7 APPROACH FOR ASSESSMENT OF ALTERNATIVE WATER CONTROL OPERATING PLANS

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7.1 Overview

The identification of attributes, indicators and criteria within the watershed forms the basis for the assessment of alternative water control strategies. In compiling information on the river for which the water management plan is being developed, issues and concerns were revealed as a result of consultation with the water control operators, government agencies, stakeholders and the public. From this information, a set of attributes or values was developed pertaining to priority issues within the watershed. These attributes are related to key objectives of the water control plan and an approach to meeting the key objectives was then identified for each attribute. Then, by using the ARSP hydrologic computer model as discussed in Section 6, the potential effects of the alternative water management strategies were assessed using simplified indicators related to flows and water levels. The results of each alternative were compared to the base case and to each other as a means to aid in the decision-making process. Based on conclusions drawn from these comparisons, the most effective water management strategy was selected based on cost and other factors that included how well the preferred strategy would achieve the key objectives.

7.2 Attributes and Objectives

The identification of attributes for the Magnetawan River system was founded on important issues and concerns identified for the waterway. Numerous issues and concerns were identified through the agency and public consultation process as discussed in Section 5. These issues were reviewed by the consultants, the MNR and the PAC. Known problems and issues believed to be occurring as a result of the operation of the control dams and spill structures were then prioritized. These were summarized in Section 5.6.

Based on this information, it was evident that the priority issues for the Magnetawan River system encompass the following natural environment, social and economic attributes. These are identified below and explained in Table 7.1:

- aquatic ecosystems (natural environment)
- flood management (social)
- tourism/recreation (social)
- small hydro potential (social)
- operational costs (economic).

Table 7.1
Attributes and Approach to Meeting Objectives

Attribute	Key Objective	Approach to Meet Objective
Environmental		
Aquatic ecosystems	To provide healthy aquatic ecosystems by maintaining and enhancing ecosystem functions.	Maintain or improve aquatic ecological conditions through reservoir water level and river flow manipulations.
Social		
Flood management	To provide flood management capability thereby minimizing property damage and protecting human life.	Minimize risk of exceeding existing maximum reservoir levels or maximum flows in river reaches.
Tourism/recreation	To provide tourism and recreation opportunities by equitably allocating water during the summer.	Maintain or improve average summer reservoir water levels and minimum river flows from May 15 to October 15.
Small hydro potential	To maintain development potential for small hydro generation.	Maintain adequate water levels and flows conducive to electricity generation at identified sites.
Economic		
Operational Costs	To ensure cost-effective and safe operation of the dams.	Maintain or reduce MNR’s net operational costs through integrated operational management of the control dams. Ensure that all water control structures are repaired and maintained as necessary to meet current dam safety standards.

7.3 Indicators and Criteria

Indicators are defined as parameters that can be used to measure the effects on a given attribute of the environment. The indicators, in turn provide a means to assess the relative advantages and/or disadvantages for a particular water management strategy under consideration. In addition, indicators provide a measurable means to assess whether the key objectives for a given attribute are being achieved.

Pursuant to MNR's Draft Water Management Guidelines (MNR, 2001), indicators can be either quantitative or qualitative. For the Magnetawan River system, estimates of water levels on the lakes and flows in the river were used as the primary indicators. These indicators were supplemented with indicators for power generation and cost. Table 7.2 lists the indicators that were identified for each attribute. The water level and flow indicators were applied to every reservoir (defined as the affected lake upstream of the control/spill dam) and river reach (defined as the affected river section downstream of a control/spill dam). The power indicator was applied at the existing Burk's Falls hydro site and the two potential small hydro sites; Magnetawan dam and Knoepfli dam. The cost indicator was applied as a single parameter on a watershed-wide basis.

Criteria were developed for each indicator to define the quantitative bounds or conditions, against which effects were to be identified and assessed. Criteria are defined as the numeric measures that determine if the indicator effect is positive, negative or not significant. For the Magnetawan River system, three criteria ratings were established to enable comparison with the base case operating regime. The purpose of the ratings was to determine if a potential new water management strategy is better, worse or no different than the base case. Table 7.2 lists the criteria that were developed for each indicator.

7.3.1 Natural Environment Attribute, Indicators and Criteria

For the aquatic and riparian habitats attribute, indicators *of average annual minimum water levels in the reservoirs and minimum flows in the river reaches* were identified for evaluation against the base case and the rationale is presented in Table 7.2. Aquatic and riparian habitats are reflected by both spatial characteristics which are defined as water levels and flows at different locations along the river and temporal characteristics which are defined as their variability from year-to-year, seasonally and weekly patterns. The quality of aquatic and riparian habitat is likely influenced to a large degree, by water levels and flows, and by the fluctuations between them.

Table 7.2
Criteria for Evaluating Alternative Water Management Strategies

Attribute	Indicator	Criteria for Comparison to Base		
		Positive Effect +	No Significant Effect =	Negative Effect -
Natural Environment				
Aquatic and Riparian Habitat	Reservoirs* - Minimum Levels	>0.05m higher	+/- 0.05m of base case	>0.05m lower
	River Reaches* - Minimum Flows	>10% higher	+/- 10% of base case	>10% lower
Social				
Flood Management	Reservoirs - Maximum Levels	>0.05 m lower	+/- 0.05m of base case	>0.05 m higher
	River Reaches - Maximum Flows	>10% lower	+/- 10% of base case	>10% higher
Tourism/Recreation	Reservoirs - Average Levels between May 15 to Oct 15	>0.05 m and < 0.15 m higher	+/- 0.05m of base case	<0.05m lower or ≥0.15m higher
	River Reaches - Average Flows between May 15 to Oct. 15	>10% higher	+/- 10% of base case	>10% lower
	River Reaches - Minimum Flows between May 15 to Oct. 15	>10% higher	+/- 10% of base case	>10% lower
Small Hydro Potential	Average Annual Power Generated	>1% higher	+/- 1% of base case	>1% lower
Economic				
Operational Costs	MNR Net Operational Costs	>5% lower	+/- 5% of base case	>5% higher

* For the purposes of this plan, a *Reservoir* is defined as the ‘affected’ lake(s) upstream of control/spill dam. A *River Reach* is defined as the ‘affected’ river section downstream of a control/spill dam and outside the influence of a downstream lake.

In terms of aquatic and riparian habitats, an increase in the average annual minimum reservoir level by >0.05 m was considered to be a positive effect. This is based on the assumption that such an increase corresponds to an increase in the permanently wetted zone available for long-term aquatic productivity. Conversely, a decrease of >0.05 m in minimum reservoir level was considered a negative effect associated with a loss of permanent aquatic habitat. Aquatic and riparian habitat was also evaluated against the base case on the basis of average annual minimum flows through the river reaches. An increase of minimum flow was assumed to provide greater aeration and water depth particularly in spawning habitat. Increases were assumed not to be of such magnitude that eggs would be washed away. An increase in minimum flow of >10% was considered to be a positive effect and a decrease in minimum of >10% considered to be a negative effect.

7.3.2 Social Attributes, Indicators and Criteria

Three types of social attributes were identified for the Magnetawan River system: flood management, tourism/recreation and small hydro potential. For each attribute, different indicators and criteria were defined and are presented in Table 7.2. A brief discussion of the rationale follows.

For the flood management attribute, indicators *of maximum daily water levels in the reservoirs and maximum daily flows in the river reaches* were identified for evaluation against the base case. In terms of flood management capability, a lowering of the present maximum reservoir level by >0.05 m was considered to be a positive effect while an increase in the present maximum reservoir level of >0.05 m was considered to negatively affect flood management capability. Similarly, a reduction in maximum flows of >10% was considered to be a positive effect while an increase in maximum flows of >10% was considered to be a negative effect. These ranges were selected to illustrate that a moderate decrease in flow or level indicates improved flood management capability and similarly a moderate increase in flow or level indicates reduced flood management capability.

For the tourism/recreation attribute, indicators *of average summer water levels in the reservoirs, and minimum and average summer flows in the river reaches* were identified for evaluation against the base. The critical period for maintaining stable water levels and flows is considered to be May 15 to October 15. In terms of the water-based tourism and recreational activities, the following criteria ranges were established. For the reservoir levels, an increase in the average summer water level by >0.05 m, but <0.15 m was considered a positive effect on activities related to boating and fishing, etc, due to improved boat navigation through shallow areas and better access to shorelines. Conversely, a lowering of the present average summer reservoir level by >0.05 m was considered a negative effect associated with reduced boat navigation and shoreline access. An increase of ≥0.15 m in average summer water levels was considered a negative effect on existing waterfront infrastructure, which may become more susceptible to wave and bank erosion, and to fixed structures such as docks and boathouses that may be made more difficult to access due to higher lake levels. Similarly, for the river reaches, an increase in minimum flows of >10% was considered to be a benefit, while a decrease in minimum flows of >10% had the potential to negatively affect the existing river-based tourism/recreation activities. These ranges were selected to reflect overall approval by the recreational users of slightly increased water depth and disapproval of a decrease in water levels.

For the small hydro potential attribute, a single indicator of *average annual power generation* was identified for evaluation against the base (see Table 7.2). This attribute was included to provide an assessment of the effects of alternatives on the small hydro potential. Specific consideration was given to the existing small hydropower site in Burk’s Falls and the potential small hydro sites at the Magnetawan and Knoepfli dams. An alternative water management strategy would be considered neutral if the average annual power generation at the site remained within 1% of the base case. Since the useable head estimated at each site is assumed to be relatively constant, increases in power generation of >1% would be attributed to increases in flows from upstream and considered a positive effect on the small hydro potential. Conversely, if there was a >1% reduction in power generation, this was considered to be a negative effect. A small range was used for this attribute as very minor changes to power generation are noticeable to the power producers.

7.3.3 Economic Attribute, Indicators and Criteria

For the economic attribute, a single indicator of *operational costs* was identified for evaluation against the base. This attribute was included to provide an assessment of the economic effects of the alternatives as they relate to MNR’s operational management of the Magnetawan River control dams. This attribute provides an indication of the potential increased or decreased costs associated with increased or decreased operational effort necessary to make log changes in response to improved minimum flow releases and/or flood management capability. The effect was considered to be positive if the estimated operational costs were >5% below the base case and negative if the estimated operational costs were >5% above the base case.

7.4 Use of the 'Base Case' as a Neutral Condition for Assessment of Preliminary Model Runs and for Evaluation of Alternative Water Control Strategies

The assessment of alternative water control strategies required that baseline conditions be established to provide a reference set of operating conditions in the Magnetawan River system. These would be considered neutral in terms of impact to the indicators, when comparisons were undertaken. The base case water management strategy was fully described in Section 4 and covers a range of water levels and flows that is represented graphically in Section 8. Before this strategy was adopted as representative of the present 'base case' water management conditions, it was reviewed in terms of the historical operational information. A total of 83 years of historical flow data from 1916 to 1998 inclusive, is available for the Magnetawan River. This period is considered to be representative of the base case water management conditions, not only from an operational context, but also in terms of hydrologic diversity as this period contains years corresponding to long-term historic average, severe wet and dry basin runoff conditions. The data, combined with the established normal operational constraints around which the present system of control dams is operated was used to characterize the range of flow and water level variations to be expected on the lakes and river reaches. Typical weekly patterns of simulated lake levels and outflows from the existing control and spill dams are presented in Section 8. However, the ARSP simulation model makes "operational decisions" for flow releases at dams through an optimization process, taking into consideration the various constraints on the system. In reality, since the MNR operators use their experience to determine actual operations, the Ministry maintains significant flexibility in adjusting water levels and flows that may not necessarily correspond to model results.

The effects of the base case strategy on the aquatic ecology are not well understood since there is no historic baseline information prior to the construction of the dams on the Magnetawan River system against which to assess such effects. Therefore, for the purpose of this water management plan, the existing environment will be used as the ecological baseline to make compare any proposed changes to the present operations on the system that could benefit the aquatic ecology.

In terms of the effects of the base case strategy on social conditions, private property has better flood protection with the existing regulated system than without regulation. In addition, the base case strategy includes provision for MNR to maintain stable water levels on the Magnetawan River system lakes and river reaches during the summer for cottaging and recreational water use while maintaining flood management capability. This appears to be working well, based on historical operations and public input, and considering some expected deviations during very wet or dry runoff periods, especially in the mid to lower river reaches and lakes. In terms of small hydro power generation, limited historical data is available for the Burk's Fall hydro facility and none for the two potential sites to corroborate the base case strategy. In this regard, less emphasis is placed on quantifying actual power generation, but rather whether or not a significant change to the base case estimates would result from a particular alternative management strategy. In summary, the existing social constraints that were incorporated into the base case were therefore assumed to be a neutral condition when comparing alternative strategies.

In terms of the effects of the base case strategy on economic conditions, MNR has a prescribed budget for operation and maintenance of the control and spill dams within the Magnetawan system. The base case strategy represents the existing cost of operation for the control dams.

8 IDENTIFICATION AND MODELING OF ALTERNATIVE WATER CONTROL OPERATING STRATEGIES

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8.1 Overview

The development of alternative water control strategies for the Magnetawan River was premised on the key study objectives set out in Section 7. The primary objective was to provide more equitable sharing of water along the river system from upstream areas to downstream areas that currently exhibit environmental and social problems associated with low river flows during summer drought periods. The development of the alternative strategies was also founded on, and closely linked to, objectives to maintain acceptable lake levels for tourism and recreational uses, flood management capability, aquatic habitat and water power generation. The general objectives, specific management objectives, and issues and concerns, discussed in previous sections, were considered when reviewing the base case water management strategy and used to determine potentially improved alternative water management strategies.

With these objectives in mind, alternative water control strategies were developed, modeled and then refined based on the modeling results. The following section describes the alternatives and provides an explanation of the modeling results, including the results of a comparison of the alternatives. For each alternative strategy, a description of the effects on each lake and river reach is provided.

8.2 Identification of Alternatives

In the recent past, the operations of the Magnetawan River dams have concentrated on maintaining summer water levels on the controlled lakes to within relatively small ranges of ±0.1 to 0.3 m for Loon Lake (Pevensey dam), Perry Lake (Ayres dam), Doe Lake (Watts dam) and Bernard Lake (Bernard Lake dam). Both Cecebe Lake (Magnetawan dams) and Ahmic Lake (Feighens and Knoepfli dams) are controlled to within ±0.05 m. In this regard, the operations have not strived to maintain a specific minimum flow release from the dams as a means to maintain or enhance a particular downstream ecological function or water use. Consequently, the potential problems caused by low water releases from the dams during summer drought periods and/or during the early spring have not been addressed or in fact realized until this water management planning process. As a result of this planning process, the low flows that occur in the lower reaches of the Magnetawan River downstream of Ahmic Lake during summer drought conditions were identified as one of the major public issues and objectives of this study.

Given this objective, the project team discussed possible opportunities for operational changes to the control dams situated on Ahmic Lake and upstream, that could increase minimum flows in the lower reaches. The dams downstream of Ahmic Lake, including Wahwashkesh Lake dam, Gooseneck Lake dam, Kashegaba Lake dam, Harris Lake dams and American Trail dam are non-operable spill dams and were not considered further as means to augment flows during summer drought conditions. The Burk's Falls dam is operable, but its head pond has insufficient storage to augment low flows and therefore, was not considered further. Thus only Pevensey dam, Ayres dam, Watts dam, Bernard Lake dam, the Magnetawan dams and Ahmic Lake dams (Feighens and Knoepfli dams) were considered for operational changes. As part of the identification of alternatives, only operational changes to the existing rule curves were investigated. The construction of new dams and/or significant structural modifications to the existing dams were not considered unless required for reasons of dam safety.

For the Magnetawan River system, the objective of increasing minimum flows during drought periods requires the redistribution of water from the middle and upper reaches to the lower reaches. The augmentation of low flows requires the utilization of the water held in storage within the controlled lakes in a manner different than in the past. The basic options in using the lake storage to augment flows are to either: i) make more effective use of the existing storage available in the lakes; ii) draw down the lakes further to utilize the existing storage; or iii) capture and store more water in the lakes during the spring and use it for additional storage.

Accordingly, three alternative operating strategies were identified for initial analyses that have the potential to mitigate low flows during summer drought conditions:

- Case1: Operate the controlled lakes within the Normal Operating Zone (NOZ) but utilize the available storage in the controlled lakes to store water for release during summer drought periods.
- Case 2: Operate the controlled lakes within the NOZ and Lower Operating Zones (LOZ) to store water in the controlled lakes for release during summer drought periods.
- Case 3: Operate the controlled lakes at a higher level during the summer period by raising the upper level of the summer NOZ and release the water stored within the new NOZ during summer drought periods.

The alternative operating strategies are plotted for each control dam/lake and discussed further in Sections 8.3 and 8.4. Figure 8.1 depicts an example of the operational options for Cases 1, 2 and 3 for the Ahmic Lake dams, along with the existing base case operating regime for the lake.

The alternatives were modeled using ARSP to determine the benefits that could be derived from operating the control dams/lakes in a manner different from that in the past. The alternatives that have been modeled are not completely exhaustive in terms of mitigating low flows below Ahmic Lake. Numerous combinations and permutations of the three presented strategies exist that could provide equal or slightly better results than just one of these schemes. In recognition of this, the proposed operational changes associated with each of the alternative strategies were applied consistently to each control dam/lake. This avoided the creation of numerous sub-alternatives, allowing for more concise interpretation of the results.

Based on the modeling findings for Cases 1, 2 and 3, a fourth alternative was developed. Case 4 was developed by refining the operational zones for each of the control dams on a lake-by-lake basis while recognizing the operational constraints and limitations identified from the simulation results for Cases 1 to 3. Once the Case 4 alternative was defined, it was simulated using the ARSP model. The results are discussed in Section 8.5.

8.2.1 Sensitivity Runs

Sensitivity runs were undertaken to provide initial information that was used to guide the development of the operational alternative strategies. The sensitivity runs consisted of ARSP modeling of four different minimum flow values (1, 2, 5 and 10 m^3/s) in each of the strategies. These minimum flows were requested to be released from Ahmic Lake. The sensitivity runs are not, by themselves, considered alternative water management strategies. Rather, the results of the sensitivity runs were used to provide a better understanding of the range of minimum flows that could be attainable while achieving the water management plan objectives.

The sensitivity runs showed that during the recreation season a minimum discharge of 1 or 2 m^3/s could be maintained in the Magnetawan River downstream of Ahmic Lake for each of the strategies. Maintaining a minimum river flow of 5 and 10 m^3/s however, placed demands that could not be supplied 100% of the time during the recreation season. From these promising initial results it was postulated that minimum flows of 5 to 7 m^3/s could be supplied most of the time, except during the extreme dry years, which occurred on average, 5 years out of the 83 years simulated.

The results of the sensitivity runs also served to emphasize that the amount of water available in the river system is a finite quantity. Any increases in minimum flow discharges that can be supplied are entirely dependent upon the amount of storage that can be utilized in each of the controlled lakes. Utilization of water stored in the controlled lakes does not provide extra water to the river system as a whole. Instead, the pattern and timing of river flows is altered as water is ‘reallocated’ to and from storage during different times of the year. In the case of the Magnetawan River system, the suggested operating schemes store water during periods of mid-range flows and then release it during periods of low flow to increase the minimum flows.

8.2.2 Refinement of Alternatives

Following the results of the sensitivity runs, several additional model runs were undertaken to refine each operational strategy. The purpose of these runs was to determine how much water could be supplied downstream of Ahmic Lake during the summer recreation season (May 15 to October 15). This required a trial and error approach that consisted of running the ARSP model for each strategy for a range of minimum flow demands below Ahmic Lake. For Case 1, minimum flow demands of 3, 4, 5, and 6 m^3/s were simulated. For Cases 2 and 3, demands of 4, 5, 6, 7, and 8 m^3/s were simulated. Successive model runs were conducted by increasing the minimum flow demand until it was evident that the amount of lake rise or drop exceeded the operating limits prescribed for each alternative.

The results showed that for Case 1 a minimum discharge of 3 m^3/s could be provided 100% of the time and 5 m^3/s could be provided 95% of the time downstream of Ahmic Lake. For Cases 2 and 3, a minimum discharge of 4 m^3/s could be provided 100% of the time and 7 m^3/s could be provided 95% of the time. Cases 2 and 3 produced similar results because they utilize approximately the same amount of storage in each of the controlled lakes. The difference between Case 2 and 3 is that Case 2 provides the storage by drawing down the lakes into the LOZ, whereas Case 3 seeks to provide the storage by increasing the NOZ above its present level.

Typically in water management planning it is better to supply a higher minimum flow demand for a lower percentage of time than to supply a lower demand 100% of the time. The criterion of supplying a requested demand 95% of the time, typically meets the satisfaction of most users of a water resource, and was therefore applied in this study.

The results of applying the 95% reliability criteria are best presented through a flow duration curve, which shows the percentage of time that a particular flow value can expect to be exceeded. Flow duration curves were derived for all of the alternatives from the weekly average flows of all simulated years. These curves are plotted and discussed further in Section 8.4. Figure 8.2 depicts the flow duration curve derived for downstream of Ahmic Lake. Compared to the Base Case, each of the alternatives considerably increases the minimum flows experienced during the dry periods.

Based on these findings, using the 95% reliability objective for minimum discharges, the three alternative strategies were restated as follows:

- Case 1: Operate the controlled lakes within the NOZ but utilize the available storage in the controlled lakes to store water for release during summer drought periods to maintain a minimum flow discharge of 5 m^3/s below Ahmic Lake 95% of the time.

- Case 2: Operate the controlled lakes within the NOZ and LOZ to store water in the controlled lakes for release during summer drought periods to maintain a minimum flow discharge of 7 m^3/s below Ahmic Lake 95% of the time.

- Case 3: Operate the controlled lakes at a higher level during the summer period by raising the upper level of the summer NOZ and release the water stored within the new NOZ during drought period to maintain a minimum flow discharge of 7 m^3/s below Ahmic Lake 95% of the time.

8.3 Modeling of Operational Alternatives

The modeling of the operational alternatives for the Magnetawan River dams was performed using the ARSP computer model. The existing condition (Base Case) and each alternative strategy (Cases 1, 2 and 3) were modeled using 83 years of historical hydrologic data using the operational policies and demands to be tested. Performing the simulation with this extensive period of data gives a very accurate picture of the range of river discharges and water levels on the lakes that can be expected to occur under each strategy. The results produced by the program are a set of water levels and river discharges that would likely have happened in the past if the tested polices and demands had been imposed. Comparing the results of the simulations of different alternative strategies allows for a better understanding of the feasibility of implementing the different operational changes at the control dam.

8.3.1 Base Case

The Base Case model is a representation of the historical flows and water levels based on the present operating strategy for maintaining consistent water levels on the lakes. This simulation is similar to, but not an exact replication of the past operations. The model makes decisions based on the criteria provided, which may not exactly reflect the decision of the dam operators at the time.

The modeling for the Base Case was conducted based on the assumption that the dams would be operated to maintain the water level at the IRL[1], although in reality the operators will allow the water level to deviate from this line. During low flow periods, which are the periods of most interest, the water levels are held fairly close to the IRL. As well, during high river discharges the dams are operated to pass as much water as is physically possible through the structure(s); this discharge capacity is accurately modeled in ARSP. Thus, the model gives an accurate picture of the levels and flows that would occur during both low and high flow periods. This allows for an accurate comparison of the differences between the Base Case and the alternatives.

The IRL for all of the control dams follows a set annual pattern of draw down and filling. During the fall and winter, the lakes are drawn down to provide storage of spring runoff. This mode of operation is typical of most Ontario dams where the storage of spring runoff reduces flood discharges and therefore flood levels on the lakes and rivers downstream of each of the controlled dams. After the spring runoff, the IRL during the summer is set equal to the top of the stop logs and spillways for most of the lakes. Setting this level as the ideal level makes operations of the dams an easier task when the basin is experiencing low to average flows during the summer, since stop log operations would not be required unless a rainfall event creates enough runoff to raise the lakes above the NOZ.

For each of the controlled dams, the indicated operating ranges of High Water Level (HWL), upper operating, NOZ and LOZ are used by the model in an attempt balance the lake levels. Through the use of these ranges, the model has been setup to balance water levels such that it attempts to maintain all the controlled lakes within the same zone. One effect of this balancing is that the model will attempt to prevent a downstream lake from exceeding the HWL by restricting discharges from upstream dams. The discharge will be restricted until all upstream dams also reach their respective HWLs. Only after this condition has been satisfied will the model allow the HWL to be exceeded in the downstream dam. At Perry Lake for example, the HWL is exceeded on a number of occasions even when there is sufficient capacity in the discharge facilities to avoid going above the HWL. However, if Doe Lake is exceeding the HWL, the model causes the same to happen at Perry Lake. The model, and real operations, can only attempt to balance the lake levels. The characteristics of local inflows during high inflows will often make balancing impossible. The same balancing rules apply for the Low Water Levels (LWL).

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[1] The IRL or Ideal Regulated Level provides a target level within the NOZ that acts as a guide for dam operations but is not meant to represent ideal conditions. If lake water levels are tracking near the IRL then operators know that changes in stop log settings are not required. If lake water levels begin to deviate away from the line at a rapid rate, the operators know that stop log settings need to be changed.

The IRL for the spill dams (uncontrolled dams) was set to the weir crest level. This level tells the ARSP model to attempt to draw the lakes down to the crest level using the maximum discharge capacity of the weir as given in the rating curve for the structure. This explicitly models the actual water levels and downstream discharges for the spill dams because unlike the controlled dams, the model does not have to mimic any operator-guided stop log changes. The same strategy was used to model the naturally controlled lakes like Sand Lake and Trout Lake where the natural routing of flows through these lakes was required to calibrate the model.

For the Base Case, requested minimum flows, in terms of a specific ecological and/or social user demand(s) were not specified below any of the dams since no previous information exists to quantify these flows. However, most of the dams have stop log leakage that provides some release of water. These flows were modeled in ARSP by utilizing the model features for stop log structures. The flows were calculated using the assumption that 1.5 mm gap exists between each of the stop logs and this acts as an orifice to release water. The Bernard Lake dam has a valve that is used to control the discharge from the dam during periods of low flow. Since set minimum flow rates have not been established for the dam outflows, the valve was not explicitly modeled. Consequently, any discharge that occurred downstream of Bernard Lake during dry periods was assumed to be through stop log leakage.

8.3.2 Case 1 - Use Available Storage in Normal Operating Zone

For Case 1, the assumption was that the operations could be changed to force the water level up to the top of the NOZ during times of average to high flows through the summer recreation period. Thus, the full range of water that can be stored in the NOZ of Ahmic Lake and the lakes upstream would be available for release to enhance the minimum discharges below Ahmic Lake during low flow periods. This was modeled in ARSP by raising the IRL of all the controlled lakes to the top of the NOZ during the summer and is shown in Figure 8.1. The operating rules used for balancing the lake levels were not changed.

The main change from the Base Case model was the implementation of a minimum flow demand below Ahmic Lake. For Case 1, a minimum flow demand of 5 m^3/s was applied throughout the year. The only time of year that there is a problem with supplying this demand is during the summer recreation period, when it can be supplied only 95% of the time. The policy for this minimum flow demand was such that it could demand water from the NOZ's of Ahmic Lake and all lakes upstream. The lake level balancing rules would cause Ahmic Lake to be drawn on first and then each successive lake working upstream would be drawn on to meet the 5 m^3/s demand. Each lake would be drawn down to the bottom of their respective NOZ's to meet this minimum flow demand. Once all lakes were drawn down to the bottom of the NOZ's, the supply of water downstream of Ahmic Lake would be reduced to the sum of all the local inflows to the upstream basin minus the lake evaporation.

8.3.3 Case 2 - Use Available Storage in Normal Operating Zone and Lower Operating Zone

For Case 2, the IRL and the lake operating rules for balancing the lake levels were the same as for Case 1. The only change was an increase in the minimum flow water requirement from 5 to 7 m^3/s and the priority of the flow demand downstream of Ahmic Lake such that it could now draw on water from both the NOZ and the LOZ of the upstream lakes (refer to Figure 8.1). This operating policy combined with the lake balancing rules, results in a first draw down of each of the lakes to the bottom of the NOZ. Once all the lakes have been drawn down to this level, a further draw down into the LOZ will occur to meet the flow demand

8.3.4 Case 3 - Increase Range of Normal Operating Zone by 15 cm

For Case 3, the proposed operations would raise the upper level of the NOZ by 15 cm of Ahmic Lake and all the controlled lakes upstream, but maintain the lower level of the NOZ. This is shown in Figure 8.1. The operations of the dams would utilize the full range of water levels within the new NOZ of the lakes to store water for release of minimum flows during dry periods.

The operations would be changed to force the water level up to the top of the new NOZ during times of average to high flows during the summer period. During low flow periods the release of water from Ahmic Lake would be controlled to deliver 7 m^3/s by drawing down the lakes to release the water stored within the new NOZ.

8.4 Modeling Results

The modeling results of lake water levels and river discharges are graphed and discussed at each of the dams and at specific points of interest along the river system for each alternative operational strategy.

Changes in lake water levels are illustrated for all 83 years of simulation results along with statistical analysis of the weekly results. The statistical analysis is presented in graphs that display the maximum, minimum, mean, median, and the 90 and 10 percentile values. The maximum and minimum are self-explanatory, the median shows the mid-point where 50% of the flows are higher and 50% are lower than this value, and the mean is the average of the values from all the simulated years. A shaded bar shows the range of water levels that are typically experienced and presents the 90 and 10 percentile. Therefore, 80% of the levels that occur are within the shaded blue bar.

Changes in river discharges are depicted with flow duration curves. One graph for each dam location and other point of interests along the river system are used to illustrate and compare the effects of the alternative operating strategies.

8.4.1 Loon Lake (Pevensey Dam)

Figure 8.3 shows the water level results for Loon Lake and Figure 8.4 shows the water level statistics. The statistical graphs show very little change in the average water levels experienced on the lake for any of the alternatives.

For Case 1, the results show that raising the water level to the top of the NOZ (elevation 30.1 m) is not possible at Loon Lake because of the physical characteristics of Pevensey dam. The dam's spillwall crest is at elevation 29.95 m. Consequently, anytime the water level rises above this elevation it spills over the 18.3 m long spillwall. This limits the benefit of the Case 1 alternative. Under these conditions, stop log manipulations to the dam's single sluiceway have little effect on the resulting lake levels. Thus, the results for Case 1 show what would happen if the stop logs were not manipulated under normal flow conditions - only one event, during the Summer of 1957, was identified where removal of the stop logs was required. Thus, the adoption of this style of operation would reduce the number of stop log operations to almost zero during the summer and would provide a gradual release of water automatically controlled by the spillwall.

The results for Case 2 are similar to Case 1 since the spillwall is still releasing water whenever the water level on Loon Lake rises above 29.95 m. The only difference is that during the years with low summer flows, the lake is drawn down into the LOZ to as much as 0.30 m below the summer average lake level in order to supply water to the downstream river reaches. This occurred for 18 years of the 83 years simulated or, on average, once every 4.6 years. Given the marginal benefits of the flow increases (see below), this drop in lake level may be too great and too frequent an occurrence for the residents on Loon Lake.

The results for Case 3 are almost identical to Case 1. The only difference is caused by the slightly different demands from the influences of the downstream lakes that respond differently to their raised operating levels. If simulation runs were performed with identical demands downstream, while imposing Case 1 or Case 3 operations at Loon Lake, there would be no difference between the two sets of results. The only way to change this situation would be to raise the crest elevation of the spillwall on Pevensey dam. However, this would increase flood levels on the lake.

The recreation period flow duration curves for the river downstream of Loon Lake are illustrated in Figure 8.22a. For all three alternative strategies, there is very little change in the river discharges below Loon Lake for the very low drought flows up to 0.5 m^3/s. Notably, flow increases that do occur are for the higher summer flows above 0.6 m^3/s. This is evident by large inflection in the Base Case curve, which is not apparent for the alternative strategies. This is caused by the more steady release of water from Loon Lake with Cases 1 to 3 as water is steadily spilled over the spillwall. Although some minor low-flow augmentation benefits may be realized in the river reach immediately downstream of Loon Lake, none of the alternatives provide a measurable benefit to increase minimum drought flows on the river downstream of Ahmic Lake.

8.4.2 Perry Lake (Ayres Dam)

Figure 8.5 shows the water level results for Perry Lake and Figure 8.6 shows the water level statistics. The statistical graphs show that all of the alternative strategies would increase water levels on the lake throughout the summer recreation period. The modeling results indicate no increase in summer flood levels would occur with any of the alternatives. But, there is always the potential for an increase in flood levels when normal water levels are raised. The use of flood forecasting tools and safe management of dam operations during high-risk periods would alleviate these concerns.

The results for Case 1 show that raising the water level to the top of the NOZ (elevation 333.35 m) is not always achievable at Perry Lake because water will flow over the spillwalls on Ayres dam whenever the water level is above the spillwall crest elevation of 335.17 m. This limits the benefit of the Case 1 alternative. For Case 1, the summer water levels are typically 0.20 m above the levels in the Base Case, decreasing to about 0.10 m higher during the summer low flow period. During this period the lake level is sometimes drawn down to the bottom of the NOZ. This occurs only 9 times during the 83 years.

The results for Case 2 are similar to Case 1, but the lower operating range results in lower lake levels during droughts. The mean water levels for Case 2 are generally 0.10 to 0.20 m higher than the Base Case for the summer except for the mid-August to mid-September, when the mean levels are about the same as the Base Case. This is a result of the higher minimum flow demand (i.e., 7 vs 5 m^3/s) and lower range of operation into the LOZ. During drought periods, the lake is drawn down into the LOZ to 0.40 m below the Base Case summer lake level.

This occurs for 13 years of the 83 years simulated or, on average, once every 6.4 years. Given the marginal benefits of the flow increases (see below), this drop in lake level may be too great and too frequent an occurrence for the residents on Perry Lake.

The results for Case 3 are similar to Case 1, but the water levels are higher and there are more spills over the spillwalls because of the higher IRL. The full benefit of this strategy cannot be realized at this dam because of the spillwalls. To achieve the full benefit would require raising the crest elevation of the spillwalls on Ayres dam, which would increase flood levels on the lake.

The recreation period flow duration curves for the river downstream of Perry Lake are illustrated in Figure 8.22a. Cases 1 and 3 result in very little measurable change in the river discharges below Perry Lake, because of the effects of the spillwalls. Case 2 shows a slight increase in the discharges of only 0.1 m^3/s during the low flow periods. Although some minor low flow augmentation benefits maybe realized in the river reach immediately downstream of Perry Lake, none of the alternatives are seen as providing a significant measurable benefit to reduce drought problems on the river downstream of Ahmic Lake.

8.4.3 Doe Lake (Watts Dam)

Figure 8.7 shows the water level results for Doe Lake and Figure 8.8 shows the water level statistics. The statistical graphs show that all of the alternative strategies would result in a substantial increase in the average water levels experienced on Doe Lake. Any of the alternative strategies have the potential to increase summer flood levels if implemented. However, none of the alternatives would cause higher spring flood water levels, which are the worst conditions for this lake. The use of flood forecasting tools and safe management of dam operations would decrease the risks.

The results for Case 1 show that raising the water level to the top of the NOZ (elevation 294.4 m) provides a large amount of storage for release during drought periods. The spillwalls on Watts dam (elevation ±295.1 m) are higher than the NOZ so the full benefit of this alternative can be realized at this lake. The mean lake levels are close to the IRL, which is 0.45 m higher than the levels for the Base Case. This would alleviate the low water problems that otherwise cause restricted boat navigation between Little Doe and Doe Lakes, and between Little Doe Lake and the river during drought conditions. However, the higher NOZ would raise summer flood levels by 0.35 m and could possibly aggravate existing shoreline erosion problems on Doe Lake. Case 1 is still plausible for this lake, but increasing the IRL to as high as 294.4 m may not be acceptable for these reasons.

The results for Case 2 are about the same as Case 1 for the first part of the recreation season until mid-July. However, the increased minimum flow demand from 5 to 7 m^3/s and lower range of operation into the LOZ (elevation 293.5 m) result in mean water levels that are slightly higher than the Base Case level of 294.0 m in the latter part of the summer. For average years, acceptable navigation levels could be maintained for boat access through the shallow connecting channels on the lake; however during years with low flow, drawing down the lake levels to 293.5 m would severely restrict boat access in these areas[1]. This drawdown occurs for 23 years of the 83 years simulated or, on average, once every 3.8 years.

The results for Case 3 show that the implementation of this alternative on Doe Lake would substantially raise water levels during the summer, thus alleviating the low water problems on Doe Lake. However, the higher water levels for this case would increase summer flood levels by 0.35 m. The increase in summer flood levels for this case are the same as Case 1, but because of the higher starting level there is less chance that operators could react to reduce the risk.

The flow duration curve for river discharges downstream of Doe Lake during the recreation period are illustrated in Figure 8.22a. The results for all alternative cases indicate that Doe Lake can provide significant low-flow augmentation benefits because of the large amount of available storage on this lake. The effects of using the lake storage are very evident in the duration curves. Water in the high flow periods that was released in the Base Case is being stored in the lake. This is seen in the reduction of the high flows (5 to 20% exceedance). During the low flow periods (50 to 96% exceedance), the stored water is released thus increasing the flows above the Base Case. During extremely dry periods (96 to 100% exceedance) it would seem that drought period flows for the alternative cases are less than the Base Case. This is due to the model making weekly decisions such as releasing 2 m^3/s one week and then zero the next. Whereas, in reality, an operator would take into account long drought periods and provide a more gradual release of water.

8.4.4 Magnetawan River at Burk's Falls (Burk's Falls Dam)

The rules used by the power producer for setting the water levels at the Burk's Falls dam could not be modeled in ARSP. Therefore, a spreadsheet calculation outside of the model was performed to make an estimate of the water levels at the

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[1] The current lower limit of the NOZ is 293.8 m. The lowest summer water level recorded on July 18, 2001 on Doe Lake was 293.9 m. Reconnaissance of the boat channels at this time confirmed that boat access was still possible, but only for small boats. Any further lowering of the lake below 293.8 m would significantly restrict, if not completely eliminate, boat access through the shallow connecting channels.

dam based on the flow results obtained from the ARSP model. Figure 8.9 shows the estimated water levels and Figure 8.10 shows the water level statistics based on the 83 years of flow data.

The Burk's Falls dam is operated, but there are no Case 1, 2 or 3 operational alternatives possible for the dam because there is limited storage in the head pond to augment low flows and the requirement that the operators maintain the head pond level as high as possible, close to the IRL at all times to maximize power generation at the hydro facility. This means that the dam is operated as a run-of-the-river plant.

The statistical graphs show that there is no appreciable difference in average water levels throughout the year for all of the alternative strategies. A small increase of ±0.10 m in water levels is evident for all three cases during the mid-June to mid-September months. This is attributed to the increased minimum flows resulting from the operational changes to the Pevensey, Ayres and Watts dams located upstream.

Given that the alternative strategies at the upstream control dams would result in changes to the river discharges at the Burk's Falls small hydro facility, an examination of the potential effects to the power production were modeled. At most hydropower sites in Ontario, increasing minimum flows would have a negative impact on power production. But this is not the case at Burk's Falls since the facility is relatively undersized when compared to the available water. Thus, the shifting of high flows to low flows provides a slight benefit to the hydropower station because water that would have been spilled can now be used for power generation. Figure 8.9 shows power duration curves, which clearly depicts the overall increase in power production for each case. The increased minimum flows could also improve the aesthetic appeal of the flow of water over the Burk's Falls dam, addressing a concern that has been raised by the public.

The flow duration curve for river discharges at the Burk's Falls dam during the recreation period are illustrated in Figure 8.22a. Since the flows below Burk's Falls are the sum of the discharges from Watts dam and the North Magnetawan River, the results for all alternative cases are similar to, and reflective of the changes in flows below Watts dam (Figure 8.21a).

8.4.5 Bernard Lake (Bernard Lake Dam)

Figure 8.11 shows the water level results for Bernard Lake and Figure 8.12 shows the water level statistics. The statistical graphs show that all the alternative strategies will increase water levels on the lake throughout the recreation period. There is no indication in the results that there is potential for an increase in flood levels if Cases 1 or 2 were implemented; Case 3 would increase flood levels, because the IRL is at the lower limit of the High Water Zone.

The results for Case 1 show that raising the water level to the top of the NOZ (elevation 329.55 m) provides storage for release of minimum flows but provides no more storage than the Base Case during extreme drought periods. The mean lake levels during the recreation season start at the higher IRL, which is 0.10 m higher than the Base Case, but decrease to the same levels as the Base Case as the season progresses. This is a consequence of low summer inflows to the lake relative to the evaporative losses that occur. Thus, this alternative provides for more water to be released for minimum flows during average conditions, but has little effect during extreme dry periods.

The results for Case 2 are similar to Case 1, except that the lower operating range results in lower lake water levels during summer droughts. The mean water levels for Case 2 are almost identical to the Base Case in the latter part of the recreation period because the Base Case water levels typically dip into the LOZ at this time in the year. As with Case 1, this alternative provides for more water to be released for minimum flows during average conditions, but has little effect during extreme dry periods.

The results for Case 3 show that the implementation of this alternative on Bernard Lake would significantly raise water levels during the summer and provide usable storage for releasing water during extreme dry periods. The higher water levels also create the risk of increasing summer flood levels, although the results indicate no problem with historic floods.

The recreation period flow duration curves for Stirling Creek downstream of Bernard Lake are illustrated in Figure 8.22b. The figure shows that on average, Cases 1, 2 and 3 provide appreciably more water during the recreation period than the Base Case. But at the low end (80 to 100% exceedance) these alternatives are no different than the Base Case as Cases 1 and 2 provide no additional storage during the extreme drought periods as discussed above. Only the results for Case 3 show an increase in minimum flows during drought periods. These results indicate that the operational changes on Bernard Lake may not overly benefit the extreme drought flows downstream in Stirling Creek and in the Magnetawan River below Ahmic Lake. However, recognizing that Stirling Creek is prone to low, and at times, stagnant flow conditions, positive ecological effects to Stirling Creek are anticipated for the noted flow increases that are predicted.

8.4.6 Cecebe Lake (Magnetawan Dams)

Figure 8.13 shows the water level results for Cecebe Lake and Figure 8.14 shows the water level statistics. The statistical graphs show that there is very little change in the average water levels experienced on the lake for Case 1 and Case 2. The implementation of Case 3 would moderately raise average summer water levels by about 0.20 m.

The results for Case 1 show that raising the water level to the top of the NOZ (elevation 282.76 m) provides significant storage for release during drought periods. The mean summer lake levels are close to the IRL, which is 0.05 m higher than the levels for the Base Case. This increase may provide some benefits to the boaters on Cecebe Lake as it would increase water levels at the Magnetawan dam lock. The weekly water level results presented in the figures indicated that Case 1 may increase summer flood levels. A review of the detailed daily results from ARSP was prompted to confirm this finding as the weekly results do not provide peak levels unless the peak level occurs on the last day of the week. The daily water level results for this case show that the higher summer operating level would not raise summer flood levels.

The results for Case 2 indicate that Cecebe Lake can provide significant benefits because of the available storage on this lake. The results are about the same as Case 1 during the first part of the recreation season, up to late July. However, the higher minimum flow demand of 7 vs 5 m^3/s and lower range of operation into the LOZ (elevation 282.55 m) result in mean water levels that are slightly lower (0.05 m) than the Base Case in the latter part of the summer. During years with low flow, the lake is drawn down into the LOZ to 0.16 m below the Base Case summer lake level. This drawdown occurs for 25 years of the 83 years simulated or, on average, once every 3.3 years.

The results for Case 3 show that implementation of this alternative on Cecebe Lake would provide substantial storage. The spillwalls on the Main dam (elevation 282.70 m) and the East dam (282.71 m) would spill part of the flow when the level is maintained at the higher IRL (282.91 m). This type of operation may reduce the number of stop log changes on the dam since the large spillwalls would take care of small fluctuations in discharge without manipulation of the stop logs. The detailed daily results show that an increase in the summer levels would not increase summer flood levels since the dam has sufficient capacity to compensate for the increased starting level. Compared to the Base Case, this alternative would increase average water levels during the recreation season by 0.2 m for the months of May to July and 0.1 m for August to mid-October.

The flow duration curves for river discharges downstream of Cecebe Lake during the recreation period are illustrated in Figure 8.22b. The positive effects of using the available storage on Cecebe Lake are evident when comparing the duration curves for Cecebe Lake with the duration curves for Burk's Falls. The comparison shows a moderate increase in the minimum drought flows in the river below Cecebe Lake. For the 95% exceedance criteria, increases of approximately 1.1 m^3/s, 2.1 m^3/s, and 1.3 m^3/s are expected for Cases 1, 2 and 3, respectively.

8.4.7 Ahmic Lake (Feighens and Knoepfli Dams)

Figure 8.15 shows the water level results for Ahmic Lake and Figure 8.16 shows the water level statistics. The statistical graphs show that for Cases 1 and 2, there is very little change in the average water levels experienced on the lake in the late summer months. Case 3 will result in a greater change in the range of water levels, but the average water levels for late summer will not be substantially different than the Base Case.

The results for Case 1 show that raising the water level to the top of the NOZ (elevation 279.46 m) provides extensive storage for release during drought periods. The mean lake levels are close to the IRL, which is 0.05 m higher than the levels for the Base Case. This increase may provide some benefits to the boaters on Ahmic Lake as tailwater levels would increase at the Magnetawan dam lock. The higher operating level would not raise summer flood levels.

The results for Case 2 indicate that Ahmic Lake can provide significant benefits because of the additional lake storage available in the LOZ. The results are about the same as Case 1 during the first part of the recreation season up to mid-July. But, the higher minimum flow demand of 7 vs 5 m^3/s and lower range of operation into the LOZ (elevation 279.31 m) result in mean water levels in the latter part of the summer during August to mid-September that are slightly lower (0.02 m) than the Base Case. During years with low flow, the lake is drawn down into the LOZ to 0.10 m below the Base Case summer lake level. This occurs for 27 years of the 83 years simulated or, on average, once every 3.1 years.

The results for Case 3 show that implementation of this alternative on Ahmic Lake would provide a large amount of storage. The north spillwall on Feighens dam (elevation 279.4 m) would be spilling part of the flow when the level is being maintained at the higher IRL (elevation 279.61 m). This operating strategy may reduce the number of stop log changes on the dam, as the spillwall would take care of small fluctuations in discharge without manipulation of the stop logs. The results show that increasing the summer water levels would not increase summer flood levels as the dam has sufficient capacity to compensate for the increased starting level. Compared to the Base Case, this alternative would increase average water levels during the recreation season by 0.2 m for the months of May and June and by 0.1 in the latter part of the season.

The flow duration curves for river discharges downstream of Ahmic Lake during the recreation period are illustrated in Figure 8.22b. The positive effects of using the available storage on Ahmic Lake, combined with the contribution from the upstream lakes are evident from examination of the duration curves. As evident from the curves, there is a moderate increase in the minimum drought flows in the river downstream of Ahmic Lake. For the 95% exceedance criteria, increases of approximately 1.6 m^3/s, 3.6 m^3/s, and 3.5 m^3/s are expected for Cases 1, 2 and 3, respectively.

8.4.8 Wahwashkesh Lake (Wahwashkesh Lake Dam)

Figure 8.17 shows the daily water levels results for Wahwashkesh Lake and Figure 8.18 shows the water level statistics. Since the dam is a self-regulated weir there are no Case 1, 2 or 3 operational alternatives for this dam. However, since the alternative strategies at the upstream control dams/lakes result in changes to the river discharges at the Magnetawan damsite, graphs are provided for discussion purposes.

For all cases, the IRL shown in Figure 8.17 corresponds to the crest level of the overflow weir (elevation 224.67 m). Since the weir regulates the water levels on the lake, the IRL is a reference line rather than a regulated water level. Two of the years in the figure are highlighted, 1998 in black and 1928 in red. These 2 years show the range levels that can be expected from a wet year (1928) and a dry year (1998). The water levels on Wahwashkesh Lake exhibit much more variation than those on the controlled lakes; records indicate that the highest level in recent history was 228.3 m, which gives a fluctuation of 3.6 m on Wahwashkesh Lake compared to 1.4 m on Ahmic Lake. The level of Wahwashkesh Lake is established by the amount of flow over the weir, thus an increase in flow will cause an increase in water level.

The water level statistics for the cases are illustrated in Figure 8.18. This figure shows that Cases 1 through 3 will cause a small increase of 0.1 m in the 10 percentile and minimum summer levels compared to the Base Case. This is solely a consequence of the provision of increased minimum flows from the upstream control dams since no operation changes are proposed for the Wahwashkesh Lake dam. The predicted water level increase is expected to help improve low water levels on the lake during summer drought conditions, thereby providing a benefit to the users of Wahwashkesh Lake.

The recreation period flow duration curves for the river downstream of Wahwashkesh Lake are illustrated in Figure 8.22b. For the 95% exceedance criteria, Case 1 results in an increase in the minimum drought flows of about 1 to 2 m^3/s. The Cases 2 and 3 results show increases of 3 to 4 m^3/s, respectively. These results confirm that the increases in minimum flows from upstream will extend from Ahmic Lake to Wahwashkesh Lake and to the mid-lower river reaches.

8.4.9 Kashegaba Lake (Kashegaba Lake Dam) and Gooseneck Lake (Gooseneck Lake Dam)

Figure 8.19 shows the daily water levels and statistics on Kashegaba Lake and Gooseneck Lake. Only the Base Case results are presented, as the dams are self-regulated weirs and no Case 1, 2 or 3 operational alternatives are considered for these dams. Also, these lakes are off-line and are not subject to the flow changes resulting from the alternative strategies at the upstream control dams/lakes.

The IRLs shown in the figures correspond to the crest level of the overflow weir for Kashegaba Lake dam (elevation 99.7 m) and the top of the spillwall for Gooseneck Lake dam (elevation 29.81 m). The water levels on both lakes show the variation that is typical for an uncontrolled lake with an overflow weir. Two of the years in the figure are highlighted, 1998 in black and 1928 in red. These 2 years show the range levels that can be expected from a wet year (1928) and a dry year (1998). The results for Kashegaba Lake indicate that the highest water level was 100.5 m and the lowest was 99.7 m, a fluctuation of 0.8 m. The results for Gooseneck Lake indicate that the highest water level was 30.1 m and the lowest was 29.4 m, a water level fluctuation of 0.7 m. For both lakes, the simulations show a drop in summer water levels due to the lower inflows to the lakes and evaporative losses that occur during the recreation season. For Gooseneck Lake, the summer water levels drop below the IRL, indicative of the effects of relatively large lake evaporation versus summer inflows.

The recreation period flow duration curves for the tributary river reaches downstream of Kashegaba dam and Gooseneck dam are illustrated in Figure 8.22c. Only the Base Case flows are presented since there are no operational alternative cases for the dams.

8.4.10 Magnetawan River Flow Split (Trout Lake)

For the locations downstream of Wahwashkesh Lake, Figure 8.22c shows the flow duration curves below Trout Lake where the river splits into two branches, namely the Magnetawan River and the South Magnetawan River. Compared to the Base Case, the modeling results show that all of the cases result in an increase in the minimum low flows in the Magnetawan River branch below Trout Lake, but the South Magnetawan River branch experiences no such increase and in fact, a slight reduction to the mid-range flows occurs. This reduction is a consequence of the operational effects of the upstream control dams and the hydraulics associated with the Trout Lake flow split. The effect of the operational changes to the management of the upstream lakes for Cases 1 to 3, is a reallocation of water that increases the minimum flows, but reduces some of the mid-range flows. This is apparent in all of the flow duration curves to some degree. Examination of the flow duration curve for the Magnetawan River below Wahwashkesh Lake (Figure 8.22b) shows that for all cases, the mid-range flows above ±10 m^3/s are reduced and the minimum flows below this value are increased. Based on the hydraulic characteristics of the flow split at Trout Lake, diversion of water from the main branch into the South Magnetawan River only occurs when the inflow to Trout Lake exceeds ±12 m^3/s[1]. At flows below this value, no diversion of water into the south branch occurs. Since the noted increases to the minimum flows are below the 12 m^3/s diversion threshold they are not diverted to the South Magnetawan River. Rather, the increased flows remain in the main channel and are conveyed to the watershed outlet. Only the reduced mid-range flows above the 12 m^3/s diversion threshold are passed onto the South Magnetawan River. In addition, the percentage of time is also reduced when sufficient flow is available to cause diversion into the south branch. This reduction in turn, results in the slight reduction to the mid-range flow in the south branch. There is no change to the minimum drought flows for the 60 to 100% exceedance.

8.4.11 Harris Lake (Harris Lake Dams and American Trail Dam)

Figure 8.20 shows the water level results for Harris Lake and Figure 8.21 shows the water level statistics. These dams are self-regulated weirs therefore there are no Case 1, 2 or 3 operational alternative for these dams. Graphs are provided for discussion.

The IRL shown in the figure depicts the crest level of the Harris Lake overflow weir (elevation 202.4 m). The water levels on Harris Lake show the variation that is typical for an uncontrolled lake with an overflow weir. The level of Harris Lake is established by the amount of flow over four weirs (American Trail dam and three Harris Lake dams). Thus, an increase in flow on the South Magnetawan River branch, if one were to occur, would cause an increase in water level on Harris Lake.

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[1] Estimated value derived from surveyed cross sections of the two outlets from Trout Lake.

The water level statistics for the cases are illustrated in Figure 8.21. This figure shows that Cases 1 to 3 have no measurable effect on Harris Lake water levels. The lack of flow increase for the South Magnetawan River branch is due to the previously discussed characteristics of the flow split at Trout Lake, which prevents flows increases at Harris Lake.

The recreation period flow duration curves for the river downstream of the Harris Lake dam and American Trail dam are illustrated in Figure 8.22d. Cases 1 through 3 result in a slight decrease in average flows and no effect on minimum flows. No significant changes in the South Magnetawan River inflows to the lake due to the characteristics of the flow split at Trout Lake causes these results.

8.4.12 Magnetawan River at the Mouth

The modeling results have shown that the increase in minimum river flows will extend downstream to the mouth of the Magnetawan River at Byng Inlet for all cases. Figure 8.22d shows the recreation season flow duration curves for all the cases. The figure illustrates that all of the alternatives would significantly improve minimum flows during dry periods. The average increase in flows will be 1.5 m^3/s, 3.1 m^3/s, and 3.1 m^3/s for Cases 1, 2, and 3 respectively.

8.5 Development and Modeling of Fourth Operational Alternative: Case 4

Based on the findings of the modeling of the Case 1, 2 and 3 alternatives, it was evident that no single operational protocol would be appropriate for uniform application to all of the control dams. As discussed in Section 8.4, the benefits of some of the cases are not fully realized due to physical limitations at some of the dams. In other instances, certain cases would either raise the controlled lake level too much, possibly aggravating existing flooding and/or erosion conditions or would lower the lake level too much, possibly restricting boat navigation.

These aspects were reviewed and discussed with the Project Team, the MNR and the PAC. Input received from the MNR dam operators and the PAC provided important insight into the possible public reaction from the various lake and river users situated on the system. This input was used to assist the Project Team’s understanding of what amount of flow and/or water level change might be acceptable to most users, given that some amount of change will be necessary to meet the objectives of the Water Management Plan. Accordingly, for the reasons noted, a fourth alternative – Case 4 was developed and is discussed herein.

Case 4 was developed by refining the operational zones for each of the control dams on a lake-by-lake basis by recognizing the operational constraints and limitations identified from the simulation results for Cases 1 to 3 and by considering the input received from MNR and the PAC. The basic premise for setting the operating levels for each of the controlled dams/lakes was to allow a 0.30 m fluctuation in water level during the summer recreation season. Typically the water level would fluctuate between 0.25 m below the IRL and 0.05 m above the IRL. With the operating levels set, a series of model simulations were processed to determine the allowable discharge demand downstream of Ahmic Lake using the 95% reliability criteria. Results from these simulations indicated that a discharge of 6 m^3/s could be provided downstream of Ahmic Lake.

The development of the Case 4 operational alternative was comprised of the following components:

- Loon Lake (Pevensey dam) – Modified Case 1
- Perry Lake (Ayres dam) – Modified Case 1
- Doe Lake (Watts dam) – Modified Case 1
- Magnetawan River (Burk's Fall dam) – Base Case Operation Unchanged
- Bernard Lake (Bernard Lake dam) – Modified Case 1
- Cecebe Lake (Magnetawan dams) – Modified Case 1 / Case 2
- Ahmic Lake (Feighens and Knoepfli dams) – Modified Case 1 / Case 2
- Wahwashkesh Lake (Wahwashkesh Lake dam) – Non-Operable, No Changes
- Kashegaba Lake ((Kashegaba Lake dam) – Non-Operable, No Changes
- Gooseneck Lake (Gooseneck Lake dam) – Base Case Operation Unchanged
- Harris Lake (Harris Lake and American Trail dams) – Non-Operable, No Changes.

With these established operating levels, an analysis was performed to review spring flooding within the basin. This analysis involved adjusting the IRL during the spring freshet period to determine if changes could be made that would reduce high water levels on the lakes. The analysis showed that starting at low lake levels prior to the freshet was the only management practice that would effect high water levels. This is the current operating strategy on the lakes, thus very little improvement could be realized from the Base Case operations other than to lower the starting lake levels below the existing levels given by the Base Case IRL. Also, no benefits to downstream areas were realized by holding back water in Loon, Perry, and Bernard Lakes since the inflows to these lakes are relatively small. Thus balancing water levels in these upper lakes was not part of the Case 4 alternative and the frequency of high levels was reduced on these three lakes. To reflect the current operating strategy of maintaining low water levels until the freshet, the IRL was adjusted during the spring freshet period for Case 4. One of the adjustments involved extending the time period for maintaining the low water level so that the simulation would not prematurely raise the water level at the dams. Other adjustments to the IRL are illustrated in the water level plots for each lake, and are discussed in the following sections.

8.5.1 Loon Lake (Pevensey Dam)

The operating levels for the Case 1 alternative were adopted for Loon Lake, but were revised by changing the IRL from 29.95 m to 30.05 m during the summer recreation period. Neither the top nor bottom of the NOZ were changed, nor were the operating levels through the remainder of the year. Figure 8.24 shows the operating rules established for Loon Lake. Since the use of the storage in Loon Lake provided little benefit to the flows downstream of Ahmic Lake, the storage in Loon Lake would be used only to enhance flows directly downstream of Loon Lake. A minimum weekly flow demand of 0.2 m^3/s was established below Loon Lake for this objective. Flows would also increase farther downstream, but only as a secondary benefit.

Figure 8.24 also shows the results from the Case 4 ARSP model simulation. The water levels for the 83 years of results, the water level statistics, and the flow duration curve for the river discharges below Loon Lake are presented. A comparison of the results to the Base Case shows little change in the average summer water levels experienced on the lake (0.01 m increase) and a small increase in river discharges below Loon Lake.

Based on the simulation results, there are no apparent flooding problems on this lake since the inflows are small compared to the lake area. Thus, the water levels can be raised as the spring freshet occurs to store water for the coming recreation season.

8.5.2 Perry Lake (Ayres Dam)

The operating levels for the Case 1 alternative were adopted for Perry Lake, but were revised by changing the lower bound of the NOZ from 335.00 to 335.05 m during the summer recreation season. The IRL was changed from 335.14 m to 335.30 m. for the summer season up to September 1. After September 1, the IRL is gradually brought back down to its Base Case level of 335.15 m by October 14 to reduce potential flood problems in the fall. Figure 8.25 shows the operating rules established for Perry Lake. Since the use of the storage in Perry Lake provided little benefit to the flows downstream of Ahmic Lake, the storage in Perry Lake would be used only to enhance flows directly downstream of Perry Lake. A minimum weekly flow demand of 1.1 m^3/s was established below Perry Lake to achieve this objective. Flows would be increased farther downstream, but only as a secondary benefit. Figure 8.25 also shows the results from the Case 4 ARSP model simulation. The water levels for the 83 years of results, the water level statistics, and the flow duration curve for the river discharges below Perry Lake are presented.

A comparison of the results to the Base Case shows there is a 0.08 m increase in the average summer water levels experienced on the lake and an improvement to the minimum flows in the river downstream. By not balancing the high water levels on Perry Lake during the spring freshet, the frequency of high water levels is reduced.

8.5.3 Doe Lake (Watts Dam)

The operating levels for the Case 1 alternative were adopted for Doe Lake, but were revised by changing the lower bound of the NOZ from 393.80 m to 293.90 m during the summer recreation season. The IRL was changed from 293.95 to 294.20 m during the summer season up to September 1. After September 1, the IRL is gradually brought back down to its Base Case level of 293.95 m by October 14 to reduce potential flood problems in the fall. Figure 8.26 shows the operating rules established for Doe Lake.

Figure 8.26 also shows the results from the Case 4 ARSP model simulation. The water levels for the 83 years of results, the water level statistics, and the flow duration curves for the river discharges below Doe Lake are presented. A comparison of the results with the Base Case shows a 0.20 m increase in the average summer water levels on the lake and a minor increase in drought period flows downstream of Watts dam**.**

None of the modifications resulted in a reduction of the spring high water levels on Doe Lake. These high levels are a result of the naturally restricted capacity of the Magnetawan River below Watts dam, which reduces the ability to pass high flows through the structure.

8.5.4 Magnetawan River at Burk's Falls (Burk's Falls Dam)

The upstream head pond associated with the Burk's Falls dam has no useable storage, therefore no Case 4 operational alternative for this control dam could be developed. Figure 8.27 shows the predicted range in water levels at the dam, along with the power generation curve compared with the Base Case. With the increase in minimum flows from upstream, the power generation curve for Case 4 exhibits an increase at the existing Burk's Falls hydro facility.

8.5.5 Bernard Lake (Bernard Lake Dam)

The operating levels for the Case 1 alternative were adopted for the Bernard Lake, but were revised by raising the top of the NOZ was from 329.55 m to 329.60 m during the summer recreation season. From mid-March to mid-April, the IRL was dropped to 328.95 and the lower bound of the NOZ was changed from 328.95 m to 328.90 m to help reduce spring flood levels on the lake. In addition, the IRL was raised from 329.45 m to 329.55 m for the summer period. Figure 8.28 shows the operating rules established for Bernard Lake. Since the use of the storage in Bernard Lake provided little benefit to the minimum flows downstream of Ahmic Lake, the storage in the lake would only be used to enhance flows directly downstream in Stirling Creek. A minimum weekly flow demand of 0.2 m^3/s was established below Bernard Lake for this objective. This aspect of the Case 4 operating strategy is already in place at Bernard Lake through minimum flow releases from the stop logs and the valve**.**

Figure 8.28 also shows the results from the Case 4 ARSP model simulation. The water levels for the 83 years of results, the water level statistics, and the flow duration curve for the river discharges below Bernard Lake are presented. A comparison of the results to the Base Case shows that there is a 0.05 m increase in the average summer water levels experienced on the lake and a slight improvement to the minimum flows in the river downstream.

The effect of lowering the starting water level before the spring freshet can be seen in Figure 8.28. Comparison with the Base Case shown in Figure 8.11, shows both the magnitude and frequency of high water levels on Bernard Lake during the spring freshet have been effectively reduced.

8.5.6 Cecebe Lake (Magnetawan Dams)

Cases 2 and 3 alternatives were combined to provide the 0.3 m range in operation for Cecebe Lake. The top of the NOZ was raised from 282.76 m to 282.90 m and the bottom of the NOZ was lowered from 282.66 m to 282.60 m during the summer recreation season. The IRL was raised from 282.71 m to 282.85 m for the summer period up to September 1. After September 1, the top level of the NOZ and the IRL were gradually lowered to their existing Base Case levels by October to reduce potential flood problems in the fall. In addition, the IRL was adjusted during the spring freshet to reflect an operating policy of maintaining water levels low until the freshet. Figure 8.29 shows the operating rules established for Cecebe Lake.

Figure 8.29 also shows the results from the Case 4 ARSP model simulation. The water levels for the 83 years of results, the water level statistics, and the flow duration curve for the river discharges below Cecebe Lake are presented. A comparison of the results with the Base Case shows a 0.08 m increase in the average summer water levels experienced on the lake and an improvement to the minimum flows in the river downstream.

The effect of adjusting the IRL during the spring can be seen in Figure 8.28. Comparison with the Base Case shown in Figure 8.14, shows that the magnitude of the spring flood level is not altered as the lake is currently operated in this manner. The frequency of some of the lower magnitude flood events is reduced.

8.5.7 Ahmic Lake (Feighens and Knoepfli Dams)

The 0.3-m operating range on Ahmic Lake is provided by adopting Cases 2 and 3 in Case 4. The top of the NOZ was raised from 279.46 m to 279.60 m and the bottom was lowered from 279.36 to 279.31 m for the summer recreation season. The IRL was raised from 279.41 m to 279.56 m for the summer period up to September 1. After September 1 the top level of NOZ and the IRL are gradually lowered to their existing Base Case levels by October to reduce potential flood problems in the fall. In addition, the IRL was adjusted during the spring freshet to reflect an operating policy of maintaining low water levels until the freshet. Figure 8.30 shows the operating rules established for Ahmic Lake.

Figure 8.30 also shows the results from the Case 4 ARSP model simulation. The water levels for the 83 years of results, the water level statistics, and the flow duration curve for the river discharges below Ahmic Lake are presented. Comparing the results with the Base Case shows that there is a 0.07 m increase in the average summer water levels experienced on the lake and the minimum flows in the river downstream are greatly improved.

The effect of adjusting the IRL during the spring can be seen in Figure 8.28. Comparison with the Base Case shown in Figure 8.15 shows that neither magnitude nor frequency of the spring flood levels are altered as the lake is already operated in this manner.

8.5.8 Wahwashkesh Lake (Wahwashkesh Lake Dam)

The dam on Wahwashkesh Lake is a spill dam, thus there are no changes to the operations at this lake. The level of Wahwashkesh Lake is established by the amount of flow over the dam, thus an increase in flow causes an increase in water level. The water level statistics for Case 4 are illustrated in Figure 8.31. The figure shows a small increase in the 10 percentile and minimum summer levels, corresponding to a water level increase of 0.1 m. The provision of increased minimum flows from the upstream control dams will provide a small, but measurable benefit, of increased water level to the users of Wahwashkesh Lake.

The recreation period flow duration curves in the river downstream of Wahwashkesh Lake for Case 4 and the Base Case are also illustrated in Figure 8.31. Case 4 results in an increase in the minimum drought flows of about 1.8 m^3/s on average. These results show that increases in minimum flows from upstream will extend from Ahmic Lake to Wahwashkesh Lake and to the mid-lower river reaches.

8.5.9 Kashegaba Lake (Kashegaba Lake Dam) and Gooseneck Lake (Gooseneck Lake Dam)

Kashegaba Lake and Gooseneck Lake are controlled by self-regulated spill dams, therefore Case 4 operational alternatives were not developed. The dams are also located off-line from the main river, thus flow changes associated with the upstream control dams have no effect on lake levels or river discharges on either of these lakes. Consequently, no figures are provided other than the Base Case graphs, previously shown in Figure 8.19.

8.5.10 Magnetawan River Flow Split (Trout Lake)

The Case 4 modeling results are the same as the previous cases where the increase in minimum flows occur only on the main branch of the Magnetawan River. Figure 8.32 shows the duration curves for flow into Trout Lake and the two outlets, Magnetawan River and South Magnetawan River.

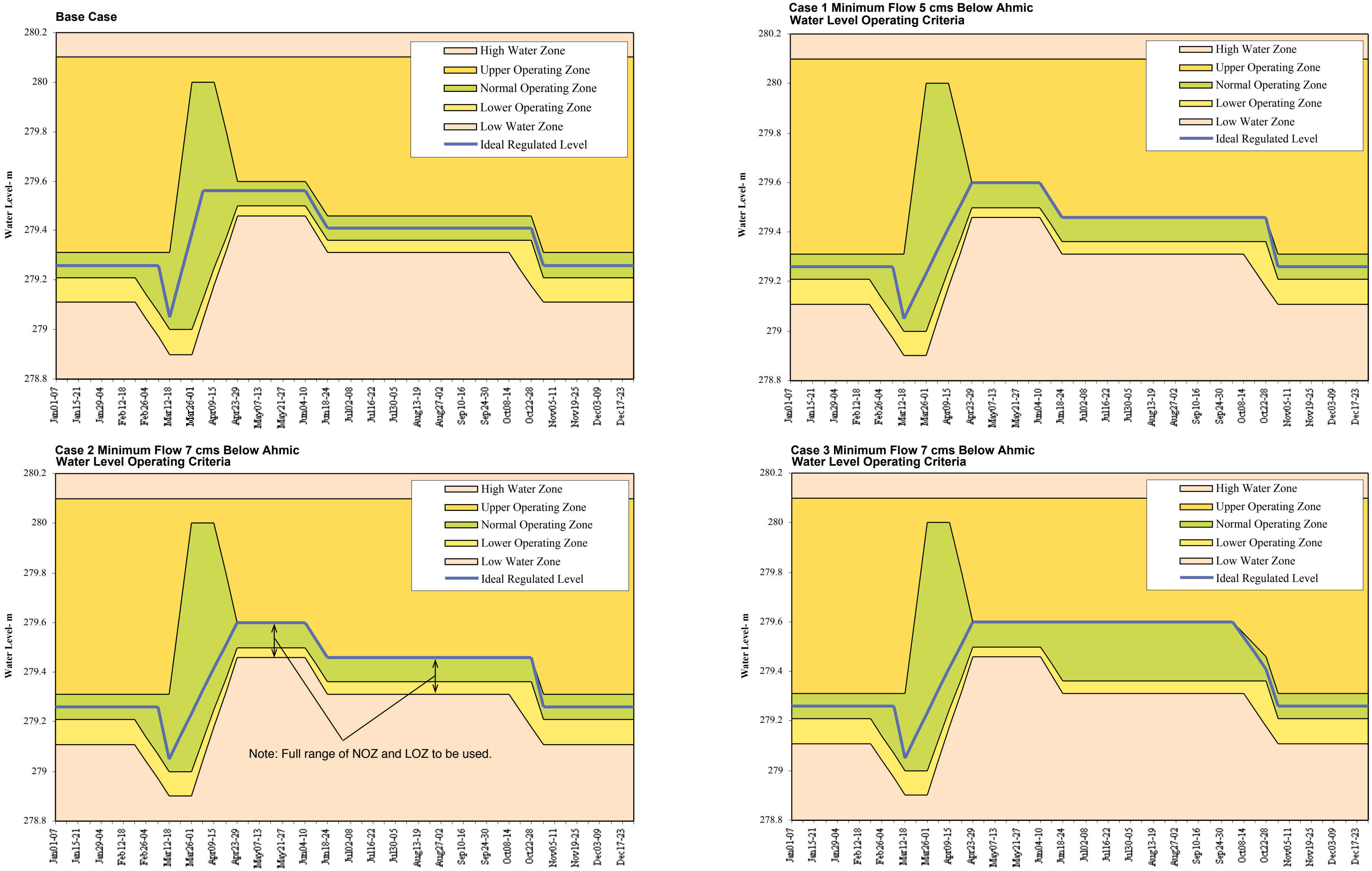
Management of flows during the spring freshet period in Case 4 seems to have mitigated the slight decrease in minimum flows that was indicated for Cases 1 to 3 (refer to Sections 8.4.10 and 8.4.11). The figure shows that Case 4 results in a slight increase in the recreation season low flows to Trout Lake, and to the Magnetawan River below Trout Lake. However, the south branch experiences very little change in the diversion flows. It is hard to verify this since the modeling of the flow split at Trout Lake is a rough estimate of this phenomenon. Based on what is known about the flow split characteristics, the change in flows to the South Magnetawan River is so small that it is less than the accuracy of the model, but the modeling clearly indicates that the change would be imperceptible to the users of the South Magnetawan River and Harris Lake. To accurately verify these findings, a more thorough study of the flow split characteristics would have to be done.

8.5.11 Harris Lake (Harris Lake Dams and American Trail Dam)

No operational changes are proposed for these self-regulating dams, therefore Case 4 alternatives were not developed for these dams. Figure 8.33 shows the water level and flow duration effects on Harris Lake resulting from the Case 4 operational changes on the upstream control dams. The figure shows that Case 4 has no measurable effect on Harris Lake water levels because of the previously discussed characteristics of the flow split at Trout Lake.

8.5.12 Magnetawan River at the Mouth

The Case 4 modeling results have shown that the increase in minimum river flows will extend downstream to the mouth of the Magnetawan River at Byng Inlet. Figure 8.32 shows the recreation season duration curves for the Base Case and Case 4. As shown in the duration curve for the recreation season, the alternative operating strategy would substantially improve minimum flows during dry periods.


Base Case

Case 1 Minimum Flow 5 cms Below Ahmic
Water Level Operating Criteria

Case 2 Minimum Flow 7 cms Below Ahmic
Water Level Operating Criteria

Note: Full range of NOZ and LOZ to be used.

Case 3 Minimum Flow 7 cms Below Ahmic
Water Level Operating Criteria

Figure 8.1
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan

Alternative Water Management Strategies for Magnetawan River Control Dams

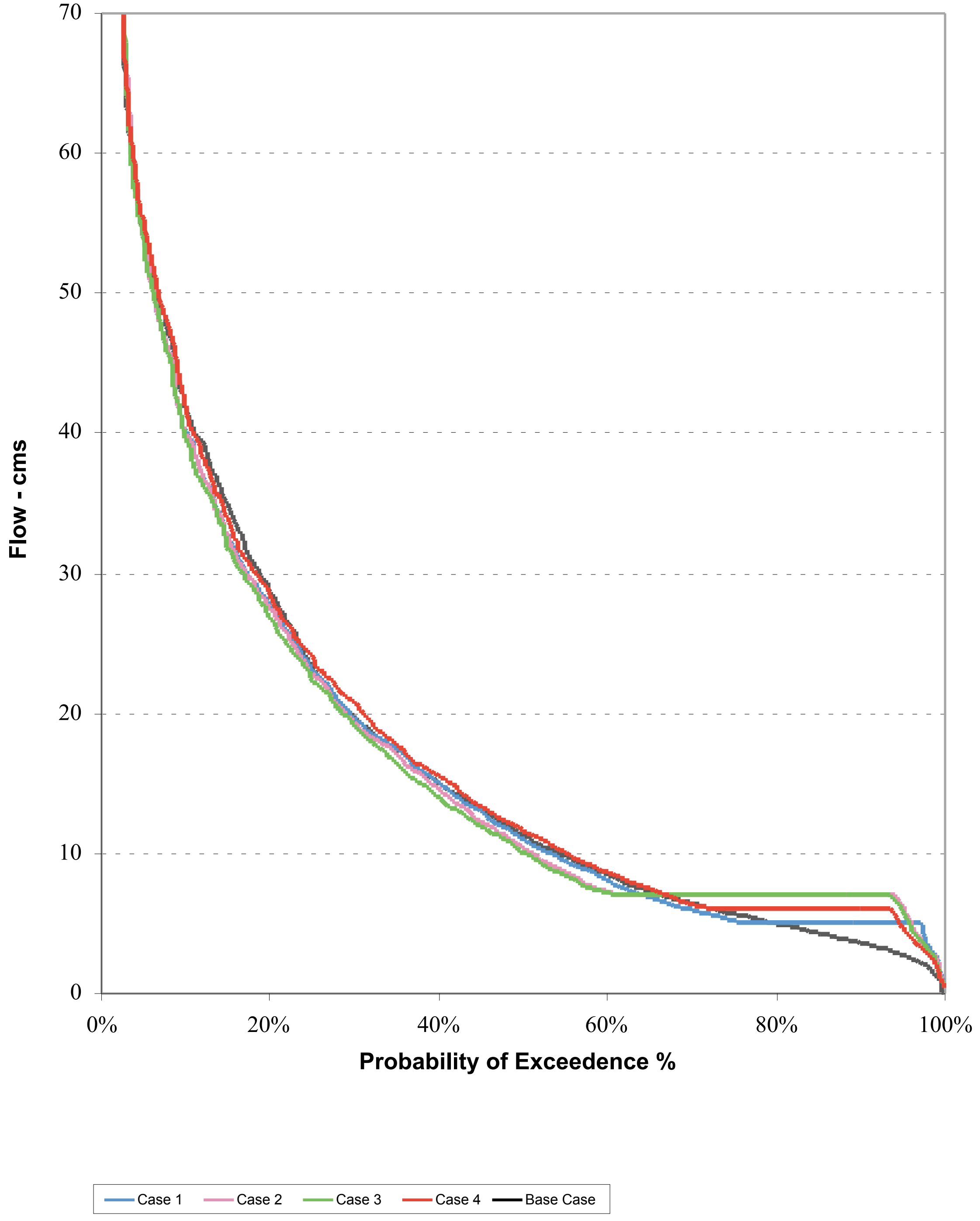
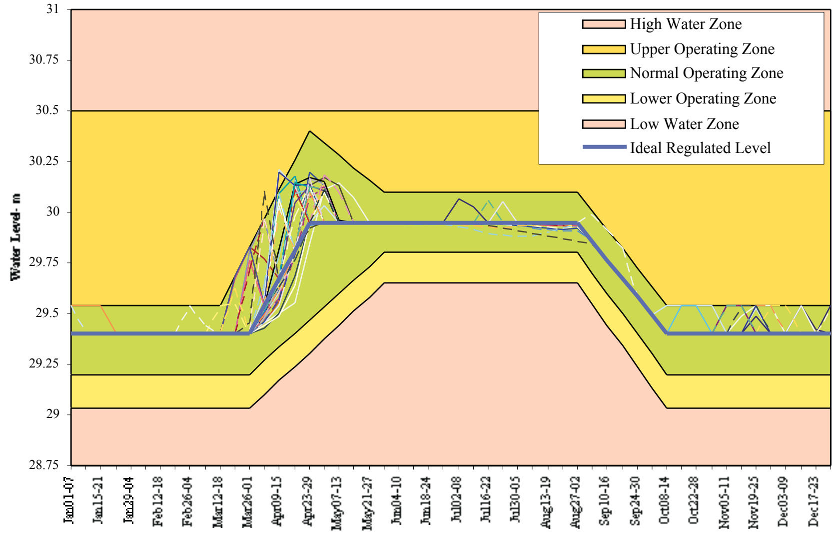
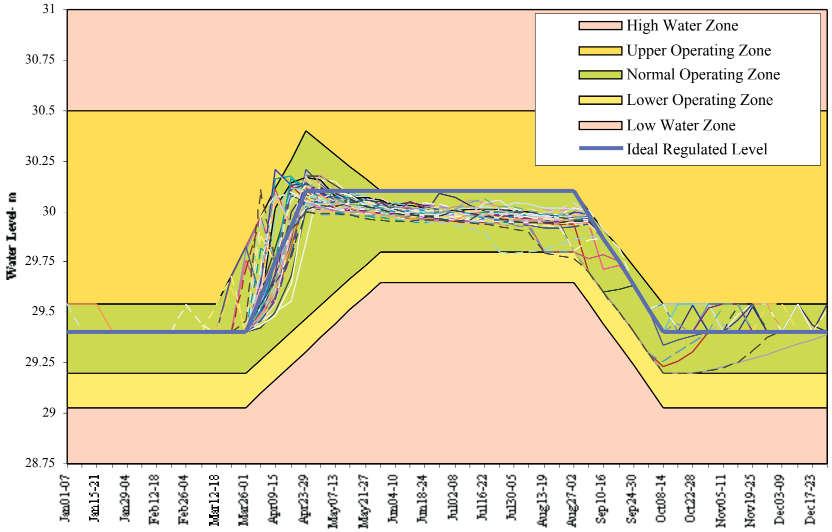


Figure 8.2
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Magnetawan River Below Ahmic Lake Flow Duration Curves

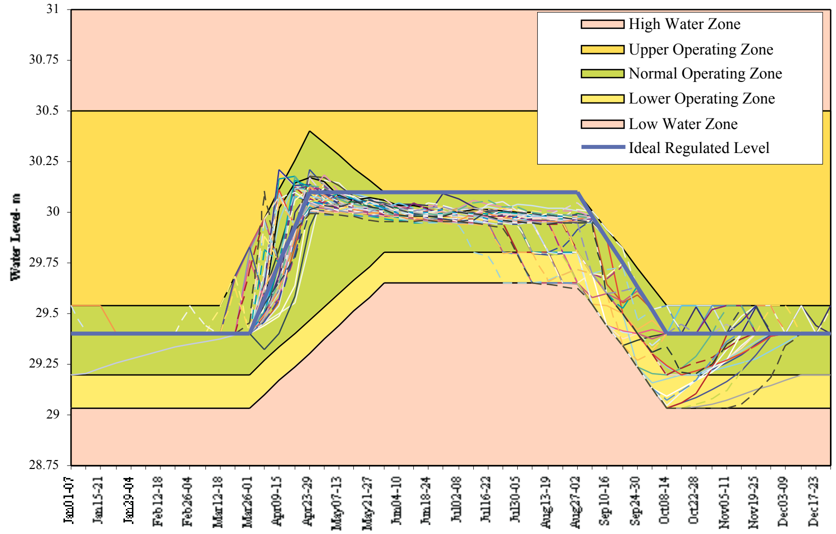
Base Case



Case 1 Minimum Flow 5 cms Below Ahmic Lake



Case 2 Minimum Flow 7 cms Below Ahmic Lake



Case 3 Minimum Flow 7 cms Below Ahmic Lake

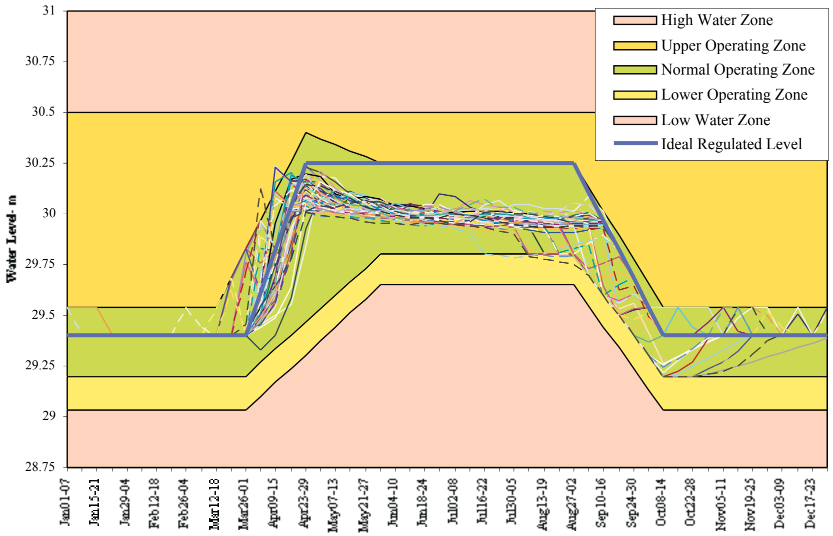
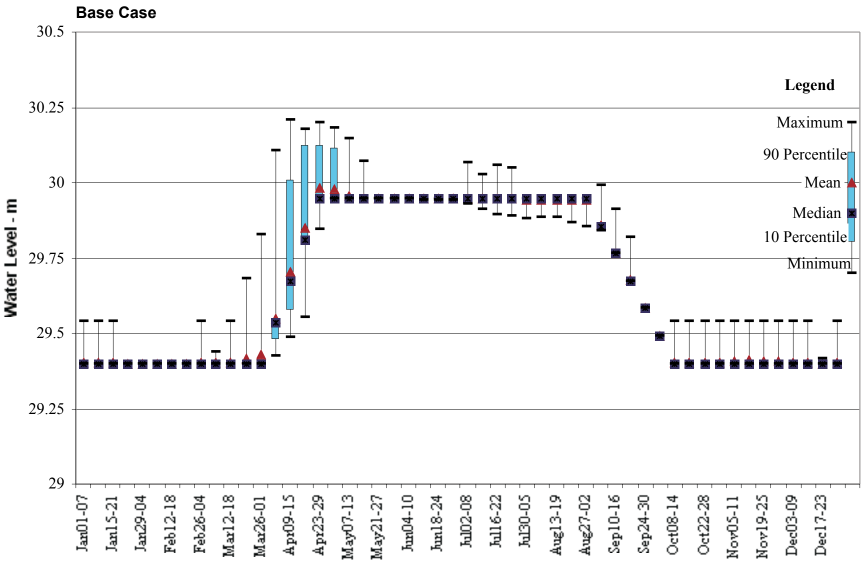
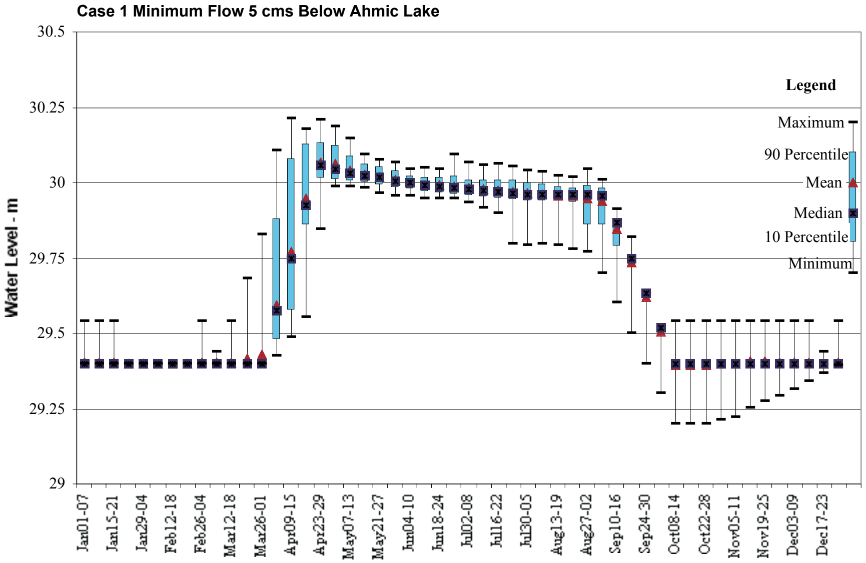
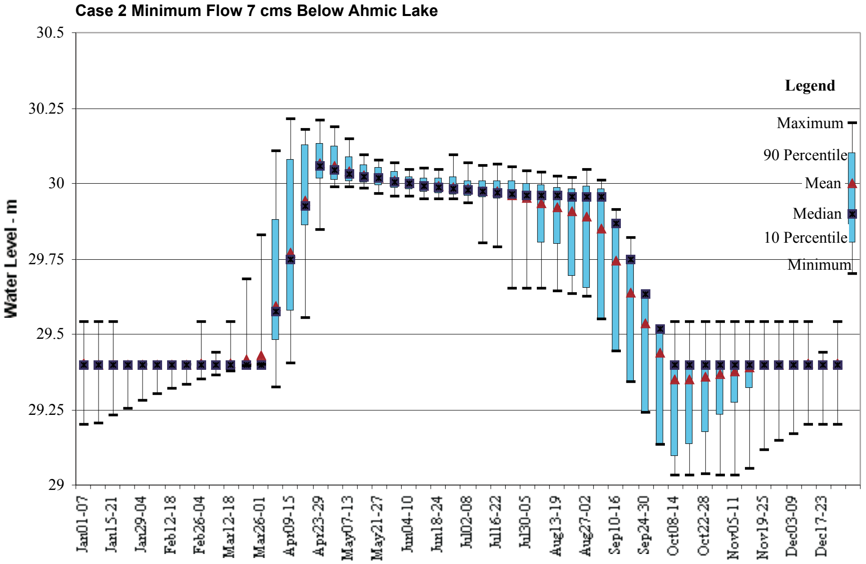


Figure 8.3
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 - Loon Lake (Pevensey Dam)

ACRES International


Base Case


Case 1 Minimum Flow 5 cms Below Ahmic Lake


Case 2 Minimum Flow 7 cms Below Ahmic Lake

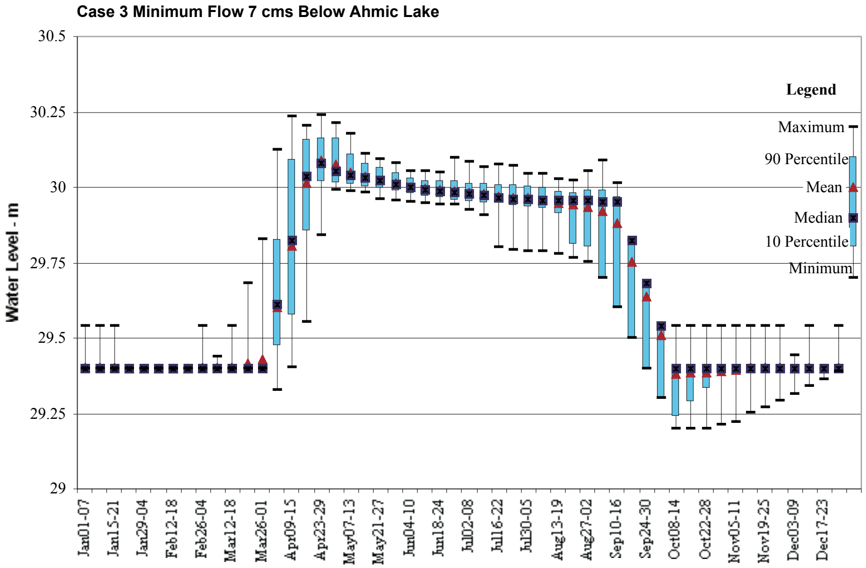
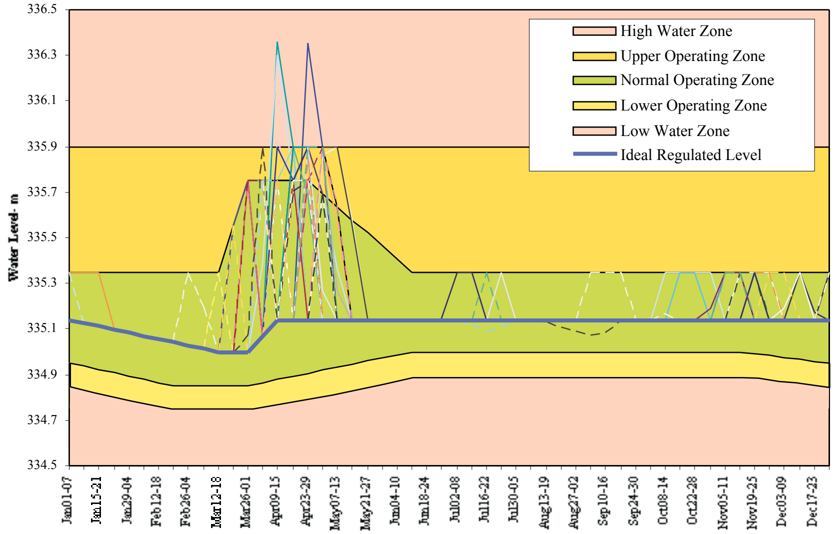

Case 3 Minimum Flow 7 cms Below Ahmic Lake

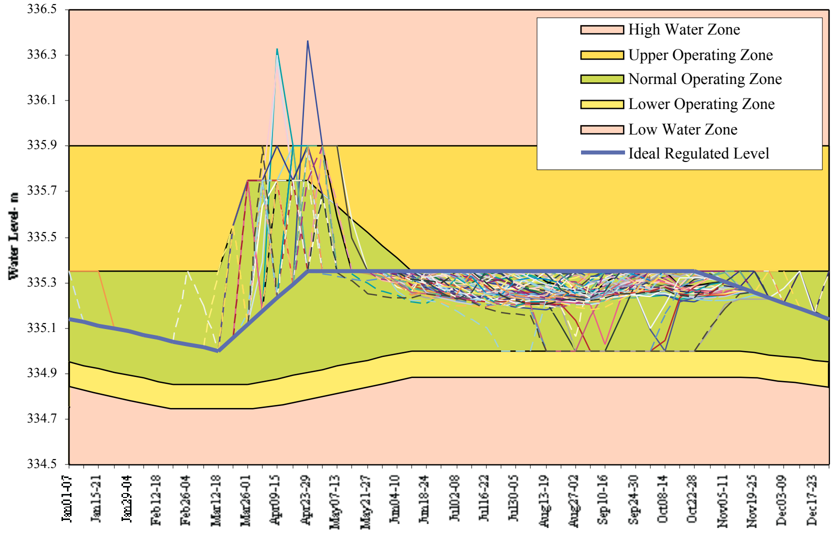
Figure 8.4
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan

Weekly Water Level Statistics - Loon Lake (Pevensey Dam)

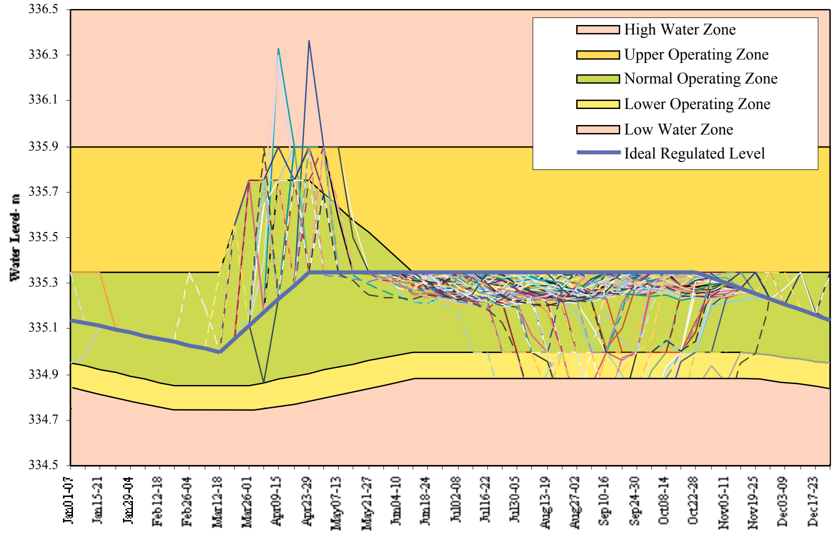
Base Case



Case 1 Minimum Flow 5 cms Below Ahmic Lake



Case 2 Minimum Flow 7 cms Below Ahmic Lake



Case 3 Minimum Flow 7 cms Below Ahmic Lake

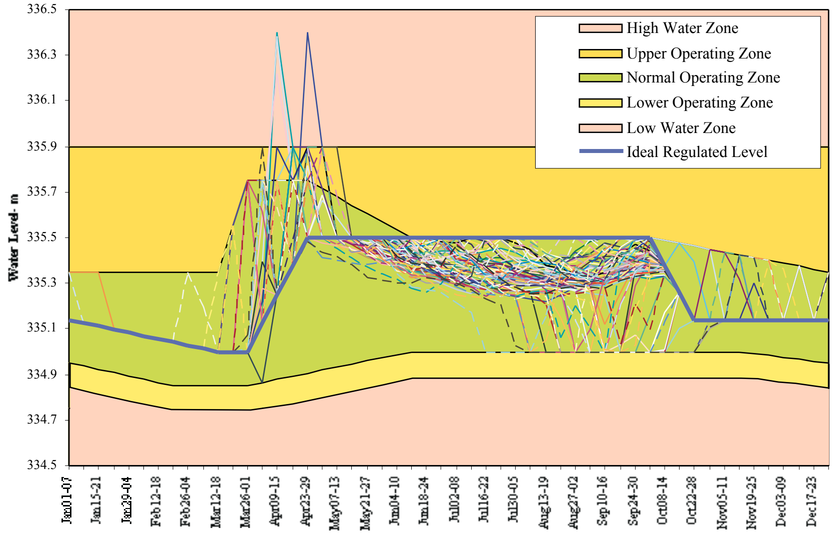
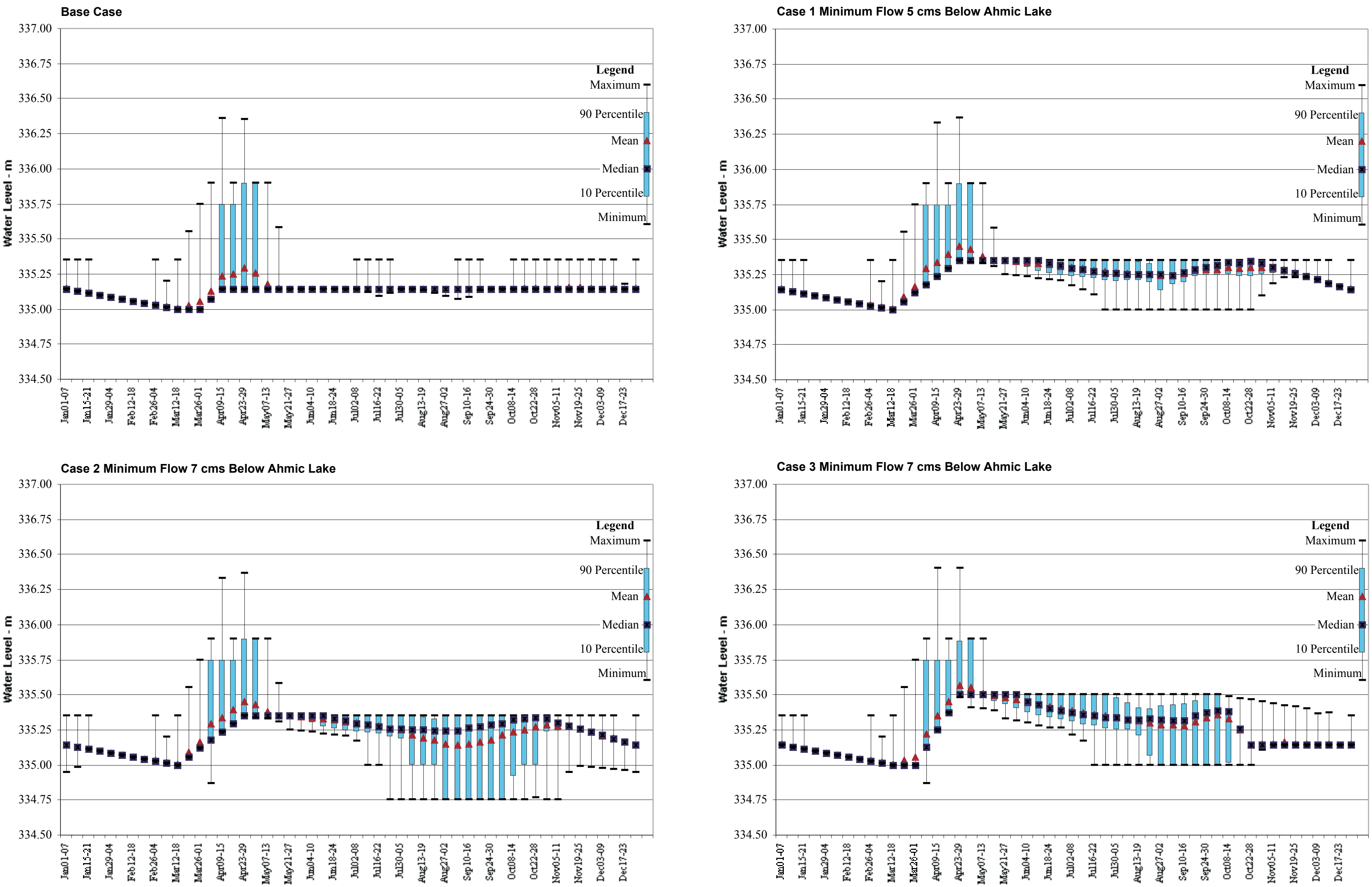


Figure 8.5
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 - Perry Lake

ACRES
International


Base Case

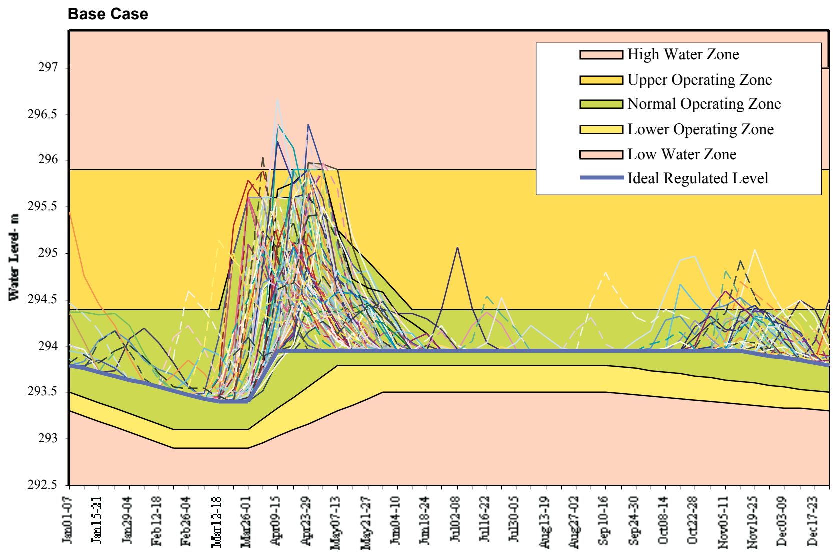
Case 1 Minimum Flow 5 cms Below Ahmic Lake

Case 2 Minimum Flow 7 cms Below Ahmic Lake

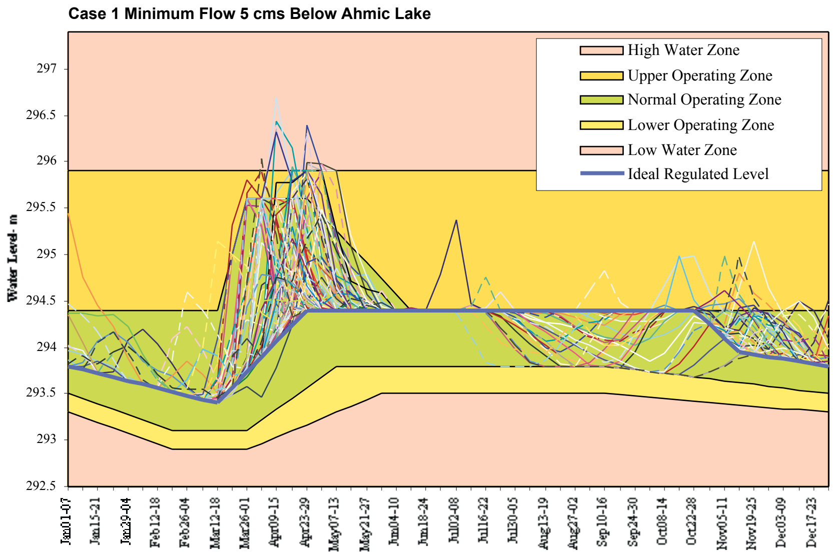
Case 3 Minimum Flow 7 cms Below Ahmic Lake

Figure 8.6
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Level Statistics - Perry Lake

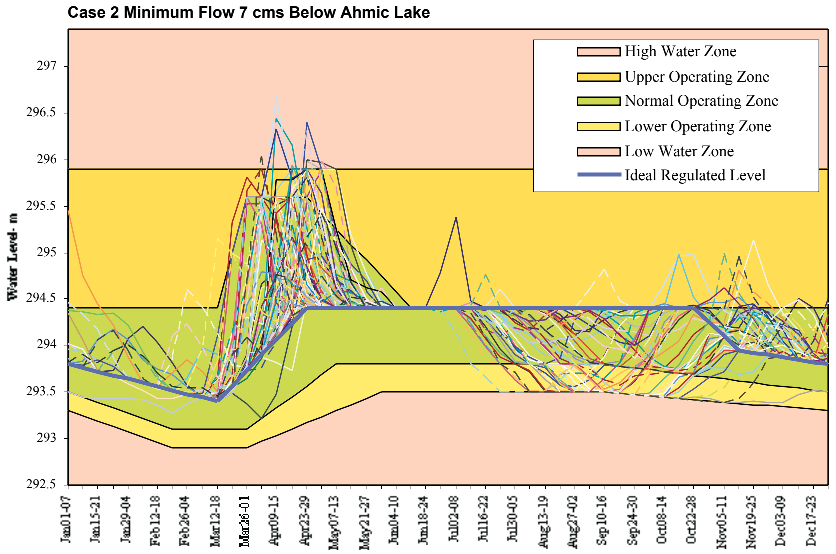
ACRES International



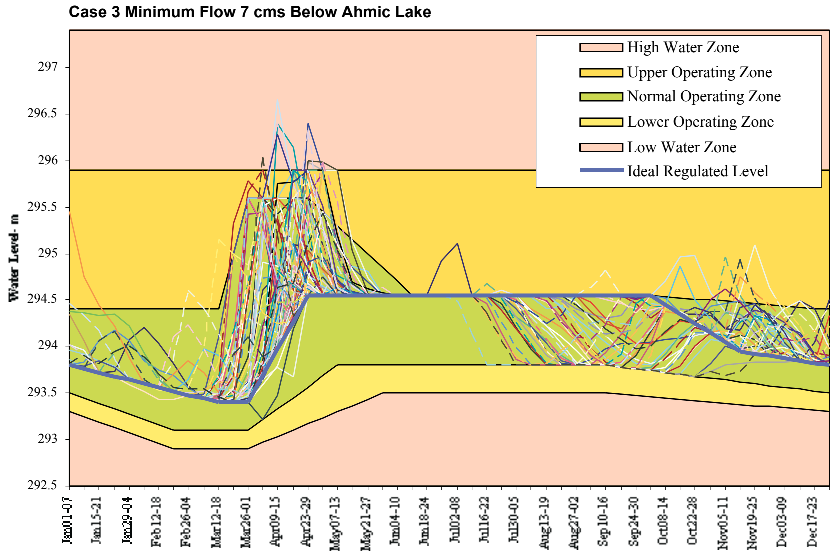
Base Case



Case 1 Minimum Flow 5 cms Below Ahmic Lake

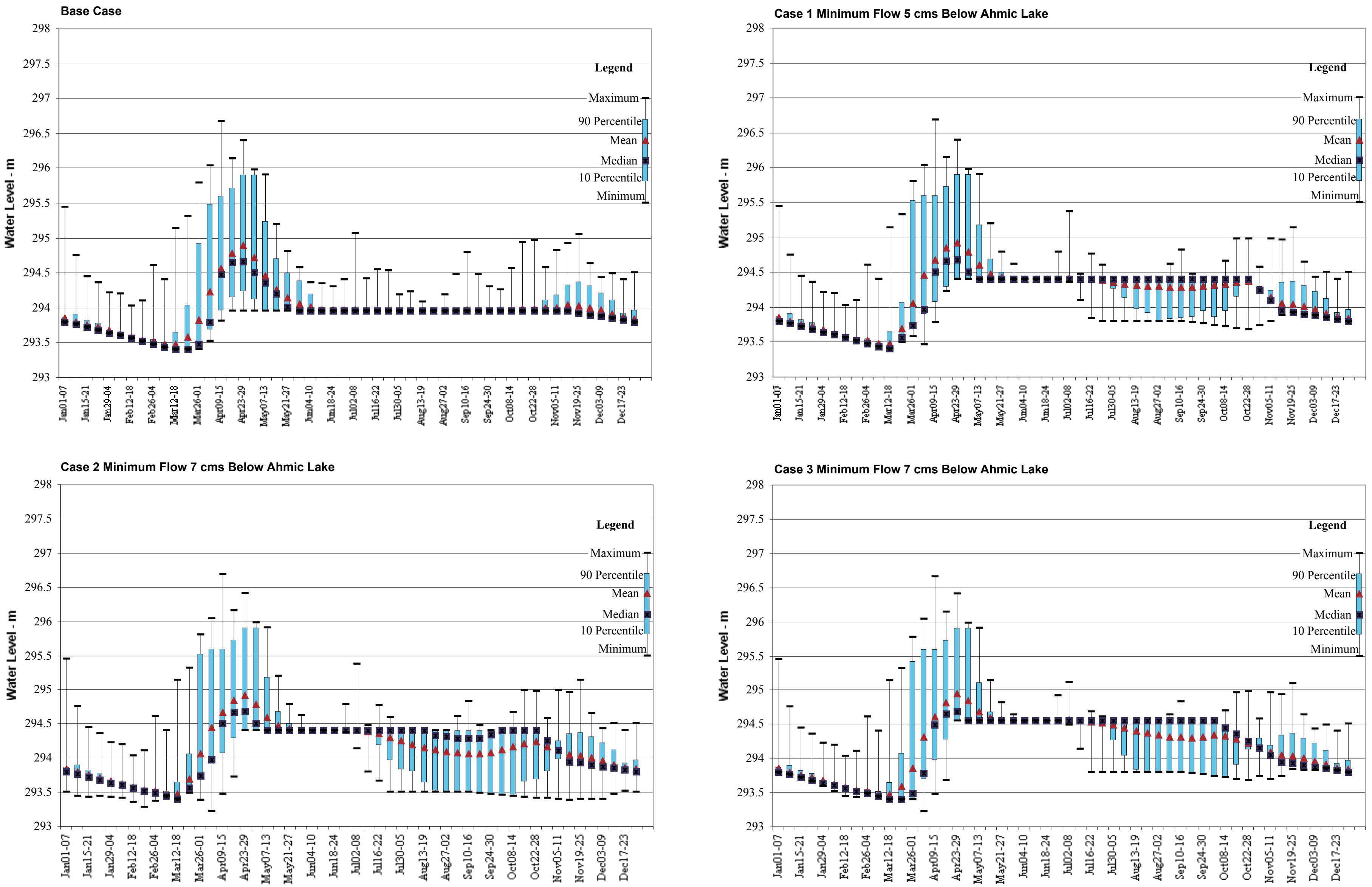


Case 2 Minimum Flow 7 cms Below Ahmic Lake



Case 3 Minimum Flow 7 cms Below Ahmic Lake

Figure 8.7
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 - Doe Lake



Base Case

Case 1 Minimum Flow 5 cms Below Ahmic Lake

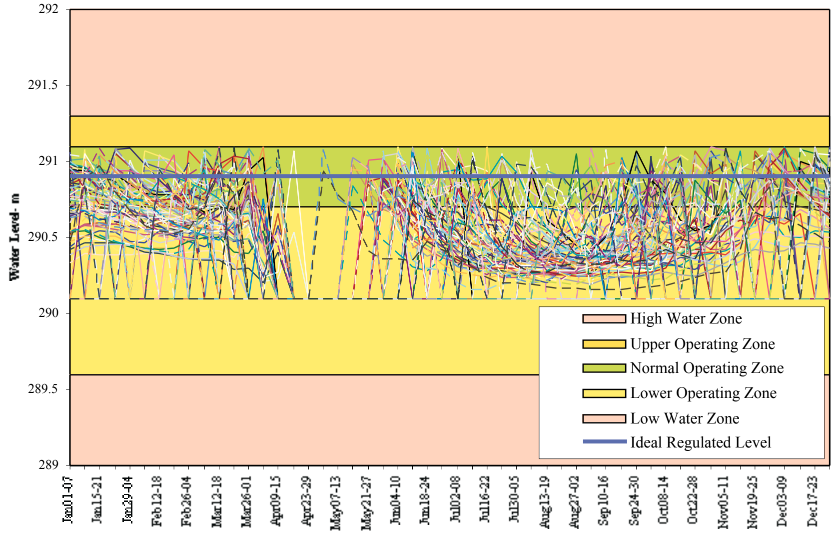
Case 2 Minimum Flow 7 cms Below Ahmic Lake

Case 3 Minimum Flow 7 cms Below Ahmic Lake

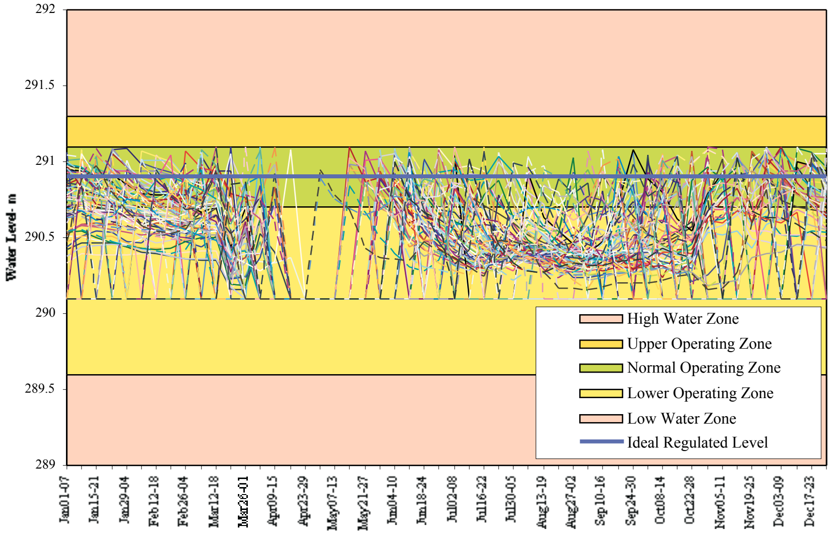
Figure 8.8
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Level Statistics - Doe Lake

ACRES International

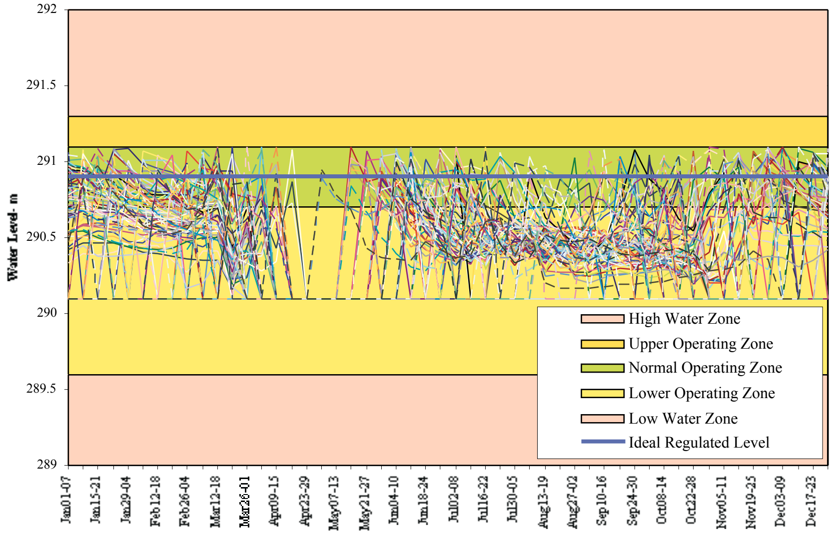
Base Case



Case 1 Minimum Flow 5 cms Below Ahmic Lake



Case 2 Minimum Flow 7 cms Below Ahmic Lake



Case 3 Minimum Flow 7 cms Below Ahmic Lake

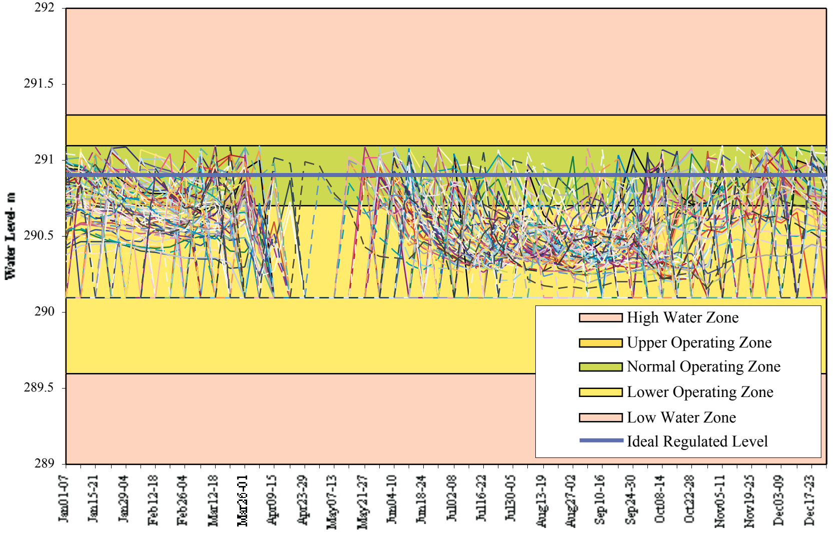
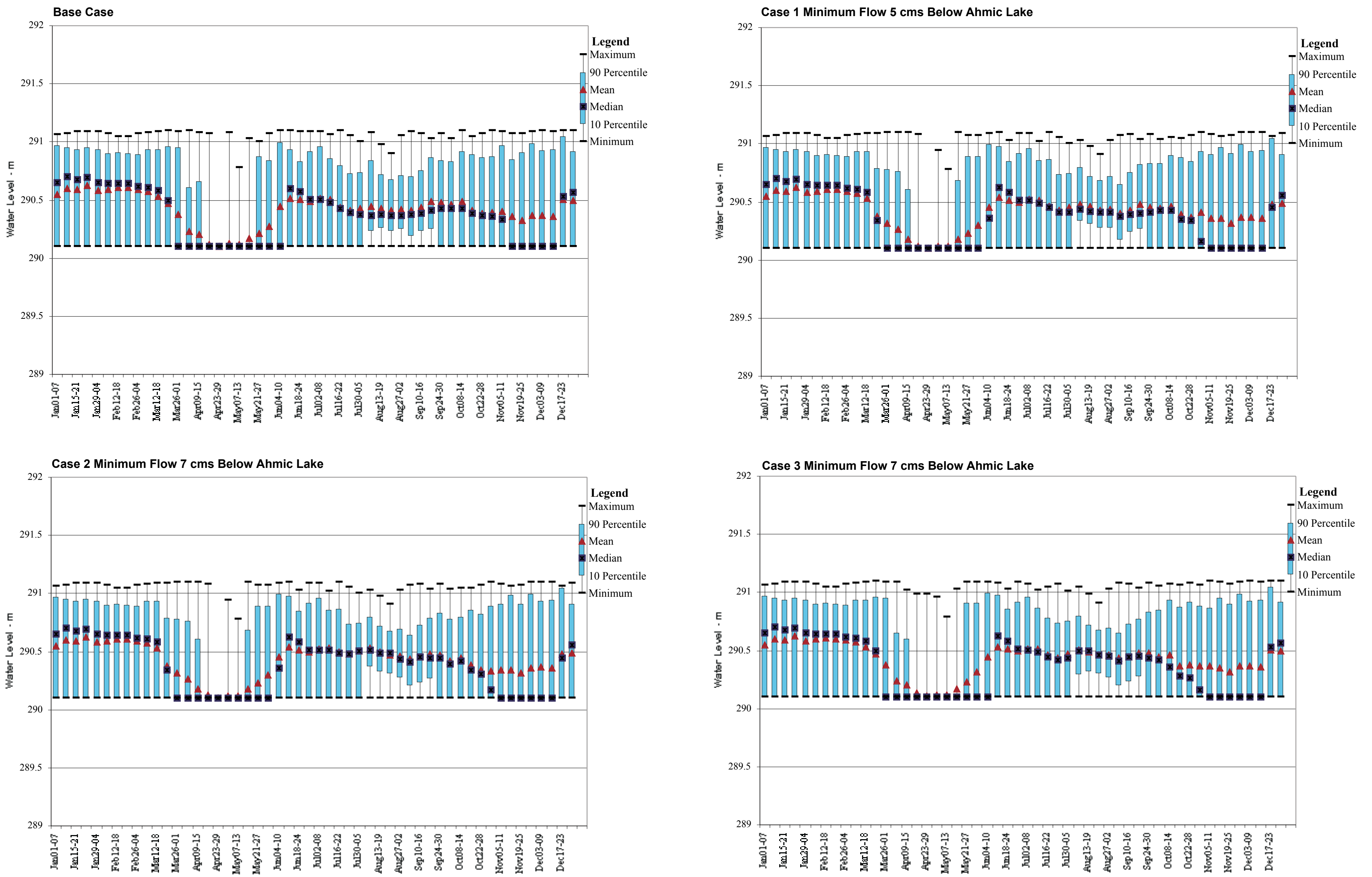


Figure 8.9
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 - Burk's Falls

ACRES
International



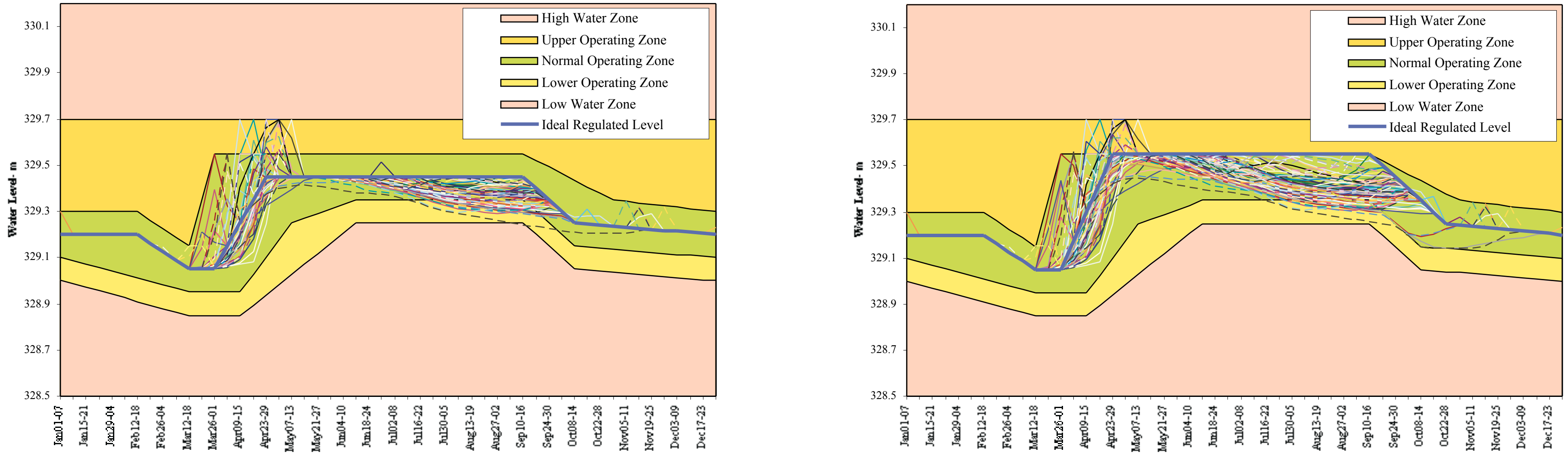
Base Case

Case 1 Minimum Flow 5 cms Below Ahmic Lake

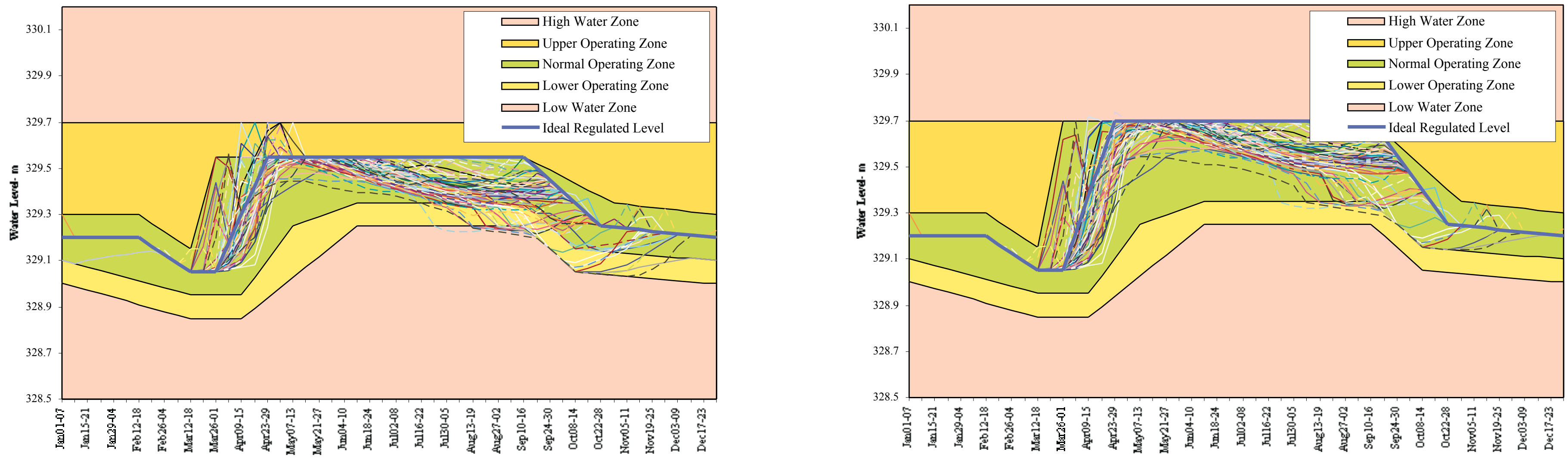
Case 2 Minimum Flow 7 cms Below Ahmic Lake

Case 3 Minimum Flow 7 cms Below Ahmic Lake

Figure 8.10
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Level Statistics - Burk's Falls


Base Case

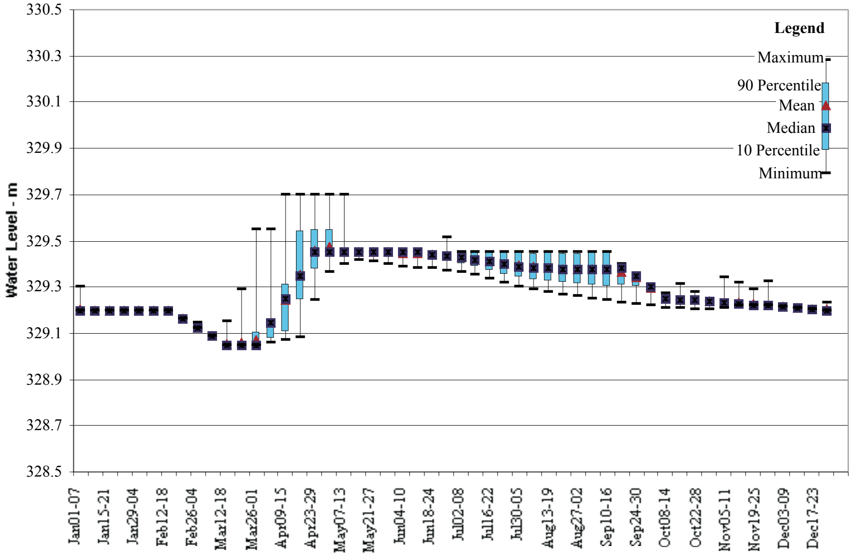
Case 1 Minimum Flow 5 cms Below Ahmic Lake


Case 2 Minimum Flow 7 cms Below Ahmic Lake

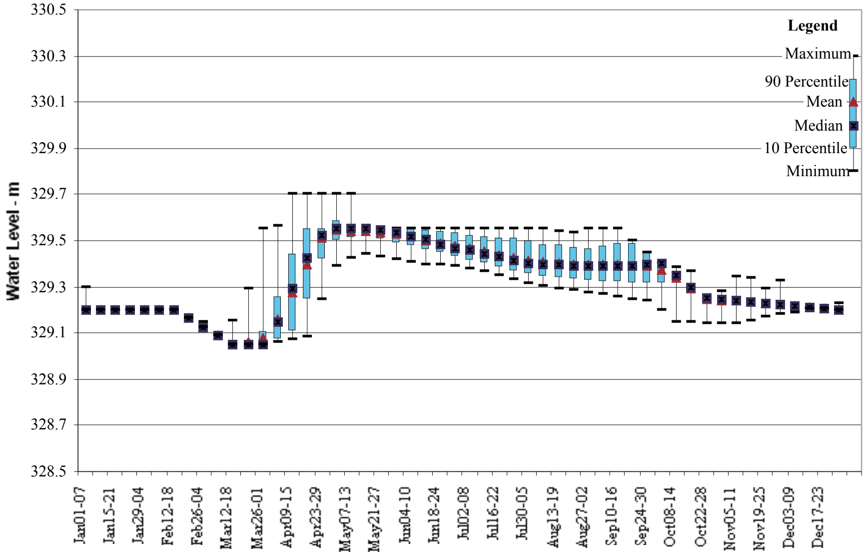
Case 3 Minimum Flow 7 cms Below Ahmic Lake

Figure 8.11
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 - Bernard Lake

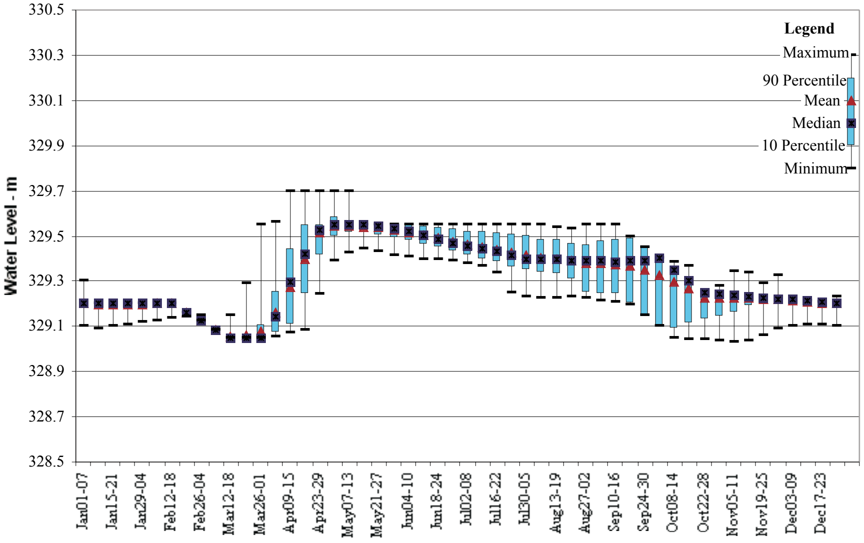
Base Case



Case 1 Minimum Flow 5 cms Below Ahmic Lake



Case 2 Minimum Flow 7 cms Below Ahmic Lake



Case 3 Minimum Flow 7 cms Below Ahmic Lake

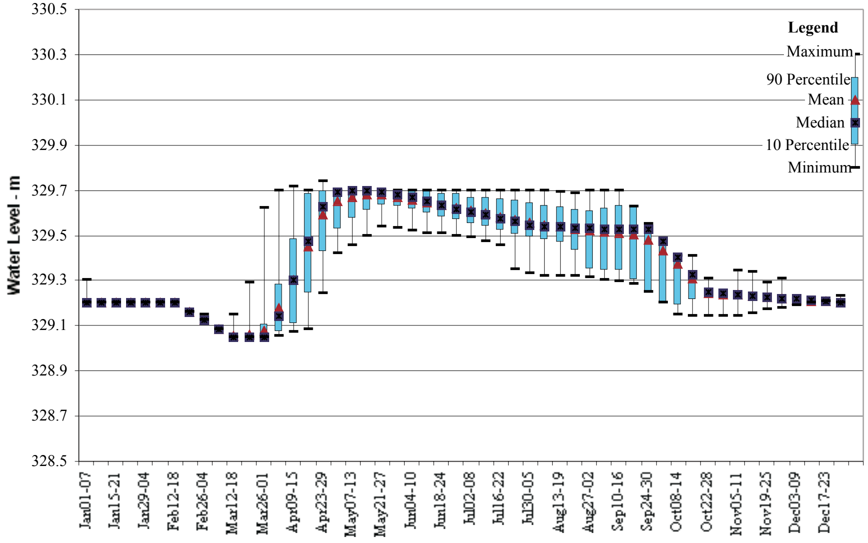


Figure 8.12
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Level Statistics - Bernard Lake

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International

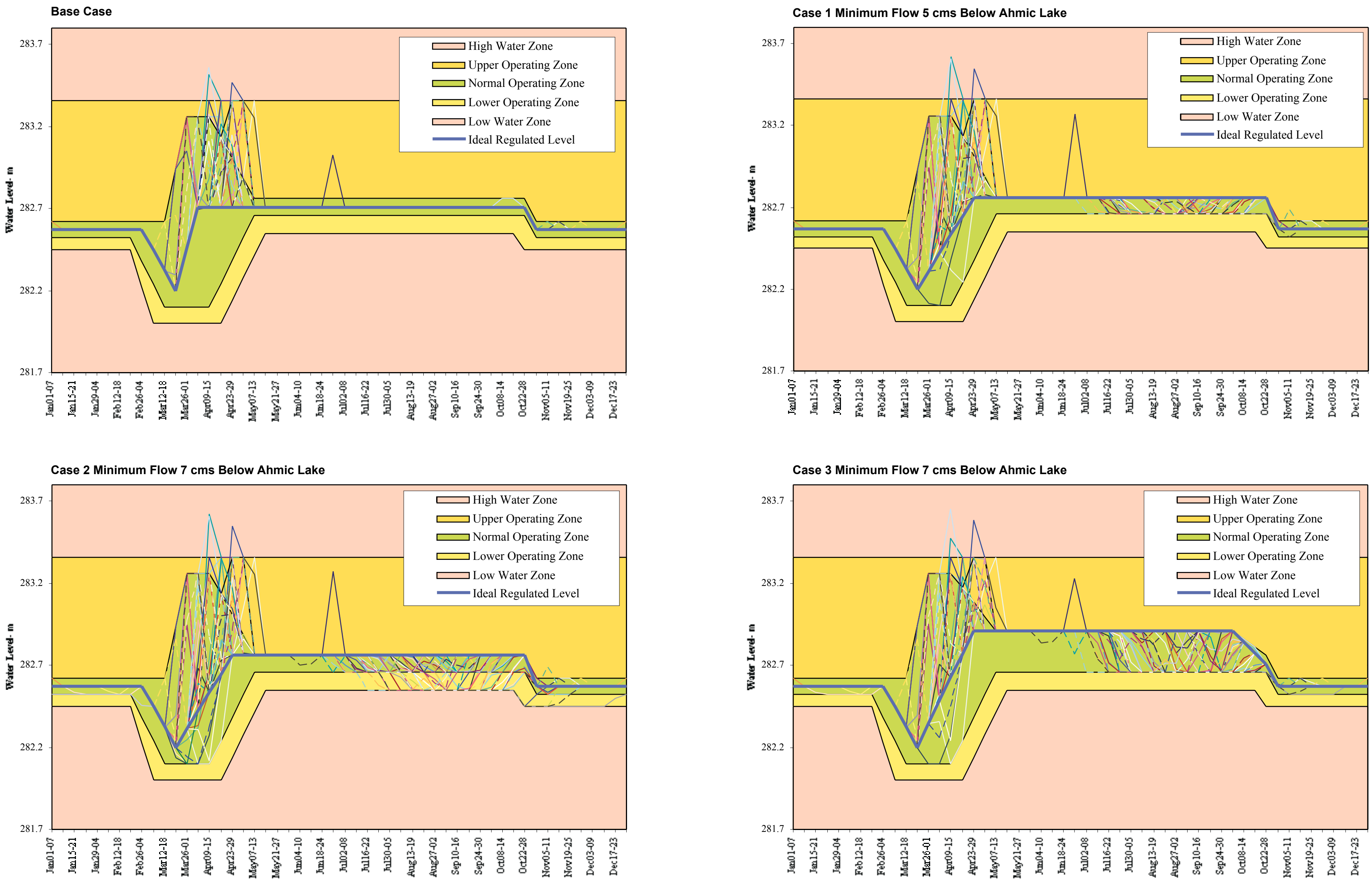
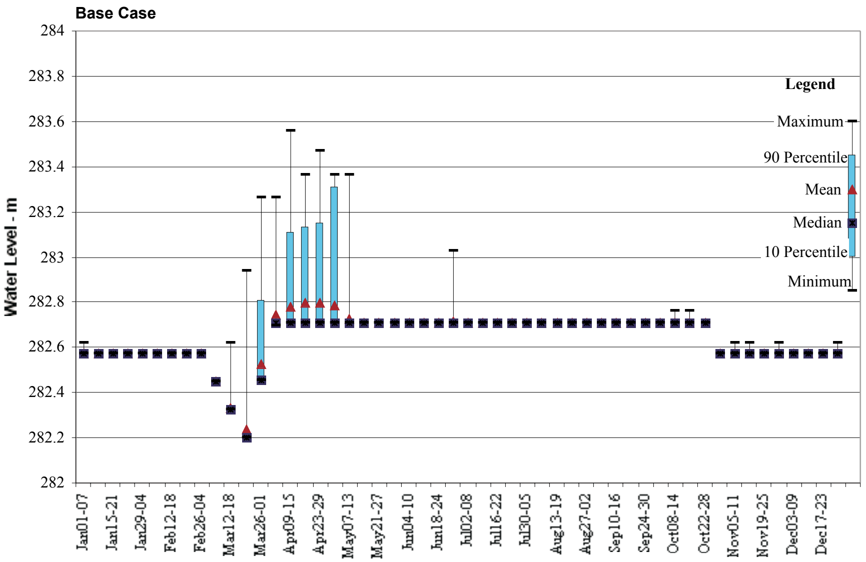
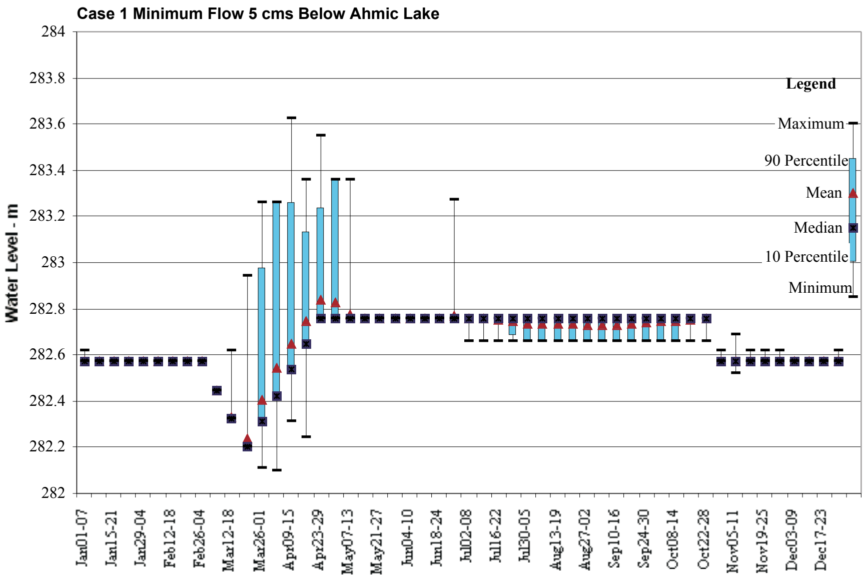
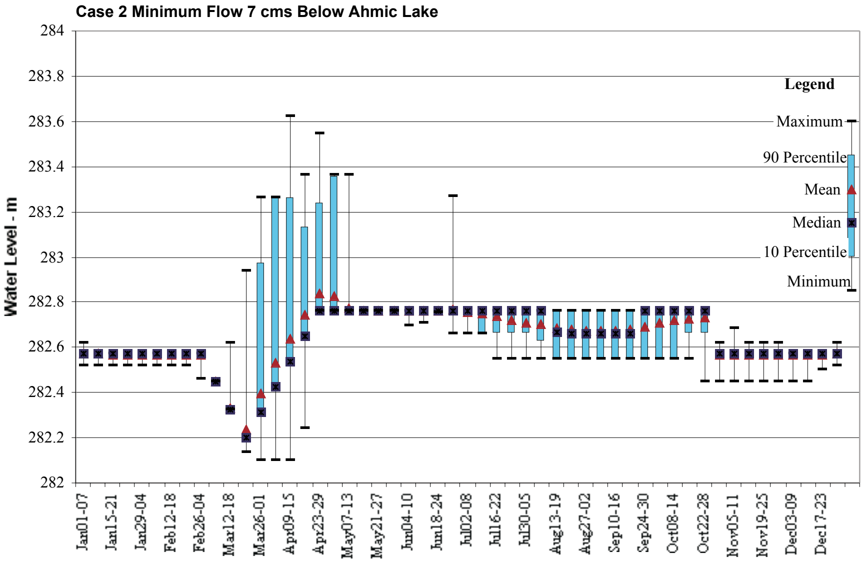


Figure 8.13
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 - Cecebe Lake

ACRES International







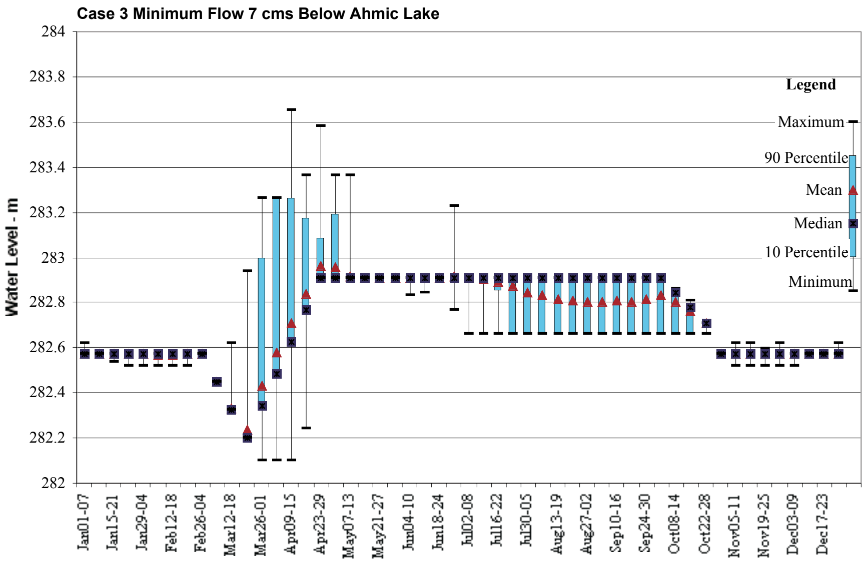
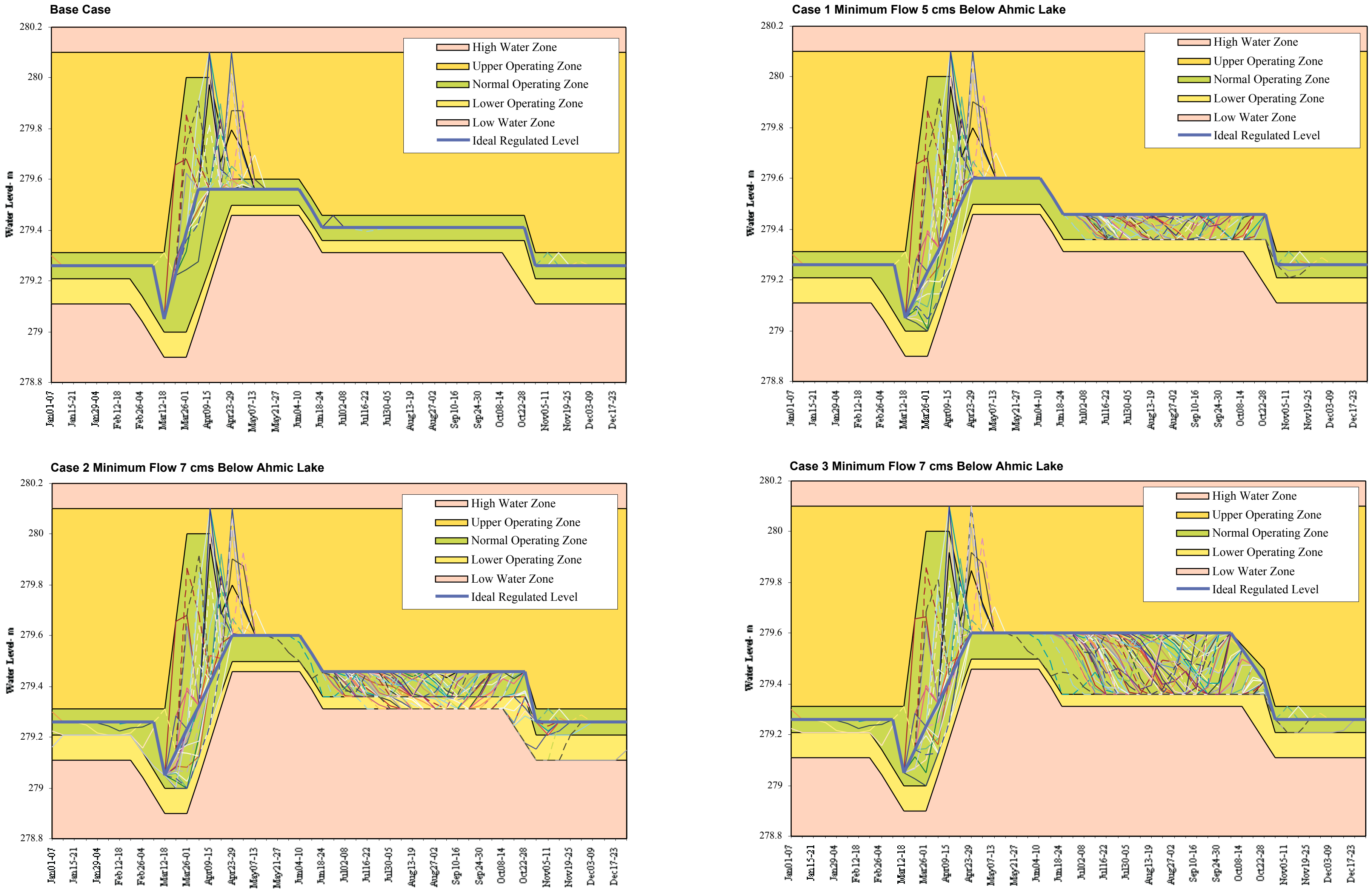


Figure 8.14
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan

Weekly Water Level Statistics - Cecebe Lake



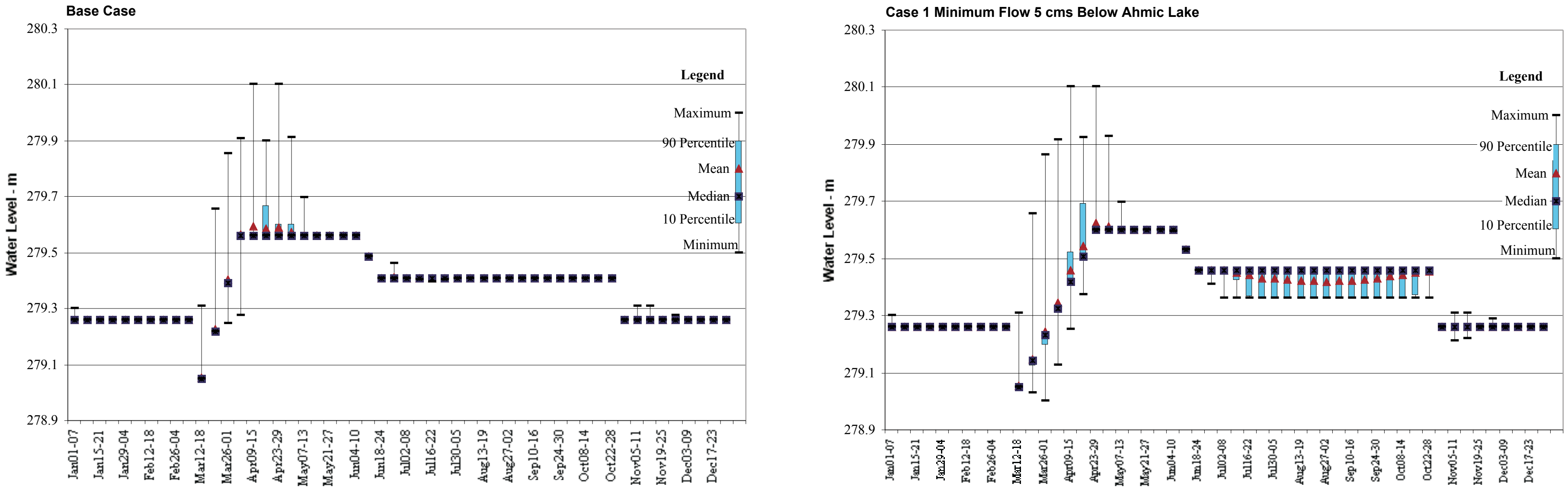
Base Case

Case 1 Minimum Flow 5 cms Below Ahmic Lake

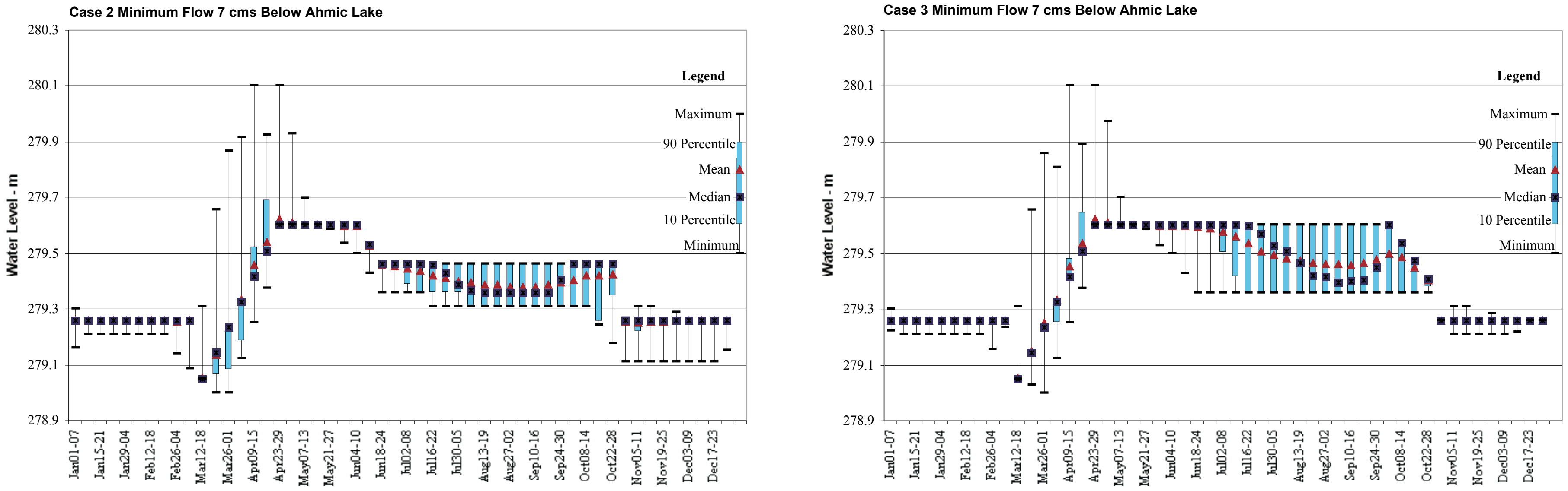
Case 2 Minimum Flow 7 cms Below Ahmic Lake

Case 3 Minimum Flow 7 cms Below Ahmic Lake

Figure 8.15
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 - Ahmic Lake


Base Case

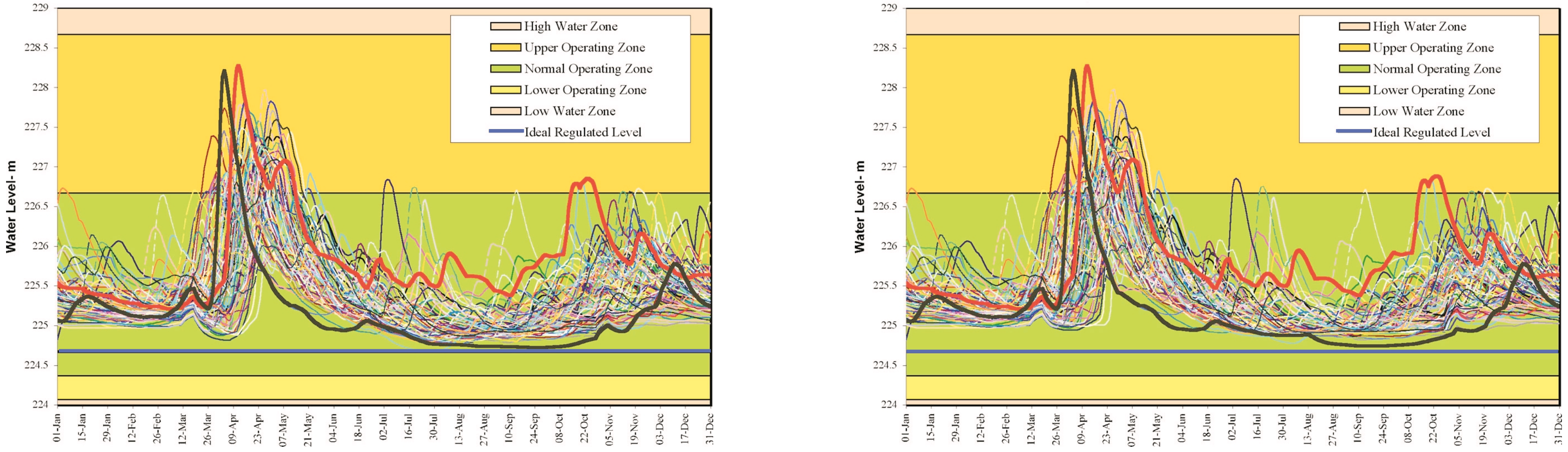
Case 1 Minimum Flow 5 cms Below Ahmic Lake


Case 2 Minimum Flow 7 cms Below Ahmic Lake

Case 3 Minimum Flow 7 cms Below Ahmic Lake

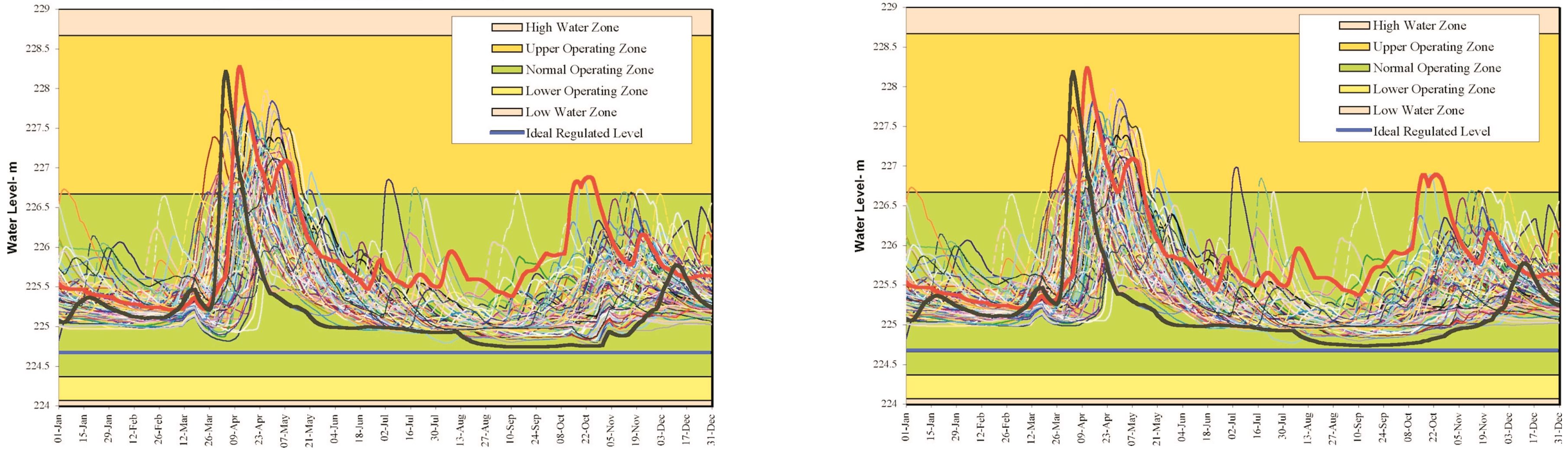
Figure 8.16
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Level Statistics - Ahmic Lake

ACRES International



Base Case

Case 1 Minimum Flow 5 cms Below Ahmic Lake



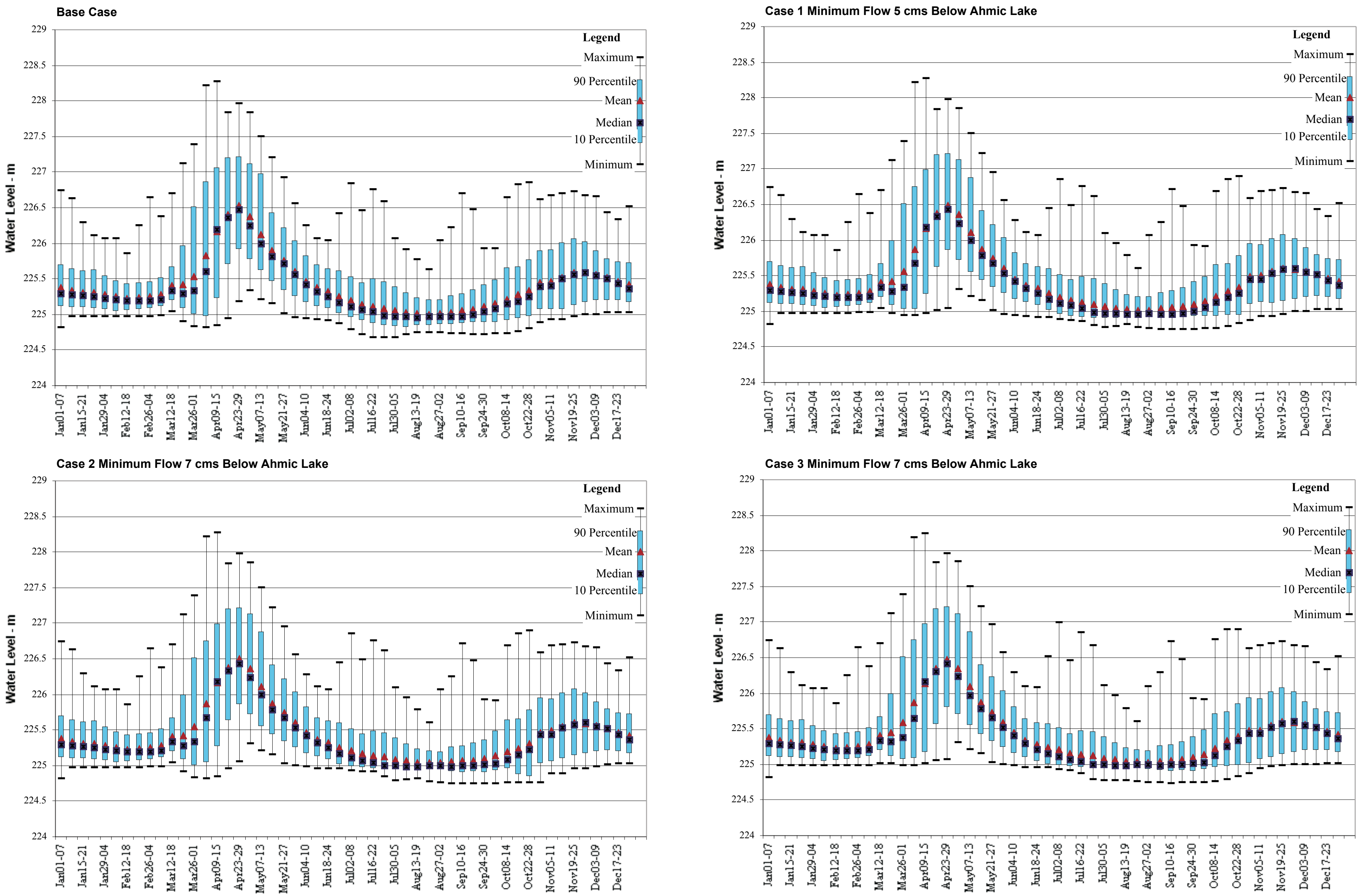
Case 2 Minimum Flow 7 cms Below Ahmic Lake

Case 3 Minimum Flow 7 cms Below Ahmic Lake

Figure 8.17
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan

Daily Water Levels Model Results 1916 to 1998 - Wahwashkesh Lake

ACRES International



Base Case

Case 1 Minimum Flow 5 cms Below Ahmic Lake

Case 2 Minimum Flow 7 cms Below Ahmic Lake

Case 3 Minimum Flow 7 cms Below Ahmic Lake

Figure 8.18

Ministry of Natural Resources

Magnetawan River Water Control Operating Plan

Daily Water Level Statistics - Wahwashkesh Lake

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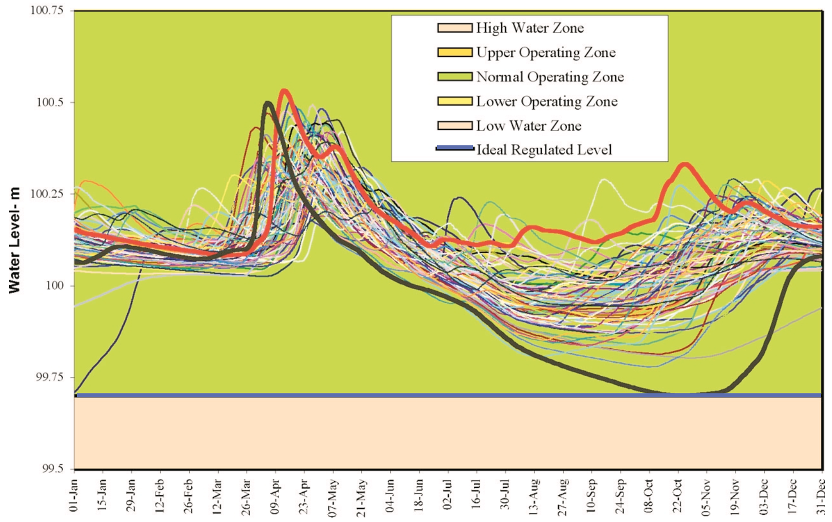
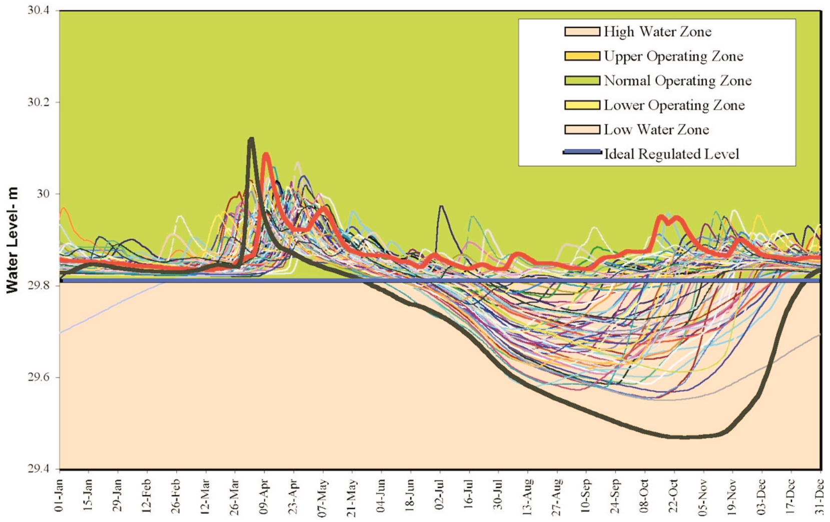
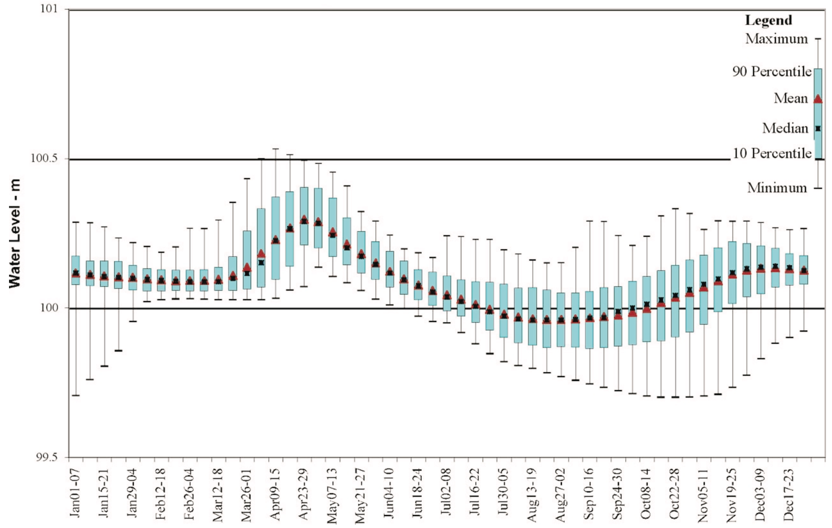
Kashegaba Lake - Daily Water Levels Model Results 1916 to 1998
Base Case



Gooseneck Lake - Daily Water Levels Model Results 1916 to 1998
Base Case



Kashegaba Lake - Daily Water Level Statistics
Base Case



Gooseneck Lake - Daily Water Level Statistics
Base Case

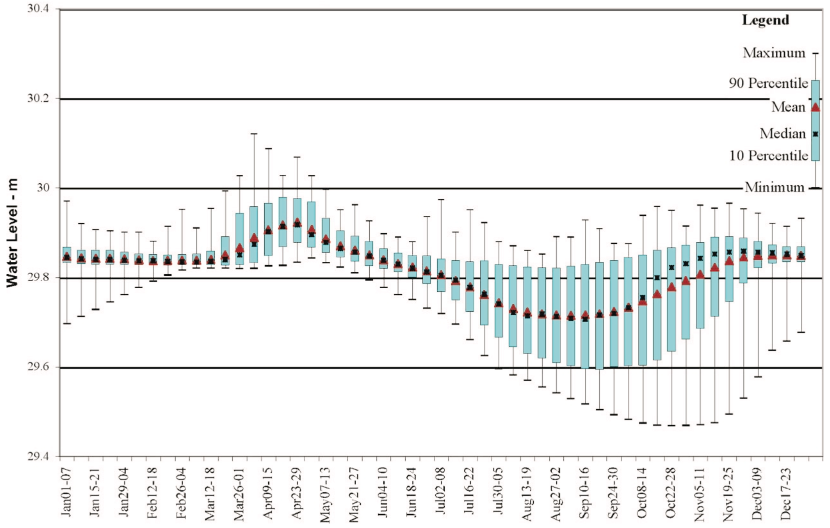
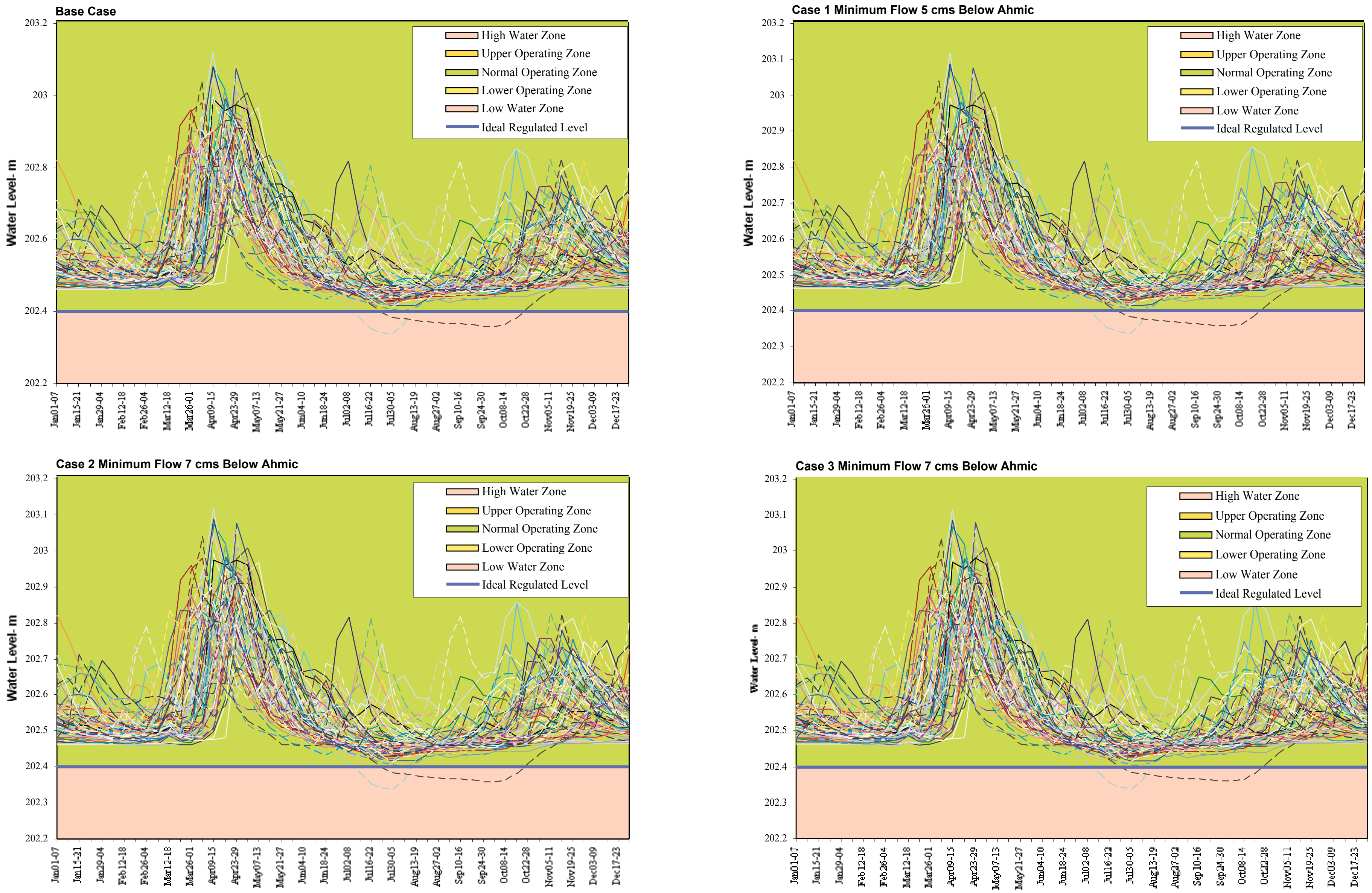


Figure 8.19
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Weekly Water Levels Model Results 1916 to 1998 and Statistics - Kashegaba and Gooseneck Lakes


Base Case

Case 1 Minimum Flow 5 cms Below Ahmic

Case 2 Minimum Flow 7 cms Below Ahmic

Case 3 Minimum Flow 7 cms Below Ahmic

Figure 8.20

Ministry of Natural Resources

Magnetawan River Water Control Operating Plan

Weekly Water Levels Model Results 1916 to 1998 - Harris Lake

ACRES International

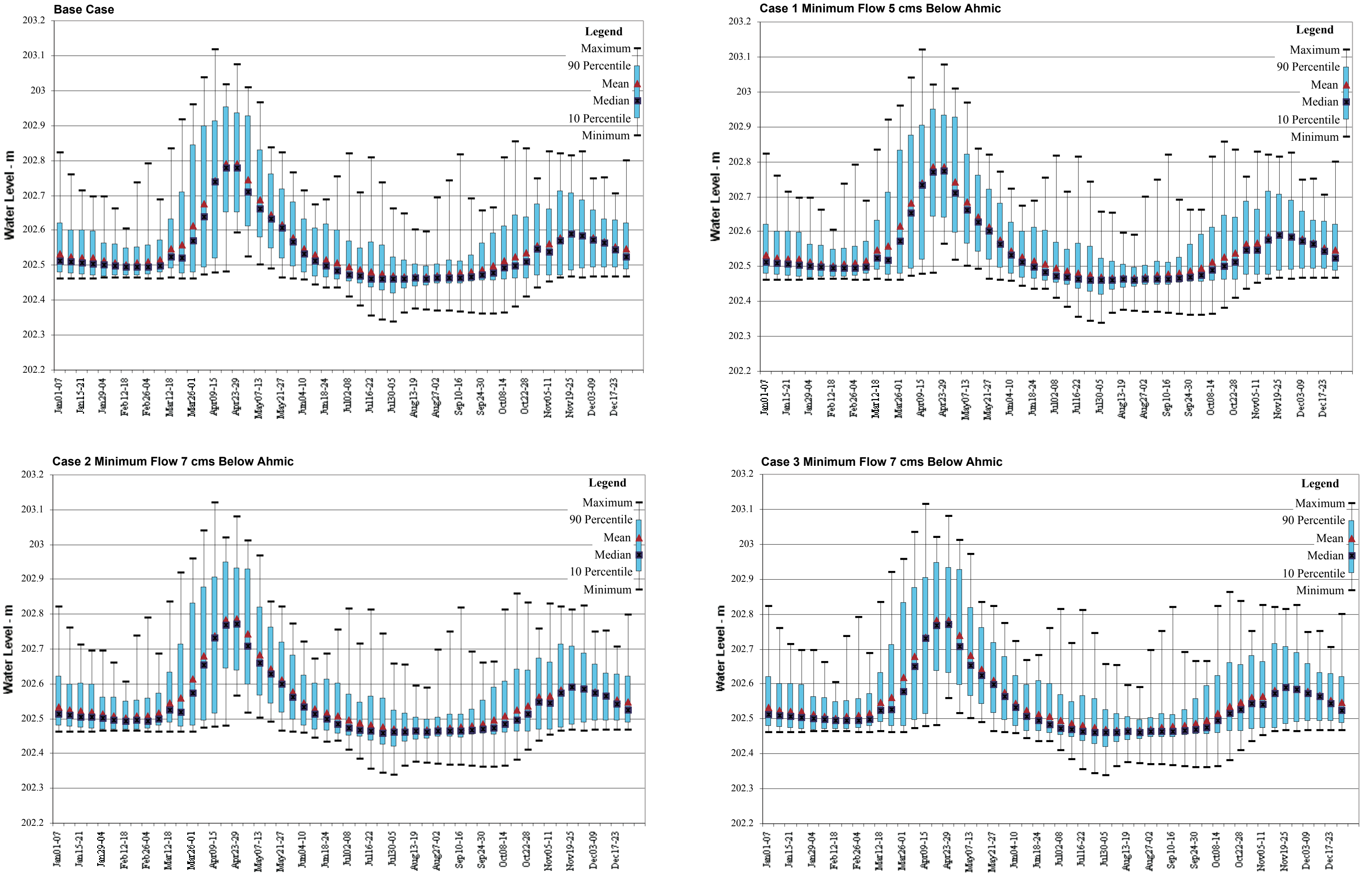


Figure 8.21

Ministry of Natural Resources

Magnetawan River Water Control Operating Plan

Weekly Water Level Statistics - Harris Lake

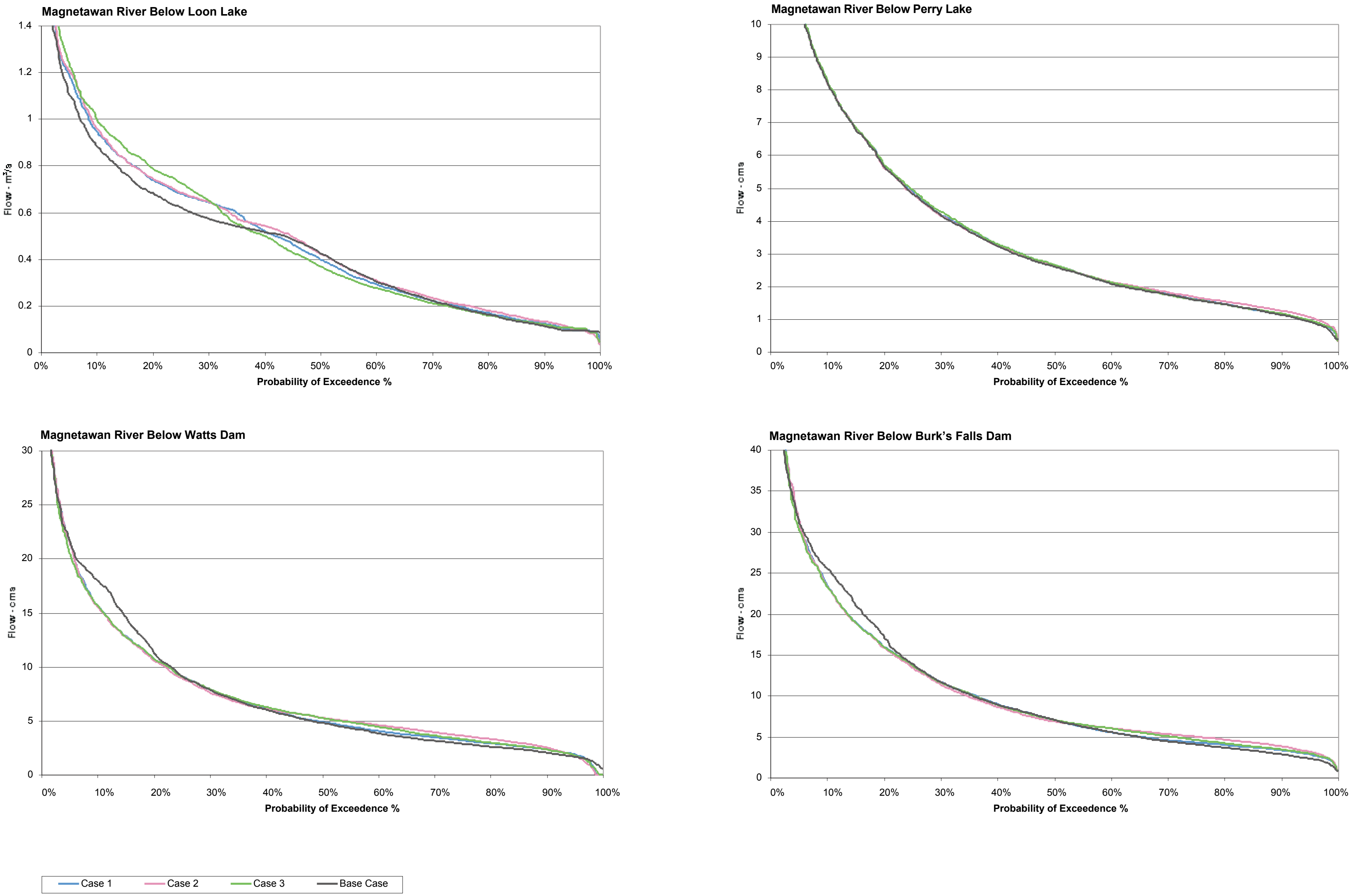


Figure 8.22a
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Recreational Season Weekly Flow Duration Curves

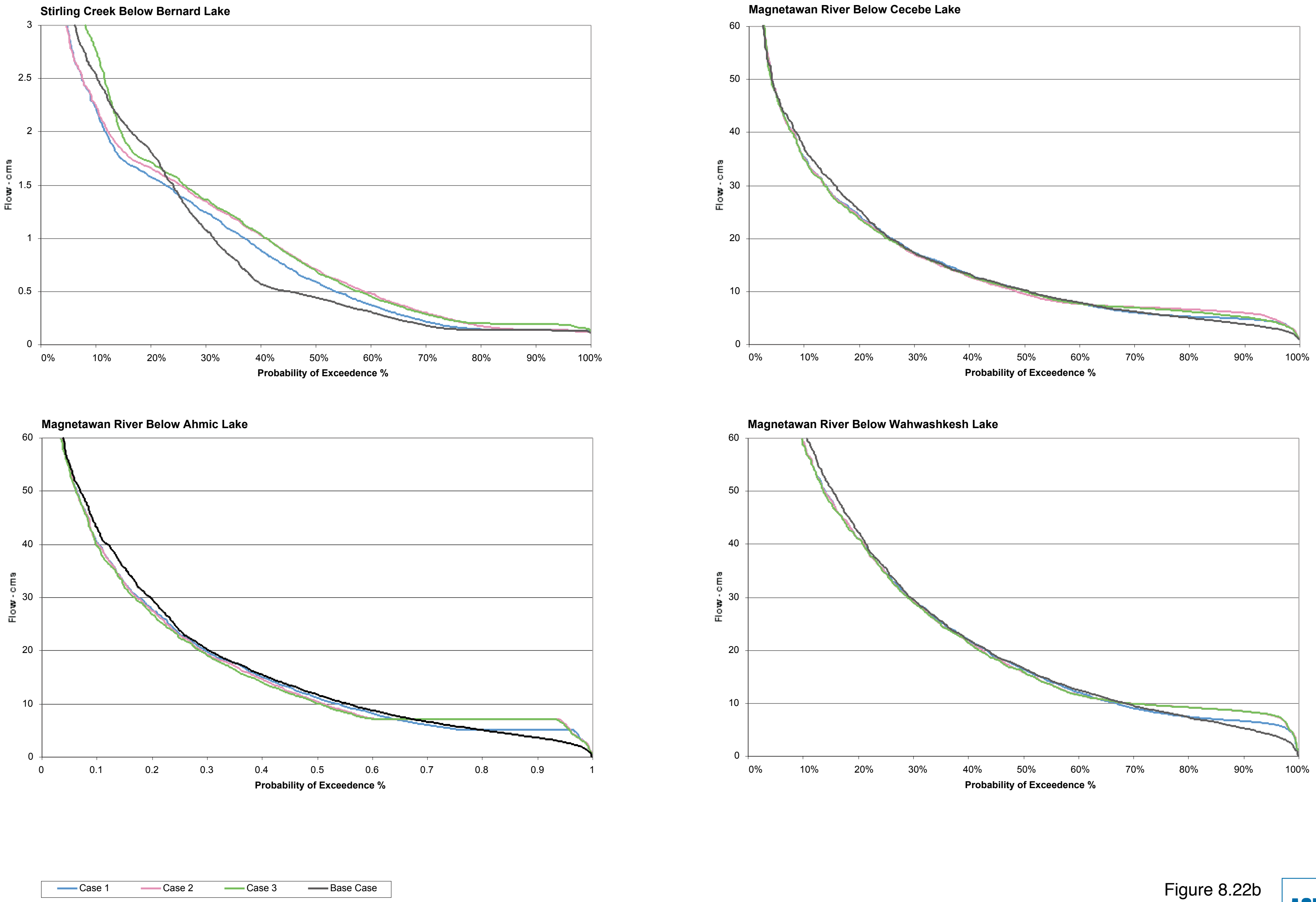


Figure 8.22b

Ministry of Natural Resources

Magnetawan River Water Control Operating Plan

Recreational Season Weekly Flow Duration Curves

ACRES International

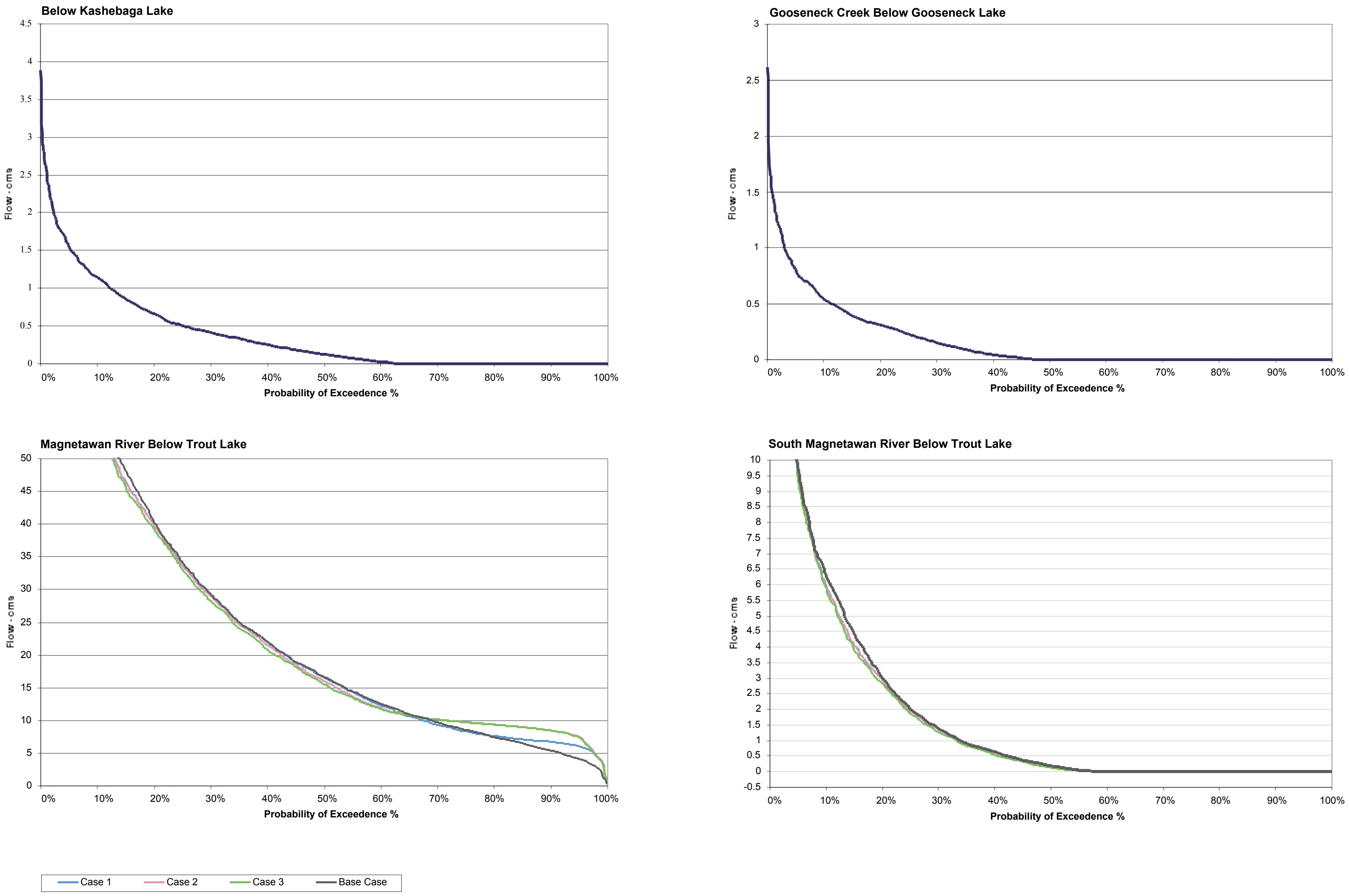


Figure 8.22c
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Recreational Season Weekly Flow Duration Curves

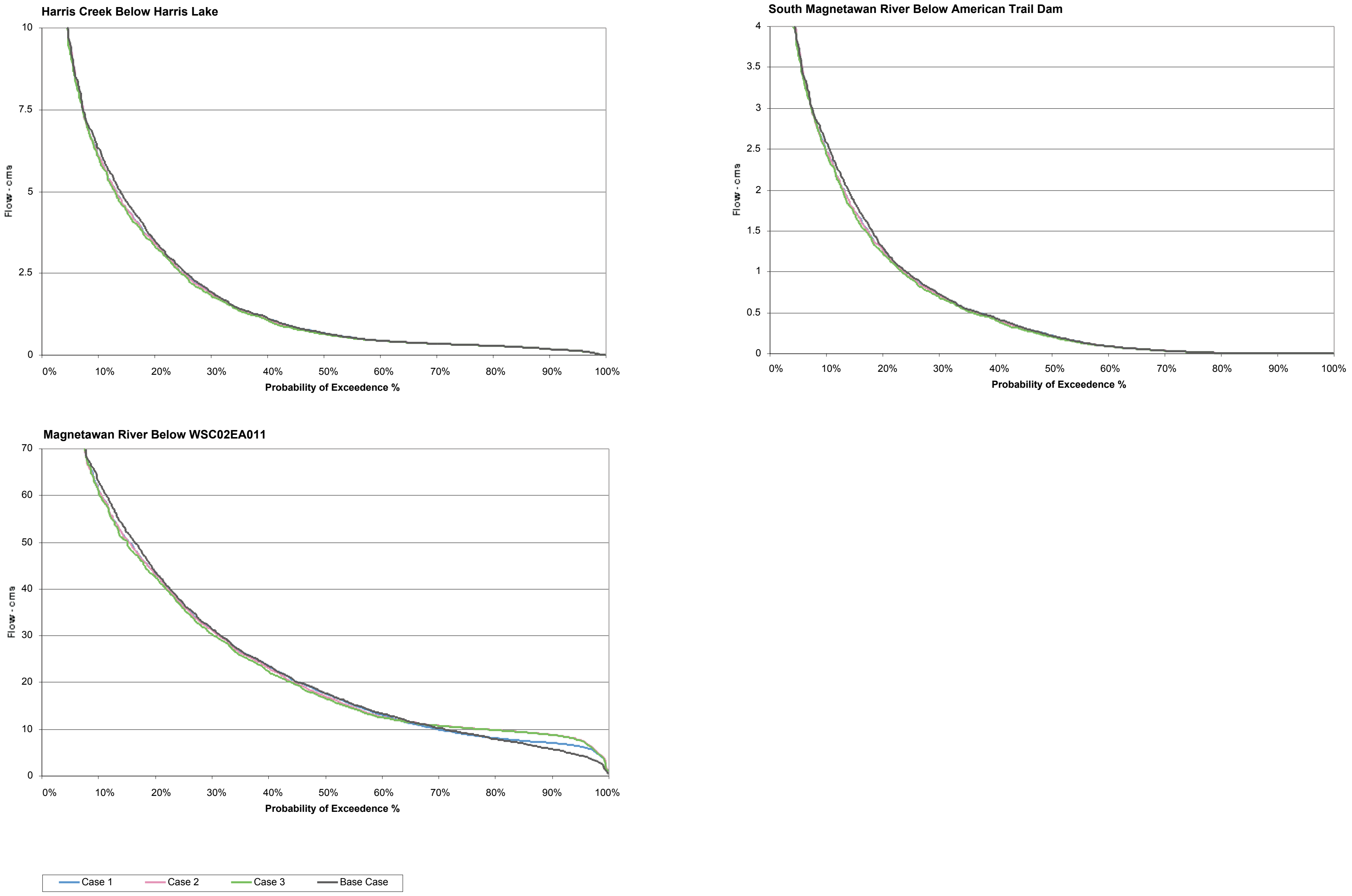


Figure 8.22d
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Recreational Season Weekly Flow Duration Curves

ACRES International

Daily Power Production Duration

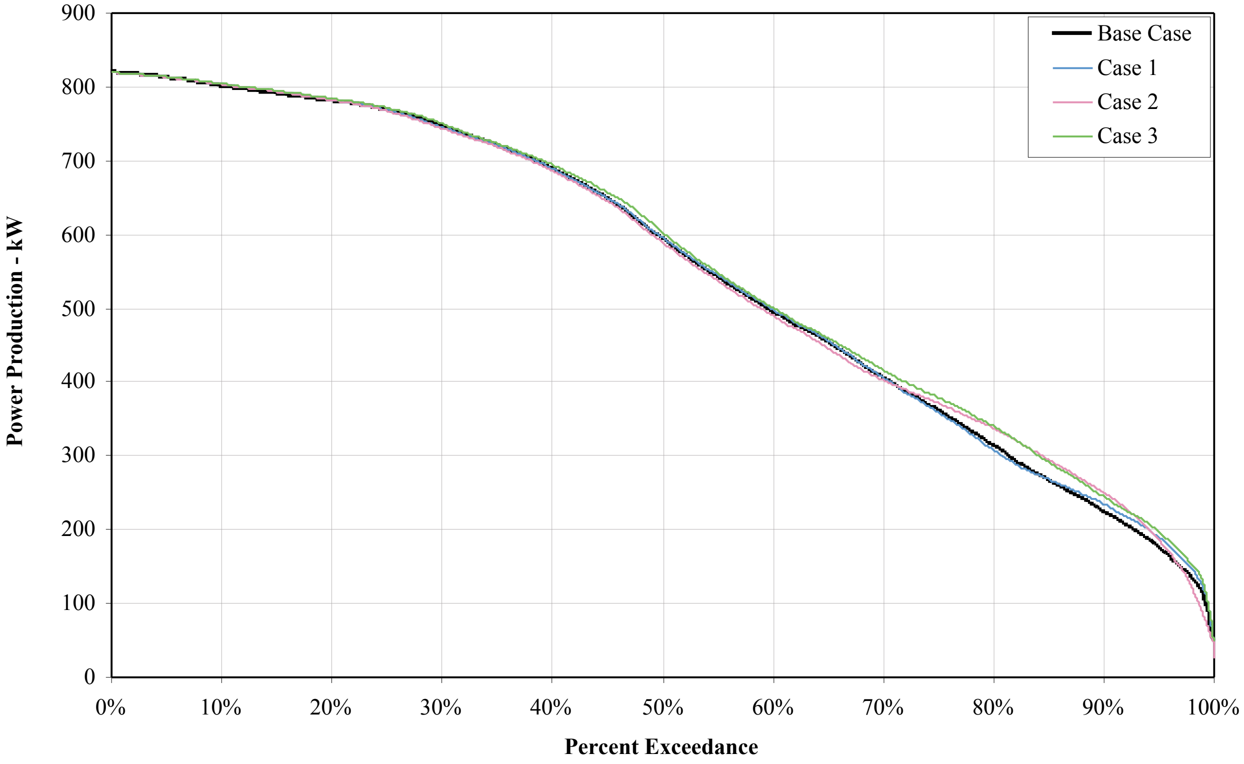
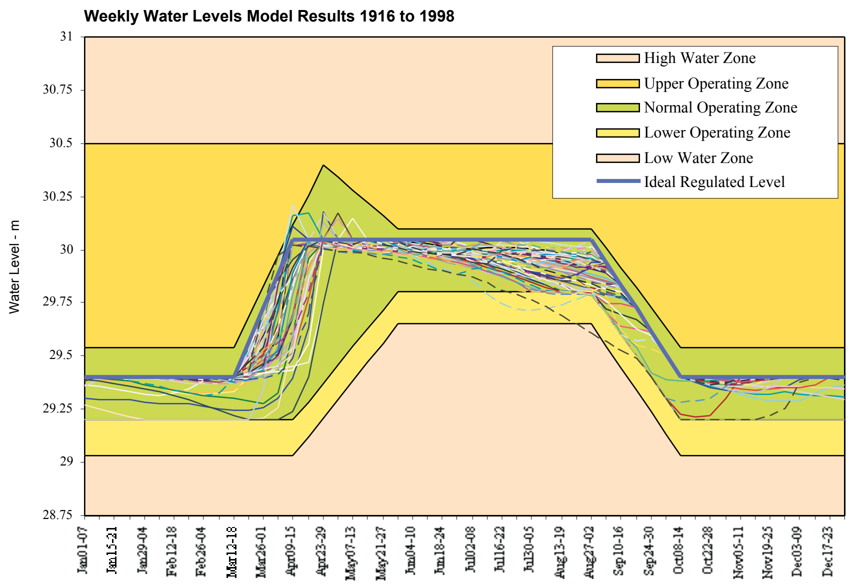


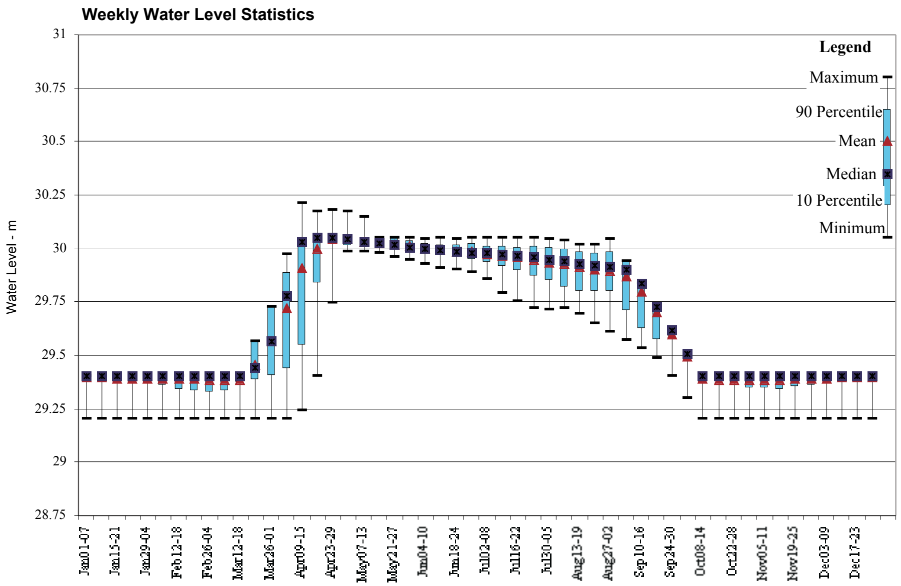
Figure 8.23
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan

Daily Power Production - Burk’s Falls Dam

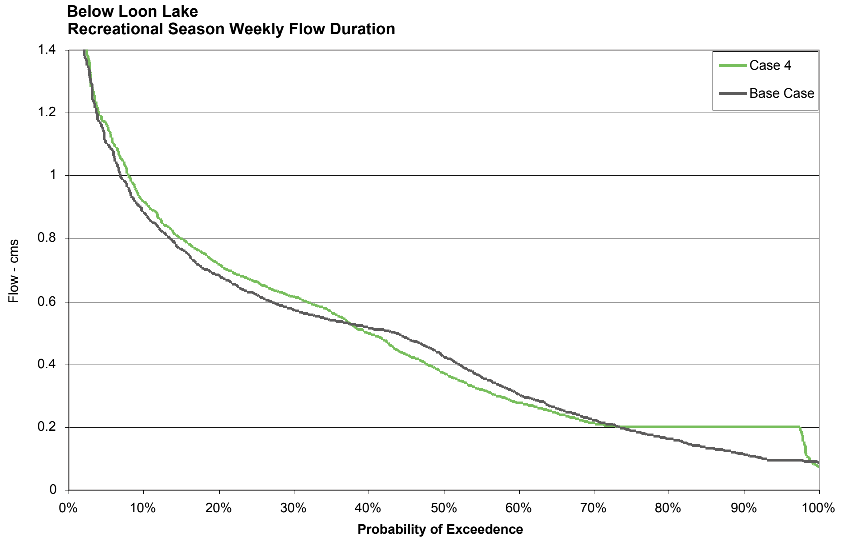
ACRES International



Weekly Water Levels Model Results 1916 to 1998

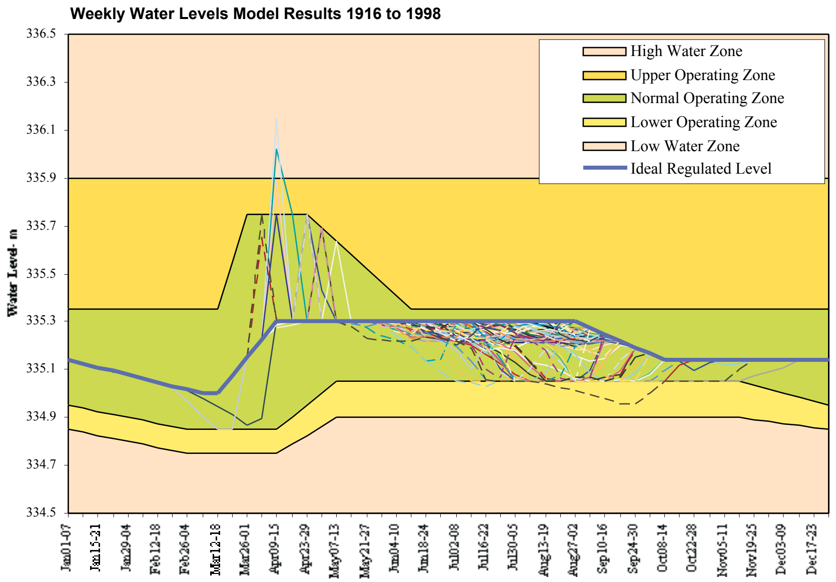


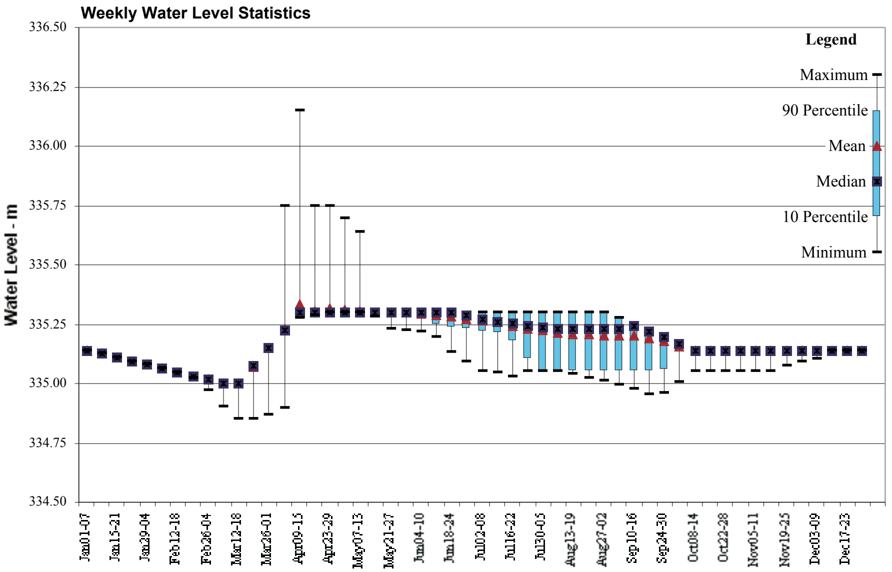
Weekly Water Level Statistics



Below Loon Lake
Recreational Season Weekly Flow Duration

Figure 8.24
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Loon Lake


Weekly Water Levels Model Results 1916 to 1998


Weekly Water Level Statistics

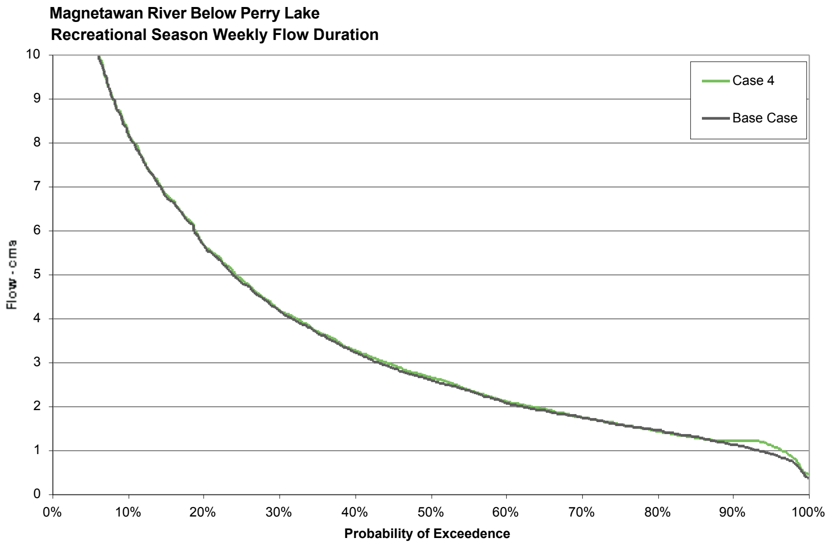
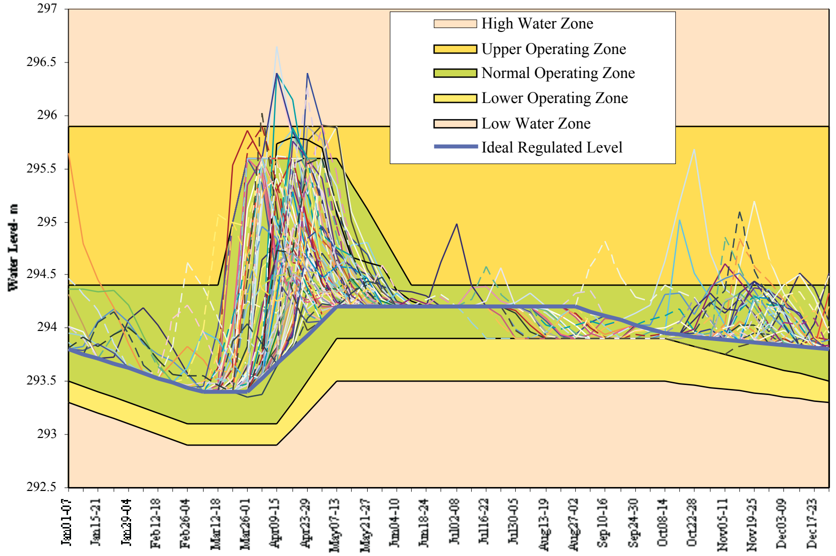
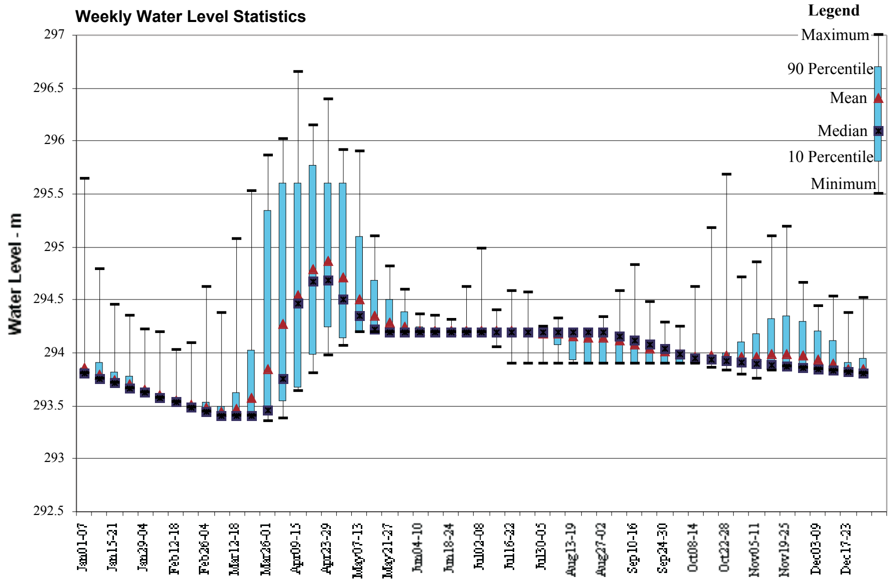

Magnetawan River Below Perry Lake
Recreational Season Weekly Flow Duration

Figure 8.25
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Perry Lake

Weekly Water Levels Model Results 1916 to 1998



Weekly Water Level Statistics



Magnetawan River Below Watt's Dam
Recreational Season Weekly Flow Duration

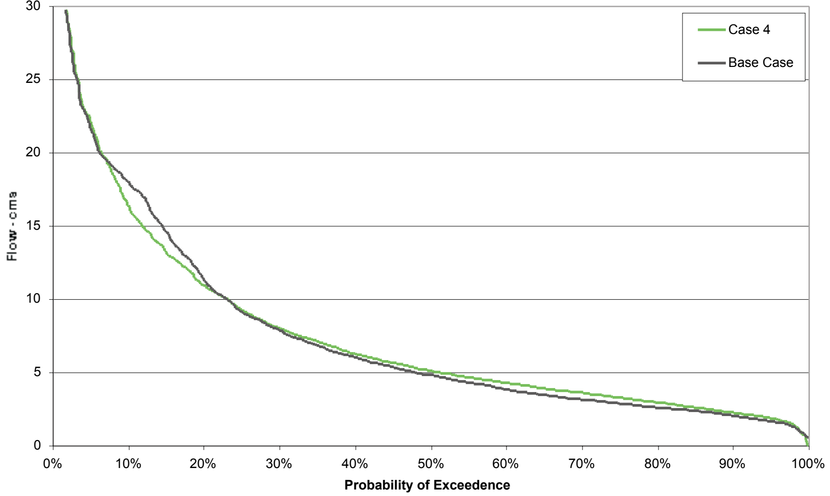


Figure 8.26
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Doe Lake

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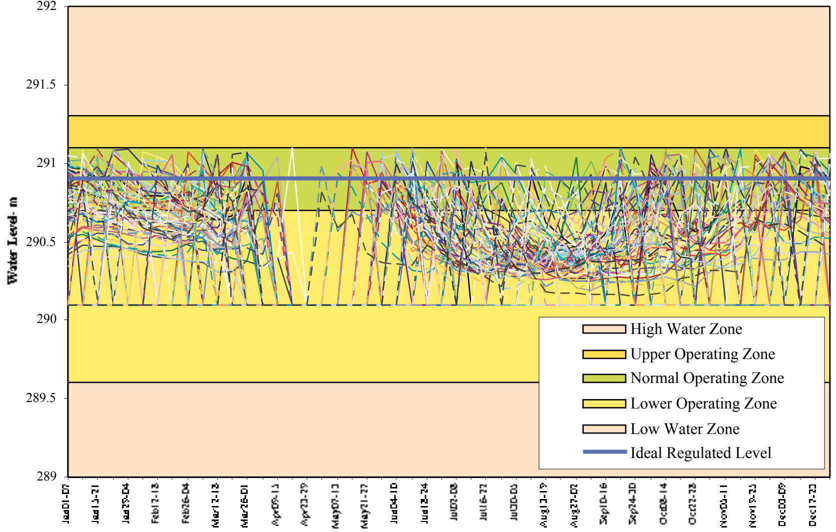
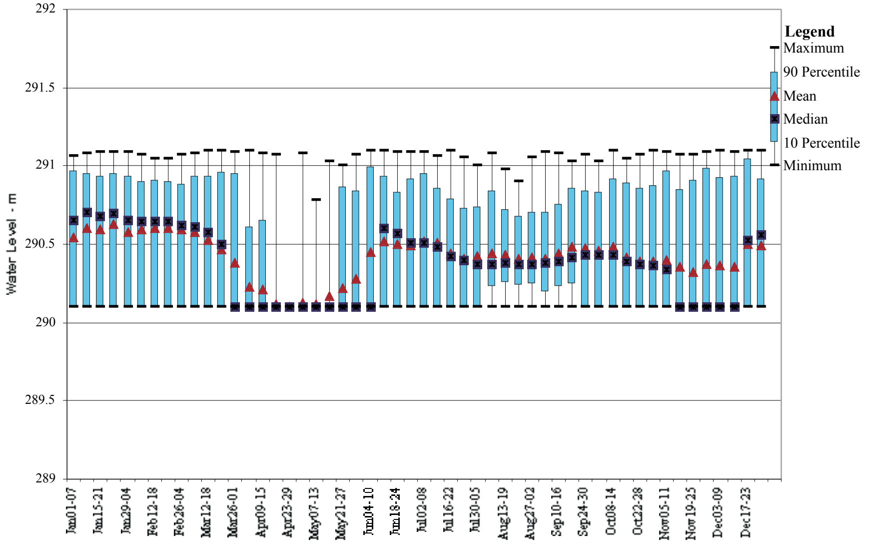
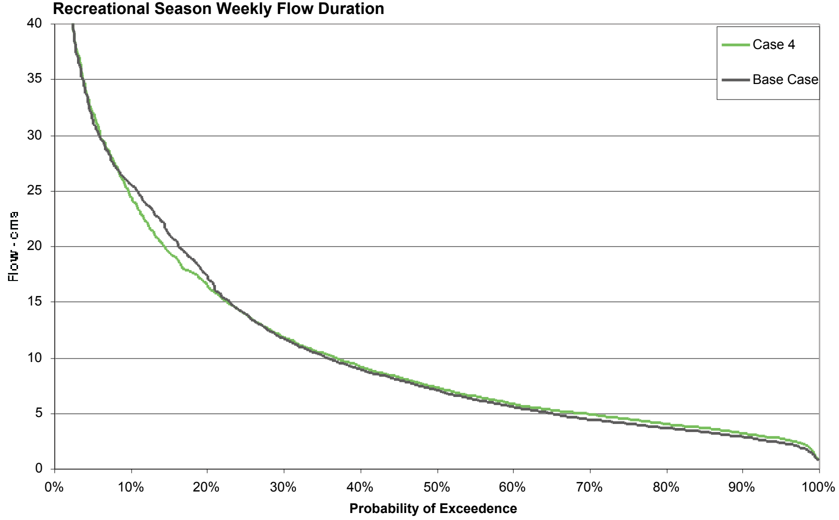
Weekly Water Levels Model Results 1916 to 1998



Weekly Water Level Statistics



Magnetawan River Below Burk's Falls Dam
Recreational Season Weekly Flow Duration



Daily Power Production Duration

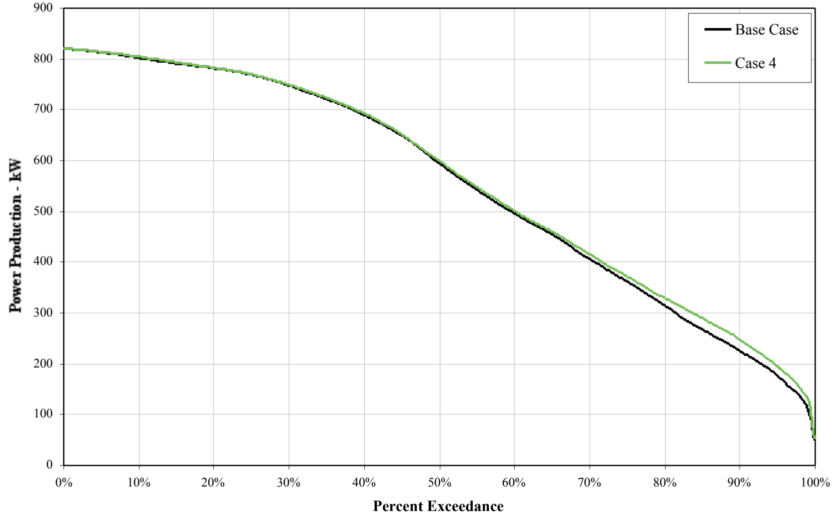


Figure 8.27
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Burk's Falls

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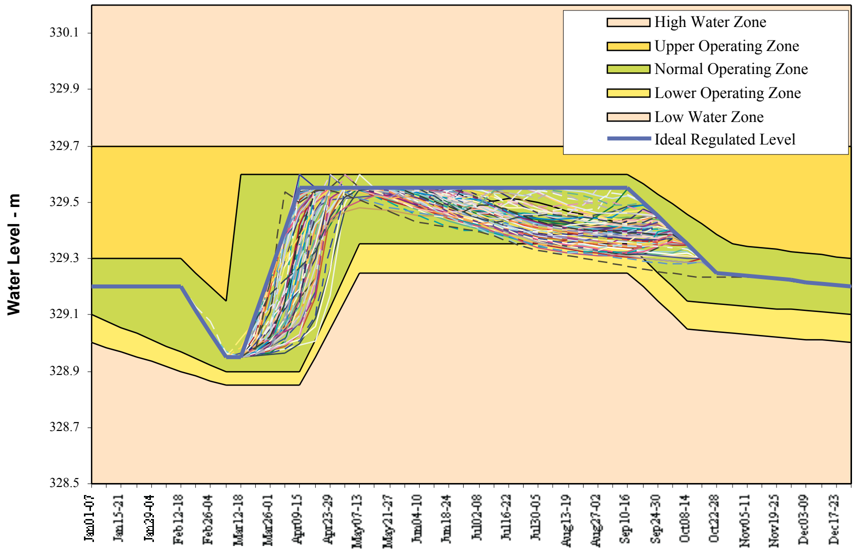
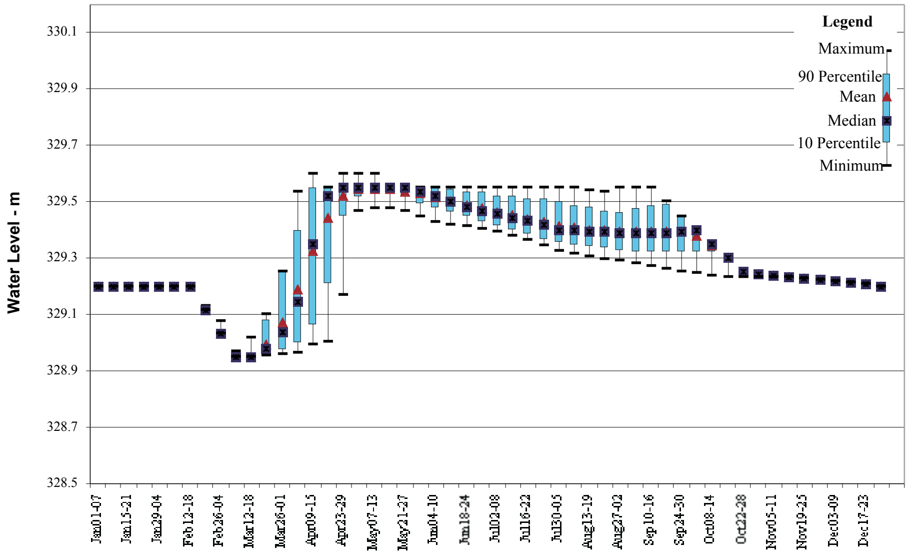
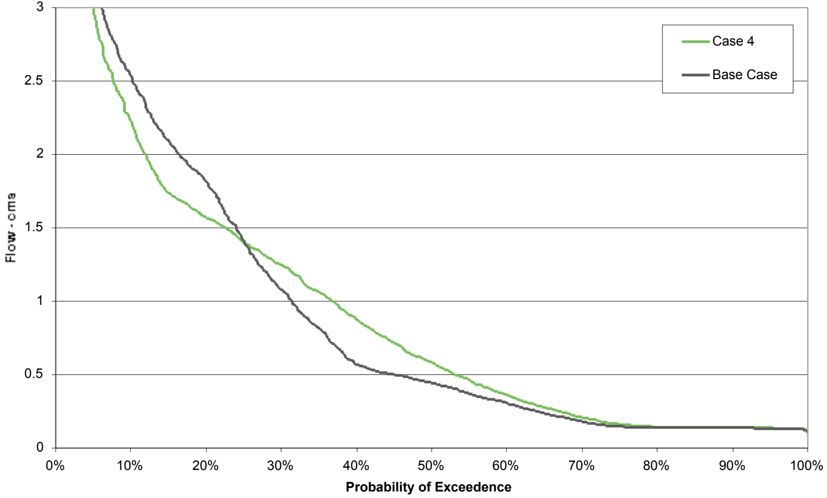


Weekly Water Levels Model Results 1916 to 1998



Weekly Water Level Statistics



Stirling Creek Below Bernard Lake
Recreational Season Weekly Flow Duration

Figure 8.28
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Bernard Lake

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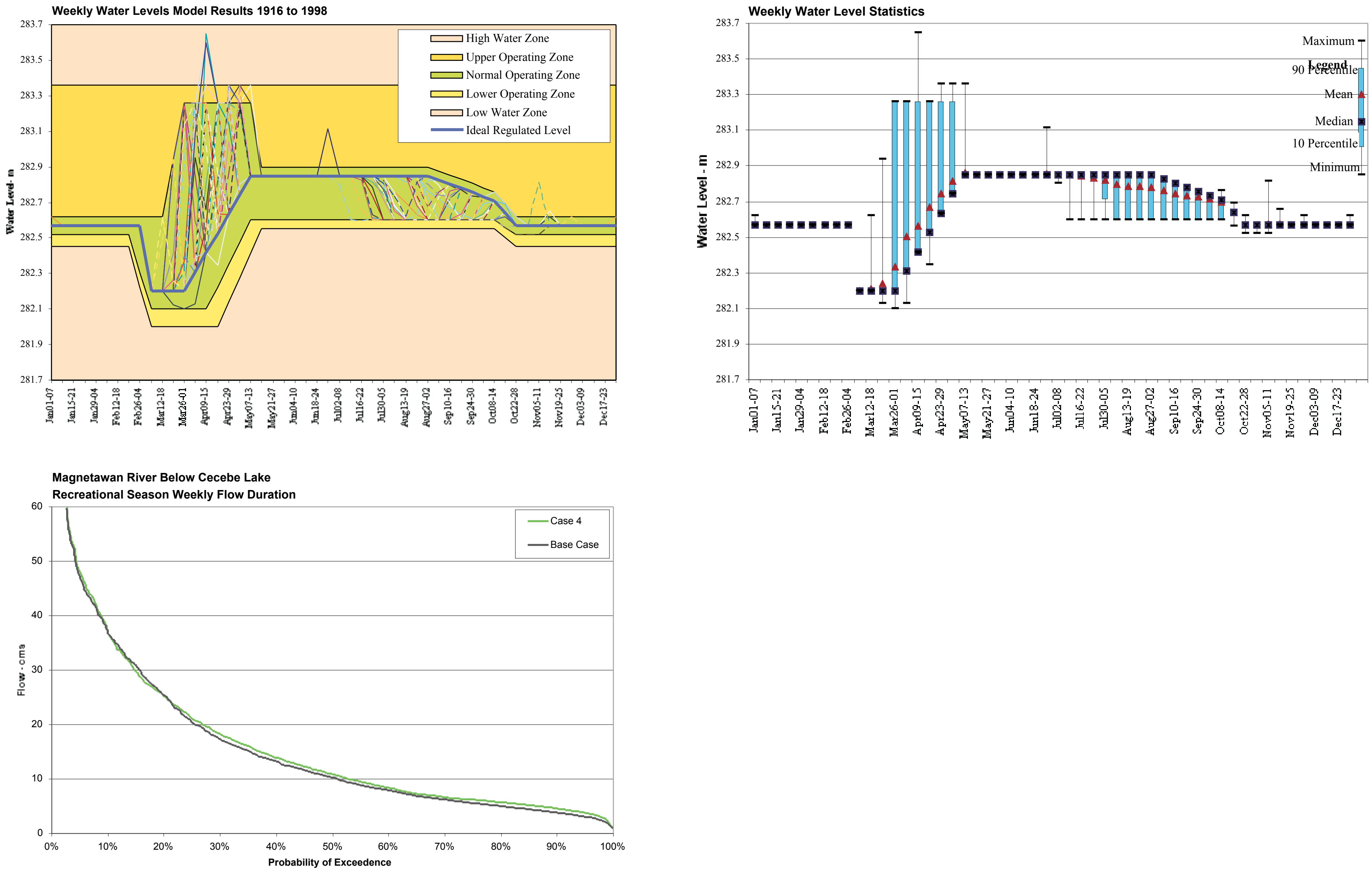

Figure 8.29
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Cecebe Lake

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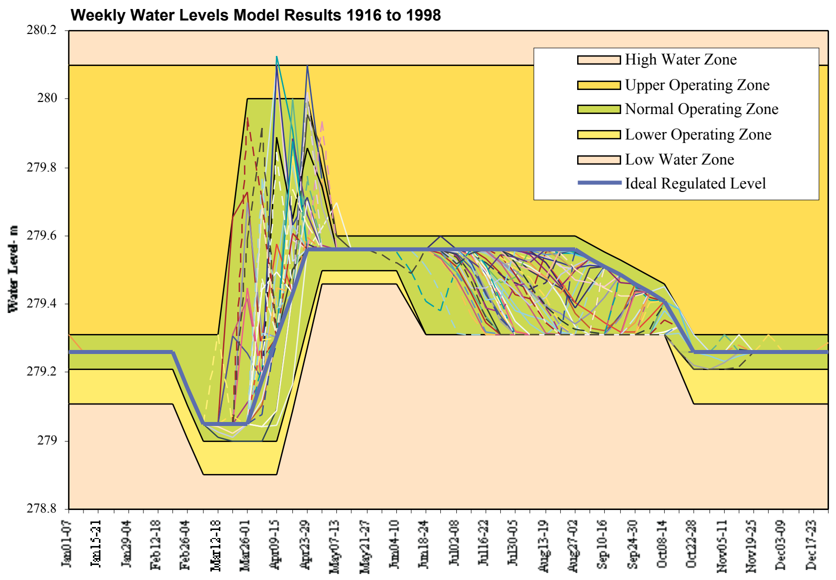
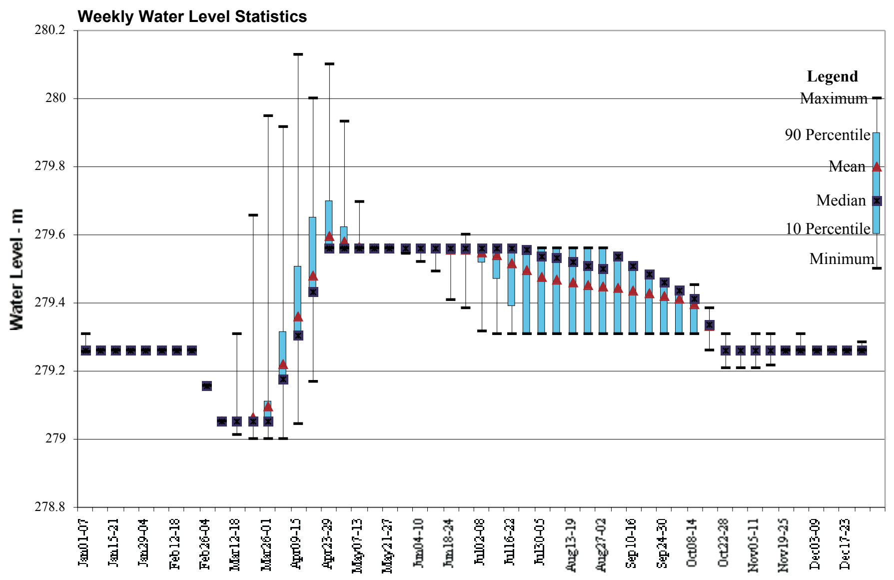
International


Weekly Water Levels Model Results 1916 to 1998


Weekly Water Level Statistics

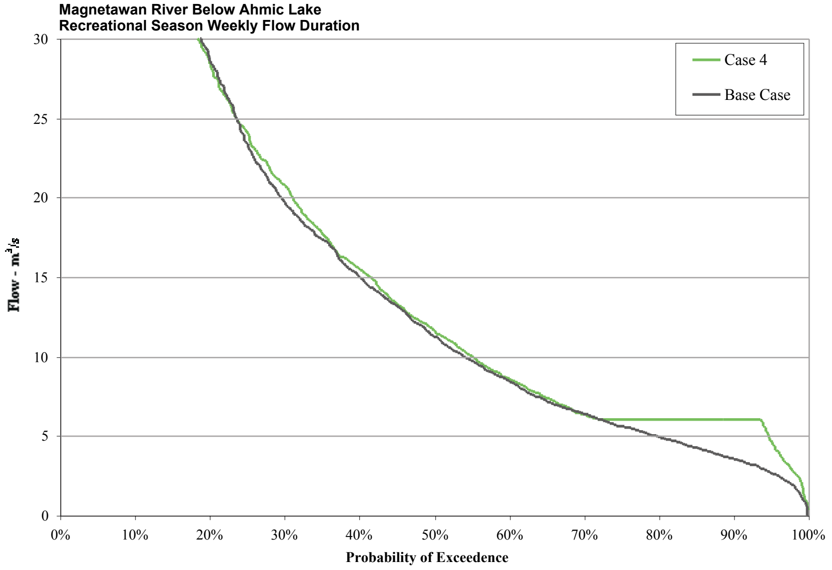

Magnetawan River Below Ahmic Lake
Recreational Season Weekly Flow Duration

Figure 8.30
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Ahmic Lake

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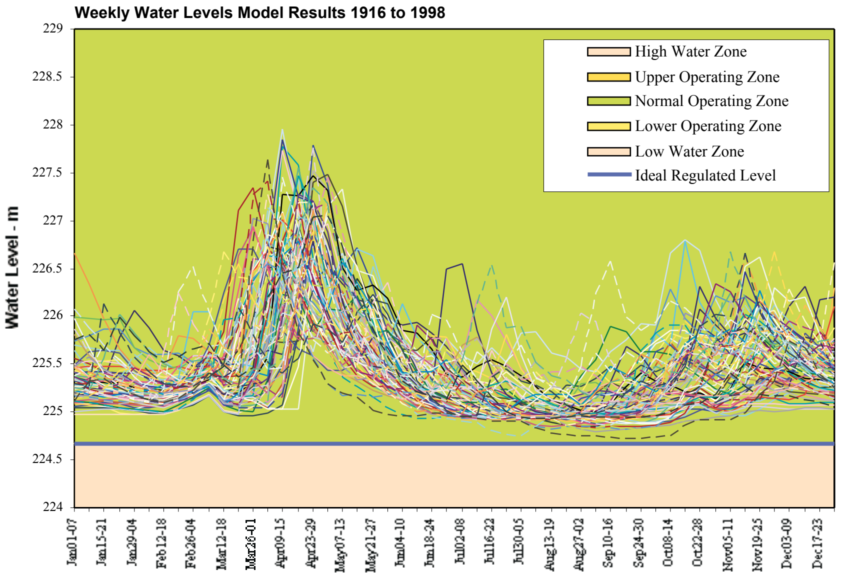
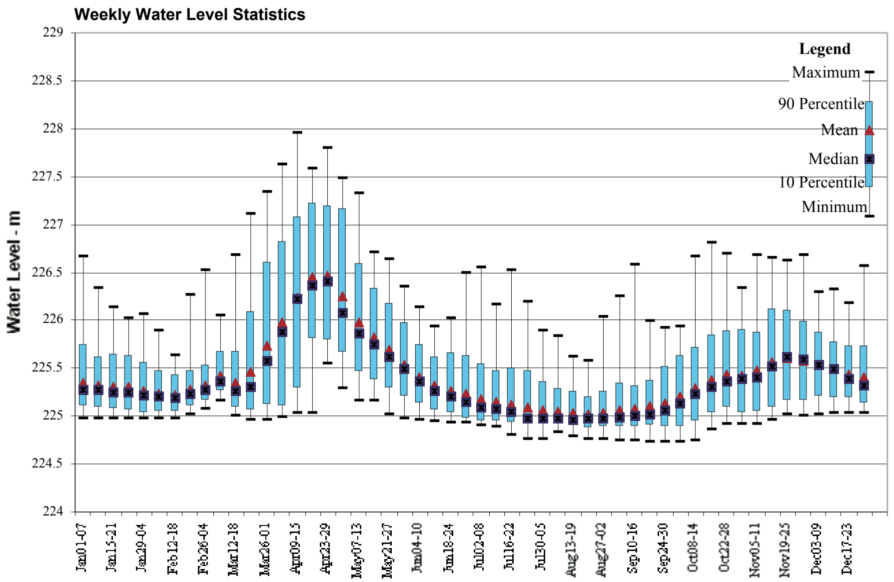




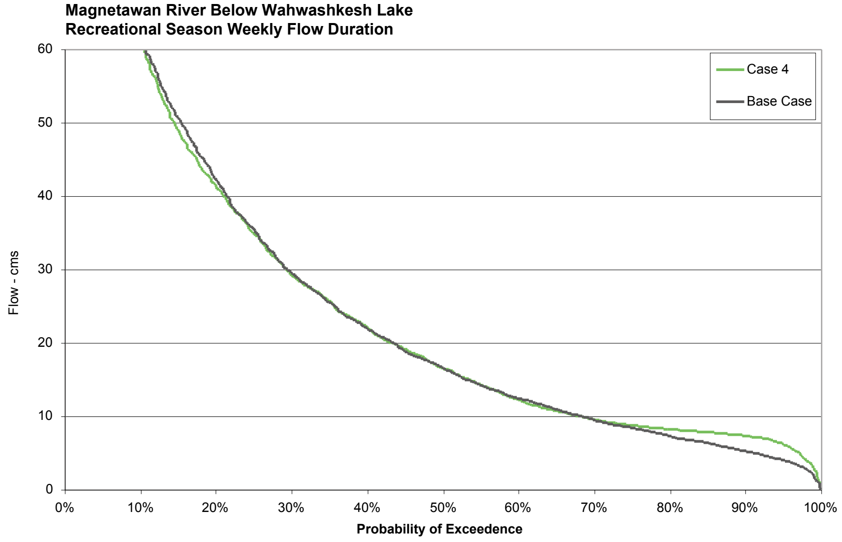
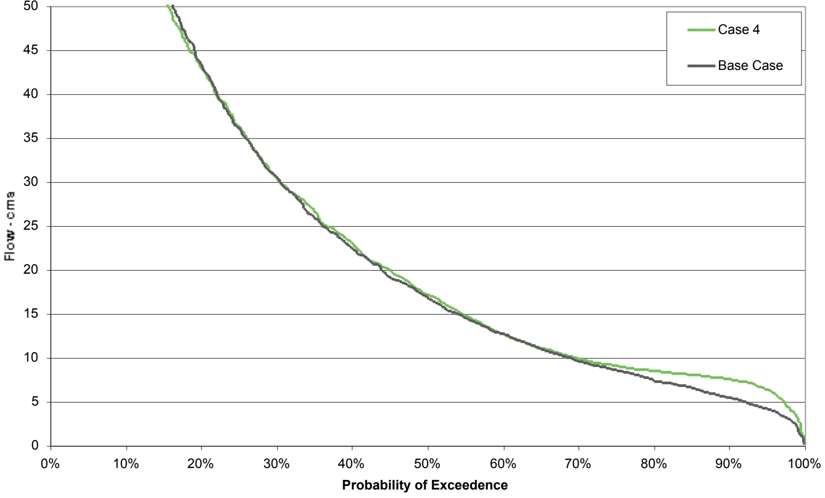
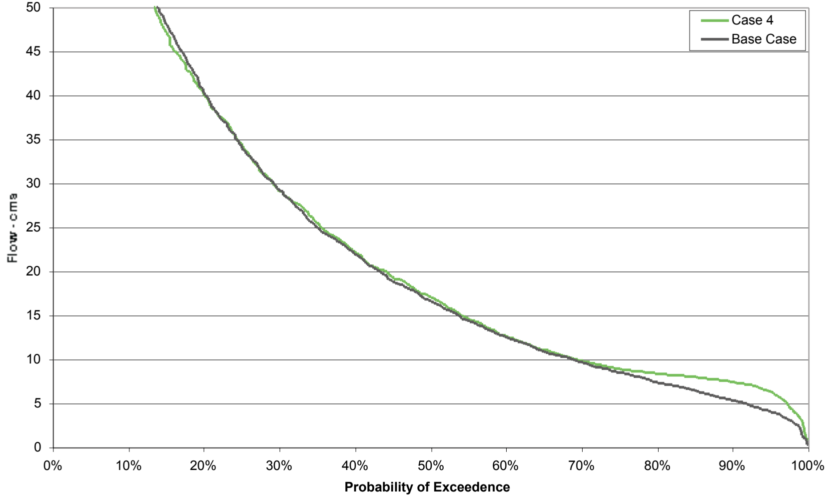


Figure 8.31
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Case 4 - Wahwashkesh Lake

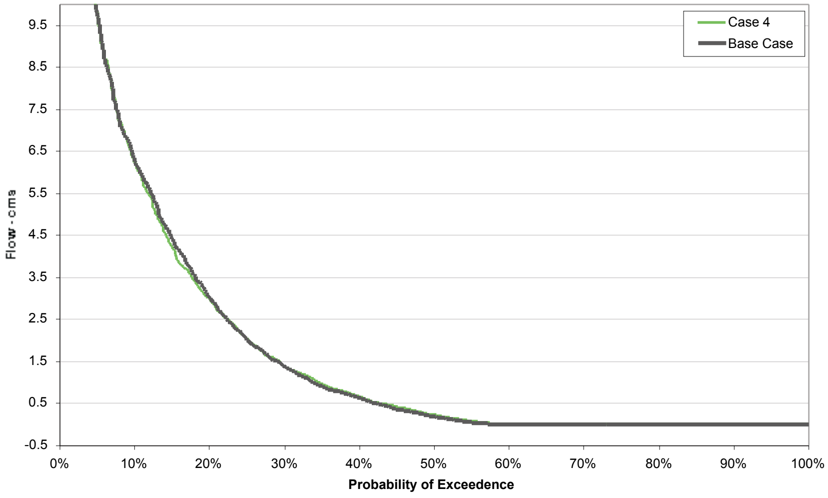
Magnetawan River Flow into Trout Lake
Recreational Season Weekly Flow Duration



Magnetawan River Below Trout Lake
Recreational Season Weekly Flow Duration



South Magnetawan River Below Trout Lake
Recreational Season Weekly Flow Duration



Magnetawan River Below WSC02EA011
Recreational Season Weekly Flow Duration

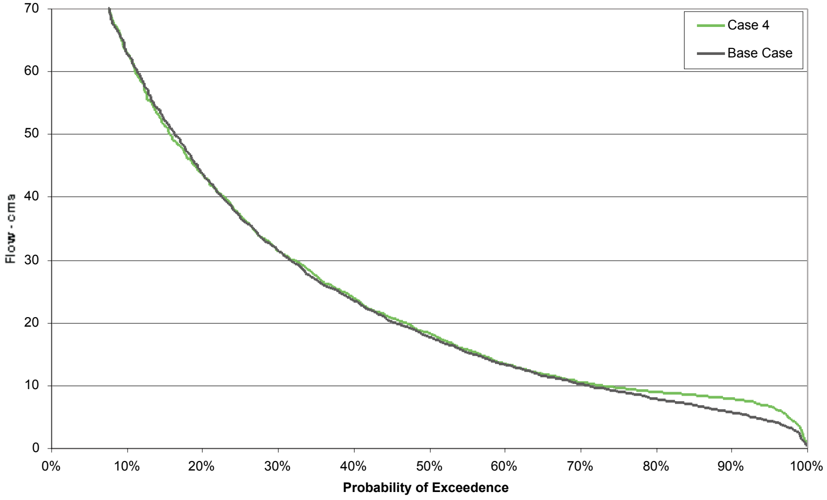


Figure 8.32
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Recreation Season Weekly Flow Duration Curves

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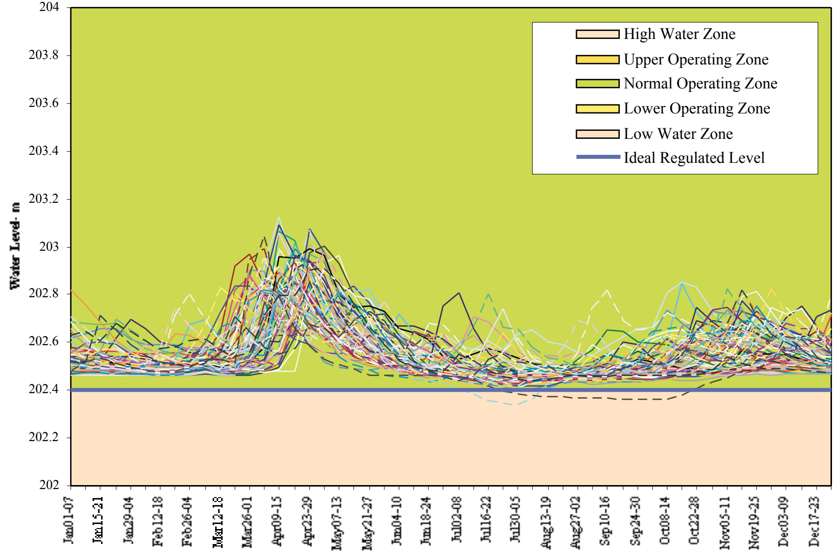
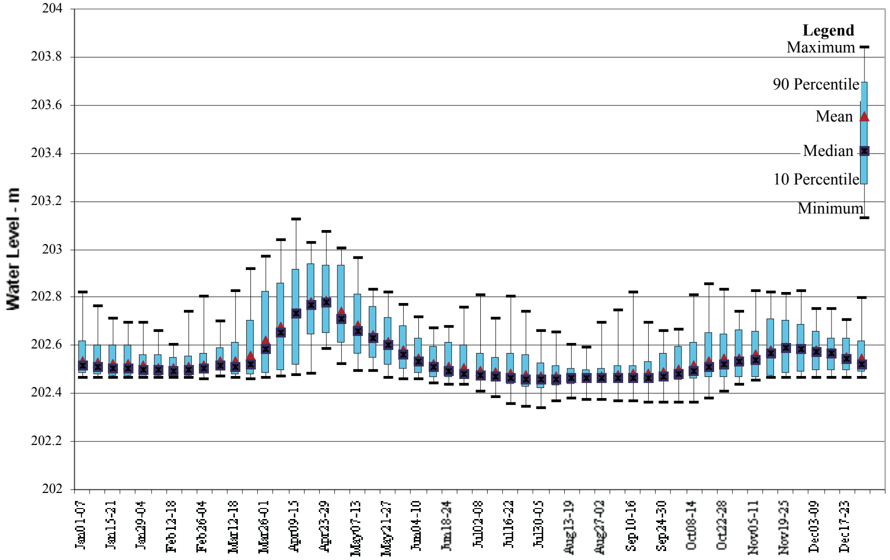
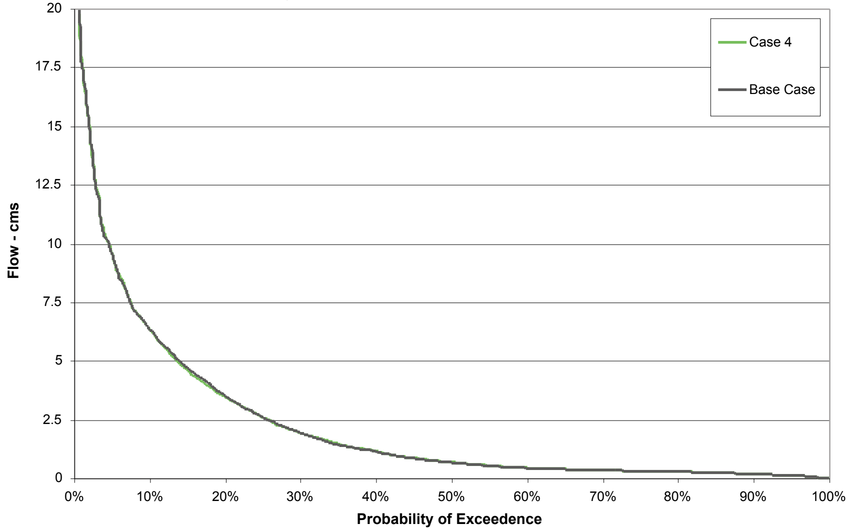
Weekly Water Levels Model Results 1916 to 1998



Weekly Water Level Statistics



Harris Creek Below Harris Lake
Recreational Season Weekly Flows Duration



South Magnetawan River Below American Trail Dam
Recreational Season Weekly Flows Duration

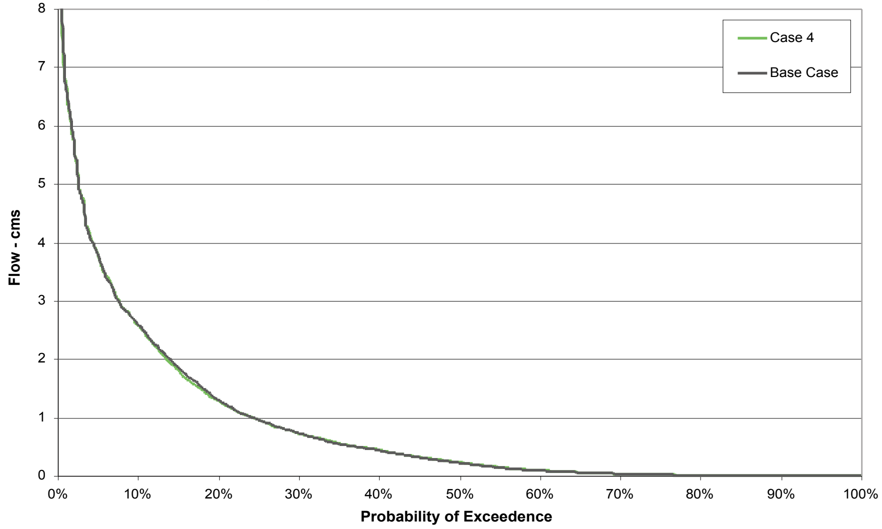


Figure 8.33
Ministry of Natural Resources
Magnetawan River Water Control Operating Plan
Harris Lake Water Levels

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