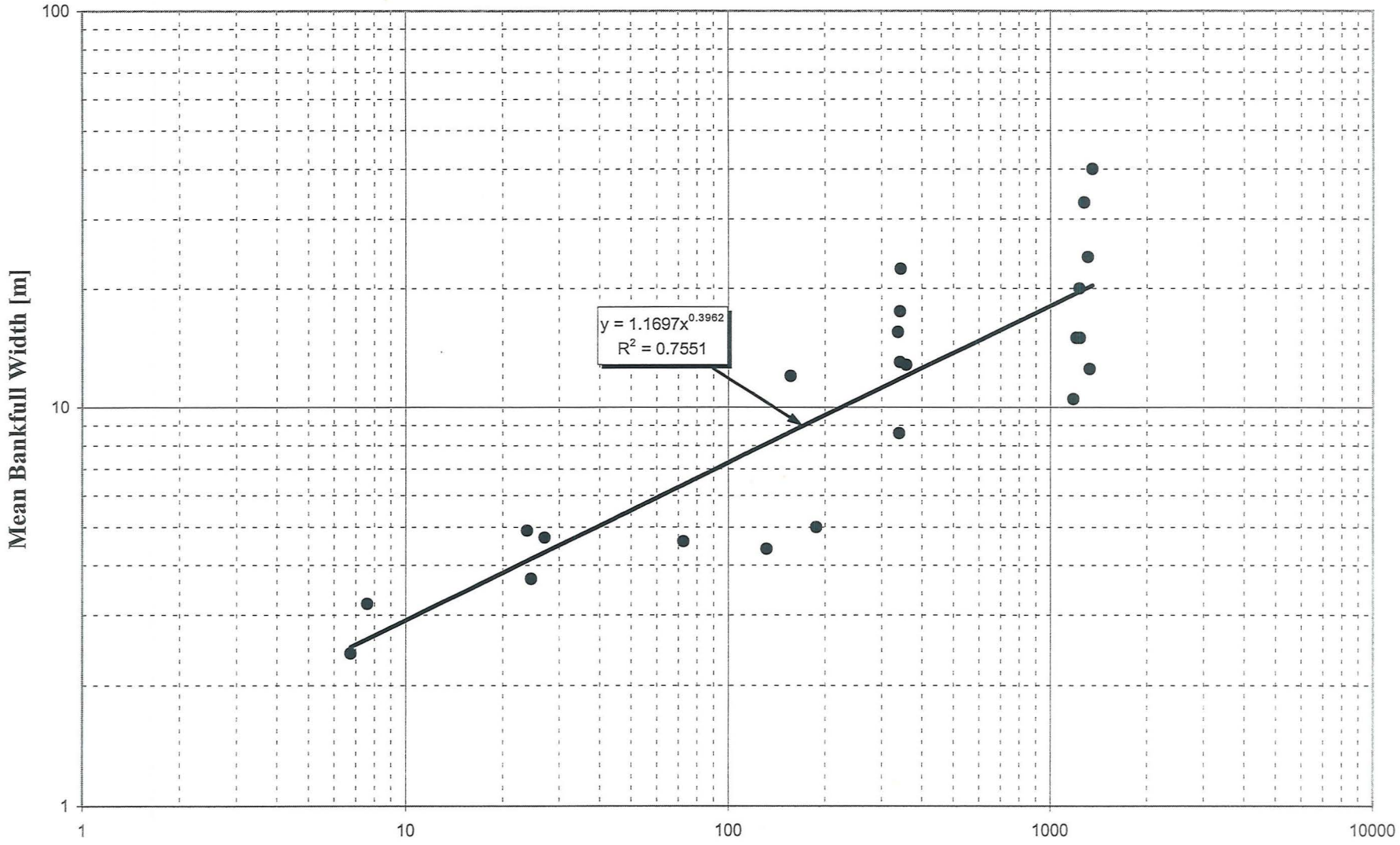

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CORRELATION BETWEEN MEAN BANKFULL WIDTH AND BASIN AREA

29 NOV 97	Figure 2.2	DRAWN BY: BGM

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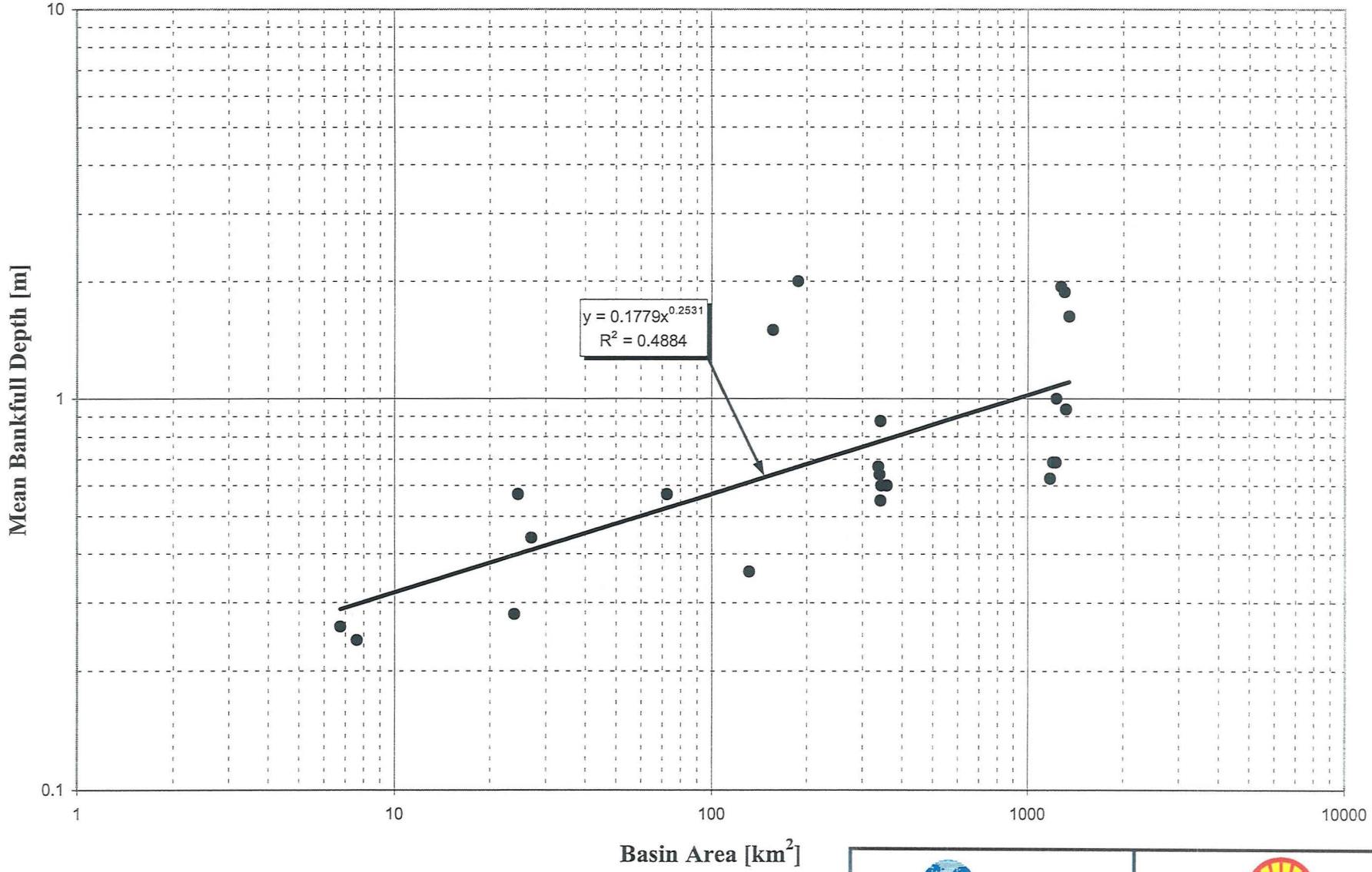

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CORRELATION BETWEEN MEAN BANKFULL DEPTH AND BASIN AREA

29 NOV 97	Figure 2.3	DRAWN BY: BGM

correlation relationship for channel bed slope

The channel bed slope is also correlated with basin area (A) as shown in Figure 2.4. The correlation relationship is defined by the following equation:

$$S_c = 0.0583\ A^{-0.6521} \qquad (r^2 = 0.75)$$

where S_c is the channel bed slope.

rating of stream bed stability

The stream bed stability was rated as "stable" for most of the sites. A degrading stream was observed at M15 (Blackfly Creek). At this location, the banks were rated as moderately to highly erodible. No other physical parameters (e.g., bank materials and channel bed slope) distinguish this stream from others in the region except that the survey site was situated in the proximity of a harvest cut-block (Figure 2.4). The high erodibility rating of Blackfly Creek is likely due to the impact of forest activities and should not be considered as a natural baseline condition.

typical stream bed material sizes

The channel bed material typically consists of sand and silt/clay varying proportions. The average D_{50} (median particle size) was measured to be 0.22 mm (medium sand) and the average D_{100} (maximum particle size) was measured to be 1.19 mm (coarse sand). Larger particles sizes such as gravel, cobble and boulders were observed at some locations. Figure 2.5 shows that the size of bed material particles is inversely proportional to basin area (A) for both D_{50} and D_{100}.

stream meandering and occurence of beaver dams

The stream meander pattern of most streams is irregular with sinuosities varying mostly from 1.2 to 1.5. The amount of obstruction to flow caused by debris in the stream channel varies significantly between streams. The debris material includes small floating materials such as needles and leaves, as well as active or abandoned beaver dams. Beaver dams have altered the morphology of the streams as a result of ponding and the occurrence of beaver dam failures. No evidence of lateral channel migration was noted.

most of the streams are "E" types in the Rosgen classification

Most of the surveyed streams were classified as E5 or E6 in the Rosgen classification. E streams are very stable and feature low gradients, meandering riffle/pool streams with low width to depth ratios and little sediment deposition. They are typically found in broad alluvial-type valleys. Their entrenchment ratios are greater than 2.2 indicative of a wide floodplain. The banks are typically stable and well-vegetated.

distinction between E5 and E6 ratings

An E5 or E6 rating depends on the channel substrate soil conditions. The E5 class of stream is composed mainly of sand and E6 is composed mainly of silt/clay. This type of stream is typically sensitive to disturbance, but has a good potential for recovery following disturbance. The sediment supply

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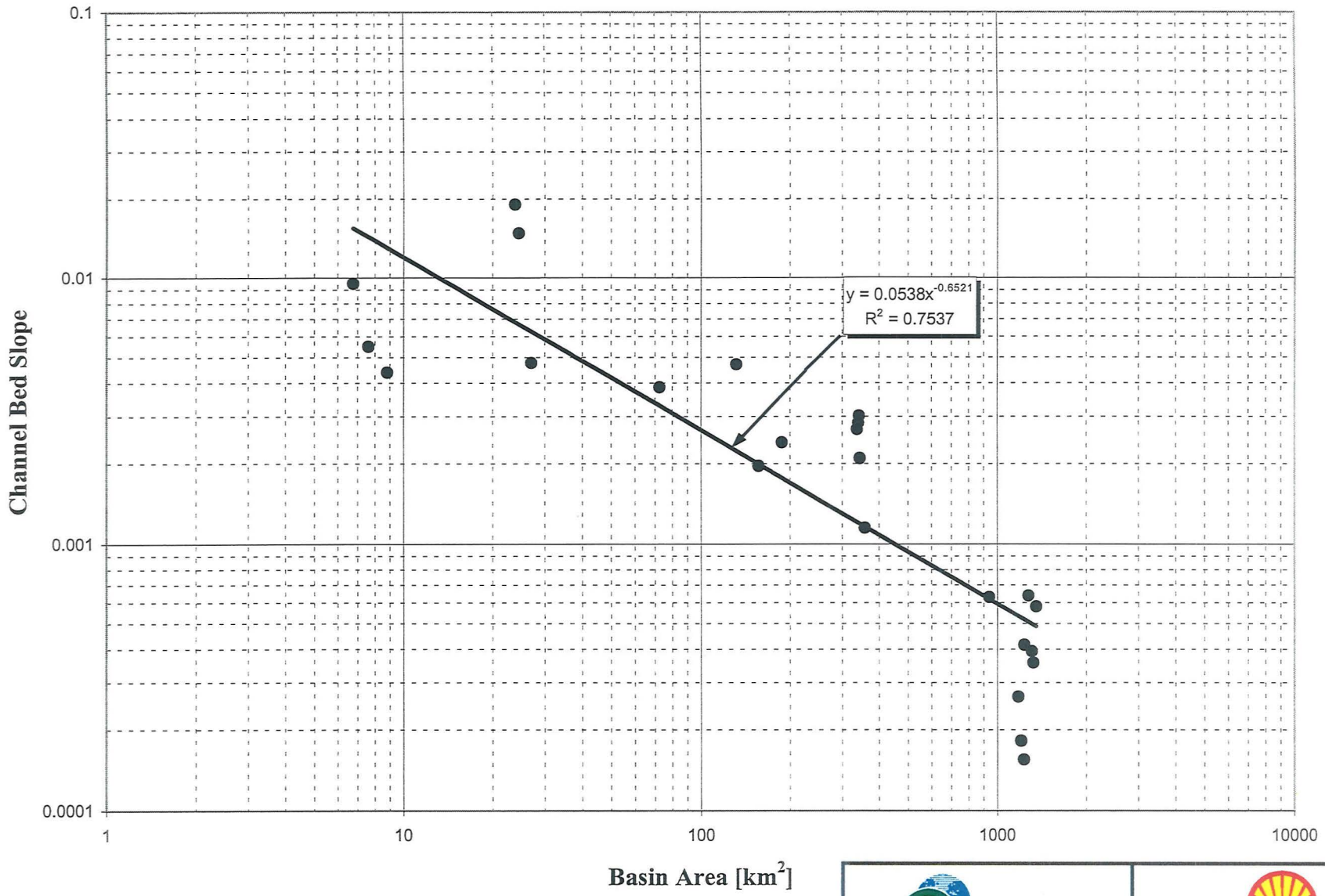

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CORRELATION BETWEEN CHANNEL BED SLOPE AND BASIN AREA

29 NOV 97	Figure 2.4	DRAWN BY: BGM

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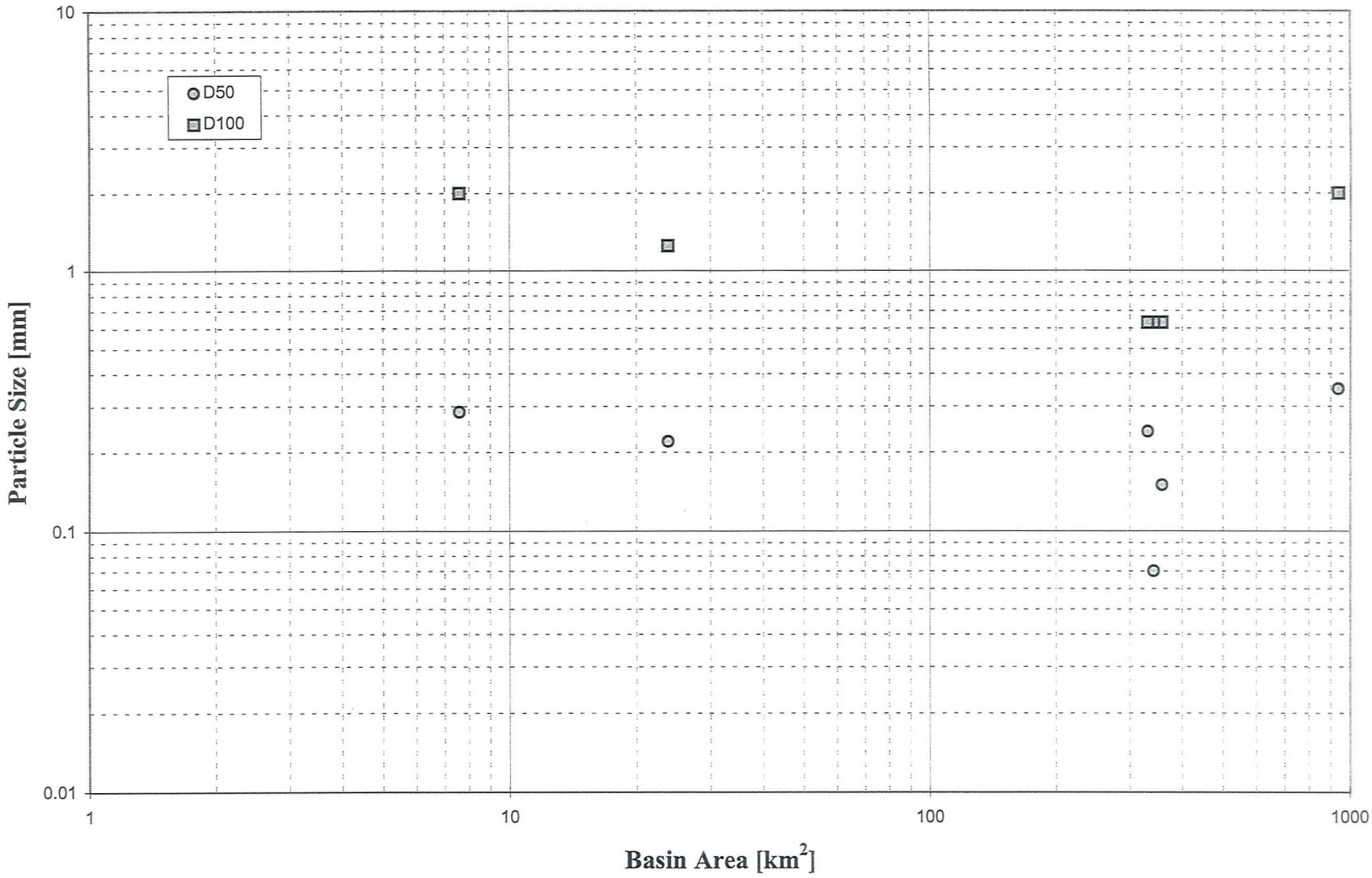

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CORRELATION BETWEEN BED MATERIAL PARTICAL SIZE AND BASIN AREA

29 NOV 97	Figure 2.5	DRAWN BY: BGM

of E5 and E6 streams is moderate and the streambank erosion potential is high. Vegetation on the banks governs the stability of these banks.

other stream type classification

A number of other stream types were found in the LSA, including two B5's, two C5's and three G5's. The designation "5" indicates a sandy substrate. A "B" stream is characterized by moderate entrenchment, moderate gradient and riffle-dominated channel with infrequently-spaced pools. Its sensitivity to disturbance is moderate and its recovery potential is high. A "C" stream has low gradient, meandering point-bars, riffle and pools and alluvial channels with broad and well defined floodplains. Its sensitivity to disturbance is very high, but its recovery potential is only fair. A "G" stream is entrenched "gully" with low width/depth ratios on moderate gradients. This type of stream has the highest sensitivity to disturbance and has a very poor recovery potential.

summary description of stream channel stability

In summary, most of the streams in and adjacent to the LSA are characterized by pronounced meandering, wide floodplain, and low to moderate width to depth ratios. These types of streams typically occur in alluvial valleys which exhibit low to moderate elevation relief. They are highly stable if the floodplain and the width to depth ratio are maintained. However, if these two characteristic features are disrupted, the streams can become rapidly de-stabilized.

3. SUMMER STREAMFLOW MEASUREMENTS

3.1 NEED FOR STREAMFLOW MEASUREMENTS

purpose of streamflow measurements

The available hydrologic database of small basins in the LSA has a limited amount of recorded streamflow data. Additional manual streamflow measurements were needed to develop reliable stage-discharge rating curves at the local streamflow gauging stations shown in Figure 3.1, and to derive streamflow hydrographs based on recorded water levels at the stations. Pertinent details of these stations are provided in Table 3.1.

Table 3.1 Description of the Streamflow Gauging Stations in LSA

Station No.	Creek / River Name	Station Location		Basin Area (km^2)	Date of Installation
		Latitude (North)	Longitude (West)		
S1	Alsands Drain	57° 15' 20"	111° 29' 30"	15.8	May 1995
S2	Jackpine Creek	57° 15' 33"	111° 27' 53"	358	May 1995
S3	Iyinimin Creek	57° 14' 58"	111° 10' 21"	24.5	May 1995
S4	Blackfly Creek	57° 12' 11"	111° 15' 21"	38.2	May 1995
S5	Muskeg River	57° 21' 13"	111° 20' 11"	434	May 1995
S6	Mills Creek	57° 15' 13"	111° 29' 49"	23.8	May 1997

basis for hydrologic model calibration

The available, short-term streamflow hydrographs were used to calibrate a hydrologic model. The data were then used to simulate a historic flow series based on the available long-term climate data. The simulated flow series were then analyzed to characterize natural runoff conditions of small sub-basins in the LSA.

3.2 RESULTS OF SUMMER STREAMFLOW MEASUREMENTS

types of measurements

Manual streamflow measurements were conducted once a month at each streamflow gauging station (S1 to S6), for the period June to October 1997. The water levels at these stations were continuously monitored by pressure transducers and dataloggers during the entire 1997 summer period.

collected data in the summer of 1997

Table 3.2 summarizes the manual streamflow measurements taken in summer of 1997, as well as the measurements conducted during the winter and spring of 1997. Appendix II presents the detailed streamflow measurements conducted at stations S1 to S6 during the summer of 1997.

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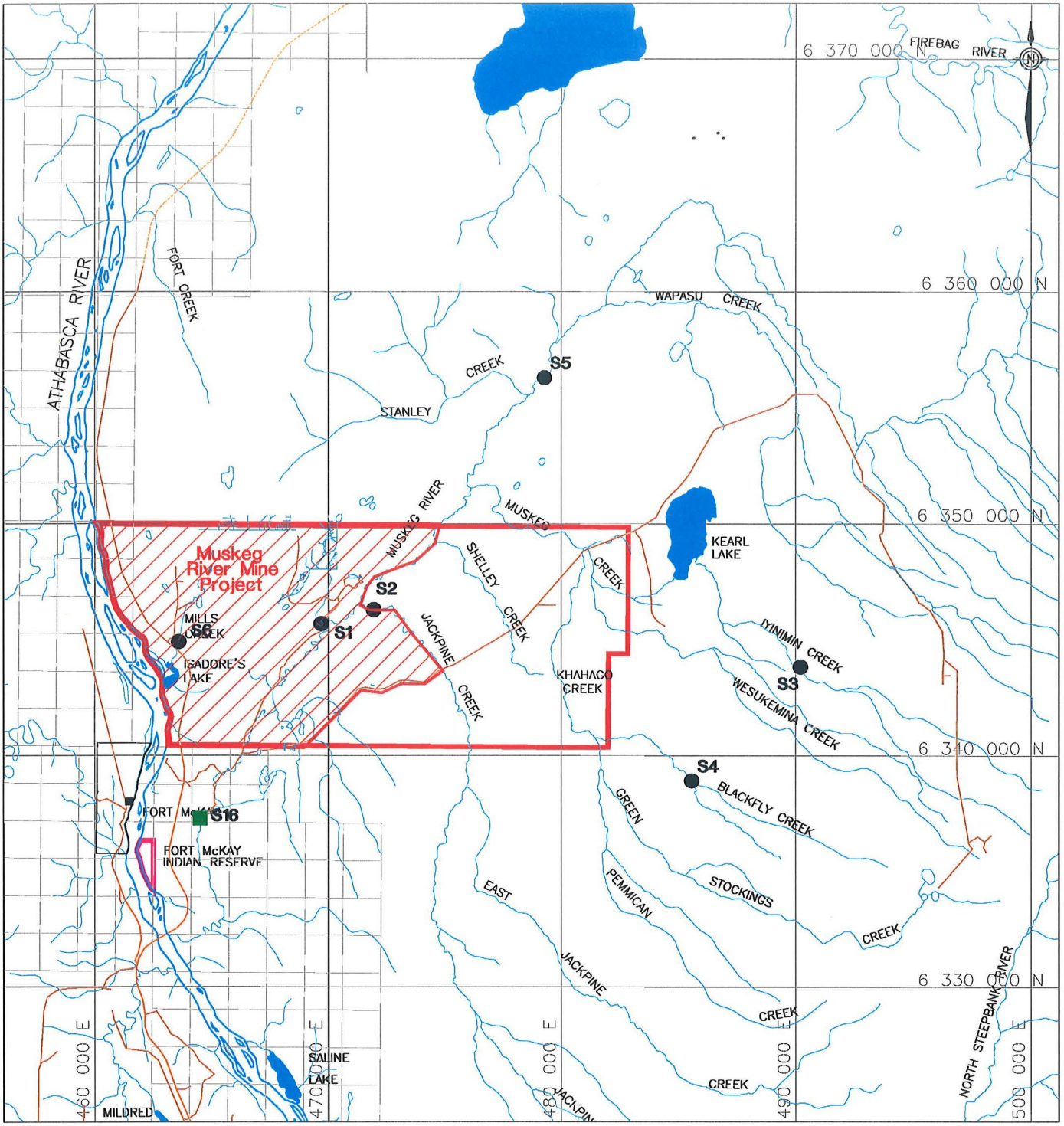

LEGEND

- LOCAL, SHORT TERM HYDROLOGIC MONITORING STATION
- WSC HYDROLOGIC MONITORING STATION

0 2.5 5 7.5 10 12.5 km

SCALE 1:250,000

REFERENCE

DIGITAL DATA SETS 74D, 74E, 74I
84A AND 84H FROM RESOURCE DATA DIVISION
ALBERTA ENVIRONMENTAL PROTECTION, 1997.

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LOCATIONS OF HYDROLOGIC MONITORING STATIONS IN THE LOCAL STUDY AREA

29 NOV 97	Figure 3.1	DRAWN BY: BGM/DC

Table 3.2 Summary of Manual Streamflow Measurements (March to October, 1997)

Station No	Creek / River Name	Winter		Snowmelt		Summer	
		Discharge (m^3/s)	Date	Discharge (m^3/s)	Date	Discharge (m^3/s)	Date
S1	Alsands Drain	0.084 0.074	Mar 17 Mar 28	0.12 0.16 0.076 0.059	Apr 16 Apr 23 Apr 30 May 09	0.031 0.035 0.016 0.059 0.19	Jun 04 Jun 23 Jul 22 Aug 19 Sep 23
S2	Jackpine Creek	0.023 0.098	Mar 16 Mar 28	0.12 3.8 6.0 4.50	Apr 17 Apr 25 May 01 May 08	1.84 1.53 0.89 2.84	Jun 03 Jun 21 Jul 23 Aug 20
S3	Iyinimin Creek	No Flow No Flow	Mar 18 Mar 27	No Flow 0.24 0.295 0.478	Apr 17 Apr 25 May 01 May 08	0.40 0.20 0.36 1.34 1.05	Jun 03 Jun 21 Jul 23 Aug 20 Oct 03
S4	Blackfly Creek	No Flow No Flow	Mar 17 Mar 28	No Flow 0.75 0.63 0.56	Apr 17 Apr 25 May 01 May 08	0.39 0.28 0.17 1.12 0.74	Jun 03 Jun 21 Jul 23 Aug 20 Oct 03
S5	Muskeg River	0.16 0.22	Mar 18 Mar 27	0.65 4.00 4.21 4.24	Apr 17 Apr 25 May 01 May 08	1.77 1.14 5.95 6.70	Jun 03 Jun 23 Aug 20 Oct 03
S6	Mills Creek	0.034 0.044	Mar 15 Mar 28	0.11 0.17 0.095 0.084	Apr 16 Apr 23 Apr 30 May 07	0.066 0.062 0.047 0.067 0.11	Jun 04 Jun 21 Jul 22 Aug 19 Sep 23

3.3 RATING CURVES AND STREAMFLOW HYDROGRAPHS

basis for developing the rating curves

The available streamflow measurements obtained during the 1997 data collection program and previously for the Syncrude Aurora Project (AGRA 1995b), were used to develop the stage-discharge rating curves for the streamflow gauging stations S1 to S5 as shown in Figures 3.2 to 3.6.

The stage-discharge rating curve in Figure 3.7 for Mills Creek station (S6) has shown a clear shift in rating curve due to beaver dam activities at the temporary weir structure during the summer period and water leakage through the weir cutoff wall as a result of high discharges, which occurred during the snowmelt period.

Therefore, at this station, the measured streamflow data were not used to derive the stage-discharge rating curve. As shown in Figure 3.7, a theoretical stage-discharge rating curve was developed based on a composite weir formula. For future flow monitoring, a permanent weir structure, with complete cutoff and beaver dam control, will be built at the site. Permitting approval has been received from the Alberta Community Development but approval from Land Administration Branch of Alberta Environmental Protection is pending. The gauging station will be installed as soon as permits are received.

derivation of hydrographs based on stage records

The above stage-discharge rating curves were used to derive a continuous sequence of flows based on the continuos stage hydrographs recorded by pressure transducers and dataloggers installed at the streamflow gauging stations S1 to S6. The derived streamflows are presented in Figures 3.8 to 3.12.

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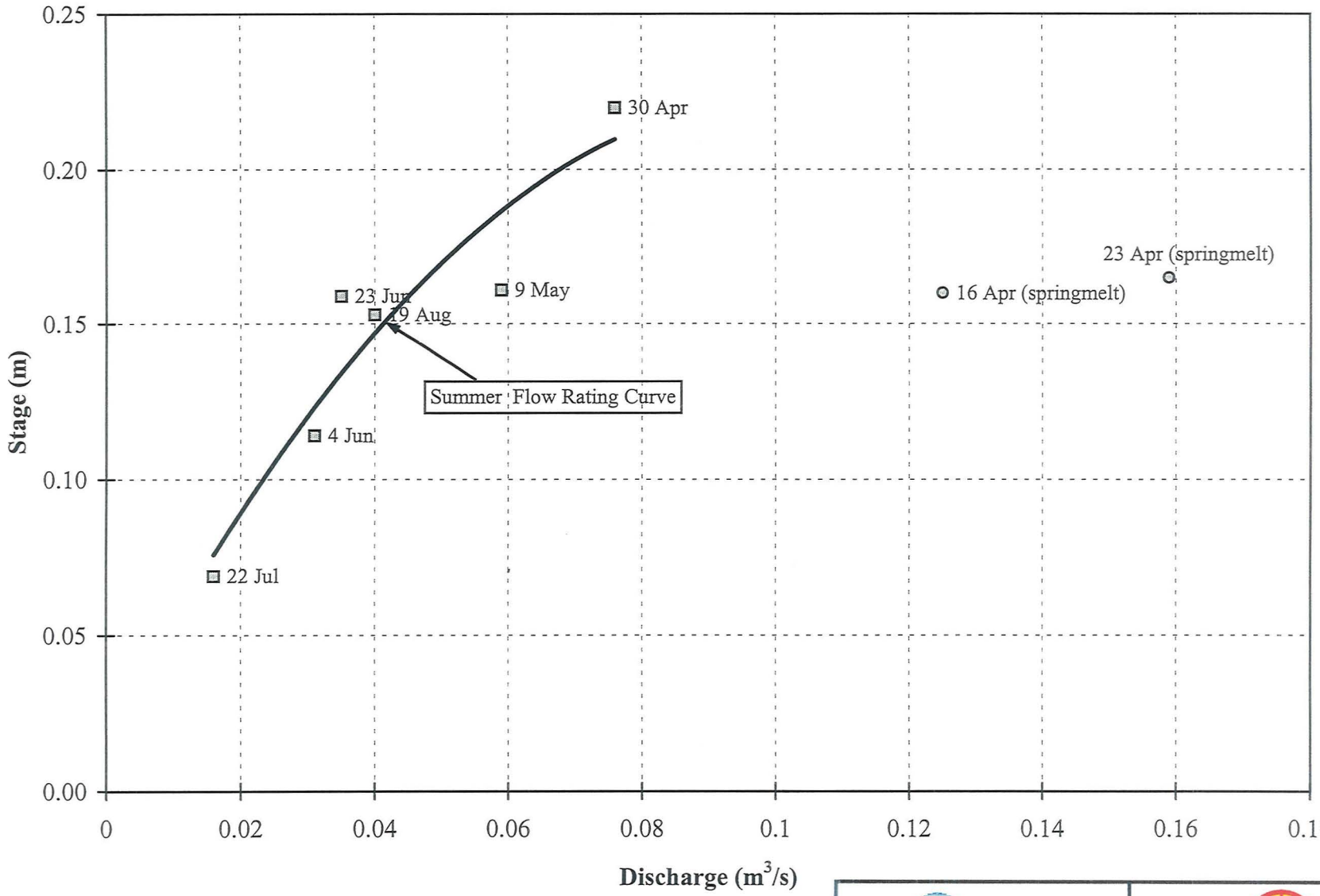

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STAGE - DISCHARGE RATING CURVE AT ALSANDS DRAIN (S1)

29 NOV 97	Figure 3.2	DRAWN BY: BGM

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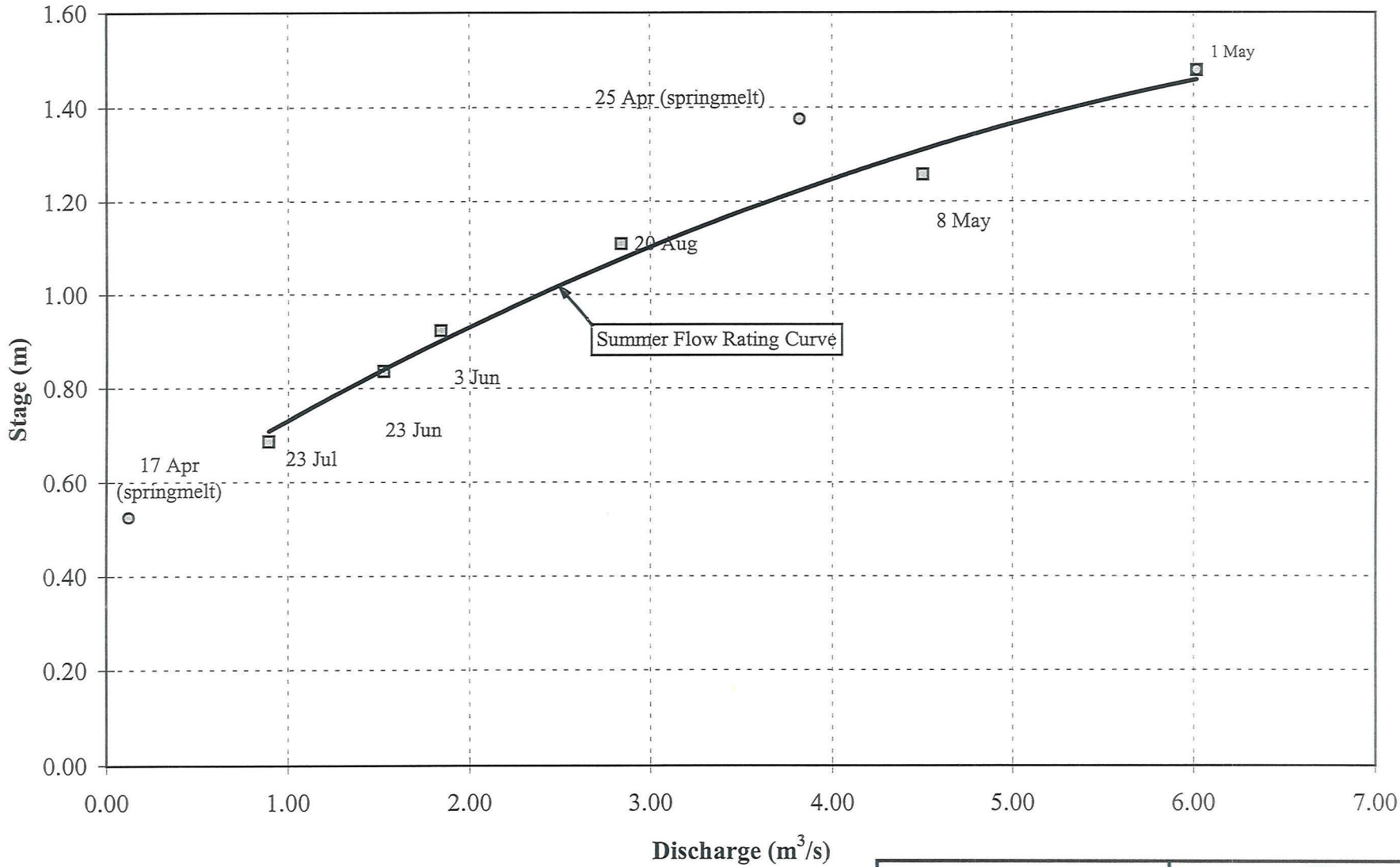

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STAGE - DISCHARGE RATING CURVE AT JACKPINE CREEK (S2)

29 NOV 97	Figure 3.3	DRAWN BY: BGM

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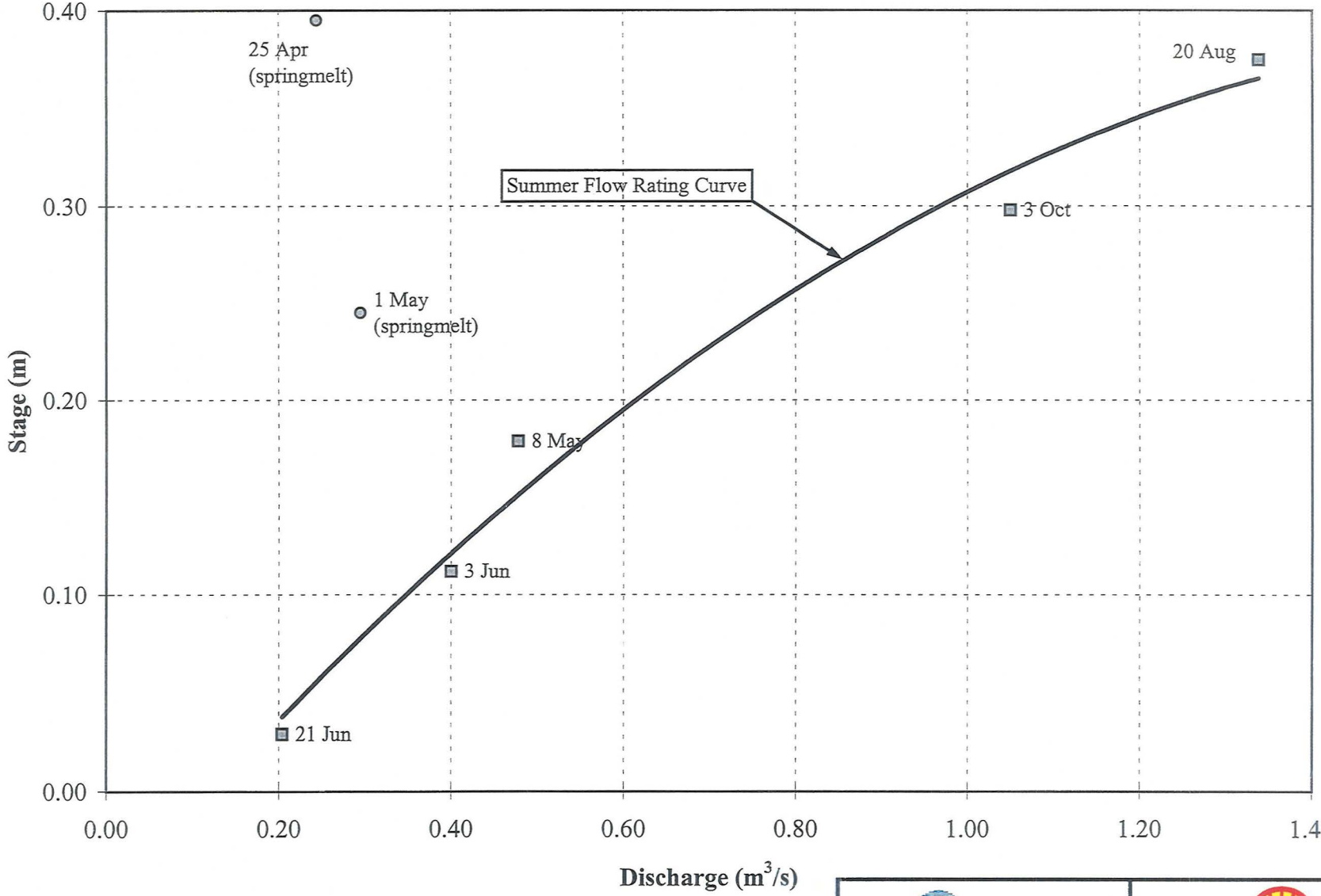

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STAGE - DISCHARGE RATING CURVE AT IYINIMIN CREEK (S3)

29 NOV 97	Figure 3.4	DRAWN BY: BGM

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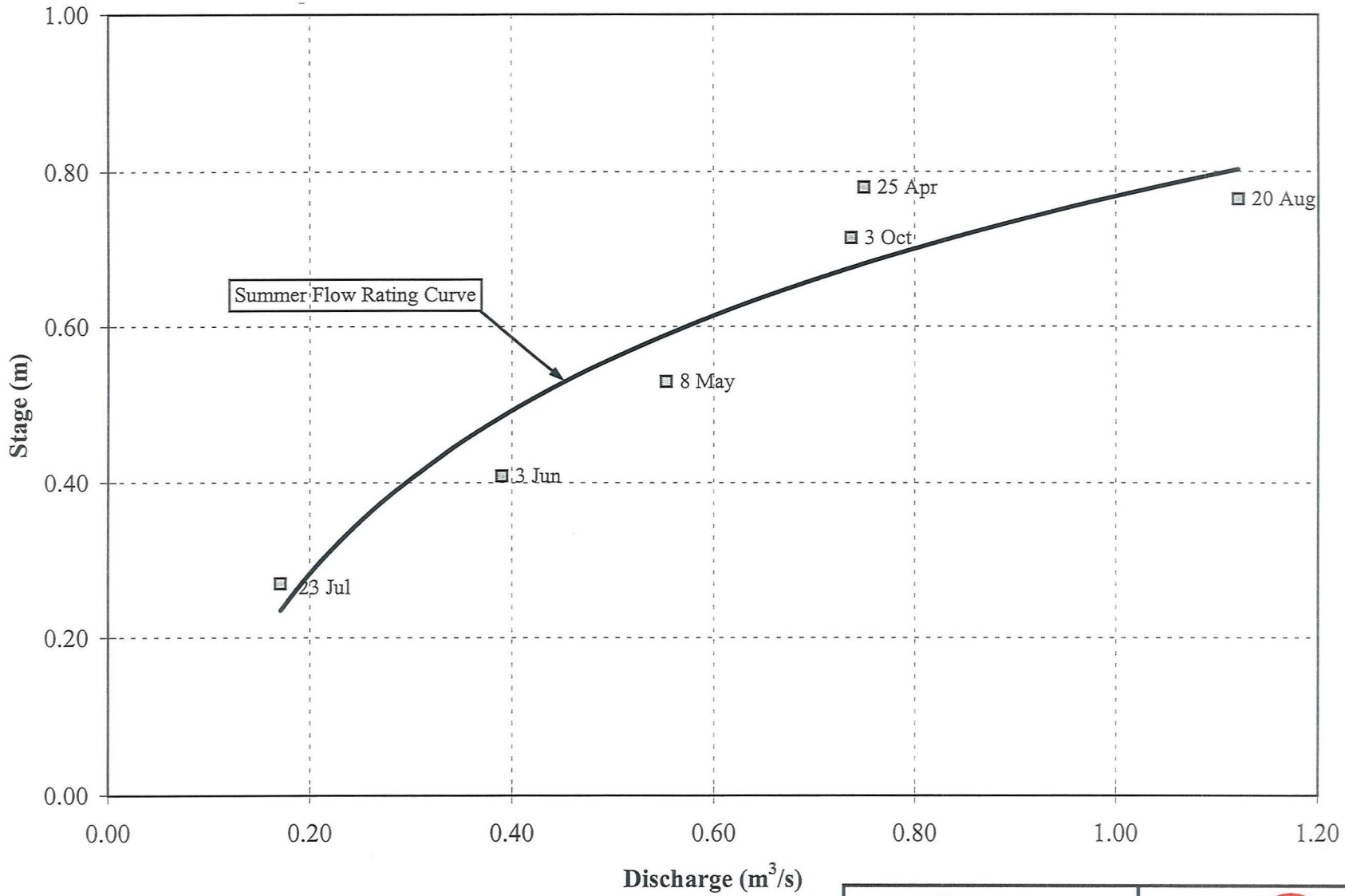

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STAGE - DISCHARGE RATING CURVE AT BLACKFLY CREEK (S4)

29 NOV 97	Figure 3.5	DRAWN BY: BGM

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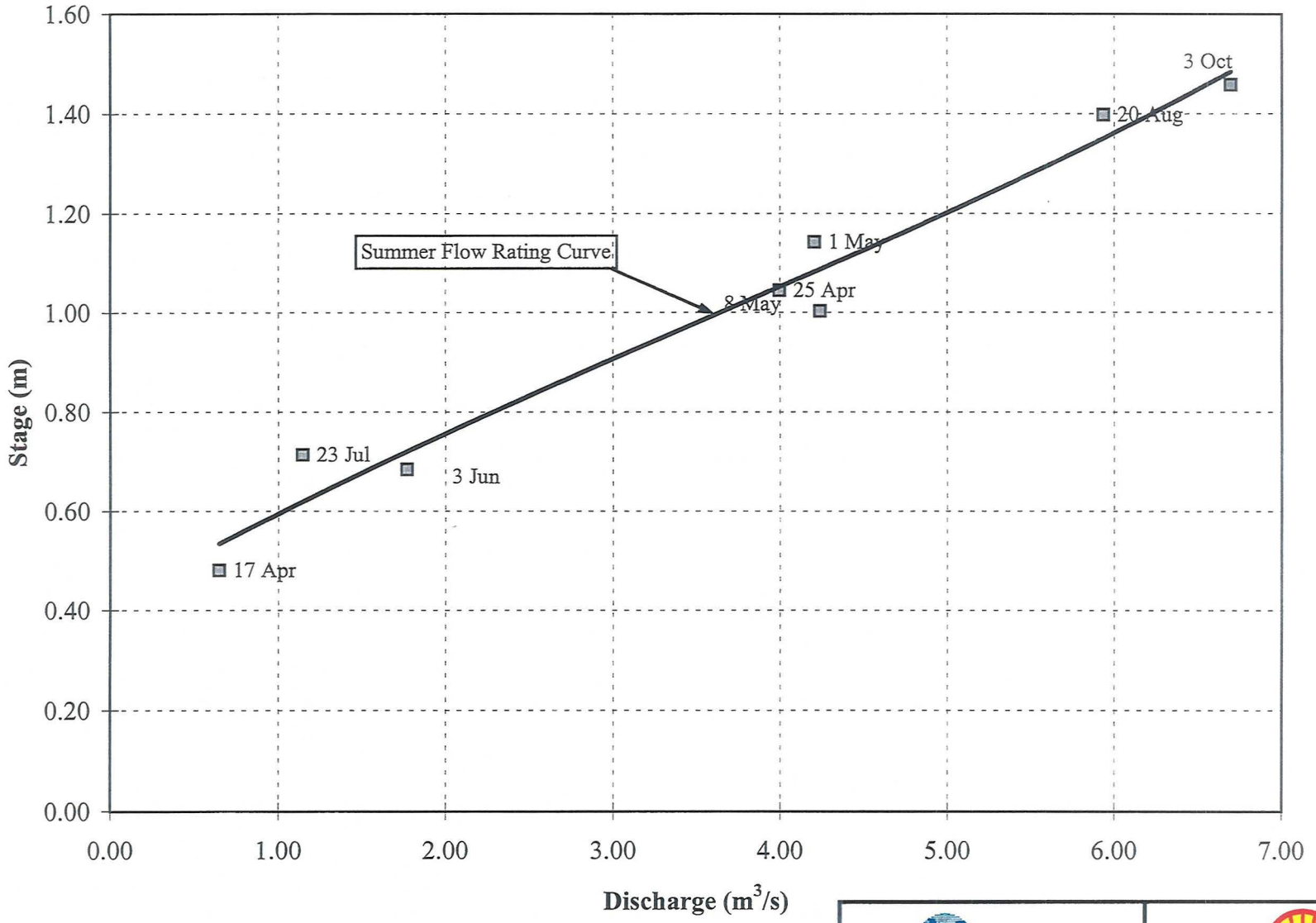

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STAGE - DISCHARGE RATING CURVE AT MUSKEG RIVER (S5)

29 NOV 97	Figure 3.6	DRAWN BY: BGM

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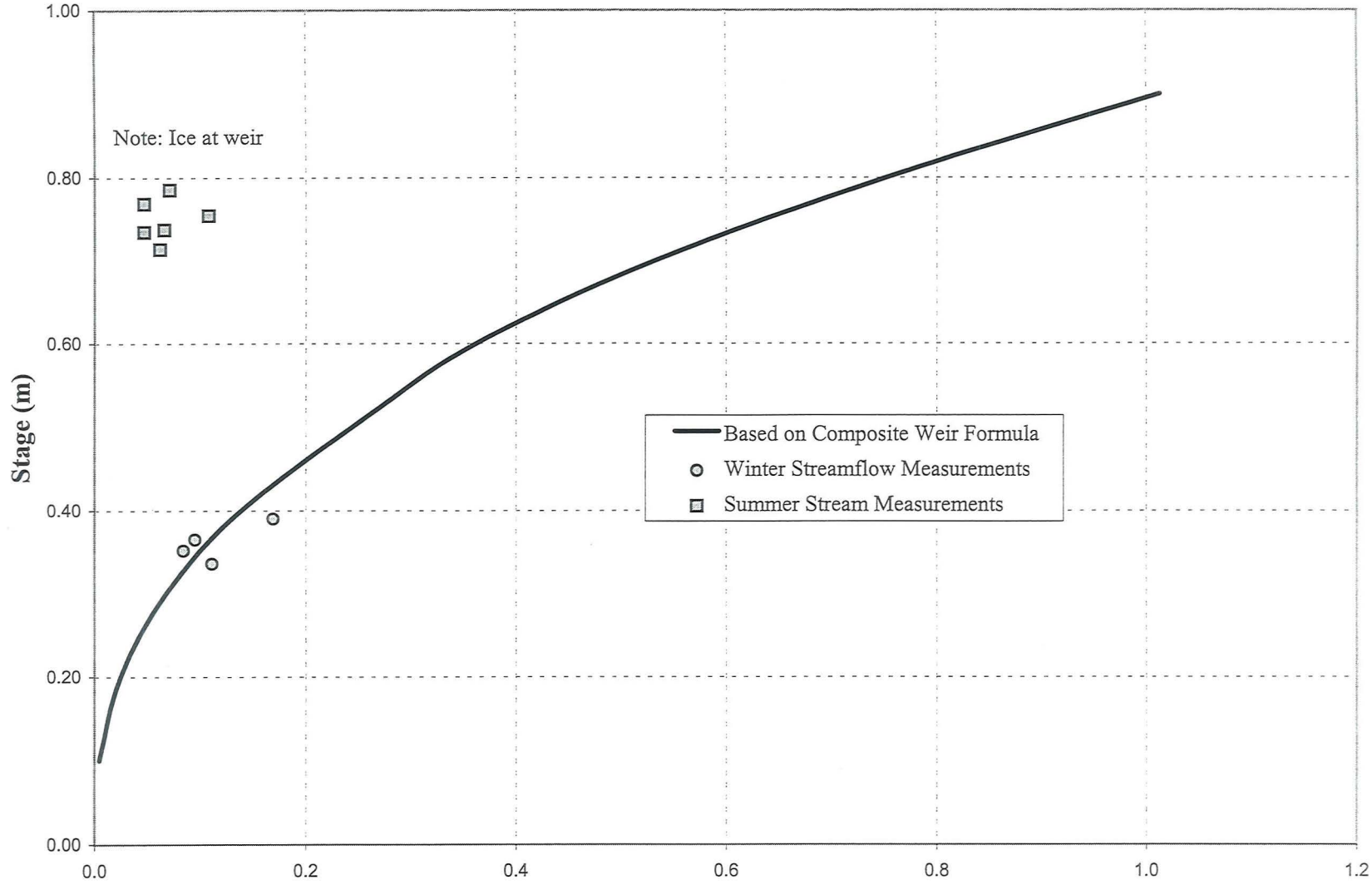

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STAGE - DISCHARGE RATING CURVE AT MILLS CREEK (S6)

29 NOV 97	Figure 3.7	DRAWN BY: BGM

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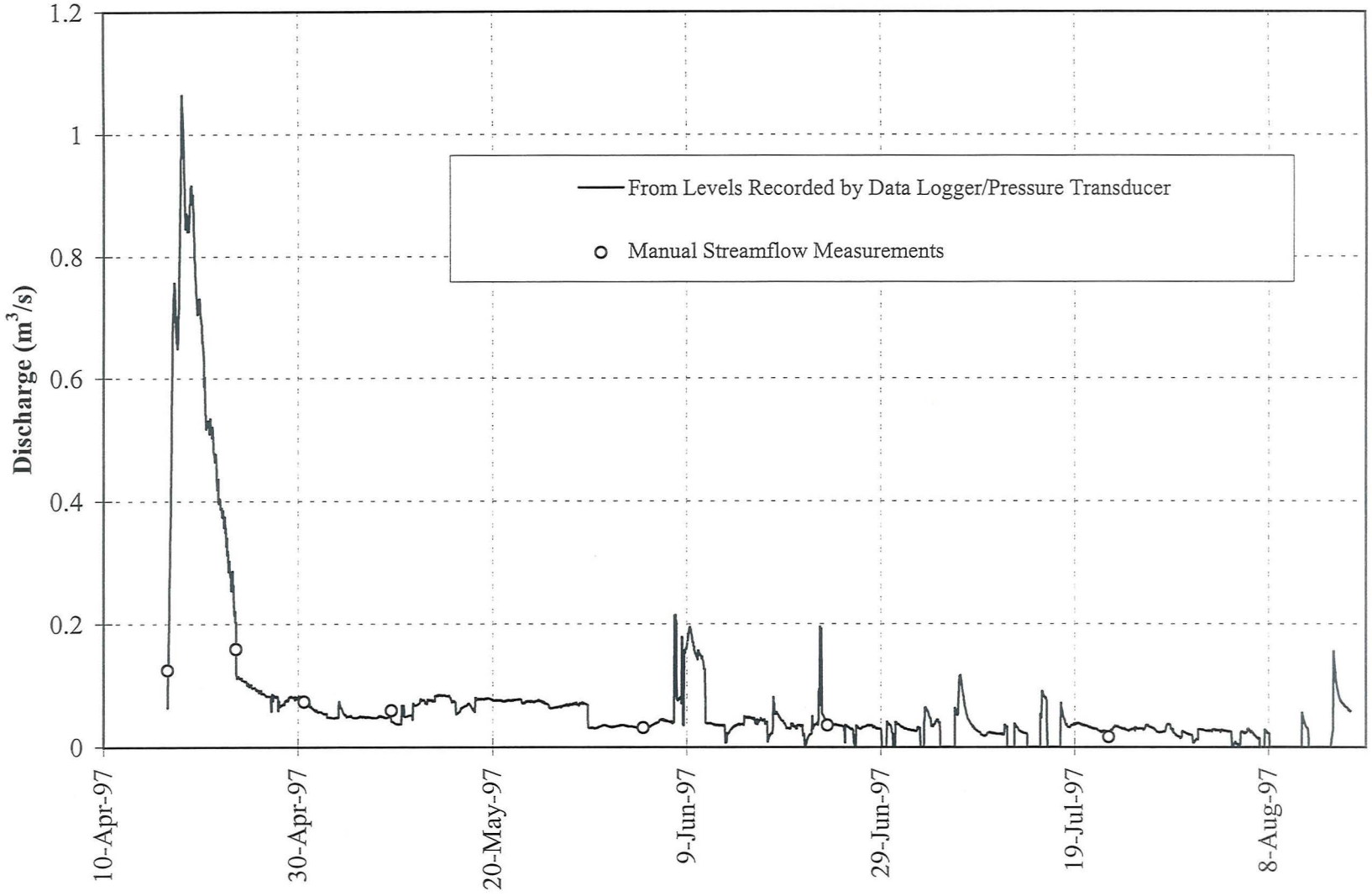

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DISCHARGE HYDROGRAPH AT ALSANDS DRAIN (S1)

29 NOV 97	Figure 3.8	DRAWN BY: BGM

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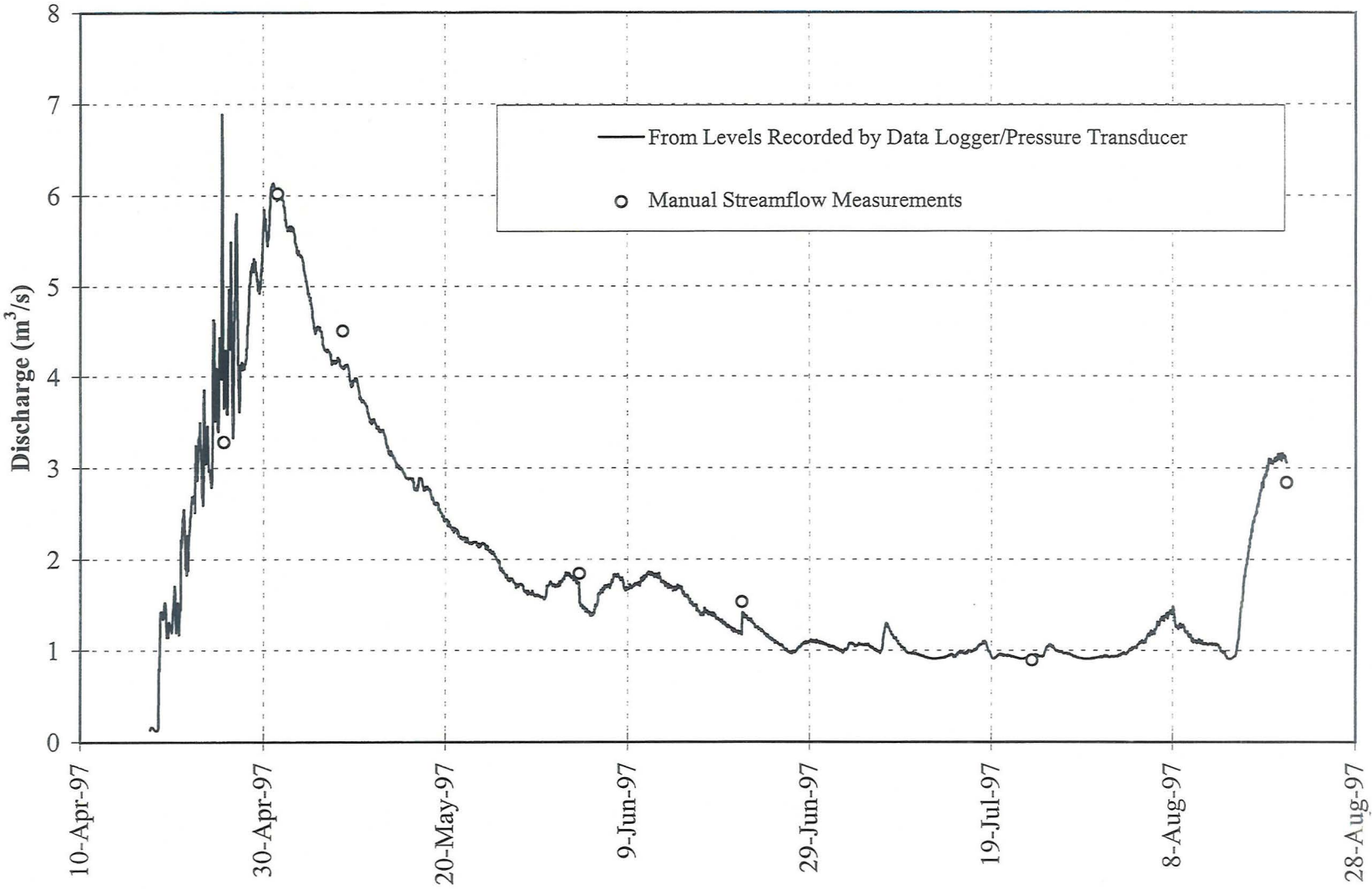

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DISCHARGE HYDROGRAPH AT JACKPINE CREEK (S2)

29 NOV 97	Figure 3.9	DRAWN BY: BGM

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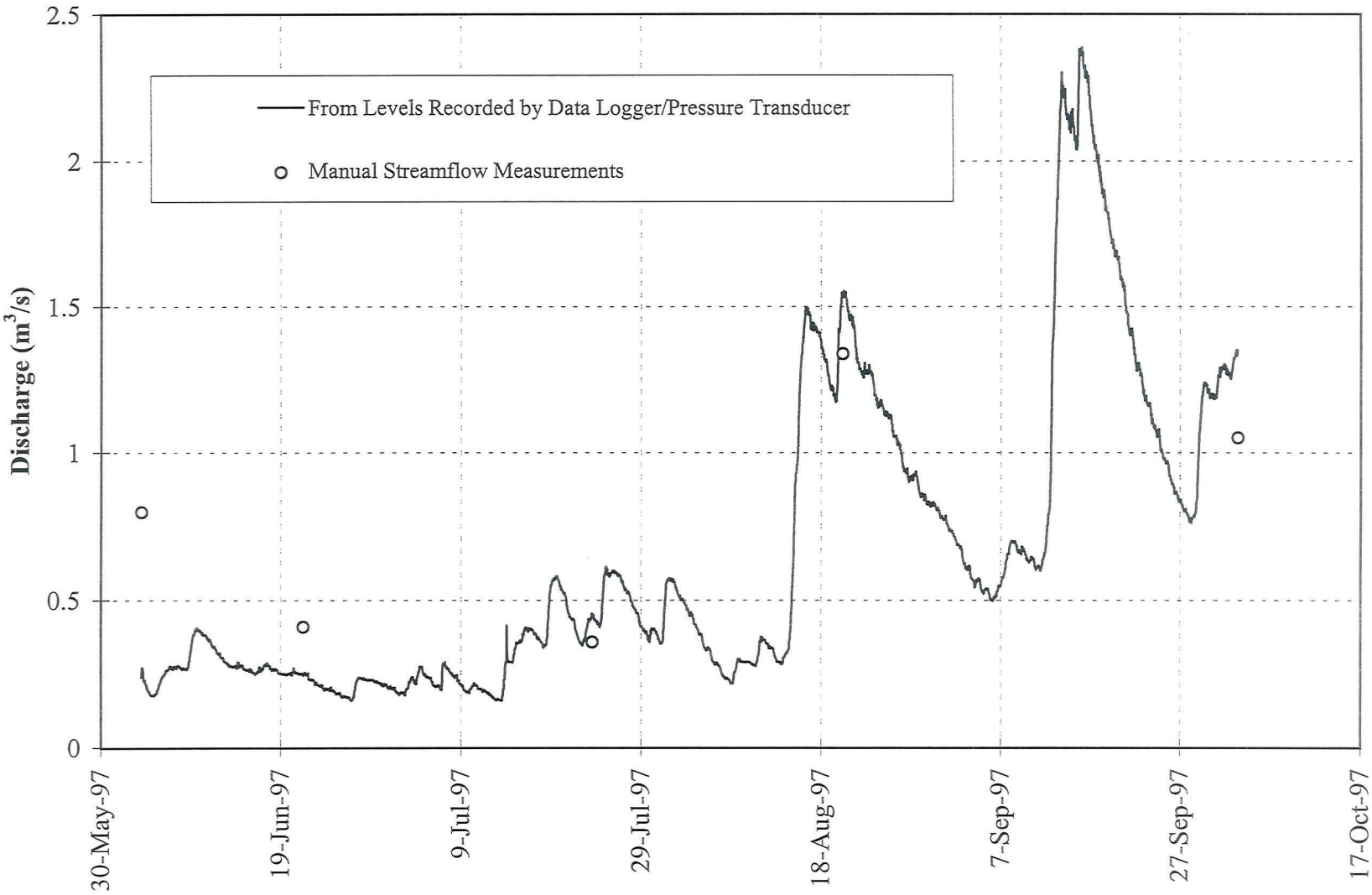

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DISCHARGE HYDROGRAPH AT IYINIMIN CREEK (S3)

29 NOV 97	Figure 3.10	DRAWN BY: BGM

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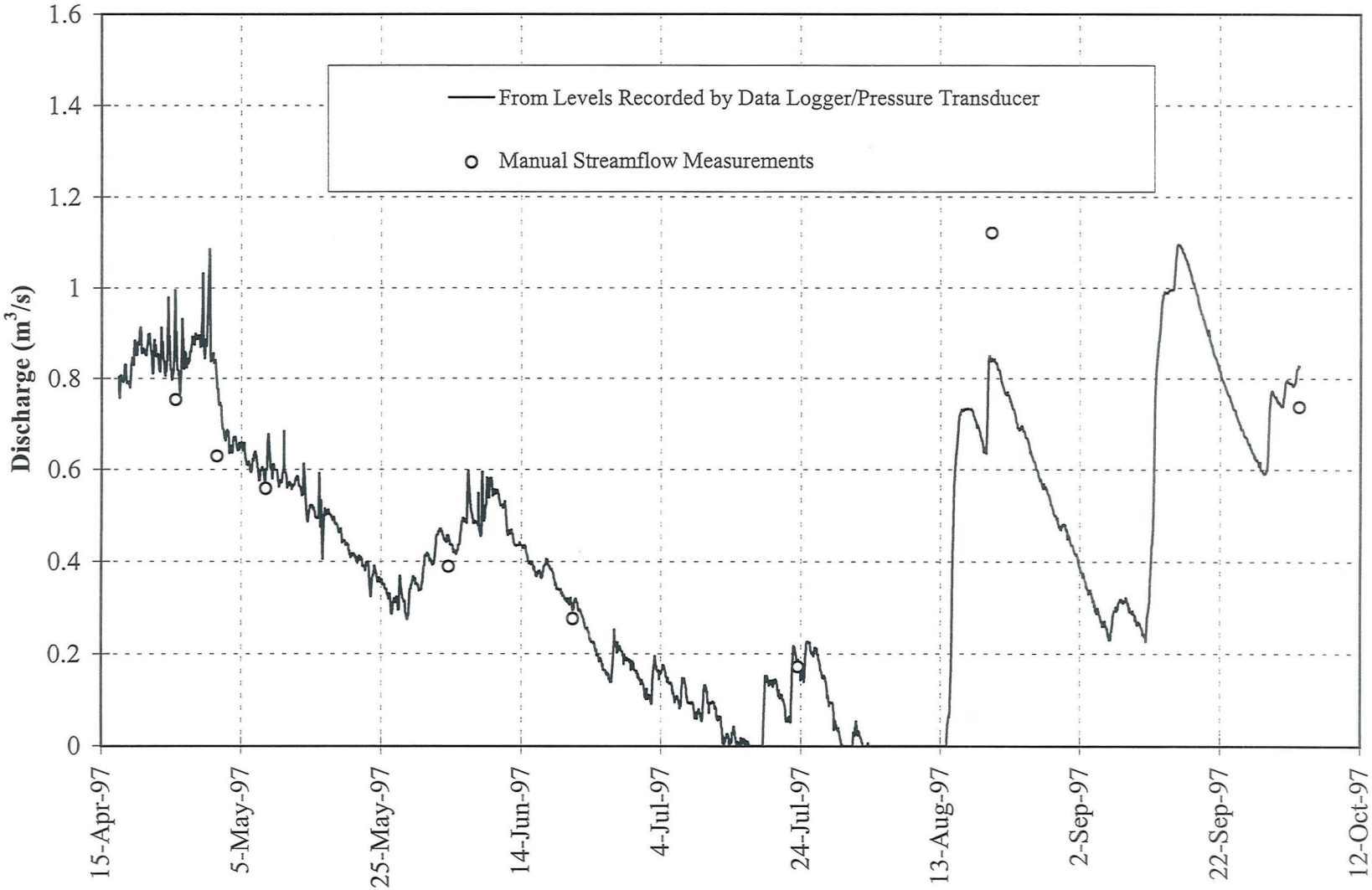

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DISCHARGE HYDROGRAPH AT BLACKFLY CREEK (S4)

29 NOV 97	Figure 3.11	DRAWN BY: BGM

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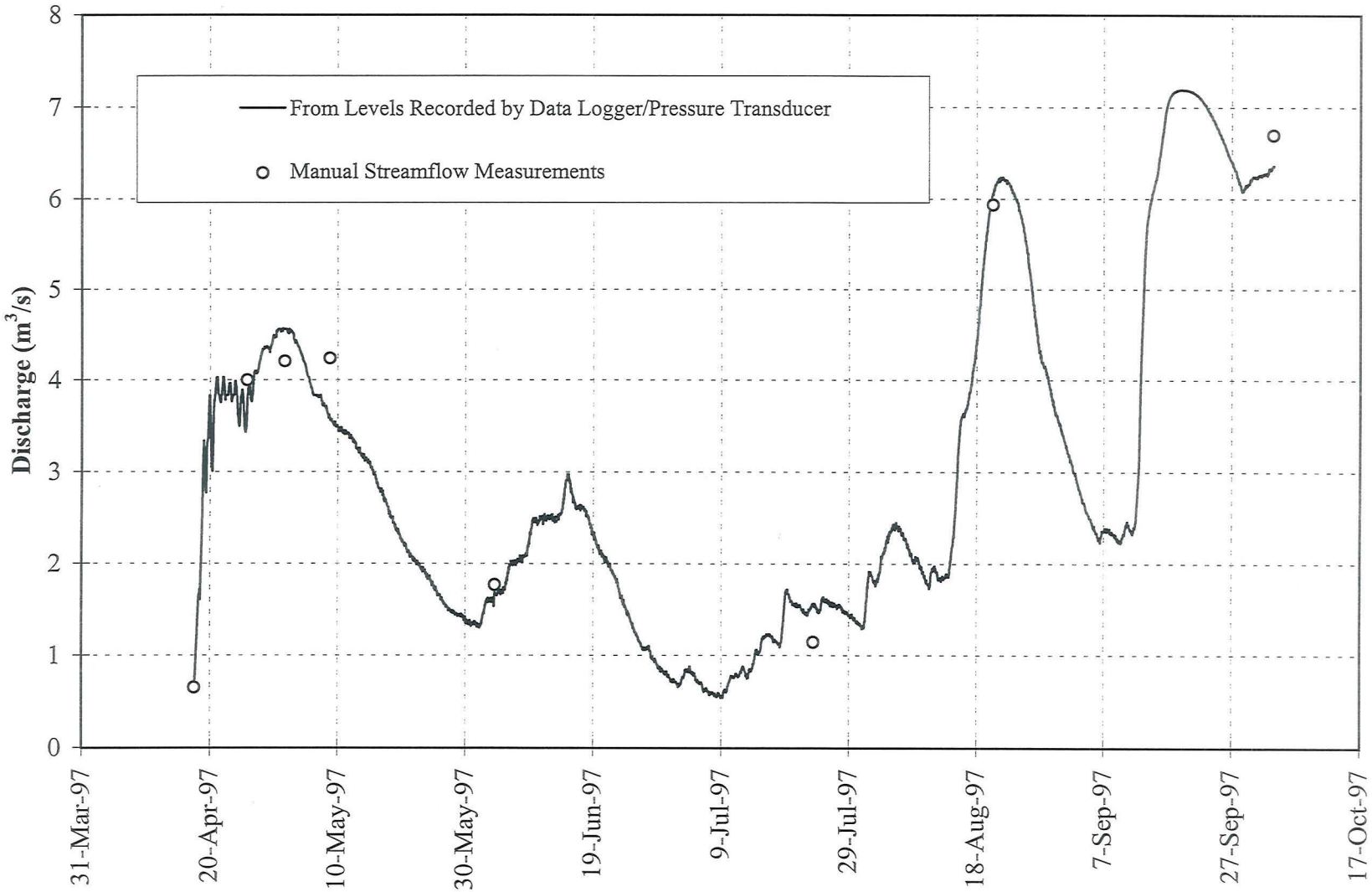

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DISCHARGE HYDROGRAPH AT MUSKEG RIVER (S5)

29 NOV 97	Figure 3.12	DRAWN BY: BGM

4. TOTAL SUSPENDED SEDIMENT MEASUREMENTS AND ANALYSIS

TSS measurements

Total suspended sediment (TSS) was measured at each of the stream gauging stations (S1 to S6) during the 1997 summer (April to September) period. The measured TSS data are presented in Table 4.1.

Table 4.1 Total Suspended Sediment Data (April to October 1997)

Sampling Date	Measured Total Suspended Sediment Concentration (mg/L)					
	Alsands Drain (S1)	Jackpine Creek (S2)	Iyinimin Creek (S3)	Blackfly Creek (S4)	Muskeg River (S5)	Mills Creek (S6)
Apr 04			3			
Apr 23	2					6
Apr 25		20		12	3	
Apr 30	1					3
May 01		24	7	89	3	
May 07						5
May 08		13	56	42	3	
May 09	8					
Jun 03	3	3	27	20	3	
Jun 04						8
Jun 09						
Jun 21		3	13	9		
Jun 23	2					3
Jul 22	3					2
Jul 23		2	31	6	2	
Jul 24						
Jul 25						
Aug 19	2					2
Aug 20		20	128	57	40	
Oct 03		6	28	19	8	

analysis of TSS data

Figure 4.1 shows a plot of measured TSS data against the daily discharges measured during the 1997 baseline data collection program. The figure indicates that the TSS concentrations measured on the smallest streams (e.g., S1 and S2 stations) are much higher than those on larger streams (e.g., S3 and S4 stations).

TSS discharge relationships for the Muskeg River

The available TSS data from 1976 to 1983 at the long-term hydrometric station located on the Muskeg River near Fort McKay (WSC 07DA008) were analyzed to determine the relationships between TSS concentrations and discharges at the station. Figure 4.2 shows a plot of the measured TSS data against the daily discharges for the snowmelt period from April 1 to May 15 and spring/summer period from May 15 to October 31. The figure shows that TSS concentrations during the snowmelt period were relatively high with values up to 40 mg/L and that the TSS concentrations measured during the spring/summer period are much smaller than the those measured during the snowmelt period.

J:\1997\2237\6600\DATARPT\FIG4.DWG

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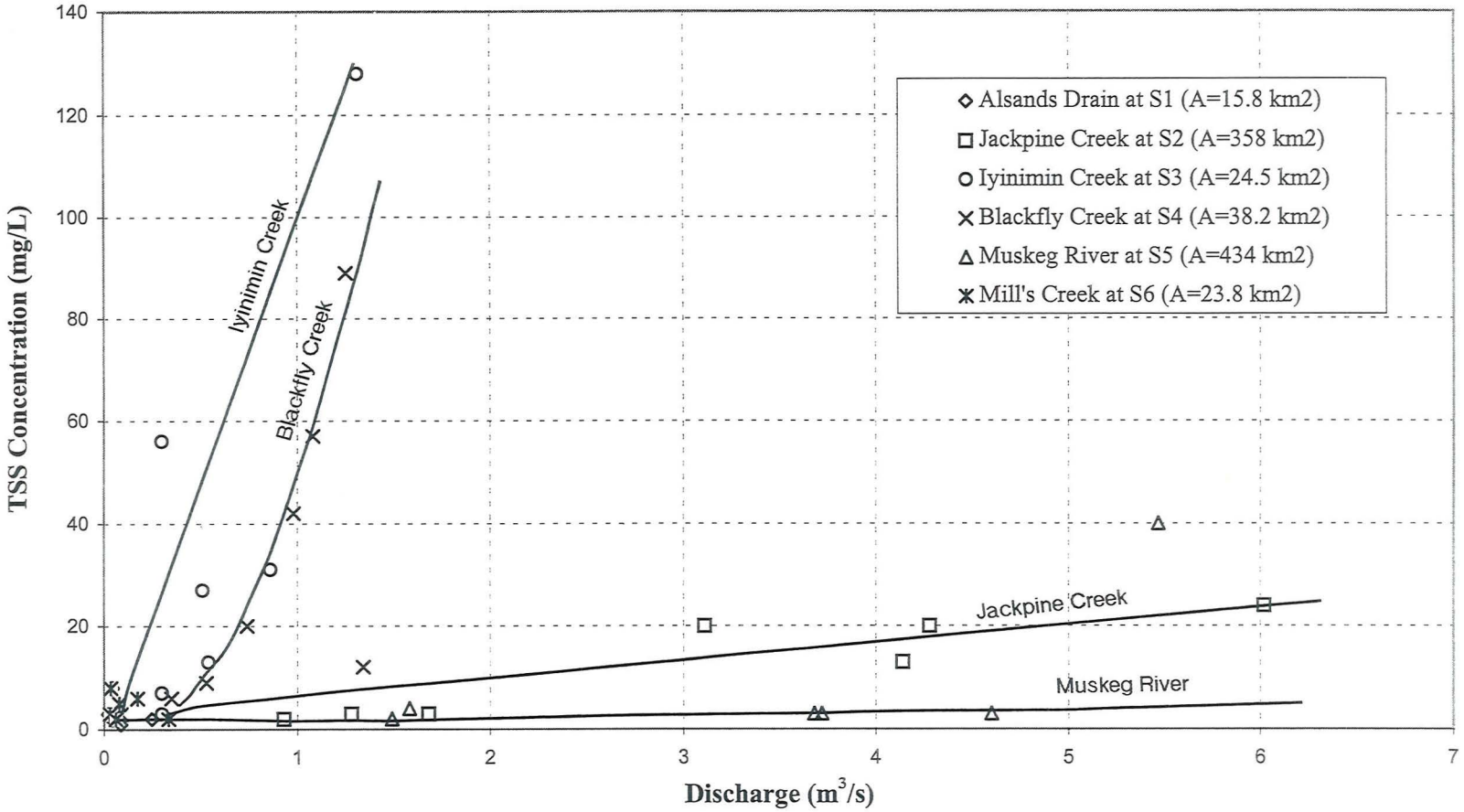

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TSS CONCENTRATION DATA FOR SMALL STREAMS IN LOCAL STUDY AREA (PERIOD OF RECORD: APRIL TO SEPTEMBER, 1997)

29 NOV 97	Figure 4.1	DRAWN BY: BGM

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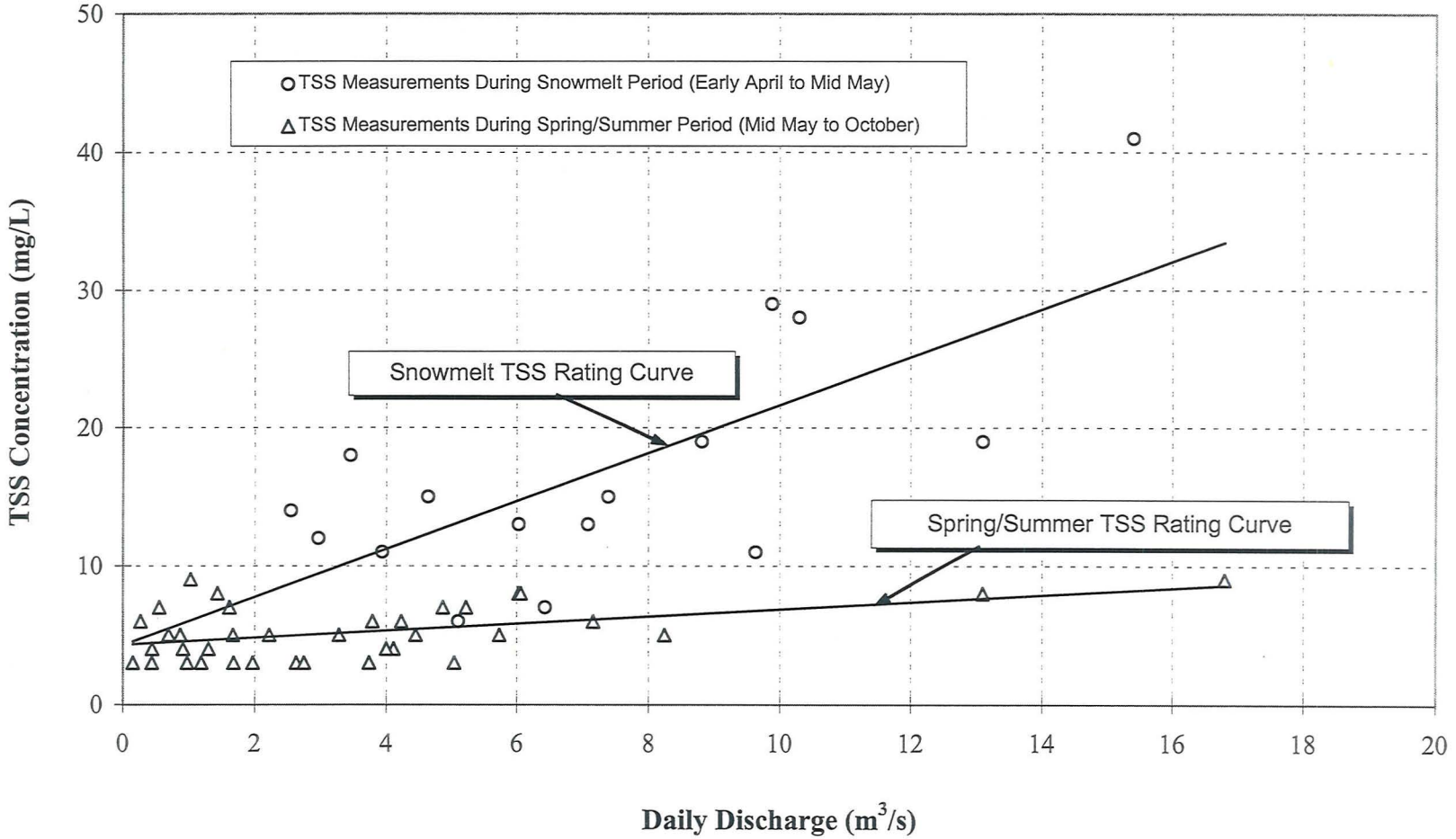
R:\1997\2600\972-2609\6600\6600\SUMMER-REP\FIGURE4.2.XLS



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TSS RATING CURVES OF WSC STATION ON THE MUSKEG RIVER (PERIOD OF RECORD: 1976 TO 1983)

29 NOV 97	Figure 4.2	DRAWN BY: BGM

5. WATER LEVEL MEASUREMENTS

installation of staff gauges

Eight water level staff gauges were installed along the Muskeg River (G1 to G4) and Jackpine Creek (G5 to G8) as shown in Figure 5.1. Each staff gauge was equipped with a floating mechanism to record the high water marks. The staff gauges were installed in May 1997.

available water level readings

Manual readings of water levels at the staff gauges were recorded from May through August, 1997. The resulting water level measurements are summarized in Table 5.1.

geodetic survey

The water level staff gauges were tied to the geodetic datum. The geodetic survey was carried out by CAN-AM Survey Ltd., under supervision of Golder Associates Ltd. Table 5.2 provides the latitude, longitude and elevation coordinates of the staff gauges.

Table 5.1 Summary of Water Level Measurements (May to August 1997)

Date of	Water Levels on the Muskeg River (m)				Water Levels on the Jackpine Creek (m)			
Measurement	G1	G2	G3	G4	G5	G6	G7	G8
May 10	272.91	274.09	277.77	281.58	298.09	297.09	278.70	-
May 20	-	-	277.33	-	-	-	-	-
May 21	273.49	273.65	-	-	-	-	-	-
May 22	-	-	-	-	-	-	278.20	-
May 24	-	-	-	281.10	298.39	296.98	-	-
June 03	273.24	273.49	277.11	281.08	298.34	296.96	278.09	301.96
June 23	273.19	274.70	276.97	-	298.28	296.91	278.06	301.90
July 22	272.90	-	276.72	-	298.17	296.86	-	-
July 23	272.93	275.52	276.76	280.82	298.22	296.89	277.80	301.93
August 19	273.88	-	277.90	-	299.51	298.05	-	-
August 20	-	276.57	-	281.72	-	-	278.82	302.3

Table 5.2 Survey Details of the Water Level Staff Gauges

Staff Gauge Name	Latitude (North)	Longitude (West)	Reference Point Elevation (m)
G1	57° 12' 22"	111° 33' 13"	273.346
G2	57° 14' 12"	111° 31' 20"	274.571
G3	57° 15' 09"	111° 29' 52"	276.659
G4	57° 17' 08"	111° 25' 13"	280.089
G5	57° 14' 18"	111° 24' 44"	299.075
G6	57° 14' 21"	111° 24' 53"	297.586
G7	57° 15' 40"	111° 28' 16"	277.901
G8	57° 13' 58"	111° 24' 26"	301.390

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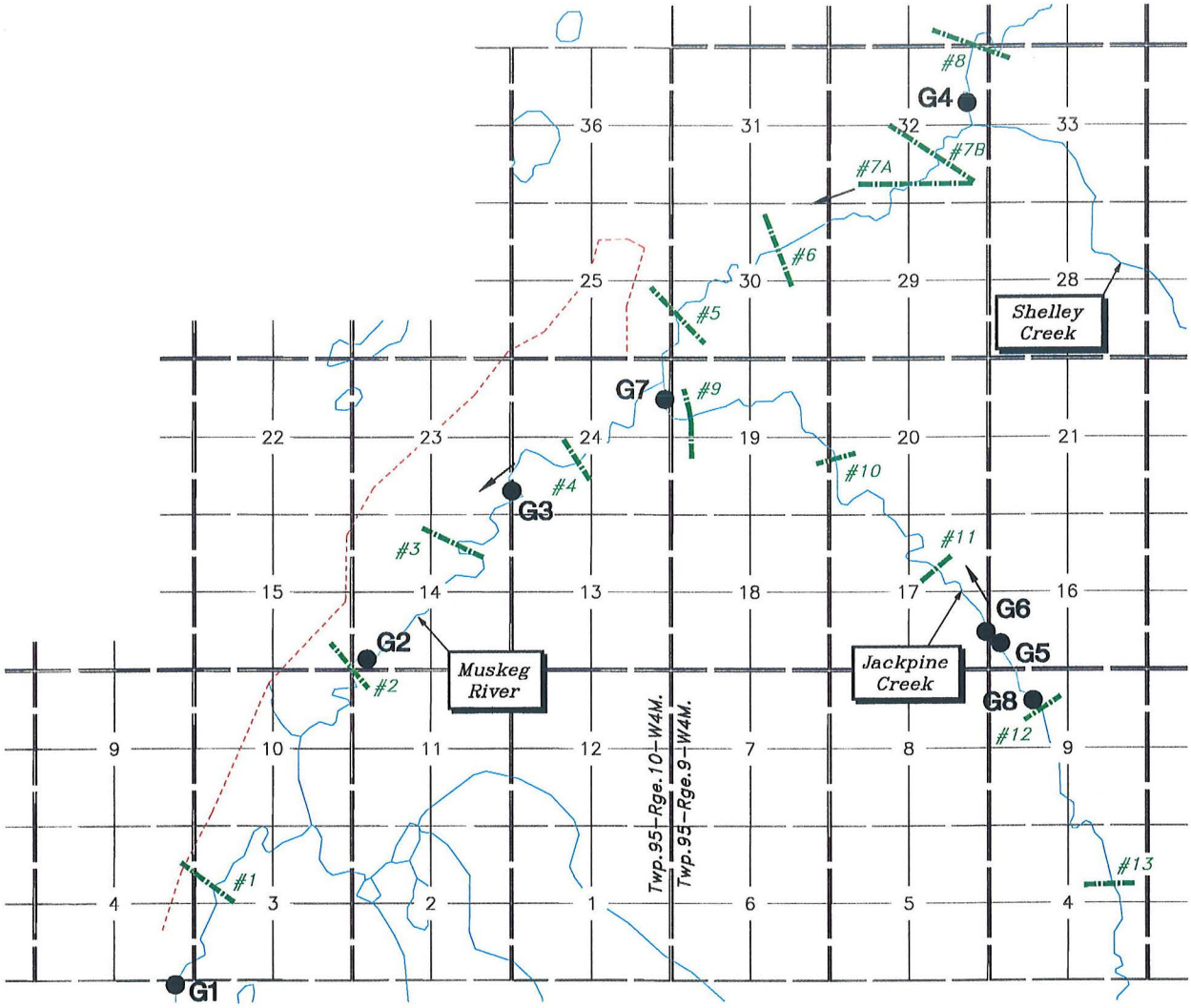

LOCATION PLAN
SCALE = 1 : 75,000

REFERENCE

DRAWING FROM CAN–AM SURVEYS LTD.
FIGURE A1, APRIL 8, 1997

LEGEND

#1 CROSS–SECTION

G1 WATER LEVEL STAFF GAUGES

Golder Associates

SHELL CANADA LIMITED

LOCATION OF WATER LEVEL STAFF GAUGES MUSKEG RIVER AND JACKPINE CREEK

29 NOV 97	Figure 5.1	REV NO

6. FLOODPLAIN MAPPING

6.1 NEED FOR FLOODPLAIN MAPPING

purpose of floodplain mapping

The Muskeg River Mine Project development may encroach onto the floodplains of the Muskeg River and Jackpine Creek and could potentially impact flow velocities and flow levels. This could have negative impacts on stream habitat and hydrologic stability of the stream channels. Encroachment onto the floodplains could also endanger mine safety. Flood protections measures are therefore required for the design of facilities adjacent to the streams. Floodplain mapping was conducted along the study reaches of the Muskeg River and Jackpine Creek for 10 and 100 year events to characterize the flood conditions for design of flood protection measures and to provide a basis for assessing environmental impacts.

6.2 HYDRAULIC MODELLING

6.2.1 HEC-RAS Model

capabilities and required input data by the HEC-RAS program

Flood water surface profiles for the 10 and 100 year events were calculated using the HEC-RAS program developed by Hydrologic Engineering Centre of the U.S. Army Corps of Engineers (July 1995). This model was designed for calculating water surface profiles for steady and gradually varied flow in natural or man-made channel networks. The HEC-RAS model solves the one dimensional energy equation by iteration to attain an energy balance between each successive cross-section along the channel. The following main input data are required for the model to calculate the water surface profile along each channel reach:

- geometric data including channel and floodplain cross-sectional data, and reach lengths;
- roughness parameters including main channel and floodplain roughness coefficients; and
- discharge.

6.2.2 Cross-Sectional Data

cross-sectional data used for the hydraulic modelling

Channel and floodplain cross sections were surveyed along the study reaches of the Muskeg River and Jackpine Creek by CAN-AM Survey Ltd., during the Shell's Winter Data Collection Program in May 1997. The surveyed data included 17 selected cross-sections. The locations of the surveyed cross sections on the Muskeg River (10 cross-sections) and Jackpine Creek (7 cross-sections) are shown in Figure 5.1. Channel reach lengths between cross-sections were determined based on the surveyed horizontal (x, y) coordinates of the cross-sections scaled along the river thalwegs.

6.2.3 Hydraulic Roughness Parameters

computation of energy losses

Total energy losses associated with the calculation of water surface profiles in the hydraulic model include transition and friction losses. Contraction or expansion coefficients are used for computing the transition losses and the Manning's roughness coefficient is used for computing the friction losses.

selection of expansion and contraction coefficients

A contraction coefficient of 0.1 and an expansion coefficient of 0.3 were used for the hydraulic modelling because the natural expansion or contraction of flow along the study reaches of the Muskeg River and Jackpine Creek is considered to be gradual.

method for calibrating main channel Manning's roughness

The Manning's roughness coefficient for the main channel is the most important hydraulic parameter and needs to be calibrated based on high-water level measurements. The adopted methodology in this study was to use the HEC-RAS model to reproduce measured high water levels by adjusting the channel Manning's roughness, without varying the floodplain Manning's roughness. A conservatively (high) Manning's roughness value of 0.15 was assumed for the floodplain.

high water level data were used for the hydraulic model calibration

The highest water level measurements available for this hydraulic modelling study were recorded on August 19 and 20, 1997, as shown in Table 5.1. These data were used to calibrate the Manning's roughness parameters for both the Muskeg River and the Jackpine Creek. In the model calibration for the Muskeg River, various main channel Manning's roughness values of 0.035 to 0.06 were assigned to different reaches of the river to reproduce the high water levels. For the Jackpine Creek, a constant Manning's roughness value of 0.05 was used along the study reach. On the basis of these calibrated roughness parameters, the water surface profiles for the study reaches of the Muskeg River and the Jackpine Creek were calculated using the HEC-RAS model and compared against the measured high water levels, as shown in Figures 6.1 and 6.2.

6.3 FLOODPLAIN MAPPING

preparation of a flood risk map

A flood risk map shown in Figure 6.3 for the 13 km reach of the Muskeg River and the 8 km reach of the Jackpine Creek was prepared based on the flood levels computed by the HEC-RAS model. Mapping of the Muskeg River and Jackpine Creek floodplains was conducted for both the 10 and 100 year flood events. The flood risk areas were delineated on the 1:5,000 scale orthophoto maps with an overlay of 2 metre interval contours as shown in Figure 6.3.

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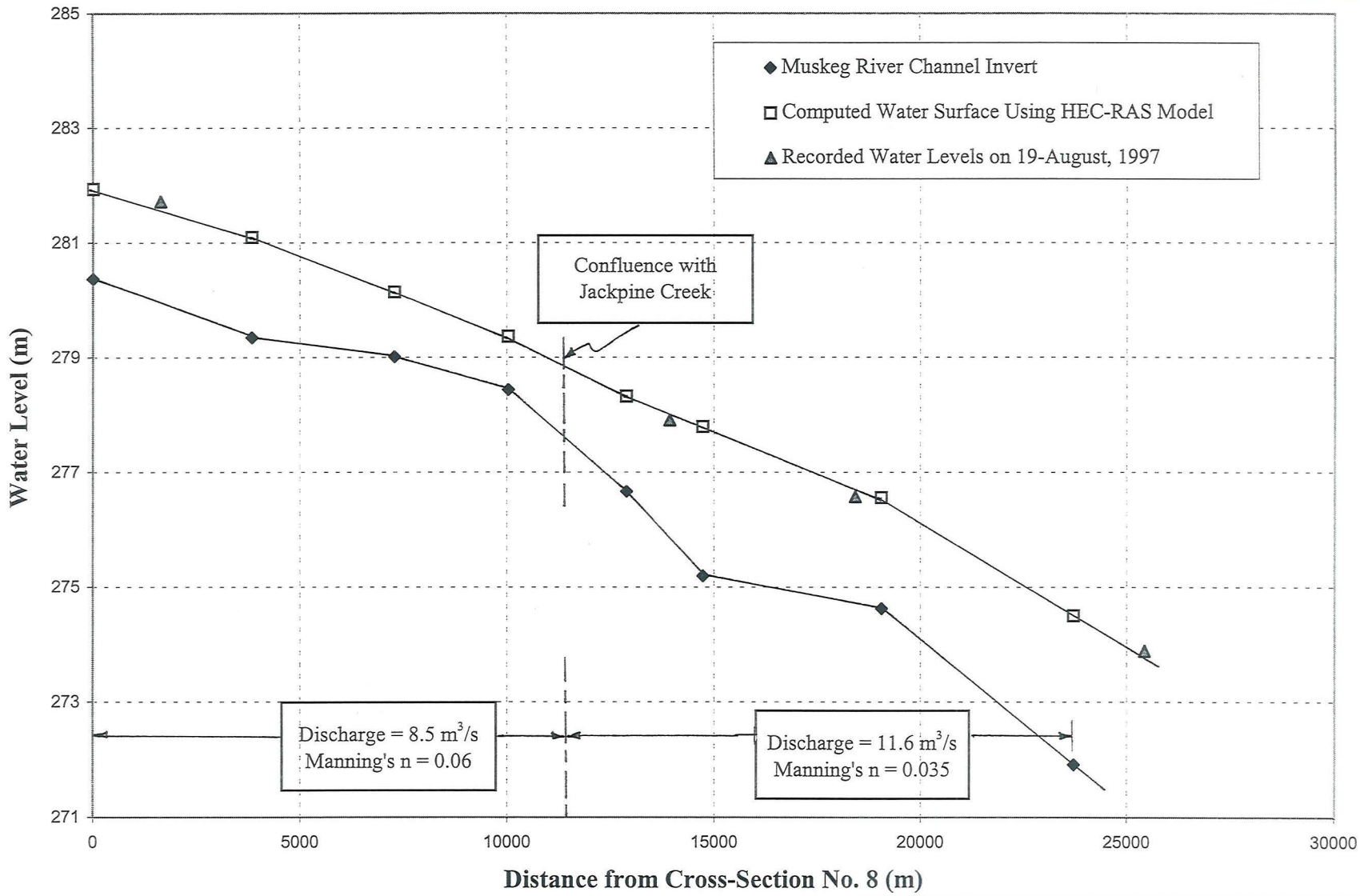

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HYDRAULIC MODEL CALIBRATION FOR FLOWS OF MUSKEG RIVER

29 NOV 97	Figure 6.1	DRAWN BY: BGM

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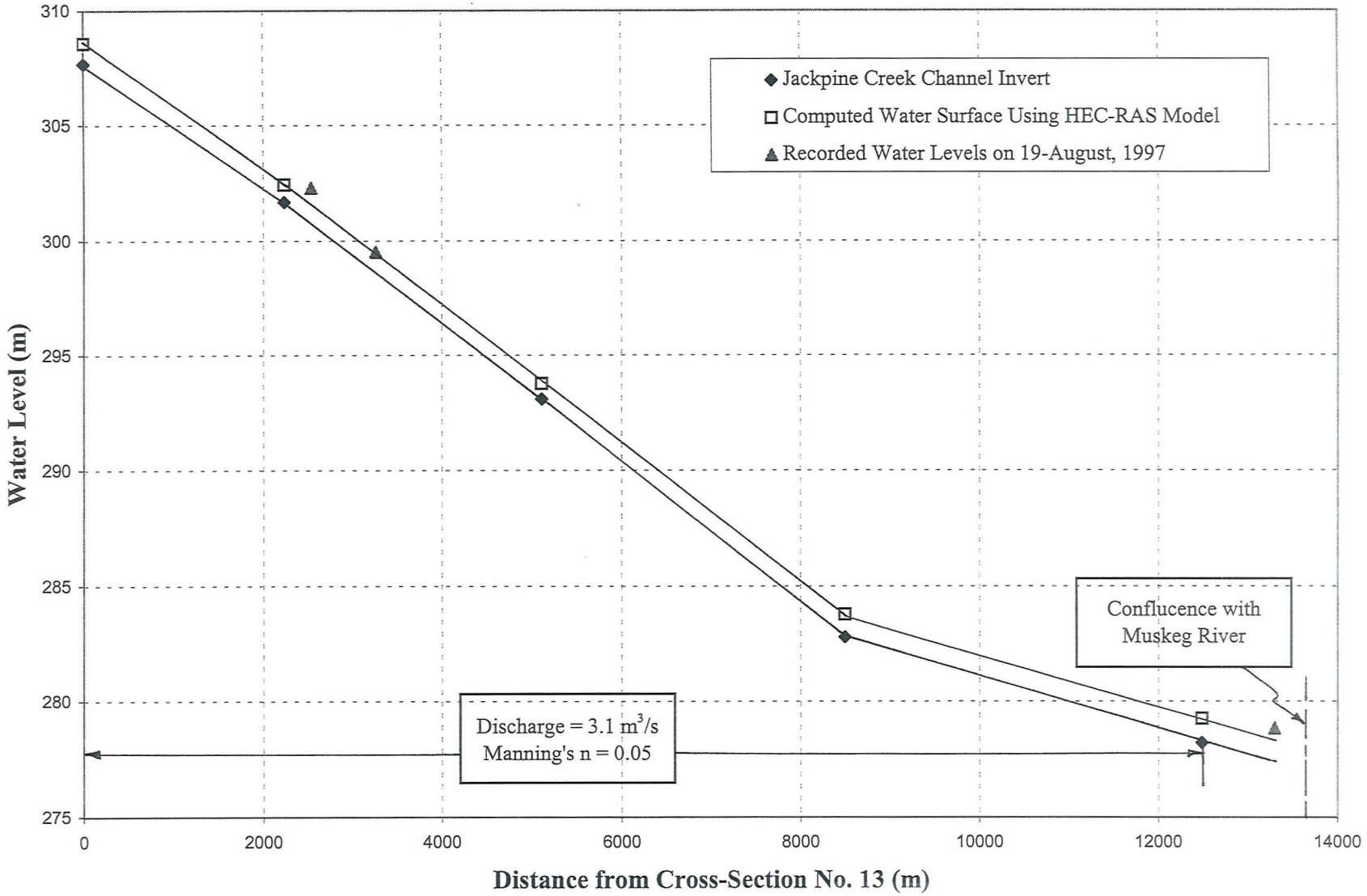

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HYDRAULIC MODEL CALIBRATION FOR FLOWS OF JACKPINE CREEK

29 NOV 97	Figure 6.2	DRAWN BY: BGM

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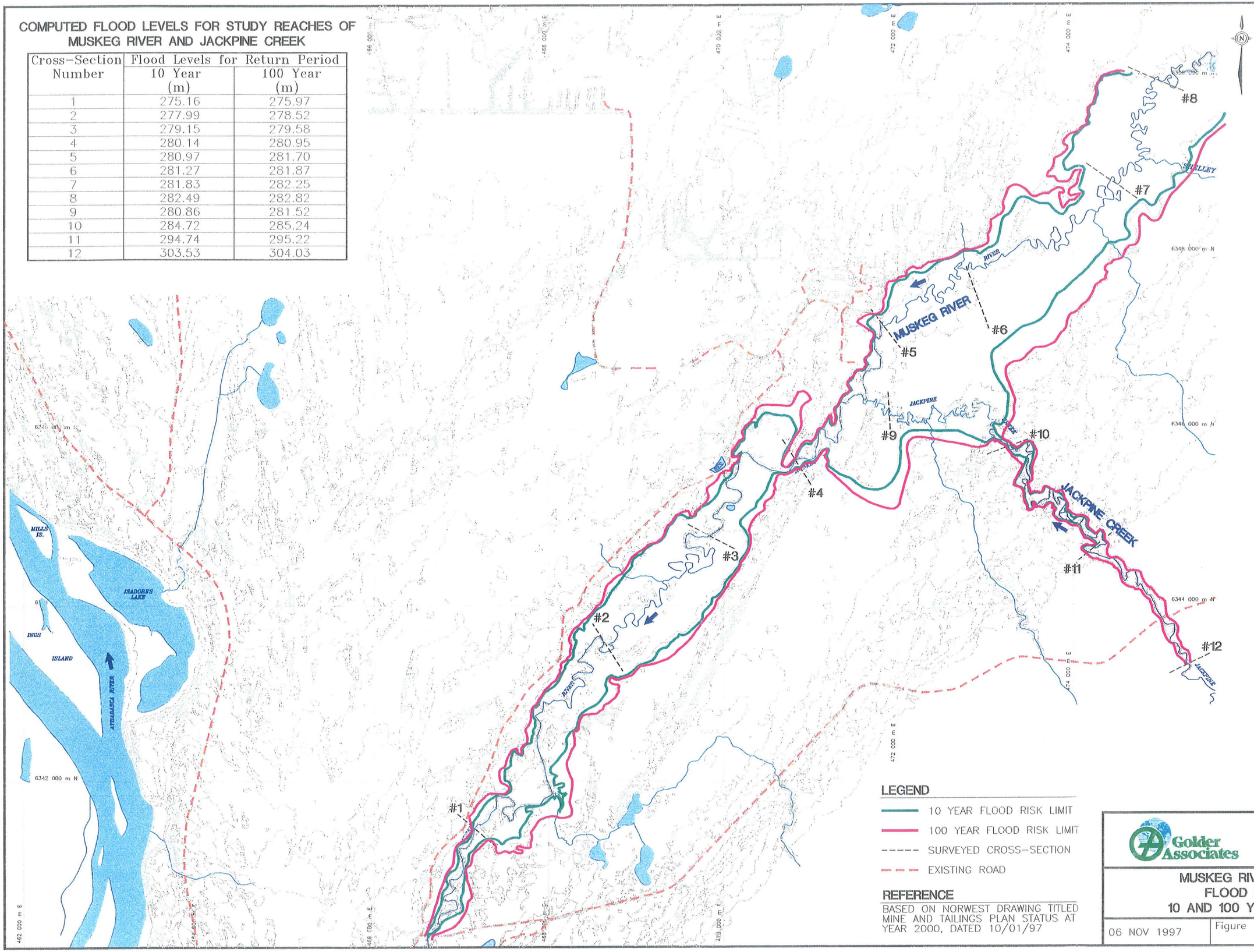
COMPUTED FLOOD LEVELS FOR STUDY REACHES OF MUSKEG RIVER AND JACKPINE CREEK

Cross-Section Number	Flood Levels for Return Period	
	10 Year (m)	100 Year (m)
1	275.16	275.97
2	277.99	278.52
3	279.15	279.58
4	280.14	280.95
5	280.97	281.70
6	281.27	281.87
7	281.83	282.25
8	282.49	282.82
9	280.86	281.52
10	284.72	285.24
11	294.74	295.22
12	303.53	304.03



LEGEND

- 10 YEAR FLOOD RISK LIMIT
- 100 YEAR FLOOD RISK LIMIT
- SURVEYED CROSS-SECTION
- EXISTING ROAD

REFERENCE

BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97

COORDINATE SYSTEM: NAD27

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MUSKEG RIVER MINE PROJECT
FLOOD RISK MAP FOR
10 AND 100 YEAR FLOOD EVENTS

06 NOV 1997	Figure 6.3	DRAWN BY: TM/DC

7. HYDROLOGIC MODELLING

7.1 INTRODUCTION

scope of the baseline hydrologic modelling study

The hydrologic modelling study conducted as part of the baseline hydrologic program included the following tasks:

- calibrate a hydrologic model based on all available streamflow measurements in the LSA;
- conduct hydrologic simulations using the calibrated model to derive historic flow series based on long-term climatic data; and
- analyze the simulated flow series to characterize the baseline runoff conditions of small and large sub-basins in the LSA.

The methodology and results of this baseline hydrologic study are presented in the following sections.

7.2 HYDROLOGIC MODEL SELECTION

basis for selection of the HSPF hydrologic model

The Hydrological Simulation Program - Fortran (HSPF, Bicknell 1993) was used in this study to perform the hydrological simulations required to generate long-term historic flow series for the natural basins in the LSA. The model was selected based on a recent review of computer models used in watershed hydrology (Singh 1995) and the specific needs for the Muskeg River Mine Project EIA. A summary of this review is shown in Table 7.1. The review determined that the HSPF model was more comprehensive and flexible than most models, especially in its data management features and usability for a wide range of water quality and quantity problems. The review also indicated that the HSPF model is the only available model that can simulate the continuous (dynamic) or steady-state hydrologic and water quality processes in a watershed with an integrated linkage of surface, soil and stream processes. The HSPF model is unique in its ability to represent the hydrologic regimes of a wide variety of streams and rivers with reasonable accuracy. The ability of the HSPF model to reasonably simulate snowfall accumulation, compaction, sublimation and snowmelt also gives it an added advantage over most models. A schematic diagram of the water movement and storage components as modelled by the HSPF is shown in Figure 7.1.

Table 7.1 Hydrologic Processes and Options in Several Continuous Streamflow Simulation Models
(Source: Singh 1995)

	Hydrological Models							
Modelled Components	**HYMO**	**HSPF**	**SSARR**	**WEPP**	**Tank**	**PRMS**	**HBV**	**UBC**
1) Data Requirements								
Rainfall	x	x	x	x	x	x	x	x
Snow	x	x	x	x	x	x	x	x
Air Temperature	x	x	x	x	x	x	x	x
Solar Radiation		x		x		x		
Dewpoint Temperature		x						
Wind Velocity		x		x				
Wind Direction				x				
2) Infiltration & Losses								
SCS Curve Number	x							
Soil Moisture			x		x	x	x	x
Upper And Lower Zone		x						
3) Direct Runoff	x		x	x	x	x		x
Mannings Equation		x						
4) Interflow Separation	x	x	x	x	x	x		x
5) Baseflow Separation		x	x		x	x		x
6) Catchment Routing		x		x	x		x	
2 Parameter Response	x							
Linear Reservoir			x					x
Kinematic Wave						x		
7) Channel Routing		x		x	x	x		
Variable Storage Coeff.	x							
Linear Reservoir			x					
Muskingum								
Kinematic Wave						x		
8) Reservoir Routing		x	x					
Storage Indication								
9) Snowmelt	x	x		x	x	x	x	
Degree Day Method			x					
Energy Budget Method			x					
10) Time Interval (Hour)	Flexible	Flexible	0.1- 24	Daily	0.1 - 24	0.1 - 24	≤ 24	0.1 - 24

HYMO - Hydrologic Model by United States Agricultural Research Service
SSARR - Streamflow Synthesis and Reservoir Regulation
WEPP - Water Erosion Prediction Project
PRMS - Precipitation - Runoff Modelling System
UBC - University of British Columbia

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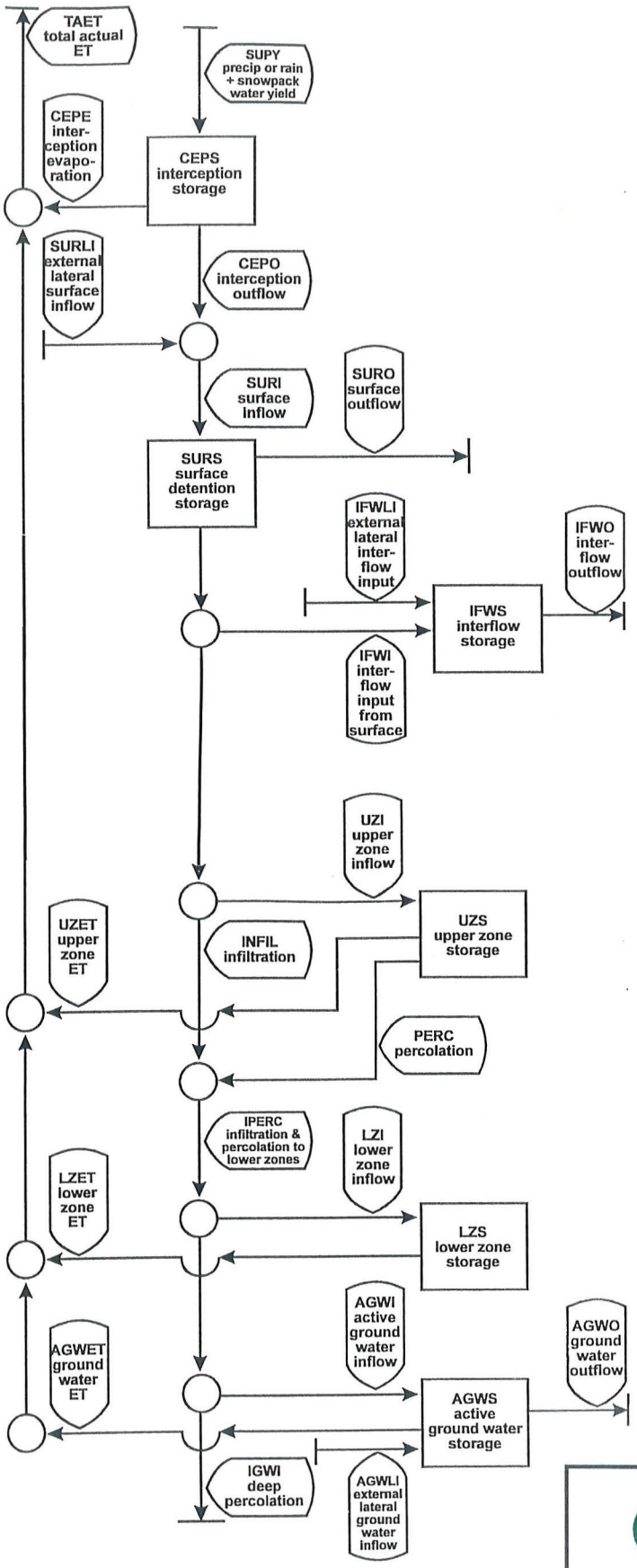

REFERENCE

Singh, V. (1995) (Ed.)
Computer Model of Watershed Hydrology,
Water Resources, Highlands Ranch,
Colorado, USA.

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SCHEMATIC DIAGRAM OF THE HSPF MODEL

09 JAN 98	Figure 7.1	DRAWN BY: CG

7.3 MODEL CALIBRATION

7.3.1 Climate Data

regional climate stations

There are no long-term climate records for the Muskeg River watershed. The only existing climate station in the watershed is the Aurora climate station which is operated by Syncrude and has been in operation since October 1995. The regional climate stations in the neighbourhood of the Muskeg River watershed include Mildred Lake, Fort McMurray airport, Muskeg Lookout and Bitumount Lookout. The locations, elevations and periods of available record are given in Table 7.2.

Table 7.2 Climate Monitoring Stations Within a 40 Kilometre Radius of the Aurora Climate Station

Station Name	Location		Station Elevation (m)	Frequency of Observation	Period of Available Record
	Latitude (north)	Longitude (west)			
Mildred Lake	57° 05'	111° 36'	310	Hourly	1973 - 1982 1993 to date
Muskeg Mountain Lookout	57° 08'	110° 54'	652	Daily	1959 to date
Bitumount Lookout	57° 22'	111° 32'	349	Daily	1962 to date
Aurora	57° 14'	111° 24'	310	Daily	1995 to date

Fort McMurray climatic data were used for the long-term simulation

The climate data recorded at the Fort McMurray airport climate station were used in simulating long-term historic flow series to compare with the recorded flow series at the WSC gauging station on the Muskeg River for calibrating the HSPF model. The climate station at Fort McMurray was used because it is the only regional station which has a long period of record. The precipitation data at the Fort McMurray airport were adjusted for the elevation difference between the station and the Muskeg River basin.

data from nearby climate stations were used for the short-term simulation

The short-term streamflow data recorded at the local streamflow monitoring stations S1 to S6 were compared with the simulated flow series based on local climate data. Precipitation data for the simulation were derived by combining the recorded data from the Mildred Lake, Aurora, Muskeg Lookout and Bitumount Lookout climate stations, adjusting for the elevation differences between the climate stations and the gauged sub-basins. Details of the climate data used for calibrating the HSPF model are summarized in Tables 7.3 and 7.4.

Table 7.3 Summary of Climatic and Hydrologic Data Used for Simulating Flows at the WSC Gauging Station on the Muskeg River

Parameter	Period of Record	Unit	Time Interval	Location	Comment
Precipitation	1 Jan 95 to 31 Dec 96	mm	hourly	Fort McMurray	
Solar Radiation	1 Jan 95 to 31 Dec 96	kJ/m^2	hourly	Fort McMurray	Based on calculations by AES
Dew Point Temperature	1 Jan 95 to 31 Dec 96	°C	hourly	Fort McMurray	
Wind Speed	1 Jan 95 to 31 Dec 96	km/hr	hourly	Fort McMurray	
Air Temperature	1 Jan 95 to 31 Dec 96	°C	hourly	Fort McMurray	
Discharge	1 Jan 74 to 31 Dec 96	m^3/s	daily	Muskeg River near Fort McKay (07DA008)	Station was not operated in the winter months from 1988 to 1996

Table 7.4 Summary of Climatic and Hydrologic Data Used for Simulating Flows at the Local, Short-term Streamflow Gauging Stations (S1 to S6)

Parameter	Period of Record	Unit	Time Interval	Location	Comment
Precipitation	1 Jan 1994 to 31 July 1997	mm	hourly/daily	Mildred Lake	
	May to Oct. 95 & 96	mm	daily	Bitumount Lookout	
	May to Oct. 95 & 96	mm	daily	Muskeg Lookout	
	5 Oct 1995 to 22 July 1997	mm	hourly	Aurora	some missing data
Solar Radiation	1 Jan 1994 to 15 May 1997	kJ/m^2	hourly	Stoney Plains	Based on calculations by AES
	16 May 1997 to 31 May 1997	kJ/m^2	hourly	Stoney Plains	copied from the previous year
Dew Point Temperature	1 Jan 1994 to 5 Aug 1997	°C	hourly	Mildred Lake	
Wind Speed	1 Jan 1994 to 5 Aug 1997	km/hr	hourly	Mildred Lake	
Air Temperature	1 Jan 1994 to 5 Aug 1997	°C	hourly	Mildred Lake	
Discharge	May to Oct. 1995 and 1996	m^3/s	daily	Hydrometric Stations S1 to S6	Station S6 was installed in May 1997
	Mar to May 1997	m^3/s	daily		

7.3.2 Streamflow Data

streamflow data used for the model calibration

The recorded streamflow data used for the model calibration included those at the long-term WSC station on the Muskeg River near Fort McKay and at the short-term monitoring stations (S1 to S6) operated by Syncrude and Shell. The long-term streamflow data on the Muskeg River have been recorded by WSC since 1974. The recorded flow data at this station for the period 1974 to 1996 were used for the model calibration. Five short-term hydrometric stations (S1 to S5) have been in operation since May 1995, while Station S6 has recorded flow data since May 1997.

7.3.3 Calibration Methodology

methods of calibration for upland and lowland areas

In a previous hydrologic study by AGRA Earth and Environmental (1996), the HSPF model was calibrated for the natural upland conditions based on the recorded flow data at the WSC gauging station on the Beaver River. These calibration parameters were adopted for modelling the upland areas in the Muskeg River basin because of their similar runoff characteristics. The model parameters for the lowland areas were then calibrated based on the recorded flow data in the LSA. The values for the upper and lower zone nominal storages were increased to account for the larger storage capacity of lowland areas. The topographic slope used for the overland flow calculation was decreased to 0.15 percent to account for the flatter slopes in the lowland areas. Table 7.5 lists the model parameters requiring calibration and their calibrated values for the upland and lowland areas.

process of using the HSPF model

Figure 7.2 shows the HSPF model calibration process. The user specifies the operations to be performed in a run, the model parameters and initial conditions for each run, and the time series in a user's control input file ("uci" file). The hourly climate data are stored in a watershed data management file ("wdm" file) which can only be created and modified by an interactive program referred to as the Annie Program. The "uci" file recalls the appropriate climate data from the "wdm" file and in conjunction with the model parameters simulates the hydrologic response of the watershed. Two "uci" files were developed for simulating the short-term flow series at the hydrometric stations S1 to S5 and the long-term flow series at the WSC station. The of model parameters were adjusted until the simulated flows closely matched the recorded flow series.

Table 7.5 Modelling Parameters and the Calibrated Values for Upland and Lowland Areas

Parameter Description	Parameter Name	Unit	Min Value	Max Value	Calibrated Values	
					Lowland Areas	Upland Areas
1)Elevation Adjustments						
Precipitation, Coefficient =1 at Fort	PREC	mm			1.017	1.017
Air temperature	ATMP	°C			varies	varies
2) Snow Simulation						
Latitude of Pervious Land Segment	LAT	degrees	-90	90	56.8	56.8
Mean Elevation of PLS	MELEV	m	0	10000	varies	varies
Shade Fraction of PLS	SHADE	none	0	1	0.9	0.9
Snow Catch Factor	SNOWCF	none	1	100	1.1	1.1
Maximum Pack (Water Equivalent)	COVIND	mm	0.25	none	100	100
Density of Cold, New Snow relative to	RDCSN	none	0.01	1	0.19	0.19
Air Temperature below which Precip will be Snow, under Saturated	TSNOW	deg C	-1	5	5	5
Parameter which Adapts the Snow Evaporation Equation to Field	SNOEVP	none	0	1	0.02	0.02
Parameter which Adapts the Snow Condensation Melt Equation to Field	CCFACT	none	0	2	1	1
Maximum Water Content of the Snow	MWATER	none	0	1	0.1	0.1
Maximum rate of snow melt by ground	MGMELT	mm/day	0	25	0	0
3) Rainfall Runoff Simulation						
Fraction of the PLS Which Is Covered by	FOREST	none	0	1	0.9	0.9
Lower Zone Nominal Storage in	LZSN	mm	0.25	2500	225	200
Lower Zone Nominal Storage in	LZSN	mm	0.25	2500	100	100
Index to the Infiltration Capacity of the Soil in	INFILT	mm/hour	0.0025	2500	70	70
Index to the Infiltration Capacity of the Soil in	INFILT	mm/hour	0.0025	2500	2	2
Length of the Assumed Overland Flow	LSUR	m	0.3	none	830	830
Slope of the Assumed Overland Flow	SLSUR	none	0.000001	10	0.0015	0.00777
Parameter Which Affects the Behavior of Groundwater Recession	KVARY	1/mm	0	none	0.05	0.05
Basic Groundwater Recession	AGWRC	1/day	0.001	1	0.096	0.096
Ratio between the Max. and Mean Infiltration Capacity over	INFILD	none	1	2	2	2
Fraction of Groundwater Inflow Which Will Enter Deep	DEEPFR	none	0	1	0	0
Fraction of Remaining Potential E-T Which Can Be Satisfied from	BASETP	none	0	1	0.03	0.03
Fraction of Remaining Potential E-T Which Can Satisfied from Groundwater Storage	AGWETP	none	0	1	0.05	0.05
Interception Storage Capacity (varies by month, max value is	CEPSC	mm	0	250	4	8
Upper Zone Nominal Storage (varies by month, max value is	UZSN	mm	0.25	250	100	195
Manning's n for the Assumed Overland Flow	NSUR	none	0.001	1	0.25	0.25
Interflow Inflow Parameter	INTFW	none	1E-30	none	3	3
Interflow Recession Parameter	IRC	1/day	1E-30	1	0.9	0.9
Lower Zone E-T Parameter (varies by month, max value is	LZETP	none	0	1	0.55	0.85
4) Channel Routing Simulation						
Length of the	LEN	km	0.016	none	varies	varies
Drop in Water Elevation from Upstream to	DELTH	m	0	none	varies	varies
Correction to the Channel depth to Calculate	STCOR	m	none	none	0	0
Weighting Factor for Hydraulic Routing	KS	none	0	0.99	0.5	0.5

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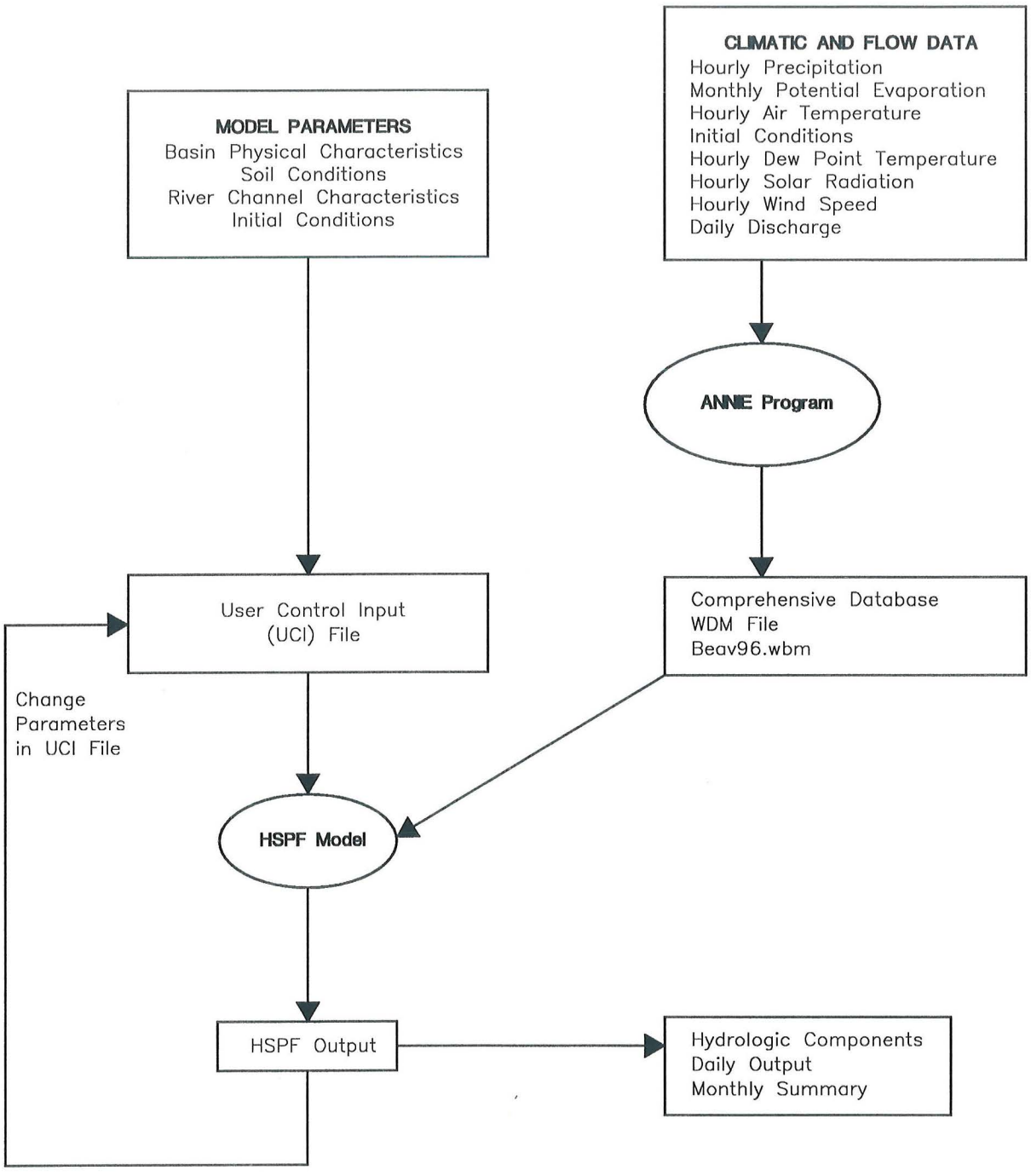

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HSPF MODEL CALIBRATION PROCESS

09 JAN 98	Figure 7.2	DRAWN BY: BGM

model calibration criteria

The model calibration was evaluated based on the correspondence of the following measured and simulated flow values:

- mean annual discharge;
- mean monthly discharges;
- mean annual peak daily discharge;
- mean annual peak snowmelt discharge;
- mean discharge in the open-water season (mid April to mid November);
- mean discharge in the ice-cover season (mid November to mid April);
- 7Q10 (7-day low flow with 10 year return period) for the summer season (mid April to mid November); and
- annual 7Q10.

7.4 CALIBRATION RESULTS

comparison of simulated and measured flows at the WSC station on the Muskeg River

Figure 7.3 shows the simulated daily flows in comparison with the measured daily flow at the WSC station on the Muskeg River. The comparison shows that the simulated hydrograph match the recorded hydrograph for most of the years from 1974 to 1996. The worst comparison occurs in 1975 and 1976. This is probably because the climate data of these years at the Fort McMurray airport did not represent the climate conditions in the Muskeg River watershed. Figure 7.4 illustrates this by comparing the annual precipitation at Fort McMurray airport to the annual runoff from the Muskeg River basin. The correlation is fairly good except for 1975, 1976 and 1984. Therefore, the simulated results for these three years were not used in calibrating the HSPF model.

evaluation of the calibration results based on the long-term flow series

An evaluation of the calibration is summarized in Table 7.6. The table shows that the simulated values for the discharge parameters compare very well with the measured values. The distribution of measured monthly discharges is reproduced by the simulation as shown in Figure 7.5. The frequency distributions of the simulated daily peak flows, and the 7Q low flows in the open-water and ice-cover seasons are also in fairly good agreement with the measurements as shown in Figures 7.6, 7.7 and 7.8.

Table 7.6 Summary of Calibration Results (Muskeg River near Fort McKay, WSC Station 07DA008)

Hydrologic Parameters	Simulated Value (1974 - 1996)[a]	Measured Value (1974 - 1996)	Percentage Difference (%)
Mean Annual Flow (m^3/s)	4.12	4.11	-0.2
Mean Annual Peak Daily Discharge (m^3/s)	28.8	27.5	5
Mean Annual Peak Daily Snowmelt Flow (m^3/s)	24.4	23.0	6
Mean Flow in the Open Water Season (m^3/s)	6.68	6.85	3
Mean Flow in the Ice Cover Season (m^3/s)	1.65	1.31[b]	21
7Q10 in the Open Water Season (m^3/s)	0.26	0.22	18
Annual 7Q10 (m^3/s)	0.052	0.05[c]	-4

[a] 1975, 1976 and 1984 Simulated Values were excluded
[b] Period of Available Record 1975 to 1987
[c] Period of Available Record 1974 to 1986

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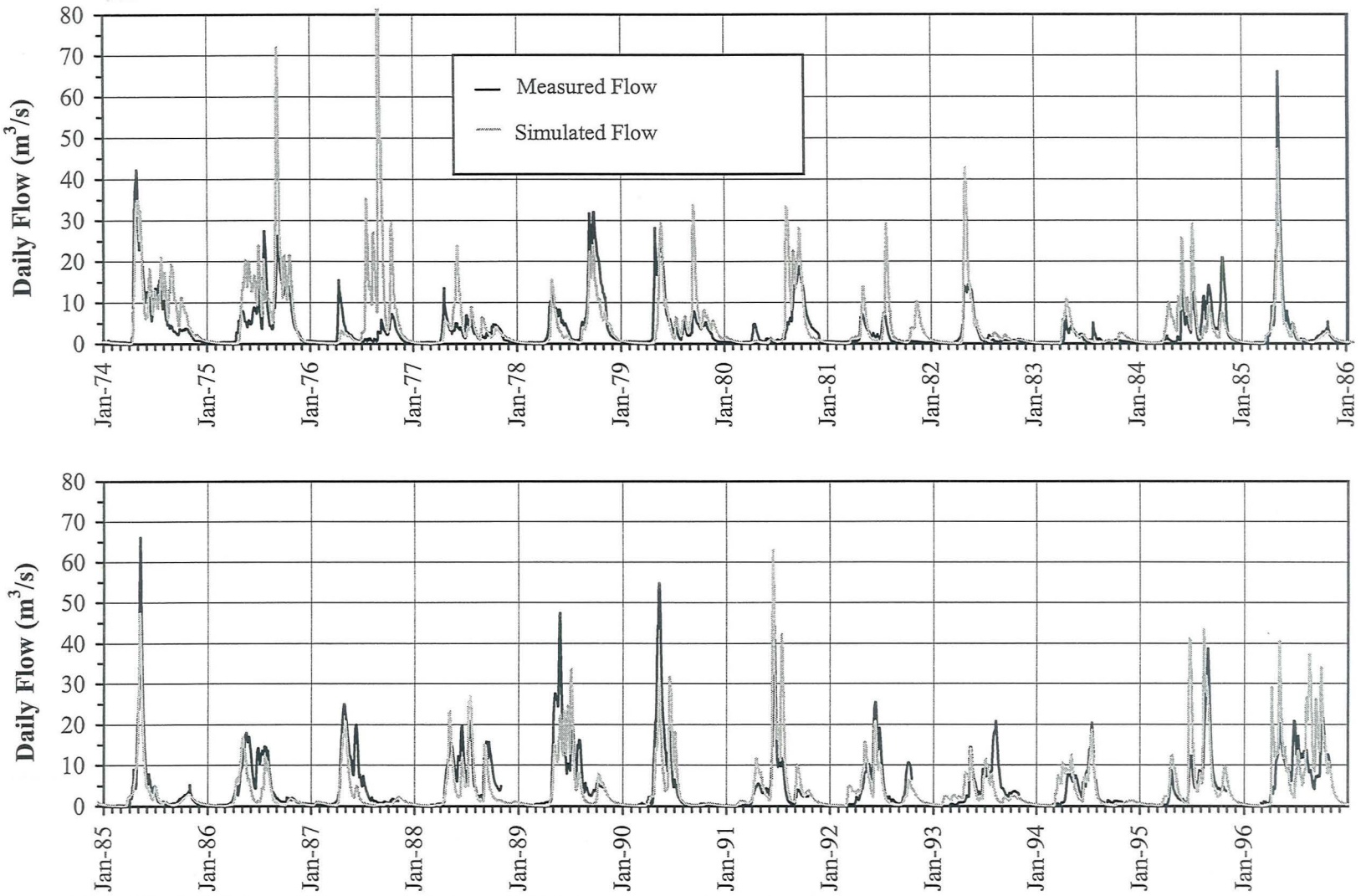

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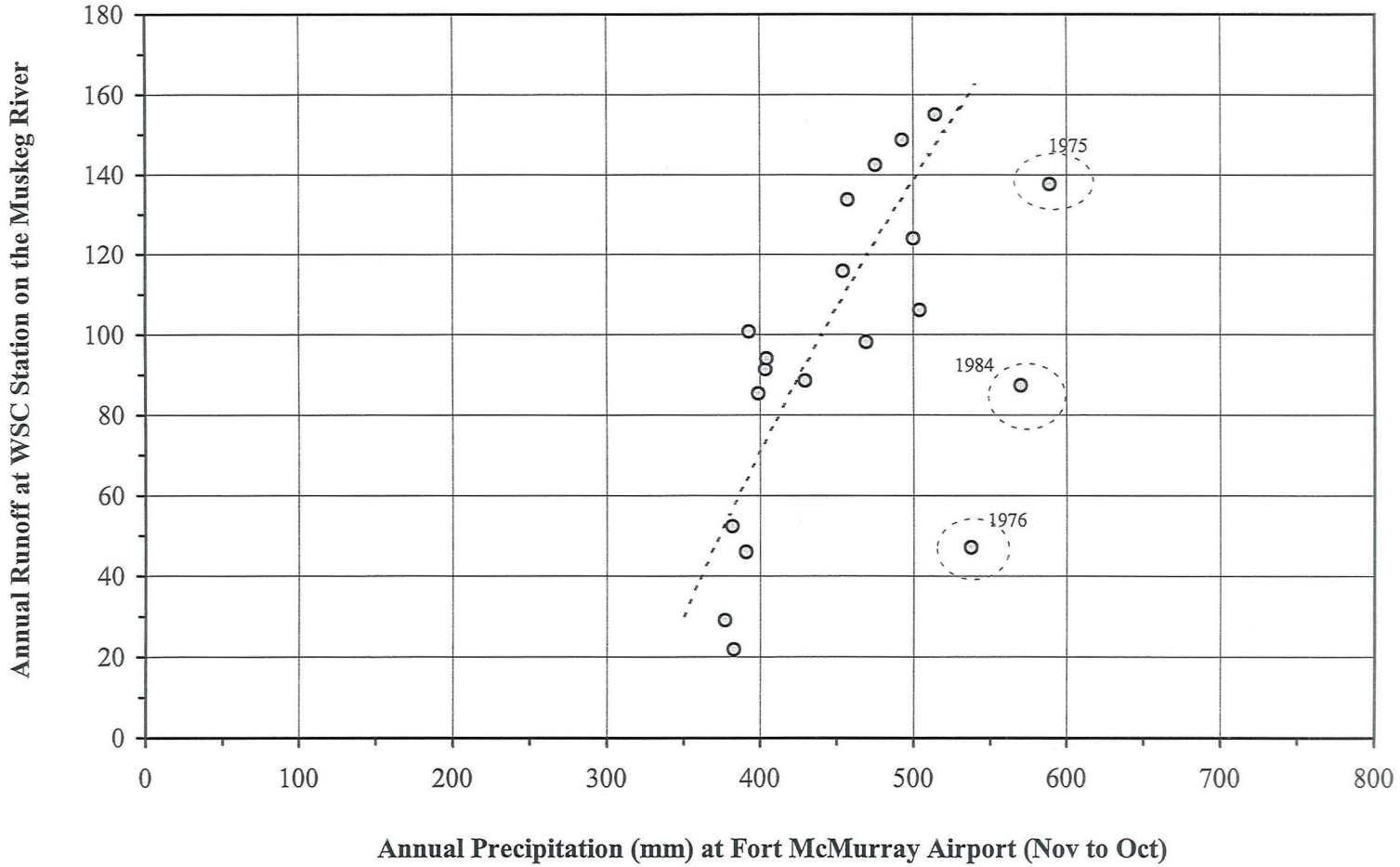
COMPARISON OF MEASURE AND SIMULATED HYDROGRAPHS AT MUSKEG RIVER NEAR FORT McKAY

29 NOV 97	Figure 7.3	DRAWN BY: BGM



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COMPARISON BETWEEN ANNUAL MUSKEG RIVER BASIN WATER YIELD AND ANNUAL PRECIPITATION AT THE FORT McMURRAY AIRPORT

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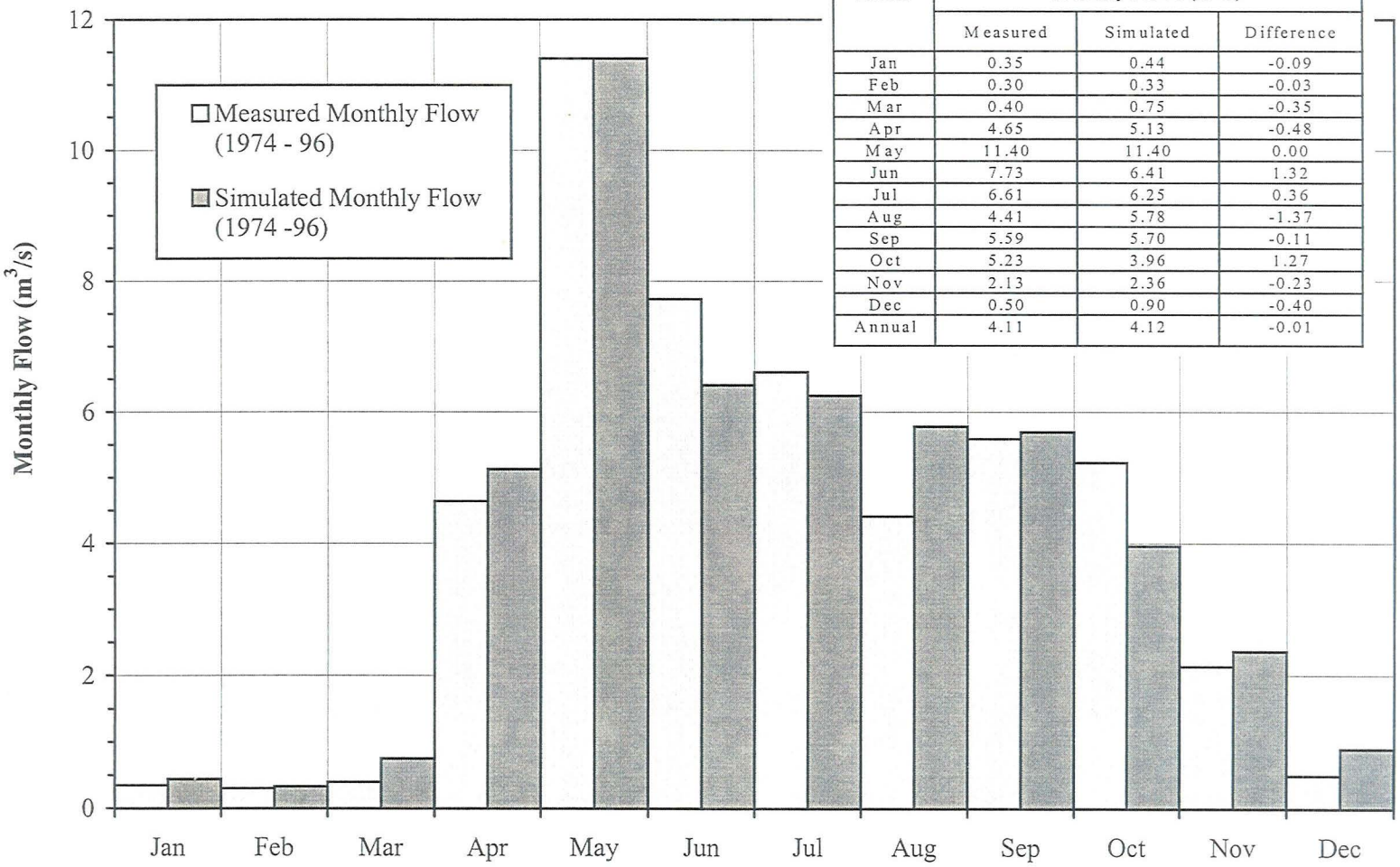

Month	Monthly Flows (m^3/s)		
	Measured	Simulated	Difference
Jan	0.35	0.44	-0.09
Feb	0.30	0.33	-0.03
Mar	0.40	0.75	-0.35
Apr	4.65	5.13	-0.48
May	11.40	11.40	0.00
Jun	7.73	6.41	1.32
Jul	6.61	6.25	0.36
Aug	4.41	5.78	-1.37
Sep	5.59	5.70	-0.11
Oct	5.23	3.96	1.27
Nov	2.13	2.36	-0.23
Dec	0.50	0.90	-0.40
Annual	4.11	4.12	-0.01

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COMPARISON OF MEASURED AND SIMULATED MONTHLY FLOWS AT WSC STATION ON MUSKEG RIVER

29 NOV 97	Figure 7.5	DRAWN BY: BGM

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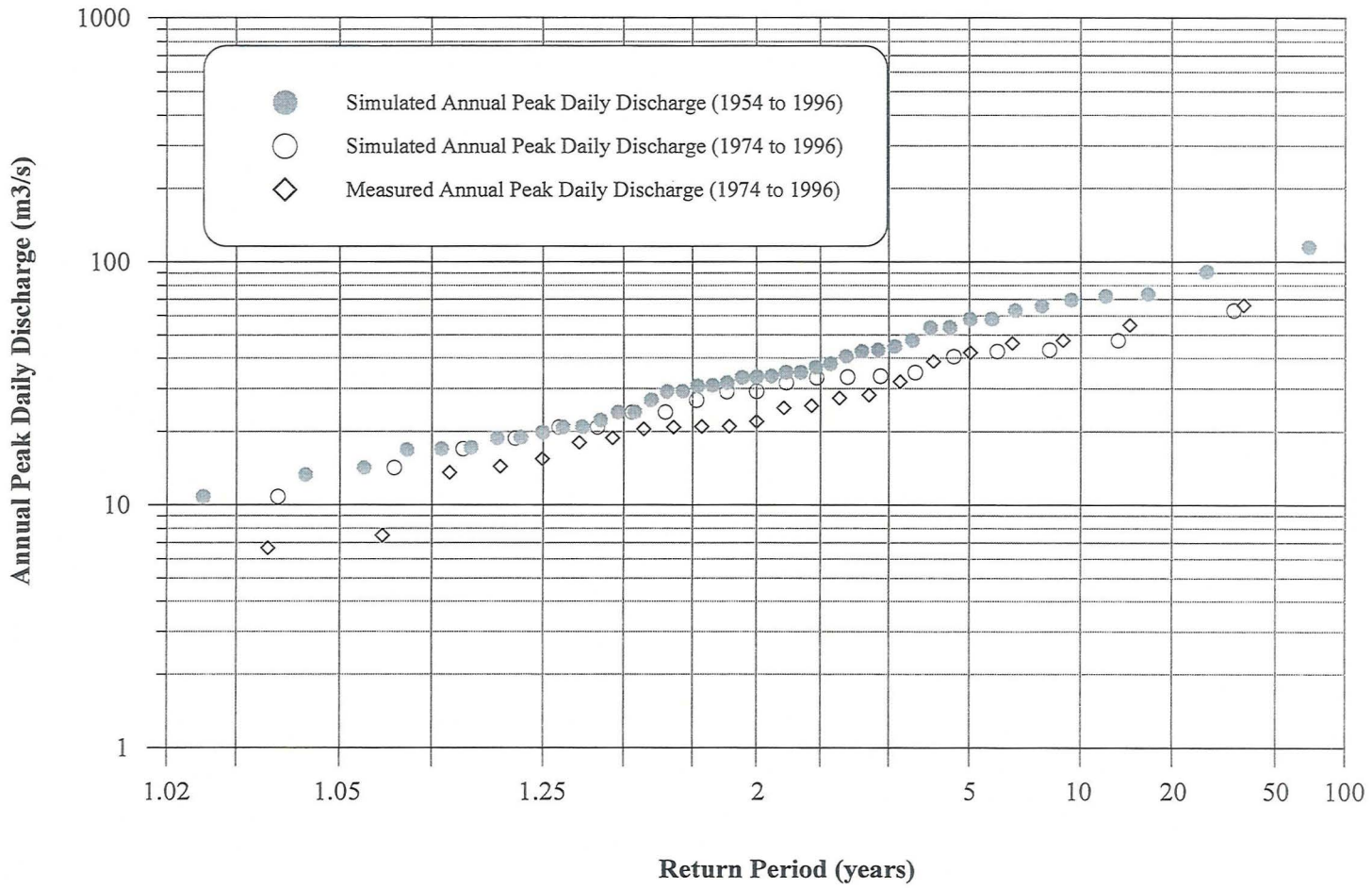

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FREQUENCY ANALYSIS OF SIMULATED AND MEASURED ANNUAL PEAK DAILY DISCHARGES AT WSC STATION ON MUSKEG RIVER

29 NOV 97	Figure 7.6	DRAWN BY: BGM

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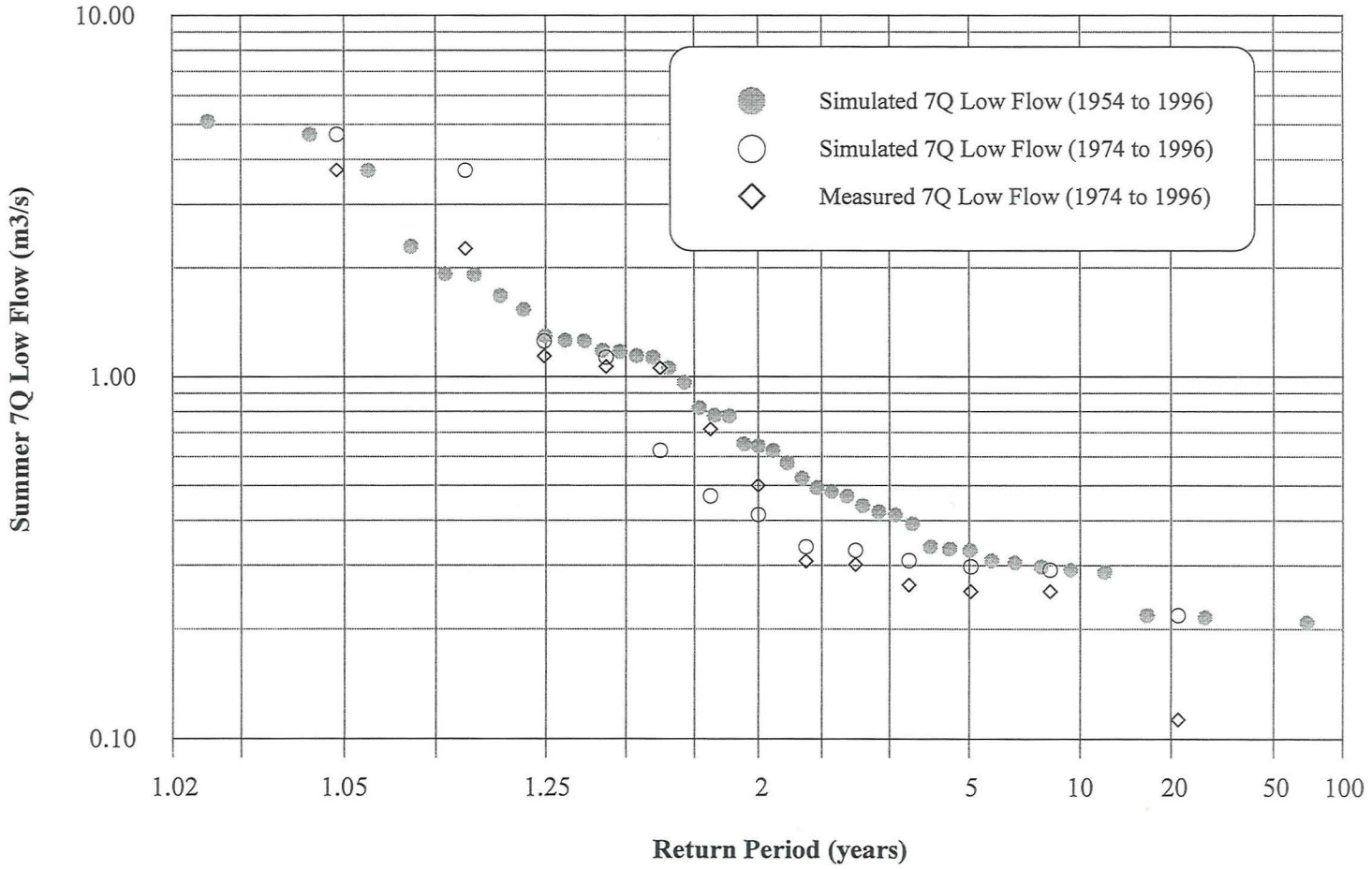

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FREQUENCY ANALYSIS OF SIMULATED AND RECORDED 7Q LOW FLOWS FOR THE SUMMER PERIOD AT WSC STATION ON MUSKEG RIVER

29 NOV 97	Figure 7.7	DRAWN BY: BGM

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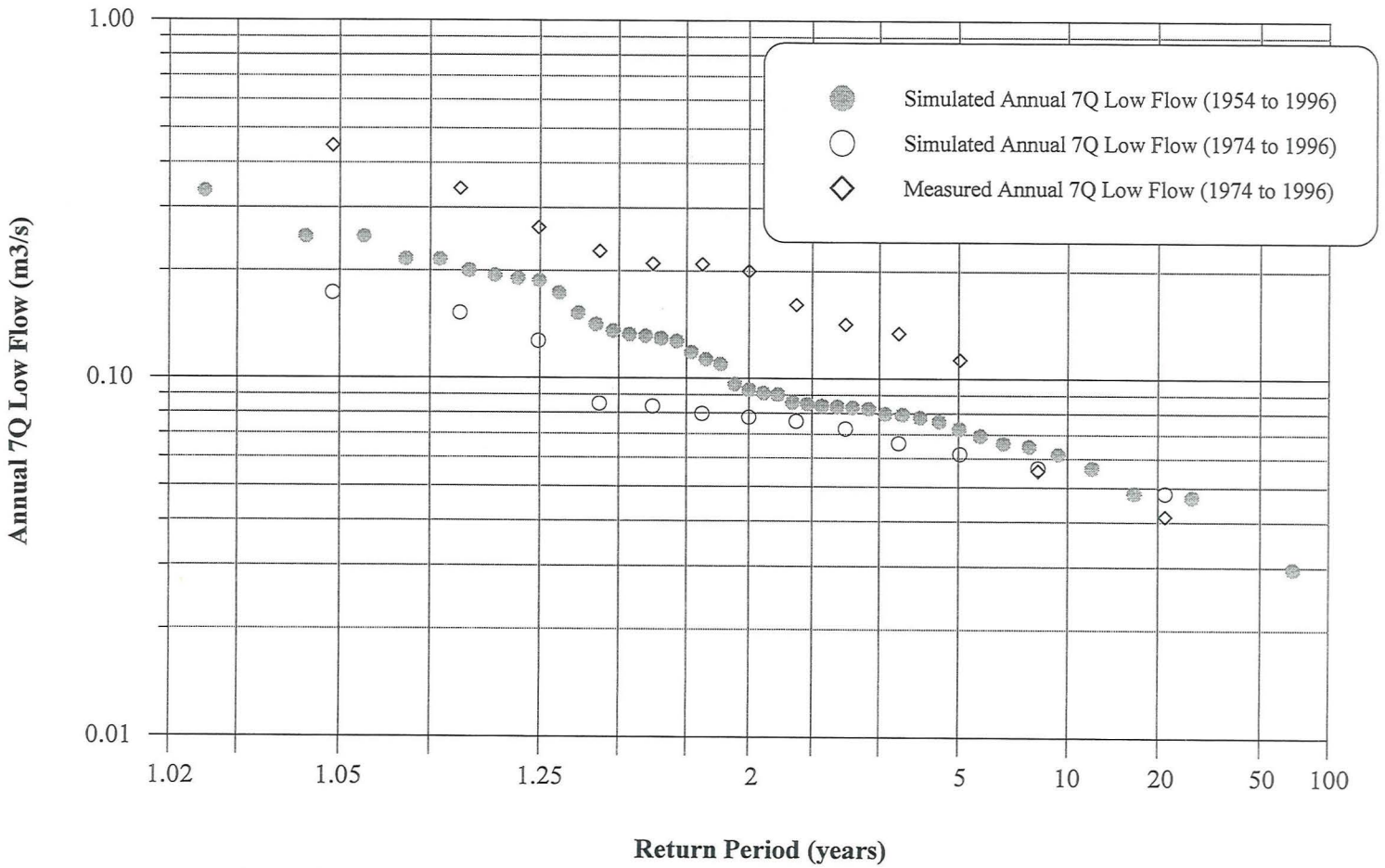

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FREQUENCY ANALYSIS OF SIMULATED AND RECORDED ANNUAL 7Q LOW FLOWS AT WSC STATION ON MUSKEG RIVER

29 NOV 97	Figure 7.8	DRAWN BY: BGM

evaluation of the calibration results based on the short-term flow series

Figures 7.9 and 7.10 show the comparisons of measured and simulated daily flows at Stations S2 to S5 for the period January 1995 to May 1997. The measured daily flows in 1995 at Stations S3 and S5 were generally low and appear to be erroneous. For this reason, these measured flows were not used in calibrating the model. The figure shows that the simulated daily flows are generally in good agreement with the measured daily flows.

7.5 SIMULATION OF NATURAL FLOWS

method of derivation of simulated natural flows

The calibrated HSPF model was used to simulate long-term historic flow series for various types of natural terrain in the Muskeg River watershed based on the long-term climatic data recorded at the Fort McMurray Airport. The simulated flow series were analyzed to derive the streamflow statistics of small basins in the LSA.

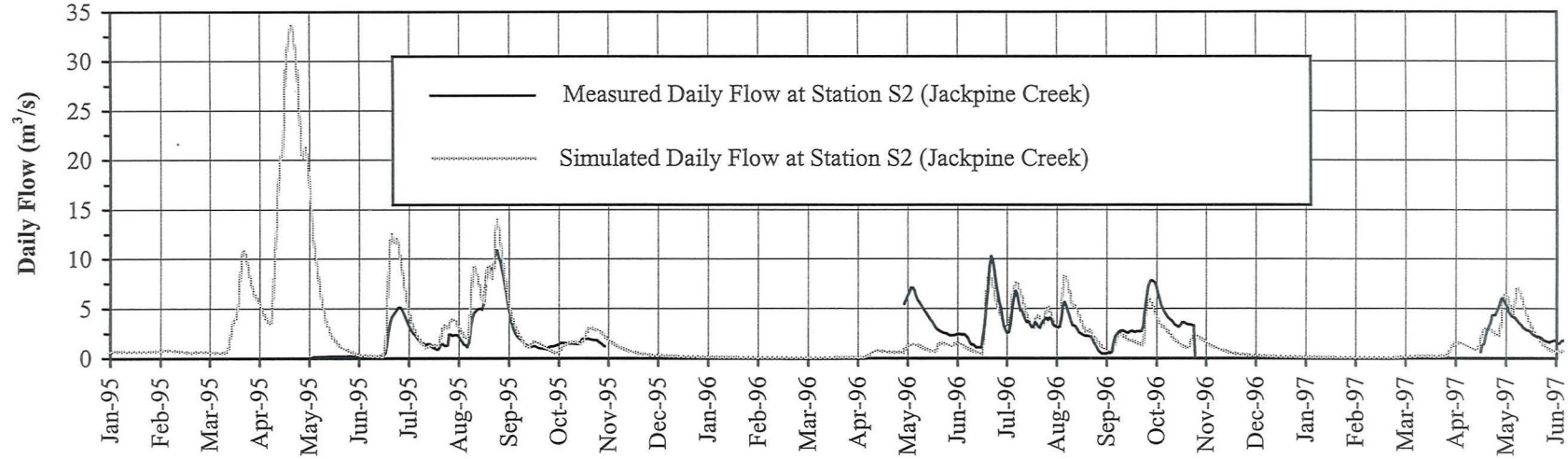
basis for derivation of streamflow characteristics of small basins in LSA

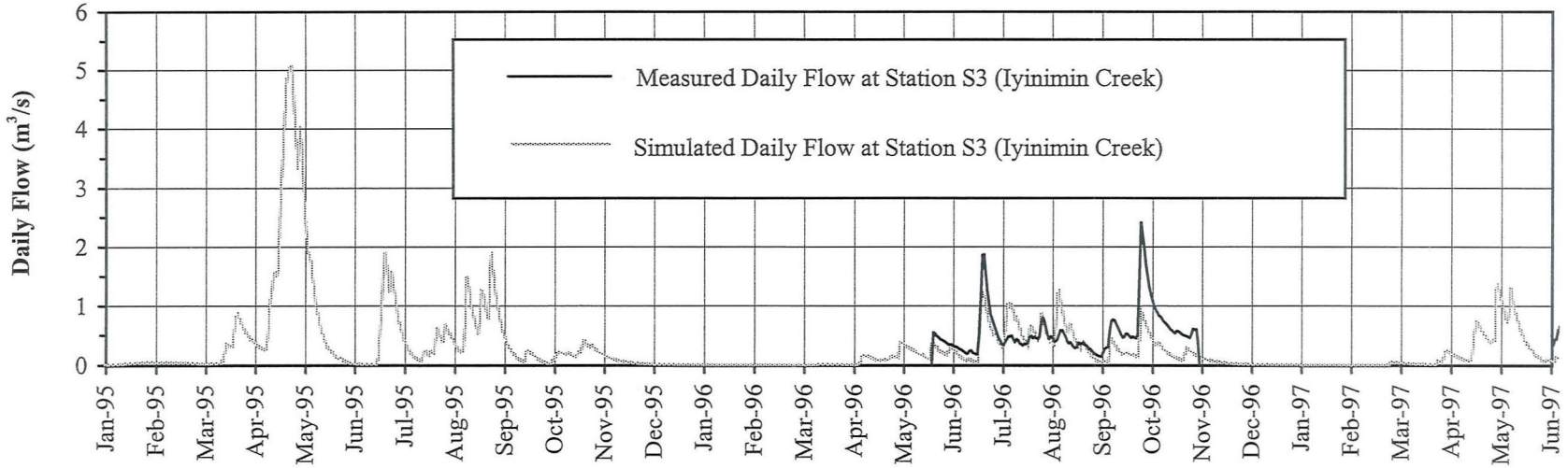
The small gauged basins in the local study area have short periods of record (less than 2 years), except for S2 station on Jackpine Creek (formerly Hartley Creek) which has a longer period of record. The locations of these stations S1 to S6 are shown in Figure 3.1. Other nodes of interest for the Shell EIA (S9 to S15) are shown in Figure 3.1. These nodes are not gauged. The streamflow characteristics of these small streams including S1, S3 to S6, and S9 to S15, were derived based on the hydrologic simulations. The streamflow characteristics of the Jackpine Creek (S2 station) were derived based on the recorded data at the long-term WSC station.

description of annual water yield characteristics of small basins in LSA

The proportion of upland and lowland areas is an important factor affecting the annual water yield of a small basin.

The simulated mean annual discharges of the small streams in the LSA are presented in Table 7.7. Figure 7.11 shows the temporal distributions of the simulated monthly flows for the S3 station on Iyinimin Creek which is a typical, small upland basin, and the S6 station on Mills Creek which is a typical lowland basin.





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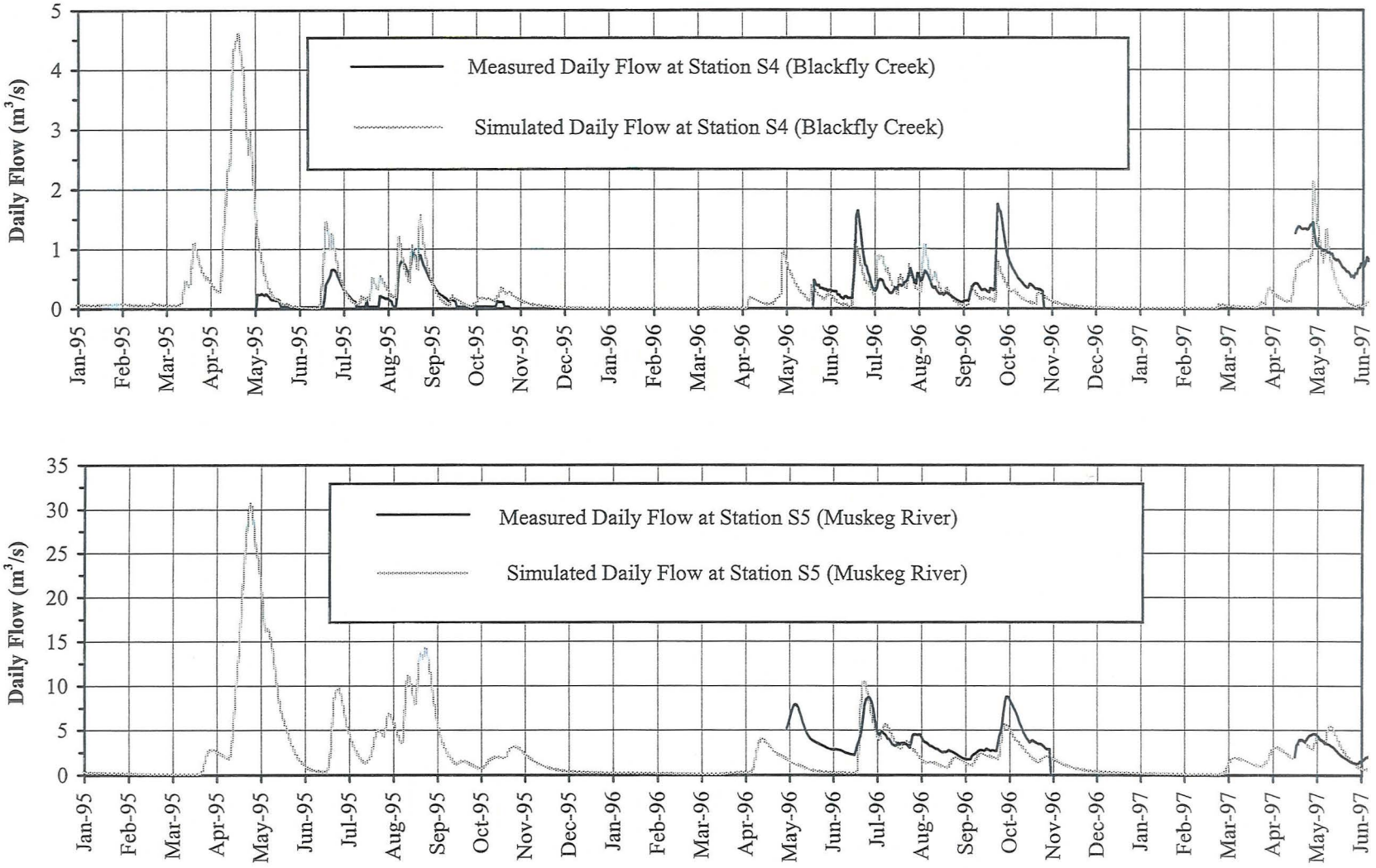
COMPARISON OF MEASURED AND SIMULATED DAILY FLOWS AT JACKPINE CREEK (STATION S2) AND IYINIMIN CREEK (STATION S3)

29 NOV 97	Figure 7.9	DRAWN BY: BGM



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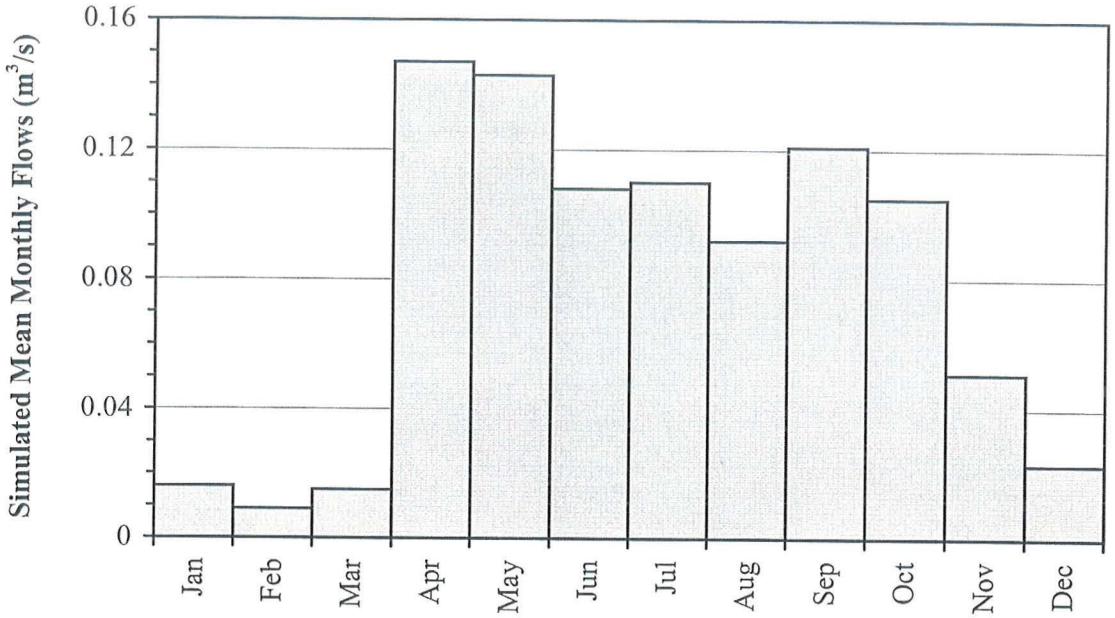
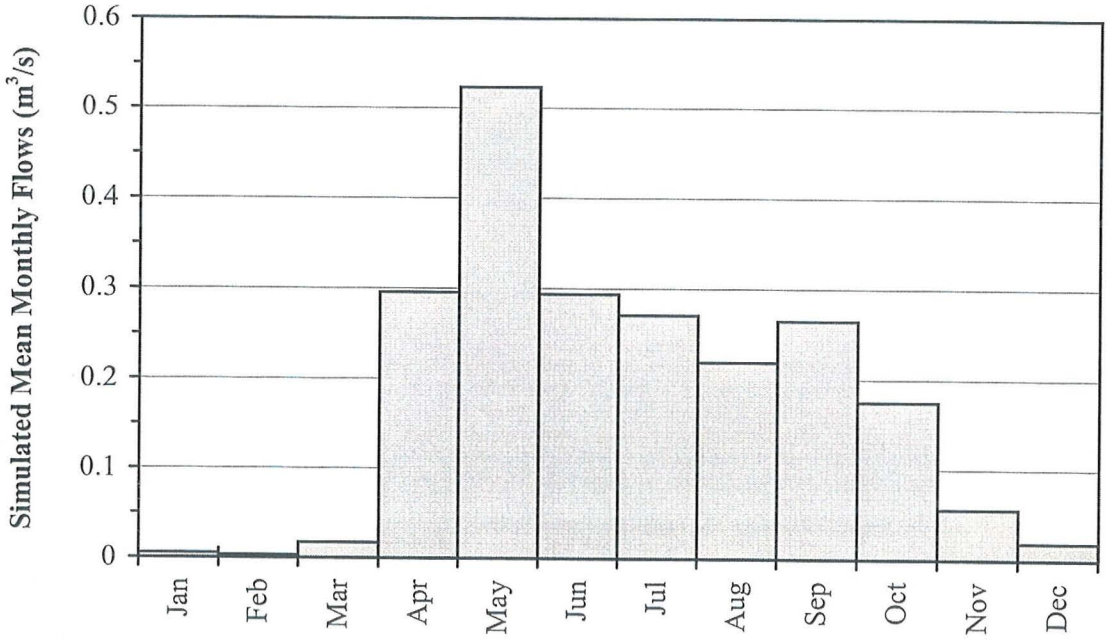
COMPARISON OF MEASURED AND SIMULATED DAILY FLOWS AT BLACKFLY CREEK (STATION S4) AND MUSKEG RIVER (STATION S5)

29 NOV 97	Figure 7.10	DRAWN BY: BGM

Simulated Mean Monthly Flows at Station S6 on Mills Creek



Simulated Mean Monthly Flows at Station S3 on Iyinimin Creek



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TYPICAL MONTHLY FLOWS AT SMALL BASINS IN THE LOCAL STUDY AREA

29 NOV 97	Figure 7.11	DRAWN BY: BGM

Table 7.7 Simulated Mean Annual Discharges of Small Streams in the Local Study Area

Station or Node No.	Stream Name	Basin Area (km^2)			Mean Annual Discharge	
		Upland	Lowland	Total	(m^3/s)	mm/yr
S1	Alsands Drain	0	15.8	15.8	0.046	92
S2	Jackpine Creek[a]	203.0	155.0	358.0	1.387	122
S3	Iyinimin Creek	39.5	0	39.5	0.179	143
S4	Blackfly Creek	31.0	0	38.2	0.158	143
S5	Muskeg River	218	172	390	1.561	126
S6	Mills Creek	0	23.8	23.8	0.069	91
S9	Stanley Creek	36.9	27.3	64.2	0.239	117
S10	Iyinimin Creek	58.4	9.6	68	0.332	154
S11	Shelley Creek	18.4	0	18.4	0.047	81
S12	Muskeg Creek	270.0	97.2	367.2	1.584	133
S13	Muskeg Creek	58.4	15.2	73.6	0.342	134
S15	Wapasu Creek	81.6	44.7	126	0.510	124

[a] Mean annual discharge was estimated based on recorded data at Jackpine Creek (Hartley Creek) WSC Station between 1975 and 1993.

description of flood peak discharges of small basins in LSA

Table 7.8 presents the flood peak discharges of the local streams derived based on the hydrologic simulations and frequency analyses of simulated flood peak discharges.

Table 7.8 Simulated Flood Peak Discharges of Small Streams in the Local Study Area

Station or Node No.	Stream Name	Flood Peak Discharge for Specified Return Period (m^3/s)		
		2 Years	10 Years	100 Years
S1	Alsands Drain	0.3	0.7	1.6
S2	Jackpine Creek	9.5	18.9	33.8
S3	Iyinimin Creek	1.7	3.3	5.8
S4	Blackfly Creek	1.5	2.9	5.1
S5	Muskeg River	10.4	20.6	35.7
S6	Mills Creek	0.5	1.2	2.5
S9	Stanley Creek	2.0	4.1	8.1
S10	Iyinimin Creek	3.0	6.2	11.1
S11	Shelley Creek	0.3	0.8	2.1
S12	Muskeg Creek	10.6	20.3	33.7
S13	Muskeg Creek	1.1	1.5	1.8
S15	Wapasu Creek	3.4	6.5	10.6

description of low flow characteristics of small basins in LSA

Low flow characteristics of these streams are represented by the 7Q10 parameter, which denotes mean low flow of 7-day duration with 10-year return period. Table 7.9 presents these low flow statistics derived for both the open-water (mid April to mid November) and ice-cover (mid November to mid April) seasons.

Table 7.9 Low Flow Statistics of Small Streams in Local Study Area

Station or Node No.	Stream Name	Low Flow Parameter 7Q10 ($10^{-3}m^3/s$ or l/s)	
		Open-Water Season (MID APRIL TO MID NOVEMBER)	Ice-Cover Season (mid April to mid November)
S1	Alsands Drain[(a)]	3	1
S2	Jackpine Creek	73	12
S3	Iyinimin Creek	0	0
S4	Blackfly Creek	0	0
S5	Muskeg River	83	16
S6	Mills Creek[(a)]	5	1
S9	Stanley Creek[(a)]	6	1
S10	Iyinimin Creek[(a)]	4	1
S11	Shelley Creek	0	0
S12	Muskeg Creek	53	4
S13	Muskeg Creek	27	1
S15	Wapasu Creek	32	4

[(a)] low flow statistics at this station (or node) were estimated based on the ratio of the natural lowland area at the station (or node) to the Muskeg River area at Node 16.

8. CONCLUSIONS

result summary of the 1997 data collection program

The 1997 summer surface water hydrology data collection program included a collection of geomorphic data in the Muskeg River watershed and measurement of hydrologic and hydrometric conditions during the summer of 1997. The program expanded the available baseline hydrologic and hydrometric databases needed for the Muskeg River Mine Project EIA. The specific contributions of this summer data collection program towards development of an improved hydrologic database for the EIA are summarized below.

geomorphic survey summary

- The geomorphic surveys at eighteen selected stream locations in the Muskeg River watershed provide the baseline geomorphologic information and data for the local streams in the LSA.

streamflow measurement summary

- The 1997 summer streamflow measurements contribute to an expansion of the available hydrometric database that is required to develop reliable stage-discharge rating curves and discharge-hydrographs for the streamflow gauge stations in the Muskeg River watershed.

TSS measurement summary

- Total Suspended Sediment (TSS) measurements contribute to continuing development of a TSS database for the Muskeg River basin required to establish future TSS permit allowances and to assist in calibrating a water quality model.

baseline hydrologic and hydraulic studies conducted in this 1997 program

The following baseline hydraulic and hydrologic studies were conducted during the 1997 summer program to provide the baseline data and information required for the EIA.

- The flood risk boundaries along the study reaches of the Muskeg River and Jackpine Creek were delineated for the 10 and 100 year flood events.

- The dynamic HSPF model was calibrated based on the up-to-date flow measurements in the Muskeg River basin. The calibrated hydrologic model was used to derive the natural flows of various sub-basins in the Muskeg River watershed.

the available baseline data provide a sound basis for the EIA

The improved hydrologic database, complete with supplemental new data from the 1997 winter and summer data collection programs, and the baseline hydrologic and hydraulic studies conducted during the 1997 program provide a sound basis for conducting the EIA.

9. CLOSURE

This report presents the collected information, data, and study results for the 1997 baseline summer work program.

Respectfully submitted by:

GOLDER ASSOCIATES LTD.

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APPENDIX I

GEOMORPHIC SURVEY DATA

The site is located on Mills Creek at the S6 stream gauging station, upstream of Isadore's Lake. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (coniferous). The surficial geology of the area is of lacustrine origin.

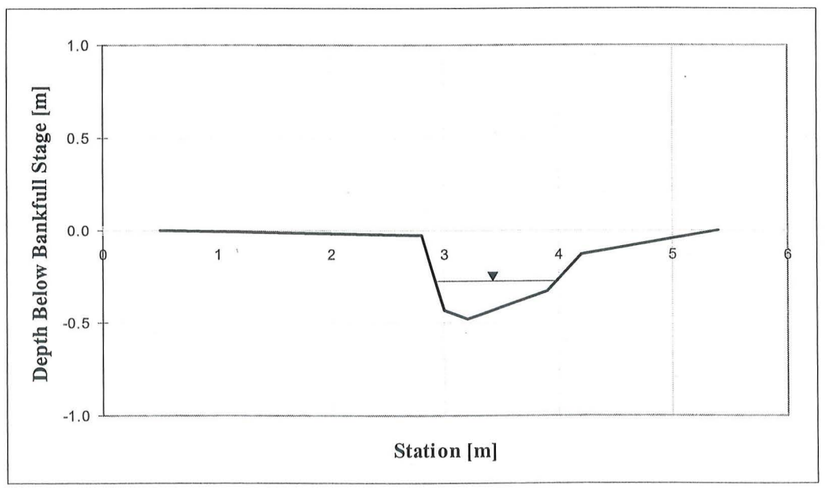
At the survey location, the valley is stream cut and is approximately 25 m wide at the bottom. The valley walls are vegetated with grass and mixed deciduous forest (25 to 75%) on both sides and feature no slumping. The valley flat is grass-covered and sparsely forested (deciduous). The stream bank material consists primarily of sand with some clay. The thickness of the alluvial deposits is 0.3 m. The banks are 90% vegetated and have a low erodability. The entrenchment ratio is 1.46 and the width to depth ratio is 17.5. The vertical stream bed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bed form is of a riffle/pool nature. The channel bed material consists of sand and clay. The meander pattern is irregular (sinuosity 1.5). Obstructions to flow/debris included a few beaver dams such that natural stream conditions occur between dams. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6344400 Northing	464350 Easting
Latitude/Longitude	57 14 34 Latitude	111 35 30 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Area (at the survey site)	23.8 km^2	Rosgen Stream Type	B5
Channel Slope	0.019	Sensitivity to Disturbance	Moderate
Channel Mean Depth	0.28 m	Recovery Potential	Excellent
Channel Max Depth	0.48 m	Sediment Supply	Moderate
Bankfull Width	4.9 m	Streambank Erosion Potential	Moderate
Sinuosity	1.5	Influence of Vegetation on bank stability	Moderate

BED MATERIAL GRADATION		BED MATERIAL PROPORTION
Size Fraction	Grain Size [mm]	
D_{100}	1.250	Gravel 0%
D_{85}	0.315	Sand 95%
D_{50}	0.220	Silt 1.3%
D_{15}	0.150	Clay 3.7%



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

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SITE M1 - LOWER MILLS CREEK

10 NOV 1997	Figure I-1	DRAWN BY: TM/DC

The site is located on Upper Mills Creek upstream of the M1 site, upstream of Isadore's Lake. Above the wide stream valley, upstream from the site, the topography features little relief (wetlands) and is moderately forested (coniferous). The surficial geology of the area is of lacustrine origin. The site was visited from the air only.

At the survey location, the valley is wide and flat (approximately 150 to 500 m wide). The valley walls are vegetated with grass and mixed deciduous forest (25 to 75%) on both sides. The valley flat is sparsely forested (coniferous) and vegetated with grass. The banks are grass vegetated and have a low erodability. The entrenchment ratio greater than 2.2 and the width to depth ratio is unknown. The vertical streambed stability was rated as "stable".

The channel is poorly defined and the water surface is uniform with no boils. Obstructions to flow/debris included infrequent woody debris. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6345500 Northing	464500 Easting
Latitude/Longitude	57 15 05 Latitude	111 35 18 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	n/a	Stream Type	n/a
Channel Slope	n/a	Sensitivity to Disturbance	n/a
Channel Mean Depth	n/a	Recovery Potential	n/a
Channel Max Depth	n/a	Sediment Supply	n/a
Bankfull Width	n/a	Streambank Erosion Potential	n/a
Sinuosity	n/a	Influence of Vegetation on Bank Stability	n/a

AERIAL VIEW LOOKING DOWNSTREAM

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SITE M2 - UPPER MILLS CREEK

10 NOV 1997	Figure I-2	DRAWN BY: TM/DC

The site is located on Jackpine Creek at the S2 stream gauging station, downstream from a road crossing. Above the stream valley, upstream from the site, the terrain is of an upland nature and is heavily forested (coniferous). The surficial geology of the area is of lacustrine origin.

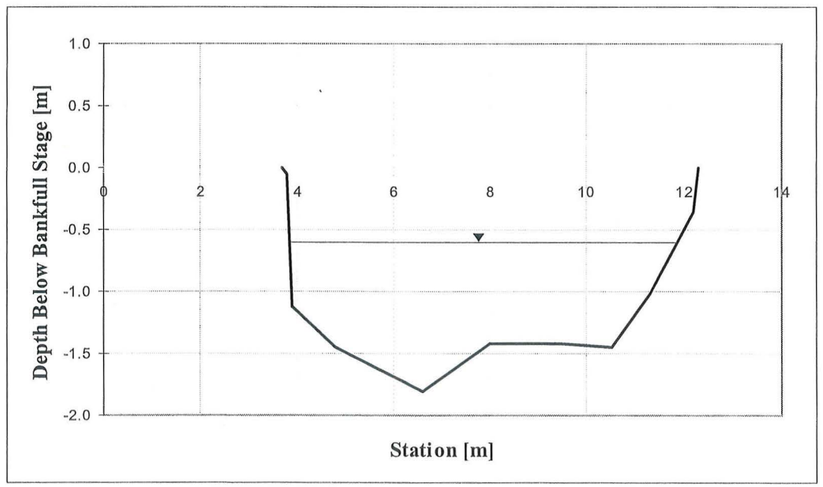
At the survey location, the channel flows through an alluvial floodplain. The valley flat is heavily forested (mixed deciduous). The stream bank material consists primarily of clay/silt with some sand. The thickness of the alluvial deposits is 0.2 m. The banks are 100% vegetated and have a moderate erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 7.6. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a step/pool nature. The channel bed material consists of clay with some sand. The meander pattern is tortuous (sinuosity 2.5). Obstructions to flow/debris are infrequent. The lateral channel activity was of a general nature.

SITE LOCATION		
UTM (NAD 27)	6346500 Northing	471850 Easting
Latitude/Longitude	57 15 33 Latitude	111 27 00 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	358 km^2	Stream Type	E6
Channel Slope	0.003	Sensitivity to Disturbance	Very High
Channel Mean Depth	1.1 m	Recovery Potential	Good
Channel Max Depth	1.8 m	Sediment Supply	Low
Bankfull Width	8.6 m	Streambank Erosion Potential	Moderate
Sinuosity	2.5	Influence of Vegetation on Bank Stability	Very High

BED MATERIAL GRADATION		BED MATERIAL PROPORTION
Size Fraction	Grain Size [mm]	
D_{100}	0.630	Gravel 0%
D_{85}	0.250	Sand 83%
D_{50}	0.150	Silt 12%
D_{15}	0.068	Clay 5%



AERIAL VIEW

GROUNDVIEW LOOKING DOWNSTREAM

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SITE M3 - JACKPINE CREEK

21 NOV 1997	Figure I-3	DRAWN BY: TM/DC

The site is located on an unnamed creek (#1), downstream from a road crossing. Above the stream valley, upstream from the site, the terrain is of a flat lowland nature and is heavily forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

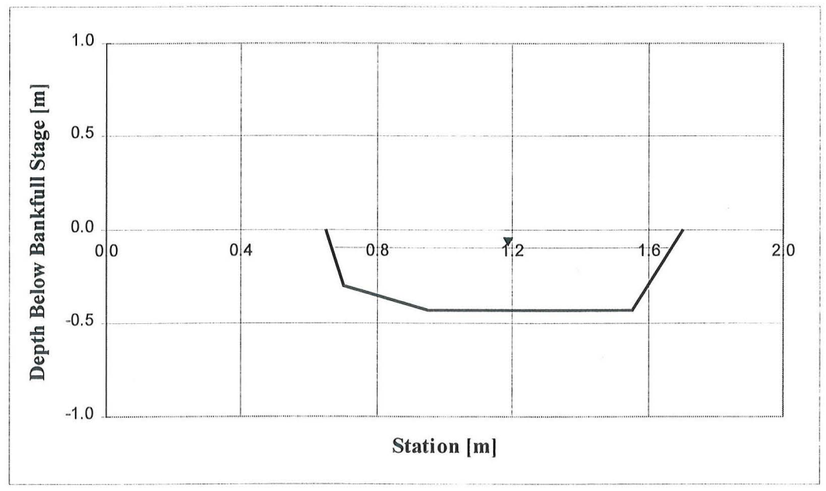
At the survey location, the channel flows through a stream cut valley. The valley flat is swamp/muskeg. The stream bank material consists primarily of sand. The thickness of the alluvial deposits is 0.6 m. The banks are 90% vegetated and have a low erodability. The width to depth ratio is 7.6. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a riffle/pool nature. The channel bed material consists of sand. The meander pattern is irregular (sinuosity 1.4). Obstructions to flow/debris are dominating and occupy 50% of the active channel cross-section. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6343400 Northing	473680 Easting
Latitude/Longitude	57 14 11 Latitude	111 26 21 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	6.75 km^2	Stream Type	E5
Channel Slope	0.0102	Sensitivity to Disturbance	Very High
Channel Mean Depth	0.4 m	Recovery Potential	Good
Channel Max Depth	0.43 m	Sediment Supply	Moderate
Bankfull Width	1.05 m	Streambank Erosion Potential	High
Sinuosity	1.4	Influence of Vegetation on Bank Stability	Very High

BED MATERIAL GRADATION		BED MATERIAL PROPORTION
Size Fraction	Grain Size [mm]	
D_{100}		
D_{85}		
D_{50}		
D_{15}		



GROUNDVIEW LOOKING DOWNSTREAM

GROUNDVIEW LOOKING UPSTREAM

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SITE M4 - UNNAMED CREEK

10 NOV 1997	Figure I-4	DRAWN BY: TM/DC

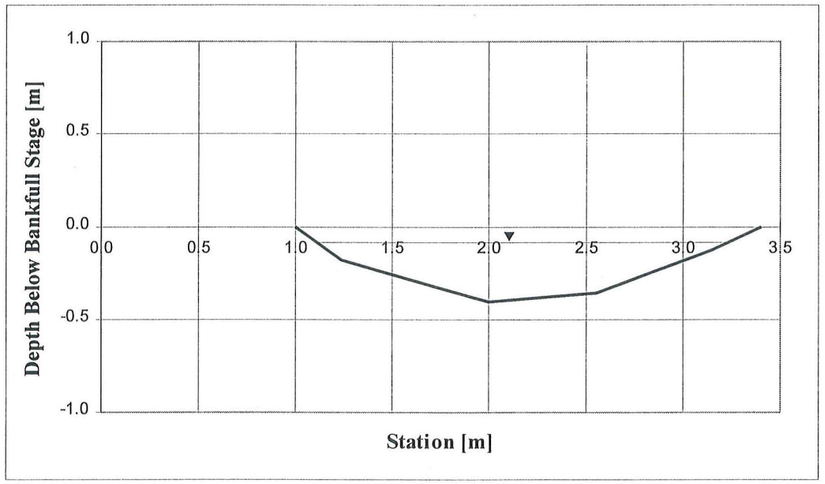
The site is located on the same unnamed creek (#1) as site M4, yet upstream from a road crossing. Above the stream valley, upstream from the site, the terrain is of a flat lowland nature and is heavily forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

At the survey location, the channel flows through a stream cut valley. The valley flat is heavily forested (mixed deciduous). The stream bank material consists primarily of sand. The thickness of the alluvial deposits is 0.6 m. The banks are 90% vegetated and have a low erodability. The width to depth ratio is 7.6. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a uniform nature. The channel bed material consists primarily of sand with some clay. The meander pattern is irregular (sinuosity 1.5). Obstructions to flow/debris include predominantly larger material and occupy 30 to 50% of the active channel cross-section. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6343400 Northing	473680 Easting
Latitude/Longitude	57 14 00 Latitude	111 26 18 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	6.75 km^2	Stream Type	E5
Channel Slope	0.009	Sensitivity to Disturbance	Very High
Channel Mean Depth	0.26 m	Recovery Potential	Good
Channel Max Depth	0.41 m	Sediment Supply	Moderate
Bankfull Width	2.4 m	Streambank Erosion Potential	High
Sinuosity	1.5	Influence of Vegetation on Bank Stability	Very High



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

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SITE M5 - UNNAMED CREEK

10 NOV 1997	Figure I-5	DRAWN BY: TM/DC

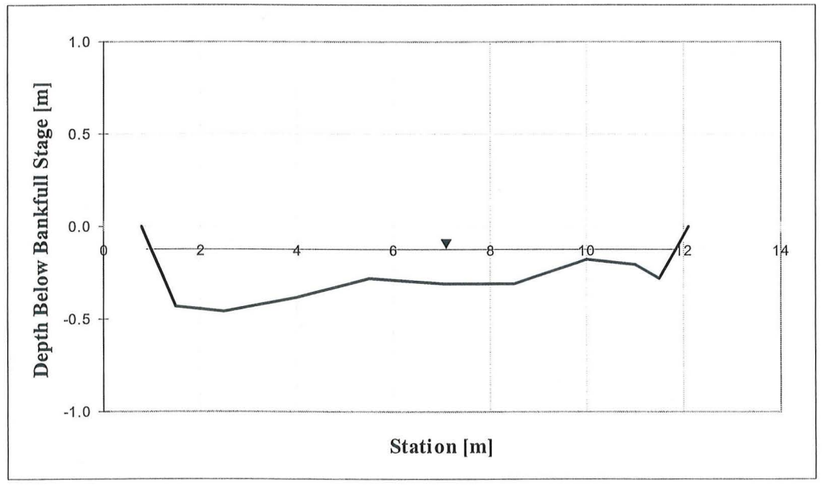
The site is located on Jackpine Creek, downstream from the road crossing. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

At the survey location, the valley is stream cut and is approximately 50 m wide at the bottom. The valley walls are vegetated with grass and mixed deciduous forest (75 to 100%) on both sides and feature no slumping. The valley flat is heavily forested (mixed deciduous). The bank material consists primarily of sand with some clay. The thickness of the alluvial deposits is 0.0 m. The banks are 30% vegetated and have a low erodability. The entrenchment ratio is 1.63 and the width to depth ratio is 35.5. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a riffle/pool nature. The channel bed material consists of sand and some clay. The meander pattern is regular (sinuosity 1.2). Obstructions to flow/debris included small, easily moved floatable materials (e.g., leaves, etc.). The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6343950 Northing	474950 Easting
Latitude/Longitude	57 14 20 Latitude	111 24 55 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	342 km^2	Stream Type	B5c
Channel Slope	0.0028	Sensitivity to Disturbance	Moderate
Channel Mean Depth	0.31 m	Recovery Potential	Excellent
Channel Max Depth	0.46 m	Sediment Supply	Moderate
Bankfull Width	11.3 m	Streambank Erosion Potential	Moderate
Sinuosity	1.2	Influence of Vegetation on Bank Stability	Moderate



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

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SITE M6 - JACKPINE CREEK

21 NOV 1997	Figure I-6	DRAWN BY: TM/DC

The site is located on Jackpine Creek, upstream from the road crossing. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

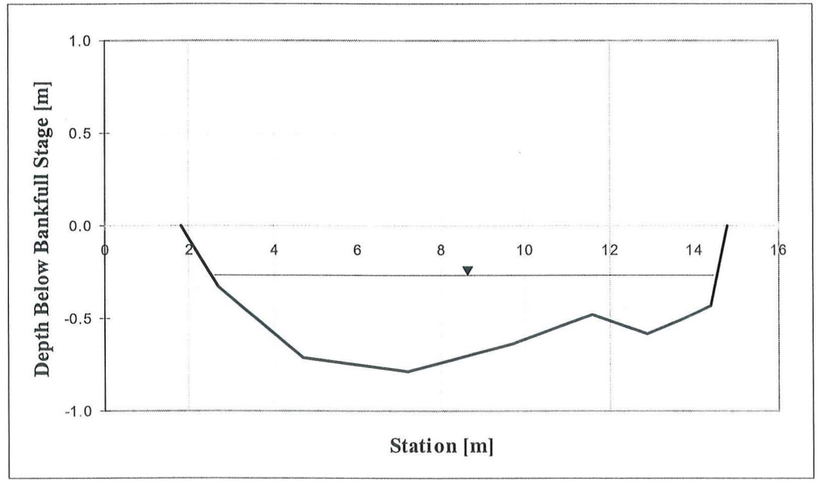
At the survey location, the valley is stream cut. The valley walls are forested (mixed deciduous) (75 to 100%) on both sides and feature no slumping. The valley flat is heavily forested (mixed deciduous). The bank material consists primarily of sand. The thickness of the alluvial deposits is 0.1 m. The banks are 90% vegetated and have a low erodability. The entrenchment ratio is 2.1 and the width to depth ratio is 23.6. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a riffle/pool nature. The channel bed material consists of sand. The meander pattern is irregular. Obstructions to flow/debris included small and medium sized material (e.g., large limb branches) of moderate frequency. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6343800 Northing	475050 Easting
Latitude/Longitude	57 14 16 Latitude	111 24 50 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	342 km^2	Stream Type	C5
Channel Slope	n/a	Sensitivity to Disturbance	Very High
Channel Mean Depth	0.55 m	Recovery Potential	Fair
Channel Max Depth	0.78 m	Sediment Supply	Very High
Bankfull Width	13 m	Streambank Erosion Potential	Very High
Sinuosity	n/a	Influence of Vegetation on Bank Stability	Very High

BED MATERIAL GRADATION		BED MATERIAL PROPORTION
Size Fraction	Grain Size [mm]	
D_{100}	0.630	Gravel 0%
D_{85}	0.150	Sand 46%
D_{50}	0.070	Silt 48%
D_{15}	0.035	Clay 6%



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

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SITE M7 - JACKPINE CREEK

21 NOV 1997	Figure I-7	DRAWN BY: TM/DC

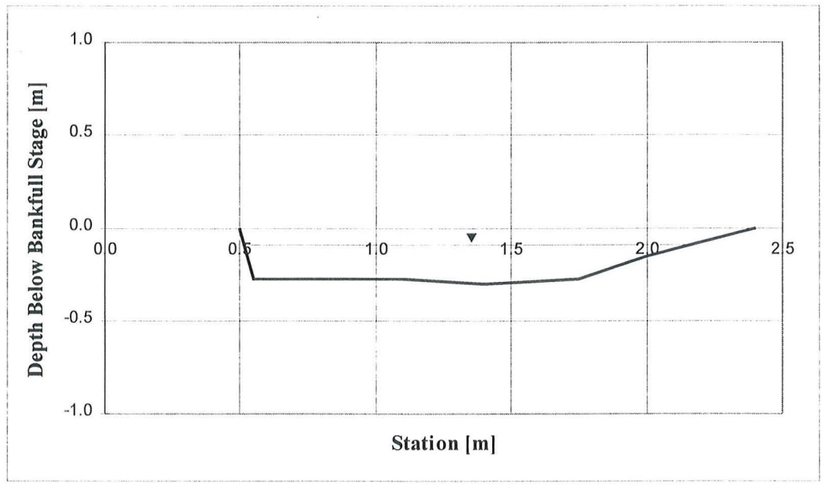
The site is located on a permanent to ephemeral unnamed creek (#2), east of Jackpine Creek, downstream from the road crossing. Above the stream valley, upstream from the site, the topography is of an upland nature and is heavily forested (mixed-deciduous) and features some muskeg areas. The surficial geology of the area is of lacustrine origin.

At the survey location, the stream flows through an alluvial fan. The bank material consists primarily of sand with some clay. The thickness of the alluvial deposits is 0.4 m. The entrenchment ratio is greater than 4 and the width to depth ratio is 7.3.

At the time of the site visit, the streamflow discharge was falling.

SITE LOCATION		
UTM (NAD 27)	6344530 Northing	476572 Easting
Latitude/Longitude	57 14 45 Latitude	111 23 23 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	8.8 km^2	Stream Type	E5
Channel Slope	0.004	Sensitivity to Disturbance	Very High
Channel Mean Depth	0.26 m	Recovery Potential	Good
Channel Max Depth	0.30 m	Sediment Supply	Moderate
Bankfull Width	1.9 m	Streambank Erosion Potential	High
Sinuosity	1.2	Influence of Vegetation on Bank Stability	Very High



GROUNDVIEW LOOKING DOWNSTREAM

GROUNDVIEW LOOKING UPSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M9 - UNNAMED CREEK 2

10 NOV 1997	Figure I-8	DRAWN BY: TM/DC

J:\1997\2237\6630\m10.dwg

The site is located on a permanent to ephemeral unnamed creek (#2), east of Jackpine Creek, upstream from the road crossing. Above the stream valley, upstream from the site, the topography is of an upland nature and is heavily forested (mixed-deciduous) and features some muskeg areas. The surficial geology of the area is of lacustrine origin.

At the survey location, no clearly defined channel existed. A large beaver dam was noted upstream of a wetland which extended to the road crossing.

SITE LOCATION		
UTM (NAD 27)	6344530 Northing	476572 Easting
Latitude/Longitude	57 14 36 Latitude	111 23 12 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	8.8 km^2	Stream Type	n/a
Channel Slope	0.004	Sensitivity to Disturbance	n/a
Channel Mean Depth	n/a	Recovery Potential	n/a
Channel Max Depth	n/a	Sediment Supply	n/a
Bankfull Width	n/a	Streambank Erosion Potential	n/a
Sinuosity	1.2	Influence of Vegetation on Bank Stability	n/a

BEAVER DAM

WETLANDS

Golder Associates

SHELL CANADA LIMITED

SITE M10 - UNNAMED CREEK 2

10 NOV 1997 | Figure I-9 | DRAWN BY: TM/DC

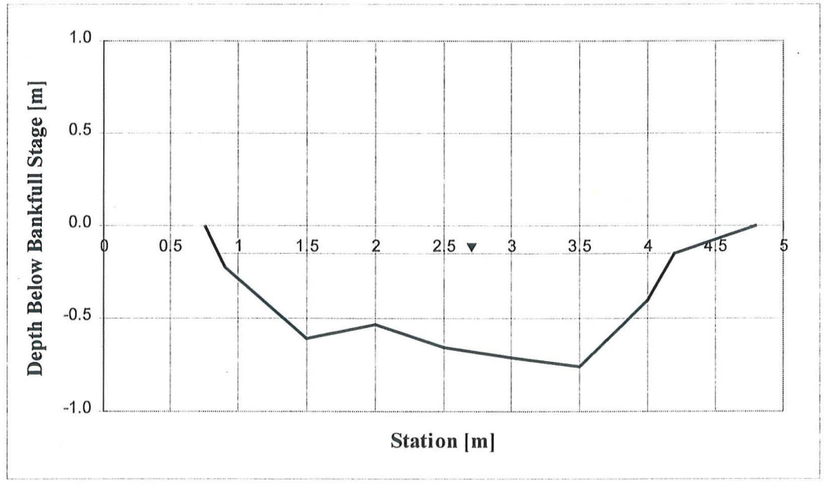
The site is located on Shelley Creek, downstream from the road crossing. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is sparsely forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

At the survey location, the streams runs through a streamcut valley in a wide valley and is approximately 70 m wide at the bottom. The valley walls are vegetated with shrubs on both sides and feature no slumping. The vegetation on the valley flat is primarily grass. The bank material consists primarily of sand with some silt/clay. The banks are 100% vegetated and have a low erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 8.8. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform was of a step/pool nature. The channel bed material consists of sand and some clay/silt. The meanders are truncated (sinuosity 1.5). Obstructions to flow/debris included small, easily moved, floatable materials (e.g. leaves). The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6345404 Northing	477920 Easting
Latitude/Longitude	57 15 07 Latitude	111 21 54 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	7.6 km^2	Stream Type	E5
Channel Slope	0.005	Sensitivity to Disturbance	Very High
Channel Mean Depth	0.45 m	Recovery Potential	Good
Channel Max Depth	0.76 m	Sediment Supply	Moderate
Bankfull Width	4.0 m	Streambank Erosion Potential	High
Sinuosity	1.5	Influence of Vegetation on Bank Stability	Very High



AERIAL VIEW

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M12 - SHELLEY CREEK

10 NOV 1997 | Figure I-10 | DRAWN BY: TM/DC

The site is located on Shelly Creek, upstream from the road crossing. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is sparsely forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

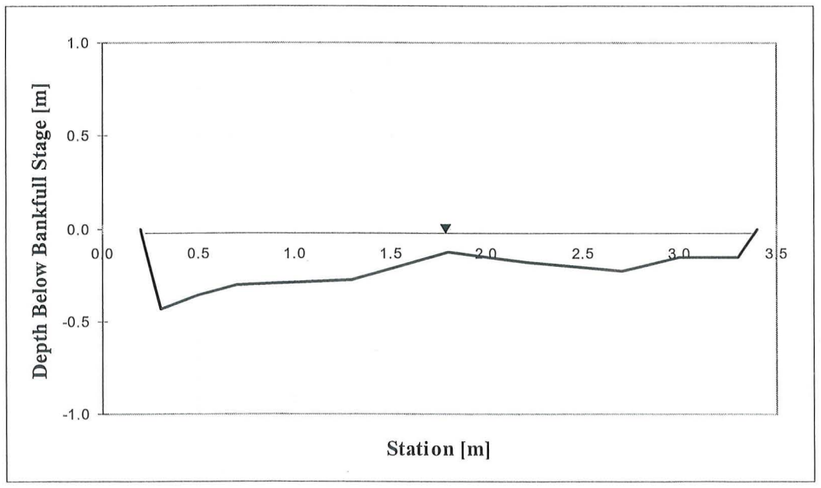
At the survey location, the stream runs through a streamcut in a wide valley. The valley walls are heavily forested (mixed deciduous) on both sides and feature no slumping. The vegetation on the valley flat is also mixed deciduous forest. The bank material consists primarily of sand. The banks are 100% vegetated and have a low erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 13.3. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform was of a riffle/pool nature. The channel bed material consists of sand and some cobbles. The meander pattern is irregular (sinuosity 1.4). Obstructions to flow/debris included frequent beaver dams such that backwater conditions exist for channel reaches between structures, including some which have filled with sediment and breached, initiating a series of channel adjustments such as bank erosion. The lateral channel activity was of a general nature.

SITE LOCATION		
UTM (NAD 27)	6345404 Northing	477920 Easting
Latitude/Longitude	57 15 04 Latitude	111 21 54 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	7.6 km^2	Stream Type	C5
Channel Slope	0.005	Sensitivity to Disturbance	Very High
Channel Mean Depth	0.24 m	Recovery Potential	Fair
Channel Max Depth	0.43 m	Sediment Supply	Very High
Bankfull Width	3.2 m	Streambank Erosion Potential	Very High
Sinuosity	1.4	Influence of Vegetation on Bank Stability	Very High

BED MATERIAL GRADATION		BED MATERIAL PROPORTION
Size Fraction	Grain Size [mm]	
D_{100}	2.0	Gravel 0%
D_{85}	0.570	Sand 93.7%
D_{50}	0.285	Silt 2.5%
D_{15}	0.140	Clay 3.3%



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M13 - SHELLEY CREEK

21 NOV 1997 | Figure I-11 | DRAWN BY: TM/DC

The site is located on Khahago Creek, away from anthropogenic influences, close to the confluence of Blackfly Creek. Above the stream valley, upstream from the site, the topography features little relief (swamp/muskeg). The surficial geology of the area is of lacustrine origin.

At the survey location, the stream runs through an alluvial fan. The valley flat is a swampy muskeg area. The bank material consists primarily of organic material. No defined stream banks were observed. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 8.0. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling and slow-moving. The water surface was uniform. The channel bed material consists of organic material. The meander pattern is regular (sinuosity 1.5). Obstructions to flow/debris included a few beaver dams such that natural stream conditions occur between dams. Minor amounts of small floatable materials were observed as well. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6340950 Northing	481175 Easting
Latitude/Longitude	57 12 47 Latitude	111 18 4 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	156 km^2	Stream Type	E3
Channel Slope	0.0019	Sensitivity to Disturbance	High
Channel Mean Depth	1.5 m (estimated)	Recovery Potential	Good
Channel Max Depth	2.0 m (estimated)	Sediment Supply	Low
Bankfull Width	12 m (estimated)	Streambank Erosion Potential	Moderate
Sinuosity	1.5	Influence of Vegetation on Bank Stability	Very High

AERIAL VIEW

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M14 - KHAHAGO CREEK

21 NOV 1997 | Figure I-12 | DRAWN BY: TM/DC

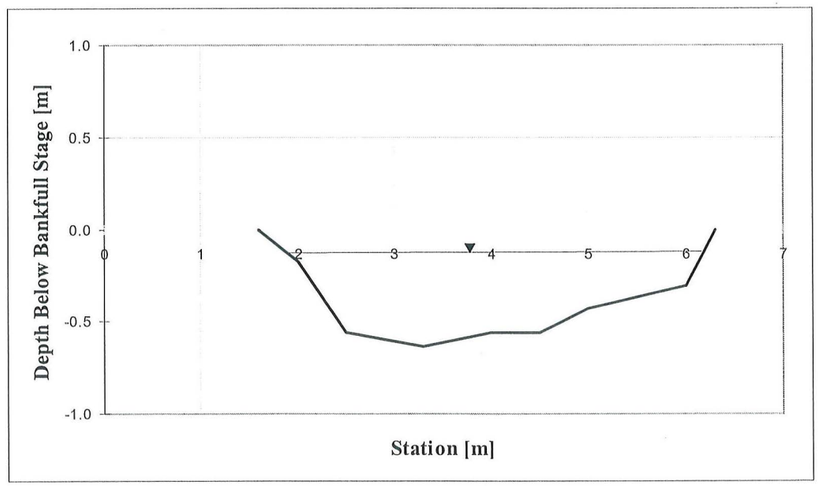
The site is located on Blackfly Creek, away from anthropogenic disturbance, to the south-east of site M14. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (coniferous). The surficial geology of the area is of lacustrine origin.

At the survey location, the valley is stream cut and is approximately 100 m wide at the bottom. The valley walls are heavily forested (coniferous) on both sides and feature no slumping. The valley flat is heavily forested as well. The bank material consists equal amounts of sand with clay/silt. The thickness of the alluvial deposits is 0.5 m. The banks are 100% vegetated and have moderate to high erodability. The entrenchment ratio is 1.27 and the width to depth ratio is 10.6. The vertical streambed stability was rated as "degrading".

At the time of the site visit, the streamflow discharge was falling and slow-moving. The water surface was uniform. The channel bed material consists of equal amounts of sand and clay/silt. The meander pattern is irregular (sinuosity 1.5). Obstructions to flow/debris included small to medium sized materials (e.g., large limb branches) which affect less than 10% of the active channel. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6338600 Northing	486000 Easting
Latitude/Longitude	57 11 36 Latitude	111 14 00 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	27 km^2	Stream Type	G5c
Channel Slope	0.0047	Sensitivity to Disturbance	Extreme
Channel Mean Depth	0.44 m	Recovery Potential	Very Poor
Channel Max Depth	0.63 m	Sediment Supply	Very High
Bankfull Width	4.7 m	Streambank Erosion Potential	Very High
Sinuosity	1.5	Influence of Vegetation on Bank Stability	High



Golder Associates

SHELL CANADA LIMITED

SITE M15 - BLACKFLY CREEK

10 NOV 1997 | Figure I-13 | DRAWN BY: TM/DC

The site is located on Muskeg Creek, downstream from a road crossing. Above the stream valley, upstream from the site, the is of an upland nature and is heavily forested (coniferous). The surficial geology of the area is of lacustrine origin.

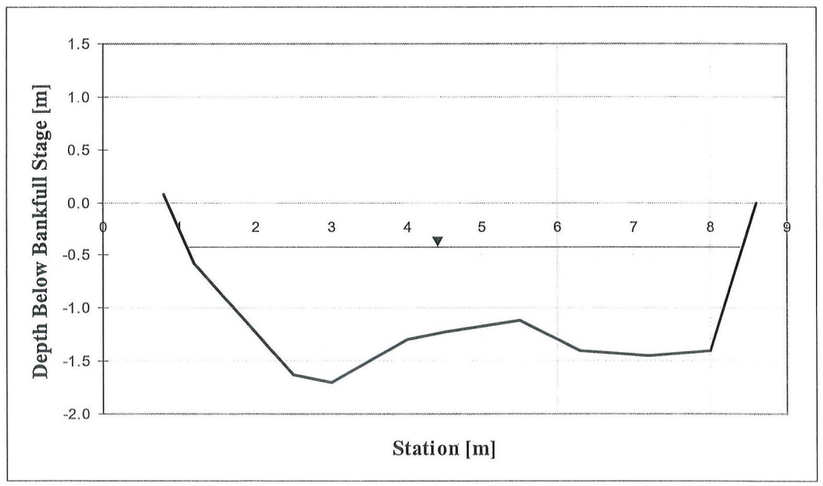
At the survey location, the valley is stream cut and is approximately 250 m wide at the bottom. The valley walls are heavily forested on both sides and feature no slumping. The valley flat is moderately forested (mixed deciduous). The bank material consists primarily of sand. The banks are 100% vegetated and have a low erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 6.0. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling and slow-moving. The water surface was uniform. The channel bed material consists of sand. The meander pattern is tortuous (sinuosity 2.5). Obstructions to flow/debris included small to medium sized materials (e.g., large limb branches) which affect less than 10% of the active channel. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6349475 Northing	480300 Easting
Latitude/Longitude	57 17 25 Latitude	111 19 36 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site):	331 km^2	Stream type	E5
Channel Slope:	0.0018	Sensitivity to Disturbance	Very High
Channel Mean Depth:	1.3	Recovery Potential	Good
Channel Max Depth:	1.7 m	Sediment Supply	Moderate
Bankfull Width:	7.8 m	Streambank Erosion Potential	High
Sinuosity	2.5	Influence of Vegetation on Bank Stability	Very High

BED MATERIAL GRADATION		BED MATERIAL PROPORTION
Size Fraction	Grain Size [mm]	
D_{100}	0.63	Gravel 0%
D_{85}	0.30	Sand 94%
D_{50}	0.24	Silt 2.7%
D_{15}	0.13	Clay 3.3%



AERIAL VIEW

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M16 - MUSKEG CREEK

10 NOV 1997	Figure I-14	DRAWN BY: TM/DC

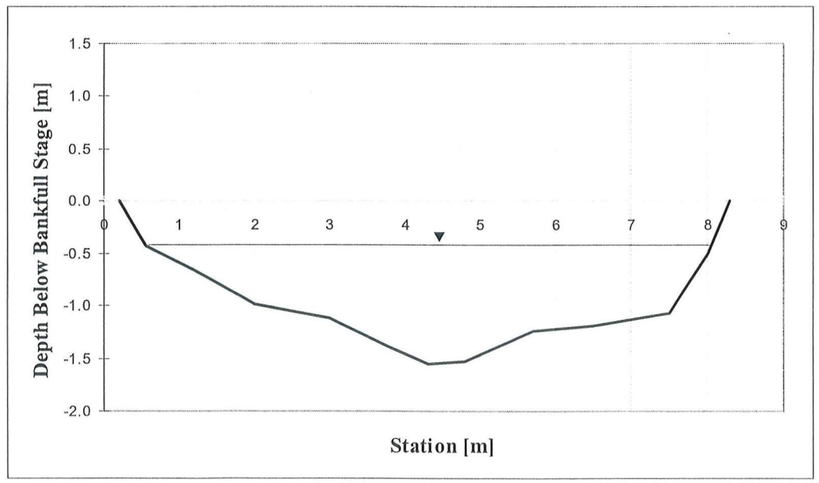
The site is located on Muskeg Creek, downstream from a road crossing. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (coniferous). The surficial geology of the area is of lacustrine origin.

At the survey location, the valley is stream cut and is approximately 40 m wide at the bottom. The valley walls are moderately forested (mixed deciduous) on both sides and feature no slumping. The valley flat is moderately forested (mixed deciduous). The bank material consists primarily of sand with some clay. The thickness of the alluvial deposits is 0.3 m. The banks are 30% vegetated and have a low erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 6.9. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The water surface was uniform. The channel bed material consists of sand, with small amounts of gravel and cobbles. The meander pattern is regular (sinuosity 1.3). Obstructions to flow/debris included significant build-up of small to medium sized materials (e.g., large limb branches) that occupy 10 to 30% of the active stream channel. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6348825 Northing	480975 Easting
Latitude/Longitude	57 16 58 Latitude	111 18 55 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	329 km^2	Stream Type	E5
Channel Slope	0.0031	Sensitivity to Disturbance	Very High
Channel Mean Depth	1.0 m	Recovery Potential	Good
Channel Max Depth	1.55 m	Sediment Supply	Moderate
Bankfull Width	8.1 m	Streambank Erosion Potential	High
Sinuosity	1.3	Influence of Vegetation on Bank Stability	Very High



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M17 - MUSKEG CREEK

10 NOV 1997 | Figure I-15 | DRAWN BY: TM/DC

The site is located on Muskeg River. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

At the survey location, the stream runs through an alluvial fan. The valley flat is heavily forested with deciduous vegetation. The bank material consists primarily of clay/silt with some sand and some gravel. The banks are 95% vegetated and have a moderate erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is less than 12. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The water surface was uniform. The channel bed material consists of equal parts of clay/silt, sand and gravel, with some cobbles. The meander pattern is irregular (sinuosity 1.2). Obstructions to flow/debris only minor amounts of small floatable material. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6346492 Northing	471614 Easting
Latitude/Longitude	57 15 54 Latitude	111 28 07 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	938 km^2	Stream type	E5
Channel Slope	0.00063	Sensitivity to Disturbance	Very High
Channel Mean Depth	n/a	Recovery Potential	Good
Channel Max Depth	n/a	Sediment Supply	Moderate
Bankfull Width	n/a	Streambank Erosion Potential	High
Sinuosity	n/a	Influence of Vegetation on Bank Stability	Very High

BED MATERIAL GRADATION		BED MATERIAL PROPORTION
Size Fraction	Grain Size [mm]	
D_{100}	2.0	Gravel 0%
D_{85}	0.55	Sand 93%
D_{50}	0.35	Silt 3%
D_{15}	0.17	Clay 3%

GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M18 - MUSKEG RIVER

10 NOV 1997	Figure I-16	DRAWN BY: TM/DC

The site is located on an unnamed creek (#3), upstream from a road crossing. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

At the survey location, the valley is stream cut and is approximately 60 m wide at the bottom. The valley walls are heavily forested (coniferous) on both sides and feature no slumping. The valley flat is swamp/muskeg. The bank material consists primarily of sand with some clay/silt. The banks are 80% vegetated and have a low erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is greater than 12. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a riffle/pool nature. The channel bed material consists of sand with some clay/silt and organic material. The meander pattern is confined (sinuosity 1.7). Obstructions to flow/debris included small to medium sized materials (e.g., large limb branches) of increasing frequency. The lateral channel activity included progression and cut-offs.

SITE LOCATION		
UTM (NAD 27)	6348700 Northing	481200 Easting
Latitude/Longitude	57 16 56 Latitude	111 18 53 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	187 km^2	Stream Type	E5
Channel Slope	0.0024	Sensitivity to Disturbance	Very High
Channel Mean Depth	2.0 m (estimated)	Recovery Potential	Good
Channel Max Depth	n/a	Sediment Supply	Moderate
Bankfull Width	5.0 m	Streambank Erosion Potential	High
Sinuosity	1.7	Influence of Vegetation on Bank Stability	Very High

GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M19 - UNNAMED CREEK 3

10 NOV 1997 | Figure I-17 | DRAWN BY: TM/DC

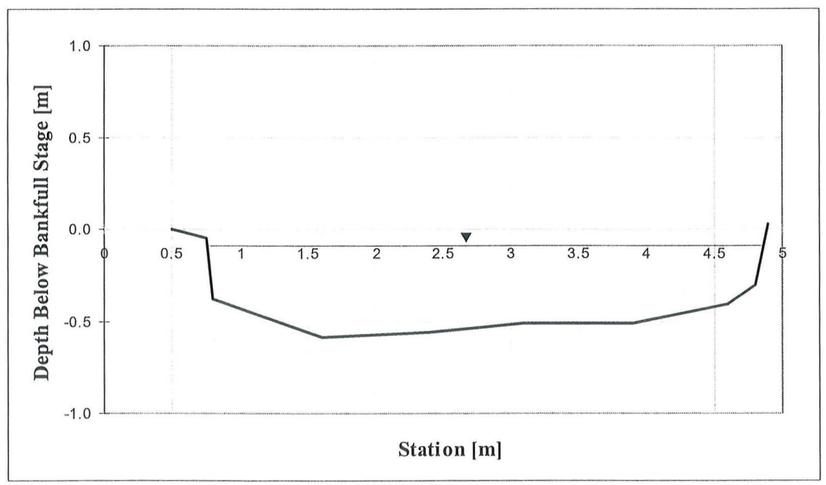
The site is located on an unnamed creek (#4). Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

At the survey location, the valley is stream cut and is approximately 100 m wide at the bottom. The valley walls are vegetated with moderately forested (coniferous) on both sides and feature no slumping. The valley flat is moderately forested (mixed deciduous). The bank material consists primarily of sand with some clay. The thickness of the alluvial deposits is 0.1 m. The banks are 75% vegetated and have a low erodability. The entrenchment ratio is 1.3 and the width to depth ratio is greater than 12. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a riffle/pool nature. The channel bed material consists primarily of sand and cobbles. The meander pattern is regular (sinuosity 1.3). Obstructions to flow/debris included small to medium sized materials (e.g., large limb branches) of increasing frequency. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6348900 Northing	481300 Easting
Latitude/Longitude	57 16 56 Latitude	111 18 52 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	131.5 km^2	Stream Type	G5c
Channel Slope	0.0047	Sensitivity to Disturbance	Extreme
Channel Mean Depth	0.36 m	Recovery Potential	Very Poor
Channel Max Depth	0.58 m	Sediment Supply	Very High
Bankfull Width	4.4 m	Streambank Erosion Potential	Very High
Sinuosity	1.3	Influence of Vegetation on Bank Stability	High



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M20 - UNNAMED CREEK 4

10 NOV 1997 | Figure I-18 | DRAWN BY: TM/DC

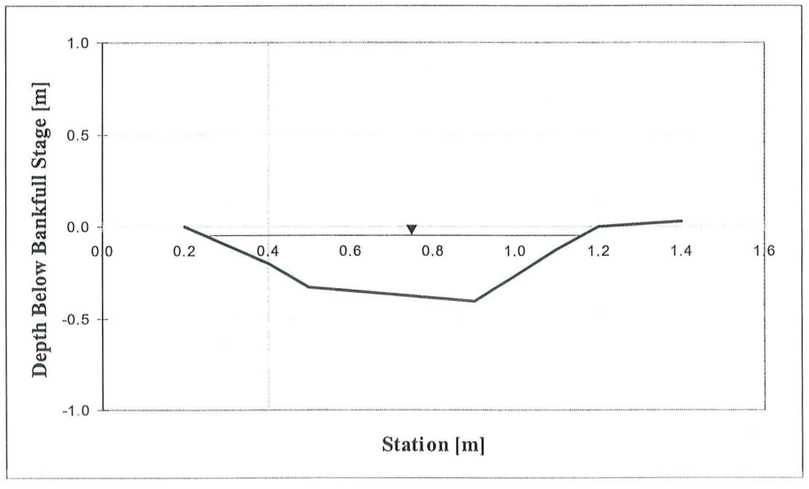
The site is located on Wesukemina Creek. Above the stream valley, upstream from the site, the topography features little relief (swamp/muskeg). The surficial geology of the area is of lacustrine origin.

At the survey location, the stream runs through an alluvial plain. The valley flat is swamp/muskeg. The bank material consists primarily of organic material. The thickness of the alluvial deposits is 0.2 m. The banks are 100% vegetated and have a low erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 3.8. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The water surface was uniform. The channel bed material consists of equal parts of clay/silt, sand and gravel, with some cobbles/boulders (less than 10%). The meander pattern is irregular. Obstructions to flow/debris included significant build-up of small to medium sized materials (e.g., large limb branches) as well as numerous abandoned beaver dams, many of which have filled with sediment and breached, initiating a series of channel adjustment such as bank erosion. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6343900 Northing	485200 Easting
Latitude/Longitude	57 13 36 Latitude	111 14 33 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	40 km^2	Stream Type	E6
Channel Slope	0.0035	Sensitivity to Disturbance	Very high
Channel Mean Depth	0.26 m	Recovery Potential	Good
Channel Max Depth	0.41 m	Sediment Supply	Low
Bankfull Width	1.0 m	Streambank Erosion Potential	Moderate
Sinuosity	1.2	Influence of Vegetation on Bank Stability	Very High



AERIAL VIEW

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M21 - WESUKEMINA CREEK

21 NOV 1997 | Figure I-19 | DRAWN BY: TM/DC

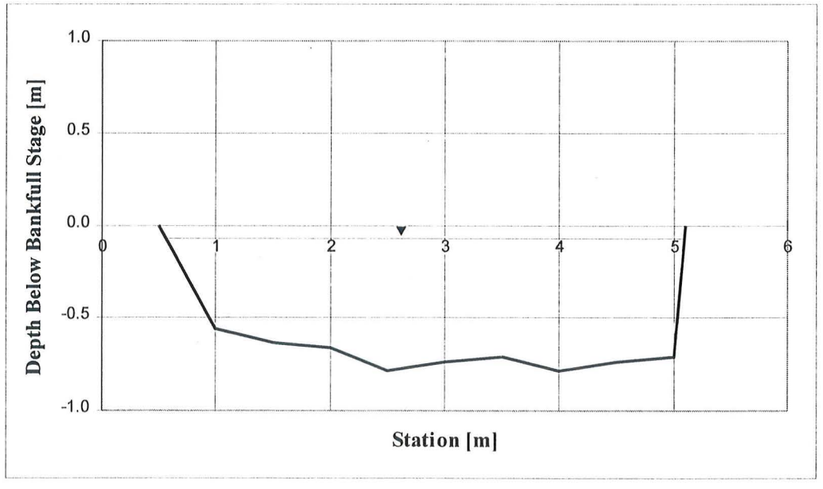
The site is located at the Kearl Lake outlet. Above the stream valley, upstream from the site and the lake, the topography features little relief (wetlands) and is moderately forested (mixed deciduous). The surficial geology of the area is of lacustrine origin.

At the survey location, the valley is stream cut and is greater than 100 m wide at the bottom. The valley walls are sparsely forested (deciduous) on both sides and feature no slumping. The valley flat is swamp/muskeg and vegetated with grass. The bank material consists primarily of sand with clay/silt. The thickness of the alluvial deposits is less than 0.1 m. The banks are 70% vegetated and have a low erodability. The entrenchment ratio is greater than 2.2 and the width to depth ratio is 8.0. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The water surface was uniform. The channel bed material consists of sand, clay/silt and some cobbles (less than 10%). The meander pattern is irregular (sinuosity < 1.2). Obstructions to flow/debris included small floatable material such as leaves. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6346750 Northing	483400 Easting
Latitude/Longitude	57 15 58 Latitude	111 15 58 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	72 km^2	Stream Type	E5
Channel Slope	0.0038	Sensitivity to Disturbance	Very High
Channel Mean Depth	0.57 m	Recovery Potential	Good
Channel Max Depth	0.79 m	Sediment Supply	Moderate
Bankfull Width	4.6 m	Streambank Erosion Potential	High
Sinuosity	1.1	Influence of Vegetation on Bank Stability	Very High



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M22 - KEARL LAKE OUTLET

10 NOV 1997 | Figure I-20 | DRAWN BY: TM/DC

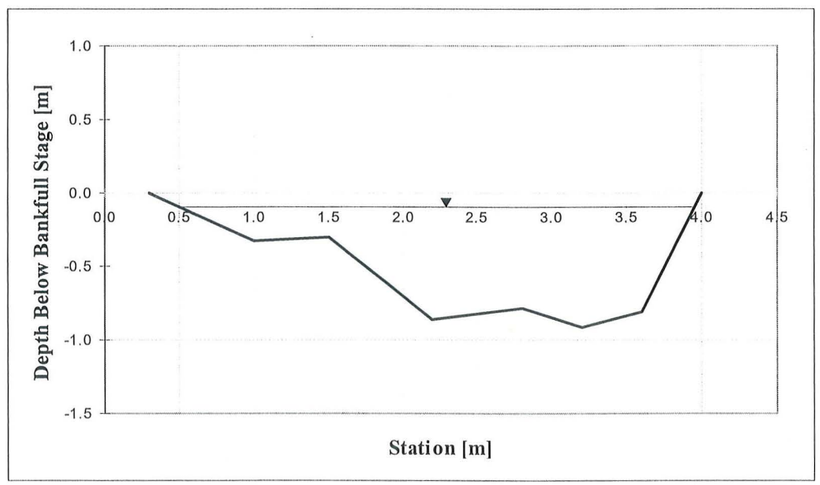
The site is located on Iyinimin Creek at the S3 stream gauging station. Above the stream valley, upstream from the site, the topography features little relief (wetlands) and is heavily forested (coniferous). The surficial geology of the area is of lacustrine origin.

At the survey location, the valley is stream cut and is approximately 70 m wide at the bottom. The valley walls are heavily forested (coniferous) on both sides and feature no slumping. The valley flat is moderately forested (coniferous). The bank material consists primarily of sand with some clay/silt. The thickness of the alluvial deposits is 0.2 m. The banks are 70% vegetated and have a low erodability. The entrenchment ratio is 1.21 and the width to depth ratio is 6.49. The vertical streambed stability was rated as "stable".

At the time of the site visit, the streamflow discharge was falling. The bedform is of a step/pool nature. The channel bed material consists of sand and clay. The meander pattern is irregular (sinuosity 1.5). Obstructions to flow/debris included excessive debris dams of predominantly larger materials (e.g., branches, logs, etc.) occupying 30 to 50% of the active channel cross-section. The lateral channel activity was non-detectable.

SITE LOCATION		
UTM (NAD 27)	6344800 Northing	489650 Easting
Latitude/Longitude	57 14 53 Latitude	111 10 19 Longitude

STREAM CHARACTERISTICS		ROSGEN CLASSIFICATION	
Basin Size (upstream of survey site)	24.5 km^2	Stream Type	G5c
Channel Slope	0.0148	Sensitivity to Disturbance	Extreme
Channel Mean Depth	0.57 m	Recovery Potential	Very Poor
Channel Max Depth	0.91 m	Sediment Supply	Very High
Bankfull Width	3.7 m	Streambank Erosion Potential	Very High
Sinuosity	1.5	Influence of Vegetation on Bank Stability	High



GROUNDVIEW LOOKING UPSTREAM

GROUNDVIEW LOOKING DOWNSTREAM

Golder Associates

SHELL CANADA LIMITED

SITE M23 - IYINIMIN CREEK

21 NOV 1997 | Figure I-21 | DRAWN BY: TM/DC

APPENDIX II

SUMMER STREAMFLOW MEASUREMENTS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 17 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0830 hr.
MEASUREMENT END TIME: 0930 hr.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.1	0.000
1	0.20	0.00	0.04			-0.010	0.2	0.000
2	0.40	0.00	0.09			0.000	0.2	0.000
3	0.60	0.00	0.13			0.570	0.2	0.015
4	0.80	0.00	0.14			0.710	0.2	0.020
5	1.00	0.00	0.13			1.030	0.2	0.027
6	1.20	0.00	0.10			0.800	0.2	0.016
7	1.40	0.00	0.09			-0.020	0.2	0.000
8	1.60	0.00	0.08			0.370	0.2	0.006
9	1.80	0.00	0.05			0.130	0.2	0.001
10	2.00	0.00	0.01			0.000	0.15	0.000
Right Bank	2.10	0.00	0.00			0.000	0.05	0.000
						Total Discharge		**0.084**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Ice thickness was not measured

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471657.4E/6346353.7N
Substrate: Sand and silt

MEASUREMENT DATE: 16 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: KA/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1228 hrs.
MEASUREMENT END TIME: 1330 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.425	0.000
1	0.85	0.65	0.72	0.00	0.03	0.015	0.825	0.009
2	1.65	0.57	0.76	0.01	0.02	0.015	0.59	0.007
3	2.03	0.58	0.75	0.01	0.01	0.010	0.4	0.003
4	2.45	0.59	0.66	0.01	0.00	0.005	0.46	0.002
5	2.95	0.58	0.52	0.01	0.01	0.010	0.5	0.003
6	3.45	0.62	0.32	0.00	0.00	0.000	0.525	0.000
Right Bank	4.00	0.00	0.00	0.00	0.00	0.000	0.275	0.000
						Total Discharge		**0.023**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Snow depth on stream channel average 0.52m

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 18 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1040 hr.
MEASUREMENT END TIME: 1230 hr.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.25	0.000
1	0.50	0.45	1.17	0.00	0.01	0.005	0.625	0.004
2	1.25	0.46	1.25	0.01	0.01	0.010	0.775	0.010
3	2.05	0.40	1.24	0.02	0.02	0.020	0.755	0.019
4	2.76	0.41	1.26	0.01	0.02	0.015	0.74	0.014
5	3.53	0.44	1.26	0.03	0.02	0.025	0.79	0.025
6	4.34	0.44	1.20	0.03	0.03	0.030	0.74	0.027
7	5.01	0.45	1.15	0.02	0.02	0.020	0.755	0.017
8	5.85	0.43	1.07	0.01	0.02	0.015	0.875	0.014
9	6.76	0.42	1.01	0.01	0.02	0.015	0.825	0.012
10	7.50	0.46	1.02	0.01	0.02	0.015	0.745	0.011
11	8.25	0.49	0.89	0.01	0.01	0.010	0.68	0.006
12	8.86	0.52	0.82	0.00	0.00	0.000	0.575	0.000
Right Bank	9.40	0.00	0.00	0.00	0.00	0.000	0.27	0.000
						Total Discharge		**0.159**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES: 463828.7E/6344743.3N
Substrate: Silt and Gravel

MEASUREMENT DATE: 15 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: KA/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1430 hrs.
MEASUREMENT END TIME: 1515 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.22			0.050	0.5	0.006
2	1.00	0.00	0.24			0.090	0.5	0.011
3	1.50	0.00	0.20			0.100	0.5	0.010
4	2.00	0.00	0.16			0.090	0.5	0.007
5	2.50	0.00	0.08			0.020	0.28	0.000
Right Bank	2.56	0.00	0.00			0.000	0.03	0.000
							Total Discharge	**0.034**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Ice thickness was not measured

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 28 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0945 hrs.
MEASUREMENT END TIME: 1020 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.10	0.000
1	0.20	0.00	0.09			0.090	0.20	0.002
2	0.40	0.00	0.17			0.140	0.20	0.005
3	0.60	0.00	0.17			0.220	0.20	0.007
4	0.80	0.00	0.19			0.470	0.20	0.018
5	1.00	0.00	0.20			0.810	0.20	0.032
6	1.20	0.00	0.15			0.330	0.20	0.010
7	1.40	0.00	0.11			0.020	0.20	0.000
8	1.60	0.00	0.09			-0.010	0.25	0.000
Right Bank	1.90	0.00	0.00			0.000	0.15	0.000
						Total Discharge		**0.074**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Ice thickness was very thin - average thickness at the edge was 45mm and at the middle was 15mm.
3. Ice covered was broken up and flow was measured as open water

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 28 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1230 hrs.
MEASUREMENT END TIME: 1300 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.50	0.00			0.000	0.15	0.000
1	0.30	0.37	0.72			0.110	0.3	0.024
2	0.60	0.30	0.76			0.140	0.35	0.037
3	1.00	0.30	0.75			-0.030	0.35	-0.008
4	1.30	0.35	0.66			0.150	0.45	0.045
Right Bank	1.90	0.35	0.00			0.000	0.3	0.000
						Total Discharge		**0.098**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water surface was below the bottom of ice
3. Flow was measured as open water

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 27 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1150 hrs.
MEASUREMENT END TIME: 1310 hrs.

STATION	DISTANCE FROM LEFT BANK	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.35	0.000
1	0.70	0.41	1.21	0.00	0.01	0.005	0.75	0.005
2	1.50	0.42	1.31	0.02	0.01	0.015	0.8	0.016
3	2.30	0.38	1.20	0.01	0.02	0.015	0.75	0.014
4	3.00	0.31	1.32	0.03	0.04	0.035	0.8	0.037
5	3.90	0.45	1.24	0.03	0.03	0.030	0.8	0.030
6	4.60	0.46	1.17	0.04	0.03	0.035	0.7	0.029
7	5.30	0.46	1.13	0.03	0.04	0.035	0.75	0.030
8	6.10	0.45	1.00	0.03	0.02	0.025	0.85	0.021
9	7.00	0.43	0.98	0.01	0.02	0.015	0.85	0.012
10	7.80	0.47	1.02	0.02	0.02	0.020	0.8	0.016
11	8.60	0.50	0.88	0.01	0.01	0.010	0.65	0.006
12	9.10	0.52	0.80	0.01	0.01	0.010	0.45	0.004
Right Bank	9.50	0.00	0.00	0.00	0.00	0.000	0.2	0.000
						Total Discharge		**0.218**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 28 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0820 hrs.
MEASUREMENT END TIME: 0920 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00	0.000	0.000	0.000	0.15	0.000
1	0.30	0.00	0.12	0.020	0.020	0.020	0.3	0.001
2	0.60	0.00	0.22	0.070	0.050	0.060	0.3	0.004
3	0.90	0.00	0.25	0.070	0.070	0.070	0.3	0.005
4	1.20	0.00	0.26	0.090	0.077	0.084	0.3	0.007
5	1.50	0.00	0.26	0.100	0.080	0.090	0.3	0.007
6	1.80	0.00	0.26	0.100	0.090	0.095	0.3	0.007
7	2.10	0.00	0.29	0.100	0.090	0.095	0.3	0.008
8	2.40	0.00	0.25	0.060	0.050	0.055	0.3	0.004
9	2.70	0.00	0.22	0.020	0.010	0.015	0.3	0.001
10	3.00	0.00	0.13	0.000	0.000	0.000	0.3	0.000
Right Bank	3.30	0.00	0.00	0.000	0.000	0.000	0.15	0.000
						Total Discharge		**0.044**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Ice thickness was easily broken up - thickness at the edge of stream was 20mm and at the middle was 3mm
3. Ice was broken up and flow was measured as open water

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 16 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1204 hrs.
MEASUREMENT END TIME: 1250 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.04			0.190	0.30	0.002
2	0.60	0.00	0.08			0.130	0.30	0.003
3	0.90	0.00	0.08			0.080	0.30	0.002
4	1.20	0.00	0.14			0.540	0.30	0.023
5	1.50	0.00	0.20			1.240	0.30	0.074
6	1.80	0.00	0.08			0.690	0.30	0.017
7	2.10	0.00	0.05			0.290	0.25	0.004
Right Bank	2.30	0.00	0.00			0.000	-1.05	0.000
						Total Discharge		**0.125**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 17 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1400 hrs.
MEASUREMENT END TIME: 1438 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.02	0.00			0.000	0.4	0.000
1	0.80	0.02	0.16			0.040	0.85	0.005
2	1.70	0.15	0.19			0.030	0.65	0.004
3	2.10	0.08	0.36			0.130	0.45	0.021
4	2.60	0.10	0.53			0.180	0.45	0.043
5	3.00	0.10	0.38			0.130	0.45	0.022
6	3.50	0.05	0.17			0.190	0.75	0.024
Right Bank	4.50	0.00	0.00			0.000	0.5	0.000
							Total Discharge	**0.120**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$

2. Water was flowing on top of the ice - approxiameately 25cm deep
3. Flow was measured as open water
4. Backflow was noticed at the augered hole distance 3.0m i.e. water from underneath the ice was flow to the surface
5. Pressure transducer was installed.

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 17 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1115 hrs.
MEASUREMENT END TIME: 1257 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.65	0.000
1	1.30	0.39	1.28	0.08	0.08	0.080	1.00	0.102
2	2.00	0.34	1.36	0.09	0.08	0.085	0.8	0.092
3	2.90	0.48	1.30	0.10	0.10	0.100	0.8	0.104
4	3.60	0.43	1.30	0.09	0.10	0.095	1.55	0.191
5	6.00	0.44	1.03	0.08	0.04	0.060	2.55	0.158
Right Bank	8.70	0.35	0.00	0.00	0.00	0.000	1.35	0.000
						Total Discharge		**0.648**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Approximately 10 cm of water ponded in the mid-stream
3. Pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 16 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0920 hrs.
MEASUREMENT END TIME: 1015 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.14			0.100	0.3	0.004
2	0.60	0.00	0.16			0.210	0.3	0.010
3	0.90	0.00	0.26			0.180	0.3	0.014
4	1.20	0.00	0.24			0.200	0.3	0.014
5	1.50	0.00	0.27			0.220	0.3	0.018
6	1.80	0.00	0.30			0.240	0.3	0.022
7	2.10	0.00	0.30			0.200	0.3	0.018
8	2.40	0.00	0.22			0.120	0.3	0.008
9	2.70	0.00	0.18			0.050	0.3	0.003
10	3.00	0.00	0.10			0.000	0.25	0.000
Right Bank	3.20	0.00	0.00			0.000	0.1	0.000
						Total Discharge		**0.111**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 23 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1230 hrs.
MEASUREMENT END TIME: 1355 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.19	0.000
1	0.38	0.00	0.07			0.320	0.29	0.006
2	0.58	0.00	0.07			0.380	0.20	0.005
3	0.78	0.00	0.04			0.020	0.19	0.000
4	0.95	0.00	0.04			0.160	0.18	0.001
5	1.13	0.00	0.06			0.190	0.18	0.002
6	1.30	0.00	0.12			0.090	0.19	0.002
7	1.50	0.00	0.15			0.850	0.20	0.026
8	1.70	0.00	0.17			1.660	0.20	0.056
9	1.90	0.00	0.14			1.220	0.20	0.034
10	2.10	0.00	0.11			1.060	0.20	0.023
11	2.30	0.00	0.09			0.170	0.18	0.003
12	2.45	0.00	0.09			0.010	0.16	0.000
Right Bank	2.61	0.00	0.00			0.000	0.08	0.000
						Total Discharge		**0.159**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T. Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1315 hrs.
MEASUREMENT END TIME: 1635 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.1	0.000
1	0.20	0.00	1.09	0.18	0.01	0.095	0.35	0.036
2	0.70	0.00	1.37	0.21	0.05	0.130	0.5	0.089
3	1.20	0.00	1.46	0.10	-0.12	-0.010	0.5	-0.007
4	1.70	0.00	1.75	0.48	0.07	0.275	0.5	0.241
5	2.20	0.00	1.83	0.70	0.08	0.390	0.5	0.357
6	2.70	0.00	1.75	0.92	0.58	0.750	0.5	0.656
7	3.20	0.00	1.35	0.86	0.65	0.755	0.75	0.764
8	4.20	0.00	1.10	0.68	0.26	0.470	1	0.517
9	5.20	0.00	0.93	0.69	0.45	0.570	1	0.530
10	6.20	0.00	0.81	0.61	0.35	0.480	1	0.389
11	7.20	0.00	0.55	0.40	0.36	0.380	1	0.209
12	8.20	0.00	0.57	0.20	0.01	0.105	0.67	0.040
Right Bank	8.54	0.00	0.00	0.00	0.00	0.000	0.17	0.000
						Total Discharge		**3.821**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Measurement taken usung the cablecart
3. Ice sheet and slush flowing downstream - difficult to measure
4. Possible ice at bottom of creek
5. Water sample taken
6. No problem with pressure transducer
7. Readings in bold need to recheck

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B.Kulcum/Tom Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0920 hrs.
MEASUREMENT END TIME: 1130 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.15	0.000
1	0.30		0.08			-0.600	0.30	-0.014
2	0.60		0.10			-0.100	0.25	-0.003
3	0.80		0.22			-0.040	0.20	-0.002
4	1.00		0.24			0.020	0.20	0.001
5	1.20		0.28			0.290	0.25	0.020
6	1.50		0.33			0.630	0.25	0.052
7	1.70		0.32			1.010	0.20	0.065
8	1.90		0.35			0.630	0.20	0.044
9	2.10		0.38			0.750	0.20	0.057
10	2.30		0.34			0.280	0.25	0.024
11	2.60		0.32			0.020	0.25	0.002
12	2.80		0.26			0.070	0.25	0.005
13	3.10		0.23			-0.100	0.30	-0.007
14	3.40		0.22			0.000	0.25	0.000
15	3.60		0.24			0.010	0.20	0.000
Right Bank	3.80		0.00			0.000	0.10	0.000
						Total Discharge		**0.244**

Note: 1. Water flowing on top of ice
2. Water was silty
3. Water sample taken
4. No problem with pressure transducer

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1135 hrs.
MEASUREMENT END TIME: 1300 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			-0.020	0.10	0.000
1	0.20		0.12			-0.020	0.20	0.000
2	0.40		0.16			-0.030	0.20	-0.001
3	0.60		0.20			0.050	0.25	0.003
4	0.90		0.21			0.160	0.25	0.008
5	1.10		0.22			0.310	0.20	0.014
6	1.30		0.23			0.510	0.20	0.023
7	1.50		0.24			0.700	0.20	0.034
8	1.70		0.30			0.910	0.20	0.055
9	1.90		0.32			1.000	0.20	0.064
10	2.10		0.32			1.010	0.20	0.065
11	2.30		0.35			1.120	0.20	0.078
12	2.50		0.35			1.120	0.20	0.078
13	2.70		0.34			1.120	0.20	0.076
14	2.90		0.33			1.000	0.20	0.066
15	3.10		0.32			0.900	0.20	0.058
16	3.30		0.33			0.850	0.20	0.056
17	3.50		0.29			0.860	0.20	0.050
18	3.70		0.21			0.530	0.24	0.026
Right Bank	3.97		0.00			0.000	0.14	0.000
						Total Discharge		**0.752**

Note: 1. Drilled through the ice to substrate - no flow
2. Water was flowing on top of the ice
3. No problem with pressure transducer

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1645 hrs.
MEASUREMENT END TIME: 1945 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.25	0.000
1	0.50		0.15			0.000	0.5	0.000
2	1.00		0.24			0.000	0.5	0.000
3	1.50		0.37			0.010	0.5	0.002
4	2.00		0.50			0.000	0.5	0.000
5	2.50		1.72	0.01	0.06	0.035	0.75	0.045
7	3.50		2.23	0.12	0.14	0.130	1	0.290
9	4.50		2.35	0.25	0.24	0.245	1	0.576
11	5.50		2.35	0.24	0.29	0.265	1	0.623
13	6.50		2.30	0.31	0.29	0.300	1	0.690
15	7.50		2.22	0.29	0.26	0.275	1	0.611
17	8.50		2.25	0.24	0.23	0.235	1	0.529
19	9.50		2.17	0.15	0.15	0.150	1	0.326
21	10.50		1.98	0.10	0.17	0.135	1	0.267
23	11.50		0.95	0.05	0.02	0.035	1.2	0.040
Right Bank	12.90		0.00	0.00	0.00	0.000	0.7	0.000
						Total Discharge		**3.997**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water was too silty
3. Possible layer of ice at bottom of river
4. No problem with the pressure transducer
5. Water sample was taken

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 23 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1435 hrs.
MEASUREMENT END TIME: 1535 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.1	0.000
1	0.20	0.00	0.11			0.150	0.2	0.003
2	0.40	0.00	0.18			0.230	0.2	0.008
3	0.60	0.00	0.24			0.270	0.2	0.013
4	0.80	0.00	0.22			0.380	0.15	0.013
5	0.90	0.00	0.28			0.310	0.1	0.009
6	1.00	0.00	0.26			0.300	0.15	0.012
7	1.20	0.00	0.21			0.360	0.2	0.015
8	1.40	0.00	0.18			0.340	0.2	0.012
9	1.60	0.00	0.20			0.350	0.2	0.014
10	1.80	0.00	0.17			0.390	0.2	0.013
11	2.00	0.00	0.18			0.350	0.2	0.013
12	2.20	0.00	0.18			0.400	0.2	0.014
13	2.40	0.00	0.18			0.270	0.2	0.010
14	2.60	0.00	0.20			0.270	0.2	0.011
15	2.80	0.00	0.20			0.170	0.2	0.007
16	3.00	0.00	0.16			0.070	0.2	0.002
17	3.20	0.00	0.12			0.010	0.2	0.000
18	3.40	0.00	0.04			0.000	0.205	0.000
Right Bank	3.61	0.00	0.00			0.000	0.105	0.000
						Total Discharge		**0.169**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 30 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1340 hrs.
MEASUREMENT END TIME: 1435 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.02			0.000	0.30	0.000
2	0.60	0.00	0.04			0.020	0.30	0.000
3	0.90	0.00	0.06			0.170	0.30	0.003
4	1.20	0.00	0.04			0.270	0.30	0.003
5	1.50	0.00	0.05			0.250	0.30	0.004
6	1.80	0.00	0.04			0.230	0.30	0.003
7	2.10	0.00	0.04			0.180	0.30	0.002
8	2.40	0.00	0.06			0.340	0.30	0.006
9	2.70	0.00	0.07			0.430	0.30	0.009
10	3.00	0.00	0.09			0.390	0.30	0.011
11	3.30	0.00	0.13			0.460	0.30	0.018
12	3.60	0.00	0.11			0.540	0.23	0.013
13	3.75	0.00	0.08			0.290	0.15	0.003
Right Bank	3.89	0.00	0.00			0.000	0.07	0.000
						Total Discharge		**0.076**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T. Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1135 hrs.
MEASUREMENT END TIME: 1350 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.68			-0.020	0.4	-0.005
2	0.80	0.00	0.93	0.21	0.30	0.255	0.5	0.119
3	1.30	0.00	1.11	0.58	0.45	0.515	0.75	0.429
5	2.30	0.00	1.30	0.69	0.44	0.565	1	0.735
7	3.30	0.00	1.25	0.78	0.52	0.650	1	0.813
9	4.30	0.00	1.02	0.84	0.72	0.780	0.75	0.597
10	4.80	0.00	1.24	0.90	0.75	0.825	0.5	0.512
11	5.30	0.00	1.31	0.93	0.86	0.895	0.5	0.586
12	5.80	0.00	1.94	0.94	0.60	0.770	0.5	0.747
13	6.30	0.00	1.73	0.90	0.46	0.680	0.5	0.588
14	6.80	0.00	1.62	0.39	0.53	0.460	0.5	0.373
15	7.30	0.00	1.39	0.32	0.37	0.345	0.75	0.360
17	8.30	0.00	1.09	0.22	0.22	0.220	0.7	0.168
Right Bank	8.70	0.00	0.00	0.00	0.00	0.000	0.2	0.000
						Total Discharge		**6.019**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Measurement taken usung the inflated boat
3. Water temperature was 4oC
4. Water sample taken for TSS
5. No problem with pressure transducer

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B.Kulcum/Tom Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0915 hrs.
MEASUREMENT END TIME: 1010 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.08	0.000
1	0.15		0.13			0.010	0.25	0.000
2	0.50		0.13			0.040	0.33	0.002
3	0.80		0.19			0.230	0.30	0.013
4	1.10		0.25			0.610	0.30	0.046
5	1.40		0.30			0.800	0.30	0.072
6	1.70		0.35			0.720	0.30	0.076
7	2.00		0.35			0.800	0.30	0.084
8	2.30		0.31			0.060	0.30	0.006
9	2.60		0.28			-0.010	0.30	-0.001
10	2.90		0.16			-0.040	0.30	-0.002
11	3.20		0.12			-0.010	0.30	0.000
12	3.50		0.15			0.000	0.30	0.000
Right Bank	3.80		0.00			0.000	0.00	0.000
							Total Discharge	**0.295**

Note: 1. Ice on stream bottom

2. Water was silty and temperature was 0oC

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1020 hrs.
MEASUREMENT END TIME: 1125 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.18	0.000
1	0.35		0.03			0.190	0.33	0.002
2	0.65		0.04			0.250	0.30	0.003
3	0.95		0.11			0.540	0.30	0.018
4	1.25		0.11			0.610	0.30	0.020
5	1.55		0.27			0.710	0.30	0.058
6	1.85		0.40			0.780	0.30	0.094
7	2.15		0.46			0.730	0.30	0.101
8	2.45		0.46			0.730	0.30	0.101
9	2.75		0.42			0.680	0.30	0.086
10	3.05		0.39			0.540	0.30	0.063
11	3.35		0.30			0.320	0.30	0.029
12	3.65		0.26			0.270	0.30	0.021
13	3.95		0.22			0.260	0.30	0.017
14	4.25		0.20			0.270	0.30	0.016
15	4.55		0.06			0.080	0.33	0.002
Right Bank	4.90		0.00			0.000	0.00	0.000
						Total Discharge		**0.629**

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1405 hrs.
MEASUREMENT END TIME: 1645 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.25	0.000
1	0.50		0.11			0.000	0.5	0.000
2	1.00		0.23			0.000	0.5	0.000
3	1.50		0.25			0.030	0.5	0.004
4	2.00		0.33			0.010	0.5	0.002
5	2.50		0.45			0.010	0.5	0.002
6	3.00		0.54			0.010	0.5	0.003
7	3.50		0.78			0.010	0.5	0.004
8	4.00		1.84	0.11	0.13	0.120	0.5	0.110
9	4.50		2.07	0.17	0.14	0.155	0.5	0.160
10	5.00		2.25	0.23	0.24	0.235	0.5	0.264
11	5.50		2.15	0.23	0.26	0.245	0.5	0.263
12	6.00		2.50	0.32	0.21	0.265	0.75	0.497
14	7.00		2.50	0.25	0.26	0.255	1	0.638
16	8.00		2.44	0.35	0.26	0.305	1	0.744
18	9.00		2.38	0.16	0.25	0.205	1	0.488
20	10.00		2.33	0.15	0.22	0.185	1	0.431
22	11.00		2.27	0.14	0.10	0.120	1	0.272
24	12.00		2.10	0.09	0.18	0.135	1	0.284
26	13.00		1.02	0.04	0.04	0.040	1	0.041
28	14.00		0.75	0.00	0.00	0.000	0.7	0.000
Right Bank	14.40		0.00	0.00	0.00	0.000	0.2	0.000
						Total Discharge		**4.207**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water was temperature was 4oC
3. No problem with the pressure transducer
4. Water sample was taken for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 30 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1450 hrs.
MEASUREMENT END TIME: 1535 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.12			0.100	0.25	0.003
2	0.50	0.00	0.15			0.270	0.2	0.008
3	0.70	0.00	0.16			0.310	0.2	0.010
4	0.90	0.00	0.25			0.210	0.2	0.011
5	1.10	0.00	0.19			0.250	0.25	0.012
6	1.40	0.00	0.16			0.210	0.3	0.010
7	1.70	0.00	0.14			0.260	0.3	0.011
8	2.00	0.00	0.13			0.280	0.3	0.011
9	2.30	0.00	0.14			0.210	0.3	0.009
10	2.60	0.00	0.16			0.200	0.3	0.010
11	2.90	0.00	0.15			0.030	0.25	0.001
12	3.10	0.00	0.1			0.000	0.2	0.000
Right Bank	3.30	0.00	0.00			0.000	0.1	0.000
						Total Discharge		**0.095**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 09 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1335 hrs.
MEASUREMENT END TIME: 1421 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.04			0.170	0.30	0.002
2	0.60	0.00	0.04			0.140	0.30	0.002
3	0.90	0.00	0.03			0.010	0.30	0.000
4	1.20	0.00	0.04			0.250	0.30	0.003
5	1.50	0.00	0.04			0.230	0.30	0.003
6	1.80	0.00	0.06			0.410	0.30	0.007
7	2.10	0.00	0.06			0.540	0.30	0.010
8	2.40	0.00	0.07			0.670	0.30	0.014
9	2.70	0.00	0.06			0.290	0.30	0.005
10	3.00	0.00	0.05			0.350	0.30	0.005
11	3.30	0.00	0.06			0.230	0.30	0.004
12	3.60	0.00	0.06			0.150	0.28	0.002
Right Bank	3.85	0.00	0.00			0.000	0.13	0.000
						Total Discharge		**0.059**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Temporary transducer was removed and replaced with permanent transducer inside the perforated horizontal pipe
3. Water sample taken for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1250 hrs.
MEASUREMENT END TIME: 1655 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.15	0.000
1	0.30	0.00	0.56	-0.05	-0.04	-0.045	0.4	-0.010
2	0.80	0.00	0.78	0.23	0.28	0.255	0.75	0.149
3	1.80	0.00	1.16	0.65	0.40	0.525	1	0.609
4	2.80	0.00	1.04	0.65	0.46	0.555	1	0.577
5	3.80	0.00	1.19	0.71	0.45	0.580	1	0.690
6	4.80	0.00	1.14	0.69	0.60	0.645	1	0.735
7	5.80	0.00	1.57	0.89	0.42	0.655	1	1.028
8	6.80	0.00	1.24	0.37	0.46	0.415	1	0.515
9	7.80	0.00	0.95	0.38	0.11	0.245	0.9	0.209
Right Bank	8.60	0.00	0.00	0.00	0.00	0.000	0.4	0.000
						Total Discharge		**4.503**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Measurement taken from the cablecart as the boat was punctured
3. Water temperature was 9oC
4. Water sample taken for TSS
5. No problem with pressure transducer - unable to retrieve the temporary transducer as water was too high
6. The temporary transducer was left as it was before - hope to replace it next trip

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1120 hrs.
MEASUREMENT END TIME: 1230 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.20	0.000
1	0.40	0.00	0.16			0.270	0.35	0.015
2	0.70	0.00	0.23			0.180	0.30	0.012
3	1.00	0.00	0.26			0.160	0.30	0.012
4	1.30	0.00	0.26			0.240	0.30	0.019
5	1.60	0.00	0.43			0.300	0.30	0.039
6	1.90	0.00	0.50			0.460	0.30	0.069
7	2.20	0.00	0.58			0.600	0.30	0.104
8	2.50	0.00	0.60			0.140	0.30	0.025
9	2.80	0.00	0.50			0.090	0.30	0.014
10	3.10	0.00	0.48			0.240	0.30	0.035
11	3.40	0.00	0.52			0.430	0.30	0.067
12	3.70	0.00	0.35			0.400	0.30	0.042
13	4.00	0.00	0.43			0.260	0.23	0.025
Right Bank	4.15	0.00	0.00			0.000	0.00	0.000
							Total Discharge	**0.478**

Note: 1. No Ice on stream bottom - trace of snow/ice at LDB

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0930 hrs.
MEASUREMENT END TIME: 1115 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.08	0.000
1	0.15		0.19			0.010	0.23	0.000
2	0.45		0.26			0.090	0.30	0.007
3	0.75		0.29			0.240	0.28	0.019
4	1.00		0.33			0.380	0.28	0.034
5	1.30		0.40			0.440	0.30	0.053
6	1.60		0.44			0.550	0.30	0.073
7	1.90		0.45			0.600	0.30	0.081
8	2.20		0.44			0.620	0.30	0.082
9	2.50		0.45			0.520	0.30	0.070
10	2.80		0.41			0.430	0.30	0.053
11	3.10		0.36			0.300	0.30	0.032
12	3.40		0.30			0.230	0.30	0.021
13	3.70		0.32			0.150	0.30	0.014
14	4.00		0.27			0.150	0.30	0.012
15	4.30		0.20			0.020	0.34	0.001
Right Bank	4.68		0.00			0.000	-2.15	0.000
						Total Discharge		**0.553**

Note: 1. No ice at bottom of the creek
2. No problem with temporary pressure transducer - replaced with permanent transducer
3. Water temperature 50C
4. Water sample was collected for TSS
5. The stilling well was still iced up

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1705 hrs.
MEASUREMENT END TIME: 1935 hrs.

STATION	DISTANCE FROM LEFT BANK	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.18			0.000	0.5	0.000
2	1.00	0.00	0.55			0.000	0.5	0.000
3	1.50	0.00	0.75			0.000	0.5	0.000
4	2.00	0.00	1.11	0.01	0.00	0.005	0.5	0.003
5	2.50	0.00	1.30	0.04	0.04	0.040	0.5	0.026
6	3.00	0.00	1.79	0.08	0.17	0.125	0.75	0.168
7	4.00	0.00	2.20	0.19	0.21	0.200	1	0.440
8	5.00	0.00	2.36	0.13	0.23	0.180	1	0.425
9	6.00	0.00	2.32	0.36	0.27	0.315	1	0.731
10	7.00	0.00	2.28	0.32	0.30	0.310	1	0.707
11	8.00	0.00	2.12	0.32	0.29	0.305	1	0.647
12	9.00	0.00	2.23	0.22	0.22	0.220	1	0.491
13	10.00	0.00	2.01	0.16	0.22	0.190	1	0.382
14	11.00	0.00	1.38	0.15	0.17	0.160	1	0.221
Right Bank	12.00	0.00	0.00	0.00	0.00	0.000	0.5	0.000
						Total Discharge		**4.239**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water was temperature was 9oC
3. No problem with the temporary pressure transducer - was removed and replaced with the permanent transducer
4. Downloaded the data into the computer
5. Water sample was taken for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 07 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0845 hrs.
MEASUREMENT END TIME: 0905 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.13			0.080	0.3	0.003
2	0.60	0.00	0.16			0.180	0.3	0.009
3	0.90	0.00	0.12			0.230	0.3	0.008
4	1.20	0.00	0.13			0.180	0.3	0.007
5	1.50	0.00	0.13			0.230	0.3	0.009
6	1.80	0.00	0.14			0.240	0.3	0.010
7	2.10	0.00	0.18			0.220	0.3	0.012
8	2.40	0.00	0.19			0.290	0.3	0.017
9	2.70	0.00	0.15			0.220	0.3	0.010
Right Bank	3.00	0.00	0.00			0.000	0.15	0.000
						Total Discharge		**0.084**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water sample was taken for TSS
3. Installation of a new gauging station - 75% completionby 07 May '97. The transducer was not installed inside the horizontal perforated pipe.
4. Installation of the weir was carried out - managed to complete the construction. Installation took approx. 10 hours due to high discharge
5. The pressure transducer was moved and installed temporary at a different elevation by 1200 hours on 07 May
6. The permanent transducer was installed inside the perforated horizontal pipe by 09 May '97

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 04 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/C. Proudfoot
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1205 hrs.
MEASUREMENT END TIME: 1300 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.04			0.160	0.30	0.002
2	0.60	0.00	0.04			0.150	0.30	0.002
3	0.90	0.00	0.04			0.150	0.30	0.002
4	1.20	0.00	0.08			0.320	0.30	0.008
5	1.50	0.00	0.06			0.230	0.30	0.004
6	1.80	0.00	0.08			0.140	0.30	0.003
7	2.10	0.00	0.07			0.380	0.30	0.008
8	2.40	0.00	0.05			0.160	0.30	0.002
Right Bank	2.70	0.00	0.00			0.000	0.15	0.000
						Total Discharge		**0.031**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water sample taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 03 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: C. Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1515 hrs.
MEASUREMENT END TIME: 1655 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.64			0.000	0.5	0.000
2	1.00	0.00	0.77			0.350	0.5	0.135
3	1.50	0.00	0.88	0.39	0.18	0.285	0.5	0.125
4	2.00	0.00	0.80	0.40	0.07	0.235	0.5	0.094
5	2.50	0.00	0.75			0.230	0.5	0.086
6	3.00	0.00	0.82	0.45	0.13	0.290	0.5	0.119
7	3.50	0.00	0.66			0.270	0.5	0.089
8	4.00	0.00	0.80	0.56	0.19	0.375	0.5	0.150
9	4.50	0.00	0.90	0.45	0.09	0.270	0.5	0.122
10	5.00	0.00	0.92	0.53	0.13	0.330	0.5	0.152
11	5.50	0.00	0.90	0.42	0.14	0.280	0.5	0.126
12	6.00	0.00	1.02	0.52	0.37	0.445	0.5	0.227
13	6.50	0.00	0.95	0.38	0.30	0.340	0.5	0.162
14	7.00	0.00	0.86	0.32	0.17	0.245	0.5	0.105
15	7.50	0.00	0.70			0.210	0.5	0.074
16	8.00	0.00	0.59			0.220	0.5	0.065
17	8.50	0.00	0.29			0.070	0.5	0.010
Right Bank	9.00	0.00	0.00			0.000	0.25	0.000
						Total Discharge		**1.840**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Measurement taken using wading rod
3. Water sample taken for TSS
4. Temporary transducer was able to retrieve and replaced with a permanent transducer

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 03 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: C. Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1100 hrs.
MEASUREMENT END TIME: 1208 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.36			0.110	0.30	0.012
2	0.60	0.00	0.44			0.290	0.30	0.038
3	0.90	0.00	0.48			0.420	0.30	0.060
4	1.20	0.00	0.40			0.060	0.30	0.007
5	1.50	0.00	0.43			0.020	0.30	0.003
6	1.80	0.00	0.58			0.240	0.30	0.042
7	2.10	0.00	0.51			0.560	0.30	0.086
8	2.40	0.00	0.54			0.430	0.30	0.070
9	2.70	0.00	0.45			0.210	0.30	0.028
10	3.00	0.00	0.34			0.090	0.30	0.009
11	3.30	0.00	0.26			0.280	0.30	0.022
12	3.60	0.00	0.23			0.190	0.30	0.013
13	3.90	0.00	0.16			0.190	0.30	0.009
Right Bank	4.20	0.00	0.00			0.000	0.15	0.000
						Total Discharge		**0.399**

Note: 1. Water sample taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 03 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: C.Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0922 hrs.
MEASUREMENT END TIME: 1055 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.15	0.000
1	0.30		0.15			0.150	0.30	0.007
2	0.60		0.19			0.200	0.30	0.011
3	0.90		0.24			0.270	0.30	0.019
4	1.20		0.30			0.320	0.30	0.029
5	1.50		0.36			0.330	0.30	0.036
6	1.80		0.38			0.430	0.30	0.049
7	2.10		0.41			0.490	0.30	0.060
8	2.40		0.40			0.520	0.30	0.062
9	2.70		0.35			0.400	0.30	0.042
10	3.00		0.32			0.350	0.30	0.034
11	3.30		0.30			0.230	0.30	0.021
12	3.60		0.22			0.190	0.30	0.013
13	3.90		0.22			0.100	0.30	0.007
14	4.20		0.22			0.000	0.30	0.000
15	4.50		0.12			0.000	0.25	0.000
Right Bank	4.70		0.00			0.000	0.10	0.000
						Total Discharge		**0.389**

Note: 1. Water sample was collected for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 03 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: C. Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1245 hrs.
MEASUREMENT END TIME: 1445 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	1.30	0.00	0.00	0.000	0.5	0.000
2	1.00	0.00	1.68	0.08	0.06	0.070	0.75	0.088
3	2.00	0.00	2.05	0.10	0.10	0.100	1	0.205
4	3.00	0.00	2.05	0.19	0.16	0.175	1	0.359
5	4.00	0.00	2.00	0.21	0.13	0.170	1	0.340
6	5.00	0.00	1.95	0.19	0.09	0.140	1	0.273
7	6.00	0.00	1.88	0.10	0.14	0.120	1	0.226
8	7.00	0.00	1.90	0.06	0.06	0.060	1	0.114
9	8.00	0.00	1.65	0.10	0.01	0.055	1	0.091
10	9.00	0.00	1.14	0.07	0.09	0.080	0.75	0.068
11	9.50	0.00	1.00	0.02	-0.01	0.005	0.5	0.003
12	10.00	0.00	0.80	0.02	-0.01	0.005	0.55	0.002
Right Bank	10.60	0.00	0.00	0.00	0.00	0.000	0.3	0.000
						Total Discharge		**1.768**

Note: 1. Water sample was taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 04 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/C. Proudfoot
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1400 hrs.
MEASUREMENT END TIME: 1545 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.04			0.270	0.3	0.003
2	0.60	0.00	0.09			0.500	0.3	0.014
3	0.90	0.00	0.11			0.470	0.3	0.016
4	1.20	0.00	0.10			0.370	0.3	0.011
5	1.50	0.00	0.08			0.410	0.3	0.010
6	1.80	0.00	0.06			0.250	0.3	0.005
7	2.10	0.00	0.04			0.200	0.3	0.002
8	2.40	0.00	0.05			0.260	0.3	0.004
9	2.70	0.00	0.05			0.130	0.25	0.002
Right Bank	2.90	0.00	0.00			0.000	-1.35	0.000
						Total Discharge		**0.066**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water sample was taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 23 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T Neff /K. Proudfoot
COMPUTATIONS BY: K.P.

MEASUREMENT START TIME: 11.35 hrs.
MEASUREMENT END TIME: 1.00 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.10	0.000
1	0.20	0.00	0.00			0.000	0.23	0.000
2	0.45	0.00	0.00			0.000	0.20	0.000
3	0.60	0.00	0.10			0.200	0.15	0.003
4	0.75	0.00	0.10			0.250	0.15	0.004
5	0.90	0.00	0.13			0.230	0.15	0.004
6	1.05	0.00	0.14			0.270	0.15	0.006
7	1.20	0.00	0.24			0.330	0.15	0.012
8	1.35	0.00	0.16			0.220	0.15	0.005
9	1.50	0.00	0.11			0.050	0.15	0.001
10	1.65	0.00	0.105			0.010	0.13	0.000
11	1.75	0.00	0.08			0.020	0.13	0.000
12	1.9	0.00	0.07			0.020	0.18	0.000
13	2.1	0.00	0.05			0.000	0.20	0.000
14	2.3	0.00	0.04			0.000	0.10	0.000
Right Bank	2.3	0.00	0.04			0.000	0.00	0.000
						Total Discharge		**0.035**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Water sample taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 21 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. Proudfoot/T.Neff
COMPUTATIONS BY: KP

MEASUREMENT START TIME: 1:25 hrs.
MEASUREMENT END TIME: 2:35 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	1.00	0.00	0.00			0.000	0.55	0.000
1	1.10	0.00	0.10			0.030	0.275	0.001
2	1.55	0.00	0.38			0.000	0.45	0.000
3	2.00	0.00	0.60			0.170	0.425	0.043
4	2.40	0.00	0.67			0.180	0.425	0.051
5	2.85	0.00	0.80	0.27	0.18	0.225	0.45	0.081
6	3.30	0.00	0.90	0.35	0.23	0.290	0.45	0.117
7	3.75	0.00	0.96	0.49	0.22	0.355	0.45	0.153
8	4.20	0.00	0.96	0.49	0.32	0.405	0.45	0.175
9	4.65	0.00	0.80	0.44	0.17	0.305	0.45	0.110
10	5.10	0.00	0.81	0.39	0.17	0.280	0.45	0.102
11	5.55	0.00	0.76	0.47	0.09	0.280	0.45	0.096
12	6.00	0.00	0.74			0.230	0.45	0.077
13	6.45	0.00	0.66			0.210	0.45	0.062
14	6.90	0.00	0.74			0.250	0.45	0.083
15	7.35	0.00	0.74			0.180	0.45	0.060
16	7.80	0.00	0.80	0.31	0.07	0.190	0.45	0.068
17	8.25	0.00	0.86	0.42	0.02	0.220	0.45	0.085
18	8.70	0.00	0.78	0.40	0.05	0.225	0.45	0.079
19	9.15	0.00	0.58			0.200	0.45	0.052
20	9.60	0.00	0.48			0.130	0.45	0.028
21	10.05	0.00	0.09			0.040	0.225	0.001
Right Bank	10.05	0.00	0.09			0.040	0.225	0.001
						Total Discharge		**1.527**

Note: 1. Water sample taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 21June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. Proudfoot/ T. Neff
COMPUTATIONS BY: K.P.

MEASUREMENT START TIME: 1140 hrs.
MEASUREMENT END TIME: 1240 hrs.

STATION	DISTANCE FROM LEFT BANK	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	14	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.00	0.000
1	0.00	0.00	0.50			0.000	0.15	0.000
2	0.30	0.00	0.54			0.300	0.28	0.045
3	0.55	0.00	0.58			0.340	0.20	0.039
4	0.70	0.00	0.62			0.280	0.15	0.026
5	0.85	0.00	0.62			0.230	0.15	0.021
6	1.00	0.00	0.59			0.150	0.15	0.013
7	1.15	0.00	0.61			0.240	0.15	0.022
8	1.30	0.00	0.57			0.180	0.15	0.015
9	1.45	0.00	0.50			0.270	0.15	0.020
10	1.60	0.00	0.49			0.200	0.15	0.015
11	1.75	0.00	0.47			0.230	0.15	0.016
12	1.90	0.00	0.47			0.250	0.15	0.018
13	2.05	0.00	0.47			0.170	0.15	0.012
14	2.20	0.00	0.41			0.180	0.15	0.011
15	2.35	0.00	0.37			0.100	0.15	0.006
16	2.50	0.00	0.32			0.060	0.28	0.005
17	2.90	0.00	0.25			0.070	0.20	0.004
Right Bank	2.90	0.00	0.25			0.070	0.00	0.000
						Total Discharge		**0.204**

Note: 1. Water sample taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 21 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K.Proudfoot/T. Neff
COMPUTATIONS BY: K.P.

MEASUREMENT START TIME: 10:00 hrs.
MEASUREMENT END TIME: 11:15 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.20		0.00			0.000	0.50	0.000
1	1.00		0.16			0.010	0.90	0.001
2	2.00		0.26			-0.010	0.65	-0.002
3	2.30		0.35			0.080	0.23	0.006
4	2.45		0.35			0.140	0.15	0.007
5	2.60		0.32			0.210	0.15	0.010
6	2.75		0.30			0.350	0.15	0.016
7	2.90		0.36			0.460	0.15	0.025
8	3.05		0.37			0.570	0.15	0.032
9	3.20		0.39			0.590	0.15	0.035
10	3.35		0.38			0.560	0.15	0.032
11	3.50		0.37			0.600	0.15	0.033
12	3.65		0.37			0.630	0.15	0.035
13	3.80		0.35			0.550	0.15	0.029
14	3.95		0.32			0.290	0.13	0.012
15	4.05		0.32			0.170	0.13	0.007
16	4.20		0.21			0.000	0.20	0.000
17	4.45		0.00			0.000	0.13	0.000
Right Bank	4.45		0.00			0.000	0.00	0.000
						Total Discharge		**0.276**

Note: 1. Water sample was collected for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 23 June 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Neff K. Proudfoot
COMPUTATIONS BY: TN KP

MEASUREMENT START TIME: 10:15 hrs
MEASUREMENT END TIME: 11:15 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.140	0.000
1	0.28	0.00	0.00			0.000	0.235	0.000
2	0.47	0.00	0.05			0.900	0.185	0.008
3	0.65	0.00	0.07			0.170	0.165	0.002
4	0.80	0.00	0.09			0.130	0.150	0.002
5	0.95	0.00	0.10			0.120	0.150	0.002
6	1.10	0.00	0.11			0.160	0.150	0.003
7	1.25	0.00	0.12			0.230	0.150	0.004
8	1.40	0.00	0.13			0.350	0.150	0.007
9	1.55	0.00	0.13			0.370	0.150	0.007
10	1.70	0.00	0.14			0.360	0.150	0.008
11	1.85	0.00	0.12			0.390	0.150	0.007
12	2.00	0.00	0.08			0.250	0.150	0.003
13	2.15	0.00	0.08			0.230	0.150	0.003
14	2.30	0.00	0.08			0.270	0.150	0.003
15	2.45	0.00	0.08			0.200	0.150	0.002
16	2.60	0.00	0.07			0.130	0.150	0.001
17	2.75	0.00	0.06			0.010	0.150	0.000
18	2.90	0.00	0.05			0.020	0.250	0.000
19	3.25	0.00	0.00			0.000	0.000	0.000
Right Bank	3.25	0.00	0.00			0.000	0.000	0.000
						Total Discharge		**0.062**

›1. Water san mple taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 22 July 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/K. Proudfoot
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1125 hrs.
MEASUREMENT END TIME: 1215 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.10	0.000
1	0.20	0.00	0.04			0.020	0.20	0.000
2	0.40	0.00	0.04			0.000	0.20	0.000
3	0.60	0.00	0.03			0.010	0.20	0.000
4	0.80	0.00	0.04			-0.010	0.20	0.000
5	1.00	0.00	0.05			0.060	0.20	0.001
6	1.20	0.00	0.07			0.070	0.20	0.001
7	1.40	0.00	0.08			0.150	0.20	0.002
8	1.60	0.00	0.08			0.100	0.20	0.002
9	1.80	0.00	0.10			0.140	0.20	0.003
10	2.00	0.00	0.10			0.270	0.20	0.005
11	2.20	0.00	0.06			0.130	0.20	0.002
12	2.40	0.00	0.02			0.030	0.20	0.000
Right Bank	2.60	0.00	0.00			0.000	0.10	0.000
						Total Discharge		**0.016**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water sample taken for TSS
3. Staff gauge was installed and surveyed

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 23 July 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1200 hrs.
MEASUREMENT END TIME: 1300 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.38			-0.020	0.5	-0.004
2	1.00	0.00	0.46			0.070	0.5	0.016
3	1.50	0.00	0.69			0.120	0.5	0.041
4	2.00	0.00	0.58			0.260	0.5	0.075
5	2.50	0.00	0.48			0.200	0.5	0.048
6	3.00	0.00	0.48			0.130	0.5	0.031
7	3.50	0.00	0.46			0.240	0.5	0.055
8	4.00	0.00	0.50			0.100	0.5	0.025
9	4.50	0.00	0.69			0.260	0.5	0.090
10	5.00	0.00	0.67			0.170	0.5	0.057
11	5.50	0.00	0.72			0.210	0.5	0.076
12	6.00	0.00	0.92	0.15	0.13	0.140	0.5	0.064
13	6.50	0.00	1.20	0.12	0.28	0.200	0.5	0.120
14	7.00	0.00	0.82	0.11	0.34	0.225	0.5	0.092
15	7.50	0.00	0.58			0.200	0.5	0.058
16	8.00	0.00	0.46			0.200	0.5	0.046
17	8.50	0.00	0.22			0.000	0.35	0.000
Right Bank	8.70	0.00	0.00			0.000	0.1	0.000
							Total Discharge	**0.891**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Measurement taken using wading rod
3. Water sample taken for TSS
4. Staff gauge was installed and surveyed

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 23 July 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1330 hrs.
MEASUREMENT END TIME: 1410 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.41			0.070	0.30	0.009
2	0.60	0.00	0.42			-0.060	0.30	-0.008
3	0.90	0.00	0.55			0.290	0.30	0.048
4	1.20	0.00	0.58			0.110	0.30	0.019
5	1.50	0.00	0.60			0.080	0.30	0.014
6	1.80	0.00	0.62			0.180	0.30	0.033
7	2.10	0.00	0.62			0.270	0.30	0.050
8	2.40	0.00	0.54			0.500	0.30	0.081
9	2.70	0.00	0.50			0.390	0.30	0.059
10	3.00	0.00	0.39			0.230	0.30	0.027
11	3.30	0.00	0.24			0.170	0.30	0.012
12	3.60	0.00	0.20			0.200	0.30	0.012
13	3.90	0.00	0.06			0.030	0.25	0.000
Right Bank	4.10	0.00	0.00			0.000	0.10	0.000
						Total Discharge		**0.357**

Note: 1. Water sample taken for TSS
2. Staff gauge was installed and surveyed

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 23 July 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K.Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1420 hrs.
MEASUREMENT END TIME: 1500 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.15	0.000
1	0.30		0.09			0.140	0.30	0.004
2	0.60		0.12			0.320	0.30	0.012
3	0.90		0.15			0.380	0.30	0.017
4	1.20		0.14			0.440	0.30	0.018
5	1.50		0.16			0.440	0.30	0.021
6	1.80		0.18			0.420	0.30	0.023
7	2.10		0.18			0.320	0.30	0.017
8	2.40		0.22			0.270	0.30	0.018
9	2.70		0.16			0.330	0.30	0.016
10	3.00		0.14			0.330	0.30	0.014
11	3.30		0.11			0.290	0.38	0.012
Right Bank	3.75		0.00			0.000	0.23	0.000
						Total Discharge		**0.171**

Note: 1. Water sample was collected for TSS
2. Staff gauge was installed and surveyed

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 23 July 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0915 hrs.
MEASUREMENT END TIME: 1115 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.40	0.00	0.00	0.000	0.5	0.000
2	1.00	0.00	1.00	0.01	0.01	0.010	0.5	0.005
3	1.50	0.00	1.25	0.07	0.03	0.050	0.5	0.031
4	2.00	0.00	1.51	0.04	0.02	0.030	0.5	0.023
5	2.50	0.00	1.68	0.01	0.03	0.020	0.5	0.017
6	3.00	0.00	1.84	0.08	0.02	0.050	0.5	0.046
7	3.50	0.00	1.90	0.07	0.04	0.055	0.5	0.052
8	4.00	0.00	1.90	0.11	0.09	0.100	0.5	0.095
9	4.50	0.00	1.87	0.10	0.10	0.100	0.5	0.094
10	5.00	0.00	1.90	0.09	0.10	0.095	0.5	0.090
11	5.50	0.00	1.95	0.09	0.10	0.095	0.5	0.093
12	6.00	0.00	1.97	0.10	0.09	0.095	0.5	0.094
13	6.50	0.00	2.00	0.04	0.11	0.075	0.5	0.075
14	7.00	0.00	2.00	0.07	0.12	0.095	0.5	0.095
15	7.50	0.00	2.10	0.09	0.11	0.100	0.5	0.105
16	8.00	0.00	2.00	0.07	0.12	0.095	0.5	0.095
17	8.50	0.00	1.97	0.04	0.07	0.055	0.5	0.054
18	9.00	0.00	1.83	0.07	0.06	0.065	0.5	0.059
19	9.50	0.00	1.50	0.03	0.04	0.035	0.5	0.026
20	10.00	0.00	1.34	-0.01	-0.01	-0.010	0.45	-0.006
Right Bank	10.40	0.00	0.00	0.00	0.00	0.000	0.2	0.000
						Total Discharge		**1.143**

Note: 1. Water sample was taken for TSS
2. Staff gauge was installed and surveyed

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 22 July 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/K. Proudfoot
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0920 hrs.
MEASUREMENT END TIME: 1107 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.04			-0.020	0.3	0.000
2	0.60	0.00	0.06			-0.020	0.3	0.000
3	0.90	0.00	0.06			0.120	0.3	0.002
4	1.20	0.00	0.10			0.180	0.3	0.005
5	1.50	0.00	0.13			0.370	0.3	0.014
6	1.80	0.00	0.11			0.350	0.3	0.012
7	2.10	0.00	0.10			0.320	0.3	0.010
8	2.40	0.00	0.07			0.010	0.3	0.000
9	2.70	0.00	0.06			0.150	0.3	0.003
10	3.00	0.00	0.04			0.120	0.35	0.002
Right Bank	3.40	0.00	0.00			0.000	0.2	0.000
						Total Discharge		**0.047**

Note: 1. Weir was repaired from 0955 hrs. to 1055 hrs.
2. Water sample was taken for TSS
3. Installed staff gauge near transducer at 1055 hrs. and surveyed.

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 19 August 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: R.M /K. Proudfoot
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 11:15 hrs.
MEASUREMENT END TIME: 11:50 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.10	0.000
1	0.20		0.04			0.090	0.20	0.001
2	0.40		0.04			0.210	0.20	0.002
3	0.60		0.02			0.170	0.20	0.001
4	0.80		0.02			0.000	0.20	0.000
5	1.00		0.02			0.150	0.20	0.001
6	1.20		0.04			0.170	0.20	0.001
7	1.40		0.04			0.160	0.80	0.005
8	1.60		0.05			0.080	0.80	0.003
9	1.80		0.05			0.360	0.20	0.004
10	2.00		0.05			0.360	0.20	0.004
11	2.20		0.08			0.440	0.20	0.007
12	2.40		0.07			0.370	0.20	0.005
13	2.60		0.06			0.170	0.80	0.008
14	2.80		0.05			0.240	0.80	0.010
15	3.00		0.06			0.310	0.20	0.004
16	3.20		0.06			0.200	0.20	0.002
17	3.40		0.06			0.050	0.20	0.001
18	3.60		0.05			0.180	0.20	0.002
Right Bank	3.80		0.00			0.000	0.10	0.000
						Total Discharge		**0.059**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water sample taken for TSS
3. W.L. 0.45 m

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 20 August 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. Proudfoot/R.M.
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1035 hrs.
MEASUREMENT END TIME: 1150 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.79	0.36	0.02	0.190	0.5	0.075
2	1.00	0.00	0.90	0.25	0.39	0.320	0.5	0.144
3	1.50	0.00	1.30	0.53	0.29	0.410	0.5	0.267
4	2.00	0.00	1.25	0.59	0.17	0.380	0.5	0.238
5	2.50	0.00	1.04	0.62	0.10	0.360	0.5	0.187
6	3.00	0.00	1.02	0.69	0.13	0.410	0.5	0.209
7	3.50	0.00	0.96	0.59	0.14	0.365	0.5	0.175
8	4.00	0.00	0.98	0.64	0.14	0.390	0.5	0.191
9	4.50	0.00	1.02	0.54	0.10	0.320	0.5	0.163
10	5.00	0.00	1.04	0.55	0.33	0.440	0.5	0.229
11	5.50	0.00	1.02	0.56	0.16	0.360	0.5	0.184
12	6.00	0.00	1.07	0.55	0.44	0.495	0.5	0.265
13	6.50	0.00	1.02	0.32	0.45	0.385	0.5	0.196
14	7.00	0.00	0.96	0.20	0.33	0.265	0.5	0.127
15	7.50	0.00	1.00	0.24	0.14	0.190	0.5	0.095
16	8.00	0.00	0.92	0.17	0.11	0.140	0.5	0.064
17	8.50	0.00	0.75			0.080	0.5	0.030
18	9.00	0.00	0.35			0.000	0.45	0.000
Right Bank	9.40	0.00	0.00			0.000	0.2	0.000
							Total Discharge	**2.839**

Note: 1. Velocity at 0.6 Depth was computed as (V0.2+V0.8)/2
2. Water Level @ 0.542 m
3. Water sample taken for TSS

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 20 August 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. ProudfootR.M.
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0950 hrs.
MEASUREMENT END TIME: 1025 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.24			-0.100	0.30	-0.007
2	0.60	0.00	0.40			-0.020	0.30	-0.002
3	0.90	0.00	0.56			0.260	0.30	0.044
4	1.20	0.00	0.69			0.420	0.30	0.087
5	1.50	0.00	0.72			0.680	0.30	0.147
6	1.80	0.00	0.75			0.880	0.30	0.198
7	2.10	0.00	0.92	0.96	0.40	0.680	0.30	0.188
8	2.40	0.00	0.94	0.96	0.04	0.500	0.30	0.141
9	2.70	0.00	0.94	0.88	0.09	0.485	0.30	0.137
10	3.00	0.00	0.84	1.09	0.26	0.675	0.30	0.170
11	3.30	0.00	0.84	0.26	0.24	0.250	0.30	0.063
12	3.60	0.00	0.76			0.600	0.30	0.137
13	3.90	0.00	0.67			-0.040	0.30	-0.008
14	4.20	0.00	0.62			0.250	0.30	0.047
15	4.50	0.00	0.18			-0.060	0.35	-0.004
Right Bank	4.90	0.00	0.00			0.000	0.20	0.000
						Total Discharge		**1.336**

Note: 1. Water sample taken for TSS
2. Staff gauge was installed and surveyed

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 20 August 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K.Proudfoot/R.M
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0900 hrs.
MEASUREMENT END TIME: 0930 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00			0.000	0.15	0.000
1	0.30		0.32			-0.010	0.30	-0.001
2	0.60		0.41			0.060	0.30	0.007
3	0.90		0.45			0.350	0.30	0.047
4	1.20		0.50			0.440	0.30	0.066
5	1.50		0.55			0.530	0.30	0.087
6	1.80		0.64			0.580	0.30	0.111
7	2.10		0.73			0.580	0.30	0.127
8	2.40		0.76			0.620	0.30	0.141
9	2.70		0.74			0.550	0.30	0.122
10	3.00		0.68			0.600	0.30	0.122
11	3.30		0.68			0.670	0.30	0.137
12	3.60		0.60			0.580	0.30	0.104
13	3.90		0.46			0.350	0.30	0.048
14	4.20		0.05			0.030	0.28	0.000
Right Bank	4.45		0.00			0.000	0.13	0.000
						Total Discharge		**1.121**

Note: 1. Water sample was collected for TSS
2. Staff gauge was installed and surveyed
3. W.L. 0.67 m @ 9:30

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 20 August 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: K. Proudfoot/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0915 hrs.
MEASUREMENT END TIME: 1115 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.4	0.000
1	0.80	0.00	0.22			-0.030	0.8	-0.005
2	1.60	0.00	0.34			-0.040	0.8	-0.011
3	2.40	0.00	0.49			-0.030	0.8	-0.012
4	3.20	0.00	1.24	-0.03	-0.02	-0.025	0.8	-0.025
5	4.00	0.00	1.25	0.09	-0.05	0.020	0.8	0.020
6	4.80	0.00	0.12	0.17	0.19	0.180	0.8	0.017
7	5.60	0.00	2.58	0.20		0.310	0.8	0.640
8	6.40	0.00	2.75	0.13		0.360	0.8	0.792
9	7.20	0.00	2.70	0.25		0.350	0.8	0.756
10	8.00	0.00	2.70	0.32		0.290	0.8	0.626
11	8.80	0.00	2.70	0.31		0.300	0.8	0.648
12	9.60	0.00	2.51	0.33		0.400	0.8	0.803
13	10.40	0.00	2.54	0.30		0.380	0.8	0.772
14	11.20	0.00	2.55	0.19		0.320	0.8	0.653
15	12.00	0.00	2.10	0.19		0.070	0.8	0.118
16	12.80	0.00	2.08	0.19		0.070	0.8	0.116
17	13.60	0.00	1.70	0.07		0.020	1.1	0.037
Right Bank	15.00	0.00	0.00	0.00		0.000	0.7	0.000
						Total Discharge		**5.946**

Note: 1. Water sample was taken for TSS
2. Water Level @ 0.25 m Above Meter Stick

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE:19 August 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: R.M./K. Proudfoot
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0950 hrs.
MEASUREMENT END TIME: 1050 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.1	0.000
1	0.20	0.00	0.04			-0.010	0.2	0.000
2	0.40	0.00	0.07			0.010	0.2	0.000
3	0.60	0.00	0.06			0.000	0.2	0.000
4	0.80	0.00	0.07			0.080	0.2	0.001
5	1.00	0.00	0.09			0.290	0.2	0.005
6	1.20	0.00	0.08			0.440	0.2	0.007
7	1.40	0.00	0.08			0.430	0.2	0.007
8	1.60	0.00	0.05			0.350	0.2	0.004
9	1.80	0.00	0.05			0.380	0.2	0.004
10	2.00	0.00	0.06			0.350	0.2	0.004
11	2.20	0.00	0.09			0.300	0.2	0.005
12	2.40	0.00	0.12			0.350	0.2	0.008
13	2.60	0.00	0.16			0.330	0.2	0.011
14	2.80	0.00	0.16			0.060	0.2	0.002
15	3.00	0.00	0.19			0.140	0.2	0.005
16	3.20	0.00	0.18			0.190	0.2	0.007
17	3.40	0.00	0.18			0.010	0.2	0.000
18	3.60	0.00	0.60			-0.030	0.2	-0.004
Right Bank	3.80	0.00	0.00			0.000	0.1	0.000
						Total Discharge		**0.067**

Note: 1. Water sample was taken for TSS
2. Water Level at 0.24 m (10:35)

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: September 23 1997
METER NUMBER: Flow mate 2000

MEASUREMENT BY: KP/LB
COMPUTATIONS BY: SG

MEASUREMENT START TIME: 12:00 noon
MEASUREMENT END TIME: 12:40 pm

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
Left Bank	0.00		0.00				0.20	0.000
1	0.40		0.04			0.021	0.40	0.000
2	0.80		0.02			0.122	0.40	0.001
3	1.20		0.05			0.168	0.40	0.003
4	1.60		0.04			0.174	0.40	0.003
5	2.00		0.05			0.256	0.40	0.005
6	2.40		0.05			0.277	0.40	0.006
7	2.80		0.12			0.265	0.40	0.013
8	3.20		0.17			0.035	0.40	0.002
9	3.60		0.17			0.518	0.40	0.035
10	4.00		0.15			0.265	0.40	0.016
11	4.40		0.16			0.567	0.40	0.036
12	4.80		0.12			0.622	0.40	0.030
13	5.20		0.07			0.594	0.40	0.017
14	5.60		0.07			0.070	0.40	0.002
15	6.00		0.08			0.363	0.40	0.012
16	6.40		0.06			0.244	0.30	0.004
Right Bank	6.60		0.00			0.000	0.10	0.000
						Total Discharge		**0.185**

Note:
Meter calibrated in ft/s
Water Sample taken for TSS @ 12:35
WL n/a : staff gauge washed out in flood

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: Oct 3 1997
METER NUMBER: Flowmate 2000

MEASUREMENT BY: KP/LB
COMPUTATIONS BY: SG

MEASUREMENT START TIME: 9:40 AM
MEASUREMENT END TIME: 10:20 AM

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LB	0.00						0.10	0.000
1	0.20		0.08			-0.010	0.20	0.000
2	0.40		0.30			-0.020	0.20	-0.001
3	0.60		0.40			0.020	0.20	0.002
4	0.80		0.47			0.280	0.20	0.026
5	1.00		0.48			0.490	0.20	0.047
6	1.20		0.55			0.410	0.20	0.045
7	1.40		0.62			0.550	0.20	0.068
8	1.60		0.65			0.800	0.20	0.104
9	1.80		0.70			0.790	0.20	0.111
10	2.00		0.75			0.900	0.20	0.135
11	2.20		0.78	0.93	0.32	0.625	0.20	0.098
12	2.40		0.84	1.10	0.17	0.635	0.20	0.107
13	2.60		0.80	0.90	0.13	0.515	0.20	0.082
14	2.80		0.75			0.160	0.20	0.024
15	3.00		0.74			0.160	0.20	0.024
16	3.20		0.70			0.260	0.20	0.036
17	3.40		0.66			0.130	0.20	0.017
18	3.60		0.62			0.100	0.20	0.012
19	3.80		0.56			0.150	0.20	0.017
20	4.00		0.47			0.190	0.20	0.018
21	4.20		0.45			0.370	0.20	0.033
22	4.40		0.44			0.480	0.20	0.042
23	4.60		0.40			0.040	0.18	0.003
RB	4.75		0.00			0.000	0.07	0.000
						Total Discharge		**1.050**

Note:
Water sample taken for TSS @ 10:07
WL @ 31.3 cm @ 10:05

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: OCT 3 1997
METER NUMBER: FLOWMATE 2000

MEASUREMENT BY: KP/LB
COMPUTATIONS BY: SG

MEASUREMENT START TIME: 8:35
MEASUREMENT END TIME: 9:30

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LB	0.00						0.10	0.000
1	0.20		0.35			0.020	0.20	0.001
2	0.40		0.42			0.230	0.20	0.019
3	0.60		0.48			0.210	0.20	0.020
4	0.80		0.50			0.280	0.20	0.028
5	1.00		0.52			0.350	0.20	0.036
6	1.20		0.56			0.400	0.20	0.045
7	1.40		0.61			0.440	0.20	0.054
8	1.60		0.64			0.460	0.20	0.059
9	1.80		0.66			0.550	0.20	0.073
10	2.00		0.66			0.460	0.20	0.061
11	2.20		0.66			0.460	0.20	0.061
12	2.40		0.66			0.410	0.20	0.054
13	2.60		0.62			0.310	0.20	0.038
14	2.80		0.58			0.490	0.20	0.057
15	3.00		0.58			0.410	0.20	0.048
16	3.20		0.61			0.360	0.20	0.044
17	3.40		0.62			0.280	0.20	0.035
18	3.60		0.36			0.070	0.20	0.005
RB	3.80		0.00			0.000	0.10	0.000
						Total Discharge		**0.737**

Note:
Water sample taken for TSS @ 9:12 am
WL 0.62 @ 9:10

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: OCT 3 1997
METER NUMBER: FLOWMATE 2000

MEASUREMENT BY: KP/LB
COMPUTATIONS BY: SG

MEASUREMENT START TIME: 11:10 AM
MEASUREMENT END TIME: 13:25

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LB	0							
1	1.00		0.21			-0.010	1	-0.002
2	2.00		0.41			-0.010	1	-0.004
3	3.00		0.51			0.010	1	0.005
4	4.00		1.26	0.01	0.01	0.010	1	0.013
5	5.00		1.90	0.22	0.05	0.135	1	0.257
6	6.00		2.36	0.22	0.20	0.210	1	0.496
7	7.00		2.75			0.200	1	0.550
8	8.00		2.72			0.350	1	0.952
9	9.00		2.74			0.430	1	1.178
10	10.00		2.78			0.340	1	0.945
11	11.00		2.73			0.250	1	0.683
12	12.00		2.75			0.320	1	0.880
13	13.00		2.12			0.260	1	0.551
14	14.00		1.86	0.06	0.09	0.075	1	0.140
15	15.00		0.93	0.08	0.04	0.060	1	0.056
16	16.00		0.22			-0.010	1	-0.002
RB	17.00		0.00			0.000	0.5	0.000
						Total Discharge		**6.696**

Note: 1. Water sample was taken for TSS at 13:06
WL 31 cm above staff gauge @ 13.14 99.459

PROJECT NAME: Syncrude/Summer Flow/Ft. McMurray
PROJECT NO.: 972-2609-1000
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: September 23 1997
METER NUMBER: Flow mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME: 9:45 am
MEASUREMENT END TIME: 11:40 am.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LB	0.00						0.025	0.000
1	0.05		0.06			0.012	0.1	0.000
2	0.20		0.12			0.076	0.15	0.001
3	0.35		0.11			0.457	0.15	0.008
4	0.50		0.12			0.488	0.15	0.009
5	0.65		0.14			0.579	0.15	0.012
6	0.80		0.14			0.789	0.175	0.019
7	1.00		0.15			0.622	0.175	0.016
8	1.15		0.14			0.619	0.15	0.013
9	1.30		0.15			0.485	0.15	0.011
10	1.45		0.13			0.082	0.15	0.002
11	1.60		0.13			0.003	0.15	0.000
12	1.75		0.13			0.168	0.15	0.003
13	1.90		0.13			0.210	0.15	0.004
14	2.05		0.14			0.268	0.15	0.006
15	2.20		0.13			0.204	0.15	0.004
RB	2.35		0.00			0.000	0.15	0.000
						Total Discharge		**0.108**

Note:
Meter is calibrated in ft/s
Water Sample Taken for TSS @ 11:33 AM
wLL 22oC at 10:00 am