Examining municipal water treatment plant and fish hatchery data to determine how these facilities have been impacted by the 2000 Rule Curves

2015

Report prepared as part of the International Joint Commission 2000 Rule Curve Review

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Executive Summary

The purpose of this study is to assess whether municipal water treatment and fish hatchery operations on Rainy River have been affected by the 2000 Rule Curves for Rainy Lake and Namakan Reservoir. Interviews were held with the managers of the Rainy River and Emo water treatment plants, as well as the Rainy River First Nation lake sturgeon hatchery to discuss potential impacts of the changes to the rule curves on their operations. Due to the short time period that the hatchery is currently in operation each spring, any identified impacts were minor in nature and costs. The water treatment plant operators indicated that changes in the turbidity levels of the Rainy River would increase the time spent at the plant adjusting the Aluminum sulphate levels and thus increasing salary and/or chemical costs to the municipality. Plant operators also indicated that the Little Fork River is the primary source of turbid waters that affect their operations. Using daily raw water turbidity data from the water treatment plants and daily discharge data from the Little Fork R., a comparison was conducted to determine the relationship between the Little Fork R. discharge and raw water turbidity at the water treatment plants under the 1970 and 2000 rule curves. The results indicate that the correlation between these two data sets is similar for both rule curves, therefore this analysis did not show evidence of an effect of the 2000 rule curve on the water treatment plants downstream. Subsequent modeling may be undertaken in an attempt to assess these linkages in more detail. It was obvious from the analysis that the source of sediment input into the Rainy River was the Little Fork River. The sediment load from the Little Fork River masks all other background sediment signals flowing downstream along the main stem of the Rainy River. This factor, along with the distance from the water intake for the Town of Rainy River to the Rainy Lake outlet, makes it difficult to ascertain the potential impacts of the rule curve changes to areas and/or facilities located further upstream on the Rainy River.

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1.0 Introduction

In 2001 the International Joint Commission (IJC) issued an Order prescribing the method of regulating the levels of the boundary waters of Rainy and Namakan lakes, consolidating and replacing a number of previous orders and supplementary orders. This "Consolidated Order" was effective on February 28, 2001, and contained the following provision: "This order shall be subject to review 15 years following adoption of the Commission's Supplementary Order of 5 January 2000, or as otherwise determined by the Commission. The review shall, at a minimum, consider monitoring information collected by natural resource management agencies and others during the interim that may indicate the effect of the changes contained in the Supplementary Order of January 5, 2000."

In 2007, the IJC formed a Rule Curve Assessment Workgroup to develop a plan of study (POS) in which the Workgroup would prioritize the monitoring and analysis required to review the IJC Order in 2015. Specifically, the POS was written to identify priority studies and describe information/data that remained to be collected, identify what entities might collect the data and perform the studies, and to provide an estimate for the cost to accomplish this work by 2015. The Plan of Study (POS) for the Evaluation of the International Joint Commission (IJC) 2000 Order for Rainy and Namakan Lakes and Rainy River was completed in 2009.

The purpose of this study is to assess whether municipal water treatment and fish hatchery operations on Rainy River have been affected by the 2000 Rule Curves for Rainy Lake and Namakan Reservoir. This study is identified in the POS as one of the priority studies.

The Township of Emo and Town of Rainy River, both located on the Canadian side of the Rainy River in Ontario, are the only communities that lie downstream of the Fort Frances/International Falls dam that rely entirely on the Rainy River for municipal water supply needs. In recent years, Emo's intake was moved closer to shore in deeper water but there are still concerns about the effects of water levels, sediment build up, and in the winter, ice buildup. Rainy River's intake is located in depths that do not cause water quantity to be of concern, but there are concerns about water quality and the amount of suspended sediment in the source water. The Rainy River First Nation uses both river and well water in its fish hatchery where the emphasis is on the culture of lake sturgeon, which is classified as a Species of Special Concern in Minnesota and Threatened in Ontario.

Constructed in 1969, Emo's water treatment facility was operated by the Ontario Ministry of the Environment (MOE) until the 1990's, when the Ontario Clean Water Agency (OCWA) took over the plant. The township has operated the facility since 1998 (Brenda Cooke and Ed Bullied, Township of Emo, personal communications during a meeting at the township office on June 27, 2012).

Constructed in the 1970's, Rainy River's water treatment facility was operated by MOE until the 1990's, when OCWA took over the plant. The town has operated the facility since 1996 (Veldron Vogan, Town of Rainy River, personal communications during a telephone conversation on July 13, 2012).

Fort Frances and International Falls intakes for municipal water are located within the reach of the Rainy River that lies above the dam between the two cities. Neither has expressed a concern about the effects of the 2000 Rule Curves on their operations.

Figure 1 – Map of study area

2.0 Objective

The objective of this study is to determine if the implementation of the 2000 Rule Curves affected the use of water from the Rainy River for municipal purposes by the Township of Emo and the Town of Rainy River or the operation of the fish hatchery located at Manitou Rapids in Rainy River First Nation.

3.0 Methods

With the goal of determining the impacts of the 2000 Rule Curve on the water treatment plants and fish hatchery on the Rainy River, the operators/managers of these facilities were the primary source of information on potential impacts. Interviews were held with the manager/owner of the fish hatchery (Joe Hunter) as well as the water treatment plant operators in both the Town of Rainy River and the Township of Emo. These interviews provided the direction for future data collection and analysis.

Once the initial interviews were completed, all available data sets were explored to provide potential comparisons between the 1970 and 2000 Rule Curves. Fortunately, the Town of Rainy River had raw water data from 1991 to 2014 available for analysis. This data included raw water turbidity, which had been identified as the primary impact on the daily operations and costs for these facilities. Discussions with the operators also indicated that the Little Fork River was the largest factor affecting the turbidity levels at both the Emo and Rainy River water treatment plants. An exploration of available data sets for the Little Fork River yielded daily discharge levels for the entire time period that raw water data was available from the Town of Rainy River (1991 to 2014).

In order to ensure that the data sets emphasized the comparisons between the 1970 and 2000 Rule Curves, significant drought and flood years were removed from the data sets. It was felt drought and flood years, when water levels were significantly above or below the Rule Curve for significant lengths of time, were a product of extreme weather conditions and would have resulted in similar levels in the Rainy River regardless of the Rule Curve regime. In addition, major flood events can result in irregularities in the Little Fork River historical discharge and/or sediment data and the removal of flood years from the data set is felt to address these discrepancies (Jesse Anderson, Minnesota Pollution Control Agency, personal communications during the 2015 Water Quality Forum).

Once the flood and drought years were removed from the data sets they were split into the time period when the 1970 Rule Curve was being used (1991 to 1999) and when the 2000 Rule Curve was implemented (2000 to 2014). Using the data sets for the discharge from the Little Fork River and raw water turbidity from the Town of Rainy River water treatment plant, a correlation coefficient was calculated for each time period. These two coefficients were then compared to determine if the relationship between these two variables differed under the two different rule curves.

4.0 Results

4.1 Interviews

An interview was conducted with Joe Hunter, owner/operator of the Rainy River Fish Hatchery on November 20th, 2014. The fish hatchery currently operates for a few weeks each spring during the lake sturgeon spawning period. Once the lake sturgeon have hatched, the fry are then sold or released and the hatchery closes for the season. The water for the operation of the hatchery each spring comes from Rainy River. The facility also has the ability to draw water from a well, but this source was designed for when the hatchery operated as a rearing facility. There were not any identified significant impacts to the operation of the hatchery based on water quality and/or quantity. During low water years, the hatchery will place a floating dock near the shore to access areas with sufficient depth to operate their water pumps. High turbidity in the river water will result in increased maintenance of the filters, but the fish do not appear to be adversely impacted by the more turbid waters while in the hatchery. Due to the fact that the operator of the fish hatchery did not feel that the operations were adversely impacted by the water quality and/or quantity of the Rainy River, the effects of the 2000 Rule Curves on the hatchery were not explored any further.

Figure 2 – Alum storage in Emo treatment plant

Interviews were held with water treatment plant operators in the Town of Rainy River (November 10^{th}, 2014) and Township of Emo (December 5^{th}) to determine potential impacts of water quality and quantity on the water treatment plants. Interview questions focused on turbidity, temperature, pH, and bacteria levels found in the raw water samples. Through these discussions, it was identified that changes in turbidity had the greatest impact on the operation on these facilities. Temperature, pH, and bacteria are all factors that can affect the operation of a water treatment plant, but these variables were not felt to vary significantly enough to cause increased costs in terms of supplies or time to the plants. Therefore, the focus for the data analysis was on the raw water turbidity results and its potential impacts.

When there are large changes in raw water turbidity levels in Rainy River, the water treatment plants need to adjust the levels of Aluminum sulphate (Alum) being added to the raw water as part of the treatment process. When the Alum is added to the raw water, it acts as a coagulant and binds to the particles in the water to assist with the filtration process. As the turbidity levels in the water increase or decrease, the Alum levels must be adjusted manually to compensate. Therefore, changes in turbidity levels will result in increased chemical costs and/or labour costs for the water treatment plants. During the interviews with the operators, it became clear that the Little Fork River is the major source of turbidity affecting the downstream water treatment plants.

4.2 Data Collection

Once it had been identified that turbidity changes had a significant impact on the water treatment plants, data collection efforts focused on collecting all of the available raw water turbidity data for the Rainy River. The water treatment plants have excellent, multi-year data sets for daily raw water turbidity. An example of a monthly data sheet found at the water treatment plants can be found in Appendix 1. The Town of Rainy River had the most complete turbidity data set, extending from 1991 to 2014, so this was the data set used for analyses.

With the knowledge that increases in amounts of Alum and labour were associated with turbidity changes at the water treatment plants, efforts were made to obtain labour costs and chemical purchases from both the Town of Rainy River and Township of Emo. While labour costs and chemical purchase records were produced, they were insufficient both temporally (no data prior to 2005) and in scope (labour costs by month and chemical purchased annually) to conduct an effective comparison with either the daily raw water turbidity data from the water treatment plants or the daily discharge data from the Little Fork River. Given that the water treatment plant operators indicated that they experienced an increase in Alum and labour associated with changes in turbidity, it was felt that raw water turbidity was a reasonable representation of the increased costs to the municipalities associated with turbidity fluctuations.

All of the water treatment plant operators at Emo and Rainy River identified the Little Fork River as the greatest input of turbid waters affecting their operations. Research efforts for the Little Fork River focussed on finding a complete data set for daily sediment load from 1991 to present. While this data set was not available (any turbidity data or sediment load information was either sporadically sampled or annual summaries), there was a complete data set of daily discharge from the Little Fork River for the time period from 1991 to present (USGS 2015). It was felt that the daily discharge data was a reasonable representation of the turbidity inputs from the Little Fork River in order to explore the relationship with Rainy River raw water turbidity.

In order to ensure that the impacts of the Rule Curve are being studied and not the impacts of extreme weather events, flood (1996, 2001, 2002, 2008, 2014) and drought (1998, 2003) years were removed from the data set. The removal of flood and drought years is based on the assumption that in years of either extremely high or extremely low flows the levels in Rainy Lake and the Rainy River would be the same regardless of which rule curve (1970 or 2000) is in existence at the time. This decision was further supported by discussions with Jesse Anderson from the MPCA during the 2015 Water Quality Forum, where Jesse indicated that flood years present perplexing data from the Little Fork River that would only introduce further "noise" into the data analyses. The Rainy Lake elevation levels from 1991 to 2014 are shown in Appendix 2.

4.3 Water Quality Forum

The data collected and initial analysis for this project was presented at the International Rainy-Lake of the Woods Watershed Forum on March 11th, 2015 in International Falls, MN. The poster presentation provided an excellent opportunity to discuss the results and analysis with researchers with a range of backgrounds. In addition, the forum presentation allowed for the quality and quantity of data sets at the water treatment plants to be shared with the research community for potential future projects.

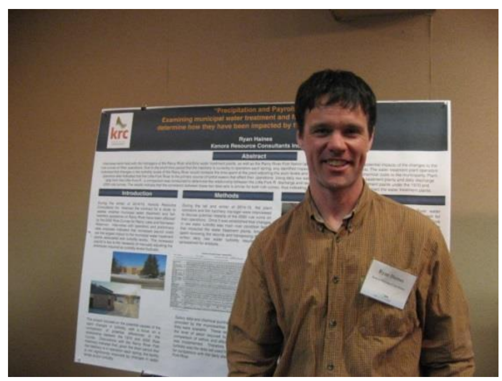


Figure 3 – Watershed forum poster presentation

5.0 Analysis

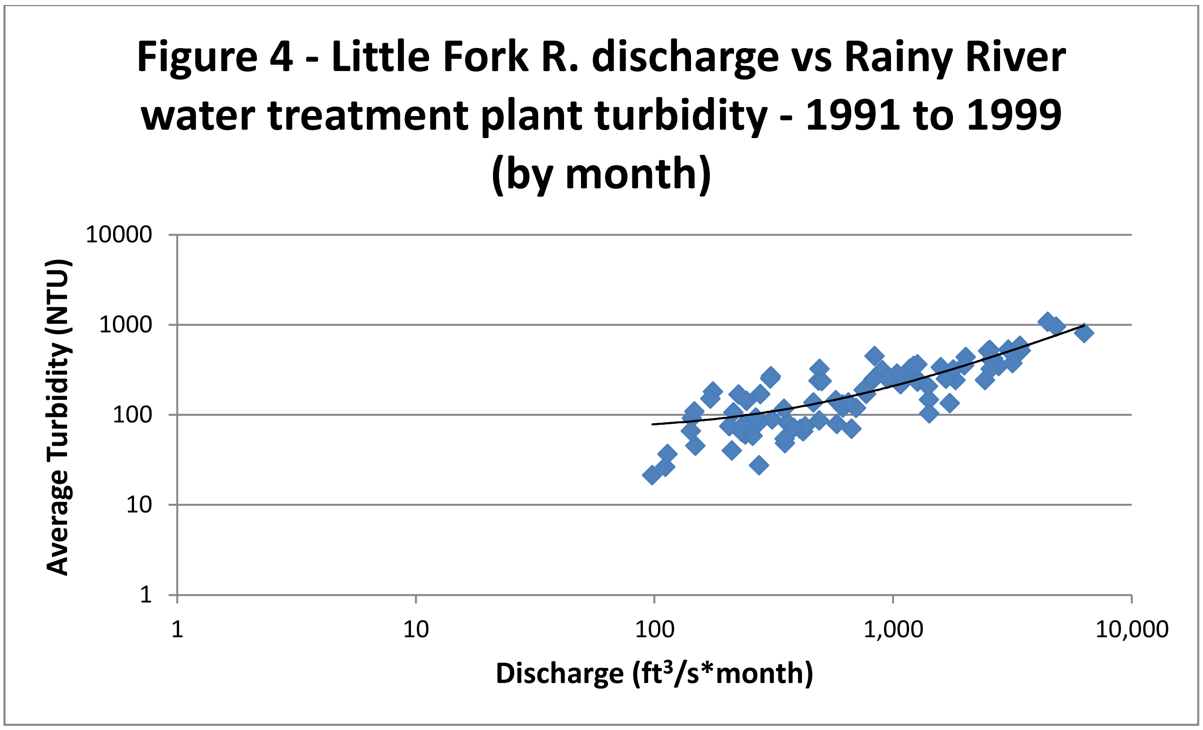
5.1 Little Fork Discharge vs Raw Water Turbidity

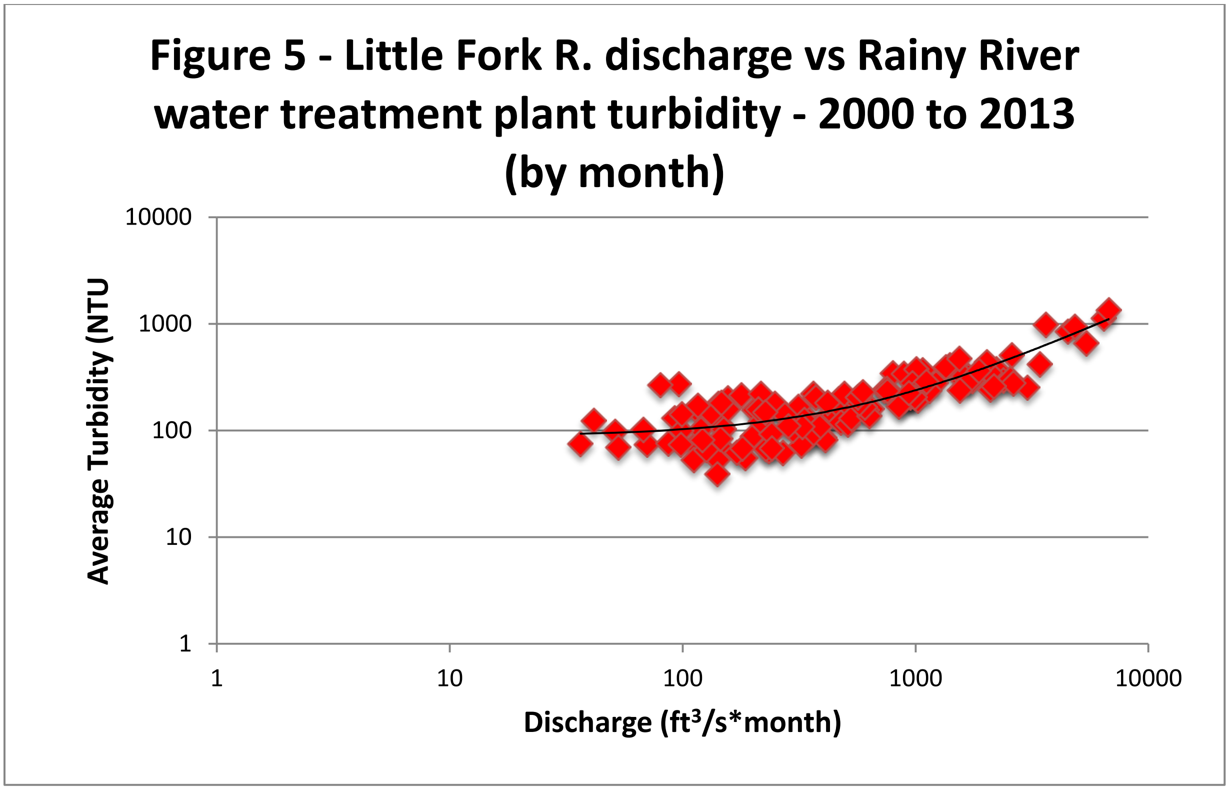
The daily discharge data for the Little Fork River and the daily raw water turbidity data for the Town of Rainy River water treatment plant provide two data sets for comparison of the potential impacts of the 2000 Rule Curves. These data sets were divided into two time periods, one during the 1970 Rule Curves regime (1991 to 1999) and one during the 2014 Rule Curve regime. The results are shown in Table 1.

Table 1. Correlation coefficients for daily Little Fork R. discharge vs Rainy River turbidity

Time Period	Correlation Coefficient
1991 to 1999	0.7576
2000 to 2014	0.7776

A summary of this data is displayed graphically in Figures 4 and 5. In order to present the data in a clear manner, the data presented in the graphs is based on monthly total for discharge and daily average by month for turbidity, not the daily data used for the calculation of the correlation coefficient.

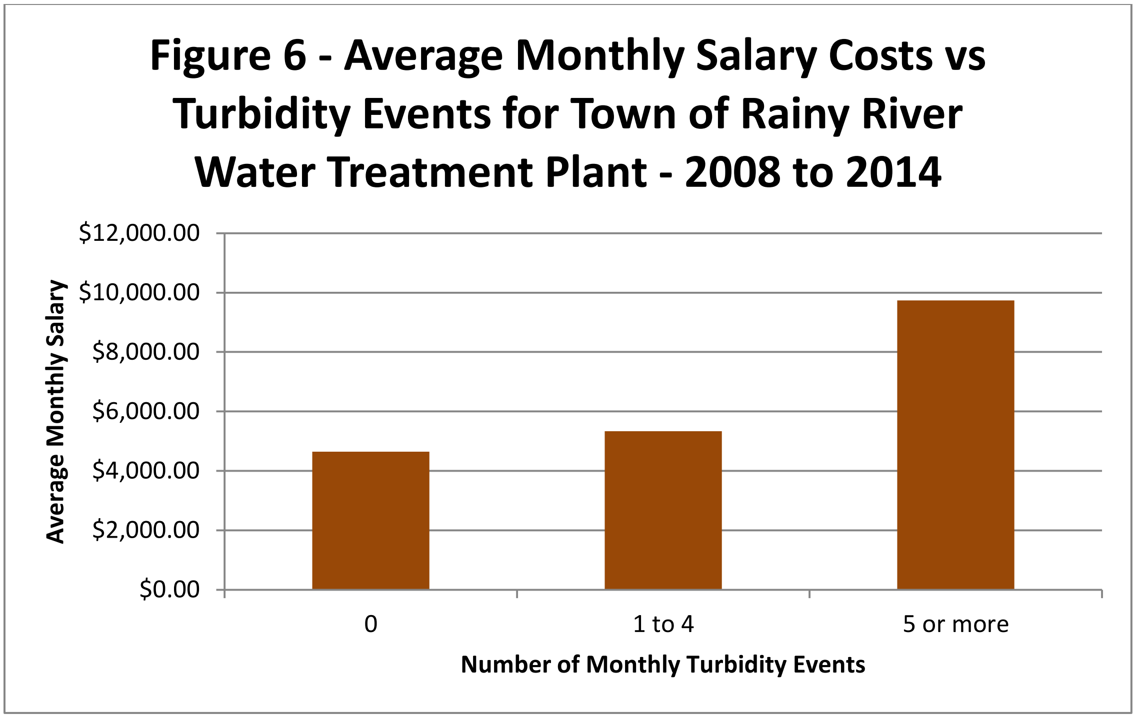




5.2 Monthly Salary Costs vs Daily Turbidity Changes

In discussions with water treatment plant operators, they indicated that the time spent at the plant to adjust the levels of Alum increases significantly when the daily Nephelometric Turbidity Units (NTU) changes by a factor of 10 or more (Bob Jenson, personal communications, November 10, 2014). For the remainder of this report, a daily change in turbidity of 10 NTU or more will be referred to as a "turbidity event".

In an attempt to quantify the costs associated with turbidity events, monthly salary for the water treatment plant for the time period from 2008 to 2014 was obtained from the Town of Rainy River finance department. The monthly salary was then compared to the number of 24 hour events where turbidity changed by 10 NTU or greater. This was done for the open water season (April to October) as maintenance and repair is often conducted at the water treatment plants over the winter resulting in potential increased salary costs that are not related to turbidity levels. As shown in Figure 6, the average monthly salary costs for months when there were no turbidity events was $4,648.57. This amount increased slightly when there were one to four turbidity events (monthly average $5,331.44), but there was a significant increase in the salary costs to the town when there were five or more turbidity events during a month (monthly average $9,740.60).



It is felt that this significant increase in the costs once the number of turbidity events exceeded four likely reflects the municipal staff's ability to adjust their work load to accommodate turbidity changes. The water treatment plant operators in the Town of Rainy River and Township of Emo are responsible for all public works activities in their respective communities. As a result, work at the water treatment plants is just a part of their responsibilities each month. Therefore, when turbidity events occur the operators are likely able to delay some of their other activities/ responsibilities to offset any increase in salary costs. However, at a certain point (the data analysis indicates that this is five or more turbidity events) the operators no longer have the flexibility in their work schedule to offset time spent at the plant and the municipality begins to experience higher salary costs associated with the overtime required to maintain the municipal infrastructure in addition to managing the turbidity events.

The manner in which the Town of Rainy River and the Township of Emo order their chemicals (annually or bi-annually) did not allow for the analysis of potential increases in costs associated with the changes in Alum required for increased turbidity events. Discussions with the operators indicated that increased salary is the largest cost associated with turbidity events and the chemical expenses were insignificant in comparison (Bob Jenson, personal communications, November 10, 2014).

6.0 Discussion

At the outset of this project, the intent was to have the operators of the subject facilities identify the potential impacts of the 2000 Rule Curves on their operations. The operators of the Town of Rainy River and Township of Emo water treatment plants identified turbidity as the largest impact on the operation of these facilities. The identified cost to the municipalities was both in salary costs and chemicals purchased. While the available data for the operational costs for the water treatment plants was not sufficient for a detailed analysis of the direct impacts of the rule curves, it was felt that the information provided by the operators was sufficient to allow the daily raw water turbidity data to be used as an indicator of water treatment costs borne by the municipalities.

The water treatment operators both at the Town of Emo and the Township of Rainy River identified the Little Fork River as the major contributor of turbid waters to the Rainy River. When presented with the possibility of the Rainy Lake waters passing though the dams at Fort Frances/International Falls diluting the waters from the Little Fork River and impacting their operations, the operators felt that this was a relationship worth exploring. While the available sediment load data from the Little Fork River was not available in a manner that allowed for a detailed comparison, the daily discharge data provided an excellent data set that was related to sediment load and could be compared to the raw water turbidity data provided by the water treatment plants.

Therefore, it was felt that correlation tests of the two available data sets for time periods under the 1970 and 2000 Rule Curves would provide an indication if this relationship varied under two different flow regimes. Following the removal of major flood and drought years from the data sets; when the flows would likely be the similar regardless of which rule curve was used; a correlation coefficient was calculated for the time periods from 1991 to 1999 and 2000 to 2014. The correlation coefficients for these two time periods were similar (0.7576 and 0.7776, respectively) indicating that the relationship between the discharge from the Little Fork River and the raw water turbidity at the Town of Rainy River did not differ significantly under the two different rule curve regimes.

It was obvious from the analysis that the source of sediment input into the Rainy River was the Little Fork River. The sediment load from the Little Fork River masks all other background sediment signals flowing downstream along the main stem of the Rainy River. This factor, along with the distance from the water intake for the Town of Rainy River to the Rainy Lake outlet, makes it difficult to ascertain the potential impacts of the rule curve changes to areas and/or facilities located further upstream on the Rainy River.

During discussions with the owner of the Rainy River First Nation fish hatchery, it became apparent that any financial or time costs associated with changes in water quantity or quality in the Rainy River were minor in nature. The hatchery only operates for several weeks each spring and the impacts were limited to the placement of a floating dock near the water intake during low water years and more frequent cleaning of filters during time periods of high turbidity. In addition to negligible costs, the owner of the hatchery did not feel that the change from the 1970 to the 2000 Rule Curves had affected the operation in any way.

7.0 Conclusion

The results of the correlations conducted between the discharge data from the Little Fork River and the turbidity results from Rainy River, in addition to discussions with the owner of the Rainy

River First Nation fish hatchery, do not show any evidence that the 2000 Rule Curves have had significant impacts on the water treatment plants or fish hatchery located on the Rainy River.

8.0 Recommendations

While more detailed analyses and modelling is beyond the scope of this project, it is felt that the available data sets may provide opportunity for subsequent modelling. If there is interest, subsequent modeling could be completed to assess the potential impacts of the 2000 Rule Curves in more detail. These modeling efforts could include answering questions that arose during discussions stemming from this study including:

a. Is it possible to separate the influences of rule curve changes and hydrological impacts of Rainy River tributaries including the Little Fork River?
b. Do the impacts of the rule curve changes and/or the influence of the sediment load from the Little Fork River weaken further downstream from the Rainy River outlet and/or Little Fork River confluence?
c. Is there a theoretical Rule Curve regime that would mitigate the downstream turbidity fluctuations and associated costs to the township of Emo and town of Rainy River?

9.0 Acknowledgements

We would like to acknowledge the following for their help in making this project possible:

- Bob Jenson, Veldron Vogan, Julie Tiboni (Town of Rainy River)
- Ed Bullied, Jason Smith (Township of Emo)
- Joe Hunter (Rainy River First Nation Fish Hatchery)
- Wayne Jenkinson, Ryan Maki, Claire Kissane, Nolan Baratono, Jesse Anderson

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Appendix 1 – Sample Water Treatment Plant Monthly Data Sheet

Township of Emo/Emo Water Treatment Plant

WW # 210000657

Month: April   Year: 2008   Superintendent/Chief Operator: [signature]

D1 = Municipal Garage D2 = Emo Inn D3 = 42 Kitchener Street D4 = Donald Young School D5 = Other (see daily log book)

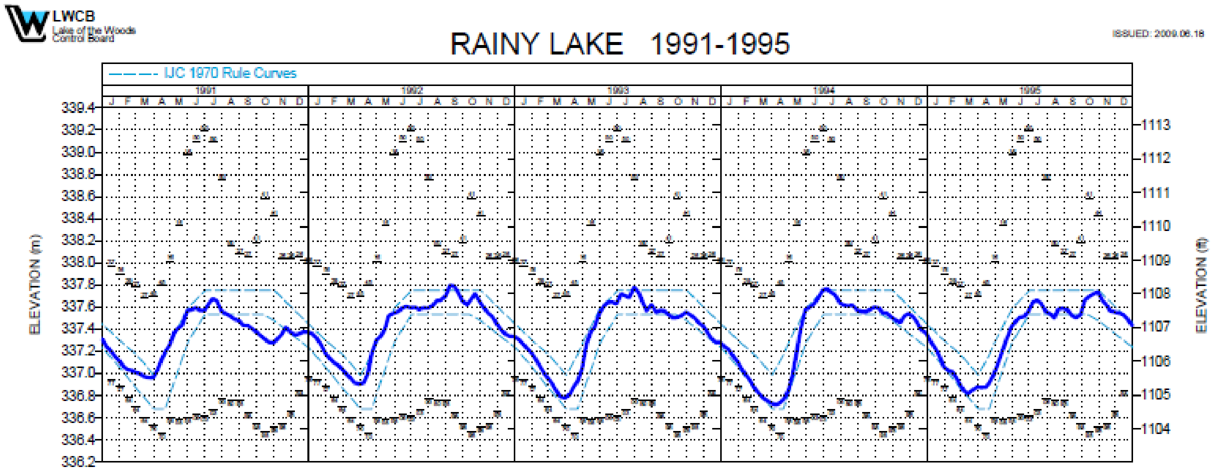
	1	2	3	4	5	6	7	8	9	10
Operator Initials	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B
Time	8:30	8:35	8:[illegible]	8:30	9:00	9:00	8:3[illegible]	8:30	8:40	8:30
Raw Water volume m3	404	316	378	398	391	218	386	333	378	393
Treated Water volume m3	318	346	321	342	339	314	297	328	331	343
D.I.P.F.	525	600	563	563	625	563	563	625	563	563
Raw Water Flow Rate m3/h	16.6	16.5	16.5	16.5	16.4	16.4	16.5	16.0	16.1	16.1
Raw Water PH	7.3	7.2	7.4	7.2	7.4	7.3	7.4	7.3	7.3	7.3
Raw Water Turbidity NTU	2.0	2.7	4.6	6.1	6.9	5.5	5.9	3.1	4.9	3.9
Raw Water Temperature °C	3.6	4.3	4.0	5.6	4.6	4.8	4.9	4.0	5.2	5.5
CL2 Used kg	1.35	.90	1.35	1.35	1.50	1.35	1.80	1.35	1.35	1.35
WTP Free CL2 Resid. mg/l	1.65	1.70	1.57	1.36	1.36	1.52	1.58	1.77	1.91	2.05
Dist. Free CL2 Resid. mg/l	.57	.67	.68	.66	.57	.56	.24	.44	.70	.68
Location	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1
Time	8:30	9:00	7:55	7:55	8:30	8:40	9:30	8:00	8:00	8:00
Operator Initials	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B
Treated Water PH	7.5	7.6	7.7	7.5	7.6	7.4	7.4	7.2	7.4	7.4
Treated Water Turbidity NTU	.57	.56	.51	.41	.34	.49	.33	.35	.37	.18
Treated Water Temperature °C	4.6	4.5	5.0	5.1	5.1	5.3	5.8	5.4	5.2	5.6
Alum Residual mg/l	.04	.04	.04	.03	.03	.04	.01	.01	.02	.01
Alum Used m3	.024	.044	.044	.030	.060	.034	.036	.024	.036	.034
Polymer Used kg	.044	.057	.050	.050	.060	.031	.050	.050	.060	.056
Soda Ash Used kg	22.7	/	22.7	/	22.7	/	22.7	/	22.7	22.7
No. of Filters in Use	2	2	2	2	2	2	2	2	2	2
INF Turbidity NTU	.42	.47	.58	.81	.64	.61	.67	.64	.35	.46
EFF Turbidity NTU	.05	.06	.06	.07	.07	.06	.06	.06	.06	.07
Average Filter Run Hours	24.3	19.1	24.2	24.3	24.1	17.1	23.7	20.4	23.7	24.4
Backwash volume m3	23.4			23.4				23.4		
Clarifier Sludge										
Raw Sewage Daily Flow m3	466	634	394	847	609	519	505	649	553	512

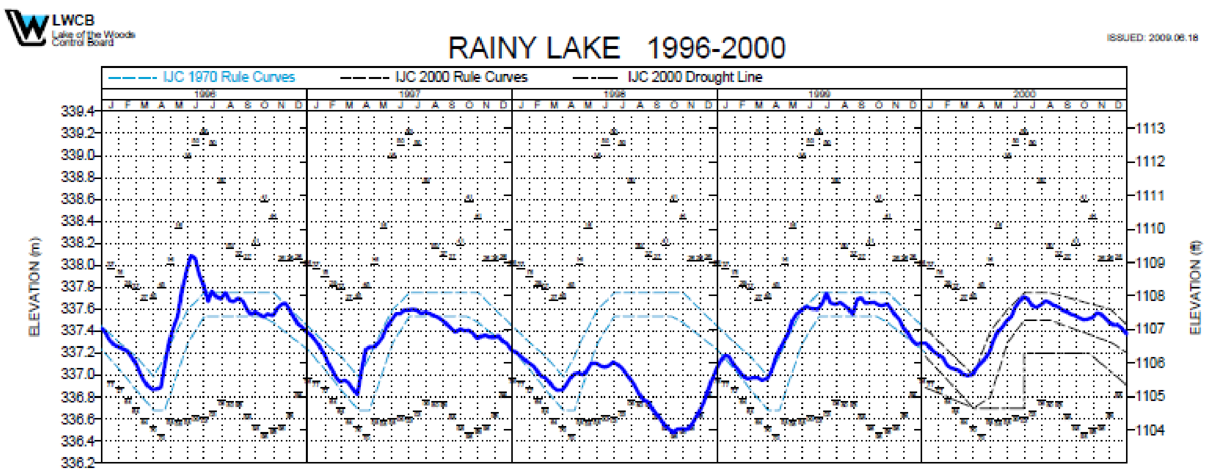
	11	12	13	14	15	16	17	18	19	20
Operator Initials	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B
Time	8:45	8:30	9:00	8:45	8:30	8:25	8:30	8:30	8:30	8:30
Raw Water volume m3	331	328	381	388	281	384	325	371	385	378
Treated Water volume m3	289	334	380	326	339	331	319	315	333	330
D.I.P.F.	438	525	525	675	625	575	563	675	563	563
Raw Water Flow Rate m3/h	16.0	16.0	16.2	16.0	16.0	16.0	16.1	16.0	16.0	15.6
Raw Water PH	7.4	7.5	7.4	7.2	7.4	7.3	7.2	7.4	7.3	7.5
Raw Water Turbidity NTU	4.6	6.1	5.0	4.2	6.1	12.3	22.4	23.6	31.6	144
Raw Water Temperature °C	3.8	3.6	5.3	5.1	4.7	6.8	5.0	6.1	5.5	4.4
CL2 Used kg	1.35	1.35	1.35	1.80	1.35	1.80	1.35	.90	1.80	1.35
WTP Free CL2 Resid. mg/l	1.63	1.57	1.50	1.52	1.50	1.53	1.56	1.51	1.61	1.64
Dist. Free CL2 Resid. mg/l	.63	.57	.52	.37	.71	.83	.40	.53	.57	.52
Location	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1
Time	8:20	8:40	8:10	9:20	8:00	8:00	8:00	8:10	7:50	8:00
Operator Initials	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B
Treated Water PH	7.3	7.4	7.4	7.4	7.3	7.5	7.3	7.3	7.2	7.2
Treated Water Turbidity NTU	.26	.27	0.39	.25	.26	.37	.24	.56	.32	.42
Treated Water Temperature °C	5.6	5.8	5.7	5.7	6.0	6.7	6.2	6.5	6.1	6.5
Alum Residual mg/l	.01	.02	.02	.03	.01	.01	.02	.04	.02	.01
Alum Used m3	.080	.060	.030	.036	.038	.036	.036	.041	.044	.034
Polymer Used kg	.040	.050	.050	.044	.063	.056	.050	.050	.050	.044
Soda Ash Used kg	/	22.7	/	22.7	22.7	/	22.7	/	22.7	22.7
No. of Filters in Use	2	2	2	2	2	2	2	2	2	2
INF Turbidity NTU	.59	.69	.54	.48	.66	.37	.66	.57	.58	1.2
EFF Turbidity NTU	.06	.07	.06	.06	.06	.06	.07	.07	.07	.07
Average Filter Run Hours	20.6	20.5	23.5	24.2	23.9	22.7	20.2	23.5	24.4	23.9
Backwash volume m3	23.4				23.4			23.4		
Clarifier Sludge										
Raw Sewage Daily Flow m3	475	451	447	465	491	637	543	515	481	452

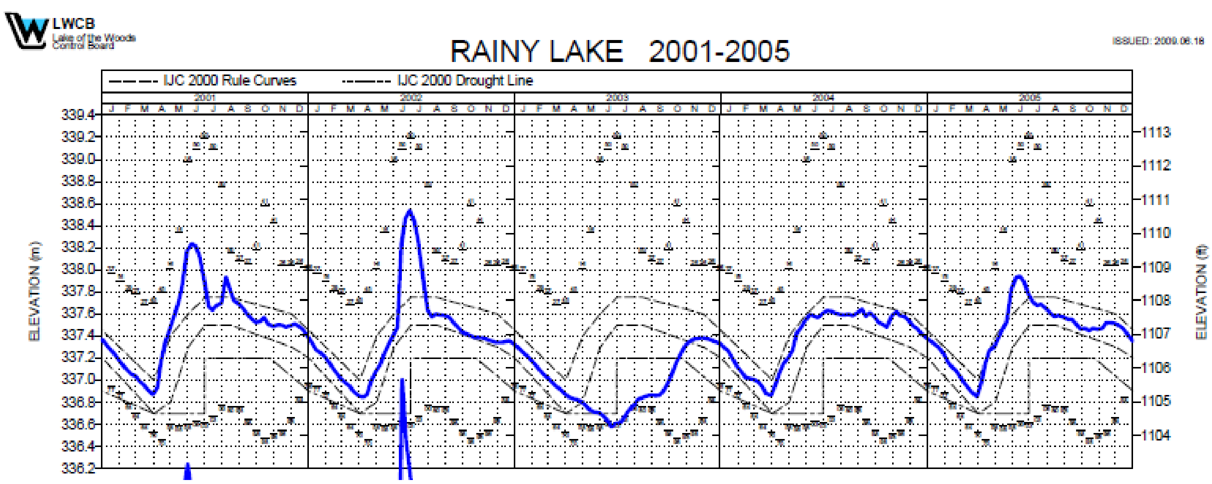
	21	22	23	24	25	26	27	28	29	30	31	Total	Average
Operator Initials	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B			
Time	8:30	8:15	8:30	8:30	8:30	8:30	8:30	8:30	8:30	8:30			
Raw Water volume m3	367	379	365	364	347	263	378	286	383	338		10,448	348.2
Treated Water volume m3	352	351	302	311	278	281	342	297	315	317		9,369	312.3
D.I.P.F.	563	563	500	563	563	563	625	563	625	625		17,183	572.7
Raw Water Flow Rate m3/h	15.7	15.4	15.4	14.7	15.8	15.9	16.1	16.1	16.1	15.9		480.5	16.0
Raw Water PH	7.3	7.3	7.3	7.4	7.6	7.7	7.7	7.7	7.5	7.5		221.9	7.39
Raw Water Turbidity NTU	147	106	105	116	133	117	67	45	28.6	21.5		1,184.9	39.49
Raw Water Temperature °C	4.8	6.4	6.2	7.3	6.4	5.5	5.0	4.0	4.5	4.7		151.0	5.03
CL2 Used kg	1.35	1.80	1.35	1.35	1.35	.90	1.35	1.35	1.35	.90		41.40	1.38
WTP Free CL2 Resid. mg/l	1.66	1.71	1.78	1.74	1.69	1.70	1.56	1.52	1.42	1.64		48.27	1.609
Dist. Free CL2 Resid. mg/l	.46	.91	.72	.83	.54	.62	.46	.18	.45	.58		16.96	0.565
Location	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1	D-1			
Time	9:45	8:00	8:00	8:00	8:30	9:00	8:10	9:35	8:00	8:00			
Operator Initials	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B	E.B			
Treated Water PH	7.2	7.0	7.1	7.2	7.5	7.6	7.4	7.6	7.4	7.5		221.6	7.38
Treated Water Turbidity NTU	.61	.60	.58	.63	.65	.58	.68	.72	.81	.77		14.15	0.47
Treated Water Temperature °C	6.8	6.1	6.2	7.7	7.1	6.7	6.6	6.8	6.7	6.2		179.1	5.97
Alum Residual mg/l	.05	.04	.04	.05	.06	.05	.08	.07	.06	.06		1.03	0.034
Alum Used m3	.054	.060	.048	.048	.048	.036	.054	.036	.036	.036		1.122	0.037
Polymer Used kg	.044	.044	.066	.066	.056	.037	.050	.037	.044	.037		1.445	0.048
Soda Ash Used kg	/	22.7	22.7	/	22.7	22.7	22.7	/	22.7	/		408.6	13.62
No. of Filters in Use	2	2	2	2	2	2	2	2	2	1			2
INF Turbidity NTU	.80	1.4	1.7	1.5	1.7	1.8	.82	1.2	1.0	.77		24.48	0.81
EFF Turbidity NTU	.07	.06	.07	.07	.08	.08	.08	.07	.07	.07		1.99	0.066
Average Filter Run Hours	23.7	24.6	23.9	23.9	23.3	16.6	24.4	17.9	23.9	21.8		677.8	22.59
Backwash volume m3	11.7	11.7			23.4				23.4			210.6	7.02
Clarifier Sludge													
Raw Sewage Daily Flow m3	549	556	485	931	715	600	655	762	1001	975		18,394	613.1

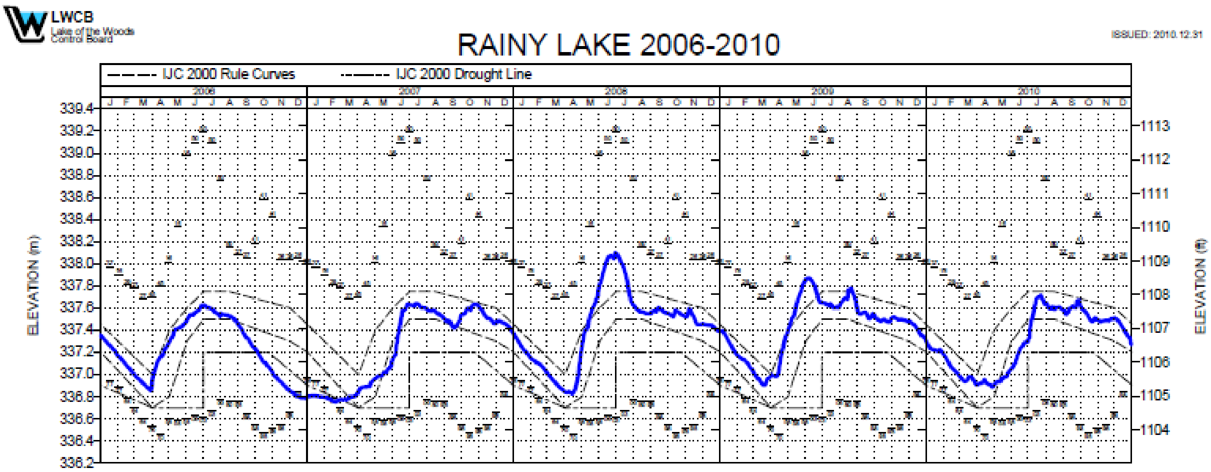
* D.I.P.F. (Daily Instantaneous Peak Flow)

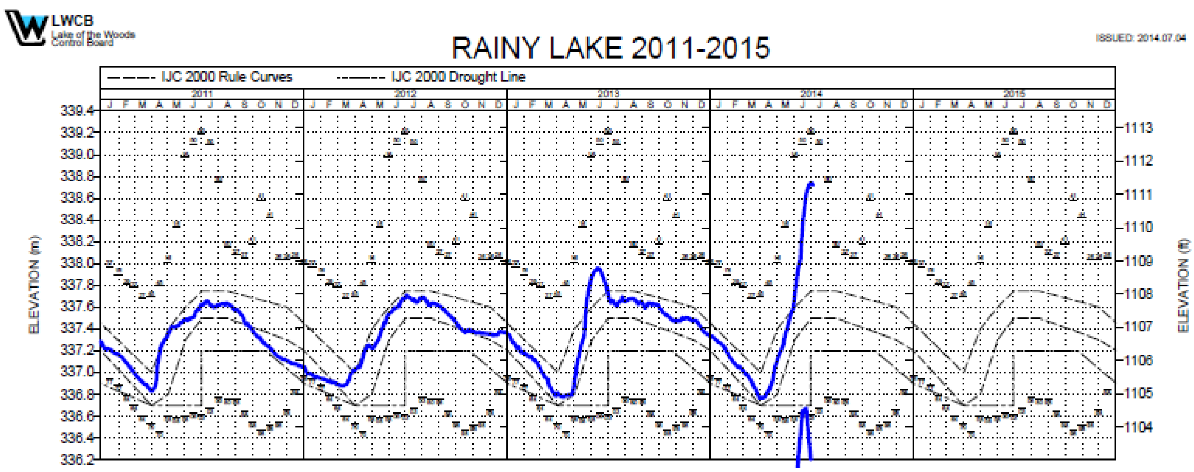
Appendix 2 – Rainy Lake Elevation Levels, 1991 to 2014








LWCB
Lake of the Woods Control Board
RAINY LAKE 2006-2010
ISSUED: 2010.12.31
IJC 2000 Rule Curves
IJC 2000 Drought Line
ELEVATION (m)
ELEVATION (ft)


LWCB
Lake of the Woods Control Board
RAINY LAKE 2011-2015
ISSUED: 2014.07.04
IJC 2000 Rule Curves
IJC 2000 Drought Line
ELEVATION (m)
ELEVATION (ft)