HYDRO
THE POWER OF
COMMITMENT

THE Lower Churchill PROJECT

January 2008

MF1130 - River Operation During Construction and Impounding

prepared by

HATCH™

in association with

RSW inc.
Statnett
TGS TransGrid Solutions

PROVINCE OF NEWFOUNDLAND AND LABRADOR
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This Permit Allows
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DATE
NEWFOUNDLAND & LABRADOR

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Executive Summary

Newfoundland and Labrador Hydro (Hydro) is undertaking preliminary engineering studies of the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. As part of these feasibility studies, Hatch has carried out several analyses related to river operation during construction and impounding. The principal objectives of this study were to determine the routing effect of the discharge facilities under flood conditions, analyse the average water levels expected during construction of the spillway, and determine reservoir impoundment times.

The current reservoir filling scheme for Muskrat Falls involves no cessation of flow since the strategy is to have spillway capacity available during reservoir impoundment. Therefore, dewatering of the downstream reach and potential salt water intrusion during reservoir filling are not expected to have the same level of concern as noted for the Gull Island development. It is recommended that these concerns be reviewed in light of any changes in the reservoir filling scheme.

The attenuating effect of the reservoir during construction was investigated. In each of the three flood scenarios considered (1999 historic peak, 1/20 Annual Exceedence Probability (AEP) Construction Design Flood, and 1/40 AEP Construction Design Flood), the peak water level was lesser than the current upstream cofferdam design elevation. These results indicate that should similar flow conditions be encountered during construction, the proposed cofferdam at elevation 25 m should be adequate.

The number of days required to fill the reservoir was calculated for each month assuming a compensation flow of 0% and 30% of the mean annual flow. The range in total reservoir filling times was determined to be between 7 days (May) and 19 days (September).

1. Introduction

Newfoundland and Labrador Hydro (Hydro) is undertaking preliminary engineering studies of the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. These sites are located downstream 225 km and 285 km respectively from the Upper Churchill hydroelectric facility that was developed in the early 1970's. The total potential capacity at the two sites is approximately 2800 megawatts (MW), the Gull Island site being the larger at 2000 MW. In addition to the development of these sites, the overall concept includes various potential alternative power transmission arrangements involving combinations of AC and DC lines of various capacities.

In April, 2007, Hydro contracted Hatch Ltd of St. John's to undertake a program of studies to address aspects of this development relating primarily, but not exclusively, to hydrology/hydraulics and transmission components. Approximately thirty such studies have been carried out by Hatch and its associated subconsultants- RSW of Montreal, Statnett of Oslo, and Transgrid of Winnipeg. The program has been managed from Hatch's office in St. John's using the company's project management tools and a project services team that has liaised throughout with a similar group in Hydro.

The current reservoir filling scheme for Muskrat Falls involves no cessation of flow since the strategy is to have spillway capacity available during reservoir impoundment. Therefore dewatering of the downstream reach and potential salt water intrusion during reservoir filling are not expected to have the same level of concern as noted for the Gull Island development.

In the current study, the Acres Reservoir Simulation Package (ARSP) was used to determine the routing effect of the diversion facilities under flood conditions, as described in Section 2. Section 3 provides a summary of the time required for reservoir impoundment.

2. Routing Effect and Discharge Capacity of Diversion Facilities

The discharge capacity of the diversion facilities and storage curve for the Muskrat Falls reservoir have been provided by Hydro, as presented in Appendix A. It is proposed that diversion flows will be controlled by the sluiceway and have a total discharge capacity of 5,300 m^3/s at elevation 21.7 m. The objective of this analysis is to determine the routing effect of the discharge facilities, taking into account the attenuating effect of the local storage behind the upstream cofferdam and the capacity of the diversion facilities. This analysis was completed using Acres Reservoir Simulation Package (ARSP), an in-house reservoir routing software package.

For this analysis, three 31-day inflow hydrographs were developed for the following scenarios.

- 1999 Historic Peak Inflow Hydrograph.
- 1/20 AEP Construction Design Flood (CDF) Inflow Hydrograph.
- 1/40 AEP CDF Inflow Hydrograph.

Historic data for 1999 were chosen for the analysis, since this year has the highest daily flow in the study period of record (since 1978). A daily flow of 6,220 m^3/s was measured at the Muskrat Falls hydrometric station (03OE001) on May 12, 1999. Another reason for reviewing the routing effect using this year is that the peak is greater than the current diversion capacity.

For the proposed 1/20 and 1/40 AEP CDFs, the flood peaks based on the "PMF and Construction Design Flood Study" WTO (GI1140) are 5,930 m^3/s and 6,500 m^3/s, respectively. The historic flood hydrograph for 1998 (peak occurred May 16, 1998) was used to develop the CDF hydrographs, since this flood had the highest 31-day volume on record and would therefore provide the most conservative peak elevations during routing. The results of the simulation for each scenario listed above are provided in Figures 2.1 to 2.3.

As can be seen in these figures, for all scenarios, the current cofferdam design elevation of 25 m would not be exceeded. A summary of the results follows.

- Peak Elevation 1999 Flows 22.8 m
- Peak Elevation 1/20 AEP CDF Flows 22.7 m
- Peak Elevation 1/40 AEP CDF Flows 23.8 m

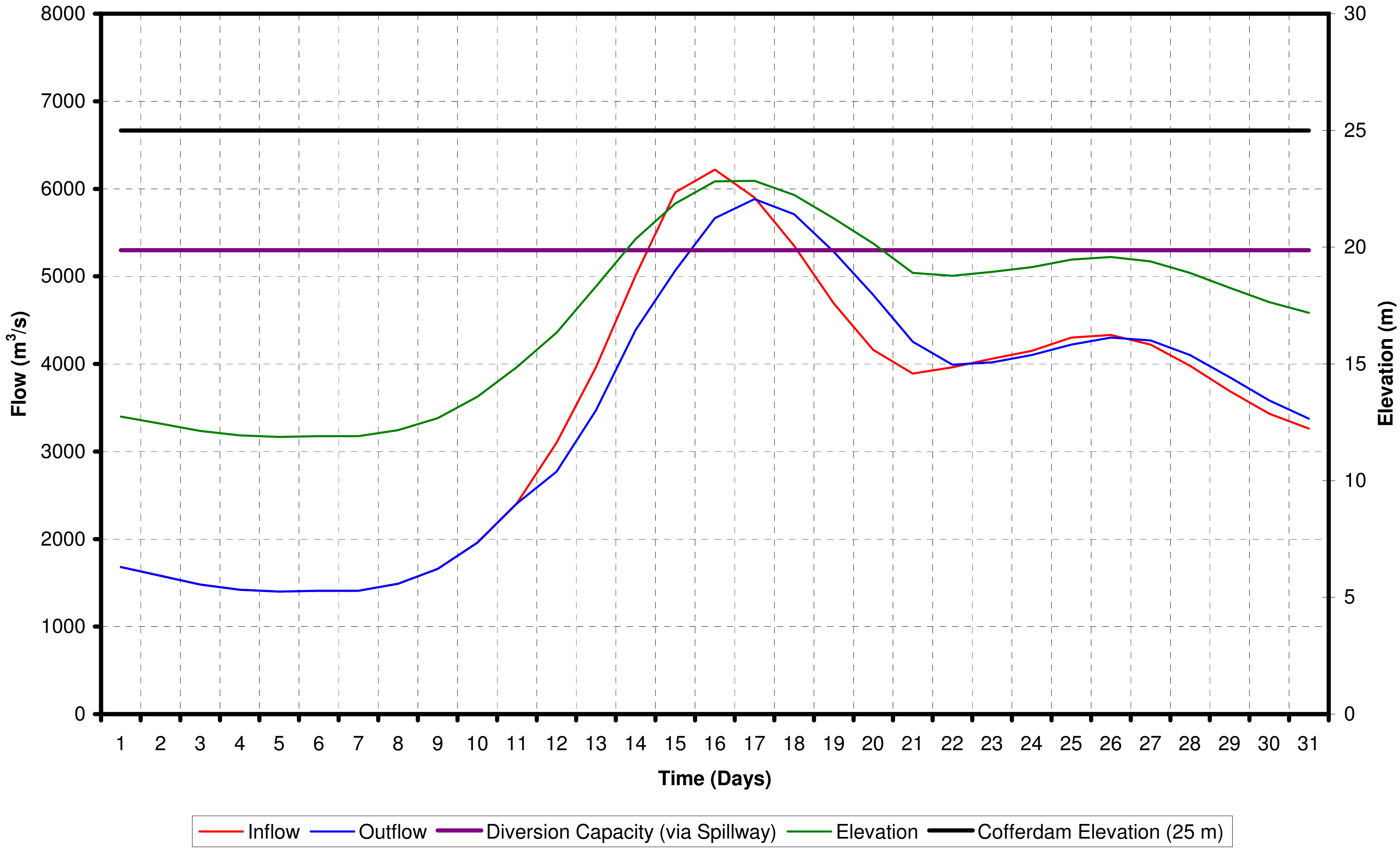

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Figure 2.1
Muskrat Falls Diversion Routing - 1999 Flood
River Operation during Construction & Impounding (Muskrat Falls)
Newfoundland and Labrador Hydro - Lower Churchill Project

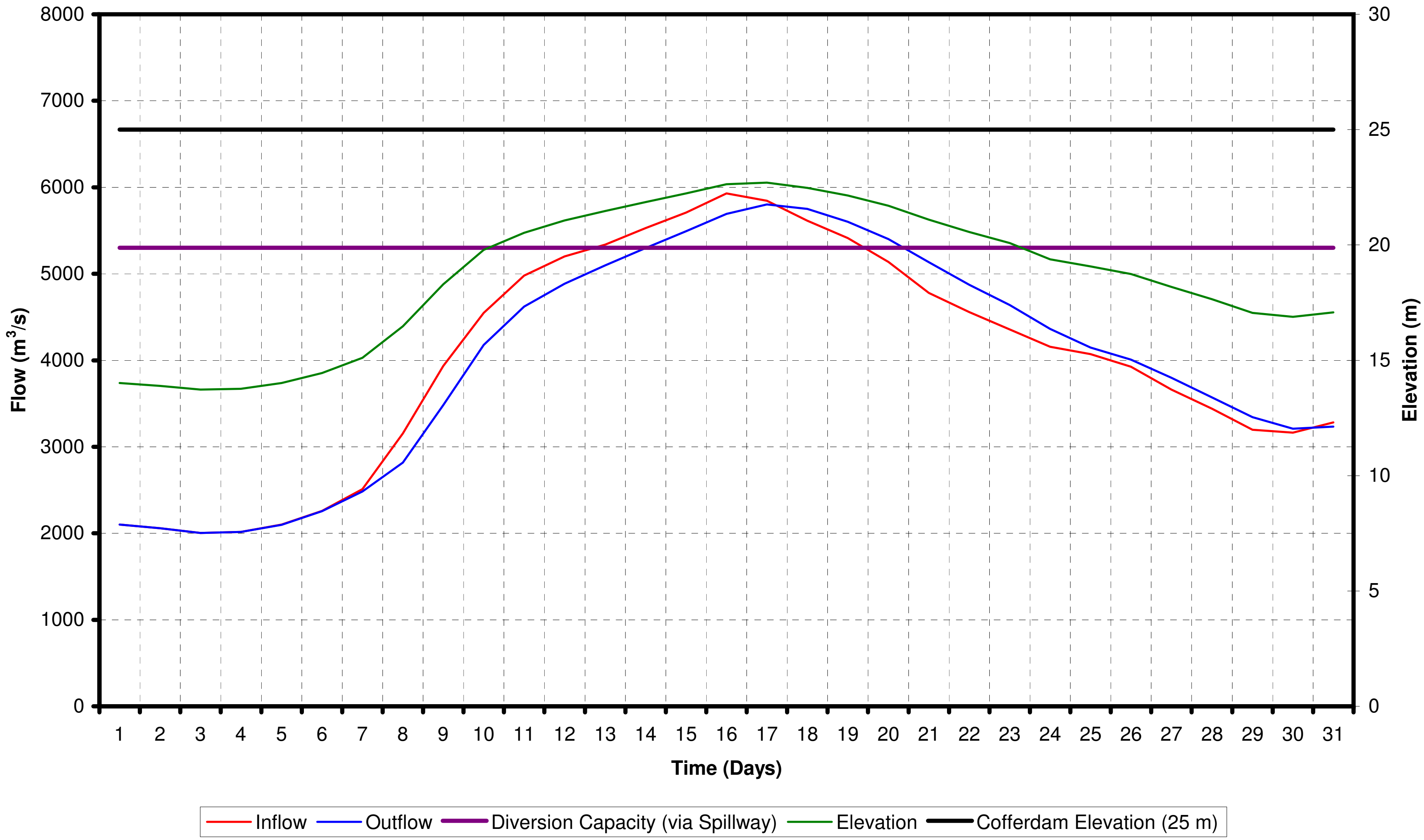

Figure 2.2
Muskrat Falls Diversion Routing - 1/20 AEP Construction Design Flood
River Operation during Construction & Impounding (Muskrat Falls)
Newfoundland and Labrador Hydro - Lower Churchill Project

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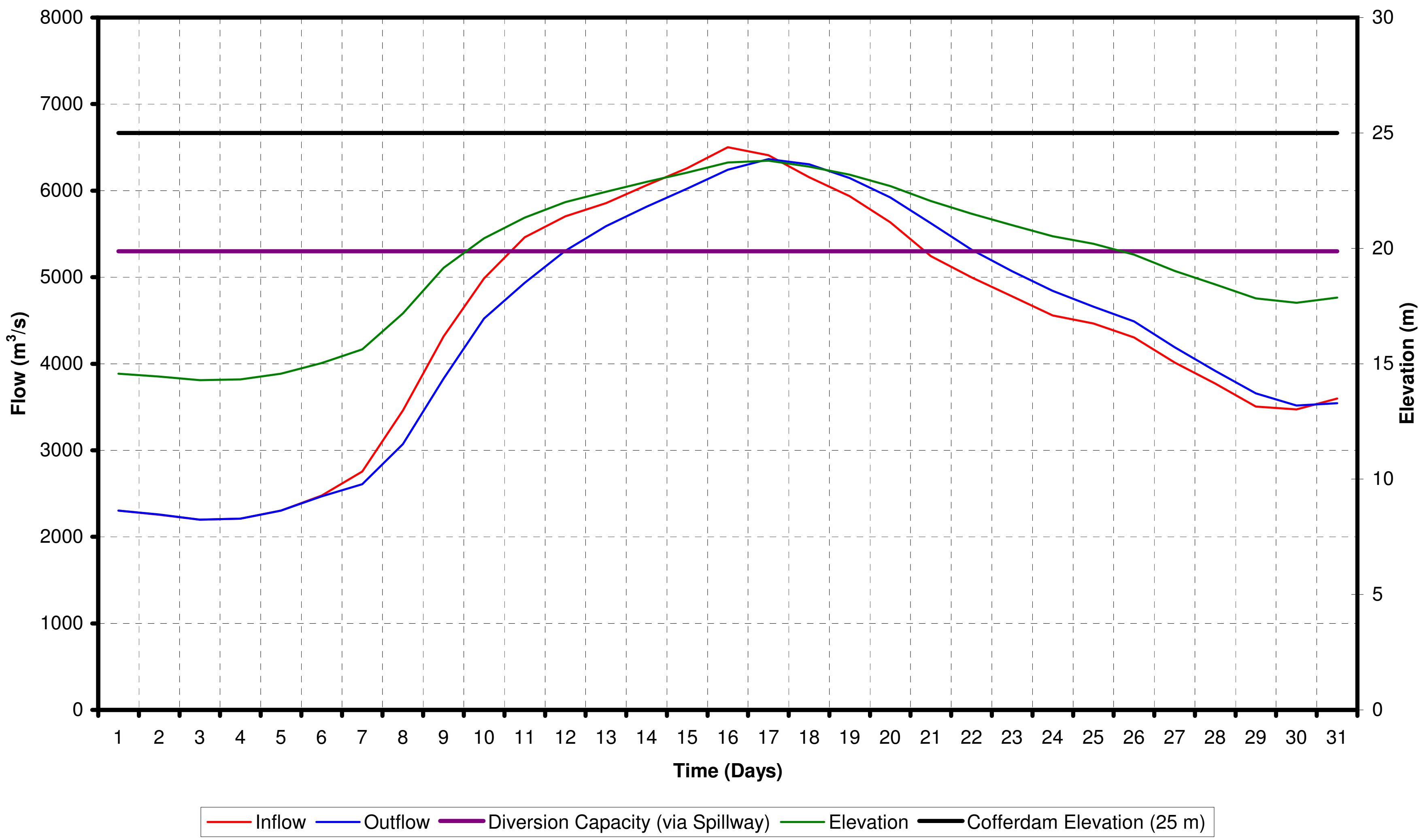

Figure 2.3
Muskrat Falls Diversion Routing - 1/40 AEP Construction Design Flood
River Operation during Construction & Impounding (Muskrat Falls)
Newfoundland and Labrador Hydro - Lower Churchill Project

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3. Reservoir Impoundment

The number of days required to impound the reservoir was determined assuming the average monthly flow for each month of the year. Average monthly flows were taken from the Environment Canada hydrometric station at Muskrat Falls (03OE001). The period of record used to derive the average annual and monthly flows was 1978 – 2006. This corresponds to the period since full operation at the Churchill Falls hydroelectric development upstream. The impoundment time was defined as the time to complete the filling of the reservoir from existing water level to full supply level (39 m). The analysis was carried out for zero compensation flow and for 550 m^3/s (30% of the mean annual flow) compensation flow, for comparative purposes. Table 3.1 summarizes the impoundment times.

Table 3.1
Summary of Impoundment Times

Month	Average Flow (m^3/s)	*Total Days 0% Compensation Flow	*Total Days 30% Compensation Flow
Jan	1860	10	14
Feb	1860	10	14
Mar	1740	10	15
Apr	1550	12	18
May	2660	7	9
Jun	2250	8	11
Jul	1700	11	16
Aug	1590	11	17
Sep	1500	12	19
Oct	1680	11	16
Nov	1770	10	15
Dec	1810	10	14
Average Annual	**1830**		

**Total days have been rounded to the nearest day.*

4. Conclusions

The current reservoir filling scheme for Muskrat Falls involves no cessation of flow since the strategy is to have spillway capacity available during reservoir impoundment. Therefore, dewatering of the downstream reach and potential salt water intrusion during reservoir filling are not expected to have the same level of concern as noted for the Gull Island development. It is recommended that these concerns be reviewed in light of any changes in the reservoir filling scheme.

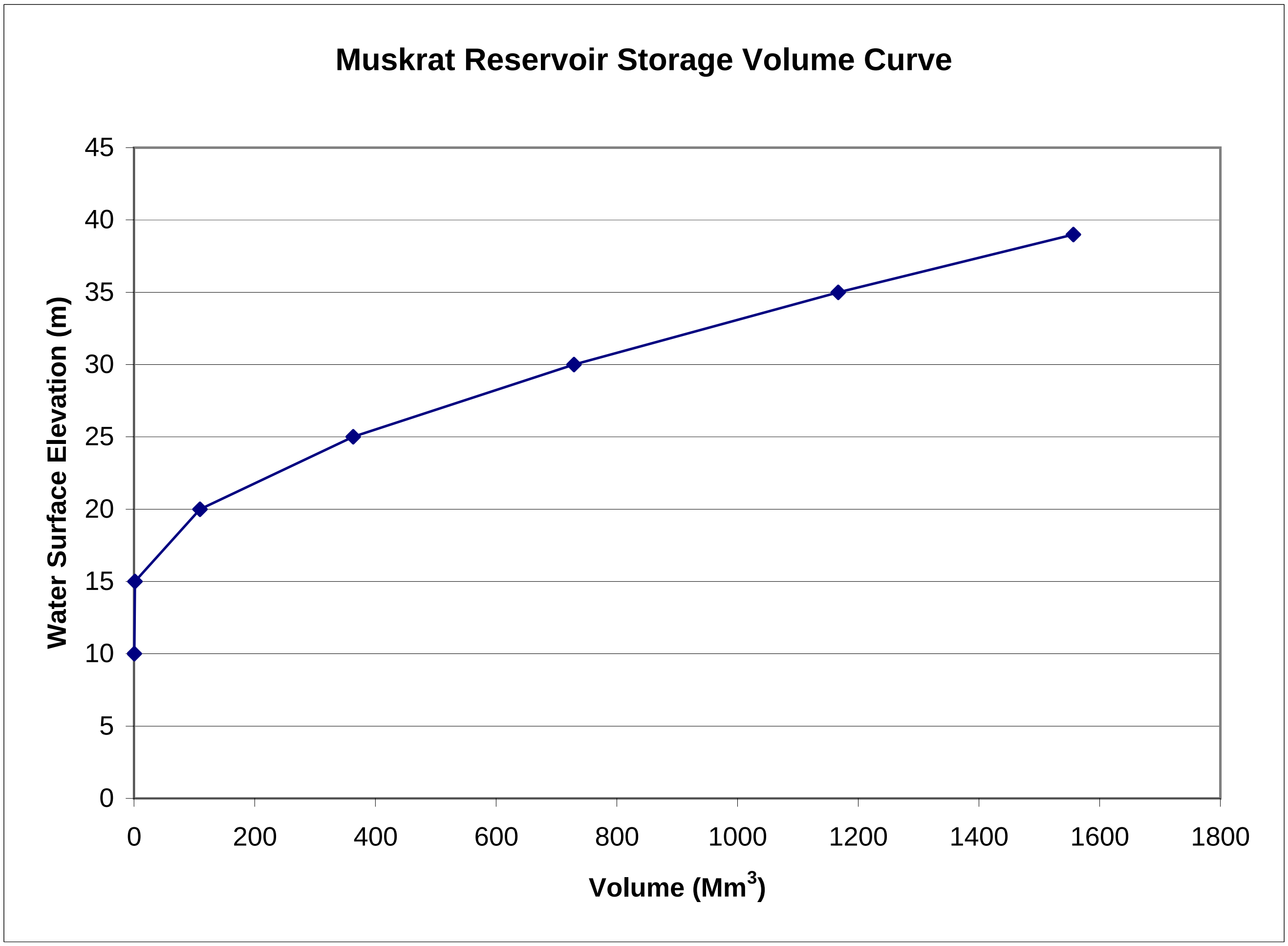
The attenuating effect of the reservoir during construction was investigated based on the discharge capacity of the diversion facilities as provided by Hydro. Three flood scenarios were considered: the largest flood since 1978, a 1/20 AEP flood, and a 1/40 AEP flood. In each case, the peak water level was less than the current upstream cofferdam design elevation. These results indicate that should similar flow conditions be encountered during construction, the proposed cofferdam at elevation 25 m should be adequate.

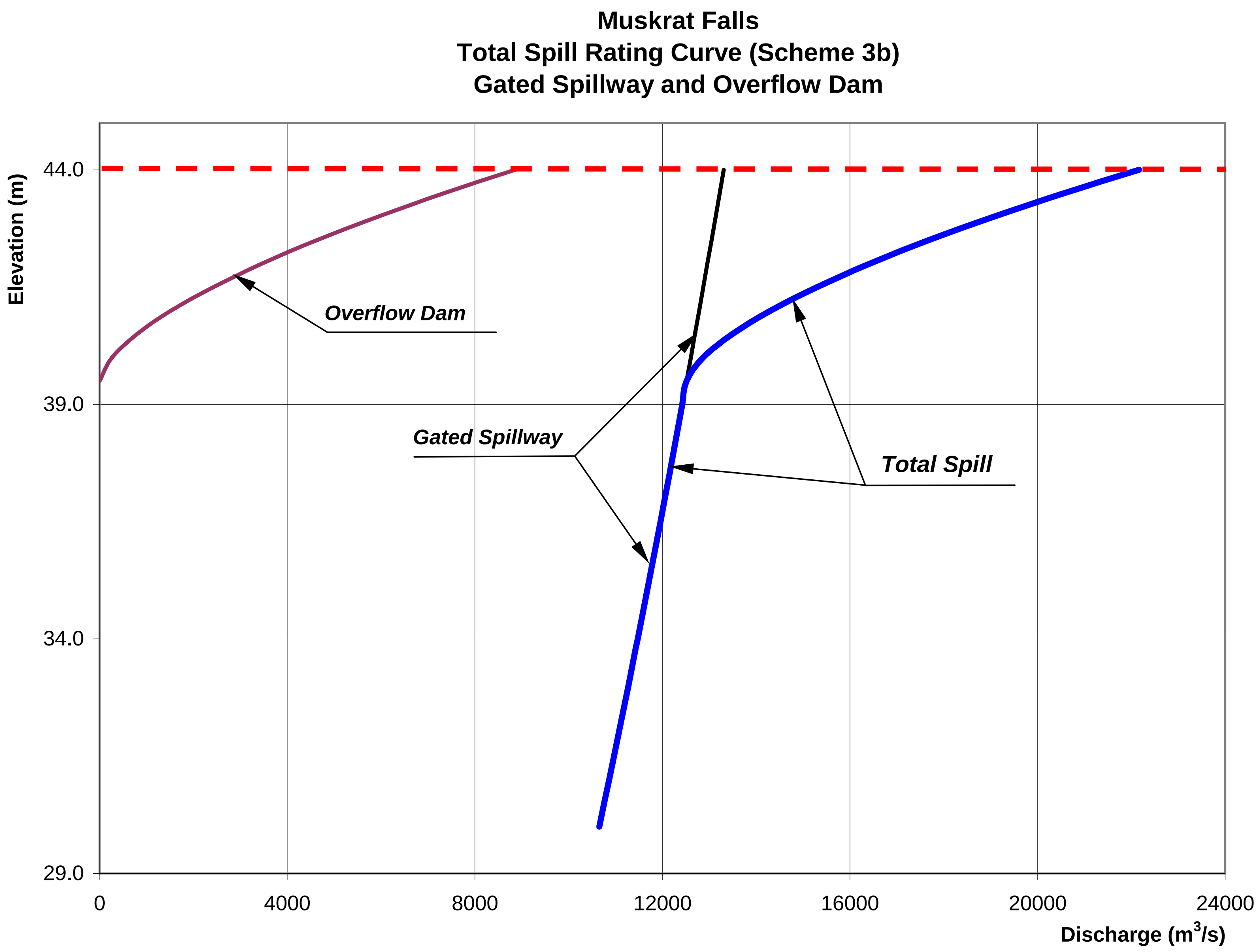
The number of days required to fill the reservoir during impoundment, assuming a compensation flow of 0% and 30% mean annual flow, was calculated for each month. The total time ranged from 7 days (May) to 19 days (September).

Appendix A

Muskrat Falls Spill Capacity and Storage Curves

Contour (m)	Area True (m^2)	Cumulative Volume (m^3) above 10 m contour	Cumulative Volume (Mm^3) above 10 m contour
10	228584	403981	0.4
15	865384	1627952	2
20	39326684	109380850	109
25	60404462	362963437	363
30	84763228	729079750	729
35	96849161	1166937072	1167
39	10426334	1556660815	1557




Muskrat Falls
Total Spill Rating Curve (Scheme 3b)
Gated Spillway and Overflow Dam
Elevation (m)
44.0
39.0
34.0
29.0
0
4000
8000
12000
16000
20000
24000
Discharge (m3/s)
Overflow Dam
Gated Spillway
Total Spill