8 Baseline Data Collection

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8.1 Original Data Collection Program

Baseline data describing the physical, biological and socio-economic characteristics of the Muskoka River system and the various water control structures (and any issues associated with their operation) was collected from the following sources:

- published reports and data
- unpublished MNR data (natural resource values, water control structure characteristics and operations, etc)
- waterpower producers (OPG, OPGC, BBG, & AP)
- discussions with local agencies and municipalities
- information from the public.

The ARSP was set up to simulate the hydrologic characteristics of the managed lakes, reservoirs and river reaches within the Muskoka River system. A limited field investigation was undertaken during the Phase 1 data collection process to investigate the elevation of existing infrastructure (docks, boathouses, etc) in Lake of Bays and Kawagama Lake relative to typical operating levels. The Phase 1 data was summarized and reported in the Background Information Report (A&A, 2003a).

8.2 Information Collected During the Planning Period

Since Phase 1 was completed, a number of studies have been undertaken to fill specific data gaps as identified in Section 7. Only studies that were directly related to water levels and flow manipulations were approved by the Planning Team/Steering Committee. The following provides a brief description and summary of the results for those additional investigations.

8.2.1 Infrastructure Survey

An infrastructure survey was conducted on nine lakes within the Muskoka River watershed to investigate the elevation of existing shoreline infrastructure (i.e., docks and boathouses) in relation to lake water levels (Acres, 2003a). The lakes studied included:

- Lake Muskoka
- Lake Rosseau
- Lake Joseph
- Tasso Lake
- Camp Lake
- Lake Vernon
- Peninsula Lake
- Fairy Lake
- Mary Lake and North Muskoka River (south of Huntsville).

On each lake, a random sampling of infrastructure (docks and boathouses) was measured to determine the amount of freeboard to the top of the deck surface and the bottom of the splashboard, and the water depth/level at the entrance to the boathouse or at the end of the dock (if shallow water depth was considered to be a constraint to access to the structure). The average, minimum and maximum freeboard values were calculated and correlated to lake elevation.

The results of the study provided an indication of the average amount of freeboard for the structures on each lake, as well as the range of variability between lakes. These values can be used to determine the potential impact of different water level management options on shoreline infrastructure for each of the lakes.

8.2.2 Matthias Reservoir Fisheries Survey

During the Phase 1 public consultation activities, comments were received regarding the potential impact of Matthias GS head-pond operations on river flows, water levels, and fish and wildlife communities in the reservoir. At that time, no information was available on biological communities within the reservoir. A study was subsequently conducted in August 2003 (Acres, 2003b) to provide baseline information on the biological resources (i.e., fish communities, aquatic and wetland habitat conditions) of the reservoir to support development of the WMP.

The study methodology included a fish community assessment (gill nets, seine nets, minnow traps) to document species presence/absence and comparative species abundance, and a riparian/littoral zone habitat assessment to investigate any potential effects of water level fluctuations. The study revealed a warm water fish community dominated by centrarchid species (smallmouth bass, rock bass and pumpkinseed) with few large predators (only one large northern pike collected), and a forage base dominated by shiners. Habitat conditions appear to be conducive to centrarchid species, although a distinct drawdown zone was noted that contained a reduced vegetation community of limited habitat value. Extensive wetlands were present in two large embayments at the upper limit of the head pond, as well as smaller wetlands within small embayments along the periphery of the reservoir. These wetlands likely contribute valuable spawning and rearing habitat for spring spawning species. Extensive (i.e., >1 m) and long duration water level changes within the head pond during the spring could adversely affect the reproductive success of spring spawning species in these wetland environments.

8.2.3 Kawagama Lake Trout Spawning Survey

A study was conducted during the fall of 2003 (Acres, 2004b) to determine the potential impacts of water level management (i.e., fall and winter draw down) on lake trout reproductive success on Kawagama Lake. Specific aspects of the study included:

- lake trout spawning habitat assessment and mapping using Geographic Positioning System (GPS) technology to accurately map substrates and water depths over prospective spawning areas
- surveys of spawning lake trout at 18 potential spawning shoals
- lake trout egg collection at the two primary spawning sites
- estimation of egg deposition abundance within specific depth contours at each spawning site to determine proportion of eggs potentially susceptible to exposure during winter draw down of the lake.
- determination of egg/fry viability in late spring at the typical winter/spring drawdown level.

The study found that one shoal is the primary spawning location within the lake, and accounted for the majority of the spawning activity. Based on the results of the subsequent egg collection activities, it was estimated that approximately 30% of the eggs deposited on the primary spawning shoal were within the winter drawdown zone and would therefore be potentially subject to dewatering or ice scour prior to fry dispersion in late April/early May. Egg collections at a secondary spawning shoal revealed that all eggs at this location were deposited below the drawdown zone, although egg abundance was significantly lower than was observed at the primary spawning site.

Additional field studies were conducted in March 2004, when the lake reached its maximum drawdown level, in order to determine any potential impact of this drawdown on previously deposited eggs and developing fry. The study was able to differentiate between previously dead and frozen (but dead) eggs and larvae, and recovered frozen eggs and larva from the drawdown zone, indicating that the drawdown was directly responsible for the associated mortality. It was noted that all eggs or fry located more than 5 to 7 cm above the active lake water level were frozen/affected by the drawdown. The study concluded that the existing winter (0.62 m) drawdown was adversely affecting lake trout reproductive success and provided recommendations to reduce this mortality.

8.2.4 Wetlands, Littoral Zones and Water Level Fluctuations

The Planning Team identified the need for background information on the degree of water level fluctuation that is considered acceptable or ‘healthy’ for wetland communities and shoreline littoral zones. A limited literature review was undertaken to address this issue (A&A, 2003b).

Ecological principles acknowledge that seasonal and annual variability is an integral component of any normal ecosystem and contributes to the diversity of its flora and fauna. Studies have shown that water level regulation can impact riverine and lacustrine ecosystems by changing hydrological variables such as the annual water level fluctuation range, the year-to-year variability of water levels and the timing of water level fluctuation. These variables may impact numerous components of the aquatic and terrestrial ecosystem, including wetland and littoral zone vegetation composition, and its associated diversity and function, as well as the species (i.e., fish, insects, mammals) that depend on these habitats. A winter drawdown, whether for hydropower production or to provide water storage to reduce spring flooding, can also have significant negative impacts on aquatic ecosystems.

The literature review presented a number of generalizations that could be utilized in the ecological evaluation of alternative water management strategies for the Muskoka River watershed. These recommendations are most applicable to regulated waterbodies that exhibit typical altered hydrological regimes, in an effort to move them toward more natural hydrologic cycles. Recommendations include:

- Implement a gradual summer/fall drawdown so that stable water levels are attained before the ice forms.
- The amplitude of the water level fluctuation should more closely approximate natural fluctuations, and in particular, limit the amount of winter drawdown that occurs over natural conditions.
- In lakes with a considerable fall/winter drawdown, spring lake levels should reach a minimum sustainable level (based on habitat availability and hydrologic/hydraulic linkages) earlier in the season to allow fish to access appropriate spawning habitats.
- Maximum vegetation species richness can be achieved by managing water levels to provide either
  - decreased within-year and high among-year variation
  - moderate within-year and among-year variation
  - high within-year and low among-year variation.
- Employ an ecologically based regulation practice: adjust the timing, progression and magnitude of water level manipulation according to the specifics of the managed waterbody.

For example an analysis of the hydrologic tolerances and requirements of several common wet meadow vegetation species within the Muskoka River watershed indicates that these habitats should be flooded for at least 20 to 25 days during the growing season to facilitate their growth and survival (i.e., providing sufficient amounts of water to eliminate competition from non-wetland species). Another example of basing water level management decisions on ecological requirements of species found in the Muskoka watershed could involve northern pike, a typical species of many of the regulated lakes in the area. Recommendations for other controlled lakes (i.e., Rainy Lake/Namakan Reservoir) include an earlier spring rise in water levels to provide access for northern pike to flooded shoreline habitats, and maintenance of these levels for at least 30 days in order for fry resulting from spawning activities in these areas to return to the main water body. Therefore, any alterations in the water level management regime must take into account the requirements of particular plant and animal species found in and around the lake.

Several studies indicated that among-year variations were very important to maintain ecological functions by providing appropriate levels of environmental disturbance. Recommendations for appropriate ranges or timing of among-year variation included:

- variability in the yearly range of water level fluctuation (i.e., higher or lower than normal) should be allowed to occur more or less every 5 years

- the minimum range of fluctuation should encompass the water level exceeded 10% of the time and the level exceeded 90% of the time (in an unregulated waterbody), with both levels achieved at least once every 15 years.

The literature review concluded that appropriate ranges of water level fluctuation and timing of water level change are specific to individual watersheds, and cannot be specifically based on results from other watersheds. However, studies have concluded that the best way to enhance wetland and littoral zone ecological functions and the populations of flora and fauna that inhabit these areas in regulated waterbodies, is to implement a water management regime that more closely approximates the naturally occurring hydrologic regime that would be present in the absence of existing structures and water level regulation.

8.2.5 Loon Abundance and Distribution

A review of loon abundance and distribution data during the nesting season was undertaken to determine potential impacts of water management activities on loon populations (A&A, 2003d). Information on loon nesting on 11 lakes (6 regulated, 5 unregulated) within the Muskoka watershed was obtained from Bird Studies Canada (BSC), and analyzed to determine whether a correlation could be established between water level fluctuations and loon nesting success. Water level data for the regulated lakes was obtained from MNR to supplement water level data contained within the BSC data. In the Muskoka watershed, loon nesting and incubation generally occur in late May/early June, with the period of most susceptibility to water level changes extending to the end of June.

The results of the analysis of eggs and hatching success did not show any consistent trend in relation to water level. Five occurrences of eggs that did not hatch were noted on regulated lakes, but only one of these occurrences was during a water level fluctuation of more than 30 cm during the nesting period. All other occurrences of unhatched eggs were from years when there was no significant water level fluctuation. A further complication was that no eggs were observed on unregulated lakes (but young were later observed) during the survey period.

No consistent correlation could be established between production of young and water levels from the data either. The number of loon pairs with at least one large young increased from 1997 to 1999 within the regulated waterbodies within the watershed, but this trend was also consistent across most of Ontario and Quebec, and cannot be related to water level management. The reproductive success data from regulated lakes showed a slight trend toward improved productivity in years when water levels did not fluctuate more than 30 cm in June or July (the important nesting and incubation period). However, young loons were also produced during several years that experienced significant water level fluctuation. In addition, young were produced on unregulated lakes during years with significant water level fluctuation. In summary, the data indicate that water level is not the only influence on loon reproductive success.

Despite the lack of correlation of reproductive success with water levels in the Muskoka watershed lakes, the information on loon ecology and nesting characteristics can provide some direction for water management planning. Water management strategies that limit or provide gradual water level changes during the mid-May to late-June period would be preferred (to provide optimum conditions for loons) over those that make significant changes (i.e., >30 cm) during that time period.

8.2.6 Computer Modeling Studies

ARSP was set up during Phase 1 of the project to simulate current water management within the Muskoka River system (see A&A, 2003a for details of model set up and calibration). Once the model was established, it could be used to evaluate different flow and water level scenarios. The Planning Team authorized four studies to investigate the following topics:

- Flow available at Moon Falls for walleye spawning
- Flow available at South Falls for walleye spawning
- Base flow within river reaches below existing dams
- Comparison of historical versus simulated water level fluctuations at two lakes within the Muskoka River system.

This work was undertaken in order to provide better information on which to base the subsequent Phase 2 evaluation of alternative water management strategies.

Flow for Walleye Spawning in Moon River below Moon Dam
A study was undertaken in spring 2003 (A&A, 2003c) to address the availability of flow for walleye spawning at the Moon Falls location in relation to other demands for water (i.e., stable Lake Muskoka levels with no damage to infrastructure, power generation, etc). Flow originating from Lake Muskoka is divided below Moon Chutes, and passes through the Moon River and the OPG power stations (Ragged Rapids and Big Eddy) on the Musquash River. The provision of a consistent, reliable flow quantity at Moon Falls is considered an important component of improving the habitat conditions at the spawning site downstream of the falls. Further work is planned to define the flow value that provides adequate coverage of spawning substrates.

A number of scenarios were tested to determine the outcome of different water allocation strategies. Historical records from Lake Muskoka were examined to determine whether the required flow (walleye and waterpower) could be provided throughout the spawning and incubation period (approximately April 15 to June 3). The model utilized 31 years of simulated data, and also examined scenarios that utilized the full extent of the Normal Operating Zone (NOZ) of Lake Muskoka.

The first scenario examined the existing operating plan, and calculated the flow available for power generation if 14 m^3/s is provided to the Moon River for walleye spawning on a priority basis. Under average hydrologic conditions, a flow of at least 14 m^3/s could be provided for 29 of the 31 years modeled, with the annual value ranging from 7 to 141 m^3/s, and an overall (31 yr) average of 62 m^3/s. This shows that, during extremely dry years, there would not be enough water for walleye spawning, even if it is provided preferentially. In addition, the reported average flow would not necessarily provide 14 m^3/s throughout the entire spawning and incubation period, as the average value may be influenced by large, often short-duration flow peaks that usually occurs at some point during the April 15 to June 3 period. These flow peaks are the result of snow melt or rain events, which are presently passed through the system without attempting to store large portions in upstream lakes or reservoirs. When these high flows are bypassed to the Moon River, they may cause walleye to spawn in unsuitable areas that are subsequently dewatered when these flow peaks recede. The average flow available for power generation under this scenario ranges from 6 to 84 m^3/s, with a 31-yr average of 62 m^3/s. With the present operational strategy, it is apparent that there are a number of times when there is insufficient water available for walleye spawning, even when it is given preference over waterpower, and there are few years when the full waterpower potential (i.e., a flow of 85 m^3/s) is obtained.

A number of other scenarios were then evaluated, to determine whether an improved flow regime could be obtained if Lake Muskoka was utilized to capture and subsequently release a portion of the spring freshet. In each instance, upstream lakes were modeled according to historical operating practices, while Lake Muskoka was maintained within the NOZ (not allowed to enter upper or lower operating zone). The following walleye/waterpower flow scenarios were evaluated (in m^3/s):

- 8 for walleye and 85 for waterpower
- 14 for walleye and 85 for waterpower
- 14 for walleye and 42 for waterpower
- 28 for walleye and 42 for waterpower
- 21 for walleye and 42 for waterpower
- 14 for walleye and 42 for waterpower.

The results showed that utilization of the full operating zone improved the ability to provide a constant flow of 8 or 14 m^3/s for walleye and 85 m^3/s for waterpower throughout the walleye spawning period. There were however 4 years out of the 31 modeled that the allocation for waterpower was substantially less than 85 m^3/s if the constant flow of 8 or 14 m^3/s was maintained for walleye. For the third scenario, the 14 m^3/s for walleye and 42 m^3/s for waterpower could be provided for all but three of the 31 years modeled. For the fourth scenario, the 28 m^3/s for walleye and 42 m^3/s for waterpower could be provided all but 4 of the 31 years modeled with the overall average flow for power generation being 64 m^3/s. Similar to the third scenario, the fifth provided 21 m^3/s for walleye and 42 m^3/s for waterpower on all but 3 years, with the overall average for waterpower being 69 m^3/s if 21 m^3/s was provided for walleye spawning. Finally, the last scenario duplicated scenario three but allowed more change to Lake Muskoka water levels. When 14 m^3/s was provided on a constant basis for walleye spawning, an average flow of 67 m^3/s would be available for power production, with flows falling below 42 m^3/s on only 3 of the 31 years modeled.

The results of the scenarios showed that there was significant room for improvement of flows for walleye spawning and for hydropower during the spring freshet period if the storage within the NOZ of Lake Muskoka is used to its greatest extent. This would capture a larger part of the spring freshet than is presently undertaken, and then release it during the spawning period. In order to implement this type of operation, a foreknowledge of incoming flows is required, thus a flow forecasting system would be required for the Muskoka River basin. The first set of scenarios that were tested raised the water level to the top of the normal operating zone at least 50% of the time during the spring freshet for Lake Muskoka and it was anticipated that this would not be acceptable to the local residents. The last scenario discussed can be implemented with only a slight increase in the spring Target Operating Level (TOL). If the concept were applied to all the lakes in the Muskoka Basin, there could be a very significant improvement in flows for walleye spawning, as well as additional water for hydropower.

Base Flows for Walleye Spawning below South Falls

A study was undertaken in April 2003 (A&A, 2003c) to address the availability of flow during the spring for walleye spawning at the South Falls location. As noted in Section 8.2.2 above, peaking operations at Matthias GS occasionally resulted in the provision of less than the required flow at the spawning area. The study was undertaken to determine whether a higher base flow from Lake of Bays could improve the existing situation.

Historical flow records from Lake of Bays were examined to determine whether the required flow could be provided throughout the spawning and incubation period (approximately April 15 to June 3) by alternate operation of the dam, while still maintaining the lake within the NOZ. The ARSP model was used to determine whether the flow releases from Lake of Bays could be increased and maintained above the 3 m^3/s level. The basic premise was that Matthias could moderate its peaking operations and continue to provide a consistent minimum flow of 3 m^3/s if additional flow was available. Four scenarios were evaluated (flows of 6, 9, 12 and 27 m^3/s) under various operating regimes. The results showed that a constant flow release of up to 9 m^3/s could be provided from Lake of Bays during the walleye spawning period without significantly impacting water levels on Lake of Bays.

Base Flows below Operational Dams

This task looked at improving base flow throughout the entire river basin by utilizing the storage available in the NOZ below the TOL on the lakes. To perform this study the ARSP model was used to run base flow demands at each operational dam. The analysis showed, that the existing base flows, as identified in the Muskoka River Dam Operational Manual, are achievable at least 90% of the time at most of the dams in the lower part of the basin. In the upper part of the watershed, some of the established demands could be achieved, except at Camp Lake and Tasso Lake. There was also the possibility of increasing base flows at some of the dams, under normal conditions.

Review of Historical Water Level Fluctuation Events

Historical water level data for two representative lakes (Lake Muskoka and the Huntsville lakes) for the period from 1982 to 1998 was analyzed to determine the range of historical water level fluctuation around the TOL. This degree of fluctuation was then incorporated into the ARSP Base Case to allow the model to more closely simulate water level and flow conditions.

8.2.7 Matthias Infrastructure

A study to investigate water depth associated with docks and water lines in the Matthias head pond was undertaken in October 2004 to provide input into the development of the operating range for the facility (Acres, 2004c). All docks were investigated, with a number of measurements of water depth obtained at the offshore and inshore ends to assist with the evaluation of potential effects of water level fluctuation on access to the structures. If water lines were present, the water depth at the offshore was also measured.

The study found that many of the docks within the head pond were constructed with fixed and floating sections (similar to Kawagama Lake), which provide improved access during variable water levels. In these instances, water depth was obtained at both the offshore and inshore end of the floating section. In some cases, floating sections had been removed from their moorings and pulled onto shore in preparation for the winter season.

Of the 57 structures surveyed, 38 (approximately 67%) had their offshore end at or beyond the 292.0-m contour (>0.84 m depth on day of survey), while the floating section of 8 structures were entirely beyond the 292.0-m contour. All water lines (21) also extended beyond the 292.0 m contour. An additional 15 (26%) structures had their offshore end located between the 292.0-m and 292.3-m contour, and 4 (7%) were above the 292.3-m contour.

The study concluded that a reservoir water level of >292.3-m elevation would provide water access to the majority (93%) of the structures, and should address public concerns. It was suggested that the 292.3-m elevation be adopted as a Best Management Practice (BMP) lower operating limit within the Matthias GS operating plan.